THE UNITED STATES WEATHER SERVICE:
THE FIRST 100 YEARS

by

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Preface

This is a book of facts. It was written to get some of the history of the Weather Bureau in one place, and in such a form that all information could be checked with references, as much as possible with original references. The U.S. weather service started with the Signal Service in 1870, was given the name Weather Bureau in 1891, and the name National Weather Service in 1970 with the formation of the National Oceanic and Atmospheric Administration. Therefore, this early history of the Weather Bureau spans 100 years.

The Chief Signal Officer of the War Department and then the Chief of the Weather Bureau under the Department of Agriculture and later under the Department of Commerce, wrote voluminous annual reports. For later years, there are *Weather Bureau Topics*, *ESSA News*, and *ESSA World*. These documents are all on line, have been read, and what seemed to the author to be important events have been abstracted here. An important source for centrally provided products are the *Technical Procedures Bulletins* that started in 1967.

The weather service has been under three Departments of the U.S. Government. This document contains pictures of all 10 heads of the service since its beginning in 1870 to 1970. It also contains pictures of the four buildings used as headquarters during that time. Since 1970, there have been five more directors of the National Weather service, and there has been one more move to another location; pictures of these directors and the currently occupied building are shown in the Epilogue.

Being essentially a compilation of facts with little or no interpretation, this document may be dry reading, but it is hoped it will be a useful reference. Access should be easier than the thousands of pages of reference material. Of course, the inclusion of facts is necessarily selective, and whole books could be written about only a few of those included and others not included. But these facts show the evolution of the technology and the service provided to the citizens of the United States by the Weather Bureau.

The picture on the cover is of the Ferguson Building, the headquarters of the weather service for 53 of its first 100 years.

Bob Glahn

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June 2012

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Establishment of a Weather Service

President Ulysses S. Grant approved a joint resolution of Congress passed without dissent on February 9, 1870, as follows:

> "Be it resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of War be, and he hereby is, authorized and required to provide for taking meteorological observations at the military stations in the interior of the continent, and at other points in the States and Territories of the United States, and for giving notice on the northern lakes and on the seacoast, by magnetic telegraph and marine signals, of the approach and force of storms… ."

The Chief Signal Officer of the Army was charged, by letter of the Secretary of War, William B. Belknap, dated February 28, 1870, and in General Orders No. 29, March 15, 1870, with the immediate supervision of the service. General Albert J. Meyer, Chief Signal Officer and head of the Signal Service, put the new responsibilities under a new division, the "Division of Telegrams and Reports for the Benefit of Commerce,"[1] but the work quickly expanded and consumed much of the time and resources of other elements of the Signal Service (see Appendix I).

General Albert J. Meyer, Chief Signal Officer, head of the weather service 1870-1880.

A number of persons and organizations had taken or collected meteorological observations for many years, including the Smithsonian Institution. Professor A. Joseph Henry, secretary of the Smithsonian, was an early experimenter with telegraphy, a technology that was to play a critical role in the collection of weather data.[2] By 1849, Henry had persuaded telegraph companies to transmit for free local weather data to the Smithsonian. He also supplied barometers and thermometers to some observers. By 1857, telegraph stations from New York to New Orleans were

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[1] Meyer, A. J., *Annual Report of the Chief Signal Officer* for 1870, p. 6.

[2] According to A. J. Henry, 1895, "Early Individual Observers in the United States," in Report of the International Congress , Chicago, 1893, Part 2, Bulletin 11, pp. 292, 293, (available at the National Agricultural Library, Beltsville Maryland, 1W37B), the earliest documented observer on the western continent was Rev. Jno. Campanius, a member of a Swedish Colony near the present city of Wilmington, Delaware, who took observations during 1644-1645.

cooperating. Henry devised a large daily weather map, which he mounted in 1856 in the Smithsonian "Castle." The map became popular, and the *Washington Evening Star* began publishing daily weather conditions at nearly 20 different cities. The Civil War disrupted the work; after the war in his annual report for 1865, Henry called for the federal government to establish a national weather service capable of issuing storm warnings and other weather predictions.[3,4,5]

Considerable discussion about the topic of a weather service had preceded the act of Congress, and in the 1860's several organizations, in addition to Henry of the Smithsonian, proposed elements of a weather service, not necessarily a national one. Increase Allen Lapham had kept observations since 1822 and had attempted for years to build up a service in Wisconsin; he was instrumental in the Wisconsin Legislature considering a bill in 1850 to establish a state weather service, but the bill failed to pass.[6] Cleveland Abbe, head of the Cincinnati Observatory, a relative newcomer to meteorology,[7] had secured the support of the Cincinnati Chamber of Commerce and had for a 3-month period in late 1869 collected daily telegraphic observations and made forecasts published in the *Cincinnati Weather Bulletin* which he called "probabilities."[8] Lapham supported Abbe's work, as he had Joseph's work, and in November 1869 arranged for the submission of a resolution regarding the need for a weather service to the National Board of Trade to protect shipping on the Great Lakes; after considerable modification, it was forwarded to Congressman Halbert E. Paine of Milwaukee. Paine, who was graduated at age 19 as head of his class in 1845[9] had actually studied under Elias Loomis[10] at the Western Reserve College in Ohio when Loomis was studying the structure of severe storms and their movement, and therefore was familiar with the state of meteorology at that time. Paine was receptive; he broadened the concept from regional to national and drafted the bill that was introduced into Congress on December 16, 1869.[11]

While the bill proposed the assignment of the responsibility for the service to the Secretary of War, there is considerable documentation that indicates the War Department was not included in the

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[3] Weightman, R. H., 1952: Establishment of a National Weather Service–Who was responsible for it. U.S. Weather Bureau unpublished manuscript, U.S. Department of Commerce (available from the NOAA Library), p. 4, references J. Henry, *Annual Report of Smithsonian*, 1865, pp. 57-59.

[4] Millikan, F. R., undated manuscript. The Joseph Henry Papers Project, 3 pp.

[5] _____, 1997, Joseph Henry's grand meteorological crusade. *Weatherwise*, **50**, pp. 14-17.

[6] Miller, E. R, 1931: New light on the beginnings of the Weather Bureau from the papers of Increase A. Lapham. *Mon. Wea. Rev.*, p. 66.

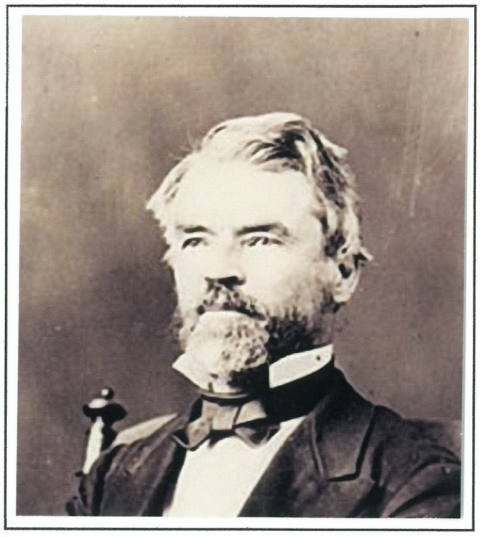
[7] Whitnah, D. R., 1961: *A History of the United States Weather Bureau*. University of Illinois Press, Urbana, 267 pp. Page 15, references William J. Humphreys, "Cleveland Abbe," Dictionary of American Biography (New York, 1928), **1**, p. 1-2, and states: "Abbe attended the New York Free Academy, now City college of New York. During 1861-64 he helped Dr. B. A. Gould at Harvard with the determination of longitude for the United States Coast Survey. For the next two years Abbe studied at Pulkova Observatory in Russia. He returned to the United States in 1867 to become aide to the United States Naval Observatory at Washington, D.C., but within a year left this position to become director of the Cincinnati Observatory."

[8] Abbe, C., 1916: A short account of the circumstances attending the inception of weather forecast work by the United States. *Mon. Wea. Rev.*, **44**, 206, 207.

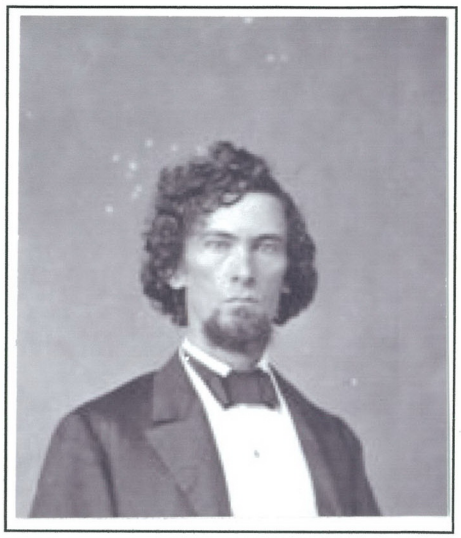
[9] History of the United States Patent Office, Chapter 31, p. 193.

[10] Miller, 1931, ibid. p. 68.

[11] Whitnah, ibid., pp. 16-20.



Increase A. Lapham who influenced Congressman Paine to Introduce the bill establishing a national weather service.



Halbert Paine, Congressman from Wisconsin, who introduced the bill into Congress.

first draft. It is believed that it was only after a campaign by General Meyer, Chief Signal Officer, that the War Department was included in the bill.[12] For instance, Paine writes as follows:

> "Immediately after the introduction of the measure, a gentleman called on me and introduced himself as Colonel Albert Meyer, Chief Signal Officer. He was greatly excited and expressed a most intense desire that the execution of the law be entrusted to him."[13]

However, it may not have taken much encouragement for assigning it to a military organization instead of, say, the Smithsonian Institution that had a long history taking observations. Paine had been a major general in the Union Army,[14] and may have had leanings toward the Army. He later wrote:

> "It seemed to me at the outset, military discipline would probably secure the greatest promptness, regularity, and accuracy in the required observations." [15]

While the Signal Service had a prime asset for collecting weather observations–telegraphic facilities[16]–it was a small and young organization, having been organized only 10 years earlier by Assistant Surgeon General Albert Meyer, a major at the time. A bill of 1866 allowed one chief, six

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[12] Miller, 1931, ibid., p. 68.
[13] Weightman, 1952, ibid., p. 31, provides several references.
[14] History of the United States Patent Office, Chapter 31, p. 193.
[15] Miller, 1931, ibid., p. 68.
[16] Whitnah, ibid., p. 22.

officers, and 100 non-commissioned officers.[17] By 1871, the number of full time personnel of the weather service was still only 233.[18] As indicated above, Lapham and Paine were the prime movers in establishing the meteorological enterprise, and Meyer is generally credited as being influential for the assignment of the meteorological responsibilities to the Signal Service.[19] It is unclear that Abbe had any overt influence on this activity,[20],[21] but his work served as an example, as had Henry's, that observations could be taken, transmitted, and forecasts made.

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[17] Whitnah, ibid., p. 20.

[18] Whitnah, ibid., p. 21.

[19] Kvam, E. L., 1960, pp. 12, 13. The Evolution of the U.S. Weather Bureau in Meeting the Needs of Radically Changing Times. MA in Public Administration Thesis, George Washington University, 128 pp.

[20] Miller, 1931, ibid., p. 68. In fact, Abbe wrote to Lapham on January 7, 1870, suggesting that the best decision had not been made in assigning the responsibility to the War Department, and instead suggested "intelligent telegraph operators or managers of offices or other employees" might be a better choice for the taking of observations, as "the meteorological observations of the Army have generally proved themselves very unreliable and are certainly no better than the telegraph operators could easily make." The quote is taken from papers in the collections of the Wisconsin Historical Society.

[21] *Weather Bureau Topics*, July 1952, p. 110.

The Signal Service Years

The Signal Service lost little time in organizing the endeavor and established meteorological training classes at Fort Whipple, Virginia (which later became Fort Meyer), as early as that summer.[22] For a small organization that had not been previously charged with meteorological duties, it seems quite an achievement that Meyer was able to write that same year:

> "On November 1, 1870, at 7:35 a.m., the first systematized synchronous meteoric reports ever taken in the United States were read from the instruments by the observer-sergeants of the Signal Service at twenty-four stations, and placed upon the telegraphic wires for transmission."[23]

This claim to "being the first" may have not been completely accurate, considering Henry's and Abbe's work, but an achievement nonetheless. But, perhaps Henry's and Abbe's were not synchronous.

In that same month, Lapham was employed as assistant to the Chief Signal Officer and stationed at Chicago. On November 8, Meyer requested Lapham to assume responsibility for the Great Lakes region, and on that same day, Lapham issued the first storm warning:[24]

> "High wind all day yesterday at Cheyenne and Omaha; a very high wind this morning at Omaha; barometer falling, with high winds at Chicago and Milwaukee today; barometer falling and thermometer rising at Chicago, Detroit, Toledo, Cleveland, Buffalo, and Rochester; high winds probable along the Lakes."

However, Lapham had many interests, and personal business caused him to return to his home town Milwaukee, an arrangement that could not have been satisfactory for Meyer.[25, 26] Lapham was released from the service May 31, 1872.[27]

Meyer asked Abbe to become special assistant to the Chief Signal Officer, and the appointment became effective January 3, 1871. Abbe started issuing regular forecasts, styled "Weather Synopses and Probabilities," thrice daily starting February 19, 1871.[28] Abbe's work at the Cincinnati Observatory influenced the style of these first forecasts; they were called "probabilities" until the

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[22] Meyer, A. J., Annual Report of the Chief Signal Officer for 1870, p. 5, states, " ...forty-one (41) observer sergeants, intended for assignment in the division of telegrams and reports for the benefit of commerce, have received the ... instruction necessary ... for their duties." Table 10, p. IV, lists instruction dates in August and September.

[23] Meyer, A. J., Annual Report of the Chief Signal Officer for 1871, p. 6.

[24] Whitnah, ibid., p. 22.

[25] Whitnah, ibid., p. 22.

[26] Miller, 1931, ibid., p. 69.

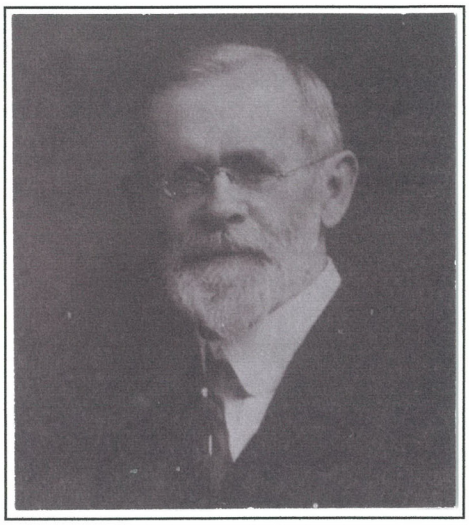
[27] Miller, 1931 ibid., p. 70.

[28] Meyer, A. J., Annual Report of the Chief Signal Officer for 1871, p. 8.

name was changed to "indications" December 1, 1876,[29] and finally on June 1, 1889, the name was officially changed to "forecasts."[30] A typical forecast was:

> "Probabilities: It is probable that the low pressure in Missouri will make itself felt decidedly tomorrow with northerly winds and clouds on the lakes, and brisk southerly winds on the gulf."[31]

While Abbe's role in actually establishing a national weather service seems to have been minor at best, he was a scientist, in distinction to the generals who headed the Signal Service, and undoubtedly did more to establish and guarantee the new service as a scientific organization than any other person.



Cleveland Abbe served as Special Assistant to the Chief Signal Officer starting in 1871, and was on Weather Bureau staff until near his death in 1916.

The Signal Service headquarters was located at 1719 G Street, Washington, D.C. However the building was too small, and the adjoining building at 1721 G Street was rented in November 1871. An additional floor was added to both buildings. Meteorological observations were taken on the roof of the original building, but with the addition of the floor, the roof could not support the equipment, so a shelter was built projecting from a window on the northern side of the building.[32] This was the location where the official observations for Washington D.C. were taken from November 1, 1870, when the station was established until August 15, 1888. The Signal Service occupied several buildings in the coming years,[33] and from August 15, 1888, until March 22, 1889, the official observations were taken at a Signal Service building diagonally across the street, 1744 G Street.[34]

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[29] *Weather Bureau Topics and Personnel*, May 1946, p. 33. A definitive original reference has not been found for this date. However, the 1877 fiscal year Annual Report of the Chief Signal Officer states, "The preparation of the matter for the publication of the 'Synopses, Indications, and Facts,' commenced in 1872 as the 'Synopses, Probabilities, and Facts,' has been continued (p. 134). Also, in that same report under the November weather section on verification is the statement, "*Probabilities*–The detailed comparison of the tri-daily weather probabilities with the telegraphic reports…" (p. 421), and under the December section the statement changed to "*Indications*--The detailed comparison of the tri-daily weather indications with the telegraphic reports" (p. 429). This gives reasonable assurance the date of December 1, 1876, is correct.

[30] Greely, A. W., Annual Report of the Chief Signal Officer for 1889, Part 1, Appendix 2, p. 57.

[31] Whitnah, ibid., p. 23, references Abbe Papers. This forecast was based on 4:35 p.m. observations taken on February 20, 1871, the day after the first official forecast.

[32] Meyer, A. J., Annual Report of the Chief Signal Officer for 1871, p. 47 and for 1872, p. 73.

[33] Hazen, W. B., Annual Report of the Chief Signal Officer for 1882, Part 1, p. 89, states the Signal Service at that time occupied 10 buildings on G and H Streets and Pennsylvania Ave.

[34] Grice, Gary K., 2005: History of Weather Observing in Washington, D.C. 1821-1950. Sponsored by the Midwestern Regional Climate Center, pp. 8, 9. The locations where the observations were taken were obtained from the actual observational records. These dates agree with Abbe (1914: *Mon. Wea. Rev.*, Washington and Paris Winters, **42**, November 1914, p. 626, except for the move from 1744 G Street is given as March 29.

The service was extended throughout the United States by an Act of Congress on June 10, 1872, for "the benefit of agricultural and commercial interests," the original resolution having technically covered only the Gulf and Atlantic Coasts and the Great Lakes.[35] The Signal Service made great strides in the 21 years it was in charge of the national weather enterprise. The Chief Signal Officer issued voluminous reports each year to the War Department detailing its meteorological activities, as well as its original signal service duties. The Signal Service was in charge of the military telegraphic network, and thereby could transmit observations and warnings; soon maps were being prepared and distributed on which "meteoric conditions at stations throughout the country were exhibited by symbols."[36] In fact, the meteorological activities soon began to occupy more time and attention than the original Signal Service duties.[37]

The double building, picture taken facing south, at 1719 and 1721 G Street, the headquarters of the Signal Service 1870-1888. Note the slightly different facades on the right and left.

In addition to the operational activities, the science was being extended in various ways, much under the leadership of Abbe. For instance, he established the *Monthly Weather Review* (*MWR*) in 1873,[38] and was its editor for many years.[39] The *MWR* remains a viable journal today, being for 100 years a government scientific journal until the end of 1973, and now is published by the American Meteorological Society. Abbe remained in the Weather Bureau until he resigned in February 1916, but had not been active because of ill health for some years. He

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[35] Meyer, A. J., Annual Report of the Chief Signal Officer for 1872, p. 83.

[36] Meyer, A. J., Annual Report of the Chief Signal Officer for 1871, p. 7.

[37] Greely, A. W., Annual Report of the Chief Signal Officer 1889, Part 1, p. 7. "The duties … are of such an extended and important character as to practically absorb the attention and time of the grater part of the Signal Corps."

[38] Whitnah, ibid., p. 38.

[39] *Weather Bureau Topics and Personnel*, August 1916, p. 2. Actually, there was a Volume 0 in 1872, with articles other than maps just starting. Perhaps the 1872, issues were done in retrospect.

died October 26, 1916,[40] just a few months after he was the recipient of the Marcellus Hartley medal for Eminence in the Application of Science to the Public Welfare. Even though Abbe couldn't attend the ceremony, and the medal was accepted by the Chief of the Weather Bureau, he wrote for presentation an article "A Short Account of the Circumstances Attending the Inception of Weather Forecast Work by the United States."[41]

A daily International Weather Map was commenced July 1, 1878.[42] Synopses and Indications were being furnished for the press at 1:00 a.m., 11:30 a.m., and 7:30 p.m.[43] Several different forms for disseminating the forecasts were devised. Special frost indications were started in November 1879 and transmitted to New Orleans for the benefit of the sugar interests of Louisiana.[44]

On November, 18, 1879, the time of taking the morning telegraphic observations was changed to from 7:35 a.m. to 7:00 a.m. Washington mean time , and the afternoon observations were changed from 4:35 p.m. to 3:00 p.m. The observation at 11:00 p.m. remained, making the three observations exactly 8 hours apart.[45] "Cautionary" and "cautionary offshore" signals were used with reference to wind, flags during the day and lights at night. In 1880, these were being displayed at 106 ports.[46]

General Meyer died August 24, 1880, after heading the weather service for 10 years. During that decade, the Signal Service had grown and the number of observational stations had grown to 247; of that number, daily reports were being received from 181.[47] While the organization used the name "Signal Service" on some occasions,[48] the name most used was "Signal Corps," and Corps designation had been sought by Signal Officer Meyer since 1862.[49] Miller reports that the Signal Service was renamed the Signal Corps on February 24, 1880.[50] The annual reports were habitually signed "Chief Signal Officer" without regard to the parent organization. Under General William B. Hazen, who succeeded Meyer,[51] the service continued to expand, even though the staff and dollars

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[40] *Weather Bureau Topics and Personnel*, October 1916, p. 8. As an indication of his great esteem, flags were flown at half mast on the main buildings of the Department of Agriculture and the Headquarters of the Weather Bureau on the day of his funeral. In 1963, the American Meteorological Society named a major award in his honor–the Cleveland Abbe Award. In 1952, a bronze plaque in his honor was installed in the Weather Bureau office in Cincinnati, Ohio (*Weather Bureau Topics*, April 1952, p. 48).

[41] *Weather Bureau Topics and Personnel*, April 1916, p. 1.

[42] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, p. 180.

[43] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, p. 191

[44] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, p. 173. The use of "indications" rather than "forecasts" seems cumbersome. The wording is, " …special frost indications were ordered to be forecasted… ." During this time, it seemed weather was not being forecasted, but rather indications of the weather were being forecasted.

[45] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, p. 167. The 7:35 observations were continued until agreement could be reached with other countries.

[46] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, pp. 199, 200.

[47] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, p. 10.

[48] For instance, Meyer, A. J., Annual Report of the Chief Signal Officer for 1879, p. 4.

[49] Meyer, A. J., 1862, Report, p. 13.

[50] Miller, E. R., 1930, Tradition versus history in American meteorology, *Mon. Wea. Rev.*, **58**, p. 65.

[51] Whitnah, ibid., p. 34.

soon saw reduction.[52] It was estimated that one-third the households in the United States were receiving daily weather information from the Service.[53] The duties of the enlisted men at each station consisted of reading " ...at different fixed times ... the barometer, the thermometer, the wind velocity and direction, the rain-gauge, the dew-point, the character, kind, and movement of upper and lower clouds, and the condition of the weather. These observations are taken simultaneously throughout the whole extent of the territory of the United States." In addition, three other observations were taken and recorded at each station, one of them being at the exact hour of sunset.[54]

Monthly mean temperature maps for the United States were made for the years 1871-1880 with isotherms every 5 degrees.[55] Farmers' bulletins gave the general synopsis of the meteorological conditions throughout the country during the preceding 24 hours and the weather indications for the next 24 hours.[56] During the months of November, December, and January, special indications were prepared for the benefit of those interested in canal navigation, and a special bulletin was issued for the press starting in 1881.[57] A railway bulletin service was established giving the forecast for the ensuing day; by 1882, 50 companies with 2,306 stations were receiving these reports daily.[58] Watching, recording, and giving timely warnings of the rise and fall or rivers was another service.[59] Cold Wave signals were inaugurated in 1883.[60] Weather Crop Bulletins were inaugurated in 1888.[61] The civilian telegraph and railway companies cooperated in a major way. The information was relayed by telegraph and was posted at railway stations; in cities and towns; and on flat, iron sheets attached to railway cars.[62] In some locations, a steam whistle was used to signal

General William B. Hazen, Chief Signal Officer, who was head of the weather service 1880-1887. He was appointed following the death of Gen. Meyer on August 24, 1880.

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[52] Hazen, W. B., Annual Report of the Chief Signal Officer for 1882, p. 1. Hazen indicates there were only two officers to do the "indications" work.

[53] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, p. 213.

[54] Hazen, W. B., Annual Report of the Chief Signal Officer for 1882, p. 20.

[55] Drum, R. O. Annual Report of the Chief Signal Officer (acting) for 1880, p. 216.

[56] Hazen, W. B., Annual Report of the Chief Signal Officer for 1882, p. 22.

[57] Hazen, W. B., Annual Report of the Chief Signal Officer for 1882, p. 46.

[58] Hazen, W. B., Annual Report of the Chief Signal Officer for 1882, p. 23.

[59] Hazen, W. B., Annual Report of the Chief Signal Officer 1882, p. 49.

[60] Hazen, W. B., Annual Report of the Chief Signal Officer 1885, Part 1, p. 11.

[61] Greely, W. W., Annual Report of the Chief Signal Officer for 1889, Part 1, p. 16.

[62] Hazen, W. B., Annual Report of the Chief Signal Officer for 1885, Part 1, p. 517.

forecasts.[63] From the beginning,[64] the reports were encoded "in cipher" for efficiency, and the current code was judged to be "thoroughly satisfactory" in 1889.[65]

Upon the death of General Hazen, General Adolphus W. Greely was chosen to succeed.[66] The Signal Service had recommended for several years that better quarters be obtained. Finally:

> "On February 25, 1888, H. R. No. 4359 was passed, appropriating the sum of $150,000 for the purchase of a site (the northeast corner of square No. 25 bounded on the north by M street, on the east by Twenty-fourth street, and on the south and west by the grounds of the Columbia Hospital), including the building thereon; also for the creation of the necessary store-houses for the use of the office of the Chief Signal Officer.
>
> "The additional buildings required were erected ... and on March 5, 1889, this office was advised that the work on the Signal Office buildings had been practically completed... ."

General Adolphus W. Greely, Chief Signal Officer from 1887 until the meteorological activities transferred to the Department of Agriculture in 1891.

However, before accepting the buildings, an inspection was made. It was found that:

> "The ... building was found, both the materials used and in the workmanship, to be inferior to ... the specifications, and, although it has been occupied, it has not as yet been formally accepted.
>
> "It is believed that considerable repairs will be necessary during the coming year to keep it in habitable condition.
>
> "More storage room is needed. To secure the same, additional buildings should be erected as recommended below; the present stables and carriage house be converted into store-rooms, and a suitable stable rented."[67]

So, besides the $150,000 paid to David Ferguson for the property and structures, an additional $38,000 "was expended for the erection of additional structures required for use as storehouses, printing office, stable, machine shop, etc., these latter structures being constructed under the supervision of the Treasury Department."[68]

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[63] Greely, A. W., Annual Report of the Chief Signal Officer for 1890, p. 214. For instance, in Columbia, Missouri, one long and one short whistle indicated fair and colder.

[64] Meyer, A. J., Annual Report of the Chief Signal Officer for 1870, p. 7.

[65] Greely, A. W., Annual Report of the Chief Signal Officer for 1889, Part 1, p. 40.

[66] Whitnah, op cit, p. 57.

[67] Greely, A. W., Annual Report of the Chief Signal Officer for 1889, Part 1, pp. 113, 114.

[68] Moore, W. L., Report of the Chief of the Weather Bureau for 1895, p. 93. Also, see Appendix II, Fig. 9, in this document. The Treasury Department was in charge of building Government buildings.

The official observation site for "Washington City," as it was called in many reports, changed from 1744 G Street to a cupola on the new building at 2416 M Street. This building had been built by the Ferguson family as a residence,[69] but when the family relocated to California, the building was sold. It was an imposing structure, variously described as Mexican and Spanish architecture and "castle-like."[70] Evidently the move from G Street was made after the appropriation in February 1888. Greely reports the observation station was moved on August 21, 1888,[71] but the official observations continued at G Street until March1889.[72] Grice, in examining the actual reporting forms, states the official reporting station changed to the Ferguson building on March 22, 1889.[73]

The Ferguson building at 2416 M Street occupied by the Signal Corps in 1888. It faced M Street on the north, this picture being taken toward the southeast. The official Washington D.C. observations were taken on the roof–except wind from an adjacent tower–from March 22, 1889, until March 5, 1942. This building, along with its associated buildings to the east, south, and west served as the headquarters of the Weather Bureau from its inception on July 1, 1891, until a new building was built in front of it in 1941.

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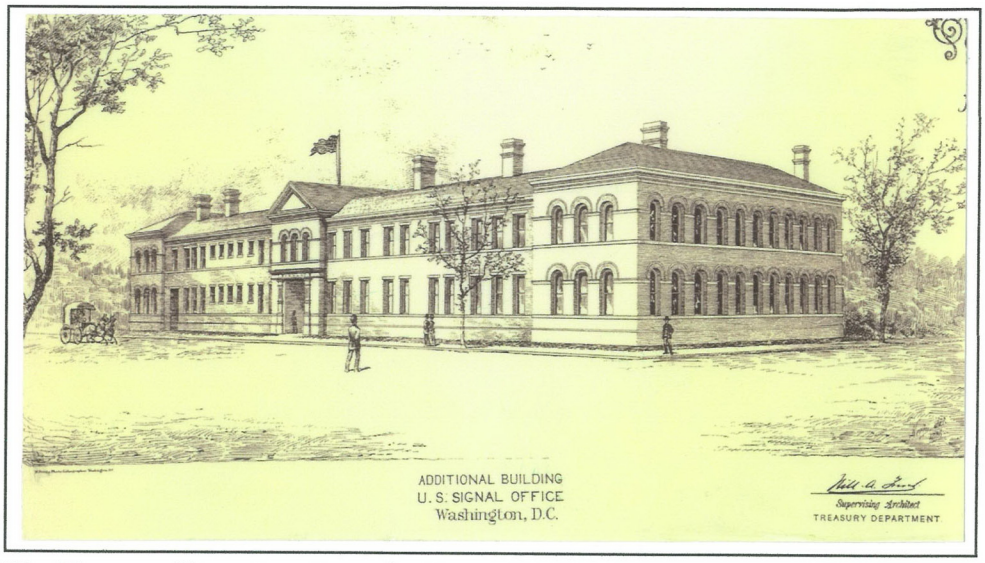
[69] Williams, P. K., *The InTowner*, November 2003, p. 12. Construction was started in 1886.

[70] Williams, ibid., p. 12.

[71] Greely, A. W., Annual Report of the Chief Signal Officer for 1889, Part 1, p. 127

[72] Abbe, C., Jr., 1914: Washington and Paris winters. *Mon. Wea. Rev.*, **42**, p. 626. Abbe gives the date as March 29.

[73] Grice, G. K., 2005, "History of Weather Observing in Washington, D.C. 1821-1950," p. 9. Manuscript sponsored by the Midwestern Regional Climate Center, 35 pp.



The Treasury Department was in charge of building government buildings and was commissioned to augment the space in the Ferugson Building. This is an artist's sketch of the building. It was built facing 24th Street. (Photo from National Archives, 1888 Report of the Supervising Architect, Bureau of Engraving and Printing, Treasury Department.)

Up until 1889, all forecasts were made at the Central Office, but at that time the local weather observers were authorised to make local forecasts for weather for the next 24 hours. It was envisioned, if this were successful, authority would also be granted for temperature and other atmospheric conditions.[74] On June 1, 1889, the official designation of the predictions was changed from "indications" to "forecasts."[75]

In addition to the "national" weather service operated by the Signal Service, working with it were several state weather services.[76]

By the end of 1891, there were 541 stations in operation, of which 26 were first-order stations making continuous records by means of self-registering instruments, and 117 were second-order stations, making at least two observations daily.[77]

While the Signal Service spun up its meteorological work quite rapidly, and even gained recognition internationally and birthed a scientific journal that exists today,[78] there was considerable

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[74] Greely, A. W., Annual Report of the Chief Signal Officer for 1889, Part 1, p. 27.
[75] Greely, A. W., Annual Report of the Chief Signal Officer for 1889, Part 1, Appendix 2, p. 57.
[76] Hazen, W. B., Annual Report of the Chief Signal Officer for 1885, p. 11.
[77] Greely, A. W., Annual Report of the Chief Signal Officer for 1891, p. 21.
[78] Whitnah, op cit, pp. 36-42.

internal and external strife concerning it,[79] especially after the death of General Meyer. The War Department didn't seem to strongly support the meteorological activities, and at the same time Secretary of Agriculture Jeremiah M. Rusk head of the very new Department of Agriculture wanted the weather responsibility. Gen. Greely did not strongly oppose the loss of the meteorological portion of the Signal Corps, and on December 18, 1889, Senator William B. Bate of Tennessee introduced S. 1454 to increase the efficiency of the Signal Corps by transfer of the weather service to the Department of Agriculture.[80]

Accordingly,[81] the weather service was transferred to the Department of Agriculture by law signed by President Benjamin Harrison on October 1, 1890. This act states:

> "*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, that the civilian duties now performed by the Signal Corps of the Army shall hereafter devolve upon a bureau to be known as the Weather Bureau, which, on and after July first, eighteen hundred and ninety-one shall be established in and attached to the Department of Agriculture, and the Signal Corps of the Army shall remain a part of the military establishment under the direction of the Secretary of War... .[82]
>
> " *Sec. 3.* The Chief of the Weather Bureau, under the direction of th Secretary of Agriculture, on and after July first, eighteen hundred and ninety one, shall be charged with the forecasting of weather, the issue of storm warnings, the display of weather and flood signals for the benefit of agriculture, commerce, and navigation, the gauging and reporting of rivers, the maintenance and operation of sea-coast telegraph lines and the collection and transmission of marine intelligence for the benefit of commerce and navigation, the reporting of temperature and rainfall conditions for the cotton states, the display of frost and cold wave signals, the distribution of meteorological information in the interest of agriculture and commerce, and the taking of such meteorological observations as may be necessary to establish and record the climatic conditions of the Untied states, or as are essential for the proper execution of the foregoing duties."

As noted later by Weather Bureau Chief Marvin, "This organic act, with interpretations and extensions by subsequent annual appropriations, assigns the Weather Bureau the entire domain of meteorology."[83]

It is noted that the Signal Service never considered that it officially had the responsibility of making forecasts, evidently differentiating between "warnings," for which it did have the responsibility, and "forecasts." In his annual report for 1890, Gen. Greely states:

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[79] Clayton, H. H., 1889: The Transfer of the United States Weather Service to a Civil Bureau. Alfred Mudge and Son, 31 pp.

[80] Whitnah, op cit, pp. 48-60.

[81] Whitnah, op cit, p. 60, cites *Statues at Large* 653 (1890).

[82] Greathouse, C. H., 1907: Historical Sketch of the U.S. Department of Agriculture. U.S. Dept. of Agriculture, p. 61.

[83] Marvin, C. F., Report of the Chief of the Weather Bureau for 1919, pp. 1, 2.

> "The civil duties imposed upon the Honorable Secretary of War by Joint Resolution of February 8, 1870, and which by his orders have devolved upon the Chief Signal Officer of the Army, are yearly growing in extent and importance. Apart from the weather forecasts, which are voluntary, not being provided for by law (underlining by author for emphasis), these duties involve by specific legislation the issuing storm-warnings; the display on the northern lakes, the Gulf, and sea coast of signals for the benefit of maritime interests; the gauging and reporting of rivers for navigation and flood-warnings; the maintenance and operation of sea-coast lines for the benefit of commerce and navigation, and of interior military lines for the use of the Army; the reporting of temperature and rainfall conditions for the cotton interests; the display of freeze warnings in the interest of agriculture, and the notification of advancing cold-waves for the benefit of the general public."

This ended 21 years of military command of what was only now to be officially called the Weather Bureau. The official observations were taken from a shelter on the Ferugson Building and the wind from a tower east of the building.[84] Sometime after a new building was built in 1941, the reporting was evidently from a shelter on top of the new building.[85] The official reporting for Washington was shifted to Bolling Field in 1929, to Washington-Hoover Airport in 1931, and to Washington National Airport in 1941, where the official site remains today.[86] After the transfer on July 1, 1891, Gen. Greely stated in his last annual report,

> "It is a source of gratification to the Chief Signal Officer that his methods of business were such that to this time, more than three months after the transfer, they are continued without modification of any importance. Three officers of the Army remain on duty, and no change has been made in the forecasting force or methods. It is interesting that the first predicting official (Professor Abbe) detailed by the Chief Signal Officer was a civilian, so the first predicting official formally detailed by the Chief of the Weather Bureau was an Army officer, Lieutenant Glassford."[87]

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[84] Grice, G. K., 2005, op. cit., p. 19, shows a picture of the Ferguson Building with a tower to the left, which would be to the east. Also, Fig. 2 in Appendix II in this document shows the wind tower at the time the new building was under construction.

[85] Grice, G. K., 2005, op. cit., p. 22, states the "Station location forms for the 1950s and 1960s indicate the location was 100 feet north of the site at 2416 M Street NW." This was undoubtedly the new building, and the author remembers a "weather station" atop the building.

[86] Grice, G. K., 2005, op. cit., pp. 2, 23-26.

[87] Greely, W. W., Annual Report of the Chief Signal Officer for 1891, p. 34.

The Weather Bureau Under the Department of Agriculture

Finally, the service was officially given the name Weather Bureau. Although the service had been called at times the Weather Bureau, it had not been formally so designated; Professor Mark W. Harrington was appointed its Chief.[88]

During the next 50 years, the Ferguson building was used as the headquarters. It had nearby buildings along 24th Street to the east, and to the south and west. Legend had it that these buildings were the stables[89] of the Mexican (or Spanish) Embassy,[90] but that is false. It is clear that the building along 24th street was built at the time of the move; it is likely the buildings to the south and west were also built at that time or not long thereafter. As can be seen in the picture below, there was a beautiful lawn between the building and M Street.

Another view of the Ferugson Building showing a building on the west, similar to that on the east and south (not visible).

As the Bureau got underway, Chief Harrington followed the practice of the previous administration and issued detailed reports, the first being a special report on October 1, 1891, and another covering the first 6 months July to December 1891. In his first semiannual report, he writes:

> "Our first care, on the transfer, was to improve the forecasts and their distribution in every possible way. The time covered by the forecasts has been lengthened to thirty-six hours, and the forecasters have been encouraged to make their predictions still longer whenever they see a fair prospect of verification."[91]

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[88] Whitnah, op cit, p. 61.

[89] Glahn, H. R., 1993: Remarks preceding the SCI/IMSC Outstanding Achievement Award to Glenn Brier, *Bul. Amer. Meteor. Soc.*, **74**, p. 1723. This was the going belief when the author entered the Weather Bureau in 1958 and worked in "the Old Annex."

[90] The picture caption of the Ferguson building in the *Weather Bureau Topics*, May 1961, reads, "The old Central Office building was acquired by the Signal Corps in 1888 and is still in use today. The interior decorations indicate that the building may have been intended for use as a Central American embassy." Evidently the Weather Bureau paid as little attention to its history then as it does today.

[91] Harrington, M. W., Report of the Chief of the Weather Bureau for 1891, p. 540.

Under civilian leadership, the meteorological enterprise continued to grow. By 1891, there were 41 weather services representing every state and territory in the United States with the exception of Idaho and the Indian Territory.[92] Harrington stated that "New York can properly lay claim to establishing the pioneer state weather service" in 1826.[93] By 1892, the entire territory of the United States, with the exception of Alaska, was covered by local weather services.[94]

In 1891, a satisfactory method of printing daily maps in newspapers was developed and implemented in several cities.[95] Maps made from observations at 8 o'clock were issued only 2 ½ hours later in a number of large cities.[96] The National Weather Crop Bulletin, always a much demanded product, continued to be improved and by 1893 was publically displayed in 130 cities. Decentralization of forecasts that started in 1889 continued; the river and flood service was reorganized by putting the forecasting of river stages and changes in the hands of experienced observers.[97]

Professor Mark W. Harrington, the first Chief of the Weather Bureau. He served from 1891 to 1895.

It was important to the agency that "In January 1893, the entire force of local forecast officials and observers was brought within the classified service, … and since that date all appointments to such force have been made through the Civil Service Commission."[98] The Civil Service Act had come into being through the so called "Pendleton Act" on January 16, 1883.[99]

It had been maintained by the Signal Corps that a military organization was needed for discipline for such a far flung organization. However, Chief Harrington writes in 1893:

> "Experience has demonstrated that military management and discipline are not essential to an efficient weather service, and it is gratifying to report that the present civilian management has found no difficulty in maintaining the necessary stations at the most isolated points."[100]

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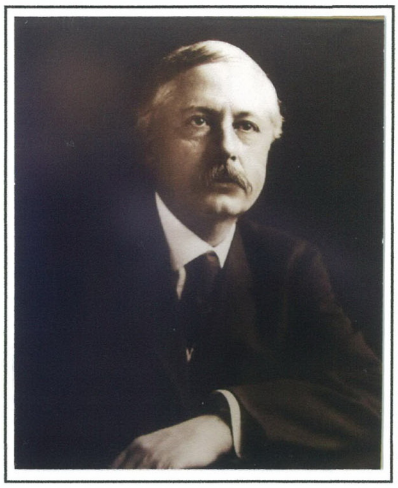
[92] Harrington, M. W., Report of the Chief of the Weather Bureau for 1891, p. 554.
[93] Harrington, M. W., Report of the Chief of the Weather Bureau for 1891, p. 568.
[94] Harrington, M. W., Report of the Chief of the Weather Bureau for1892, p. 573.
[95] Harrington, M. W., Report of the Chief of the Weather Bureau for 1891, p. 544.
[96] Harrington, M. W., Report of the Chief of the Weather Bureau for 1891, p. 549.
[97] Harrington, M. W., Report of the Chief of the Weather Bureau for 1893, pp. 102, 106.
[98] Harrington, M. W., Report of the Chief of the Weather Bureau for 1893, p. 89.
[99] *Weather Bureau Topics*, February 1956, p. 21.
[100] Harrington, M. W., Report of the Chief of the Weather Bureau for1893, p. 91.

Under Willis Moore, who became Chief of the Weather Bureau in 1895, 410 voluntary meteorological stations were established, the total number now being over 8,100.[101] That same year, a new hurricane signal was established,[102] and by 1896 signals were being displayed at 308 stations and by 32 government vessels and 30 lines of steamers.[103] River and flood forecasts were continued, but the rules of flood forecasting were largely empirical.[104] Chief Moore observed in 1897:



Professor Willis L. Moore, Chief of the Weather Bureau from 1895 to 1913.

> "The greatest field of usefulness of the Service lies, as has been observed in previous reports, in forecasting the severe storms that at times visit our shores and the marked cold waves that occasionally sweep from the Rocky Mountains eastward, rather than the ordinary changes in temperature, wind and weather."[105]

It was also clear that measurements in the upper atmosphere were needed, and experiments with kites were ongoing. Chief Moore stated:

> "The objective of perfecting an apparatus for more successfully flying kites is to secure meteorological observations at great attitudes above the surface of the earth.... I do not hesitate to express the opinion that we have reached the highest degree of accuracy in making of forecasts and storm warnings possible to be obtained with surface readings only."[106]

On March 1,1899, the night forecast was extended from 36 to 48 hours, following a 2-year study that indicated the practicality and usefulness of doing so.[107] New dissemination methods included the construction of steel towers for the display of storm warnings;[108] by 2001, 60 had been erected and equipped with improved lanterns,[109] and by 1904, 149 had been installed along the Great Lakes and Atlantic and Pacific seacoasts.[110] By 1903, about 25,000 11 by 16-inch maps were being issued 6 days a week, about half by a chalk-plate process, and the others by the less desirable milliograph, or wax-stencil, process.[111] The chalk-plate process was not phased out until 1946.[112]

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[101] Moore, W. L., Report of the Chief of the Weather Bureau for 1895, p. 79.
[102] Moore, W. L., Report of the Chief of the Weather Bureau for 1895, p. 69.
[103] Moore, W. L., Report of the Chief of the Weather Bureau for 1896, p. 248.
[104] Moore, W. L., Report of the Chief of the Weather Bureau for 1896, p. 248
[105] Moore, W. L., Report of the Chief of the Weather Bureau for 1897, p. 9.
[106] Moore, W. L., Report of the Chief of the Weather Bureau for 1897, p. 26.
[107] Moore, W. L., Report of the Chief of the Weather Bureau for 1898-1899, p. 3.
[108] Moore, W. L., Report of the Chief of the Weather Bureau for 1899-1900, p. 13.
[109] Moore, W. L., Report of the Chief of the Weather Bureau for 1900-1901, p. 13.
[110] Moore, W. L., Report of the Chief of the Weather Bureau for 1903-1904, p. XXXIII.
[111] Moore, W. L., Report of the Chief of the Weather Bureau for 1902-1903, p. XII.
[112] Weather Bureau *Circular Letter* **59-46**, 1946: Chalk plate Supplies and Equipment.

Research was not being neglected. An observatory was established at Mount Weather on the crest of the Blue Ridge Mountains and appropriately named "The Mount Weather Research Observatory."[113] In 2003, even before the observatory, the elasticity of thin balloons and the sluggishness of thermographs in the rapidly changing conditions of ascension were being studied. The library had grown to over 24,000 books and 4,000 pamphlets with a complete author card index and partial subject index.[114] Long range forecasts were being contemplated, but " ...that time has not yet arrived." Moore goes on in his annual report to state, "The proof of a forecast is in its verification... .The success of a long-range weather forecaster is usually measured by the extent to which he can impose upon the credulous and the ignorant."[115]

An important increase in responsibility occurred in 1904. Chief Moore stated,

> "Pursuant to recommendations in the report of the Interdepartmental Board on Wireless Telegraphy, dated July 12, 1904, and approved by the President July 29, 1904, the control of meteorological work on the oceans has been transferred from the Hydrographic Office, Navy Department, to the Department of Agriculture, and all meteorological work, heretofore done by the Navy Department for the purpose of publication or for making forecasts of storm warnings, has been assigned to the Weather Bureau of the Department of Agriculture."[116]

Devices for measuring the stage of rivers had not come into use because a "suitable form of apparatus at reasonable cost was not on the market" and because of the considerable expense of installation. However, by 1906, one designed by the Weather Bureau had been installed at one location and another location planned.[117]

The San Francisco earthquake of 1906 caused renewed interest in seismic reports. A simple instrument had been installed in Washington D.C. as early as 1886 that "was able to show, by stopping a clock, only the beginning of slight disturbances." Better instruments had been devised and one had been installed in Washington in 1903, the only such instrument operated by the Weather Bureau at the time of the San Francisco earthquake. Its recording of the San Francisco earthquake was so violent that the "pen was carried off the sheet" for about 3 minutes, even though no one in Washington was able to feel the earthquake, attesting to the sensitivity of such instruments.[118] Other violent earthquakes the following year prompted Chief Moore to recommend "the Weather Bureau be authorized to inaugurate and maintain systematic seismological observations within the Untied States and its territories."[119]

The importance of the atmosphere above the earth's surface had been recognized for some time. The Mount Weather Observatory was beginning to make observations by kite and obtain vertical

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[113] Moore, W. L., Report of the Chief of the Weather Bureau for 1902-1903, p. XVII; 1903-1904, p. XVII; 1904-1905, pp. X-XII.
[114] Moore, W. L., Report of the Chief of the Weather Bureau for 1902-1903, pp. XXX, XXXII.
[115] Moore, W. L., Report of the Chief of the Weather Bureau for 1903-1904, pp. XIII, XIV.
[116] Moore, W. L., Report of the Chief of the Weather Bureau for 1904-1905, Part I, p. XIX.
[117] Moore, W. L., Report of the Chief of the Weather Bureau for 1905-1906, Part I, p. XVII.
[118] Moore, W. L., Report of the Chief of the Weather Bureau for 1905-1906, Part I, p. XVII.
[119] Moore, W. L., Report of the Chief of the Weather Bureau for 1906-1907, Part I, p. XIII.

gradients of temperature and wind direction to several thousand feet. On October 3, 1907, the world's record for such observations was broken–an attitude of 23,111 ft. was reached. The results of such measurements were influencing the forecasts for Washington D.C.[120] Moore states "For instance, it has been found that the average wind direction at Mount Weather at about 10,000 feet above sea level is northwest, and that shifts of wind to west and southwest usually forerun by about two days the beginning of rain on the middle Atlantic seaboard."[121]

The administration building at Mount Weather was destroyed by fire in October 1907. The eight persons sleeping there barely escaped with their lives; two were seriously injured. In addition to administration, the building had also been used as an ordinary observing station.[122] The main observation building was rebuilt and the first observation was made on February 18, 1910.[123]

While kite flights were started in 1897, and it was contemplated that the 17 stations so equipped would provide data for daily synoptic charts, owing to difficulties of insufficient wind on many days, the synoptic charts were abandoned. Also, kites and captive balloons furnished data to only about 10,000 ft. So, following work in Europe, "sounding balloons" began to be used in 1909. The small balloons were filled with hydrogen gas, and when they burst at a high altitude, possibly 40,000 ft., a parachute brought the instrument safely to the ground. The recovery rate of the balloons initially was about 90%, and provided data for research and publication, but not for real-time maps.[124]

In 1908 and 1909, kiosks were being placed in 21 cities. The kiosk consisted "... of an ornamental iron structure devised for installation on public thoroughfares or in parks for the purpose of exhibiting meteorological charts and bulletins and for maintaining certain meteorological instruments showing the temperature, humidity, rainfall, etc."[125]

In 1910, Chief Moore included the following in his report, " ...forecasts for a week or 10 days in advance have been issued from time to time when certain well-defined weather types were shown by reports from selected stations throughout th Northern Hemisphere." At that time, about 200 Bureau stations were fully equipped with recording instruments; 3,000 cooperative observers were supplied with maximum and minimum thermometers, rain gages, and instrument shelters; and about 150 stations had steel towers and high-power oil or electric lanterns for the display of storm warnings.[126]

In 1911, a new Division of Observations and Reports was formed. The forecasts were being made at centers in six districts–Washington, D.C.; Chicago; Denver; Portland, Oregon; San Francesco; and New Orleans. By the next year, the forecasts were distributed to 2,059 regular

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[120] Moore, W. L., Report of the Chief of the Weather Bureau for 1906-1907, Part I, pp. VII, VIII. There is evidently a mistake in this report, as it states the observations were being made by aeroplanes (paragraph 2, p. VII) and is repeated in the 1907 report (paragraph 2, p. 5).

[121] Moore, W. L., Report of the Chief of the Weather Bureau for 1908-1909, Part I, p. 11.

[122] Moore, W. L., Report of the Chief of the Weather Bureau for 1906-07, p. XI; 1908, p. 3. (For some years, there appears to be two reports, likely one was for inclusion in the Department of Agriculture report.)

[123] Moore, W. L., Report of the Chief of the Weather Bureau for 1909-1910, p. 9.

[124] Moore, W. L., Report of the Chief of the Weather Bureau for 1909-1910, Part I, pp. 9, 10.

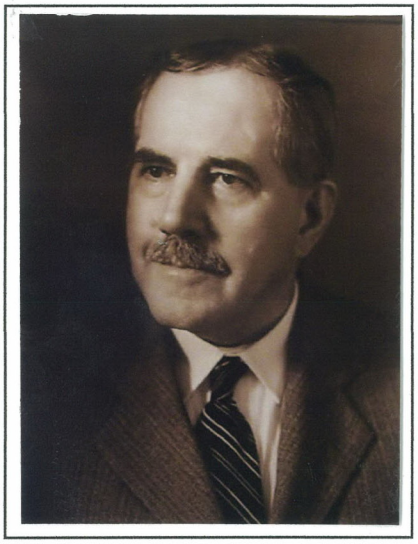
[125] Moore, W. L., Report of the Chief of the Weather Bureau for 1908-1909, Part I, p. 21.

[126] Moore, W. L., Report of the Chief of the Weather Bureau for 1909-1910, Part I, pp. 15, 19.

Weather Bureau stations and forecast distribution centers, from which points the forecasts were made available by telegraph and telephone to over 5.4 million subscribers and others, and by rural free delivery and mail to over 120,000 places.[127]

In 1912, the Weather Bureau initiated a vessel weather service on the Atlantic, Pacific, and Gulf coasts. Vessels were equipped with aneroid barometers and were to take two observations daily and radiograph them to the nearest wireless station. Forecasts were distributed to the vessels at sea.[128] Also, numerous stations were established in orchards in North carolina, Colorado, Utah, California, and Oregon with the object of correlating climatic phenomena and topographic conditions to frosts.[129]

Chief Moore retired, and Charles F. Marvin became chief on August 4, 1913.[130] Interestingly, in the 1913 report, the first one signed by Professor Marvin, the lead item was not research at Mount Weather, departing from a practice followed by Moore since 1907. The use of Mount Weather declined, and in 1919 Congress was asked for permission to sell the property.[131]



Professor Charles R. Marvin served as Chief of the Weather Bureau from 1913 until 1934.

In 1915, a previous publication that listed monthly personnel changes was expanded in scope and issued as *Weather Bureau Topics and Personnel*.[132] These are a storehouse of Weather Bureau events, in addition to the Chief's annual reports, and extend beyond the years of the annual reports. In 1939, the section on personnel assignments, promotions, resignations, etc., was dropped, and in 1948, the title was shortened to *Weather Bureau Topics*.[133]

It had been recognized that evaporation measurements would be very useful. However, such measurements were difficult. Even so, the Weather Bureau adopted a standard type of apparatus and inaugurated measurements of evaporation in 1915, and by the next year, eight stations had been so equipped.[134] Measuring the stages of rivers was done with either vertical staff gages, sloping gages of concrete, or chain and weight gages.[135] In 1916, a division of Agricultural Meteorology was formed, and several seemingly new developments or services related to agriculture were started. These included corn and wheat region service, cotton region service, sugar and rice region service, special fruit region service, special tobacco service, special cattle region service,

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[127] Moore, W. L., Report of the Chief of the Weather Bureau for 1910-1911, Part I, p. 21 and for 1911-1912, Part I, p. 21.

[128] Moore, W. L., Report of the Chief of the Weather Bureau for 1911-1912, Part I, pp. 25, 26.

[129] Marvin, C. F., Report of the Chief of the Weather Bureau for 1913, p. 1.

[130] Marvin, C. F., Report of the Chief of the Weather Bureau for 1913, p. 1.

[131] *Weather Bureau Topics and Personnel*, November 1919, p. 4.

[132] *Weather Bureau Topics and Personnel*, July 1915, p. 1.

[133] *Weather Bureau Topics*, January 1958, p. 3.

[134] Marvin, C. F., Report of the Chief of the Weather Bureau for 1915, p. 6 and for 1916, p. 5.

[135] Marvin, C. F., Report of the Chief of the Weather Bureau for 1915, p. 11.

special alfalfa service, special temperature and storm warnings for sheepmen, special fruit studies, and weather and crop studies, the latter being in progress by the Chief of the Weather Bureau in his previous position. The ever popular Weather and Crop Bulletin was now under this division.[136]

World War I brought changes to the Weather Bureau. As Chief Marvin stated, "Never in the history of conflicts of the world has the weather proved such a potent factor in the war that is now in progress in Europe. This is largely due to the use of aeroplanes, dirigibles, and captive balloons, to the highly perfected and powerful artillery, and to the modern methods of warfare first brought into practice in this conflict." Close cooperation with the military was necessary. The Weather Bureau's work initially expanded into two main areas: "(1) the forecasting of the weather purely for the purpose of military operations, and (2) the sounding of the upper air for the benefit of aviators, balloonists, and artillerists." The Signal Corps cooperated with the Weather Bureau, and a forecaster was commissioned as a major in the Signal Officers Reserve Corps for each of (1) and (2) above. The Signal Corps was independently operating free air observation stations.[137]

The climatological and agricultural interests also continued to expand with a new climatological service in Alaska; cranberry warning service; artificial protection of orchards, gardens, etc., from frost; potato frost warning service; and rice harvest forecasts.[138]

Daylight savings time caused extra work in 1918 by the Bureau having to maintain records at standard time, and also to issue forecasts according to the new time, but as Chief Marvin stated, "The daylight saving scheme has doubtless come to stay... ."[139] Prophetic words come true. On December 1, 1918, the Weather Bureau, in cooperation with the Signal Corps, inaugurated a service of flying forecasts. At the close of the war, the Weather Bureau had over 200 fully equipped meteorological stations, 1,400 substations (special observing stations), and 4,500 cooperative stations for climatological work. It consisted of 800 commissioned employees, about 1,400 who received a small compensation, and nearly 6,000 who served gratuitously.[140]

At that time, 1919, the stable of forecasts and warnings consisted of day-to-day forecasts 36 to 48 hours in advance of weather, temperature, and wind; weekly forecasts issued once a week; local forecasts; shippers' forecasts; special forecasts as the occasion required; day-to-day forecasts along the trans-Atlantic steamship lanes; day-to day forecasts transmitted to vessels at sea through naval radio; aviation forecasts each day for the Post Office and U.S. Army and Naval Air Services; and warnings as needed. A new "Highways Weather Service" was also started.[141]

Investigations in volcanology were formally started February 15, 1919, focusing first at "Kilauea Volcano on Hawaii Island of the Hawaiian group."[142]

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[136] Marvin, C. F., Report of the Chief of the Weather Bureau for 1916, pp. 9-13.
[137] Marvin, C. F., Report of the Chief of the Weather Bureau for 1917, pp. 1-2.
[138] Marvin, C. F., Report of the Chief of the Weather Bureau for 1917, pp. 7, 16-19.
[139] Marvin, C. F., Report of the Chief of the Weather Bureau for 1918, pp. 1-2.
[140] Marvin, C. F., Report of the Chief of the Weather Bureau for 1919, pp. 2, 3.
[141] Marvin, C. F., Report of the Chief of the Weather Bureau for 1919, pp. 4, 5, 8.
[142] Marvin, C. F., Report of the Chief of the Weather Bureau for 1919, pp. 11, 12.

Forest fire forecasts were provided for in a new $15,000 item: "For the establishment and maintenance of special stations in national forests and elsewhere… ." Also, Congress approved 36 Stat. L., p. 508, on June 17, 1919, for the extension of marine work:[143]

> "For the extension of marine meteorological work, the collection of weather and water temperature reports at sea, the preparation of charts, the determining of fog zones, the distribution of marine meteorological information in the aid of navigation and … for furnishing of meteorological information to the Hydrographic Office of the Navy Department… ."

The Weather Bureau created a Marine Division in 1920.[144] A new enterprise of weather and rain insurance imposed obligations on the Weather Bureau to supply data and facts to support the enterprise.[145] Fire weather forecasts were issued on a part time basis as early as 1921, and special appropriations made extension possible in 1926.[146,147] The service was still recovering from the disruption of the war, and the vessel weather service had been gradually restored, and was operating "on a higher plane of efficiency than ever before." Nearly 100 vessels were participating. However, weather maps that had been discontinued could not be resumed because of lack of funds.[148]

Radio was recognized as a potential medium for the dissemination of weather forecasts as early at 1921,[149] and within a year, gratifying reports were being received as to the success and efficiency of the distribution by radio.[150] Radiographic distribution of forecasts had already been employed to some extent, especially to ships at sea. On June 1, 1921, an extensive morning bulletin began to be broadcast from Arlington, Virginia, with a range of about 1000 miles. This was designed especially to meet the needs of marine and aviation interests, and covered the area east of the Mississippi River.[151]

Also in 1921, 100 nephoscopes were installed at selected stations, with the intent of establishing a regular program for nephoscopic observations of clouds.[152]

The activities aiding aviation materially increased in 1922. Daily forecasts covering 13 zones into which the country was divided were issued regularly and furnished to Army, Navy, and Post Office officials and to the flying fields. Radiographic distribution of forecasts increased dramatically, and on July 1, 1922, 98 stations in 35 states were daily broadcasting weather forecasts and warnings, even though the Weather Bureau did not own or operate any wireless equipment. The

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[143] *Weather Bureau Topics and Personnel*, November 1919, p. 3.
[144] *Weather Bureau Topics and Personnel*, March 1920, p. 22.
[145] Marvin, C. F., Report of the Chief of the Weather Bureau for 1920, p. 2.
[146] Marvin, C. F., Report of the Chief of the Weather Bureau for 1921, p. 6.
[147] Marvin, C. F., Report of the Chief of the Weather Bureau for 1926, p. 3.
[148] Marvin, C. F., Report of the Chief of the Weather Bureau for 1921, p. 6.
[149] *Weather Bureau Topics and Personnel*, May 1921, p. 49.
[150] *Weather Bureau Topics and Personnel*, September 1922, p. 266.
[151] Marvin, C. F., Report of the Chief of the Weather Bureau for 1921, pp. 7, 8.
[152] Marvin, C. F., Report of the Chief of the Weather Bureau for 1921, p. 20.

radio distribution work was accomplished through plants operated by other Government agencies, by corporations, and by private individuals.[153]

By 1923, the Hawaiian forecast service, in operation since 1918, was greatly improved through the cooperation of the Navy Department. Also, reports were being received with some degree of regularity from 11 stations in Alaska. These were very useful for forecasting purposes on the West Coast.[154]

In 1924, dust particles were being counted at Washington D.C. It was noted that the number per cubic centimeter ranged from 15 on clear mornings following precipitation, to as many as 3,000 at other times.[155] A special service to beekeepers, in effect for some years, was increased at the request of the Honey Producers League. Transcontinental air-mail service was extended across the continent in the early summer of 1924, including night flying, and forecasts were extended to support this service. That year, for purposes of governmental efficiency, the volcanology studies at Kilauea were transferred to the Geological Survey of the Interior Department.[156]

In 1926, the Weather Bureau began to seriously to adopt relatively new concepts of forecasting developed in Europe. The following is quoted from the *Weather Bureau Topics and Personnel*:

> "A method of treating and discussing cyclones and anti-cyclones mathematically and on hydrodynamical principles, based on the so-called polar front theory, was developed some time ago at the Meteorological Institute at Bergen, Norway, under the direction of Dr. V. F. K. Bjerknes. The Scandinavian meteorological services have applied this theory intensively, in fact almost exclusively, to the day to day weather forecasting. While many of the essentials of this system have been used by the Weather Bureau forecasters in this country, they have never used it exclusively. In order to become more familiar with the intensive application of such methods, Mr. Carl-Gustaf Arvid Rossby, who is one of the official forecasters at Stockholm, has been employed temporarily in the capacity of research associate. He will assist the forecasters, and others interested, in applying the Bjerknes method to the conditions in this country."[157]

Mr. Rossby stayed in this assignment until December 17, 1927.[158]

In 1928, instructions were issued that all first-order stations would keep exposed a rain trace catcher, or slip of paper ruled in copying ink, as an aid to existing methods of determining the occurrence of small quantities of rain. Evidently of limited use, the instructions were modified a few months later to permit discontinuance at the discretion of the official in charge because of "difficulty

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[153] Marvin, C. F., Report of the Chief of the Weather Bureau for 1922, pp. 10-12.
[154] Marvin, C. F., Report of the Chief of the Weather Bureau for 1923, p. 6.
[155] *Weather Bureau Topics and Personnel*, January 1923, p. 287.
[156] Marvin, C. F., Report of the Chief of the Weather Bureau for 1924, pp. 5, 6, 16, 17.
[157] *Weather Bureau Topics and Personnel*, July 1926, p. 135.
[158] *Weather Bureau Topics and Personnel*, December 1927, p. 265.

in distinguishing rain from dew, fog, etc." Later, there was some use of smoked glass for the same purpose. [159]

Continuous 24-h service to airlines started in 1928, and by 1930, such service was being rendered at 50 of the more important terminals.[160,161]

The Weather Bureau throughout its history made efforts to increase the length of its forecasts. By 1919, it had initiated weekly outlooks, and later investigated making even longer range forecasts. As stated in 1931, "... no sufficiently conclusive scientific basis has been found on which to make successful forecasts for longer periods." In coming to that conclusion, three methods were investigated: "(1) the direct physical process of cause-and-effect relationship between known physical causes and attendant weather conditions, (2) the so-called periodicities or cyclical recurrences of weather phenomena ... (and) (3) the mathematical correlations between the present weather in one locality and either past weather in the same locality or the past weather in some other locality."[162]

Kite observations had over the years yielded results of genuine importance, but flights could not be made when the wind was very light or very strong. Accordingly, the 6 kite stations were phased out and replaced with airplane observations starting in 1931 at Chicago, Cleveland, Dallas, and Omaha,[163] with only one kite station remaining until 1933. By 1933, aircraft flights were being made reliably to 15,000 ft.[164] By 1935 the number of upper air observations made by airplanes had increased to 25.[165] In addition, pilot balloon observations were maintained at 75 stations, including three in Alaska and one in Puerto Rico.[166] A pilot balloon is a small balloon whose ascent is followed by a theodolite in order to obtain data for the computation of winds aloft.

Service to aviation had become such an important activity, that Chief Marvin felt he should enumerate the other important activities of the Weather Bureau: Primary network of stations, twice-daily public forecasts of all kinds, river gaging and flood warnings, hurricane warnings and storms on the Great Lakes, secondary network of stations, network of climatic stations, weekly bulletins of crop-weather conditions, frost warnings for horticulture, shippers forecasts, cattle and stock-raising service, solar-radiation investigations, as well as aid to air navigation.[167]

Marvin left his position, and Willis R. Greg was appointed as Chief effective January 31, 1934.[168]

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[159] *Weather Bureau Topics and Personnel*, September 1928, p. 353; January 1929, pp. 394-395, March 1929, p. 411.
[160] *Weather Bureau Topics and Personnel*, March 1928, p. 291.
[161] Marvin, C . F., Report of the Chief of the Weather Bureau for 1930, p. 8.
[162] Marvin, C . F., Report of the Chief of the Weather Bureau for 1931, p. 4.
[163] *Weather Bureau Topics and Personnel*, June 1931, p. 167.
[164] Marvin, C . F., Report of the Chief of the Weather Bureau for 1933, p. 6.
[165] Gregg, W. R., Report of the Chief of the Weather Bureau for 1935, Part 1, p. 8.
[166] Gregg, W. R., Report of the Chief of the Weather Bureau for 1934, Part 1, p. 2.
[167] Marvin, C . F., Report of the Chief of the Weather Bureau for 1933, Part I, pp. 1, 2.
[168] *Weather Bureau Topics and Personnel*, January 1934, p. 1.

Evidently the Scandinavian methods had not been rapidly adopted. A Science Advisory Board had been created by the President on July 31, 1933, " ...for the purpose of cooperating with the Federal Government in the handling of all problems in which science is involved." A report was published and was approved in January 1934. According to Chief Gregg in his first annual report:

> "The most important recommendation is that relating to the development of forecasting on the basis of what is known as 'air-mass analysis.' Briefly stated, air-mas analysis consists of a detailed study of masses of air of decidedly different structure as to temperature, moisture, and wind that meet along an irregular line variously referred to as a 'discontinuity line,' 'polar front,' 'wind shift,' etc. These masses of air, cold and dry from polar regions, warm and humid from equatorial, do not readily mix but tend to preserve their individual identities, the warm, moist air being forced to rise above and flow over the denser cold air, with resulting condensation and precipitation and other attendant phenomena which give us most of the stormy weather characteristic of temperature latitudes."[169]

The next year, Chief Gregg reported the turmoil from changing from one method of forecasting where the weather maps consisted of "isobars..., isotherms..., and symbols for cloudiness, wind direction and velocity ... " to one where "a synoptic map giving boundaries, or fronts, of the different masses of air over a given large territory, together with the states and conditions of these masses, and the directions and speeds of their movements" was used. Gregg goes on, "It is not obvious ... from which of the two synoptic maps ... one could most clearly foresee the coming weather. Presumably some combination of the two ... would be better than is either alone." A satisfactory solution had been reached by 1941 and adopted.[170]

Dr. Willis R. Gregg served as Chief of the Weather Bureau from 1934 until 1938.

The hurricane warning service was reorganized in 1935 to include three new centers– Jacksonville, Florida; New Orleans, Louisiana; and San Juan, Puerto Rico (planned). A new teletype circuit was inaugurated on July 1, 1935, to connect these centers and 10 coastal stations. Forecasts were then issued by these centers as well as from Washington D.C.[171]

By 1937, a project supported by the Works Progress Administration (WPA) was nearly completed at New Orleans whereby 5 million observations taken on ships during the years 1880 to 1933 were being put onto cards which were "to be preserved in filing cabinets so as to afford ready reference to weather records, by months, for any part of the oceans."[172] By 1939, all upper air records were put onto punch cards, and arrangements were made whereby all future observations of this nature would be so recorded by the Weather Bureau.[173]

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[169] Gregg, W. R., Report of the Chief of the Weather Bureau for 1934, Part I, pp. 1, 2.
[170] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1941, p. 142.
[171] Gregg, W. R., Report of the Chief of the Weather Bureau for 1935, Part I, pp. 9, 10.
[172] Gregg, W. R., Report of the Chief of the Weather Bureau for 1937, p. 9.
[173] Reichelderfer F. W., Report of the Chief of the Weather Bureau for 1939, p. 5.

In 1938, Chief Gregg quoted a portion of the Civil Aeronautic Act, approved June 23, 1938:

> "Sec. 803. ...the Chief of the Weather Bureau... (4) detail annually not to exceed ten members of the Weather Bureau personnel for training at Government expense, either at civilian institutions or otherwise, in advanced methods of meteorological science... ."

Chief Gregg then states that plans were being worked out to put this legislation into effect. This was the beginning of a program that would last for many years whereby employees were given fellowships of one or more years at a university to study meteorology or related topics.[174]

Research conducted in the past few years at the National Bureau of Standards had yielded a "generally satisfactory" radiometeorograph, as shown by comparison with airplane observations, and plans were made to use these at six stations beginning July 1, 1938. By 1939, these were being called radiosondes with the definition: "a radiosonde is a radiometeorograph, an instrument which is sent aloft by a small balloon and which transmits a radio signal indicating pressure, temperature, and humidities in the upper air."[175] For 1940, it was planned that airplane observations would be discontinued, and radiosondes would be used at 34 stations, 28 operated by the Weather Bureau and the rest by the Army and Navy.[176] Acton was taken to increase the pilot balloon observations to four per day, and generally with larger 100-gram balloons. Helium instead of hydrogen was being investigated to eliminate explosions. In addition, the River and Flood Service was reorganized and expanded in three main directions: "(1) Refinement of the observation and reporting system of effective rainfall in upstream basins of major drainage areas; (2) analysis of rainfall and storm data for use by the Army in the design of flood-control works; (and) (3) expansion of the mountain-snowfall service in the West."[177]

Dr. Gregg died in office on September 14, 1938.[178,179] He was replaced on December 15, 1938, in an acting capacity by Commander Francis W. Reichelderfer, who was on detail from the Navy.[180] This appointment became permanent on January 2, 1939.[181,182] An honorary degree of doctor of science was conferred upon Reichelderfer by his alma matter Northwestern University on June 10, 1939.[183]

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[174] Gregg, W. R., Report of the Chief of the Weather Bureau for 1938, p. 2. The author was the recipient of such a fellowship to the Pennsylvania State University for the 1961-62 academic term. Many recipients earned MS or Ph.D. degrees. The practice was gradually replaced with shorter or more directed study programs for forecasters, and finally was discontinued.

[175] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1939, p. 3.

[176] *Weather Bureau Topics and Personnel*, June 1939, p. 231.

[177] Gregg, W. R., Report of the Chief of the Weather Bureau for 1938, pp. 9, 11.

[178] *Weather Bureau Topics and Personnel*, August 1938, p. 81.

[179] Little, D. M., 1945: Obituary. *Bul. Amer. Meteor. Soc.*, **26**, p. 241.

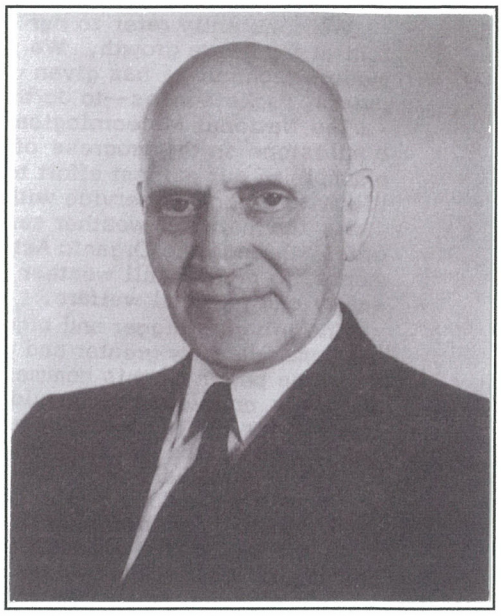
[180] *Weather Bureau Topics and Personnel*, November 1938, p. 123.

[181] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1939, p. 1. This reference lists Gregg's death as September 15, which is incorrect according to other references.

[182] *Weather Bureau Topics and Personnel*, February 1939, p. 165.

[183] *Weather Bureau Topics and Personnel*, May 1939, p. 207.

In 1939, pilot balloon observations were inaugurated at 23 additional stations, including Anchorage, Alaska, bringing the total number to 102. The use of larger (100-gram) balloons, capable of ascending to 20 km. or more, was adopted at 23 additional stations. Helium was substituted for hydrogen in the inflation of balloons at about one-third of the stations. Because the use of helium completely eliminates the explosion hazard, arrangements were made to extend the use of helium to nearly all balloon stations during the fiscal year 1940.[184] Evidently a pilot balloon sent aloft with a lantern or lighted candle posed a fire hazzard, and the California State Legislature made it a misdemeanor to do so. Accordingly, instructions were issued to use electric lighting units instead.[185]



Dr. Francis W. Reichelderfer served as Chief of the Weather Bureau from 1939 until 1963, the longest of any Weather Bureau Chief.

With the assistance of the WPA, all upper-air wind records, involving about one million observations, were reduced to punch cards in 1939, and arrangements were made whereby all future observations of that nature would be so recorded by the Weather Bureau. At this point in time, there were 720 locations in the continental U.S. at which observations were made for, or utilized in, the airway meteorological service.[186]

On April 8, 1939, the first automatic weather forecast service in the country was inaugurated in New York by the New York Telephone Company. This was a huge success. Designed to handle 30,000 calls a day, the capacity had to be increased to 100,000 within the first few days.[187]

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[184] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1939, p. 4.
[185] *Weather Bureau Topics and Personnel*, August 1939, p. 242, 243.
[186] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1939, p. 5.
[187] Weather Bureau *Circular Letter* **34-40**, August 15, 1940.

The Weather Bureau Under the Department of Commerce

On June 30, 1940, the Weather Bureau was transferred to the Department of Commerce (DoC) under President Franklin D. Roosevelt's Reorganization Plan No. IV which was approved June 4, 1940. In the transmittal message, the President stated:

> "The importance of the Weather Bureau's functions to the Nations's commerce has also led to the decision to transfer this Bureau to the Department of Commerce. The development of the aviation industry has imposed upon the Weather Bureau a major responsibility in the field of air transportation. The transfer to the Department of Commerce, as provided in this plan, will permit better coordination of Government activities relating to aviation and to commerce in general, without in any way lessening the Bureau's contribution to agriculture."[188]

Chief Reichelderfer stated that fiscal year 1940 saw greater development than any other similar period for many years. Improvements included the establishment of 30 new airport stations at major terminals which rendered 24-hour service, took four pilot balloon observations, and prepared four weather maps per day. Two Coast Guard cutters were stationed between New York and the Azores for making daily weather observations and to replace to some extent the daily reports from merchant vessels which had been greatly curtailed since the outbreak of war in Europe.[189] The observations were made by Weather Bureau personnel.[190] To take care of the thousands of telephone requests for weather information, telephone companies installed voice-recording equipment in several cities which repeated the Weather Bureau forecast once every 30 seconds.[191]

About 53 years after the Weather Service occupied the Ferugson Building and 1 year after it was transferred to the Department of Commerce, it was moving its primary administrative function into a new building built to the north along M Street. It was intended that a "left wing" would be built to match the right wing, providing a symmetrical building. However, this was never done, and the Ferugson Building and the "old annex" were still being used until the Bureau relocated to Silver Spring, Maryland,[192] (see Appendix II) in 1966.[193] Observations were taken from the new site starting March 5, 1942.[194] Even so, the M Street complex was soon bursting at its seams.[195] Some portions of the Weather Bureau were located outside the 2400 M Street complex; in 1951, the Division of Climatological and Hydrologic Services was located a block from the Administration Building.[196] The sixth floor of the right wing was not added until 1961.[197]

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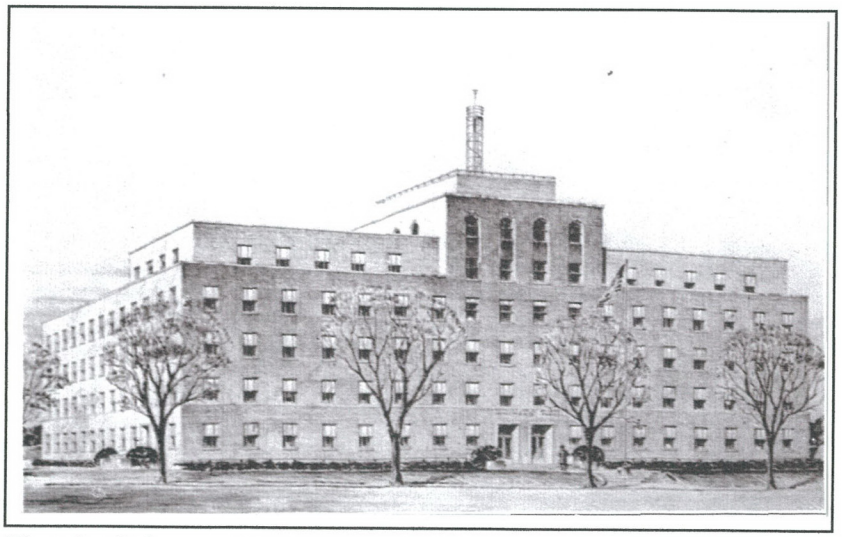
[188] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1940, pp. 1, 4, 5.
[189] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1940, pp. 1, 6, 7.
[190] *Weather Bureau Topics*, September 1949, p. 467.
[191] *Weather Bureau Topics and Personnel*, January 1940, p. 279.
[192] *Weather Bureau Topics and Personnel*, July 1941, pp. 486-488.
[193] *ESSA News*, **2**, February 21 1966.
[194] Grice, op. cit., p. 9.
[195] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1946, pp. 224, 225.
[196] *Weather Bureau Topics*, March 1951, p. 60.
[197] *Weather Bureau Topics*, March 1961, Topigrams; May 1961, p. 78, picture caption.

The building at 2400 M Street that was the home of Weather Bureau Headquarters from 1941 until it moved to Silver Spring, Maryland, in 1966. It was built in front of the Ferguson Building that was used as the headquarters for approximately 53 years. The Ferguson Building still existed and was also used, along with the "Old Annex." The top, sixth, floor to the right was not added until 1961.

On August 19, 1940, Chief Reichelderfer signed a *Circular Letter* declaring that all communications given wide distribution would be named "*Circular Letters*." These *Letters* contained announcements of events of general information to Bureau personnel. Distribution was to be made to each station. "*Multiple Address Letters*" were given more limited distribution.[198] From this date on, a file was kept of the *Letters*, and they are available from the NOAA Library.

The Weather Bureau was gearing up for national defense, a first step being the formation of the Defense Meteorological Committee, representing the Army, Navy, Civil Aeronautics Administration (CAA), and the Weather Bureau. The number of radiosonde measurements at the 30 sites was doubled and four sites were added. At 25 sites, surface observations were stepped up from four per day to eight, and a new teletype circuit, Schedule C, augmented Schedule A. Forecasts were released earlier, being based on the 1:30 a.m. observations rather than the 7:30 ones. Five day forecasts were increased from weekly to twice per week.[199] Schedule C was to carry forecasts, 3- and 6-hourly observations, ship reports, pilot balloon and radiosonde observations, and other reports required for map purposes.[200]

The annual reports of the Bureau Chief were somewhat curtailed during the war because they were classified as secret. By Executive Order, the Weather Bureau and the War and Navy Departments were placed in a closer working relationship. The Chief of the Bureau was to serve as the liaison officer between the Departments.[201]



Sketch of the new headquarters building that had been planned, but was never completed past the central part and right wing. The left wing would have probably extended to 24th street, and is shown replacing the old annex. (Picture taken from July 1941 *Weather Bureau Topics and Personnel.*)

The forecasting operation was decentralized by creating seven field regions to provide closer contact with the field service. While there had been centers in the field that had provided regionalized forecasts, this was an administrative change. The Regional Directors were to be, in effect, parts of the Central Office with residence in the field. The seven regions were given numbers with headquarters in (1) New York, New York; (2) Atlanta, Georgia; (3) Chicago, Illinois;

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[198] Weather Bureau *Circular Letter* **35-40**, 1940: *Circular Letters* and *Multiple Address Letters*; **65-50,** 1950: Material Contained in *Circular Letters*, *Multiple Address Letters*, and Memoranda.

[199] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1941, pp. 137-145.

[200] Weather Bureau *Circular Letter* **29-41**, 1941: Proposed Schedule "C" Circuit.

[201] Weather Bureau *Circular Letter* **183-41**, 1941: Executive Order Re-Meteorological Services for War Purposes.

(4) Fort Worth, Texas; (5) Kansas City, Missouri; (6) San Francisco, California; and (7) Seattle, Washington. Puerto Rico was assigned to Region 2, Swan Island to Region 4, and Hawaii to Region 6. Alaska was not included in this reorganization, their activities already being somewhat regionalized at Juneau.[202] Full implementation was delayed because of the war, but evidently components of it were in effect by January 1, 1942, including the establishment of the Regional Directors.[203]

In 1941, uniformity of map preparation was addressed by *circular letter*: "In the interest of uniformity, an interval of 3 millibars is recommended for drawing isobars on surface manuscript maps, also on newspaper maps and printed and duplicated maps for public distribution. Other intervals may be used at airport stations at the discretion of the official in charge... ." [204] This 3-millibar spacing was mandated for maps with a scale of 1:7.5 million or 1:10 million in 1942.[205]

By 1941, the Government had evidently decided the airplane was safe and economical for travel, and was here to stay. Travel regulations were amended in Bureau of the Budget Circular No. 370, dated March 7, 1941, to the effect that travel by airplane on official business would be on the same basis as travel by any other form of common carrier when it results in advantage to the government.[206]

Chief Reichelderfer emphasized that the local forecaster was responsible for the local forecast, and was in fact expected to modify as necessary the forecasts of the district center, and to localize them. He distributed a *Circular Letter* in part "to remove all restrictions on local forecast authority." Up to this time a form "differing local forecast" was to be prepared which documented local changes to the district center guidance; it was discontinued at this time. The local forecasters were to use the state forecasts as a guide and provide to the public information on "temperature, time and character of precipitation when feasible, passage of fronts when important, and other useful information... ."[207]

As of September 15, 1941, the release time of radiosonde observation (raob) balloons was changed from12:30 to 11:00 a.m. and p.m.[208]

A central Analysis Center was established in 1942 in Washington, with eventual facsimile dissemination; this was an important step in providing weather service to aviation, both military and civil. It was the initial step in a long-planned method of placing the daily weather analysis, after preparation by a staff of experts, promptly in the hands of local offices.[209]

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[202] Weather Bureau *Circular Letter* **143-41**, 1941: Plan of Regionalization for Weather Bureau Field Service.
[203] Weather Bureau *Circular Letter* **178-41**, 1941: Effective Date of Regionalization.
[204] Weather Bureau *Circular Letter* **35-41**, 1941: Spacing of Isobars.
[205] Weather Bureau *Circular Letter* **19-42**, 1942: Spacing Isobars.
[206] Weather Bureau *Circular Letter* **43-41**, 1941: Travel by Airplane on Official Business.
[207] Weather Bureau *Circular Letter* **47-41**, 1941: Local Forecast Responsibility.
[208] Weather Bureau *Circular Letter* **117-41**, 1941: Change in Time of Raobs.
[209] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1942, pp. 129, 131, 133; Weather Bureau *Circular Letter* **39-42**, 1942: Establishment of Analysis Center, Washington, D.C.

Effective January 19, 1942, the work week was extended from 39 to 44 hours, by Order of the Secretary of Commerce.[210]

"War Time" was established whereby all clocks were set forward by one hour on February 9, 1942. This was to remain in effect until 6 months after the termination of the war or on such an earlier date that Congress would designate.[211]

Because of the large number of types of forecasts issued by the Bureau and their distribution, curtailing weather information to conform to the Office of Censorship and still provide for the protection of life and property was difficult. By January 19, 1942, the Office of Censorship requested newspapers to confine the publication of current weather to (1) routine forecasts and special warnings covering the city and state and not more than four adjoining states within 150 miles; (2) temperature and precipitation limited to 20 other stations, but to not include Montana, Idaho, Utah, Nevada, Arizona, California, Oregon, or Washington; (3) news stories of warning the public of dangerous roads or streets within 150 miles; and (4) round-up stories covering one state. Sky conditions were not to be published.[212] The issue of information to newspapers and press associations were to include (except special warnings intended for radio broadcast) the statement, "This Information Must Not Be Broadcast By Radio." Special warnings issued to radio stations were to include the statement "Authorized for radio broadcast."[213] This was followed by restrictions effective November 1, 1943, that radio transmission of wether reports, maps, and analyses less than 7 days old would not be made in the clear. In addition, material furnished to commercial radio stations by the Weather Bureau for broadcast in the clear would contain no direct mention of ceiling, visibility, wind direction, or atmospheric pressure less than 7 days old, except when the data were released as special warnings by proper authority. This was seen as a relaxation of restrictions pertaining to the continental United States, and lifted all wartime restrictions on release of United States weather information within the Untied States except as stated above.[214]

Chief Reichelderfer issued instructions to the effect: "All Weather Bureau personnel will remain at their posts of duty in the city and airport offices during air raid and emergency conditions as long as effective service can be rendered by the station, unless ordered to do otherwise by appropriate military authority." [215]

Speed limits were imposed by General Order ODT 23 issued by the Director of Defense Transportation on September 26, 1942, such that vehicles would not be operated above the posted speed limit or 35 miles per hour, whichever was the lesser. This did not apply to an emergency for the protection or preservation of life, health, or public safety.[216]

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[210] Weather Bureau *Circular Letter* **3-42**, 1942: Extension of Working Hours to 44 Hours per Week.

[211] Weather Bureau *Circular Letter* **15-42**, 1942: Conversion to "War Time."

[212] Weather Bureau *Circular Letter* **8-42**, 1942: Weather Information in Newspapers.

[213] Weather Bureau *Circular Letter* **62-42**, 1942: Radio Silence on Weather information.

[214] Weather Bureau *Circular Letter* **101-43**, 1943: Relaxation of War Restrictions on Distribution of Weather Information.

[215] Weather Bureau *Circular Letter* **126-42**, 1942: Procedure to be Observed During Air Raids.

[216] Weather Bureau *Circular Letter* **133-42**, 1942: Limitation on Speed of Motor Vehicles.

A *Circular Letter* noted: "The Weather Bureau, like the Army and Navy, was until recently largely a man's organization. Now, women in rapidly increasing numbers are being appointed as weather observers. First appointments were made in February 1942, two women going to each radiosonde station and one to each Section Center to be trained to replace men for other assignments." [217]

An agency or industry could request a Weather Bureau employee be transferred there, and could file the request with the War Transfer Board. This procedure was in addition to transfers arranged by the Joint Meteorological Committee of the Army, Navy, and Weather Bureau to permit the utilization of an employee with special qualifications in a particular assignment where he could render more valuable professional service to the war effort.[218]

The hurricane warning system was revised effective September 1, 1943, to include a "Preliminary Hurricane Alert," in addition to the advisory messages and storm and hurricane warnings. This new alert was "to cover a period of uncertainty when winds of a hurricane may endanger a locality or area within 24 to 36 hours, but the indications are not yet sufficient to justify a definite warning."[219] Evidently these were not issued as often as desired in 1954, and instructions were reissued. The definition was still essentially the same, but the word "preliminary" was dropped.[220] After the 1955 season, the Hurricane Alert was changed to Hurricane Watch, after studies revealed that many persons mistook the word "alert" as synonymous with "warning." [221] Instructions were provided for preparing local operating instructions regrading hurricane warnings.[222] The hurricane forecasts were to include statements about the expected water level above normal tide–hurricane surge. Case studies had been prepared, and it was recommended these be used as guidance in forecasting water level.[223]

The work week was extended to 48 hours. The Director of the Bureau of the Budget issued Circular No. 416 dated April 26, 1943, that stated in part: "The President in his memorandum issued December 22, 1942, to the heads of all agencies stated, 'It is my desire that the head of each department and agency establish … a general minimum work schedule of a six day, 48-hour week for both the departmental and field service.' "[224] Also, a memorandum written by the Administrative assistant to the President dated May 12, 1943, states: "The necessity for maintaining maximum output in Government activities throughout the war period requires that days normally observed by the departments and agencies as holidays should, with the exception of Christmas, be considered as regular work days for the duration of the war."[225] As of August 30, 1945, the administrative work

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[217] Weather Bureau *Circular Letter* **162-42**, 1942: Women Employees in the Weather Bureau.

[218] Weather Bureau *Circular Letter* **13-43**, 1943: Release for Transfer or for Employment in Industry.

[219] Weather Bureau *Circular Letter* **81-43**, 1943: Preliminary Hurricane Alert.

[220] Weather Bureau *Circular Letter* **14-55**, 1955: Hurricane Alerts.

[221] Weather Bureau *Circular Letter* **5-56**, 1956: Hurricane Watches.

[222] Weather Bureau *Circular Letter* **26-55**, 1955: Hurricane Emergency Operating Procedures.

[223] Weather Bureau *Circular Letter* **36-55**, 1955: Inclusion of High Water Information in Hurricane Advisories and Warnings and in Local Bulletins.

[224] Weather Bureau *Circular Letter* **36-43**, 1943: 48-Hour Workweek.

[225] Weather Bureau *Circular Letter* **51-43**, 1943: Observance of Holidays During the War Period.

week went to 40 hours.[226] Another effect of the war was that surplus stocks of equipment, materials, and supplies could not be held for future needs. No stocks could be allowed to remain idle, but must be used to meet day to day requirements. Any surplus had to be reported.[227]

"Corn brooms" seemed to be in very short supply; a number of *circular letters* pertaining to their purchase was issued. For instance, "Authority has been granted by the Procurement Division of the Treasury Department in a letter dated May 2, 1944, and by the Federal Prison Industries, Inc., in a letter dated May 3, 1944, for purchases of corn brooms locally during the fiscal year beginning July 1, 1944 to meet requirements in lots not exceeding one-half (½) dozen at a time.[228]

Discussions were being held in 1944 as to the use of Greenwich time in teletype transmissions. A proposal was made by the CAA to use it for all transmissions on Schedules A and C. It was agreed to wait until later when it would be less disturbing to military aircraft.[229] Six-hourly synoptic reports and pilot balloons and radiosonde observations had been in Greenwich Civil Time since October 1, 1942.[230]

By 1944, information was being distributed over more than 600 commercial broadcasting stations, approximately 100 of which maintained their own microphones in Weather Bureau offices for direct use by the Bureau. Basic forecasts for airway routes were prepared at 15 District Forecasting Centers in the continental U.S. A specialized type of airway weather information was provided through the Flight Advisory Weather Service (FAWS).[231] Twenty-six FAWS units, paralleling the Airway Traffic Control Centers of the CAA, functioned in close co-operation with those CAA units. Transferring tabulated data onto punch cards continued (or resumed after the war) in cooperation with the Army and Navy. By 1946, a library of 60 million punched cards containing weather observations existed, and the Weather Bureau became the central repository for this library.[232]

Before the war, emergency flood warning amateur radio networks were organized in several river districts in cooperation with the American Radio Relay League. With the advent of war, it became necessary to disband the networks. By 1944, the Bureau was encouraging similar networks again be established.[233]

On January 19, 1945, the Secretary of Commerce signed Department Order No. 355 giving the following guidance:

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[226] Weather Bureau *Circular Letter* **73-45**, 1945: Federal Employees Pay Act, 1945, and Amendment dated October 22, 1945.

[227] Weather Bureau *Circular Letter* **82-43**, 1943: Surplus Serviceable Field Property.

[228] Weather Bureau *Circular Letter* **40-44**, 1944: Purchase of Corn Brooms During the Fiscal Year Beginning July1, 1944.

[229] *Weather Bureau Topics and Personnel*, September 1944, p. 353.

[230] *Weather Bureau Circular Letter* **118-42**, 1942: Adoption of Greenwich Civil Time for Meteorological Transmissions on the Teletype.

[231] *Weather Bureau Topics and Personnel*, January 1944, p. 248.

[232] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1946, pp. 213-217.

[233] Weather Bureau *Circular Letter* **57-45**, 1945: Emergency Flood and Storm Warning Radio Networks.

> "In compliance with instructions of the Director of War Mobilization and Reconversion to meet the existing fuel emergency, it is hereby ordered that the maximum temperatures in all buildings under control of the Department of Commerce shall not exceed 68 degrees, and that effective measures be taken to stop the unnecessary use of electric current such as may be consumed by unnecessary lights burning and failure to turn off fans, machines, motors, etc., when not actually in use."[234]

A questionnaire produced a consensus of field forecasters that the 10 most important tools in making forecasts 24 to 48 hours in advance were: isobars, fronts, 3-h isallobars, precipitation patterns, air masses analyzed and indicated on the sea-level map, 12-h pressure-change map, and upper-air charts drawn near the levels of 5, 10, and 20 thousand feet.[235]

The Weather Bureau, Army, and Navy agreed, for the purpose of furthering international uniformity, to change the radiosonde code to report constant pressure rather than constant level data. The introductory period was to start May 1, 1945.[236] The change had been tested on a limited basis by the Analysis Center. Benefits of the change were seen to be:

> "... constant pressure charts have the advantage of requiring only one wind scale for all levels, and also of permitting easier interpretation of isotherms in terms of density or potential temperature, or of mixing ratio in terms of dew point or wet bulb temperature. With a minimum of additional effort it is possible, by use of differential methods, to obtain further information of forecast value that cannot readily be obtained from constant level charts."

Standard intervals between contour lines on the 700 and 500-mb surfaces were to be 200 ft., and isotherms drawn in intervals of 5 degrees C. Transparent geostrophic wind scales for the 1:15,000,000 Lambert conformal conic protection were furnished.[237] An assortment of such scales were provided to the field in 1950.[238] A new, revised tephigram was furnished to aid the plotting and analyzing upper-air soundings.[239]

An emergency service unit was organized in each of the seven regions in the continental United States. The name "flying squadron" had been given the units, but the name was changed to Mobile Emergency Unit (MOBEU). These units were set up primarily to reenforce local station staffs during storm, flood, or other emergencies.[240]

The increasing demand for upper-wind data to at least 40,000 ft. in all weather conditions led to the development of two methods of obtaining such data. They were designated on teletype circuits

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[234] Weather Bureau *Circular Letter* **7-45**, 1945: Fixing Maximum Temperatures in Buildings and Restricting Use of Electric Current.

[235] *Weather Bureau Topics and Personnel*, October 1945, p. 511.

[236] Weather Bureau *Circular Letter* **28-45**, 1945: Amendment to 1943 Radiosonde code.

[237] Weather Bureau *Circular Letter* **51-45**, 1945: Adoption of Constant Pressure analysis.

[238] Weather Bureau *Circular Letter* **10-50**, 1950: Geostrophic Wind Scales Designed to Give Wind Velocities in Knots.

[239] Weather Bureau *Circular Letter* **67-45**, 1945: Tephigram, W. B. Form 1125 (Revised 2-21-45).

[240] Weather Bureau *Circular Letter* **55-44**, 1944: Mobile Emergency Unit (MOBEU).

as RAWIN data. The definition was: "A winds aloft observation made by balloon and radio methods, without optical aid." This was not to be confused with RABAL, which denoted the method of determining upper-air winds by observing a radiosonde balloon through a theodolite.[241] By 1946, the Weather Bureau had acquired 50 units developed by the Signal Corps, and deployed them.[242] This conversion from radiosonde to rawinsonde started on November 12, 1945, when an SCR-658 radio direction-finding set was installed at San Antonio, Texas, and was completed when McGrath, Alaska, was equipped with electronic wind-finding equipment on October 12, 1956.[243] Never content with using outdated equipment, the Weather Bureau contracted in 1957 for the procurement of 41 new systems, a major upgrade being that the tracking could be down to 6 degrees as compared to 15 degrees for the SCR-658.[244] On March 23, 1959, the first new set, now dubbed WBRT-57, was delivered to Silver Hill Observatory in Washington D.C.; the next two sets went to Columbia, Missouri, and Anchorage, Alaska.[245]

Annual reports were resumed in 1946, after an apparent gap from 1943-45; the house publication *Weather Bureau Topics and Personnel* had continued. Censorship restraints on public distribution of weather information were lifted completely after VJ-Day, September 2, 1945. [246] Restrictions had begun to be removed in European and Atlantic areas with the ending of the war there, especially after VE day on May 8, 1945.[247] The number of patrol ships was reduced, and by the end of 1946, there were only two ships operating, both by the United States.[248]

Significant progress was made in 1945 in the development of specialized forecast services for agriculture, in collaboration with State Extension Service specialists and agents. The Bureau saw these services as increasing and encouraged offices to establish partnerships and obtain the cooperation of radio stations in providing regular daily schedules for broadcasts.[249] Such work was strongly encouraged. For instance in 1946, Chief Reichelderfer stated:

> "The value of the Bureau's forecast advisory service for agriculture is firmly established. Hundreds of commendatory letters have been received... . Existing services should be continued, seasonal programs should be extended so far as feasible to areas not already covered. Regional Offices should assist local offices in further establishment of expansion of service as required to meet agricultural needs as fully and effectively as possible. Contacts with Extension Service representatives in all states should be continued." [250]

In October 1945, Chief Reichelderfer stated that the release of verification information to the public may lead to misinterpretation unless there is proper coordination. He stated that no

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[241] *Weather Bureau Topics and Personnel*, June 1944, p. 301.
[242] *Weather Bureau Topics and Personnel*, January 1946, pp. 1-3.
[243] *Weather Bureau Topics*, February 1957, p. 28.
[244] *Weather Bureau Topics*, April 1957, p. 65.
[245] *Weather Bureau Topics*, April 1959, p. 65.
[246] Weather Bureau *Circular Letter* **76-45**, 1945: Weather Security.
[247] Weather Bureau *Circular Letter* **49-45**, 1945: Removal of Weather Security Measures in Certain Areas.
[248] Weather Bureau *Circular Letter* **104-46**, 1946: Atlantic Weather Patrol Ship Stations.
[249] Weather Bureau *Circular Letter* **41-45**, 1945: Specialized Forecasts and Advices for Agriculture.
[250] Weather Bureau *Circular Letter* **22-46**, 1946: Specialized Forecasts and Advices for Agriculture.

information about the verification scores of Weather Bureau forecasts be released for public dissemination except by the Central Office over the signature of the Chief of the Bureau.[251]

Principal distribution of agricultural forecasts to farmers were by radio, and if possible the forecasts were included in the extension service farm programs.[252] The agricultural programs were still being strongly encouraged in 1948.[253]

By summer 1946, a pictorial weather map, depicting forecast weather information, was appearing in several newspapers and practice was expected to grow. The map carried the heading "Weather FOTOCAST" and contained a credit to the Weather Bureau.[254]

Effective July 1, 1946, the Division of Climate and Crop Weather and the Office of the Hydrologic Director were combined into a Division of Climatological and Hydrologic Services with Merrill Bernard as Chief.[255]

On September 5, 1946, the announcement was made that River Forecast Centers (RFC) would be established. The first was established at Cincinnati, Ohio, on September 23, and a second a few weeks later at Kansas City, Missouri.[256]

Also in 1946, Chief Reichelderfer reasoned that use of analogue synoptic charts would be a good way to add to forecasters' practical knowledge of forecasting. Bureau forecasters were well trained, but sometimes lacked experience. Guidance was given as to what was a good analogue, but it was acknowledged that the size of the area over which the analogue was defined played a large role.[257]

"Shippers" forecasts being issued as early as 1919 had evidently been discontinued, because on October 15, 1946, the following notified the field:

> "To fill a need for nationwide temperature indications, predictions of maximum and minimum temperature for a representative area centered around selected cities throughout the United States will be prepared and given teletype distribution effective November 1, 1946. These transmissions will be known as 'Shippers' Temperature Bulletins.' "[258]

In 1946, The Short Range Forecast Development Section was established in Washington. The unit conducted studies of such things as quantitative precipitation of interest to the Tennessee Valley

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[251] Weather Bureau *Circular Letter* **82-45**, 1945: Release of Information on Forecast Verifications.

[252] Weather Bureau *Circular Letter* **15-47**, 1947: Specialized Forecasts and Advices for Agriculture.

[253] Weather Bureau *Circular Letter* **8-48**, 1948: Specialized Forecasts for Agriculture.

[254] Weather Bureau *Circular Letter* **66-46**, 1946: Pictorial Newspaper Weather Forecasts.

[255] Weather Bureau *Circular Letter* **53-46**, 1946: Reorganization of Climatological and Hydrological Services in the Central Office.

[256] *Weather Bureau Topics*, April 1952, pp. 57, 58.

[257] Weather Bureau *Circular Letter* **69-46**, 1946: Transmission of Analogue Data, with attachment "Use of Analogue Synoptic Charts in Forecasting," manuscript of Weather Forecast Branch, Army Air Force, Washington, D.C., dated February 1944.

[258] Weather Bureau *Circular Letter* **81-46**, 1946: Shippers' Temperature Bulletins.

Authority and winter minimum temperature and precipitation at Washington D.C. and New York. Local climatologies of airport stations were established. The results were aimed at assisting experienced forecasters in conserving their time and in making their forecasts more explicit. These studies generally resulted in manuscripts for internal distribution or publications in hard copy form, as computers were not yet available. The new unit had also made progress in developing methods of expressing the likelihood of occurrence of weather elements "in terms of statistical probabilities."[259] The latter statement, in Chief Reichelderfer's 1946 annual report, was likely made in recognition of "objective (or statistical) forecasting" which was now coming into being.[260,261]

By 1946, 64 stations were taking radiosonde measurements. When the balloon carrying the sonde aloft bursts, it comes down by parachute. When sondes are found, they can be returned to the Bureau according to instructions on them, and many are recovered. The Weather Bureau Radiosonde Reconditioning Center had been established in Joliet, Illinois, in 1945, and the first lot of 30 reconditioned sondes was completed on April 30, 1945. After establishing this as a profitable adventure, the number of employees was increased from one to 10, and the quarters were moved. In the calendar year 1946, the goal of 10,000 reconditioned sondes per year was exceeded by 698. Once again, the operation was increased to achieve the optimum number of 14,000 per year, and in 1950 the total was 14,192.[262] In 1955, each returned radiosonde saved the program about $10.00.[263] By April 1968, 400,000 had been repaired,[264] some as many as 11 times.[265]

Also, by 1946, the development of a "ceilometer" had progressed to the point that 100 units had been installed,[266] and a total of 140 installations were completed by the end of 1947. This instrument used a modulated light beam and sensitive electronic detector that could be used day or night to detect cloud heights.[267]

The Weather Bureau was authorized by Congress:

> "... to establish a network of stations in the high latitudes of the Western Hemisphere in cooperation with other interested countries for the purposes of taking surface and upper-air observations and making such other meteorological studies of arctic weather conditions as may be practicable."

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[259] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1946, p. 220. This reference refers to the organization as a "Unit," but the name was "Section" by 1958, and probably always was.

[260] Jorgenson, D. L., 1949: An objective method of forecasting rain in Central California during the raisin drying season. *Mon. Wea. Rev.*, **77**, No. 2, February 1949.

[261] Klein, W. H., 1949: An objective method of forecasting five-day precipitation for the Tennessee Valley. *Res. Paper* No. **29**, Washington D.C.

[262] *Weather Bureau* Topics, June 1952, pp. 86-88.

[263] Weather Bureau *Circular Letter* **30-55**, 1955: Recovered Radiosondes.

[264] *ESSA News*, **4**, April 5, 1968, p. 2.

[265] *ESSA World*, **1**, October 1966, p. 31.

[266] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1946, p. 222 ; for 1947, p. 248.

[267] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1947, p. 248.

This work began, the Arctic Meteorological Service Section was organized, and a complete surface and upper-air observation station was established at Thule, Greenland.[268] With the headquarters change effective July 1, 1946–the Division of Climate and Crop Weather and the Office of Hydrologic Director were consolidated into the Division of Climatological and Hydrologic Service–the river and flood service was expanded. Under this new division, a pilot "on-station punching" program was started, whereby all current hourly, 6-hourly, summary of day, pibal, raob, and rason[269] observations were punched into International Business Machine (IBM) tabulating cards by observers at first-order stations;[270] the program was extended to all regions in 1947,[271] and Regional Weather Records Processing Centers (WRPC) were established.[272] In addition to hand key-punches, basic IBM 405 tabulators were delivered to stations.[273] In 1949, the punching on-station was expanded when the Bureau embarked on a project to maintain the series of Northern Hemisphere Historical Maps on a current basis. Each station engaged in an upper air observational program was requested to punch a few cards daily, starting March 1, 1949, in addition to those already being prepared, and to send them to the Weather Bureau Tabulation Unit in New Orleans.[274] Effective February 1, 1952, the cards were to be mailed to the National Weather Records Center Asheville, North Carolina.[275]

The "snow and ice" bulletin seemed to be quite important. For a number of years, a circular announced the start and discontinuance of the bulletin as the seasons changed. [276]

By the end of 1947, 175 commercial radio stations were broadcasting weather information direct from 132 Weather Bureau offices.[277] Regional airway forecasts were prepared by 19 Airway Forecast Centers including Alaska. The FAWS units in 26 traffic control centers continued to provide required service. The Provisional International Civil Aviation Organization became a permanent organization (ICAO).[278]

Development of statistical forecast techniques continued, and to extend this program, Research Forecasters were assigned to District Forecast Centers at Boston and San Francisco; this Research Forecaster program was to expand in the coming years. Taking another tack, the Weather Bureau worked with the Institute for Advance Study at Princeton, New Jersey, to determine possible application of the computer to the rapid solution of complex forecasting equations–the beginnings

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[268] *Weather Bureau Topics and Personnel*, September 1946, p. 58.

[269] Weather Bureau Topics, November 1949, p 492. Other definitions of abbreviations are given in this reference, including ABOB: A meteorological sounding made by means of an aircraft flight.

[270] *Weather Bureau Topics and Personnel*, July 1946, p. 47; September 1946, pp. 58, 59.

[271] *Weather Bureau Topics and Personnel*, September 1947, pp. 162-164.

[272] Weather Bureau *Circular Letter* **77-47**, 1947: Inauguration of Machine Processing of Weather Records.

[273] *Weather Bureau Topics*, May 1948, p. 267.

[274] Weather Bureau *Circular Letter* **7–49**, 1949: On-Station Card Punching for Northern Hemisphere Historical Map Project.

[275] Weather Bureau *Circular Letter* **9-52**, 1952: Change in Mailing.

[276] Weather Bureau *Circular Letter* **20-47**, 1947: Discontinuance of Snow and Ice Bulletin; **102-47**: Resumption of Snow and Ice Bulletin.

[277] Weather Bureau *Circular Letter* **124-47**, 1947: Direct Radio Broadcasts.

[278] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1947, pp. 235, 238.

of Numerical Weather Prediction (NWP). The assignment of employees to institutes of higher learning for advanced training continued, with six being assigned to New York university in 1947.[279]

In April 1946, the Weather Bureau was requested by the National Advisory Committee for Aeronautics (NACA) to provide leadership to extend the NACA "Standard Atmosphere" above its original level of 65,000 feet. A tentative standard atmosphere up to a height of 75 miles was determined by piecing together many sources of evidence, some from V-2 rockets launched at White Sands, New Mexico.[280] By 1957, 23 U.S. scientific and engineering organizations had adopted a new standard to 300 km., the first 32 km being called "standard" and upper portions being called "tentative" and "speculative." This effort was led by the Weather Bureau and the Air Force Geophysics Research Directorate.[281]

The Weather Bureau did its part in rebuilding the war-ravaged Philippines, required by Public Law No. 370 of the 79th Congress. The Bureau did this by contracts with the Philippines' Weather Bureau.[282] As detailed in issues of *Topics*, this was a challenging task, and was brought to completion June 30, 1950.[283] The Weather Bureau also helped rehabilitate the German Weather Service.[284]

In his 1948 annual report, Dr. Reichelderfer noted that the Weather Bureau was operating several diverse functions, the principal statutes being the following:

- The Organic Act approved October 1, 1890 (15 U.S.C. 311-313);
- Amendment of Civil Aeronautics Act of 1938, Public Law 691, Seventy-ninth Congress;
- Act authorizing establishment of arctic meteorological stations, Public Law 296, Seventy-ninth Congress;
- Section 308, Philippine Rehabilitation Act, Public Law 370, Seventy-ninth Congress;
- Enabling Act of 1948, Public Law 573, Eightieth Congress;
- International Aviation Facilities act, Public Law 647, Eightieth Congress; and
- Act to provide safety in aviation and to direct a study of the causes and characteristics of thunderstorms and other atmospheric disturbances, Public Law 657, Eightieth Congress.

The also stated that the meteorological services of the Weather Bureau could be grouped into three general categories, (1) The daily or current weather information services, (2) the hydrologic or hydrometeorological services, and (3) the climatological services.[285]

The Analysis Center was organized in 1942 a few months after the United State entered the war and had started operations in March of that year (see page 31). In 1947, it was operating on the

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[279] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1947, pp. 246-248.

[280] *Weather Bureau Topics and Personnel*, March 1947, pp. 100, 101.

[281] Weather Bureau and Geophysics Research Directorate (AFCRC), 1957: Extension to the Standard Atmosphere. *Bul. Amer. Meteor. Soc.*, **38**, 78-80.

[282] *Weather Bureau Topics and Personnel*, April 1947, pp. 110, 111.

[283] *Weather Bureau Topics*, August 1950, p. 111.

[284] *Weather Bureau Topics and Personnel*, December 1947, pp. 204-206.

[285] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1948, p. 268.

first floor of the Ferguson Building with a staff of 65. Six-hour maps were prepared and transmitted daily.[286] By December 1944, it had started transmitting 30-h prognostic charts on Circuit C.[287] It was consolidated into a joint center, the WBAN (Weather Bureau, Army, Navy) Combined Weather Analysis Center on July 17, 1947, and was staffed by a combination of Weather Bureau, Air Force, and Navy personnel. This consolidated the three centers established in 1942 to meet wartime demands.[288,289] On September 1949, the Center began preparing a chart showing the district forecasts assembled for the entire United States, including the areas of expected weather changes. These national charts were coded and distributed once each day on Service C.[290] By 1950, the Center had a staff of about 150, and the operations included plotting 140 raobs on pseudo-adiabatic charts, and 850-, 700-, and 500-mb charts within ½ hours after the data began to arrive. In order to achieve the latter, charts were cut into sections according to the teletype circuits over which the data arrived. After the plotting was completed, the charts were taped together for the analysts.[291]

In 1948, the Weather Bureau was operating 17 general forecasting centers; approximately 350 field offices which served as local weather reporting stations, forecast dissemination points, and in some cases pilot balloon stations; and other multiple purpose offices. Experimental "flow-control forecasts" were being made at several FAWS units. Two mobile weather units were added to the seven already in use; these provided service to the national forests and grazing lands in the West. There were three extensive teletype circuits in use, Services A, C, and O; these were leased by the Civil Aeronautics Administration from commercial communications companies, and the Weather Bureau was responsible for the scheduling of the weather information on them. The daily weather map, a product in great demand, was enhanced by the inclusion of a 700-mb constant pressure chart and the extension of the small surface chart to cover all of north America. Hand operated card punching machines were installed at all full time Weather Bureau offices in the continental United States. Several demonstration projects were initiated making use of television for dissemination of weather information,[292] and careful consideration was made of the time it takes to prepare a television program in comparison to a radio program in determining policy regarding Bureau personnel participation.[293] In 1952, the Federal Communications Commission issued an order that permitted a considerable increase in the number of television stations operated in the United States. This was seen as an increased demand for weather data to support television.[294]

As of April 1, 1948, by international agreement, the raobs and rasons were to be released at 0300 and 1500 GCT and the winds aloft at those times plus 0900 and 2100. GCT[295]

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[286] *Weather Bureau Topics and Personnel*, April 1947, pp. 113-115.

[287] Weather Bureau *Circular Letter* **90-44**, 1944: Additional Prognostic Charts to be Transmitted by Analysis Center.

[288] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1948, p. 269.

[289] *Weather Bureau Topics and Personnel*, August 1947, p. 153.

[290] Weather Bureau *Circular Letter* **94-49**, 1949: National Forecast Charts.

[291] *Weather Bureau Topics*, March 1950, p. 42. Some of these "cut and taped" charts exist at the National Archives in College Park, Maryland, (observed by author in 2011).

[292] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1948, pp. 268-287. Also, *Weather Bureau Topics*, September 1949, p. 480.

[293] Weather Bureau *Circular Letter* **13-48**, 1948: Television.

[294] Weather Bureau *Circular Letter* **22-52**, 1952: Television.

[295] Weather Bureau *Circular Letter* **20-48**, 1948: Scheduled Times of Upper Air Observations.

A 2-h terminal forecast was being issued by some stations according to a program started in 1946.[296] When staff and work load permitted, the program was recommended to be continuous each hour from sunrise to sunset.[297] A new form for writing terminal forecasts was introduced a few months later in 1948.[298] The 2-h forecast was discontinued in 1957 because a new In-Flight Weather Safety Service program rendered it unnecessary in the continental U.S. (CONUS); it was to be continued as already implemented in Alaska and Hawaii. The new program, effective about March 1, provided airmen in flight with advance notice of potentially hazardous weather developments.[299]

By early 1950, a Broadcast Television Unit had been installed at the Central Office and was sending a 6.5-minute summary of the nation's weather nightly over the nation-wide facilities of the new major network, the Liberty Broadcasting System. This was only an analysis of the current conditions, and contained no forecasts; control was returned to the local station for the forecasts. News "cut-ins" were also prepared in the Unit to cover rapidly changing severe weather anywhere in the nation. Through the cooperation of the network newsroom that feeds news programs from Washington to nearly 300 affiliated stations, it was possible for the Weather Bureau studio to cut into any, and if necessary all, network news presentations with special reports when conditions justified.[300]

The use of radar to detect storms started in 1947 with installation at four stations–Washington D.C.; Wichita, Kansas; Norfolk, Nebraska; and Wichita Falls, Texas. The equipment, surplus from the military, was designated AN/APS-2. Although the reports had no acronym, they were put into a message designated RAREP.[301,302] By 1949, the Weather Bureau, Navy, and Air Force combined had approximately 45 weather stations within the CONUS that were equipped with, or had access to, radar equipment suited to storm detection. Most of the stations were transmitting their radar reports on Service A. The Bureau encouraged the use of radar information, not only for the detection of severe storms, but in pilot briefings and forecasting.[303]

With the January 1948 issue, the house organ's title *Weather Bureau Topics and Personnel* was changed to *Weather Bureau Topics*.

The radiosonde (AN/AMT-8) was now being used in a "downward" mode, being dropped from airplanes, and the name "dropsonde" was coined.[304]

The publication of the results of research performed by Bureau employees was encouraged from time to time, and instructions for clearance and publication procedures had been in local station

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[296] Weather Bureau *Circular Letter* **73-46**, 1946: Broadcast of Local Terminal Forecasts Over CAA Range Stations.
[297] Weather Bureau *Circular Letter* **28-48**, 1948: 2-Hour Terminal Forecast Program.
[298] Weather Bureau *Circular Letter* **110-48**, 1948: New Form of Writing Aviation Weather Forecasts.
[299] Weather Bureau *Circular Letter* **3-57**, 1957: Discontinuance of 2-hour Terminal Forecast Program.
[300] *Weather Bureau Topics*, March 1951, p. 62.
[301] *Weather Bureau Topics*, December 1949, p. 493.
[302] *Weather Bureau Topics and Personnel*, October 1947, p. 183, 184; Reichelderfer, 1948, op cit. p. 290.
[303] Weather Bureau *Circular Letter* **82-49**, 1949: Use of Weather Radar Reports.
[304] *Weather Bureau Topics*, November 1948, p. 323.

regulations since 1938 or before. In 1948, Chief Reichelderfer advised caution in case of controversial issues, and a disclaimer such as saying that the views expressed are the author's own and not necessarily those of the Weather Bureau was suggested.[305] Some wartime restrictions had been lifted in March of 1946.[306]

The Wisconsin cranberry service completed its first year in 1948. Frost warnings help farmers with the decision to flood or not to flood fields in possible frost situations.[307]

A cooperative project with the Massachusetts Institute of Technology was begun on July 1, 1948 for the collection of data from the Southern Hemisphere for the study of the general circulation.[308]

The Weather Bureau weathered the challenge of implementing on January 1, 1949, the revised observation instructions and new codes and procedures adopted by the International Meteorological Organization Conference in Washington in 1947. Despite the short time remaining between full concurrence and implementation, the changeover was made with practically no confusion.[309]

In order to further the exchange of ideas, suggestions, and reports of special interest to forecasters and others engaged in the Bureau's forecast service, a "Forecaster's Forum" was established in 1949. The Forum was by mail, and anyone could contribute with either signed or unsigned letters. Contributions were mimeographed for publication and issued periodically with distribution to all first-order stations, as was the case with *Circular Letters*.[310]

The bureau announced that on March 1, 1950, the CAA planed to upgrade the teletype circuits O, C, and A from 60 to 75 words per minute.[311] This upgrade eventually allowed 20 more terminal forecasts to be transmitted on each Service A circuit.[312]

In order to facilitate the timely distribution of aviation weather, Telautograph circuits were set up. Where the first two were installed, at Chicago and LaGuardia Airport Offices, users gave enthusiastic endorsement.[313] Even though in use in 1949, Chief Reichelderfer stated in 1953, "Telautograph is not, as yet, widely used by the Bureau." Evidently such communications were

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[305] Weather Bureau *Circular Letter* **102-48**, 1948: Clearance of Text for Publication, Talks or for Local Radio Broadcasts.

[306] Weather Bureau *Circular Letter* **13-46**, 1946: Clearance of Text for Publication, Talks or for Local Radio Broadcasts.

[307] *Weather Bureau Topics*, December 1948, p. 333.

[308] *Weather Bureau Topics*, November 1949, p. 500.

[309] *Weather Bureau Topics*, March 1949, p. 376; February 1948, pp. 227, 228.

[310] Weather Bureau *Circular Letter* **42-49**, 1949: Forecaster's Forum.

[311] Weather Bureau *Circular Letter* **90-49**, 1949: Conversion of CAA Teletype Service to Seventy-five Words Per Minute Operation.

[312] Weather Bureau *Circular Letter* **10-54**, 1954: Service A Transmissions of Aviation Weather Forecasts.

[313] Weather Bureau *Circular Letter* **47-49**, 1949: Local Distribution of Airway Weather Information by Weather Telautograph Circuit.

under the control of the Regions and the MICs of the offices, and the necessary facilities were not being set up as much as desired by the Weather Bureau Headquarters.[314]

As indications of the myriad of details associated with equipment and supply, two excerpts are provided from *Weather Bureau Topics*:

> "Oiled stencil board 8 X 10 inches for use on the Revised forms 1009-48 is now stocked in the Central Office."[315]

> "No Jupiter pencil sharpening machines or cutting wheels have been issued for several years and none can be located as a source for re-sharpening the wheels. It is also understood that there are very few machines in service. Since Jupiter machines and cutting wheels therefor are no longer obtainable, the dull cutting wheels should not be forwarded to the Central Office for re-sharpening. A new pencil sharpener should be requisitioned in such cases."[316]

Three Weather Bureau offices, Upton, New York; Oak Ridge, Tennessee; and Idaho Falls, Idaho, were established in 1949 and 1950 exclusively to fulfill the needs of the U.S. Atomic Energy Commission (AEC).[317] The Upton office worked closely with the Brookhaven National Laboratory, especially in measuring and forecasting diffusion conditions. The Oak Ridge office initially investigated the micrometeorological conditions over the Oak Ridge Reservation. The office also served in an advisory capacity to the Office of Oak Ridge Operations of the AEC. Such work expanded, and by 1956, six more stations were established: Middletown, Connecticut; Shippingport, Pennsylvania; Dawsonville, Georgia; Fort Worth, Texas; and Las Vegas, Nevada. Much of the Weather Bureau experience in this field at the time was summarized in *Meteorology and Atomic Energy* prepared for the Atomic Energy Commission.[318]

For nearly 35 years, *Weather Bureau Topics* had been set in type by hand, but with the July 1949 issue the process was shifted to using the " 'justifying' typewriter, which evens the right-hand margin," and printing by the photo-offset process.[319]

During the early 1920's, the Weather Bureau maintained the only three stations in the Untied States where pyrheliometric observations of the amount of solar radiation received on a horizontal surface were taken. By the end of 1949, 71 stations in the U.S. were gathering data on solar radiation.[320] By September 1959, there were 62 operated by the Weather Bureau and an additional 26 stations operated by other organizations in co-operation with the Weather Bureau. In addition, there were five stations in the Antarctic and one in the Arctic.[321]

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[314] Weather Bureau *Circular Letter* **21-53**, 1953: Local Distribution of Weather Information by Weather Telautograph Circuit.

[315] *Weather Bureau Topics*, November 1948, p. 266.

[316] *Weather Bureau Topics*, January 1948, p. 220.

[317] *Weather Bureau Topics*, April 1949, p. 378; October 1950, p. 130.

[318] *Weather Bureau Topics*, October 1956, pp. 172-175. Reference says a total of nine, but only eight are listed.

[319] *Weather Bureau Topics*, July 1949, p. 427.

[320] *Weather Bureau Topics*, July 1949, p. 435.

[321] *Weather Bureau Topics*, September 1959, pp. 149-151.

The "rounding rule" used for many years was changed. The practice had been to round a number ending in 0.5 to the nearest even number; this was replaced by always "rounding up" for positive numbers and "rounding down" for negative numbers. The rules became exactly:

1. If the decimal to be disposed of is a five or greater, the preceding digit is increased by one.
2. If the decimal to be disposed is less than five, the preceding digit remains unchanged.
3. Algebraic signs are disregarded, e.g., 1.5 becomes 2 and -1.5 becomes -2.[322]

In 1949, the seven regional offices in the CONUS created in 1942 were consolidated into four (described in *Circular Letters* **45-49**, **83-49**, **129-49**, and **153-49**). The Regions were designated by numbers 1 through 4 with headquarters in New York, Fort Worth, Kansas City, and Salt Lake City, respectively; Anchorage remained as headquarters for Region 5. This was the catalyst for station rehabilitation, a program that was successful. In coordination with the CAA, stations were established in new airport terminals or administration buildings.[323] As part of the reorganization, instead of there being Regional Engineer positions, there were Area Hydrologic Engineers. These engineers maintained liaison with field offices of cooperating agencies, and acted in an advisory capacity to the River District Offices, RFCs, and Section Centers.[324] Also, the seven Weather Records Processing Centers established in 1947 were reduced to three in 1950, located at Chattanooga, Kansas City, and San Francisco.[325]

Actions were taken because of the Korean conflict. In 1950, two new stations were established in the Hawaiian Islands and a skeleton staff was maintained at Midway Island after the Navy no longer staffed it. This military support continued into 1951, including establishing a main meteorological office at Wake Island.[326] The Department of Commerce issued a new handbook "Security Regulation" and all personnel cleared o have access to classified information and material were provided a personal copy. The handbook specified that each cleared employee was to read and execute the security agreement.[327]

A comprehensive text on modern hydrologic methods was released by McGraw-Hill in 1950. The three authors, Ray Linsley, Max Kohler, and J. Paulhus were all employees of the Weather Bureau.[328]

Three Pacific ocean stations were being jointly operated by the Coast Guard and the Weather Bureau in 1950–NAN, OBOE, and PETER,[329] or N, O, and P, respectively (although some may remember the latter name as PAPA). The next year, the Canadian Government began operation of PETER, and the U.S. opened another station designated UNCLE. Positions of the ships changed

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[322] *Weather Bureau Topics*, December 1949, p. 528.
[323] *Weather Bureau Topics*, February 1950, pp. 20, 21; June 1952, pp. 96-98.
[324] Weather Bureau *Circular Letter* **13-50**, 1950: Adjustment of Field Program for Hydrologic Services.
[325] Weather Bureau *Circular Letter* **2-50**, 1950: Consolidation of Weather Records Processing Centers.
[326] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1950, p. 6; 1951, p. 3
[327] Weather Bureau *Circular Letter* **26-51**, 1951: Security Regulations Handbook.
[328] *Weather Bureau Topics*, January 1950, p. 4.
[329] *Weather Bureau Topics*, January 1950, p. 7.

from time to time.[330] In September 1951, the Pacific Station "V" became operated by the Coast Guard and Weather Bureau, taking over from the U.S. Navy.

The Division of Climatological and Hydrologic Services formed in 1946 was separated into the Climatological Services Division and the Hydrologic Services Division, effective September 15, 1951. These divisions were headed by W. F. McDonald (temporarily) and W. E. Hiatt, respectively.[331] Also, as of March 20, 1951, the three Area Training Offices were consolidated, leaving only the one in Kansas City.[332]

Weather Bureau personnel were occasionally being called into active duty, sometimes for a 5-day period during which it was determined whether or not they were physically and otherwise acceptable for extended active duty. In other cases, 30 days were given for them to put personal affairs in order and to report for active duty.[333]

The Teletype Corporation of America requested the CAA to recognize that "teletype" was trademarked, and should not be used generically. To be in conformance, the Weather Bureau instructed the preferred usage was "teletypewriter" as noun and adjective and "teletypewrite" as verb.[334]

Public Law 657 directed the Weather Bureau to investigate severe storms such as thunderstorms, squalls, tornadoes, hurricanes, etc. It was planned in 1950 to establish a dense network of observing stations in the Midwest for this purpose, and to specifically investigate the "pressure jump" hypothesis proposed by Morris Tepper of the Weather Bureau and published in the *Journal of Meteorology* in February 1950.[335] By 1956, networks of automatic pressure jump indicators were operating under the direction of the Severe Local Storms Research Unit of the Office of Meteorological Research (OMR) headed by Dr. Harry Wexler. *Weather Bureau Topics* states, "The networks thus make it possible to detect and to determine the orientation and movement of pressure jump lines through the area. The forecaster at each of the key stations can then predict the time of arrival at any point…, and can be quite sure that if a severe storm is to occur, it will occur with or very near the time of passage of the pressure jump line. In this respect, the pressure jump line can be considered as a triggering mechanism, with severe storms occurring along its length only at such places where other necessary condition exist."[336] On February 1, 1953, distribution of pressure jump data started on Service A.[337] Later, it was noted that radar was able to detect weak, narrow line echoes associated with the passage of a wind-shift line and accompanying pressure rise or jump.[338]

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[330] *Weather Bureau Topics*, January 1951, p. 12.

[331] *Weather Bureau Topics*, September 1951, p. 163.

[332] Weather Bureau *Circular Letter* **12-51**, 1951: Reorganization of the Training Section.

[333] Weather Bureau *Circular Letter* **14-51**, 1951: Military Duty, and Procedure for Notification to Central Office; **24-51**: Military Duty, and Procedure for Notification to Central Office.

[334] *Weather Bureau Topics*, September 1951, p. 164.

[335] *Weather Bureau Topics*, January 1950, p. 9.

[336] *Weather Bureau Topics*, September 1956, pp. 152-154.

[337] Weather Bureau *Circular Letter* **4-53**, 1953: Utilization of Pressure Jump Data.

[338] *Weather Bureau Topics*, January 1958, p 8.

The Weather Bureau had been interested in facsimile for many years, the first transmission being in 1926. The Air Weather Service was operating a large number of machines on a nationwide network put into operation in 1947, but maintenance problems were difficult to solve. In 1948, the Weather Bureau judged that improvements were necessary before a nationwide program would be established.[339] Finally, in 1951, the Bureau was installing facsimile equipment at nine locations. Experimental use at Weather Bureau Airport Station (WBAS) St. Louis and Weather Bureau Station Chicago in 1950 had been enthusiastically received. Most material originated with the WBAN Analysis Center. Only 55 to 60 charts could be transmitted per day owing to the 22 minutes it took to transmit one 12 x 16 inch chart and circuit line-up time. This relieved station personnel of some work and in each case personnel offsets were possible.[340,341] The facsimile program of the WBAN Analysis Center, along with a diagram showing the communication network, was provided in March 1955, prior to the establishment of the National Analysis Center.[342] This was updated after the WBAN Analysis Center became the National Analysis Center.[343]

As of July 17, 1951, the title of the person in charge of a station was called "Meteorologist in Charge" (MIC) rather than the title generally used "Official in Charge," except at those stations under the supervision of another station in the same city or locality. If the position were other than Meteorologist, the working title would so indicate, for example, "Observer in Charge." The title of the airport station supervisor working under the direction of a city office MIC became "Chief Airport Meteorologist" rather than "Official in Charge." The title of the city office supervisor, working under the direction of an MIC at the Airport, became his working title, such as "Meteorologist," "Climatologist, or "Section Director." [344] The MIC in a city or locality was in charge of all offices in that city or locality. This gave considerable authority to the MIC. For instance, he was responsible for full coordination of all units to provide the most effective service with assigned staff, and could interchange personnel between units regularly or in emergencies for more effective utilization of staff and liquidation of leave.[345]

Department Order No. 68 (amended), issued May 21, 1952, increased the authority delegated to the Bureau to administer personnel activities. The Chief then increased the authority of the Regional Directors (RD) in several ways. For instance, all actions concerning grades GS-7 and below could be handled by the RD.[346]

In 1951, the Bureau announced that a National Weather Records Center (NWRC) would be established at Asheville, North Carolina, to be operated jointly by the Weather Bureau, Navy, and Air Force. It would replace the present New Orleans Tabulation Unit, and the facilities would be moved to Asheville. The quarters to be occupied were the four-story Government owned Arcade

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[339] *Weather Bureau Topics*, August 1948, pp. 289, 290.

[340] Weather Bureau *Circular Letter* **17-51**, 1951: Joint National Facsimile Network.

[341] *Weather Bureau Topics*, September 1951, p. 170.

[342] Weather Bureau *Circular Letter* **8-55**, 1955: The Facsimile Chart Program of the WBAN Analysis Center.

[343] Weather Bureau *Circular Letter* **32-55**, 1955: The Facsimile Chart Program of the National Weather Analysis Center.

[344] Weather Bureau *Circular Letter* **21-51**, 1951: Change in Organizational Title of "Official in Charge."

[345] Weather Bureau *Circular Letter* **22-51**, 1951: Coordination of Multiple Offices in One Locality.

[346] Weather Bureau *Circular Letter* **31-52**, 1952: Delegation of Authority to Regional Directors to Administer Personnel Activities.

Building. The move involving some 300 persons and 3 million pounds of records and equipment was planned for early 1952. As stated in *Weather Bureau Topics*, "The primary business will be the handling, filing, cataloging, tabulating, and summarizing what probably amounts to the greatest assembly of observational meteorological data in the world."[347] In January 1952, the Central Office Radiosonde Verification Unit (RAVU) moved there.[348] In the July 1955, the Northern Hemisphere Historical Map Unit moved from Federal Office Building (FOB4) in Suitland, Maryland, to NWRC; the Unit produced, each month, one time per day sea-level pressure and 500-mb maps. The series was planned to extend from 1899 to current time.[349] Later in 1970 under the newly formed Environmental Science Services Administration's Environmental Data Service, NWRC was renamed the National Climatic Center.[350]

Storm warning flags and lanterns were still being used in 1944[351] and flags in 1950,[352] a practice started prior to 1880.[353]

A publication, "Machine Methods of Weather Statistics," was prepared in 1950 and distributed. This was to publicize the extensive punched card files that existed in New Orleans,[354] the results of a project that started in 1937.[355]

The Weather Bureau purchased a new airplane, a 5-passenger Cessna Model 190 to replace an aged "Norseman." The airplane was equipped with modern instruments and radio air-navigation aids, including VHF radio equipment that permitted navigation by reference to the new CAA "omni-range" type radio ranges. It was used for in-flight checking and on-station inspection of the domestic aviation weather service, and for familiarization of personnel with practical bearing on their day-to-day work on the safety and efficiency of flight operations. One of the pilots was George Brewster, who championed the use of an airplane to secure first-hand operational contacts for evaluation of the aviation weather service.[356]

Machine checking of radiosonde data resulted in increased accuracy and value of upper level data in 1950. Also, procedures for the use of the new Electronic Flood Routing Machine to provide faster and more accurate analysis of data for flood forecasting were being established.[357]

The World Meteorological Organization (WMO) was established as a specialized agency of the Untied Nations in March 1951. It was the successor to the less formal International Meteorological

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[347] *Weather Bureau Topics*, November 1951, pp. 202, 203; September 1952, pp. 131, 132.
[348] *Weather Bureau Topics*, February 1952, p. 17; October-November 1953, pp. 114-116 .
[349] *Weather Bureau Topics*, October 1955, pp. 156, 157.
[350] *ESSA News*, **6**, June 12, 1970, p. 2.
[351] Weather Bureau *Circular Letter* **11-44**, 1944: Directional Displays of Storm Warnings.
[352] *Weather Bureau Topics*, March 1950, p. 38.
[353] Drum, R. O., Annual Report of the Chief Signal Officer (acting) for 1880, pp. 199, 200.
[354] *Weather Bureau Topics*, March 1950, p. 39.
[355] Gregg, W. R., Report of the Chief of the Weather Bureau for 1937, p. 9.
[356] *Weather Bureau Topics*, July 1950, p. 95.
[357] *Weather Bureau Topics*, October 1950, p. 130.

Organization which had been in existence since 1878. The member states elected Chief Reichelderfer as its first president.[358]

The Daily Weather Map started in 1871[359],[360] had been a mainstay ever since, 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 might be of benefit.[361] They evidently fulfilled their purpose, and were being lauded by a forecaster in 1957.[362] The map-back program was expanded, and from July to October 1959, 35 map backs were published.[363] The Daily Weather Maps were being sent to all stations daily. They served multiple purposes, in addition to the usefulness of the map-backs. They provided a standard with which locally prepared maps could be compared; they could be used for training meteorological aids; the data were more accurate and complete than those on facsimile maps; and they were to be retained and could be used for research.[364]

In 1951, the FAWS and Aviation Forecast Units were being combined as first steps in a sweeping reorganization of Flight Advisory Warning Service and Aviation Forecasting, a reorganization that would probably not be completed until 1953. The Aviation Forecast Regions were made to coincide with the Air Route Traffic Control (ARTC) Areas.[365]

A pilot project for cooperative climatological work involving machine card processing of backlog records was developed at Iowa State College in 1943. This expanded to the Universities of Missouri and North Carolina. A standard procedure was developed, and by May 1951, requests for information about such cooperative projects were received from 26 states.[366]

The Weather Bureau, continuing to search for means of adequately meeting the increased demands for weather information, planed in 1951 to install at Durham, North Carolina, an automatic telephone forecast distribution service. This service, by which persons who call a certain number would hear a recorded local forecast, was somewhat similar to the system installed in a number of large cities by the telephone companies. This would be the first Bureau owned system.[367] By April 1953, 10 such systems had been installed.[368]

In addition, taking a cue from the success of automatic WE 1212 success in several cities,[369] the Weather Bureau obtained the frequency of 162.55 megacycles and inaugurated an automatic, continuous recorded FM broadcast of aviation weather information. The information was stored on

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[358] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1951, p. 4.
[359] Meyer, A. J., Annual Report of the Chief Signal Officer for 1871, p. 7.
[360] *Weather Bureau Topics*, May 1961, p. 77.
[361] *Weather Bureau Topics*, November 1951, p. 213.
[362] *Weather Bureau Topics*, November 1957, p. 214.
[363] *Weather Bureau Topics*, October 1959, p. 174.
[364] Weather Bureau *Circular Letter* **15-57**, 1957: Use of the Printed Daily Weather Map.
[365] *Weather Bureau Topics*, December 1951, p. 219.
[366] *Weather Bureau Topics*, December 1951, p. 221.
[367] *Weather Bureau Topics*, January 1951, p. 14.
[368] *Weather Bureau Topics*, April l953, p. 33.
[369] Ten cities were using this service by August 1952, *Weather Bureau Topics*, September 1952, p. 133.

magnetic tape and revised as needed at LaGuardia Field, New York. It could be heard within a radius of 30 miles.[370] A second such station was inaugurated in 1953 in Chicago.[371] By 1955, a station had been operating at Arcola, Virginia, and it was planned to implement 21 other locations in 1956.[372] Pilot response to the Arcola broadcasts was very positive.[373]

A Federal Inter-Agency River Basin Committee (FIARBC) was formed in 1943 to better utilize, conserve, and control the nation's water resources. Members included the U.S. Departments of War (Army), Interior, and Agriculture, and the Federal Power Commission. The Department of Commerce joined in 1946, and later the Federal Security Agency. The Weather Bureau was particularly interested in the subcommittee on hydrology.[374] Regional committees were established to implement the policies and purposes of FIARBC by providing a means through which the field representatives could effectively coordinate water-resource development activities.[375]

With the January issue of 1952, *Weather Bureau Topics* went to a larger page format, the first change in page size since *Weather Bureau Topics and Personnel* started in 1915. Stated in the 1952 issue:

> *"Weather Bureau Topics* is published monthly to inform all employees about newsworthy operations and work programs of the Bureau; to give background on instructions; to carry news of new personnel assignments, retirements, deaths, and similar information about employees; and to serve as a medium through which ideas and views may be exchanged to promote efficiency and teamwork in attaining our common goals. While the contents, unless otherwise specified, reflect the Central Office viewpoint, they are not instructions but are presented for information. Opinions, discussions or comments by readers are invited; they should be marked for the attention of the Editor, *Topics*. *Weather Bureau Topics* is distributed for official use only." [376]

The annual and sick leave act of 1951 went into effect January 6, 1952. Essentially, it provided 13.5 days annual leave for those having less than 3 years service, 20 days for those having 3 to 15 years, and 26.5 days for those with over 15 years service.[377]

The Weather Bureau established a new mountain observatory near the summit of Mauna Loa, one of Hawaii's still active volcanoes. Standard first-order station instrumentation was installed together with special recorders for wind direction and speed, sunshine, and precipitation, which would operate unattended continuously for three months or more. The February 1952 *Weather Bureau Topics* noted that the establishment had been recommended in 1920 by the first Pan Pacific Science Congress. The minimum access road was completed using prison labor. The Territory had

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[370] *Weather Bureau Topics*, May 1951, p. 93.
[371] *Weather Bureau Topics*, June 1953, p. 67.
[372] *Weather Bureau Topics*, February 1956, p. 28.
[373] *Weather Bureau Topics*, November 1955, p. 184.
[374] *Weather Bureau Topics*, December 1951, p. 222.
[375] *Weather Bureau Topics*, March 1952, p. 32.
[376] *Weather Bureau Topics*, January 1952, p. 2.
[377] Weather Bureau *Circular Letter* **2-52**, 1952: Annual and Sick Leave Act of 1951.

a plan to develop a winter sports park above the snowline (about 12,000 ft.).[378] On June 28, 1956, a "slope" unit was dedicated to augment the one at the summit that was erected in 1951.[379]

The Weather Bureau established a 1-year program to evaluate a new instrument, the turbulence telemeter, or "gustsonde," in collaboration with the National Advisory Committee for Aeronautics. Observations were being made at Silver Hill Observatory, Maryland; Grand Junction, Colorado; Miami, Florida; and Caribou, Maine. [380]

The SKEW T-log p adiabatic diagram made its debut in 1952. Brought into play by the Air Force, the Bureau obtained enough to send some to each station for trial use. Air Weather Service manual 105-124 was available for explanation of this chart designated AWS APC 9-16. However, the Bureau deemed that it was not to be used at raob stations in lieu of WBAN-31A-B for evaluating raobs.[381]

Weather Bureau *Circular Letter* No. 52-50 provided for warnings of tornadoes in official weather forecasts issued by the Bureau whenever the facts "made verification of the forecast reasonably certain." While warnings of severe local storms, which at times were designated to include tornadoes, had been published by the Weather Bureau for many years, it was not until March 1952 that 12- to 24-hour tornado warnings began as a regular service.[382] Such service was not without difficulty, and in April 1952, Chief Reichelderfer wrote, "In some parts of the country there have recently been severe criticisms of the Weather Bureau in press and over radio with reference to warnings of destructive local storms, especially tornadoes." He issued a 3.5-page *Circular Letter* explaining the program, the difficulties involved, and how to address them. He stated there were two general bases for local warnings:

> "First, the synoptic weather situation which normally reveals conditions conductive to development of severe squalls and tornadoes in any particular region within the ensuing 24 hours.
>
> "Second, local storm reporting networks which provide for telephoning to the nearest Weather Bureau Office immediately and reporting destructive local storms actually observed. This affords means for the local forecaster to prepare immediate warnings to people directly in the path of the storms." [383]

Beginning May 12, 1952, the WBAN Analysis Center started issuing "National Severe Weather Round-Ups" or bulletins describing lines, zones, and areas of severe local weather conditions. These were to aid field forecasts, who still had the responsibility for issuing the official warnings.[384]

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[378] *Weather Bureau Topics*, January 1952, p. 6.
[379] *Weather Bureau Topics*, September, 1956, pp. 141, 142.
[380] *Weather Bureau Topics*, January 1952, p. 10.
[381] Weather Bureau *Circular Letter* **41-52**, 1952: SKEW T-log p Adiabatic Diagram.
[382] *Weather Bureau Topics*, February 1952, p. 37; March 1953, p. 19.
[383] Weather Bureau *Circular Letter* **14-52**, 1952: Tornado Warnings.
[384] Weather Bureau *Circular Letter* **20-52**, 1952: Severe Weather Bulletins.

Implementation of a new phonetic alphabet was started in 1952. The one previously in use "was adopted by English speaking people for use by English speaking people" and contained words which were either not known or pronounced differently by users of other languages. It was expected this alphabet would be adopted by other agencies, both national and international.[385]

On March 10, 1952, a group of Central Office personnel, led by the Scientific Services Division, met to discuss the desirability of couching forecasts in terms of probability. It was pointed out that probabilistic forecasts were already being made, including quantitative precipitation forecasts for the Los Angles area by an objective method in a form which gave probabilities of the complete range of possible precipitation values. A conclusion was: "In general, but by no means unanimous, opinion seemed to be that, for specialized users who understand them, the probability forecasts are helpful, but that they might be confusing to the general public." [386,387] How little progress has been made in the last 60 years!

In 1952, the Weather Bureau announced: "An electronic flood routing analogue was installed in each of seven RFCs. The apparatus automatically produces the hydrograph for the lower end of any selected river reach while the operator traces with a stylus the hydrograph of the expected inflow at the upper end of the reach. Thus, the predicted timing, peak, duration, and slope of the flood hydrograph for the downstream point become known in a few minutes." [388]

In order to make timely forecasts, the observational data need to be timely. To increase the time the forecaster had to study the upper air data, the Weather Bureau raob stations in the continental United States were authorized to transmit the first part of their raob report, if available, with their pibal or rawin report, effective October 24, 1952.[389] This was evidently the start of the "first transmission" later well known to forecasters.

The Weather Bureau policy with respect to cooperation with those engaged in the private practice of applied meteorology was stated in *Circular Letter* **22-48**, and was repeated in *Weather Bureau Topics*:

> "It is a responsibility of the Weather Bureau to gather weather observations and distribute meteorological information including reports and forecasts for agriculture, aviation, commerce, navigation and other general branches of the business community and the general public. The Bureau also has a responsibility to promote and develop meteorological science and its

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[385] *Weather Bureau Topics*, February 1952, p. 38.

[386] *Weather Bureau Topics*, March 1952, p. 56.

[387] 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, 84 pp. This Technical Memorandum, although it is in the Office of Meteorology series, was authored by the Chief of the Scientific Services Division in the Central Region. It is a definitive history of the beginnings of the probability forecasting program in the NWS, and gives appropriate references. The first probability forecasts issued to the public were from the forecast office in San Francisco in 1956 A nationwide program was started in 1965, and forecasts were issued to the public in 1966.

[388] *Weather Bureau Topics*, April 1952, p. 59.

[389] Weather Bureau *Circular Letter* **36-52**, 1952: Earlier Transmission of Continental U.S. Raob Reports on Service C. (There are two *circular letters* with this number; likely the second was misnumbered.)

> practicable applications in benefit of the national economy and national defense. Under this provision, the Bureau encourages extension of the private practice of meteorology in specialized services to business and private individuals. However, it is not the function of a Government agency like the Weather Bureau to offer individual services. In its meteorological services to the general public the Bureau cannot give attention to many of the local features of weather that are of significance in private commercial and industrial operations... . Cooperation between private meteorologists and the Weather Bureau in extending the applications and benefits of meteorology into fields beyond the scope of the Bureau's services to the general public brings manifold advantages... ."[390]

Essentially this same policy was repeated in *Circular Letters* **13-54** and **6-55**, and in an editorial by Chief Reichelderfer in 1963.[391]

By 1952, an instrument with trade name "Metameter" that allowed the reading of a thermometer remotely had been installed at Baltimore's Friendship Airport for reading the temperature at the old City Office, and at Weather Bureau Office (WBO) Cincinnati for reading the temperature from the Abbe Observatory.[392] Also, seven local teletypewriter circuits were operating–Boston, Baltimore, Houston, Los Angeles, New York, Pittsburgh, and San Francisco,[393] and the number continued to grow to 11 in 1953[394] and to 55 in 1956.[395] Such local networks were encouraged since 1948, when one had been established in two large cities.[396]

In recognition of suggestions, the Weather Bureau carefully considered in 1951 the collection and dissemination of reports on the conditions of highways. The conclusion was this was a service "quite beyond the scope of the Weather Bureau." [397] However, the Bureau was willing to cooperate with agencies that carry the main responsibility for this service, particularly when the reports dealt with hazardous driving conditions resulting directly from weather or flood, and so stated this in 1957.[398]

Multiple Address Letter No. **127-52** announced the selection of the first Area Climatologist.[399]

In 1950, a new distribution of forecasts was tried in Georgia, whereby the state was divided into areas or zones, and a forecast for each zone was furnished thrice daily to press associations. By 1953, there were 19 states with a rather uniform program of such forecasts. This program was in addition to the localized forecasts for specific communities that had been made for a number of

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[390] *Weather Bureau Topics*, June 1952, p. 68.

[391] *Weather Bureau Topics*, June-July 1963, p. 91.

[392] *Weather Bureau Topics*, June 1952, p. 94. The Abbe Observatory was built in 1915 by the Weather Bureau. It was the only weather station with a commemorative name. Ownership of the observatory was transferred to the University of Cincinnati in 1965.

[393] *Weather Bureau Topics*, September 1952, p. 130.

[394] *Weather Bureau Topics*, October-November 1953, p. 112.

[395] *Weather Bureau Topics*, December 1956, p. 226.

[396] Weather Bureau *Circular Letter* **88-48**, 1948: Local Public Service Weather Teletype Circuits.

[397] *Weather Bureau Topics*, September 1952, p. 135.

[398] Weather Bureau *Circular Letter* **10-57**, 1957: Weather Bureau Cooperation in Distributing Road Conditions.

[399] *Weather Bureau Topics*, November-December 1952, p. 152.

years.[400] By August 1954, the number of states with such a program had grown to 31.[401] By 1955, 43 states were making more localized forecasts over areas called "zones."[402] While the locations, sizes, etc. would vary over time, the terminology "zone forecasts" would extend into the next century when the "zones" actually became counties.

As announced by Chief Reichelderfer, "The name 'Celsius' will be used to designate the centigrade degree for temperature in official communications publications, manuals, records, forms, etc...., beginning January 1, 1953." This name was in use by the WMO, the Civil Aviation Organization, and many other scientific organizations.[403]

The Bureau's agricultural meteorology program was under review in 1953. Each MIC was asked to make a short resume of the station's activities. The Bureau was the "executive agency" of the United States with respect to membership in the WMO. It's Commission for Agricultural Meteorology was meeting in Paris, and the Bureau wanted to report on programs over the past 6 years.[404]

In May 1953, the Secretary of Commerce appointed an Advisory Committee on Weather Services (ACWS). The committee published its report December 1, 1953.[405] The report contained various exhibits from the Bureau, including *Circular Letter* **22-48** "Policy With Respect to Private Practice of Meteorology and Instructions Regarding Cooperation with Private Meteorologists." Chief Reichelderfer summarized the report as follows:

> "In general, the recommendations of the Committee support the policies and plans of the Weather Bureau. The principal distinction is that the Committee urges faster action in carrying out such things as decentralization of forecasting, encouragement of younger well qualified professional personnel, and a delegation of certain additional duties to the Regional level. The Bureau undertook some years ago to bring most of these plans into operation but in order to avoid interruption of services and possible dislocation of personnel, the practice has been to modify such programs as forecasting on a step-by-step basis with considerable care and examination of results before proceeding further. This necessarily takes much longer than would be the case under a general reorganization. It was believed to be a more certain–a slow but sure–process that would represent also the least impairment of morale and hardship to personnel involved in transfers under difficult housing conditions and present high costs of moving. With the emphasis on a speedier action by the ACWS, a study is being made to see what measures should be taken in the near future. Field personnel will be kept advised of these plans as rapidly as they can be formulated and released for information of all concerned."[406]

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[400] *Weather Bureau Topics*, July 1953, p. 80.
[401] *Weather Bureau Topics*, August 1954, p. 78.
[402] *Weather Bureau Topics*, July 1955, p. 105.
[403] Weather Bureau *Circular Letter* **42-52**, 1952: Meteorological Terminology: Celsius (Centigrade).
[404] Weather Bureau *Circular Letter* **22-53**, 1953: Review of the Agricultural Meteorology Program.
[405] U.S. Secretary of Commerce Press Release, December 11, 1953.
[406] Weather Bureau *Circular Letter* **31-53**, 1953: Publication of Report of Advisory Committee on Weather Services.

Many of the actions taken in the next few years were in agreement with the Committee's recommendations. The report noted, "We should like to make it clear that we believe the present Chief of the Bureau has served with a devotion to duty, and conscientious effort, seldom found in any organization." The report also commented on the "frugality of this Bureau's operation ... (and) is to be commended in the manner which they have administered public funds. We know of no other government agency that has been so economical in the expenditure of its funds." The committee presented a rough comparison of the per capita costs of weather services in other countries, showing the United States as 18 cents; England, 20 cents; U.S.S.R., 47 cents; and Canada, 50 cents.

Interviews with field employees by the ACWS found many who stated that they were not certain about the policies of the Bureau with respect to cooperation in the development of the private practice of meteorology. Accordingly, the Bureau again provided by *Circular Letter* the relevant policy, and provided a number of prior documents and talks stating the policy.[407]

The aviation forecast underwent change on October 15, 1953. Voluminous documents were prepared so that they could be eventually substituted in Chapters B-20 and 21 of the Weather Bureau Manual.[408] Shortly, the instructions were modified to substitute knots for miles per hour. When referring to distance, miles would be used with the understanding they were nautical miles, not statute.[409] Further instructions were issued clarifying that most uses of wind speed were still miles per hour, including climatological records. But punching of WBAN Card Nos. 1 and 3 were to be in whole knots.[410]

Once again in 1954, the use of local teletypewriter circuits was encouraged. Although weather information was distributed by the press, radio, television, and automatic telephone, such local circuits had proven useful. Instructions were provided for the establishment of such circuits.[411] In a change in policy, the Bureau was willing to pay for the communications equipment in the Weather Bureau Office and the connecting line to the communications office; previously, subscribers had been required to share the expenses.[412]

For several years after the inauguration of the *Average Monthly Weather Resume and Outlook* in 1948, the printed prognostic charts carried the notation "Not for Publication." During this period, the Central Office consistently discouraged the publication of the charts by newspapers and magazines on the basis that without the special data on page 1, the charts were too rigidly interpreted with respect to local areas and could not be properly interpreted anyway without the auxiliary charts and guidance material carried in the original publication. This restriction was removed in 1953, after a press association and some magazines and papers began republication of the charts from the printed outlook.[413]

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[407] Weather Bureau *Circular Letter* **13-54**, 1954: Cooperation With Meteorologists in Industry.
[408] Weather Bureau *Circular Letter* **23-53**, 1953: Modification of Domestic Aviation Forecast Program.
[409] Weather Bureau *Circular Letter* **27-54**, 1954: Use of Knots as Dimensional Unit in Aviation Forecasts.
[410] Weather Bureau *Circular Letter* **31-54**, 1954: Recording Wind Data.
[411] Weather Bureau *Circular Letter* **34-54**, 1954: Local Public Service Weather Circuits.
[412] Weather Bureau *Circular Letter* **38-55**, 1955: Local Public Weather Teletypewriter Circuits.
[413] *Weather Bureau Topics*, December 1953, p. 129.

Chief Reichelderfer stated in his 1953 annual report, "Of the instruments needed, the most important and most costly are radars used for storm detection. The Bureau has developed inexpensive means of converting surplus and obsolescent airplane-detection radar equipment for weather observations use on the ground and has managed to double their range from 50 to 100 miles." He also stated, "One of the most important developments was the design of an unattended station which takes observations and automatically sends the reports on the teletype, doing the work of a group of observers and communicators."[414]

In March 1954, the Weather Bureau encouraged local stations to add information about expected weather beyond the regular period covered by the daily forecast when the synoptic situation and available guidance from the forecast centers made it possible to do so.[415] It was suggested the FP 1 forecasts prepared by District Forecast Centers and being sent on Service C include brief information for "the third day ahead." This was to help local officials in their preparation of tailored forecasts for agriculture. It was recognized that "it may not be possible to include more than a statement that precipitation is or is not expected or that conditions are 'unsettled.' " [416] The *circular letters* noted that the Bureau's "long term objective is to provide the farmer by radio at his breakfast hour with weather advice suited to his requirements, as localized as possible, for as long in advance as we can prepare reliable outlooks." The Bureau went so far as to provide tables of farming operations related to specific crops in specific locations. For instance, if rain were expected in the critical period May 10-20, the advice in Pima county to cotton farmers would be to "delay planting."[417] The inclusion of the third-day outlook in the FP 1 forecasts was emphasized in May 1956.[418]

Each year since the first explosion of the atomic bomb, the Weather Bureau received many requests about the possible effects on the weather. The Bureau stated in 1954, that it had in cooperation with the AEC, tracked radioactive clouds and found no instance of an affect on weather beyond a few miles from the explosion. However, because of the potential importance and the considerable interest from the public, a study was started to document, insofar as possible, all plausible relationships between the firing of atomic weapons, their radioactive debris, and weather conditions.[419]

Instructions were issued in 1954 that "All field personnel should become familiar with techniques for computing fallout of radioactive debris resulting from atomic explosions in order that they will be able to provide information to Civil Defense authorities in case of a disaster or in connection with Civil Defense exercises." [420] The techniques were modified in 1955 by the AEC for thermonuclear weapons because of the higher penetration into the atmosphere.[421] On June 1, 1955, it became mandatory that fallout winds would be computed for 15 specific stations and

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[414] Reichelderfer, F. W., Report of the Chief of the Weather Bureau for 1953, p. 2.
[415] *Weather Bureau Topics*, March 1954, p. 19.
[416] Weather Bureau *Circular Letter* **5-54**, 1954: Localized Forecasts and Advices for Agriculture.
[417] Weather Bureau *Circular Letter* **6-54**, 1954: Specialized Forecasts for Agriculture.
[418] Weather Bureau *Circular Letter* **19-56**, 1956: Third-Day Outlook in Guidance forecasts (FP-1).
[419] *Weather Bureau Topics*, March 1954, p. 25.
[420] Weather Bureau *Circular Letter* **16-54**, 1954: Fallout of Radioactive Debris from Atomic Bombs.
[421] Weather Bureau *Circular Letter* **7-55**, 1955: Fallout of Radioactive Debris.

transmitted.[422] On January 16, 1956, the number of stations was increased to 39 Weather Bureau and 11 military stations.[423] Information was issued regarding the Bureau liaison activities with the various levels of the Civil Defense Agencies–Federal, State, and Local. Two Bureau meteorologists were assigned at the Federal level to work in Battle Creek, Michigan.[424] On July 2, 1958, the Bureau participation in the Federal Fallout Monitoring Network became effective. The general objective was to develop and maintain, within Weather Bureau facilities, the capability to observe and report radiation dose rates, not only for purposes of self-preservation but also as an important contribution to local and national survival efforts in the event of a nuclear attack.[425] A Radiation Dosage Calculator was supplied to each first order station.[426]

Observing and forecasting dew is important for agriculture. For instance for wheat rust, the spores must be in contact with the plant and be wet for a sufficient period, generally 6 to 9 hours, to develop. Two stations–Bismarck and Fargo, North Dakota, made dew observations in the summer of 1953. In response to *Circular Letter* **22-53**, six local offices in the cotton region took observations in 1954. The Weather Bureau hoped to expand the dew investigation network in 1955.[427]

In response to numerous suggestions, the Weather Bureau in 1954 studied the efficiency and expense of punching of cards locally and centrally. It was found that the current practice of local punching was preferable and would be continued.[428]

A "mapped forecast" program started in 1954 was expanded in 1955. While not explained in detail in the reference, it evidently involved making a map of the forecast, and then sending it in coded form on Service C in conjunction with the FP-1 guidance material. It was hoped the forecast could eventually be sent on facsimile, thereby eliminating the coding and decoding and making it more useful.[429] This program started in the East, and expanded westward.[430,431,432]

The Weather Bureau was in the process of establishing State Forecast Centers. Guidance would be furnished by the District Forecast Centers, and the State Forecast Centers would issue the FP State

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[422] Weather Bureau *Circular Letter* **24-55**, 1955: Computation of Civil Defense Fallout Winds.

[423] Weather Bureau *Circular Letter* **2-56**, 1956: Computation of Civil Defense Fallout Winds.

[424] Weather Bureau *Circular Letter* **41-55**, 1955: Liaison with State and Local Civil Defense Agencies.

[425] Weather Bureau *Circular Letter* **5-58**, 1958: Implementation of Weather Bureau Participation in Federal Fallout Monitoring Network.

[426] Weather Bureau *Circular Letter* **11-58**, 1958: Radiation Dosage Calculators.

[427] *Weather Bureau Topics*, July 1954, p. 36.

[428] *Weather Bureau Topics*, July 1954, p. 65.

[429] *Weather Bureau Topics*, November 1955, p. 185.

[430] Weather Bureau *Circular Letter* **13-55**, 1955: Mapped Forecast Experiment–Kansas City.

[431] Weather Bureau *Circular Letter* **17-55**, 1955: Mapped Forecast Experiment–Washington District.

[432] Weather Bureau *Circular Letter* **11-56**, 1956: Changes in State Forecast Responsibility (FP) for Minnesota, Ohio, Kentucky, and Tennessee.

Forecasts based on the mapped FP-1s from the WBAN National Center.[433] They would also be assigned responsibility for the Shippers' Temperature Forecasts.[434]

In June 1954, The Weather Bureau Library moved to FOB4 in Suitland, Maryland. It had at its inception with the Signal Service been located on G Street, then was moved to the Ferugson Building when the Signal Service moved. Before moving to FOB4, it was located in the Packard Building, one-half block north of the Central Office Administration Building for about 7 years.[435]

On July 1, 1954, the Joint Numerical Weather Prediction Unit (JNWPU) began its official life. It was organized under a joint agreement between the Weather Bureau, Air Weather Service, and Navy Aerological Service. The purpose of the unit was to convert to routine procedure the forecasting methods developed through research in NWP, and to produce prognostic weather charts on an operational basis using numerical techniques. It had long been a goal in meteorology to obtain an accurate quantitative answer to the problem of describing the atmosphere by means of the basic physical equations, but until recently, the efforts had been stalled by the seemingly endless calculations required. The plan was to start with simple models following a plan laid down by Jules Charney and the pioneering work at the Institute of Advanced Study at Princeton, New Jersey. Quarters were readied in FOB4. The computer was to be delivered about March 1955. Charts of constant pressure, temperature, and vertical velocities, and precipitation would be produced initially, and probably for only 24 hours in advance. The area covered was to be North America, to be expanded to the Northern Hemisphere in about 2 years. In addition to prediction, the need for objective analysis of data was recognized. Although much of the drudgery of calculations would be taken over by the computer, the problem of interpretation of the improved prognostic charts in terms of "weather" for the present would remain the problem of the forecaster. As the forecaster "... is gradually relieved of the necessity for making the large-scale prognosis, he will be able to devote more of his time to translating his prognosis into smaller-scale weather effects, taking into account more effectively topography, coastlines, and other influences."[436] The latter was a great prediction; it is also a great prediction of the future even today!

Following devastating hurricanes in 1954 (Carla, Edna, Hazel) and 1955 (Connie, Diane), Chief Reichelderfer, with funds specifically appropriated by Congress for modernizing the hurricane warning network and for research, formed the National Hurricane Research Project (NHRP) with Dr. Robert Simpson as Director. Later, following the formation of the Environmental Science Services Administration, NHRP became the National Hurricane Research Laboratory (NHRL) in 1964.[437,438]

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[433] Weather Bureau *Circular Letter* **35-54**, 1954: State Forecasts (FP) for New York, Maryland, and Delaware.

[434] Weather Bureau *Circular Letter* **10-55**, 1955: State Forecasts (FP) for Pennsylvania and Southern New Jersey.

[435] *Weather Bureau Topics*, September 1956, pp. 146-148.

[436] *Weather Bureau Topics*, December 1954, pp. 109, 110.

[437] Dorst, N. M., 2007: The National Hurricane Research Project: 50 years of research, rough rides, and name changes. *Bul. Amer. Meteor. Soc.*, **88**, 1966-1988.

[438] 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.

About March 1, 1955, the National Weather Analysis Center (NWAC) moved to FOB4 in Suitland, Maryland, and was now adjacent to the newly formed JNWP; prior to that time, it was named the WBAN Analysis Center and was in the Old Main building at 24th and M Streets in Washington, D.C. Established as a joint center, the Bureau was authorized to take over the operation as of July 1, 1955.[439] As of May, 1955, a total of 187 persons were employed by the Center, 104 from the Weather Bureau, 45 from the Air Force, and 38 from the Navy. It occupied 13,215 square feet of floor space in FOB4. Its products were extensive.[440]

By November 1955, the 36-h 500-mb prognostic chart produced by JNWPU was being transmitted on Service C in code, about 9 hours after data time. This did not replace the official NWAC chart, and was primarily to get forecasters used to the product. The model was a three-level baroclinic model developed by Charney[441] with a grid spacing of "about 300 km (or, to be exact, 0.8 inches on a mapscale of 1:15 million)." The most restrictive assumptions were as follows:[442]

(1) The flow was assumed to be geostrophic for purposes of computing vorticity and horizontal advection.
(2) The flow was assumed to be nonviscous and adiabatic.
(3) The underlying terrain was assumed to be very nearly flat.
(4) The static stability was assumed to vary only in the horizontal.

The equipment used figured in defining the grid spacing. The IBM 1401 printed 10 characters per inch both horizontally and vertically. One inch on a polar stereographic map with a mapscale of 1:30 million at 60° N. latitude is 381 km; that was the basic grid unit, and came to be called the "bedient" in honor of Art Bedient who devised much of the design, equipment, and code for the numerical models for many years. Still today, models are run at fractions of a bedient. Note that 0.8 inches on this scale is 304.8 km, about what is in the paragraph above.[443]

Sometime prior to April 24, 1956, a 72-h barotropic forecast was being transmitted on facsimile, the model being "well known" as termed in a JNWP prepared document, and a Charney and Phillips reference is given. The grid spacing was double that of the above described baroclinic model and the time step was 2 hours.[444,445]

On July 2, 1956, the thermotropic, two-level model replaced the baroclinic three-level model. The operational system at this time consisted of (1) plotting the data by hand, (2) analyzing the data

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[439] *Weather Bureau Topics*, April 1956, pp. 65, 66.

[440] *Weather Bureau Topics*, May 1955, p. 64.

[441] Charney, J. G., 1954: Numerical prediction of cyclogenesis. *National Academy of sciences Proceedings*, **40**, No. 2, pp. 99-110.

[442] Weather Bureau *Circular Letter* **44-55**, 1955: Transmission of JNWP Prognostic Charts on Service "C", and enclosure.

[443] Hoke, J. E., J. L. Hayes, and L. R. Renninger, 1981: Map projections and grid systems for meteorological applications. Air Force Global Weather Central, U.S. Air Force, **AFGWC/TN - 79/003**, 85 pp.

[444] Weather Bureau *Circular Letter* **16-56**, 1956: Information on on Barotropic Forecasts Prepared by the Joint Numerical Weather Prediction Unit.

[445] Charney, J. G., and N. A. Phillips, 1953: Numerical integration of the quasi-geostrophic equations for barotropic and simple baroclinic flows. *J. Meteor*, **10**, pp. 71-99.

manually, (3) interpolating by eye values at gridpoints and punching them onto cards, and (4) loading the punched data cards and instruction deck into the machine, and running the model. Output was still at 12, 24, and 36 hours. The height values were automatically plotted and "shaded" between specified contours, and lines were manually drawn along the shaded boundaries.[446] (Author's note: This was the so-called zebra chart.) A reference to the thermotropic theory was given as Thompson and Gates.[447] On March 11, 1957, vertical velocities at 500 mb from the thermotropic model were sent coded on Service C.[448] Evidently, the early 2- and 3- level baroclinic models had sufficient problems that they were replaced by a barotropic model.[449] Later, a successful 3-level baroclinic model was implemented in 1962.[450]

In September 1955, the Extended Forecast Section moved from the Old Main Building where it had been located since 1941 to Suitland, Maryland. Prior to that, it had been at the Massachusetts Institute of Technology (MIT) after being established in August 1940. The basic methods used by the 46-member Section were developed at MIT between 1935 and 1940 in cooperation with the Weather Bureau, the Bureau of Agricultural Economics, and the Department of Agriculture. The Section's primary functions were to prepare 5- and 30-day forecasts and to conduct research designed to improve extended-period forecasting.[451] One of the regular publications from the unit was a series in the *Monthly Weather Review* describing the weather and circulation of the month. Members of the unit alternated as authors, recurring ones included William H. Klein,[452] James F. Andrews, and Charles M. Woffinden. The 30-day outlooks had been provided to first-order field stations twice monthly since July 1948. The outlooks were given in anomalies for long periods and large areas; they did not attempt to indicate what weather conditions would exist at any particular time or place. These outlooks were for use on station and were not to be given further distribution.[453] However, in response to increasing pressure from news-disseminating agencies, and the fact that some newspapers had been printing their own version of the outlook obtained from the published charts secured through the Superintendent of Documents, the Bureau started transmitting an experimental 30-day outlook in 1950. It was on Service C in plain language near the 1st and 15th of each month.[454] Eventually, in 1954, they were put on facsimile and consisted of 700-mb mean contours and the expected temperature and precipitation anomalies.[455]

Initially, the analyses on which the NWP models operated were prepared by NWAC, but since October 1, 1956, "...raw data have been fed directly into the computers and analyzed

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[446] Weather Bureau *Circular Letter* **30-56**, 1956: Prognostic Charts Prepared by the Joint Numerical Weather Prediction Unit.

[447] Thompson, P. D., and W. L. Gates, 1956: *J. Meteorology*, **13**, pp. 127-144.

[448] Weather Bureau *Circular Letter* **6-57**, 1957: Coded JNWP Vertical Motion Prognostics.

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

[450] Shuman, F. G., op cit., pp. 290, 291.

[451] *Weather Bureau Topics*, February 1956, pp. 22-24.

[452] Klein, W. H., 1956: The weather and circulation of January 1956–a month with a record low index. *Mon. Wea. Rev.*, **84**, pp. 25-34.

[453] Weather Bureau *Circular Letter* **63-48**, 1948: 30-Day Outlook.

[454] Weather Bureau *Circular Letter* **29-50**, 1950: Teletype Distribution of Experimental Thirty-Day Outlook.

[455] Weather Bureau *Circular Letter* **20-54**, 1954: 30-Day Outlook on Facsimile.

automatically."[456] The data were first collected on perforated paper tape, then fed into a tape-to-card converter which delivered IBM punch cards with the same information. These cards were provided to the IBM 701, which in turn digested the data and made the analyses and predictions. This automated operation was in place for the barotropic model. An IBM 704 was expected to be delivered in July 1957, which would be about five times as fast, and all the NWP models would be fed from automated analyses.[457,458]

Some reorganization of climatological services, was announced in July 1954. The Section Center consolidating was discontinued, and the station designation as Section Center was discontinued. At many stations, the MIC was to carry out the State Climatologist functions and acted as the State Climatologist. In states with sufficient need, the Bureau envisioned a full-time State Climatologist, and even in some cases a separate State Climatologist office. Substation management functions invested in a Section Center were transferred to the Weather Records Processing Center in Asheville, except for Alaska, Hawaii, and the West Indies.[459]

On July 27, 1954, the Secretary of Commerce announced the appointment of a five-man Advisory Committee on Weather Services to assist the U.S. Weather Bureau in a plan for the active encouragement and development of the field of private meteorology in the interests of the national economy and national defense.[460] Likely this action was in response to the 1953 Advisory Committee on Weather Services report (see page 54).

In agreement with user needs, the Bureau reduced the number of state (FP) forecasts from four to three per day. It was believed this would meet the public need. One benefit was that this schedule provided more time for the study of upper air data.[461]

During August and September 1954, the Severe Local Storms Warning Service (SELS) moved to Kansas City, Missouri. The impetus for the forecasting of severe storms, and tornadoes in particular, by a specialized unit reached back to the Major Fawbush and Captain Miller forecast of a tornado at Tinker Air Force Base (AFB) on March 25, 1948.[462] The Air Force organized a Severe Weather Warning Center (SWWC) at Tinker AFB in February 1951. The Weather Bureau formed

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[456] *Weather Bureau Topics*, December 1956, p. 222.

[457] *Weather Bureau Topics*, February 1957, pp. 27, 28.

[458] Cressman, G., 1959: An operational objective analysis system. *Mon. Weather Review*, **87**, 367-374. Methods of analysis by curve fitting had been proposed, and B. Gilcrest and Cressman (1954: An experiment in objective analysis. *Tellus*, **6**, 309-318) had developed such a method that was put into operation on October 10, 1955 (see C. H. Dey, 1989: The evolution of objective analysis methodology at the National Meteorological Center. *Wea Forecasting*, **4**, 297-312.) This method used a sectionalized fit of second-degree polynomials, but because it had difficulties with uneven data distribution and was expensive in machine time (F.G. Shuman, 1989: History of Numerical weather prediction at the National Meteorological Center. *Wea Forecasting* **4**, p. 290), Cressman adopted and adapted a method proposed by P. Bergthorsson and R. Doos (1955: Numerical weather map analysis. *Tellus* **3**, 329-340.) which went into operations in April 1958 (see Dey, 1989, p. 306). By early 1970, this method was universally employed in all NMC objective analyses (Dey, 1989, p. 306).

[459] Weather Bureau *Circular Letter* **22-54**, 1954: Section Center Consolidation.

[460] *Weather Bureau Topics*, July 1954, p. 66.

[461] Weather Bureau *Circular Letter* **24-54**, 1954: Reduction to Three Scheduled State Forecasts Per Day.

[462] Grice, G. K. and others, 1999: The golden anniversary celebration of the first tornado forecast. *Bul. Amer. Meteor. soc.*, **80**, pp. 1341-1348.