its own severe weather unit within the WBAN Center in Washington D.C., in March 1952, and issued its first Tornado Bulletin on March 17. The unit became permanent and was formally recognized on May 21 as the Severe Weather Unit (SWU). Although it was still located with the WBAN Center, it was a separate entity. SWU was renamed Severe Local Storm Warning Service (SELS) on June 17, 1953, the year before it moved to Kansas City.[463] In 1966, the WBO Kansas City was named the National Severe Storms Forecast Center (NSSFC) with Allen Pearson as Director, in which SELS was incorporated.[464] An IMB 1620 computer was installed in April 1963 to be used in preparing forecasts and warnings.[465] The IBM 1620 was replaced by a Control Data Corporation CDC 3100 in December 1965.[466]

On August 29, 1954, the Federal Employees Group Life Insurance Act of 1954 came into being. This applied to all Weather Bureau employees, and the Weather Bureau was proactive in providing information concerning it.[467]

The Weather Bureau made good use of cooperative observers. In January 1955, it had 12,591 substations, a substation being defined as a station at which observations were taken, or other services rendered, by part-time, non-classified Weather Bureau personnel who were not certified for aviation and synoptic observations.[468,469]

The Bureau of Standards under the joint sponsorship of the Weather Bureau, Air Weather Service, and Navy Office of Aerology investigated a Film Optical Sensing Device for Input to Computers (FOSDIC). The device was built around an automatic electronic cathode ray scanner for reading digital values and codes from microfilm of punched cards. It was expected those data could then be fed into other machines to repunch cards, create magnetic tape, or as direct input to computers. The mountain of punched cards was growing at an astonishing rate, and the paper stock in the earlier card decks had deteriorated with age to the point of uselessness for machine processing. If FOSDIC proved successful, it would be possible to solve the card problem by storing data on microfilm. Even so, this would not be "permanent," but have life expectancy of perhaps 75 to 100 years.[470] FOSDIC did prove successful, and with a new version put into operation in 1961, NWRC disposed of 105 million punched cards, representing 8,000 square feet of storage space.[471] In January, 1963, the responsibilities of the three Weather Records Processing Centers at Chattanooga, Kansas City, and San Francisco were transferred to NWRC. These three centers were a consolidation from seven located in Albany, New York; Chattanooga, Tennessee; Kansas City,

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[463] Corfidi, S. F., 1999: The birth and early years of the Storm Prediction Center. *Wea, Forecasting*, **14**, pp. 507-525. As detailed by Corfidi, SELS was joined by the SWWC unit at Tinker in January 1956. SWWC was disbanded in February 1961, but was later resurrected as the Military Weather Warning Center in 1964. It was collocated with SELS until January 1970 when it moved to Offutt AFB in Omaha, Nebraska, as part of a reorganization of the Air Force Global Weather Central.

[464] *ESSA NEWS*, **2**, February 25, 1966, p. 3.

[465] *Weather Bureau Topics*, August-September 1963, p. 108.

[466] ESSA NEWS, **1**, December 28, 1965, p. 5.

[467] *Weather Bureau Topics*, November 1957, p. 215.

[468] *Weather Bureau Topics*, November-December 1950, p. 160.

[469] *Weather Bureau Topics*, January 1955, p. 6.

[470] *Weather Bureau Topics*, March 1955, p. 24.

[471] *Weather Bureau Topics*, August 1962, p. 127.

Missouri; Chicago, Illinois; Fort Worth, Texas; San Francisco, California; and Seattle, Washington, that took place in 1950. These seven centers corresponded to the seven Weather Bureau Regions then in existence.[472]

In 1955, continuous feed facsimile recorders became available and several per month were being installed at local offices.[473]

A practice forecast program for GS-7 and GS-9 meteorologists who wished to become forecasters was started in 1955. The main objectives were to discover talent and to assist in the development of forecasting skills. It was to be used as an aid in selecting persons for GS-11 positions. Forecasts were made of temperature, precipitation amount, and surface wind speed. Punched cards were used for verification. It seems that all who wanted to could participate, and while official time could be used when it did not interfere with official duties, it was a volunteer program and it was expected that much of the practice forecasting would be done outside of regular hours.[474] The response was spirited; over 600 applications were received. Only 200 could be accommodated initially.[475]

Chief Reichelderfer stated Weather Bureau policy that attendance of employees at scientific meetings was encouraged, but because of limited travel funds, would be, in general, supported for only those persons giving a paper. When going without expense to the Federal Government, official time could be granted when the individual could be spared from official duties.[476] This policy has essentially been unchanged until the present.

In early 1955, the need for close liaison among organizational elements was encouraged. The forecasting structure was at that time:

> "... the organization of the Weather Bureau's forecasting service establishes certain functions for the WBAN Analysis Center, the SELS Center, the several classes of forecast centers and field offices in such a way that these functions complement one another. That is, the Analysis Center has the responsibility for issuing master analyses and guiding prognostic charts, the forecast centers aided by these analyses and prognoses determine the broadscale weather patterns of temperature, precipitation, and other elements, and the latter indications are in turn further refined by the local office for use in meeting the weather service requirements of the community it serves."[477]

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[472] *Weather Bureau Topics*, January 1963, p. 7.

[473] *Weather Bureau Topics*, April 1955, p. 51.

[474] Weather Bureau *Circular Letter* **36-54**, 1954: Practice Forecast Program.

[475] Weather Bureau *Circular Letter* **11-55**, 1955: Practice Forecast Program.

[476] Weather Bureau *Circular Letter* **3-55**, 1955: Travel to Scientific Meetings at Government Expense.

[477] Weather Bureau *Circular Letter* **16-55**, 1955: Need for Continued Close Liaison Between Field Stations and Forecast Centers.

In order to accommodate turbo-power transport aircraft that were to begin operation April 1, 1955, on some routes, winds aloft forecasts (AW's) issued from some FAWS Centers were modified to include temperatures.[478]

An Advisory Committee on Climatology was established by the National Research Council at the request of Dr. Reichelderfer, and the first meeting in April 1955 yielded a number of constructive comments and suggestions.[479]

Arrangements were made for Chicago to prepare and enter on Service C twice a day a tabular bulletin of 50 selected locations. Daily maximum temperatures, 24-h precipitation, and state of weather were included.[480] This "Selected Cities" bulletin also carried into the next century, although the exact content, and methods and location of preparation changed over time.

Another change in 1955 was the planning for a new type of office. These offices would operate part-time with small staffs. The purpose was primarily for the distribution of warnings and advisories of severe or critical weather conditions, and the duty would be flexible to concentrate on those critical times. Forecasts would be made by forecast offices, but detailed data and interpretation and refinements on strictly local phenomena could be added. Such information could be based on local objective forecasting schemes. In addition, two new RFCs were established, bringing the total to nine. Eight others were planned.[481]

Arrangements were made in 1955 through contract with the University of Miami to obtain quantitative rainfall estimates from radar observations. These estimates would augment the measurements made by raingauge networks. This was to be done by integration of continuous photographs of the Plan Position Integrator (PPI) radar scope so that the end product would be a pattern of light and gray-scale proportional to the accumulated echo intensity on the scope, and hence proportional to the rainfall amounts. These would be calibrated to yield the estimates desired.[482]

In order to improve the severe weather warning service, a new system of internal RAREP and warning coordination teletypewriter circuits (RAWARC) was put into operation on September 1, 1955.[483]

In 1955, funds were provided under Public Law 71 for studies of hurricane forecasting. The law charged the U.S. engineers to make studies of measures needed to protect low-lying coastal areas against damage from hurricane induced high waters. "The Hurricane Project" as it was called came to have historical significance.[484]

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[478] Weather Bureau *Circular Letter* **16-55**, 1955: Upper Air Temperature and Wind Forecasts for Turbo-prop Aircraft Operations.

[479] *Weather Bureau Topics*, June 1955, p. 84.

[480] *Weather Bureau Topics*, July 1955, p. 105.

[481] *Weather Bureau Topics*, October 1955, pp. 154, 155.

[482] *Weather Bureau Topics*, October 1955, p. 158.

[483] *Weather Bureau Topics*, October 1955, p. 159.

[484] *Weather Bureau Topics*, October 1955, p. 159.

The establishment of District Meteorological Offices started in late 1955 with the assignment of a District Meteorological Officer at Kansas City. This employee was to give almost full-time attention to organization of district, airway, and severe weather forecasting and to further implementation and expansion of the mapped forecast program.[485]

In 1956, a new publication series called "*Climatography of the States*" was established to accommodate publication of a monograph type. It was designed to reflect climatic conditions and trends, as distinguished from current data.[486]

The term "normals" was defined to conform to the WMO definition: "A mean based upon the 30-year period of record 1921-1950, revised each decade by dropping the first 10 years of data and adding the 10 most recent years." A lexicon of "means" was established.[487]

A new Weather Bulletin Unit located in FOB4 was established to prepare national weather summaries transmitted on Service C. By February 1, 1956, those previously prepared at Chicago, Atlanta, and New York were being prepared there. This was to establish a weather "watch" and to issue timely weather releases for distribution over press and radio wires.[488]

A fledgling storm surge program was moving, and forecasts were being made in 1955 at Washington National Airport, Miami, and New Orleans. Plans were to extend this work to other offices.[489]

At the request of the Weather Bureau, the National Academy of Sciences appointed an Advisory Committee on Meteorology. The committee met for the first time in April 1956.[490]

Television was being explored for weather briefings. In 1956, a closed circuit was operating from the Weather Bureau Airport Station to the Flight Service Building in Billings, Montana.[491]

Obtaining weather data from infrequently traveled ocean areas was a major problem. Possible solutions included fixed ocean stations occupied by vessels, fixed platforms set in shoals ("Texas towers"), and marine automatic weather stations. The former two were very expensive; tests of the latter were underway in the mid 1950's. Specifically, five were placed by a ship departing Norfolk, Virginia, in August 1956.[492]

On July 31, 1956, the Weather Bureau announced that it was procuring 39 new radars, 8 of them for the U.S. Navy. These radars would have a wavelength of 10 cm, 500 kw power output, and pulse

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[485] *Weather Bureau Topics*, December 1955, p. 190.
[486] *Weather Bureau Topics*, January 1956, p. 9.
[487] Weather Bureau *Circular Letter* **18-56**, 1956: Definition of Climatic Means.
[488] *Weather Bureau Topics*, February 1956, p. 19.
[489] *Weather Bureau Topics*, March 1956, p. 37.
[490] *Weather Bureau Topics*, April 1956, p. 55.
[491] *Weather Bureau Topics*, May 1956, pp. 78, 79.
[492] *Weather Bureau Topics*, May 1959, pp. 83, 64.

lengths of ½ and 4 microseconds. They would be considerably more flexible than the existing APS-2 radars in use,[493] and would eventually be called WSR-57.[494]

In the mid 1950's, a "spherics" research program was underway. Instruments were designed to detect the discharge from lightning; the theory was that if triangulation could be made from two or more stations, the location of high density of flashes could be correlated with radar echoes to warn of tornados. There was the question of whether all tornadoes had high density of lightning. In June 1957, spherics devices were located at Austin, Abilene, Oklahoma City, Shreveport, and Victoria.[495] This work was superceded when Doppler radar came on the scene, and experimentation started in June 1957 at Wichita.[496]

In 1957, the organization of the Weather Bureau forecast service was described as follows:

> "The organization of the Weather Bureau's forecast team could be represented by a flow diagram resembling a wheel. The hub represents the central analysis function comprising the National Weather Analysis Center, Extended Forecast Section, and Joint Numerical Weather Prediction Unit. The area forecast centers, such as District Forecast Centers, State Forecast Centers, and Severe Local Storm Unit, may be regarded as the spokes, radiating outward to the local forecast offices at the rim which represents the direct service to the public–the 'grass roots' contracts. From the hub outward, successive stages of localization and detailed refinement of forecasts is the purpose." [497]

In 1957, the Weather Bureau with the cooperation of the Air Force and Navy installed a "first of a kind" system to transmit PPI radar data from the Air Force CPS-9 radar at Blue Hill near Boston to WBAS East Boston 12 miles away and to the Naval Air Station at South Weymouth, Massachusetts, 10 miles away. The system used a commercial television camera to pick up and transmit the signal.[498] In 1958, the Bureau agreed for a television sation to install a microwave unit in a Bureau office to televise the radar scope image. Results were positive, and in 1959 permission was extended to other television stations. Expenses were borne by the television station.[499]

"Runway Visual Range (RVR)" was being investigated by the Weather Bureau in 1956-57. This is the distance a pilot about to land can expect to see the high intensity runway lights. Equipment was installed at Newark airport, Newark, New Jersey, in 1956, with no plans to expand to other airports.[500] At about the same time, transmissometers with indicators in both the control tower and the Weather Bureau office were installed to measure runway visibility near the touchdown

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[493] *Weather Bureau Topics*, August 1956, pp. 129, 130.
[494] *Weather Bureau Topics*, February 1958, pp. 26, 27.
[495] *Weather Bureau Topics*, January 1957, pp. 5-7.
[496] *Weather Bureau Topics*, May 1957, pp. 96, 97.
[497] *Weather Bureau Topics*, April 1957, pp. 63, 64.
[498] *Weather Bureau Topics*, July 1957, pp. 143, 144.
[499] Weather Bureau *Circular Letter* **2-59**, 1959: Telecast of Images from Weather Bureau radar Scopes.
[500] Weather Bureau *Circular Letter* **7-56**, 1956: Runway Visual Range Program–Newark, N. J.

point on the instrument runway at 20 airports.[501] RVR was so favorably received by the CAA that the program was planned to be expanded to other sites from the initial installation at Newark.[502]

Department of Commerce Order No. 91 (amended) carried 1956 authorization for the Weather Bureau of not only the Chief and Deputy Chief, but also for three Assistant Chiefs–one for Technical Services, one for Administration, and one for Program Planning. There were three Directors–one for the Office of Climatology, one for the Office of Meteorological Research, and one for the Physical Science Laboratory.[503]

In May 1956, Chief Reichelderfer issued instructions that 5-day forecasts would be issued by District Forecasters three times weekly following facsimile guidance from the Extended Forecast Section. This information could be released to the press and other interested parties starting on May 21.[504] 1957 saw what was hailed as a major step in the preparation of 5-day forecasts. Daily circulation maps were prepared by NWP, then integrated into 5-day means centered on each day in the future. The new technique also speeded up the former process so that the forecasts could be disseminated sooner.[505,506] Statistical techniques were now being employed whereby surface temperature was related to these upper air circulation parameters.[507] This was one of the first uses of the "perfect prog" approach in statistical weather forecasting. The predictand, temperature in this case, was related to upper air variables that could be forecast by NWP, then the assumption was made that the NWP was correct, and the same relationships applied in a forecast sense. A excellent history of long range forecasting was later prepared by Namias.[508] In early January 1958, the Bureau put into effect an authorization by the Department of Commerce that the 5-day forecasts could be sold at the rate of 30 cents per month. The stations "still publishing and distributing" this information were directed to put the subscription plan into effect, and the bulletins would have the specific title "Five-Day Forecast Bulletin." [509]

A Tropical Weather Summary product covering the Miami and San Juan Districts west of longitude 60°W had been issued for several years in the hurricane season from WBO Miami. It was so popular and successful, that in 1957, it was extended to cover essentially all the Gulf and Atlantic coastal areas. The product was to provide assurance to areas in the main hurricane belt that conditions were stable, or to give an additional day or two of alert in areas where conditions were becoming more favorable for tropical storm inception.[510] Also in 1957, 30-day Hurricane Probability Statements were prepared by HURIC, Miami, on the basis of semi-monthly hurricane outlooks

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[501] Weather Bureau *Circular Letter* **9-56**, 1956: Runway Visibility Observations.

[502] *Weather Bureau Topics*, October 1957, pp. 192, 193.

[503] Weather Bureau *Circular Letter* **10-56**, 1956: Organization and Functions of the Weather Bureau.

[504] Weather Bureau *Circular Letter* **20-56**, 1956: Five-Day Forecast.

[505] *Weather Bureau Topics*, December 1957, p. 231.

[506] Namias, J., 1957: Progress in objectivization and automation of extended forecasting. *Transactions of the New York Academy of Sciences*, Ser. II, **19**, pp. 581-592.

[507] Klein, W. H., B. M. Lewis, and C. W. Crockett, 1962: Objective forecasts of daily and mean surface temperature. *Mon. Wea. Rev.*, **90**, pp 11–17.

[508] Namias, J., 1968: Long range weather forecasting–history, current status and outlook. *Bul. Amer. Meteor. Soc.*, **49**, pp. 438-470.

[509] Weather Bureau *Circular Letter* **3-58**, 1958: Fees for Five-Day Forecast Bulletins.

[510] Weather Bureau *Circular Letter* **9-57**, 1957: Tropical Weather Summary.

furnished by the Extended Forecast Section. Such statements had been prepared the past 2 years for internal use; now they were to be issued to the public.[511]

The surface observation times for record aviation and synoptic reports was advanced 30 minutes starting June 1, 1957. That is, the 0000 GCT observation would be made at 2330 GCT. Second order stations were to, in general, take observations 30 minutes earlier than usual. A lexicon of "times" was provided, consisting of actual time, standard time, ascribed time, filing time, scheduled filing time, scheduled time of transmission, and actual time of transmission.[512]

Chief Reichelderfer stated the Bureau's long-range plans for two rawinsondes and two rawins per day at stations in the rawinsonde network. Starting October 1, 1957, the 22 stations taking four rawinsonde measurements would reduce to two per day, those being at 0000 and 1200 GCT.[513]

By 1958, NWP under JNWP and its associated activities in NAWAC and the Extended Forecast Section had progressed to the point that they were consolidated into the National Meteorological Center (NMC) with the director of JNWP, Dr. George Cressman, as its head. It was placed administratively directly under the Office of the Bureau Chief. Thus, NAWAC was removed from the Forecasts and Synoptic Reports Division, and the Extended Forecast Section was removed from OMR. It is interesting that the Weather Bureau recognized the scientific capabilities of Dr. Cressman, and stated, "In order to provide the greatest possible emphasis on technical and scientific aspects, it is expected that the Director of NMC will have a minimum of administrative responsibility, and in time the administrative functions of the Suitland organizations may be consolidated, and it is anticipated that these duties will be delegated to an executive assistant." [514]

In 1958, a Special Projects Section was established under OMR with Dr. Lester Machta as its head. This Section had rather broad responsibilities, including coordinating the work for the Atomic Energy Commission. It was physically located in the Old Annex,[515] the next rooms down from the Short Range Forecast Development Section headed by Roger Allen. This was the group that formed the nucellus of the Air Resources Laboratory formed under a later reorganization.

On January 6, 1958, the Federal Communications Commission and the U.S. Air Force authorized all radio and television stations in the United States to use the CONELRAD (CONtrol of ELectromagnetic RADiation) alert signal to preface the broadcast of an emergency weather or flood warning when requested to do so by the local Weather Bureau office. While devised for alerting the nation to an enemy aircraft attack, CONELRAD was now to be used for weather emergencies.[516,517]

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[511] Weather Bureau *Circular Letter* **14-57**, 1957: Thirty-Day Hurricane Probability Statement.

[512] Weather Bureau *Circular Letter* **12-57**, 1957: Change in Times of Surface Observations.

[513] Weather Bureau *Circular Letter* **17-57**, 1957: Discontinuance Transmission 0600 and 1800 GCT Raob Data.

[514] *Weather Bureau Topics*, February 1958, pp. 23, 24; January 1961, p. 5.

[515] *Weather Bureau Topics*, March 1958, pp. 39, 40.

[516] *Weather Bureau Topics*, April 1958, pp. 61, 62.

[517] Weather Bureau *Circular Letter* **2-58**, 1958: Use of the CONELRAD Alerting Signal in Dissemination of Emergency Weather and Flood Warnings.

The final report of the Advisory Committee on Weather Control, established as a temporary agency in August 1953, submitted its final report on December 31, 1957. The essential conclusion was, "statistical evidence for increases in precipitation of 10 to 15 percent exists from several West Coast orographic seeding operations conducted during winter and spring months. Flat land projects yielded no evidence of 'unnatural' effects from the evaluation techniques applied." [518] But the Bureau was concerned about statements made by Bureau personnel, and had previously directed that clearance was to be obtained from the Central Office before issuance of statements, primarily because of possible legal action.[519]

On July 1, 1958, the Hurricane Forecast Center in Miami was relocated to the Aviation Building from its previous location in the Lindsey Hopkins Hotel. Besides needing additional space, a major reason for the move was to provide a suitable site for the new WSR-57 radar to be installed that summer.[520] At that time, there were five hurricane forecast centers forecasting for the Atlantic, Caribbean, and Gulf of Mexico located at San Juan, Puerto Rico; New Orleans; Miami; Washington; and Boston. The Pacific centers were at Honolulu, Los Angeles, and San Francisco.[521]

In November 1957, forecasters at WBAS Los Angeles began issuing experimental probability rainfall forecasts for the local metropolitan area. The concept had been tested the preceding season at San Francisco. The "rain index" forecasts were kept rather simple with the local forecasts for each forecast period containing a brief statement describing the chance of rain in percentages. Because the rainy season ends by April, the probabilities were discontinued at the end of April. On that date, a press release was distributed in Los Angeles requesting comments on the usefulness of the program. About 75 written replies were received, and only one of the 75 expressed disfavor.[522] This was the beginning of probability forecasting in the Weather Bureau, but a national program was not established until 1965. The national program was due largely to the efforts of Charles Roberts. The first year was primarily for familiarization and training; release of the forecasts to the public started in early 1966.[523]

On October 1, 1958, the Weather Bureau started a limited project in specialized agricultural weather service for the Delta area of Mississippi. On that date, a Weather Bureau Agricultural Service Office (WBASO) headed by Jack Riley opened at the Delta Branch Experimental Station at Stoneville, Mississippi, and an Agricultural Weather Forecast for the Delta area was issued. A teletypewriter circuit was established that had drops at WBAS Jackson, WBAS Memphis, WBASO Stoneville, and WBO Vicksburg. It was a Weather Bureau "first" in that it was the first time a "local" public service loop was expanded to an "area" loop covering several cities not previously

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[518] *Weather Bureau Topics*, April 1958, p. 68.

[519] Weather Bureau *Circular Letter* **75-47**, 1947: Artificial Inducement of Precipitation; **98-47**: Legal Aspects of Rainfall Allegedly Produced by Artificial Means; **10-51**: Statement on Artificial Rainmaking.

[520] *Weather Bureau Topics*, August 1958, p. 144.

[521] *Weather Bureau Topics*, June 1959, pp. 102-104. This reference gives a brief history of the Hurricane Warning Service.

[522] *Weather Bureau Topics*, August 1958, p. 149.

[523] Hughes, L. A., 1980: Probability forecasting–reasons procedures, problems. NOAA *Tech. Memo* **NWS FCST 24**, Meteorological Services Division, Office of Meteorology, National Weather Service, NOAA, U.S. Department of Commerce, pp. 4, 5.

served by the Bureau.[524] According to the Mississippi Extension Service, the project was very successful in its first year of operation.[525]

The Federal Aviation Act of 1958 created the Federal Aviation Administration, and replaced the Air Commence Act of 1926, the Civil Aeronautics Act of 1938, and the Airways Modernization act of 1957.[526]

The National Aeronautics and Space Administration (NASA) invited the Weather Bureau to act as its agent in the field of meteorological satellites. The Weather Bureau readily accepted the proposal, and had in fact already started research on this subject. A Meteorological Satellite Section under Dr. Sigmund Fritz was formed in OMR and was located in close proximity to NMC. The ultimate utilization of data from satellites would involve problems concerning instrumentation, data reduction and processing, and meteorological analysis.[527]

By 1958, 16 automatic weather stations were reporting some or all of the following weather elements: runway visibility, temperature, dewpoint, wind direction and speed, altimeter setting, precipitation amount, and thunderstorm. Observations were being formatted for Service A. Intensive work was underway to observe other elements, all composed of a series of "plug-in" units which could be grouped together for any set of desired variables.[528]

In June 1959, the Radar Analysis and Development Unit (RADU) at Kansas City inaugurated a new service of providing a 3-Hourly Radar Analysis giving a synoptic interpretation of radar reports plotted for three consecutive hours by RADU. The analysis gave locations and movement of synoptically important echoes, and called attention to their formation, their changes in length and width, their acceleration or deceleration, and wave formations. The service made this "pre-digested" radar information available to stations lacking the time to plot and interpret hourly RADU summaries. The information was sent on the RAWARC in plain language.[529]

As part of its research program, the Weather Bureau in the late 1950's was investigating what role, if any, "freezing" nuclei (also sometimes called sublimation or deposition nuclei with slightly different connotations) have on rainfall. Researchers collaborated with scientists in Australia, and built "cold boxes" to count such nuclei.[530,531]

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[524] *Weather Bureau Topics*, October 1958, p. 186. [The author's first research project, as a member of the Short Range Forecast Development Section, was to develop an objective method for forecasting the probability of precipitation in the Mississippi Delta (Glahn, H. R., 1962: An experiment in forecasting rainfall probabilities by objective methods. *Mon. Wea. Rev.* **90**, pp. 59-67). Screening regression popularized by Bob Miller of the Traveler's Research Center and Empirical Orthogonal Functions rediscovered by Ed Lorenz of MIT had recently arrived on the objective forecasting scene.]

[525] *Weather Bureau Topics*, December 1959, p. 208.

[526] *Weather Bureau Topics*, January 1959, p. 3.

[527] *Weather Bureau Topics*, January 1959, pp. 4, 5.

[528] *Weather Bureau Topics*, January 1959, pp. 15, 16.

[529] Weather Bureau *Circular Letter* **6-59**, 1959: 3-Hourly Radar Analysis.

[530] *Weather Bureau Topics*, April 1959, p. 66.

[531] Kline, D. B., and G. W. Brier, 1958: A note on freezing nuclei anomalies. *Mon. Wea. Rev.*, **86**, 329–333.

The Weather Bureau airplane, a Cessna purchased in 1950, was retired and a twin-engine Beachcraft, N122G, was obtained form the Air Force in January 1959. The Cessna had been in the air 1,123 of the 3,430 days it was on Weather Bureau roles, and about 3,700 takeoffs and landings were made. The Beachcraft was renovated, including installation of new communications and navigation systems.[532] Unfortunately, with George Brewster as pilot and six passengers, it went down on July 25, 1960, on the way to Nome, Alaska, for a field station inspection.[533] The wreckage was not found until August 24, 1963.[534]

The Weather Bureau and the Federal Aviation Agency jointly organized a pilot weather briefing service which made greater use of FAA flight service stations to handle preflight briefings and to answer air-ground requests for weather information. This was one of the most important steps taken in recent years to provide pilots with the aviation weather support they needed. A Pilot Weather Briefing Course was designed by the Bureau in co-operation with the FAA. It was given at the FAA School in Oklahoma City from July to November 1960.[535] Soon, closed circuit TV was being used for pilot weather briefings, the first being installed at New York International Airport.[536] Also, the Bureau began transmitting radar scope data from the WSR-57's for purposes of pilot briefings; by 1961, such equipment was operating at WBAS's Miami, Florida, and Charleston, South Carolina.[537] A closed circuit TV system identical to the one in New York was put into operation at Miami the next year.[538]

An experiment in Quantitative Precipitation Forecasting (QPF) was conducted March through May 1960 by the SELS Center in Kansas City. Messages were posted on RAWARC. Locations of isohyets plus a descriptive explanation similar to the FT-1 was given.[539] The method was evidently based on the work of Charles Gilman and Randall Peterson.[540] A specialized QPF unit was established at NMC-NAWAC manned by personnel especially trained in objective procedures for forecasting precipitation quantitatively. Guidance was distributed beginning September 15, 1960, on RAWARC and Service O. The objective techniques employed the numerical and subjective analyses and prognoses produced within NMC, and the forecasts produced were internally consistent with those products. QPFs prepared in this manner had proven to be superior to the subjective forecasts being distributed over facsimile. Major departures from this guidance were to be coordinated with adjacent Forecast Centers to avoid discontinuities at forecast boundaries, and it was suggested coordination directly with NAWAC might be necessary.[541]

In April 1960, the supervisory responsibilities were emphasized. Each Official in Charge of a field operating unit was to receive necessary guidance and direction from the appropriate Regional

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[532] *Weather Bureau Topics*, October 1959, pp. 165, 166.
[533] *Weather Bureau Topics*, October 1961, p. 175.
[534] *Weather Bureau Topics*, August-September 1963, Topigrams.
[535] *Weather Bureau Topics*, January 1961, p. 8.
[536] *Weather Bureau Topics*, March 1961, p. 44.
[537] *Weather Bureau Topics*, April 1961, p. 62.
[538] *Weather Bureau Topics*, January 1962, Topigrams.
[539] Weather Bureau *Circular Letter* **3-60**, 1960: Experiment in Quantitative Precipitation Forecasting.
[540] Gilman, C. S., and K. R. Peterson, 1960: Notes on a Procedure for Quantitative Precipitation Forecasting, U.S. Weather Bureau Manuscript.
[541] Weather Bureau *Circular Letter* **8-60**, 1960: Centralized Quantitative Precipitation Forecasts Unit.

Administrative Officer (Pacific Supervisory Officer for the Pacific) in all matters pertaining to administrative and support services. On technical matters, the direction and guidance was to come from the responsible technical division under the Assistant Chief for Technical Services. On other subject matters, such as aviation, climatology, and research, direction and guidance was to come from the office of the responsible director of these activities.[542] The Bureau had made adjustments in the forecasting structure as explained in *Multiple Address Letter* 40-59. The areas of responsibility were laid out in maps for seven areas:

(1) Aviation Weather Forecast Areas and FAWS Centers,
(2) Aviation Regional Forecast Areas,
(3) Guidance (FP-1) and Coordination Areas,
(4) Forecast Areas (FP) and Centers,
(5) Five-Day Forecast (FE) Districts,
(6) Quantitative Rainfall Forecast Zones, and
(7) Zone Forecast Areas.

According to the maps, Kansas City had a different area of responsibility in each of these areas.[543] Hurricane warning responsibilities were assigned to the Hurricane Forecast Centers, and Severe Local Storm Warnings were assigned to the local Bureau offices (the warning responsibility being separate and distinct from the severe local storm forecast responsibility assigned to the SELS Center).[544]

Effective November 15, 1960, the name of the National Severe Local Storms Research Project was changed to the National Severe Storms Project. The headquarters was at Kansas City, and central office functions were under the Office of the Deputy Director of Meteorological Research (Severe Storms). The aircraft operation program was dubbed Operation Roughrider, and was nominally headquartered in Oklahoma City.[545]

The National Science Foundation announced in the summer of 1960 the establishment of a National Center for Atmospheric Research near Boulder, Colorado.[546] This facility was destined to have considerable effect on the progress of the atmospheric sciences and on the work of the Bureau.

A new class of observing station was agreed to by the Bureau and the FAA to provide for a local source of observations at towers that did not have them. These stations were called LAWRS for Limited Airport Weather Reporting Stations, and reported only ceiling and sky conditions, visibility, weather and obstructions to vision, wind direction and speed, temperature and dew point (if remote reading equipment were available), altimeter setting, RVR where applicable, and remarks.[547]

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[542] Weather Bureau *Circular Letter* **4-60**, 1960: Amendment to Position Descriptions of Field Officials "In Charge."
[543] Weather Bureau *Circular Letter* **5-60**, 1960: Adjustments of the U.S. Weather Bureau Forecasting Organization.
[544] Amendment to Weather Bureau *Circular Letter* **5-60**, 1960: Forecast Realignment.
[545] Weather Bureau *Circular Letter* **11-60**, 1960: Severe Storms Research project.
[546] *Weather Bureau Topics*, April 1961, p. 62.
[547] Weather Bureau *Circular Letter* **2-61**, 1961: Establishment of Limited Airport Weather Reporting Stations (LAWRS).

The Civil Aeronautics Board Economic Regulation 314 permissively authorized U.S. air carriers to provide free transportation to aviation forecasters of the Weather Bureau for flight familiarization purposes. This provided for a possible flight familiarization program so that aviation forecasters could be familiar with flight crew weather problems.[548]

The research aircraft program, formerly attached to NHRP, was established in 1961 as a separate organization called the Research Flight Facility.[549]

JNWPU/NMC replaced the IBM 704 with an IBM 7090, 6 to 10 times as fast as the 704. This greatly increased the production capacity and timeliness of products. Three automatic data plotters were installed in 1960, which produced maps more accurately and faster than older manual methods. The development of a satisfactory baroclinic forecasting model was JNWPU's main developmental project, and in trying to solve the numerical instabilities of the "primitive equations."[550] A number of analyses and forecasts were being prepared solely by numerical methods.[551]

The Weather Bureau had been out of space at 24th and M Streets for years, and alternative space had been sought. The Bureau was asked in 1961 to consider the Bureau of Standards space which would be available in about 3 years. The Bureau agreed, and the Under Secretary of Commerce agreed. 500,000 square feet were requested.[552] A new building at the site to house all computer-oriented activities was planned.[553] The move was never made.

An atomic-powered automatic weather station was successfully installed in the Canadian Arctic, and the first report was received on August 17, 1961.[554]

Agricultural services continued to expand, and by spring 1962, services were provided in eight broad areas. Teletypewriter circuits were installed in each area to carry timely and frequent forecasts to local radio and television stations, as well as to farm publications and newspapers.[555]

The name of the Office of Civil Defense Management was changed to the Office of Emergency Planning (OEP), and in 1962 the instructions for notification of severe weather was essentially changed from a 24-hour notification to only 40 hours per week, except for reports of destructive tornadoes, first advisories on tropical storms, bulletins of major floods in progress, and seismic sea wave warnings. These were to be reported through a calling tree.[556] Additional instructions were issued the next year to inform OEP about only reports of destructive tornadoes, first advisory on tropical storms, and bulletins on major floods in progress. It was emphasized that OEP did not now

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[548] Weather Bureau *Circular Letter* **7-61**, 1961: Flight Familiarization by Aviation Forecasters on U.S. Air Carriers–Operating Instructions.

[549] *Weather Bureau Topics*, January 1961, Topigrams.

[550] *Weather Bureau Topics*, February 1961, pp. 25-27.

[551] *Weather Bureau Topics*, January 1961, p. 13.

[552] *Weather Bureau Topics*, April 1961, Briefs from CO Staff Conference; September 1961, Briefs from CO Staff Conference.

[553] *Weather Bureau Topics*, May 1964, Topigrams.

[554] *Weather Bureau Topics*, September 1961, Topigrams.

[555] *Weather Bureau Topics*, September 1961, p. 155.

[556] Weather Bureau *Circular Letter* **3-62**, 1962: Notifying Office of Emergency Planning about Severe Storms.

have RAWARC. The OEP Headquarters desired nationwide information, but Regional OEP offices, of which there were eight, desired only regional information.[557]

Instructions were issued to provide a climatological forecast for each major holiday, starting with Memorial Day 1962. The forecasts were to be prepared by the Extended Forecast Branch of NMC both as written statements and in mapped form, and were to be released from 2 weeks to a month before each holiday. The forecasts were to be clearly labeled as "not a specific forecast but is based on climatological indications" and could be given local distribution as seemed appropriate.[558]

Attention was called in 1962 to the fact that the accepted definition of VFR (Visual Flight Rules) of "...ceiling 1,000 ft and visibility 3 miles..." was no longer strictly accurate, and impressed on personnel that pilot briefings were to be given in terms of ceiling and visibility, not VFR.[559]

The Bureau had access to radar data from many cooperating facilities. In July 1962, Chief Reichelderfer listed 221 such facilities.[560]

Always short of space, the Bureau secured space for the Hydrologic Services Division, the Training Section, and the Office of Forecast Development at 4880 MacArthur Boulevard, Washington, D.C. The move was in February 1962.[561] (See Appendix III, Fig. 13.)

Guidance forecasts were extended to 72 hours on September 18, 1961, with daily transmission of sea-level isobars and fronts, precipitation, and surface temperature.[562] The use of such guidance was beginning to catch on. For instance, Salt Lake City discontinued local preparation of surface synoptic maps on August 1, 1961, as well as local preparation of a 500-mb chart twice daily.[563]

The Bureau's satellite program continued to grow. TIROS 5 had been launched on June 19, 1962.[564] The Meteorological Satellite Activities organization became the National Weather Satellite Center. As such, it was responsible for the development and management of the National Operational Meteorological Satellite System.[565] The facility was dedicated on September 6, 1963.[566]

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[557] Weather Bureau *Circular Letter* **6-63**, 1963: Notification of Office of Emergency Planning about Severe Storms.

[558] Weather Bureau *Circular Letter* **4-62**, 1962: Climatological Outlooks for Major Holidays.

[559] Weather Bureau *Circular Letter* **5-62**, 1962: Minimum Ceiling and Visibility Requirements for VRF Flight and Use of the Term VFR in Pilot Briefing.

[560] Weather Bureau *Circular Letter* **7-62**, 1962: Radar Weather Observations from Cooperative agencies.

[561] *Weather Bureau Topics*, January 1962, Topigrams.

[562] *Weather Bureau Topics*, January 1962, p. 9.

[563] *Weather Bureau Topics*, January 1962, p. 18.

[564] *Weather Bureau Topics*, June 1962, Topigrams.

[565] *Weather Bureau Topics*, July 1962, Topigrams.

[566] *Weather Bureau Topics*, November1963, p. 125, 126.

After 3 years of development and testing, the Bureau placed an order for 11 Automatic Meteorological Observing Stations (AMOS) to be delivered in approximately a year. AMOS-IV would outperform the AMOS-IIIs in use.[567]

The first useful numerical prediction at sea-level was achieved by Reed.[568] This model went into operation in 1962. Although it could not compete successfully with manual methods, it did provide useful information, and the decrease of sea level pressure forecast error from 1962 to 1965 was largely attributed to Reed's model.[569]

A new Weather Radar Laboratory was opened in 1962, organized by the National Severe Storms Project. It was expected to conduct research on many aspects of severe weather detection and to study the dynamical and kinematical properties of squall lines and thunderstorms. It was located adjacent to the Atmospheric Research Laboratories of the University of Oklahoma.[570] It was separated from the National Severe Storms Project in 1963 and operated as a separate unit under Dr. Edwin Kessler.[571] Later in March 1964, the Laboratory and Project were consolidated into the National Severe Storms Laboratory (NSSL) in Norman, Oklahoma, with Kessler as Director.[572,573]

Dr. Harry Wexler, Director of the Bureau's OMR, died on August 11, 1962, at 51 years of age. Much of the Bureau's research the past few years had been orchestrated by Dr. Wexler.[574] He was supportive, along with Dr. Reichelderfer, of the numerical weather prediction activities, that were to play a pivotal role in the future.[575] The 1963 October-December issue of the *Monthly Weather Review* was devoted to Wexler and his work. One can only wonder how this event affected the future of the Bureau.

The Bureau, along with the Navy and the National Science Foundation, established Project Stormfury in 1962 with Dr. Joanne Simpson as Director. The goal of the project was to explore the structure and dynamics of hurricanes, and to achieve better understanding, improve prediction, and investigate the possibly of modifying some aspects of these destructive storms.[576] It was thought "seeding" would create instabilities in the hurricane wind system which would cause the ring of maximum winds near the eye to expand outward and diminish. Building on the 1961 experiment with hurricane Esther, a new device for dispensing the silver iodide seeding crystals was used in 1962.[577] Stormfury ended in mid 1983. A comprehensive summary states that while the project

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[567] *Weather Bureau Topics*, July 1962, p. 105.

[568] Reed, R. J., 1963: Experiments in 1000 mb prognosis. *NMC Tech. Memo.* **26**, 43 pp.

[569] Shuman, F. G., 1989: History of Numerical weather prediction at the National Meteorological Center. **Wea Forecasting 4**, p. 291.

[570] *Weather Bureau Topics*, July 1962, p. 106.

[571] *Weather Bureau Topics*, November 1963, p. 133.

[572] *Weather Bureau Topics*, March 1964, p. 43.

[573] Corfitti, S. F., 1999: The birth and early years of the Storm Prediction Center. *Wea Forecasting* **14**, pp. 507-525.

[574] *Weather Bureau Topics*, July 1962, p. 111.

[575] Harper, K. C., 2008: *Weather by the Numbers*. The MIT Press, 328 pp.

[576] *ESSA World*, **1**, October 1966, pp. 4, 5.

[577] *Weather Bureau Topics*, August 1962, p. 121.

provided funds for much useful research and development of instrumentation, operational seeding was "neither microphysically nor statistically feasible." [578]

The Bureau's General Circulation Research Laboratory (GCRL) acquired an IMB STRETCH computer. The laboratory, essentially an outgrowth of JNWP, was formed in 1955 as the General Circulation Research Section with Dr. Joseph Smagorinsky as Director, and the name was changed to the General Circulation Research Laboratory in 1959.[579] Its purpose was to study the longer range problem of the general circulation, and hence attack the question of whether long-range prediction was possible. In the meantime, NMC concentrated on the day-to-day weather. GCRL became the Geophysical Fluid Dynamics Laboratory (GFDL) in 1963 just before Dr. White's reorganization in 1964.[580] GCRL and the STRETCH were located at 615 Pennsylvania Ave., Washington, D.C. The computer was available, as was the IBM 704 at NMC previously, for other researchers in OMR located at the Central Office to use. Punched cards, prepared on an IBM 026 or 029 card punch, were sent by a routine courier in tin boxes to be fed into the STRETCH during the night, and the folded, 11-inch paper from the IBM 1401 would be returned the next morning for eager eyes. (GFDL later became part of the research arm of ESSA, and moved to a building constructed for it at Princeton University in 1968.[581] Dedication of the laboratory at Princeton occurred on January 25, 1969.[582])

As an indication of the accuracy of weather forecasts in 1962, the American Meteorological Society (AMS) issued a statement on weather forecasting which states,

> "For periods extending to about 72 hours, weather forecasts of moderate skill and usefulness are possible.... Average weather conditions for periods of about a week can be predicted with reasonable skill. Beyond 3 days, skill in day-to-day predictions is small. Average temperature conditions for periods up to a month can be predicted with some skill. Day-to-day or week-to-week forecasts within this time period have not demonstrated skill." [583]

In 1963, the Bureau's Radar Laboratory in Norman, Oklahoma, began tests on a radar data processor to be used in flood forecasting. The device, called a precipitation integrator, integrated echo intensity of the radar over extended periods so that the total accrued precipitation was observed. The information was transmitted to an RFC.[584]

The Bureau was supporting Antarctic research. Bureau employees accompanied Richard Byrd's 1928, 1934, and 1939 expeditions. Since 1954, the Bureau was involved continuously in Antarctic

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[578] Willoughby, H. E., D. P. Jorgensen, R. A. Black, and S. L. Rosenthal, 1985: Project STORMFURY: A scientific chronicle 1962-1983. *Bul. Amer. Meteor. Soc.* **66**, 505-514.

[579] *Weather Bureau Topics*, September-December 1962, p. 133.

[580] Smagorinsky, J. 1983: The beginnings of numerical weather prediction and general circulation modeling: Early Recollections. *Advances in Geophysics*, **25**, pp. 3-37. Also see history maintained by GFDL.

[581] *ESSA News*, **3**, June 23, 1967, p. 1.

[582] *ESSA News*, **5**, January 24, 1969, p. 3.

[583] American Meteorological Society, 1962: AMS Statement of Weather Forecasting. *Bul. Amer. Meteor. soc.*, **43**, p. 251.

[584] *Weather Bureau Topics*, February 1963, p. 24.

operations, including the earlier expeditions preparatory to the international Geophysical Year, 1957-58. In 1963, meteorological programs were being carried out at five stations, including Amundsen-Scott at the South Pole. A number of geographical features had been named for Bureau employees.[585]

The Bureau converted from helium to hydrogen for balloon inflation where local conditions permitted. This was a cost saving measure, and balloons were expected to go a few thousand feet higher. New inflation shelters were built with safety considerations in mind. No other country was using helium for this purpose. As recorded earlier, the Bureau had completed a switch from hydrogen to helium for safety purposes in 1940.[586]

By 1963, an experimental TV Weather station, called VIDMET (Video-Meteorology) had been constructed on the top floor of the central Office building by James Fidler. The purpose was to experiment with methods of presenting the output of the Bureau in an efficient and economical manner.[587]

On October 1, 1963, Dr. Robert M. White became Chief of the Weather Bureau. Dr. Reichelderfer had served for 24 years, longer than any head of the weather service before or after.[588] He had written a letter resignation to President Kennedy on July 24 asking for an effective date of retirement not later than September 30, or "sooner if convenient."[589]

In late 1963, the Bureau decided that the current configuration of the Nimbus satellite being developed by NASA would not be used in the National Operational Meteorological Satellite System. The first operational satellite was expected to be an improved version of TIROS. Nimbus would be used by NASA in its research and development program.[590] Nimbus I, launched on August 28, 1964, was a failure in that the solar panels froze, and batteries could not be recharged.[591]

On November 13, 1963, the Bureau of the Budget issued a Circular that directed the Department of Commerce to prepare, and keep current, a plan for Federal meteorological services and research, with the assistance of other Federal Agencies. Chief White stated, "One implication of the Circular is clear. In Federal meteorological programs, the Department of Commerce has been given the leading role."[592] The Department of Commerce formed the Office of the Federal Coordinator for Meteorological Services and Supporting Research, more briefly known as the Office of the Federal Coordinator for Meteorology, in 1964.[593]

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[585] *Weather Bureau Topics*, March 1963, pp. 39, 42.
[586] *Weather Bureau Topics*, May 1963, p. 76.
[587] *Weather Bureau Topics*, May 1963, p. 79.
[588] *Weather Bureau Topics*, August-Septeber1963, pp. 106, 109.
[589] *Weather Bureau Topics*, October Special Issue1963, p. 2.
[590] *Weather Bureau Topics*, November 1963, p. 126.
[591] *Weather Bureau Topics*, October-November 1964, p. 145.
[592] *Weather Bureau Topics*, January 1964, pp. 2, 12-14.
[593] OFCM 2012: Home page, p. 1, cites Public Law 87-843.

TIROS VIII was launched on December 21, 1963, and carried, in addition to the standard TIROS TV camera, automatic picture transmission (APT) equipment enabling it to take meteorological photographs and send them immediately to relatively simple ground stations around the world. Unfortunately, the pictures were distorted.[594]

The role of the industry-government interface in weather services had been dealt with several times in the past. In January 1964, Dr. White issued a statement, written in the first person, on his views. He established a position of Special Assistant for Industrial Meteorology on his staff.[595]

On March 15, 1964, the production of the daily weather maps shifted from 24th and M Streets to NMC.[596]

Dr. Robert M. White served as Chief of the Weather Bureau from 1963 until the Environmental Science Services Administration (ESSA) was formed in 1965. White then became the Administrator of ESSA.

Dr. White lost no time in bringing change to the Bureau. Department Order 91 (revised) went into effect on April 15, 1964. It announced the creation of an Office of National Meteorological Services to provide executive direction of Bureau and field services, and named Dr. George P. Cressman as it's head; Dr. Frederick G. Shuman was named to succeed Cressman as Director of NMC. Also established were a Systems Development Office with Merritt Techter as Director, an Office of Hydrology with W. E. Hyatt as Director, and a Chief Scientist position. Other Directors were: Dr. Helmut Landsberg, Director of Climatology; David Johnson, Director of the National Weather Satellite Center; R. C. Grubb, Director of Administration and Technical Services; N. A. Lieurance, Director of Aviation Weather Services; Gorden Cartwright, Director of International Affairs; Walter Hahn, Director of Policy Planning; and J. M. Beall, Director of Public Information. The Regional Administrative Offices became Regional Offices, and a new Region VI was established in Hawaii, bringing the total to six.[597]

Also in 1964, a State User Service Representative (STATUS REP) and Regional User Service Representative (REGUS REP) program was started. This was all part of the goal of providing responsive weather services. These representatives were to maintain liaison with user groups,

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[594] *Weather Bureau Topics*, January 1964, p. 6; February 1964, p. 23.

[595] Weather Bureau *Circular Letter* **2-64**, 1964: Government–Private Meteorological Services.

[596] *Weather Bureau Topics*, March 1964, Topigrams.

[597] *Weather Bureau Topics*, April 1964, pp 50-54, 63-67; September 1964, pp 128-134.

receive requests from users, recommend actions in light of related programs and probable effect on all services, and evaluate effectiveness for the user of weather services.[598]

The electronic maintenance training centers at Sterling, Virginia, and Kansas City were consolidated at Kansas City in 1964.[599]

By mid 1964, the Bureau had been operating a Local Forecast Verification Program for over 6 years. The results had proven valuable in several areas, including replies to Congressional inquiries and accuracy of local forecasts on a geographic basis. However, the time required for each station to compute the means, prepare the contingency tables, and compute various statistics was considerable. Also, the time checking the WB Forms 650-10 sent by the field offices by the Central Office staff was a heavy workload. Accordingly, the form was simplified, and a simple punch card was devised and cards were provided to each station. Most rules were unchanged. One card was to be punched per day giving the maximum temperature forecast and observed for "today," "tonight," and "tomorrow," and the precipitation for the same periods as a "yes" or "no." Cards, together with the forms, were to sent to the Central Office monthly. The cards were then machine processed to produce the data desired.[600]

It had been noted that, "Because precipitation is of more concern to the public than any other element in the daily forecast, meteorologists tend to overforecast showers." While precipitation could occur on the mesoscale as well as the synoptic scale, forecasts were made based on spacing of stations at the synoptic scale. Instructions were issued that, with the exception of certain locations where objective techniques had been developed that used parameters of specific local significance, precipitation should be predicted only when one of the following conditions existed:

(1) there is reasonable expectancy that there will be precipitation associated with synoptic scale systems; or

(2) the development of significant precipitation on a more local scale can be tracked by radar or anticipated from analyses of motion systems on scales smaller than the spacing of the conventual observing networks.

To try to curb this overforecasting, a six-month trial was started on August 31, 1964, such that predictions of precipitation 12 hours or more in advance of "map time" would be limited to those circumstances in which rainfall, in amounts of significance to the general public, would occur over at least 20% of the surrounding synoptic scale area which was meteorologically homogeneous. "Synoptic scale area" referred to the area within a 50 to 150 mile radius of the center of the locality concerned. As a policy, it was proposed that showers be included in the area or local forecast only when 20% or more of the observing points in the surrounding synoptic scale area were (a) expected to receive precipitation measuring 0.05 inches or more during the forecast period, or (b) expected

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[598] Weather Bureau *Circular Letter* **9-64**, 1964: Establishment of User Service Representative in Each State.
[599] *Weather Bureau Topics*, May 1964, p. 76.
[600] Weather Bureau *Circular Letter* **5-64**, 1964: Local Forecast Verification Program.

to receive continuous precipitation in any amount for more than one hour. It was suggested that the score proposed by Brier[601] be used for verification.[602]

On or about August 5, 1964, the winds aloft FD program for the 48 states was partially assumed by NMC, and was later to be fully assumed when resources were available. Transmission was made only on Service A and facsimile. The FDs were produced by computer, essentially one forecast for each grid square of the NMC computer standard grid. The forecast transmitted was for the center of each square, and each square was represented by a primary Service A weather reporting station selected as near the center of the square as possible. Winds were at 6-hour intervals at levels above mean sea level of 3,000, 5,000, 10,000, 15,000, 20,000, and 25,000 ft.[603] The program was fully implemented on February 24, 1965, and included temperatures as well as winds.[604] Amendments to these machine-produced forecasts could be made by FAWS offices for briefing or other local uses when deemed necessary, but had to be reported monthly.[605] Observations to be used for verification were defined.[606]

The Weather Bureau's first Marine Automatic Meteorological Observing Station (MAMOS) was developed. Two units were moved to fixed positions in the Gulf of Mexico. MAMOS was similar to the Navy's NOMAD.[607]

Effective January 1, 1965, the synoptic weather observations were reported in degrees Celsius instead of Fahrenheit (F) in the Coded Synoptic Reports. However, this did not apply to aviation observations nor imply use of Celsius units in public weather forecasts. NMC and forecast centers could use the temperature scale that was more convenient, or more applicable to the problem at hand.[608,609]

On October 25, 1964, President Johnson announced a United States-Soviet agreement whereby weather information would be exchanged on a direct communications link. On October 28 data were

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[601] Brier, G. W., 1950: Verification of forecasts expressed in terms of probability, *Mon. Wea. Rev.*, **78**, pp. 1-3.

[602] Weather Bureau *Circular Letter* **8-64**, 1964, and appendix: Precipitation Forecasts. Actually the directions for the use of the score proposed by Brier were not according to his formulation. As proposed by Brier, the forecast was for probability forecasts (expressed as a decimal number from zero to one) and the observation was either zero or one. The instructions stated that both the forecast and observation would be fractional, the latter being the fraction of the defined area receiving precipitation. But, that suited the purpose of the experiment.

[603] Weather Bureau *Circular Letter* **4-64**, 1964 plus addendum No. 1: Winds Aloft Forecasts; FD Program in the 48 Contagious states.

[604] Weather Bureau *Circular Letter* **2-65**, 1965: Winds Aloft (and Temperature) Forecasts; FD Program in the 48 Contagious states.

[605] Weather Bureau *Circular Letter* **2-65**, 1965: Amendment No. 1: Manual Override of Machine Prepared Upper Wind Forecasts.

[606] Weather Bureau *Circular Letter* **2-65**, 1965: Addendum No. 1 to Amendment No. 1: Manual Override of Machine Prepared Upper Wind Forecasts.

[607] *Weather Bureau Topics*, May 1964, p. 79; July-August, Topigrams.

[608] *Weather Bureau Topics*, December 1964, p. 168.

[609] Weather Bureau *Circular Letter* **10-64**, 1964: Use of Celsius Temperature Scale in Coded Synoptic Reports.

flowing on a 5000-mile cable circuit from Washington to Moscow by way of London, Frankfurt, Berlin, and Warsaw.[610]

The use of the CONELRAD system for emergency alerting was replaced by the Emergency Broadcast System. The Weather Bureau was authorized to use the system to disseminate emergency weather warnings. Two features proved useful–Emergency Acton Notification Signal and the State Defense Network (FM).[611]

The World Weather System being developed by the World Meteorological Organization called for three World Weather Centers, one in Washington, one in Moscow, and one in Melbourne. The World Weather Center in Washington began operations on January 1, 1965. The Center activities were carried out by NMC, the National Weather Satellite Center, the NWRC, and other Bureau components in such activities as training and archiving.[612]

In early 1965, the IBM STRETCH and 1620 computers at GFDL and the 7094-II and 1401 computers at the National Satellite Center were replaced by a Control Data Corporation (CDC) 6600 computer. The 6600 was six times faster than the STRETCH. It was planned that the 7094-II and 1401 at NMC would be used for a short overlapping period, but within a year all Bureau major computer work in Washington would be done in a single facility.[613] The CDC was a 60-bit word machine and considerable work was required to convert software from the 32-bit IBM machines.

The term AIRMET for "Airmen's Meteorological Information" replaced "Advisory for Light Aircraft" in the In-Flight Weather Safety Service.[614]

On May 13, 1965, President Lyndon B. Johnson submitted to Congress a reorganization plan consolidating the Weather bureau and the Coast and Geodetic Survey (C&GS) to crate a new Commerce agency called the Environmental Science Services Administration (ESSA). It was to be effective in 60 days.[615]

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[610] *Weather Bureau Topics*, December 1964, p. 166.

[611] Weather Bureau *Circular Letter* **11-64**, 1964: Use of Emergency Broadcast System for Dissemination of Emergency Weather and Flood Warnings.

[612] *Weather Bureau Topics*, January-February 1965, p. 10.

[613] *Weather Bureau Topics*, January-February 1965, p. 13.

[614] Weather Bureau *Circular Letter* **3-65**, 1965: Substitution of term "AIRMET" for "Advisory for Light Aircraft" in In-Flight Weather Safety Service.

[615] *Weather Bureau Topics*, May-June 1965, pp. 71-73; July-August 1965, p. 104.

The Weather Bureau Under the Environmental Science Services Administration

ESSA came into existence on July 13, 1965, under the President Johnson's Reorganization Plan No. 2 of 1965. It was a consolidation of the Weather Bureau and C&GS, both of which continued under their names as organizational components of ESSA. With the transfer of the Central Radio Propagation Laboratory of the National Bureau of Standards planned for October, ESSA would comprise all the environmental science service activities of the Department of Commerce. ESSA Headquarters' functions were conducted at the Weather Bureau site at 24th and M Streets, Washington, D.C. until ESSA staff could occupy a new site in Rockville, Maryland.[616] Dr. White became Administrator of ESSA, and George Cressman was appointed as Acting Director of the Weather Bureau; the Office of the Chief of the Weather Bureau created in the Act of October 1, 1890, was abolished by the reorganization–essentially a change in title.[617] ESSA was still under the Department of Commerce, but now there was one more layer in the organization, the Weather Bureau not now reporting directly to the Department.

A new publication *ESSA News* was inaugurated. Its second issue stated, "*ESSA NEWS* is not intended to replace the Weather Bureau's *TOPICS, TOPIGRAMS*, or Coast and Geodetic Survey's *PERSONNEL PANORAMA*. Those publications will continue to be issued with the same distribution as before until further notice."[618] However, in October 1965, Dr. White issued a statement: "(ESSA NEWS) is intended as your news organ to report on your activities, your accomplishments, on items of direct and immediate concern to you." This evidently was notice that *ESSA News* would replace *Weather Bureau Topics*.[619] NOAA Central Library archives indicate the 1965 July-August issue of *Weather Bureau Topics* was the last one issued, thereby stopping a venerable house organ that started as *Weather Bureau Topics and Personnel* in 1915. This termination was formalized by a statement in *ESSA News* in February 1966: "For 50 years, *TOPICS* was the official publication of the Weather Bureau. With the creation of ESSA it has become necessary to discontinue it as well as Coast and Geodetic Survey's *PERSONNEL PANORAMA*. A new monthly ESSA magazine is now being planned but until it becomes a reality ESSA NEWS will do its best to bridge the gap… ." [620]

The ESSA Administrator and staff and supporting staff from the Bureau's Service Programs located at 24th and M Streets moved to ESSA Headquarters in Rockville in August 1965. Movement of staff to Rockville made room to move the Weather Bureau offices located in the Longfellow Building back to 24th and M Streets in August 1965. Also, the Bureau Personnel Division's training activities moved from 4880 MacArthur Blvd. in Washington D.C. to Rockville in August. Regional warehouses of the Weather Bureau and C&GS were consolidated in Kansas City.

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[616] *ESSA News*, **1**, July 13, 1965.

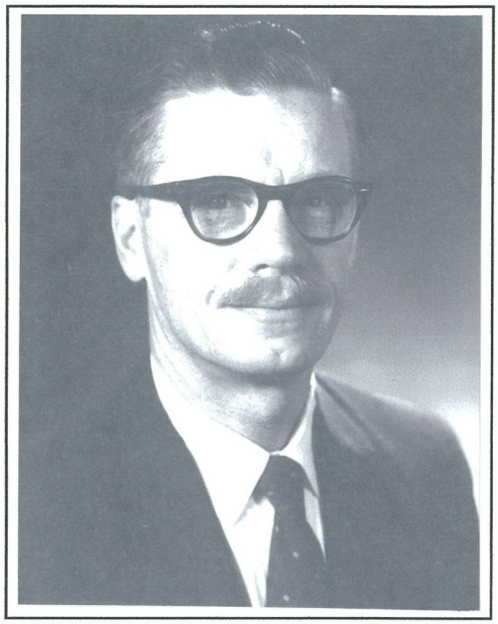
[617] *Weather Bureau Topics*, May-June 1965, pp. 71-73; July-August 1965, p. 104.

[618] *ESSA News*, **1**, July 21, 1965, pp. 1-3.

[619] *ESSA News*, **1**, November 18,, 1965, p. 1.

[620] ESSA News, **2**, February 11, 1966, p. 2.

There was little immediate change at the working level, but some functions, especially of the Weather Bureau, moved to ESSA. The Bureau's Office of Meteorological Research and Data Acquisition Division moved from the Longfellow Building to 24th and M in late August.[621,622]



Dr. George P. Cressman was Director of the Weather Bureau from 1965 when ESSA was formed until NOAA was formed in 1970, then Director of the National Weather Service until 1979.

The Weather Bureau's central warehousing facility moved from the Logan Building to Kansas City, Missouri, in July 1965.[623] This move consolidated the Bureau's and C&GS facilities.

The Bureau's Office of Aviation Weather Affairs, National Weather Satellite Center, Office of Climatology, and Office of Meteorological Research were administratively moved directly under the ESSA Administrator. In addition, the Deputy Director for Service Programs of the Office of National Meteorological Services was transferred to ESSA and reported to the Administrator. These realignment actions were on an interim basis pending the issuance of Department order 2-B.[624]

With the issuance of Department Order 2-B effective October 1, *ESSA News* published the organizational structure. The Bureau organization was given as follows:[625]

Director–Dr. George Cressman
Office of Meteorological Operations–Dr. Robert (Bob) Simpson (acting)
Office of Hydrology–William (Bud) Hiatt (acting)
National Meteorological Center–Dr. Frederick (Fred) Shuman
Office of Systems Development–Merritt Techter
Executive and Technical Services Staff–Russell (Russ) Grubb
Regions–Eastern–Dr. Karl Johannessen; Central–Roy Fox; Southern–Wilmer (Tommy) Thompson; Western–Hazen Bedke; Alaska–Mac Emerson; Pacific–James (Jim) Osmun

The titles were, with some exceptions, "Director" down to and including the 4th organizational level for Laboratory, Observatory, and Center, but for Division, was "Chief." Lower levels were

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621 *ESSA News*, **1**, July 29, 1965, p. 3.
622 *ESSA News*, **1**, August 9, 1965, p. 1.
623 *ESSA News*, **1**, July 21, 1965, p. 3.
624 *ESSA News*, **1**, August 26, 1965, p. 1.
625 *ESSA News*, **1**, October 4, 1965, p. 3.

"Chief."[626] Issues of *NOAA News* described the functions of the various elements of NOAA; Dr. Cressman, described those of the Weather Bureau in December 1965.[627]

Verification procedures were being changed in 1965. Local offices continued their present verification system including punched cards which were sent to the Central Office for processing and printout. Selected local offices upon notification by their respective Regional Office punched out an additional set of cards showing the FP Forecast for their station. Some FP offices began verifying NMC forecasts for selected stations in their area of responsibility in addition to their own forecasts. Precipitation probabilities were included in verification forms when the office had been authorized to issue probability forecasts to the public.[628]

On October 14, 1965, recorded weather forecasts via telephone became available to residents of the entire State of New Jersey through the cooperation of WBFO New York and the New Jersey Bell Telephone Company. Heretofore, this type of automatic answering service had been provided only in certain metropolitan areas.[629]

In November 1965, the Bureau began issuing daily warnings and forecasts of near-shore wave conditions, including surf and breakers, by the San Diego and Los Angeles offices for the section of California coast from La Jolla to the Mexican Border.[630]

Aviation and other users of Weather Bureau products stated a need for upper wind and temperature information in digital form as a direct, numerically-derived product input to their computers for flight planning purposes. The Bureau stated:

> "The Weather Bureau will make available in digital form products of the national meteorological service computer system to any user or users. Data furnished shall be made available wherever the data exist in the national meteorological service system. Costs of duplicating and communicating the data for use outside the system shall be borne by the user(s).
>
> "Reasonable notice (usually at least 90 days) of changes to existing programs, schedules, or formats will be given to users." [631]

By 1966, non-government users were being given remote access to Weather Bureau APT receivers.[632] The first APT picture sent by the satellite ESSA 2 was on February 28, 1966.[633]

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[626] *ESSA News*, **1**, October 12, 1965, pp. 3-6.

[627] *ESSA News*, **1**, December 15, 1965.

[628] Weather Bureau *Circular Letter* **5-65**, 1965 Amendment 1: Use of Probability Statements in Precipitation Forecasts; **6-65**: Verification Procedures.

[629] *ESSA News*, **1**, December 1, 1965, p. 8.

[630] *ESSA News*, **1**, December 28, 1965, p. 8.

[631] Weather Bureau *Circular Letter* **1-66**, 1966 : Weather Bureau Policy on Provision of Processed Digital Weather Data.

[632] Weather Bureau *Circular Letter* **5-66**, 1966: Agreement for Remoting of APT Data.

[633] ESSA World, July 1966: Administrator Eyes First APT Picture of ESSA 2, p. 12.

In the spring of 1966, the Weather Bureau moved from 2400 M Street, Washington, D.C. to the Gramax Building at 8060 13th Street in Silver Spring, Maryland. This was a new building and the interior was designed largely according to Bureau requirements. The moves in the April and May included the following elements and activities:

- All Weather Bureau activities at 2400 M Street,
- The ESSA Administrative Operations Support Services Section at 2400 M Street,
- the Institute of Atmospheric Sciences at 2400 M Street,
- Weather Bureau 150,000-volume Library at FOB4 at Suitland,
- ESSA's Environmental Data Service at FOB4 at Suitland,
- WB Equipment Development Laboratory, Office of Systems Development at Naval Observatory offices,
- WB Engineering Division, Executive and Technical Services Staff at Naval Observatory offices,
- Institute for Oceanography from the Washington Science Center in Rockville,
- C&GS Aeronautical Charting and Cartography Division (sans Charting and Distribution Divisions) from the Washington Science Center in Rockville, and
- C&GS Radio Facility Chart Branch, from 512 9th Street, Washington.

The Gramax Building at 8060 13th Street in Silver Spring, Maryland, the home of the Weather Bureau and National Weather Service from 1966 to 1990. (Photo by Bob Glahn, 1989.)

This move consolidated all of the Weather Bureau Central Office except the Office of Hydrology remained at 4880 MacArthur Boulevard. Space vacated in FOB4 was used for NMC, the (soon to be ESSA) Computation Division, and the National Environmental Satellite Center to meet expanding requirements.[634] The Bureau Personnel Division's training activities moved from MacArthur Blvd. to Rockville in August.[635]

The Gramax Bldg. had accommodations not available at 2400 M Street, including a spacious Montgomery County parking garage across the street, a nearby post office,[636] some in-building parking, a small restaurant in the building, a health unit, a DOC Credit Union office, and bus lines

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[634] *ESSA News*, **2**, February 21 1966.
[635] *ESSA News*, **1**, July 29, 1965, p. 3.
[636] *ESSA News*, **2**, February 21 1966, map p. 2.

that ran to the building. The building was sometimes called the heliport building because there was a helicopter pad on the roof.[637] The pad was not routinely used, and perhaps never, once the Bureau moved in.

The Weather Service Director's office was in the southwest corner of the 14th floor, the top full floor. There was a partial 15th floor that was used as a conference room; years later, it was banned for safety reasons, as it had only one exit stairwell. There was a small parking garage on the first floor entered from the rear along Kennett Street, and a portion of the 1st floor entered from the front was also a garage.

On June 5, 1966, the six-layer primitive equation (PE) model became operational. Research with the primitive equations had been going on at JNWP since 1959. This model produced another impressive advance in skill over the previous models.[638],[639]

The last *Circular Letter* in the NOAA Library files is, No. **5-66**, dated November 16,1966. They either stopped at this point or were no longer archived, slightly more than a year after ESSA came into existence. In the meantime, *ESSA Circulars* had been established.[640] Almost synonymously, a new publication *ESSA World* appeared, its first issue in July 1966, on NOAA's first anniversary.[641]

The Weather Bureau personnel from WBAS Honolulu and Air Force personnel teamed up with the Navy at the Fleet Weather Central at Pearl Harbor to produce numerical analyses and forecasts of common interest to users, civil and military in the tropical pacific. These products included computer plotted charts, printouts, teletypewriter messages, and facsimile charts, four times daily.[642]

Department Order 2-B was amended, as announced by *ESSA News* in April 1966, to include an Office of World Weather Systems to be directed by Dr. Richard Hallgren. The new office was to provide leadership and coordination in the development of plans and operations for Untied States participation in the cooperative international meteorological program knows as the World Weather Watch. WMO's World Weather Program had two major goals: "development and operation of a World Weather Watch–an international system to observe the atmosphere and to communicate, process, and analyze global wether data; and a comprehensive research program to accomplish long-range weather prediction and for the theoretical study and evaluation of the feasibility of large-scale weather climate modification."[643]

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[637] *ESSA News*, **2**, February 25 1966, p. 2.

[638] Shuman, F. G., 1989: History of Numerical weather prediction at the National Meteorological Center. *Wea Forecasting* 4, p. 287.

[639] Shuman, G. G., and J. B. Hovermale, 1968: An operational six-layer primitive equation model. *J. Appl. Meteor.* 7, 525-547.

[640] *ESSA News*, **1**, August 26, 1965, p. 1.

[641] ESSA World, July 1966, 16 pp.

[642] *ESSA News*, **2**, March 4, 1966, p. 3.

[643] *ESSA World*, **2**, April 1967, pp. 9-11.

In 1966, the Washington Forecast Center activities at the Washington National Airport moved to quarters adjacent to NMC at Suitland, Maryland. Radar, surface, and synoptic observational programs continued at the airport.[644]

Also in 1966, construction started at Palmer, Alaska, on a Seismological Observatory, which would serve a the "nerve center" for the Alaskan Seismic Sea Wave Warning System and would provide vital information to Honolulu for use in the Pacific Seismic Sea Wave Warning System. It was scheduled to be completed by September 1967.[645] With the installation of a continuous recording tide gage at Cold Bay, the network of tide-gage stations for the Alaska Seismic Sea Wave Warning System was complete. Other stations were at Sitka, Seward, Kodiak, Unalaska, Adak, and Shemya.[646]

Administrative functions in ESSA were realigned in mid 1966. A new division, the Scientific Information and Documentation Division under Jim Caskey consolidated functions previously under the Weather Bureau and C&GS. A Computer Division under Mirco Snidero subsumed the Bureau's Computation Division, and was now in charge of the CDC-6600 which was designated as the central computer of ESSA.[647]

Two new fire weather mobile units were added to the mobile fleet, bringing the total to 20 which were dispatched to key locations to forecast weather conditions for forest fire protection agencies.[648] These mobile units were called into service in other weather situations, such as providing forecasts when an oil spill occurred.[649]

The Bureau under the sponsorship of the Office of Naval Research resumed meteorological observations including radiosonde on the floating arctic ice island T-3 in June 1966. It had last been manned in December 1960.[650] In January 1969, the sponsor proposed observations be continued through 1970.[651] The ice island, sometimes called Fletcher's Ice Island in honor of Col. Joseph Fletcher who first landed and set up camp there, was photographed from the air in 1947. The name "T-3" came from "Target-3." It was thought to have broken off from ice on Ellesmere Island.[652]

The production of the daily weather map was changed in1966 to in-house, two-color printing in lieu of overprinting base maps printed by the Government Printing Office. This was achieved by using C&GS's reproduction facility.[653] By 1969, the subscription price was $7.50 per year.[654]

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[644] *ESSA News*, **2**, May 20, 1966, p. 1.
[645] *ESSA News*, **2**, May 27, 1966, p. 3.
[646] *ESSA News*, **2**, December 23, 1966, p. 2.
[647] *ESSA News*, **2**, July 29, 1966, p. 1.
[648] *ESSA News*, **2**, June 3, 1966, p. 2.
[649] *ESSA World*, **4**, July 1969 , p 10.
[650] *ESSA News*, **2**, May 6, 1966, p. 4; June 3, p. 3.
[651] *ESSA News*, **4**, January 10, 1969, p. 6.
[652] *ESSA World*, **4**, October 1969, pp. 9-11
[653] *ESSA News*, **2**, September 2 1966, p. 2.
[654] ESSA News, **5**, June 6, 1969, p. 4.

A Federal Plan for a National Agricultural Weather Service was completed in January 1967. This was the first in a series of plans to be published by the Office of the Federal Coordinator for Meteorological Services and Supporting Research.[655] It was released to the public in April and proposed a nine-phase expansion of agricultural weather service to cover the entire nation.[656]

On January 17, 1967, a high-speed weather communications circuit was dedicated linking North America and Europe. The new circuit was capable of voice, teletypewriter, or pictorial transmission to replace a low speed teletypewrite line at 100 words per minute.[657]

The first experimental seeding of supercooled fog at Anchorage international Airport was conducted on January 13, 1967.[658]

NMC added latent heat to the PE model. In tests, the modified model had improved forecasts of vertical motion, trough movement, and the intensity of the low centers during two heavy snowstorms.[659]

The Techniques Development Laboratory (TDL) had been formed in 1964, and techniques were being developed that had the potential of being implemented at NMC. In late 1965, Merritt Techter, Director of the Systems Development Office (OSD), of which TDL was an element, saw the need for a coordinating mechanism whereby recommendations could be made as to what would be implemented at NMC. His efforts resulted in an Ad Hoc Committee on Implementation, which morphed into a permanent Committee on Analysis and Forecast Technique Implementation (CAFTI) chaired by Dr. William Klein, Director of TDL/OSD and with membership from the Office of Meteorological Operations (OMO) and NMC. The first meeting of CAFTI was on September 17, 1969. This committee played a major role in what was implemented at NMC for about 35 years. The membership was expanded and the chair was changed to Office of Meteorology and Oceanography (OM&O) (new name for OMO) from OSD on June 5, 1980, on the recommendation of Dr. William Bonner, then Deputy Director of NWS and on signature of Dr. Richard Hallgren, Director of NWS.[660] CAFTI was disbanded by Gen. John Kelly (Ret.) while he was director of the NWS, circa 2001.

The functions of CAFTI were spelled out in Terms of Reference, which were amended several times, along with specific named members. Major achievements were the following:

(1) It assured that the techniques implemented were of scientific merit, were backed-up with verification when appropriate, and had field involvement in the evaluation when appropriate.
(2) It assured that organizations other than NMC had a say in what was implemented.

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[655] *ESSA News*, **3**, January 6, 1967, p. 6.
[656] *ESSA News*, **3**, April 14, 1967, p. 1.
[657] *ESSA News*, **3**, January 20, 1967, p. 3.
[658] *ESSA News*, **3**, February 3, 1967, p. 7.
[659] *ESSA News*, **3**, March 3, 1967, p. 2.
[660] Glahn, H. R., 1990: The evolution of CAFTI. Unpublished manuscript, Techniques Development Laboratory, National Weather Service, NOAA, U.S. Department of Commerce, 5 pp.

(3) It assured that Technical Procedures Bulletins (TPB) were routinely prepared and disseminated.

The TPBs had been started by Charles Roberts of OM&O as a way of informing all personnel, but mainly field forecasters, of the data and forecasts being distributed and their formats. They were not under the purview of CAFTI, but CAFTI took a very active interest, and usually would not recommend implementation unless a TPB had been prepared and distributed, or was imminent. This close tie of CAFTI and TPBs was enhanced because the OMO/OM&O member of CAFTI was usually responsible for assuring the TPBs were prepared and distributed.[661]

ESSA's Deputy Administrator signed ESSA Circular dated April 19, 1967, to the effect that the term "ESSA" was generally recognized by the public, and it should be used in answering telephone calls at public service offices.[662]

A major improvement to ESSA's nationwide Natural Disaster Warning (NADWARN) system was announced to the public in May 1967. The system was designed to improve warnings of such natural hazards as tornadoes, hurricanes, floods, severe winter storms, seismic sea waves, and solar disturbances. The most important step in 1967 was the expansion of teletypewriter circuits in states with the highest tornado frequencies; these circuits were called the ESSA Weather Wire Network.[663]

A new tropical cyclone tracking program was put into operation at NMC for testing during the 1967 season. It provided a dynamical method of forecasting storm trajectories to run with NMC's numerical analysis and PE model for the tropical belt. The NMC primitive equation free-surface barotropic was designed for a Mercator map projection for the tropical belt between 48 degrees north and south latitude with a 5-degree longitude grid.[664,665]

Beginning with the July 5, 1967, model run, the effects of solar heating and radiative cooling were introduced into the 6-layer PE model.[666] As this indicates, the models were in their early stages of evolution. Processes were many times rudimentary. For instance, precipitation forecasts from the PE model had been noted to be excessively deficient during the summer, and in July 1967, a change was made for it to produce precipitation when the mean relative humidity was only 70 percent or greater in the lowest three layers for the summer, but the previous 80 percent criterion was to be retained for the fall, winter, and spring. This change affected the feed-back of latent heat of

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[661] Glahn, H. R., 1990: The evolution of CAFTI. Unpublished manuscript, Techniques Development Laboratory, National Weather Service, NOAA, U.S. Department of Commerce, 5 pp.

[662] *ESSA News*, **3**, 16, April 21, 1967 p. 2.

[663] *ESSA News*, **3**, May 19, 1967, p. 2.

[664] NWS Office of Meteorology, July 1967: New tropical tracking program. *Tech. Proc. Bul. 1,* 3 pp.

[665] Shuman, F. S., and L. W. Vanderman, 1966: Difference system and boundary conditions for the primitive-equation barotropic forecast. *Mon. Wea. Rev.*, **94**, pp. 329-335.

[666] NWS Office of Meteorology, July 1967: External and internal heat sources and sinks in the 6-layer (primitive equation) numerical prediction model. *Tech. Proc. Bul. 2,* 5 pp.

condensation.[667] In August of that year, an improved moisture analysis that included surface observations of precipitation was introduced into the model.[668]

The Alaskan Tsunami Warning System became operational on schedule in September 1967 with the dedication of the Palmer Seismological Observatory at Palmer, Alaska.[669]

The Office of Hydrology experimentally used NASA's ATS-1 satellite to collect river state and rainfall measurements from remote locations. Hydrologic stations at Benton, Arkansas, and at Salem, Oregon, began transmitting data to the satellite in August 1967. These stations automatically recorded the river level and the accumulated precipitation every 15 minutes.[670] Sacramento, California, was added in September, and a station at Bureau headquarters began receiving direct readout of the reports.[671] Later in the year, 23 gaging stations including seven microwave repeater stations were established north of San Francisco.[672]

In 1967, the Bureau formed the Tropical Analysis Center as part of the National Hurricane Center (NHC) in Miami. Dr. Robert Simpson, who was to become head of the center in January 1968, pointed out that weather prediction problems in the tropics involve different processes from those of the midlatitudes.[673]

A complete weather observing system small enough to fit into a suitcase was developed by the Bureau, called AMOS III-70. It was intended to replace the 10 times larger original AMOS III.[674]

On November 1, 1967, Boston became the 14th city to have a VHF weather radio transmission system.[675] The number increased to 21 with the addition of Weather Forecast Office Hartford, Connecticut.[676]

As indications of both the importance of statistics and the development of technology for long-distance learning, six Bureau employees at Kansas City remotely attended a graduate level statistics course being taught at the University of Missouri in 1967. The students in Kansas City could hear the instructor, see his notes and references being written and projected on a screen, and could ask questions.[677]

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[667] NWS Office of Meteorology, July 1967: Saturation criterion for precipitation forecasts in 6-layer (PE) numerical prediction model. *Tech. Proc. Bul. 3,* 2 pp.

[668] NWS Office of Meteorology, August 1967: Initial moisture analysis in the 6-layer (PE) numerical prediction model. *Tech. Proc. Bul. 5,*43 pp.

[669] *ESSA News*, **3**, August 11, 1967, p 1.

[670] *ESSA News*, **3**, September 1, 1967, p. 1.

[671] *ESSA News*, **3**, September 22, 1967, p. 2.

[672] *ESSA News*, **3**, November 17, 1967, p. 6.

[673] *ESSA World*, **2**, July 1967, p. 15.

[674] *ESSA News*, **3**, October 27, 1967, p. 1.

[675] *ESSA News*, **3**, October 27, 1967, p. 2.

[676] *ESSA News*, **5**, November 28, 1969, p. 1.

[677] *ESSA News*, **3**, November 17, 1967, p. 7.

On November 5, 1967, the Communications Branch of NMC composed of 51 positions was transferred to the Communications Division of the Office of Meteorological Operations.[678]

A large antenna was installed on the 15th floor penthouse roof in 1967 to provide several backup communication capabilities for the Bureau, including emergency communications between NMC and the central office and backup for the hurricane hot line. Similar antennae existed at military bases, but this was the first one installed in a downtown metropolitan area. It was large, occupying a space 70 by 80 ft., and with its extreme sensitively could pick up high frequency radio signals from virtually any part of the globe.[679]

By November 1967, NMC was transmitting maps of air pollution potential. These computer generated maps were not of actual pollution, but rather showed the areas where there was a potential problem.[680]

On the weekend of January 13, 1968, the Office of Hydrology moved from the MacArthur Blvd. location to the 4th and 5th floors of the Gramax Building. Eleven employees of NMC's Upper Air Branch had moved from the Gramax to Iverson Mall at 3737 Iverson St., Hillcrest Heights, Maryland. Also, three units of the National Environmental Satellite Center–the Meteorological Satellite Laboratory, the Environmental Sciences Group, and the Office of Operation's Documentation Section–involving 45 employees moved to the Iverson Mall address.[681]

On February 1, 1968, the Weather Bureau and the National Environmental Satellite Center (NESC) began operating a joint facsimile circuit with a principal objective to assess the effectiveness of a centralized APT network and to provide a scheduled outlet for NESC products. If successful, the Bureau would be responsible for the network operation.[682]

Eleven additional WSR-57radars were contracted for in early 1968. Installation during the next 18 months was to be a major step in the nationwide Natural Disaster Warning (NADWARN) System.[683]

On April 22, 1968, the Daily Weather Map began as a weekly publication by the Environmental Data Service replacing the Weather Bureau daily series ending on April 14. The eight-page publication, *Daily Weather Maps–Weekly Series*, consisted of four maps each day: General surface weather at 7:00 a.m. EST, winds and temperatures at about 18,000 feet, high and low temperatures for selected U.S. cities, and precipitation areas and amounts during the preceding 24 hours.[684] The

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[678] *ESSA News*, **3**, December 1, 1967, p. 2.

[679] *ESSA World*, **2**, July 1967, p. 36.

[680] Stackpole, J. D., 1967: The air pollution potential forecast program. *ESSA Tech. Memo.* **WBTM-NMC 43**, National Meteorological Center, ESSA, U.S. Department of Commerce, 8 pp.

[681] *ESSA News*, **4**, January 12, 1968, p. 1.

[682] *ESSA News*, **4**, February 2, 1968, p. 3.

[683] *ESSA News*, **4**, February 9, 1968, p. 3.

[684] *ESSA News*, **4**, April 12, 1968, p. 1.

Daily Weather Map started in 1871,[685,686] and some of the maps had information printed on the back. These "map-backs" were to encourage developments in applied meteorology and to help field offices in showing their local public how weather information may be of benefit.[687] This change ended the map-back program.

An automated system to forecast wind-wave height developed by the Techniques Development Laboratory (TDL) of the Office of Systems Development was implemented on the CDC-6600 at NMC. The guidance at projections of 12 to 36 hours was being evaluated by marine forecasters along the Atlantic and Gulf of Mexico coasts.[688]

Dr. Cressman announced in April 1968 a new, long-range forecast reorganization program. The essential feature of the new program consisted of a flow of forecast information directly from NMC, NHC, and NSSFC to newly designated Weather Forecast Offices (WFO) which would prepare and issue forecasts for public use. The changes were made possible by the advances in techniques and skills made at NMC in the past 10 to 15 years. During this time, the roles of NHC and NSSFC had also changed as a result of their successful forecast specialization. The goal was to establish 50 WFOs within 5 years. There were 24 Area Forecast Centers which could be considered WFOs under the reorganized structure; 26 new ones would be established. The functions of warning coordination, area-wide forecasts for aviation, and quality control would be done by Regional Weather Centers to be designated by the end of the 5-year period. The remainder of the existing Weather Bureau operating locations would be designated as Weather Service Offices (WSO), of which there would be about 200. The WSOs would disseminate the forecast products from the WFOs to the users, and would also take weather observations. They would have the responsibility for issuing warnings based on known weather hazards and for localizing the WFO zone forecasts. Some WSOs would retain key roles in special agricultural and fire weather programs. A number of meteorologists would be trained at selected WSOs to carry out special service programs. Many of the WSOs would be headed by Officials in Charge (OIC) selected from the meteorological technician series of Weather Bureau employees. This new organization should improve quality and timeliness of forecasts and warnings, and would provide round-the-clock meteorologist coverage at more than 50 locations as opposed to about 30 in the existing structure. Career opportunities for meteorologists would be improved by the increase in number of locations with a full staff of meteorologists. The meteorological technician career ladder would be expanded by opening the position of OIC to meteorological technicians at many WSOs.[689] As of August 23, 1970, the majority of meteorological technicians were in higher grade levels, with the approval of the Civil Service Commission of a GS-9/10/11 grade structure. This change recognized the technological changes in the past decade.[690]

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[685] Meyer, A. J., Annual Report of the Chief Signal Officer for 1871, p. 7.
[686] *Weather Bureau Topics*, May 1961, p. 77.
[687] *Weather Bureau Topics*, November 1951, p. 213.
[688] *ESSA News*, **4**, April 12, 1968, p. 3.
[689] *ESSA News*, **4**, April 19, 1968, pp. 1, 2.
[690] *ESSA News*, **6**, August 28, 1970, p. 4.

A method was developed at the Pittsburgh WSR-57 Radar Unit to derive by computer a radar climatology. This was tested successfully at the RFC at Cincinnati. In April 1968, it was being readied for use at other WSR-57 locations.[691]

In early 1968, fully automatic computer switching of weather data being relayed to or through the United States replaced manual methods on several Weather Bureau communication circuits. Data from all parts of the world were received at NMC and were switched to many other locations in the world.[692]

The Observations and Methods Branch of SDO's Test and Evaluation Laboratory ended a major phase of its program on June 28, 1968, when it moved from the National Aviation Facilities Experimental Center in Atlantic City, New Jersey, to the Sterling, Virginia, Research and Development Center. The Branch had cooperated in an applied research program with the Federal Aviation Administration for the past 9 years, and had been active in mesometeorology and specialized studies of aviation visibility.[693]

The Data Acquisition Division completed initial testing in June 1968 of a system in which radar facsimile pictures could be transmitted over regular, commercial telephone lines. Radar and Telephone Transmission Systems (RATTS) were already operational in several sections of the U.S., but specially conditioned leased lines were necessary. If proven feasible, the system would allow forecast facilities such as NSSFC to obtain valuable radar data from any radar having a RATTS transmitter.[694]

A new computer model named the Subsynoptic Advection Model (SAM) developed by TDL was made operational for testing at NMC over the eastern United States in September 1967. The model operated at one-fourth the gridlength of the PE model and was a combination of the "Reed"[695,696] and "SLYH"[697] models that had been used at NMC at lower resolution prior the implementation of the PE model. It also used the latest surface observations, analyzed them, and advected them with upper level winds from the PE model. The teletypewriter and facsimile forecasts were of only the basic variables of the model.[698] After a successful test, showing the forecasts were about 10 percent better than those produced by the PE model alone,[699] the model was made operational on June 10, 1968, for wind and categorical precipitation. In addition to the geostrophic

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[691] *ESSA News*, **4**, April 19, 1968, p. 3.

[692] *ESSA News*, **4**, June 21, 1968, p. 2.

[693] *ESSA News*, **4**, June 21, 1968, p. 2.

[694] *ESSA News*, **4**, June 21, 1968, p. 6.

[695] Reed, R. J., 1957: A graphical method for preparing 1000-millibar prognostic charts. *J. Meteor.*, **14**, 65-70.

[696] Reed, R. J., 1963: Experiments in 1000 mb prognosis. *NMC Tech. Memo.* **26**, 43 pp.

[697] Younkin, R. S., J. A. LaRue, and F. Sanders, 1965: The objective prediction of clouds and precipitation using vertically integrated moisture and vertical motions. *J. Appl. Meteor*, **4**, pp. 3-17

[698] NWS Office of Meteorology, August 1967: Implementation test of a numerical subsynoptic precipitation prediction model. *Tech. Proc. Bul.* ***6,*** 6 pp.

[699] *ESSA News*, **4**, June 21, 1968, p. 3.

wind, statistically derived surface winds were included[700,701] for about 100 cities over the eastern third of the U.S. This was the first instance of Model Output Statistics (MOS) in operational guidance distributed to forecast offices.

Later in the year, on October 1, charts of 3-hourly precipitation amounts from SAM were implemented on the WENEF facsimile circuit for the eastern U.S.[702] This same model drove forecasts for guidance winds for Lakes Erie and Ontario. These forecasts, along with forecasts of abnormal water levels in Lake Erie at Buffalo and Toledo based on sea-level pressure forecasts from NMC's PE model, were transmitted to the WBFO Cleveland on RAWARC. The operational forecasts were produced by methods developed by TDL in early January 1970.[703]

The SAM facsimile forecasts were expanded on February 12, 1969, to include probability of precipitation (PoP), sea level pressure, and 1000-500 mb thickness. The MOS PoP forecasts covered 6- and 12-hour periods and were the first computer produced forecasts of PoP and the first covering less than a 12-hour period produced by any method provided as guidance to field forecasters. In addition, the probability of precipitation type was provided.[704,705,706]

The first regular commercial air service between Moscow and New York began July 15, 1968. Route forecasts for the weekly westbound flights from New York to Moscow were provided by the Weather Bureau at Kennedy International Airport, requiring transmission of three additional forecast charts from NMC.[707]

Another new guidance product developed by TDL commenced on September 19, 1968. The twice-daily computer forecasts of maximum and minimum surface temperature for 131 cities were transmitted on an experimental basis from NMC on the Service C network.[708,709] The first such forecasts were based on NMC's "barotropic mesh" and the "Reed" models. They were about 1 to 3 degrees more accurate than the old system and were fully competitive with subjective

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[700] NWS Office of Meteorology, June 1968: Operational forecasts with the sub-synoptic advection model (SAM). *Tech. Proc. Bul.* ***14,*** Weather Bureau, ESSA, U.S. Department of Commerce, 19 pp.

[701] Glahn, H. R., and D. A. Lowry, 1967: Short range, subsynoptic surface wether prediction. *ESSA Tech Memo.* **WBTM TDL-11**, Techniques Development laboratory, U.S. Weather Bureau, ESSA, U.S. Department of Commerce, 10 pp.

[702] *ESSA News*, **4**, October 11, 1968, p. 2.

[703] *ESSA News*, **6**, January 16, 1970, p. 2.

[704] *ESSA News*, **5**, February 14, 1969, p. 3.

[705] NWS Office of Meteorology, February 1969: Operational forecasts with the sub-synoptic advection model (SAM)–No. 3. *Tech. Proc. Bul.* ***21,*** Weather Bureau, ESSA, U.S. Department of Commerce, 12 pp.

[706] NWS Office of Meteorology, April 1969: Operational forecasts with the sub-synoptic advection model (SAM)–No. 4. *Tech. Proc. Bul.* ***23,*** Weather Bureau, ESSA, U.S. Department of Commerce, 5 pp.

[707] *ESSA News*, **4**, July 19, 1968, p. 3.

[708] *ESSA News*, **4**, September 20, 1968, p. 2.

[709] NWS Office of Meteorology, September 1968: Experimental computer forecasts of maximum and minimum surface temperature. *Tech. Proc. Bul.* ***16,*** Weather Bureau, ESSA, U.S. Department of Commerce, 19 pp.

forecasts.[710,711,712] These guidance forecasts were produced by the "Perfect Prog" method. Because they had not been evaluated by field forecasters, they were called "experimental" and were the first transmitted for field use, although the method and similar forecasts had been used internally at NMC for several years.[713] An improved product for these cities giving forecasts 24 to 60 hours in advance based on the PE model commenced on teletypewriter on March 18, 1970, and were put on facsimile shortly thereafter. At this time, the computer-derived product replaced the subjectively-derived one previously transmitted.[714]

Another guidance product developed by TDL became operational on October 1, 1968. It consisted of facsimile charts produced at NMC of 24- and 48-hour forecasts of significant height of wind waves, swell, and combined wave height conditions. The driving winds were produced by NMC's PE model. This guidance was for use in high seas weather broadcasts and to alert coastal forecasters to the possibility of dangerous breakers and surf.[715,716,717]

That same year, 1965, the Bureau started using the terms "Watch" and "Warning" for winter weather hazards in much the same way they were used in tornado and hurricane forecasts. "Watch" alerts the public that a storm has formed and is approaching the area; "Warning" means that a storm is imminent and immediate action to protect life and property should begin.[718]

Another guidance product developed by TDL went into operation in December 1968 at NMC as a 4-panel facsimile chart on the Forecast Office Facsimile (FOFAX) Network. The 24-hour predictions were of temperature, relative humidity, and dew point at three levels, and net vertical displacement. These forecasts were driven from NMC's PE model, and by using trajectory methods were slightly more accurate forecasts than those that came directly from the PE model. The guidance was for use in predicting severe local storms, fog, cloudiness, and precipitation.[719,720,721] Net vertical

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[710] *ESSA News*, **6**, March 27, 1970, p. 1.

[711] NWS Office of Meteorology, March 1970: Use of P.E. input in objective temperature forecasts. *Tech. Proc. Bul.* ***42***, Weather Bureau, ESSA, U.S. Department of Commerce, 4 pp.

[712] Klein, W. H., F. Lewis, and G. P. Casely, 1969: Computer forecasts of maximum and minimum surface temperatures. *ESSA Tech. Memorandum* **WBTM TDL 26**, Weather Bureau, U.S. Department of Commerce, 119 pp.

[713] Klein, W. H., F. Lewis, and G. P. Casely, 1967: Automated nationwide forecasts of maximum and minimum temperature. *J. App. Meteor*, **6**, pp. 215-228.

[714] NWS Office of Meteorology, March 1970: Facsimile display of objective temperature forecasts. *Tech. Proc. Bul.* ***43***, Weather Bureau, ESSA, U.S. Department of Commerce, 19 pp.

[715] *ESSA News*, **4**, October 4, 1968, p. 2; November 8, 1968, p. 4.

[716] NWS Office of Meteorology, September 1968: Wind-wave, swell, and combined wave forecasts.. *Tech. Proc. Bul.* ***17***, Weather Bureau, ESSA, U.S. Department of Commerce, 11 pp.

[717] Pore, N. A., and W. S. Richardson, 1967: Interim report on sea and swell forecasting. *Tech. Memo.* **TDL-13**, Weather Bureau, ESSA, U.S. Department of Commerce, 21 pp.

[718] *ESSA News*, **4**, December 20, 1968, p. 2.

[719] *ESSA News*, **4**, December 27, 1968, p. 3.

[720] NWS Office of Meteorology, February 1969: Three-dimensional trajectory forecasts. *Tech. Proc. Bul.* ***20***, Weather Bureau, ESSA, U.S. Department of Commerce, 5 pp.

[721] Reap, R. M., 1968: Prediction of temperature and dew point by three-dimensional trajectories. ESSA Tech. Memo., ***WBTM TDL*** **15**, Techniques Development Laboratory, U.S. Weather Bureau, ESSA, U.S. Department of Commerce, 20 pp.

displacement is the vertical change of an air parcel originating at a particular level in the atmosphere, a variable that no other product had.

The Data Acquisition Division announced plans to initiate a 3-month test using time-shared computers for reduction of rawinsonde data to start in February 1969.[722] Evidently this was successful; the program was in effect at Midland, Texas, and Nashville, Tennessee, by January 16, 1970, and was planned for Albuquerque, New Mexico.[723]

In cooperation with the Office of Emergency Preparedness, the Office of Civil Defense, and the American Red Cross, the Weather Bureau launched an intensive campaign called SKYWARN to lower the death toll caused by tornadoes. SKYWARN was part of ESSA's nationwide National Disaster Warning System which provided warnings of impending environmental hazards, including hurricanes, floods, winter storms, and solar disturbances.[724]

At the request of the FAA, the Test and Evaluation Laboratory at the Sterling Research and Development Center in Virginia tested a novel transmissometer that used a simple gas laser. The purpose was to learn whether the instrument could be used to calibrate the standard transmissometer during low visibilities. It was thought the new instrument might also be useful for objective observations of meteorological visibility.[725]

The Center also built a room-sized test chamber that could simulate practically any climate in the world. It could produce temperatures ranging from -80 to +130 degrees F, humidity ranging from 10 to 90 percent, air flow up to 20 miles per hour, and rainfall up to 4 inches per hour. The chamber was used to test instruments in the conditions they would encounter when fielded.[726]

The Weather Bureau, in cooperation with the Department of Health, Education, and Welfare's Air Pollution Control Administration, opened a special station in each of five cities in support of air pollution control. One was opened at Washington National Airport on May 16, 1969; stations had been placed at Chicago and St. Louis in April, and two others would be placed at Philadelphia and New York. The stations would be supported by a camper-type vehicle that would serve as a mobile observatory.[727] Low level soundings were included in the program;[728] radiosondes would be flown to about 10,000 ft. and the results interpreted by specially trained air pollution meteorologists and transmitted to air pollution control agencies. The last of the five stations was put into place on August 18.[729] The first major episode occurred August 23 to September 1, and the new system was reported to work well.[730] The first mobile observatory was ready for operation in late October.[731]

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[722] *ESSA News*, **5**, January 10, 1969, p. 4.
[723] *ESSA News*, **6**, January 16, 1970, p. 3.
[724] *ESSA News*, **5**, February 14, 1969, p. 1.
[725] *ESSA News*, **5**, February 21, 1969, p. 1.
[726] *ESSA News*, **5**, February 28, 1969, p. 3.
[727] *ESSA News*, **5**, May 16, 1969, p. 1.
[728] *ESSA News*, **5**, June 27, 1969, p. 1.
[729] *ESSA News*, **5**, August 15, 1969, p. 1.
[730] *ESSA News*, **5**, September 12, 1969, p. 1.
[731] *ESSA News*, **5**, October 24, 1969, p. 2.

ESSA News reported that the working hours at the Gramax building would be 8:00 a.m. to 4:30 p.m. beginning September 2, 1969, except for the C&GS's Aeronautical Chart Division, whose hours would remain 8:15 a.m. to 4:25 p.m.[732] On January 4, 1970, all at the Gramax were put on the 8:00 to 4:30 schedule.[733]

The recorded forecast program continued to expand with five additional cities in 1970; about 14 of these WE6-1212 systems were already in operation.[734]

By mid 1969, automatic answering telephone equipment designed to disseminate abbreviated weather forecasts had been designed by the telephone industry and, sponsored by independent phone companies, installed at Winter Park, Orlando, and Fort Meyer, Florida; Galesburg, Illinois; and Gainesville, Georgia. Two more cities were scheduled to receive the service in the next few months. The new equipment disseminated weather information similar to the WE6-1212 system, but the Weather Bureau's input was radically different. The new system, called AUDICHRON, had a catalog of 1,000 prerecorded abbreviated forecasts and warnings. The Weather Bureau selected an appropriate message, and "programed" the telephone answering equipment by transmitting a coded message on ESSA Weather Wire Service.[735]

On August 19, 1969, NMC began transmitting a new stability index, the lifted index, to replace the Showalter Index previously transmitted.[736,737]

A new Marine Forecast center at WBFO Anchorage, Alaska, began operations on October 1, 1969. Twenty-four hour service was provided to all civil marine users in the coastal and offshore waters surrounding Alaska.[738]

The Weather Bureau began a new outlook program on February 9, 1970, to replace the 5-day forecasts. The new outlook was issued daily by forecast offices and included anticipated weather conditions for the ensuing third, fourth, and fifth days.[739]

By October 1969, NMC was preparing basic maps of Northern Hemisphere weather from temperature measurements obtained from experimental satellite soundings made by the Satellite Infrared Spectrometer–one of the instruments aboard NASA's Nimbus III. This provided unprecedented coverage of existing conditions over oceans and other areas where few upper-air measurements are made.[740]

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[732] *ESSA News*, **5**, August 29, 1969, p. 4.

[733] *ESSA News*, **5**, December 19, 1969, p. 4.

[734] *ESSA News*, **5**, September 12, 1969, p. 1.

[735] *ESSA News*, **5**, September 19, 1969, p. 2.

[736] NWS Office of Meteorology, July 1969: The Lifted Index computation. *Tech. Proc. Bul.* ***28,*** Weather Bureau, ESSA, U.S. Department of Commerce, 2 pp.

[737] Stackpole, J. D., 1967: Numerical analysis of atmospheric soundings. *J. Appl. Meteor.* **7**, 464-467.

[738] *ESSA News*, **5**, October 10, 1969, p. 3.

[739] *ESSA News*, **5**, October 24, 1969, p. 2; **6**, February 6, 1970. p. 2.

[740] *ESSA News*, **5**, October 31, 1969, p. 2.

The Weather Bureau Western Region, in cooperation with state and Federal forestry officials, inaugurated a forecasting service in support of slash burning operations in Washington and Oregon. Foresters were required to burn slash or residue from lumbering operations as a safety factor to guard against uncontrolled forest fires. The new service provided forecasts of wind, atmospheric stability, and temperature inversion height in the mountainous areas. The forecasts were prepared locally by the fire weather meteorologists at Olympia, Washington, and at Portland, Salem, and Medford, Oregon.[741]

A Federal Plan for Clear Air Turbulence (CAT) was announced the first week in January 1970. The plan included a provision that the Weather Bureau would establish a central CAT Forecasting facility with a 24-hour CATwatch for quick alert and revision of forecasts, and would distribute its products via facsimile every 6 hours. It would coordinate selection and engineering of systematic CAT forecast methods for computer operations and would test new concepts in forecasting.[742] This plan was in response to the Weather Bureau being given the responsibility for ESSA's part of the National Clear Air Turbulence Program in 1967.[743]

The Bureau formed a group of forecasters to advise on maters relating to career development and field operations. The first Line Forecasters Advisory Conference met during January 30-February 4, 1970.[744]

By April 1970, an input device had been developed for manual entry of observations into AMOS III-70. These observations would supplement the automated ones, and could consist of up to three cloud layers, visibility, weather, obstructions to visibility, and sea level pressure. The device could be remoted up to 2 miles from the AMOS III-70.[745]

In mid 1970, the ESSA Office of Public Information printed a pamphlet "Precipitation Probability Forecasts" that "explains how Weather Bureau meteorologists arrive at this helpful but poorly understood figure." It sold for 10 cents per copy. [746]

A new experimental heavy precipitation guidance facsimile product was started on May 15, 1970. These short-range forecasts, in both probabilistic and categorical form, were produced by NMC's Quantitative Forecast Branch. They were for two 12-h periods and were based on subjective assessment of model forecasts, climatology, and past verification statistics.[747]

On July 9, President Nixon forwarded to Congress Reorganization Plan Number 4 of 1970, combining ESSA and several other organizations with responsibilities in the marine environment

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[741] *ESSA News*, **5**, October 31, 1969, p. 3.
[742] *ESSA News*, **6**, January 2, 1970, p. 1.
[743] *ESSA News*, **3**, June 2, 1967, p. 2.
[744] *ESSA News*, **6**, February 13, 1970, p. 2.
[745] *ESSA News*, **6**, April 10, 1970, p. 2.
[746] *ESSA News*, **6**, July 10, 1970, p. 2.
[747] NWS Office of Meteorology, May 1970: Experimental heavy rainfall guidance. *Tech. Proc. Bul.* ***46,*** Weather Bureau, ESSA, U.S. Department of Commerce, 2 pp.

into a new Department of Commerce organization–the National Oceanic and Atmospheric Administration (NOAA). The new organization was to come into being in 60 days from this date.[748]

A new tri-agency Fire Weather Center was dedicated at Boise, Idaho, on July 25, 1970. This was a joint effort by the Weather Bureau, the Bureau of Land Management, and the U.S. Forest Service.[749]

The Bureau started issuing special forecasts to alert stockmen to dangerous combinations of heat and humidity that were potential killers of livestock. A 12-year study conducted by Livestock Conservation Inc. indicated that high temperature, in association with high relative humidity, resulted in an abnormally high death rate among animals being transferred to market. The study was primarily for hogs, but the relationship for cattle and other animals was found to be similar. A "Livestock Weather Safety Index" much like the "Temperature-Humidity Index" for humans was devised by the Bureau.[750]

A new air pollution potential guidance product prepared by NMC was distributed via facsimile starting September 9, 1970.[751,752]

A high-speed communications circuit was opened between Washington and Tokyo, in August 1970. As part of the system of global telecommunications for the World Weather Watch, it was expected soon to be in operation 24 hours per day. It carried information at the rate of 3,000 5-character words per minute, and replaced the 100-word per minute circuit put into operation in 1969. At that speed, it was almost three times as fast at the World Weather Watch circuit to Europe, operating at 1,050 words per minute; the Europe circuit was to be upgraded to 3,000 words per minute in December.[753]

In the fall of 1970, the Weather Bureau was equipping its nationwide network of VHF-FM weather radio stations with a device that alerted listeners to special warnings of hazardous weather. The device, called "tone-alert" transmitted a signal which automatically turned up the volume on special receivers within a 40- to 50-mile radius of the station. The tone alert assured positive notice of warnings of severe weather such as hurricanes, tornadoes, severe thunderstorms, winter storms, and high winds to schools, hospitals, civil disaster agencies, newspapers, radio and television stations, and individuals who had radio receivers with a "weather band" at 162, 550, or 163.275 megahertz.[754]

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[748] *ESSA News*, **6**, July 13, 1970, 8 pp.

[749] *ESSA News*, **6**, August 14, 1970, p. 3.

[750] *ESSA News*, **6**, August 21, 1970, p. 3.

[751] NWS Office of Meteorology, August 1970: Facsimile display of air pollution potential. *Tech. Proc. Bul.* ***52***, Weather Bureau, ESSA, U.S. Department of Commerce, 5 pp.

[752] Gross, E., 1970: The national air pollution potential forecast program. *ESSA Tech. Memo.* **WBTM NMC-47**, 28 pp.

[753] *ESSA News*, **6**, September 4, 1970, p. 1.

[754] *ESSA News*, **6**, September 11, 1970, p. 1.

ESSA News ended with a message from Dr. White about NOAA on October 2,1970.[755]

This ended just over 100 years of weather service to the nation that started in the Signal Service in 1870.

[755] *ESSA News*, **6**, October 2, 1970, p. 1.

Epilogue

President Richard Nixon's Reorganization Plan No. 4 of 1970 Effective October 3, 1970, created the National Oceanic and Atmospheric Administration. This was a consolidation in the Department of Commerce of ESSA and several other organizations in other Departments. At this time, the Weather Bureau's name was changed to the National Weather Service (NWS); Cressman remained as its Director.

Dr. Richard E. Hallgren served as NWS Director from 1979 through 1988, when Dr. Elbert W. Friday became Director. During the next few years, many scientific and technological advancements were made to improve forecasts and service to the Nation, including Doppler radar, high speed communication circuits, and ever more powerful computers for running improved Numerical Weather Prediction Models. In the mid-1980's, the NWS embarked upon an ambitious modernization and associated restructuring to take advantage of the technological advances possible both in National Centers and in Weather Forecast Offices.

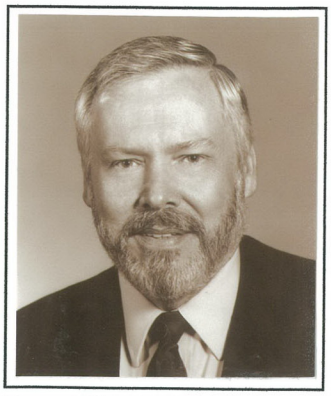
In 1990, the NWS Headquarters moved a few blocks to the Silver Spring Metro Center II at 1325 East West Highway, Silver Spring, Maryland. It was a new building, and was configured to NWS needs; the NWS remains there today and occupies most of the building.

Continuing the work of the last decade, the NWS achieved a remarkable modernization. A primary element was the network of WSR-88D Doppler radars for the detection and forecasting of severe local storms. The density and frequency of surface observations were increased by the Automated Surface Observing System (ASOS). The NWS has a two-tier forecast structure with the National Centers for Environmental Prediction (NCEP) furnishing guidance directly to the new Weather Forecast Offices (WFO) and River Forecast Centers (RFC). Relocations of offices brought many modern new facilities, and staffing emphasizes science. Improved numerical weather predication models were implemented at NCEP, and Model Output Statistics (MOS) provides interpretative guidance.

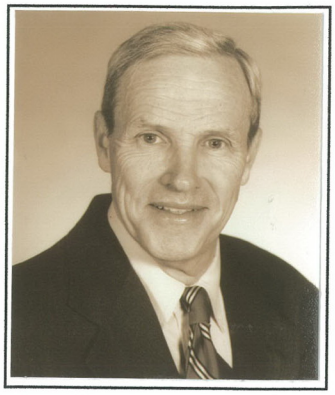
Data from satellites became more abundant and useful. The Advanced Weather Interactive Processing System (AWIPS) replaced the Automated Field Operations and Services (AFOS) system and furnished the display, communications, and interactive capabilities necessary to complete the modernization, and to improve weather warnings and forecasts. Methods of producing and communicating forecasts changed markedly with the introduction of the Interactive Forecast Preparation System (IFPS). Grids of forecasts with a resolution as fine as 2.5 km now cover the United States and reside in a National Digital Forecast Database (NDFD). From these grids, a detailed forecast can be produced automatically for any point, rather than for just a few points or zones or counties.

Gen. John J. Kelly, Jr. (Ret.) served as Director from 1997 until 2004; Gen. David L. Johnson (Ret.) became Director in 2004, and Dr. John L. Hayes in 2007.

Dr. Richard E. Hallgren, NWS Director 1979-1988.



Dr. Elbert W. Friday, NWS Director 1988-1997.



Gen. John J. Kelly (Ret), NWS Director 1997-2004.

Gen. David L. Johnson (Ret), NWS Director 2004-2007.

Dr. John L. Hayes, NWS Director 2007-present.

NWS Headquarters at Silver Spring Metro Center II, 1325 East West Highway, Silver Spring, Maryland, 1990-present. (Photo by Bob Glahn)

APPENDIX I
The First Name of the U.S. Weather Service

It has been stated in various recent documents that the Division of Telegrams and Reports for the Benefit of Commerce was the first name of the national weather service. General Meyer did create that division to deal with the new weather work, but there is no indication that he expected all weather service work to be housed there, and it certainly wasn't. So it is problematic that the "weather service" was ever formally named the "Division of Telegrams and Reports for the Benefit of Commerce."

In any case, it is a mistake to imply that that name persisted from the inception of the new service until its transfer to the Department of Agriculture and by law acquired the name "Weather Bureau." One recent document goes so far as to say,

> "So on July 1, 1891, the weather stations, telegraph lines, apparatus, and personnel ... were transferred from the Signal Corps' Division of Telegrams and Reports for the Benefit of Commerce to the Department of Agriculture's new civilian Weather Bureau."

However, when that transfer was made, there was no reference in the official transfer documents to this division name, but reference was rather just to the Signal Corps. In fact, from the annual reports of the Chief Signal Officer, it can be noted that the weather duties permeated much of the Signal Service, and was explicitly so stated by General Meyer. It is doubtful this particular division still existed upon transfer to the Department of Agriculture; if it did, it had lost its significance, although there is still mention of it in Gen. Hazen's Annual Report in 1883.

The Weather Bureau was directly under the Department of Agriculture, and the Signal Service was directly under the Department of War, so a better interpretation might be that the weather service under the Department of War never had a specific name, but was an important part of the duties of the Signal Corps.

APPENDIX II
The 2400 M Street Compound

This appendix shows the layout of the 2400 M Street compound as it existed when the new building had been completed in 1941. Figure 1 shows the Ferguson Building, called "Old Main,"[756] with the construction of the new building in front just starting. To the left is the "Old Annex" where the author worked from 1958 until the Weather Bureau moved to Silver Spring in 1966. Note that the part of the Old Annex closer to M Street, to the north in the foreground, also extends farther to the west, to the right in the picture, than the portion of the Old Annex in the background.

Figure 1. The Ferguson Building with the tower for measuring wind and the Old Annex to the left. The new building construction is in the foreground. Picture taken facing south-southeast.

According to personal views of John P. Finley, who inspected the Ferguson Building with General Hazen on several occasions, the last being in December 1886,

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[756] *Weather Bureau Topics and Personnel*, April 1947, p. 118.

"This property was improved as one of the 'show places' of the Capital City, by the erection of a singular appearing residence, that with its surrounding grounds, occupied a large portion of the square on which it was located. It was built after the Spanish-American or Mexican style of architecture, with a patio, or open inner court, around which the many rooms were built, each opening upon the court on the first story, and upon a balcony overlooking the court on the second story." [757]

Figure 2 is that of the new building. Note the connection between it on the left and the Old Annex at the level of the 2nd floor. This was the only enclosed walkway to any of the other buildings in the compound. However, one could walk the entire extent of the Old Annex at the 2nd floor level, but it did not connect to the Ferguson Building. The tower for wind measurements is also visible.

Figure 2. The new 2400 M Street Building.

[757] Grice, G. K. ed., circa 1985: The beginning of the National Weather Service: The Signal Service Years (1870-1891) as viewed by early weather pioneers. National Weather Service, NOAA, U.S. Department of Commerce, 52 pp.

Below is the rear of the new building. The stairs to Old Main are to the left. To the right is the portion of the Old Annex that connected to the new building.

Figure 3. The rear of the new building. Picture taken from the small parking lot to the east of the Ferguson Building. Note the construction of the end of the Old Annex matches that in other pictures. The east end of the new building is not bricked in the same way as the rest of the building, indicating that it was expected to build on to that end (see main text and photo). The five stories are shown, the parking lot being a bit higher than M Street in front, so the rear windows are partially below ground level. A partial 6th floor also existed (also see Fig. 1).

The four pictures below were all taken by the author in late 1965.

Figure 4. The entrance to the parking lot through the Old Annex from 24th Street NW. Note the sign "US DEPARTMENT OF COMMERCE WEATHER BUREAU." The taller building in the background is the new building.

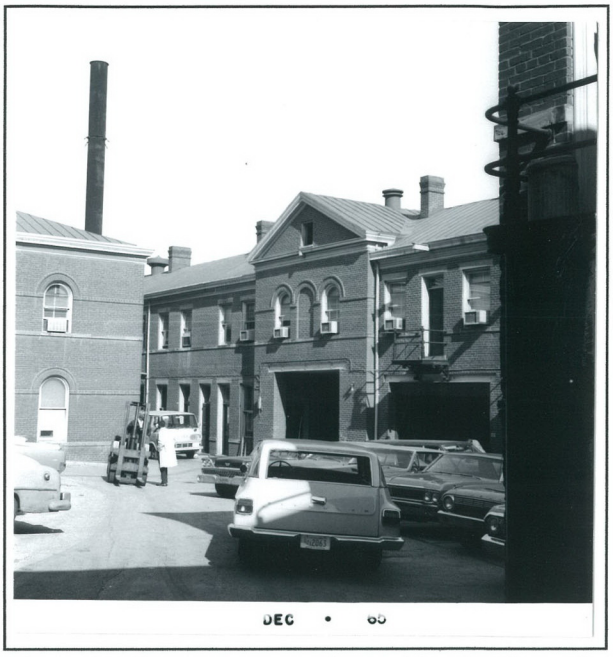

Figure 5. The entrance to the parking lot from the parking lot side. The building to the left is the same one shown in Fig. 3 on the right.

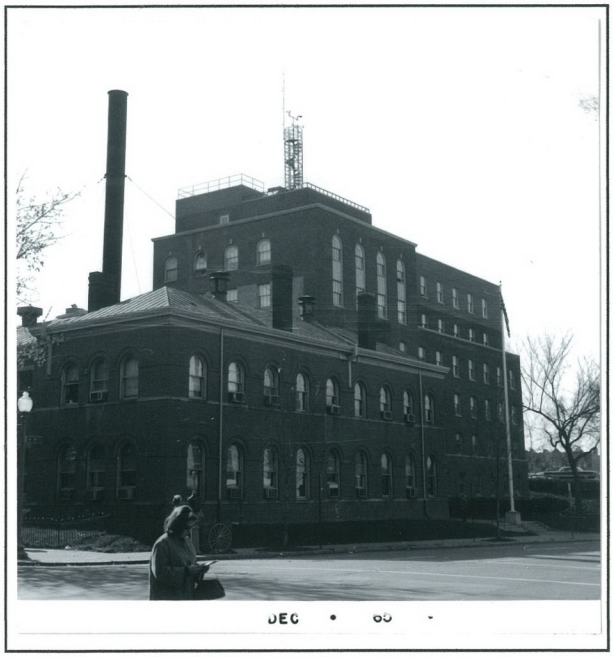

Figure 6. Northeast corner of the Old Annex . It is closer to M Street, to the right, than the taller new building in the background.

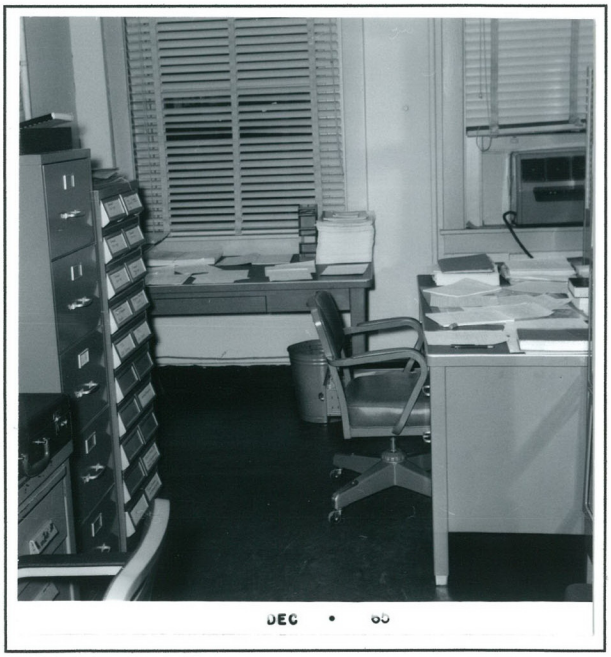

Figure 7. The author's office in the Old Annex, along 24th Street. Grey metal furniture. Punched card cabinet on the left. Window air conditioner.

The picture to the right of the new building appeared in the July 1941 issue of *Topics and Personnel*. The accompanying article indicates the Weather Bureau was just in the process of moving in. Note the Old Annex to the left extending nearer to M Street than the new building

Figure 8. The new building nearing construction with the Old Annex to the left. (Picture taken from July 1941 *Weather Bureau Topics and Personnel.*)

Figure 9 shows an excerpt from the 1889 Report of the supervising Architect regarding the purchase of the Ferugson building and the erection of additional buildings.

STATEMENT OF APPROPRIATIONS.

Act of March 5, 1888, authorizes purchase of grounds and building, corner of Twenty-fourth and M streets northwest, of David Fergusson, at a cost not to exceed $112,000, and the erection of store-houses, with fireproof vaults, limiting cost to $150,000.		
Act of April 24, 1888, appropriates to carry out provisions of act approved March 5, 1888	$150,000.00	
Total amount appropriated		$150,000.00
Amount expended for site and building	112,000.00	
Amount expended for repairs to building prior to September 30, 1888	831.50	
Amount expended for repairs to building during the year ending September 30, 1889	33,175.52	
Total expenditure		146,007.02
Balance in Treasury September 30, 1889		3,992.98
Amount of contract liabilities		3,646.69
Amount actually available September 30, 1889		346.29

Figure 9. Abstracted from the 1889 Report of the Supervising Architect (National Archives).

The diagram below shows the layout of the 24th and M Streets Weather Bureau complex as it existed between 1941 when the new building was built and 1966 when the Bureau moved to Silver Spring. The diagram, not to scale but reasonably accurate, was pieced together from the pictures in this appendix and the author's memory. At one time, there was a building to the west of Old Main (right in the picture), possibly as an extension of the Annex, as can be seen in a picture in the main text.

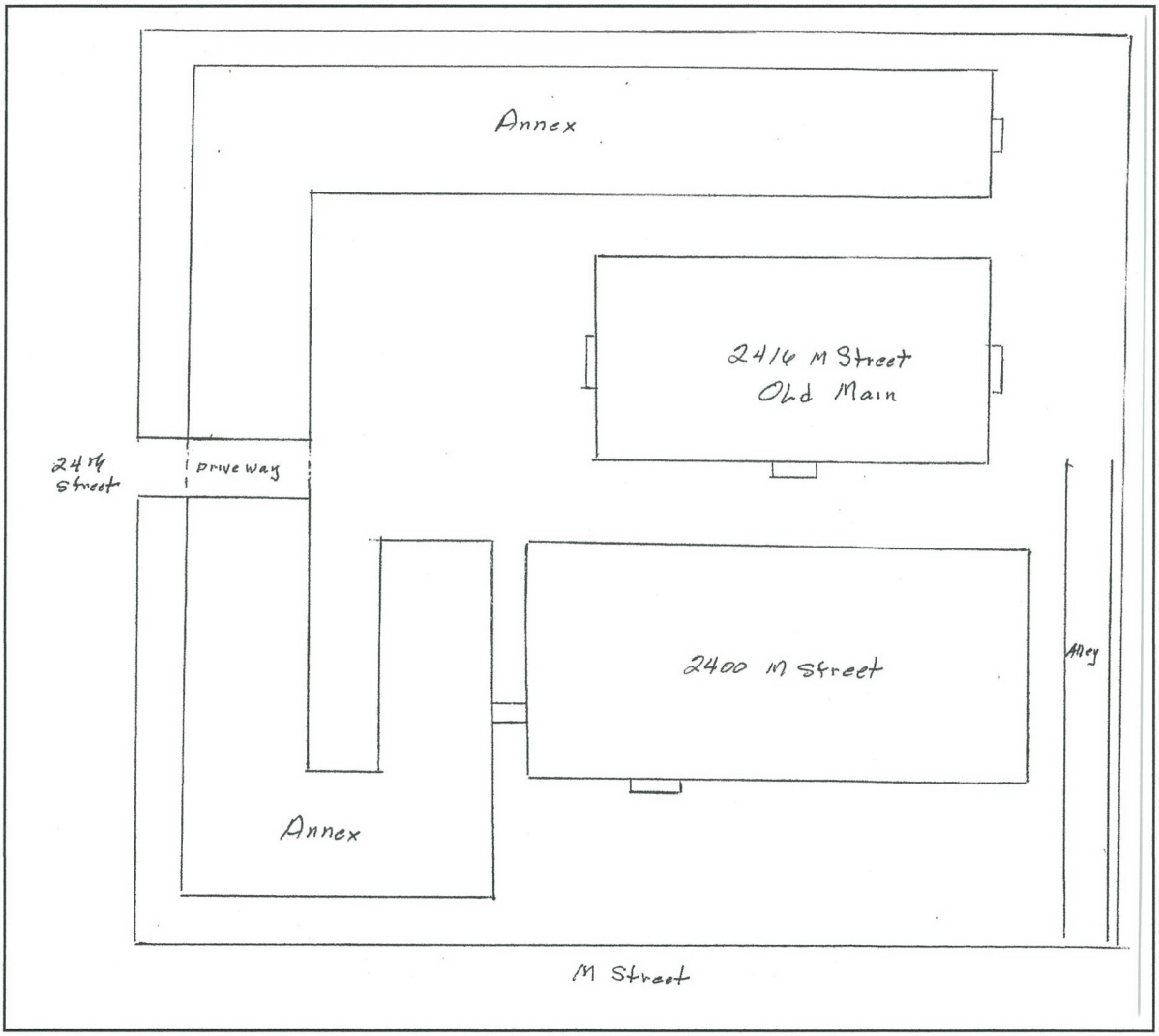

Figure 10. The 24th and M Streets Weather Bureau facilities were essentially unchanged between 1941 and 1966.

The driveway from 24th Street led to a small parking lot. The parking spaces were assigned according to position in the Bureau. The Annex was wide enough for desks on each side near the windows and a walkway between. One could thread his way through the extent of the Annex on the 2nd level (note the walkway between the buildings, see Fig. 2), essentially by walking through employees' working areas–there were no partitions to isolate the walkway. Some movable partitions separated workers spaces, and there were permanent walls separating the Annex into rooms.

APPENDIX III
Other Weather Bureau Headquarters Locations

A number of other buildings were also used while the Bureau was at 24th and M Streets. The Longfellow Building, shown in Fig. 11, a few blocks to the east housed the Administrative offices for a time.

Federal Building No. 4 (FOB4) housed the National Meteorological Center and the satellite operations. The organizations there were counted as "field" or "headquarters," depending on the purpose of the count. In any case, the organizations there were a critical part of the Bureau infrastructure. FOB4 is shown below in Fig. 12.

Figure 11. The Longfellow Building on M Street east of 24th and M Streets. Picture taken facing south.

Figure 12. Federal Office Building No. 4 in Suitland, Maryland. Picture taken facing east.

Always short of space, the Bureau secured space for the Hydrologic Services Division, the Training Section, and the Office of Forecast Development at 4880 MacArthur Boulevard, Washington, D.C. The move was in February 1962.[758] Training personnel moved to Rockville, Maryland, in August 1965 with the formation of ESSA. The Hydrologic Services Division moved to the Gramax Building in January 1968. The building is pictured to the right.

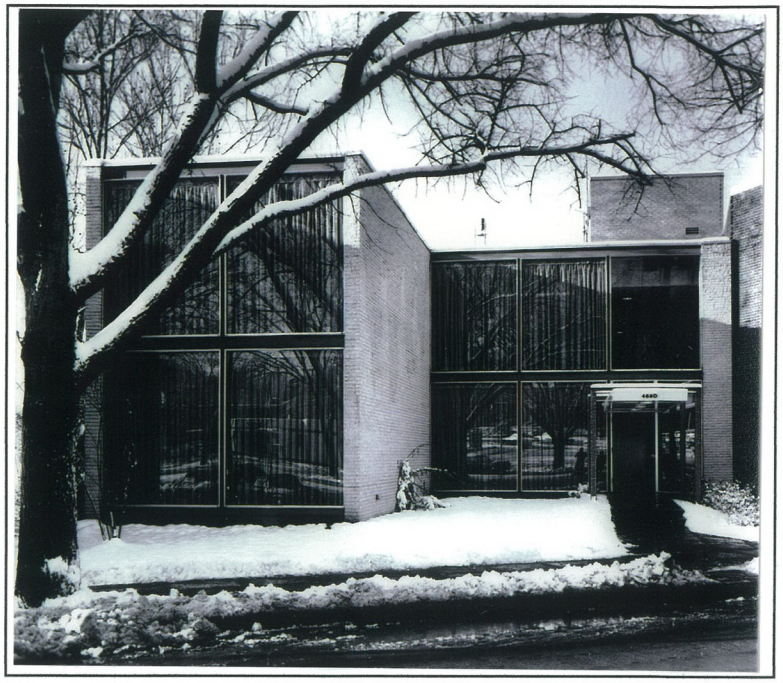

Figure 13. The building at 4880 MacArthur Boulevard where the Hydrologic services Division, the Training Section, and the Office of Forecast Development were located for some years. (Picture from the National Archives.)

[758] *Weather Bureau Topics*, January 1962, Topigrams.

APPENDIX IV
Other Views of the Gramax Building

Figure 14. The Kennett Street side (right side of picture) and back of the Gramax Building. Taken from the top of the Montgomery County parking garage, looking southeast. (Photo by Bob Glahn, 1989)

Figure 15. The front and south sides of the Gramax Building. (Picture from the NOAA Library.)

APPENDIX V
Primary Information Sources

1870-1891 Report of the Chief Signal Officer–Voluminous annual reports written to the Secretary of War.
(http://docs.lib.noaa.gov/rescue/cso/data_rescue_signal_corps_annual_reports.html/)

1891-1953 Report of the Chief of the Weather Bureau Officer–Voluminous annual reports written to the Secretary of Agriculture and Commerce.
(http://docs.lib.noaa.gov/rescue/journals/reportofthechief/reportofthechief.html/)

1915-1947 Weather Bureau Topics and Personnel–Monthly house organ written for employees.
(http://docs.lib.noaa.gov/rescue/journals/topicsandpersonnel/topicsand personnel.html/)

1948-1965 Weather Bureau Topics–Same as above with name shortened; all one series.
(http://docs.lib.noaa.gov/rescue/journals/topicsandpersonnel/topicsand personnel.html/)

1940-1966 Weather Bureau Circular Letters–Unscheduled announcements of events, procedures, or items of interest; written for employees whenever needed; signed by the Chief of the Bureau or designee.
(http://docs.lib.noaa.gov/rescue/wb_circular_ltrs/circularletters.html/)

1965-1970 ESSA News–Weekly, written for employees by ESSA Public Affairs.
(http://docs.lib.noaa.gov/rescue/journals/essa_news/)

1966-1969 ESSA World–Primarily feature stories for employee or public consumption.
(http://docs.lib.noaa.gov/rescue/journals/essa_world/)

1970 ESSA–Evidently a name change from ESSA World
(http://docs.lib.noaa.gov/rescue/journals/essa/)

1967-1970 Technical Procedures Bulletins (TPB)–Documentation of data and products that were centrally implemented by the Weather Bureau. Hard copies exist in the Meteorological Development Laboratory library.

APPENDIX VI
Acronyms

ACWS - Advisory Committee on Weather Services
AEC - Atomic Energy Commission
AFB - Air Force Base
AMOS - Automatic Meteorological Observing Station
AMS - American Meteorological Society
AN/AMT-8 - A type of radiosonde
ARTC - Air Route Traffic Control
ASOS - Automated Surface Observing System
AW - winds aloft forecast
AWIPS - Advanced Weather Interactive Processing System
C&GS - Coast and Geodetic Survey
CAA - Civil Aeronautics Administration
CAFTI - Committee on Analysis and Forecast Technique Implementation
CAT - Clear Air Turbulence
CDC - Control Data Corporation
DoC - Department of Commerce
CONUS - continental U.S.
CONELRAD - CONtrol of ELectromagnetic RADiation
ESSA - Environmental Science Services Administration
F - Fahrenheit
FAWS - Flight Advisory Weather Service
FIARBC - Federal Inter-Agency River Basin Committee
FM - State Defense Network
GCRL - General Circulation Research Laboratory
GFDL - Geophysical Fluid Dynamics Laboratory
FOB4 - Federal Office Building No. 4
FOFAX - Forecast Office Facsimile
FOSDIC - Film Optical Sensing Device for Input to Computers
FP - State Forecast
IBM - International Business Machine
ICAO - International Civil Aviation Organization
IFPS - Interactive Forecast Preparation System
JNWPU - Joint Numerical Weather Prediction Unit
LAWRS - Limited Airport Weather Reporting Stations.
MAMOS - Marine Automatic Meteorological Observing Station
MIC - Meteorologist in Charge
MIT - Massachusetts Institute of Technology
NOAA - National Oceanic and Atmospheric Administration
MOBEU - Mobile Emergency Unit
MOS - Model Output Statistics
MWR - Monthly Weather Review
NACA - National Advisory Committee for Aeronautics
NADWARN - Natural Disaster Warning

NASA - National Aeronautics and Space Administration
NCEP - National Centers for Environmental Prediction
NESC - National Environmental Satellite Center
NDFD - National Digital Forecast Database
NHC - National Hurricane Center
NHRL - National Hurricane Research Laboratory
NHRP - National Hurricane Research Project
NMC - National Meteorological Center
NSSFC - National Severe Storms Forecast Center
NSSL - National Severe Storms Laboratory
NWAC - National Weather Analysis Center
NWP - Numerical Weather Prediction
NWRC - National Weather Records Center
NWS - National Weather Service
OEP - Office of Emergency Planning
OIC - Official in Charge
OMO - Office of Meteorological Operations
OMR - Office of Meteorological Research
OM&O - Office of Meteorology and Oceanography
SDO - Systems Development Office
PE - primitive equations
PoP - probability of precipitation
PPI - Plan Position Integrator
QPF - Quantitative Precipitation Forecast
RADU - Radar Analysis and Development Unit
raob - radiosonde observation
RATTS - Radar and Telephone Transmission System
RAVU - Radiosonde Verification Unit
RAWARC - RAREP and warning coordination teletypewriter circuit
RD - Regional Director
REGUS REP - Regional User Service Representative
RFC - River Forecast Center
RVR - Runway Visual Range
SAM - Subsynoptic Advection Model
SELS - Severe Local Storms Warning Service
STATUS REP - State User Service Representative
SWU - Severe Weather Unit
SWWC - Severe Weather Warning Center
TDL - Techniques Development Laboratory
TPB - Technical Procedures Bulletin
VFR - Visual Flight Rules
VIDMET - Video-Meteorology
WB - Weather Bureau
WBAN - Weather Bureau, Army, Navy
WBAS - Weather Bureau Airport Station
WBASO - Weather Bureau Agricultural Service Office

WBO - Weather Bureau Office
WFO - Weather Forecast Offices
WMO - World Meteorological Organization
WPA - Works Progress Administration
WSO - Weather Service Office