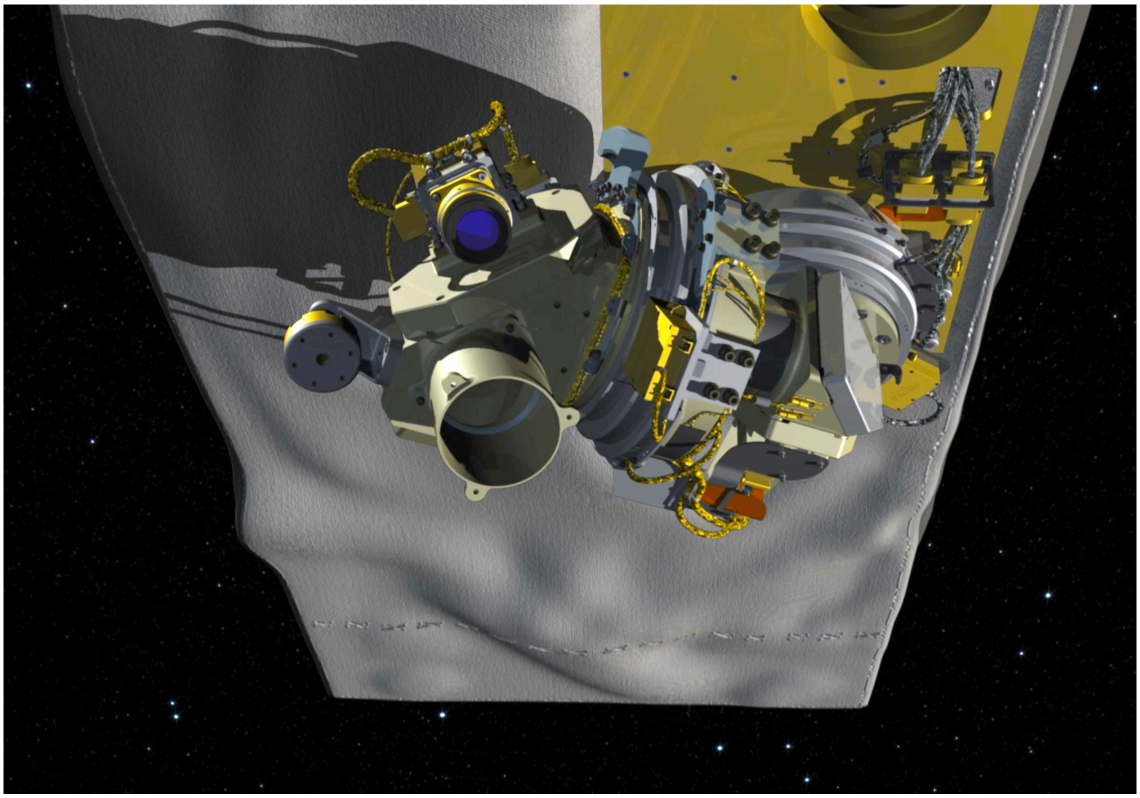
NASAfacts

# Orbiting Carbon Observatory 3



Breathe in. Breathe out. That act makes you part of Earth's carbon cycle, like every other living thing on the planet. Carbon, including carbon dioxide, has always cycled into and out of the air from plants and animals, the ocean, and land, with the cycle staying in balance over the long term. Humans are pushing the carbon cycle off balance by fossil fuel burning and deforestation, causing carbon dioxide levels in the atmosphere to continue to rise.

How is our planet handling this change to one of the key elements of life on Earth? To answer that, we need to keep a close eye on carbon: how and where it is entering and leaving the atmosphere, and how it is interacting with weather and climate.

NASA is launching the Orbiting Carbon Observatory 3 (OCO-3) in the spring of 2019 to add a new perspective to its carbon observations. OCO-3 will extend the exceptionally accurate OCO-2 data set on atmospheric carbon, which began in July 2014. But the new sensor will be using a different vantage point.

Where OCO-2 is in a polar orbit, OCO-3 will be mounted to the International Space Station, which circles Earth from 52 degrees north to 52 degrees south latitudes — about from London to Patagonia. Most of Earth's living things are found within these limits. The orbit will allow OCO-3 to collect a denser data set than its predecessor over high-carbon regions such as the Amazon rainforest. OCO-2 has begun to reveal some of the subtle ways that carbon links everything on Earth, and OCO-3 will increase scientists' opportunities to gain more insight into still-obscure aspects of the carbon cycle.

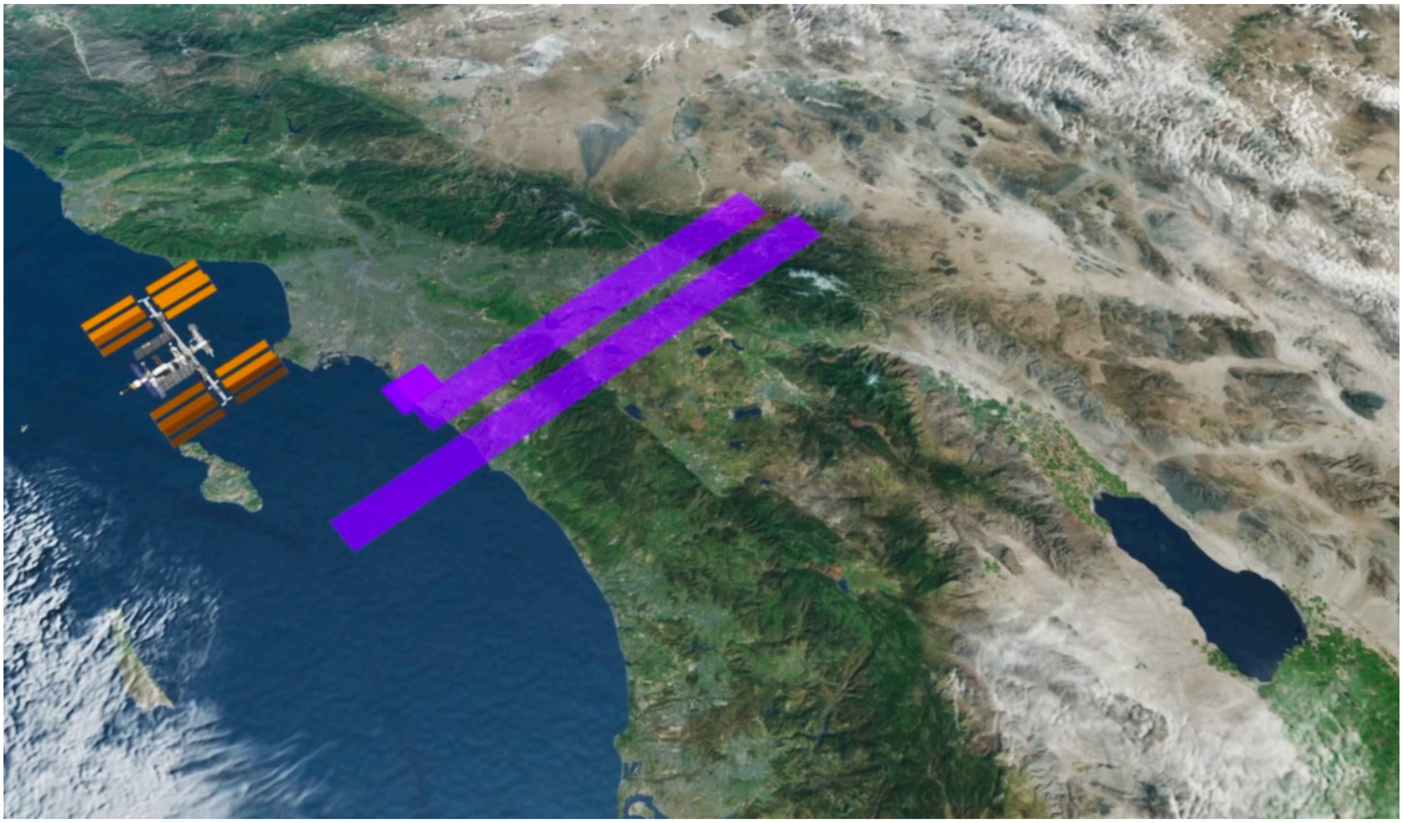


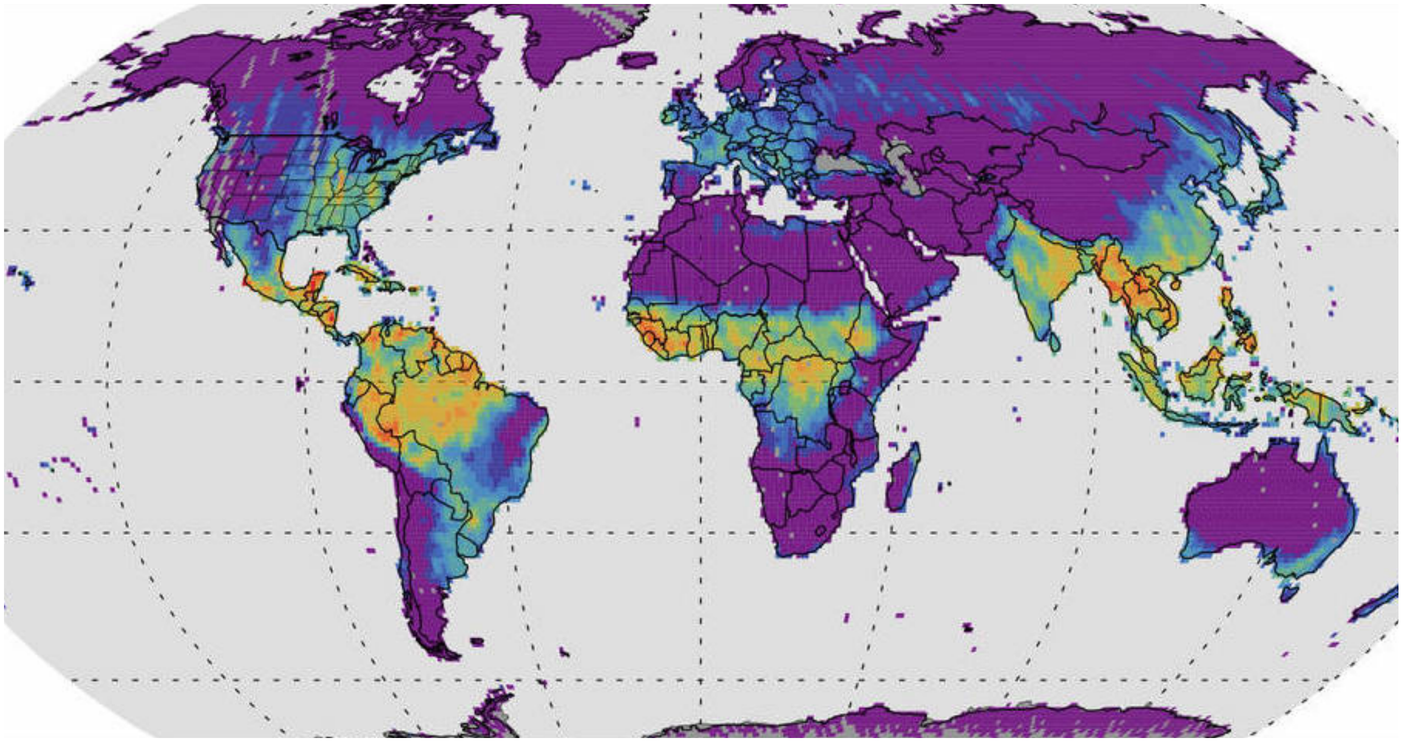
*Illustration of OCO-3 on the space station collecting data in snapshot mode over the Los Angeles Basin. As the space station approaches the Southern California coastline, OCO-3 is already starting its third parallel data swath of a total of five. The complete "snapshot" will provide dense carbon dioxide data over an area of about 250 square miles (650 square kilometers) — the entire Los Angeles metropolitan area. Credit: NASA/JPL-Caltech*

**Mission Overview**

OCO-3's berth on the space station will give scientists the first opportunity to observe how carbon dioxide concentrations change throughout the day in many parts of the globe. We know that local carbon dioxide levels rise and fall during the day with changes in emissions and photosynthesis rates, but these changes are measured sparsely worldwide — for example, in large industrialized cities but not the surrounding croplands. The changes can't be observed globally by a polar-orbiting satellite like OCO-2, which always goes over any given location at the same time of day. The station's orbit will carry OCO-3 over any location a little earlier on each orbit, spanning all sunlit hours within about a month.

OCO-3 will be another step toward monitoring emissions hotspots, volcanic eruptions and other local carbon sources from space. More than 70 percent of carbon dioxide emissions from human activities come from cities, but because the gas mixes rapidly into the atmosphere, urban emissions are challenging to isolate. OCO-3's "snapshot" mode of observing on a scale of about 50 by 50 miles (80 by 80 kilometers) is a demonstration of how this capability might be improved.

Besides carbon dioxide, OCO-3's high-resolution spectrometers can observe a type of radiation from plants called solar-induced fluorescence (SIF). Plants emit SIF only during photosynthesis, and that is also the only time they absorb carbon dioxide. As the changing climate affects growing seasons worldwide, researchers need to understand when photosynthesis is occurring, especially in inaccessible locations like the Arctic. They sometimes use space-based observations of vegetation greenness as a stand-in for photosynthesis, but that's not totally accurate: Evergreen trees, for example, stay green year round but do not absorb carbon dioxide in winter. OCO-3 will allow scientists to explore the value of the SIF measurement for improving understanding of the carbon cycle in forests and plants.



*This map shows solar-induced fluorescence (SIF) measured by OCO-2 from Aug. through Oct. 2014. The highest SIF rates are shown in red and yellow (for example, the Amazon in Southern Hemisphere spring), with blues and greens indicating less fluorescence and purple indicating none. OCO-3 will make dense measurements of SIF in the midlatitude and tropics. Credit: NASA/JPL-Caltech*

**Instrument Overview**

OCO-3 was built using OCO-2's spare instrument and the appropriate electronics and interfaces to operate on the space station's Japanese Experiment Module - Exposed Facility (JEM-EF), an external platform that holds up to 10 instruments. The total cost of building, testing and launching the mission was less than $100 million.

The OCO-3 instrument consists of three high-resolution spectrometers integrated into a common structure and illuminated by a common telescope. One spectrometer measures how much sunlight the oxygen in the atmosphere has absorbed, and the other two measure sunlight absorption by carbon dioxide at two different sets of wavelengths. The ratio of carbon dioxide to oxygen is used to determine the concentration of atmospheric carbon dioxide.

Currently, the concentration of carbon dioxide in the atmosphere averages about 405 molecules out of every 1 million molecules of air, a ratio that scientists call "405 parts per million." OCO-3 will measure this tiny percentage to an accuracy of about 0.3 to 0.5 percent.

Obtaining such a precise measurement requires eliminating any sources of instability for the instrument. The external temperature at the space station varies by about 500 degrees Fahrenheit (almost 300 degrees Celsius) between the sunlit and dark parts of each orbit. The extreme temperature swings could affect the measurement. To prevent that, the instrument includes a space "refrigerator" called a cryocooler that will keep the detector near minus 244 degrees Fahrenheit (minus 153 degrees Celsius).

**Launch and Docking**

The payload will be launched to the space station with other cargo on Commercial Resupply Services mission 17 no earlier than April 25, 2019. It will fly in the unpressurized portion of a SpaceX Dragon spacecraft — called the trunk — atop a Falcon 9 rocket. It will reach the station about two days after launch.

Several days after the Dragon is berthed, a tele-controlled robot on the station called the Special Purpose Dexterous Manipulator will remove OCO-3 from the Dragon trunk and hand it off to the JEM robotic arm. The arm will install OCO-3 at JEM-EF unit 3.

OCO-3 will not require attention from space station astronauts for science operations during its mission life. It will be controlled remotely by mission operators at NASA's Jet Propulsion Laboratory in Pasadena, California, using the communications link managed by NASA's Payload Operations Integration Center at the Huntsville Operations Support Center in Alabama.

**Mission Duration**

The mission is expected to last for three years on the space station. At the end of mission, OCO-3 will be returned to a Dragon trunk. The Dragon capsule will jettison the trunk and payload as it descends, and they will burn up in Earth's atmosphere.

**Partners**

JPL manages OCO-3 for NASA's Science Mission Directorate in Washington. The science instrument was built by JPL, based on the instrument design co-developed for the original Orbiting Carbon Observatory by Hamilton Sundstrand in Pomona, California, and JPL. NASA's Human Exploration and Operations Mission Directorate is providing the launch and the installation of OCO-3 on the space station, command and telemetry infrastructure, and disposal of the payload at the end of the mission.

The OCO-3 project is part of the Earth System Science Pathfinder Program, directed by the program director of the NASA Earth Science Division.

**National Aeronautics and Space Administration**

**Jet Propulsion Laboratory**
**California Institute of Technology**
**Pasadena, California**

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