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U. S. DEPARTMENT OF COMMERCE

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WEATHER BUREAU

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History of Verification of Weather Records in The United States Weather Bureau



Washington, D. C. - 1962

PREFACE

This bulletin presents a history of the verification of weather records during the lifetime of the United States Weather Bureau. The Weather Bureau has always placed considerable importance on checking weather data. A number of checking units have been operated by the Bureau since its establishment, and these offices and their functions are described herein. This bulletin is intended to be helpful to the historian as well as to the user of weather data.

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CHAPTER 1

Early History of U. S. Weather Observations and Their Verification

While unofficial weather observations were taken in the New World almost from the very beginning of colonization, the United States Government first took official notice of meteorological matters on May 2, 1814, when Dr. James Tilton, Surgeon General of the United States Army, directed all hospital surgeons to keep a diary of the weather [1]. From this beginning there gradually evolved the civilian weather service of today.

The Weather Bureau became a civilian agency July 1, 1891, when it was transferred from the Signal Service to the U. S. Department of Agriculture. Detailed instructions for taking and recording observations at first order stations were first carried by the civilian agency under the title "Instructions for Preparing Meteorological Forms" which accompanied the basic forms for 1892. This series of instructions continued unbroken through 1948 and was the basis on which checking of first order station records was done and corrections made.

The 1892 issue of Instructions, carrying the name of Mark W. Harrington, Chief of Weather Bureau, has the following to say about errors in the records:

"(1) Each original correction made in the examination will be counted as one error, but supplementary errors resulting from the original entry will not be charged.

"(2) A failure to comply with any order or instructions, however given, will be counted as one error when sufficient time has elapsed for the observer to receive the necessary orders or instructions.

"(3) If an observer has been charged with an error for failure to comply with any order or instructions, and again fails to do so on forms for succeeding months he will be charged with one error for each erroneous entry in the form, caused by his disregard of the orders, etc. in question.

"(4) Errors of omission will be counted in the same manner as errors of commission."

The following is taken from the Station Regulations [2] issued in 1905 by Willis L. Moore, Chief of Bureau:

"Each observation should be verified when recorded, and all entries, compilations, and computations of data must be checked each day by the employee responsible for their accuracy. . . . A strict record of the accuracy of each employee in the preparation of meteorological forms and the taking of observations is maintained at the Central Office. . . . Employees who prepare (various record forms) and do not make more than nine errors in six months or do not exceed the rate of nine errors in six months for any period not less than three months will have the fact noted on their efficiency records. . . . When an employee makes seventy or more errors in six consecutive months an investigation into his fitness for continuance in the Bureau will be made. . . .

"Data of questionable accuracy should be eliminated, and efforts made to ascertain and remove the cause of defects in the records."

These instructions were essentially repeated in later issues of Stations Regulations.

Topics and Personnel, October 1922 [3] refers to a circular of June 6, 1922, in which ". . . the accuracy of original records and the elimination of errors in statistical data were discussed." The item goes on to stress the importance of stations correcting their records "in accordance with error letters received from the Central Office."

This was emphasized also in Topics and Personnel for June 1926 and again in January 1928 [3]. In the latter issue each Official in Charge was required to check all error letters on file since the last inspection, make sure that all records were corrected, and then report this fact by letter to the Chief of Bureau.

From all this it is quite evident that a rigorous check was made of records from first order stations and this has been continued throughout the life of the Weather Bureau. Checking of first order station records was done by a small group of clerks and technicians in the Washington Central Office of the Weather Bureau until the fall of 1939 when the work was transferred to Elkins, West Virginia.

Different procedures were followed for substation data. Paragraphs 421 and 422 of Station Regulations June 15, 1905 [2], define a Climatological Section as a State or group of States with the central station known as the Section Center. The Section Director would have charge (among other things) of ". . .the examination and computation of meteorological reports." This responsibility was repeated in the 1915 and 1934 issues of Stations Regulations.

Paragraph 428 of the 1905 issue of Station Regulations, in speaking of temperature and precipitation charts, says "Data of questionable accuracy should be eliminated and efforts made to ascertain and remove the cause of defects in the records."

Paragraph 443, same issue, has this to say: "Every effort will be made to secure accuracy in the data published and telegraphed. When there is any indication of inaccuracy in a report, particularly in reports of exceptionally heavy rainfalls, or unusually high or low temperatures, a careful inquiry will be made, and if the report is found to be erroneous a correction will be telegraphed, if practicable, and the station records corrected, the error reported to the Central Office, and the observer cautioned." [2]

River and rainfall substations, in contrast to climatological substations, forwarded their records to a central station known as a River District Center. The various watersheds were divided into districts. According to paragraph 378 of the 1905 Station Regulations the officials in charge of River District Centers had supervision over (among other things) the ". . . examination and correction of reports." This regulation was repeated in the 1915 edition of Station Regulations and, by implication, in the 1934 edition [2].

As indicated above, substation data were checked at the Section Center or River District Center. In addition there was an over-all review of the records at the Central Office. As the number of substations increased some of the work of the Central Office review was "farmed out" to field stations where there was time available for checking. These monitoring stations were instructed to verify means of temperature columns, total precipitation, monthly prevailing wind direction, and summary entries.

Upper air observations by means of kites were initiated by the Weather Bureau in 1895 and terminated in 1933. Data were checked by the Aerological Division of the Central Office, where the entire observations were reworked and data prepared for publication. Checking of upper air observations continued in the Aerological Division for many years. An item in the May 1936 issue of Topics and Personnel discusses error letters for pilot balloon and for airplane observations [3].

Eventually the surface checking work was transferred to Elkins, West Virginia, and the upper air checking to Chattanooga, Tennessee. These checking stations are described in the next chapter.

Other checking carried on in the Weather Bureau consisted of assigning records from airway stations (second order, Supplementary Airway Weather Reporting Stations, and similar stations taking more than one observation per day but without commissioned personnel) to a first order station where they were manually checked for such things as internal consistency and consistency between one observation and the following.

CHAPTER 2

1. The Elkins Checking Station

In the fall of 1939 checking of the first order station records for all United States stations was transferred from the Climate and Crop Weather Division of the Central Office to the newly established Weather Bureau Checking Station at Elkins, West Virginia, which was opened September 1, 1939.

For about one year the only records received were from slightly less than 200 first order stations. At the end of that time, checking of substations (some 7,000) was added. Eventually surface observational forms from the United States, Mexico, Alaska, Hawaii, and Puerto Rico came to Elkins. The staff was gradually increased as the number of stations grew until there was a maximum of nine employees.

Records, first order and substation, were given a thorough manual check at Elkins. The standard, comprehensive check of first order records included such things as verification of daily temperature extremes with autographic records, recomputation of excessive and maximum precipitation, inspection of records for omissions, inconsistencies and discrepancies, comparison of precipitation times with amounts, verification of sums, means and all summary entries. Errors on first order station records were corrected on the forms and stations notified of them by a form letter. Errors on substation forms were noted on error letters and the records returned to Section Center for correction. This checking at Elkins was in addition to the checking of substation records done at the various Section Centers. Checked records were sent monthly to the Climate and Crop Weather Division (later Climatological and Hydrologic Services Division) of the Central Office. The station was closed in July 1948 [3].

2. The Chattanooga Checking Station (Upper Air Observations)

A radiosonde checking unit was established in 1939 in the Central Office Aerological Division. During March 1940 this work was assigned to Chattanooga, Tennessee, where a checking unit was set up to check radiosonde and pilot balloon observations. The radiosonde records for February 1940 were the first to go there.

According to the February 1940 Topics and Personnel [3] pilot balloon checking was deferred until later since not all of the personnel had entered on duty. Specific instructions were to be issued to pilot-balloon stations advising them when their records should be sent to Chattanooga.

Pibal forms were examined for proper identification and notations. Monthly resultant winds were computed for standard levels, and these plotted and examined. If the resultant wind for any station month level did not fit the pattern as established from the entire network of stations, records from that station were examined in detail to determine if proper orientation of the theodolite had been made, and individual records recomputed to determine if instructions had been followed and adequate care taken in the performance of computations.

The checking of raob records consisted of:

1. examination of all forms for proper identification and notations;
2. examination of all base-line checks and settings of instrument elements;
3. examination of all pressure height curves (on adiabatic charts) for smoothness and reasonableness;
4. examination of all super-adiabatic lapse rates, unusual inversions, and shifts in the temperature curve on the recorder records;
5. complete recomputation of two raobs per month at each stations;

6. computation and plotting of monthly mean values, and examination of records from those stations whose data did not fit the monthly pattern; and
7. sending of error letters where required.

In Topics and Personnel for November 1941 a change in the Chattanooga station was announced, as follows:

"The raob checking unit will be moved from Chattanooga, Tennessee, to the Washington National Airport, Washington, D. C., about November 1, 1941. Having this work close to the Central Office will be advantageous in view of the changes still being made from time to time in raob technique. Such changes are expected to continue until this type of observation is fully developed so that standard procedures may be adopted.

"The checking of pibal forms will be continued at Chattanooga, as at present." 3/.

The checking station (pibals) continued at Chattanooga until July 1948 when its work was assumed by the Weather Records Processing Centers.

3. The Radiosonde Analysis and Verification Units

When the Raob Checking Unit which had operated in Chattanooga for nearly two years was closed in November 1941 its functions were transferred to a new unit that was organized at Washington National Airport. The new unit was known thereafter as RAVU (Radiosonde Analysis and Verification Unit). Four of the incumbents of the Chattanooga station were transferred to the new unit at WNA and additional staff were recruited to meet requirements of the expanding program.

During the organizational period, work was divided between two sections. Three to four employees specialized on processing of monthly summary records and four to five employees (trained and experienced in radiosonde observational duties) performed the function of analyzing and post auditing daily observational records consisting of recorder records, computation sheets, and adiabatic charts.

Early in 1942 a radiosonde school was set up at Washington National Airport. The first class consisted of specially selected civilian candidates. This training school ended January 7, 1944 3/.

After the first civilian class had completed its training, the training staff was expanded and over the period of World War II trained nine classes of Army Air Force technicians. Each class consisted of approximately 45 members. All students were given assignments to the RAVU and the station Raob program.

In 1944 the staff of RAVU at Washington National Airport totaled 28 members with a subsection of the unit (started in November 1943) in operation at the Weather Bureau Airport Station in Boston, Massachusetts. Another subsection was established early in 1945 at Mt. Weather, Virginia, where approximately 50 conscientious objectors performed raob post-auditing duties. The sub-unit at Boston was comprised of Atlantic Patrol crews.

Radiosonde records from around-the-world bases of the Navy and Air Force, ocean weather records, and records from Mexican stations were processed in addition to records from raob stations in the Weather Bureau land network.

The principal processes of post-auditing the records were:

1. Inspection of every recorder record and adiabatic chart.

2. On basis of above inspection at least one of the records for each weekly submission was completely rechecked for each station.
3. Fixed height (now pressure) charts were inspected in the forecast room each day to select for subsequent rechecking any observation for which values appeared to be questionable or erroneous.
4. In many instances complete weekly submissions were returned to stations for recomputation because of significant baseline errors or other errors which seriously impaired the value of the sounding.
5. Mean charts were drawn at the three principal levels at the close of each month and any lack of compatibility of values at a station in the network would be thoroughly investigated until the reason was determined and the procedure corrected.
6. Variations of height of the tropopause and temperatures at this level were closely watched to detect defective elements of the radiosonde.

Personnel changes throughout this period were frequent and added to the problem of efforts of the RAVU to maintain a high degree of accuracy and uniformity of data over the entire military and civilian network.

The conscientious objectors unit at Mt. Weather was closed in the first part of 1946, when verification of military observations was transferred to the New Orleans Tabulating Unit.

The work done at the Boston subsection of RAVU was transferred back to the Washington unit after the war years when the number of ocean station vessels decreased.

A pilot project of on-station punching of upper air data was established at New Orleans in 1946, and included data from the States of Texas, Louisiana, and Mississippi. General on-station punching of surface and upper air data started in 1948.

In early 1948 RAVU was made a part of the Climatological Branch of the Climatological and Hydrologic Services Division, and it was moved from the Washington National Airport to the Central Office in December 1948.

On February 1, 1950, IBM machines were installed in the Central Office to process and summarize the raob data. Beginning on that date all observations were checked for internal consistency by machine computation of the hypsometric formula and comparison with on-station data. Later, comparison listing methods were used in some cases to approximate the same results. Other items were checked by machine and impossible or unlikely items flagged for detailed verification. Beginning on the above date, all raob summaries were machine prepared and on-station hand tabulation of these data eliminated, except that Pacific, Alaskan, and Antarctic stations still continued to summarize upper air data for the CLIMAT TEMP message each month.

In January 1952 the unit was moved to Asheville, N. C., as part of the National Weather Records Center. At that time the Weather Bureau raob unit, the military raob unit, and the upper wind verification unit were consolidated into one. The Air Weather Service upper air data are now (1962) verified by a staff of AWS employees with the Weather Bureau furnishing technical consultation. The Navy observations are verified by Weather Bureau personnel with Navy support.

In 1960 the Weather Records Processing Centers began punching upper air observations, eliminating on-station punching of these data.

4. The Hydrologic Units

A plan to overcome the deficiencies in existing precipitation data in order to meet the increasing needs of hydrology as an applied science was developed by the Weather Bureau in cooperation with the War Department, Corps of Engineers and the Department of Agriculture during the latter half of 1939. The general purpose of the program was to organize a nationwide network of precipitation stations to provide data of prescribed quality, insure continuity of records, and establish efficient and economical machinery for processing and disseminating data.

The service was organized under the general administration of the Central Office of the Weather Bureau and under the direct supervision of the Chief of the River and Flood Division, Merrill Bernard. Nine Regional Centers were established throughout the country under the direct supervision of the Weather Bureau Regional Hydrologic Supervisors to carry out the field implementation and operation of the program. A typical unit was comprised of from 12 to 15 employees depending on the size of the region and the number of stations involved. The country was divided into the following regions:

<u>Region No.</u>	<u>Region Designation</u>	<u>First Issue of Hydrologic Bulletin</u>	<u>Last Issue of Hydrologic Bulletin</u>	<u>Location of Center</u>
1.	North Atlantic	Jan. 1940	July 1948	Albany, N. Y.
2.	Southeastern	Jan. 1940	Aug. 1948	Macon, Ga.
3.	Ohio River	Jan. 1940	Aug. 1948	Cincinnati, Ohio
4.	Upper Mississippi	Jan. 1940	July 1948	Iowa City, Iowa
5.	Missouri River	Jan. 1940	July 1948	Kansas City, Mo.
6.	Lower Mississippi and West Gulf	Jan. 1940	July 1948	Fort Worth, Texas
7.	Southwestern	Jan. 1940	July 1948	Albuquerque, N. Mex.
9.	North Pacific	Jan. 1940	Apr. 1948	Portland, Oregon
10.	South Pacific	Jan. 1940	July 1948	San Francisco, Calif.

Hourly amounts of precipitation were tabulated for all stations equipped with recording gages and 24-hour amounts for stations with non-recording gages. These data were published regularly in monthly Hydrologic Bulletins for regions designated above. For certain special storms, additional data were collected and organized to meet the requirements of the cooperators especially with regard to excessive rates of precipitation for short periods. These data were published in 33 "Supplements to the Hydrologic Bulletin" for specific heavy rainstorms.

One of the principal functions of each of the regional centers was to improve the quality of record obtained from all stations in the region. This was accomplished by a staff of Field Inspectors assigned to each region to visit the stations regularly.

The Hydrologic Units and their work were absorbed into the seven Weather Records Processing Centers or transferred to other Weather Bureau Offices in 1948. The processing centers are described in Chapter 3.

5. The New Orleans Tabulating Unit and the National Weather Records Center

Possibly the earliest mention of machine punching of weather records in the Weather Bureau was in a June 15, 1895 letter from Chief of Bureau Mark W. Harrington to Secretary of Agriculture J. Sterling Morton. The letter is as follows:

"Sir:

"I have the honor to inform you that ten thousand (10,000) cards, for use in connection with the Hollerith punching machine, one hundred (100) copies of a meteorological report for a given station, and one hundred (100) copies of instructions as to the manner of punching the data on the cards, have been sent to the United States Civil Service Commission in accordance with your letter of the 12th instant.

Very respectfully,

/s/

Mark W. Harrington
Chief of Bureau"

While this was a precursor of things to come, nearly four decades were to elapse before the Weather Bureau started in earnest to put weather records on punched cards.

A forerunner of the New Orleans Tabulating Unit was a WPA project established in New Orleans in 1934. Ocean vessel observations which had accumulated since 1880 were converted into a much needed marine atlas. By 1936 useful weather summaries were produced by machine methods from about 400 airway stations. Heavy demands were made upon this unit by the military during the war years. The New Orleans Tabulating Unit (NOTU) was established in 1945 at the New Orleans Port of Embarkation where a joint Weather Bureau-Navy-Army (and later Air Force) punch card library was established.

The predecessor of the Weather Records Processing Centers was a pilot project set up at the New Orleans Tabulating Unit in 1945. At first only first-order stations in Louisiana and Mississippi were involved; later Arkansas, Oklahoma, and Texas were added.

In 1947 the first of seven regional centers to be called Weather Records Processing Centers was established at the Fort Worth, Texas Regional Office. These seven centers are described in the next chapter.

In the years following the war, processing of weather data for climatological purposes became centralized in New Orleans, with regional processing centers (WRPCs) carrying out quality control programs and forwarding records and cards to the NOTU for use in answering requests, preparing special jobs and archiving.

The NOTU gained much needed space by moving to Asheville, N. C., between September 1951 and January 1952 where the Weather Bureau facilities are known as the National Weather Records Center.

The NWRC has been designated by the National Archivist to be the official custodian of weather records. Approximately 350 million punched cards containing weather data are housed and serviced there, and these files are growing at the rate of some 30 million cards per year. The Center is equipped with a full array of electric accounting machines and uses digital computers.

Its two basic functions are (1) the collection and archiving of meteorological records as well as making them available to users, and (2) performing both routine and special data processing. The Center consists of six sections; some 400 employees are required to carry on its manifold activities 5 / 6.

The Radiosonde Analysis and Verification Unit, discussed elsewhere in this bulletin, and the Hourly Precipitation Data Unit operate at the NWRC. This latter unit with some 26 employees was established in 1951 and assumed the work of evaluating weighing rain gage charts discontinued by the three WRPCs in September 1951, as well as preparing copy for the publication Hourly Precipitation Data.

CHAPTER 3

The Weather Records Processing Centers

The following explanation of the Weather Bureau's punched card program is taken from Topics and Personnel for September 1947 [3] under the title "Punched Card Program":

"Punched Card Units, officially known as the Weather Records Processing Centers, are now being activated in all the regions. An account of the history and future prospects of the program is given below.

"Punched cards were first developed in the U. S. Census Bureau in 1890, as a means of handling the vast numbers of census data. Their meteorological uses date from 1921, when they were utilized by the British Admiralty for the sorting of marine observational data. In 1927 they were used by the British for the summation as well as the sorting of weather data. In the United States, punched cards were employed in the early thirties to handle marine data in the preparation of 'The Atlas of Climatic Charts of the Oceans.' The weekly averages of precipitation for many stations in the United States were another early punched card achievement. Later came the punching of the 1130 data, resulting in the 1141 series of airport data and the 'Airway Meteorological Atlas for the United States.'

"During World War II, an urgent need arose for climatological data processed in such form as to be readily interpretable in terms of military operations. By the end of the war, the Army had punched a large number of Northern Hemisphere weather observations and some Southern Hemisphere data for periods of 40 years or more. The Northern Hemisphere Historical Weather Maps were thus made possible.

". . . .

"When the punched card program is fully implemented, all first-order stations will be equipped with a hand punch and will be provided with detailed instructions for the punching of their local observational data. This will be the only equipment furnished field stations. In each region there will be a Weather Records Processing Center, with the necessary machines to process the punched cards.

"The first phase of this program, that affecting the first-order stations, has already been started and is expected to be in operation by the end of the year. Liaison men are distributing the hand-operated punching machines and instructing station personnel in their use. The second phase of the program, the establishment of Regional Processing Centers, is similarly making progress. The Fort Worth Center is already in operation, and the establishment of the remaining centers is in an advanced planning stage. During the period August 1-October 15, mechanically inclined young men in the SP-6 grade will be selected and given special training to qualify as machine-checking supervisors in the centers.

"When the program is in full-scale operation, all climatological observations, including river and rainfall, evaporation, etc., will be reported weekly to the Section Centers on a revised Form 1009, which will supersede Forms 1009, 1006, 1024A, and 1053A. The observer will make a single carbon copy of this form, as a safeguard against loss in the mail. He will be given an Annual Diary, replacing the present Form 1011, in order to facilitate his recording of the data and to have a more permanent record of the original observations than 1011 provides.

"When the weekly 1009 reaches the Section Center, it will be examined for obvious errors and omissions, and passed on to the Regional Weather Records Processing Center where the data will be placed on tabulating cards. After

"being machine-checked, the cards in error will be repunched. Form 1009, after microfilming, will be returned to the Section Centers. At the end of each month, the cards will be sorted and summarized, automatically punching the summarized data on a summary card. This summary card will be processed by another machine, which will make the necessary divisions for the means. It will next be run through in conjunction with a card on which the normals have been punched, resulting in the punching of the departures from normal on the summary card, which is now complete with sums, means, and departures. The equivalent of the monthly Form 1009 will subsequently be reproduced by means of the monthly deck of cards and the summary card. Four copies will be made, two of which will go to the Section Center. One of the latter may be sent to the observer.

"The extension of punched card methods to first-order station routine has necessitated a thoroughgoing review of present practices, many of which will be eliminated, simplified, or absorbed by the Weather Records Processing Center. It is proposed to eliminate Forms 1014, 1001, 1002, and 1003 at most first-order stations, and eventually the Climatological Record Book. A revised Form 1130A and the records from the recording instruments will then be the only records maintained, thus ending the excessive copying of data from one form to another, with the concurrent necessity of extensive checking. Two copies of Form 1130A will be made, one of which will be sent to the Weather Records Processing Center and the other retained in special binders which will be provided for the purpose. The only data to be summarized will be those for which there is a definite demand. Once the original observation has been certified by the observer to be correct, and the observation card punched at the local office, the work of that office will be completed. From there on, the machines will take over--checking, summarizing, and preparing the data for various types of publication."

In Topics for May 1948 [4] further progress in the program was reported. It was stated that representatives of Climatological and Hydrologic Services Division would be detailed to each WRPC "to assist in the inauguration of WB Form 1009 processing, and other phases of the WRPC program. . . ."

The item went on to state that ". . . Each Section Center will be visited and individual State problems resolved before that State is fully incorporated into the program. It is expected that the complete transition will require approximately 90 days in each region."

In the June 1949 issue of Topics [4] some idea of the work done by the WRPCs is given as follows: "In addition to combining the former Hydrologic Bulletin with Climatological Data, by adopting more flexible procedures for the bulletin layouts, the number of daily precipitation stations carried in the bulletin has been increased from 6,563 a year ago to 9,822 as of today, and the number of temperature stations carried in the bulletin has been increased from 2,377 a year ago to 4,646 as of today. These figures do not include an additional 2,500 hourly precipitation stations."

Most of the large increase in the number of stations is accounted for by stations that were already in existence but not published, because of lack of space in the type-set Climatological Data bulletin. An attempt was made by the WRPCs to publish all data where the observations were considered reliable.

The objectives of the Weather Records Processing Centers are stated in Item 10 of Status Report No. 5, December 1, 1947, as follows:

"It appears necessary to reemphasize the principal objectives of the WRPC's. These units are being set up for the express purpose of applying modern mechanical and mass production techniques to the checking, processing and

SEVEN WEATHER RECORDS PROCESSING CENTERS

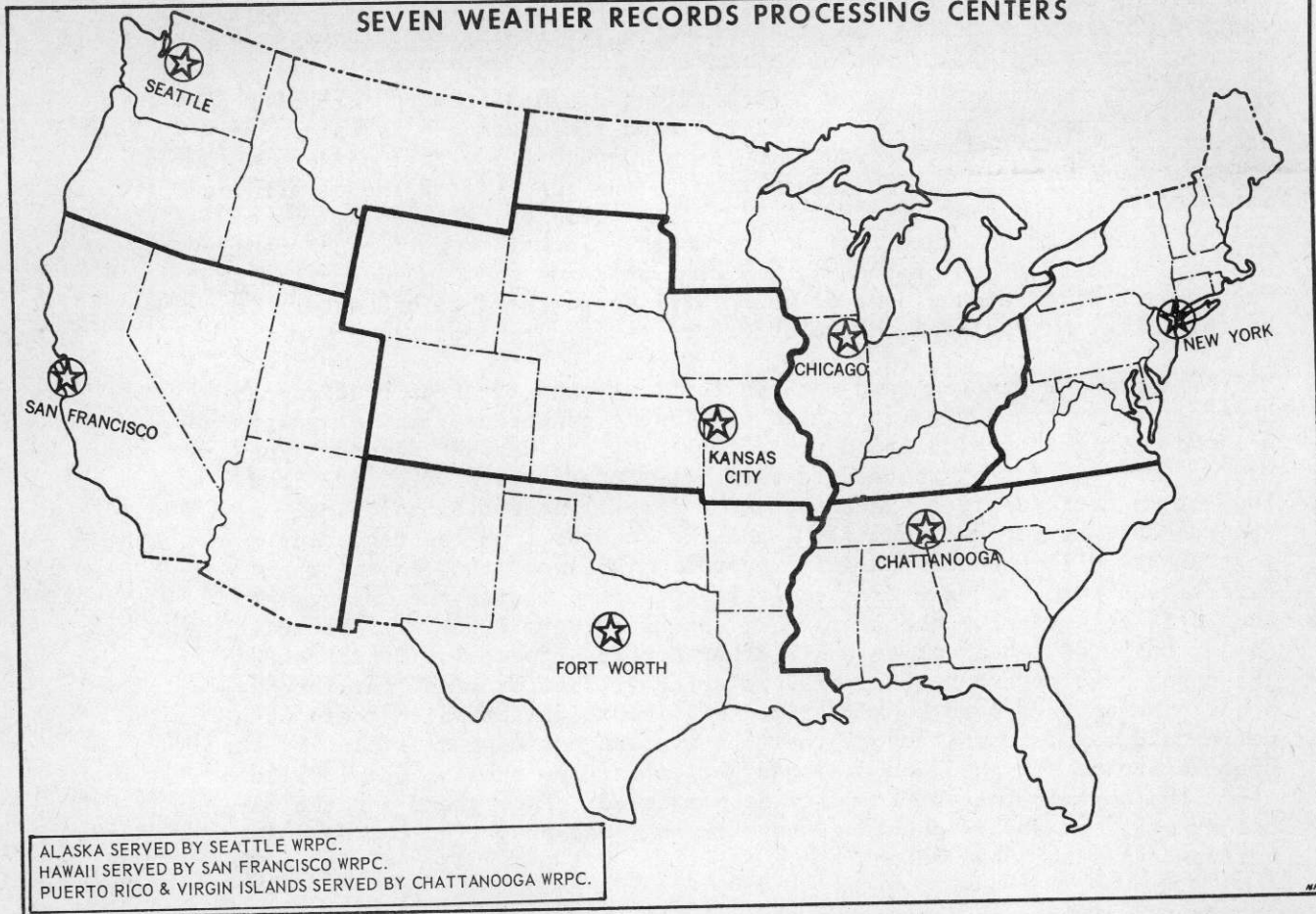


Figure 1

THREE WEATHER RECORDS PROCESSING CENTERS

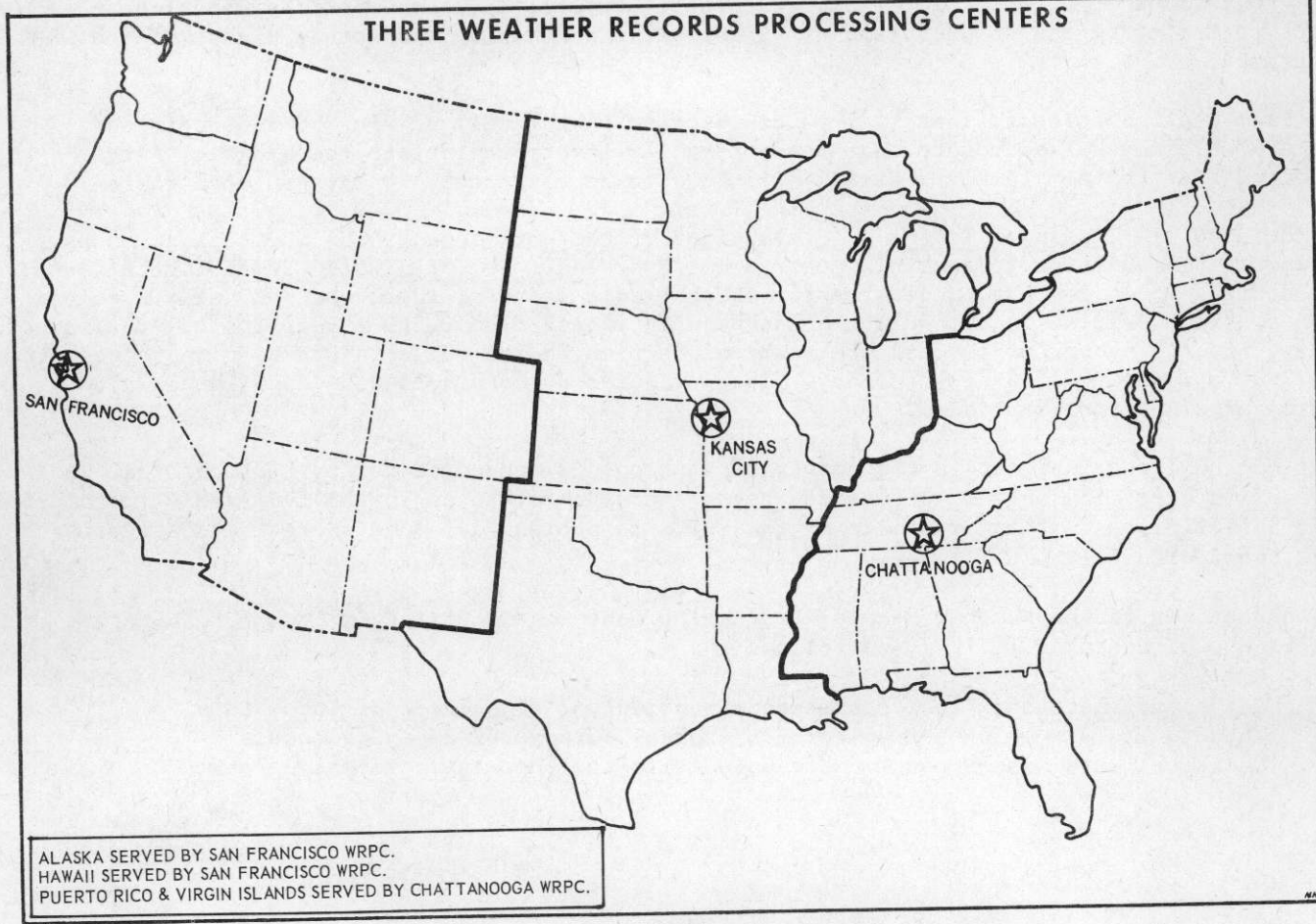


Figure 2

"summarizing of weather records. Since such techniques cannot be economically applied to single stations the utilization of processing centers becomes necessary. Among the objectives in establishing these centers are: (1) To make weather records more accessible to the user; (2) To put weather records in a more flexible form (the punched card) so that many types of special tabulations including frequency distributions, duration studies, correlations, and climatological aids to forecasters may be economically accomplished; (3) To improve the usefulness and the form of routine climatological and hydrologic summaries; (4) To provide the basis for a better method of reproducing climatological and hydrologic data; (5) To improve checking procedures and thereby improve the accuracy and reliability of weather records; (6) To reduce the burden of forms work at the field station, particularly on observer personnel.

"Item (6) above is a very important objective of the Weather Records Processing Center. It should be restated that the processing center will absorb every possible phase of local station forms checking and processing, including the preparation of local monthly summaries, annuals, etc.; the evaluation and extraction of such data as are required from autographic records such as Forms 1017, 1068, 1076, etc.; the preparation of wind resultants, etc. from pilot balloon observations; and the summarization of raob records. It is expected that Officials-in-Charge of the WRPC's shall make it a point to do everything possible to relieve the local stations of all processing work wherever such action does not hinder local climatological service. If, because of special local problems, the central processing of records hinders local service, an exception or a compromise will be considered but each such case will be studied and decided on its own merits."

Seven WRPCs were originally established. In 1950 these were consolidated into three, and, when this was written (1962) action had been started to consolidate the three Centers into the National Weather Records Center at Asheville. This consolidation was to enable the Weather Bureau to take advantage of improved electronic accounting machines and computers, which are not economical to operate in small units.

The WRPC areas originally coincided with those of the Weather Bureau regions as shown by the map in figure 1. The map in figure 2 shows the three areas after consolidation.

During the entire lifetime of the Weather Records Processing Centers their basic duties remained essentially unchanged. Their responsibilities were to collect, punch, review for errors, and prepare copy for publication from various types of stations in their assigned areas, and to microfilm weather records.

Some of the more noteworthy changes that occurred during the WRPC era are given below:

1. Combination of the Hydrologic Bulletin and Climatological Data. This occurred with various months for different States during the period April to August 1948, and involved adding hourly precipitation data to the Climatological Data bulletins, discontinuing the Hydrologic Bulletins, and changing from type-set to offset printing.

2. Changes in temperature array techniques in late 1949. The new array method reduced the raw data to a reflection of the synoptic situation for each day, arranged the stations geographically, and thus provided the basis for testing of each observation for reasonable conformity with the synoptic weather situation.

3. Publication in Climatological Data of a table of daily snowfall and snow on the ground for selected stations beginning with the winter of 1949-1950.

4. Preparation and publication of Local Climatological Data Supplement for stations taking 24 observations per day. This program was started for some stations in early 1949.

5. Consolidation of the seven WRPCs into three, located at Chattanooga, Tennessee; Kansas City, Missouri; and San Francisco, California. This took place in the first half of 1950 and resulted in closing the Centers at Albany, Chicago, Fort Worth, and Seattle. This change was made to increase efficiency by moving from small to larger units.
6. Computation and publication of monthly degree days for substations beginning in July 1950.
7. Addition of IBM 407 tabulators in 1951. These machines permitted the discontinuance of the card-operated typewriters and thus combined the tabulation of final data and preparation of printers' copy into one operation.
8. Discontinuance of machine prepared Forms 1009 (WB Form 5201) which took place with August 1951 data in the Chattanooga area, and a few months later in the rest of the country.
9. Discontinuance with September 1951 data of evaluating and publishing hourly precipitation by the WRPCs. Data from October 1951 appear in Hourly Precipitation Data, published by the National Weather Records Center.
10. Transfer of punching and verification of pilot balloon observations to the National Weather Records Center in May 1952. Addition of radiosonde and rawinsonde punching in January 1960 when this work was transferred from field stations.
11. Addition of solar radiation checking in July 1952.
12. Machine processing of fire-weather data, beginning with 1952 data and ending with 1960. This work was done by the San Francisco WRPC since most fire-weather stations were in that area.
13. Consolidation of printing at the National Weather Records Center. Use of Government Printing Office facilities in San Francisco terminated in mid-1953 when the San Francisco WRPC printing was transferred to the Weather Bureau printing plants at the Kansas City and Chattanooga WRPCs. These two printing plants were discontinued in late 1954. After that, preparation of copy was continued at the WRPCs but actual printing was done at the National Weather Records Center at Asheville, N. C.
14. Interpolation of missing monthly temperature and precipitation beginning in 1953 for precipitation (1952 data) and in 1956 for temperature.
15. Transfer of the microfilm program to the National Weather Records Center effective after filming of 1953 data.
16. Preparation of 25-year long-term means of temperature and precipitation for substations and for climatological divisions within States. This was for the period 1931-1955. Preparation of 30-year (1931-1960) normals of temperature and precipitation for substations and climatological divisions within States was completed in 1961.
17. Addition of substation management of the "a" network in the summer of 1954. Machine listings of substation accountability prepared quarterly have been very beneficial to management.
18. Preparation of duty status certifications for observers at certain types of substations, beginning with fiscal year 1955.
19. Preparation of a newsletter series to all cooperative observers in each WRPC area beginning in late 1954.
20. Reduction in punching and checking Civil Aeronautics Authority station data at the end of 1954. This work was continued for selected CAA (later FAA) stations needed by the Weather Bureau for network purposes.

21. Discontinuance of the Comparative Data table presenting State temperature and precipitation averages in Climatological Data with January 1956 data.

22. Discontinuance of the computation and publication of State averages of temperature and precipitation with January 1956 data. Averages later were computed only for climatological divisions within States.

23. Preparation of monthly and annual isoline charts of temperature and precipitation for publication in Climatological Data beginning with July 1956.

24. Change in procedures for the preparation of Climatological Data weather stories with the December 1957 issue. After that time these stories were written by the individual State Climatologists instead of at the WRPC, and were written only when the weather for the month was unusual or noteworthy.

25. Preparation of decadal maps of station location from 1890 to 1950 for the Key to Meteorological Records Documentation series. The first set of maps, for Alabama, was published in 1958.

26. Discontinuance, in 1959, of publication of storage gage data in Climatological Data for the western States in favor of a separate publication Storage-Gage Precipitation Data for Western United States.

27. The change from manual to machine preparation of first order station annuals. This was developed by the Kansas City WRPC and first used by all three WRPCs with the annuals for 1960.

Some idea of the operations of the three Weather Records Processing Centers is given by the following table which was published in Climatological Services Memorandum No. 73:

NUMBER PER WRPC DURING 1958

	<u>Chattanooga</u>	<u>Kansas City</u>	<u>San Francisco</u>
Employees	29	30	36
States or territories in area	23	15	14
First order stations	106	95	102
FAA stations in basic 24-hour network	4	8	41
FAA stations not in basic 24-hour network	55	65	51
Substations, temp. and precip.	1,570	1,865	1,917
Substations, precip. non-recording	1,687	3,242	936
Substations, precip. recording	1,012	1,124	892
Substations, evaporation	88	136	176
Solar radiation stations	26	32	34
Soil temp. stations	16	16	18
Storage gages	4	7	357
LCD annuals prepared	103	85	101
LCD supplements prepared	816	852	756
Pages CD prepared	3,001	3,036	3,056
Pages other publications prepared	8	28	51
Cards punched	1,392,000	1,430,000	1,813,224
Cards from first order stations	690,000	730,180	562,750

The following table shows the times of establishment and consolidation of the WRPCs:

<u>WRPC</u>	<u>Established</u>	<u>Closed</u>
Albany, New York	January 1948	March 1950
Chattanooga, Tennessee	Late 1947	--
Chicago, Illinois	October 1947	February 1950
Fort Worth, Texas	June 1947	April 1950
Kansas City, Missouri	September 1947	--
San Francisco, California	January 1948	--
Seattle, Washington	September 1947	June 1950

Special tasks performed by the Chattanooga WRPC included the following: A special cooperative arrangement between the Tennessee Valley Authority and the Chattanooga WRPC whereby the WRPC checked data for nearly 300 TVA stations and prepared copy for TVA publications. Also, the checking, preparation of copy, and publication of Climatological Data for the West Indies and Caribbean starting with January 1960. This involved cooperation with 15 meteorological services, and required publication of the entire issue in metric units, with explanations in French, Spanish, and English.

Special tasks carried out at the Fort Worth WRPC included: Implementing and testing the use of a weekly instead of a monthly form. As a result of the test, decision was reached in July 1948 to return to the use of the monthly reporting form. The Fort Worth WRPC also pioneered in the preparation of first order station summaries from punched cards. Another important task assigned to Fort Worth was the training of supervisory personnel for the other six WRPCs.

Punching and verification of observations taken by Atlantic and Pacific Ocean Station Vessels from 1951 to July 1952 were assigned to the San Francisco Center. That Center also was responsible for preparation of copy for Climatological Data - Pacific, first published in January 1956; cooperation in a phenological study of the lilac plant in the 11 western States; a cooperative arrangement with the State of California whereby some 100 additional stations desired by the State would be checked at the WRPC and in return the State would finance a Field Inspector and an assistant in the Center.

A special job of great magnitude undertaken by the Kansas City WRPC was the publication of Weather Bureau Technical Paper No. 17 "Kansas-Missouri Floods of June-July 1951". This 106-page publication, prepared under the direction of Hydrologic Services Division, presented basic data, photos, flood damage, and a meteorological analysis of the event. It was printed in June 1952. A similar job done by Kansas City was known as the Wet States project, and involved publication of data for five States for April and May 1957.

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