REPORT OF THE CHIEF OF THE WEATHER BUREAU.

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
OFFICE OF THE CHIEF,
Washington, D. C., September 27, 1917.

SIR: I have the honor to submit herewith a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1917.

Very respectfully,

C. F. MARVIN,
Chief of Bureau.

Hon. D. F. HOUSTON,
Secretary of Agriculture.

In addition to the daily work of the Weather Bureau in its comprehensive and important service to the public, a prominent feature of the bureau's activities during the year has been the linking of its work with the military operations of the Government in the great war. This cooperation has been secured through arrangements for forecasting the weather over the region of actual warfare in France, the extension of aerological work to provide for the making of upper air observations for the benefit of the Army aviators, ballonists, and artillerists; and assistance to the Government and marine interests by vessel-reporting and seacoast stations and communication facilities in aid of coast patrol.

Never in the history of conflicts of the world has the weather proved such a potent factor as 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. Foreknowledge of existing and expected weather conditions, both in the air and on the surface has, therefore, become of the utmost importance. When active preparations for the military preparedness of this country were begun—when the declaration was made by the United States that a state of war existed with the German Government—it was apparent that the Weather Bureau had an important part to play. In recognition of this fact the Secretary of Agriculture communicated with the Secretary of War and invited attention to the service which might be rendered by the Weather Bureau in furnishing the fullest possible information concerning the meteorological conditions in the United States and adjacent regions. He also indicated the service that trained meteorologists could render as aids to commanders in planning military opera-

National Oceanic and Atmospheric Administration
Report of the Chief of the Weather Bureau

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tions. The Secretary of War heartily accepted the suggestions and preparations were made at once for the fullest cooperation in carrying out the plan.

It was obvious that the activities of the bureau for the time being at least would necessarily be extended to two primary projects: (1) The forecasting of the weather for purely military operations, (2) the sounding of the upper air for the benefit of aviators, ballonists, and artillerists.

In connection with the first project, one of the foremost forecasters of the bureau has been commisioned major in the Signal Officers' Reserve Corps and has been granted a furlough from the Weather Bureau for that purpose. In the furtherance of his duties it is expected that the closest cooperation will exist with the French and English meteorological services in the use of data obtained by them, supplemented by additional observations in the field and cable reports from the United States and its possessions.

The official in charge of the aerological investigations of the bureau has also been commissioned a major in the Signal Officers' Reserve Corps and placed in charge of the military aerological work. The aerological work heretofore performed by the Weather Bureau will be continued, in addition to the enlarged activities made possible by the appropriation of $100,000 for this work, as contained in the Army bill, which became a law May 12, 1917. This item reads as follows:

> For the establishment and maintenance by the Weather Bureau of additional aerological stations, for observing, measuring, and investigating atmospheric phenomena in the aid of aeronautics, including salaries, travel, and other expenses in the city of Washington and elsewhere, $100,000, to be expended under the direction of the Secretary of Agriculture.

It is planned that, for the duration of the war, the aerological work of the Weather Bureau and the Signal Corps shall be closely coordinated, and that such of the free-air observations made at the six primary stations to be operated by the Weather Bureau, as may be required, shall be made telegraphically available to the military authorities, supplementing similar observations made at the various military stations conducted independently by the Signal Corps. All of the data secured at the Weather Bureau and military stations will be turned over to the Weather Bureau for tabulation and study.

Some details of the work of the bureau during the past year are briefly summarized and discussed under separate topics, as follows:

FORECASTS AND WARNINGS.

DISTRIBUTION OF WEATHER FORECASTS.

There was a considerable increase during the year in the number of cooperating rural telephone lines, and a corresponding extension of distribution to the farming communities. The forecasts by this means reach the farmers in nearly all instances by noon of the day of issue, and reports show that the service is very highly valued. Distribution by wireless, which was expected to be extended, was abridged or suspended through the control of all wireless communications exercised by the Government as a military necessity. The distribution of the weekly forecasts was materially extended by tele-

graphing them to the central offices of about 250 rural telephone lines in the 13 central grain-growing States, by which they were made available to all the subscribers on those lines by noon of the day of issue.

WEST INDIAN AND CARIBBEAN SEA SERVICE.

The extension and improvement of the weather service in this region was accomplished, at already established stations, by the perfecting of arrangements for taking and telegraphing two observations a day during the period June 1 to November 30, and the taking of one observation a day during the remainder of the year. New stations were established at Belize, British Honduras; Bluefields, Nicaragua; Colon, Canal Zone; Guantanamo Bay, Cuba; and St. Thomas, Virgin Islands. The work of the extension of this service is still in progress.

ALASKAN SERVICE.

A full meteorological station was established at Juneau, Alaska, and arrangements effected whereby twice-daily reports are received from all Alaskan stations.

STORM-WARNING STATIONS.

The number of storm-warning stations on June 30, 1917, was as follows:

Paid stations, 150; a decrease of 35 during the year.

Cooperative stations, 145; an increase of 32.

Weather Bureau stations displaying storm warnings, 58; a decrease of 2.

The decrease in the paid stations and the increase in the cooperative stations are almost wholly due to the taking over by the United States Coast Guard Service of the duties of displaymen wherever practicable.

VESSEL WEATHER STATIONS, INCLUDING LIGHTSHIPS.

At the close of the year 47 of these were in operation, somewhat less than last year, owing to war conditions. Two lightship stations were added; namely, at Diamond Shoals and Heald Bank. The reports from these vessel weather stations were of great value during the hurricane season.

SPECIAL METEOROLOGICAL STATIONS.

Two special meteorological stations for forecast purposes were established during the year, namely, at Needles, Cal., and at Midway Island, in the Pacific Ocean. Reports from the last-named station have been found to be of great value in connection with the preparation of the weekly forecasts.

CONSOLIDATION OF FORECAST DISTRICTS.

The San Francisco (Cal.) and Portland (Oreg.) forecast districts were consolidated during the year, with headquarters at San Francisco, Cal.

SEVERE STORMS.

Four tropical storms, for which hurricane warnings were ordered, occurred during the year—two in July and one each in August and October. The first of these, that of July 1–10, developed in the west Caribbean Sea and moving northward passed over Mobile, Ala., July 5, causing a maximum wind velocity of 106 miles per hour at that station and 104 miles at Pensacola; these velocities being the highest on record at those stations up to that time. The unusually high tides and torrential rains attending this storm caused enormous losses in central and southern portions of the east Gulf States. The second, that of July 12–15, developed in the Bahama Islands and moved northwest, passing over Charleston, S. C., on July 14, with a velocity of 64 miles per hour from the northeast. No severe losses attended this storm. The third, that of August 12–18, was first observed in the vicinity of the Barbadoes and moved northwest through the Yucatan Channel and across the Gulf of Mexico, passing inland between Corpus Christi and Brownsville, Tex., on the 18th. Considerable damage was caused on the west Texas coast by the high winds, the highest velocity, estimated at 90 miles per hour, occurring at Corpus Christi. Some of the 20 vessels held at New Orleans on account of the warnings probably would have encountered the hurricane in the Yucatan Channel and might have met the same fate as the *Admiral Clarke*, which was lost on the night of the 16th. Vessel masters and agents who held their vessels until the routes were declared safe expressed the highest commendation for the manner in which the Weather Bureau kept them advised. The fourth, that of October 9–19, developed over the central Caribbean Sea, moved west across the Yucatan Peninsula and then northeast across the Gulf, passing over Pensacola on the morning of the 18th. Maximum wind velocities of 120 miles from the southeast at Pensacola and 128 miles from the east at Mobile, the highest on record at these stations, attended this storm. The storm did little damage, comparatively speaking, as ample precautions had been taken as a result of the advance warnings.

A storm of marked intensity, for which whole-gale warnings were ordered, passed over the Lake region on November 23–24. It was reported that these warnings were so thoroughly distributed throughout the region that no vessels left port until after the severe gales subsided; and further, that the absence of wrecks and loss of life is evidence that the marine interests generally heeded the warnings issued by the Weather Bureau.

SEVERE COLD WAVES.

A notable feature of the meteorological history of the year was the severe cold wave, which, reaching the Mississippi Valley by the night of January 31, overspread the entire eastern half of the country during February 1–3. On the latter date the temperature fell to 16° at Jacksonville and below freezing throughout the Florida Peninsula, Miami reporting a minimum of 28°, the lowest of record at that station. This was the most severe freeze in Florida since February, 1899. Ample warnings of the cold wave were issued well in advance, the accurate forecasts of expected minimum temperatures in Florida proving of great value.

STORM-WARNING SERVICE.

The work of improving the storm-warning service by the installation of the three-lantern system has gone forward, the installation on the Great Lakes having been completed in the fall of 1916. Preliminary plans for the installation on the South Atlantic and Gulf coast have been completed and material is either on the ground or en route. Plans for the extension of the system to the North Atlantic coast are well underway.

AEROLOGICAL INVESTIGATIONS.

The work of obtaining free-air observations by means of kites has been continued at the Drexel aerological station during the past year. The data thus obtained include atmospheric pressure, temperature, humidity, wind velocity and direction, electric potential, and cloud altitude and movement. Flights were made on all but 11 days during the year, and a daily telegram giving the atmospheric conditions at one or two selected levels in the free air has been sent to the forecast centers of the Weather Bureau at Washington, D. C., and Chicago, Ill. In addition to the daily observations, series of observations continuing for a period of 30 to 36 hours have been made whenever conditions were favorable. The data thus obtained enable the bureau to follow atmospheric changes in considerable detail. In all, 516 observations have been made during the year—July 1, 1916, to June 30, 1917. Of these 160 were made in 21 different diurnal series, the remaining 356 being made as daily observations.

Plans have been made for more practical application of the results of free-air investigations to problems connected with aeronautics and the firing of projectiles. With this end in view the bureau furnished an exhibit at the Aeronautic Exposition held in New York City February 8–15, 1917, and also participated in the discussion held at that time under the auspices of the Aero Club of America. A paper on "Aerology in Aid of Aeronautics" was presented at the symposium on aeronautics before the American Philosophical Society in Philadelphia on April 13, 1917. This paper is to be published by that society.

Since February, 1917, considerable work has been done in the preparation of a manual or handbook for aeronauts. It will include a survey of the different parts of the United States, showing relative suitability of various localities for the establishment of aeronautic stations and will also contain a summary of free-air conditions most likely to be met with under different types of pressure distribution at the earth's surface. Copy for this book has been nearly completed and will soon be ready for publication. Frequent conferences have been held with officials of the aeronautic branches of the War and Navy Departments with a view to establishing closer cooperation between these services and this bureau. As a result of these conferences, plans are being perfected for making free-air observations in aid of aeronautics and the firing of projectiles at several of the training camps, including those at San Diego, Cal., Pensacola, Fla., Mineola, N. Y., Hampton, Va., and others. Free-air wind data, as observed at the Drexel aerological station, are furnished daily

for the information of the balloon training school at Fort Omaha. In addition to this, the officers and men at this school have on several occasions used the kite field at Drexel in connection with their experimental work.

STATIONS AND OBSERVATIONS.

New, regular, full-reporting stations were established at Juneau, Alaska, in rented quarters; and at Port Arthur, Tex., in the Federal Building. No additional stations have been established, and there are now 203 principal or fully equipped stations.

OBSERVATORY BUILDINGS AND STATION OFFICES.

After several years of litigation, a decree was finally handed down on January 6, 1917, by the United States district court, Fargo, N. Dak., in the case of the United States *v.* Northern Pacific Railway Co., confirming title to Weather Bureau reservation at Bismarck, N. Dak. This decree gives to the United States (Weather Bureau) all that part of the property north of the railroad tracks, including projections of Second Street and Mandan Avenue, with the triangular pieces of land at the extremity of same, and secures for the Weather Bureau a valuable tract of land of about 3 acres which will insure the continuity of meteorological observations for the future as has been maintained since June 1, 1894. Action has been taken to change the location of the residence building and effect desired improvements at that station.

Pursuant to authority contained in appropriation act of the Department of Agriculture for the fiscal year 1917 a site for the proposed Weather Bureau observatory building at Cape Henry, Va., was purchased on the water front, consisting of lots 5 and 6, block 7, in all 15,000 square feet. Drawings and specifications were prepared for a building adapted to the special requirements of a fully equipped vessel-reporting and meteorological station and as the northern terminus of the Cape Henry-Hatteras telegraph line, and bids invited for the erection of the building, but without results, as all bids were too high. The appropriation being continuous into the next fiscal year further attempt will be made to secure the erection of a suitable building within the appropriation made therefor.

By decision of the judge of the United States district court, Seattle, Wash., dated June 12, 1917, the bureau is granted possession of lot No. 1, block 32, town site of Port Angeles, Wash., litigation in regard to which has been in the courts for some time.

COOPERATIVE CLIMATOLOGICAL WORK.

The increasing demand for information as to past and current weather conditions for all parts of the country, and from practically every standpoint of business, pleasure, health, etc., clearly indicates the great value to the public of the weather information now being gathered through the voluntary services of our corps of unpaid observers, located in nearly every county of the Union.

INSPECTION OF COOPERATIVE STATIONS.

A recognition of the great benefits to be derived from a more frequent inspection of cooperative stations by the trained officials of the bureau resulted in a considerable increase in this work during the past year, and provisions have been made whereby all cooperative stations are to be visited at least once in each three years if possible. Improvement is always noted in the records from stations that have been inspected; more uniform methods of exposure are adopted, points of doubt as to the manner of observing and recording the indications of the instruments are cleared up, the observers become more enthusiastic in their work, and frequently the continuation of a station, where the observer had grown tired of the work, results from the personal appeal of the inspector.

NEW CLIMATOLOGICAL SERVICE IN ALASKA.

Beginning with the new calendar year provision has been made for the establishment of a full climatological service for Alaska, with headquarters at Juneau. Reports are now being received with more or less regularity from about 60 points in that Territory, and printed summaries similar to those for the States are being prepared.

An annual summary of climatological data, 1915, for the Territory was prepared mainly at the central office of the bureau and printed at the Seattle station. Action has also been taken to prepare a similar report for 1916, which will likewise be printed at the Seattle office.

ATLAS OF AMERICAN AGRICULTURE.

The preparation of climatological data for the proposed atlas of American agriculture has progressed, and the precipitation section, consisting of about 80 separate charts and diagrams, illustrating in great detail the distribution of the precipitation over the entire country, together with about 15,000 words of text, have been forwarded to the Public Printer. Work on the temperature and miscellaneous sections, embracing about the same number of charts with appropriate text, has also been nearly completed and much of the matter has already been forwarded for printing.

SNOW AND ICE BULLETIN.

The weekly bulletin showing the snow and ice conditions over the country during the winter season was somewhat enlarged by additional reports from the high mountain regions of the West, thereby permitting better estimates of the prospective water supply for irrigation and other important uses. A new base chart, showing the latest attempts at depicting the topography of the country, put in use during the past winter, has added greatly to a proper interpretation of the snowfall values appearing on the chart and in the accompanying tables.

The snow bulletins issued for each of the western mountain States were also considerably enlarged by the addition of reports from points in the mountains.

OCEAN METEOROLOGY.

Action has been taken during the year to increase materially the number of vessels reporting over the North Pacific Ocean, where hitherto but little information has been available.

The charting of these reports has been taken up, and it is believed a comprehensive study of the weather over this vast area will add greatly to our knowledge of the origin, development, and progress of the storms entering the western part of the country.

TELEGRAPH SERVICE.

Weather reports (in cipher) are transmitted to and from about 200 Weather Bureau stations twice daily—at 8 a. m. and 8 p. m.—and approximately 800 forecast telegrams are sent daily from this office. In addition, there are audited at the Weather Bureau all telegraph, telephone, and radio accounts, amounting to nearly $300,000 annually, dealing with about 60 companies, also all Weather Bureau telegraph and telephone lines and other line tolls for commercial business. Repairing and rebuilding of Weather Bureau lines is also supervised by the central office of the bureau.

Further revisions of circuits were made and put into operation during the past year, by which a yearly saving of over $1,000 was effected, in addition to increasing the number of reports to several stations. A considerable saving also was effected by having certain contracts reduced.

BLOCK ISLAND-NARRAGANSETT SECTION.

The Weather Bureau owns the cable, three conductors 10¾ miles in length, and the land lines are owned by the Providence Telephone & Telegraph Co. For the use of two conductors in the cable the Providence Telephone & Telegraph Co. furnish 15 miles of land lines, connecting with Narragansett Pier and Block Island ends of the cable, in addition to paying $600 annual rental to the bureau.

This line affords telegraphic communication between Narragansett Pier and Block Island. Observational reports from the latter place are of inestimable value to the bureau. Block Island is also a storm-warning display station.

A leak in the cable was repaired last August at a cost of $1,750.

Telegraph receipts during the year:

For commercial business	$958.29
For rental of conductors (2)	600.00
Total receipts	1,558.29

Cost of repairs:

Ordinary	$4.00
Repairing cable	1,750.00

NORFOLK-HATTERAS SECTION.

This line is 162½ miles in length, including three cables—one across Pamlico Sound 3 miles in length, one three-fourths of a mile across Oregon Inlet, and one three-fourths of a mile across New Inlet.

This line connects with the Western Union Telegraph Co. at Norfolk. The United States Coast Guard Service telephone wires are attached to the Weather Bureau poles. During the year this line was almost completely rebuilt. The work of rebuilding was done by employees of the Coast Guard Service. Communication was interrupted for a total of 26 days during the year. The line is in first-class condition at the present time.

Total number of messages handled, 30,232.
Telegraph receipts, $2,195.34.
Cost of repairs, ordinary, $98.23.

MOUNT WEATHER-BLUEMONT (VA.) SECTION.

(Telephone and telegraph.) Length, 5.9 miles. This line is not now in use.

No expense; no receipts.

KEY WEST-SAND KEY SECTION.

(Telephone.) Cable; no land lines. Length, 8½ miles. Used for vessel reporting and display of storm warnings at Sand Key. This cable was laid in 1903 and is in poor condition. A new cable should be provided; probable cost, $25,000. Interruptions during the year: July, 1916, and December, 1916.

Cost of repairs, $443.17. No receipts.

GLEN HAVEN-NORTH AND SOUTH MANITOU SECTION.

(Telephone.) Connects with the Citizens Telephone Exchange at Glen Haven, Mich., and works in connection with the Coast Guard Service. It is used for the display of storm warnings and for commercial business.

Interruptions, November 9, 1916, to January 5, 1917.
Cost of repairs, $650.
Receipts, $96.98.

ALPENA-MIDDLE ISLAND-THUNDER BAY ISLAND SECTION.

(Telephone.) This line is 22 miles in land lines and 5½ miles in cable. It worked well during the year. It affords communication between the above-named places for the display of storm warnings, and connects with Coast Guard stations at these places. It was interrupted for four days and seven hours during the year.

Cost of repairs, $122.70.
Receipts, none.

GRAND MARAIS-WHITEFISH POINT SECTION.

(Telephone.) This line is 10 miles in length and connects with the Coast Guard telephone at Vermillion Station No. 9. It is used to obtain meteorological reports from Whitefish Point and for the display of storm warnings. No interruptions during the year. No expenses. No receipts.

BEAVER ISLAND SECTION.

(Telephone.) From Charlevoix to St. James, Beaver Island, Mich., 33½ miles cable, 1½ miles land; connects with the Michigan State Telephone Co.'s exchange at Charlevoix; is used for the transmission of storm warnings displayed at and for obtaining meteorological reports from St. James, and for commercial business. This cable was fouled by a steamer on April 22, 1917, and repairs were completed June 25, 1917, at an approximate cost of $1,500; 2¼ miles of cable having been carried away by the steamer.

Cost of repairs, $1,500.
Receipts, $495.80.

TATOOSH-PORT ANGELES SECTION.

(Telegraph.) Length, 95 miles. This line runs through a wooded country where lumbering operations are carried on very extensively. As fast as the land is cleared and roads built, the line is moved to the public roads. Several miles have been moved during the past year, and it is expected that considerable work of this kind will be done during the coming year, costing approximately $750 for rebuilding and removing the line. It was interrupted for a total of 15 days and 20 hours during the past year.

Besides the use of the line for transmitting observational reports from and the display of storm warnings at Tatoosh Island and of commercial business between the stations and the interior, many commercial messages are handled to and from ships at sea through the United States naval wireless station at Tatoosh, which has direct communication with the line. Tatoosh also reports all vessels that pass in or out of the Straits of Juan de Fuca.

Cost of repairs, $718.50.
Receipts, $1,564.

NORTH HEAD SECTION.

(Telegraph.) Length from North Head to Fort Canby, Wash., 2½ miles land lines; from Fort Canby to Fort Stevens, 6 miles cable. By a working agreement with the Western Union Telegraph Co., direct communication is afforded with the Weather Bureau office at Portland, Oreg. The line also connects with the United States naval radio wireless station at North Head, which station is the relay point for Alaskan reports. In addition to giving the radio service a direct outlet for their business, this line is used to obtain important meteorological reports from and transmission of storm warnings to North Head. The cable was fouled on June 9, 1916, and repaired at a cost of approximately $2,300. Communication was restored on May 19, 1917.

Total cost of repairs, $2,348.74.
Receipts, none.

SAN FRANCISCO-POINT REYES SECTION.

(Telephone.) Length, 70 miles, 20 of which are leased from the Pacific Telephone & Telegraph Co. Fifty miles are owned by the Weather Bureau, 22 miles of which are attached to the Western Union Telegraph Co.'s poles. No charge is made for these attachments. The line is used for the transmission of observational reports and

storm warnings and for vessel reporting. The portion of the line owned by the Weather Bureau is in good condition, having been rebuilt during the past year.

Cost of repairs, $2,142.37.
Receipts, none.

RIVER AND FLOOD SERVICE.

As foreshadowed in my last annual report, the work in connection with the issue of flood warnings has been strengthened during the year and extended to districts not hitherto covered. Two new river districts have been organized in California, one for the Los Angeles River, with headquarters in Los Angeles, Cal., the other for the Eel River, in Humboldt County, with headquarters in Eureka, Cal. The flood-warning service in Alabama has been extended during the year to include the Cahaba River, a tributary of the Alabama in the central portion of the State. In times of flood the rich agricultural lands along this stream are overflowed, greatly to the detriment of farming interests. It is the purpose of the bureau to anticipate, so far as possible, floods in this stream, in order that the resulting damage may be minimized.

A rearrangement of the substations in Montana and the establishment of three new stations along the Missouri in North Dakota has been effected. These changes have enabled the bureau to render more efficient service during the spring breakup of the ice in the Missouri throughout the Dakotas.

A small number of rainfall stations, reporting by mail and telegraph, have been established during the year in the watershed of the Lake of the Woods in the United States. The reports furnished by these stations are for use of the International Joint Commission, which, it may be remembered, has jurisdiction over all cases involving the use or obstruction or diversion of waters forming the international boundry, or crossing the boundry between the United States and Canada.

LOSS BY FLOOD IN THE UNITED STATES DURING THE CALENDAR YEAR 1916.

The aggregate loss by floods, computed as accurately as the circumstances will permit, was $35,967,000. As in former years, a great share of this loss fell upon the agricultural interests. This unusually large loss was due principally to the movement over the east Gulf and South Atlantic States of two tropical storms, during July, 1916. Following these two storms there was an absence of destructive floods in all parts of the country, which lasted until March, 1917.

HYDROLOGIC WORK IN SOUTHERN CALIFORNIA.

Progress in this work has been slow because of the fact that the mountain region of Los Angeles County, Cal., where the work is being done, is practically uninhabited. It has been possible to establish 16 rainfall stations in the foothills and at points within the mountains accessible by trail. Four of the stations in this study are equipped with automatically recording rain gages that are visited once a week or oftener, when possible. Twenty-eight rainfall stations are now in operation.

INTENSIVE SNOW SURVEYS.

Intensive snow surveys were conducted on Cottonwood Creek, a tributary of the Boise River, of Idaho, also in the Paradise Creek Valley, in the headquarters of the White River of Arizona. These surveys were in addition to the series of daily measurements of the amount of snowfall made at elevated stations in the Western States.

PRINTING AND PUBLICATIONS.

The demands made on the bureau for printing and lithographic work of every description have been such as to tax our force and plant to their fullest capacity. The edition of the National Weather and Crop Bulletin, which was 3,750 copies at the close of the last fiscal year, had to be increased to 4,200 copies at present, although nearly 600 addresses were dropped during the annual purging of the mailing list in March. A reduction of 120 copies in the edition of the daily Washington weather map resulted from the purging process in April.

The following table shows the principal output of our printing plant during the year:

LITHOGRAPHIC.

	Copies.
Daily Washington Weather Map	467,550
National Weather and Crop Bulletin	130,470
Snow and Ice Bulletin	21,670
Charts for Monthly Weather Review	551,625
Charts for Climatological Data	615,432
Map A	102,516
Miscellaneous charts and maps	36,925
Blank forms	13,520

PRINTING.

Station map bases (Forms DD, E, and CM)	6,827,600
Blank forms	2,363,055
Daily forecast cards	482,240
Weekly forecast	9,959
Monthly Meteorological Summary	2,980
Forecast cards franked for stations	21,554,800
Rural free delivery slips	2,183,600
Covers	21,840
Letterheads	108,500
Climatological Data	29,165
Envelopes addressed	57,425
Memorandum slips	114,550
Skeleton letters	8,400
Cards	114,010
Instructions	17,591
Weather Bureau Topics and Personnel	4,020
Amendments to Station Regulations	6,275
Circulars and circular letters	26,175
Labels and tags	147,718
Binding and Meteorological Data, complete sets	3,720
Flexotype work	7,680
Miscellaneous prints	160,975

PERIODICAL PUBLICATIONS.

The daily, weekly, and monthly issues of our periodical publications at the close of the fiscal year were as follows:

	Copies.
Monthly Weather Review	1,475
Monthly Climatological Data for the United States	310
Washington Weather Map, 1st edition, daily, except Sundays and holidays	850
Washington Weather Map, 2d edition, daily, except Sundays and holidays	385
Washington Weather Map, Sundays and holidays	475
National Weather and Crop Bulletin (weekly from April to September, monthly from October to March)	4,200
Snow and Ice Bulletin (weekly during the winter)	1,210
Forecast cards (daily, except Sundays and holidays)	1,570
Weekly forecasts	875
Monthly Meteorological Summary for Washington, D. C	250

PAID SUBSCRIPTIONS.

The number of paid subscriptions on our mailing lists at the close of the year was as follows:

	Subscribers.
Washington Weather Map	43
National Weather and Crop Bulletin	575
Snow and Ice Bulletin	25
Climatological Data	11

Subscriptions for the Monthly Weather Review are filled direct by the Superintendent of Documents from the 100 copies furnished him monthly by this division.

Remittances received by the Superintendent of Documents during the year, covering subscriptions for Weather Bureau publications, were reported as follows:

Washington Weather Map	$122.45
National Weather and Crop Bulletin	135.65
Snow and Ice Bulletin	9.50
Climatological Data	59.90
Station weather maps	207.39
Total	534.89

NEW PUBLICATIONS.

The following is a list of the principal nonperiodical publications issued during the year:

Daily River Stages at River Gage Stations on the Principal Rivers of the United States for the Year 1915. Vol. XIII. 176 pages. W. B. No. 582. July, 1916. Gov. Print. Office.

Weather Code, for the Transmission of Meteorological Observations. Revised edition, 1916. 100 pages. W. B. No. 584. August, 1916. Gov. Print. Office.

Weather Forecasting in the United States. 370 pages, illus., charts. W. B. No. 583. August, 1916. Gov. Print. Office.

Aerology No. 1. 67 pages, illus., Supplement No. 3, Monthly Weather Review. W. B. No. 592. December, 1916. Gov. Print. Office.

Instructions for the Management and Care of Storm Warning Stations. 26 pages, illus. W. B. No. 587. December, 1916. Gov. Print. Office.

Weather Forecasting, with Introductory Note on Atmospherics. Bulletin No. 42, second edition. 37 pages, illus. W. B. No. 598. January, 1917. Gov. Print. Office.

Annual Report of the Chief of the Weather Bureau, 1915–16. 282 pages, charts. January, 1917. Gov. Print. Office.

Description of Cloud Forms; revised edition. 1 sheet, illus. January, 1917. Weather Bureau Print.

Types of Anticyclones of the United States and Their Average Movements. 25 pages, illus., charts. Supplement No. 4, Monthly Weather Review. W. B. No. 600. February, 1917. Gov. Print. Office.

Aerology No. 2. 59 pages, illus. Supplement No. 5, Monthly Weather Review. W. B. No. 603. April, 1917. Gov. Print. Office.

Weather Code for West Indian and Caribbean Sea Observers. 32 pages. May, 1917. W. B. No. 612. Gov. Print. Office.

Relative Humidities and Vapor Pressures over the United States, Including a Discussion of Data from Recording Hair Hygrometers. 61 pages, illus., charts. Supplement No. 6, Monthly Weather Review. W. B. No. 609. May, 1917. Gov. Print. Office.

The Daily Weather Map, with explanation. 8 pages, 4 charts. June, 1917. Weather Bureau Print.

EXPENDITURES OF THE WEATHER BUREAU AT THE GOVERNMENT PRINTING OFFICE DURING THE FISCAL YEAR 1916–17.

	Copies.	Cost.
Blank forms and maps	10,058,800	$10,750.78
Cards	6,000	22.73
Blank books	234	225.06
Binding	2,256	2,775.85
Posters, placards, charts, etc	7,100	553.19
Separates and pamphlets	35,600	1,317.84
Publications, miscellaneous	17,945	7,985.60
Publications, periodical	19,100	7,189.48
Congressional	1,009	4,178.63
	10,147,244	34,999.16
Amount allotted		$35,000.00
Amount expended		34,999.16
Unexpended		.84

LIBRARY.

During the year, 827 books and pamphlets were added to the library, bringing the total strength of the collection up to about 36,300. On account of conditions abroad there was a marked decrease in the number of foreign publications received, and the files of many important foreign periodicals are seriously in arrears.

Considerable progress has been made in strengthening the station libraries, especially that at Chicago, which serves as a depository for a reserve collection of important books available for transfer to the central office or elsewhere in case of need.

SEISMOLOGY.

The work of collecting and publishing earthquake data, begun December 9, 1914, has been continued during the past year. These data are of two kinds, noninstrumental reports of earthquakes felt and instrumental records, often of quakes wholly imperceptible to the senses. The noninstrumental reports are rendered by all the regular stations of the bureau, about 200 in number, and also by nearly all the bureau's 4,500 cooperative observers. The instrumental records published by the bureau have been obtained in part by instru-

ments owned and operated by the bureau itself, one at Washington, D. C., the other Northfield, Vt., and partly through the cooperation of 18 additional stations distributed from Panama to Alaska and from the Hawaiian Islands to Porto Rico.

During the calendar year 1916, 131 earthquakes were felt within the borders of the United States proper. The great majority of these produced no damage whatever, and only six or seven were severe enough to produce even slight damage.

SOLAR RADIATION INVESTIGATIONS.

Solar radiation measurements of much the same character as those for 1915–16 have been obtained throughout the year at Washington, D. C., Madison, Wis., Lincoln, Nebr., and Santa Fe, N. Mex., and the results have been published each month in the Monthly Weather Review. The instrumental equipment at Washington has been increased by the purchase from the Smithsonian Institution of a pyranometer, which will be used principally in restandardizing recording pyrheliometers.

Excellent observations were obtained of a cloud layer of high haze that overspread the United States from the Atlantic coast southwestward to southern California at the end of July, 1916. These included measurements of the height of the haze layer, and its direction and velocity of movement, and descriptions of the brilliant twilight colors, especially the purple afterglows, that accompanied it. The measurements of height and movement are in accord with similar measurements of the movement of balloons above a height of about 16 kilometers, and are confirmatory of the existence of air currents from the east at these high levels. In California and Arizona the haze and the brilliant afterglows were observed until after the end of 1916.

Photometric measurements of the intensity of twilight previously made at Mount Weather, Va., have been supplemented by further measurements at Salt Lake City, Utah. These are summarized in the Review for November, 1916. In connection therewith are published tables showing the duration of both civil and astronomical twilight at different latitudes; and the term "civil twilight," which does not appear in English dictionaries, is definitely defined.

At Salt Lake City photometric measurements have also been made of the intensity of twilight illumination on a cloudless day with a clear sky and on a similar day except for the presence of a dense layer of surface smoke. The measurements include illumination from direct sunlight, from diffuse skylight, and from the two combined, which latter is the total daylight illumination. They show that the total illumination averages about one-third less on a smoky day than on a clear day and that the illumination from direct sunlight averages one-half less.

A study has been made of the shading effect of wire insect cages, such as are employed by the Bureau of Entomology to protect plants from insect pests, and also of various kinds of shade cloth employed by tobacco growers in certain sections to improve the quality of the tobacco leaf. The shading may be expressed by a simple mathematical formula, as has been shown in the Review for September, 1916.

The shade cloth is also used at the Arlington Farm by the Bureau of Plant Industry to determine the relation between sunlight intensity and the development of certain standard plants. In these investigations the solar radiation measurements for Washington, referred to above, are also utilized.

AGRICULTURAL METEOROLOGY.

The Division of Agricultural Meteorology was established February 21, 1916, for the purpose of conducting studies of every character of the relation of weather to crops and the collection of statistical data required in such studies, including the direction and supervision of cooperative relations with the State experiment stations and other contributing organizations. The division conducts investigations of the effect of weather and climate upon the growth and yield of crops, determines the distribution of frost warnings and forecasts for special agricultural interests, conducts studies for the protection of crops and orchards from frost, has general supervision over all special services and, in general, supervises the activities of the Weather Bureau which relate particularly to agriculture.

CORN AND WHEAT REGION SERVICE.

This service covers the 16 principal grain States, and its organization, as well as the service given, is indicated by the following table:

Region center (Chicago, Ill.)	1
District centers	13
Special reporting stations	189
Stations opened during year	21
Stations closed during year	9
Stations issuing daily corn and wheat region bulletin	18
Total number daily bulletins issued	2,964

This service has been improved during the year by the establishment of additional stations in the western grain districts. Also by the completion of arrangements for publishing a weekly corn and wheat region bulletin at the region center; the issue of these bulletins began the first part of July, 1917, with a list of approximately 600 addresses.

COTTON REGION SERVICE.

This service covers the principal cotton States, and its organization, as well as the service given, is indicated in the following table:

Region center (New Orleans)	1
District centers	13
Special reporting stations	167
Stations opened during year	2
Stations closed during year	0
Stations issuing daily cotton region bulletins	26
(In addition to this Galveston, Tex., publishes the cotton information on a large glass map.)	
Total number daily bulletins issued	2,358

As will be seen from the foregoing table this service was reorganized during the spring of 1917 by the establishment of a region center at New Orleans. The telegraphing of the district averages was discontinued, and in their place a summary is being telegraphed

from the region center to 26 different points and there published in the form of daily bulletins and given to the press; this information is also used at New Orleans in the same manner. Data covering the rainfall at each of the 167 stations, and temperature at 5 stations in each State are telegraphed to the region center, and after being tabulated and charted the summary mentioned above is prepared. In addition to the general weather conditions heavy rainfalls at individual stations are included.

SUGAR AND RICE REGION SERVICE.

This service covers the rice-growing region of Texas and Louisiana and the sugar-cane-growing sections of the South. The stations covering these crops are seven in number, and the information is published in the cotton region bulletins. The district center is at New Orleans.

CATTLE REGION SERVICE.

There is one district center, located at Amarillo, Tex., with 11 special stations covering this service; in addition to these, special reports are received from 20 other points in western Texas and Oklahoma. This cattle-region service covers southeastern Colorado and central and eastern New Mexico, in addition to western Texas and Oklahoma. A second cattle-region bulletin distributing point was established at Roswell, N. Mex., during the year. The number of daily bulletins published at these two points is 657. Preliminary steps are under way for the establishment of a new district center at Phoenix, Ariz., as well as at Salt Lake City, Utah.

CRANBERRY WARNING SERVICE.

Special cranberry-warning services are maintained in eastern Massachusetts, southern and northwestern Wisconsin, and central and southern New Jersey. Ten special stations are maintained in these districts, from which daily weather reports are sent to the forecast centers to aid in making frost and minimum-temperature forecasts.

SPECIAL FRUIT-WARNING SERVICE.

Special frost and minimum-temperature warning services, with special reporting stations, are maintained as follows:

Center.	*District covered.*
Columbus, Ohio	Most of State.
Medford, Oreg	Rogue River Valley, Oreg.
Walla Walla, Wash	Upper Columbia River Valley in Washington and Oregon.
Boise, Idaho	Boise-Payette district.
Do	Twin Falls district.
Salt Lake City, Utah	Northern Utah.
Delta, Colo	Gunnison River Valley.
Grand Junction, Colo	Grand River Valley.
Pueblo, Colo	Canon City, Colo., district.
El Paso, Tex	Rio Grande Valley.
Roswell, N. Mex	Pecos Valley.
Los Angeles, Cal	Southern California.
San Francisco, Cal	Central California.
Portland, Oreg	Salem, Oreg., vicinity of.
Jacksonville, Fla	Central and southern Florida.

Recent studies of methods for making more definite minimum-temperature forecasts, based on mathematical hygrometric and thermometric formulæ, have proven very helpful, and these studies will be continued. These local officials are studying the topographic and other conditions, and give expert information to those orchardists who are prepared to prevent frost damage by artificial means.

Special frost warnings are also distributed from a large number of Weather Bureau stations for fruit and truck interests, although no special station reports may be received.

ARTIFICIAL PROTECTION OF ORCHARDS, GARDENS, ETC., FROM FROST.

The service described in the preceding section has been maintained for many years. Beginning with the fiscal year July 1, 1917, Congress made available a special appropriation for the study of the efficiency of methods of artificially protecting orchards, gardens, etc. Preliminary preparations for the inauguration of this work were begun before the close of the year, in order to take advantage of the spring frosts of that season, and the work will be carried forward during the year with the appropriation available.

FROST AND TEMPERATURE STUDIES IN NORTH CAROLINA.

In 1912 the bureau inaugurated a study of the very interesting atmospheric phenomena and anomalous climatic features which have been designated thermal or frostless belts and verdant zones, and which are strikingly developed in some of the mountainous sections of western North Carolina.

The observational program of this project was brought to a completion December 31, 1916, with nearly five years of accumulated data from about 68 stations.

This project has been supervised by Prof. H. J. Cox, who is now engaged in the completion of his report, which will doubtless supply a much more comprehensive and detailed account of these climatic phenomena than ever heretofore attempted.

ALFALFA SEED-WARNING SERVICE.

A minimum-temperature forecast service is maintained at Salt Lake City, Utah, for the benefit of the alfalfa seed growers in central Utah. Four special reporting stations are in operation and the information from these is used as an aid in making the minimum temperature predictions. The plan of the seed growers is to leave their last stand of alfalfa for seed; if freezing temperature occurs while the matured or nearly matured plants are standing the seed is ruined; if the warning can be received a sufficient time in advance to cut the alfalfa, only the top layer will be damaged. The growers frequently run their mowing machines all night long preceding a dangerous temperature.

A similar service has been put into operation during the present season in western South Dakota, with Rapid City as the distributing point. No special stations have yet been established, however. This service is susceptible of expansion.

ALFALFA HARVEST SERVICE.

Special three- or four-day forecasts are being made for the benefit of the alfalfa growers throughout the whole western part of the country. Information of fair or rainy weather periods is telegraphed from the district centers to the large alfalfa-growing sections, to enable harvesters to cut and cure the alfalfa to best advantage.

POTATO FROST-WARNING SERVICE.

In the fall of 1916 special freezing-temperature forecasts were issued by the district forecaster at Denver for western, south-central, and north-central Colorado, at the request of the State Potato Growers' Association. These warnings are of value and will be continued.

RICE HARVEST FORECASTS.

A three- or four-day forecast, especially in connection with heavy rains, is sent from New Orleans to the rice growers in Arkansas.

SPECIAL STORM WARNINGS FOR SHEEP INTERESTS.

Special rain and temperature forecasts are made at Portland, Oreg., during the shearing and lambing season, for wide distribution in Oregon, Washington, and Idaho. This service fosters early shearing and lambing by enabling the ranchmen to keep the newly shorn sheep and young lambs near shelter when a cold storm is anticipated.

WASHINGTON : GOVERNMENT PRINTING OFFICE : 1917