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(2006). "One-to-one coupling of glacial climate variability in Greenland and Antarctica." Nature **444**(7116): 195-8.

Precise knowledge of the phase relationship between climate changes in the two hemispheres is a key for understanding the Earth's climate dynamics. For the last glacial period, ice core studies have revealed strong coupling of the largest millennial-scale warm events in Antarctica with the longest Dansgaard-Oeschger events in Greenland through the Atlantic meridional overturning circulation. It has been unclear, however, whether the shorter Dansgaard-Oeschger events have counterparts in the shorter and less prominent Antarctic temperature variations, and whether these events are linked by the same mechanism. Here we present a glacial climate record derived from an ice core from Dronning Maud Land, Antarctica, which represents South Atlantic climate at a resolution comparable

with the Greenland ice core records. After methane synchronization with an ice core from North Greenland, the oxygen isotope record from the Dronning Maud Land ice core shows a one-to-one coupling between all Antarctic warm events and Greenland Dansgaard-Oeschger events by the bipolar seesaw6. The amplitude of the Antarctic warm events is found to be linearly dependent on the duration of the concurrent stadial in the North, suggesting that they all result from a similar reduction in the meridional overturning circulation.

Abramsky, Z. and M. L. Rosenzweig (1984). "Tilman's predicted productivity-diversity relationship shown by desert rodents." Nature **309**(5964): 150-1.

Tilman has developed a model to predict the number of plant species that can coexist competitively on a limited resource base. Species diversity first increases over low resource supplies, then declines as the environment becomes richer. Although Tilman 's model was developed to describe interspecific interactions between plant species, it may also apply to animal species. Tilman questions whether animals specialize on particular proportions of nutrients. However, we believe animals probably specialize on relatively subtle microhabitat differences, especially in a multispecies competitive regime. Thus, microhabitats may act like nutrients. We hypothesize that animal species, too, show a peaked curve of diversity over productivity. The present data provide a confirmation of the hypothesis using rodent species. We have investigated the number of rodent species along a geographical gradient of increasing rainfall. The gradient extends from extremely poor desert habitats to those with annual rainfall over 300 mm. Because of the aridity , precipitation reflects productivity. The diversity pattern in desert rodents agrees with that predicted by Tilman for plants. It even possesses similar asymmetry, rising steeply then falling slowly. The pattern is duplicated in rocky and sandy habitats, each of which has a distinct and almost nonoverlapping assemblage of species. As mean precipitation is closely correlated with the variability of precipitation, the diversity pattern might also be caused by a decline in the frequency of disturbances, models for which have been proposed by several investigators.

Ackerman, A. S., M. P. Kirkpatrick, et al. (2004). "The impact of humidity above stratiform clouds on indirect aerosol climate forcing." Nature **432**(7020): 1014-7.

Some of the global warming from anthropogenic greenhouse gases is offset by increased reflection of solar radiation by clouds with smaller droplets that form in air polluted with aerosol particles that serve as cloud condensation nuclei. The resulting cooling tendency, termed the indirect aerosol forcing, is thought to be comparable in magnitude to the forcing by anthropogenic CO2, but it is difficult to estimate because the physical processes that determine global aerosol and cloud populations are poorly understood. Smaller cloud droplets not only reflect sunlight more effectively, but also inhibit precipitation, which is expected to result in increased cloud water. Such an increase in cloud water would result in even more reflective clouds, further increasing the indirect forcing. Marine boundary-layer clouds polluted by aerosol particles, however, are not generally observed to hold more water. Here we simulate stratocumulus clouds with a fluid dynamics model that includes detailed treatments of cloud microphysics and radiative transfer. Our simulations show that the response of cloud water to suppression of precipitation from increased droplet concentrations is determined by a competition between moistening from decreased surface precipitation and drying from increased entrainment of overlying air. Only when the overlying air is humid or droplet concentrations are very low does sufficient precipitation reach the surface to allow cloud water to increase with droplet concentrations. Otherwise, the response of cloud water to aerosol-induced suppression of precipitation is dominated by enhanced entrainment of overlying dry air. In this scenario, cloud water is reduced as droplet concentrations increase, which diminishes the indirect climate forcing.

Adam, D. (2001). "Plan for medical research base secures future of UK lab." Nature **410**(6825): 136.

Adam, D. (2001). "Royal Society disputes value of carbon sinks." Nature **412**(6843): 108.

Adam, D. (2001). "Green-fingered gang could hold climate key." Nature **412**(6850): 847.

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Adger, W. N. and J. Barnett (2005). "Compensation for climate change must meet needs." Nature **436**(7049): 328.

Adger, W. N. and J. Barnett (2005). "Compensation for climate change must meet needs." Nature **436**(7049): 328.

Alahiotis, S., S. Miller, et al. (1977). "Natural selection at the alpha-GDH locus in Drosophila." Nature **269**(5624): 144-5.

Aldhous, P. (2004). "Land remediation: Borneo is burning." Nature **432**(7014): 144-6.

Aldhous, P. (2005). "Energy: China's burning ambition." Nature **435**(7046): 1152-4.

Alexandrov, G. (2004). "Best scientific advice is to read the climate report." Nature **431**(7010): 739.

Alexandrov, G. (2004). "Best scientific advice is to read the climate report." Nature **431**(7010): 739.

Alford, M. H. (2003). "Redistribution of energy available for ocean mixing by long-range propagation of internal waves." Nature **423**(6936): 159-62.

Ocean mixing, which affects pollutant dispersal, marine productivity and global climate, largely results from the breaking of internal gravity waves--disturbances propagating along the ocean's internal stratification. A global map of internal-wave dissipation would be useful in improving climate models, but would require knowledge of the sources of internal gravity waves and their propagation. Towards this goal, I present here computations of horizontal internal-wave propagation from 60 historical moorings and relate them to the source terms of internal waves as computed previously. Analysis of the two most energetic frequency ranges--near-inertial frequencies and semidiurnal tidal frequencies--reveals that the fluxes in both frequency bands are of the order of 1 kW x m(-1) (that is, 15-50% of the energy input) and are directed away from their respective source regions. However, the energy flux due to near-inertial waves is stronger in winter, whereas the tidal fluxes are uniform throughout the year. Both varieties of internal waves can thus significantly affect the space-time distribution of energy available for global mixing.

Allen, M. (2003). "Liability for climate change." Nature **421**(6926): 891-2.

Allen, M. (2003). "Liability for climate change." Nature **421**(6926): 891-2.

Allen, M. R. (2003). "Climate forecasting: possible or probable?" Nature **425**(6955): 242.

Allen, M. R. (2003). "Climate forecasting: possible or probable?" Nature **425**(6955): 242.

Allen, M. R. and W. J. Ingram (2002). "Constraints on future changes in climate and the

hydrologic cycle." Nature **419**(6903): 224-32.

What can we say about changes in the hydrologic cycle on 50-year timescales when we cannot predict rainfall next week? Eventually, perhaps, a great deal: the overall climate response to increasing atmospheric concentrations of greenhouse gases may prove much simpler and more predictable than the chaos of short-term weather. Quantifying the diversity of possible responses is essential for any objective, probability-based climate forecast, and this task will require a new generation of climate modelling experiments, systematically exploring the range of model behaviour that is consistent with observations. It will be substantially harder to quantify the range of possible changes in the hydrologic cycle than in global-mean temperature, both because the observations are less complete and because the physical constraints are weaker.

Allen, M. R. and R. Lord (2004). "The blame game." Nature **432**(7017): 551-2.

Allen, M. R. and D. A. Stainforth (2002). "Towards objective probabalistic climate forecasting." Nature **419**(6903): 228.

Allen, M. R., P. A. Stott, et al. (2000). "Quantifying the uncertainty in forecasts of anthropogenic climate change." Nature **407**(6804): 617-20.

Forecasts of climate change are inevitably uncertain. It is therefore essential to quantify the risk of significant departures from the predicted response to a given emission scenario. Previous analyses of this risk have been based either on expert opinion, perturbation analysis of simplified climate models or the comparison of predictions from general circulation models. Recent observed changes that appear to be attributable to human influence provide a powerful constraint on the uncertainties in multi-decadal forecasts. Here we assess the range of warming rates over the coming 50 years that are consistent with the observed near-surface temperature record as well as with the overall patterns of response predicted by several general circulation models. We expect global mean temperatures in the decade 2036-46 to be 1-2.5 K warmer than in pre-industrial times under a 'business as usual' emission scenario. This range is relatively robust to errors in the models' climate sensitivity, rate of oceanic heat uptake or global response to sulphate aerosols as long as these errors are persistent over time. Substantial changes in the current balance of greenhouse warming and sulphate aerosol cooling would, however, increase the uncertainty. Unlike 50-year warming rates, the final equilibrium warming after the atmospheric composition stabilizes remains very uncertain, despite the evidence provided by the emerging signal.

Allen, P. A. and P. F. Hoffman (2005). "Extreme winds and waves in the aftermath of a Neoproterozoic glaciation." Nature **433**(7022): 123-7.

The most severe excursions in the Earth's climatic history are thought to be associated with Proterozoic glaciations. According to the 'Snowball Earth' hypothesis, the Marinoan glaciation, which ended about 635 million years ago, involved global or nearly global ice cover. At the termination of this glacial period, rapid melting of continental ice sheets must have caused a large rise in sea level. Here we show that sediments deposited during this sea level rise contain remarkable structures that we interpret as giant wave ripples. These structures occur at homologous stratigraphic levels in Australia, Brazil, Canada, Namibia and Svalbard. Our hydrodynamic analysis of these structures suggests maximum wave periods of 21 to 30 seconds, significantly longer than those typical for today's oceans. The reconstructed wave conditions could only have been generated under sustained high wind velocities exceeding 20 metres per second in fetch-unlimited ocean basins. We propose that these extraordinary wind and wave conditions were characteristic of the climatic transit, and provide observational targets for atmospheric circulation models.

Alley, R. B., D. E. Lawson, et al. (2003). "Stabilizing feedbacks in glacier-bed erosion." Nature **424**(6950): 758-60.

Glaciers often erode, transport and deposit sediment much more rapidly than nonglacial environments, with implications for the evolution of glaciated mountain belts and their associated sedimentary basins. But modelling such glacial processes is difficult, partly because stabilizing feedbacks similar to those operating in rivers have not been identified for glacial landscapes. Here we combine new and existing data of glacier morphology and the processes governing glacier evolution from diverse settings to reveal such stabilizing feedbacks. We find that the long profiles of beds of highly erosive glaciers tend towards steady-state angles opposed to and slightly more than 50 per cent steeper than the overlying ice-air surface slopes, and that additional subglacial deepening must be enabled by non-glacial processes. Climatic or glaciological perturbations of the ice-air surface slope can have large transient effects on glaciofluvial sediment flux and apparent glacial erosion rate.

Alston, T. A. (2004). "Don't have a cow! Fight global warming with CFC." Nature **430**(7003): 965.

Altabet, M. A., M. J. Higginson, et al. (2002). "The effect of millennial-scale changes in Arabian Sea denitrification on atmospheric CO2." Nature **415**(6868): 159-62.

Most global biogeochemical processes are known to respond to climate change, some of which have the capacity to produce feedbacks through the regulation of atmospheric greenhouse gases. Marine denitrification-the reduction of nitrate to gaseous nitrogen-is an important process in this regard, affecting greenhouse gas concentrations directly through the incidental production of nitrous oxide, and indirectly through modification of the marine nitrogen inventory and hence the biological pump for CO2. Although denitrification has been shown to vary with glacial-interglacial cycles, its response to more rapid climate change has not yet been well characterized. Here we present nitrogen isotope ratio, nitrogen content and chlorin abundance data from sediment cores with high accumulation rates on the Oman continental margin that reveal substantial millennial-scale variability in Arabian Sea denitrification and productivity during the last glacial period. The detailed correspondence of these changes with Dansgaard-Oeschger events recorded in Greenland ice cores indicates rapid, century-scale reorganization of the Arabian Sea ecosystem in response to climate excursions, mediated through the intensity of summer monsoonal upwelling. Considering the several-thousand-year residence time of fixed nitrogen in the ocean, the response of global marine productivity to changes in denitrification would have occurred at lower frequency and appears to be related to climatic and atmospheric CO2 oscillations observed in Antarctic ice cores between 20 and 60 kyr ago.

Ambrose, S. H. and M. J. DeNiro (1987). "Bone nitrogen isotope composition and climate." Nature **325**(6101): 201.

Andersen, K. K., N. Azuma, et al. (2004). "High-resolution record of Northern Hemisphere climate extending into the last interglacial period." Nature **431**(7005): 147-51.

Two deep ice cores from central Greenland, drilled in the 1990s, have played a key role in climate reconstructions of the Northern Hemisphere, but the oldest sections of the cores were disturbed in chronology owing to ice folding near the bedrock. Here we present an undisturbed climate record from a North Greenland ice core, which extends back to 123,000 years before the present, within the last interglacial period. The oxygen isotopes in the ice imply that climate was stable during the last interglacial period, with temperatures 5 degrees C warmer than today. We find unexpectedly large temperature differences between our new record from northern Greenland and the undisturbed sections of the cores from

central Greenland, suggesting that the extent of ice in the Northern Hemisphere modulated the latitudinal temperature gradients in Greenland. This record shows a slow decline in temperatures that marked the initiation of the last glacial period. Our record reveals a hitherto unrecognized warm period initiated by an abrupt climate warming about 115,000 years ago, before glacial conditions were fully developed. This event does not appear to have an immediate Antarctic counterpart, suggesting that the climate see-saw between the hemispheres (which dominated the last glacial period) was not operating at this time.

Anderson, C. (1991). "Polar psychology. Coping with it all." Nature **350**(6316): 290.

Anderson, D. (1999). "Climatology: extremes in the Indian ocean." Nature **401**(6751): 337-8.

Anderson, D. M. and D. Archer (2002). "Glacial--interglacial stability of ocean pH inferred from foraminifer dissolution rates." Nature **416**(6876): 70-3.

The pH of the ocean is controlled by the chemistry of calcium carbonate. This system in turn plays a large role in regulating the CO2 concentration of the atmosphere on timescales of thousands of years and longer. Reconstructions of ocean pH and carbonate-ion concentration are therefore needed to understand the ocean's role in the global carbon cycle. During the Last Glacial Maximum (LGM), the pH of the whole ocean is thought to have been significantly more basic, as inferred from the isotopic composition of boron incorporated into calcium carbonate shells, which would partially explain the lower atmospheric CO2 concentration at that time. Here we reconstruct carbonate-ion concentration--and hence pH--of the glacial oceans, using the extent of calcium carbonate dissolution observed in foraminifer faunal assemblages as compiled in the extensive global CLIMAP data set. We observe decreased carbonate-ion concentrations in the glacial Atlantic Ocean, by roughly 20 micromolkg-1, while little change occurred in the Indian and Pacific oceans relative to today. In the Pacific Ocean, a small (5 micromolkg-1) increase occurred below 3,000m. This rearrangement of ocean pH may be due to changing ocean circulation from glacial to present times, but overall we see no evidence for a shift in the whole-ocean pH as previously inferred from boron isotopes.

Anderson, D. M. and C. A. Woodhouse (2005). "Climate change: let all the voices be heard." Nature **433**(7026): 587-8.

Anderson, D. M. and C. A. Woodhouse (2005). "Climate change: let all the voices be heard." Nature **433**(7026): 587-8.

Andreae, M. O. (2001). "The dark side of aerosols." Nature **409**(6821): 671-2.

Andreae, M. O. (2004). "Atmospheric chemistry: fire and ice." Nature **429**(6993): 713.

Andreae, M. O., C. D. Jones, et al. (2005). "Strong present-day aerosol cooling implies a hot future." Nature **435**(7046): 1187-90.

Atmospheric aerosols counteract the warming effects of anthropogenic greenhouse gases by an uncertain, but potentially large, amount. This in turn leads to large uncertainties in the sensitivity of climate to human perturbations, and therefore also in carbon cycle feedbacks and projections of climate change. In the future, aerosol cooling is expected to decline relative to greenhouse gas forcing, because of the aerosols' much shorter lifetime and the pursuit of a cleaner atmosphere. Strong aerosol cooling in the past and present would then imply that future global warming may proceed at or even above the upper extreme of the range projected by the Intergovernmental Panel on Climate Change.

Arbic, B. K., D. R. Macayeal, et al. (2004). "Palaeoclimate: ocean tides and Heinrich events." Nature **432**(7016): 460.

Climate varied enormously over the most recent ice age--for example, large pulses of ice-rafted debris, originating mainly from the Labrador Sea, were deposited into the North Atlantic at roughly 7,000-year intervals, with global climatic implications. Here we show that ocean tides within the Labrador Sea were exceptionally large over the period spanning these huge, abrupt ice movements, which are known as Heinrich events. We propose that tides played a catalytic role in liberating iceberg armadas during that time.

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Aronson, R. B., W. F. Precht, et al. (2000). "Coral bleach-out in Belize." Nature **405**(6782): 36.

Attrill, M. J. and M. Power (2002). "Climatic influence on a marine fish assemblage." Nature **417**(6886): 275-8.

Understanding the fluctuations in marine fish stocks is important for the management of fisheries, and attempts have been made to demonstrate links with oceanographic and climatic variability, including the North Atlantic Oscillation (NAO). The NAO has been correlated with a range of long-term ecological measures, including certain fish stocks. Such environmental influences are most likely to affect susceptible juveniles during estuarine residency, as estuaries are critical juvenile nursery or over-wintering habitats. Here we show that, during a 16-year period, climatic forcing (by means of the NAO) is consistently the most important parameter explaining variation in assemblage composition, abundance and growth of juvenile marine fish during estuarine residency. A possible mechanism for the effect of the NAO is a temperature differential between estuarine and marine waters that allows fish to facultatively exploit optimal thermal habitats. The connection has potentially important implications for the size and numbers of individuals recruited to the fishery, for understanding and predicting the composition of juvenile fish stocks using estuaries, and for the appropriate conservation of estuarine systems in relation to fish stocks.

Augustin, L., C. Barbante, et al. (2004). "Eight glacial cycles from an Antarctic ice core." Nature **429**(6992): 623-8.

The Antarctic Vostok ice core provided compelling evidence of the nature of climate, and of climate feedbacks, over the past 420,000 years. Marine records suggest that the amplitude of climate variability was smaller before that time, but such records are often poorly resolved. Moreover, it is not possible to infer the abundance of greenhouse gases in the atmosphere from marine records. Here we report the recovery of a deep ice core from Dome C, Antarctica, that provides a climate record for the past 740,000 years. For the four most recent glacial cycles, the data agree well with the record from Vostok. The earlier period, between 740,000 and 430,000 years ago, was characterized by less pronounced warmth in interglacial periods in Antarctica, but a higher proportion of each cycle was spent in the warm mode. The transition from glacial to interglacial conditions about 430,000 years ago (Termination V) resembles the transition into the present interglacial period in terms of the magnitude of change in temperatures and

greenhouse gases, but there are significant differences in the patterns of change. The interglacial stage following Termination V was exceptionally long--28,000 years compared to, for example, the 12,000 years recorded so far in the present interglacial period. Given the similarities between this earlier warm period and today, our results may imply that without human intervention, a climate similar to the present one would extend well into the future.

Austin, A. T. and L. Vivanco (2006). "Plant litter decomposition in a semi-arid ecosystem controlled by photodegradation." Nature **442**(7102): 555-8.

The carbon balance in terrestrial ecosystems is determined by the difference between inputs from primary production and the return of carbon to the atmosphere through decomposition of organic matter. Our understanding of the factors that control carbon turnover in water-limited ecosystems is limited, however, as studies of litter decomposition have shown contradictory results and only a modest correlation with precipitation. Here we evaluate the influence of solar radiation, soil biotic activity and soil resource availability on litter decomposition in the semi-arid Patagonian steppe using the results of manipulative experiments carried out under ambient conditions of rainfall and temperature. We show that intercepted solar radiation was the only factor that had a significant effect on the decomposition of organic matter, with attenuation of ultraviolet-B and total radiation causing a 33 and 60 per cent reduction in decomposition, respectively. We conclude that photodegradation is a dominant control on above-ground litter decomposition in this semi-arid ecosystem. Losses through photochemical mineralization may represent a short-circuit in the carbon cycle, with a substantial fraction of carbon fixed in plant biomass being lost directly to the atmosphere without cycling through soil organic matter pools. Furthermore, future changes in radiation interception due to decreased cloudiness, increased stratospheric ozone depletion, or reduced vegetative cover may have a more significant effect on the carbon balance in these water-limited ecosystems than changes in temperature or precipitation.

Azar, C. and U. M. Persson (2005). "Fighting future fires with fairness." Nature **433**(7021): 13.

Bai, Y., X. Han, et al. (2004). "Ecosystem stability and compensatory effects in the Inner Mongolia grassland." Nature **431**(7005): 181-4.

Numerous studies have suggested that biodiversity reduces variability in ecosystem productivity through compensatory effects; that is, a species increases in its abundance in response to the reduction of another in a fluctuating environment. But this view has been challenged on several grounds. Because most studies have been based on artificially constructed grasslands with short duration, long-term studies of natural ecosystems are needed. On the basis of a 24-year study of the Inner Mongolia grassland, here we present three key findings. First, that January-July precipitation is the primary climatic factor causing fluctuations in community biomass production; second, that ecosystem stability (conversely related to variability in community biomass production) increases progressively along the hierarchy of organizational levels (that is, from species to functional group to whole community); and finally, that the community-level stability seems to arise from compensatory interactions among major components at both species and functional group levels. From a hierarchical perspective, our results corroborate some previous findings of compensatory effects. Undisturbed mature steppe ecosystems seem to culminate with high biodiversity, productivity and ecosystem stability concurrently. Because these relationships are correlational, further studies are necessary to verify the causation among these factors. Our study provides new insights for better management and restoration of the rapidly degrading Inner Mongolia grassland.

Bains, S., R. D. Norris, et al. (2000). "Termination of global warmth at the Palaeocene/Eocene boundary through productivity feedback." Nature **407**(6801): 171-4.

The onset of the Palaeocene/Eocene thermal maximum (about 55 Myr ago) was marked by global surface temperatures warming by 5-7 degrees C over approximately 30,000 yr (ref. 1), probably because of enhanced mantle outgassing and the pulsed release of approximately 1,500 gigatonnes of methane carbon from decomposing gas-hydrate reservoirs. The aftermath of this rapid, intense and global warming event may be the best example in the geological record of the response of the Earth to high atmospheric carbon dioxide concentrations and high temperatures. This response has been suggested to include an intensified flux of organic carbon from the ocean surface to the deep ocean and its subsequent burial through biogeochemical feedback mechanisms. Here we present firm evidence for this view from two ocean drilling cores, which record the largest accumulation rates of biogenic barium--indicative of export palaeoproductivity--at times of maximum global temperatures and peak excursion values of delta13C. The unusually rapid return of delta13C to values similar to those before the methane release and the apparent coupling of the accumulation rates of biogenic barium to temperature, suggests that the enhanced deposition of organic matter to the deep sea may have efficiently cooled this greenhouse climate by the rapid removal of excess carbon dioxide from the atmosphere.

Baker, A. C. (2001). "Reef corals bleach to survive change." Nature **411**(6839): 765-6.

Baker, A. C., C. J. Starger, et al. (2004). "Coral reefs: corals' adaptive response to climate change." Nature **430**(7001): 741.

The long-term response of coral reefs to climate change depends on the ability of reef-building coral symbioses to adapt or acclimatize to warmer temperatures, but there has been no direct evidence that such a response can occur. Here we show that corals containing unusual algal symbionts that are thermally tolerant and commonly associated with high-temperature environments are much more abundant on reefs that have been severely affected by recent climate change. This adaptive shift in symbiont communities indicates that these devastated reefs could be more resistant to future thermal stress, resulting in significantly longer extinction times for surviving corals than had been previously assumed.

Baker, A. C., C. J. Starger, et al. (2004). "Coral reefs: corals' adaptive response to climate change." Nature **430**(7001): 741.

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Baker, P. A., C. A. Rigsby, et al. (2001). "Tropical climate changes at millennial and orbital timescales on the Bolivian Altiplano." Nature **409**(6821): 698-701.

Tropical South America is one of the three main centres of the global, zonal overturning circulation of the equatorial atmosphere (generally termed the 'Walker' circulation). Although this area plays a key role in global climate cycles, little is known about South American climate history. Here we describe sediment cores and down-hole logging results of deep drilling in the Salar de Uyuni, on the Bolivian Altiplano, located in the tropical Andes. We demonstrate that during the past 50,000 years the Altiplano underwent important changes in effective moisture at both orbital (20,000-year) and millennial timescales. Long-duration

wet periods, such as the Last Glacial Maximum--marked in the drill core by continuous deposition of lacustrine sediments--appear to have occurred in phase with summer insolation maxima produced by the Earth's precessional cycle. Short-duration, millennial events correlate well with North Atlantic cold events, including Heinrich events 1 and 2, as well as the Younger Dryas episode. At both millennial and orbital timescales, cold sea surface temperatures in the high-latitude North Atlantic were coeval with wet conditions in tropical South America, suggesting a common forcing.

Baker, P. J. and J. S. Wilson (2003). "Plant ecology: Coexistence of tropical tree species." Nature **422**(6932): 581-2; discussion 852.

Bakker, D. and A. Watson (2001). "Global change. A piece in the CO2 jigsaw." Nature **410**(6830): 765-6.

Baldocchi, D. (2005). "Environmental science: the carbon cycle under stress." Nature **437**(7058): 483-4.

Bange, H. W. (2000). "Global change. It's not a gas." Nature **408**(6810): 301-2.

Barber, V. A., G. P. Juday, et al. (2000). "Reduced growth of Alaskan white spruce in the twentieth century from temperature-induced drought stress." Nature **405**(6787): 668-73.

The extension of growing season at high northern latitudes seems increasingly clear from satellite observations of vegetation extent and duration. This extension is also thought to explain the observed increase in amplitude of seasonal variations in atmospheric CO2 concentration. Increased plant respiration and photosynthesis both correlate well with increases in temperature this century and are therefore the most probable link between the vegetation and CO2 observations. From these observations, it has been suggested that increases in temperature have stimulated carbon uptake in high latitudes and for the boreal forest system as a whole. Here we present multi-proxy tree-ring data (ring width, maximum late-wood density and carbon-isotope composition) from 20 productive stands of white spruce in the interior of Alaska. The tree-ring records show a strong and consistent relationship over the past 90 years and indicate that, in contrast with earlier predictions, radial growth has decreased with increasing temperature. Our data show that temperature-induced drought stress has disproportionately affected the most rapidly growing white spruce, suggesting that, under recent climate warming, drought may have been an important factor limiting carbon uptake in a large portion of the North American boreal forest. If this limitation in growth due to drought stress is sustained, the future capacity of northern latitudes to sequester carbon may be less than currently expected.

Barbraud, C. and H. Weimerskirch (2001). "Emperor penguins and climate change." Nature **411**(6834): 183-6.

Variations in ocean-atmosphere coupling over time in the Southern Ocean have dominant effects on sea-ice extent and ecosystem structure, but the ultimate consequences of such environmental changes for large marine predators cannot be accurately predicted because of the absence of long-term data series on key demographic parameters. Here, we use the longest time series available on demographic parameters of an Antarctic large predator breeding on fast ice and relying on food resources from the Southern Ocean. We show that over the past 50 years, the population of emperor penguins (Aptenodytes forsteri) in Terre Adelie has declined by 50% because of a decrease in adult survival during the late 1970s. At this time there was a prolonged abnormally warm period with reduced sea-ice extent. Mortality rates increased when warm sea-surface temperatures occurred in the foraging area and when annual sea-ice extent was reduced, and were higher for males than for females. In contrast with survival, emperor

penguins hatched fewer eggs when winter sea-ice was extended. These results indicate strong and contrasting effects of large-scale oceanographic processes and sea-ice extent on the demography of emperor penguins, and their potential high susceptibility to climate change.

Barnett, S. A. (1960). "An adaptive change in an inbred mouse strain maintained in a cold environment." Nature **188**: 500-1.

Barnett, S. A. and K. M. Munro (1971). "Persistent corpora lutea of mice in a cold environment." Nature **232**(5310): 406-7.

Barnett, T. P., J. C. Adam, et al. (2005). "Potential impacts of a warming climate on water availability in snow-dominated regions." Nature **438**(7066): 303-9.
All currently available climate models predict a near-surface warming trend under the influence of rising levels of greenhouse gases in the atmosphere. In addition to the direct effects on climate--for example, on the frequency of heatwaves--this increase in surface temperatures has important consequences for the hydrological cycle, particularly in regions where water supply is currently dominated by melting snow or ice. In a warmer world, less winter precipitation falls as snow and the melting of winter snow occurs earlier in spring. Even without any changes in precipitation intensity, both of these effects lead to a shift in peak river runoff to winter and early spring, away from summer and autumn when demand is highest. Where storage capacities are not sufficient, much of the winter runoff will immediately be lost to the oceans. With more than one-sixth of the Earth's population relying on glaciers and seasonal snow packs for their water supply, the consequences of these hydrological changes for future water availability--predicted with high confidence and already diagnosed in some regions--are likely to be severe.

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Barrett, P. (2003). "Palaeoclimatology: Cooling a continent." Nature **421**(6920): 221-3.

Barrett, P. (2003). "Palaeoclimatology: Cooling a continent." Nature **421**(6920): 221-3.

Barrie Pittock, A., R. N. Jones, et al. (2001). "Probabilities will help us plan for climate change." Nature **413**(6853): 249.

Barry, L., G. C. Craig, et al. (2002). "Poleward heat transport by the atmospheric heat engine." Nature **415**(6873): 774-7.
The atmospheric heat transport on Earth from the Equator to the poles is largely

carried out by the mid-latitude storms. However, there is no satisfactory theory to describe this fundamental feature of the Earth's climate. Previous studies have characterized the poleward heat transport as a diffusion by eddies of specified horizontal length and velocity scales, but there is little agreement as to what those scales should be. Here we propose instead to regard the baroclinic zone--the zone of strong temperature gradients and active eddies--as a heat engine which generates eddy kinetic energy by transporting heat from a warmer to a colder region. This view leads to a new velocity scale, which we have tested along with previously proposed length and velocity scales, using numerical climate simulations in which the eddy properties have been varied by changing forcing and boundary conditions. The experiments show that the eddy velocity varies in accordance with the new scale, while the size of the eddies varies with the well-known Rhines beta-scale. Our results not only give new insight into atmospheric eddy heat transport, but also allow simple estimates of the intensities of mid-latitude storms, which have hitherto only been possible with expensive general circulation models.

Basile-Doelsch, I., J. D. Meunier, et al. (2005). "Another continental pool in the terrestrial silicon cycle." Nature **433**(7024): 399-402.

Silicon is the second most abundant element on Earth. It is an important nutrient for phytoplankton and is readily absorbed by terrestrial vegetation; it also assists the removal of carbon dioxide from the atmosphere through the weathering of silicates. But the continental cycle of silicon is not well known, and only a few studies have attempted to use silicon stable isotopes (28Si, 29Si and 30Si) to quantify the continental silicon reservoirs. Dissolved silicon in sea and river waters forms a reservoir of mean isotopic value +1.1 per thousand (refs 7, 10). It is enriched in 30Si with respect to the igneous rocks reservoir, which has a mean isotopic value of -0.3 per thousand (refs 4, 9). This enrichment can only be produced by a major fractionation during weathering, and should result in the formation of a continental 30Si-depleted reservoir. Such a reservoir, however, has not been identified to date. Here we analyse silicon isotopes of in situ quartz from a sandstone series in France, using a new-generation secondary ion mass spectrometry apparatus. We show that quartz that precipitates as siliceous cements forms a strongly 30Si-depleted reservoir with isotopic values down to -5.7 per thousand, a more negative value than any previously published for terrestrial samples. Our findings suggest that quartz re-precipitation plays an important role in the biogeochemical cycle of silicon.

Bates, N. R., A. C. Pequignet, et al. (2002). "A short-term sink for atmospheric CO2 in subtropical mode water of the North Atlantic Ocean." Nature **420**(6915): 489-93.

Large-scale features of ocean circulation, such as deep water formation in the northern North Atlantic Ocean, are known to regulate the long-term physical uptake of CO2 from the atmosphere by moving CO2-laden surface waters into the deep ocean. But the importance of CO2 uptake into water masses that ventilate shallower ocean depths, such as subtropical mode waters of the subtropical gyres, are poorly quantified. Here we report that, between 1988 and 2001, dissolved CO2 concentrations in subtropical mode waters of the North Atlantic have increased at a rate twice that expected from these waters keeping in equilibrium with increasing atmospheric CO2. This accounts for an extra 0.4-2.8 Pg C (1 Pg = 10(15) g) over this period (that is, about 0.03-0.24 Pg C yr(-1)), equivalent to 3-10% of the current net annual ocean uptake of CO2 (ref. 3). We suggest that the lack of strong winter mixing events, to greater than 300 m in depth, in recent decades is responsible for this accumulation, which would otherwise disturb the mode water layer and liberate accumulated CO2 back to the atmosphere. However, future climate variability (which influences subtropical mode water formation) and changes in the North Atlantic Oscillation (leading to a return of deep winter mixing events) may reduce CO2 accumulation in subtropical mode waters. We therefore conclude that, although CO2 uptake by

subtropical mode waters in the North Atlantic--and possibly elsewhere--does not always represent a long-term CO2 sink, the phenomenon is likely to contribute substantially to interannual variability in oceanic CO2 uptake.

Bauch, D., K. Darling, et al. (2003). "Palaeoceanographic implications of genetic variation in living North Atlantic Neogloboquadrina pachyderma." Nature **424**(6946): 299-302.

The shells of the planktonic foraminifer Neogloboquadrina pachyderma have become a classical tool for reconstructing glacial-interglacial climate conditions in the North Atlantic Ocean. Palaeoceanographers utilize its left- and right-coiling variants, which exhibit a distinctive reciprocal temperature and water mass related shift in faunal abundance both at present and in late Quaternary sediments. Recently discovered cryptic genetic diversity in planktonic foraminifers now poses significant questions for these studies. Here we report genetic evidence demonstrating that the apparent 'single species' shell-based records of right-coiling N. pachyderma used in palaeoceanographic reconstructions contain an alternation in species as environmental factors change. This is reflected in a species-dependent incremental shift in right-coiling N. pachyderma shell calcite delta18O between the Last Glacial Maximum and full Holocene conditions. Guided by the percentage dextral coiling ratio, our findings enhance the use of delta18O records of right-coiling N. pachyderma for future study. They also highlight the need to genetically investigate other important morphospecies to refine their accuracy and reliability as palaeoceanographic proxies.

Beardsley, T. (1982). "In vitro fertilization: MRC tests the climate." Nature **300**(5890): 309.

KIE: It is reported that Britain's Medical Research Council has published guidelines for MRC-supported research involving human embryos obtained through in vitro fertilization. In ethics committee-approved projects, researchers may use deliberately fertilized ova or, with parents' consent, fertilized ova left over from therapeutic programs. In vitro culture of human embryos is permitted only up to the implantation stage. Conditions are also set for experiments on interspecies fertilization and on freezing of embryos. Concern over physician and public reception of these guidelines has been expressed by the British Medical Association.

Beckmann, B., S. Flogel, et al. (2005). "Orbital forcing of Cretaceous river discharge in tropical Africa and ocean response." Nature **437**(7056): 241-4.

The tropics have been suggested as the drivers of global ocean and atmosphere circulation and biogeochemical cycling during the extreme warmth of the Cretaceous period; but the links between orbital forcing, freshwater runoff and the biogeochemistry of continental margins in extreme greenhouse conditions are not fully understood. Here we present Cretaceous records of geochemical tracers for freshwater runoff obtained from a sediment core off the Ivory Coast that indicate that alternating periods of arid and humid African climate were driven by orbital precession. Our simulations of the precession-driven patterns of river discharge with a global climate model suggest that ocean anoxia and black shale sedimentation were directly caused by high river discharge, and occurred specifically when the northern equinox coincided with perihelion (the minimum distance between the Sun and the Earth). We conclude that, in a warm climate, the oceans off tropical continental margins respond rapidly and sensitively to even modest changes in river discharge.

Behrenfeld, M. J., K. Worthington, et al. (2006). "Controls on tropical Pacific Ocean productivity revealed through nutrient stress diagnostics." Nature **442**(7106): 1025-8.

In situ enrichment experiments have shown that the growth of bloom-forming diatoms in the major high-nitrate low-chlorophyll (HNLC) regions of the world's

oceans is limited by the availability of iron. Yet even the largest of these manipulative experiments represents only a small fraction of an ocean basin, and the responses observed are strongly influenced by the proliferation of rare species rather than the growth of naturally dominant populations. Here we link unique fluorescence attributes of phytoplankton to specific physiological responses to nutrient stress, and use these relationships to evaluate the factors that constrain phytoplankton growth in the tropical Pacific Ocean on an unprecedented spatial scale. On the basis of fluorescence measurements taken over 12 years, we delineate three major ecophysiological regimes in this region. We find that iron has a key function in regulating phytoplankton growth in both HNLC and oligotrophic waters near the Equator and further south, whereas nitrogen and zooplankton grazing are the primary factors that regulate biomass production in the north. Application of our findings to the interpretation of satellite chlorophyll fields shows that productivity in the tropical Pacific basin may be 1.2-2.5 Pg C yr(-1) lower than previous estimates have suggested, a difference that is comparable to the global change in ocean production that accompanied the largest El Nino to La Nina transition on record.

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Beighton, P. (1971). "Fluid balance in the Sahara." Nature **233**(5317): 275-7.

Bekker, A., H. D. Holland, et al. (2004). "Dating the rise of atmospheric oxygen." Nature **427**(6970): 117-20.

Several lines of geological and geochemical evidence indicate that the level of atmospheric oxygen was extremely low before 2.45 billion years (Gyr) ago, and that it had reached considerable levels by 2.22 Gyr ago. Here we present evidence that the rise of atmospheric oxygen had occurred by 2.32 Gyr ago. We found that syngenetic pyrite is present in organic-rich shales of the 2.32-Gyr-old Rooihoogte and Timeball Hill formations, South Africa. The range of the isotopic composition of sulphur in this pyrite is large and shows no evidence of mass-independent fractionation, indicating that atmospheric oxygen was present at significant levels (that is, greater than 10(-5) times that of the present atmospheric level) during the deposition of these units. The presence of rounded pebbles of sideritic iron formation at the base of the Rooihoogte Formation and an extensive and thick ironstone layer consisting of haematitic pisolites and oolites in the upper Timeball Hill Formation indicate that atmospheric oxygen

rose significantly, perhaps for the first time, during the deposition of the Rooihoogte and Timeball Hill formations. These units were deposited between what are probably the second and third of the three Palaeoproterozoic glacial events.

Bell, J. F. and A. Massey (1996). "Significance of birth-dates." Nature **382**(6593): 666.

Bellamy, P. H., P. J. Loveland, et al. (2005). "Carbon losses from all soils across England and Wales 1978-2003." Nature **437**(7056): 245-8.

More than twice as much carbon is held in soils as in vegetation or the atmosphere, and changes in soil carbon content can have a large effect on the global carbon budget. The possibility that climate change is being reinforced by increased carbon dioxide emissions from soils owing to rising temperature is the subject of a continuing debate. But evidence for the suggested feedback mechanism has to date come solely from small-scale laboratory and field experiments and modelling studies. Here we use data from the National Soil Inventory of England and Wales obtained between 1978 and 2003 to show that carbon was lost from soils across England and Wales over the survey period at a mean rate of 0.6% yr(-1) (relative to the existing soil carbon content). We find that the relative rate of carbon loss increased with soil carbon content and was more than 2% yr(-1) in soils with carbon contents greater than 100 g kg(-1). The relationship between rate of carbon loss and carbon content is irrespective of land use, suggesting a link to climate change. Our findings indicate that losses of soil carbon in England and Wales--and by inference in other temperate regions-are likely to have been offsetting absorption of carbon by terrestrial sinks.

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Bellouin, N., O. Boucher, et al. (2005). "Global estimate of aerosol direct radiative forcing from satellite measurements." Nature **438**(7071): 1138-41.

Atmospheric aerosols cause scattering and absorption of incoming solar radiation. Additional anthropogenic aerosols released into the atmosphere thus exert a direct radiative forcing on the climate system. The degree of present-day aerosol forcing is estimated from global models that incorporate a representation of the aerosol cycles. Although the models are compared and validated against observations, these estimates remain uncertain. Previous satellite measurements of the direct effect of aerosols contained limited information about aerosol type, and were confined to oceans only. Here we use state-of-the-art satellite-based measurements of aerosols and surface wind speed to estimate the clear-sky direct radiative forcing for 2002, incorporating measurements over land and ocean. We

use a Monte Carlo approach to account for uncertainties in aerosol measurements and in the algorithm used. Probability density functions obtained for the direct radiative forcing at the top of the atmosphere give a clear-sky, global, annual average of -1.9 W m(-2) with standard deviation, +/- 0.3 W m(-2). These results suggest that present-day direct radiative forcing is stronger than present model estimates, implying future atmospheric warming greater than is presently predicted, as aerosol emissions continue to decline.

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Benham, B. R., D. Lonsdale, et al. (1974). "Is polymorphism in two-spot ladybird an example of non-industrial melanism?" Nature **249**(453): 179-80.

Berner, R. A. (2003). "The long-term carbon cycle, fossil fuels and atmospheric composition." Nature **426**(6964): 323-6.

The long-term carbon cycle operates over millions of years and involves the exchange of carbon between rocks and the Earth's surface. There are many complex feedback pathways between carbon burial, nutrient cycling, atmospheric carbon dioxide and oxygen, and climate. New calculations of carbon fluxes during the Phanerozoic eon (the past 550 million years) illustrate how the long-term carbon cycle has affected the burial of organic matter and fossil-fuel formation, as well as the evolution of atmospheric composition.

Betts, R. A. (2000). "Offset of the potential carbon sink from boreal forestation by decreases in surface albedo." Nature **408**(6809): 187-90.

Carbon uptake by forestation is one method proposed to reduce net carbon dioxide emissions to the atmosphere and so limit the radiative forcing of climate change. But the overall impact of forestation on climate will also depend on other effects associated with the creation of new forests. In particular, the albedo of a forested landscape is generally lower than that of cultivated land, especially when snow is lying, and decreasing albedo exerts a positive radiative forcing on climate. Here I simulate the radiative forcings associated with changes in surface albedo as a result of forestation in temperate and boreal forest areas, and translate these forcings into equivalent changes in local carbon stock for comparison with estimated carbon sequestration potentials. I suggest that in many boreal forest areas, the positive forcing induced by decreases in albedo can offset the negative forcing that is expected from carbon sequestration. Some high-latitude forestation activities may therefore increase climate change, rather than mitigating it as intended.

Bibring, J. P., Y. Langevin, et al. (2004). "Perennial water ice identified in the south polar cap of Mars." Nature **428**(6983): 627-30.

The inventory of water and carbon dioxide reservoirs on Mars are important clues for understanding the geological, climatic and potentially exobiological evolution of the planet. From the early mapping observation of the permanent ice caps on the martian poles, the northern cap was believed to be mainly composed of water ice, whereas the southern cap was thought to be constituted of carbon dioxide ice. However, recent missions (NASA missions Mars Global Surveyor and Odyssey) have revealed surface structures, altimetry profiles, underlying buried hydrogen, and temperatures of the south polar regions that are thermodynamically consistent with a mixture of surface water ice and carbon dioxide. Here we present the first direct identification and mapping of both carbon dioxide and water ice in the martian high southern latitudes, at a resolution of 2 km, during the local summer, when the extent of the polar ice is at its minimum. We observe that this south polar cap contains perennial water ice in extended areas: as a small admixture to carbon dioxide in the bright regions; associated with dust, without carbon dioxide, at the edges of this bright cap; and, unexpectedly, in large areas tens of kilometres away from the bright cap.

Bills, B. G. (1998). "An oblique view of climate." Nature **396**(6710): 405-6.

Billups, K. (2004). "Palaeoclimate: low-down on a rhythmic high." Nature **427**(6976): 686-7.

Billups, K. (2004). "Palaeoclimate: low-down on a rhythmic high." Nature **427**(6976): 686-7.

Billups, K. (2005). "Climate change: snow maker for the ice ages." Nature **433**(7028): 809-10.

Bintanja, R., R. S. van de Wal, et al. (2005). "Modelled atmospheric temperatures and global sea levels over the past million years." Nature **437**(7055): 125-8.

Marine records of sediment oxygen isotope compositions show that the Earth's climate has gone through a succession of glacial and interglacial periods during the past million years. But the interpretation of the oxygen isotope records is complicated because both isotope storage in ice sheets and deep-water temperature affect the recorded isotopic composition. Separating these two effects would require long records of either sea level or deep-ocean temperature, which are currently not available. Here we use a coupled model of the Northern Hemisphere ice sheets and ocean temperatures, forced to match an oxygen isotope record for the past million years compiled from 57 globally distributed sediment cores, to quantify both contributions simultaneously. We find that the ice-sheet contribution to the variability in oxygen isotope composition varied from ten per cent in the beginning of glacial periods to sixty per cent at glacial maxima, suggesting that strong ocean cooling preceded slow ice-sheet build-up. The model yields mutually consistent time series of continental mean surface temperatures between 40 and 80 degrees N, ice volume and global sea level. We find that during extreme glacial stages, air temperatures were 17 +/- 1.8 degrees C lower than present, with a 120 +/- 10 m sea level equivalent of continental ice present.

Bishop, M. J., R. Lohrmann, et al. (1972). "Prebiotic phosphorylation of thymidine at 65 degrees C in simulated desert conditions." Nature **237**(5351): 162-4.

Bishop, W. W. (1973). "The tempo of human evolution." Nature **244**(5416): 405-9.

Blackburn, T. M. and R. P. Duncan (2001). "Determinants of establishment success in introduced birds." Nature **414**(6860): 195-7.

A major component of human-induced global change is the deliberate or accidental translocation of species from their native ranges to alien environments, where they may cause substantial environmental and economic damage. Thus we need to understand why some introductions succeed while others fail. Successful introductions tend to be concentrated in certain regions, especially islands and the temperate zone, suggesting that species-rich mainland and tropical locations are harder to invade because of greater biotic resistance. However, this pattern could also reflect variation in the suitability of the abiotic environment at introduction locations for the species introduced, coupled with known confounding effects of nonrandom selection of species and locations for introduction. Here, we test these alternative hypotheses using a global data set of historical bird introductions, employing a statistical framework that accounts for differences among species and regions in terms of introduction success. By removing these confounding effects, we show that the pattern of avian introduction success is not consistent with the biotic resistance hypothesis. Instead, success depends on the suitability of the abiotic environment for the exotic species at the introduction site.

Blaustein, A. R. and A. Dobson (2006). "Extinctions: a message from the frogs." Nature **439**(7073): 143-4.

Bloxham, J. (2000). "Sensitivity of the geomagnetic axial dipole to thermal core-mantle interactions." Nature **405**(6782): 63-5.

Since the work of William Gilbert in 1600 (ref. 1), it has been widely believed that the Earth's magnetic field, when suitably time-averaged, is that of a magnetic dipole positioned at the Earth's centre and aligned with the rotational axis. This 'geocentric axial dipole' (GAD) hypothesis has been the central model for the study of the Earth's magnetic field--it underpins almost all interpretations of palaeomagnetic data, whether for studies of palaeomagnetic secular variation, for plate tectonic reconstructions, or for studies of palaeoclimate. Although the GAD hypothesis appears to provide a good description of the Earth's magnetic field over at least the past 100 Myr (ref. 2), it is difficult to test the hypothesis for earlier periods, and there is some evidence that a more complicated model is required for the period before 250 Myr ago. Kent and Smethurst suggested that this additional complexity might be because the inner core would have been smaller at that time. Here I use a numerical geodynamo model and find that reducing the size of the inner core does not significantly change the character of the magnetic field. I also consider an alternative process that could lead to the breakdown of the GAD hypothesis on this timescale, the evolution of heat-flux variations at the core-mantle boundary, induced by mantle convection. I find that a simple pattern of heat-flux variations at the core-mantle boundary, which is plausible for times before the Mesozoic era, results in a strong octupolar contribution to the field, consistent with previous findings.

Borchert, R., S. S. Renner, et al. (2005). "Photoperiodic induction of synchronous flowering near the Equator." Nature **433**(7026): 627-9.

In tropical rainforests, 30-65% of tree species grow at densities of less than one individual per hectare. At these low population densities, successful cross-pollination relies on synchronous flowering. In rainforests with low climatic seasonality, photoperiodic control is the only reliable mechanism for inducing synchronous flowering. This poses a problem because there is no variation in day length at the Equator. Here we propose a new mechanism of photoperiodic timekeeping based on the perception of variation in sunrise or sunset time, which explains and predicts the annually repeated, staggered, synchronous and bimodal flowering of many tree species in Amazonian rainforests near the Equator.

Both, C., S. Bouwhuis, et al. (2006). "Climate change and population declines in a long-distance migratory bird." Nature **441**(7089): 81-3.

Phenological responses to climate change differ across trophic levels, which may lead to birds failing to breed at the time of maximal food abundance. Here we investigate the population consequences of such mistiming in the migratory pied flycatcher, Ficedula hypoleuca. In a comparison of nine Dutch populations, we find that populations have declined by about 90% over the past two decades in areas where the food for provisioning nestlings peaks early in the season and the birds are currently mistimed. In areas with a late food peak, early-breeding birds still breed at the right time, and there is, at most, a weak population decline. If food phenology advances further, we also predict population declines in areas with a late food peak, as in these areas adjustment to an advanced food peak is insufficient. Mistiming as a result of climate change is probably a widespread phenomenon, and here we provide evidence that it can lead to population declines.

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Both, C. and M. E. Visser (2001). "Adjustment to climate change is constrained by arrival date in a long-distance migrant bird." Nature **411**(6835): 296-8.

Spring temperatures in temperate regions have increased over the past 20 years, and many organisms have responded to this increase by advancing the date of their growth and reproduction. Here we show that adaptation to climate change in a long-distance migrant is constrained by the timing of its migratory journey. For long-distance migrants climate change may advance the phenology of their breeding areas, but the timing of some species' spring migration relies on endogenous rhythms that are not affected by climate change. Thus, the spring migration of these species will not advance even though they need to arrive earlier on their breeding grounds to breed at the appropriate time. We show that the migratory pied flycatcher Ficedula hypoleuca has advanced its laying date over the past 20 years. This temporal shift has been insufficient, however, as indicated by increased selection for earlier breeding over the same period. The shift is hampered by its spring arrival date, which has not advanced. Some of the numerous long-distance migrants will suffer from climate change, because either their migration strategy is unaffected by climate change, or the climate in breeding and wintering areas are changing at different speeds, preventing adequate adaptation.

Both, C. and M. E. Visser (2001). "Adjustment to climate change is constrained by arrival date in a long-distance migrant bird." Nature **411**(6835): 296-8.

Spring temperatures in temperate regions have increased over the past 20 years, and many organisms have responded to this increase by advancing the date of

their growth and reproduction. Here we show that adaptation to climate change in a long-distance migrant is constrained by the timing of its migratory journey. For long-distance migrants climate change may advance the phenology of their breeding areas, but the timing of some species' spring migration relies on endogenous rhythms that are not affected by climate change. Thus, the spring migration of these species will not advance even though they need to arrive earlier on their breeding grounds to breed at the appropriate time. We show that the migratory pied flycatcher Ficedula hypoleuca has advanced its laying date over the past 20 years. This temporal shift has been insufficient, however, as indicated by increased selection for earlier breeding over the same period. The shift is hampered by its spring arrival date, which has not advanced. Some of the numerous long-distance migrants will suffer from climate change, because either their migration strategy is unaffected by climate change, or the climate in breeding and wintering areas are changing at different speeds, preventing adequate adaptation.

Bousquet, P., P. Ciais, et al. (2006). "Contribution of anthropogenic and natural sources to atmospheric methane variability." Nature **443**(7110): 439-43.

Methane is an important greenhouse gas, and its atmospheric concentration has nearly tripled since pre-industrial times. The growth rate of atmospheric methane is determined by the balance between surface emissions and photochemical destruction by the hydroxyl radical, the major atmospheric oxidant. Remarkably, this growth rate has decreased markedly since the early 1990s, and the level of methane has remained relatively constant since 1999, leading to a downward revision of its projected influence on global temperatures. Large fluctuations in the growth rate of atmospheric methane are also observed from one year to the next, but their causes remain uncertain. Here we quantify the processes that controlled variations in methane emissions between 1984 and 2003 using an inversion model of atmospheric transport and chemistry. Our results indicate that wetland emissions dominated the inter-annual variability of methane sources, whereas fire emissions played a smaller role, except during the 1997-1998 El Nino event. These top-down estimates of changes in wetland and fire emissions are in good agreement with independent estimates based on remote sensing information and biogeochemical models. On longer timescales, our results show that the decrease in atmospheric methane growth during the 1990s was caused by a decline in anthropogenic emissions. Since 1999, however, they indicate that anthropogenic emissions of methane have risen again. The effect of this increase on the growth rate of atmospheric methane has been masked by a coincident decrease in wetland emissions, but atmospheric methane levels may increase in the near future if wetland emissions return to their mean 1990s levels.

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Bowen, B. W., A. B. Meylan, et al. (1991). "Evolutionary distinctiveness of the endangered Kemp's ridley sea turtle." Nature **352**(6337): 709-11.

The endangered Kemp's ridley sea turtle (Lepidochelys kempi) nests almost exclusively at a single locality in the western Gulf of Mexico, whereas the olive ridley (L. olivacea) nests globally in warm oceans. Morphological similarities between kempi and olivacea, and a geographical distribution that "...makes no sense at all under modern conditions of climate and geography", raise questions about the degree of evolutionary divergence between these taxa. Analysis of mitochondrial (mt) DNA restriction sites shows that Kemp's ridley is distinct from the olive ridley in matriarchal phylogeny, and that the two are sister taxa with respect to other marine turtles. Separation of olive and the Kemp's ridley lineages may date to formation of the Isthmus of Panama, whereas the global spread of the olive ridley lineage occurred recently. In contrast to recent examples in which molecular genetic assessments challenged systematic assignments underlying conservation programmes, our mtDNA data corroborate the taxonomy of an endangered form.

Bowen, G. J., D. J. Beerling, et al. (2004). "A humid climate state during the Palaeocene/Eocene thermal maximum." Nature **432**(7016): 495-9.

An abrupt climate warming of 5 to 10 degrees C during the Palaeocene/Eocene boundary thermal maximum (PETM) 55 Myr ago is linked to the catastrophic release of approximately 1,050-2,100 Gt of carbon from sea-floor methane hydrate reservoirs. Although atmospheric methane, and the carbon dioxide derived from its oxidation, probably contributed to PETM warming, neither the magnitude nor the timing of the climate change is consistent with direct greenhouse forcing by the carbon derived from methane hydrate. Here we demonstrate significant differences between marine and terrestrial carbon isotope records spanning the PETM. We use models of key carbon cycle processes to identify the cause of these differences. Our results provide evidence for a previously unrecognized discrete shift in the state of the climate system during the PETM, characterized by large increases in mid-latitude tropospheric humidity and enhanced cycling of carbon through terrestrial ecosystems. A more humid atmosphere helps to explain PETM temperatures, but the ultimate mechanisms underlying the shift remain unknown.

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Bower, A. S., B. Le Cann, et al. (2002). "Directly measured mid-depth circulation in the northeastern North Atlantic Ocean." Nature **419**(6907): 603-7.

The circulation of water masses in the northeastern North Atlantic Ocean has a strong influence on global climate owing to the northward transport of warm subtropical water to high latitudes. But the ocean circulation at depths below the reach of satellite observations is difficult to measure, and only recently have comprehensive, direct observations of whole ocean basins been possible. Here we present quantitative maps of the absolute velocities at two levels in the northeastern North Atlantic as obtained from acoustically tracked floats. We find that most of the mean flow transported northward by the Gulf Stream system at the thermocline level (about 600 m depth) remains within the subpolar region, and only relatively little enters the Rockall trough or the Nordic seas. Contrary to previous work, our data indicate that warm, saline water from the Mediterranean Sea reaches the high latitudes through a combination of narrow slope currents and mixing processes. At both depths under investigation, currents cross the Mid-Atlantic Ridge preferentially over deep gaps in the ridge, demonstrating that sea-floor topography can constrain even upper-ocean circulation patterns.

Bowler, J. M., H. Johnston, et al. (2003). "New ages for human occupation and climatic change at Lake Mungo, Australia." Nature **421**(6925): 837-40.

Australia's oldest human remains, found at Lake Mungo, include the world's oldest ritual ochre burial (Mungo III) and the first recorded cremation (Mungo I). Until now, the importance of these finds has been constrained by limited chronologies and palaeoenvironmental information. Mungo III, the source of the world's oldest human mitochondrial DNA, has been variously estimated at 30 thousand years (kyr) old, 42-45 kyr old and 62 +/- 6 kyr old, while radiocarbon estimates placed the Mungo I cremation near 20-26 kyr ago. Here we report a new series of 25 optical ages showing that both burials occurred at 40 +/- 2 kyr ago and that humans were present at Lake Mungo by 50-46 kyr ago, synchronously with, or soon after, initial occupation of northern and western Australia. Stratigraphic evidence indicates fluctuations between lake-full and drier conditions from 50 to 40 kyr ago, simultaneously with increased dust deposition, human arrival and continent-wide extinction of the megafauna. This was followed by sustained aridity between 40 and 30 kyr ago. This new chronology corrects previous estimates for human burials at this important site and provides a new picture of Homo sapiens adapting to deteriorating climate in the world's driest inhabited continent.

Boyd, P. W., C. S. Law, et al. (2004). "The decline and fate of an iron-induced subarctic phytoplankton bloom." Nature **428**(6982): 549-53.

Iron supply has a key role in stimulating phytoplankton blooms in high-nitrate low-chlorophyll oceanic waters. However, the fate of the carbon fixed by these blooms, and how efficiently it is exported into the ocean's interior, remains largely unknown. Here we report on the decline and fate of an iron-stimulated diatom bloom in the Gulf of Alaska. The bloom terminated on day 18, following the depletion of iron and then silicic acid, after which mixed-layer particulate organic carbon (POC) concentrations declined over six days. Increased particulate silica export via sinking diatoms was recorded in sediment traps at depths between 50 and 125 m from day 21, yet increased POC export was not evident until day 24. Only a small proportion of the mixed-layer POC was intercepted by the traps, with more than half of the mixed-layer POC deficit attributable to bacterial remineralization and mesozooplankton grazing. The depletion of silicic acid and the inefficient transfer of iron-increased POC below the permanent thermocline

have major implications both for the biogeochemical interpretation of times of greater iron supply in the geological past, and also for proposed geo-engineering schemes to increase oceanic carbon sequestration.

Brad Adams, J., M. E. Mann, et al. (2003). "Proxy evidence for an El Nino-like response to volcanic forcing." Nature **426**(6964): 274-8.

Past studies have suggested a statistical connection between explosive volcanic eruptions and subsequent El Nino climate events. This connection, however, has remained controversial. Here we present support for a response of the El Nino/Southern Oscillation (ENSO) phenomenon to forcing from explosive volcanism by using two different palaeoclimate reconstructions of El Nino activity and two independent, proxy-based chronologies of explosive volcanic activity from ad 1649 to the present. We demonstrate a significant, multi-year, El Nino-like response to explosive tropical volcanic forcing over the past several centuries. The results imply roughly a doubling of the probability of an El Nino event occurring in the winter following a volcanic eruption. Our empirical findings shed light on how the tropical Pacific ocean-atmosphere system may respond to exogenous (both natural and anthropogenic) radiative forcing.

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Bradford, D. F. (2001). "Global change. Time, money and tradeoffs." Nature **410**(6829): 649-50.

Bradley, R. S., M. K. Hughes, et al. (2006). "Authors were clear about hockey-stick uncertainties." Nature **442**(7103): 627.

Bradshaw, W. E. (1976). "Geography of photoperiodic response in diapausing mosquito." Nature **262**(5567): 384-6.

Braun, H., M. Christl, et al. (2005). "Possible solar origin of the 1,470-year glacial climate cycle demonstrated in a coupled model." Nature **438**(7065): 208-11.

Many palaeoclimate records from the North Atlantic region show a pattern of rapid climate oscillations, the so-called Dansgaard-Oeschger events, with a quasi-periodicity of approximately 1,470 years for the late glacial period. Various hypotheses have been suggested to explain these rapid temperature shifts, including internal oscillations in the climate system and external forcing, possibly from the Sun. But whereas pronounced solar cycles of approximately 87 and approximately 210 years are well known, a approximately 1,470-year solar cycle has not been detected. Here we show that an intermediate-complexity climate model with glacial climate conditions simulates rapid climate shifts similar to the Dansgaard-Oeschger events with a spacing of 1,470 years when forced by periodic freshwater input into the North Atlantic Ocean in cycles of approximately 87 and approximately 210 years. We attribute the robust 1,470-year response time

to the superposition of the two shorter cycles, together with strongly nonlinear dynamics and the long characteristic timescale of the thermohaline circulation. For Holocene conditions, similar events do not occur. We conclude that the glacial 1,470-year climate cycles could have been triggered by solar forcing despite the absence of a 1,470-year solar cycle.

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Briggs, J. C. (1967). "Dispersal of tropical marine shore animals: coriolis parameters or competition?" Nature **216**(5113): 350.

Brinkhuis, H., S. Schouten, et al. (2006). "Episodic fresh surface waters in the Eocene Arctic Ocean." Nature **441**(7093): 606-9.

It has been suggested, on the basis of modern hydrology and fully coupled palaeoclimate simulations, that the warm greenhouse conditions that characterized the early Palaeogene period (55-45 Myr ago) probably induced an intensified hydrological cycle with precipitation exceeding evaporation at high latitudes. Little field evidence, however, has been available to constrain oceanic conditions in the Arctic during this period. Here we analyse Palaeogene sediments obtained during the Arctic Coring Expedition, showing that large quantities of the free-floating fern Azolla grew and reproduced in the Arctic Ocean by the onset of the middle Eocene epoch (approximately 50 Myr ago). The Azolla and accompanying abundant freshwater organic and siliceous microfossils indicate an episodic freshening of Arctic surface waters during an approximately 800,000-year interval. The abundant remains of Azolla that characterize basal middle Eocene marine deposits of all Nordic seas probably represent transported assemblages resulting from freshwater spills from the Arctic Ocean that reached as far south as the North Sea. The termination of the Azolla phase in the Arctic coincides with a local sea surface temperature rise from approximately 10 degrees C to 13 degrees C, pointing to simultaneous increases in salt and heat supply owing to the influx of waters from adjacent oceans. We suggest that onset and termination of the Azolla phase depended on the degree of oceanic exchange between Arctic Ocean and adjacent seas.

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Bronnimann, S., J. Luterbacher, et al. (2004). "Extreme climate of the global troposphere and stratosphere in 1940-42 related to El Nino." Nature **431**(7011): 971-4.

Although the El Nino/Southern Oscillation phenomenon is the most prominent mode of climate variability and affects weather and climate in large parts of the world, its effects on Europe and the high-latitude stratosphere are controversial. Using historical observations and reconstruction techniques, we analyse the anomalous state of the troposphere and stratosphere in the Northern Hemisphere from 1940 to 1942 that occurred during a strong and long-lasting El Nino event. Exceptionally low surface temperatures in Europe and the north Pacific Ocean coincided with high temperatures in Alaska. In the lower stratosphere, our reconstructions show high temperatures over northern Eurasia and the north Pacific Ocean, and a weak polar vortex. In addition, there is observational evidence for frequent stratospheric warmings and high column ozone at Arctic and mid-latitude sites. We compare our historical data for the period 1940-42 with more recent data and a 650-year climate model simulation. We conclude that the observed anomalies constitute a recurring extreme state of the global troposphere-stratosphere system in northern winter that is related to strong El Nino events.

Brown, K. (2004). "Today is the time to take environmental action." Nature **431**(7011): 897.

Brumfiel, G. (2002). "Developing nations take initiative on greenhouse gases." Nature **419**(6910): 869.

Brumfiel, G. (2003). "Strategy for climate research gets cool response." Nature **424**(6948): 475.

Brumfiel, G. (2004). "Bush administration dismisses allegations of scientific bias." Nature **428**(6983): 589.

Brumfiel, G. (2004). "Climate researcher takes academy hot seat." Nature **429**(6994): 795.

Brumfiel, G. (2005). "Scientists urged to end feud with White House." Nature **433**(7027): 674.

Brumfiel, G. (2005). "Scientist quits climate-change panel." Nature **437**(7055): 9.

Brumfiel, G. (2006). "Academy affirms hockey-stick graph." Nature **441**(7097): 1032-3.

Brumfiel, G. and J. Knight (2003). "Climate of conflict: in the shadow of war." Nature **426**(6968): 748-9.

Bryden, H. L., H. R. Longworth, et al. (2005). "Slowing of the Atlantic meridional overturning circulation at 25 degrees N." Nature **438**(7068): 655-7.

The Atlantic meridional overturning circulation carries warm upper waters into far-northern latitudes and returns cold deep waters southward across the Equator. Its heat transport makes a substantial contribution to the moderate climate of maritime and continental Europe, and any slowdown in the overturning circulation would have profound implications for climate change. A transatlantic section along latitude 25 degrees N has been used as a baseline for estimating the overturning circulation and associated heat transport. Here we analyse a new 25 degrees N transatlantic section and compare it with four previous sections taken over the past five decades. The comparison suggests that the Atlantic meridional overturning circulation has slowed by about 30 per cent between 1957 and 2004. Whereas the northward transport in the Gulf Stream across 25 degrees N has remained nearly constant, the slowing is evident both in a 50 per cent larger southward-moving mid-ocean recirculation of thermocline waters, and also in a 50 per cent decrease in the southward transport of lower North Atlantic Deep Water between 3,000 and 5,000 m in depth. In 2004, more of the northward Gulf Stream flow was recirculating back southward in the thermocline within the subtropical gyre, and less was returning southward at depth.

Buchanan, M. (2002). "A game of chance." Nature **419**(6909): 787.

Buckley, L. B. and J. Roughgarden (2004). "Biodiversity conservation: effects of changes in climate and land use." Nature **430**(6995): 2 p following 33; discussion following 33.

Thomas et al. argue, contrary to Sala et al. that climate change poses an equal or greater threat to global biodiversity than land-use change. We contest this claim, however, on the grounds that Thomas et al. incorrectly apply species-area relationships.

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Buczko, C. M. and L. Vas (1977). "Effect of climate on chemical composition of fossil bones." Nature **269**(5631): 792-3.

Budd, G. M. (1962). "Acclimatization to cold in Antarctica as shown by rectal temperature. Response to a standard cold stress." Nature **193**: 886.

Bunt, J. S., K. E. Cooksey, et al. (1970). "Assay of algal nitrogen fixation in the marine subtropics by acetylene reduction." Nature **227**(5263): 1163-4.

Burkitt, D. (1962). "A children's cancer dependent on climatic factors." Nature **194**: 232-4.

Bussell, K. (2004). "Ecology: chalk-hill blues." Nature **428**(6978): 27.

Butchart, N. and A. A. Scaife (2001). "Removal of chlorofluorocarbons by increased mass exchange between the stratosphere and troposphere in a changing climate." Nature

410(6830): 799-802.
Chlorofluorocarbons (CFCs), along with bromine compounds, have been unequivocally identified as being responsible for most of the anthropogenic destruction of stratospheric ozone. With curbs on emissions of these substances, the recovery of the ozone layer will depend on their removal from the atmosphere. As CFCs have no significant tropospheric removal process, but are rapidly photolysed above the lower stratosphere, the timescale for their removal is set mainly by the rate at which air is transported from the troposphere into the stratosphere. Using a global climate model we predict that, in response to the projected changes in greenhouse-gas concentrations during the first half of the twenty-first century, this rate of mass exchange will increase by 3% per decade. This increase is due to more vigorous extra-tropical planetary waves emanating from the troposphere. We estimate that this increase in mass exchange will accelerate the removal of CFCs to an extent that recovery to levels currently predicted for 2050 and 2080 will occur 5 and 10 years earlier, respectively.

Butler, D. (2003). "Heatwave underlines climate-model failures." Nature **424**(6951): 867.

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Butler, D. (2005). "Global observation project gets green light." Nature **433**(7028): 789.

Butler, D. (2006). "Murders halt rainforest research." Nature **441**(7093): 555.

Butler, D. (2006). "Science academies target G8 agenda." Nature **441**(7095): 790-1.

Butler, D. and Q. Schiermeier (2005). "Grim but determined--the G8 reaches accord on Africa and climate." Nature **436**(7048): 156-7.

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Butler, J. H. (2000). "Atmospheric chemistry. Better budgets for methyl halides." Nature **403**(6767): 260-1.

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Byravan, S. and S. C. Rajan (2005). "Immigration could ease climate-change impact." Nature **434**(7032): 435.

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Caldeira, K. (1998). "Too intelligent for our own good." Nature **395**(6697): 9.

Caldeira, K. and J. F. Kasting (1992). "Susceptibility of the early Earth to irreversible glaciation caused by carbon dioxide clouds." Nature **359**: 226-8.
Simple energy-balance climate models of the Budyko/Sellers type predict that a small (2-5%) decrease in solar output could result in runaway glaciation on the Earth. But solar fluxes 25-30% lower early in the Earth's history apparently did not lead to this result. One currently favoured explanation is that high partial pressures of carbon dioxide, caused by higher volcanic outgassing rates and/or slower rates of silicate weathering, created a large enough greenhouse effect to keep the planet warm. This does not resolve the problem of climate stability, however, because as we argue here, the oceans can freeze much more quickly than CO2 can accumulate in the atmosphere. Had such a transient global glaciation

occurred in the distant past when solar luminosity was low, it might have been irreversible because of the formation of highly reflective CO2 clouds, similar to those encountered in climate simulations of early Mars. Our simulations of the early Earth, incorporating the possible formation of such clouds, suggest that the Earth might not be habitable today had it not been warm during the first part of its history.

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Caldeira, K. and J. F. Kasting (1992). "The life span of the biosphere revisited." Nature **360**(6406): 721-3.

A decade ago, Lovelock and Whitfield raised the question of how much longer the biosphere can survive on Earth. They pointed out that, despite the current fossil-fuel induced increase in the atmospheric CO2 concentration, the long-term trend should be in the opposite direction: as increased solar luminosity warms the Earth, silicate rocks should weather more readily, causing atmospheric CO2 to decrease. In their model, atmospheric CO2 falls below the critical level for C3 photosynthesis, 150 parts per million (p.p.m.), in only 100 Myr, and this is assumed to mark the demise of the biosphere as a whole. Here, we re-examine this problem using a more elaborate model that includes a more accurate treatment of the greenhouse effect of CO2, a biologically mediated weathering parameterization, and the realization that C4 photosynthesis can persist to much lower concentrations of atmospheric CO2(<10 p.p.m.). We find that a C4-plant-based biosphere could survive for at least another 0.9 Gyr to 1.5 Gyr after the present time, depending respectively on whether CO2 or temperature is the limiting factor. Within an additional 1 Gyr, Earth may lose its water to space, thereby following the path of its sister planet, Venus.

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Canals, M., P. Puig, et al. (2006). "Flushing submarine canyons." Nature **444**(7117): 354-7.

The continental slope is a steep, narrow fringe separating the coastal zone from the deep ocean. During low sea-level stands, slides and dense, sediment-laden flows erode the outer continental shelf and the continental slope, leading to the formation of submarine canyons that funnel large volumes of sediment and organic matter from shallow regions to the deep ocean(1). During high sea-level stands, such as at present, these canyons still experience occasional sediment gravity flows(2-5), which are usually thought to be triggered by sediment failure or river flooding. Here we present observations from a submarine canyon on the Gulf of Lions margin, in the northwest Mediterranean Sea, that demonstrate that these flows can also be triggered by dense shelf water cascading (DSWC)-a type of current that is driven solely by seawater density contrast. Our results show that DSWC can transport large amounts of water and sediment, reshape submarine canyon floors and rapidly affect the deep-sea environment. This cascading is seasonal, resulting from the formation of dense water by cooling and/or evaporation, and occurs on both high- and low-latitude continental margins(6-8). DSWC may therefore transport large amounts of sediment and organic matter to the deep ocean. Furthermore, changes in the frequency and intensity of DSWC driven by future climate change may have a significant impact on the supply of organic matter to deep-sea ecosystems and on the amount of carbon stored on continental margins and in ocean basins.

Cane, M. A. and P. Molnar (2001). "Closing of the Indonesian seaway as a precursor to east African aridification around 3-4 million years ago." Nature **411**(6834): 157-62.

Global climate change around 3-4 Myr ago is thought to have influenced the evolution of hominids, via the aridification of Africa, and may have been the precursor to Pleistocene glaciation about 2.75 Myr ago. Most explanations of these climatic events involve changes in circulation of the North Atlantic Ocean due to the closing of the Isthmus of Panama. Here we suggest, instead, that closure of the Indonesian seaway 3-4 Myr ago could be responsible for these climate changes, in particular the aridification of Africa. We use simple theory and results from an ocean circulation model to show that the northward displacement of New Guinea, about 5 Myr ago, may have switched the source of flow through Indonesia-from warm South Pacific to relatively cold North Pacific waters. This would have decreased sea surface temperatures in the Indian Ocean, leading to reduced rainfall over eastern Africa. We further suggest that the changes in the equatorial Pacific may have reduced atmospheric heat transport from the tropics to higher latitudes, stimulating global cooling and the eventual growth of ice sheets.

Cardillo, M. and A. Lister (2002). "Death in the slow lane." Nature **419**(6906): 440-1.

Carpenter, S. J., J. M. Erickson, et al. (2003). "Migration of a Late Cretaceous fish." Nature **423**(6935): 70-4.

Late Cretaceous sediments from the Western Interior of North America yield exceptionally well preserved fossils that serve as proxies for the rapidly changing climate preceding the Cretaceous/Tertiary boundary (about 67-65 Myr ago). Here we reconstruct the ontogenetic history of a Maastrichtian-age fish, Vorhisia vulpes, by using the carbon, oxygen and strontium isotope ratios of four aragonite otoliths collected from the Fox Hills Formation of South Dakota. Individuals of

V. vulpes spawned in brackish water (about 70-80% seawater) and during their first year migrated to open marine waters of the Western Interior Seaway, where they remained for 3 years before returning to the estuary, presumably to spawn and die. The mean delta(18)O from the marine growth phase of V. vulpes yields a seawater temperature of 18 degrees C, which is consistent with leaf physiognomy and general-circulation-model temperature estimates for the Western Interior during the latest Maastrichtian.

Carr, M. H. and J. Garvin (2001). "Mars exploration." Nature **412**(6843): 250-3.
An international flotilla of spacecraft are to be sent to Mars over the next decade in an effort to understand the planet's geology and climate history, and to determine whether some form of life ever started there. At least two spacecraft will be sent at each launch opportunity, and at times up to four spacecraft may be operating simultaneously at the planet.

Cattadori, I. M., D. T. Haydon, et al. (2005). "Parasites and climate synchronize red grouse populations." Nature **433**(7027): 737-41.
There is circumstantial evidence that correlated climatic conditions can drive animal populations into synchronous fluctuations in abundance. However, it is unclear whether climate directly affects the survival and fecundity of individuals, or indirectly, by influencing food and natural enemies. Here we propose that climate affects trophic interactions and could be an important mechanism for synchronizing spatially distributed populations. We show that in specific years the size of red grouse populations in northern England either increases or decreases in synchrony. In these years, widespread and correlated climatic conditions during May and July affect populations regionally and influence the density-dependent transmission of the gastrointestinal nematode Trichostrongylus tenuis, a parasite that reduces grouse fecundity. This in turn forces grouse populations into synchrony. We conclude that specific climatic events may lead to outbreaks of infectious diseases or pests that may cause dramatic, synchronized changes in the abundance of their hosts.

Cazenave, A. (2005). "Global change: sea level and volcanoes." Nature **438**(7064): 35-6.

Cerling, T. E., R. L. Hay, et al. (1977). "Isotopic evidence for dramatic climatic changes in East Africa during the Pleistocene." Nature **267**(5607): 137-8.
Rainfall decreased dramatically in the Lake Turkana region 1.8-2.0 Myr ago and in the Olduvai Gorge region 0.5-0.6 Myr ago. This is documented by a major increase in the delta18O values of pedogenic and groundwater carbonates at these times. The data suggest that meteoric water of the earlier, more humid climate was 2-4 per mil lower in 18O content than modern waters of these regions.

Chaimanee, Y., V. Suteethorn, et al. (2004). "A new orang-utan relative from the Late Miocene of Thailand." Nature **427**(6973): 439-41.
The fossil record of the living great apes is poor. New fossils from undocumented areas, particularly the equatorial forested habitats of extant hominoids, are therefore crucial for understanding their origins and evolution. Two main competing hypotheses have been proposed for orang-utan origins: dental similarities support an origin from Lufengpithecus, a South Chinese and Thai Middle Miocene hominoid; facial and palatal similarities support an origin from Sivapithecus, a Miocene hominoid from the Siwaliks of Indo-Pakistan. However, materials other than teeth and faces do not support these hypotheses. Here we describe the lower jaw of a new hominoid from the Late Miocene of Thailand, Khoratpithecus piriyai gen. et sp. nov., which shares unique derived characters with orang-utans and supports a hypothesis of closer relationships with orang-utans than other known Miocene hominoids. It can therefore be considered as the closest known relative of orang-utans. Ancestors of this great ape were therefore

evolving in Thailand under tropical conditions similar to those of today, in contrast with Southern China and Pakistan, where temperate or more seasonal climates appeared during the Late Miocene.

Chambers, J. Q., N. Higuchi, et al. (2001). "Carbon sink for a century." Nature **410**(6827): 429.

Chandler, R. F., Jr. (1969). "Improving the rice plant and its culture." Nature **221**(5185): 1007-10.

Chang, P., Y. Fang, et al. (2006). "The cause of the fragile relationship between the Pacific El Nino and the Atlantic Nino." Nature **443**(7109): 324-8.

El Nino, the most prominent climate fluctuation at seasonal-to-interannual timescales, has long been known to have a remote impact on climate variability in the tropical Atlantic Ocean, but a robust influence is found only in the northern tropical Atlantic region. Fluctuations in the equatorial Atlantic are dominated by the Atlantic Nino, a phenomenon analogous to El Nino, characterized by irregular episodes of anomalous warming during the boreal summer. The Atlantic Nino strongly affects seasonal climate prediction in African countries bordering the Gulf of Guinea. The relationship between El Nino and the Atlantic Nino is ambiguous and inconsistent. Here we combine observational and modelling analysis to show that the fragile relationship is a result of destructive interference between atmospheric and oceanic processes in response to El Nino. The net effect of El Nino on the Atlantic Nino depends not only on the atmospheric response that propagates the El Nino signal to the tropical Atlantic, but also on a dynamic ocean-atmosphere interaction in the equatorial Atlantic that works against the atmospheric response. These results emphasize the importance of having an improved ocean-observing system in the tropical Atlantic, because our ability to predict the Atlantic Nino will depend not only on our knowledge of conditions in the tropical Pacific, but also on an accurate estimate of the state of the upper ocean in the equatorial Atlantic.

Chave, J., D. Alonso, et al. (2006). "Theoretical biology: comparing models of species abundance." Nature **441**(7089): E1; discussion E1-2.

Ecologists are struggling to explain how so many tropical tree species can coexist in tropical forests, and several empirical studies have demonstrated that negative density dependence is an important mechanism of tree-species coexistence. Volkov et al. compare a model incorporating negative density dependence with a dispersal-limited neutral model and claim that each predicts six empirical species-abundance distributions of tropical-tree communities equally well. However, we show here that their main conclusion is premature: when the two models are compared in an improved analysis, we find that the dispersal-limited model outcompetes the density-dependent model in all six cases. Hence, although density dependence is certainly an important diversity-maintaining mechanism, our improved approach indicates that the dispersal-limited model provides a more parsimonious explanation of empirical species-abundance distributions.

Chen, D., M. A. Cane, et al. (2004). "Predictability of El Nino over the past 148 years." Nature **428**(6984): 733-6.

Forecasts of El Nino climate events are routinely provided and distributed, but the limits of El Nino predictability are still the subject of debate. Some recent studies suggest that the predictability is largely limited by the effects of high-frequency atmospheric 'noise', whereas others emphasize limitations arising from the growth of initial errors in model simulations. Here we present retrospective forecasts of the interannual climate fluctuations in the tropical Pacific Ocean for the period 1857 to 2003, using a coupled ocean-atmosphere model. The model successfully predicts all prominent El Nino events within this period at lead times of up to two

years. Our analysis suggests that the evolution of El Nino is controlled to a larger degree by self-sustaining internal dynamics than by stochastic forcing. Model-based prediction of El Nino therefore depends more on the initial conditions than on unpredictable atmospheric noise. We conclude that throughout the past century, El Nino has been more predictable than previously envisaged.

Cherry, M. (2003). "Genetics to unlock secrets of our African past." Nature **422**(6931): 460.

Cherry, M. (2005). "Ministers agree to act on warnings of soaring temperatures in Africa." Nature **437**(7063): 1217.

Chiang, J. C. and A. Koutavas (2004). "Climate change: tropical flip-flop connections." Nature **432**(7018): 684-5.

Chown, S. L. and K. J. Gaston (2000). "Island-hopping invaders hitch a ride with tourists in South Georgia." Nature **408**(6813): 637.

Christensen, J. H. and O. B. Christensen (2003). "Climate modelling: Severe summertime flooding in Europe." Nature **421**(6925): 805-6.

Christensen, P. R. (2003). "Formation of recent martian gullies through melting of extensive water-rich snow deposits." Nature **422**(6927): 45-8.

The observation of gullies on Mars indicates the presence of liquid water near the surface in recent times, which is difficult to reconcile with the current cold climate. Gullies have been proposed to form through surface runoff from subsurface aquifers or through melting of near-surface ice under warmer conditions. But these gullies are observed to occur preferentially in cold mid-latitudes, where the presence of liquid water is less likely, and on isolated surfaces where groundwater seepage would not be expected, making both potential explanations unsatisfactory. Here I show that gullies can form by the melting of water-rich snow that has been transported from the poles to mid-latitudes during periods of high obliquity within the past 10(5) to 10(6) years (refs 5, 6). Melting within this snow can generate sufficient water to erode gullies in about 5,000 years. My proposed model for gully formation is consistent with the age and location of the gullies, and it explains the occurrence of liquid water in the cold mid-latitudes as well as on isolated surfaces. Remnants of the snowpacks are still present on mid-latitude, pole-facing slopes, and the recent or current occurrence of liquid water within them provides a potential abode for life.

Chuine, I., P. Yiou, et al. (2004). "Historical phenology: grape ripening as a past climate indicator." Nature **432**(7015): 289-90.

French records of grape-harvest dates in Burgundy were used to reconstruct spring-summer temperatures from 1370 to 2003 using a process-based phenology model developed for the Pinot Noir grape. Our results reveal that temperatures as high as those reached in the 1990s have occurred several times in Burgundy since 1370. However, the summer of 2003 appears to have been extraordinary, with temperatures that were probably higher than in any other year since 1370.

Church, J. A., N. J. White, et al. (2005). "Significant decadal-scale impact of volcanic eruptions on sea level and ocean heat content." Nature **438**(7064): 74-7.

Ocean thermal expansion contributes significantly to sea-level variability and rise. However, observed decadal variability in ocean heat content and sea level has not been reproduced well in climate models. Aerosols injected into the stratosphere during volcanic eruptions scatter incoming solar radiation, and cause a rapid cooling of the atmosphere and a reduction in rainfall, as well as other changes in the climate system. Here we use observations of ocean heat content and a set of

climate simulations to show that large volcanic eruptions result in rapid reductions in ocean heat content and global mean sea level. For the Mt Pinatubo eruption, we estimate a reduction in ocean heat content of about 3 x 10(22) J and a global sea-level fall of about 5 mm. Over the three years following such an eruption, we estimate a decrease in evaporation of up to 0.1 mm d(-1), comparable to observed changes in mean land precipitation. The recovery of sea level following the Mt Pinatubo eruption in 1991 explains about half of the difference between the long-term rate of sea-level rise of 1.8 mm yr(-1) (for 1950-2000), and the higher rate estimated for the more recent period where satellite altimeter data are available (1993-2000).

Ciais, P., M. Reichstein, et al. (2005). "Europe-wide reduction in primary productivity caused by the heat and drought in 2003." Nature **437**(7058): 529-33.

Future climate warming is expected to enhance plant growth in temperate ecosystems and to increase carbon sequestration. But although severe regional heatwaves may become more frequent in a changing climate, their impact on terrestrial carbon cycling is unclear. Here we report measurements of ecosystem carbon dioxide fluxes, remotely sensed radiation absorbed by plants, and country-level crop yields taken during the European heatwave in 2003. We use a terrestrial biosphere simulation model to assess continental-scale changes in primary productivity during 2003, and their consequences for the net carbon balance. We estimate a 30 per cent reduction in gross primary productivity over Europe, which resulted in a strong anomalous net source of carbon dioxide (0.5 Pg C yr(-1)) to the atmosphere and reversed the effect of four years of net ecosystem carbon sequestration. Our results suggest that productivity reduction in eastern and western Europe can be explained by rainfall deficit and extreme summer heat, respectively. We also find that ecosystem respiration decreased together with gross primary productivity, rather than accelerating with the temperature rise. Model results, corroborated by historical records of crop yields, suggest that such a reduction in Europe's primary productivity is unprecedented during the last century. An increase in future drought events could turn temperate ecosystems into carbon sources, contributing to positive carbon-climate feedbacks already anticipated in the tropics and at high latitudes.

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Cincotta, R. P., J. Wisnewski, et al. (2000). "Human population in the biodiversity

hotspots." Nature **404**(6781): 990-2.

Biologists have identified 25 areas, called biodiversity hotspots, that are especially rich in endemic species and particularly threatened by human activities. The human population dynamics of these areas, however, are not well quantified. Here we report estimates of key demographic variables for each hotspot, and for three extensive tropical forest areas that are less immediately threatened. We estimate that in 1995 more than 1.1 billion people, nearly 20% of world population, were living within the hotspots, an area covering about 12% of Earth's terrestrial surface. We estimate that the population growth rate in the hotspots (1995-2000) is 1.8% yr(-1), substantially higher than the population growth rate of the world as a whole (1.3% yr(-1)) and above that of the developing countries (1.6% yr(-1)). These results suggest that substantial human-induced environmental changes are likely to continue in the hotspots and that demographic change remains an important factor in global biodiversity conservation. The results also underline the potential conservation significance of the continuing worldwide declines in human fertility and of policies and programs that influence human migration.

Clark, J. S. and J. S. McLachlan (2003). "Stability of forest biodiversity." Nature **423**(6940): 635-8.

Two hypotheses to explain potentially high forest biodiversity have different implications for the number and kinds of species that can coexist and the potential loss of biodiversity in the absence of speciation. The first hypothesis involves stabilizing mechanisms, which include tradeoffs between species in terms of their capacities to disperse to sites where competition is weak, to exploit abundant resources effectively and to compete for scarce resources. Stabilization results because competitors thrive at different times and places. An alternative, 'neutral model' suggests that stabilizing mechanisms may be superfluous. This explanation emphasizes 'equalizing' mechanisms, because competitive exclusion of similar species is slow. Lack of ecologically relevant differences means that abundances experience random 'neutral drift', with slow extinction. The relative importance of these two mechanisms is unknown, because assumptions and predictions involve broad temporal and spatial scales. Here we demonstrate that predictions of neutral drift are testable using palaeodata. The results demonstrate strong stabilizing forces. By contrast with the neutral prediction of increasing variance among sites over time, we show that variances in post-Glacial tree abundances among sites stabilize rapidly, and abundances remain coherent over broad geographical scales.

Clark, P. U., N. G. Pisias, et al. (2002). "The role of the thermohaline circulation in abrupt climate change." Nature **415**(6874): 863-9.

The possibility of a reduced Atlantic thermohaline circulation in response to increases in greenhouse-gas concentrations has been demonstrated in a number of simulations with general circulation models of the coupled ocean-atmosphere system. But it remains difficult to assess the likelihood of future changes in the thermohaline circulation, mainly owing to poorly constrained model parameterizations and uncertainties in the response of the climate system to greenhouse warming. Analyses of past abrupt climate changes help to solve these problems. Data and models both suggest that abrupt climate change during the last glaciation originated through changes in the Atlantic thermohaline circulation in response to small changes in the hydrological cycle. Atmospheric and oceanic responses to these changes were then transmitted globally through a number of feedbacks. The palaeoclimate data and the model results also indicate that the stability of the thermohaline circulation depends on the mean climate state.

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Clarke, T. (2003). "Geologists seek to put an end to blind dates." Nature **425**(6958): 550-1.

Clift, P. D. and J. Blusztajn (2005). "Reorganization of the western Himalayan river system after five million years ago." Nature **438**(7070): 1001-3.

Uplift of mountains driven by tectonic forces can influence regional climate as well as regional drainage patterns, which in turn control the discharge of eroded sediment to the ocean. But the nature of the interactions between tectonic forces, climate and drainage evolution remains contested. Here we reconstruct the erosional discharge from the Indus river over the past 30 million years using seismic reflection data obtained from drill core samples from the Arabian Sea and neodymium isotope data. We find that the source of the Indus sediments was dominated by erosion within and north of the Indus suture zone until five million years ago; after that, the river began to receive more erosional products from Himalayan sources. We propose that this change in the erosional pattern is caused by a rerouting of the major rivers of the Punjab into the Indus, which flowed east into the Ganges river before that time. Seismic reflection profiles from the Indus fan suggest high mass accumulation rates during the Pleistocene epoch partly driven by increased drainage to the Indus river after five million years ago and partly by faster erosion linked to a stronger monsoon over the past four million years. Our isotope stratigraphy for the Indus fan provides strong evidence for a significant change in the geometry of western Himalayan river systems in the recent geologic past.

Coakley, J. (2005). "Atmospheric physics: reflections on aerosol cooling." Nature **438**(7071): 1091-2.

Cobb, K. M., C. D. Charles, et al. (2003). "El Nino/Southern Oscillation and tropical Pacific climate during the last millennium." Nature **424**(6946): 271-6.

Any assessment of future climate change requires knowledge of the full range of natural variability in the El Nino/Southern Oscillation (ENSO) phenomenon. Here we splice together fossil-coral oxygen isotopic records from Palmyra Island in the tropical Pacific Ocean to provide 30-150-year windows of tropical Pacific climate variability within the last 1,100 years. The records indicate mean climate conditions in the central tropical Pacific ranging from relatively cool and dry during the tenth century to increasingly warmer and wetter climate in the twentieth century. But the corals also document a broad range of ENSO behaviour that correlates poorly with these estimates of mean climate. The most intense ENSO activity within the reconstruction occurred during the mid-seventeenth century. Taken together, the coral data imply that the majority of ENSO variability over the last millennium may have arisen from dynamics internal to the ENSO system itself.

Cochrane, M. A. (2003). "Fire science for rainforests." Nature **421**(6926): 913-9.

Forest fires are growing in size and frequency across the tropics. Continually eroding fragmented forest edges, they are unintended ecological disturbances that transcend deforestation to degrade vast regions of standing forest, diminishing ecosystem services and the economic potential of these natural resources. Affecting the health of millions, net forest fire emissions may have released carbon equivalent to 41% of worldwide fossil fuel use in 1997-98. Episodically more severe during El Nino events, pan-tropical forest fires will increase as more damaged, less fire-resistant, forests cover the landscape. Here I discuss the current state of tropical fire science and make recommendations for advancement.

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Cockell, C. S. and M. D. Stokes (2004). "Ecology: widespread colonization by polar hypoliths." Nature **431**(7007): 414.

High-latitude polar deserts are among the most extreme environments on Earth. Here we describe a large and previously unappreciated habitat for photosynthetic life under opaque rocks in the Arctic and Antarctic polar deserts. This habitat is created by the periglacial movement of the rocks, which allows some light to reach their underside. The productivity of this ecosystem is at least as great as that of above-ground biomass and potentially doubles previous productivity estimates for the polar desert ecozone.

Colaprete, A., J. R. Barnes, et al. (2005). "Albedo of the south pole on Mars determined by topographic forcing of atmosphere dynamics." Nature **435**(7039): 184-8.

The nature of the martian south polar cap has remained enigmatic since the first spacecraft observations. In particular, the presence of a perennial carbon dioxide ice cap, the formation of a vast area of black 'slab ice' known as the Cryptic region and the asymmetric springtime retreat of the cap have eluded explanation. Here we present observations and climate modelling that indicate the south pole of Mars is characterized by two distinct regional climates that are the result of dynamical forcing by the largest southern impact basins, Argyre and Hellas. The style of surface frost deposition is controlled by these regional climates. In the cold and stormy conditions that exist poleward of 60 degrees S and extend 180 degrees in longitude west from the Mountains of Mitchel (approximately 30 degrees W), surface frost accumulation is dominated by precipitation. In the opposite hemisphere, the polar atmosphere is relatively warm and clear and frost accumulation is dominated by direct vapour deposition. It is the differences in these deposition styles that determine the cap albedo.

Cole, J. (2003). "Global change: Dishing the dirt on coral reefs." Nature **421**(6924): 705-6.

Cole, J. (2003). "Global change: Dishing the dirt on coral reefs." Nature **421**(6924): 705-6.

Colhoun, E. H. (1954). "Temperature acclimatization in insects." Nature **173**(4404): 582.

Coluzzi, M., A. Sabatini, et al. (1977). "Behavioural divergences between mosquitoes with different inversion karyotypes in polymorphic populations of the Anopheles gambiae complex." Nature **266**(5605): 832-3.

Conover, D. O. and S. W. Heins (1987). "Adaptive variation in environmental and genetic sex determination in a fish." Nature **326**(6112): 496-8.

Two general mechanisms of sex determination have been identified among gonochoristic vertebrates: environmental sex determination where offspring become male or female in response to an environmental factor(s) during development (for example, some fishes and reptiles); and genetic sex determination where sex is determined by genotype at conception (as in birds and mammals). How do these sex-determining systems evolve? Direct evidence is virtually non-existent because the sex-determining systems of most species appear to have little genetic variation. Here we provide the first evidence of adaptive variation in environmental and genetic sex determination within a species. We show that in a fish with temperature-dependent sex determination, populations at different latitudes compensate for differences in thermal environment and seasonality by adjusting the response of sex ratio to temperature, and by altering the level of environmental as opposed to genetic control. The adjustments observed are precisely those predicted by adaptive sex ratio theory.

Conway, H., G. Catania, et al. (2002). "Switch of flow direction in an Antarctic ice stream." Nature **419**(6906): 465-7.

Fast-flowing ice streams transport ice from the interior of West Antarctica to the ocean, and fluctuations in their activity control the mass balance of the ice sheet. The mass balance of the Ross Sea sector of the West Antarctic ice sheet is now positive--that is, it is growing--mainly because one of the ice streams (ice stream C) slowed down about 150 years ago. Here we present evidence from both surface measurements and remote sensing that demonstrates the highly dynamic nature of the Ross drainage system. We show that the flow in an area that once discharged into ice stream C has changed direction, now draining into the Whillans ice stream (formerly ice stream B). This switch in flow direction is a result of continuing thinning of the Whillans ice stream and recent thickening of ice stream C. Further abrupt reorganization of the activity and configuration of the ice streams over short timescales is to be expected in the future as the surface topography of the ice sheet responds to the combined effects of internal dynamics and long-term climate change. We suggest that caution is needed when using observations of short-term mass changes to draw conclusions about the large-scale mass balance of the ice sheet.

Copley, J. (2000). "Ecology goes underground." Nature **406**(6795): 452-4.

Copley, J. (2000). "Climate change: the great ice mystery." Nature **408**(6813): 634-6.

Correge, T., M. K. Gagan, et al. (2004). "Interdecadal variation in the extent of South Pacific tropical waters during the Younger Dryas event." Nature **428**(6986): 927-9.

During the Younger Dryas event, about 12,000 years ago, the Northern Hemisphere cooled by between 2 and 10 degrees C (refs 1, 2) whereas East Antarctica experienced warming. But the spatial signature of the event in the southern mid-latitudes and tropics is less well known, as records are sparse and inconclusive. Here we present high-resolution analyses of skeletal Sr/Ca and 18O/16O ratios for a giant fossil Diploastrea heliopora coral that was preserved in growth position on the raised reef terraces of Espiritu Santo Island, Vanuatu, in the southwestern tropical Pacific Ocean. Our data indicate that sea surface temperatures in Vanuatu were on average 4.5 +/- 1.3 degrees C cooler during the

Younger Dryas event than today, with a significant interdecadal modulation. The amplified annual cycle of sea surface temperatures, relative to today, indicates that cooling was caused by the compression of tropical waters towards the Equator. The positive correlation in our record between the oxygen isotope ratios of sea water and sea surface temperatures suggests that the South Pacific convergence zone, which brings 18O-depleted precipitation to the area today, was not active during the Younger Dryas period.

Cossins, A. R. (1991). "Physiology. Cold facts and naked truth." Nature **353**(6346): 699.

Cox, P. M., R. A. Betts, et al. (2000). "Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model." Nature **408**(6809): 184-7.

The continued increase in the atmospheric concentration of carbon dioxide due to anthropogenic emissions is predicted to lead to significant changes in climate. About half of the current emissions are being absorbed by the ocean and by land ecosystems, but this absorption is sensitive to climate as well as to atmospheric carbon dioxide concentrations, creating a feedback loop. General circulation models have generally excluded the feedback between climate and the biosphere, using static vegetation distributions and CO2 concentrations from simple carbon-cycle models that do not include climate change. Here we present results from a fully coupled, three-dimensional carbon-climate model, indicating that carbon-cycle feedbacks could significantly accelerate climate change over the twenty-first century. We find that under a 'business as usual' scenario, the terrestrial biosphere acts as an overall carbon sink until about 2050, but turns into a source thereafter. By 2100, the ocean uptake rate of 5 Gt C yr(-1) is balanced by the terrestrial carbon source, and atmospheric CO2 concentrations are 250 p.p.m.v. higher in our fully coupled simulation than in uncoupled carbon models, resulting in a global-mean warming of 5.5 K, as compared to 4 K without the carbon-cycle feedback.

Coxall, H. K., P. A. Wilson, et al. (2005). "Rapid stepwise onset of Antarctic glaciation and deeper calcite compensation in the Pacific Ocean." Nature **433**(7021): 53-7.

The ocean depth at which the rate of calcium carbonate input from surface waters equals the rate of dissolution is termed the calcite compensation depth. At present, this depth is approximately 4,500 m, with some variation between and within ocean basins. The calcite compensation depth is linked to ocean acidity, which is in turn linked to atmospheric carbon dioxide concentrations and hence global climate. Geological records of changes in the calcite compensation depth show a prominent deepening of more than 1 km near the Eocene/Oligocene boundary (approximately 34 million years ago) when significant permanent ice sheets first appeared on Antarctica, but the relationship between these two events is poorly understood. Here we present ocean sediment records of calcium carbonate content as well as carbon and oxygen isotopic compositions from the tropical Pacific Ocean that cover the Eocene/Oligocene boundary. We find that the deepening of the calcite compensation depth was more rapid than previously documented and occurred in two jumps of about 40,000 years each, synchronous with the stepwise onset of Antarctic ice-sheet growth. The glaciation was initiated, after climatic preconditioning, by an interval when the Earth's orbit of the Sun favoured cool summers. The changes in oxygen-isotope composition across the Eocene/Oligocene boundary are too large to be explained by Antarctic ice-sheet growth alone and must therefore also indicate contemporaneous global cooling and/or Northern Hemisphere glaciation.

Crutzen, P. J. (2002). "Geology of mankind." Nature **415**(6867): 23.

Cruz, F. W., Jr., S. J. Burns, et al. (2005). "Insolation-driven changes in atmospheric circulation over the past 116,000 years in subtropical Brazil." Nature **434**(7029): 63-6.

During the last glacial period, large millennial-scale temperature oscillations--the 'Dansgaard/Oeschger' cycles--were the primary climate signal in Northern Hemisphere climate archives from the high latitudes to the tropics. But whether the influence of these abrupt climate changes extended to the tropical and subtropical Southern Hemisphere, where changes in insolation are thought to be the main direct forcing of climate, has remained unclear. Here we present a high-resolution oxygen isotope record of a U/Th-dated stalagmite from subtropical southern Brazil, covering the past 116,200 years. The oxygen isotope signature varies with shifts in the source region and amount of rainfall in the area, and hence records changes in atmospheric circulation and convective intensity over South America. We find that these variations in rainfall source and amount are primarily driven by summer solar radiation, which is controlled by the Earth's precessional cycle. The Dansgaard/Oeschger cycles can be detected in our record and therefore we confirm that they also affect the tropical hydrological cycle, but that in southern subtropical Brazil, millennial-scale climate changes are not as dominant as they are in the Northern Hemisphere.

Cuffey, K. M. (2004). "Palaeoclimate: into an ice age." Nature **431**(7005): 133-4.

Cuffey, K. M. and F. Vimeux (2001). "Covariation of carbon dioxide and temperature from the Vostok ice core after deuterium-excess correction." Nature **412**(6846): 523-7.

Ice-core measurements of carbon dioxide and the deuterium palaeothermometer reveal significant covariation of temperature and atmospheric CO2 concentrations throughout the climate cycles of the past ice ages. This covariation provides compelling evidence that CO2 is an important forcing factor for climate. But this interpretation is challenged by some substantial mismatches of the CO2 and deuterium records, especially during the onset of the last glaciation, about 120 kyr ago. Here we incorporate measurements of deuterium excess from Vostok in the temperature reconstruction and show that much of the mismatch is an artefact caused by variations of climate in the water vapour source regions. Using a model that corrects for this effect, we derive a new estimate for the covariation of CO2 and temperature, of r2 = 0.89 for the past 150 kyr and r2 = 0.84 for the period 350-150 kyr ago. Given the complexity of the biogeochemical systems involved, this close relationship strongly supports the importance of carbon dioxide as a forcing factor of climate. Our results also suggest that the mechanisms responsible for the drawdown of CO2 may be more responsive to temperature than previously thought.

Curry, R., B. Dickson, et al. (2003). "A change in the freshwater balance of the Atlantic Ocean over the past four decades." Nature **426**(6968): 826-9.

The oceans are a global reservoir and redistribution agent for several important constituents of the Earth's climate system, among them heat, fresh water and carbon dioxide. Whereas these constituents are actively exchanged with the atmosphere, salt is a component that is approximately conserved in the ocean. The distribution of salinity in the ocean is widely measured, and can therefore be used to diagnose rates of surface freshwater fluxes, freshwater transport and local ocean mixing--important components of climate dynamics. Here we present a comparison of salinities on a long transect (50 degrees S to 60 degrees N) through the western basins of the Atlantic Ocean between the 1950s and the 1990s. We find systematic freshening at both poleward ends contrasted with large increases of salinity pervading the upper water column at low latitudes. Our results extend a growing body of evidence indicating that shifts in the oceanic distribution of fresh and saline waters are occurring worldwide in ways that suggest links to global warming and possible changes in the hydrologic cycle of the Earth.

Cyranoski, D. (2003). "China plans clean sweep on dust storms." Nature **421**(6919): 101.

Cyranoski, D. (2003). "Ocean drilling: digging in." Nature **426**(6966): 492-4.

Cyranoski, D. (2004). "Extinction meeting kicks off Japan's plans for networking." Nature **427**(6974): 477.

Cyranoski, D. (2004). "Deluge of typhoons may aid forecast models." Nature **431**(7012): 1028.

Cyranoski, D. (2005). "Climate change: the long-range forecast." Nature **438**(7066): 275-6.

Cyranoski, D. (2005). "Climate change: the long-range forecast." Nature **438**(7066): 275-6.

Cyranoski, D. and I. Fuyuno (2005). "Climatologists seek clear view of Asia's smog." Nature **434**(7030): 128.

Dalton, R. (2002). "Ocean tests raise doubts over use of algae as carbon sink." Nature **420**(6917): 722.

Dalton, R. (2003). "Climate studies hold key to future of desalination plant." Nature **422**(6927): 4-5.

Dalton, R. (2003). "Archaeology: The coast road." Nature **422**(6927): 10-2.

Dalton, R. (2003). "Report raises hopes for grand network of US ecology centres." Nature **425**(6956): 332.

Darling, K. F., C. M. Wade, et al. (2000). "Molecular evidence for genetic mixing of Arctic and Antarctic subpolar populations of planktonic foraminifers." Nature **405**(6782): 43-7.

Bipolarity, the presence of a species in the high latitudes separated by a gap in distribution across the tropics, is a well-known pattern of global species distribution. But the question of whether bipolar species have evolved independently at the poles since the establishment of the cold-water provinces 16-8 million years ago, or if genes have been transferred across the tropics since that time, has not been addressed. Here we examine genetic variation in the small subunit ribosomal RNA gene of three bipolar planktonic foraminiferal morphospecies. We identify at least one identical genotype in all three morphospecies in both the Arctic and Antarctic subpolar provinces, indicating that trans-tropical gene flow must have occurred. Our genetic analysis also reveals that foraminiferal morphospecies can consist of a complex of genetic types. Such occurrences of genetically distinct populations within one morphospecies may affect the use of planktonic foraminifers as a palaeoceanographic proxy for climate change and necessitate a reassessment of the species concept for the group.

Dausmann, K. H., J. Glos, et al. (2004). "Physiology: hibernation in a tropical primate." Nature **429**(6994): 825-6.

The Madagascan fat-tailed dwarf lemur, Cheirogaleus medius, hibernates in tree holes for seven months of the year, even though winter temperatures rise to over 30 degrees C. Here we show that this tropical primate relies on a flexible thermal response that depends on the properties of its tree hole: if the hole is poorly insulated, body temperature fluctuates widely, passively following the ambient temperature; if well insulated, body temperature stays fairly constant and the animal undergoes regular spells of arousal. Our findings indicate that arousals are determined by maximum body temperatures and that hypometabolism in

hibernating animals is not necessarily coupled to a low body temperature.

Davidson, E. A. and I. A. Janssens (2006). "Temperature sensitivity of soil carbon decomposition and feedbacks to climate change." Nature **440**(7081): 165-73.

Significantly more carbon is stored in the world's soils--including peatlands, wetlands and permafrost--than is present in the atmosphere. Disagreement exists, however, regarding the effects of climate change on global soil carbon stocks. If carbon stored belowground is transferred to the atmosphere by a warming-induced acceleration of its decomposition, a positive feedback to climate change would occur. Conversely, if increases of plant-derived carbon inputs to soils exceed increases in decomposition, the feedback would be negative. Despite much research, a consensus has not yet emerged on the temperature sensitivity of soil carbon decomposition. Unravelling the feedback effect is particularly difficult, because the diverse soil organic compounds exhibit a wide range of kinetic properties, which determine the intrinsic temperature sensitivity of their decomposition. Moreover, several environmental constraints obscure the intrinsic temperature sensitivity of substrate decomposition, causing lower observed 'apparent' temperature sensitivity, and these constraints may, themselves, be sensitive to climate.

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Davidson, E. A., S. E. Trumbore, et al. (2000). "Soil warming and organic carbon content." Nature **408**(6814): 789-90.

Davidson, E. A., S. E. Trumbore, et al. (2000). "Soil warming and organic carbon content." Nature **408**(6814): 789-90.

Davies, R., J. Cartwright, et al. (2001). "Early Oligocene initiation of North Atlantic Deep Water formation." Nature **410**(6831): 917-20.

Dating the onset of deep-water flow between the Arctic and North Atlantic oceans is critical for modelling climate change in the Northern Hemisphere and for explaining changes in global ocean circulation throughout the Cenozoic era (from about 65 million years ago to the present). In the early Cenozoic era, exchange between these two ocean basins was inhibited by the Greenland-Scotland ridge, but a gateway through the Faeroe-Shetland basin has been hypothesized. Previous estimates of the date marking the onset of deep-water circulation through this basin-on the basis of circumstantial evidence from neighbouring basins-have been contradictory, ranging from about 35 to 15 million years ago. Here we describe the newly discovered Southeast Faeroes drift, which extends for 120 km parallel to the basin axis. The onset of deposition in this drift has been

dated to the early Oligocene epoch (approximately 35 million years ago) from a petroleum exploration borehole. We show that the drift was deposited under a southerly flow regime, and conclude that the initiation of deep-water circulation from the Norwegian Sea into the North Atlantic Ocean took place much earlier than is currently assumed in most numerical models of ancient ocean circulation.

Davis, A. J., L. S. Jenkinson, et al. (1998). "Making mistakes when predicting shifts in species range in response to global warming." Nature **391**(6669): 783-6.

Many attempts to predict the biotic responses to climate change rely on the 'climate envelope' approach, in which the current distribution of a species is mapped in climate-space and then, if the position of that climate-space changes, the distribution of the species is predicted to shift accordingly. The flaw in this approach is that distributions of species also reflect the influence of interactions with other species, so predictions based on climate envelopes may be very misleading if the interactions between species are altered by climate change. An additional problem is that current distributions may be the result of sources and sinks, in which species appear to thrive in places where they really persist only because individuals disperse into them from elsewhere. Here we use microcosm experiments on simple but realistic assemblages to show how misleading the climate envelope approach can be. We show that dispersal and interactions, which are important elements of population dynamics, must be included in predictions of biotic responses to climate change.

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De Datta, S. K., R. T. Bantilan, et al. (1969). "Selective control of annual grassy weeds in transplanted tropical rice with alpha-2,2,2-trichloroethyl styrene." Nature **221**(5175): 64-5.

de Garidel-Thoron, T., Y. Rosenthal, et al. (2005). "Stable sea surface temperatures in the western Pacific warm pool over the past 1.75 million years." Nature **433**(7023): 294-8.

About 850,000 years ago, the period of the glacial cycles changed from 41,000 to 100,000 years. This mid-Pleistocene climate transition has been attributed to global cooling, possibly caused by a decrease in atmospheric carbon dioxide concentrations. However, evidence for such cooling is currently restricted to the cool upwelling regions in the eastern equatorial oceans, although the tropical warm pools on the western side of the ocean basins are particularly sensitive to changes in radiative forcing. Here we present high-resolution records of sea surface temperatures spanning the past 1.75 million years, obtained from oxygen isotopes and Mg/Ca ratios in planktonic foraminifera from the western Pacific warm pool. In contrast with the eastern equatorial regions, sea surface temperatures in the western Pacific warm pool are relatively stable throughout

the Pleistocene epoch, implying little long-term change in the tropical net radiation budget. Our results challenge the hypothesis of a gradual decrease in atmospheric carbon dioxide concentrations as a dominant trigger of the longer glacial cycles since 850,000 years ago. Instead, we infer that the temperature contrast across the equatorial Pacific Ocean increased, which might have had a significant influence on the mid-Pleistocene climate transition.

De Leo, G. A., L. Rizzi, et al. (2001). "Carbon emissions. The economic benefits of the Kyoto Protocol." Nature **413**(6855): 478-9.

The third Conference of the Parties in Kyoto set the target of reducing greenhouse-gas emissions by an average of 5.3% with respect to 1990 values by 2008-2012. One of the main objections to the protocol's ratification is that compliance would pose an unbearable economic burden on the countries involved. But we show here that this is not the case if costs apart from the direct costs of energy production are also considered. Costs are also incurred in rectifying damage to human health, material goods, agriculture and the environment related to greenhouse-gas emissions.

De Silva, S. (2003). "Global change: eruptions linked to El Nino." Nature **426**(6964): 239-41.

DeConto, R. M. and D. Pollard (2003). "Rapid Cenozoic glaciation of Antarctica induced by declining atmospheric CO2." Nature **421**(6920): 245-9.

The sudden, widespread glaciation of Antarctica and the associated shift towards colder temperatures at the Eocene/Oligocene boundary (approximately 34 million years ago) (refs 1-4) is one of the most fundamental reorganizations of global climate known in the geologic record. The glaciation of Antarctica has hitherto been thought to result from the tectonic opening of Southern Ocean gateways, which enabled the formation of the Antarctic Circumpolar Current and the subsequent thermal isolation of the Antarctic continent. Here we simulate the glacial inception and early growth of the East Antarctic Ice Sheet using a general circulation model with coupled components for atmosphere, ocean, ice sheet and sediment, and which incorporates palaeogeography, greenhouse gas, changing orbital parameters, and varying ocean heat transport. In our model, declining Cenozoic CO2 first leads to the formation of small, highly dynamic ice caps on high Antarctic plateaux. At a later time, a CO2 threshold is crossed, initiating ice-sheet height/mass-balance feedbacks that cause the ice caps to expand rapidly with large orbital variations, eventually coalescing into a continental-scale East Antarctic Ice Sheet. According to our simulation the opening of Southern Ocean gateways plays a secondary role in this transition, relative to CO2 concentration.

Denlinger, D. L. (1974). "Diapause potential in tropical flesh flies." Nature **252**(5480): 223-4.

Dennis, C. (2002). "Reef under threat from 'bleaching' outbreak." Nature **415**(6875): 947.

Dennis, C. (2004). "Vaccine targets gut reaction to calm livestock wind." Nature **429**(6988): 119.

Dennis, C. (2005). "Brown clouds cast a dark shadow." Nature **435**(7046): 1154.

Dennis, C. (2006). "Culture of fear reigns at Australian research lab." Nature **439**(7079): 896-7.

Dennis, C. and P. Aldhous (2004). "Biodiversity: a tragedy with many players." Nature **430**(6998): 396-8.

Dennis, D. T. (2005). "Activists should accept mainstream view of GM." Nature **435**(7042): 561.

Denyes, A. and J. Baumber (1965). "Comparison of brown fat metabolism in cold-exposed rats and golden hamsters." Nature **206**(985): 722-3.

Desjardins, C., F. H. Bronson, et al. (1986). "Genetic selection for reproductive photoresponsiveness in deer mice." Nature **322**(6075): 172-3.

Seasonal breeding is common in mammals, particularly in habitats outside the tropics. Climate and availability of food are the ultimate factors that usually dictate the optimal time of year for a mammal to breed; however, day length (photoperiod) often serves as the proximal cue to signal the onset or cessation of seasonal reproduction. Some individuals in some populations of deer mice are reproductively responsive to photoperiod, while other individuals in the same population are not. As shown here, selection can dramatically alter the frequency of photoresponsiveness in a laboratory population in only two generations. To our knowledge this is the first demonstration of selection for reproductive photoresponsiveness in any mammal. By implication, some wild populations of deer mice must use multiple, genetic-based reproductive strategies, and the degree to which each such strategy is exhibited must be subject to rapid change in response to both seasonally and momentarily changing climatic and dietary conditions.

Dev, B. (1964). "Excretion and Osmoregulation in the Leech, Hirudinaria Granulosa (Savigny)." Nature **202**: 414.

Diamond, J. M. (1993). "Evolutionary physiology. Quantitative design of life." Nature **366**(6454): 405-6.

Diamond, J. M. (2002). "Archaeology. Life with the artificial Anasazi." Nature **419**(6907): 567-9.

Dickens, G. R. (2004). "Global change: hydrocarbon-driven warming." Nature **429**(6991): 513-5.

Dickens, G. R. (2004). "Global change: hydrocarbon-driven warming." Nature **429**(6991): 513-5.

Dickson, B., I. Yashayaev, et al. (2002). "Rapid freshening of the deep North Atlantic Ocean over the past four decades." Nature **416**(6883): 832-7.

The overflow and descent of cold, dense water from the sills of the Denmark Strait and the Faroe Shetland channel into the North Atlantic Ocean is the principal means of ventilating the deep oceans, and is therefore a key element of the global thermohaline circulation. Most computer simulations of the ocean system in a climate with increasing atmospheric greenhouse-gas concentrations predict a weakening thermohaline circulation in the North Atlantic as the subpolar seas become fresher and warmer, and it is assumed that this signal will be transferred to the deep ocean by the two overflows. From observations it has not been possible to detect whether the ocean's overturning circulation is changing, but recent evidence suggests that the transport over the sills may be slackening. Here we show, through the analysis of long hydrographic records, that the system of overflow and entrainment that ventilates the deep Atlantic has steadily changed over the past four decades. We find that these changes have already led to sustained and widespread freshening of the deep ocean.

Dickson, D. (2000). "Deadlock in The Hague, but hopes remain for spring climate deal." Nature **408**(6812): 503-4.

Dickson, D. (2000). "Deadlock in The Hague, but hopes remain for spring climate deal." Nature **408**(6812): 503-4.

Diekmann, B. (2004). "Palaeoclimate: message from the fish teeth." Nature **430**(6995): 26-7.

Diekmann, B. (2004). "Palaeoclimate: message from the fish teeth." Nature **430**(6995): 26-7.

Diekmann, B. (2004). "Palaeoclimate: message from the fish teeth." Nature **430**(6995): 26-7.

Dietrich, W. E. and J. T. Perron (2006). "The search for a topographic signature of life." Nature **439**(7075): 411-8.

Landscapes are shaped by the uplift, deformation and breakdown of bedrock and the erosion, transport and deposition of sediment. Life is important in all of these processes. Over short timescales, the impact of life is quite apparent: rock weathering, soil formation and erosion, slope stability and river dynamics are directly influenced by biotic processes that mediate chemical reactions, dilate soil, disrupt the ground surface and add strength with a weave of roots. Over geologic time, biotic effects are less obvious but equally important: biota affect climate, and climatic conditions dictate the mechanisms and rates of erosion that control topographic evolution. Apart from the obvious influence of humans, does the resulting landscape bear an unmistakable stamp of life? The influence of life on topography is a topic that has remained largely unexplored. Erosion laws that explicitly include biotic effects are needed to explore how intrinsically small-scale biotic processes can influence the form of entire landscapes, and to determine whether these processes create a distinctive topography.

DiTullio, G. R., J. M. Grebmeier, et al. (2000). "Rapid and early export of Phaeocystis antarctica blooms in the Ross Sea, Antarctica." Nature **404**(6778): 595-8.

The Southern Ocean is very important for the potential sequestration of carbon dioxide in the oceans and is expected to be vulnerable to changes in carbon export forced by anthropogenic climate warming. Annual phytoplankton blooms in seasonal ice zones are highly productive and are thought to contribute significantly to pCO2 drawdown in the Southern Ocean. Diatoms are assumed to be the most important phytoplankton class with respect to export production in the Southern Ocean; however, the colonial prymnesiophyte Phaeocystis antarctica regularly forms huge blooms in seasonal ice zones and coastal Antarctic waters. There is little evidence regarding the fate of carbon produced by P. antarctica in the Southern Ocean, although remineralization in the upper water column has been proposed to be the main pathway in polar waters. Here we present evidence for early and rapid carbon export from P. antarctica blooms to deep water and sediments in the Ross Sea. Carbon sequestration from P. antarctica blooms may influence the carbon cycle in the Southern Ocean, especially if projected climatic changes lead to an alteration in the structure of the phytoplankton community.

Dokken, T. M. and K. H. Nisancioglu (2004). "Palaeoclimatology: fresh angle on the polar seesaw." Nature **430**(7002): 842-3.

Domack, E., D. Duran, et al. (2005). "Stability of the Larsen B ice shelf on the Antarctic Peninsula during the Holocene epoch." Nature **436**(7051): 681-5.

The stability of the Antarctic ice shelves in a warming climate has long been discussed, and the recent collapse of a significant part, over 12,500 km2 in area, of the Larsen ice shelf off the Antarctic Peninsula has led to a refocus toward the

implications of ice shelf decay for the stability of Antarctica's grounded ice. Some smaller Antarctic ice shelves have undergone periodic growth and decay over the past 11,000 yr (refs 7-11), but these ice shelves are at the climatic limit of ice shelf viability and are therefore expected to respond rapidly to natural climate variability at century to millennial scales. Here we use records of diatoms, detrital material and geochemical parameters from six marine sediment cores in the vicinity of the Larsen ice shelf to demonstrate that the recent collapse of the Larsen B ice shelf is unprecedented during the Holocene. We infer from our oxygen isotope measurements in planktonic foraminifera that the Larsen B ice shelf has been thinning throughout the Holocene, and we suggest that the recent prolonged period of warming in the Antarctic Peninsula region, in combination with the long-term thinning, has led to collapse of the ice shelf.

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Donnadieu, Y., Y. Godderis, et al. (2004). "A 'snowball Earth' climate triggered by continental break-up through changes in runoff." Nature **428**(6980): 303-6.

Geological and palaeomagnetic studies indicate that ice sheets may have reached the Equator at the end of the Proterozoic eon, 800 to 550 million years ago, leading to the suggestion of a fully ice-covered 'snowball Earth'. Climate model simulations indicate that such a snowball state for the Earth depends on anomalously low atmospheric carbon dioxide concentrations, in addition to the Sun being 6 per cent fainter than it is today. However, the mechanisms producing such low carbon dioxide concentrations remain controversial. Here we assess the effect of the palaeogeographic changes preceding the Sturtian glacial period, 750 million years ago, on the long-term evolution of atmospheric carbon dioxide levels using the coupled climate-geochemical model GEOCLIM. In our simulation, the continental break-up of Rodinia leads to an increase in runoff and hence consumption of carbon dioxide through continental weathering that decreases atmospheric carbon dioxide concentrations by 1,320 p.p.m. This indicates that tectonic changes could have triggered a progressive transition from a 'greenhouse' to an 'icehouse' climate during the Neoproterozoic era. When we combine these results with the concomitant weathering effect of the voluminous basaltic traps erupted throughout the break-up of Rodinia, our simulation results in a snowball glaciation.

Doran, P. T., J. C. Priscu, et al. (2002). "Antarctic climate cooling and terrestrial ecosystem response." Nature **415**(6871): 517-20.

The average air temperature at the Earth's surface has increased by 0.06 degrees C per decade during the 20th century, and by 0.19 degrees C per decade from 1979 to 1998. Climate models generally predict amplified warming in polar regions, as

observed in Antarctica's peninsula region over the second half of the 20th century. Although previous reports suggest slight recent continental warming, our spatial analysis of Antarctic meteorological data demonstrates a net cooling on the Antarctic continent between 1966 and 2000, particularly during summer and autumn. The McMurdo Dry Valleys have cooled by 0.7 degrees C per decade between 1986 and 2000, with similar pronounced seasonal trends. Summer cooling is particularly important to Antarctic terrestrial ecosystems that are poised at the interface of ice and water. Here we present data from the dry valleys representing evidence of rapid terrestrial ecosystem response to climate cooling in Antarctica, including decreased primary productivity of lakes (6-9% per year) and declining numbers of soil invertebrates (more than 10% per year). Continental Antarctic cooling, especially the seasonality of cooling, poses challenges to models of climate and ecosystem change.

Dore, J. E., R. Lukas, et al. (2003). "Climate-driven changes to the atmospheric CO2 sink in the subtropical North Pacific Ocean." Nature **424**(6950): 754-7.

The oceans represent a significant sink for atmospheric carbon dioxide. Variability in the strength of this sink occurs on interannual timescales, as a result of regional and basin-scale changes in the physical and biological parameters that control the flux of this greenhouse gas into and out of the surface mixed layer. Here we analyse a 13-year time series of oceanic carbon dioxide measurements from station ALOHA in the subtropical North Pacific Ocean near Hawaii, and find a significant decrease in the strength of the carbon dioxide sink over the period 1989-2001. We show that much of this reduction in sink strength can be attributed to an increase in the partial pressure of surface ocean carbon dioxide caused by excess evaporation and the accompanying concentration of solutes in the water mass. Our results suggest that carbon dioxide uptake by ocean waters can be strongly influenced by changes in regional precipitation and evaporation patterns brought on by climate variability.

Dunbar, R. B. (2003). "Global change: Leads, lags and the tropics." Nature **421**(6919): 121-2.

Dunbar, R. B. (2003). "Global change: Leads, lags and the tropics." Nature **421**(6919): 121-2.

Duplessy, J. C., J. Labeyrie, et al. (1970). "Continental climatic variations between 130,000 and 90,000 years BP." Nature **226**(5246): 631-3.

Edwards, M. and A. J. Richardson (2004). "Impact of climate change on marine pelagic phenology and trophic mismatch." Nature **430**(7002): 881-4.

Phenology, the study of annually recurring life cycle events such as the timing of migrations and flowering, can provide particularly sensitive indicators of climate change. Changes in phenology may be important to ecosystem function because the level of response to climate change may vary across functional groups and multiple trophic levels. The decoupling of phenological relationships will have important ramifications for trophic interactions, altering food-web structures and leading to eventual ecosystem-level changes. Temperate marine environments may be particularly vulnerable to these changes because the recruitment success of higher trophic levels is highly dependent on synchronization with pulsed planktonic production. Using long-term data of 66 plankton taxa during the period from 1958 to 2002, we investigated whether climate warming signals are emergent across all trophic levels and functional groups within an ecological community. Here we show that not only is the marine pelagic community responding to climate changes, but also that the level of response differs throughout the community and the seasonal cycle, leading to a mismatch between trophic levels and functional groups.

Edwards, M. and A. J. Richardson (2004). "Impact of climate change on marine pelagic phenology and trophic mismatch." Nature **430**(7002): 881-4.

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Elderfield, H. (2000). "A world in transition." Nature **407**(6806): 851-2.

Elderfield, H. and G. Ganssen (2000). "Past temperature and delta18O of surface ocean waters inferred from foraminiferal Mg/Ca ratios." Nature **405**(6785): 442-5.

Determining the past record of temperature and salinity of ocean surface waters is essential for understanding past changes in climate, such as those which occur across glacial-interglacial transitions. As a useful proxy, the oxygen isotope composition (delta18O) of calcite from planktonic foraminifera has been shown to reflect both surface temperature and seawater delta18O, itself an indicator of global ice volume and salinity. In addition, magnesium/calcium (Mg/Ca) ratios in foraminiferal calcite show a temperature dependence due to the partitioning of Mg during calcification. Here we demonstrate, in a field-based calibration experiment, that the variation of Mg/Ca ratios with temperature is similar for eight species of planktonic foraminifera (when accounting for Mg dissolution effects). Using a multi-species record from the Last Glacial Maximum in the North Atlantic Ocean we found that past temperatures reconstructed from Mg/Ca ratios followed the two other palaeotemperature proxies: faunal abundance and alkenone saturation. Moreover, combining Mg/Ca and delta18O data from the same faunal assemblage, we show that reconstructed surface water delta18O from all foraminiferal species record the same glacial-interglacial change--representing changing hydrography and global ice volume. This reinforces the potential of this combined technique in probing past ocean-climate interactions.

Ellwood, M. D. and W. A. Foster (2004). "Doubling the estimate of invertebrate biomass in a rainforest canopy." Nature **429**(6991): 549-51.

Forest canopies represent the functional interface between 90% of the Earth's terrestrial biomass and the atmosphere and include some of the most threatened of all terrestrial ecosystems. However, we lack even a basic understanding of how the biomass of plants and animals is distributed throughout forest canopies, even though this information is vital for estimating energy flow, carbon cycling, resource use and the transfer of materials within this ecosystem. Here we measure the biomass of invertebrates living in a common rainforest epiphyte, describe a striking relationship between fern size and the biomass of animals within the ferns, and reveal that one large epiphyte may contain an invertebrate biomass similar to that found in the whole of the rest of the tree crown on which it is growing. Using these data, we show that including the fauna of these epiphytes--a neglected component in rainforest ecosystems--can more than double our

estimate of the total invertebrate biomass in an entire rainforest canopy.

Emanuel, K. (2005). "Increasing destructiveness of tropical cyclones over the past 30 years." Nature **436**(7051): 686-8.

Theory and modelling predict that hurricane intensity should increase with increasing global mean temperatures, but work on the detection of trends in hurricane activity has focused mostly on their frequency and shows no trend. Here I define an index of the potential destructiveness of hurricanes based on the total dissipation of power, integrated over the lifetime of the cyclone, and show that this index has increased markedly since the mid-1970s. This trend is due to both longer storm lifetimes and greater storm intensities. I find that the record of net hurricane power dissipation is highly correlated with tropical sea surface temperature, reflecting well-documented climate signals, including multi-decadal oscillations in the North Atlantic and North Pacific, and global warming. My results suggest that future warming may lead to an upward trend in tropical cyclone destructive potential, and--taking into account an increasing coastal population--a substantial increase in hurricane-related losses in the twenty-first century.

Enquist, B. J., E. P. Economo, et al. (2003). "Scaling metabolism from organisms to ecosystems." Nature **423**(6940): 639-42.

Understanding energy and material fluxes through ecosystems is central to many questions in global change biology and ecology. Ecosystem respiration is a critical component of the carbon cycle and might be important in regulating biosphere response to global climate change. Here we derive a general model of ecosystem respiration based on the kinetics of metabolic reactions and the scaling of resource use by individual organisms. The model predicts that fluxes of CO2 and energy are invariant of ecosystem biomass, but are strongly influenced by temperature, variation in cellular metabolism and rates of supply of limiting resources (water and/or nutrients). Variation in ecosystem respiration within sites, as calculated from a network of CO2 flux towers, provides robust support for the model's predictions. However, data indicate that variation in annual flux between sites is not strongly dependent on average site temperature or latitude. This presents an interesting paradox with regard to the expected temperature dependence. Nevertheless, our model provides a basis for quantitatively understanding energy and material flux between the atmosphere and biosphere.

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Epstein, M. A. (1978). "Epstein-Barr virus as the cause of a human cancer." Nature **274**(5673): 740.

Eschenbach, W. W. (2004). "Ecology: climate-change effect on Lake Tanganyika?" Nature **430**(6997): 1 p following 309; discussion following 309.

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Evans, D. A. (2006). "Proterozoic low orbital obliquity and axial-dipolar geomagnetic field from evaporite palaeolatitudes." Nature **444**(7115): 51-5.

Palaeomagnetism of climatically sensitive sedimentary rock types, such as glacial deposits and evaporites, can test the uniformitarianism of ancient geomagnetic fields and palaeoclimate zones. Proterozoic glacial deposits laid down in near-equatorial palaeomagnetic latitudes can be explained by 'snowball Earth' episodes, high orbital obliquity or markedly non-uniformitarian geomagnetic fields. Here I present a global palaeomagnetic compilation of the Earth's entire basin-scale evaporite record. Magnetic inclinations are consistent with low orbital obliquity and a geocentric-axial-dipole magnetic field for most of the past two billion years, and the snowball Earth hypothesis accordingly remains the most viable model for low-latitude Proterozoic ice ages. Efforts to reconstruct Proterozoic supercontinents are strengthened by this demonstration of a consistently axial and dipolar geomagnetic reference frame, which itself implies stability of geodynamo processes on billion-year timescales.

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Fang, C., P. Smith, et al. (2005). "Similar response of labile and resistant soil organic matter pools to changes in temperature." Nature **433**(7021): 57-9.

Our understanding of the relationship between the decomposition of soil organic matter (SOM) and soil temperature affects our predictions of the impact of climate change on soil-stored carbon. One current opinion is that the decomposition of soil labile carbon is sensitive to temperature variation whereas resistant components are insensitive. The resistant carbon or organic matter in mineral soil is then assumed to be unresponsive to global warming. But the global pattern and magnitude of the predicted future soil carbon stock will mainly rely on the temperature sensitivity of these resistant carbon pools. To investigate this sensitivity, we have incubated soils under changing temperature. Here we report that SOM decomposition or soil basal respiration rate was significantly affected by changes in SOM components associated with soil depth, sampling method and incubation time. We find, however, that the temperature sensitivity for SOM decomposition was not affected, suggesting that the temperature sensitivity for resistant organic matter pools does not differ significantly from that of labile pools, and that both types of SOM will therefore respond similarly to global warming.

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Feachem, R. G. and C. A. Medlin (2002). "Health is wealth." Nature **417**(6890): 695.

Felis, T., G. Lohmann, et al. (2004). "Increased seasonality in Middle East temperatures during the last interglacial period." Nature **429**(6988): 164-8.

The last interglacial period (about 125,000 years ago) is thought to have been at least as warm as the present climate. Owing to changes in the Earth's orbit around the Sun, it is thought that insolation in the Northern Hemisphere varied more strongly than today on seasonal timescales, which would have led to corresponding changes in the seasonal temperature cycle. Here we present seasonally resolved proxy records using corals from the northernmost Red Sea, which record climate during the last interglacial period, the late Holocene epoch and the present. We find an increased seasonality in the temperature recorded in the last interglacial coral. Today, climate in the northern Red Sea is sensitive to the North Atlantic Oscillation, a climate oscillation that strongly influences winter temperatures and precipitation in the North Atlantic region. From our coral records and simulations with a coupled atmosphere-ocean circulation model, we conclude that a tendency towards the high-index state of the North Atlantic Oscillation during the last interglacial period, which is consistent with European proxy records, contributed to the larger amplitude of the seasonal cycle in the Middle East.

Ferris, J. P. and Y. Ishikawa (1987). "HCN and chromophore formation on Jupiter." Nature **326**: 777-8.

The formation of HCN and chromophores are two of the major unsolved problems of the atmospheric chemistry of Jupiter. The question to be dealt with is the same in each case: how can these unsaturated organic compounds be formed in the highly reducing atmosphere (89% H2) present on Jupiter? The photolysis of ammonia/acetylene mixtures provides an answer to this question. Here we report the formation of both HCN and chromophores along with experimental data which support the premise that this photochemical process provides a route for the formation of both substances. It is not clear whether significant amounts of HCN are also formed by lightning on Jupiter.

Filchak, K. E., J. B. Roethele, et al. (2000). "Natural selection and sympatric divergence in the apple maggot Rhagoletis pomonella." Nature **407**(6805): 739-42.

In On the Origin of Species, Darwin proposed that natural selection had a fundamental role in speciation. But this view receded during the Modern Synthesis

when allopatric (geographic) models of speciation were integrated with genetic studies of hybrid sterility and inviability. The sympatric hypothesis posits that ecological specialization after a host shift can result in speciation in the absence of complete geographic isolation. The apple maggot, Rhagoletis pomonella, is a model for sympatric speciation in progress. Hawthorn (Crataegus spp.) is the native host for R. pomonella in N. Americas. But in the mid-1800s, a new population formed on introduced, domesticated apple (Malus pumila). Recent studies have conferred 'host race' status on apple flies as a potentially incipient species, partially isolated from haw flies owing to host-related adaptation. However, the source of selection that differentiates apple and haw flies is unresolved. Here we document a gene-environment interaction (fitness trade-off) that is related to host phenology and that genetically differentiates the races.

Finney, B. P., I. Gregory-Eaves, et al. (2002). "Fisheries productivity in the northeastern Pacific Ocean over the past 2,200 years." Nature **416**(6882): 729-33.

Historical catch records suggest that climatic variability has had basin-wide effects on the northern Pacific and its fish populations, such as salmon, sardines and anchovies. However, these records are too short to define the nature and frequency of patterns. We reconstructed approximately 2,200-year records of sockeye salmon abundance from sediment cores obtained from salmon nursery lakes on Kodiak island, Alaska. Large shifts in abundance, which far exceed the decadal-scale variability recorded during the past 300 years, occurred over the past two millennia. A marked, multi-centennial decline in Alaskan sockeye salmon was apparent from approximately 100 BC to AD 800, but salmon were consistently more abundant from AD 1200 to 1900. Over the past two millennia, the abundances of Pacific sardine and Northern anchovy off the California coast, and of Alaskan salmon, show several synchronous patterns of variability. But sardines and anchovies vary out of phase with Alaskan salmon over low frequency, which differs from the pattern detected in historical records. The coherent patterns observed across large regions demonstrate the strong role of climatic forcing in regulating northeastern Pacific fish stocks.

Fisher, B. and R. Costanza (2005). "Environmental policy: regional commitment to reducing emissions." Nature **438**(7066): 301-2.

The non-participation of the United States in the recently ratified Kyoto Protocol is a matter for global concern because it is estimated that the country produces 24% of all greenhouse-gas emissions worldwide. Here we analyse the commitment of individual states and municipalities to addressing this problem and find that, despite the federal policy, between 24 and 35% of the US population are currently (or soon will be) engaged in policies directed towards significantly reducing anthropogenic climate change. The importance of this sub-national effort, which we estimate corresponds to 27-49% of the gross domestic product, will depend--like the targets adopted in Kyoto--on the real reductions achieved in greenhouse-gas emissions.

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Flint, E. A. and J. D. Stout (1960). "Microbiology of some soils from Antarctica." Nature **188**: 767-8.

Foukal, P., C. Frohlich, et al. (2006). "Variations in solar luminosity and their effect on the Earth's climate." Nature **443**(7108): 161-6.

Variations in the Sun's total energy output (luminosity) are caused by changing dark (sunspot) and bright structures on the solar disk during the 11-year sunspot cycle. The variations measured from spacecraft since 1978 are too small to have contributed appreciably to accelerated global warming over the past 30 years. In this Review, we show that detailed analysis of these small output variations has greatly advanced our understanding of solar luminosity change, and this new understanding indicates that brightening of the Sun is unlikely to have had a significant influence on global warming since the seventeenth century. Additional climate forcing by changes in the Sun's output of ultraviolet light, and of magnetized plasmas, cannot be ruled out. The suggested mechanisms are, however, too complex to evaluate meaningfully at present.

France, K. E. and J. E. Duffy (2006). "Diversity and dispersal interactively affect predictability of ecosystem function." Nature **441**(7097): 1139-43.

Theory and small-scale experiments predict that biodiversity losses can decrease the magnitude and stability of ecosystem services such as production and nutrient cycling. Most of this research, however, has been isolated from the immigration and emigration (dispersal) processes that create and maintain diversity in nature. As common anthropogenic drivers of biodiversity change--such as habitat fragmentation, species introductions and climate change--are mediated by these understudied processes, it is unclear how environmental degradation will affect ecosystem services. Here we tested the interactive effects of mobile grazer diversity and dispersal on the magnitude and stability of ecosystem properties in experimental seagrass communities that were either isolated or connected by dispersal corridors. We show that, contrary to theoretical predictions, increasing the number of mobile grazer species in these metacommunities increased the spatial and temporal variability of primary and secondary production. Moreover, allowing grazers to move among and select patches reduced diversity effects on production. Finally, effects of diversity on stability differed qualitatively between patch and metacommunity scales. Our results indicate that declining biodiversity and habitat fragmentation synergistically influence the predictability of ecosystem functioning.

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Francois, R. (2004). "Palaeoclimate: cool stratification." Nature **428**(6978): 31-2.

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Fraser, E. D. and W. Mabee (2002). "Summit: vague answers to well-known problems?" Nature **418**(6900): 817.

Frederickson, M. E., M. J. Greene, et al. (2005). "Ecology: 'Devil's gardens' bedevilled by ants." Nature **437**(7058): 495-6.

'Devil's gardens' are large stands of trees in the Amazonian rainforest that consist almost entirely of a single species, Duroia hirsuta, and, according to local legend, are cultivated by an evil forest spirit. Here we show that the ant Myrmelachista schumanni, which nests in D. hirsuta stems, creates devil's gardens by poisoning all plants except its host plants with formic acid. By killing these other plants, M. schumanni provides its colonies with abundant nest sites--a long-lasting benefit as colonies can live for 800 years.

Freeman, C., N. Fenner, et al. (2004). "Export of dissolved organic carbon from peatlands under elevated carbon dioxide levels." Nature **430**(6996): 195-8.

Peatlands represent a vast store of global carbon. Observations of rapidly rising dissolved organic carbon concentrations in rivers draining peatlands have created concerns that those stores are beginning to destabilize. Three main factors have been put forward as potential causal mechanisms, but it appears that two alternatives--warming and increased river discharge--cannot offer satisfactory explanations. Here we show that the third proposed mechanism, namely shifting trends in the proportion of annual rainfall arriving in summer, is similarly unable to account for the trend. Instead we infer that a previously unrecognized mechanism--carbon dioxide mediated stimulation of primary productivity--is responsible. Under elevated carbon dioxide levels, the proportion of dissolved organic carbon derived from recently assimilated carbon dioxide was ten times higher than that of the control cases. Concentrations of dissolved organic carbon appear far more sensitive to environmental drivers that affect net primary productivity than those affecting decomposition alone.

Freeman, C., N. Ostle, et al. (2001). "An enzymic 'latch' on a global carbon store." Nature **409**(6817): 149.

Fu, Q., C. M. Johanson, et al. (2004). "Contribution of stratospheric cooling to satellite-inferred tropospheric temperature trends." Nature **429**(6987): 55-8.

From 1979 to 2001, temperatures observed globally by the mid-tropospheric channel of the satellite-borne Microwave Sounding Unit (MSU channel 2), as well as the inferred temperatures in the lower troposphere, show only small warming trends of less than 0.1 K per decade (refs 1-3). Surface temperatures based on in situ observations however, exhibit a larger warming of approximately 0.17 K per decade (refs 4, 5), and global climate models forced by combined anthropogenic and natural factors project an increase in tropospheric temperatures that is somewhat larger than the surface temperature increase. Here we show that trends in MSU channel 2 temperatures are weak because the instrument partly records stratospheric temperatures whose large cooling trend offsets the contributions of tropospheric warming. We quantify the stratospheric contribution to MSU channel 2 temperatures using MSU channel 4, which records only stratospheric temperatures. The resulting trend of reconstructed tropospheric temperatures from satellite data is physically consistent with the observed surface temperature trend. For the tropics, the tropospheric warming is approximately 1.6 times the

surface warming, as expected for a moist adiabatic lapse rate.

Furness, R. W. (2003). "Metabolism: it's in the genes." Nature **425**(6960): 779-80.

Gabrielli, P., C. Barbante, et al. (2004). "Meteoric smoke fallout over the Holocene epoch revealed by iridium and platinum in Greenland ice." Nature **432**(7020): 1011-4.

An iridium anomaly at the Cretaceous/Tertiary boundary layer has been attributed to an extraterrestrial body that struck the Earth some 65 million years ago. It has been suggested that, during this event, the carrier of iridium was probably a micrometre-sized silicate-enclosed aggregate or the nanophase material of the vaporized impactor. But the fate of platinum-group elements (such as iridium) that regularly enter the atmosphere via ablating meteoroids remains largely unknown. Here we report a record of iridium and platinum fluxes on a climatic-cycle timescale, back to 128,000 years ago, from a Greenland ice core. We find that unexpectedly constant fallout of extraterrestrial matter to Greenland occurred during the Holocene, whereas a greatly enhanced input of terrestrial iridium and platinum masked the cosmic flux in the dust-laden atmosphere of the last glacial age. We suggest that nanometre-sized meteoric smoke particles, formed from the recondensation of ablated meteoroids in the atmosphere at altitudes >70 kilometres, are transported into the winter polar vortices by the mesospheric meridional circulation and are preferentially deposited in the polar ice caps. This implies an average global fallout of 14 +/- 5 kilotons per year of meteoric smoke during the Holocene.

Gaffin, S. R. (2002). "Laws stay constant but the world changes." Nature **419**(6905): 337.

Gaffin, S. R. and B. C. O'Neill (1998). "Combat climate change by reducing fertility." Nature **396**(6709): 307.

Gage, D. A., D. Rhodes, et al. (1997). "A new route for synthesis of dimethylsulphoniopropionate in marine algae." Nature **387**(6636): 891-4.

The 3-dimethylsulphoniopropionate (DMSP) produced by marine algae is the main biogenic precursor of atmospheric dimethylsulphide (DMS). This biogenic DMS, formed by bacterial and algal degradation of DMSP, contributes about 1.5 x 10(13) g of sulphur to the atmosphere annually, and plays a major part in the global sulphur cycle, in cloud formation and potentially in climate regulation. Although DMSP biosynthesis has been partially elucidated in a higher plant, nothing is known about how algae make DMSP except that the whole molecule is derived from methionine. Here we use in vivo isotope labelling to demonstrate that DMSP synthesis in the green macroalga Enteromorpha intestinalis proceeds by a route entirely distinct from that in higher plants. From methionine, the steps are transamination, reduction and S-methylation to give the novel sulphonium compound 4-dimethylsulphonio-2-hydroxybutyrate (DMSHB), which is oxidatively decarboxylated to DMSP. The key intermediate DMSHB was also identified in three diverse phytoplankton species, indicating that the same pathway operates in other algal classes that are important sources of DMS. The fact that a transamination initiates this pathway could help explain how algal DMSP (and thereby DMS) production is enhanced by nitrogen deficiency.

Ganachaud, A. and C. Wunsch (2000). "Improved estimates of global ocean circulation, heat transport and mixing from hydrographic data." Nature **408**(6811): 453-7.

Through its ability to transport large amounts of heat, fresh water and nutrients, the ocean is an essential regulator of climate. The pathways and mechanisms of this transport and its stability are critical issues in understanding the present state of climate and the possibilities of future changes. Recently, global high-quality hydrographic data have been gathered in the World Ocean Circulation Experiment (WOCE), to obtain an accurate picture of the present circulation.

Here we combine the new data from high-resolution trans-oceanic sections and current meters with climatological wind fields, biogeochemical balances and improved a priori error estimates in an inverse model, to improve estimates of the global circulation and heat fluxes. Our solution resolves globally vertical mixing across surfaces of equal density, with coefficients in the range (3-12) x 10(-4) m2 s(-1). Net deep-water production rates amount to (15 +/- 12) x 10(6) m3 s(-1) in the North Atlantic Ocean and (21 +/- 6) x 10(6) m3 s(-1) in the Southern Ocean. Our estimates provide a new reference state for future climate studies with rigorous estimates of the uncertainties.

Ganeshram, R. S. (2002). "Global change: oceanic action at a distance." Nature **419**(6903): 123-5.

Ganeshram, R. S. (2002). "Global change: oceanic action at a distance." Nature **419**(6903): 123-5.

Ganeshram, R. S., T. F. Pedersen, et al. (2002). "Reduced nitrogen fixation in the glacial ocean inferred from changes in marine nitrogen and phosphorus inventories." Nature **415**(6868): 156-9.

To explain the lower atmospheric CO2 concentrations during glacial periods, it has been suggested that the productivity of marine phytoplankton was stimulated by an increased flux of iron-bearing dust to the oceans. One component of this theory is that iron-an essential element/nutrient for nitrogen-fixing organisms-will increase the rate of marine nitrogen fixation, fuelling the growth of other marine phytoplankton and increasing CO2 uptake. Here we present data that questions this hypothesis. From a sediment core off the northwestern continental margin of Mexico, we show that denitrification and phosphorite formation-processes that occur in oxygen-deficient upwelling regions, removing respectively nitrogen and phosphorus from the ocean-declined in glacial periods, thus increasing marine inventories of nitrogen and phosphorus. But increases in phosphorus were smaller and less rapid, leading to increased N/P ratios in the oceans. Acknowledging that phytoplankton require nitrogen and phosphorus in constant proportions, the Redfield ratio, and that N/P ratios greater than the Redfield ratio are likely to suppress nitrogen fixation, we suggest therefore that marine productivity did not increase in glacial periods in response to either increased nutrient inventories or greater iron supply.

Ganopolski, A. and S. Rahmstorf (2001). "Rapid changes of glacial climate simulated in a coupled climate model." Nature **409**(6817): 153-8.

Abrupt changes in climate, termed Dansgaard-Oeschger and Heinrich events, have punctuated the last glacial period (approximately 100-10 kyr ago) but not the Holocene (the past 10 kyr). Here we use an intermediate-complexity climate model to investigate the stability of glacial climate, and we find that only one mode of Atlantic Ocean circulation is stable: a cold mode with deep water formation in the Atlantic Ocean south of Iceland. However, a 'warm' circulation mode similar to the present-day Atlantic Ocean is only marginally unstable, and temporary transitions to this warm mode can easily be triggered. This leads to abrupt warm events in the model which share many characteristics of the observed Dansgaard-Oeschger events. For a large freshwater input (such as a large release of icebergs), the model's deep water formation is temporarily switched off, causing no strong cooling in Greenland but warming in Antarctica, as is observed for Heinrich events. Our stability analysis provides an explanation why glacial climate is much more variable than Holocene climate.

Garrett, T. J. and C. Zhao (2006). "Increased Arctic cloud longwave emissivity associated with pollution from mid-latitudes." Nature **440**(7085): 787-9.

There is consensus among climate models that Arctic climate is particularly

sensitive to anthropogenic greenhouse gases and that, over the next century, Arctic surface temperatures are projected to rise at a rate about twice the global mean. The response of Arctic surface temperatures to greenhouse gas thermal emission is modified by Northern Hemisphere synoptic meteorology and local radiative processes. Aerosols may play a contributing factor through changes to cloud radiative properties. Here we evaluate a previously suggested contribution of anthropogenic aerosols to cloud emission and surface temperatures in the Arctic. Using four years of ground-based aerosol and radiation measurements obtained near Barrow, Alaska, we show that, where thin water clouds and pollution are coincident, there is an increase in cloud longwave emissivity resulting from elevated haze levels. This results in an estimated surface warming under cloudy skies of between 3.3 and 5.2 W m(-2) or 1 and 1.6 degrees C. Arctic climate is closely tied to cloud longwave emission, but feedback mechanisms in the system are complex and the actual climate response to the described sensitivity remains to be evaluated.

Gascard, J. C., A. J. Watson, et al. (2002). "Long-lived vortices as a mode of deep ventilation in the Greenland Sea." Nature **416**(6880): 525-7.

The Greenland Sea is one of a few sites in the world ocean where convection to great depths occurs-a process that forms some of the densest waters in the ocean. But the role of deep convective eddies, which result from surface cooling and mixing across density surfaces followed by geostrophic adjustment, has not been fully taken into account in the description of the initiation and growth of convection. Here we present tracer, float and hydrographic observations of long-lived (approximately 1 year) and compact (approximately 5 km core diameter) vortices that reach down to depths of 2 km. The eddies form in winter, near the rim of the Greenland Sea central gyre, and rotate clockwise with periods of a few days. The cores of the observed eddies are constituted from a mixture of modified Atlantic water that is warm and salty with polar water that is cold and fresh. We infer that these submesoscale coherent eddies contribute substantially to the input of Atlantic and polar waters to depths greater than 500 m in the central Greenland Sea.

Gavaghan, H. (2002). "Life in the deep freeze." Nature **415**(6874): 828-30.

Gedney, N., P. M. Cox, et al. (2006). "Detection of a direct carbon dioxide effect in continental river runoff records." Nature **439**(7078): 835-8.

Continental runoff has increased through the twentieth century despite more intensive human water consumption. Possible reasons for the increase include: climate change and variability, deforestation, solar dimming, and direct atmospheric carbon dioxide (CO2) effects on plant transpiration. All of these mechanisms have the potential to affect precipitation and/or evaporation and thereby modify runoff. Here we use a mechanistic land-surface model and optimal fingerprinting statistical techniques to attribute observational runoff changes into contributions due to these factors. The model successfully captures the climate-driven inter-annual runoff variability, but twentieth-century climate alone is insufficient to explain the runoff trends. Instead we find that the trends are consistent with a suppression of plant transpiration due to CO2-induced stomatal closure. This result will affect projections of freshwater availability, and also represents the detection of a direct CO2 effect on the functioning of the terrestrial biosphere.

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Geist, V. (1968). "Horn-like structures as rank symbols, guards and weapons." Nature **220**(5169): 813-4.

Genty, D., D. Blamart, et al. (2003). "Precise dating of Dansgaard-Oeschger climate oscillations in western Europe from stalagmite data." Nature **421**(6925): 833-7.

The signature of Dansgaard-Oeschger events--millennial-scale abrupt climate oscillations during the last glacial period--is well established in ice cores and marine records. But the effects of such events in continental settings are not as clear, and their absolute chronology is uncertain beyond the limit of (14)C dating and annual layer counting for marine records and ice cores, respectively. Here we present carbon and oxygen isotope records from a stalagmite collected in southwest France which have been precisely dated using 234U/230Th ratios. We find rapid climate oscillations coincident with the established Dansgaard-Oeschger events between 83,000 and 32,000 years ago in both isotope records. The oxygen isotope signature is similar to a record from Soreq cave, Israel, and deep-sea records, indicating the large spatial scale of the climate oscillations. The signal in the carbon isotopes gives evidence of drastic and rapid vegetation changes in western Europe, an important site in human cultural evolution. We also find evidence for a long phase of extremely cold climate in southwest France between 61.2 +/- 0.6 and 67.4 +/- 0.9 kyr ago.

Gewin, V. (2004). "Disease control: virtual plagues get real." Nature **427**(6977): 774-5.

Gewin, V. (2005). "Industry lured by the gains of going green." Nature **436**(7048): 173.

Ghanem, Y. S. and F. A. Soliman (1957). "Thyrotrophic and gonadotrophic hormone contents of pituitaries and blood of dogs during the winter and summer." Nature **179**(4550): 102.

Giles, J. (2002). "When doubt is a sure thing." Nature **418**(6897): 476-8.

Giles, J. (2002). "Norway sinks ocean carbon study." Nature **419**(6902): 6.

Giles, J. (2004). "Problems of the poor set to face cost-benefit treatment." Nature **428**(6979): 110.

Giles, J. (2004). "Ice machine sheds light on climate history written in dust." Nature **428**(6981): 355.

Giles, J. (2004). "Ocean fix for climate change finds tentative support." Nature **431**(7005): 115.

Giles, J. (2004). "Ocean fix for climate change finds tentative support." Nature **431**(7005): 115.

Giles, J. (2004). "Blair to seek consensus on safe greenhouse-gas levels." Nature **431**(7009): 619.

Giles, J. (2004). "Climatologists get real over global warming." Nature **432**(7020): 937.

Giles, J. (2005). "Fallout of fertilizers set too low, studies warn." Nature **434**(7031): 262.

Giles, J. (2005). "Climate science: the dustiest place on Earth." Nature **434**(7035): 816-9.

Giles, J. (2005). "Hikes in surface ozone could suffocate crops." Nature **435**(7038): 7.

Giles, J. (2005). "Climate sceptics place bets on world cooling down." Nature **436**(7053): 897.

Giles, J. (2006). "Plans to pare down climate centre anger UK ecologists." Nature **439**(7078): 770-1.

Giles, J. (2006). "US posts sensitive climate report for public comment." Nature **441**(7089): 6-7.

Giles, J. (2006). "The outlook for Amazonia is dry." Nature **442**(7104): 726-7.

Giles, J. (2006). "The outlook for Amazonia is dry." Nature **442**(7104): 726-7.

Gillespie, A. R., D. R. Montgomery, et al. (2005). "Planetary science: are there active glaciers on Mars?" Nature **438**(7069): E9-10; discussion E10.

Head et al. interpret spectacular images from the Mars Express high-resolution stereo camera as evidence of geologically recent rock glaciers in Tharsis and of a piedmont ('hourglass') glacier at the base of a 3-km-high massif east of Hellas. They attribute growth of the low-latitude glaciers to snowfall during periods of increased spin-axis obliquity. The age of the hourglass glacier, considered to be inactive and slowly shrinking beneath a debris cover in the absence of modern snowfall, is estimated to be more than 40 Myr. Although we agree that the maximum glacier extent was climatically controlled, we find evidence in the images to support local augmentation of accumulation from snowfall through a mechanism that does not require climate change on Mars.

Gillett, N. P. (2005). "Climate modelling: Northern Hemisphere circulation." Nature **437**(7058): 496.

Air pressure at sea level during winter has decreased over the Arctic and increased in the Northern Hemisphere subtropics in recent decades, a change that has been associated with 50% of the Eurasian winter warming observed over the past 30 years, with 60% of the rainfall increase in Scotland and with 60% of the rainfall decrease in Spain. This trend is inconsistent with the simulated response to greenhouse-gas and sulphate-aerosol changes, but it has been proposed that other climate influences--such as ozone depletion--could account for the discrepancy. Here I compare observed Northern Hemisphere sea-level pressure trends with those simulated in response to all the major human and natural climate influences in nine state-of-the-art coupled climate models over the past 50 years. I find that these models all underestimate the circulation trend. This inconsistency suggests that we cannot yet simulate changes in this important property of the climate system or accurately predict regional climate changes.

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Gillett, N. P., B. D. Santer, et al. (2004). "Atmospheric science: stratospheric cooling and the troposphere." Nature **432**(7017): 2 p following 572; discussion following 572.

Satellite observations of tropospheric temperatures seem to show less warming than surface temperatures, contrary to physical predictions. Fu et al. show that statistical correction for the effect of stratospheric cooling brings the satellite-based estimates of tropospheric warming into closer agreement with observations of surface warming. Here we apply the method of Fu et al. to output from a state-of-the-art coupled climate model and show that simulated tropospheric temperature trends are consistent with those observed and that their method is robust.

Gillett, N. P., F. W. Zwiers, et al. (2003). "Detection of human influence on sea-level pressure." Nature **422**(6929): 292-4.

Greenhouse gases and tropospheric sulphate aerosols--the main human influences on climate--have been shown to have had a detectable effect on surface air temperature, the temperature of the free troposphere and stratosphere and ocean temperature. Nevertheless, the question remains as to whether human influence is detectable in any variable other than temperature. Here we detect an influence of anthropogenic greenhouse gases and sulphate aerosols in observations of winter sea-level pressure (December to February), using combined simulations from four climate models. We find increases in sea-level pressure over the subtropical North Atlantic Ocean, southern Europe and North Africa, and decreases in the polar regions and the North Pacific Ocean, in response to human influence. Our analysis also indicates that the climate models substantially underestimate the magnitude of the sea-level pressure response. This discrepancy suggests that the upward trend in the North Atlantic Oscillation index (corresponding to strengthened westerlies in the North Atlantic region), as simulated in a number of global warming scenarios, may be too small, leading to an underestimation of the impacts of anthropogenic climate change on European climate.

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strengthened westerlies in the North Atlantic region), as simulated in a number of global warming scenarios, may be too small, leading to an underestimation of the impacts of anthropogenic climate change on European climate.

Gillon, J. (2000). "Carbon fixation." Nature **405**(6785): 412.

Gillon, J. (2000). "Feedback on Gaia." Nature **406**(6797): 685-6.

Gillon, J. (2004). "People power against climate change." Nature **430**(6995): 15.

Gleckler, P. J., T. M. Wigley, et al. (2006). "Volcanoes and climate: Krakatoa's signature persists in the ocean." Nature **439**(7077): 675.

We have analysed a suite of 12 state-of-the-art climate models and show that ocean warming and sea-level rise in the twentieth century were substantially reduced by the colossal eruption in 1883 of the volcano Krakatoa in the Sunda strait, Indonesia. Volcanically induced cooling of the ocean surface penetrated into deeper layers, where it persisted for decades after the event. This remarkable effect on oceanic thermal structure is longer lasting than has previously been suspected and is sufficient to offset a large fraction of ocean warming and sea-level rise caused by anthropogenic influences.

Goetz, W., P. Bertelsen, et al. (2005). "Indication of drier periods on Mars from the chemistry and mineralogy of atmospheric dust." Nature **436**(7047): 62-5.

The ubiquitous atmospheric dust on Mars is well mixed by periodic global dust storms, and such dust carries information about the environment in which it once formed and hence about the history of water on Mars. The Mars Exploration Rovers have permanent magnets to collect atmospheric dust for investigation by instruments on the rovers. Here we report results from Mossbauer spectroscopy and X-ray fluorescence of dust particles captured from the martian atmosphere by the magnets. The dust on the magnets contains magnetite and olivine; this indicates a basaltic origin of the dust and shows that magnetite, not maghemite, is the mineral mainly responsible for the magnetic properties of the dust. Furthermore, the dust on the magnets contains some ferric oxides, probably including nanocrystalline phases, so some alteration or oxidation of the basaltic dust seems to have occurred. The presence of olivine indicates that liquid water did not play a dominant role in the processes that formed the atmospheric dust.

Gonzalez-Jose, R., A. Gonzalez-Martin, et al. (2003). "Craniometric evidence for Palaeoamerican survival in Baja California." Nature **425**(6953): 62-5.

A current issue on the settlement of the Americas refers to the lack of morphological affinities between early Holocene human remains (Palaeoamericans) and modern Amerindian groups, as well as the degree of contribution of the former to the gene pool of the latter. A different origin for Palaeoamericans and Amerindians is invoked to explain such a phenomenon. Under this hypothesis, the origin of Palaeoamericans must be traced back to a common ancestor for Palaeoamericans and Australians, which departed from somewhere in southern Asia and arrived in the Australian continent and the Americas around 40,000 and 12,000 years before present, respectively. Most modern Amerindians are believed to be part of a second, morphologically differentiated migration. Here we present evidence of a modern Amerindian group from the Baja California Peninsula in Mexico, showing clearer affinities with Palaeoamerican remains than with modern Amerindians. Climatic changes during the Middle Holocene probably generated the conditions for isolation from the continent, restricting the gene flow of the original group with northern populations, which resulted in the temporal continuity of the Palaeoamerican morphological pattern to the present.

Goodwin, I. (2001). "United States treads its own path on climate change." Nature **411**(6835): 225.

Goodwin, I. (2001). "United States treads its own path on climate change." Nature **411**(6835): 225.

Gopal, E. S. (2000). "EPA error risked halving India's rice harvest." Nature **403**(6766): 130.

Gordon, A. L., R. D. Susanto, et al. (2003). "Cool Indonesian throughflow as a consequence of restricted surface layer flow." Nature **425**(6960): 824-8.

Approximately 10 million m3 x s(-1) of water flow from the Pacific Ocean into the Indian Ocean through the Indonesian seas. Within the Makassar Strait, the primary pathway of the flow, the Indonesian throughflow is far cooler than estimated earlier, as pointed out recently on the basis of ocean current and temperature measurements. Here we analyse ocean current and stratification data along with satellite-derived wind measurements, and find that during the boreal winter monsoon, the wind drives buoyant, low-salinity Java Sea surface water into the southern Makassar Strait, creating a northward pressure gradient in the surface layer of the strait. This surface layer 'freshwater plug' inhibits the warm surface water from the Pacific Ocean from flowing southward into the Indian Ocean, leading to a cooler Indian Ocean sea surface, which in turn may weaken the Asian monsoon. The summer wind reversal eliminates the obstructing pressure gradient, by transferring more-saline Banda Sea surface water into the southern Makassar Strait. The coupling of the southeast Asian freshwater budget to the Pacific and Indian Ocean surface temperatures by the proposed mechanism may represent an important negative feedback within the climate system.

Gorman, J. G. (1964). "Selection against the Rh-Negative Gene by Malaria." Nature **202**: 676-7.

Gowlett, J. A. (2001). "Archaeology. Out in the cold." Nature **413**(6851): 33-4.

Grace, J. and Y. Malhi (2002). "Global change: carbon dioxide goes with the flow." Nature **416**(6881): 594.

Grace, J. and Y. Malhi (2002). "Global change: carbon dioxide goes with the flow." Nature **416**(6881): 594.

Grace, J. and M. Rayment (2000). "Respiration in the balance." Nature **404**(6780): 819-20.

Grantham, B. A., F. Chan, et al. (2004). "Upwelling-driven nearshore hypoxia signals ecosystem and oceanographic changes in the northeast Pacific." Nature **429**(6993): 749-54.

Seasonal development of dissolved-oxygen deficits (hypoxia) represents an acute system-level perturbation to ecological dynamics and fishery sustainability in coastal ecosystems around the globe. Whereas anthropogenic nutrient loading has increased the frequency and severity of hypoxia in estuaries and semi-enclosed seas, the occurrence of hypoxia in open-coast upwelling systems reflects ocean conditions that control the delivery of oxygen-poor and nutrient-rich deep water onto continental shelves. Upwelling systems support a large proportion of the world's fisheries, therefore understanding the links between changes in ocean climate, upwelling-driven hypoxia and ecological perturbations is critical. Here we report on the unprecedented development of severe inner-shelf (<70 m) hypoxia and resultant mass die-offs of fish and invertebrates within the California Current System. In 2002, cross-shelf transects revealed the development of abnormally

low dissolved-oxygen levels as a response to anomalously strong flow of subarctic water into the California Current System. Our findings highlight the sensitivity of inner-shelf ecosystems to variation in ocean conditions, and the potential impacts of climate change on marine communities.

Gregg, M. C., T. B. Sanford, et al. (2003). "Reduced mixing from the breaking of internal waves in equatorial waters." Nature **422**(6931): 513-5.

In the oceans, heat, salt and nutrients are redistributed much more easily within water masses of uniform density than across surfaces separating waters of different densities. But the magnitude and distribution of mixing across density surfaces are also important for the Earth's climate as well as the concentrations of organisms. Most of this mixing occurs where internal waves break, overturning the density stratification of the ocean and creating patches of turbulence. Predictions of the rate at which internal waves dissipate were confirmed earlier at mid-latitudes. Here we present observations of temperature and velocity fluctuations in the Pacific and Atlantic oceans between 42 degrees N and 2 degrees S to extend that result to equatorial regions. We find a strong latitude dependence of dissipation in accordance with the predictions. In our observations, dissipation rates and accompanying mixing across density surfaces near the Equator are less than 10% of those at mid-latitudes for a similar background of internal waves. Reduced mixing close to the Equator will have to be taken into account in numerical simulations of ocean dynamics--for example, in climate change experiments.

Gregory, J. M., P. Huybrechts, et al. (2004). "Climatology: threatened loss of the Greenland ice-sheet." Nature **428**(6983): 616.

The Greenland ice-sheet would melt faster in a warmer climate and is likely to be eliminated--except for residual glaciers in the mountains--if the annual average temperature in Greenland increases by more than about 3 degrees C. This could raise the global average sea-level by 7 metres over a period of 1,000 years or more. We show here that concentrations of greenhouse gases will probably have reached levels before the year 2100 that are sufficient to raise the temperature past this warming threshold.

Grevemeyer, I., R. Herber, et al. (2000). "Microseismological evidence for a changing wave climate in the northeast Atlantic Ocean." Nature **408**(6810): 349-52.

One possible consequence of a change in climate over the past several decades is an increase in wave heights, potentially threatening coastal areas as well as the marine industry. But the difficulties in observing wave heights exacerbates a general problem of climate-change detection: inhomogeneities in long-term observational records owing to changes in the instruments or techniques used, which may cause artificial trends. Ground movements with periods of 4-16 seconds, known as microseisms, are associated with ocean waves and coastal surf, and have been recorded continuously since the early days of seismology. Here we use such a 40-year record of wintertime microseisms from Hamburg, Germany, to reconstruct the wave climate in the northeast Atlantic Ocean. For the period 1954-77, we detect an average of seven days per month with strong microseismic activity, without a significant trend. This number increases significantly in the second half of the record, reaching approximately 14 days of strong microseisms per month. The implied increase in northeast Atlantic wave height over the past 20 years parallels increased surface air temperatures and storminess in this region, suggesting a common forcing.

Grottoli, A. G., L. J. Rodrigues, et al. (2006). "Heterotrophic plasticity and resilience in bleached corals." Nature **440**(7088): 1186-9.

Mass coral bleaching events caused by elevated seawater temperatures have resulted in extensive coral mortality throughout the tropics over the past few

decades. With continued global warming, bleaching events are predicted to increase in frequency and severity, causing up to 60% coral mortality globally within the next few decades. Although some corals are able to recover and to survive bleaching, the mechanisms underlying such resilience are poorly understood. Here we show that the coral host has a significant role in recovery and resilience. Bleached and recovering Montipora capitata (branching) corals met more than 100% of their daily metabolic energy requirements by markedly increasing their feeding rates and CHAR (per cent contribution of heterotrophically acquired carbon to daily animal respiration), whereas Porites compressa (branching) and Porites lobata (mounding) corals did not. These findings suggest that coral species with high-CHAR capability during bleaching and recovery, irrespective of morphology, will be more resilient to bleaching events over the long term, could become the dominant coral species on reefs, and may help to safeguard affected reefs from potential local and global extinction.

Gruber, N. (2005). "Oceanography: a bigger nitrogen fix." Nature **436**(7052): 786-7.

Grubler, A. and N. Nakicenovic (2001). "Identifying dangers in an uncertain climate." Nature **412**(6842): 15.

Grubler, A., B. O'Neill, et al. (2006). "Avoiding hazards of best-guess climate scenarios." Nature **440**(7085): 740.

Guo, Z. T., W. F. Ruddiman, et al. (2002). "Onset of Asian desertification by 22 Myr ago inferred from loess deposits in China." Nature **416**(6877): 159-63.

The initial desertification in the Asian interior is thought to be one of the most prominent climate changes in the Northern Hemisphere during the Cenozoic era. But the dating of this transition is uncertain, partly because desert sediments are usually scattered, discontinuous and difficult to date. Here we report nearly continuous aeolian deposits covering the interval from 22 to 6.2 million years ago, on the basis of palaeomagnetic measurements and fossil evidence. A total of 231 visually definable aeolian layers occur as brownish loesses interbedded with reddish soils. This new evidence indicates that large source areas of aeolian dust and energetic winter monsoon winds to transport the material must have existed in the interior of Asia by the early Miocene epoch, at least 14 million years earlier than previously thought. Regional tectonic changes and ongoing global cooling are probable causes of these changes in aridity and circulation in Asia.

Gupta, A. K., D. M. Anderson, et al. (2003). "Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean." Nature **421**(6921): 354-7.

During the last ice age, the Indian Ocean southwest monsoon exhibited abrupt changes that were closely correlated with millennial-scale climate events in the North Atlantic region, suggesting a mechanistic link. In the Holocene epoch, which had a more stable climate, the amplitude of abrupt changes in North Atlantic climate was much smaller, and it has been unclear whether these changes are related to monsoon variability. Here we present a continuous record of centennial-scale monsoon variability throughout the Holocene from rapidly accumulating and minimally bioturbated sediments in the anoxic Arabian Sea. Our monsoon proxy record reveals several intervals of weak summer monsoon that coincide with cold periods documented in the North Atlantic region--including the most recent climate changes from the Medieval Warm Period to the Little Ice Age and then to the present. We therefore suggest that the link between North Atlantic climate and the Asian monsoon is a persistent aspect of global climate.

Guthrie, R. D. (2003). "Rapid body size decline in Alaskan Pleistocene horses before extinction." Nature **426**(6963): 169-71.

About 70% of North American large mammal species were lost at the end of the Pleistocene epoch. The causes of this extinction--the role of humans versus that of climate--have been the focus of much controversy. Horses have figured centrally in that debate, because equid species dominated North American late Pleistocene faunas in terms of abundance, geographical distribution, and species variety, yet none survived into the Holocene epoch. The timing of these equid regional extinctions and accompanying evolutionary changes are poorly known. In an attempt to document better the decline and demise of two Alaskan Pleistocene equids, I selected a large number of fossils from the latest Pleistocene for radiocarbon dating. Here I show that horses underwent a rapid decline in body size before extinction, and I propose that the size decline and subsequent regional extinction at 12,500 radiocarbon years before present are best attributed to a coincident climatic/vegetational shift. The present data do not support human overkill and several other proposed extinction causes, and also show that large mammal species responded somewhat individualistically to climate changes at the end of the Pleistocene.

Guthrie, R. D. (2006). "New carbon dates link climatic change with human colonization and Pleistocene extinctions." Nature **441**(7090): 207-9.

Drastic ecological restructuring, species redistribution and extinctions mark the Pleistocene-Holocene transition, but an insufficiency of numbers of well-dated large mammal fossils from this transition have impeded progress in understanding the various causative links. Here I add many new radiocarbon dates to those already published on late Pleistocene fossils from Alaska and the Yukon Territory (AK-YT) and show previously unrecognized patterns. Species that survived the Pleistocene, for example, bison (Bison priscus, which evolved into Bison bison), wapiti (Cervus canadensis) and, to a smaller degree, moose (Alces alces), began to increase in numbers and continued to do so before and during human colonization and before the regional extinction of horse (Equus ferus) and mammoth (Mammuthus primigenius). These patterns allow us to reject, at least in AK-YT, some hypotheses of late Pleistocene extinction: 'Blitzkrieg' version of simultaneous human overkill, 'keystone' removal, and 'palaeo-disease'. Hypotheses of a subtler human impact and/or ecological replacement or displacement are more consistent with the data. The new patterns of dates indicate a radical ecological sorting during a uniquely forage-rich transitional period, affecting all large mammals, including humans.

Haag, A. (2004). "Greenland ice sheet to get underhand inspection." Nature **430**(7003): 955.

Haag, A. (2004). "US proves a wet blanket at international climate meeting." Nature **432**(7020): 936.

Haag, A. (2005). "Climate talks edge towards twin-track future." Nature **438**(7069): 721.

Haag, A. (2005). "Developing nations offer hope in climate talks." Nature **438**(7070): 895.

Hall, A. and R. J. Stouffer (2001). "An abrupt climate event in a coupled ocean-atmosphere simulation without external forcing." Nature **409**(6817): 171-4.

Temperature reconstructions from the North Atlantic region indicate frequent abrupt and severe climate fluctuations during the last glacial and Holocene periods. The driving forces for these events are unclear and coupled atmosphere-ocean models of global circulation have only simulated such events by inserting large amounts of fresh water into the northern North Atlantic Ocean. Here we report a drastic cooling event in a 15,000-yr simulation of global circulation with present-day climate conditions without the use of such external forcing. In our simulation,

the annual average surface temperature near southern Greenland spontaneously fell 6-10 standard deviations below its mean value for a period of 30-40 yr. The event was triggered by a persistent northwesterly wind that transported large amounts of buoyant cold and fresh water into the northern North Atlantic Ocean. Oceanic convection shut down in response to this flow, concentrating the entire cooling of the northern North Atlantic by the colder atmosphere in the uppermost ocean layer. Given the similarity between our simulation and observed records of rapid cooling events, our results indicate that internal atmospheric variability alone could have generated the extreme climate disruptions in this region.

Hall, I. R., I. N. McCave, et al. (2001). "Intensified deep Pacific inflow and ventilation in Pleistocene glacial times." Nature **412**(6849): 809-12.

The production of cold, deep waters in the Southern Ocean is an important factor in the Earth's heat budget. The supply of deep water to the Pacific Ocean is presently dominated by a single source, the deep western boundary current east of New Zealand. Here we use sediment records deposited under the influence of this deep western boundary current to reconstruct deep-water properties and speed changes during the Pleistocene epoch. In physical and isotope proxies we find evidence for intensified deep Pacific Ocean inflow and ventilation during the glacial periods of the past 1.2 million years. The changes in throughflow may be directly related to an increased production of Antarctic Bottom Water during glacial times. Possible causes for such an increased bottom-water production include increasing wind strengths in the Southern Ocean or an increase in annual sea-ice formation, leaving dense water after brine rejection and thereby enhancing deep convection. We infer also that the global thermohaline circulation was perturbed significantly during the mid-Pleistocene climate transition between 0.86 and 0.45 million years ago.

Hallett, T. B., T. Coulson, et al. (2004). "Why large-scale climate indices seem to predict ecological processes better than local weather." Nature **430**(6995): 71-5.

Large-scale climatic indices such as the North Atlantic Oscillation are associated with population dynamics, variation in demographic rates and values of phenotypic traits in many species. Paradoxically, these large-scale indices can seem to be better predictors of ecological processes than local climate. Using detailed data from a population of Soay sheep, we show that high rainfall, high winds or low temperatures at any time during a 3-month period can cause mortality either immediately or lagged by a few days. Most measures of local climate used by ecologists fail to capture such complex associations between weather and ecological process, and this may help to explain why large-scale, seasonal indices of climate spanning several months can outperform local climatic factors. Furthermore, we show why an understanding of the mechanism by which climate influences population ecology is important. Through simulation we demonstrate that the timing of bad weather within a period of mortality can have an important modifying influence on intraspecific competition for food, revealing an interaction between climate and density dependence that the use of large-scale climatic indices or inappropriate local weather variables might obscure.

Hannah, L. and B. Phillips (2004). "Extinction-risk coverage is worth inaccuracies." Nature **430**(6996): 141.

Harms, K. E., S. J. Wright, et al. (2000). "Pervasive density-dependent recruitment enhances seedling diversity in a tropical forest." Nature **404**(6777): 493-5.

Negative density-dependent recruitment of seedlings, that is, seeds of a given species are less likely to become established seedlings if the density of that species is high, has been proposed to be an important mechanism contributing to the extraordinary diversity of tropical tree communities because it can potentially

prevent any particular species from usurping all available space, either in close proximity to seed sources or at relatively larger spatial scales. However, density-dependent recruitment does not necessarily enhance community diversity. Furthermore, although density-dependent effects have been found at some life stages in some species, no study has shown that density-dependent recruitment affects community diversity. Here we report the results of observations in a lowland, moist forest in the Republic of Panama in which the species identities of 386,027 seeds that arrived at 200 seed traps were compared with the species identities of 13,068 seedlings that recruited into adjacent plots over a 4-year period. Across the 200 sites, recruit seedling diversity was significantly higher than seed diversity. Part of this difference was explained by interspecies differences in average recruitment success. Even after accounting for these differences, however, negative density-dependent recruitment contributes significantly to the increase in diversity from seeds to seedling recruits.

Harries, J. E., H. E. Brindley, et al. (2001). "Increases in greenhouse forcing inferred from the outgoing longwave radiation spectra of the Earth in 1970 and 1997." Nature **410**(6826): 355-7.

The evolution of the Earth's climate has been extensively studied, and a strong link between increases in surface temperatures and greenhouse gases has been established. But this relationship is complicated by several feedback processes-most importantly the hydrological cycle-that are not well understood. Changes in the Earth's greenhouse effect can be detected from variations in the spectrum of outgoing longwave radiation, which is a measure of how the Earth cools to space and carries the imprint of the gases that are responsible for the greenhouse effect. Here we analyse the difference between the spectra of the outgoing longwave radiation of the Earth as measured by orbiting spacecraft in 1970 and 1997. We find differences in the spectra that point to long-term changes in atmospheric CH4, CO2 and O3 as well as CFC-11 and CFC-12. Our results provide direct experimental evidence for a significant increase in the Earth's greenhouse effect that is consistent with concerns over radiative forcing of climate.

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Harrison, S. P., G. Yu, et al. (2001). "Palaeovegetation. Diversity of temperate plants in east Asia." Nature **413**(6852): 129-30.

The exceptionally broad species diversity of vascular plant genera in east Asian temperate forests, compared with their sister taxa in North America, has been attributed to the greater climatic diversity of east Asia, combined with opportunities for allopatric speciation afforded by repeated fragmentation and coalescence of populations through Late Cenozoic ice-age cycles. According to Qian and Ricklefs, these opportunities occurred in east Asia because temperate

forests extended across the continental shelf to link populations in China, Korea and Japan during glacial periods, whereas higher sea levels during interglacial periods isolated these regions and warmer temperatures restricted temperate taxa to disjunct refuges. However, palaeovegetation data from east Asia show that temperate forests were considerably less extensive than today during the Last Glacial Maximum, calling into question the coalescence of tree populations required by the hypothesis of Qian and Ricklefs.

Harte, J., A. Ostling, et al. (2004). "Biodiversity conservation: climate change and extinction risk." Nature **430**(6995): 3 p following 33; discussion following 33.

Thomas et al. have carried out a useful analysis of the extinction risk from climate warming. Their overall conclusion, that a large fraction of extant species could be driven to extinction by expected climate trends over the next 50 years, is compelling: it adds to the many other reasons why new energy policies are needed to reduce the pace of warming.

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Hauber, E., S. van Gasselt, et al. (2005). "Discovery of a flank caldera and very young glacial activity at Hecates Tholus, Mars." Nature **434**(7031): 356-61.

The majority of volcanic products on Mars are thought to be mafic and effusive. Explosive eruptions of basic to ultrabasic chemistry are expected to be common, but evidence for them is rare and mostly confined to very old surface features. Here we present new image and topographic data from the High Resolution Stereo Camera that reveal previously unknown traces of an explosive eruption at 30 degrees N and 149 degrees E on the northwestern flank of the shield volcano Hecates Tholus. The eruption created a large, 10-km-diameter caldera approximately 350 million years ago. We interpret these observations to mean that large-scale explosive volcanism on Mars was not confined to the planet's early evolution. We also show that glacial deposits partly fill the caldera and an adjacent depression. Their age, derived from crater counts, is about 5 to 24 million years. Climate models predict that near-surface ice is not stable at mid-latitudes today, assuming a thermo-dynamic steady state. Therefore, the discovery of very young glacial features at Hecates Tholus suggests recent climate changes. We show that the absolute ages of these very recent glacial deposits correspond very well to a period of increased obliquity of the planet's rotational axis.

Haug, G. H., A. Ganopolski, et al. (2005). "North Pacific seasonality and the glaciation of North America 2.7 million years ago." Nature **433**(7028): 821-5.

In the context of gradual Cenozoic cooling, the timing of the onset of significant Northern Hemisphere glaciation 2.7 million years ago is consistent with Milankovitch's orbital theory, which posited that ice sheets grow when polar summertime insolation and temperature are low. However, the role of moisture supply in the initiation of large Northern Hemisphere ice sheets has remained unclear. The subarctic Pacific Ocean represents a significant source of water vapour to boreal North America, but it has been largely overlooked in efforts to explain Northern Hemisphere glaciation. Here we present alkenone unsaturation ratios and diatom oxygen isotope ratios from a sediment core in the western subarctic Pacific Ocean, indicating that 2.7 million years ago late-summer sea surface temperatures in this ocean region rose in response to an increase in

stratification. At the same time, winter sea surface temperatures cooled, winter floating ice became more abundant and global climate descended into glacial conditions. We suggest that the observed summer warming extended into the autumn, providing water vapour to northern North America, where it precipitated and accumulated as snow, and thus allowed the initiation of Northern Hemisphere glaciation.

Hay, S. I., J. Cox, et al. (2002). "Climate change and the resurgence of malaria in the East African highlands." Nature **415**(6874): 905-9.

The public health and economic consequences of Plasmodium falciparum malaria are once again regarded as priorities for global development. There has been much speculation on whether anthropogenic climate change is exacerbating the malaria problem, especially in areas of high altitude where P. falciparum transmission is limited by low temperature. The International Panel on Climate Change has concluded that there is likely to be a net extension in the distribution of malaria and an increase in incidence within this range. We investigated long-term meteorological trends in four high-altitude sites in East Africa, where increases in malaria have been reported in the past two decades. Here we show that temperature, rainfall, vapour pressure and the number of months suitable for P. falciparum transmission have not changed significantly during the past century or during the period of reported malaria resurgence. A high degree of temporal and spatial variation in the climate of East Africa suggests further that claimed associations between local malaria resurgences and regional changes in climate are overly simplistic.

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Head, J. W., J. F. Mustard, et al. (2003). "Recent ice ages on Mars." Nature **426**(6968): 797-802.

A key pacemaker of ice ages on the Earth is climatic forcing due to variations in planetary orbital parameters. Recent Mars exploration has revealed dusty, water-ice-rich mantling deposits that are layered, metres thick and latitude dependent, occurring in both hemispheres from mid-latitudes to the poles. Here we show evidence that these deposits formed during a geologically recent ice age that occurred from about 2.1 to 0.4 Myr ago. The deposits were emplaced symmetrically down to latitudes of approximately 30 degrees--equivalent to Saudi Arabia and the southern United States on the Earth--in response to the changing stability of water ice and dust during variations in obliquity (the angle between Mars' pole of rotation and the ecliptic plane) reaching 30-35 degrees. Mars is at present in an 'interglacial' period, and the ice-rich deposits are undergoing reworking, degradation and retreat in response to the current instability of near-

surface ice. Unlike the Earth, martian ice ages are characterized by warmer polar climates and enhanced equatorward transport of atmospheric water and dust to produce widespread smooth deposits down to mid-latitudes.

Head, J. W., G. Neukum, et al. (2005). "Tropical to mid-latitude snow and ice accumulation, flow and glaciation on Mars." Nature **434**(7031): 346-51.
Images from the Mars Express HRSC (High-Resolution Stereo Camera) of debris aprons at the base of massifs in eastern Hellas reveal numerous concentrically ridged lobate and pitted features and related evidence of extremely ice-rich glacier-like viscous flow and sublimation. Together with new evidence for recent ice-rich rock glaciers at the base of the Olympus Mons scarp superposed on larger Late Amazonian debris-covered piedmont glaciers, we interpret these deposits as evidence for geologically recent and recurring glacial activity in tropical and mid-latitude regions of Mars during periods of increased spin-axis obliquity when polar ice was mobilized and redeposited in microenvironments at lower latitudes. The data indicate that abundant residual ice probably remains in these deposits and that these records of geologically recent climate changes are accessible to future automated and human surface exploration.

Hegerl, G. C., T. J. Crowley, et al. (2006). "Climate sensitivity constrained by temperature reconstructions over the past seven centuries." Nature **440**(7087): 1029-32.
The magnitude and impact of future global warming depends on the sensitivity of the climate system to changes in greenhouse gas concentrations. The commonly accepted range for the equilibrium global mean temperature change in response to a doubling of the atmospheric carbon dioxide concentration, termed climate sensitivity, is 1.5-4.5 K (ref. 2). A number of observational studies, however, find a substantial probability of significantly higher sensitivities, yielding upper limits on climate sensitivity of 7.7 K to above 9 K (refs 3-8). Here we demonstrate that such observational estimates of climate sensitivity can be tightened if reconstructions of Northern Hemisphere temperature over the past several centuries are considered. We use large-ensemble energy balance modelling and simulate the temperature response to past solar, volcanic and greenhouse gas forcing to determine which climate sensitivities yield simulations that are in agreement with proxy reconstructions. After accounting for the uncertainty in reconstructions and estimates of past external forcing, we find an independent estimate of climate sensitivity that is very similar to those from instrumental data. If the latter are combined with the result from all proxy reconstructions, then the 5-95 per cent range shrinks to 1.5-6.2 K, thus substantially reducing the probability of very high climate sensitivity.

Henderson, G. M. and N. C. Slowey (2000). "Evidence from U-Th dating against Northern Hemisphere forcing of the penultimate deglaciation." Nature **404**(6773): 61-6.
Milankovitch proposed that summer insolation at mid-latitudes in the Northern Hemisphere directly causes the ice-age climate cycles. This would imply that times of ice-sheet collapse should correspond to peaks in Northern Hemisphere June insolation. But the penultimate deglaciation has proved controversial because June insolation peaks 127 kyr ago whereas several records of past climate suggest that change may have occurred up to 15 kyr earlier. There is a clear signature of the penultimate deglaciation in marine oxygen-isotope records. But dating this event, which is significantly before the 14C age range, has not been possible. Here we date the penultimate deglaciation in a record from the Bahamas using a new U-Th isochron technique. After the necessary corrections for alpha-recoil mobility of 234U and 230Th and a small age correction for sediment mixing, the midpoint age for the penultimate deglaciation is determined to be 135 +/- 2.5 kyr ago. This age is consistent with some coral-based sea-level estimates, but it is difficult to reconcile with June Northern Hemisphere insolation as the trigger for the ice-age cycles. Potential alternative driving mechanisms for the ice-age cycles that are

consistent with such an early date for the penultimate deglaciation are either the variability of the tropical ocean-atmosphere system or changes in atmospheric CO2 concentration controlled by a process in the Southern Hemisphere.

Henrotte, J. G., G. Krishnamurthi, et al. (1960). "Potassium tolerance tests in South Indian people." Nature **187**: 328-9.

Henrotte, J. G. and P. S. Krishnaraj (1962). "Climatic variations of plasma potassium in men." Nature **195**: 184-5.

Hessler, A. M., D. R. Lowe, et al. (2004). "A lower limit for atmospheric carbon dioxide levels 3.2 billion years ago." Nature **428**(6984): 736-8.

The quantification of greenhouse gases present in the Archaean atmosphere is critical for understanding the evolution of atmospheric oxygen, surface temperatures and the conditions for life on early Earth. For instance, it has been argued that small changes in the balance between two potential greenhouse gases, carbon dioxide and methane, may have dictated the feedback cycle involving organic haze production and global cooling. Climate models have focused on carbon dioxide as the greenhouse gas responsible for maintaining above-freezing surface temperatures during a time of low solar luminosity. However, the analysis of 2.75-billion-year (Gyr)-old palaeosols--soil samples preserved in the geologic record--have recently provided an upper constraint on atmospheric carbon dioxide levels well below that required in most climate models to prevent the Earth's surface from freezing. This finding prompted many to look towards methane as an additional greenhouse gas to satisfy climate models. Here we use model equilibrium reactions for weathering rinds on 3.2-Gyr-old river gravels to show that the presence of iron-rich carbonate relative to common clay minerals requires a minimum partial pressure of carbon dioxide several times higher than present-day values. Unless actual carbon dioxide levels were considerably greater than this, climate models predict that additional greenhouse gases would still need to have a role in maintaining above-freezing surface temperatures.

Hetherington, A. M. and F. I. Woodward (2003). "The role of stomata in sensing and driving environmental change." Nature **424**(6951): 901-8.

Stomata, the small pores on the surfaces of leaves and stalks, regulate the flow of gases in and out of leaves and thus plants as a whole. They adapt to local and global changes on all timescales from minutes to millennia. Recent data from diverse fields are establishing their central importance to plant physiology, evolution and global ecology. Stomatal morphology, distribution and behaviour respond to a spectrum of signals, from intracellular signalling to global climatic change. Such concerted adaptation results from a web of control systems, reminiscent of a 'scale-free' network, whose untangling requires integrated approaches beyond those currently used.

Hetzel, R. and A. Hampel (2005). "Slip rate variations on normal faults during glacial-interglacial changes in surface loads." Nature **435**(7038): 81-4.

Geologic and palaeoseismological data document a marked increase in the slip rates of the Wasatch fault and three adjacent normal faults in the Basin and Range Province during the Late Pleistocene/Early Holocene epochs. The cause of this synchronous acceleration of fault slip and the subsequent clustering of earthquakes during the Holocene has remained enigmatic, although it has been suggested that the coincidence between the acceleration of slip and the shrinkage of Lake Bonneville after the Last Glacial Maximum may indicate a causal relationship. Here we use finite-element models of a discrete normal fault within a rheologically layered lithosphere to evaluate the relative importance of two competing processes that affect fault slip: postglacial unloading (the removal of mass), which decreases the slip rate, and lithospheric rebound, which promotes

faster slip. We show that lithospheric rebound caused by regression of Lake Bonneville and deglaciation of adjacent mountain ranges provides a feasible mechanism for the high Holocene rates of faulting in the Wasatch region. Our analysis implies that climate-controlled changes in loads applied to Earth's surface may exert a fundamental control on the slip history of individual normal faults.

Hewitt, G. (2000). "The genetic legacy of the Quaternary ice ages." Nature **405**(6789): 907-13.

Global climate has fluctuated greatly during the past three million years, leading to the recent major ice ages. An inescapable consequence for most living organisms is great changes in their distribution, which are expressed differently in boreal, temperate and tropical zones. Such range changes can be expected to have genetic consequences, and the advent of DNA technology provides most suitable markers to examine these. Several good data sets are now available, which provide tests of expectations, insights into species colonization and unexpected genetic subdivision and mixture of species. The genetic structure of human populations may be viewed in the same context. The present genetic structure of populations, species and communities has been mainly formed by Quaternary ice ages, and genetic, fossil and physical data combined can greatly help our understanding of how organisms were so affected.

Hill, A., S. Ward, et al. (1992). "Earliest Homo." Nature **355**(6362): 719-22.

The origin of our own genus, Homo, has been tentatively correlated with worldwide climatic cooling documented at about 2.4 Myr (million years). It has also been conjectured that members of Homo made the first stone tools, currently dated at 2.6-2.4 Myr. But fossil specimens clearly attributable to Homo before about 1.9 Myr have been lacking. In 1967 a fossil hominoid temporal bone (KNM-BC1) from the Chemeron Formation of Kenya was described as family Hominidae gen. et sp. indet. Although a surface find, its provenance within site JM85 (BPRP site K002) was established and a stratigraphic section provided indicating the specimen's position. This evidence has been affirmed but the exact age of the fossil was never determined, and the absence of suitable comparative hominid material has precluded a more definitive taxonomic assignment. Here we present 40Ar/39Ar age determinations on material from the hominid site indicating an age of 2.4 Myr. In addition, comparative studies allow us to assign KNM-BC1 to the genus Homo, making it the earliest securely known fossil of our own genus found so far.

Hillaire-Marcel, C., A. de Vernal, et al. (2001). "Absence of deep-water formation in the Labrador Sea during the last interglacial period." Nature **410**(6832): 1073-7.

The two main constituent water masses of the deep North Atlantic Ocean-North Atlantic Deep Water at the bottom and Labrador Sea Water at an intermediate level-are currently formed in the Nordic seas and the Labrador Sea, respectively. The rate of formation of these two water masses tightly governs the strength of the global ocean circulation and the associated heat transport across the North Atlantic Ocean. Numerical simulations have suggested a possible shut-down of Labrador Sea Water formation as a consequence of global warming. Here we use micropalaeontological data and stable isotope measurements in both planktonic and benthic foraminifera from deep Labrador Sea cores to investigate the density structure of the water column during the last interglacial period, which was thought to be about 2 degrees C warmer than present. Our results indicate that today's stratification between Labrador Sea Water and North Atlantic Deep Water never developed during the last interglacial period. Instead, a buoyant surface layer was present above a single water mass originating from the Nordic seas. Thus the present situation, with an active site of intermediate-water formation in the Labrador Sea, which settled some 7,000 years ago, has no analogue throughout the last climate cycle.

Hoag, H. (2003). "Genomes take pole position in the icy wastes." Nature **421**(6926): 880.

Holbourn, A., W. Kuhnt, et al. (2005). "Impacts of orbital forcing and atmospheric carbon dioxide on Miocene ice-sheet expansion." Nature **438**(7067): 483-7.

The processes causing the middle Miocene global cooling, which marked the Earth's final transition into an 'icehouse' climate about 13.9 million years ago (Myr ago), remain enigmatic. Tectonically driven circulation changes and variations in atmospheric carbon dioxide levels have been suggested as driving mechanisms, but the lack of adequately preserved sedimentary successions has made rigorous testing of these hypotheses difficult. Here we present high-resolution climate proxy records, covering the period from 14.7 to 12.7 million years ago, from two complete sediment cores from the northwest and southeast subtropical Pacific Ocean. Using new chronologies through the correlation to the latest orbital model, we find relatively constant, low summer insolation over Antarctica coincident with declining atmospheric carbon dioxide levels at the time of Antarctic ice-sheet expansion and global cooling, suggesting a causal link. We surmise that the thermal isolation of Antarctica played a role in providing sustained long-term climatic boundary conditions propitious for ice-sheet formation. Our data document that Antarctic glaciation was rapid, taking place within two obliquity cycles, and coincided with a striking transition from obliquity to eccentricity as the drivers of climatic change.

Holland, H. D., B. Lazar, et al. (1986). "Evolution of the atmosphere and oceans." Nature **320**(6057): 27-33.

The residence times of most constituents of the atmosphere and oceans are small fractions of the age of the Earth and, in general, their rate of output has been nearly equal to their rate of input. We are disturbing a number of these dynamic equilibria quite severely. The mineralogy of marine evaporites rules out drastic changes in the composition of sea water during the last 900 Myr. The chemistry of soils formed more than 1,000 Myr ago suggests that the atmosphere then contained significantly more CO2 and less O2 than at present. Hydrogen peroxide may well have been the principal oxidant and formaldehyde the main reductant in rain water between 3,000 and 1,000 Myr ago. Major changes in atmospheric chemistry since that time are almost certainly related to the evolution of the biosphere.

Hong, S. Y. and E. Kalnay (2000). "Role of sea surface temperature and soil-moisture feedback in the 1998 Oklahoma-Texas drought." Nature **408**(6814): 842-4.

The drought that affected the US states of Oklahoma and Texas in the summer of 1998 was strong and persistent, with soil moisture reaching levels comparable to those of the 1930s 'dust bowl'. Although other effects of the record-strength 1997-98 El Nino were successfully predicted over much of the United States, the Oklahoma-Texas drought was not. Whereas the response of the tropical atmosphere to strong anomalies in sea surface temperature is quite predictable, the response of the extratropical atmosphere is more variable. Here we present results from mechanistic experiments to clarify the origin and maintenance of this extratropical climate extreme. In addition to global atmospheric models, we use a regional model to isolate regional climate feedbacks. We conclude that during April and May 1998, sea surface temperature anomalies combined with a favourable atmospheric circulation to establish the drought. In June-August, the regional positive feedback associated with lower evaporation and precipitation contributed substantially to the maintenance of the drought. The drought ended in the autumn, when stronger large-scale weather systems were able to penetrate the region and overwhelm the soil-moisture feedback. Our results show the potential for numerical models including appropriate physical processes to make skillful

predictions of regional climate.

Hopkin, M. (2005). "Biodiversity and climate form focus of forest canopy plan." Nature **436**(7050): 452.

Hopkin, M. (2005). "Biodiversity and climate form focus of forest canopy plan." Nature **436**(7050): 452.

Hopkin, M. (2005). "Antarctic ice puts climate predictions to the test." Nature **438**(7068): 536-7.

Hoppe, H. G., K. Gocke, et al. (2002). "Bacterial growth and primary production along a north-south transect of the Atlantic Ocean." Nature **416**(6877): 168-71.

The oceanic carbon cycle is mainly determined by the combined activities of bacteria and phytoplankton, but the interdependence of climate, the carbon cycle and the microbes is not well understood. To elucidate this interdependence, we performed high-frequency sampling of sea water along a north-south transect of the Atlantic Ocean. Here we report that the interaction of bacteria and phytoplankton is closely related to the meridional profile of water temperature, a variable directly dependent on climate. Water temperature was positively correlated with the ratio of bacterial production to primary production, and, more strongly, with the ratio of bacterial carbon demand to primary production. In warm latitudes (25 degrees N to 30 degrees S), we observed alternating patches of predominantly heterotrophic and autotrophic community metabolism. The calculated regression lines (for data north and south of the Equator) between temperature and the ratio of bacterial production to primary production give a maximum value for this ratio of 40% in the oligotrophic equatorial regions. Taking into account a bacterial growth efficiency of 30%, the resulting area of net heterotrophy (where the bacterial carbon demand for growth plus respiration exceeds phytoplankton carbon fixation) expands from 8 degrees N (27 degrees C) to 20 degrees S (23 degrees C). This suggests an output of CO2 from parts of the ocean to the atmosphere.

Hornbach, M. J., D. M. Saffer, et al. (2004). "Critically pressured free-gas reservoirs below gas-hydrate provinces." Nature **427**(6970): 142-4.

Palaeoceanographic data have been used to suggest that methane hydrates play a significant role in global climate change. The mechanism by which methane is released during periods of global warming is, however, poorly understood. In particular, the size and role of the free-gas zone below gas-hydrate provinces remain relatively unconstrained, largely because the base of the free-gas zone is not a phase boundary and has thus defied systematic description. Here we evaluate the possibility that the maximum thickness of an interconnected free-gas zone is mechanically regulated by valving caused by fault slip in overlying sediments. Our results suggest that a critical gas column exists below most hydrate provinces in basin settings, implying that these provinces are poised for mechanical failure and are therefore highly sensitive to changes in ambient conditions. We estimate that the global free-gas reservoir may contain from one-sixth to two-thirds of the total methane trapped in hydrate. If gas accumulations are critically thick along passive continental slopes, we calculate that a 5 degrees C temperature increase at the sea floor could result in a release of approximately 2,000 Gt of methane from the free-gas zone, offering a mechanism for rapid methane release during global warming events.

Hoskin, C. J., M. Higgie, et al. (2005). "Reinforcement drives rapid allopatric speciation." Nature **437**(7063): 1353-6.

Allopatric speciation results from geographic isolation between populations. In the absence of gene flow, reproductive isolation arises gradually and incidentally

as a result of mutation, genetic drift and the indirect effects of natural selection driving local adaptation. In contrast, speciation by reinforcement is driven directly by natural selection against maladaptive hybridization. This gives individuals that choose the traits of their own lineage greater fitness, potentially leading to rapid speciation between the lineages. Reinforcing natural selection on a population of one of the lineages in a mosaic contact zone could also result in divergence of the population from the allopatric range of its own lineage outside the zone. Here we test this with molecular data, experimental crosses, field measurements and mate choice experiments in a mosaic contact zone between two lineages of a rainforest frog. We show that reinforcing natural selection has resulted in significant premating isolation of a population in the contact zone not only from the other lineage but also, incidentally, from the closely related main range of its own lineage. Thus we show the potential for reinforcement to drive rapid allopatric speciation.

Hostetler, S. W., P. J. Bartlein, et al. (2000). "Stimulated influences of Lake Agassiz on the climate of central North America 11,000 years ago." Nature **405**(6784): 334-7.

Eleven thousand years ago, large lakes existed in central and eastern North America along the margin of the Laurentide Ice Sheet. The large-scale North American climate at this time has been simulated with atmospheric general circulation models, but these relatively coarse global models do not resolve potentially important features of the mesoscale circulation that arise from interactions among the atmosphere, ice sheet, and proglacial lakes. Here we present simulations of the climate of central and eastern North America 11,000 years ago with a high-resolution, regional climate model nested within a general circulation model. The simulated climate is in general agreement with that inferred from palaeoecological evidence. Our experiments indicate that through mesoscale atmospheric feedbacks, the annual delivery of moisture to the Laurentide Ice Sheet was diminished at times of a large, cold Lake Agassiz relative to periods of lower lake stands. The resulting changes in the mass balance of the ice sheet may have contributed to fluctuations of the ice margin, thus affecting the routing of fresh water to the North Atlantic Ocean. A retreating ice margin during periods of high lake level may have opened an outlet for discharge of Lake Agassiz into the North Atlantic. A subsequent advance of the ice margin due to greater moisture delivery associated with a low lake level could have dammed the outlet, thereby reducing discharge to the North Atlantic. These variations may have been decisive in causing the Younger Dryas cold event.

Howard, A. D. (2002). "Tracking the martian climate." Nature **419**(6905): 350-1.

Hsieh, C. H., S. M. Glaser, et al. (2005). "Distinguishing random environmental fluctuations from ecological catastrophes for the North Pacific Ocean." Nature **435**(7040): 336-40.

The prospect of rapid dynamic changes in the environment is a pressing concern that has profound management and public policy implications. Worries over sudden climate change and irreversible changes in ecosystems are rooted in the potential that nonlinear systems have for complex and 'pathological' behaviours. Nonlinear behaviours have been shown in model systems and in some natural systems, but their occurrence in large-scale marine environments remains controversial. Here we show that time series observations of key physical variables for the North Pacific Ocean that seem to show these behaviours are not deterministically nonlinear, and are best described as linear stochastic. In contrast, we find that time series for biological variables having similar properties exhibit a low-dimensional nonlinear signature. To our knowledge, this is the first direct test for nonlinearity in large-scale physical and biological data for the marine environment. These results address a continuing debate over the origin of rapid shifts in certain key marine observations as coming from essentially stochastic

processes or from dominant nonlinear mechanisms. Our measurements suggest that large-scale marine ecosystems are dynamically nonlinear, and as such have the capacity for dramatic change in response to stochastic fluctuations in basin-scale physical states.

Hsieh, C. H., S. M. Glaser, et al. (2005). "Distinguishing random environmental fluctuations from ecological catastrophes for the North Pacific Ocean." Nature **435**(7040): 336-40.

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Huang, S. (2005). "Climate blog could score with newer hockey stick." Nature **433**(7028): 800.

Huang, S., H. N. Pollack, et al. (2000). "Temperature trends over the past five centuries reconstructed from borehole temperatures." Nature **403**(6771): 756-8.

For an accurate assessment of the relative roles of natural variability and anthropogenic influence in the Earth's climate, reconstructions of past temperatures from the pre-industrial as well as the industrial period are essential. But instrumental records are typically available for no more than the past 150 years. Therefore reconstructions of pre-industrial climate rely principally on traditional climate proxy records, each with particular strengths and limitations in representing climatic variability. Subsurface temperatures comprise an independent archive of past surface temperature changes that is complementary to both the instrumental record and the climate proxies. Here we use present-day temperatures in 616 boreholes from all continents except Antarctica to reconstruct century-long trends in temperatures over the past 500 years at global, hemispheric and continental scales. The results confirm the unusual warming of the twentieth century revealed by the instrumental record, but suggest that the cumulative change over the past five centuries amounts to about 1 K, exceeding recent estimates from conventional climate proxies. The strength of temperature reconstructions from boreholes lies in the detection of long-term trends, complementary to conventional climate proxies, but to obtain a complete picture of past warming, the differences between the approaches need to be investigated in detail.

Huisman, J., N. N. Pham Thi, et al. (2006). "Reduced mixing generates oscillations and chaos in the oceanic deep chlorophyll maximum." Nature **439**(7074): 322-5.

Deep chlorophyll maxima (DCMs) are widespread in large parts of the world's oceans. These deep layers of high chlorophyll concentration reflect a compromise of phytoplankton growth exposed to two opposing resource

gradients: light supplied from above and nutrients supplied from below. It is often argued that DCMs are stable features. Here we show, however, that reduced vertical mixing can generate oscillations and chaos in phytoplankton biomass and species composition of DCMs. These fluctuations are caused by a difference in the timescales of two processes: (1) rapid export of sinking plankton, withdrawing nutrients from the euphotic zone and (2) a slow upward flux of nutrients fuelling new phytoplankton production. Climate models predict that global warming will reduce vertical mixing in the oceans. Our model indicates that reduced mixing will generate more variability in DCMs, thereby enhancing variability in oceanic primary production and in carbon export into the ocean interior.

Hulbert, A. J., G. Gordon, et al. (1971). "Rediscovery of the marsupial Echymipera rufescens in Australia." Nature **231**(5301): 330-1.

Humphries, M. M., D. W. Thomas, et al. (2002). "Climate-mediated energetic constraints on the distribution of hibernating mammals." Nature **418**(6895): 313-6.

To predict the consequences of human-induced global climate change, we need to understand how climate is linked to biogeography. Energetic constraints are commonly invoked to explain animal distributions, and physiological parameters are known to vary along distributional gradients. But the causal nature of the links between climate and animal biogeography remain largely obscure. Here we develop a bioenergetic model that predicts the feasibility of mammalian hibernation under different climatic conditions. As an example, we use the well-quantified hibernation energetics of the little brown bat (Myotis lucifugus) to parameterize the model. Our model predicts pronounced effects of ambient temperature on total winter energy requirements, and a relatively narrow combination of hibernaculum temperatures and winter lengths permitting successful hibernation. Microhabitat and northern distribution limits of M. lucifugus are consistent with model predictions, suggesting that the thermal dependence of hibernation energetics constrains the biogeography of this species. Integrating projections of climate change into our model predicts a pronounced northward range expansion of hibernating bats within the next 80 years. Bioenergetics can provide the simple link between climate and biogeography needed to predict the consequences of climate change.

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Huxman, T. E., M. D. Smith, et al. (2004). "Convergence across biomes to a common

rain-use efficiency." Nature **429**(6992): 651-4.

Water availability limits plant growth and production in almost all terrestrial ecosystems. However, biomes differ substantially in sensitivity of aboveground net primary production (ANPP) to between-year variation in precipitation. Average rain-use efficiency (RUE; ANPP/precipitation) also varies between biomes, supposedly because of differences in vegetation structure and/or biogeochemical constraints. Here we show that RUE decreases across biomes as mean annual precipitation increases. However, during the driest years at each site, there is convergence to a common maximum RUE (RUE(max)) that is typical of arid ecosystems. RUE(max) was also identified by experimentally altering the degree of limitation by water and other resources. Thus, in years when water is most limiting, deserts, grasslands and forests all exhibit the same rate of biomass production per unit rainfall, despite differences in physiognomy and site-level RUE. Global climate models predict increased between-year variability in precipitation, more frequent extreme drought events, and changes in temperature. Forecasts of future ecosystem behaviour should take into account this convergent feature of terrestrial biomes.

Huybers, P. and W. Curry (2006). "Links between annual, Milankovitch and continuum temperature variability." Nature **441**(7091): 329-32.

Climate variability exists at all timescales-and climatic processes are intimately coupled, so that understanding variability at any one timescale requires some understanding of the whole. Records of the Earth's surface temperature illustrate this interdependence, having a continuum of variability following a power-law scaling. But although specific modes of interannual variability are relatively well understood, the general controls on continuum variability are uncertain and usually described as purely stochastic processes. Here we show that power-law relationships of surface temperature variability scale with annual and Milankovitch-period (23,000- and 41,000-year) cycles. The annual cycle corresponds to scaling at monthly to decadal periods, while millennial and longer periods are tied to the Milankovitch cycles. Thus the annual, Milankovitch and continuum temperature variability together represent the response to deterministic insolation forcing. The identification of a deterministic control on the continuum provides insight into the mechanisms governing interannual and longer-period climate variability.

Huybers, P. and C. Wunsch (2005). "Obliquity pacing of the late Pleistocene glacial terminations." Nature **434**(7032): 491-4.

The 100,000-year timescale in the glacial/interglacial cycles of the late Pleistocene epoch (the past approximately 700,000 years) is commonly attributed to control by variations in the Earth's orbit. This hypothesis has inspired models that depend on the Earth's obliquity (approximately 40,000 yr; approximately 40 kyr), orbital eccentricity (approximately 100 kyr) and precessional (approximately 20 kyr) fluctuations, with the emphasis usually on eccentricity and precessional forcing. According to a contrasting hypothesis, the glacial cycles arise primarily because of random internal climate variability. Taking these two perspectives together, there are currently more than thirty different models of the seven late-Pleistocene glacial cycles. Here we present a statistical test of the orbital forcing hypothesis, focusing on the rapid deglaciation events known as terminations. According to our analysis, the null hypothesis that glacial terminations are independent of obliquity can be rejected at the 5% significance level, whereas the corresponding null hypotheses for eccentricity and precession cannot be rejected. The simplest inference consistent with the test results is that the ice sheets terminated every second or third obliquity cycle at times of high obliquity, similar to the original proposal by Milankovitch. We also present simple stochastic and deterministic models that describe the timing of the late-Pleistocene glacial terminations purely in terms of obliquity forcing.

Hyde, W. T., T. J. Crowley, et al. (2000). "Neoproterozoic 'snowball Earth' simulations with a coupled climate/ice-sheet model." Nature **405**(6785): 425-9.

Ice sheets may have reached the Equator in the late Proterozoic era (600-800 Myr ago), according to geological and palaeomagnetic studies, possibly resulting in a 'snowball Earth'. But this period was a critical time in the evolution of multicellular animals, posing the question of how early life survived under such environmental stress. Here we present computer simulations of this unusual climate stage with a coupled climate/ice-sheet model. To simulate a snowball Earth, we use only a reduction in the solar constant compared to present-day conditions and we keep atmospheric CO2 concentrations near present levels. We find rapid transitions into and out of full glaciation that are consistent with the geological evidence. When we combine these results with a general circulation model, some of the simulations result in an equatorial belt of open water that may have provided a refugium for multicellular animals.

Hyder, M. (1969). "Gonadal development and reproductive activity of the cichlid fish Tilapia leucosticta (Trewavas) in an equatorial lake." Nature **224**(5224): 1112.

Ibisch, P. L., M. D. Jennings, et al. (2005). "Biodiversity needs the help of global change managers, not museum-keepers." Nature **438**(7065): 156.

Ibisch, P. L., M. D. Jennings, et al. (2005). "Biodiversity needs the help of global change managers, not museum-keepers." Nature **438**(7065): 156.

Irwin, D. E., S. Bensch, et al. (2001). "Speciation in a ring." Nature **409**(6818): 333-7.

The evolutionary divergence of a single species into two has never been directly observed in nature, primarily because speciation can take a long time to occur. A ring species, in which a chain of intergrading populations encircles a barrier and the terminal forms coexist without interbreeding, provides a situation in which variation in space can be used to infer variation in time. Here we reconstruct the pathway to speciation between two reproductively isolated forms of greenish warbler (Phylloscopus trochiloides). These two taxa do not interbreed in central Siberia but are connected by a long chain of intergrading populations encircling the Tibetan Plateau to the south. Molecular data and climatic history imply that the reproductively isolated taxa came into contact following expansions northward around the western and eastern sides of the plateau. Parallel selection pressures for increased song complexity during the northward expansions have been accompanied by divergence in song structure. Playback experiments show that the two Siberian forms do not recognize each other's songs. Our results show how gradual divergence in a trait involved in mate choice leads to the formation of new species.

Ivany, L. C., W. P. Patterson, et al. (2000). "Cooler winters as a possible cause of mass extinctions at the Eocene/Oligocene boundary." Nature **407**(6806): 887-90.

The Eocene/Oligocene boundary, at about 33.7 Myr ago, marks one of the largest extinctions of marine invertebrates in the Cenozoic period. For example, turnover of mollusc species in the US Gulf coastal plain was over 90% at this time. A temperature change across this boundary--from warm Eocene climates to cooler conditions in the Oligocene--has been suggested as a cause of this extinction event, but climate reconstructions have not provided support for this hypothesis. Here we report stable oxygen isotope measurements of aragonite in fish otoliths--ear stones--collected across the Eocene/Oligocene boundary. Palaeo-temperatures reconstructed from mean otolith oxygen isotope values show little change through this interval, in agreement with previous studies. From incremental microsampling of otoliths, however, we can resolve the seasonal variation in temperature, recorded as the otoliths continue to accrete new

material over the life of the fish. These seasonal data suggest that winters became about 4 degrees C colder across the Eocene/Oligocene boundary. We suggest that temperature variability, rather than change in mean annual temperature, helped to cause faunal turnover during this transition.

Ives, A. R. and B. J. Cardinale (2004). "Food-web interactions govern the resistance of communities after non-random extinctions." Nature **429**(6988): 174-7.

Growing concern about how loss of biodiversity will affect ecosystems has stimulated numerous studies. Although most studies have assumed that species go extinct randomly, species often go extinct in order of their sensitivity to a stress that intensifies through time (such as climate change). Here we show that the consequences of random and ordered extinctions differ. Both depend on food-web interactions that create compensation; that is, the increase of some species when their competitors and/or predators decrease in density due to environmental stress. Compensation makes communities as a whole more resistant to stress by reducing changes in combined species densities. As extinctions progress, the potential for compensation is depleted, and communities become progressively less resistant. For ordered extinctions, however, this depletion is offset and communities retain their resistance, because the surviving species have greater average resistance to the stress. Despite extinctions being ordered, changes in the food web with successive extinctions make it difficult to predict which species will show compensation in the future. This unpredictability argues for 'whole-ecosystem' approaches to biodiversity conservation, as seemingly insignificant species may become important after other species go extinct.

Jacobson, M. Z. (2001). "Strong radiative heating due to the mixing state of black carbon in atmospheric aerosols." Nature **409**(6821): 695-7.

Aerosols affect the Earth's temperature and climate by altering the radiative properties of the atmosphere. A large positive component of this radiative forcing from aerosols is due to black carbon--soot--that is released from the burning of fossil fuel and biomass, and, to a lesser extent, natural fires, but the exact forcing is affected by how black carbon is mixed with other aerosol constituents. From studies of aerosol radiative forcing, it is known that black carbon can exist in one of several possible mixing states; distinct from other aerosol particles (externally mixed) or incorporated within them (internally mixed), or a black-carbon core could be surrounded by a well mixed shell. But so far it has been assumed that aerosols exist predominantly as an external mixture. Here I simulate the evolution of the chemical composition of aerosols, finding that the mixing state and direct forcing of the black-carbon component approach those of an internal mixture, largely due to coagulation and growth of aerosol particles. This finding implies a higher positive forcing from black carbon than previously thought, suggesting that the warming effect from black carbon may nearly balance the net cooling effect of other anthropogenic aerosol constituents. The magnitude of the direct radiative forcing from black carbon itself exceeds that due to CH4, suggesting that black carbon may be the second most important component of global warming after CO2 in terms of direct forcing.

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Jakosky, B. M. and R. J. Phillips (2001). "Mars' volatile and climate history." Nature **412**(6843): 237-44.

There is substantial evidence that the martian volatile inventory and climate have changed markedly throughout the planet's history. Clues come from areas as disparate as the history and properties of the deep interior, the composition of the crust and regolith, the morphology of the surface, composition of the present-day atmosphere, and the nature of the interactions between the upper atmosphere and the solar wind. We piece together the relevant observations into a coherent view of the evolution of the martian climate, focusing in particular on the observations that provide the strongest constraints.

Jayaraman, K. S. (2002). "Climate model under fire as rains fail India." Nature **418**(6899): 713.

Jean-Baptiste, P. and E. Fourre (2004). "Arctic Ocean: hydrothermal activity on Gakkel Ridge." Nature **428**(6978): 36.

In the hydrothermal circulation at mid-ocean ridges, sea water penetrates the fractured crust, becomes heated by its proximity to the hot magma, and returns to the sea floor as hot fluids enriched in various chemical elements. In contradiction to earlier results that predict diminishing hydrothermal activity with decreasing spreading rate, a survey of the ultra-slowly spreading Gakkel Ridge (Arctic Ocean) by Edmonds et al. and Michael et al. suggests that, instead of being rare, the hydrothermal activity is abundant--exceeding by at least a factor of two to three what would be expected by extrapolation from observation on faster spreading ridges. Here we use helium-3 (3He), a hydrothermal tracer, to show that this abundance of venting sites does not translate, as would be expected, into an anomalous hydrothermal 3He output from the ridge. Because of the wide implications of the submarine hydrothermal processes for mantle heat and mass fluxes to the ocean, these conflicting results call for clarification of the link between hydrothermal activity and crustal production at mid-ocean ridges.

Jean-Baptiste, P., J. R. Petit, et al. (2001). "Constraints on hydrothermal processes and water exchange in Lake Vostok from helium isotopes." Nature **411**(6836): 460-2.

Lake Vostok, the largest subglacial lake in Antarctica, is covered by the East Antarctic ice sheet, which varies in thickness between 3,750 and 4,100 m (ref. 1). At a depth of 3,539 m in the drill hole at Vostok station, sharp changes in stable isotopes and the gas content of the ice delineate the boundary between glacier ice and ice accreted through re-freezing of lake water. Unlike most gases, helium can be incorporated into the crystal structure of ice during freezing, making helium isotopes in the accreted ice a valuable source of information on lake environment. Here we present helium isotope measurements from the deep section of the Vostok ice core that encompasses the boundary between the glacier ice and accreted ice, showing that the accreted ice is enriched by a helium source with a radiogenic isotope signature typical of an old continental province. This result rules out any significant hydrothermal energy input into the lake from

high-enthalpy mantle processes, which would be expected to produce a much higher 3He/4He ratio. Based on the average helium flux for continental areas, the helium budget of the lake leads to a renewal time of the lake of the order of 5,000 years.

Jenkyns, H. C., A. Forster, et al. (2004). "High temperatures in the Late Cretaceous Arctic Ocean." Nature **432**(7019): 888-92.

To understand the climate dynamics of the warm, equable greenhouse world of the Late Cretaceous period, it is important to determine polar palaeotemperatures. The early palaeoceanographic history of the Arctic Ocean has, however, remained largely unknown, because the sea floor and underlying deposits are usually inaccessible beneath a cover of floating ice. A shallow piston core taken from a drifting ice island in 1970 fortuitously retrieved unconsolidated Upper Cretaceous organic-rich sediment from Alpha ridge, a submarine elevated feature of probable oceanic origin. A lack of carbonate in the sediments from this core has prevented the use of traditional oxygen-isotope palaeothermometry. Here we determine Arctic palaeotemperatures from these Upper Cretaceous deposits using TEX86, a new palaeothermometer that is based on the composition of membrane lipids derived from a ubiquitous component of marine plankton, Crenarchaeota. From these analyses we infer an average sea surface temperature of approximately 15 degrees C for the Arctic Ocean about 70 million years ago. This calibration point implies an Equator-to-pole gradient in sea surface temperatures of approximately 15 degrees C during this interval and, by extrapolation, we suggest that polar waters were generally warmer than 20 degrees C during the middle Cretaceous (approximately 90 million years ago).

Jerolmack, D. J. and D. Mohrig (2005). "Palaeoclimatology: formation of Precambrian sediment ripples." Nature **436**(7049): E1; discussion E1-2.

Jockel, P. and C. A. Brenninkmeijer (2005). "Atmospheric chemistry: natural bleach under scrutiny." Nature **436**(7053): 921-2.

Johnsen, S. J., W. Dansgaard, et al. (1970). "Climatic oscillations 1200-2000 AD." Nature **227**(5257): 482-3.

Johnson, R. H., J. L. Corbett, et al. (1968). "Desert journeys by Bedouin: sweating and concentration of urine during travel by camel and on foot." Nature **219**(5157): 953-4.

Jones, G. A. (1991). "Climate change. A stop-start ocean conveyer." Nature **349**(6308): 364-5.

Jones, J. M. and M. Widmann (2004). "Atmospheric science: early peak in Antarctic oscillation index." Nature **432**(7015): 290-1.

The principal extratropical atmospheric circulation mode in the Southern Hemisphere, the Antarctic oscillation (or Southern Hemisphere annular mode), represents fluctuations in the strength of the circumpolar vortex and has shown a trend towards a positive index in austral summer in recent decades, which has been linked to stratospheric ozone depletion and to increased atmospheric greenhouse-gas concentrations. Here we reconstruct the austral summer (December-January) Antarctic oscillation index from sea-level pressure measurements over the twentieth century and find that large positive values, and positive trends of a similar magnitude to those of past decades, also occurred around 1960, and that strong negative trends occurred afterwards. This positive Antarctic oscillation index and large positive trend during a period before ozone-depleting chemicals were released into the atmosphere and before marked anthropogenic warming, together with the later negative trend, indicate that natural forcing factors or internal mechanisms in the climate system must also strongly influence the state

of the Antarctic oscillation.

Joughin, I., W. Abdalati, et al. (2004). "Large fluctuations in speed on Greenland's Jakobshavn Isbrae glacier." Nature **432**(7017): 608-10.

It is important to understand recent changes in the velocity of Greenland glaciers because the mass balance of the Greenland Ice Sheet is partly determined by the flow rates of these outlets. Jakobshavn Isbrae is Greenland's largest outlet glacier, draining about 6.5 per cent of the ice-sheet area, and it has been surveyed repeatedly since 1991 (ref. 2). Here we use remote sensing data to measure the velocity of Jakobshavn Isbrae between 1992 and 2003. We detect large variability of the velocity over time, including a slowing down from 6,700 m yr(-1) in 1985 to 5,700 m yr(-1) in 1992, and a subsequent speeding up to 9,400 m yr(-1) by 2000 and 12,600 m yr(-1) in 2003. These changes are consistent with earlier evidence for thickening of the glacier in the early 1990s and rapid thinning thereafter. Our observations indicate that fast-flowing glaciers can significantly alter ice discharge at sub-decadal timescales, with at least a potential to respond rapidly to a changing climate.

Kabat, P., W. van Vierssen, et al. (2005). "Climate proofing the Netherlands." Nature **438**(7066): 283-4.

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Kalnay, E. and M. Cai (2003). "Impact of urbanization and land-use change on climate." Nature **423**(6939): 528-31.

The most important anthropogenic influences on climate are the emission of greenhouse gases and changes in land use, such as urbanization and agriculture. But it has been difficult to separate these two influences because both tend to increase the daily mean surface temperature. The impact of urbanization has been estimated by comparing observations in cities with those in surrounding rural areas, but the results differ significantly depending on whether population data or satellite measurements of night light are used to classify urban and rural areas. Here we use the difference between trends in observed surface temperatures in the continental United States and the corresponding trends in a reconstruction of surface temperatures determined from a reanalysis of global weather over the past 50 years, which is insensitive to surface observations, to estimate the impact of land-use changes on surface warming. Our results suggest that half of the observed decrease in diurnal temperature range is due to urban and other land-use changes. Moreover, our estimate of 0.27 degrees C mean surface warming per century due to land-use changes is at least twice as high as previous estimates based on urbanization alone.

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decrease in diurnal temperature range is due to urban and other land-use changes. Moreover, our estimate of 0.27 degrees C mean surface warming per century due to land-use changes is at least twice as high as previous estimates based on urbanization alone.

Kanipe, J. (2006). "Climate change: a cosmic connection." Nature **443**(7108): 141-3.

Kashiwaya, K., S. Ochiai, et al. (2001). "Orbit-related long-term climate cycles revealed in a 12-Myr continental record from Lake Baikal." Nature **410**(6824): 71-4.

Quaternary records of climate change from terrestrial sources, such as lake sediments and aeolian sediments, in general agree well with marine records. But continuous records that cover more than the past one million years were essentially unavailable until recently, when the high-sedimentation-rate site of Lake Baikal was exploited. Because of its location in the middle latitudes, Lake Baikal is highly sensitive to insolation changes and the entire lake remained uncovered by ice sheets throughout the Pleistocene epoch, making it a valuable archive for past climate. Here we examine long sediment cores from Lake Baikal that cover the past 12 million years. Our record reveals a gradual cooling of the Asian continental interior, with some fluctuations. Spectral analyses reveal periods of about 400 kyr, 600 kyr and 1,000 kyr, which may correspond to Milankovitch periods (reflecting orbital cycles). Our results indicate that changes in insolation were closely related to long-term environmental variations in the deep continental interior, over the past 12 million years.

Kasting, J. F. (1992). "Paradox lost and paradox found." Nature **355**: 676-7.

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Kasting, J. F. (2004). "Palaeoclimatology: Archaean atmosphere and climate." Nature **432**(7016): 1 p following 460.

Ohmoto et al. argue that carbon dioxide was abundant in the late Archaean and early Proterozoic atmosphere and that methane was probably scarce, based on a reanalysis of the occurrence of siderite, FeCO3, in ancient rocks. Here I consider several factors that may undermine their conclusions.

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Kaufman, Y. J., D. Tanre, et al. (2002). "A satellite view of aerosols in the climate system." Nature **419**(6903): 215-23.

Anthropogenic aerosols are intricately linked to the climate system and to the hydrologic cycle. The net effect of aerosols is to cool the climate system by reflecting sunlight. Depending on their composition, aerosols can also absorb sunlight in the atmosphere, further cooling the surface but warming the atmosphere in the process. These effects of aerosols on the temperature profile, along with the role of aerosols as cloud condensation nuclei, impact the hydrologic cycle, through changes in cloud cover, cloud properties and precipitation. Unravelling these feedbacks is particularly difficult because aerosols take a multitude of shapes and forms, ranging from desert dust to urban pollution, and because aerosol concentrations vary strongly over time and space. To accurately study aerosol distribution and composition therefore requires continuous observations from satellites, networks of ground-based instruments and dedicated field experiments. Increases in aerosol concentration and changes in

their composition, driven by industrialization and an expanding population, may adversely affect the Earth's climate and water supply.

Kemp, A. (2000). "Geology. Probing the memory of mud." Nature **406**(6799): 951-3.

Kemp, D. B., A. L. Coe, et al. (2005). "Astronomical pacing of methane release in the Early Jurassic period." Nature **437**(7057): 396-9.

A pronounced negative carbon-isotope (delta13C) excursion of approximately 5-7 per thousand (refs 1-7) indicates the occurrence of a significant perturbation to the global carbon cycle during the Early Jurassic period (early Toarcian age, approximately 183 million years ago). The rapid release of 12C-enriched biogenic methane as a result of continental-shelf methane hydrate dissociation has been put forward as a possible explanation for this observation. Here we report high-resolution organic carbon-isotope data from well-preserved mudrocks in Yorkshire, UK, which demonstrate that the carbon-isotope excursion occurred in three abrupt stages, each showing a shift of -2 per thousand to -3 per thousand. Spectral analysis of these carbon-isotope measurements and of high-resolution carbonate abundance data reveals a regular cyclicity. We interpret these results as providing strong evidence that methane release proceeded in three rapid pulses and that these pulses were controlled by astronomically forced changes in climate, superimposed upon longer-term global warming. We also find that the first two pulses of methane release each coincided with the extinction of a large proportion of marine species.

Kennett, J. P. and N. D. Watkins (1970). "Geomagnetic polarity change, volcanic maxima and faunal extinction in the South Pacific." Nature **227**(5261): 930-4.

Studies of deep-sea sedimentary cores from Antarctic Pacific waters show that some volcanic maxima occurred when the geomagnetic polarity was changing. Upper mantle activity and geomagnetic polarity change may therefore be related. Coincidences of faunal extinction and geomagnetic polarity change may be explained by corresponding volcanically induced climatic changes.

Keppler, F., J. T. Hamilton, et al. (2006). "Methane emissions from terrestrial plants under aerobic conditions." Nature **439**(7073): 187-91.

Methane is an important greenhouse gas and its atmospheric concentration has almost tripled since pre-industrial times. It plays a central role in atmospheric oxidation chemistry and affects stratospheric ozone and water vapour levels. Most of the methane from natural sources in Earth's atmosphere is thought to originate from biological processes in anoxic environments. Here we demonstrate using stable carbon isotopes that methane is readily formed in situ in terrestrial plants under oxic conditions by a hitherto unrecognized process. Significant methane emissions from both intact plants and detached leaves were observed during incubation experiments in the laboratory and in the field. If our measurements are typical for short-lived biomass and scaled on a global basis, we estimate a methane source strength of 62-236 Tg yr(-1) for living plants and 1-7 Tg yr(-1) for plant litter (1 Tg = 10(12) g). We suggest that this newly identified source may have important implications for the global methane budget and may call for a reconsideration of the role of natural methane sources in past climate change.

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Methane is an important greenhouse gas and its atmospheric concentration has almost tripled since pre-industrial times. It plays a central role in atmospheric oxidation chemistry and affects stratospheric ozone and water vapour levels. Most of the methane from natural sources in Earth's atmosphere is thought to originate from biological processes in anoxic environments. Here we demonstrate

using stable carbon isotopes that methane is readily formed in situ in terrestrial plants under oxic conditions by a hitherto unrecognized process. Significant methane emissions from both intact plants and detached leaves were observed during incubation experiments in the laboratory and in the field. If our measurements are typical for short-lived biomass and scaled on a global basis, we estimate a methane source strength of 62-236 Tg yr(-1) for living plants and 1-7 Tg yr(-1) for plant litter (1 Tg = 10(12) g). We suggest that this newly identified source may have important implications for the global methane budget and may call for a reconsideration of the role of natural methane sources in past climate change.

Kienast, M., S. S. Kienast, et al. (2006). "Eastern Pacific cooling and Atlantic overturning circulation during the last deglaciation." Nature **443**(7113): 846-9.

Surface ocean conditions in the equatorial Pacific Ocean could hold the clue to whether millennial-scale global climate change during glacial times was initiated through tropical ocean-atmosphere feedbacks or by changes in the Atlantic thermohaline circulation. North Atlantic cold periods during Heinrich events and millennial-scale cold events (stadials) have been linked with climatic changes in the tropical Atlantic Ocean and South America, as well as the Indian and East Asian monsoon systems, but not with tropical Pacific sea surface temperatures. Here we present a high-resolution record of sea surface temperatures in the eastern tropical Pacific derived from alkenone unsaturation measurements. Our data show a temperature drop of approximately 1 degrees C, synchronous (within dating uncertainties) with the shutdown of the Atlantic meridional overturning circulation during Heinrich event 1, and a smaller temperature drop of approximately 0.5 degrees C synchronous with the smaller reduction in the overturning circulation during the Younger Dryas event. Both cold events coincide with maxima in surface ocean productivity as inferred from 230Th-normalized carbon burial fluxes, suggesting increased upwelling at the time. From the concurrence of equatorial Pacific cooling with the two North Atlantic cold periods during deglaciation, we conclude that these millennial-scale climate changes were probably driven by a reorganization of the oceans' thermohaline circulation, although possibly amplified by tropical ocean-atmosphere interaction as suggested before.

Kiesecker, J. M., A. R. Blaustein, et al. (2001). "Complex causes of amphibian population declines." Nature **410**(6829): 681-4.

Amphibian populations have suffered widespread declines and extinctions in recent decades. Although climatic changes, increased exposure to ultraviolet-B (UV-B) radiation and increased prevalence of disease have all been implicated at particular localities, the importance of global environmental change remains unclear. Here we report that pathogen outbreaks in amphibian populations in the western USA are linked to climate-induced changes in UV-B exposure. Using long-term observational data and a field experiment, we examine patterns among interannual variability in precipitation, UV-B exposure and infection by a pathogenic oomycete, Saprolegnia ferax. Our findings indicate that climate-induced reductions in water depth at oviposition sites have caused high mortality of embryos by increasing their exposure to UV-B radiation and, consequently, their vulnerability to infection. Precipitation, and thus water depth/UV-B exposure, is strongly linked to El Nino/Southern Oscillation cycles, underscoring the role of large-scale climatic patterns involving the tropical Pacific. Elevated sea-surface temperatures in this region since the mid-1970s, which have affected the climate over much of the world, could be the precursor for pathogen-mediated amphibian declines in many regions.

Klak, C., G. Reeves, et al. (2004). "Unmatched tempo of evolution in Southern African semi-desert ice plants." Nature **427**(6969): 63-5.

The Succulent Karoo is an arid region, situated along the west coast of southern Africa. Floristically this region is part of the Greater Cape Flora and is considered one of the Earth's 25 biodiversity hotspots. Of about 5,000 species occurring in this region, more than 40% are endemic. Aizoaceae (ice plants) dominate the Succulent Karoo both in terms of species numbers (1,750 species in 127 genera) and density of coverage. Here we show that a well-supported clade within the Aizoaceae, representing 1,563 species almost exclusively endemic to southern Africa, has diversified very recently and very rapidly. The estimated age for this radiation lies between 3.8 and 8.7 million years (Myr) ago, yielding a per-lineage diversification rate of 0.77-1.75 per million years. Both the number of species involved and the tempo of evolution far surpass those of any previously postulated continental or island plant radiation. Diversification of the group is closely associated with the origin of several morphological features and one anatomical feature. Because species-poor clades lacking these features occur over a very similar distribution area, we propose that these characteristics are key innovations that facilitated this radiation.

Kling, G. W. (2000). "Aquatic ecology. A lake's life is not its own." Nature **408**(6809): 149-50.

Knoll, A. H. and M. R. Walter (1992). "Latest Proterozoic stratigraphy and Earth history." Nature **356**: 673-7.

The end of the Proterozoic Eon was a time of pronounced biological, biogeochemical, climatic and tectonic change. New bio- and chemostratigraphic data provide an improved framework for stratigraphic correlation, making possible a deeper understanding of latest Proterozoic Earth history and providing tools for a chronostratigraphic division of late Proterozoic time.

Knorr, G. and G. Lohmann (2003). "Southern Ocean origin for the resumption of Atlantic thermohaline circulation during deglaciation." Nature **424**(6948): 532-6.

During the two most recent deglaciations, the Southern Hemisphere warmed before Greenland. At the same time, the northern Atlantic Ocean was exposed to meltwater discharge, which is generally assumed to reduce the formation of North Atlantic Deep Water. Yet during deglaciation, the Atlantic thermohaline circulation became more vigorous, in the transition from a weak glacial to a strong interglacial mode. Here we use a three-dimensional ocean circulation model to investigate the impact of Southern Ocean warming and the associated sea-ice retreat on the Atlantic thermohaline circulation. We find that a gradual warming in the Southern Ocean during deglaciation induces an abrupt resumption of the interglacial mode of the thermohaline circulation, triggered by increased mass transport into the Atlantic Ocean via the warm (Indian Ocean) and cold (Pacific Ocean) water route. This effect prevails over the influence of meltwater discharge, which would oppose a strengthening of the thermohaline circulation. A Southern Ocean trigger for the transition into an interglacial mode of circulation provides a consistent picture of Southern and Northern hemispheric climate change at times of deglaciation, in agreement with the available proxy records.

Knorr, W., I. C. Prentice, et al. (2005). "Long-term sensitivity of soil carbon turnover to warming." Nature **433**(7023): 298-301.

The sensitivity of soil carbon to warming is a major uncertainty in projections of carbon dioxide concentration and climate. Experimental studies overwhelmingly indicate increased soil organic carbon (SOC) decomposition at higher temperatures, resulting in increased carbon dioxide emissions from soils. However, recent findings have been cited as evidence against increased soil carbon emissions in a warmer world. In soil warming experiments, the initially increased carbon dioxide efflux returns to pre-warming rates within one to three years, and apparent carbon pool turnover times are insensitive to temperature. It has already

been suggested that the apparent lack of temperature dependence could be an artefact due to neglecting the extreme heterogeneity of soil carbon, but no explicit model has yet been presented that can reconcile all the above findings. Here we present a simple three-pool model that partitions SOC into components with different intrinsic turnover rates. Using this model, we show that the results of all the soil-warming experiments are compatible with long-term temperature sensitivity of SOC turnover: they can be explained by rapid depletion of labile SOC combined with the negligible response of non-labile SOC on experimental timescales. Furthermore, we present evidence that non-labile SOC is more sensitive to temperature than labile SOC, implying that the long-term positive feedback of soil decomposition in a warming world may be even stronger than predicted by global models.

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Knutti, R., J. Fluckiger, et al. (2004). "Strong hemispheric coupling of glacial climate through freshwater discharge and ocean circulation." Nature **430**(7002): 851-6.

The climate of the last glacial period was extremely variable, characterized by abrupt warming events in the Northern Hemisphere, accompanied by slower temperature changes in Antarctica and variations of global sea level. It is generally accepted that this millennial-scale climate variability was caused by abrupt changes in the ocean thermohaline circulation. Here we use a coupled ocean-atmosphere-sea ice model to show that freshwater discharge into the North Atlantic Ocean, in addition to a reduction of the thermohaline circulation, has a direct effect on Southern Ocean temperature. The related anomalous oceanic southward heat transport arises from a zonal density gradient in the subtropical North Atlantic caused by a fast wave-adjustment process. We present an extended and quantitative bipolar seesaw concept that explains the timing and amplitude of Greenland and Antarctic temperature changes, the slow changes in Antarctic temperature and its similarity to sea level, as well as a possible time lag of sea level with respect to Antarctic temperature during Marine Isotope Stage 3.

Knutti, R., T. F. Stocker, et al. (2002). "Constraints on radiative forcing and future climate change from observations and climate model ensembles." Nature **416**(6882): 719-23.

The assessment of uncertainties in global warming projections is often based on

expert judgement, because a number of key variables in climate change are poorly quantified. In particular, the sensitivity of climate to changing greenhouse-gas concentrations in the atmosphere and the radiative forcing effects by aerosols are not well constrained, leading to large uncertainties in global warming simulations. Here we present a Monte Carlo approach to produce probabilistic climate projections, using a climate model of reduced complexity. The uncertainties in the input parameters and in the model itself are taken into account, and past observations of oceanic and atmospheric warming are used to constrain the range of realistic model responses. We obtain a probability density function for the present-day total radiative forcing, giving 1.4 to 2.4 W m-2 for the 5-95 per cent confidence range, narrowing the global-mean indirect aerosol effect to the range of 0 to -1.2 W m-2. Ensemble simulations for two illustrative emission scenarios suggest a 40 per cent probability that global-mean surface temperature increase will exceed the range predicted by the Intergovernmental Panel on Climate Change (IPCC), but only a 5 per cent probability that warming will fall below that range.

Koelle, K., X. Rodo, et al. (2005). "Refractory periods and climate forcing in cholera dynamics." Nature **436**(7051): 696-700.

Outbreaks of many infectious diseases, including cholera, malaria and dengue, vary over characteristic periods longer than 1 year. Evidence that climate variability drives these interannual cycles has been highly controversial, chiefly because it is difficult to isolate the contribution of environmental forcing while taking into account nonlinear epidemiological dynamics generated by mechanisms such as host immunity. Here we show that a critical interplay of environmental forcing, specifically climate variability, and temporary immunity explains the interannual disease cycles present in a four-decade cholera time series from Matlab, Bangladesh. We reconstruct the transmission rate, the key epidemiological parameter affected by extrinsic forcing, over time for the predominant strain (El Tor) with a nonlinear population model that permits a contributing effect of intrinsic immunity. Transmission shows clear interannual variability with a strong correspondence to climate patterns at long periods (over 7 years, for monsoon rains and Brahmaputra river discharge) and at shorter periods (under 7 years, for flood extent in Bangladesh, sea surface temperatures in the Bay of Bengal and the El Nino-Southern Oscillation). The importance of the interplay between extrinsic and intrinsic factors in determining disease dynamics is illustrated during refractory periods, when population susceptibility levels are low as the result of immunity and the size of cholera outbreaks only weakly reflects climate forcing.

Kolb, C. E. (2002). "Iodine's air of importance." Nature **417**(6889): 597-8.

Korner, C., H. Wanner, et al. (2005). "Scientists need back-up by climate organizations." Nature **435**(7041): 413.

Korner, C., H. Wanner, et al. (2005). "Scientists need back-up by climate organizations." Nature **435**(7041): 413.

Kortner, G., R. M. Brigham, et al. (2000). "Winter torpor in a large bird." Nature **407**(6802): 318.

Krafsur, E. S., H. Townson, et al. (1986). "Screwworm eradication is what it seems." Nature **323**(6088): 495-6.

Krebs, J. R. and M. J. Coe (1985). "Sahel famine. An ecological perspective." Nature **317**(6032): 13-4.

Krinner, G., J. Mangerud, et al. (2004). "Enhanced ice sheet growth in Eurasia owing to

adjacent ice-dammed lakes." Nature **427**(6973): 429-32.

Large proglacial lakes cool regional summer climate because of their large heat capacity, and have been shown to modify precipitation through mesoscale atmospheric feedbacks, as in the case of Lake Agassiz. Several large ice-dammed lakes, with a combined area twice that of the Caspian Sea, were formed in northern Eurasia about 90,000 years ago, during the last glacial period when an ice sheet centred over the Barents and Kara seas blocked the large northbound Russian rivers. Here we present high-resolution simulations with an atmospheric general circulation model that explicitly simulates the surface mass balance of the ice sheet. We show that the main influence of the Eurasian proglacial lakes was a significant reduction of ice sheet melting at the southern margin of the Barents-Kara ice sheet through strong regional summer cooling over large parts of Russia. In our simulations, the summer melt reduction clearly outweighs lake-induced decreases in moisture and hence snowfall, such as has been reported earlier for Lake Agassiz. We conclude that the summer cooling mechanism from proglacial lakes accelerated ice sheet growth and delayed ice sheet decay in Eurasia and probably also in North America.

Kump, L. R. (2000). "What drives climate?" Nature **408**(6813): 651-2.

Kump, L. R. (2001). "Global change. Chill taken out of the tropics." Nature **413**(6855): 470-1.

Kump, L. R. (2001). "Global change. Chill taken out of the tropics." Nature **413**(6855): 470-1.

Kump, L. R. (2002). "Reducing uncertainty about carbon dioxide as a climate driver." Nature **419**(6903): 188-90.

The lack of an adequate ancient analogue for future climates means that we ultimately must use and trust climate models, evaluated against modern observation and our best geologic records of warm and cold climates of the past. Armed with an elevated confidence in the models, we will then be able to make reliable predictions of the Earth's response to our risky experiment with the climate system.

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Kump, L. R. (2005). "Palaeoclimate: foreshadowing the glacial era." Nature **436**(7049): 333-4.

Kump, L. R. (2005). "Palaeoclimate: foreshadowing the glacial era." Nature **436**(7049): 333-4.

Kurschner, W. M. (2001). "Leaf sensor for CO2 in deep time." Nature **411**(6835): 247-8.

Kurschner, W. M. (2001). "Leaf sensor for CO2 in deep time." Nature **411**(6835): 247-8.

Ladle, R. J., P. Jepson, et al. (2004). "Dangers of crying wolf over risk of extinctions." Nature **428**(6985): 799.

Lamb, S. and P. Davis (2003). "Cenozoic climate change as a possible cause for the rise of the Andes." Nature **425**(6960): 792-7.

Causal links between the rise of a large mountain range and climate have often been considered to work in one direction, with significant uplift provoking climate change. Here we propose a mechanism by which Cenozoic climate change could have caused the rise of the Andes. Based on considerations of the force balance in the South American lithosphere, we suggest that the height of, and tectonics in, the Andes are strongly controlled both by shear stresses along the plate interface in the subduction zone and by buoyancy stress contrasts between the trench and highlands, and shear stresses in the subduction zone depend on the amount of subducted sediments. We propose that the dynamics of subduction and mountain-building in this region are controlled by the processes of erosion and sediment deposition, and ultimately climate. In central South America, climate-controlled sediment starvation would then cause high shear stress, focusing the plate boundary stresses that support the high Andes.

Lambeck, K., T. M. Esat, et al. (2002). "Links between climate and sea levels for the past three million years." Nature **419**(6903): 199-206.

The oscillations between glacial and interglacial climate conditions over the past three million years have been characterized by a transfer of immense amounts of water between two of its largest reservoirs on Earth -- the ice sheets and the oceans. Since the latest of these oscillations, the Last Glacial Maximum (between about 30,000 and 19,000 years ago), approximately 50 million cubic kilometres of ice has melted from the land-based ice sheets, raising global sea level by approximately 130 metres. Such rapid changes in sea level are part of a complex pattern of interactions between the atmosphere, oceans, ice sheets and solid earth, all of which have different response timescales. The trigger for the sea-level fluctuations most probably lies with changes in insolation, caused by astronomical forcing, but internal feedback cycles complicate the simple model of causes and effects.

Lambers, J. H., J. S. Clark, et al. (2002). "Density-dependent mortality and the latitudinal gradient in species diversity." Nature **417**(6890): 732-5.

Ecologists have long postulated that density-dependent mortality maintains high tree diversity in the tropics. If species experience greater mortality when abundant, then more rare species can persist. Agents of density-dependent mortality (such as host-specific predators, and pathogens) may be more prevalent or have stronger effects in tropical forests, because they are not limited by climatic factors. If so, decreasing density-dependent mortality with increasing latitude could partially explain the observed latitudinal gradient in tree diversity. This hypothesis has never been tested with latitudinal data. Here we show that several temperate tree species experience density-dependent mortality between seed dispersal and seedling establishment. The proportion of species affected is equivalent to that in tropical forests, failing to support the hypothesis that this mechanism is more prevalent at tropical latitudes. We further show that density-dependent mortality is misinterpreted in previous studies. Our results and evidence from other studies suggest that density-dependent mortality is important in many forests. Thus, unless the strength of density-dependent mortality varies with latitude, this mechanism is not likely to explain the high diversity of tropical forests.

Landsea, C. W. (2005). "Meteorology: hurricanes and global warming." Nature **438**(7071): E11-2; discussion E13.

Anthropogenic climate change has the potential for slightly increasing the intensity of tropical cyclones through warming of sea surface temperatures. Emanuel has shown a striking and surprising association between sea surface temperatures and destructiveness by tropical cyclones in the Atlantic and western

North Pacific basins. However, I question his analysis on the following grounds: it does not properly represent the observations described; the use of his Atlantic bias-removal scheme may not be warranted; and further investigation of a substantially longer time series for tropical cyclones affecting the continental United States does not show a tendency for increasing destructiveness. These factors indicate that instead of "unprecedented" tropical cyclone activity having occurred in recent years, hurricane intensity was equal or even greater during the last active period in the mid-twentieth century.

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Langenberg, H. (2002). "Climate of care for a changing world." Nature **417**(6888): 4-6.

Langenberg, H. (2002). "Climate of care for a changing world." Nature **417**(6888): 4-6.

Langenberg, H. (2003). "Global effort to plot climate change." Nature **425**(6954): 112.

Langenberg, H. (2005). "Palaeoclimate: ripples of stormy weather." Nature **433**(7022): 115.

Langenberg, H. and P. Aldhous (2000). "Global warming. A climate of uncertainty." Nature **408**(6815): 896-7.

Laskar, J., B. Levrard, et al. (2002). "Orbital forcing of the martian polar layered deposits." Nature **419**(6905): 375-7.

Since the first images of polar regions on Mars revealed alternating bright and dark layers, there has been speculation that their formation might be tied to the planet's orbital climate forcing. But uncertainties in the deposition timescale exceed two orders of magnitude: estimates based on assumptions of dust deposition, ice formation and sublimation, and their variations with orbital forcing suggest a deposition rate of 10(-3) to 10(-2) cm yr(-1) (refs 5, 6), whereas estimates based on cratering rate result in values as high as 0.1 to 0.2 cm yr(-1) (ref. 7). Here we use a combination of high-resolution images of the polar layered terrains, high-resolution topography and revised calculations of the orbital and rotational parameters of Mars to show that a correlation exists between ice-layer radiance as a function of depth (obtained from photometric data of the images of the layered terrains) and the insolation variations in summer at the martian north pole, similar to what has been shown for palaeoclimate studies of the Earth. For the best fit between the radiance profile and the simulated insolation parameters, we obtain an average deposition rate of 0.05 cm yr(-1) for the top 250 m of deposits on the ice cap of the north pole of Mars.

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Lawrence, E. N. (1971). "Clean air act." Nature **229**(5283): 334-5.

Laxon, S., N. Peacock, et al. (2003). "High interannual variability of sea ice thickness in the Arctic region." Nature **425**(6961): 947-50.

Possible future changes in Arctic sea ice cover and thickness, and consequent changes in the ice-albedo feedback, represent one of the largest uncertainties in the prediction of future temperature rise. Knowledge of the natural variability of sea ice thickness is therefore critical for its representation in global climate models. Numerical simulations suggest that Arctic ice thickness varies primarily on decadal timescales owing to changes in wind and ocean stresses on the ice, but observations have been unable to provide a synoptic view of sea ice thickness, which is required to validate the model results. Here we use an eight-year time-series of Arctic ice thickness, derived from satellite altimeter measurements of ice freeboard, to determine the mean thickness field and its variability from 65 degrees N to 81.5 degrees N. Our data reveal a high-frequency interannual variability in mean Arctic ice thickness that is dominated by changes in the amount of summer melt, rather than by changes in circulation. Our results suggest that a continued increase in melt season length would lead to further thinning of Arctic sea ice.

Lea, A. J. (1966). "Relationship between environmental temperature and the death rate of women from neoplasms of the breast." Nature **209**(5018): 57-9.

Ledwell, J. R., E. T. Montgomery, et al. (2000). "Evidence for enhanced mixing over rough topography in the abyssal ocean." Nature **403**(6766): 179-82.

The overturning circulation of the ocean plays an important role in modulating the Earth's climate. But whereas the mechanisms for the vertical transport of water into the deep ocean--deep water formation at high latitudes--and horizontal transport in ocean currents have been largely identified, it is not clear how the compensating vertical transport of water from the depths to the surface is accomplished. Turbulent mixing across surfaces of constant density is the only viable mechanism for reducing the density of the water and enabling it to rise. However, measurements of the internal wave field, the main source of energy for mixing, and of turbulent dissipation rates, have typically implied diffusivities across surfaces of equal density of only approximately 0.1 cm2 s(-1), too small to account for the return flow. Here we report measurements of tracer dispersion and turbulent energy dissipation in the Brazil basin that reveal diffusivities of 2-4 cm2 s(-1) at a depth of 500 m above abyssal hills on the flank of the Mid-Atlantic Ridge, and approximately 10 cm2 s(-1) nearer the bottom. This amount of mixing, probably driven by breaking internal waves that are generated by tidal

currents flowing over the rough bathymetry, may be large enough to close the buoyancy budget for the Brazil basin and suggests a mechanism for closing the global overturning circulation.

Leendertz, F. H., H. Ellerbrok, et al. (2004). "Anthrax kills wild chimpanzees in a tropical rainforest." Nature **430**(6998): 451-2.

Infectious disease has joined habitat loss and hunting as threats to the survival of the remaining wild populations of great apes. Nevertheless, relatively little is known about the causative agents. We investigated an unusually high number of sudden deaths observed over nine months in three communities of wild chimpanzees (Pan troglodytes verus) in the Tai National Park, Ivory Coast. Here we report combined pathological, cytological and molecular investigations that identified Bacillus anthracis as the cause of death for at least six individuals. We show that anthrax can be found in wild non-human primates living in a tropical rainforest, a habitat not previously known to harbour B. anthracis. Anthrax is an acute disease that infects ruminants, but other mammals, including humans, can be infected through contacting or inhaling high doses of spores or by consuming meat from infected animals. Respiratory and gastrointestinal anthrax are characterized by rapid onset, fever, septicaemia and a high fatality rate without early antibiotic treatment. Our results suggest that epidemic diseases represent substantial threats to wild ape populations, and through bushmeat consumption also pose a hazard to human health.

Leininger, S., T. Urich, et al. (2006). "Archaea predominate among ammonia-oxidizing prokaryotes in soils." Nature **442**(7104): 806-9.

Ammonia oxidation is the first step in nitrification, a key process in the global nitrogen cycle that results in the formation of nitrate through microbial activity. The increase in nitrate availability in soils is important for plant nutrition, but it also has considerable impact on groundwater pollution owing to leaching. Here we show that archaeal ammonia oxidizers are more abundant in soils than their well-known bacterial counterparts. We investigated the abundance of the gene encoding a subunit of the key enzyme ammonia monooxygenase (amoA) in 12 pristine and agricultural soils of three climatic zones. amoA gene copies of Crenarchaeota (Archaea) were up to 3,000-fold more abundant than bacterial amoA genes. High amounts of crenarchaeota-specific lipids, including crenarchaeol, correlated with the abundance of archaeal amoA gene copies. Furthermore, reverse transcription quantitative PCR studies and complementary DNA analysis using novel cloning-independent pyrosequencing technology demonstrated the activity of the archaea in situ and supported the numerical dominance of archaeal over bacterial ammonia oxidizers. Our results indicate that crenarchaeota may be the most abundant ammonia-oxidizing organisms in soil ecosystems on Earth.

Lelieveld, J. (2006). "Climate change: a nasty surprise in the greenhouse." Nature **443**(7110): 405-6.

Lelieveld, J. (2006). "Climate change: a nasty surprise in the greenhouse." Nature **443**(7110): 405-6.

Lelieveld, J., S. Lechtenbohmer, et al. (2005). "Greenhouse gases: low methane leakage from gas pipelines." Nature **434**(7035): 841-2.

Using natural gas for fuel releases less carbon dioxide per unit of energy produced than burning oil or coal, but its production and transport are accompanied by emissions of methane, which is a much more potent greenhouse gas than carbon dioxide in the short term. This calls into question whether climate forcing could be reduced by switching from coal and oil to natural gas. We have made measurements in Russia along the world's largest gas-transport system and find

that methane leakage is in the region of 1.4%, which is considerably less than expected and comparable to that from systems in the United States. Our calculations indicate that using natural gas in preference to other fossil fuels could be useful in the short term for mitigating climate change.

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Lempert, R. and M. E. Schlesinger (2001). "Climate-change strategy needs to be robust." Nature **412**(6845): 375.

Lenton, T. M., H. J. Schellnhuber, et al. (2004). "Climbing the co-evolution ladder." Nature **431**(7011): 913.

Leovy, C. (2001). "Weather and climate on Mars." Nature **412**(6843): 245-9.
Imagine a planet very much like the Earth, with similar size, rotation rate and inclination of rotation axis, possessing an atmosphere and a solid surface, but lacking oceans and dense clouds of liquid water. We might expect such a desert planet to be dominated by large variations in day-night and winter-summer weather. Dust storms would be common. Observations and simulations of martian climate confirm these expectations and provide a wealth of detail that can help resolve problems of climate evolution.

Levine, J. S. (2003). "Atmospheric chemistry: Burning domestic issues." Nature **423**(6935): 28-9.

Levrard, B., F. Forget, et al. (2004). "Recent ice-rich deposits formed at high latitudes on Mars by sublimation of unstable equatorial ice during low obliquity." Nature **431**(7012): 1072-5.
Observations from the gamma-ray spectrometer instrument suite on the Mars Odyssey spacecraft have been interpreted as indicating the presence of vast reservoirs of near-surface ice in high latitudes of both martian hemispheres. Ice concentrations are estimated to range from 70 per cent at 60 degrees latitude to 100 per cent near the poles, possibly overlain by a few centimetres of ice-free material in most places. This result is supported by morphological evidence of metres-thick layered deposits that are rich in water-ice and periglacial-like features found only at high latitudes. Diffusive exchange of water between the pore space of the regolith and the atmosphere has been proposed to explain this distribution, but such a degree of concentration is difficult to accommodate with such processes. Alternatively, there are suggestions that ice-rich deposits form by transport of ice from polar reservoirs and direct redeposition in high latitudes during periods of higher obliquity, but these results have been difficult to reproduce with other models. Here we propose instead that, during periods of low obliquity (less than 25 degrees), high-latitude ice deposits form in both hemispheres by direct deposition of ice, as a result of sublimation from an equatorial ice reservoir that formed earlier, during a prolonged high-obliquity excursion. Using the ice accumulation rates estimated from global climate model

simulations we show that, over the past ten million years, large variations of Mars' obliquity have allowed the formation of such metres-thick, sedimentary layered deposits in high latitude and polar regions.

Levy, M. (2005). "Oceanography: nutrients in remote mode." Nature **437**(7059): 628-31.

Lincoln, T. (2004). "Global change: glacial pace picks up." Nature **431**(7008): 519.

Liu, Z. and T. D. Herbert (2004). "High-latitude influence on the eastern equatorial Pacific climate in the early Pleistocene epoch." Nature **427**(6976): 720-3.
Many records of tropical sea surface temperature and marine productivity exhibit cycles of 23 kyr (orbital precession) and 100 kyr during the past 0.5 Myr (refs 1-5), whereas high-latitude sea surface temperature records display much more pronounced obliquity cycles at a period of about 41 kyr (ref. 6). Little is known, however, about tropical climate variability before the mid-Pleistocene transition about 900 kyr ago, which marks the change from a climate dominated by 41-kyr cycles (when ice-age cycles and high-latitude sea surface temperature variations were dictated by changes in the Earth's obliquity) to the more recent 100-kyr cycles of ice ages. Here we analyse alkenones from marine sediments in the eastern equatorial Pacific Ocean to reconstruct sea surface temperatures and marine productivity over the past 1.8 Myr. We find that both records are dominated by the 41-kyr obliquity cycles between 1.8 and 1.2 Myr ago, with a relatively small contribution from orbital precession, and that early Pleistocene sea surface temperatures varied in the opposite sense to local annual insolation in the eastern equatorial Pacific Ocean. We conclude that during the early Pleistocene epoch, climate variability at our study site must have been determined by high-latitude processes that were driven by orbital obliquity forcing.

Loewen, M. (2002). "Physical oceanography: inside whitecaps." Nature **418**(6900): 830.

Lohrer, A. M., S. F. Thrush, et al. (2004). "Bioturbators enhance ecosystem function through complex biogeochemical interactions." Nature **431**(7012): 1092-5.
Predicting the consequences of species loss is critically important, given present threats to biological diversity such as habitat destruction, overharvesting and climate change. Several empirical studies have reported decreased ecosystem performance (for example, primary productivity) coincident with decreased biodiversity, although the relative influence of biotic effects and confounding abiotic factors has been vigorously debated. Whereas several investigations focused on single trophic levels (for example, grassland plants), studies of whole systems have revealed multiple layers of feedbacks, hidden drivers and emergent properties, making the consequences of species loss more difficult to predict. Here we report functionally important organisms and considerable biocomplexity in a sedimentary seafloor habitat, one of Earth's most widespread ecosystems. Experimental field measurements demonstrate how the abundance of spatangoid urchins--infaunal (in seafloor sediment) grazers/deposit feeders--is positively related to primary production, as their activities change nutrient fluxes and improve conditions for production by microphytobenthos (sedimentatry microbes and unicellular algae). Declines of spatangoid urchins after trawling are well documented, and our research linking these bioturbators to important benthic-pelagic fluxes highlights potential ramifications for productivity in coastal oceans.

Lomborg, B. (2004). "Need for economists to set global priorities." Nature **431**(7004): 17.

Lothe, F. (1967). "Erythrocyte glucose-6-phosphate dehydrogenase deficiency in

Uganda." Nature **215**(5098): 299-300.

Lourens, L. J., R. Wehausen, et al. (2001). "Geological constraints on tidal dissipation and dynamical ellipticity of the Earth over the past three million years." Nature **409**(6823): 1029-33.

The evolution of the Solar System has been shown to be chaotic, which limits our ability to retrace the orbital and precessional motion of the Earth over more than 35-50 Myr (ref. 2). Moreover, the precession, obliquity and insolation parameters can also be influenced by secular variations in the tidal dissipation and dynamical ellipticity of the Earth induced by glacial cyclicity and mantle convection. Here we determine the average values of these dissipative effects over the past three million years. We have computed the optimal fit between an exceptional palaeoclimate record from the eastern Mediterranean Sea and a model of the astronomical and insolation history by testing a number of values for the tidal dissipation and dynamical ellipticity parameters. We find that the combined effects of dynamical ellipticity and tidal dissipation were, on average, significantly lower over the past three million years, compared to their present-day values (determined from artificial satellite data and lunar ranging). This secular variation associated with the Plio-Pleistocene ice load history has caused an average acceleration in the Earth's rotation over the past 3 Myr, which needs to be considered in the construction of astronomical timescales and in research into the stationarity of phase relations in the ocean-climate system through time.

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Lovelock, J. (2003). "Gaia: the living Earth." Nature **426**(6968): 769-70.

Lowe, D. C. (2006). "Global change: a green source of surprise." Nature **439**(7073): 148-9.

Lowe, D. C. (2006). "Global change: a green source of surprise." Nature **439**(7073): 148-9.

Lowry, A. R. (2006). "Resonant slow fault slip in subduction zones forced by climatic load stress." Nature **442**(7104): 802-5.

Global Positioning System (GPS) measurements at subduction plate boundaries often record fault movements similar to earthquakes but much slower, occurring over timescales of approximately 1 week to approximately 1 year. These 'slow

slip events' have been observed in Japan, Cascadia, Mexico, Alaska and New Zealand. The phenomenon is poorly understood, but several observations hint at the processes underlying slow slip. Although slip itself is silent, seismic instruments often record coincident low-amplitude tremor in a narrow (1-5 cycles per second) frequency range. Also, modelling of GPS data and estimates of tremor location indicate that slip focuses near the transition from unstable ('stick-slip') to stable friction at the deep limit of the earthquake-producing seismogenic zone. Perhaps most intriguingly, slow slip is periodic at several locations, with recurrence varying from 6 to 18 months depending on which subduction zone (or even segment) is examined. Here I show that such periodic slow fault slip may be a resonant response to climate-driven stress perturbations. Fault slip resonance helps to explain why slip events are periodic, why periods differ from place to place, and why slip focuses near the base of the seismogenic zone. Resonant slip should initiate within the rupture zone of future great earthquakes, suggesting that slow slip may illuminate fault properties that control earthquake slip.

Loya, W. M. and P. Grogan (2004). "Global change: carbon conundrum on the tundra." Nature **431**(7007): 406-8.

Loya, W. M. and P. Grogan (2004). "Global change: carbon conundrum on the tundra." Nature **431**(7007): 406-8.

Loya, W. M. and P. Grogan (2004). "Global change: carbon conundrum on the tundra." Nature **431**(7007): 406-8.

Lubick, N. (2002). "Snowball fights." Nature **417**(6884): 12-3.

Lubick, N. (2005). "Earth observing: something to watch over us." Nature **436**(7048): 168-9.

Lubin, D. and A. M. Vogelmann (2006). "A climatologically significant aerosol longwave indirect effect in the Arctic." Nature **439**(7075): 453-6.

The warming of Arctic climate and decreases in sea ice thickness and extent observed over recent decades are believed to result from increased direct greenhouse gas forcing, changes in atmospheric dynamics having anthropogenic origin, and important positive reinforcements including ice-albedo and cloud-radiation feedbacks. The importance of cloud-radiation interactions is being investigated through advanced instrumentation deployed in the high Arctic since 1997 (refs 7, 8). These studies have established that clouds, via the dominance of longwave radiation, exert a net warming on the Arctic climate system throughout most of the year, except briefly during the summer. The Arctic region also experiences significant periodic influxes of anthropogenic aerosols, which originate from the industrial regions in lower latitudes. Here we use multisensor radiometric data to show that enhanced aerosol concentrations alter the microphysical properties of Arctic clouds, in a process known as the 'first indirect' effect. Under frequently occurring cloud types we find that this leads to an increase of an average 3.4 watts per square metre in the surface longwave fluxes. This is comparable to a warming effect from established greenhouse gases and implies that the observed longwave enhancement is climatologically significant.

Lund, D. C., J. Lynch-Stieglitz, et al. (2006). "Gulf Stream density structure and transport during the past millennium." Nature **444**(7119): 601-4.

The Gulf Stream transports approximately 31 Sv (1 Sv = 10(6) m(3) s(-1)) of water and 1.3 x 10(15) W of heat into the North Atlantic ocean. The possibility of abrupt changes in Gulf Stream heat transport is one of the key uncertainties in predictions of climate change for the coming centuries. Given the limited length of the instrumental record, our knowledge of Gulf Stream behaviour on long

timescales must rely heavily on information from geologic archives. Here we use foraminifera from a suite of high-resolution sediment cores in the Florida Straits to show that the cross-current density gradient and vertical current shear of the Gulf Stream were systematically lower during the Little Ice Age (ad approximately 1200 to 1850). We also estimate that Little Ice Age volume transport was ten per cent weaker than today's. The timing of reduced flow is consistent with temperature minima in several palaeoclimate records, implying that diminished oceanic heat transport may have contributed to Little Ice Age cooling in the North Atlantic. The interval of low flow also coincides with anomalously high Gulf Stream surface salinity, suggesting a tight linkage between the Atlantic Ocean circulation and hydrologic cycle during the past millennium.

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Luo, Y., S. Wan, et al. (2001). "Acclimatization of soil respiration to warming in a tall grass prairie." Nature **413**(6856): 622-5.

The latest report by the Intergovernmental Panel on Climate Change (IPCC) predicts a 1.4-5.8 degrees C average increase in the global surface temperature over the period 1990 to 2100 (ref. 1). These estimates of future warming are greater than earlier projections, which is partly due to incorporation of a positive feedback. This feedback results from further release of greenhouse gases from terrestrial ecosystems in response to climatic warming. The feedback mechanism is usually based on the assumption that observed sensitivity of soil respiration to temperature under current climate conditions would hold in a warmer climate. However, this assumption has not been carefully examined. We have therefore conducted an experiment in a tall grass prairie ecosystem in the US Great Plains to study the response of soil respiration (the sum of root and heterotrophic respiration) to artificial warming of about 2 degrees C. Our observations indicate that the temperature sensitivity of soil respiration decreases--or acclimatizes--under warming and that the acclimatization is greater at high temperatures. This acclimatization of soil respiration to warming may therefore weaken the positive feedback between the terrestrial carbon cycle and climate.

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Lyons, T. W. (2004). "Geochemistry: warm debate on early climate." Nature **429**(6990): 359-60.

MacCracken, M. (2006). "Climate: open review may ease acceptance of report." Nature **441**(7092): 406.

MacCracken, M., J. Smith, et al. (2004). "Reliable regional climate model not yet on horizon." Nature **429**(6993): 699.

MacCracken, M., J. Smith, et al. (2004). "Reliable regional climate model not yet on horizon." Nature **429**(6993): 699.

MacCracken, M. C. (2005). "Consumer law is used to attack climate findings." Nature **434**(7032): 435.

Macfarlane, W. V., R. Kinne, et al. (1967). "Vasopressins and the increase of water and electrolyte excretion by sheep, cattle and camels." Nature **214**(5092): 979-81.

Macilwain, C. (2000). "Congress wakes up to climate change." Nature **405**(6785): 385.

Macilwain, C. (2000). "Emissions targets 'unrealistic' says US climate change body." Nature **406**(6794): 333-4.

Macilwain, C., G. W. Bush, et al. (2004). "Head to head: Bush vs Kerry." Nature **431**(7006): 238-43.

Mack, M. C., E. A. Schuur, et al. (2004). "Ecosystem carbon storage in arctic tundra reduced by long-term nutrient fertilization." Nature **431**(7007): 440-3.

Global warming is predicted to be most pronounced at high latitudes, and observational evidence over the past 25 years suggests that this warming is already under way. One-third of the global soil carbon pool is stored in northern latitudes, so there is considerable interest in understanding how the carbon balance of northern ecosystems will respond to climate warming. Observations of controls over plant productivity in tundra and boreal ecosystems have been used to build a conceptual model of response to warming, where warmer soils and increased decomposition of plant litter increase nutrient availability, which, in turn, stimulates plant production and increases ecosystem carbon storage. Here we present the results of a long-term fertilization experiment in Alaskan tundra, in which increased nutrient availability caused a net ecosystem loss of almost 2,000 grams of carbon per square meter over 20 years. We found that annual aboveground plant production doubled during the experiment. Losses of carbon and nitrogen from deep soil layers, however, were substantial and more than offset the increased carbon and nitrogen storage in plant biomass and litter. Our study suggests that projected release of soil nutrients associated with high-latitude warming may further amplify carbon release from soils, causing a net loss of

ecosystem carbon and a positive feedback to climate warming.

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Macpherson, R. K. (1958). "Acclimatization status of temperate-zone man." Nature **182**(4644): 1240-1.

Madden, M. E., R. J. Bodnar, et al. (2004). "Jarosite as an indicator of water-limited chemical weathering on Mars." Nature **431**(7010): 821-3.

The Mars Exploration Rover Opportunity identified the ferric sulphate mineral jarosite and possible relicts of gypsum at the Meridiani Planum landing site. On Earth, jarosite has been found to form in acid mine drainage environments, during the oxidation of sulphide minerals, and during alteration of volcanic rocks by acidic, sulphur-rich fluids near volcanic vents. Jarosite formation is thus thought to require a wet, oxidizing and acidic environment. But jarosite on Earth only persists over geologically relevant time periods in arid environments because it rapidly decomposes to produce ferric oxyhydroxides in more humid climates. Here we present equilibrium thermodynamic reaction-path simulations that constrain the range of possible conditions under which such aqueous alteration phases are likely to have formed on Mars. These calculations simulate the chemical weathering of basalt at relevant martian conditions. We conclude that the presence of jarosite combined with residual basalt at Meridiani Planum indicates that the alteration process did not proceed to completion, and that following jarosite formation, arid conditions must have prevailed.

Madin, J. S. and S. R. Connolly (2006). "Ecological consequences of major hydrodynamic disturbances on coral reefs." Nature **444**(7118): 477-80.

A recent tsunami and an apparent increase in the frequency of severe tropical storms underscore the need to understand and predict the ecological consequences of major hydrodynamic disturbances. Reef corals provide the habitat structure that sustains the high biodiversity of tropical reefs, and thus provide the foundation for the ecosystem goods and services that are critical to many tropical societies. Here we integrate predictions from oceanographic models with engineering theory, to predict the dislodgement of benthic reef corals during hydrodynamic disturbances. This generalizes earlier work, by incorporating colonies of any shape and by explicitly examining the effects of hydrodynamic gradients on coral assemblage structure. A field test shows that this model accurately predicts changes in the mechanical vulnerability of coral colonies, and

thus their size and shape, with distance from the reef crest. This work provides a general framework for understanding and predicting the effects of hydrodynamic disturbances on coral reef communities; such disturbances have a major role in determining species zonation and coexistence on coral reefs, and are critical determinants of how coral assemblages will respond to changes in the frequency and intensity of tropical storms associated with a changing climate.

Maher, B. A. and P. F. Dennis (2001). "Evidence against dust-mediated control of glacial-interglacial changes in atmospheric CO2." Nature **411**(6834): 176-80.

The low concentration of atmospheric CO2 inferred to have been present during glacial periods is thought to have been partly caused by an increased supply of iron-bearing dust to the ocean surface. This is supported by a recent model that attributes half of the CO2 reduction during past glacial stages to iron-stimulated uptake of CO2 by phytoplankton in the Southern Ocean. But atmospheric dust fluxes to the Southern Ocean, even in glacial periods, are thought to be relatively low and therefore it has been proposed that Southern Ocean productivity might be influenced by iron deposited elsewhere-for example, in the Northern Hemisphere-which is then transported south via ocean circulation (similar to the distal supply of iron to the equatorial Pacific Ocean). Here we examine the timing of dust fluxes to the North Atlantic Ocean, in relation to climate records from the Vostok ice core in Antarctica around the time of the penultimate deglaciation (about 130 kyr ago). Two main dust peaks occurred 155 kyr and 130 kyr ago, but neither was associated with the CO2 rise recorded in the Vostok ice core. This mismatch, together with the low dust flux supplied to the Southern Ocean, suggests that dust-mediated iron fertilization of the Southern Ocean did not significantly influence atmospheric CO2 at the termination of the penultimate glaciation.

Malin, M. C. and M. H. Carr (1999). "Groundwater formation of martian valleys." Nature **397**(6720): 589-91.

The martian surface shows large outflow channels, widely accepted as having been formed by gigantic floods that could have occurred under climatic conditions like those seen today. Also present are branching valley networks that commonly have tributaries. These valleys are much smaller than the outflow channels and their origins and ages have been controversial. For example, they might have formed through slow erosion by water running across the surface, either early or late in Mars' history, possibly protected from harsh conditions by ice cover. Alternatively, they might have formed through groundwater or ground-ice processes that undermine the surface and cause collapse, again either early or late in Mars' history. Long-duration surface runoff would imply climatic conditions quite different from the present environment. Here we present high-resolution images of martian valleys that support the view that ground water played an important role in their formation, although we are unable as yet to establish when this occurred.

Manne, A. S. and R. G. Richels (2001). "An alternative approach to establishing trade-offs among greenhouse gases." Nature **410**(6829): 675-7.

The Kyoto Protocol permits countries to meet part of their emission reduction obligations by cutting back on gases other than CO2 (ref. 1). This approach requires a definition of trade-offs among the radiatively active gases. The Intergovernmental Panel on Climate Change has suggested global warming potentials for this purpose, which use the accumulated radiative forcing of each gas by a set time horizon to establish emission equivalence. But it has been suggested that this approach has serious shortcomings: damages or abatement costs are not considered and the choice of time horizon for calculating cumulative radiative force is critical, but arbitrary. Here we describe an alternative framework for determining emission equivalence between radiatively active gases that

addresses these weaknesses. We focus on limiting temperature change and rate of temperature change, but our framework is also applicable to other objectives. For a proposed ceiling, we calculate how much one should be willing to pay for emitting an additional unit of each gas. The relative prices then determine the trade-off between gases at each point in time, taking into account economical as well as physical considerations. Our analysis shows that the relative prices are sensitive to the lifetime of the gases, the choice of target and the proximity of the target, making short-lived gases more expensive to emit as we approach the prescribed ceiling.

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Marcus, P. S. (2004). "Prediction of a global climate change on Jupiter." Nature **428**(6985): 828-31.

Jupiter's atmosphere, as observed in the 1979 Voyager space craft images, is characterized by 12 zonal jet streams and about 80 vortices, the largest of which are the Great Red Spot and three White Ovals that had formed in the 1930s. The Great Red Spot has been observed continuously since 1665 and, given the dynamical similarities between the Great Red Spot and the White Ovals, the disappearance of two White Ovals in 1997-2000 was unexpected. Their longevity and sudden demise has been explained however, by the trapping of anticyclonic vortices in the troughs of Rossby waves, forcing them to merge. Here I propose that the disappearance of the White Ovals was not an isolated event, but part of a recurring climate cycle which will cause most of Jupiter's vortices to disappear within the next decade. In my numerical simulations, the loss of the vortices results in a global temperature change of about 10 K, which destabilizes the atmosphere and thereby leads to the formation of new vortices. After formation, the large vortices are eroded by turbulence over a time of approximately 60 years--consistent with observations of the White Ovals-until they disappear and the cycle begins again.

Marinov, I., A. Gnanadesikan, et al. (2006). "The Southern Ocean biogeochemical divide." Nature **441**(7096): 964-7.

Modelling studies have demonstrated that the nutrient and carbon cycles in the Southern Ocean play a central role in setting the air-sea balance of CO(2) and global biological production. Box model studies first pointed out that an increase in nutrient utilization in the high latitudes results in a strong decrease in the

atmospheric carbon dioxide partial pressure (pCO2). This early research led to two important ideas: high latitude regions are more important in determining atmospheric pCO2 than low latitudes, despite their much smaller area, and nutrient utilization and atmospheric pCO2 are tightly linked. Subsequent general circulation model simulations show that the Southern Ocean is the most important high latitude region in controlling pre-industrial atmospheric CO(2) because it serves as a lid to a larger volume of the deep ocean. Other studies point out the crucial role of the Southern Ocean in the uptake and storage of anthropogenic carbon dioxide and in controlling global biological production. Here we probe the system to determine whether certain regions of the Southern Ocean are more critical than others for air-sea CO(2) balance and the biological export production, by increasing surface nutrient drawdown in an ocean general circulation model. We demonstrate that atmospheric CO(2) and global biological export production are controlled by different regions of the Southern Ocean. The air-sea balance of carbon dioxide is controlled mainly by the biological pump and circulation in the Antarctic deep-water formation region, whereas global export production is controlled mainly by the biological pump and circulation in the Subantarctic intermediate and mode water formation region. The existence of this biogeochemical divide separating the Antarctic from the Subantarctic suggests that it may be possible for climate change or human intervention to modify one of these without greatly altering the other.

Marris, E. (2004). "Climate modellers go local to target California's politicians." Nature **430**(7002): 818.

Marris, E. (2004). "Climate modellers go local to target California's politicians." Nature **430**(7002): 818.

Marris, E. (2004). "Oceanography: deckchair science." Nature **431**(7007): 394-5.

Marris, E. (2004). "Climate change clouds commercial licence to krill." Nature **432**(7013): 4.

Marris, E. (2004). "Climate change clouds commercial licence to krill." Nature **432**(7013): 4.

Marris, E. (2005). "Professors bristle as states act to mould lecture content." Nature **434**(7034): 686.

Marris, E. (2005). "Wall Street's gradual green revolution." Nature **435**(7041): 410-1.

Marris, E. (2005). "In defence of data." Nature **436**(7050): 454-5.

Marris, E. (2005). "Conservation in Brazil: the forgotten ecosystem." Nature **437**(7061): 944-5.

Marris, E. (2006). "Grizzlies, dodos and Gore put science on film." Nature **439**(7079): 902.

Marris, E. (2006). "Plant science: gardens in full bloom." Nature **440**(7086): 860-3.

Marris, E. (2006). "Wildlife caught in crossfire of US immigration battle." Nature **442**(7101): 338-9.

Marris, E. (2006). "Putting the carbon back: black is the new green." Nature **442**(7103): 624-6.

Marris, E. (2006). "Climate in court." Nature **443**(7111): 486-7.

Marris, E. (2006). "Climate in court." Nature **443**(7111): 486-7.

Marshall, C. H., R. A. Pielke, Sr., et al. (2003). "Wetlands: crop freezes and land-use change in Florida." Nature **426**(6962): 29-30.

Mason, B. (2004). "Climate change: the hot hand of history." Nature **427**(6975): 582-3.

Mason, B. (2004). "Climate change: the hot hand of history." Nature **427**(6975): 582-3.

Matthews, D. (2006). "Global change: the water cycle freshens up." Nature **439**(7078): 793-4.

Matthews, D. (2006). "Global change: the water cycle freshens up." Nature **439**(7078): 793-4.

Mayorga, E., A. K. Aufdenkampe, et al. (2005). "Young organic matter as a source of carbon dioxide outgassing from Amazonian rivers." Nature **436**(7050): 538-41.

Rivers are generally supersaturated with respect to carbon dioxide, resulting in large gas evasion fluxes that can be a significant component of regional net carbon budgets. Amazonian rivers were recently shown to outgas more than ten times the amount of carbon exported to the ocean in the form of total organic carbon or dissolved inorganic carbon. High carbon dioxide concentrations in rivers originate largely from in situ respiration of organic carbon, but little agreement exists about the sources or turnover times of this carbon. Here we present results of an extensive survey of the carbon isotope composition (13C and 14C) of dissolved inorganic carbon and three size-fractions of organic carbon across the Amazonian river system. We find that respiration of contemporary organic matter (less than five years old) originating on land and near rivers is the dominant source of excess carbon dioxide that drives outgassing in medium to large rivers, although we find that bulk organic carbon fractions transported by these rivers range from tens to thousands of years in age. We therefore suggest that a small, rapidly cycling pool of organic carbon is responsible for the large carbon fluxes from land to water to atmosphere in the humid tropics.

McBrearty, S. and N. G. Jablonski (2005). "First fossil chimpanzee." Nature **437**(7055): 105-8.

There are thousands of fossils of hominins, but no fossil chimpanzee has yet been reported. The chimpanzee (Pan) is the closest living relative to humans. Chimpanzee populations today are confined to wooded West and central Africa, whereas most hominin fossil sites occur in the semi-arid East African Rift Valley. This situation has fuelled speculation regarding causes for the divergence of the human and chimpanzee lineages five to eight million years ago. Some investigators have invoked a shift from wooded to savannah vegetation in East Africa, driven by climate change, to explain the apparent separation between chimpanzee and human ancestral populations and the origin of the unique hominin locomotor adaptation, bipedalism. The Rift Valley itself functions as an obstacle to chimpanzee occupation in some scenarios. Here we report the first fossil chimpanzee. These fossils, from the Kapthurin Formation, Kenya, show that representatives of Pan were present in the East African Rift Valley during the Middle Pleistocene, where they were contemporary with an extinct species of Homo. Habitats suitable for both hominins and chimpanzees were clearly present there during this period, and the Rift Valley did not present an impenetrable barrier to chimpanzee occupation.

McConnell, J. R., R. J. Arthern, et al. (2000). "Changes in Greenland ice sheet elevation

attributed primarily to snow accumulation variability." Nature **406**(6798): 877-9.
The response of grounded ice sheets to a changing climate critically influences possible future changes in sea level. Recent satellite surveys over southern Greenland show little overall elevation change at higher elevations, but large spatial variability. Using satellite studies alone, it is not possible to determine the geophysical processes responsible for the observed elevation changes and to decide if recent rates of change exceed the natural variability. Here we derive changes in ice-sheet elevation in southern Greenland, for the years 1978-88, using a physically based model of firn densification and records of annual snow accumulation reconstructed from 12 ice cores at high elevation. Our patterns of accumulation-driven elevation change agree closely with contemporaneous satellite measurements of ice-sheet elevation change, and we therefore attribute the changes observed in 1978-88 to variability in snow accumulation. Similar analyses of longer ice-core records show that in this decade the Greenland ice sheet exhibited typical variability at high elevations, well within the long-term natural variability. Our results indicate that a better understanding of ice-sheet mass changes will require long-term measurements of both surface elevation and snow accumulation.

McDowell, R. E. (1968). "Climate versus man and his animals." Nature **218**(5142): 641-5.

McGee, H. (1998). "In victu veritas." Nature **392**(6677): 649-50.

McKay, C. P., G. D. Clow, et al. (1985). "Thickness of ice on perennially frozen lakes." Nature **313**(6003): 561-2.
The dry valleys of southern Victoria Land, constituting the largest ice-free expanse in the Antarctic, contain numerous lakes whose perennial ice cover is the cause of some unique physical and biological properties. Although the depth, temperature and salinity of the liquid water varies considerably from lake to lake, the thickness of the ice cover is remarkably consistent, ranging from 3.5 to 6 m, which is determined primarily by the balance between conduction of energy out of the ice and the release of latent heat at the ice-water interface and is also affected by the transmission and absorption of sunlight. In the steady state, the release of latent heat at the ice bottom is controlled by ablation from the ice surface. Here we present a simple energy-balance model, using the measured ablation rate of 30 cm yr-1, which can explain the observed ice thickness.

McKay, C. P., O. B. Toon, et al. (1991). "Making Mars habitable." Nature **352**: 489-96.
Mars is believed to be lifeless, but it may be possible to transform it into a planet suitable for habitation by plants, and conceivably humans. The success of such an enterprise would depend on the abundance, distribution and form of materials on the planet that could provide carbon dioxide, water and nitrogen.

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McManus, J. F. (2004). "Palaeoclimate: a great grand-daddy of ice cores." Nature **429**(6992): 611-2.

McManus, J. F., R. Francois, et al. (2004). "Collapse and rapid resumption of Atlantic meridional circulation linked to deglacial climate changes." Nature **428**(6985): 834-7.
The Atlantic meridional overturning circulation is widely believed to affect climate. Changes in ocean circulation have been inferred from records of the deep

water chemical composition derived from sedimentary nutrient proxies, but their impact on climate is difficult to assess because such reconstructions provide insufficient constraints on the rate of overturning. Here we report measurements of 231Pa/230Th, a kinematic proxy for the meridional overturning circulation, in a sediment core from the subtropical North Atlantic Ocean. We find that the meridional overturning was nearly, or completely, eliminated during the coldest deglacial interval in the North Atlantic region, beginning with the catastrophic iceberg discharge Heinrich event H1, 17,500 yr ago, and declined sharply but briefly into the Younger Dryas cold event, about 12,700 yr ago. Following these cold events, the 231Pa/230Th record indicates that rapid accelerations of the meridional overturning circulation were concurrent with the two strongest regional warming events during deglaciation. These results confirm the significance of variations in the rate of the Atlantic meridional overturning circulation for abrupt climate changes.

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McPhaden, M. J. and D. Zhang (2002). "Slowdown of the meridional overturning circulation in the upper Pacific Ocean." Nature **415**(6872): 603-8.

Decadal temperature fluctuations in the Pacific Ocean have a significant effect on marine ecosystems and the climate of North America. The physical mechanisms responsible for these fluctuations are poorly understood. Some theories ascribe a central role to the wind-driven meridional overturning circulation between the tropical and subtropical oceans. Here we show, from observations over the past 50 years, that this overturning circulation has been slowing down since the 1970s, causing a decrease in upwelling of about 25% in an equatorial strip between 9 degrees N and 9 degrees S. This reduction in equatorial upwelling of relatively cool water, from 47 x 10(6) to 35 x 10(6) m3 s(-1), is associated with a rise in equatorial sea surface temperatures of about 0.8 degrees C. Another effect of the slowing circulation is a reduction in the outgassing of CO2 from the equatorial Pacific Ocean-at present the largest oceanic source of carbon dioxide to the atmosphere.

Mellanby, K. (1954). "Acclimatization and the thermal death point in insects." Nature **173**(4404): 582-3.

Mellars, P. (2004). "Neanderthals and the modern human colonization of Europe." Nature **432**(7016): 461-5.

The fate of the Neanderthal populations of Europe and western Asia has gripped the popular and scientific imaginations for the past century. Following at least

200,000 years of successful adaptation to the glacial climates of northwestern Eurasia, they disappeared abruptly between 30,000 and 40,000 years ago, to be replaced by populations all but identical to modern humans. Recent research suggests that the roots of this dramatic population replacement can be traced far back to events on another continent, with the appearance of distinctively modern human remains and artefacts in eastern and southern Africa.

Melville, W. K. and P. Matusov (2002). "Distribution of breaking waves at the ocean surface." Nature **417**(6884): 58-63.

Surface waves play an important role in the exchange of mass, momentum and energy between the atmosphere and the ocean. The development of the wave field depends on wind, wave-wave and wave-current interactions and wave dissipation owing to breaking, which is accompanied by momentum fluxes from waves to currents. Wave breaking supports air-sea fluxes of heat and gas, which have a profound effect on weather and climate. But wave breaking is poorly quantified and understood. Here we present measurements of wave breaking, using aerial imaging and analysis, and provide a statistical description of related sea-surface processes. We find that the distribution of the length of breaking fronts per unit area of sea surface is proportional to the cube of the wind speed and that, within the measured range of the speed of the wave fronts, the length of breaking fronts per unit area is an exponential function of the speed of the front. We also find that the fraction of the ocean surface mixed by breaking waves, which is important for air-sea exchange, is dominated by wave breaking at low velocities and short wavelengths.

Michael Beman, J., K. R. Arrigo, et al. (2005). "Agricultural runoff fuels large phytoplankton blooms in vulnerable areas of the ocean." Nature **434**(7030): 211-4.

Biological productivity in most of the world's oceans is controlled by the supply of nutrients to surface waters. The relative balance between supply and removal of nutrients--including nitrogen, iron and phosphorus--determines which nutrient limits phytoplankton growth. Although nitrogen limits productivity in much of the ocean, large portions of the tropics and subtropics are defined by extreme nitrogen depletion. In these regions, microbial denitrification removes biologically available forms of nitrogen from the water column, producing substantial deficits relative to other nutrients. Here we demonstrate that nitrogen-deficient areas of the tropical and subtropical oceans are acutely vulnerable to nitrogen pollution. Despite naturally high nutrient concentrations and productivity, nitrogen-rich agricultural runoff fuels large (54-577 km2) phytoplankton blooms in the Gulf of California. Runoff exerts a strong and consistent influence on biological processes, in 80% of cases stimulating blooms within days of fertilization and irrigation of agricultural fields. We project that by the year 2050, 27-59% of all nitrogen fertilizer will be applied in developing regions located upstream of nitrogen-deficient marine ecosystems. Our findings highlight the present and future vulnerability of these ecosystems to agricultural runoff.

Milinski, M., D. Semmann, et al. (2002). "Reputation helps solve the 'tragedy of the commons'." Nature **415**(6870): 424-6.

The problem of sustaining a public resource that everybody is free to overuse-the 'tragedy of the commons'-emerges in many social dilemmas, such as our inability to sustain the global climate. Public goods experiments, which are used to study this type of problem, usually confirm that the collective benefit will not be produced. Because individuals and countries often participate in several social games simultaneously, the interaction of these games may provide a sophisticated way by which to maintain the public resource. Indirect reciprocity, 'give and you shall receive', is built on reputation and can sustain a high level of cooperation, as shown by game theorists. Here we show, through alternating rounds of public

goods and indirect reciprocity games, that the need to maintain reputation for indirect reciprocity maintains contributions to the public good at an unexpectedly high level. But if rounds of indirect reciprocation are not expected, then contributions to the public good drop quickly to zero. Alternating the games leads to higher profits for all players. As reputation may be a currency that is valid in many social games, our approach could be used to test social dilemmas for their solubility.

Miller, S. and J. Diamond (2006). "Social sciences: a New World of differences." Nature **441**(7092): 411-2.

Mills, M. M., C. Ridame, et al. (2004). "Iron and phosphorus co-limit nitrogen fixation in the eastern tropical North Atlantic." Nature **429**(6989): 292-4.

The role of iron in enhancing phytoplankton productivity in high nutrient, low chlorophyll oceanic regions was demonstrated first through iron-addition bioassay experiments and subsequently confirmed by large-scale iron fertilization experiments. Iron supply has been hypothesized to limit nitrogen fixation and hence oceanic primary productivity on geological timescales, providing an alternative to phosphorus as the ultimate limiting nutrient. Oceanographic observations have been interpreted both to confirm and refute this hypothesis, but direct experimental evidence is lacking. We conducted experiments to test this hypothesis during the Meteor 55 cruise to the tropical North Atlantic. This region is rich in diazotrophs and strongly impacted by Saharan dust input. Here we show that community primary productivity was nitrogen-limited, and that nitrogen fixation was co-limited by iron and phosphorus. Saharan dust addition stimulated nitrogen fixation, presumably by supplying both iron and phosphorus. Our results support the hypothesis that aeolian mineral dust deposition promotes nitrogen fixation in the eastern tropical North Atlantic.

Milly, P. C., K. A. Dunne, et al. (2005). "Global pattern of trends in streamflow and water availability in a changing climate." Nature **438**(7066): 347-50.

Water availability on the continents is important for human health, economic activity, ecosystem function and geophysical processes. Because the saturation vapour pressure of water in air is highly sensitive to temperature, perturbations in the global water cycle are expected to accompany climate warming. Regional patterns of warming-induced changes in surface hydroclimate are complex and less certain than those in temperature, however, with both regional increases and decreases expected in precipitation and runoff. Here we show that an ensemble of 12 climate models exhibits qualitative and statistically significant skill in simulating observed regional patterns of twentieth-century multidecadal changes in streamflow. These models project 10-40% increases in runoff in eastern equatorial Africa, the La Plata basin and high-latitude North America and Eurasia, and 10-30% decreases in runoff in southern Africa, southern Europe, the Middle East and mid-latitude western North America by the year 2050. Such changes in sustainable water availability would have considerable regional-scale consequences for economies as well as ecosystems.

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Milly, P. C., R. T. Wetherald, et al. (2002). "Increasing risk of great floods in a changing climate." Nature **415**(6871): 514-7.

Radiative effects of anthropogenic changes in atmospheric composition are expected to cause climate changes, in particular an intensification of the global water cycle with a consequent increase in flood risk. But the detection of anthropogenically forced changes in flooding is difficult because of the substantial natural variability; the dependence of streamflow trends on flow regime further complicates the issue. Here we investigate the changes in risk of great floods--that is, floods with discharges exceeding 100-year levels from basins larger than 200,000 km(2)--using both streamflow measurements and numerical simulations of the anthropogenic climate change associated with greenhouse gases and direct radiative effects of sulphate aerosols. We find that the frequency of great floods increased substantially during the twentieth century. The recent emergence of a statistically significant positive trend in risk of great floods is consistent with results from the climate model, and the model suggests that the trend will continue.

Mitrovica, J. X., M. E. Tamisiea, et al. (2001). "Recent mass balance of polar ice sheets inferred from patterns of global sea-level change." Nature **409**(6823): 1026-9.

Global sea level is an indicator of climate change, as it is sensitive to both thermal expansion of the oceans and a reduction of land-based glaciers. Global sea-level rise has been estimated by correcting observations from tide gauges for glacial isostatic adjustment--the continuing sea-level response due to melting of Late Pleistocene ice--and by computing the global mean of these residual trends. In such analyses, spatial patterns of sea-level rise are assumed to be signals that will average out over geographically distributed tide-gauge data. But a long history of modelling studies has demonstrated that non-uniform--that is, non-eustatic--sea-level redistributions can be produced by variations in the volume of the polar ice sheets. Here we present numerical predictions of gravitationally consistent patterns of sea-level change following variations in either the Antarctic or Greenland ice sheets or the melting of a suite of small mountain glaciers. These predictions are characterized by geometrically distinct patterns that reconcile spatial variations in previously published sea-level records. Under the--albeit coarse--assumption of a globally uniform thermal expansion of the oceans, our approach suggests melting of the Greenland ice complex over the last century equivalent to -0.6 mm yr(-1) of sea-level rise.

Mix, A. C. (2003). "Climate change: chilled out in the ice-age Atlantic." Nature **425**(6953): 32-3.

Moberg, A., D. M. Sonechkin, et al. (2005). "Highly variable Northern Hemisphere temperatures reconstructed from low- and high-resolution proxy data." Nature **433**(7026): 613-7.

A number of reconstructions of millennial-scale climate variability have been carried out in order to understand patterns of natural climate variability, on decade to century timescales, and the role of anthropogenic forcing. These reconstructions have mainly used tree-ring data and other data sets of annual to decadal resolution. Lake and ocean sediments have a lower time resolution, but provide climate information at multicentennial timescales that may not be

captured by tree-ring data. Here we reconstruct Northern Hemisphere temperatures for the past 2,000 years by combining low-resolution proxies with tree-ring data, using a wavelet transform technique to achieve timescale-dependent processing of the data. Our reconstruction shows larger multicentennial variability than most previous multi-proxy reconstructions, but agrees well with temperatures reconstructed from borehole measurements and with temperatures obtained with a general circulation model. According to our reconstruction, high temperatures--similar to those observed in the twentieth century before 1990--occurred around ad 1000 to 1100, and minimum temperatures that are about 0.7 K below the average of 1961-90 occurred around ad 1600. This large natural variability in the past suggests an important role of natural multicentennial variability that is likely to continue.

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Mojzsis, S. J. (2003). "Global change: probing early atmospheres." Nature **425**(6955): 249-50.

Moller, P. R., J. G. Nielsen, et al. (2003). "Fish migration: Patagonian toothfish found off Greenland." Nature **421**(6923): 599.

Mollicone, D., H. D. Eva, et al. (2006). "Ecology: human role in Russian wild fires." Nature **440**(7083): 436-7.

Anomalies in temperature and precipitation in northern Russia over the past few years have been viewed as manifestations of anthropogenic climate change, prompting suggestions that this may also account for exceptional forest fires in the region. Here we examine the number of forest-fire events across the boreal Russian Federation for the period 2002 to 2005 in 'intact' forests, where human influence is limited, and in 'non-intact' forests, which have been shaped by human activity. Our results show that there were more fires in years during which the weather was anomalous, but that more than 87% of fires in boreal Russia were started by people.

Monbiot, G., M. Lynas, et al. (2005). "Time to speak up for climate-change science." Nature **434**(7033): 559.

Monbiot, G., M. Lynas, et al. (2005). "Time to speak up for climate-change science."

Nature **434**(7033): 559.

Monson, R. K., D. L. Lipson, et al. (2006). "Winter forest soil respiration controlled by climate and microbial community composition." Nature **439**(7077): 711-4.

Most terrestrial carbon sequestration at mid-latitudes in the Northern Hemisphere occurs in seasonal, montane forest ecosystems. Winter respiratory carbon dioxide losses from these ecosystems are high, and over half of the carbon assimilated by photosynthesis in the summer can be lost the following winter. The amount of winter carbon dioxide loss is potentially susceptible to changes in the depth of the snowpack; a shallower snowpack has less insulation potential, causing colder soil temperatures and potentially lower soil respiration rates. Recent climate analyses have shown widespread declines in the winter snowpack of mountain ecosystems in the western USA and Europe that are coupled to positive temperature anomalies. Here we study the effect of changes in snow cover on soil carbon cycling within the context of natural climate variation. We use a six-year record of net ecosystem carbon dioxide exchange in a subalpine forest to show that years with a reduced winter snowpack are accompanied by significantly lower rates of soil respiration. Furthermore, we show that the cause of the high sensitivity of soil respiration rate to changes in snow depth is a unique soil microbial community that exhibits exponential growth and high rates of substrate utilization at the cold temperatures that exist beneath the snow. Our observations suggest that a warmer climate may change soil carbon sequestration rates in forest ecosystems owing to changes in the depth of the insulating snow cover.

Mooney, H., A. Cropper, et al. (2005). "Confronting the human dilemma." Nature **434**(7033): 561-2.

Moore, G. W., G. Holdsworth, et al. (2002). "Climate change in the North Pacific region over the past three centuries." Nature **420**(6914): 401-3.

The relatively short length of most instrumental climate records restricts the study of climate variability, and it is therefore essential to extend the record into the past with the help of proxy data. Only since the late 1940s have atmospheric data been available that are sufficient in quality and spatial resolution to identify the dominant patterns of climate variability, such as the Pacific North America pattern and the Pacific Decadal Oscillation. Here we present a 301-year snow accumulation record from an ice core at a height of 5,340 m above sea level-from Mount Logan, in northwestern North America. This record shows features that are closely linked with the Pacific North America pattern for the period of instrumental data availability. Our record extends back in time to cover the period from the closing stages of the Little Ice Age to the warmest decade in the past millennium. We find a positive, accelerating trend in snow accumulation after the middle of the nineteenth century. This trend is paralleled by a warming over northwestern North America which has been associated with secular changes in both the Pacific North America pattern and the Pacific Decadal Oscillation.

Moore, P. D. (2000). "Biogeography. Chile refuges." Nature **408**(6812): 532-3.

Moore, P. D. (2002). "Biogeography: baffled over bison." Nature **416**(6880): 488-9.

Moore, P. D. (2002). "Palaeoecology: climate records spruced up." Nature **417**(6885): 133-5.

Moore, P. D. (2002). "Plant ecology: express delivery by bat." Nature **420**(6911): 34-5.

Moore, P. D. (2004). "Ecology: Hope in the hills for tundra?" Nature **432**(7014): 159-60.

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Moran, K., J. Backman, et al. (2006). "The Cenozoic palaeoenvironment of the Arctic Ocean." Nature **441**(7093): 601-5.

The history of the Arctic Ocean during the Cenozoic era (0-65 million years ago) is largely unknown from direct evidence. Here we present a Cenozoic palaeoceanographic record constructed from >400 m of sediment core from a recent drilling expedition to the Lomonosov ridge in the Arctic Ocean. Our record shows a palaeoenvironmental transition from a warm 'greenhouse' world, during the late Palaeocene and early Eocene epochs, to a colder 'icehouse' world influenced by sea ice and icebergs from the middle Eocene epoch to the present. For the most recent approximately 14 Myr, we find sedimentation rates of 1-2 cm per thousand years, in stark contrast to the substantially lower rates proposed in earlier studies; this record of the Neogene reveals cooling of the Arctic that was synchronous with the expansion of Greenland ice (approximately 3.2 Myr ago) and East Antarctic ice (approximately 14 Myr ago). We find evidence for the first occurrence of ice-rafted debris in the middle Eocene epoch (approximately 45 Myr ago), some 35 Myr earlier than previously thought; fresh surface waters were present at approximately 49 Myr ago, before the onset of ice-rafted debris. Also, the temperatures of surface waters during the Palaeocene/Eocene thermal maximum (approximately 55 Myr ago) appear to have been substantially warmer than previously estimated. The revised timing of the earliest Arctic cooling events coincides with those from Antarctica, supporting arguments for bipolar symmetry in climate change.

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Moreno, P. I., G. L. Jacobson, Jr., et al. (2001). "Interhemispheric climate links revealed by late-glacial cooling episode in southern Chile." Nature **409**(6822): 804-8.

Understanding the relative timings of climate events in the Northern and Southern hemispheres is a prerequisite for determining the causes of abrupt climate changes. But climate records from the Patagonian Andes and New Zealand for the period of transition from glacial to interglacial conditions--about 14.6-10 kyr before present, as determined by radiocarbon dating--show varying degrees of correlation with similar records from the Northern Hemisphere. It is necessary to

resolve these apparent discrepancies in order to be able to assess the relative roles of Northern Hemisphere ice sheets and oceanic, atmospheric and astronomical influences in initiating climate change in the late-glacial period. Here we report pollen records from three sites in the Lake District of southern Chile (41 degrees S) from which we infer conditions similar to modern climate between about 13 and 12.2 14C kyr before present (BP), followed by cooling events at about 12.2 and 11.4 14C kyr BP, and then by a warming at about 9.8 14C kyr BP. These events were nearly synchronous with important palaeoclimate changes recorded in the North Atlantic region, supporting the idea that interhemispheric linkage through the atmosphere was the primary control on climate during the last deglaciation. In other regions of the Southern Hemisphere, where climate events are not in phase with those in the Northern Hemisphere, local oceanic influences may have counteracted the effects that propagated through the atmosphere.

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Morris, R. J., O. T. Lewis, et al. (2004). "Experimental evidence for apparent competition in a tropical forest food web." Nature **428**(6980): 310-3.

The herbivorous insects of tropical forests constitute some of the most diverse communities of living organisms. For this reason it has been difficult to discover the degree to which these communities are structured, and by what processes. Interspecific competition for resources does occur, but its contemporary importance is limited because most pairs of potentially competing insects feed on different host plants. An alternative way in which species can interact is through shared natural enemies, a process called apparent competition. Despite extensive theoretical discussion there are few field demonstrations of apparent competition, and none in hyper-diverse tropical communities. Here, we experimentally removed two species of herbivore from a community of leaf-mining insects in a tropical forest. We predicted that other species that share natural enemies with the two removed species would experience lower parasitism and have higher population densities in treatment compared with control sites. In both cases (on removal of a dipteran and a coleopteran leaf-miner species) we found significantly lower parasitism, and in one case (removal of the dipteran) we found significantly higher abundance a year after the manipulation. Our results suggest that apparent competition may be important in structuring tropical insect communities.

Moy, C. M., G. O. Seltzer, et al. (2002). "Variability of El Nino/Southern Oscillation

activity at millennial timescales during the Holocene epoch." Nature **420**(6912): 162-5.
The variability of El Nino/Southern Oscillation (ENSO) during the Holocene epoch, in particular on millennial timescales, is poorly understood. Palaeoclimate studies have documented ENSO variability for selected intervals in the Holocene, but most records are either too short or insufficiently resolved to investigate variability on millennial scales. Here we present a record of sedimentation in Laguna Pallcacocha, southern Ecuador, which is strongly influenced by ENSO variability, and covers the past 12,000 years continuously. We find that changes on a timescale of 2-8 years, which we attribute to warm ENSO events, become more frequent over the Holocene until about 1,200 years ago, and then decline towards the present. Periods of relatively high and low ENSO activity, alternating at a timescale of about 2,000 years, are superimposed on this long-term trend. We attribute the long-term trend to orbitally induced changes in insolation, and suggest internal ENSO dynamics as a possible cause of the millennial variability. However, the millennial oscillation will need to be confirmed in other ENSO proxy records.

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Mudelsee, M., M. Borngen, et al. (2003). "No upward trends in the occurrence of extreme floods in central Europe." Nature **425**(6954): 166-9.
Extreme river floods have been a substantial natural hazard in Europe over the past centuries, and radiative effects of recent anthropogenic changes in atmospheric composition are expected to cause climate changes, especially enhancement of the hydrological cycle, leading to an increased flood risk. For the past few decades, however, observations from Europe do not show a clear increase in flood occurrence rate. Here we present longer-term records of winter and summer floods in two of the largest rivers in central Europe, the Elbe and Oder rivers. For the past 80 to 150 yr, we find a decrease in winter flood occurrence in both rivers, while summer floods show no trend, consistent with trends in extreme precipitation occurrence. The reduction in winter flood occurrence can partly be attributed to fewer events of strong freezing-following such events, breaking river ice at the end of the winter may function as a water barrier and enhance floods severely. Additionally, we detect significant long-term changes in flood occurrence rates in the sixteenth to nineteenth centuries, and conclude that reductions in river length, construction of reservoirs and deforestation have had minor effects on flood frequency.

Murphy, J. M., D. M. Sexton, et al. (2004). "Quantification of modelling uncertainties in a large ensemble of climate change simulations." Nature **430**(7001): 768-72.
Comprehensive global climate models are the only tools that account for the

complex set of processes which will determine future climate change at both a global and regional level. Planners are typically faced with a wide range of predicted changes from different models of unknown relative quality, owing to large but unquantified uncertainties in the modelling process. Here we report a systematic attempt to determine the range of climate changes consistent with these uncertainties, based on a 53-member ensemble of model versions constructed by varying model parameters. We estimate a probability density function for the sensitivity of climate to a doubling of atmospheric carbon dioxide levels, and obtain a 5-95 per cent probability range of 2.4-5.4 degrees C. Our probability density function is constrained by objective estimates of the relative reliability of different model versions, the choice of model parameters that are varied and their uncertainty ranges, specified on the basis of expert advice. Our ensemble produces a range of regional changes much wider than indicated by traditional methods based on scaling the response patterns of an individual simulation.

Murray, N. and M. Holman (2001). "The role of chaotic resonances in the Solar System." Nature **410**(6830): 773-9.

Our understanding of the Solar System has been revolutionized over the past decade by the finding that the orbits of the planets are inherently chaotic. In extreme cases, chaotic motions can change the relative positions of the planets around stars, and even eject a planet from a system. Moreover, the spin axis of a planet-Earth's spin axis regulates our seasons-may evolve chaotically, with adverse effects on the climates of otherwise biologically interesting planets. Some of the recently discovered extrasolar planetary systems contain multiple planets, and it is likely that some of these are chaotic as well.

Murray, T. (2006). "Climate change: Greenland's ice on the scales." Nature **443**(7109): 277-8.

Muscheler, R., F. Joos, et al. (2005). "Climate: how unusual is today's solar activity?" Nature **436**(7050): E3-4; discussion E4-5.

To put global warming into context requires knowledge about past changes in solar activity and the role of the Sun in climate change. Solanki et al. propose that solar activity during recent decades was exceptionally high compared with that over the preceding 8,000 years. However, our extended analysis of the radiocarbon record reveals several periods during past centuries in which the strength of the magnetic field in the solar wind was similar to, or even higher than, that of today.

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strength of the magnetic field in the solar wind was similar to, or even higher than, that of today.

Mustard, J. F., C. D. Cooper, et al. (2001). "Evidence for recent climate change on Mars from the identification of youthful near-surface ground ice." Nature **412**(6845): 411-4.

Ground ice in the crust and soil may be one of the largest reservoirs of water on Mars. Near-surface ground ice is predicted to be stable at latitudes higher than 40 degrees (ref. 4), where a number of geomorphologic features indicative of viscous creep and hence ground ice have been observed. Mid-latitude soils have also been implicated as a water-ice reservoir, the capacity of which is predicted to vary on a 100,000-year timescale owing to orbitally driven variations in climate. It is uncertain, however, whether near-surface ground ice currently exists at these latitudes, and how it is changing with time. Here we report observational evidence for a mid-latitude reservoir of near-surface water ice occupying the pore space of soils. The thickness of the ice-occupied soil reservoir (1-10 m) and its distribution in the 30 degrees to 60 degrees latitude bands indicate a reservoir of (1.5-6.0) x 104 km3, equivalent to a global layer of water 10-40 cm thick. We infer that the reservoir was created during the last phase of high orbital obliquity less than 100,000 years ago, and is now being diminished.

Mysterud, A., N. C. Stenseth, et al. (2001). "Nonlinear effects of large-scale climatic variability on wild and domestic herbivores." Nature **410**(6832): 1096-9.

Large-scale climatic fluctuations, such as the North Atlantic Oscillation (NAO), have been shown to affect many ecological processes. Such effects have been typically assumed to be linear. Only one study has reported a nonlinear relation; however, that nonlinear relation was monotonic (that is, no reversal). Here we show that there is a strong nonlinear and non-monotonic (that is, reversed) effect of the NAO on body weight during the subsequent autumn for 23,838 individual wild red deer (Cervus elaphus) and 139,485 individual domestic sheep (Ovis aries) sampled over several decades on the west coast of Norway. These relationships are, at least in part, explained by comparable nonlinear and non-monotonic relations between the NAO and local climatic variables (temperature, precipitation and snow depth). The similar patterns observed for red deer and sheep, the latter of which live indoors during winter and so experience a stable energy supply in winter, suggest that the (winter) climatic variability (for which the index is a proxy) must influence the summer foraging conditions directly or indirectly.

Najman, Y., M. Pringle, et al. (2001). "Dating of the oldest continental sediments from the Himalayan foreland basin." Nature **410**(6825): 194-7.

A detailed knowledge of Himalayan development is important for our wider understanding of several global processes, ranging from models of plateau uplift to changes in oceanic chemistry and climate. Continental sediments 55 Myr old found in a foreland basin in Pakistan are, by more than 20 Myr, the oldest deposits thought to have been eroded from the Himalayan metamorphic mountain belt. This constraint on when erosion began has influenced models of the timing and diachrony of the India-Eurasia collision, timing and mechanisms of exhumation and uplift, as well as our general understanding of foreland basin dynamics. But the depositional age of these basin sediments was based on biostratigraphy from four intercalated marl units. Here we present dates of 257 detrital grains of white mica from this succession, using the 40Ar-39Ar method, and find that the largest concentration of ages are at 36-40 Myr. These dates are incompatible with the biostratigraphy unless the mineral ages have been reset, a possibility that we reject on the basis of a number of lines of evidence. A more detailed mapping of this formation suggests that the marl units are structurally intercalated with the continental sediments and accordingly that biostratigraphy cannot be used to date the clastic succession. The oldest continental foreland

basin sediments containing metamorphic detritus eroded from the Himalaya orogeny therefore seem to be at least 15-20 Myr younger than previously believed, and models based on the older age must be re-evaluated.

Naqvi, S. W., D. A. Jayakumar, et al. (2000). "Increased marine production of N2O due to intensifying anoxia on the Indian continental shelf." Nature **408**(6810): 346-9.

Eutrophication of surface waters and hypoxia in bottom waters has been increasing in many coastal areas, leading to very large depletions of marine life in the affected regions. These areas of high surface productivity and low bottom-water oxygen concentration are caused by increasing runoff of nutrients from land. Although the local ecological and socio-economic effects have received much attention, the potential contribution of increasing hypoxia to global-change phenomena is unknown. Here we report the intensification of one of the largest low-oxygen zones in the ocean, which develops naturally over the western Indian continental shelf during late summer and autumn. We also report the highest accumulations yet observed of hydrogen sulphide (H2S) and nitrous oxide (N2O) in open coastal waters. Increased N2O production is probably caused by the addition of anthropogenic nitrate and its subsequent denitrification, which is favoured by hypoxic conditions. We suggest that a global expansion of hypoxic zones may lead to an increase in marine production and emission of N2O, which, as a potent greenhouse gas, could contribute significantly to the accumulation of radiatively active trace gases in the atmosphere.

Nathan, R., G. G. Katul, et al. (2002). "Mechanisms of long-distance dispersal of seeds by wind." Nature **418**(6896): 409-13.

Long-distance dispersal (LDD) is central to species expansion following climate change, re-colonization of disturbed areas and control of pests. The current paradigm is that the frequency and spatial extent of LDD events are extremely difficult to predict. Here we show that mechanistic models coupling seed release and aerodynamics with turbulent transport processes provide accurate probabilistic descriptions of LDD of seeds by wind. The proposed model reliably predicts the vertical distribution of dispersed seeds of five tree species observed along a 45-m high tower in an eastern US deciduous forest. Simulations show that uplifting above the forest canopy is necessary and sufficient for LDD, hence, they provide the means to define LDD quantitatively rather than arbitrarily. Seed uplifting probability thus sets an upper bound on the probability of long-distance colonization. Uplifted yellow poplar seeds are on average lighter than seeds at the forest floor, but also include the heaviest seeds. Because uplifting probabilities are appreciable (as much as 1 5%), and tree seed crops are commonly massive, some LDD events will establish individuals that can critically affect plant dynamics on large scales.

Nee, S. (2002). "Biodiversity: thinking big in ecology." Nature **417**(6886): 229-30.

Neff, J. C., A. R. Townsend, et al. (2002). "Variable effects of nitrogen additions on the stability and turnover of soil carbon." Nature **419**(6910): 915-7.

Soils contain the largest near-surface reservoir of terrestrial carbon and so knowledge of the factors controlling soil carbon storage and turnover is essential for understanding the changing global carbon cycle. The influence of climate on decomposition of soil carbon has been well documented, but there remains considerable uncertainty in the potential response of soil carbon dynamics to the rapid global increase in reactive nitrogen (coming largely from agricultural fertilizers and fossil fuel combustion). Here, using 14C, 13C and compound-specific analyses of soil carbon from long-term nitrogen fertilization plots, we show that nitrogen additions significantly accelerate decomposition of light soil carbon fractions (with decadal turnover times) while further stabilizing soil carbon compounds in heavier, mineral-associated fractions (with multidecadal to century

lifetimes). Despite these changes in the dynamics of different soil pools, we observed no significant changes in bulk soil carbon, highlighting a limitation inherent to the still widely used single-pool approach to investigating soil carbon responses to changing environmental conditions. It remains to be seen if the effects observed here-caused by relatively high, short-term fertilizer additions-are similar to those arising from lower, long-term additions of nitrogen to natural ecosystems from atmospheric deposition, but our results suggest nonetheless that current models of terrestrial carbon cycling do not contain the mechanisms needed to capture the complex relationship between nitrogen availability and soil carbon storage.

Neff, U., S. J. Burns, et al. (2001). "Strong coherence between solar variability and the monsoon in Oman between 9 and 6 kyr ago." Nature **411**(6835): 290-3.

Variations in the amount of solar radiation reaching the Earth are thought to influence climate, but the extent of this influence on timescales of millennia to decades is unclear. A number of climate records show correlations between solar cycles and climate, but the absolute changes in solar intensity over the range of decades to millennia are small and the influence of solar flux on climate is not well established. The formation of stalagmites in northern Oman has recorded past northward shifts of the intertropical convergence zone, whose northward migration stops near the southern shoreline of Arabia in the present climate. Here we present a high-resolution record of oxygen isotope variations, for the period from 9.6 to 6.1 kyr before present, in a Th-U-dated stalagmite from Oman. The delta18O record from the stalagmite, which serves as a proxy for variations in the tropical circulation and monsoon rainfall, allows us to make a direct comparison of the delta18O record with the Delta14C record from tree rings, which largely reflects changes in solar activity. The excellent correlation between the two records suggests that one of the primary controls on centennial- to decadal-scale changes in tropical rainfall and monsoon intensity during this time are variations in solar radiation.

Nelson, F. E., O. A. Anisimov, et al. (2001). "Subsidence risk from thawing permafrost." Nature **410**(6831): 889-90.

Newsom, H. E. (1996). "Planetary science. Martians in a deep freeze." Nature **379**(6562): 205-6.

Noren, A. J., P. R. Bierman, et al. (2002). "Millennial-scale storminess variability in the northeastern United States during the Holocene epoch." Nature **419**(6909): 821-4.

For the purpose of detecting the effects of human activities on climate change, it is important to document natural change in past climate. In this context, it has proved particularly difficult to study the variability in the occurrence of extreme climate events, such as storms with exceptional rainfall. Previous investigations have established storm chronologies using sediment cores from single lakes, but such studies can be susceptible to local environmental bias. Here we date terrigenous inwash layers in cores from 13 lakes, which show that the frequency of storm-related floods in the northeastern United States has varied in regular cycles during the past 13,000 years (13 kyr), with a characteristic period of about 3 kyr. Our data show four peaks in storminess during the past 14 kyr, approximately 2.6, 5.8, 9.1 and 11.9 kyr ago. This pattern is consistent with long-term changes in the average sign of the Arctic Oscillation, suggesting that modulation of this dominant atmospheric mode may account for a significant fraction of Holocene climate variability in North America and Europe.

Norris, R. D. and C. de Vargas (2000). "Evolution all at sea." Nature **405**(6782): 23-4.

Nosengo, N. (2003). "Fertilized to death." Nature **425**(6961): 894-5.

Nott, J. and M. Hayne (2001). "High frequency of 'super-cyclones' along the Great Barrier Reef over the past 5,000 years." Nature **413**(6855): 508-12.

Understanding long-term variability in the occurrence of tropical cyclones that are of extreme intensity is important for determining their role in ecological disturbances, for predicting present and future community vulnerability and economic loss and for assessing whether changes in the variability of such cyclones are induced by climate change. Our ability to accurately make these assessments has been limited by the short (less than 100 years) instrumented record of cyclone intensity. Here we determine the intensity of prehistoric tropical cyclones over the past 5,000 years from ridges of detrital coral and shell deposited above highest tide and terraces that have been eroded into coarse-grained alluvial fan deposits. These features occur along 1,500 km of the Great Barrier Reef and also the Gulf of Carpentaria, Australia. We infer that the deposits were formed by storms with recurrence intervals of two to three centuries, and we show that the cyclones responsible must have been of extreme intensity (central pressures less than 920 hPa). Our estimate of the frequency of such 'super-cyclones' is an order of magnitude higher than that previously estimated (which was once every several millennia), and is sufficiently high to suggest that the character of rainforests and coral reef communities were probably shaped by these events.

Novotny, V., Y. Basset, et al. (2002). "Low host specificity of herbivorous insects in a tropical forest." Nature **416**(6883): 841-4.

Two decades of research have not established whether tropical insect herbivores are dominated by specialists or generalists. This impedes our understanding of species coexistence in diverse rainforest communities. Host specificity and species richness of tropical insects are also key parameters in mapping global patterns of biodiversity. Here we analyse data for over 900 herbivorous species feeding on 51 plant species in New Guinea and show that most herbivorous species feed on several closely related plant species. Because species-rich genera are dominant in tropical floras, monophagous herbivores are probably rare in tropical forests. Furthermore, even between phylogenetically distant hosts, herbivore communities typically shared a third of their species. These results do not support the classical view that the coexistence of herbivorous species in the tropics is a consequence of finely divided plant resources; non-equilibrium models of tropical diversity should instead be considered. Low host specificity of tropical herbivores reduces global estimates of arthropod diversity from 31 million (ref. 1) to 4 6 million species. This finding agrees with estimates based on taxonomic collections, reconciling an order of magnitude discrepancy between extrapolations of global diversity based on ecological samples of tropical communities with those based on sampling regional faunas.

Nunes, F. and R. D. Norris (2006). "Abrupt reversal in ocean overturning during the Palaeocene/Eocene warm period." Nature **439**(7072): 60-3.

An exceptional analogue for the study of the causes and consequences of global warming occurs at the Palaeocene/Eocene Thermal Maximum, 55 million years ago. A rapid rise of global temperatures during this event accompanied turnovers in both marine and terrestrial biota, as well as significant changes in ocean chemistry and circulation. Here we present evidence for an abrupt shift in deep-ocean circulation using carbon isotope records from fourteen sites. These records indicate that deep-ocean circulation patterns changed from Southern Hemisphere overturning to Northern Hemisphere overturning at the start of the Palaeocene/Eocene Thermal Maximum. This shift in the location of deep-water formation persisted for at least 40,000 years, but eventually recovered to original circulation patterns. These results corroborate climate model inferences that a shift in deep-ocean circulation would deliver relatively warmer waters to the deep

sea, thus producing further warming. Greenhouse conditions can thus initiate abrupt deep-ocean circulation changes in less than a few thousand years, but may have lasting effects; in this case taking 100,000 years to revert to background conditions.

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O'Brien, C. M., C. J. Fox, et al. (2000). "Climate variability and North Sea cod." Nature **404**(6774): 142.

O'Dowd, C. D., P. Aalto, et al. (2002). "Aerosol formation: atmospheric particles from organic vapours." Nature **416**(6880): 497-8.

Aerosol particles produced over forested areas may affect climate by acting as nuclei for cloud condensation, but their composition (and hence the chemical species that drive their production) remains an open question. Here we show, to our knowledge for the first time, that these newly formed particles (3-5 nm in diameter) are composed primarily of organic species, such as cis-pinonic acid and pinic acid, produced by oxidation of terpenes in organic vapours released from the canopy.

O'Dowd, C. D., M. C. Facchini, et al. (2004). "Biogenically driven organic contribution to marine aerosol." Nature **431**(7009): 676-80.

Marine aerosol contributes significantly to the global aerosol load and consequently has an important impact on both the Earth's albedo and climate. So far, much of the focus on marine aerosol has centred on the production of aerosol from sea-salt and non-sea-salt sulphates. Recent field experiments, however, have shown that known aerosol production processes for inorganic species cannot account for the entire aerosol mass that occurs in submicrometre sizes. Several experimental studies have pointed to the presence of significant concentrations of organic matter in marine aerosol. There is some information available about the composition of organic matter, but the contribution of organic matter to marine aerosol, as a function of aerosol size, as well as its characterization as hydrophilic or hydrophobic, has been lacking. Here we measure the physical and chemical characteristics of submicrometre marine aerosol over the North Atlantic Ocean during plankton blooms progressing from spring through to autumn. We find that during bloom periods, the organic fraction dominates and contributes 63% to the submicrometre aerosol mass (about 45% is water-insoluble and about 18% water-soluble). In winter, when biological activity is at its lowest, the organic fraction decreases to 15%. Our model simulations indicate that organic matter can enhance the cloud droplet concentration by 15% to more than 100% and is

therefore an important component of the aerosol-cloud-climate feedback system involving marine biota.

O'Dowd, C. D., J. L. Jimenez, et al. (2002). "Marine aerosol formation from biogenic iodine emissions." Nature **417**(6889): 632-6.

The formation of marine aerosols and cloud condensation nuclei--from which marine clouds originate--depends ultimately on the availability of new, nanometre-scale particles in the marine boundary layer. Because marine aerosols and clouds scatter incoming radiation and contribute a cooling effect to the Earth's radiation budget, new particle production is important in climate regulation. It has been suggested that sulphuric acid derived from the oxidation of dimethyl sulphide is responsible for the production of marine aerosols and cloud condensation nuclei. It was accordingly proposed that algae producing dimethyl sulphide play a role in climate regulation, but this has been difficult to prove and, consequently, the processes controlling marine particle formation remains largely undetermined. Here, using smog chamber experiments under coastal atmospheric conditions, we demonstrate that new particles can form from condensable iodine-containing vapours, which are the photolysis products of biogenic iodocarbons emitted from marine algae. Moreover, we illustrate, using aerosol formation models, that concentrations of condensable iodine-containing vapours over the open ocean are sufficient to influence marine particle formation. We suggest therefore that marine iodocarbon emissions have a potentially significant effect on global radiative forcing.

O'Reilly, C. M., S. R. Alin, et al. (2003). "Climate change decreases aquatic ecosystem productivity of Lake Tanganyika, Africa." Nature **424**(6950): 766-8.

Although the effects of climate warming on the chemical and physical properties of lakes have been documented, biotic and ecosystem-scale responses to climate change have been only estimated or predicted by manipulations and models. Here we present evidence that climate warming is diminishing productivity in Lake Tanganyika, East Africa. This lake has historically supported a highly productive pelagic fishery that currently provides 25-40% of the animal protein supply for the populations of the surrounding countries. In parallel with regional warming patterns since the beginning of the twentieth century, a rise in surface-water temperature has increased the stability of the water column. A regional decrease in wind velocity has contributed to reduced mixing, decreasing deep-water nutrient upwelling and entrainment into surface waters. Carbon isotope records in sediment cores suggest that primary productivity may have decreased by about 20%, implying a roughly 30% decrease in fish yields. Our study provides evidence that the impact of regional effects of global climate change on aquatic ecosystem functions and services can be larger than that of local anthropogenic activity or overfishing.

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Oechel, W. C., G. L. Vourlitis, et al. (2000). "Acclimation of ecosystem CO2 exchange in the Alaskan Arctic in response to decadal climate warming." Nature **406**(6799): 978-81.

Long-term sequestration of carbon in Alaskan Arctic tundra ecosystems was reversed by warming and drying of the climate in the early 1980s, resulting in substantial losses of terrestrial carbon. But recent measurements suggest that continued warming and drying has resulted in diminished CO2 efflux, and in some cases, summer CO2 sink activity. Here we compile summer CO2 flux data for two Arctic ecosystems from 1960 to the end of 1998. The results show that a return to summer sink activity has come during the warmest and driest period observed over the past four decades, and indicates a previously undemonstrated capacity for ecosystems to metabolically adjust to long-term (decadal or longer) changes in climate. The mechanisms involved are likely to include changes in nutrient cycling, physiological acclimation, and population and community reorganization. Nevertheless, despite the observed acclimation, the Arctic ecosystems studied are still annual net sources of CO2 to the atmosphere of at least 40 g C m(-2) yr(-1), due to winter release of CO2, implying that further climate change may still exacerbate CO2 emissions from Arctic ecosystems.

Ohmoto, H., Y. Watanabe, et al. (2006). "Sulphur isotope evidence for an oxic Archaean atmosphere." Nature **442**(7105): 908-11.

The presence of mass-independently fractionated sulphur isotopes (MIF-S) in many sedimentary rocks older than approximately 2.4 billion years (Gyr), and the absence of MIF-S in younger rocks, has been considered the best evidence for a dramatic change from an anoxic to oxic atmosphere around 2.4 Gyr ago. This is because the only mechanism known to produce MIF-S has been ultraviolet photolysis of volcanic sulphur dioxide gas in an oxygen-poor atmosphere. Here we report the absence of MIF-S throughout approximately 100-m sections of 2.76-Gyr-old lake sediments and 2.92-Gyr-old marine shales in the Pilbara Craton, Western Australia. We propose three possible interpretations of the MIF-S geologic record: (1) the level of atmospheric oxygen fluctuated greatly during the Archaean era; (2) the atmosphere has remained oxic since approximately 3.8 Gyr ago, and MIF-S in sedimentary rocks represents times and regions of violent volcanic eruptions that ejected large volumes of sulphur dioxide into the stratosphere; or (3) MIF-S in rocks was mostly created by non-photochemical reactions during sediment diagenesis, and thus is not linked to atmospheric chemistry.

Ohmoto, H., Y. Watanabe, et al. (2004). "Evidence from massive siderite beds for a CO2-rich atmosphere before approximately 1.8 billion years ago." Nature **429**(6990): 395-9.

It is generally thought that, in order to compensate for lower solar flux and maintain liquid oceans on the early Earth, methane must have been an important greenhouse gas before approximately 2.2 billion years (Gyr) ago. This is based upon a simple thermodynamic calculation that relates the absence of siderite (FeCO3) in some pre-2.2-Gyr palaeosols to atmospheric CO2 concentrations that would have been too low to have provided the necessary greenhouse effect. Using multi-dimensional thermodynamic analyses and geological evidence, we show here that the absence of siderite in palaeosols does not constrain atmospheric CO2 concentrations. Siderite is absent in many palaeosols (both pre- and post-2.2-Gyr in age) because the O2 concentrations and pH conditions in well-aerated soils have favoured the formation of ferric (Fe3+)-rich minerals, such as goethite, rather than siderite. Siderite, however, has formed throughout geological history in subsurface environments, such as euxinic seas, where anaerobic organisms

created H2-rich conditions. The abundance of large, massive siderite-rich beds in pre-1.8-Gyr sedimentary sequences and their carbon isotope ratios indicate that the atmospheric CO2 concentration was more than 100 times greater than today, causing the rain and ocean waters to be more acidic than today. We therefore conclude that CO2 alone (without a significant contribution from methane) could have provided the necessary greenhouse effect to maintain liquid oceans on the early Earth.

Oldfield, F. (2000). "Palaeoclimatology. Out of Africa." Nature **403**(6768): 370-1.

Oldfield, F. (2000). "Palaeoclimatology. Out of Africa." Nature **403**(6768): 370-1.

Oppo, D. W., J. F. McManus, et al. (2003). "Palaeo-oceanography: Deepwater variability in the Holocene epoch." Nature **422**(6929): 277.

Orme, J. E. (1963). "An Ante-Natal Determinant of Intelligence." Nature **200**: 1239.

Orr, J. C., V. J. Fabry, et al. (2005). "Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms." Nature **437**(7059): 681-6.

Today's surface ocean is saturated with respect to calcium carbonate, but increasing atmospheric carbon dioxide concentrations are reducing ocean pH and carbonate ion concentrations, and thus the level of calcium carbonate saturation. Experimental evidence suggests that if these trends continue, key marine organisms--such as corals and some plankton--will have difficulty maintaining their external calcium carbonate skeletons. Here we use 13 models of the ocean-carbon cycle to assess calcium carbonate saturation under the IS92a 'business-as-usual' scenario for future emissions of anthropogenic carbon dioxide. In our projections, Southern Ocean surface waters will begin to become undersaturated with respect to aragonite, a metastable form of calcium carbonate, by the year 2050. By 2100, this undersaturation could extend throughout the entire Southern Ocean and into the subarctic Pacific Ocean. When live pteropods were exposed to our predicted level of undersaturation during a two-day shipboard experiment, their aragonite shells showed notable dissolution. Our findings indicate that conditions detrimental to high-latitude ecosystems could develop within decades, not centuries as suggested previously.

Osman Hel, S. (1967). "Serum transferrin polymorphism in the desert sheep in the Sudan." Nature **215**(5097): 162-3.

Overpeck, J. T. (2000). "Climate change. The hole record." Nature **403**(6771): 714-5.

Paabo, S. (1985). "Molecular cloning of Ancient Egyptian mummy DNA." Nature **314**(6012): 644-5.

Artificial mummification was practised in Egypt from approximately 2600 BC until the fourth century AD. Because of the dry Egyptian climate, however, there are also many natural mummies preserved from earlier as well as later times. To elucidate whether this unique source of ancient human remains can be used for molecular genetic analyses, 23 mummies were investigated for DNA content. One 2,400-yr-old mummy of a child was found to contain DNA that could be molecularly cloned in a plasmid vector. I report here that one such clone contains two members of the Alu family of human repetitive DNA sequences, as detected by DNA hybridizations and nucleotide sequencing. These analyses show that substantial pieces of mummy DNA (3.4 kilobases) can be cloned and that the DNA fragments seem to contain little or no modifications introduced postmortem.

Pachauri, R. (2005). "Climate change: is the US Congress bullying experts? Rajendra

Pachauri interviewed by Quirin Schiermeier." Nature **436**(7047): 7.

Pagani, M., N. Pedentchouk, et al. (2006). "Arctic hydrology during global warming at the Palaeocene/Eocene thermal maximum." Nature **442**(7103): 671-5.

The Palaeocene/Eocene thermal maximum represents a period of rapid, extreme global warming 55 million years ago, superimposed on an already warm world. This warming is associated with a severe shoaling of the ocean calcite compensation depth and a >2.5 per mil negative carbon isotope excursion in marine and soil carbonates. Together these observations indicate a massive release of 13C-depleted carbon and greenhouse-gas-induced warming. Recently, sediments were recovered from the central Arctic Ocean, providing the first opportunity to evaluate the environmental response at the North Pole at this time. Here we present stable hydrogen and carbon isotope measurements of terrestrial-plant- and aquatic-derived n-alkanes that record changes in hydrology, including surface water salinity and precipitation, and the global carbon cycle. Hydrogen isotope records are interpreted as documenting decreased rainout during moisture transport from lower latitudes and increased moisture delivery to the Arctic at the onset of the Palaeocene/Eocene thermal maximum, consistent with predictions of poleward storm track migrations during global warming. The terrestrial-plant carbon isotope excursion (about -4.5 to -6 per mil) is substantially larger than those of marine carbonates. Previously, this offset was explained by the physiological response of plants to increases in surface humidity. But this mechanism is not an effective explanation in this wet Arctic setting, leading us to hypothesize that the true magnitude of the excursion--and associated carbon input--was greater than originally surmised. Greater carbon release and strong hydrological cycle feedbacks may help explain the maintenance of this unprecedented warmth.

Page, S. E., F. Siegert, et al. (2002). "The amount of carbon released from peat and forest fires in Indonesia during 1997." Nature **420**(6911): 61-5.

Tropical peatlands are one of the largest near-surface reserves of terrestrial organic carbon, and hence their stability has important implications for climate change. In their natural state, lowland tropical peatlands support a luxuriant growth of peat swamp forest overlying peat deposits up to 20 metres thick. Persistent environmental change-in particular, drainage and forest clearing-threatens their stability, and makes them susceptible to fire. This was demonstrated by the occurrence of widespread fires throughout the forested peatlands of Indonesia during the 1997 El Nino event. Here, using satellite images of a 2.5 million hectare study area in Central Kalimantan, Borneo, from before and after the 1997 fires, we calculate that 32% (0.79 Mha) of the area had burned, of which peatland accounted for 91.5% (0.73 Mha). Using ground measurements of the burn depth of peat, we estimate that 0.19-0.23 gigatonnes (Gt) of carbon were released to the atmosphere through peat combustion, with a further 0.05 Gt released from burning of the overlying vegetation. Extrapolating these estimates to Indonesia as a whole, we estimate that between 0.81 and 2.57 Gt of carbon were released to the atmosphere in 1997 as a result of burning peat and vegetation in Indonesia. This is equivalent to 13-40% of the mean annual global carbon emissions from fossil fuels, and contributed greatly to the largest annual increase in atmospheric CO(2) concentration detected since records began in 1957 (ref. 1).

Paillard, D. (2001). "Climatology. Glacial hiccups." Nature **409**(6817): 147-8.

Palmer, T. N. (2005). "More power needed to probe cloud systems." Nature **434**(7031): 271.

Palmer, T. N. (2005). "More power needed to probe cloud systems." Nature **434**(7031):

271.

Palmer, T. N. and J. Raisanen (2002). "Quantifying the risk of extreme seasonal precipitation events in a changing climate." Nature **415**(6871): 512-4.

Increasing concentrations of atmospheric carbon dioxide will almost certainly lead to changes in global mean climate. But because--by definition--extreme events are rare, it is significantly more difficult to quantify the risk of extremes. Ensemble-based probabilistic predictions, as used in short- and medium-term forecasts of weather and climate, are more useful than deterministic forecasts using a 'best guess' scenario to address this sort of problem. Here we present a probabilistic analysis of 19 global climate model simulations with a generic binary decision model. We estimate that the probability of total boreal winter precipitation exceeding two standard deviations above normal will increase by a factor of five over parts of the UK over the next 100 years. We find similar increases in probability for the Asian monsoon region in boreal summer, with implications for flooding in Bangladesh. Further practical applications of our techniques would be helped by the use of larger ensembles (for a more complete sampling of model uncertainty) and a wider range of scenarios at a resolution adequate to analyse average-size river basins.

Palter, J. B., M. S. Lozier, et al. (2005). "The effect of advection on the nutrient reservoir in the North Atlantic subtropical gyre." Nature **437**(7059): 687-92.

Though critically important in sustaining the ocean's biological pump, the cycling of nutrients in the subtropical gyres is poorly understood. The supply of nutrients to the sunlit surface layer of the ocean has traditionally been attributed solely to vertical processes. However, horizontal advection may also be important in establishing the availability of nutrients. Here we show that the production and advection of North Atlantic Subtropical Mode Water introduces spatial and temporal variability in the subsurface nutrient reservoir beneath the North Atlantic subtropical gyre. As the mode water is formed, its nutrients are depleted by biological utilization. When the depleted water mass is exported to the gyre, it injects a wedge of low-nutrient water into the upper layers of the ocean. Contrary to intuition, cold winters that promote deep convective mixing and vigorous mode water formation may diminish downstream primary productivity by altering the subsurface delivery of nutrients.

Parfitt, S. A., R. W. Barendregt, et al. (2005). "The earliest record of human activity in northern Europe." Nature **438**(7070): 1008-12.

The colonization of Eurasia by early humans is a key event after their spread out of Africa, but the nature, timing and ecological context of the earliest human occupation of northwest Europe is uncertain and has been the subject of intense debate. The southern Caucasus was occupied about 1.8 million years (Myr) ago, whereas human remains from Atapuerca-TD6, Spain (more than 780 kyr ago) and Ceprano, Italy (about 800 kyr ago) show that early Homo had dispersed to the Mediterranean hinterland before the Brunhes-Matuyama magnetic polarity reversal (780 kyr ago). Until now, the earliest uncontested artefacts from northern Europe were much younger, suggesting that humans were unable to colonize northern latitudes until about 500 kyr ago. Here we report flint artefacts from the Cromer Forest-bed Formation at Pakefield (52 degrees N), Suffolk, UK, from an interglacial sequence yielding a diverse range of plant and animal fossils. Event and lithostratigraphy, palaeomagnetism, amino acid geochronology and biostratigraphy indicate that the artefacts date to the early part of the Brunhes Chron (about 700 kyr ago) and thus represent the earliest unequivocal evidence for human presence north of the Alps.

Parker, A. R. and C. R. Lawrence (2001). "Water capture by a desert beetle." Nature **414**(6859): 33-4.

Some beetles in the Namib Desert collect drinking water from fog-laden wind on their backs. We show here that these large droplets form by virtue of the insect's bumpy surface, which consists of alternating hydrophobic, wax-coated and hydrophilic, non-waxy regions. The design of this fog-collecting structure can be reproduced cheaply on a commercial scale and may find application in water-trapping tent and building coverings, for example, or in water condensers and engines.

Parker, D. E. (2004). "Climate: large-scale warming is not urban." Nature **432**(7015): 290.

Controversy has persisted over the influence of urban warming on reported large-scale surface-air temperature trends. Urban heat islands occur mainly at night and are reduced in windy conditions. Here we show that, globally, temperatures over land have risen as much on windy nights as on calm nights, indicating that the observed overall warming is not a consequence of urban development.

Parmesan, C. and G. Yohe (2003). "A globally coherent fingerprint of climate change impacts across natural systems." Nature **421**(6918): 37-42.

Causal attribution of recent biological trends to climate change is complicated because non-climatic influences dominate local, short-term biological changes. Any underlying signal from climate change is likely to be revealed by analyses that seek systematic trends across diverse species and geographic regions; however, debates within the Intergovernmental Panel on Climate Change (IPCC) reveal several definitions of a 'systematic trend'. Here, we explore these differences, apply diverse analyses to more than 1,700 species, and show that recent biological trends match climate change predictions. Global meta-analyses documented significant range shifts averaging 6.1 km per decade towards the poles (or metres per decade upward), and significant mean advancement of spring events by 2.3 days per decade. We define a diagnostic fingerprint of temporal and spatial 'sign-switching' responses uniquely predicted by twentieth century climate trends. Among appropriate long-term/large-scale/multi-species data sets, this diagnostic fingerprint was found for 279 species. This suite of analyses generates 'very high confidence' (as laid down by the IPCC) that climate change is already affecting living systems.

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Parr, D. (2005). "Unlike climate science, GM is full of uncertainties." Nature **436**(7049): 328.

Parr, D. (2005). "Unlike climate science, GM is full of uncertainties." Nature **436**(7049): 328.

Parry, D. A. (1951). "Microclimate close to the ground." Nature **167**(4237): 73-4.

Pastor, J. and R. A. Moen (2004). "Palaeontology: ecology of ice-age extinctions." Nature **431**(7009): 639-40.

Patel, S. S. (2006). "Climate science: a sinking feeling." Nature **440**(7085): 734-6.

Patrinos, A. and A. Bamzai (2005). "Policy needs robust climate science." Nature **438**(7066): 285.

Patrinos, A. and A. Bamzai (2005). "Policy needs robust climate science." Nature **438**(7066): 285.

Patz, J. A., D. Campbell-Lendrum, et al. (2005). "Impact of regional climate change on human health." Nature **438**(7066): 310-7.

The World Health Organisation estimates that the warming and precipitation trends due to anthropogenic climate change of the past 30 years already claim over 150,000 lives annually. Many prevalent human diseases are linked to climate fluctuations, from cardiovascular mortality and respiratory illnesses due to heatwaves, to altered transmission of infectious diseases and malnutrition from crop failures. Uncertainty remains in attributing the expansion or resurgence of diseases to climate change, owing to lack of long-term, high-quality data sets as well as the large influence of socio-economic factors and changes in immunity and drug resistance. Here we review the growing evidence that climate-health relationships pose increasing health risks under future projections of climate change and that the warming trend over recent decades has already contributed to increased morbidity and mortality in many regions of the world. Potentially vulnerable regions include the temperate latitudes, which are projected to warm disproportionately, the regions around the Pacific and Indian oceans that are currently subjected to large rainfall variability due to the El Nino/Southern Oscillation sub-Saharan Africa and sprawling cities where the urban heat island effect could intensify extreme climatic events.

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Patz, J. A., M. Hulme, et al. (2002). "Climate change: Regional warming and malaria

resurgence." Nature **420**(6916): 627-8; discussion 628.

Patz, J. A., M. Hulme, et al. (2002). "Climate change: Regional warming and malaria resurgence." Nature **420**(6916): 627-8; discussion 628.

Paytan, A. (2000). "Global change. Iron uncertainty." Nature **406**(6795): 468-9.

Pearson, P. N., P. W. Ditchfield, et al. (2001). "Warm tropical sea surface temperatures in the Late Cretaceous and Eocene epochs." Nature **413**(6855): 481-7.

Climate models with increased levels of carbon dioxide predict that global warming causes heating in the tropics, but investigations of ancient climates based on palaeodata have generally indicated cool tropical temperatures during supposed greenhouse episodes. For example, in the Late Cretaceous and Eocene epochs there is abundant geological evidence for warm, mostly ice-free poles, but tropical sea surface temperatures are generally estimated to be only 15-23 degrees C, based on oxygen isotope palaeothermometry of surface-dwelling planktonic foraminifer shells. Here we question the validity of most such data on the grounds of poor preservation and diagenetic alteration. We present new data from exceptionally well preserved foraminifer shells extracted from impermeable clay-rich sediments, which indicate that for the intervals studied, tropical sea surface temperatures were at least 28-32 degrees C. These warm temperatures are more in line with our understanding of the geographical distributions of temperature-sensitive fossil organisms and the results of climate models with increased CO2 levels.

Pearson, P. N. and M. R. Palmer (2000). "Atmospheric carbon dioxide concentrations over the past 60 million years." Nature **406**(6797): 695-9.

Knowledge of the evolution of atmospheric carbon dioxide concentrations throughout the Earth's history is important for a reconstruction of the links between climate and radiative forcing of the Earth's surface temperatures. Although atmospheric carbon dioxide concentrations in the early Cenozoic era (about 60 Myr ago) are widely believed to have been higher than at present, there is disagreement regarding the exact carbon dioxide levels, the timing of the decline and the mechanisms that are most important for the control of CO2 concentrations over geological timescales. Here we use the boron-isotope ratios of ancient planktonic foraminifer shells to estimate the pH of surface-layer sea water throughout the past 60 million years, which can be used to reconstruct atmospheric CO2 concentrations. We estimate CO2 concentrations of more than 2,000 p.p.m. for the late Palaeocene and earliest Eocene periods (from about 60 to 52 Myr ago), and find an erratic decline between 55 and 40 Myr ago that may have been caused by reduced CO2 outgassing from ocean ridges, volcanoes and metamorphic belts and increased carbon burial. Since the early Miocene (about 24 Myr ago), atmospheric CO2 concentrations appear to have remained below 500 p.p.m. and were more stable than before, although transient intervals of CO2 reduction may have occurred during periods of rapid cooling approximately 15 and 3 Myr ago.

Peeters, F. J., R. Acheson, et al. (2004). "Vigorous exchange between the Indian and Atlantic oceans at the end of the past five glacial periods." Nature **430**(7000): 661-5.

The magnitude of heat and salt transfer between the Indian and Atlantic oceans through 'Agulhas leakage' is considered important for balancing the global thermohaline circulation. Increases or reductions of this leakage lead to strengthening or weakening of the Atlantic meridional overturning and associated variation of North Atlantic Deep Water formation. Here we show that modern Agulhas waters, which migrate into the south Atlantic Ocean in the form of an Agulhas ring, contain a characteristic assemblage of planktic foraminifera. We use this assemblage as a modern analogue to investigate the Agulhas leakage history over the past 550,000 years from a sediment record in the Cape basin. Our

reconstruction indicates that Indian-Atlantic water exchange was highly variable: enhanced during present and past interglacials and largely reduced during glacial intervals. Coherent variability of Agulhas leakage with northern summer insolation suggests a teleconnection to the monsoon system. The onset of increased Agulhas leakage during late glacial conditions took place when glacial ice volume was maximal, suggesting a crucial role for Agulhas leakage in glacial terminations, timing of interhemispheric climate change and the resulting resumption of the Atlantic meridional overturning circulation.

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Peizhen, Z., P. Molnar, et al. (2001). "Increased sedimentation rates and grain sizes 2-4 Myr ago due to the influence of climate change on erosion rates." Nature **410**(6831): 891-7.

Around the globe, and in a variety of settings including active and inactive mountain belts, increases in sedimentation rates as well as in grain sizes of sediments were recorded at approximately 2-4 Myr ago, implying increased erosion rates. A change in climate represents the only process that is globally synchronous and can potentially account for the widespread increase in erosion and sedimentation, but no single process-like a lowering of sea levels or expanded glaciation-can explain increases in sedimentation in all environments, encompassing continental margins and interiors, and tropical as well as higher latitudes. We suggest that climate affected erosion mainly by the transition from a period of climate stability, in which landscapes had attained equilibrium configurations, to a time of frequent and abrupt changes in temperature, precipitation and vegetation, which prevented fluvial and glacial systems from establishing equilibrium states.

Penner, J. E. (2004). "Climate change: the cloud conundrum." Nature **432**(7020): 962-3.

Penner, J. E., X. Dong, et al. (2004). "Observational evidence of a change in radiative forcing due to the indirect aerosol effect." Nature **427**(6971): 231-4.

Anthropogenic aerosols enhance cloud reflectivity by increasing the number concentration of cloud droplets, leading to a cooling effect on climate known as the indirect aerosol effect. Observational support for this effect is based mainly on evidence that aerosol number concentrations are connected with droplet concentrations, but it has been difficult to determine the impact of these indirect effects on radiative forcing. Here we provide observational evidence for a substantial alteration of radiative fluxes due to the indirect aerosol effect. We

examine the effect of aerosols on cloud optical properties using measurements of aerosol and cloud properties at two North American sites that span polluted and clean conditions-a continental site in Oklahoma with high aerosol concentrations, and an Arctic site in Alaska with low aerosol concentrations. We determine the cloud optical depth required to fit the observed shortwave downward surface radiation. We then use a cloud parcel model to simulate the cloud optical depth from observed aerosol properties due to the indirect aerosol effect. From the good agreement between the simulated indirect aerosol effect and observed surface radiation, we conclude that the indirect aerosol effect has a significant influence on radiative fluxes.

Perakis, S. S. and L. O. Hedin (2002). "Nitrogen loss from unpolluted South American forests mainly via dissolved organic compounds." Nature **415**(6870): 416-9.

Conceptual and numerical models of nitrogen cycling in temperate forests assume that nitrogen is lost from these ecosystems predominantly by way of inorganic forms, such as nitrate and ammonium ions. Of these, nitrate is thought to be particularly mobile, being responsible for nitrogen loss to deep soil and stream waters. But human activities-such as fossil fuel combustion, fertilizer production and land-use change-have substantially altered the nitrogen cycle over large regions, making it difficult to separate natural aspects of nitrogen cycling from those induced by human perturbations. Here we report stream chemistry data from 100 unpolluted primary forests in temperate South America. Although the sites exhibit a broad range of environmental factors that influence ecosystem nutrient cycles (such as climate, parent material, time of ecosystem development, topography and biotic diversity), we observed a remarkably consistent pattern of nitrogen loss across all forests. In contrast to findings from forests in polluted regions, streamwater nitrate concentrations are exceedingly low, such that nitrate to ammonium ratios were less than unity, and dissolved organic nitrogen is responsible for the majority of nitrogen losses from these forests. We therefore suggest that organic nitrogen losses should be considered in models of forest nutrient cycling, which could help to explain observations of nutrient limitation in temperate forest ecosystems.

Percy, K. E., C. S. Awmack, et al. (2002). "Altered performance of forest pests under atmospheres enriched by CO2 and O3." Nature **420**(6914): 403-7.

Human activity causes increasing background concentrations of the greenhouse gases CO2 and O3. Increased levels of CO2 can be found in all terrestrial ecosystems. Damaging O3 concentrations currently occur over 29% of the world's temperate and subpolar forests but are predicted to affect fully 60% by 2100 (ref. 3). Although individual effects of CO2 and O3 on vegetation have been widely investigated, very little is known about their interaction, and long-term studies on mature trees and higher trophic levels are extremely rare. Here we present evidence from the most widely distributed North American tree species, Populus tremuloides, showing that CO2 and O3, singly and in combination, affected productivity, physical and chemical leaf defences and, because of changes in plant quality, insect and disease populations. Our data show that feedbacks to plant growth from changes induced by CO2 and O3 in plant quality and pest performance are likely. Assessments of global change effects on forest ecosystems must therefore consider the interacting effects of CO2 and O3 on plant performance, as well as the implications of increased pest activity.

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Peterson, A. T., M. A. Ortega-Huerta, et al. (2002). "Future projections for Mexican faunas under global climate change scenarios." Nature **416**(6881): 626-9.

Global climates are changing rapidly, with unexpected consequences. Because elements of biodiversity respond intimately to climate as an important driving force of distributional limitation, distributional shifts and biodiversity losses are expected. Nevertheless, in spite of modelling efforts focused on single species or entire ecosystems, a few preliminary surveys of fauna-wide effects, and evidence of climate change-mediated shifts in several species, the likely effects of climate change on species' distributions remain little known, and fauna-wide or community-level effects are almost completely unexplored. Here, using a genetic algorithm and museum specimen occurrence data, we develop ecological niche models for 1,870 species occurring in Mexico and project them onto two climate surfaces modelled for 2055. Although extinctions and drastic range reductions are predicted to be relatively few, species turnover in some local communities is predicted to be high (>40% of species), suggesting that severe ecological perturbations may result.

Pfeiffer, T. and M. A. Nowak (2006). "Climate change: all in the game." Nature **441**(7093): 583-4.

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Phillips, O. L., R. Vasquez Martinez, et al. (2002). "Increasing dominance of large lianas in Amazonian forests." Nature **418**(6899): 770-4.

Ecological orthodoxy suggests that old-growth forests should be close to dynamic equilibrium, but this view has been challenged by recent findings that neotropical forests are accumulating carbon and biomass, possibly in response to the increasing atmospheric concentrations of carbon dioxide. However, it is unclear whether the recent increase in tree biomass has been accompanied by a shift in community composition. Such changes could reduce or enhance the carbon storage potential of old-growth forests in the long term. Here we show that non-fragmented Amazon forests are experiencing a concerted increase in the density, basal area and mean size of woody climbing plants (lianas). Over the last two decades of the twentieth century the dominance of large lianas relative to trees has increased by 1.7-4.6% a year. Lianas enhance tree mortality and suppress tree growth, so their rapid increase implies that the tropical terrestrial carbon sink may shut down sooner than current models suggest. Predictions of future tropical carbon fluxes will need to account for the changing composition and dynamics of supposedly undisturbed forests.

Picton, H. D. (1978). "Climate and reproduction of grizzly bears in Yellowstone National Park." Nature **274**(5674): 888-9.

Pielke, R. A., Jr. (2005). "Meteorology: are there trends in hurricane destruction?"

Nature **438**(7071): E11; discussion E13.

Since the record impact of Hurricane Katrina, attention has focused on understanding trends in hurricanes and their destructive potential. Emanuel reports a marked increase in the potential destructiveness of hurricanes based on identification of a trend in an accumulated annual index of power dissipation in the North Atlantic and western North Pacific since the 1970s. If hurricanes are indeed becoming more destructive over time, then this trend should manifest itself in more destruction. However, my analysis of a long-term data set of hurricane losses in the United States shows no upward trend once the data are normalized to remove the effects of societal changes.

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Pienitz, R. and W. F. Vincent (2000). "Effect of climate change relative to ozone depletion on UV exposure in subarctic lakes." Nature **404**(6777): 484-7.

The effect of stratospheric ozone depletion on increases in ambient levels of solar ultraviolet (UV) radiation in high-latitude regions' has raised concerns about the response of northern ecosystems to environmental change. The concentration of coloured dissolved organic material, which is derived from terrestrial vegetation and acts as a screen for ultraviolet radiation, is low in high-latitude lakes. The underwater light environment in these lakes is therefore likely to be sensitive to small variations in the supply of this material, in addition to the effects of ozone depletion. Here we use fossil diatom assemblages in combination with bio-optical models to estimate the magnitude of past variations in the underwater light regime of a lake at the boreal tree line. We find large shifts in underwater UV-B, UV-A and photosynthetically available radiation associated with changes in the input of coloured dissolved organic material into subarctic lakes during the Holocene. The inferred changes in biological exposure to UV radiation were at least two orders of magnitude greater than those associated with moderate (30%) ozone depletion. Our findings indicate that freshwater ecosystems at present located across vegetation gradients will experience significant shifts in underwater spectral irradiance through the effects of climate change on catchment vegetation and the export of coloured dissolved organic material.

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The effect of stratospheric ozone depletion on increases in ambient levels of solar ultraviolet (UV) radiation in high-latitude regions' has raised concerns about the response of northern ecosystems to environmental change. The concentration of coloured dissolved organic material, which is derived from terrestrial vegetation and acts as a screen for ultraviolet radiation, is low in high-latitude lakes. The underwater light environment in these lakes is therefore likely to be sensitive to small variations in the supply of this material, in addition to the effects of ozone depletion. Here we use fossil diatom assemblages in combination with bio-optical models to estimate the magnitude of past variations in the underwater light regime of a lake at the boreal tree line. We find large shifts in

underwater UV-B, UV-A and photosynthetically available radiation associated with changes in the input of coloured dissolved organic material into subarctic lakes during the Holocene. The inferred changes in biological exposure to UV radiation were at least two orders of magnitude greater than those associated with moderate (30%) ozone depletion. Our findings indicate that freshwater ecosystems at present located across vegetation gradients will experience significant shifts in underwater spectral irradiance through the effects of climate change on catchment vegetation and the export of coloured dissolved organic material.

Pierce, J. L., G. A. Meyer, et al. (2004). "Fire-induced erosion and millennial-scale climate change in northern ponderosa pine forests." Nature **432**(7013): 87-90.

Western US ponderosa pine forests have recently suffered extensive stand-replacing fires followed by hillslope erosion and sedimentation. These fires are usually attributed to increased stand density as a result of fire suppression, grazing and other land use, and are often considered uncharacteristic or unprecedented. Tree-ring records from the past 500 years indicate that before Euro-American settlement, frequent, low-severity fires maintained open stands. However, the pre-settlement period between about ad 1500 and ad 1900 was also generally colder than present, raising the possibility that rapid twentieth-century warming promoted recent catastrophic fires. Here we date fire-related sediment deposits in alluvial fans in central Idaho to reconstruct Holocene fire history in xeric ponderosa pine forests and examine links to climate. We find that colder periods experienced frequent low-severity fires, probably fuelled by increased understory growth. Warmer periods experienced severe droughts, stand-replacing fires and large debris-flow events that comprise a large component of long-term erosion and coincide with similar events in sub-alpine forests of Yellowstone National Park. Our results suggest that given the powerful influence of climate, restoration of processes typical of pre-settlement times may be difficult in a warmer future that promotes severe fires.

Pierrehumbert, R. T. (2002). "The hydrologic cycle in deep-time climate problems." Nature **419**(6903): 191-8.

Hydrology refers to the whole panoply of effects the water molecule has on climate and on the land surface during its journey there and back again between ocean and atmosphere. On its way, it is cycled through vapour, cloud water, snow, sea ice and glacier ice, as well as acting as a catalyst for silicate-carbonate weathering reactions governing atmospheric carbon dioxide. Because carbon dioxide affects the hydrologic cycle through temperature, climate is a pas des deux between carbon dioxide and water, with important guest appearances by surface ice cover.

Pierrehumbert, R. T. (2004). "High levels of atmospheric carbon dioxide necessary for the termination of global glaciation." Nature **429**(6992): 646-9.

The possibility that the Earth suffered episodes of global glaciation as recently as the Neoproterozoic period, between about 900 and 543 million years ago, has been widely discussed. Termination of such 'hard snowball Earth' climate states has been proposed to proceed from accumulation of carbon dioxide in the atmosphere. Many salient aspects of the snowball scenario depend critically on the threshold of atmospheric carbon dioxide concentrations needed to trigger deglaciation. Here I present simulations with a general circulation model, using elevated carbon dioxide levels to estimate this deglaciation threshold. The model simulates several phenomena that are expected to be significant in a 'snowball Earth' scenario, but which have not been considered in previous studies with less sophisticated models, such as a reduction of vertical temperature gradients in winter, a reduction in summer tropopause height, the effect of snow cover and a reduction in cloud greenhouse effects. In my simulations, the system remains far

short of deglaciation even at atmospheric carbon dioxide concentrations of 550 times the present levels (0.2 bar of CO2). I find that at much higher carbon dioxide levels, deglaciation is unlikely unless unknown feedback cycles that are not captured in the model come into effect.

Pimm, S. L. (2001). "Entrepreneurial insects." Nature **411**(6837): 531-2.

Pimm, S. L. (2001). "Entrepreneurial insects." Nature **411**(6837): 531-2.

Piperno, D. R., A. J. Ranere, et al. (2000). "Starch grains reveal early root crop horticulture in the Panamanian tropical forest." Nature **407**(6806): 894-7.

Native American populations are known to have cultivated a large number of plants and domesticated them for their starch-rich underground organs. Suggestions that the likely source of many of these crops, the tropical forest, was an early and influential centre of plant husbandry have long been controversial because the organic remains of roots and tubers are poorly preserved in archaeological sediments from the humid tropics. Here we report the occurrence of starch grains identifiable as manioc (Manihot esculenta Crantz), yams (Dioscorea sp.) and arrowroot (Maranta arundinacea L.) on assemblages of plant milling stones from preceramic horizons at the Aguadulce Shelter, Panama, dated between 7,000 and 5,000 years before present (BP). The artefacts also contain maize starch (Zea mays L.), indicating that early horticultural systems in this region were mixtures of root and seed crops. The data provide the earliest direct evidence for root crop cultivation in the Americas, and support an ancient and independent emergence of plant domestication in the lowland Neotropical forest.

Pitty, A. F. (1968). "Particle size of the Saharan dust which fell in Britain in July 1968." Nature **220**(5165): 364-5.

Plug, L. J. and B. T. Werner (2002). "Nonlinear dynamics of ice-wedge networks and resulting sensitivity to severe cooling events." Nature **417**(6892): 929-33.

Patterns of subsurface wedges of ice that form along cooling-induced tension fractures, expressed at the ground surface by ridges or troughs spaced 10 30 m apart, are ubiquitous in polar lowlands. Fossilized ice wedges, which are widespread at lower latitudes, have been used to infer the duration and mean temperature of cold periods within Proterozoic and Quaternary climates, and recent climate trends have been inferred from fracture frequency in active ice wedges. Here we present simulations from a numerical model for the evolution of ice-wedge networks over a range of climate scenarios, based on the interactions between thermal tensile stress, fracture and ice wedges. We find that short-lived periods of severe cooling permanently alter the spacing between ice wedges as well as their fracture frequency. This affects the rate at which the widths of ice wedges increase as well as the network's response to subsequent climate change. We conclude that wedge spacing and width in ice-wedge networks mainly reflect infrequent episodes of rapidly falling ground temperatures rather than mean conditions.

Pockley, P. (2000). "Global warming identified as main threat to coral reefs." Nature **407**(6807): 932.

Pockley, P. (2000). "As scientists raise alarm over coral reefs." Nature **408**(6808): 9.

Pockley, P. (2000). "As scientists raise alarm over coral reefs." Nature **408**(6808): 9.

Pockley, P. (2001). "Climate change transforms island ecosystem." Nature **410**(6829): 616.

Pockley, P. (2001). "Climate change transforms island ecosystem." Nature **410**(6829):

616.

Porter, J. R. (2005). "Rising temperatures are likely to reduce crop yields." Nature **436**(7048): 174.

Post, E. and M. C. Forchhammer (2002). "Synchronization of animal population dynamics by large-scale climate." Nature **420**(6912): 168-71.

The hypothesis that animal population dynamics may be synchronized by climate is highly relevant in the context of climate change because it suggests that several populations might respond simultaneously to climatic trends if their dynamics are entrained by environmental correlation. The dynamics of many species throughout the Northern Hemisphere are influenced by a single large-scale climate system, the North Atlantic Oscillation (NAO), which exerts highly correlated regional effects on local weather. But efforts to attribute synchronous fluctuations of contiguous populations to large-scale climate are confounded by the synchronizing influences of dispersal or trophic interactions. Here we report that the dynamics of caribou and musk oxen on opposite coasts of Greenland show spatial synchrony among populations of both species that correlates with the NAO index. Our analysis shows that the NAO has an influence in the high degree of cross-species synchrony between pairs of caribou and musk oxen populations separated by a minimum of 1,000 km of inland ice. The vast distances, and complete physical and ecological separation of these species, rule out spatial coupling by dispersal or interaction. These results indicate that animal populations of different species may respond synchronously to global climate change over large regions.

Poulet, F., J. P. Bibring, et al. (2005). "Phyllosilicates on Mars and implications for early martian climate." Nature **438**(7068): 623-7.

The recent identification of large deposits of sulphates by remote sensing and in situ observations has been considered evidence of the past presence of liquid water on Mars. Here we report the unambiguous detection of diverse phyllosilicates, a family of aqueous alteration products, on the basis of observations by the OMEGA imaging spectrometer on board the Mars Express spacecraft. These minerals are mainly associated with Noachian outcrops, which is consistent with an early active hydrological system, sustaining the long-term contact of igneous minerals with liquid water. We infer that the two main families of hydrated alteration products detected-phyllosilicates and sulphates--result from different formation processes. These occurred during two distinct climatic episodes: an early Noachian Mars, resulting in the formation of hydrated silicates, followed by a more acidic environment, in which sulphates formed.

Poulsen, C. J. (2004). "Palaeoclimate: a balmy Arctic." Nature **432**(7019): 814-5.

Poulsen, C. J. (2004). "Palaeoclimate: a balmy Arctic." Nature **432**(7019): 814-5.

Pounds, J. A. (2001). "Climate and amphibian declines." Nature **410**(6829): 639-40.

Pounds, J. A., M. R. Bustamante, et al. (2006). "Widespread amphibian extinctions from epidemic disease driven by global warming." Nature **439**(7073): 161-7.

As the Earth warms, many species are likely to disappear, often because of changing disease dynamics. Here we show that a recent mass extinction associated with pathogen outbreaks is tied to global warming. Seventeen years ago, in the mountains of Costa Rica, the Monteverde harlequin frog (Atelopus sp.) vanished along with the golden toad (Bufo periglenes). An estimated 67% of the 110 or so species of Atelopus, which are endemic to the American tropics, have met the same fate, and a pathogenic chytrid fungus (Batrachochytrium dendrobatidis) is implicated. Analysing the timing of losses in relation to changes in sea surface and

air temperatures, we conclude with 'very high confidence' (> 99%, following the Intergovernmental Panel on Climate Change, IPCC) that large-scale warming is a key factor in the disappearances. We propose that temperatures at many highland localities are shifting towards the growth optimum of Batrachochytrium, thus encouraging outbreaks. With climate change promoting infectious disease and eroding biodiversity, the urgency of reducing greenhouse-gas concentrations is now undeniable.

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Pounds, J. A. and R. Puschendorf (2004). "Ecology: clouded futures." Nature **427**(6970): 107-9.

Powell, K. (2002). "Bush climate-change plan gets cool response." Nature **420**(6916): 595.

Powell, K. (2002). "Bush climate-change plan gets cool response." Nature **420**(6916): 595.

Powell, K. (2006). "Climate science: the son also rises." Nature **440**(7084): 597-9.

Powell, K. (2006). "Climate science: the son also rises." Nature **440**(7084): 597-9.

Powlson, D. (2005). "Climatology: will soil amplify climate change?" Nature **433**(7023): 204-5.

Powlson, D. (2005). "Climatology: will soil amplify climate change?" Nature **433**(7023): 204-5.

Price, C. (2000). "Evidence for a link between global lightning activity and upper tropospheric water vapour." Nature **406**(6793): 290-3.

Tropospheric water vapour is a key element of the Earth's climate, which has direct effects as a greenhouse gas, as well as indirect effects through interaction with clouds, aerosols and tropospheric chemistry. Small changes in upper-tropospheric water vapour have a much larger impact on the greenhouse effect than small changes in water vapour in the lower atmosphere, but whether this impact is a positive or negative feedback remains uncertain. The main challenge in addressing this question is the difficulty in monitoring upper-tropospheric water vapour globally over long timescales. Here I show that upper-tropospheric water-vapour variability and global lightning activity are closely linked, suggesting that upper-tropospheric water-vapour changes can be inferred from records of global

lightning activity, readily obtained from observations at a single location on the Earth's surface. This correlation reflects the fact that continental deep-convective thunderstorms transport large amounts of water vapour into the upper troposphere and thereby dominate the variations of global upper-tropospheric water vapour while producing most of the lightning on Earth. As global lightning induces Schumann resonances, an electromagnetic phenomenon in the atmosphere that can be observed easily at low cost, monitoring of these resonances might provide a convenient method for tracking upper-tropospheric water-vapour variability and hence contribute to a better understanding of the processes affecting climate change.

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Prinn, R. G. (2001). "Planetary science. Climate change on Venus." Nature **412**(6842): 36-7.

Prokopenko, A. A., E. B. Karabanov, et al. (2002). "Age of long sediment cores from Lake Baikal." Nature **415**(6875): 976.

The new BDP-98 drill core of the Baikal Drilling Project is a key palaeoclimate record in continental Asia because globally sensitive sedimentary records of such length and continuity are very rare. Kashiwaya et al. have attempted signal processing of the BDP-98 average grain-size record, but in constructing their age model they excised a 100-metre interval from the 600-metre section, stating that it is "erroneous". On the basis of our lithological studies, we consider that this excision is unjustified.

Prokopenko, A. A., D. F. Williams, et al. (2002). "Muted climate variations in continental Siberia during the mid-Pleistocene epoch." Nature **418**(6893): 65-8.

The large difference in carbon and oxygen isotope data from the marine record between marine oxygen isotope stage 12 (MIS 12) and MIS 11, spanning the interval between about 480 and 380 kyr ago, has been interpreted as a transition between an extremely cold glacial period and an unusually warm interglacial period, with consequences for global ice volume, sea level and the global carbon cycle. The extent of the change is intriguing, because orbital forcing is predicted to have been relatively weak at that time. Here we analyse a continuous sediment record from Lake Baikal, Siberia, which reveals a virtually continuous interglacial

diatom assemblage, a stable littoral benthic diatom assemblage and lithogenic sediments with 'interglacial' characteristics for the period from MIS 15a to MIS 11 (from about 580 to 380 kyr ago). From these data, we infer significantly weaker climate contrasts between MIS 12 and 11 than during more recent glacial-interglacial transitions in the late Pleistocene epoch (about 130 to 10 kyr ago). For the period from MIS 15a to MIS 11, we also infer an apparent lack of extensive mountain glaciation.

Pugh, L. G. (1957). "Physiological expedition to the Antarctic." Nature **180**(4588): 683.

Qian, H. and R. E. Ricklefs (2000). "Large-scale processes and the Asian bias in species diversity of temperate plants." Nature **407**(6801): 180-2.

An important issue in the study of biodiversity is the extent to which global patterns of species richness reflect large-scale processes and historical contingencies. Ecological interactions in local assemblages may constrain the number of species that can coexist, but differences in diversity in similar habitats within different regions (diversity anomalies) suggest that this limit is not firm. Variation in rate of species production could influence regional and perhaps local diversity independently of the ecological capacity of an area to support coexisting species, thereby creating diversity anomalies. Temperate Zone genera of plants that are disjunct between similar environments in eastern Asia and eastern North America (EAS-ENA) have twice as many species in Asia as in North America. Because lineages of these genera in Asia and North America are mostly sister pairs, they share a common history of adaptation and ecological relationship before disjunction. Thus, the diversity anomaly in EAS-ENA genera is not an artefact of taxon or habitat sampling but reflects differences in the net diversification (speciation-extinction) of the lineages in each of the continents. Here we propose that the most probable cause of the EAS-ENA anomaly in diversity is the extreme physiographical heterogeneity of temperate eastern Asia, especially compared with eastern North America, which in conjunction with climate and sea-level change has provided abundant opportunities for evolutionary radiation through allopatric speciation.

Raghoebarsing, A. A., A. J. Smolders, et al. (2005). "Methanotrophic symbionts provide carbon for photosynthesis in peat bogs." Nature **436**(7054): 1153-6.

Wetlands are the largest natural source of atmospheric methane, the second most important greenhouse gas. Methane flux to the atmosphere depends strongly on the climate; however, by far the largest part of the methane formed in wetland ecosystems is recycled and does not reach the atmosphere. The biogeochemical controls on the efficient oxidation of methane are still poorly understood. Here we show that submerged Sphagnum mosses, the dominant plants in some of these habitats, consume methane through symbiosis with partly endophytic methanotrophic bacteria, leading to highly effective in situ methane recycling. Molecular probes revealed the presence of the bacteria in the hyaline cells of the plant and on stem leaves. Incubation with (13)C-methane showed rapid in situ oxidation by these bacteria to carbon dioxide, which was subsequently fixed by Sphagnum, as shown by incorporation of (13)C-methane into plant sterols. In this way, methane acts as a significant (10-15%) carbon source for Sphagnum. The symbiosis explains both the efficient recycling of methane and the high organic carbon burial in these wetland ecosystems.

Rahmstorf, S. (2002). "Ocean circulation and climate during the past 120,000 years." Nature **419**(6903): 207-14.

Oceans cover more than two-thirds of our blue planet. The waters move in a global circulation system, driven by subtle density differences and transporting huge amounts of heat. Ocean circulation is thus an active and highly nonlinear player in the global climate game. Increasingly clear evidence implicates ocean

circulation in abrupt and dramatic climate shifts, such as sudden temperature changes in Greenland on the order of 5-10 degrees C and massive surges of icebergs into the North Atlantic Ocean --events that have occurred repeatedly during the last glacial cycle.

Rahmstorf, S. (2003). "Thermohaline circulation: The current climate." Nature **421**(6924): 699.

Raisbeck, G. M., F. Yiou, et al. (2006). "10Be evidence for the Matuyama-Brunhes geomagnetic reversal in the EPICA Dome C ice core." Nature **444**(7115): 82-4.
An ice core drilled at Dome C, Antarctica, is the oldest ice core so far retrieved. On the basis of ice flow modelling and a comparison between the deuterium signal in the ice with climate records from marine sediment cores, the ice at a depth of 3,190 m in the Dome C core is believed to have been deposited around 800,000 years ago, offering a rare opportunity to study climatic and environmental conditions over this time period. However, an independent determination of this age is important because the deuterium profile below a depth of 3,190 m depth does not show the expected correlation with the marine record. Here we present evidence for enhanced 10Be deposition in the ice at 3,160-3,170 m, which we interpret as a result of the low dipole field strength during the Matuyama-Brunhes geomagnetic reversal, which occurred about 780,000 years ago. If correct, this provides a crucial tie point between ice cores, marine cores and a radiometric timescale.

Ramos, F. M. (2005). "Internet forest-watchers a new force for conservation." Nature **437**(7063): 1232.

Randel, W. J. (2004). "Climate: wider connections for El Nino." Nature **431**(7011): 920-1.

Raper, S. C. and R. J. Braithwaite (2006). "Low sea level rise projections from mountain glaciers and icecaps under global warming." Nature **439**(7074): 311-3.
The mean sea level has been projected to rise in the 21st century as a result of global warming. Such projections of sea level change depend on estimated future greenhouse emissions and on differing models, but model-average results from a mid-range scenario (A1B) suggests a 0.387-m rise by 2100 (refs 1, 2). The largest contributions to sea level rise are estimated to come from thermal expansion (0.288 m) and the melting of mountain glaciers and icecaps (0.106 m), with smaller inputs from Greenland (0.024 m) and Antarctica (- 0.074 m). Here we apply a melt model and a geometric volume model to our lower estimate of ice volume and assess the contribution of glaciers to sea level rise, excluding those in Greenland and Antarctica. We provide the first separate assessment of melt contributions from mountain glaciers and icecaps, as well as an improved treatment of volume shrinkage. We find that icecaps melt more slowly than mountain glaciers, whose area declines rapidly in the 21st century, making glaciers a limiting source for ice melt. Using two climate models, we project sea level rise due to melting of mountain glaciers and icecaps to be 0.046 and 0.051 m by 2100, about half that of previous projections.

Rau, G. H., T. Takahashi, et al. (1989). "Latitudinal variations in plankton delta 13C: implications for CO2 and productivity in past oceans." Nature **341**(6242): 516-8.
The stable-carbon isotopic composition of marine organic material has varied significantly over geological time, and reflects significant excursions in the isotopic fractionation associated with the uptake of carbon by marine biota. For example, low 13C/12C in Cretaceous sediments has been attributed to elevated atmospheric (and hence oceanic) CO2 partial pressures. A similar depletion in 13C present-day Antarctic plankton has also been ascribed to high CO2

availability. We report, however, that this high-latitude isotope depletion develops at CO2 partial pressures (pCO2 levels) that are often below that of the present atmosphere (340 microatmospheres) , and usually below that of equatorial upwelling systems (> 340 microatmospheres). Nevertheless, because of the much lower water temperatures and, hence, greater CO2 solubility at high latitude, the preceding pCO2 measurements translate into Antarctic surface-water CO2 (aq) concentrations that are as much as 2.5 times higher than in equatorial waters. We calculate that an oceanic pCO2 level of > 800 microatmospheres (over twice the present atmospheric pCO2) in a warmer low-latitude Cretaceous ocean would have been required to produce the plankton 13C depletion preserved in Cretaceous sediments.

Ravelo, A. C., D. H. Andreasen, et al. (2004). "Regional climate shifts caused by gradual global cooling in the Pliocene epoch." Nature **429**(6989): 263-7.

The Earth's climate has undergone a global transition over the past four million years, from warm conditions with global surface temperatures about 3 degrees C warmer than today, smaller ice sheets and higher sea levels to the current cooler conditions. Tectonic changes and their influence on ocean heat transport have been suggested as forcing factors for that transition, including the onset of significant Northern Hemisphere glaciation approximately 2.75 million years ago, but the ultimate causes for the climatic changes are still under debate. Here we compare climate records from high latitudes, subtropical regions and the tropics, indicating that the onset of large glacial/interglacial cycles did not coincide with a specific climate reorganization event at lower latitudes. The regional differences in the timing of cooling imply that global cooling was a gradual process, rather than the response to a single threshold or episodic event as previously suggested. We also find that high-latitude climate sensitivity to variations in solar heating increased gradually, culminating after cool tropical and subtropical upwelling conditions were established two million years ago. Our results suggest that mean low-latitude climate conditions can significantly influence global climate feedbacks.

Raymond, P. A. (2005). "Carbon cycle: the age of the Amazon's breath." Nature **436**(7050): 469-70.

Raynaud, D., J. M. Barnola, et al. (2005). "Palaeoclimatology: the record for marine isotopic stage 11." Nature **436**(7047): 39-40.

The marine isotopic stage 11 (MIS 11) is an extraordinarily long interglacial period in the Earth's history that occurred some 400,000 years ago and lasted for about 30,000 years. During this period there were weak, astronomically induced changes in the distribution of solar energy reaching the Earth. The conditions of this orbital climate forcing are similar to those of today's interglacial period, and they rendered the climate susceptible to other forcing--for example, to changes in the level of atmospheric carbon dioxide. Here we use ice-core data from the Antarctic Vostok core to reconstruct a complete atmospheric carbon dioxide record for MIS 11. The record indicates that values for carbon dioxide throughout the interglacial period were close to the Earth's pre-industrial levels and that both solar energy and carbon dioxide may have helped to make MIS 11 exceptionally long. Anomalies in the oceanic carbonate system recorded in marine sediments at the time, for example while coral reefs were forming, apparently left no signature on atmospheric carbon dioxide concentrations.

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Reay, D. S. (2002). "Intensive farming, US-style, is not sustainable worldwide." Nature **417**(6884): 15.

Reay, D. S. (2004). "Fertilizer 'solution' could turn local problem global." Nature **427**(6974): 485.

Reay, D. S. (2004). "Climate: Russians face another disappointment." Nature **431**(7010): 739.

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Reich, P. B., S. E. Hobbie, et al. (2006). "Nitrogen limitation constrains sustainability of ecosystem response to CO2." Nature **440**(7086): 922-5.

Enhanced plant biomass accumulation in response to elevated atmospheric CO2 concentration could dampen the future rate of increase in CO2 levels and associated climate warming. However, it is unknown whether CO2-induced stimulation of plant growth and biomass accumulation will be sustained or whether limited nitrogen (N) availability constrains greater plant growth in a CO2-enriched world. Here we show, after a six-year field study of perennial grassland species grown under ambient and elevated levels of CO2 and N, that low availability of N progressively suppresses the positive response of plant biomass to elevated CO2. Initially, the stimulation of total plant biomass by elevated CO2 was no greater at enriched than at ambient N supply. After four to six years, however, elevated CO2 stimulated plant biomass much less under ambient than enriched N supply. This response was consistent with the temporally divergent effects of elevated CO2 on soil and plant N dynamics at differing levels of N supply. Our results indicate that variability in availability of soil N and deposition of atmospheric N are both likely to influence the response of plant biomass accumulation to elevated atmospheric CO2. Given that limitations to productivity resulting from the insufficient availability of N are widespread in both unmanaged and managed vegetation, soil N supply is probably an important constraint on global terrestrial responses to elevated CO2.

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Reich, W. P. (2005). "Climate research opponent is not a friend to science." Nature **438**(7070): 914.

Reich, W. P. (2005). "Climate research opponent is not a friend to science." Nature **438**(7070): 914.

Reichhardt, T. (2000). "Climate talks face uncertainty over US strategy." Nature **408**(6810): 279.

Reichhardt, T. (2002). "Call for more data forms basis of Bush climate strategy." Nature **420**(6912): 110.

Reichhardt, T. (2002). "Call for more data forms basis of Bush climate strategy." Nature **420**(6912): 110.

Reichhardt, T. (2005). "Express delivery to Venus." Nature **437**(7062): 1071.

Reimann, S., A. J. Manning, et al. (2005). "Low European methyl chloroform emissions inferred from long-term atmospheric measurements." Nature **433**(7025): 506-8.

Methyl chloroform (CH3CCl3, 1,1,1,-trichloroethane) was used widely as a solvent before it was recognized to be an ozone-depleting substance and its phase-out was introduced under the Montreal Protocol. Subsequently, its atmospheric concentration has declined steadily and recent European methyl chloroform consumption and emissions were estimated to be less than 0.1 gigagrams per year. However, data from a short-term tropospheric measurement campaign (EXPORT) indicated that European methyl chloroform emissions could have been over 20 gigagrams in 2000 (ref. 6), almost doubling previously estimated global emissions. Such enhanced emissions would significantly affect results from the CH3CC13 method of deriving global abundances of hydroxyl radicals (OH) (refs 7-12)-the dominant reactive atmospheric chemical for removing trace gases related to air pollution, ozone depletion and the greenhouse effect. Here we use long-term, high-frequency data from Mace Head, Ireland and Jungfraujoch, Switzerland, to infer European methyl chloroform emissions. We find that European emission estimates declined from about 60 gigagrams per year in the mid-1990s to 0.3-1.4 and 1.9-3.4 gigagrams per year in 2000-03, based on Mace Head and Jungfraujoch data, respectively. Our European methyl chloroform emission estimates are therefore higher than calculated from consumption data, but are considerably lower than those derived from the EXPORT campaign in 2000 (ref. 6).

Reimer, P. J. (2004). "Solar physics: spots from rings." Nature **431**(7012): 1047-8.

Reiners, P. W., T. A. Ehlers, et al. (2003). "Coupled spatial variations in precipitation and long-term erosion rates across the Washington Cascades." Nature **426**(6967): 645-7.

Past studies of tectonically active mountain ranges have suggested strong coupling and feedbacks between climate, tectonics and topography. For example, rock

uplift generates topographic relief, thereby enhancing precipitation, which focuses erosion and in turn influences rates and spatial patterns of further rock uplift. Although theoretical links between climate, erosion and uplift have received much attention, few studies have shown convincing correlations between observable indices of these processes on mountain-range scales. Here we show that strongly varying long-term (>10(6)-10(7) yr) erosion rates inferred from apatite (U-Th)/He cooling ages across the Cascades mountains of Washington state closely track modern mean annual precipitation rates. Erosion and precipitation rates vary over an order of magnitude across the range with maxima of 0.33 mm yr(-1) and 3.5 m yr(-1), respectively, with both maxima located 50 km west (windward) of the topographic crest of the range. These data demonstrate a strong coupling between precipitation and long-term erosion rates on the mountain-range scale. If the range is currently in topographic steady state, rock uplift on the west flank is three to ten times faster than elsewhere in the range, possibly in response to climatically focused erosion.

Reiter, P. (2004). "Passion and politics cloud the climate debate." Nature **431**(7010): 739.

Reiter, P. (2004). "Passion and politics cloud the climate debate." Nature **431**(7010): 739.

Rempel, A. W., E. D. Waddington, et al. (2001). "Possible displacement of the climate signal in ancient ice by premelting and anomalous diffusion." Nature **411**(6837): 568-71.

The best high-resolution records of climate over the past few hundred millennia are derived from ice cores retrieved from Greenland and Antarctica. The interpretation of these records relies on the assumption that the trace constituents used as proxies for past climate have undergone only modest post-depositional migration. Many of the constituents are soluble impurities found principally in unfrozen liquid that separates the grain boundaries in ice sheets. This phase behaviour, termed premelting, is characteristic of polycrystalline material. Here we show that premelting influences compositional diffusion in a manner that causes the advection of impurity anomalies towards warmer regions while maintaining their spatial integrity. Notwithstanding chemical reactions that might fix certain species against this prevailing transport, we find that-under conditions that resemble those encountered in the Eemian interglacial ice of central Greenland (from about 125,000 to 115,000 years ago)-impurity fluctuations may be separated from ice of the same age by as much as 50 cm. This distance is comparable to the ice thickness of the contested sudden cooling events in Eemian ice from the GRIP core.

Retallack, G. J. (2001). "A 300-million-year record of atmospheric carbon dioxide from fossil plant cuticles." Nature **411**(6835): 287-90.

To understand better the link between atmospheric CO2 concentrations and climate over geological time, records of past CO2 are reconstructed from geochemical proxies. Although these records have provided us with a broad picture of CO2 variation throughout the Phanerozoic eon (the past 544 Myr), inconsistencies and gaps remain that still need to be resolved. Here I present a continuous 300-Myr record of stomatal abundance from fossil leaves of four genera of plants that are closely related to the present-day Ginkgo tree. Using the known relationship between leaf stomatal abundance and growing season CO2 concentrations, I reconstruct past atmospheric CO2 concentrations. For the past 300 Myr, only two intervals of low CO2 (<1,000 p.p.m.v.) are inferred, both of which coincide with known ice ages in Neogene (1-8 Myr) and early Permian (275-290 Myr) times. But for most of the Mesozoic era (65-250 Myr), CO2 levels were high (1,000-2,000 p.p.m.v.), with transient excursions to even higher CO2 (>2,000 p.p.m.v.) concentrations. These results are consistent with some

reconstructions of past CO2 (refs 1, 2) and palaeotemperature records, but suggest that CO2 reconstructions based on carbon isotope proxies may be compromised by episodic outbursts of isotopically light methane. These results support the role of water vapour, methane and CO2 in greenhouse climate warming over the past 300 Myr.

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Retallack, G. J. (2002). "Triassic-Jurassic atmospheric CO2 spike." Nature **415**(6870): 387-8.

I question the claim by Tanner et al. that atmospheric CO2 levels remained constant across the Triassic-Jurassic boundary on the grounds of problems with stratigraphic completeness and contamination with atmospheric methane. Because methanogenic CH4 has a light isotope composition and oxidizes readily to CO2, methane-clathrate dissociation and oxidation events cannot be detected by palaeobarometers that use the carbon-isotope composition of palaeosol carbonate.

Ribbe, J. (2004). "Oceanography: the southern supplier." Nature **427**(6969): 23-4.

Rice, M. L. (2003). "GreenSea's interest in fertilizing sea with iron." Nature **421**(6925): 786.

Richards, P. W. (1950). "Climatic limits of vegetation." Nature **166**(4222): 536-8.

Richardson, M. I. and R. J. Wilson (2002). "A topographically forced asymmetry in the martian circulation and climate." Nature **416**(6878): 298-301.

Large seasonal and hemispheric asymmetries in the martian climate system are generally ascribed to variations in solar heating associated with orbital eccentricity. As the orbital elements slowly change (over a period of >104 years), characteristics of the climate such as dustiness and the vigour of atmospheric circulation are thought to vary, as should asymmetries in the climate (for example, the deposition of water ice at the northern versus the southern pole). Such orbitally driven climate change might be responsible for the observed layering in Mars' polar deposits by modulating deposition of dust and water ice. Most current theories assume that climate asymmetries completely reverse as the angular distance between equinox and perihelion changes by 180 degrees. Here we

describe a major climate mechanism that will not precess in this way. We show that Mars' global north-south elevation difference forces a dominant southern summer Hadley circulation that is independent of perihelion timing. The Hadley circulation, a tropical overturning cell responsible for trade winds, largely controls interhemispheric transport of water and the bulk dustiness of the atmosphere. The topography therefore imprints a strong handedness on climate, with water ice and the active formation of polar layered deposits more likely in the north.

Richey, J. E., J. M. Melack, et al. (2002). "Outgassing from Amazonian rivers and wetlands as a large tropical source of atmospheric CO2." Nature **416**(6881): 617-20.

Terrestrial ecosystems in the humid tropics play a potentially important but presently ambiguous role in the global carbon cycle. Whereas global estimates of atmospheric CO2 exchange indicate that the tropics are near equilibrium or are a source with respect to carbon, ground-based estimates indicate that the amount of carbon that is being absorbed by mature rainforests is similar to or greater than that being released by tropical deforestation (about 1.6 Gt C yr-1). Estimates of the magnitude of carbon sequestration are uncertain, however, depending on whether they are derived from measurements of gas fluxes above forests or of biomass accumulation in vegetation and soils. It is also possible that methodological errors may overestimate rates of carbon uptake or that other loss processes have yet to be identified. Here we demonstrate that outgassing (evasion) of CO2 from rivers and wetlands of the central Amazon basin constitutes an important carbon loss process, equal to 1.2 +/- 0.3 Mg C ha-1 yr-1. This carbon probably originates from organic matter transported from upland and flooded forests, which is then respired and outgassed downstream. Extrapolated across the entire basin, this flux-at 0.5 Gt C yr-1-is an order of magnitude greater than fluvial export of organic carbon to the ocean. From these findings, we suggest that the overall carbon budget of rainforests, summed across terrestrial and aquatic environments, appears closer to being in balance than would be inferred from studies of uplands alone.

Rickard, W. H. (1964). "Spring Precipitation and the Strontium-90 Contamination of Wheat in the Semi-Arid Regions of Idaho and Montana." Nature **201**: 309-10.

Rioual, P., V. Andrieu-Ponel, et al. (2001). "High-resolution record of climate stability in France during the last interglacial period." Nature **413**(6853): 293-6.

The last interglacial period (127-110 kyr ago) has been considered to be an analogue to the present interglacial period, the Holocene, which may help us to understand present climate evolution. But whereas Holocene climate has been essentially stable in Europe, variability in climate during the last interglacial period has remained unresolved, because climate reconstructions from ice cores, continental records and marine sediment cores give conflicting results for this period. Here we present a high-resolution multi-proxy lacustrine record of climate change during the last interglacial period, based on oxygen isotopes in diatom silica, diatom assemblages and pollen-climate transfer functions from the Ribains maar in France. Contrary to a previous study, our data do not show a cold event interrupting the warm interglacial climate. Instead, we find an early temperature maximum with a transition to a colder climate about halfway through the sequence. The end of the interglacial period is clearly marked by an abrupt change in all proxy records. Our study confirms that in southwestern Europe the last interglacial period was a time of climatic stability and is therefore still likely to represent a useful analogue for the present climate.

Robert, F. and M. Chaussidon (2006). "A palaeotemperature curve for the Precambrian oceans based on silicon isotopes in cherts." Nature **443**(7114): 969-72.

The terrestrial sediment record indicates that the Earth's climate varied drastically in the Precambrian era (before 550 million years ago), ranging from surface

temperatures similar to or higher than today's to global glaciation events. The most continuous record of sea surface temperatures of that time has been derived from variations in oxygen isotope ratios of cherts (siliceous sediments), but the long-term cooling of the oceans inferred from those data has been questioned because the oxygen isotope signature could have been reset through the exchange with hydrothermal fluids after deposition of the sediments. Here we show that the silicon isotopic composition of cherts more than 550 million years old shows systematic variations with age that support the earlier conclusion of long-term ocean cooling and exclude post-depositional exchange as the main source of the isotopic variations. In agreement with other lines of evidence, a model of the silicon cycle in the Precambrian era shows that the observed silicon isotope variations imply seawater temperature changes from about 70 degrees C 3,500 million years ago to about 20 degrees C 800 million years ago.

Roberts, M. B., C. B. Stringer, et al. (1994). "A hominid tibia from Middle Pleistocene sediments at Boxgrove, UK." Nature **369**(6478): 311-3.

Fossil hominids from the earlier Middle Pleistocene of Europe are very rare and the Mauer mandible is generally accepted as the most ancient, with an estimated age of 500 kyr. We report here on the discovery of a human tibia, in association with stone tools, from calcareous silts at the Lower Palaeolithic site of Boxgrove, West Sussex, UK (Fig. 1). The silt units are correlated by mammalian biostratigraphy to an, as yet unnamed, major temperate stage or interglacial that immediately pre-dates the Anglian cold stage. Accordingly, the temperate sediments are equated with oxygen isotope stage 13 (ref. 6) and are therefore roughly coeval with the Mauer mandible. The massive tibia is the oldest hominid fragment from the British Isles and provides the first information about the manufacturers of the early Acheulian industries of Europe. It is assigned to Homo cf. heidelbergensis.

Robinson, J. B. and S. J. Cohen (2000). "Climate-change analysis has been changing too." Nature **406**(6791): 13.

Roche, D., D. Paillard, et al. (2004). "Constraints on the duration and freshwater release of Heinrich event 4 through isotope modelling." Nature **432**(7015): 379-82.

Heinrich events--abrupt climate cooling events due to ice-sheet instability that occurred during the last glacial period--are recorded in sediment cores throughout the North Atlantic Ocean. Modelling studies have described likely physical mechanisms for these events, but the quantitative characteristics of Heinrich events are less well known. Here we use a climate model of intermediate complexity that explicitly calculates the distribution of oxygen isotopes in the oceans to simulate Heinrich event 4 at about 40,000 yr ago. We compare an ensemble of scenarios for this Heinrich event with oxygen isotope data measured in foraminiferal calcite of a comprehensive set of sediment cores. From this comparison, we obtain a duration of 250 +/- 150 yr and an ice release of 2 +/- 1 m sea-level equivalent for Heinrich event 4, significantly reducing the uncertainties in both values compared to earlier estimates of up to 2,000 yr and 15 m of sea-level equivalent ice release, respectively. Our results indicate that the consequences of Heinrich events may have been less severe than previously assumed, at least with respect to Greenland climate and sea level.

Rohde, R. A. and R. A. Muller (2005). "Cycles in fossil diversity." Nature **434**(7030): 208-10.

It is well known that the diversity of life appears to fluctuate during the course of the Phanerozoic, the eon during which hard shells and skeletons left abundant fossils (0-542 million years ago). Here we show, using Sepkoski's compendium of the first and last stratigraphic appearances of 36,380 marine genera, a strong 62 +/- 3-million-year cycle, which is particularly evident in the shorter-lived genera.

The five great extinctions enumerated by Raup and Sepkoski may be an aspect of this cycle. Because of the high statistical significance we also consider the contributions of environmental factors, and possible causes.

Rohling, E. J., R. Marsh, et al. (2004). "Similar meltwater contributions to glacial sea level changes from Antarctic and northern ice sheets." Nature **430**(7003): 1016-21.

The period between 75,000 and 20,000 years ago was characterized by high variability in climate and sea level. Southern Ocean records of ice-rafted debris suggest a significant contribution to the sea level changes from melt water of Antarctic origin, in addition to likely contributions from northern ice sheets, but the relative volumes of melt water from northern and southern sources have yet to be established. Here we simulate the first-order impact of a range of relative meltwater releases from the two polar regions on the distribution of marine oxygen isotopes, using an intermediate complexity model. By comparing our simulations with oxygen isotope data from sediment cores, we infer that the contributions from Antarctica and the northern ice sheets to the documented sea level rises between 65,000 and 35,000 years ago were approximately equal, each accounting for a rise of about 15 m. The reductions in Antarctic ice volume implied by our analysis are comparable to that inferred previously for the Antarctic contribution to meltwater pulse 1A (refs 16, 17), which occurred about 14,200 years ago, during the last deglaciation.

Rohling, E. J. and H. Palike (2005). "Centennial-scale climate cooling with a sudden cold event around 8,200 years ago." Nature **434**(7036): 975-9.

The extent of climate variability during the current interglacial period, the Holocene, is still debated. Temperature records derived from central Greenland ice cores show one significant temperature anomaly between 8,200 and 8,100 years ago, which is often attributed to a meltwater outflow into the North Atlantic Ocean and a slowdown of North Atlantic Deep Water formation--this anomaly provides an opportunity to study such processes with relevance to present-day freshening of the North Atlantic. Anomalies in climate proxy records from locations around the globe are often correlated with this sharp event in Greenland. But the anomalies in many of these records span 400 to 600 years, start from about 8,600 years ago and form part of a repeating pattern within the Holocene. More sudden climate changes around 8,200 years ago appear superimposed on this longer-term cooling. The compounded nature of the signals implies that far-field climate anomalies around 8,200 years ago cannot be used in a straightforward manner to assess the impact of a slowdown of North Atlantic Deep Water formation, and the geographical extent of the rapid cooling event 8,200 years ago remains to be determined.

Rohrer, F. and H. Berresheim (2006). "Strong correlation between levels of tropospheric hydroxyl radicals and solar ultraviolet radiation." Nature **442**(7099): 184-7.

The most important chemical cleaning agent of the atmosphere is the hydroxyl radical, OH. It determines the oxidizing power of the atmosphere, and thereby controls the removal of nearly all gaseous atmospheric pollutants. The atmospheric supply of OH is limited, however, and could be overcome by consumption due to increasing pollution and climate change, with detrimental feedback effects. To date, the high variability of OH concentrations has prevented the use of local observations to monitor possible trends in the concentration of this species. Here we present and analyse long-term measurements of atmospheric OH concentrations, which were taken between 1999 and 2003 at the Meteorological Observatory Hohenpeissenberg in southern Germany. We find that the concentration of OH can be described by a surprisingly linear dependence on solar ultraviolet radiation throughout the measurement period, despite the fact that OH concentrations are influenced by thousands of reactants. A detailed numerical model of atmospheric reactions and measured

trace gas concentrations indicates that the observed correlation results from compensations between individual processes affecting OH, but that a full understanding of these interactions may not be possible on the basis of our current knowledge of atmospheric chemistry. As a consequence of the stable relationship between OH concentrations and ultraviolet radiation that we observe, we infer that there is no long-term trend in the level of OH in the Hohenpeissenberg data set.

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Roig, F. A., C. Le-Quesne, et al. (2001). "Climate variability 50,000 years ago in mid-latitude Chile as reconstructed from tree rings." Nature **410**(6828): 567-70.

High-resolution proxies of past climate are essential for a better understanding of the climate system. Tree rings are routinely used to reconstruct Holocene climate variations at high temporal resolution, but only rarely have they offered insight into climate variability during earlier periods. Fitzroya cupressoides-a South American conifer which attains ages up to 3,600 years-has been shown to record summer temperatures in northern Patagonia during the past few millennia. Here we report a floating 1,229-year chronology developed from subfossil stumps of F. cupressoides in southern Chile that dates back to approximately 50,000 14C years before present. We use this chronology to calculate the spectral characteristics of climate variability in this time, which was probably an interstadial (relatively warm) period. Growth oscillations at periods of 150-250, 87-94, 45.5, 24.1, 17.8, 9.3 and 2.7-5.3 years are identified in the annual subfossil record. A comparison with the power spectra of chronologies derived from living F. cupressoides trees shows strong similarities with the 50,000-year-old chronology, indicating that similar growth forcing factors operated in this glacial interstadial phase as in the current interglacial conditions.

Root, T. L., J. T. Price, et al. (2003). "Fingerprints of global warming on wild animals and plants." Nature **421**(6918): 57-60.

Over the past 100 years, the global average temperature has increased by approximately 0.6 degrees C and is projected to continue to rise at a rapid rate. Although species have responded to climatic changes throughout their evolutionary history, a primary concern for wild species and their ecosystems is

this rapid rate of change. We gathered information on species and global warming from 143 studies for our meta-analyses. These analyses reveal a consistent temperature-related shift, or 'fingerprint', in species ranging from molluscs to mammals and from grasses to trees. Indeed, more than 80% of the species that show changes are shifting in the direction expected on the basis of known physiological constraints of species. Consequently, the balance of evidence from these studies strongly suggests that a significant impact of global warming is already discernible in animal and plant populations. The synergism of rapid temperature rise and other stresses, in particular habitat destruction, could easily disrupt the connectedness among species and lead to a reformulation of species communities, reflecting differential changes in species, and to numerous extirpations and possibly extinctions.

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Rosenfeld, D. and W. L. Woodley (2000). "Deep convective clouds with sustained supercooled liquid water down to -37.5 degrees C." Nature **405**(6785): 440-2.

In cirrus and orographic wave clouds, highly supercooled water has been observed in small quantities (less than 0.15 g m(-3)). This high degree of supercooling was attributed to the small droplet size and the lack of ice nuclei at the heights of these clouds. For deep convective clouds, which have much larger droplets near their tops and which take in aerosols from near the ground, no such measurements have hitherto been reported. However, satellite data suggest that highly supercooled water (down to -38 degrees C) frequently occurs in vigorous continental convective storms. Here we report in situ measurements in deep convective clouds from an aircraft, showing that most of the condensed water remains liquid down to -37.5 degrees C. The droplets reach a median volume diameter of 17 microm and amount to 1.8 gm(-3), one order of magnitude more than previously reported. At slightly colder temperatures only ice was found, suggesting homogeneous freezing. Because of the poor knowledge of mixed-phase cloud processes, the simulation of clouds using numerical models is difficult at present. Our observations will help to understand these cloud processes, such as rainfall, hail, and cloud electrification, together with their implications for the climate system.

Rosenstiel, T. N., M. J. Potosnak, et al. (2003). "Increased CO2 uncouples growth from isoprene emission in an agriforest ecosystem." Nature **421**(6920): 256-9.

The emission of isoprene from the leaves of forest trees is a fundamental component of biosphere-atmosphere interactions, controlling many aspects of photochemistry in the lower atmosphere. As almost all commercial agriforest

species emit high levels of isoprene, proliferation of agriforest plantations has significant potential to increase regional ozone pollution and enhance the lifetime of methane, an important determinant of global climate. Here we show that growth of an intact Populus deltoides plantation under increased CO2 (800 micromol x mol(-1) and 1,200 micromol x mol(-1)) reduced ecosystem isoprene production by 21% and 41%, while above-ground biomass accumulation was enhanced by 60% and 82%, respectively. Exposure to increased CO2 significantly reduced the cellular content of dimethylallyl diphosphate, the substrate for isoprene synthesis, in both leaves and leaf protoplasts. We identify intracellular metabolic competition for phosphoenolpyruvate as a possible control point in explaining the suppression of isoprene emission under increased CO2. Our results highlight the potential for uncoupling isoprene emission from biomass accumulation in an agriforest species, and show that negative air-quality effects of proliferating agriforests may be offset by increases in CO2.

Rowan, R. (2004). "Coral bleaching: thermal adaptation in reef coral symbionts." Nature **430**(7001): 742.

Many corals bleach as a result of increased seawater temperature, which causes them to lose their vital symbiotic algae (Symbiodinium spp.) - unless these symbioses are able to adapt to global warming, bleaching threatens coral reefs worldwide. Here I show that some corals have adapted to higher temperatures, at least in part, by hosting specifically adapted Symbiodinium. If other coral species can host these or similar Symbiodinium taxa, they might adapt to warmer habitats relatively easily.

Royer, D. L., C. P. Osborne, et al. (2003). "Carbon loss by deciduous trees in a CO2-rich ancient polar environment." Nature **424**(6944): 60-2.

Fossils demonstrate that deciduous forests covered the polar regions for much of the past 250 million years when the climate was warm and atmospheric CO2 high. But the evolutionary significance of their deciduous character has remained a matter of conjecture for almost a century. The leading hypothesis argues that it was an adaptation to photoperiod, allowing the avoidance of carbon losses by respiration from a canopy of leaves unable to photosynthesize in the darkness of warm polar winters. Here we test this proposal with experiments using 'living fossil' tree species grown in a simulated polar climate with and without CO2 enrichment. We show that the quantity of carbon lost annually by shedding a deciduous canopy is significantly greater than that lost by evergreen trees through wintertime respiration and leaf litter production, irrespective of growth CO2 concentration. Scaling up our experimental observations indicates that the greater expense of being deciduous persists in mature forests, even up to latitudes of 83 degrees N, where the duration of the polar winter exceeds five months. We therefore reject the carbon-loss hypothesis as an explanation for the deciduous nature of polar forests.

Rustad, L. (2001). "Global change. Matter of time on the prairie." Nature **413**(6856): 578-9.

Rustad, L. (2001). "Global change. Matter of time on the prairie." Nature **413**(6856): 578-9.

Rutberg, R. L., S. R. Hemming, et al. (2000). "Reduced North Atlantic Deep Water flux to the glacial Southern Ocean inferred from neodymium isotope ratios." Nature **405**(6789): 935-8.

The global circulation of the oceans and the atmosphere transports heat around the Earth. Broecker and Denton suggested that changes in the global ocean circulation might have triggered or enhanced the glacial-interglacial cycles. But proxy data for past circulation taken from sediment cores in the South Atlantic

Ocean have yielded conflicting interpretations of ocean circulation in glacial times--delta13C variations in benthic foraminifera support the idea of a glacial weakening or shutdown of North Atlantic Deep Water production, whereas other proxies, such as Cd/Ca, Ba/Ca and 231Pa/230Th ratios, show little change from the Last Glacial Maximum to the Holocene epoch. Here we report neodymium isotope ratios from the dispersed Fe-Mn oxide component of two southeast Atlantic sediment cores. Both cores show variations that tend towards North Atlantic signatures during the warm marine isotope stages 1 and 3, whereas for the full glacial stages 2 and 4 they are closer to Pacific Ocean signatures. We conclude that the export of North Atlantic Deep Water to the Southern Ocean has resembled present-day conditions during the warm climate intervals, but was reduced during the cold stages. An increase in biological productivity may explain the various proxy data during the times of reduced North Atlantic Deep Water export.

Rutherford, S. and S. D'Hondt (2000). "Early onset and tropical forcing of 100,000-year Pleistocene glacial cycles." Nature **408**(6808): 72-5.

Between 1.5 and 0.6 Myr ago, the period of the Earth's glacial cycles changed from 41 kyr, the period of the Earth's obliquity cycles, to 100 kyr, the period of the Earth's orbital eccentricity, which has a much smaller effect on global insolation. The timing of this transition and its causes pose one of the most perplexing problems in palaeoclimate research. Here we use complex demodulation to examine the phase evolution of precession and semiprecession cycles--the latter of which are phase-coupled to both precession and eccentricity--in the tropical and extratropical Atlantic Ocean. We find that about 1.5 Myr ago, tropical semiprecession cycles (with periods of about 11.5 kyr) started to propagate to higher latitudes, coincident with a growing amplitude envelope of the 100-kyr cycles. Evidence from numerical models suggests that cycles of about 10 kyr in length may be required to explain the high amplitude of the 100-kyr cycles. Combining our results with consideration of a modern analogue, we conclude that increased heat flow across the equator or from the tropics to higher latitudes around 1.5 Myr ago strengthened the semiprecession cycle in the Northern Hemisphere, and triggered the transition to sustained 100-kyr glacial cycles.

Ruttimann, J. (2006). "US satellite system loses climate sensors." Nature **441**(7095): 798.

Rye, R., P. H. Kuo, et al. (1995). "Atmospheric carbon dioxide concentrations before 2.2 billion years ago." Nature **378**(6557): 603-5.

The composition of the Earth's early atmosphere is a subject of continuing debate. In particular, it has been suggested that elevated concentrations of atmospheric carbon dioxide would have been necessary to maintain normal surface temperatures in the face of lower solar luminosity in early Earth history. Fossil weathering profiles, known as palaeosols, have provided semi-quantitative constraints on atmospheric oxygen partial pressure (pO2) before 2.2 Gyr ago. Here we use the same well studied palaeosols to constrain atmospheric pCO2 between 2.75 and 2.2 Gyr ago. The observation that iron lost from the tops of these profiles was reprecipitated lower down as iron silicate minerals, rather than as iron carbonate, indicates that atmospheric pCO2 must have been less than 10(-1.4) atm--about 100 times today's level of 360 p.p.m., and at least five times lower than that required in one-dimensional climate models to compensate for lower solar luminosity at 2.75 Gyr. Our results suggest that either the Earth's early climate was much more sensitive to increases in pCO2 than has been thought, or that one or more greenhouse gases other than CO2 contributed significantly to the atmosphere's radiative balance during the late Archaean and early Proterozoic eons.

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Sachs, J. D. (2004). "Seeking a global solution." Nature **430**(7001): 725-6.

Sachs, J. P. and R. F. Anderson (2005). "Increased productivity in the subantarctic ocean during Heinrich events." Nature **434**(7037): 1118-21.

Massive iceberg discharges from the Northern Hemisphere ice sheets, 'Heinrich events', coincided with the coldest periods of the last ice age. There is widespread evidence for Heinrich events and their profound impact on the climate and circulation of the North Atlantic Ocean, but their influence beyond that region remains uncertain. Here we use a combination of molecular fingerprints of algal productivity and radioisotope tracers of sedimentation to document eight periods of increased productivity in the subpolar Southern Ocean during the past 70,000 years that occurred within 1,000-2,000 years of a Northern Hemisphere Heinrich event. We discuss possible causes for such a link, including increased supply of iron from upwelling and increased stratification during the growing season, which imply an alteration of the global ocean circulation during Heinrich events. The mechanisms linking North Atlantic iceberg discharges with subantarctic productivity remain unclear at this point. We suggest that understanding how the Southern Ocean was altered during these extreme climate perturbations is critical to understanding the role of the ocean in climate change.

Sadhu, D. P. (1960). "Tissue respiration and transmination in cold stress." Nature **188**: 672.

Saji, N. H., B. N. Goswami, et al. (1999). "A dipole mode in the tropical Indian Ocean." Nature **401**(6751): 360-3.

For the tropical Pacific and Atlantic oceans, internal modes of variability that lead to climatic oscillations have been recognized, but in the Indian Ocean region a similar ocean-atmosphere interaction causing interannual climate variability has not yet been found. Here we report an analysis of observational data over the past 40 years, showing a dipole mode in the Indian Ocean: a pattern of internal variability with anomalously low sea surface temperatures off Sumatra and high sea surface temperatures in the western Indian Ocean, with accompanying wind and precipitation anomalies. The spatio-temporal links between sea surface temperatures and winds reveal a strong coupling through the precipitation field and ocean dynamics. This air-sea interaction process is unique and inherent in the Indian Ocean, and is shown to be independent of the El Nino/Southern Oscillation. The discovery of this dipole mode that accounts for about 12% of the

sea surface temperature variability in the Indian Ocean-and, in its active years, also causes severe rainfall in eastern Africa and droughts in Indonesia-brightens the prospects for a long-term forecast of rainfall anomalies in the affected countries.

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Salawitch, R. J. (2006). "Atmospheric chemistry: biogenic bromine." Nature **439**(7074): 275-7.

Sankaran, M., N. P. Hanan, et al. (2005). "Determinants of woody cover in African savannas." Nature **438**(7069): 846-9.

Savannas are globally important ecosystems of great significance to human economies. In these biomes, which are characterized by the co-dominance of trees and grasses, woody cover is a chief determinant of ecosystem properties. The availability of resources (water, nutrients) and disturbance regimes (fire, herbivory) are thought to be important in regulating woody cover, but perceptions differ on which of these are the primary drivers of savanna structure. Here we show, using data from 854 sites across Africa, that maximum woody cover in savannas receiving a mean annual precipitation (MAP) of less than approximately 650 mm is constrained by, and increases linearly with, MAP. These arid and semi-arid savannas may be considered 'stable' systems in which water constrains woody cover and permits grasses to coexist, while fire, herbivory and soil properties interact to reduce woody cover below the MAP-controlled upper bound. Above a MAP of approximately 650 mm, savannas are 'unstable' systems in which MAP is sufficient for woody canopy closure, and disturbances (fire, herbivory) are required for the coexistence of trees and grass. These results provide insights into the nature of African savannas and suggest that future changes in precipitation may considerably affect their distribution and dynamics.

Sanudo-Wilhelmy, S. A., A. Tovar-Sanchez, et al. (2004). "The impact of surface-adsorbed phosphorus on phytoplankton Redfield stoichiometry." Nature **432**(7019): 897-901.

The Redfield ratio of 106 carbon:16 nitrogen:1 phosphorus in marine phytoplankton is one of the foundations of ocean biogeochemistry, with applications in algal physiology, palaeoclimatology and global climate change. However, this ratio varies substantially in response to changes in algal nutrient status and taxonomic affiliation. Here we report that Redfield ratios are also strongly affected by partitioning into surface-adsorbed and intracellular phosphorus pools. The C:N:surface-adsorbed P (80-105 C:15-18 N:1 P) and total

(71-80 C:13-14 N:1 P) ratios in natural populations and cultures of Trichodesmium were close to Redfield values and not significantly different from each other. In contrast, intracellular ratios consistently exceeded the Redfield ratio (316-434 C:59-83 N:1 intracellular P). These high intracellular ratios were associated with reduced N2 fixation rates, suggestive of phosphorus deficiency. Other algal species also have substantial surface-adsorbed phosphorus pools, suggesting that our Trichodesmium results are generally applicable to all phytoplankton. Measurements of the distinct phytoplankton phosphorus pools may be required to assess nutrient limitation accurately from elemental composition. Deviations from Redfield stoichiometry may be attributable to surface adsorption of phosphorus rather than to biological processes, and this scavenging could affect the interpretation of marine nutrient inventories and ecosystem models.

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Sarmiento, J. (2000). "Global change. That sinking feeling." Nature **408**(6809): 155-6.

Sarmiento, J. L., N. Gruber, et al. (2004). "High-latitude controls of thermocline nutrients and low latitude biological productivity." Nature **427**(6969): 56-60.

The ocean's biological pump strips nutrients out of the surface waters and exports them into the thermocline and deep waters. If there were no return path of nutrients from deep waters, the biological pump would eventually deplete the surface waters and thermocline of nutrients; surface biological productivity would plummet. Here we make use of the combined distributions of silicic acid and nitrate to trace the main nutrient return path from deep waters by upwelling in the Southern Ocean and subsequent entrainment into subantarctic mode water. We show that the subantarctic mode water, which spreads throughout the entire Southern Hemisphere and North Atlantic Ocean, is the main source of nutrients for the thermocline. We also find that an additional return path exists in the northwest corner of the Pacific Ocean, where enhanced vertical mixing, perhaps driven by tides, brings abyssal nutrients to the surface and supplies them to the thermocline of the North Pacific. Our analysis has important implications for our understanding of large-scale controls on the nature and magnitude of low-latitude biological productivity and its sensitivity to climate change.

Sassen, K. (2005). "Meteorology: dusty ice clouds over Alaska." Nature **434**(7032): 456.
Particles lofted into the atmosphere by desert dust storms can disperse widely and affect climate directly through aerosol scattering and absorption. They can also affect it indirectly by changing the scattering properties of clouds and, because desert dusts are particularly active ice-forming agents, by affecting the formation and thermodynamic phase of clouds. Here I show that dust storms that occurred in Asia early in 2004 created unusual ice clouds over Alaska at temperatures far warmer than those expected for normal cirrus-cloud formation.

Satheesh, S. K. and V. V. Ramanathan (2000). "Large differences in tropical aerosol forcing at the top of the atmosphere and Earth's surface." Nature **405**(6782): 60-3.
The effect of radiative forcing by anthropogenic aerosols is one of the largest sources of uncertainty in climate predictions. Direct observations of the forcing are therefore needed, particularly for the poorly understood tropical aerosols. Here we present an observational method for quantifying aerosol forcing to within +/-5 per cent. We use calibrated satellite radiation measurements and five independent surface radiometers to quantify the aerosol forcing simultaneously at the Earth's surface and the top of the atmosphere over the tropical northern Indian Ocean. In winter, this region is covered by anthropogenic aerosols of sulphate, nitrate, organics, soot and fly ash from the south Asian continent. Accordingly, mean clear-sky solar radiative heating for the winters of 1998 and 1999 decreased at the ocean surface by 12 to 30 Wm(-2), but only by 4 to 10 Wm(-2) at the top of the atmosphere. This threefold difference (due largely to solar absorption by soot) and the large magnitude of the observed surface forcing both imply that tropical aerosols might slow down the hydrological cycle.

Saunders, M. A. and A. S. Lea (2005). "Seasonal prediction of hurricane activity reaching the coast of the United States." Nature **434**(7036): 1005-8.
Much of the property damage from natural hazards in the United States is caused by landfalling hurricanes--strong tropical cyclones that reach the coast. For the southeastern Atlantic coast of the US, a statistical method for forecasting the occurrence of landfalling hurricanes for the season ahead has been reported, but the physical mechanisms linking the predictor variables to the frequency of hurricanes remain unclear. Here we present a statistical model that uses July wind anomalies between 1950 and 2003 to predict with significant and useful skill the wind energy of US landfalling hurricanes for the following main hurricane season (August to October). We have identified six regions over North America and over the east Pacific and North Atlantic oceans where July wind anomalies, averaged between heights of 925 and 400 mbar, exhibit a stationary and significant link to the energy of landfalling hurricanes during the subsequent hurricane season. The wind anomalies in these regions are indicative of atmospheric circulation patterns that either favour or hinder evolving hurricanes from reaching US shores.

Schar, C. and G. Jendritzky (2004). "Climate change: hot news from summer 2003." Nature **432**(7017): 559-60.

Schar, C. and G. Jendritzky (2004). "Climate change: hot news from summer 2003." Nature **432**(7017): 559-60.

Schar, C., P. L. Vidale, et al. (2004). "The role of increasing temperature variability in European summer heatwaves." Nature **427**(6972): 332-6.
Instrumental observations and reconstructions of global and hemispheric temperature evolution reveal a pronounced warming during the past approximately 150 years. One expression of this warming is the observed increase in the occurrence of heatwaves. Conceptually this increase is understood as a shift of the statistical distribution towards warmer temperatures, while changes in the

width of the distribution are often considered small. Here we show that this framework fails to explain the record-breaking central European summer temperatures in 2003, although it is consistent with observations from previous years. We find that an event like that of summer 2003 is statistically extremely unlikely, even when the observed warming is taken into account. We propose that a regime with an increased variability of temperatures (in addition to increases in mean temperature) may be able to account for summer 2003. To test this proposal, we simulate possible future European climate with a regional climate model in a scenario with increased atmospheric greenhouse-gas concentrations, and find that temperature variability increases by up to 100%, with maximum changes in central and eastern Europe.

Scheffer, M., S. Carpenter, et al. (2001). "Catastrophic shifts in ecosystems." Nature **413**(6856): 591-6.

All ecosystems are exposed to gradual changes in climate, nutrient loading, habitat fragmentation or biotic exploitation. Nature is usually assumed to respond to gradual change in a smooth way. However, studies on lakes, coral reefs, oceans, forests and arid lands have shown that smooth change can be interrupted by sudden drastic switches to a contrasting state. Although diverse events can trigger such shifts, recent studies show that a loss of resilience usually paves the way for a switch to an alternative state. This suggests that strategies for sustainable management of such ecosystems should focus on maintaining resilience.

Schefuss, E., S. Schouten, et al. (2003). "African vegetation controlled by tropical sea surface temperatures in the mid-Pleistocene period." Nature **422**(6930): 418-21.

The dominant forcing factors for past large-scale changes in vegetation are widely debated. Changes in the distribution of C4 plants--adapted to warm, dry conditions and low atmospheric CO2 concentrations--have been attributed to marked changes in environmental conditions, but the relative impacts of changes in aridity, temperature and CO2 concentration are not well understood. Here, we present a record of African C4 plant abundance between 1.2 and 0.45 million years ago, derived from compound-specific carbon isotope analyses of wind-transported terrigenous plant waxes. We find that large-scale changes in African vegetation are linked closely to sea surface temperatures in the tropical Atlantic Ocean. We conclude that, in the mid-Pleistocene, changes in atmospheric moisture content--driven by tropical sea surface temperature changes and the strength of the African monsoon--controlled aridity on the African continent, and hence large-scale vegetation changes.

Schefuss, E., S. Schouten, et al. (2005). "Climatic controls on central African hydrology during the past 20,000 years." Nature **437**(7061): 1003-6.

Past hydrological changes in Africa have been linked to various climatic processes, depending on region and timescale. Long-term precipitation changes in the regions of northern and southern Africa influenced by the monsoons are thought to have been governed by precessional variations in summer insolation. Conversely, short-term precipitation changes in the northern African tropics have been linked to North Atlantic sea surface temperature anomalies, affecting the northward extension of the Intertropical Convergence Zone and its associated rainbelt. Our knowledge of large-scale hydrological changes in equatorial Africa and their forcing factors is, however, limited. Here we analyse the isotopic composition of terrigenous plant lipids, extracted from a marine sediment core close to the Congo River mouth, in order to reconstruct past central African rainfall variations and compare this record to sea surface temperature changes in the South Atlantic Ocean. We find that central African precipitation during the past 20,000 years was mainly controlled by the difference in sea surface temperatures between the tropics and subtropics of the South Atlantic Ocean, whereas we find no evidence that changes in the position of the Intertropical

Convergence Zone had a significant influence on the overall moisture availability in central Africa. We conclude that changes in ocean circulation, and hence sea surface temperature patterns, were important in modulating atmospheric moisture transport onto the central African continent.

Schiermeier, Q. (2001). "Assessment ups the ante on climate change." Nature **409**(6819): 445.

Schiermeier, Q. (2001). "Fears grow over melting permafrost." Nature **409**(6822): 751.

Schiermeier, Q. (2001). "Climate change offers bleak future." Nature **409**(6823): 971.

Schiermeier, Q. (2001). "Climate change offers bleak future." Nature **409**(6823): 971.

Schiermeier, Q. (2001). "Senate urges Bush to act on climate change." Nature **412**(6847): 575.

Schiermeier, Q. (2001). "Cycle studies see carbon sinks rise to prominence." Nature **414**(6862): 385.

Schiermeier, Q. (2003). "Climate change: The oresmen." Nature **421**(6919): 109-10.

Schiermeier, Q. (2003). "Climate change: The oresmen." Nature **421**(6919): 109-10.

Schiermeier, Q. (2003). "Climate panel to seize political hot potatoes." Nature **421**(6926): 879.

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Schiermeier, Q. (2003). "Researchers rattled as Kyoto Protocol hangs in the balance." Nature **423**(6942): 792.

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Schiermeier, Q. (2003). "Alpine thaw breaks ice over permafrost's role." Nature **424**(6950): 712.

Schiermeier, Q. (2003). "Arctic research: summer in Svalbard." Nature **424**(6952): 992-4.

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Schiermeier, Q. (2004). "Gulf Stream probed for early warnings of system failure." Nature **427**(6977): 769.

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Schiermeier, Q. (2004). "Climate findings let fishermen off the hook." Nature **428**(6978): 4.

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Schiermeier, Q. (2004). "Greenland's climate: a rising tide." Nature **428**(6979): 114-5.

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Schiermeier, Q. (2004). "Disaster movie highlights transatlantic divide." Nature **431**(7004): 4.

Schiermeier, Q. (2004). "Disaster movie highlights transatlantic divide." Nature **431**(7004): 4.

Schiermeier, Q. (2004). "Ecologists mount protest over lofty plans for Alpine ski runs." Nature **431**(7006): 235.

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Schiermeier, Q. (2005). "Past climate comes into focus but warm forecast stays put." Nature **433**(7026): 562-3.

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Schiermeier, Q. (2005). "Climate change: that sinking feeling." Nature **435**(7043): 732-3.

Schiermeier, Q. (2005). "Climate change: that sinking feeling." Nature **435**(7043): 732-3.

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Schiermeier, Q. (2005). "Clear skies raise global-warming estimates." Nature **435**(7046): 1142-3.

Schiermeier, Q. (2005). "Hurricane link to climate change is hazy." Nature **437**(7058): 461.

Schiermeier, Q. (2006). "Methane finding baffles scientists." Nature **439**(7073): 128.

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Schiermeier, Q. (2006). "The costs of global warming." Nature **439**(7075): 374-5.

Schiermeier, Q. (2006). "Arctic stations need human touch." Nature **441**(7090): 133.

Schiermeier, Q. (2006). "Arctic ecology: on thin ice." Nature **441**(7090): 146-7.

Schiermeier, Q. (2006). "Arctic ecology: on thin ice." Nature **441**(7090): 146-7.

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Schiermeier, Q. (2006). "Insurers' disaster files suggest climate is culprit." Nature **441**(7094): 674-5.

Schiermeier, Q. (2006). "Putting the carbon back: the hundred billion tonne challenge." Nature **442**(7103): 620-3.

Schiermeier, Q. and B. MacWilliams (2004). "Climate change: crunch time for Kyoto." Nature **431**(7004): 12-3.

Schimel, D. S., J. I. House, et al. (2001). "Recent patterns and mechanisms of carbon exchange by terrestrial ecosystems." Nature **414**(6860): 169-72.

Knowledge of carbon exchange between the atmosphere, land and the oceans is important, given that the terrestrial and marine environments are currently absorbing about half of the carbon dioxide that is emitted by fossil-fuel combustion. This carbon uptake is therefore limiting the extent of atmospheric and climatic change, but its long-term nature remains uncertain. Here we provide an overview of the current state of knowledge of global and regional patterns of carbon exchange by terrestrial ecosystems. Atmospheric carbon dioxide and oxygen data confirm that the terrestrial biosphere was largely neutral with respect to net carbon exchange during the 1980s, but became a net carbon sink in the 1990s. This recent sink can be largely attributed to northern extratropical areas, and is roughly split between North America and Eurasia. Tropical land areas, however, were approximately in balance with respect to carbon exchange, implying a carbon sink that offset emissions due to tropical deforestation. The evolution of the terrestrial carbon sink is largely the result of changes in land use over time, such as regrowth on abandoned agricultural land and fire prevention, in addition to responses to environmental changes, such as longer growing seasons, and fertilization by carbon dioxide and nitrogen. Nevertheless, there remain considerable uncertainties as to the magnitude of the sink in different regions and the contribution of different processes.

Schippers, A., L. N. Neretin, et al. (2005). "Prokaryotic cells of the deep sub-seafloor biosphere identified as living bacteria." Nature **433**(7028): 861-4.

Chemical analyses of the pore waters from hundreds of deep ocean sediment cores have over decades provided evidence for ongoing processes that require biological catalysis by prokaryotes. This sub-seafloor activity of microorganisms may influence the surface Earth by changing the chemistry of the ocean and by triggering the emission of methane, with consequences for the marine carbon cycle and even the global climate. Despite the fact that only about 1% of the total marine primary production of organic carbon is available for deep-sea microorganisms, sub-seafloor sediments harbour over half of all prokaryotic cells on Earth. This estimation has been calculated from numerous microscopic cell counts in sediment cores of the Ocean Drilling Program. Because these counts cannot differentiate between dead and alive cells, the population size of living microorganisms is unknown. Here, using ribosomal RNA as a target for the technique known as catalysed reporter deposition-fluorescence in situ hybridization (CARD-FISH), we provide direct quantification of live cells as defined by the presence of ribosomes. We show that a large fraction of the sub-seafloor prokaryotes is alive, even in very old (16 million yr) and deep (> 400 m) sediments. All detectable living cells belong to the Bacteria and have turnover times of 0.25-22 yr, comparable to surface sediments.

Schmidt, M. W., H. J. Spero, et al. (2004). "Links between salinity variation in the Caribbean and North Atlantic thermohaline circulation." Nature **428**(6979): 160-3.

Variations in the strength of the North Atlantic Ocean thermohaline circulation have been linked to rapid climate changes during the last glacial cycle through oscillations in North Atlantic Deep Water formation and northward oceanic heat flux. The strength of the thermohaline circulation depends on the supply of warm, salty water to the North Atlantic, which, after losing heat to the atmosphere, produces the dense water masses that sink to great depths and circulate back south. Here we analyse two Caribbean Sea sediment cores, combining Mg/Ca palaeothermometry with measurements of oxygen isotopes in foraminiferal calcite in order to reconstruct tropical Atlantic surface salinity during the last glacial cycle. We find that Caribbean salinity oscillated between saltier conditions during the cold oxygen isotope stages 2, 4 and 6, and lower salinities during the warm stages 3 and 5, covarying with the strength of North Atlantic Deep Water formation. At the initiation of the Bolling/Allerod warm interval, Caribbean surface salinity decreased abruptly, suggesting that the advection of salty tropical waters into the North Atlantic amplified thermohaline circulation and contributed to high-latitude warming.

Schmidt, M. W., M. J. Vautravers, et al. (2006). "Rapid subtropical North Atlantic salinity oscillations across Dansgaard-Oeschger cycles." Nature **443**(7111): 561-4.

Geochemical and sedimentological evidence suggest that the rapid climate warming oscillations of the last ice age, the Dansgaard-Oeschger cycles, were coupled to fluctuations in North Atlantic meridional overturning circulation through its regulation of poleward heat flux. The balance between cold meltwater from the north and warm, salty subtropical gyre waters from the south influenced the strength and location of North Atlantic overturning circulation during this period of highly variable climate. Here we investigate how rapid reorganizations of the ocean-atmosphere system across these cycles are linked to salinity changes in the subtropical North Atlantic gyre. We combine Mg/Ca palaeothermometry and oxygen isotope ratio measurements on planktonic foraminifera across four Dansgaard-Oeschger cycles (spanning 45.9-59.2 kyr ago) to generate a seawater salinity proxy record from a subtropical gyre deep-sea sediment core. We show that North Atlantic gyre surface salinities oscillated rapidly between saltier stadial conditions and fresher interstadials, covarying with inferred shifts in the Tropical Atlantic hydrologic cycle and North Atlantic overturning circulation. These salinity oscillations suggest a reduction in precipitation into the North Atlantic and/or reduced export of deep salty thermohaline waters during stadials. We hypothesize that increased stadial salinities preconditioned the North Atlantic

Ocean for a rapid return to deep overturning circulation and high-latitude warming by contributing to increased North Atlantic surface-water density on interstadial transitions.

Schmittner, A. (2005). "Decline of the marine ecosystem caused by a reduction in the Atlantic overturning circulation." Nature **434**(7033): 628-33.

Reorganizations of the Atlantic meridional overturning circulation were associated with large and abrupt climatic changes in the North Atlantic region during the last glacial period. Projections with climate models suggest that similar reorganizations may also occur in response to anthropogenic global warming. Here I use ensemble simulations with a coupled climate-ecosystem model of intermediate complexity to investigate the possible consequences of such disturbances to the marine ecosystem. In the simulations, a disruption of the Atlantic meridional overturning circulation leads to a collapse of the North Atlantic plankton stocks to less than half of their initial biomass, owing to rapid shoaling of winter mixed layers and their associated separation from the deep ocean nutrient reservoir. Globally integrated export production declines by more than 20 per cent owing to reduced upwelling of nutrient-rich deep water and gradual depletion of upper ocean nutrient concentrations. These model results are consistent with the available high-resolution palaeorecord, and suggest that global ocean productivity is sensitive to changes in the Atlantic meridional overturning circulation.

Schmittner, A. (2005). "Decline of the marine ecosystem caused by a reduction in the Atlantic overturning circulation." Nature **434**(7033): 628-33.

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Schmitz, B. (2000). "Global change. Plankton cooled a greenhouse." Nature **407**(6801): 143-4.

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Schmitz, B. (2000). "Global change. Plankton cooled a greenhouse." Nature **407**(6801): 143-4.

Schneider, S. H. (2001). "Earth systems engineering and management." Nature **409**(6818): 417-21.

Schneider, S. H. (2001). "What is 'dangerous' climate change?" Nature **411**(6833): 17-9.

Schoener, T. W., D. A. Spiller, et al. (2001). "Predators increase the risk of catastrophic

extinction of prey populations." Nature **412**(6843): 183-6.

There has been considerable research on both top-down effects and on disturbances in ecological communities; however, the interaction between the two, when the disturbance is catastrophic, has rarely been examined. Predators may increase the probability of prey extinction resulting from a catastrophic disturbance both by reducing prey population size and by changing ecological traits of prey individuals such as habitat characteristics in a way that increases the vulnerability of prey species to extinction. We show that a major hurricane in the Bahamas led to the extinction of lizard populations on most islands onto which a predator had been experimentally introduced, whereas no populations became extinct on control islands. Before the hurricane, the predator had reduced prey populations to about half of those on control islands. Two months after the hurricane, we found only recently hatched individuals--apparently lizards survived the inundating storm surge only as eggs. On predator-introduction islands, those hatchling populations were a smaller fraction of pre-hurricane populations than on control islands. Egg survival allowed rapid recovery of prey populations to pre-hurricane levels on all control islands but on only a third of predator-introduction islands--the other two-thirds lost their prey populations. Thus climatic disturbance compounded by predation brought prey populations to extinction.

Schrag, D. P. and P. F. Hoffman (2001). "Life, geology and snowball Earth." Nature **409**(6818): 306.

Schrope, M. (2000). "Climatology. Trouble in the greenhouse." Nature **407**(6800): 10-2.

Schrope, M. (2001). "US administration tries to repair green image." Nature **410**(6832): 1014.

Schrope, M. (2001). "A change of climate for big oil." Nature **411**(6837): 516-8.

Schrope, M. (2001). "Consensus science, or consensus politics?" Nature **412**(6843): 112-4.

Schulze, E. D. and A. Freibauer (2005). "Environmental science: carbon unlocked from soils." Nature **437**(7056): 205-6.

Selje, N., M. Simon, et al. (2004). "A newly discovered Roseobacter cluster in temperate and polar oceans." Nature **427**(6973): 445-8.

Bacterioplankton phylotypes of alpha-Proteobacteria have been detected in various marine regions, but systematic biogeographical studies of their global distribution are missing. Alpha-Proteobacteria comprise one of the largest fractions of heterotrophic marine bacteria and include two clades, SAR11 and Roseobacter, which account for 26 and 16% of 16S ribosomal RNA gene clones retrieved from marine bacterioplankton. The SAR11 clade attracted much interest because related 16S rRNA gene clones were among the first groups of marine bacteria to be identified by cultivation-independent approaches and appear to dominate subtropical surface bacterioplankton communities. Here we report on the global distribution of a newly discovered cluster affiliated to the Roseobacter clade, comprising only as-yet-uncultured phylotypes. Bacteria of this cluster occur from temperate to polar regions with highest abundance in the Southern Ocean, but not in tropical and subtropical regions. Between the south Atlantic subtropical front and Antarctica, we detected two distinct phylotypes, one north and one south of the polar front, indicating that two adjacent but different oceanic provinces allow the persistence of distinct but closely related phylotypes. These results suggest that the global distribution of major marine bacterioplankton components is related to oceanic water masses and controlled by their

environmental and biogeochemical properties.

Seneviratne, S. I., D. Luthi, et al. (2006). "Land-atmosphere coupling and climate change in Europe." Nature **443**(7108): 205-9.

Increasing greenhouse gas concentrations are expected to enhance the interannual variability of summer climate in Europe and other mid-latitude regions, potentially causing more frequent heatwaves. Climate models consistently predict an increase in the variability of summer temperatures in these areas, but the underlying mechanisms responsible for this increase remain uncertain. Here we explore these mechanisms using regional simulations of recent and future climatic conditions with and without land-atmosphere interactions. Our results indicate that the increase in summer temperature variability predicted in central and eastern Europe is mainly due to feedbacks between the land surface and the atmosphere. Furthermore, they suggest that land-atmosphere interactions increase climate variability in this region because climatic regimes in Europe shift northwards in response to increasing greenhouse gas concentrations, creating a new transitional climate zone with strong land-atmosphere coupling in central and eastern Europe. These findings emphasize the importance of soil-moisture-temperature feedbacks (in addition to soil-moisture-precipitation feedbacks) in influencing summer climate variability and the potential migration of climate zones with strong land-atmosphere coupling as a consequence of global warming. This highlights the crucial role of land-atmosphere interactions in future climate change.

Shipp, E., K. Keith, et al. (1963). "Reproduction in a Free-Living Population of Domestic Rabbits, Oryctolagus Cuniculus (L.), on a Sub-Antarctic Island." Nature **200**: 858-60.

Siddall, M. (2005). "Palaeoclimate: the riddle of the sediments." Nature **437**(7055): 39-41.

Siddall, M. (2005). "Palaeoclimate: the riddle of the sediments." Nature **437**(7055): 39-41.

Siddall, M., E. J. Rohling, et al. (2003). "Sea-level fluctuations during the last glacial cycle." Nature **423**(6942): 853-8.

The last glacial cycle was characterized by substantial millennial-scale climate fluctuations, but the extent of any associated changes in global sea level (or, equivalently, ice volume) remains elusive. Highstands of sea level can be reconstructed from dated fossil coral reef terraces, and these data are complemented by a compilation of global sea-level estimates based on deep-sea oxygen isotope ratios at millennial-scale resolution or higher. Records based on oxygen isotopes, however, contain uncertainties in the range of +/-30 m, or +/-1 degrees C in deep sea temperature. Here we analyse oxygen isotope records from Red Sea sediment cores to reconstruct the history of water residence times in the Red Sea. We then use a hydraulic model of the water exchange between the Red Sea and the world ocean to derive the sill depth-and hence global sea level-over the past 470,000 years (470 kyr). Our reconstruction is accurate to within +/-12 m, and gives a centennial-scale resolution from 70 to 25 kyr before present. We find that sea-level changes of up to 35 m, at rates of up to 2 cm yr(-1), occurred, coincident with abrupt changes in climate.

Sidor, C. A., F. R. O'Keefe, et al. (2005). "Permian tetrapods from the Sahara show climate-controlled endemism in Pangaea." Nature **434**(7035): 886-9.

New fossils from the Upper Permian Moradi Formation of northern Niger provide an insight into the faunas that inhabited low-latitude, xeric environments near the end of the Palaeozoic era (approximately 251 million years ago). We

describe here two new temnospondyl amphibians, the cochleosaurid Nigerpeton ricqlesi gen. et sp. nov. and the stem edopoid Saharastega moradiensis gen. et sp. nov., as relicts of Carboniferous lineages that diverged 40-90 million years earlier. Coupled with a scarcity of therapsids, the new finds suggest that faunas from the poorly sampled xeric belt that straddled the Equator during the Permian period differed markedly from well-sampled faunas that dominated tropical-to-temperate zones to the north and south. Our results show that long-standing theories of Late Permian faunal homogeneity are probably oversimplified as the result of uneven latitudinal sampling.

Siegel, D. A. (2001). "Oceanography. The Rossby rototiller." Nature **409**(6820): 576-7.

Sigman, D. M., S. L. Jaccard, et al. (2004). "Polar ocean stratification in a cold climate." Nature **428**(6978): 59-63.

The low-latitude ocean is strongly stratified by the warmth of its surface water. As a result, the great volume of the deep ocean has easiest access to the atmosphere through the polar surface ocean. In the modern polar ocean during the winter, the vertical distribution of temperature promotes overturning, with colder water over warmer, while the salinity distribution typically promotes stratification, with fresher water over saltier. However, the sensitivity of seawater density to temperature is reduced as temperature approaches the freezing point, with potential consequences for global ocean circulation under cold climates. Here we present deep-sea records of biogenic opal accumulation and sedimentary nitrogen isotopic composition from the Subarctic North Pacific Ocean and the Southern Ocean. These records indicate that vertical stratification increased in both northern and southern high latitudes 2.7 million years ago, when Northern Hemisphere glaciation intensified in association with global cooling during the late Pliocene epoch. We propose that the cooling caused this increased stratification by weakening the role of temperature in polar ocean density structure so as to reduce its opposition to the stratifying effect of the vertical salinity distribution. The shift towards stratification in the polar ocean 2.7 million years ago may have increased the quantity of carbon dioxide trapped in the abyss, amplifying the global cooling.

Sikes, E. L., C. R. Samson, et al. (2000). "Old radiocarbon ages in the southwest Pacific Ocean during the last glacial period and deglaciation." Nature **405**(6786): 555-9.

Marine radiocarbon (14C) dates are widely used for dating oceanic events and as tracers of ocean circulation, essential components for understanding ocean-climate interactions. Past ocean ventilation rates have been determined by the difference between radiocarbon ages of deep-water and surface-water reservoirs, but the apparent age of surface waters (currently approximately 400 years in the tropics and approximately 1,200 years in Antarctic waters) might not be constant through time, as has been assumed in radiocarbon chronologies and palaeoclimate studies. Here we present independent estimates of surface-water and deep-water reservoir ages in the New Zealand region since the last glacial period, using volcanic ejecta (tephras) deposited in both marine and terrestrial sediments as stratigraphic markers. Compared to present-day values, surface-reservoir ages from 11,900 14C years ago were twice as large (800 years) and during glacial times were five times as large (2,000 years), contradicting the assumption of constant surface age. Furthermore, the ages of glacial deep-water reservoirs were much older (3,000-5,000 years). The increase in surface-to-deep water age differences in the glacial Southern Ocean suggests that there was decreased ocean ventilation during this period.

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Simonite, T. (2005). "Seals net data from cold seas." Nature **438**(7067): 402-3.

Sirocko, F. (2003). "Ups and downs in the Red Sea." Nature **423**(6942): 813-4.

Sirocko, F., K. Seelos, et al. (2005). "A late Eemian aridity pulse in central Europe during the last glacial inception." Nature **436**(7052): 833-6.

Investigating the processes that led to the end of the last interglacial period is relevant for understanding how our ongoing interglacial will end, which has been a matter of much debate (see, for example, refs 1, 2). A recent ice core from Greenland demonstrates climate cooling from 122,000 years ago driven by orbitally controlled insolation, with glacial inception at 118,000 years ago. Here we present an annually resolved, layer-counted record of varve thickness, quartz grain size and pollen assemblages from a maar lake in the Eifel (Germany), which documents a late Eemian aridity pulse lasting 468 years with dust storms, aridity, bushfire and a decline of thermophilous trees at the time of glacial inception. We interpret the decrease in both precipitation and temperature as an indication of a close link of this extreme climate event to a sudden southward shift of the position of the North Atlantic drift, the ocean current that brings warm surface waters to the northern European region. The late Eemian aridity pulse occurred at a 65 degrees N July insolation of 416 W m(-2), close to today's value of 428 W m(-2) (ref. 9), and may therefore be relevant for the interpretation of present-day climate variability.

Sleep, N. H. (2004). "Palaeoclimatology: Archaean palaeosols and Archaean air." Nature **432**(7016): 2 p following 460; discussion following 460.

Ferrous carbonate, as the mineral siderite, occurs in Archaean palaeosols (ancient soils). Ohmoto et al. contend that siderite was not in equilibrium with the oxygen in Archaean air and that its presence in palaeosols provides little constraint on the partial pressure of carbon dioxide in Archaean air. But their argument is invalid because it fails to distinguish the different behaviours of the trivial component oxygen and the significant component carbon dioxide in the partly closed system of soil waters. The presence or absence of siderite in ancient soils is a valid constraint on the carbon dioxide partial pressure (pCO2) in ancient atmospheres.

Sloan, E. D., Jr. (2003). "Fundamental principles and applications of natural gas hydrates." Nature **426**(6964): 353-63.

Natural gas hydrates are solid, non-stoichiometric compounds of small gas molecules and water. They form when the constituents come into contact at low temperature and high pressure. The physical properties of these compounds, most

notably that they are non-flowing crystalline solids that are denser than typical fluid hydrocarbons and that the gas molecules they contain are effectively compressed, give rise to numerous applications in the broad areas of energy and climate effects. In particular, they have an important bearing on flow assurance and safety issues in oil and gas pipelines, they offer a largely unexploited means of energy recovery and transportation, and they could play a significant role in past and future climate change.

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Sloan, L. C., J. C. Walker, et al. (1992). "Possible methane-induced polar warming in the early Eocene." Nature **357**(6376): 320-2.

Reconstructions of early Eocene climate depict a world in which the polar environments support mammals and reptiles, deciduous forests, warm oceans and rare frost conditions. At the same time, tropical sea surface temperatures are interpreted to have been the same as or slightly cooler than present values. The question of how to warm polar regions of Earth without noticeably warming the tropics remains unresolved; increased amounts of greenhouse gases would be expected to warm all latitudes equally. Oceanic heat transport has been postulated as a mechanism for heating high latitudes, but it is difficult to explain the dynamics that would achieve this. Here we consider estimates of Eocene wetland areas and suggest that the flux of methane, an important greenhouse gas, may have been substantially greater during the Eocene than at present. Elevated methane concentrations would have enhanced early Eocene global warming, and also might specifically have prevented severe winter cooling of polar regions because of the potential of atmospheric methane to promote the formation of optically thick, polar stratospheric ice clouds.

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Sluijs, A., S. Schouten, et al. (2006). "Subtropical Arctic Ocean temperatures during the Palaeocene/Eocene thermal maximum." Nature **441**(7093): 610-3.

The Palaeocene/Eocene thermal maximum, approximately 55 million years ago, was a brief period of widespread, extreme climatic warming, that was associated with massive atmospheric greenhouse gas input. Although aspects of the resulting environmental changes are well documented at low latitudes, no data were available to quantify simultaneous changes in the Arctic region. Here we identify the Palaeocene/Eocene thermal maximum in a marine sedimentary sequence obtained during the Arctic Coring Expedition. We show that sea surface temperatures near the North Pole increased from 18 degrees C to over 23 degrees C during this event. Such warm values imply the absence of ice and thus exclude the influence of ice-albedo feedbacks on this Arctic warming. At the same time, sea level rose while anoxic and euxinic conditions developed in the ocean's bottom waters and photic zone, respectively. Increasing temperature and sea level match expectations based on palaeoclimate model simulations, but the absolute polar temperatures that we derive before, during and after the event are more than 10 degrees C warmer than those model-predicted. This suggests that higher-than-modern greenhouse gas concentrations must have operated in conjunction with other feedback mechanisms--perhaps polar stratospheric clouds or hurricane-induced ocean mixing--to amplify early Palaeogene polar temperatures.

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Smaglik, P. (2000). "US climate report underlines local impacts of warming." Nature **405**(6788): 725.

Smaglik, P. (2000). "US climate report underlines local impacts of warming." Nature **405**(6788): 725.

Smaglik, P. (2000). "Climate change expert stirs new controversy." Nature **407**(6800): 7.

Smaglik, P. (2002). "A climate of uncertainty." Nature **415**(6870): 6.

Smaglik, P. (2002). "Turning oil into science: Norway." Nature **420**(6916 Suppl): A13, A15.

Smetacek, V. and S. Nicol (2005). "Polar ocean ecosystems in a changing world." Nature **437**(7057): 362-8.

Polar organisms have adapted their seasonal cycles to the dynamic interface between ice and water. This interface ranges from the micrometre-sized brine channels within sea ice to the planetary-scale advance and retreat of sea ice. Polar marine ecosystems are particularly sensitive to climate change because small temperature differences can have large effects on the extent and thickness of sea ice. Little is known about the interactions between large, long-lived organisms and their planktonic food supply. Disentangling the effects of human exploitation of upper trophic levels from basin-wide, decade-scale climate cycles to identify long-term, global trends is a daunting challenge facing polar bio-oceanography.

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Smith, C. I. (2005). "Re-wilding: introductions could reduce biodiversity." Nature **437**(7057): 318.

Smith, H. J., H. Fischer, et al. (1999). "Dual modes of the carbon cycle since the Last Glacial Maximum." Nature **400**(6741): 248-50.

The most conspicuous feature of the record of past climate contained in polar ice is the rapid warming which occurs after long intervals of gradual cooling. During the last four transitions from glacial to interglacial conditions, over which such abrupt warmings occur, ice records indicate that the CO2 concentration of the atmosphere increased by roughly 80 to 100 parts per million by volume. But the causes of the atmospheric CO2 concentration increases are unclear. Here we present the stable-carbon-isotope composition (delta 13 CO2) of CO2 extracted from air trapped in ice at Taylor Dome, Antarctica, from the Last Glacial Maximum to the onset of Holocene times. The global carbon cycle is shown to

have operated in two distinct primary modes on the timescale of thousands of years, one when climate was changing relatively slowly and another when warming was rapid, each with a characteristic average stable-carbon-isotope composition of the net CO2 exchanged by the atmosphere with the land and oceans. delta 13 CO2 increased between 16.5 and 9 thousand years ago by slightly more than would be estimated to be caused by the physical effects of a 5 degrees C rise in global average sea surface temperature driving a CO2 efflux from the ocean, but our data do not allow specific causes to be constrained.

Smith, S. D., T. E. Huxman, et al. (2000). "Elevated CO2 increases productivity and invasive species success in an arid ecosystem." Nature **408**(6808): 79-82.

Arid ecosystems, which occupy about 20% of the earth's terrestrial surface area, have been predicted to be one of the most responsive ecosystem types to elevated atmospheric CO2 and associated global climate change. Here we show, using free-air CO2 enrichment (FACE) technology in an intact Mojave Desert ecosystem, that new shoot production of a dominant perennial shrub is doubled by a 50% increase in atmospheric CO2 concentration in a high rainfall year. However, elevated CO2 does not enhance production in a drought year. We also found that above-ground production and seed rain of an invasive annual grass increases more at elevated CO2 than in several species of native annuals. Consequently, elevated CO2 might enhance the long-term success and dominance of exotic annual grasses in the region. This shift in species composition in favour of exotic annual grasses, driven by global change, has the potential to accelerate the fire cycle, reduce biodiversity and alter ecosystem function in the deserts of western North America.

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Snow, R. W., C. A. Guerra, et al. (2005). "The global distribution of clinical episodes of Plasmodium falciparum malaria." Nature **434**(7030): 214-7.

Interest in mapping the global distribution of malaria is motivated by a need to define populations at risk for appropriate resource allocation and to provide a robust framework for evaluating its global economic impact. Comparison of older and more recent malaria maps shows how the disease has been geographically restricted, but it remains entrenched in poor areas of the world with climates suitable for transmission. Here we provide an empirical approach to estimating the number of clinical events caused by Plasmodium falciparum worldwide, by using a combination of epidemiological, geographical and demographic data. We estimate that there were 515 (range 300-660) million episodes of clinical P. falciparum malaria in 2002. These global estimates are up to 50% higher than those reported by the World Health Organization (WHO) and 200% higher for areas outside Africa, reflecting the WHO's reliance upon passive national

reporting for these countries. Without an informed understanding of the cartography of malaria risk, the global extent of clinical disease caused by P. falciparum will continue to be underestimated.

Soares-Filho, B. S., D. C. Nepstad, et al. (2006). "Modelling conservation in the Amazon basin." Nature **440**(7083): 520-3.

Expansion of the cattle and soy industries in the Amazon basin has increased deforestation rates and will soon push all-weather highways into the region's core. In the face of this growing pressure, a comprehensive conservation strategy for the Amazon basin should protect its watersheds, the full range of species and ecosystem diversity, and the stability of regional climates. Here we report that protected areas in the Amazon basin--the central feature of prevailing conservation approaches--are an important but insufficient component of this strategy, based on policy-sensitive simulations of future deforestation. By 2050, current trends in agricultural expansion will eliminate a total of 40% of Amazon forests, including at least two-thirds of the forest cover of six major watersheds and 12 ecoregions, releasing 32 +/- 8 Pg of carbon to the atmosphere. One-quarter of the 382 mammalian species examined will lose more than 40% of the forest within their Amazon ranges. Although an expanded and enforced network of protected areas could avoid as much as one-third of this projected forest loss, conservation on private lands is also essential. Expanding market pressures for sound land management and prevention of forest clearing on lands unsuitable for agriculture are critical ingredients of a strategy for comprehensive conservation.

Sokolov, W. (1962). "Skin adaptations of some rodents to life in the desert." Nature **193**: 823-5.

Sokolov, W. (1966). "Water content in the tissues of desert animals." Nature **211**(5048): 545.

Solanki, S. K., I. G. Usoskin, et al. (2004). "Unusual activity of the Sun during recent decades compared to the previous 11,000 years." Nature **431**(7012): 1084-7.

Direct observations of sunspot numbers are available for the past four centuries, but longer time series are required, for example, for the identification of a possible solar influence on climate and for testing models of the solar dynamo. Here we report a reconstruction of the sunspot number covering the past 11,400 years, based on dendrochronologically dated radiocarbon concentrations. We combine physics-based models for each of the processes connecting the radiocarbon concentration with sunspot number. According to our reconstruction, the level of solar activity during the past 70 years is exceptional, and the previous period of equally high activity occurred more than 8,000 years ago. We find that during the past 11,400 years the Sun spent only of the order of 10% of the time at a similarly high level of magnetic activity and almost all of the earlier high-activity periods were shorter than the present episode. Although the rarity of the current episode of high average sunspot numbers may indicate that the Sun has contributed to the unusual climate change during the twentieth century, we point out that solar variability is unlikely to have been the dominant cause of the strong warming during the past three decades.

Solanki, S. K., I. G. Usoskin, et al. (2004). "Unusual activity of the Sun during recent decades compared to the previous 11,000 years." Nature **431**(7012): 1084-7.

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Solomon, S. (2004). "The hole truth." Nature **427**(6972): 289-91.

Somero, G. N. and M. Soule (1974). "Genetic variation in marine fishes as a test of the niche-variation hypothesis." Nature **249**(458): 670-2.

Spicer, R. A., N. B. Harris, et al. (2003). "Constant elevation of southern Tibet over the past 15 million years." Nature **421**(6923): 622-4.

The uplift of the Tibetan plateau, an area that is 2,000 km wide, to an altitude of about 5,000 m has been shown to modify global climate and to influence monsoon intensity. Mechanical and thermal models for homogeneous thickening of the lithosphere make specific predictions about uplift rates of the Tibetan plateau, but the precise history of the uplift of the plateau has yet to be confirmed by observations. Here we present well-preserved fossil leaf assemblages from the Namling basin, southern Tibet, dated to approximately 15 Myr ago, which allow us to reconstruct the temperatures within the basin at that time. Using a numerical general circulation model to estimate moist static energy at the location of the fossil leaves, we reconstruct the elevation of the Namling basin 15 Myr ago to be 4,689 +/- 895 m or 4,638 +/- 847 m, depending on the reference data used. This is comparable to the present-day altitude of 4,600 m. We conclude that the elevation of the southern Tibetan plateau probably has remained unchanged for the past 15 Myr.

Spinage, C. A. (1970). "Giraffid horns." Nature **227**(5259): 735-6.

Sprigg, W. A. (1996). "Doctors watch the forecasts." Nature **379**(6566): 582-3.

Spurgeon, D. (2000). "Global warming threatens extinction for many species." Nature **407**(6801): 121.

Srinivasan, M. V. (2001). "Homing in on ant navigation." Nature **411**(6839): 752-3.

Staal, M., F. J. Meysman, et al. (2003). "Temperature excludes N2-fixing heterocystous cyanobacteria in the tropical oceans." Nature **425**(6957): 504-7.

Whereas the non-heterocystous cyanobacteria Trichodesmium spp. are the dominant N2-fixing organisms in the tropical oceans, heterocystous species dominate N2 fixation in freshwater lakes and brackish environments such as the Baltic Sea. So far no satisfactory explanation for the absence of heterocystous cyanobacteria in the pelagic of the tropical oceans has been given, even though heterocysts would seem to represent an ideal strategy for protecting nitrogenase from being inactivated by O2, thereby enabling cyanobacteria to fix N2 and to perform photosynthesis simultaneously. Trichodesmium is capable of N2 fixation, apparently without needing to differentiate heterocysts. Here we show that differences in the temperature dependence of O2 flux, respiration and N2 fixation activity explain how Trichodesmium performs better than heterocystous species at higher temperatures. Our results also explain why Trichodesmium is not successful in temperate or cold seas. The absence of heterocystous cyanobacteria

in the pelagic zone of temperate and cold seas, however, requires another explanation.

Stainforth, D. A., T. Aina, et al. (2005). "Uncertainty in predictions of the climate response to rising levels of greenhouse gases." Nature **433**(7024): 403-6.

The range of possibilities for future climate evolution needs to be taken into account when planning climate change mitigation and adaptation strategies. This requires ensembles of multi-decadal simulations to assess both chaotic climate variability and model response uncertainty. Statistical estimates of model response uncertainty, based on observations of recent climate change, admit climate sensitivities--defined as the equilibrium response of global mean temperature to doubling levels of atmospheric carbon dioxide--substantially greater than 5 K. But such strong responses are not used in ranges for future climate change because they have not been seen in general circulation models. Here we present results from the 'climateprediction.net' experiment, the first multi-thousand-member grand ensemble of simulations using a general circulation model and thereby explicitly resolving regional details. We find model versions as realistic as other state-of-the-art climate models but with climate sensitivities ranging from less than 2 K to more than 11 K. Models with such extreme sensitivities are critical for the study of the full range of possible responses of the climate system to rising greenhouse gas levels, and for assessing the risks associated with specific targets for stabilizing these levels.

Stanley, J. D., F. Goddio, et al. (2001). "Nile flooding sank two ancient cities." Nature **412**(6844): 293-4.

Steig, E. (2006). "Climate may not be linked with circulation slowdown." Nature **439**(7077): 660.

Steig, E. J. (2006). "Climate change: the south-north connection." Nature **444**(7116): 152-3.

Steinbach, O. C., A. P. Wolffe, et al. (1997). "Somatic linker histones cause loss of mesodermal competence in Xenopus." Nature **389**(6649): 395-9.

In Xenopus, cells from the animal hemisphere are competent to form mesodermal tissues from the morula through to the blastula stage. Loss of mesodermal competence at early gastrula is programmed cell-autonomously, and occurs even in single cells at the appropriate stage. To determine the mechanism by which this occurs, we have been investigating a concomitant, global change in expression of H1 linker histone subtypes. H1 histones are usually considered to be general repressors of transcription, but in Xenopus they are increasingly thought to have selective functions in transcriptional regulation. Xenopus eggs and embryos at stages before the midblastula transition are deficient in histone H1 protein, but contain an oocyte-specific variant called histone B4 or H1M. After the midblastula transition, histone B4 is progressively substituted by three somatic histone H1 variants, and replacement is complete by early neurula. Here we report that accumulation of somatic H1 protein is rate limiting for the loss of mesodermal competence. This involves selective transcriptional silencing of regulatory genes required for mesodermal differentiation pathways, like muscle, by somatic, but not maternal, H1 protein.

Stephanou, E. G. (2005). "Atmospheric chemistry: the decay of organic aerosols." Nature **434**(7029): 31.

Steuber, T., M. Rauch, et al. (2005). "Low-latitude seasonality of Cretaceous temperatures in warm and cold episodes." Nature **437**(7063): 1341-4.

The Cretaceous period is generally considered to have been a time of warm

climate. Evidence for cooler episodes exists, particularly in the early Cretaceous period, but the timing and significance of these cool episodes are not well constrained. The seasonality of temperatures is important for constraining equator-to-pole temperature gradients and may indicate the presence of polar ice sheets; however, reconstructions of Cretaceous sea surface temperatures are predominantly based on the oxygen isotopic composition of planktonic foraminifera that do not provide information about such intra-annual variations. Here we present intra-shell variations in delta18O values of rudist bivalves (Hippuritoidea) from palaeolatitudes between 8 degrees and 31 degrees N, which record the evolution of the seasonality of Cretaceous sea surface temperatures in detail. We find high maximum temperatures (approximately 35 to 37 degrees C) and relatively low seasonal variability (< 12 degrees C) between 20 degrees and 30 degrees N during the warmer Cretaceous episodes. In contrast, during the cooler episodes our data show seasonal sea surface temperature variability of up to 18 degrees C near 25 degrees N, comparable to the range found today. Such a large seasonal variability is compatible with the existence of polar ice sheets.

Stevenson, I. R. and D. M. Bryant (2000). "Climate change and constraints on breeding." Nature **406**(6794): 366-7.

Stocker, T. (2001). "Climate panel looked at all the evidence." Nature **410**(6826): 299.

Stocker, T. F. (2003). "Global change: south dials north." Nature **424**(6948): 496-9.

Stocker, T. F. (2004). "Climate change: models change their tune." Nature **430**(7001): 737-8.

Stocker, T. F. and C. C. Raible (2005). "Climate change: water cycle shifts gear." Nature **434**(7035): 830-3.

Stoll, H. M. (2006). "Climate change: the Arctic tells its story." Nature **441**(7093): 579-81.

Stoll, H. M. (2006). "Climate change: the Arctic tells its story." Nature **441**(7093): 579-81.

Stott, L., K. Cannariato, et al. (2004). "Decline of surface temperature and salinity in the western tropical Pacific Ocean in the Holocene epoch." Nature **431**(7004): 56-9.

In the present-day climate, surface water salinities are low in the western tropical Pacific Ocean and increase towards the eastern part of the basin. The salinity of surface waters in the tropical Pacific Ocean is thought to be controlled by a combination of atmospheric convection, precipitation, evaporation and ocean dynamics, and on interannual timescales significant variability is associated with the El Nino/Southern Oscillation cycles. However, little is known about the variability of the coupled ocean-atmosphere system on timescales of centuries to millennia. Here we combine oxygen isotope and Mg/Ca data from foraminifers retrieved from three sediment cores in the western tropical Pacific Ocean to reconstruct Holocene sea surface temperatures and salinities in the region. We find a decrease in sea surface temperatures of approximately 0.5 degrees C over the past 10,000 yr, whereas sea surface salinities decreased by approximately 1.5 practical salinity units. Our data imply either that the Pacific basin as a whole has become progressively less salty or that the present salinity gradient along the Equator has developed relatively recently.

Stott, L. D., W. Berelson, et al. (2000). "Increased dissolved oxygen in Pacific intermediate waters due to lower rates of carbon oxidation in sediments." Nature **407**(6802): 367-70.

Concentrations of dissolved oxygen in the ocean seem to correlate well with climate instabilities over the past 100,000 years. For example, the concentration of dissolved oxygen in Pacific intermediate waters was considerably higher during Pleistocene glacial periods than it is today. This has been inferred from the presence of bioturbated sediments, implying that oxygen levels were sufficient for burrowing organisms to live. Today, basins in the northeastern Pacific Ocean are floored by laminated sediments implying lower oxygen levels, which may be explained by reduced ventilation. Here we report a recent return to bioturbated sediments in the northeastern Pacific Ocean since the late 1970s. From the carbon isotope composition of benthic foraminifers living in the sediment, we infer a twofold decrease in the carbon oxidation rate occurring within sediments, equivalent to an increase in dissolved oxygen concentration of 15-20 micromoles per litre. These changes, at the edges of the Santa Barbara, Santa Monica and Alfonso basins, are coincident with a change in North Pacific climate which has reduced upwelling by 20-30% and increased sea surface temperatures by 1.5-3 degrees C. This suggests that climate effects on surface productivity, reducing the supply organic matter to sediments, may have had a greater effect on benthic oxygen levels than changes in ocean circulation patterns.

Stott, P. A. and J. A. Kettleborough (2002). "Origins and estimates of uncertainty in predictions of twenty-first century temperature rise." Nature **416**(6882): 723-6.

Predictions of temperature rise over the twenty-first century are necessarily uncertain, both because the sensitivity of the climate system to changing atmospheric greenhouse-gas concentrations, as well as the rate of ocean heat uptake, is poorly quantified and because future influences on climate-of anthropogenic as well as natural origin-are difficult to predict. Past observations have been used to help constrain the range of uncertainties in future warming rates, but under the assumption of a particular scenario of future emissions. Here we investigate the relative importance of the uncertainty in climate response to a particular emissions scenario versus the uncertainty caused by the differences between future emissions scenarios for our estimates of future change. We present probabilistic forecasts of global-mean temperatures for four representative scenarios for future emissions, obtained with a comprehensive climate model. We find that, in the absence of policies to mitigate climate change, global-mean temperature rise is insensitive to the differences in the emissions scenarios over the next four decades. We also show that in the future, as the signal of climate change emerges further, the predictions will become better constrained.

Stott, P. A., D. A. Stone, et al. (2004). "Human contribution to the European heatwave of 2003." Nature **432**(7017): 610-4.

The summer of 2003 was probably the hottest in Europe since at latest ad 1500, and unusually large numbers of heat-related deaths were reported in France, Germany and Italy. It is an ill-posed question whether the 2003 heatwave was caused, in a simple deterministic sense, by a modification of the external influences on climate--for example, increasing concentrations of greenhouse gases in the atmosphere--because almost any such weather event might have occurred by chance in an unmodified climate. However, it is possible to estimate by how much human activities may have increased the risk of the occurrence of such a heatwave. Here we use this conceptual framework to estimate the contribution of human-induced increases in atmospheric concentrations of greenhouse gases and other pollutants to the risk of the occurrence of unusually high mean summer temperatures throughout a large region of continental Europe. Using a threshold for mean summer temperature that was exceeded in 2003, but in no other year since the start of the instrumental record in 1851, we estimate it is very likely (confidence level >90%) that human influence has at least doubled the risk of a heatwave exceeding this threshold magnitude.

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Stringer, C. and W. Davies (2001). "Archaeology. Those elusive Neanderthals." Nature **413**(6858): 791-2.

Strzepek, R. F. and P. J. Harrison (2004). "Photosynthetic architecture differs in coastal and oceanic diatoms." Nature **431**(7009): 689-92.

Diatoms are a key taxon of eukaryotic phytoplankton and a major contributor to global carbon fixation. They are ubiquitous in the marine ecosystem despite marked gradients in environmental properties, such as dissolved iron concentrations, between coastal and oceanic waters. Previous studies have shown that offshore species of diatoms and other eukaryotic algae have evolved lower iron requirements to subsist in iron-poor oceanic waters, but the biochemical mechanisms responsible for their decreased iron demand are unknown. Here we show, using laboratory-cultured model species, a fundamental difference between a coastal and an oceanic diatom in their photosynthetic architecture. Specifically, the oceanic diatom had up to fivefold lower photosystem I and up to sevenfold lower cytochrome b6f complex concentrations than a coastal diatom. These changes to the photosynthetic apparatus markedly decrease the cellular iron requirements of the oceanic diatom but not its photosynthetic rates. However, oceanic diatoms might have also sacrificed their ability to acclimate to rapid fluctuations in light intensity--a characteristic of dynamic and turbid coastal waters. We suggest that diatoms, and probably other eukaryotic algal taxa, exploited this difference in the underwater light climate between oceanic and coastal waters, enabling them to decrease their iron requirements without compromising photosynthetic capacity. This adaptation probably facilitated the colonization of the open ocean by diatoms, and contributes to their persistence in this iron-impoverished environment.

Stuart, A. J., P. A. Kosintsev, et al. (2004). "Pleistocene to Holocene extinction dynamics in giant deer and woolly mammoth." Nature **431**(7009): 684-9.

The extinction of the many well-known large mammals (megafauna) of the Late Pleistocene epoch has usually been attributed to 'overkill' by human hunters, climatic/vegetational changes or to a combination of both. An accurate knowledge of the geography and chronology of these extinctions is crucial for testing these hypotheses. Previous assumptions that the megafauna of northern Eurasia had disappeared by the Pleistocene/Holocene transition were first challenged a decade ago by the discovery that the latest woolly mammoths on Wrangel Island, northeastern Siberia, were contemporaneous with ancient Egyptian civilization. Here we show that another spectacular megafaunal species, the giant deer or 'Irish elk', survived to around 6,900 radiocarbon yr bp (about

7,700 yr ago) in western Siberia-more than three millennia later than its previously accepted terminal date-and therefore, that the reasons for its ultimate demise are to be sought in Holocene not Pleistocene events. Before their extinction, both giant deer and woolly mammoth underwent dramatic shifts in distribution, driven largely by climatic/vegetational changes. Their differing responses reflect major differences in ecology.

Stuber, N., P. Forster, et al. (2006). "The importance of the diurnal and annual cycle of air traffic for contrail radiative forcing." Nature **441**(7095): 864-7.

Air traffic condensation trails, or contrails, are believed to have a net atmospheric warming effect, although one that is currently small compared to that induced by other sources of human emissions. However, the comparably large growth rate of air traffic requires an improved understanding of the resulting impact of aircraft radiative forcing on climate. Contrails have an effect on the Earth's energy balance similar to that of high thin ice clouds. Their trapping of outgoing longwave radiation emitted by the Earth and atmosphere (positive radiative forcing) is partly compensated by their reflection of incoming solar radiation (negative radiative forcing). On average, the longwave effect dominates and the net contrail radiative forcing is believed to be positive. Over daily and annual timescales, varying levels of air traffic, meteorological conditions, and solar insolation influence the net forcing effect of contrails. Here we determine the factors most important for contrail climate forcing using a sophisticated radiative transfer model for a site in southeast England, located in the entrance to the North Atlantic flight corridor. We find that night-time flights during winter (December to February) are responsible for most of the contrail radiative forcing. Night flights account for only 25 per cent of daily air traffic, but contribute 60 to 80 per cent of the contrail forcing. Further, winter flights account for only 22 per cent of annual air traffic, but contribute half of the annual mean forcing. These results suggest that flight rescheduling could help to minimize the climate impact of aviation.

Sturm, M., C. Racine, et al. (2001). "Climate change. Increasing shrub abundance in the Arctic." Nature **411**(6837): 546-7.

The warming of the Alaskan Arctic during the past 150 years has accelerated over the last three decades and is expected to increase vegetation productivity in tundra if shrubs become more abundant; indeed, this transition may already be under way according to local plot studies and remote sensing. Here we present evidence for a widespread increase in shrub abundance over more than 320 km of Arctic landscape during the past 50 years, based on a comparison of historic and modern aerial photographs. This expansion will alter the partitioning of energy in summer and the trapping and distribution of snow in winter, as well as increasing the amount of carbon stored in a region that is believed to be a net source of carbon dioxide.

Sullivan, R., D. Banfield, et al. (2005). "Aeolian processes at the Mars Exploration Rover Meridiani Planum landing site." Nature **436**(7047): 58-61.

The martian surface is a natural laboratory for testing our understanding of the physics of aeolian (wind-related) processes in an environment different from that of Earth. Martian surface markings and atmospheric opacity are time-variable, indicating that fine particles at the surface are mobilized regularly by wind. Regolith (unconsolidated surface material) at the Mars Exploration Rover Opportunity's landing site has been affected greatly by wind, which has created and reoriented bedforms, sorted grains, and eroded bedrock. Aeolian features here preserve a unique record of changing wind direction and wind strength. Here we present an in situ examination of a martian bright wind streak, which provides evidence consistent with a previously proposed formational model for such features. We also show that a widely used criterion for distinguishing between

aeolian saltation- and suspension-dominated grain behaviour is different on Mars, and that estimated wind friction speeds between 2 and 3 m s(-1), most recently from the northwest, are associated with recent global dust storms, providing ground truth for climate model predictions.

Sun, L., Z. Xie, et al. (2000). "A 3,000-year record of penguin populations." Nature **407**(6806): 858.

Sunda, W., D. J. Kieber, et al. (2002). "An antioxidant function for DMSP and DMS in marine algae." Nature **418**(6895): 317-20.

The algal osmolyte dimethylsulphoniopropionate (DMSP) and its enzymatic cleavage product dimethylsulphide (DMS) contribute significantly to the global sulphur cycle, yet their physiological functions are uncertain. Here we report results that, together with those in the literature, show that DMSP and its breakdown products (DMS, acrylate, dimethylsulphoxide, and methane sulphinic acid) readily scavenge hydroxyl radicals and other reactive oxygen species, and thus may serve as an antioxidant system, regulated in part by enzymatic cleavage of DMSP. In support of this hypothesis, we found that oxidative stressors, solar ultraviolet radiation, CO(2) limitation, Fe limitation, high Cu(2+) (ref. 9) and H(2)O(2) substantially increased cellular DMSP and/or its lysis to DMS in marine algal cultures. Our results indicate direct links between such stressors and the dynamics of DMSP and DMS in marine phytoplankton, which probably influence the production of DMS and its release to the atmosphere. As oxidation of DMS to sulphuric acid in the atmosphere provides a major source of sulphate aerosols and cloud condensation nuclei, oxidative stressors--including solar radiation and Fe limitation--may be involved in complex ocean atmosphere feedback loops that influence global climate and hydrological cycles.

Sutherst, R. W., R. J. Jones, et al. (1982). "Tropical legumes of the genus Stylosanthes immobilize and kill cattle ticks." Nature **295**(5847): 320-1.

Svensen, H., S. Planke, et al. (2004). "Release of methane from a volcanic basin as a mechanism for initial Eocene global warming." Nature **429**(6991): 542-5.

A 200,000-yr interval of extreme global warming marked the start of the Eocene epoch about 55 million years ago. Negative carbon- and oxygen-isotope excursions in marine and terrestrial sediments show that this event was linked to a massive and rapid (approximately 10,000 yr) input of isotopically depleted carbon. It has been suggested previously that extensive melting of gas hydrates buried in marine sediments may represent the carbon source and has caused the global climate change. Large-scale hydrate melting, however, requires a hitherto unknown triggering mechanism. Here we present evidence for the presence of thousands of hydrothermal vent complexes identified on seismic reflection profiles from the Voring and More basins in the Norwegian Sea. We propose that intrusion of voluminous mantle-derived melts in carbon-rich sedimentary strata in the northeast Atlantic may have caused an explosive release of methane--transported to the ocean or atmosphere through the vent complexes--close to the Palaeocene/Eocene boundary. Similar volcanic and metamorphic processes may explain climate events associated with other large igneous provinces such as the Siberian Traps (approximately 250 million years ago) and the Karoo Igneous Province (approximately 183 million years ago).

Svensen, H., S. Planke, et al. (2004). "Release of methane from a volcanic basin as a mechanism for initial Eocene global warming." Nature **429**(6991): 542-5.

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Swinbanks, D. (1989). "Midsummer days and tropical nights in Tokyo." Nature **339**(6222): 242.

Tanaka, K. L. (2005). "Geology and insolation-driven climatic history of Amazonian north polar materials on Mars." Nature **437**(7061): 991-4.

Mariner 9 and Viking spacecraft images revealed that the polar regions of Mars, like those of Earth, record the planet's climate history. However, fundamental uncertainties regarding the materials, features, ages and processes constituting the geologic record remained. Recently acquired Mars Orbiter Laser Altimeter data and Mars Orbiter Camera high-resolution images from the Mars Global Surveyor spacecraft and moderately high-resolution Thermal Emission Imaging System visible images from the Mars Odyssey spacecraft permit more comprehensive geologic and climatic analyses. Here I map and show the history of geologic materials and features in the north polar region that span the Amazonian period (approximately 3.0 Gyr ago to present). Erosion and redeposition of putative circumpolar mud volcano deposits (formed by eruption of liquefied, fine-grained material) led to the formation of an Early Amazonian polar plateau consisting of dark layered materials. Crater ejecta superposed on pedestals indicate that a thin mantle was present during most of the Amazonian, suggesting generally higher obliquity and insolation conditions at the poles than at present. Brighter polar layered deposits rest unconformably on the dark layers and formed mainly during lower obliquity over the past 4-5 Myr (ref. 20). Finally, the uppermost layers post-date the latest downtrend in obliquity <20,000 years ago.

Taylor, A. H., J. I. Allen, et al. (2002). "Extraction of a weak climatic signal by an ecosystem." Nature **416**(6881): 629-32.

The complexity of ecosystems can cause subtle and chaotic responses to changes in external forcing. Although ecosystems may not normally behave chaotically, sensitivity to external influences associated with nonlinearity can lead to amplification of climatic signals. Strong correlations between an El Nino index and rainfall and maize yield in Zimbabwe have been demonstrated; the correlation with maize yield was stronger than that with rainfall. A second example is the 100,000-year ice-age cycle, which may arise from a weak cycle in radiation through its influence on the concentration of atmospheric CO2 (ref. 5). Such integration of a weak climatic signal has yet to be demonstrated in a realistic theoretical system. Here we use a particular climatic phenomenon-the observed association between plankton populations around the UK and the position of the Gulf Stream-as a probe to demonstrate how a detailed marine ecosystem model extracts a weak signal that is spread across different meteorological variables. Biological systems may therefore respond to climatic signals other than those that dominate the driving variables.

Taylor, C. R. (1968). "Hygroscopic food: a source of water for desert antelopes?" Nature

219(5150): 181-2.

ter Steege, H., N. C. Pitman, et al. (2006). "Continental-scale patterns of canopy tree composition and function across Amazonia." Nature **443**(7110): 444-7.

The world's greatest terrestrial stores of biodiversity and carbon are found in the forests of northern South America, where large-scale biogeographic patterns and processes have recently begun to be described. Seven of the nine countries with territory in the Amazon basin and the Guiana shield have carried out large-scale forest inventories, but such massive data sets have been little exploited by tropical plant ecologists. Although forest inventories often lack the species-level identifications favoured by tropical plant ecologists, their consistency of measurement and vast spatial coverage make them ideally suited for numerical analyses at large scales, and a valuable resource to describe the still poorly understood spatial variation of biomass, diversity, community composition and forest functioning across the South American tropics. Here we show, by using the seven forest inventories complemented with trait and inventory data collected elsewhere, two dominant gradients in tree composition and function across the Amazon, one paralleling a major gradient in soil fertility and the other paralleling a gradient in dry season length. The data set also indicates that the dominance of Fabaceae in the Guiana shield is not necessarily the result of root adaptations to poor soils (nodulation or ectomycorrhizal associations) but perhaps also the result of their remarkably high seed mass there as a potential adaptation to low rates of disturbance.

ter Steege, H. and R. Zagt (2002). "Ecology: density and diversity." Nature **417**(6890): 698-9.

Tett, S. and P. Thorne (2004). "Atmospheric science: tropospheric temperature series from satellites." Nature **432**(7017): 1 p following 572; discussion following 572.

There has been considerable debate about changes in the temperature of the troposphere measured using the Microwave Sounding Unit (MSU) instrument or radiosondes. Fu et al. linearly combine time series from two MSU channels to estimate vertically integrated 850-300-hPa temperatures and claim consistency between surface and free-troposphere warming for one MSU record. We believe that their approach overfits the data, produces trends that overestimate warming and gives overly optimistic uncertainty estimates. There still remain large differences between observed tropospheric temperature trends and those simulated by a climate model.

Thomas, C. (2004). "Malaria: a changed climate in Africa?" Nature **427**(6976): 690-1.

Thomas, C. D., E. J. Bodsworth, et al. (2001). "Ecological and evolutionary processes at expanding range margins." Nature **411**(6837): 577-81.

Many animals are regarded as relatively sedentary and specialized in marginal parts of their geographical distributions. They are expected to be slow at colonizing new habitats. Despite this, the cool margins of many species' distributions have expanded rapidly in association with recent climate warming. We examined four insect species that have expanded their geographical ranges in Britain over the past 20 years. Here we report that two butterfly species have increased the variety of habitat types that they can colonize, and that two bush cricket species show increased fractions of longer-winged (dispersive) individuals in recently founded populations. Both ecological and evolutionary processes are probably responsible for these changes. Increased habitat breadth and dispersal tendencies have resulted in about 3- to 15-fold increases in expansion rates, allowing these insects to cross habitat disjunctions that would have represented major or complete barriers to dispersal before the expansions started. The emergence of dispersive phenotypes will increase the speed at which species

invade new environments, and probably underlies the responses of many species to both past and future climate change.

Thomas, C. D., A. Cameron, et al. (2004). "Extinction risk from climate change." Nature **427**(6970): 145-8.

Climate change over the past approximately 30 years has produced numerous shifts in the distributions and abundances of species and has been implicated in one species-level extinction. Using projections of species' distributions for future climate scenarios, we assess extinction risks for sample regions that cover some 20% of the Earth's terrestrial surface. Exploring three approaches in which the estimated probability of extinction shows a power-law relationship with geographical range size, we predict, on the basis of mid-range climate-warming scenarios for 2050, that 15-37% of species in our sample of regions and taxa will be 'committed to extinction'. When the average of the three methods and two dispersal scenarios is taken, minimal climate-warming scenarios produce lower projections of species committed to extinction (approximately 18%) than mid-range (approximately 24%) and maximum-change (approximately 35%) scenarios. These estimates show the importance of rapid implementation of technologies to decrease greenhouse gas emissions and strategies for carbon sequestration.

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Thomas, D. J. (2004). "Evidence for deep-water production in the North Pacific Ocean during the early Cenozoic warm interval." Nature **430**(6995): 65-8.

The deep-ocean circulation is responsible for a significant component of global heat transport. In the present mode of circulation, deep waters form in the North Atlantic and Southern oceans where surface water becomes sufficiently cold and dense to sink. Polar temperatures during the warmest climatic interval of the Cenozoic era (approximately 65 to 40 million years (Myr) ago) were significantly warmer than today, and this may have been a consequence of enhanced oceanic heat transport. However, understanding the relationship between deep-ocean circulation and ancient climate is complicated by differences in oceanic gateways, which affect where deep waters form and how they circulate. Here I report records of neodymium isotopes from two cores in the Pacific Ocean that indicate a shift in deep-water production from the Southern Ocean to the North Pacific approximately 65 Myr ago. The source of deep waters reverted back to the Southern Ocean 40 Myr ago. The relative timing of changes in the neodymium and oxygen isotope records indicates that changes in Cenozoic deep-water circulation patterns were the consequence, not the cause, of extreme Cenozoic warmth.

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Thomas, D. S., M. Knight, et al. (2005). "Remobilization of southern African desert dune systems by twenty-first century global warming." Nature **435**(7046): 1218-21.

Although desert dunes cover 5 per cent of the global land surface and 30 per cent of Africa, the potential impacts of twenty-first century global warming on desert dune systems are not well understood. The inactive Sahel and southern African dune systems, which developed in multiple arid phases since the last interglacial period, are used today by pastoral and agricultural systems that could be disrupted if climate change alters twenty-first century dune dynamics. Empirical data and model simulations have established that the interplay between dune surface erodibility (determined by vegetation cover and moisture availability) and atmospheric erosivity (determined by wind energy) is critical for dunefield dynamics. This relationship between erodibility and erosivity is susceptible to climate-change impacts. Here we use simulations with three global climate models and a range of emission scenarios to assess the potential future activity of three Kalahari dunefields. We determine monthly values of dune activity by modifying and improving an established dune mobility index so that it can account for global climate model data outputs. We find that, regardless of the emission scenario used, significantly enhanced dune activity is simulated in the southern dunefield by 2039, and in the eastern and northern dunefields by 2069. By 2099 all dunefields are highly dynamic, from northern South Africa to Angola and Zambia. Our results suggest that dunefields are likely to be reactivated (the sand will become significantly exposed and move) as a consequence of twenty-first century climate warming.

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Thomas, P. C., M. C. Malin, et al. (2000). "North-south geological differences between the residual polar caps on Mars." Nature **404**(6774): 161-4.

Polar processes can be sensitive indicators of global climate, and the geological features associated with polar ice caps can therefore indicate evolution of climate with time. The polar regions on Mars have distinctive morphologic and climatologic features: thick layered deposits, seasonal CO2 frost caps extending to mid latitudes, and near-polar residual frost deposits that survive the summer. The relationship of the seasonal and residual frost caps to the layered deposits has been poorly constrained, mainly by the limited spatial resolution of the available data. In particular, it has not been known if the residual caps represent simple thin frost cover or substantial geologic features. Here we show that the residual cap on the south pole is a distinct geologic unit with striking collapse and erosional topography; this is very different from the residual cap on the north pole, which grades into the underlying layered materials. These findings indicate that the differences between the caps are substantial (rather than reflecting short-lived differences in frost cover), and so support the idea of long-term asymmetry in the polar climates of Mars.

Thompson, P. M. and J. C. Ollason (2001). "Lagged effects of ocean climate change on fulmar population dynamics." Nature **413**(6854): 417-20.

Environmental variation reflected by the North Atlantic Oscillation affects breeding and survival in terrestrial vertebrates, and climate change is predicted to have an impact on population dynamics by influencing food quality or availability. The North Atlantic Oscillation also affects the abundance of marine fish and zooplankton, but it is unclear whether this filters up trophic levels to long-lived marine top predators. Here we show by analysis of data from a 50-year study of the fulmar that two different indices of ocean climate variation may have lagged effects on population dynamics in this procellariiform seabird. Annual variability in breeding performance is influenced by the North Atlantic Oscillation, whereas cohort differences in recruitment are related to temperature changes in the summer growing season in the year of birth. Because fulmars exhibit delayed reproduction, there is a 5-year lag in the population's response to these effects of environmental change. These data show how interactions between different climatic factors result in complex dynamics, and that the effects of climate change may take many years to become apparent in long-lived marine top predators.

Thomson, M. C., F. J. Doblas-Reyes, et al. (2006). "Malaria early warnings based on seasonal climate forecasts from multi-model ensembles." Nature **439**(7076): 576-9.

The control of epidemic malaria is a priority for the international health community and specific targets for the early detection and effective control of epidemics have been agreed. Interannual climate variability is an important determinant of epidemics in parts of Africa where climate drives both mosquito vector dynamics and parasite development rates. Hence, skilful seasonal climate forecasts may provide early warning of changes of risk in epidemic-prone regions. Here we discuss the development of a system to forecast probabilities of

anomalously high and low malaria incidence with dynamically based, seasonal-timescale, multi-model ensemble predictions of climate, using leading global coupled ocean-atmosphere climate models developed in Europe. This forecast system is successfully applied to the prediction of malaria risk in Botswana, where links between malaria and climate variability are well established, adding up to four months lead time over malaria warnings issued with observed precipitation and having a comparably high level of probabilistic prediction skill. In years in which the forecast probability distribution is different from that of climatology, malaria decision-makers can use this information for improved resource allocation.

Thuiller, W., M. B. Araujo, et al. (2004). "Biodiversity conservation: uncertainty in predictions of extinction risk." Nature **430**(6995): 1 p following 33; discussion following 33.

Thomas et al. model species-distribution responses to a range of climate-warming scenarios and use a novel application of the species-area relationship to estimate that 15-37% of modelled species in various regions of the world will be committed to extinction by 2050. Although we acknowledge the efforts that they make to measure the uncertainties associated with different climate scenarios, species' dispersal abilities and z values (predictions ranged from 5.6% to 78.6% extinctions), we find that two additional sources of uncertainty may substantially increase the variability in predictions.

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Tilman, D., P. B. Reich, et al. (2006). "Biodiversity and ecosystem stability in a decade-long grassland experiment." Nature **441**(7093): 629-32.

Human-driven ecosystem simplification has highlighted questions about how the number of species in an ecosystem influences its functioning. Although biodiversity is now known to affect ecosystem productivity, its effects on stability are debated. Here we present a long-term experimental field test of the diversity-stability hypothesis. During a decade of data collection in an experiment that directly controlled the number of perennial prairie species, growing-season climate varied considerably, causing year-to-year variation in abundances of plant species and in ecosystem productivity. We found that greater numbers of plant species led to greater temporal stability of ecosystem annual aboveground plant production. In particular, the decadal temporal stability of the ecosystem, whether measured with intervals of two, five or ten years, was significantly greater at higher plant diversity and tended to increase as plots matured. Ecosystem stability was also positively dependent on root mass, which is a measure of perenniating biomass. Temporal stability of the ecosystem increased with diversity, despite a lower temporal stability of individual species, because of both portfolio (statistical averaging) and overyielding effects. However, we found no evidence of a covariance effect. Our results indicate that the reliable, efficient and sustainable supply of some foods (for example, livestock fodder), biofuels and ecosystem services can be enhanced by the use of biodiversity.

Tiwari, R. K. and K. N. Rao (1999). "Periodicity in marine phosphorus burial rate."

Nature **400**(6739): 31-2.
There have been arguments both for and against a periodicity of 26-33 million years (Myr) in terrestrial and extraterrestrial records. The best way to identify such periodicity is the analysis of geomarine evolutionary records. We have analysed the marine sedimentary phosphorus burial rate (PBR), as fluctuations in this rate are strong indicators of the coupling of climate, continental weathering and ocean primary productivity. We find a statistically significant harmonic component of 33 +/- 3 Myr against the estimated robust background noise spectrum, supporting the idea that geomarine processes are cyclic.

Travis, D. J., A. M. Carleton, et al. (2002). "Contrails reduce daily temperature range." Nature **418**(6898): 601.
The potential of condensation trails (contrails) from jet aircraft to affect regional-scale surface temperatures has been debated for years, but was difficult to verify until an opportunity arose as a result of the three-day grounding of all commercial aircraft in the United States in the aftermath of the terrorist attacks on 11 September 2001. Here we show that there was an anomalous increase in the average diurnal temperature range (that is, the difference between the daytime maximum and night-time minimum temperatures) for the period 11-14 September 2001. Because persisting contrails can reduce the transfer of both incoming solar and outgoing infrared radiation and so reduce the daily temperature range, we attribute at least a portion of this anomaly to the absence of contrails over this period.

Treguer, P. and P. Pondaven (2000). "Global change. Silica control of carbon dioxide." Nature **406**(6794): 358-9.

Trenberth, K. E. (2004). "Climatology (communication arising): rural land-use change and climate." Nature **427**(6971): 213; discussion 214.
Kalnay and Cai claim that urbanization and land-use change have a major effect on the climate in the United States. They used surface temperatures obtained from NCEP/NCAR 50-year reanalyses (NNR) and their difference compared with observed station surface temperatures as the basis for their conclusions, on the grounds that the NNR did not include these anthropogenic effects. However, we note that the NNR also overlooked other factors, such as known changes in clouds and in surface moisture, which are more likely to explain Kalnay and Cai's findings. Although urban heat-island effects are real in cities, direct estimates of the effects of rural land-use change indicate a cooling rather than a warming influence that is due to a greater reflection of sunlight.

Treydte, K. S., G. H. Schleser, et al. (2006). "The twentieth century was the wettest period in northern Pakistan over the past millennium." Nature **440**(7088): 1179-82.
Twentieth-century warming could lead to increases in the moisture-holding capacity of the atmosphere, altering the hydrological cycle and the characteristics of precipitation. Such changes in the global rate and distribution of precipitation may have a greater direct effect on human well-being and ecosystem dynamics than changes in temperature itself. Despite the co-variability of both of these climate variables, attention in long-term climate reconstruction has mainly concentrated on temperature changes. Here we present an annually resolved oxygen isotope record from tree-rings, providing a millennial-scale reconstruction of precipitation variability in the high mountains of northern Pakistan. The climatic signal originates mainly from winter precipitation, and is robust over ecologically different sites. Centennial-scale variations reveal dry conditions at the beginning of the past millennium and through the eighteenth and early nineteenth centuries, with precipitation increasing during the late nineteenth and the twentieth centuries to yield the wettest conditions of the past 1,000 years. Comparison with other long-term precipitation reconstructions indicates a large-

scale intensification of the hydrological cycle coincident with the onset of industrialization and global warming, and the unprecedented amplitude argues for a human role.

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Triendl, R. (2002). "Chance to make a difference in Japan." Nature **417**(6888): 7.

Tripati, A., J. Backman, et al. (2005). "Eocene bipolar glaciation associated with global carbon cycle changes." Nature **436**(7049): 341-6.
The transition from the extreme global warmth of the early Eocene 'greenhouse' climate approximately 55 million years ago to the present glaciated state is one of the most prominent changes in Earth's climatic evolution. It is widely accepted that large ice sheets first appeared on Antarctica approximately 34 million years ago, coincident with decreasing atmospheric carbon dioxide concentrations and a deepening of the calcite compensation depth in the world's oceans, and that glaciation in the Northern Hemisphere began much later, between 10 and 6 million years ago. Here we present records of sediment and foraminiferal geochemistry covering the greenhouse-icehouse climate transition. We report evidence for synchronous deepening and subsequent oscillations in the calcite compensation depth in the tropical Pacific and South Atlantic oceans from approximately 42 million years ago, with a permanent deepening 34 million years ago. The most prominent variations in the calcite compensation depth coincide with changes in seawater oxygen isotope ratios of up to 1.5 per mil, suggesting a lowering of global sea level through significant storage of ice in both hemispheres by at least 100 to 125 metres. Variations in benthic carbon isotope ratios of up to approximately 1.4 per mil occurred at the same time, indicating large changes in carbon cycling. We suggest that the greenhouse-icehouse transition was closely coupled to the evolution of atmospheric carbon dioxide, and that negative carbon cycle feedbacks may have prevented the permanent establishment of large ice sheets earlier than 34 million years ago.

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Tudhope, S. and M. Collins (2003). "Global change: The past and future of El Nino." Nature **424**(6946): 261-2.

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Turner, C. and P. Raines (2002). "Rebel army need not be a barrier to conservation." Nature **418**(6894): 125.

Turner, J., J. C. King, et al. (2002). "Recent temperature trends in the Antarctic." Nature **418**(6895): 291-2; discussion 292.

It is important to understand how temperatures across the Antarctic have changed in recent decades because of the huge amount of fresh water locked into the ice sheet and the impact that temperature changes may have on the ice volume. Doran et al. claim that there has been a net cooling of the entire continent between 1966 and 2000, particularly during summer and autumn. We argue that this result has arisen because of an inappropriate extrapolation of station data across large, data-sparse areas of the Antarctic.

Turney, C. S., A. P. Kershaw, et al. (2004). "Millennial and orbital variations of El Nino/Southern Oscillation and high-latitude climate in the last glacial period." Nature **428**(6980): 306-10.

The El Nino/Southern Oscillation (ENSO) phenomenon is believed to have operated continuously over the last glacial-interglacial cycle. ENSO variability has been suggested to be linked to millennial-scale oscillations in North Atlantic climate during that time, but the proposals disagree on whether increased frequency of El Nino events, the warm phase of ENSO, was linked to North Atlantic warm or cold periods. Here we present a high-resolution record of surface moisture, based on the degree of peat humification and the ratio of sedges to grass, from northern Queensland, Australia, covering the past 45,000 yr. We observe millennial-scale dry periods, indicating periods of frequent El Nino events (summer precipitation declines in El Nino years in northeastern Australia). We find that these dry periods are correlated to the Dansgaard-Oeschger events--millennial-scale warm events in the North Atlantic climate record--although no direct atmospheric connection from the North Atlantic to our site can be invoked. Additionally, we find climatic cycles at a semiprecessional timescale (approximately 11,900 yr). We suggest that climate variations in the tropical Pacific Ocean on millennial as well as orbital timescales, which determined precipitation in northeastern Australia, also exerted an influence on North

Atlantic climate through atmospheric and oceanic teleconnections.

Ueno, Y., K. Yamada, et al. (2006). "Evidence from fluid inclusions for microbial methanogenesis in the early Archaean era." Nature **440**(7083): 516-9.

Methanogenic microbes may be one of the most primitive organisms, although it is uncertain when methanogens first appeared on Earth. During the Archaean era (before 2.5 Gyr ago), methanogens may have been important in regulating climate, because they could have provided sufficient amounts of the greenhouse gas methane to mitigate a severely frozen condition that could have resulted from lower solar luminosity during these times. Nevertheless, no direct geological evidence has hitherto been available in support of the existence of methanogens in the Archaean period, although circumstantial evidence is available in the form of approximately 2.8-Gyr-old carbon-isotope-depleted kerogen. Here we report crushing extraction and carbon isotope analysis of methane-bearing fluid inclusions in approximately 3.5-Gyr-old hydrothermal precipitates from Pilbara craton, Australia. Our results indicate that the extracted fluids contain microbial methane with carbon isotopic compositions of less than -56 per thousand included within original precipitates. This provides the oldest evidence of methanogen (> 3.46 Gyr ago), pre-dating previous geochemical evidence by about 700 million years.

Unsworth, M. J., A. G. Jones, et al. (2005). "Crustal rheology of the Himalaya and Southern Tibet inferred from magnetotelluric data." Nature **438**(7064): 78-81.

The Cenozoic collision between the Indian and Asian continents formed the Tibetan plateau, beginning about 70 million years ago. Since this time, at least 1,400 km of convergence has been accommodated by a combination of underthrusting of Indian and Asian lithosphere, crustal shortening, horizontal extrusion and lithospheric delamination. Rocks exposed in the Himalaya show evidence of crustal melting and are thought to have been exhumed by rapid erosion and climatically forced crustal flow. Magnetotelluric data can be used to image subsurface electrical resistivity, a parameter sensitive to the presence of interconnected fluids in the host rock matrix, even at low volume fractions. Here we present magnetotelluric data from the Tibetan-Himalayan orogen from 77 degrees E to 92 degrees E, which show that low resistivity, interpreted as a partially molten layer, is present along at least 1,000 km of the southern margin of the Tibetan plateau. The inferred low viscosity of this layer is consistent with the development of climatically forced crustal flow in Southern Tibet.

Urban, F. E., J. E. Cole, et al. (2000). "Influence of mean climate change on climate variability from a 155-year tropical Pacific coral record." Nature **407**(6807): 989-93.

Today, the El Nino/Southern Oscillation (ENSO) system is the primary driver of interannual variability in global climate, but its long-term behaviour is poorly understood. Instrumental observations reveal a shift in 1976 towards warmer and wetter conditions in the tropical Pacific, with widespread climatic and ecological consequences. This shift, unique over the past century, has prompted debate over the influence of increasing atmospheric concentrations of greenhouse gases on ENSO variability. Here we present a 155-year ENSO reconstruction from a central tropical Pacific coral that provides new evidence for long-term changes in the regional mean climate and its variability. A gradual transition in the early twentieth century and the abrupt change in 1976, both towards warmer and wetter conditions, co-occur with changes in variability. In the mid-late nineteenth century, cooler and drier background conditions coincided with prominent decadal variability; in the early twentieth century, shorter-period (approximately 2.9 years) variability intensified. After 1920, variability weakens and becomes focused at interannual timescales; with the shift in 1976, variability with a period of about 4 years becomes prominent. Our results suggest that variability in the tropical Pacific is linked to the region's mean climate, and that changes in both have

occurred during periods of natural as well as anthropogenic climate forcing.

Valentini, R., G. Matteucci, et al. (2000). "Respiration as the main determinant of carbon balance in European forests." Nature **404**(6780): 861-5.

Carbon exchange between the terrestrial biosphere and the atmosphere is one of the key processes that need to be assessed in the context of the Kyoto Protocol. Several studies suggest that the terrestrial biosphere is gaining carbon, but these estimates are obtained primarily by indirect methods, and the factors that control terrestrial carbon exchange, its magnitude and primary locations, are under debate. Here we present data of net ecosystem carbon exchange, collected between 1996 and 1998 from 15 European forests, which confirm that many European forest ecosystems act as carbon sinks. The annual carbon balances range from an uptake of 6.6 tonnes of carbon per hectare per year to a release of nearly 1 t C ha(-1) yr(-1), with a large variability between forests. The data show a significant increase of carbon uptake with decreasing latitude, whereas the gross primary production seems to be largely independent of latitude. Our observations indicate that, in general, ecosystem respiration determines net ecosystem carbon exchange. Also, for an accurate assessment of the carbon balance in a particular forest ecosystem, remote sensing of the normalized difference vegetation index or estimates based on forest inventories may not be sufficient.

Valladas, H., J. Clottes, et al. (2001). "Palaeolithic paintings. Evolution of prehistoric cave art." Nature **413**(6855): 479.

Sophisticated examples of European palaeolithic parietal art can be seen in the caves of Altamira, Lascaux and Niaux near the Pyrenees, which date to the Magdalenian period (12,000-17,000 years ago), but paintings of comparable skill and complexity were created much earlier, some possibly more than 30,000 years ago. We have derived new radiocarbon dates for the drawings that decorate the Chauvet cave in Vallon-Pont-d'Arc, Ardeche, France, which confirm that even 30,000 years ago Aurignacian artists, already known as accomplished carvers, could create masterpieces comparable to the best Magdalenian art. Prehistorians, who have traditionally interpreted the evolution of prehistoric art as a steady progression from simple to more complex representations, may have to reconsider existing theories of the origins of art.

van Dam, J. A., H. Abdul Aziz, et al. (2006). "Long-period astronomical forcing of mammal turnover." Nature **443**(7112): 687-91.

Mammals are among the fastest-radiating groups, being characterized by a mean species lifespan of the order of 2.5 million years (Myr). The basis for this characteristic timescale of origination, extinction and turnover is not well understood. Various studies have invoked climate change to explain mammalian species turnover, but other studies have either challenged or only partly confirmed the climate-turnover hypothesis. Here we use an exceptionally long (24.5-2.5 Myr ago), dense, and well-dated terrestrial record of rodent lineages from central Spain, and show the existence of turnover cycles with periods of 2.4-2.5 and 1.0 Myr. We link these cycles to low-frequency modulations of Milankovitch oscillations, and show that pulses of turnover occur at minima of the 2.37-Myr eccentricity cycle and nodes of the 1.2-Myr obliquity cycle. Because obliquity nodes and eccentricity minima are associated with ice sheet expansion and cooling and affect regional precipitation, we infer that long-period astronomical climate forcing is a major determinant of species turnover in small mammals and probably other groups as well.

van Noordwijk, A. J. (2003). "Climate change: The earlier bird." Nature **422**(6927): 29.

Van Wassenbergh, S., A. Herrel, et al. (2006). "Evolution: a catfish that can strike its prey on land." Nature **440**(7086): 881.

An important step towards understanding the evolution of terrestriality in vertebrates is to identify how the aquatic ancestors of tetrapods were able to access ground-based prey. We have discovered that the 'eel catfish' Channallabes apus, an inhabitant of the muddy swamps of tropical Africa, has a remarkable ability to forage and capture prey on land. The animal's capacity to bend its head down towards the ground while feeding seems to be an essential feature that may have enabled fish to make the transition from an aquatic to a terrestrial mode.

Vandergoes, M. J., R. M. Newnham, et al. (2005). "Regional insolation forcing of late Quaternary climate change in the Southern Hemisphere." Nature **436**(7048): 242-5.

In agreement with the Milankovitch orbital forcing hypothesis it is often assumed that glacial-interglacial climate transitions occurred synchronously in the Northern and Southern hemispheres of the Earth. It is difficult to test this assumption, because of the paucity of long, continuous climate records from the Southern Hemisphere that have not been dated by tuning them to the presumed Northern Hemisphere signals. Here we present an independently dated terrestrial pollen record from a peat bog on South Island, New Zealand, to investigate global and local factors in Southern Hemisphere climate changes during the last two glacial-interglacial cycles. Our record largely corroborates the Milankovitch model of orbital forcing but also exhibits some differences: in particular, an earlier onset and longer duration of the Last Glacial Maximum. Our results suggest that Southern Hemisphere insolation may have been responsible for these differences in timing. Our findings question the validity of applying orbital tuning to Southern Hemisphere records and suggest an alternative mechanism to the bipolar seesaw for generating interhemispheric asynchrony in climate change.

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In agreement with the Milankovitch orbital forcing hypothesis it is often assumed that glacial-interglacial climate transitions occurred synchronously in the Northern and Southern hemispheres of the Earth. It is difficult to test this assumption, because of the paucity of long, continuous climate records from the Southern Hemisphere that have not been dated by tuning them to the presumed Northern Hemisphere signals. Here we present an independently dated terrestrial pollen record from a peat bog on South Island, New Zealand, to investigate global and local factors in Southern Hemisphere climate changes during the last two glacial-interglacial cycles. Our record largely corroborates the Milankovitch model of orbital forcing but also exhibits some differences: in particular, an earlier onset and longer duration of the Last Glacial Maximum. Our results suggest that Southern Hemisphere insolation may have been responsible for these differences in timing. Our findings question the validity of applying orbital tuning to Southern Hemisphere records and suggest an alternative mechanism to the bipolar seesaw for generating interhemispheric asynchrony in climate change.

Vecchi, G. A., B. J. Soden, et al. (2006). "Weakening of tropical Pacific atmospheric circulation due to anthropogenic forcing." Nature **441**(7089): 73-6.

Since the mid-nineteenth century the Earth's surface has warmed, and models indicate that human activities have caused part of the warming by altering the radiative balance of the atmosphere. Simple theories suggest that global warming will reduce the strength of the mean tropical atmospheric circulation. An important aspect of this tropical circulation is a large-scale zonal (east-west) overturning of air across the equatorial Pacific Ocean--driven by convection to the west and subsidence to the east--known as the Walker circulation. Here we explore changes in tropical Pacific circulation since the mid-nineteenth century using observations and a suite of global climate model experiments. Observed Indo-Pacific sea level pressure reveals a weakening of the Walker circulation. The size of this trend is consistent with theoretical predictions, is accurately

reproduced by climate model simulations and, within the climate models, is largely due to anthropogenic forcing. The climate model indicates that the weakened surface winds have altered the thermal structure and circulation of the tropical Pacific Ocean. These results support model projections of further weakening of tropical atmospheric circulation during the twenty-first century.

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Veizer, J., Y. Godderis, et al. (2000). "Evidence for decoupling of atmospheric CO2 and global climate during the Phanerozoic eon." Nature **408**(6813): 698-701.

Atmospheric carbon dioxide concentrations are believed to drive climate changes from glacial to interglacial modes, although geological and astronomical mechanisms have been invoked as ultimate causes. Additionally, it is unclear whether the changes between cold and warm modes should be regarded as a global phenomenon, affecting tropical and high-latitude temperatures alike, or if they are better described as an expansion and contraction of the latitudinal climate zones, keeping equatorial temperatures approximately constant. Here we present a reconstruction of tropical sea surface temperatures throughout the Phanerozoic eon (the past approximately 550 Myr) from our database of oxygen isotopes in calcite and aragonite shells. The data indicate large oscillations of tropical sea surface temperatures in phase with the cold-warm cycles, thus favouring the idea of climate variability as a global phenomenon. But our data conflict with a temperature reconstruction using an energy balance model that is forced by reconstructed atmospheric carbon dioxide concentrations. The results can be reconciled if atmospheric carbon dioxide concentrations were not the principal driver of climate variability on geological timescales for at least one-third of the Phanerozoic eon, or if the reconstructed carbon dioxide concentrations are not reliable.

Velicogna, I. and J. Wahr (2006). "Acceleration of Greenland ice mass loss in spring 2004." Nature **443**(7109): 329-31.

In 2001 the Intergovernmental Panel on Climate Change projected the contribution to sea level rise from the Greenland ice sheet to be between -0.02 and +0.09 m from 1990 to 2100 (ref. 1). However, recent work has suggested that the ice sheet responds more quickly to climate perturbations than previously thought, particularly near the coast. Here we use a satellite gravity survey by the Gravity Recovery and Climate Experiment (GRACE) conducted from April 2002 to April 2006 to provide an independent estimate of the contribution of Greenland ice mass loss to sea level change. We detect an ice mass loss of 248 +/- 36 km3 yr(-1), equivalent to a global sea level rise of 0.5 +/- 0.1 mm yr(-1). The

rate of ice loss increased by 250 per cent between the periods April 2002 to April 2004 and May 2004 to April 2006, almost entirely due to accelerated rates of ice loss in southern Greenland; the rate of mass loss in north Greenland was almost constant. Continued monitoring will be needed to identify any future changes in the rate of ice loss in Greenland.

Verschuren, D. (2003). "Global change: the heat on Lake Tanganyika." Nature **424**(6950): 731-2.

Verschuren, D. (2003). "Global change: the heat on Lake Tanganyika." Nature **424**(6950): 731-2.

Verschuren, D., K. R. Laird, et al. (2000). "Rainfall and drought in equatorial east Africa during the past 1,100 years." Nature **403**(6768): 410-4.

Knowledge of natural long-term rainfall variability is essential for water-resource and land-use management in sub-humid regions of the world. In tropical Africa, data relevant to determining this variability are scarce because of the lack of long instrumental climate records and the limited potential of standard high-resolution proxy records such as tree rings and ice cores. Here we present a decade-scale reconstruction of rainfall and drought in equatorial east Africa over the past 1,100 years, based on lake-level and salinity fluctuations of Lake Naivasha (Kenya) inferred from three different palaeolimnological proxies: sediment stratigraphy and the species compositions of fossil diatom and midge assemblages. Our data indicate that, over the past millennium, equatorial east Africa has alternated between contrasting climate conditions, with significantly drier climate than today during the 'Medieval Warm Period' (approximately AD 1000-1270) and a relatively wet climate during the 'Little Ice Age' (approximately AD 1270-1850) which was interrupted by three prolonged dry episodes. We also find strong chronological links between the reconstructed history of natural long-term rainfall variation and the pre-colonial cultural history of east Africa, highlighting the importance of a detailed knowledge of natural long-term rainfall fluctuations for sustainable socio-economic development.

Vik, J. O., N. C. Stenseth, et al. (2004). "Ecology: living in synchrony on Greenland coasts?" Nature **427**(6976): 697-8; discussion 698.

Theory indicates that correlated weather may synchronize populations, but the extent to which this holds for non-identical, nonlinear systems is uncertain. Post and Forchhammer claim to have shown climate-induced synchrony for musk oxen and caribou that are separated by the Greenland ice sheet. However, logical and mathematical errors undermine their finding. Whether or not large-scale weather can be a major synchronizing factor across species remains an open question.

Visser, K., R. Thunell, et al. (2003). "Magnitude and timing of temperature change in the Indo-Pacific warm pool during deglaciation." Nature **421**(6919): 152-5.

Ocean-atmosphere interactions in the tropical Pacific region have a strong influence on global heat and water vapour transport and thus constitute an important component of the climate system. Changes in sea surface temperatures and convection in the tropical Indo-Pacific region are thought to be responsible for the interannual to decadal climate variability observed in extra-tropical regions, but the role of the tropics in climate changes on millennial and orbital timescales is less clear. Here we analyse oxygen isotopes and Mg/Ca ratios of foraminiferal shells from the Makassar strait in the heart of the Indo-Pacific warm pool, to obtain synchronous estimates of sea surface temperatures and ice volume. We find that sea surface temperatures increased by 3.5-4.0 degrees C during the last two glacial-interglacial transitions, synchronous with the global increase in atmospheric CO2 and Antarctic warming, but the temperature increase occurred 2,000-3,000 years before the Northern Hemisphere ice sheets melted.

Our observations suggest that the tropical Pacific region plays an important role in driving glacial-interglacial cycles, possibly through a system similar to how El Nino/Southern Oscillation regulates the poleward flux of heat and water vapour.

Volkov, I., J. R. Banavar, et al. (2005). "Density dependence explains tree species abundance and diversity in tropical forests." Nature **438**(7068): 658-61.

The recurrent patterns in the commonness and rarity of species in ecological communities--the relative species abundance--have puzzled ecologists for more than half a century. Here we show that the framework of the current neutral theory in ecology can easily be generalized to incorporate symmetric density dependence. We can calculate precisely the strength of the rare-species advantage that is needed to explain a given RSA distribution. Previously, we demonstrated that a mechanism of dispersal limitation also fits RSA data well. Here we compare fits of the dispersal and density-dependence mechanisms for empirical RSA data on tree species in six New and Old World tropical forests and show that both mechanisms offer sufficient and independent explanations. We suggest that RSA data cannot by themselves be used to discriminate among these explanations of RSA patterns--empirical studies will be required to determine whether RSA patterns are due to one or the other mechanism, or to some combination of both.

von Bubnoff, A. (2005). "Senate hearings strengthen calls for US action over climate." Nature **436**(7050): 450.

von Storch, H. and N. Stehr (2000). "Climate change in perspective." Nature **405**(6787): 615.

von Storch, H. and N. Stehr (2000). "Climate change in perspective." Nature **405**(6787): 615.

Vose, R. S., T. R. Karl, et al. (2004). "Climate (communication arising): impact of land-use change on climate." Nature **427**(6971): 213-4; discussion 214.

Urbanization and other changes in land use have an impact on surface-air temperatures. Kalnay and Cai report that the observed surface-temperature trend in part of the United States exceeds the trend in the NCEP/NCAR 50-year reanalysis (NNR) and conclude that changes in land use account for the difference (0.035 degrees C per decade according to their corrected values). Although land-use change may explain some of this discrepancy, the authors do not quantify the impact of the many changes in observational practice that occurred during the analysis period. Our findings indicate that these 'non-climatic' changes have a systematic effect that overwhelms the reported difference in trends and therefore calls Kalnay and Cai's central conclusion into question.

Voznesenskaya, E. V., V. R. Franceschi, et al. (2001). "Kranz anatomy is not essential for terrestrial C4 plant photosynthesis." Nature **414**(6863): 543-6.

An important adaptation to CO2-limited photosynthesis in cyanobacteria, algae and some plants was development of CO2-concentrating mechanisms (CCM). Evolution of a CCM occurred many times in flowering plants, beginning at least 15-20 million years ago, in response to atmospheric CO2 reduction, climate change, geological trends, and evolutionary diversification of species. In plants, this is achieved through a biochemical inorganic carbon pump called C4 photosynthesis, discovered 35 years ago. C4 photosynthesis is advantageous when limitations on carbon acquisition are imposed by high temperature, drought and saline conditions. It has been thought that a specialized leaf anatomy, composed of two, distinctive photosynthetic cell types (Kranz anatomy), is required for C4 photosynthesis. We provide evidence that C4 photosynthesis can function within a single photosynthetic cell in terrestrial plants. Borszczowia aralocaspica (Chenopodiaceae) has the photosynthetic features of C4 plants, yet lacks Kranz

anatomy. This species accomplishes C4 photosynthesis through spatial compartmentation of photosynthetic enzymes, and by separation of two types of chloroplasts and other organelles in distinct positions within the chlorenchyma cell cytoplasm.

Wadsworth, G. R. (1952). "Packed red-cell volume in the tropics." Nature **170**(4333): 851.

Waelbroeck, C., J. C. Duplessy, et al. (2001). "The timing of the last deglaciation in North Atlantic climate records." Nature **412**(6848): 724-7.

To determine the mechanisms governing the last deglaciation and the sequence of events that lead to deglaciation, it is important to obtain a temporal framework that applies to both continental and marine climate records. Radiocarbon dating has been widely used to derive calendar dates for marine sediments, but it rests on the assumption that the 'apparent age' of surface water (the age of surface water relative to the atmosphere) has remained constant over time. Here we present new evidence for variation in the apparent age of surface water (or reservoir age) in the North Atlantic ocean north of 40 degrees N over the past 20,000 years. In two cores we found apparent surface-water ages to be larger than those of today by 1,230 +/- 600 and 1,940 +/- 750 years at the end of the Heinrich 1 surge event (15,000 years BP) and by 820 +/- 430 to 1,010 +/- 340 years at the end of the Younger Dryas cold episode. During the warm Bolling-Allerod period, between these two periods of large reservoir ages, apparent surface-water ages were comparable to present values. Our results allow us to reconcile the chronologies from ice cores and the North Atlantic marine records over the entire deglaciation period. Moreover, the data imply that marine carbon dates from the North Atlantic north of 40 degrees N will need to be corrected for these highly variable effects.

Walker, G. (2004). "Palaeoclimate: frozen time." Nature **429**(6992): 596-7.

Walker, G. (2006). "Climate change: the tipping point of the iceberg." Nature **441**(7095): 802-5.

Walker, G. (2006). "Climate change: the tipping point of the iceberg." Nature **441**(7095): 802-5.

Walker, J. C. and K. J. Zahnle (1986). "Lunar nodal tide and distance to the Moon during the Precambrian." Nature **320**: 600-2.

The pace of tidal evolution for the past approximately 450 Myr implies an Earth/Moon collision some 1,500-2,000 Myr BP, an event for which there is no corroborating evidence. Here we present the first direct determination of the lunar distance in the Precambrian. We interpret a 23.3 +/- 0.3-yr periodicity preserved in a 2,500 Myr BP Australian banded iron formation (BIF) as reflecting the climatic influence of the lunar nodal tide, which has been detected with its modern 18.6-yr periodicity in some modern climate records. The lunar distance at 2,500 Myr BP would then have been about 52 Earth radii. The implied history of Precambrian tidal friction is in accord with both the more recent palaeontological evidence and the long-term stability of the lunar orbit. The length of the Milankovitch cycles that modulate the ice ages today also evolve with the Earth-Moon system. Their detection in the Precambrian sedimentary record would then permit an independent determination of the lunar distance.

Walker, J. J., J. R. Spear, et al. (2005). "Geobiology of a microbial endolithic community in the Yellowstone geothermal environment." Nature **434**(7036): 1011-4.

The endolithic environment, the pore space of rocks, is a ubiquitous habitat for microorganisms on the Earth and is an important target of the search for life

elsewhere in the Solar System. Photosynthetic, endolithic microbial communities commonly inhabit the outer millimetres to centimetres of all rocks exposed to the Earth's surface. In the most extreme terrestrial climates, such as hot and cold deserts, endolithic microorganisms are often the main form of life. The endolithic microhabitat gives protection from intense solar radiation and desiccation, and it provides mineral nutrients, rock moisture and growth surfaces. Here we describe the discovery and identification of the constituents of an extremely acidic (pH 1) endolithic microbial community inhabiting the pore space of rocks in the geothermal environment of Yellowstone National Park, USA. Subjected to silica mineralization, such endolithic communities constitute biomarkers that can become fossilized and potentially preserved in the geological record. Remnants of these communities could serve as biosignatures and provide important clues about ancient life associated with geothermal environments on the Earth or elsewhere in the Solar System.

Wallace, S. C. and X. Wang (2004). "Two new carnivores from an unusual late Tertiary forest biota in eastern North America." Nature **431**(7008): 556-9.

Late Cenozoic terrestrial fossil records of North America are biased by a predominance of mid-latitude deposits, mostly in the western half of the continent. Consequently, the biological history of eastern North America, including the eastern deciduous forest, remains largely hidden. Unfortunately, vertebrate fossil sites from this vast region are rare, and few pertain to the critically important late Tertiary period, during which intensified global climatic changes took place. Moreover, strong phylogenetic affinities between the flora of eastern North America and eastern Asia clearly demonstrate formerly contiguous connections, but disparity among shared genera (eastern Asia-eastern North America disjunction) implies significant periods of separation since at least the Miocene epoch. Lacustrine sediments deposited within a former sinkhole in the southern Appalachian Mountains provide a rare example of a late Miocene to early Pliocene terrestrial biota from a forested ecosystem. Here we show that the vertebrate remains contained within this deposit represent a unique combination of North American and Eurasian taxa. A new genus and species of the red (lesser) panda (Pristinailurus bristoli), the earliest and most primitive so far known, was recovered. Also among the fauna are a new species of Eurasian badger (Arctomeles dimolodontus) and the largest concentration of fossil tapirs ever recorded. Cladistical analyses of the two new carnivores strongly suggest immigration events that were earlier than and distinct from previous records, and that the close faunal affinities between eastern North America and eastern Asia in the late Tertiary period are consistent with the contemporaneous botanical record.

Walter, K. M., S. A. Zimov, et al. (2006). "Methane bubbling from Siberian thaw lakes as a positive feedback to climate warming." Nature **443**(7107): 71-5.

Large uncertainties in the budget of atmospheric methane, an important greenhouse gas, limit the accuracy of climate change projections. Thaw lakes in North Siberia are known to emit methane, but the magnitude of these emissions remains uncertain because most methane is released through ebullition (bubbling), which is spatially and temporally variable. Here we report a new method of measuring ebullition and use it to quantify methane emissions from two thaw lakes in North Siberia. We show that ebullition accounts for 95 per cent of methane emissions from these lakes, and that methane flux from thaw lakes in our study region may be five times higher than previously estimated. Extrapolation of these fluxes indicates that thaw lakes in North Siberia emit 3.8 teragrams of methane per year, which increases present estimates of methane emissions from northern wetlands (< 6-40 teragrams per year; refs 1, 2, 4-6) by between 10 and 63 per cent. We find that thawing permafrost along lake margins accounts for most of the methane released from the lakes, and estimate that an expansion of thaw lakes between 1974 and 2000, which was concurrent with regional warming,

increased methane emissions in our study region by 58 per cent. Furthermore, the Pleistocene age (35,260-42,900 years) of methane emitted from hotspots along thawing lake margins indicates that this positive feedback to climate warming has led to the release of old carbon stocks previously stored in permafrost.

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Walther, G. R., E. Post, et al. (2002). "Ecological responses to recent climate change." Nature **416**(6879): 389-95.

There is now ample evidence of the ecological impacts of recent climate change, from polar terrestrial to tropical marine environments. The responses of both flora and fauna span an array of ecosystems and organizational hierarchies, from the species to the community levels. Despite continued uncertainty as to community and ecosystem trajectories under global change, our review exposes a coherent pattern of ecological change across systems. Although we are only at an early stage in the projected trends of global warming, ecological responses to recent climate change are already clearly visible.

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Wang, X., A. S. Auler, et al. (2004). "Wet periods in northeastern Brazil over the past 210 kyr linked to distant climate anomalies." Nature **432**(7018): 740-3.

The tropics are the main source of the atmosphere's sensible and latent heat, and water vapour, and are therefore important for reconstructions of past climate. But long, accurately dated records of southern tropical palaeoclimate, which would allow the establishment of climatic connections to distant regions, have not been available. Here we present a 210,000-year (210-kyr) record of wet periods in tropical northeastern Brazil--a region that is currently semi-arid. The record is

obtained from speleothems and travertine deposits that are accurately dated using the U/Th method. We find wet periods that are synchronous with periods of weak East Asian summer monsoons, cold periods in Greenland, Heinrich events in the North Atlantic and periods of decreased river runoff to the Cariaco basin. We infer that the wet periods may be explained with a southward displacement of the Intertropical Convergence Zone. This widespread synchroneity of climate anomalies suggests a relatively rapid global reorganization of the ocean-atmosphere system. We conclude that the wet periods probably affected rainforest distribution, as plant fossils show that forest expansion occurred during these intermittent wet intervals, and opened a forest corridor between the Amazonian and Atlantic rainforests.

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Warren, M. S., J. K. Hill, et al. (2001). "Rapid responses of British butterflies to opposing forces of climate and habitat change." Nature **414**(6859): 65-9.

Habitat degradation and climate change are thought to be altering the distributions and abundances of animals and plants throughout the world, but their combined impacts have not been assessed for any species assemblage. Here we evaluated changes in the distribution sizes and abundances of 46 species of butterflies that approach their northern climatic range margins in Britain-where changes in climate and habitat are opposing forces. These insects might be expected to have responded positively to climate warming over the past 30 years, yet three-quarters of them declined: negative responses to habitat loss have outweighed positive responses to climate warming. Half of the species that were mobile and habitat generalists increased their distribution sites over this period (consistent with a climate explanation), whereas the other generalists and 89% of the habitat specialists declined in distribution size (consistent with habitat limitation). Changes in population abundances closely matched changes in distributions. The dual forces of habitat modification and climate change are likely to cause specialists to decline, leaving biological communities with reduced numbers of species and dominated by mobile and widespread habitat generalists.

Watanabe, O., J. Jouzel, et al. (2003). "Homogeneous climate variability across East Antarctica over the past three glacial cycles." Nature **422**(6931): 509-12.

Recent ice core studies have raised the disturbing possibility that glacial-interglacial climate changes may be non-uniform across Antarctica. These findings have been confined to records from the Ross Sea sector of the continent, but significant deviations in other areas would call into question the widely

assumed validity of the climate record obtained from Vostok, East Antarctica, on large spatial scales. Here we present an isotopic profile from a core drilled at Dome Fuji, situated 1,500 km from Vostok in a different sector of East Antarctica. The two records show remarkable similarities over the past three glacial cycles (the extent of the Dome Fuji record) in both large-amplitude changes, such as terminations, interglacials and interstadials and more subtle glacial events, even when the origin of precipitation is accounted for. Our results indicate that Antarctic climate is essentially homogeneous at the scale of the East Antarctic Plateau, possibly as a consequence of the symmetry of the plateau and the adjacent ocean.

Waterhouse, F. L. (1950). "Humidity and temperature in grass microclimates with reference to insolation." Nature **166**(4214): 232-3.

Watson, H. L. (2006). "Climate: US has always made IPCC drafts available." Nature **441**(7092): 406.

Weaver, A. J. and F. W. Zwiers (2000). "Uncertainty in climate change." Nature **407**(6804): 571-2.

Webb, C. G. (1964). "Thermal Discomfort in a Tropical Environment." Nature **202**: 1193-4.

Webster, P. J., A. M. Moore, et al. (1999). "Coupled ocean-atmosphere dynamics in the Indian Ocean during 1997-98." Nature **401**(6751): 356-60.

Climate variability in the Indian Ocean region seems to be, in some aspects, independent of forcing by external phenomena such as the El Nino/Southern Oscillation. But the extent to which, and how, internal coupled ocean-atmosphere dynamics determine the state of the Indian Ocean system have not been resolved. Here we present a detailed analysis of the strong seasonal anomalies in sea surface temperatures, sea surface heights, precipitation and winds that occurred in the Indian Ocean region in 1997-98, and compare the results with the record of Indian Ocean climate variability over the past 40 years. We conclude that the 1997-98 anomalies-in spite of the coincidence with the strong El Nino/Southern Oscillation event-may primarily be an expression of internal dynamics, rather than a direct response to external influences. We propose a mechanism of ocean-atmosphere interaction governing the 1997-98 event that may represent a characteristic internal mode of the Indian Ocean climate system. In the Pacific Ocean, the identification of such a mode has led to successful predictions of El Nino; if the proposed Indian Ocean internal mode proves to be robust, there may be a similar potential for predictability of climate in the Indian Ocean region.

Weissert, H. and S. M. Bernasconi (2004). "Global change: an Earth on fire." Nature **428**(6979): 130-2.

Weissert, H. and S. M. Bernasconi (2004). "Global change: an Earth on fire." Nature **428**(6979): 130-2.

Wennberg, P. O. (2006). "Atmospheric chemistry: radicals follow the Sun." Nature **442**(7099): 145-6.

Wentz, F. J. and M. Schabel (2000). "Precise climate monitoring using complementary satellite data sets." Nature **403**(6768): 414-6.

Observations from Earth-orbiting satellites have been a key component in monitoring climate change for the past two decades. This has become possible with the availability of air temperatures from the Microwave Sounding Unit (MSU) since 1979, sea surface temperatures from the Advanced Very High

Resolution Radiometer (AVHRR) since 1982 and, most recently, measurements of atmospheric water vapour content from the Special Sensor Microwave Imager (SSM/I) since 1987. Here we present a detailed comparison of each pair of these three time series, focusing on both interannual and decadal variations in climate. We find a strong association between sea surface temperature, lower-tropospheric air temperature and total column water-vapour content over large oceanic regions on both time scales. This lends observational support to the idea of a constant relative humidity model having a moist adiabatic lapse rate. On the decadal timescale, the combination of data sets shows a consistent warming and moistening trend of the marine atmosphere for 1987-1998.

Wharton, R. A., Jr., C. P. McKay, et al. (1987). "Perennial N2 supersaturation in an Antarctic lake." Nature **325**(6102): 343-5.

The dry valleys of southern Victoria Land in Antarctica contain several closed basins in which perennially ice-covered lakes are found. One of the most unusual features of these lakes is the occurrence of high O2 concentrations in the water column; values ranging from slightly more than saturation to more than four times saturation have been reported. Recently, we considered a bulk O2 budget for Lake Hoare, Antarctica, which led us to suggest that biological processes alone were not sufficient to explain the observed elevated oxygen levels. Consequently, there must be a non-biological source of O2. We suggested that this source results from the exclusion of O2 during the freezing of aerated meltstream water at the bottom of the ice cover, and predicted that this physical mechanism should also enhance the other atmospheric gases. Here we report the results of a study which, for the first time, documents the supersaturation of N2 in a lake. Dissolved N2 levels of 145% and 163% were determined from samples taken just below the ice cover and at a depth of 12 m, respectively. The relatively importance of biological and abiological sources is reflected in the ratio of N2 concentration to O2 concentration. In Lake Hoare this ratio was 1.20 at ice/water interface and 1.05 at 12 m; considerably different from the ratio in equilibrium with air (approximately 1.8). Based on these results, we have determined that about half of the net O2 production in the lake is the result of biological processes.

White, G. B. (1970). "Evidence for Anopheles squamosus migration?" Nature **227**(5259): 739-40.

Whitfield, J. (2001). "The budding amateurs." Nature **414**(6864): 578-9.

Whitfield, J. (2003). "Alaska's climate: too hot to handle." Nature **425**(6956): 338-9.

Whitfield, J. (2003). "Alaska's climate: too hot to handle." Nature **425**(6956): 338-9.

Whitfield, J. (2005). "Complex systems: order out of chaos." Nature **436**(7053): 905-7.

Whitlock, C. (2004). "Land management: forests, fires and climate." Nature **432**(7013): 28-9.

Wignall, P. B., J. M. McArthur, et al. (2006). "Palaeoceanography: methane release in the Early Jurassic period." Nature **441**(7093): E5; discussion E5-6.

Dramatic global warming, triggered by release of methane from clathrates, has been postulated to have occurred during the early Toarcian age in the Early Jurassic period. Kemp et al. claim that this methane was released at three points, as recorded by three sharp excursions of delta13C(org) of up to 3 per thousand magnitude. But they discount another explanation for the excursions: namely that some, perhaps all, of the rapid excursions could be a local signature of a euxinic basin caused by recycling of isotopically light carbon from the lower water column. This idea has been proposed previously (see ref. 3, for example) and is

supported by the lack evidence for negative delta13C excursions in coeval belemnite rostra. Kemp et al. dismiss this alternative, claiming that each abrupt shift would have required the recycling of about double the amount of organic carbon that is currently present in the modern ocean; however, their measurements are not from an ocean but from a restricted, epicontinental seaway and so would not require whole-ocean mixing to achieve the excursions.

Wikelski, M., E. M. Tarlow, et al. (2003). "Avian metabolism: Costs of migration in free-flying songbirds." Nature **423**(6941): 704.

Williams, D. M., J. F. Kasting, et al. (1998). "Low-latitude glaciation and rapid changes in the Earth's obliquity explained by obliquity-oblateness feedback." Nature **396**(6710): 453-5.

Palaeomagnetic data suggest that the Earth was glaciated at low latitudes during the Palaeoproterozoic (about 2.4-2.2 Gyr ago) and Neoproterozoic (about 820-550 Myr ago) eras, although some of the Neoproterozoic data are disputed. If the Earth's magnetic field was aligned more or less with its spin axis, as it is today, then either the polar ice caps must have extended well down into the tropics-the 'snowball Earth' hypothesis-or the present zonation of climate with respect to latitude must have been reversed. Williams has suggested that the Earth's obliquity may have been greater than 54 degrees during most of its history, which would have made the Equator the coldest part of the planet. But this would require a mechanism to bring the obliquity down to its present value of 23.5 degrees. Here we propose that obliquity-oblateness feedback could have reduced the Earth's obliquity by tens of degrees in less than 100 Myr if the continents were situated so as to promote the formation of large polar ice sheets. A high obliquity for the early Earth may also provide a natural explanation for the present inclination of the lunar orbit with respect to the ecliptic (5 degrees), which is otherwise difficult to explain.

Williams, R. (2005). "Climate change blamed for rise in hay fever." Nature **434**(7037): 1059.

Williams, R. (2005). "Climate change blamed for rise in hay fever." Nature **434**(7037): 1059.

Wilson, P. A. and R. D. Norris (2001). "Warm tropical ocean surface and global anoxia during the mid-Cretaceous period." Nature **412**(6845): 425-9.

The middle of the Cretaceous period (about 120 to 80 Myr ago) was a time of unusually warm polar temperatures, repeated reef-drowning in the tropics and a series of oceanic anoxic events (OAEs) that promoted both the widespread deposition of organic-carbon-rich marine sediments and high biological turnover. The cause of the warm temperatures is unproven but widely attributed to high levels of atmospheric greenhouse gases such as carbon dioxide. In contrast, there is no consensus on the climatic causes and effects of the OAEs, with both high biological productivity and ocean 'stagnation' being invoked as the cause of ocean anoxia. Here we show, using stable isotope records from multiple species of well-preserved foraminifera, that the thermal structure of surface waters in the western tropical Atlantic Ocean underwent pronounced variability about 100 Myr ago, with maximum sea surface temperatures 3-5 degrees C warmer than today. This variability culminated in a collapse of upper-ocean stratification during OAE-1d (the 'Breistroffer' event), a globally significant period of organic-carbon burial that we show to have fundamental, stratigraphically valuable, geochemical similarities to the main OAEs of the Mesozoic era. Our records are consistent with greenhouse forcing being responsible for the warm temperatures, but are inconsistent both with explanations for OAEs based on ocean stagnation, and with the traditional view (reviewed in ref. 12) that past warm periods were more

stable than today's climate.

Wingham, D. J., M. J. Siegert, et al. (2006). "Rapid discharge connects Antarctic subglacial lakes." Nature **440**(7087): 1033-6.

The existence of many subglacial lakes provides clear evidence for the widespread presence of water beneath the East Antarctic ice sheet, but the hydrology beneath this ice mass is poorly understood. Such knowledge is critical to understanding ice flow, basal water transfer to the ice margin, glacial landform development and subglacial lake habitats. Here we present ice-sheet surface elevation changes in central East Antarctica that we interpret to represent rapid discharge from a subglacial lake. Our observations indicate that during a period of 16 months, 1.8 km3 of water was transferred over 290 km to at least two other subglacial lakes. While viscous deformation of the ice roof above may moderate discharge, the intrinsic instability of such a system suggests that discharge events are a common mode of basal drainage. If large lakes, such as Lake Vostok or Lake Concordia, are pressurizing, it is possible that substantial discharges could reach the coast. Our observations conflict with expectations that subglacial lakes have long residence times and slow circulations, and we suggest that entire subglacial drainage basins may be flushed periodically. The rapid transfer of water between lakes would result in large-scale solute and microbe relocation, and drainage system contamination from in situ exploration is, therefore, a distinct risk.

Witze, A. (2006). "Meteorology: bad weather ahead." Nature **441**(7093): 564-6.

Wobus, C., A. Heimsath, et al. (2005). "Active out-of-sequence thrust faulting in the central Nepalese Himalaya." Nature **434**(7036): 1008-11.

Recent convergence between India and Eurasia is commonly assumed to be accommodated mainly along a single fault--the Main Himalayan Thrust (MHT)--which reaches the surface in the Siwalik Hills of southern Nepal. Although this model is consistent with geodetic, geomorphic and microseismic data, an alternative model incorporating slip on more northerly surface faults has been proposed to be consistent with these data as well. Here we present in situ cosmogenic 10Be data indicating a fourfold increase in millennial timescale erosion rates occurring over a distance of less than 2 km in central Nepal, delineating for the first time an active thrust fault nearly 100 km north of the surface expression of the MHT. These data challenge the view that rock uplift gradients in central Nepal reflect only passive transport over a ramp in the MHT. Instead, when combined with previously reported 40Ar-39Ar data, our results indicate persistent exhumation above deep-seated, surface-breaking structures at the foot of the high Himalaya. These results suggest that strong dynamic interactions between climate, erosion and tectonics have maintained a locus of active deformation well to the north of the Himalayan deformation front.

Wohlgemuth, S., B. Ronacher, et al. (2001). "Ant odometry in the third dimension." Nature **411**(6839): 795-8.

Desert ants (Cataglyphis) are renowned for their ability to perform large-scale foraging excursions and then return to the nest by path integration. They do so by integrating courses steered and the distances travelled into a continually updated home vector. Whereas the angular orientation is based on skylight cues, how the ants gauge the distances travelled has remained largely unclear. Furthermore, almost all studies on path integration in Cataglyphis, as well as in spiders, rodents, and humans, have aimed at understanding how the animals compute homebound courses in the horizontal plane. Here, we investigate for the first time how an animal's odometer operates when a path integration task has to be accomplished that includes a vertical component. We trained Cataglyphis ants within arrays of uphill and downhill channels, and later tested them on flat terrain, or vice versa. In all these cases, the ants indicated homing distances that

corresponded not to the distances actually travelled but to the ground distances; that is, to the sum of the horizontal projections of the uphill and downhill segments of the ants' paths.

WoldeGabriel, G., Y. Haile-Selassie, et al. (2001). "Geology and palaeontology of the Late Miocene Middle Awash valley, Afar rift, Ethiopia." Nature **412**(6843): 175-8.

The Middle Awash study area of Ethiopia's Afar rift has yielded abundant vertebrate fossils (approximately 10,000), including several hominid taxa. The study area contains a long sedimentary record spanning Late Miocene (5.3-11.2 Myr ago) to Holocene times. Exposed in a unique tectonic and volcanic transition zone between the main Ethiopian rift (MER) and the Afar rift, sediments along the western Afar rift margin in the Middle Awash provide a unique window on the Late Miocene of Ethiopia. These deposits have now yielded the earliest hominids, described in an accompanying paper and dated here to between 5.54 and 5.77 Myr. These geological and palaeobiological data from the Middle Awash provide fresh perspectives on hominid origins and early evolution. Here we show that these earliest hominids derive from relatively wet and wooded environments that were modulated by tectonic, volcanic, climatic and geomorphic processes. A similar wooded habitat also has been suggested for the 6.0 Myr hominoid fossils recently recovered from Lukeino, Kenya. These findings require fundamental reassessment of models that invoke a significant role for global climatic change and/or savannah habitat in the origin of hominids.

Wolff, E. W., H. Fischer, et al. (2006). "Southern Ocean sea-ice extent, productivity and iron flux over the past eight glacial cycles." Nature **440**(7083): 491-6.

Sea ice and dust flux increased greatly in the Southern Ocean during the last glacial period. Palaeorecords provide contradictory evidence about marine productivity in this region, but beyond one glacial cycle, data were sparse. Here we present continuous chemical proxy data spanning the last eight glacial cycles (740,000 years) from the Dome C Antarctic ice core. These data constrain winter sea-ice extent in the Indian Ocean, Southern Ocean biogenic productivity and Patagonian climatic conditions. We found that maximum sea-ice extent is closely tied to Antarctic temperature on multi-millennial timescales, but less so on shorter timescales. Biological dimethylsulphide emissions south of the polar front seem to have changed little with climate, suggesting that sulphur compounds were not active in climate regulation. We observe large glacial-interglacial contrasts in iron deposition, which we infer reflects strongly changing Patagonian conditions. During glacial terminations, changes in Patagonia apparently preceded sea-ice reduction, indicating that multiple mechanisms may be responsible for different phases of CO2 increase during glacial terminations. We observe no changes in internal climatic feedbacks that could have caused the change in amplitude of Antarctic temperature variations observed 440,000 years ago.

Wollin, G., D. B. Ericson, et al. (1971). "Variations in magnetic intensity and climatic changes." Nature **232**(5312): 549-51.

Woo, P. T. (1970). "Origin of mammalian trypanosomes which develop in the anterior-station of blood-sucking arthropods." Nature **228**(5276): 1059-62.

Wood, W. T., J. F. Gettrust, et al. (2002). "Decreased stability of methane hydrates in marine sediments owing to phase-boundary roughness." Nature **420**(6916): 656-60.

Below water depths of about 300 metres, pressure and temperature conditions cause methane to form ice-like crystals of methane hydrate. Marine deposits of methane hydrate are estimated to be large, amassing about 10,000 gigatonnes of carbon, and are thought to be important to global change and seafloor stability, as well as representing a potentially exploitable energy resource. The extent of these deposits can usually be inferred from seismic imaging, in which the base of the

methane hydrate stability zone is frequently identifiable as a smooth reflector that runs parallel to the sea floor. Here, using high-resolution seismic sections of seafloor sediments in the Cascadia margin off the coast of Vancouver Island, Canada, we observe lateral variations in the base of the hydrate stability zone, including gas-rich vertical intrusions into the hydrate stability zone. We suggest that these vertical intrusions are associated with upward flow of warmer fluids. Therefore, where seafloor fluid expulsion and methane hydrate deposits coincide, the base of the hydrate stability zone might exhibit significant roughness and increased surface area. Increased area implies that significantly more methane hydrate lies close to being unstable and hence closer to dissociation in the event of a lowering of pressure due to sea-level fall.

Worm, B. and R. A. Myers (2004). "Managing fisheries in a changing climate." Nature **429**(6987): 15.

Worm, B. and R. A. Myers (2004). "Managing fisheries in a changing climate." Nature **429**(6987): 15.

Wright, I. J., P. B. Reich, et al. (2004). "The worldwide leaf economics spectrum." Nature **428**(6985): 821-7.

Bringing together leaf trait data spanning 2,548 species and 175 sites we describe, for the first time at global scale, a universal spectrum of leaf economics consisting of key chemical, structural and physiological properties. The spectrum runs from quick to slow return on investments of nutrients and dry mass in leaves, and operates largely independently of growth form, plant functional type or biome. Categories along the spectrum would, in general, describe leaf economic variation at the global scale better than plant functional types, because functional types overlap substantially in their leaf traits. Overall, modulation of leaf traits and trait relationships by climate is surprisingly modest, although some striking and significant patterns can be seen. Reliable quantification of the leaf economics spectrum and its interaction with climate will prove valuable for modelling nutrient fluxes and vegetation boundaries under changing land-use and climate.

Wright, J. D. (2001). "Climate change. The Indonesian valve." Nature **411**(6834): 142-3.

Wunsch, C. (2000). "Moon, tides and climate." Nature **405**(6788): 743-4.

Yakir, D. (2002). "Global enzymes: sphere of influence." Nature **416**(6883): 795.

Yokouchi, Y., M. Ikeda, et al. (2002). "Strong emission of methyl chloride from tropical plants." Nature **416**(6877): 163-5.

Methyl chloride is the largest natural source of ozone-depleting chlorine compounds, and accounts for about 15 per cent of the present atmospheric chlorine content. This contribution was likely to have been relatively greater in pre-industrial times, when additional anthropogenic sources-such as chlorofluorocarbons-were absent. Although it has been shown that there are large emissions of methyl chloride from coastal lands in the tropics, there remains a substantial shortfall in the overall methyl chloride budget. Here we present observations of large emissions of methyl chloride from some common tropical plants (certain types of ferns and Dipterocarpaceae), ranging from 0.1 to 3.7 microg per gram of dry leaf per hour. On the basis of these preliminary measurements, the methyl chloride flux from Dipterocarpaceae in southeast Asia alone is estimated at 0.91 Tg yr-1, which could explain a large portion of missing methyl chloride sources. With continuing tropical deforestation, natural sources of chlorine compounds may accordingly decrease in the future. Conversely, the abundance of massive ferns in the Carboniferous period may have created an atmosphere rich in methyl chloride.

Yokouchi, Y., Y. Noijiri, et al. (2000). "A strong source of methyl chloride to the atmosphere from tropical coastal land." Nature **403**(6767): 295-8.

Methyl chloride (CH3Cl), the most abundant halocarbon in the atmosphere, has received much attention as a natural source of chlorine atoms in the stratosphere. The annual global flux of CH3Cl has been estimated to be around 3.5 Tg on the grounds that this must balance the loss through reaction with OH radicals (which gives a lifetime for atmospheric CH3Cl of 1.5 yr). The most likely main source of methyl chloride has been thought to be oceanic emission, with biomass burning the second largest source. But recent seawater measurements indicate that oceanic fluxes cannot account for more than 12% of the estimated global flux of CH3Cl, raising the question of where the remainder comes from. Here we report evidence of significant CH3Cl emission from warm coastal land, particularly from tropical islands. This conclusion is based on a global monitoring study and spot measurements, which show enhancement of atmospheric CH3Cl in the tropics, a close correlation between CH3Cl concentrations and those of biogenic compounds emitted by terrestrial plants, and OH-linked seasonality of CH3Cl concentrations in middle and high latitudes. A strong, equatorially located source of this nature would explain why the distribution of CH3Cl is uniform between the Northern and Southern hemispheres, despite their differences in ocean and land area.

Zachos, J. C., M. A. Arthur, et al. (2002). "Palaeoclimatology: tropical temperatures in greenhouse episodes." Nature **419**(6910): 897-8; discussion 898.

Zachos, J. C., M. A. Arthur, et al. (2002). "Palaeoclimatology: tropical temperatures in greenhouse episodes." Nature **419**(6910): 897-8; discussion 898.

Zahn, R. (2003). "Global change: Monsoon linkages." Nature **421**(6921): 324-5.

Zahn, R. (2003). "Global change: Monsoon linkages." Nature **421**(6921): 324-5.

Zazula, G. D., D. G. Froese, et al. (2003). "Palaeobotany: Ice-age steppe vegetation in east Beringia." Nature **423**(6940): 603.

Zhisheng, A., J. E. Kutzbach, et al. (2001). "Evolution of Asian monsoons and phased uplift of the Himalaya-Tibetan plateau since Late Miocene times." Nature **411**(6833): 62-6.

The climates of Asia are affected significantly by the extent and height of the Himalayan mountains and the Tibetan plateau. Uplift of this region began about 50 Myr ago, and further significant increases in altitude of the Tibetan plateau are thought to have occurred about 10-8 Myr ago, or more recently. However, the climatic consequences of this uplift remain unclear. Here we use records of aeolian sediments from China and marine sediments from the Indian and North Pacific oceans to identify three stages of evolution of Asian climates: first, enhanced aridity in the Asian interior and onset of the Indian and east Asian monsoons, about 9-8 Myr ago; next, continued intensification of the east Asian summer and winter monsoons, together with increased dust transport to the North Pacific Ocean, about 3.6-2.6 Myr ago; and last, increased variability and possible weakening of the Indian and east Asian summer monsoons and continued strengthening of the east Asian winter monsoon since about 2.6 Myr ago. The results of a numerical climate-model experiment, using idealized stepwise increases of mountain-plateau elevation, support the argument that the stages in evolution of Asian monsoons are linked to phases of Himalaya-Tibetan plateau uplift and to Northern Hemisphere glaciation.

Zhu, R. X., R. Potts, et al. (2004). "New evidence on the earliest human presence at high northern latitudes in northeast Asia." Nature **431**(7008): 559-62.

The timing of early human dispersal to Asia is a central issue in the study of human evolution. Excavations in predominantly lacustrine sediments at Majuangou, Nihewan basin, north China, uncovered four layers of indisputable hominin stone tools. Here we report magnetostratigraphic results that constrain the age of the four artefact layers to an interval of nearly 340,000 yr between the Olduvai subchron and the Cobb Mountain event. The lowest layer, about 1.66 million years old (Myr), provides the oldest record of stone-tool processing of animal tissues in east Asia. The highest layer, at about 1.32 Myr, correlates with the stone tool layer at Xiaochangliang, previously considered the oldest archaeological site in this region. The findings at Majuangou indicate that the oldest known human presence in northeast Asia at 40 degrees N is only slightly younger than that in western Asia. This result implies that a long yet rapid migration from Africa, possibly initiated during a phase of warm climate, enabled early human populations to inhabit northern latitudes of east Asia over a prolonged period.

Zuber, M. T. (2001). "The crust and mantle of Mars." Nature **412**(6843): 220-7.
Clues to the history of Mars are recorded in the chemistry and structure of the planet's crust and mantle. The mantle is the rocky, interior region of the planet that transports heat generated during accretion and subsequent core formation. The crust formed by melting of the upper mantle, and has been shaped and re-distributed by impact, volcanism, mantle flow and erosion. Observations point to a dynamically active interior in the early phases of martian history, followed by a rapid fall-off in heat transport that significantly influenced the geological, geophysical and geochemical evolution of the planet, including the history of water and climate.

Zwiers, F. W. (2002). "Climate change: the 20-year forecast." Nature **416**(6882): 690-1.