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[Advance sheets from Annual Reports of the Department of Agriculture, 1914.]

## REPORT OF THE CHIEF OF THE WEATHER BUREAU.

UNITED STATES DEPARTMENT OF AGRICULTURE,  
WEATHER BUREAU,  
*Washington, D. C., September 21, 1914.*

SIR: I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1914.

Respectfully,

C. F. MARVIN,  
*Chief of Bureau.*

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

The last year has been comparatively free from severe storms or floods such as sometimes occur. A destructive storm passed over the Great Lakes early in November, 1913, causing heavy loss of life and shipping, especially on Lakes Huron and Erie. Also in the Southwest the heavy rains of December, 1913, falling upon a soil already saturated, caused severe and in some cases unprecedented floods in the rivers of Texas.

A number of changes, mostly of a minor character, have been effected in the work of the bureau for the purpose of improving and extending the service or securing greater economies of administration. The several classes of its work are briefly discussed under separate topics, as follows:

### STATIONS AND OBSERVATIONS.

The fully equipped stations of the bureau reporting telegraphically once or twice each day are maintained primarily for forecasting and storm-warning purposes, and the existing stations of this character within the immediate confines of the United States serve practically all existing needs. Extensions are necessary within Alaska, the Canal Zone, and the regions of the Caribbean Sea, but these can be made only when additional funds are provided, which will be made the subject of estimates at the proper time.

A number of new minor stations were established during the year at points not hitherto represented, and extensions have been made in special fields from which prompt information regarding weather conditions was desirable.

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

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A new special service for reporting the daily weather conditions over the principal range region of the West, as affecting the live-stock interests, was inaugurated in the spring of 1914. Reports from a number of points in the western Great Plains region are collected daily by telegraph at Amarillo, Tex., and thence distributed in bulletin form to the cattle and financial interests of the surrounding country. This service has elicited much approval.

Action was taken during the year to improve the instrumental equipment exposure at the cooperative meteorological stations, especially those established in the sparsely settled districts of the more western States.

#### WATER RESOURCES DETERMINED BY SNOW SURVEYS.

The work of determining the water content of the blanket of snow which remains on the ground at high altitudes in some of the Western States, inaugurated in Utah a few years ago, was extended during 1913-14 into one watershed each in the States of Idaho and Nevada.

Intensive snow surveys for the country in general are not possible with the means available. The bureau is seeking, however, to increase the amount of useful information with respect to the amount of water that will be available from melting snow, through the more general use of a new form of snow scale or stake that can be permanently installed in places that are not easily accessible in the snow season, but which can be visited shortly before the melting season begins. The observations of snow depths obtained by use of these snow stakes, when supplemented by a relatively small number of density measurements, afford the best information concerning the season's water supply from the snow fields of high altitudes that can be obtained short of very laborious and expensive surveys.

Some field work has been done in Arizona on the headwaters of the Salt River, whence comes a large part of the water that supplies the Roosevelt Reservoir. In general, the installation of permanent snow stakes in the higher altitudes, although progressing slowly, is but the beginning of a campaign in the interest of water users that will eventually, it is believed, yield information of the highest importance.

#### OBSERVATORY BUILDINGS.

Work on the new observatory buildings authorized by Congress for Cincinnati, Ohio, and Sandy Hook, N. J., has progressed favorably. At Cincinnati some delay was experienced in obtaining a site. A very satisfactory location was finally purchased on Lafayette Circle, Clifton suburb. At Sandy Hook a very acceptable site has been obtained on ground closely adjacent to the Fort Hancock military reservation through the courtesy of the War Department. Both buildings are to be brick, and of good, substantial character.

#### TELEGRAPH SERVICE.

Except for temporary interruptions, the several sections of the Weather Bureau telegraph and telephone lines were in continuous operation during the year.

## FORECASTS AND WARNINGS.

During the year reports from Spitzbergen (lat., 78° N.; long., 20° E., approximately) were received by telegraph for the first time. These formed a valuable addition to the telegraphic weather reports from northern Europe and Asia. Wireless reports from newly established stations—Swan Islands (lat., 17½° N.; long., 84° W., approximately) and Cape San Antonio (on the extreme western end of the island of Cuba)—materially aid the forecast official in locating and forecasting the movement of storms of subtropical origin in the Caribbean Sea.

For several years the forecasters at the central office have prepared each day a manuscript weather map of the entire Northern Hemisphere. In view of the great value of such a map, it was deemed advisable to undertake its daily publication in the hope that by placing it in the hands of many meteorologists and scientists, both at home and abroad, the serious scientific and mathematical study of the great and complex problems of the general circulation of the atmosphere would be materially facilitated. This publication was begun January 1, 1914, and elicited numerous expressions of enthusiasm from eminent meteorologists of the United States and Europe. Unfortunately the complete suspension of the telegraphic transmission of the foreign reports with the opening of hostilities in the European countries, beginning July 31, prevented the further issue of this valuable record of atmospheric conditions.

Better data for forecasting frosts for the citrus districts are now available from new reporting stations in California and Florida. These will result in improving the methods of utilizing and distributing the warnings. The new stations are in orchards, and the temperatures reported are those to which the trees and fruits are exposed. This gives the forecaster definite information of conditions in the orchards. In the Rogue River and Yakima Valleys and the Boise (Idaho) Basin the bureau has observers on the ground during the frost season who amplify the district forecasts and apply them specifically to restricted neighborhoods. When growers make preparations to protect their orchards by modern artificial methods of heating or otherwise, the frost forecasts become indispensable. The plan in these localities is to have a number of substations equipped with thermometers and rain gauges, the local observer making daily report to the forecaster.

A new service is just being inaugurated whereby warnings will be issued during the summer of the coming of hot dry winds in the valuable timbered regions of the West—that is, warnings of atmospheric conditions that are peculiarly favorable to the inception and spread of forest fires. The forecasting of these winds is as yet tentative and experimental, and the final practicability of the service is yet to be established.

Through cooperation with the naval radio service of the Navy Department, a daily distribution of wind forecasts and storm warnings is now regularly made from two points—Radio, Va., and Key West, Fla.—for the Gulf of Mexico and the western portion of the Atlantic Ocean. During the year arrangements were completed to have a similar service for the Great Lakes. By this means valuable information is placed in the hands of vessel masters while at sea.

The study of meteorological data with a view to increasing the percentage of accuracy of the daily and the weekly forecasts, and, if possible, extending the forecast period beyond one week, will be continued.

Two notable contributions to the technical forecasting work of the service are now far advanced toward completion. The first is a study by Messrs. E. H. Bowie and R. H. Weightman, resulting in a system of normals showing the mean 24-hour movements by 5-degree squares of storms in the United States, classified into 9 types. This was completed during the year and will shortly be published as a supplement to the Monthly Weather Review. The second is a series of essays on weather forecasting by a large number of the best and most experienced forecasters of the Weather Bureau. These are now in the hands of a competent editor in chief, with advisory assistants, for the preparation of a handbook or manual on weather forecasting in the United States, to serve as a textbook and guide to all the men in the service desiring to qualify and become proficient in forecasting.

#### RIVER AND FLOOD SERVICE.

The occupation of agricultural lands and the building of towns and cities along the river bottoms of Oklahoma within the last 20 years has made it necessary to establish a flood-warning service on the principal rivers of that State. Such a service was completed on April 15, 1914, in time, fortunately, to give ample warning of a destructive flood that swept down the Canadian River during the first week of May, 1914.

Minor changes have been made in the Columbus, Ohio, Cairo, Ill., and Houston, Tex., districts, with a view to improving the distribution of flood warnings.

The absence of destructive storms and floods generally has already been mentioned. The severe and in some cases unprecedented floods in the rivers of Texas in December, 1913, however, caused a loss of 177 human lives and a property loss of approximately eight and a half millions of dollars.

The plan of reducing to writing the knowledge gained by the several officials of the bureau in the forecasting of floods has been continued during the year, and rules for the preparation of flood forecasts for the Mississippi at St. Louis and for the Susquehanna at Williamsport and Harrisburg, Pa., have been completed and put into practical use. These rules are useful not only in the daily work of the station, but also serve the purpose of preserving and transmitting to others the methods of the most successful flood forecasters.

In its hydrographic work the Weather Bureau cooperates with other branches of the public service whenever it is practicable to do so; thus, if the gaging of a stream at any point is helpful to another department, the expense of the upkeep is shared with that department. Mutually helpful working arrangements are in force with the United States Engineers, the Mississippi River Commission, the Water Resources Branch of the Geological Survey, the Reclamation Service, the Indian Office, and the Forest Service of the Department of Agriculture.

## METEOROLOGICAL RECORDS AND PUBLICATIONS.

The customary serial and other publications of the bureau were issued during the year. Bulletin Y, *The Ohio and Mississippi Floods of 1912*, by H. C. Frankenfield, and Bulletin Z, *The Floods in the Rivers of the Ohio and Lower Mississippi Valleys*, by Alfred J. Henry, complete the lettered series of bulletins of the Weather Bureau heretofore published in quarto form. Material of this character will be printed hereafter as supplements to the *Monthly Weather Review*.

The demand for Weather Bureau literature, especially from schools and colleges and from foreign applicants, has been very large and bears witness to the constantly growing appreciation of the work of the bureau on the part of students, scientists, and the general public.

CHANGES IN SERIAL PUBLICATIONS.—The compilation of climatological data for reference study and publications went forward as usual during the year.

In response to a general desire for the presentation of climatological data by States rather than by large drainage areas, the publication of such data by State units was resumed. This change went into effect with the issue of climatological data by State units for January, 1914. At the same time the *Monthly Weather Review* was restored to its form of the period prior to July 1, 1909, which was essentially that of a meteorological journal, and the so-called *Bulletin of the Mount Weather Observatory*, upon the completion of volume 6, was consolidated with the *Monthly Weather Review*.

The scope of the national weather bulletin was enlarged during the year by the introduction of information regarding the progress of crop growth and development. The form of the bulletin was also changed from that of a single large sheet to a pamphlet, quarto size, and its value further increased by the addition of diagrams showing for preceding weeks the temperature and precipitation conditions and comparison with normal value over principal crop-growing areas. The diagram also contained data showing the condition of the principal crops from month to month as furnished by the Bureau of Statistics (*Crop Estimates*).

In October, 1913, the Weather Bureau, in cooperation with the Bureau of Statistics, began publishing monthly summaries of condition of the various crops for each State in the Union. These summaries have been telegraphed monthly from the Bureau of Statistics in Washington to the several State centers of the Weather Bureau, where they are promptly printed and distributed to the press and public.

A further dissemination of weather and crop information each week has been inaugurated by telegraphing in condensed form a summary of the more important matters appearing each Tuesday in the weekly bulletin to the corn and wheat and cotton region centers distributing daily bulletins. These summaries are printed at the various stations receiving them and are promptly distributed.

Considerable work was accomplished during the year, in cooperation with the Bureau of Plant Industry, in certain investigations being carried forward by that bureau, concerning the relation of

farm enterprises to geographical factors. This bureau has assisted in the work by compiling and checking a large amount of the climatological data, particularly records of precipitation and frost.

#### LIBRARY.

Additions to the library during the year numbered 1,167 books and pamphlets, bringing the strength of the collection up to about 34,000.

The bureau is gradually building up a collection of the most important meteorological works, old and new, at its station in Chicago. These books are useful to the large staff of the Chicago station, and are also available for loan to other stations as needed.

The promotion examinations heretofore held under the direction of the librarian, as supervising examiner, in grammar, arithmetic, elementary meteorology, essay writing, algebra, and trigonometry were abolished in August, 1913. The examinations in physics, astronomy, and advanced meteorology were retained, but they are now required only of employees who desire advancement to the scientific grades of the service, while the examination in plant physiology is retained as an optional examination for employees desiring to undertake work in agricultural meteorology. The number of examination papers rated during the fiscal year was 55, of which 44, or 80 per cent, attained passing grades.

#### TECHNICAL STUDIES AND RESEARCH.

Aerial observations by means of kites and balloons and the measurement of solar radiation were continued as heretofore, chiefly at Mount Weather, although preparations were made for the transfer of this work to the Middle West.

The following extracts from the report of Prof. W. R. Blair, in charge of the aerial investigations, indicate the status of that work:

**THE DIURNAL CONVECTIVE SYSTEM.**—All observations made at Mount Weather and elsewhere in the study of this system have been summarized and published in the Bulletin of the Mount Weather Observatory, volume 6, part 6, 5.

**INTERNATIONAL COOPERATION.**—During the year free-air observations were made on days selected by the International Commission. The data obtained in these observations have been sent to the commission for study and publication. All data obtained on "international days," not elsewhere published by us, will appear in the July, 1914, number of the Monthly Weather Review.

**THE FIVE-YEAR SUMMARY.**—This summary of the data obtained at Mount Weather in the five years ending June 30, 1912, has been completed and published in the Bulletin of the Mount Weather Observatory, volume 6, part 4.

**MOUNTS WILSON AND WHITNEY EXPEDITION.**—Preparations for this expedition were all complete in June, 1913. The observations were made in July and August of the same year. The Weather Bureau made aerial soundings with free balloons at Avalon, Cal., throughout the period from July 21 to August 12, and with captive balloons at the base and summit of Mount Whitney from August 2 to 13. In five of the soundings made at Avalon self-recording pyrheliometers, devised and constructed by C. G. Abbot, were carried up in addition to the meteorographs. While these soundings were in progress, the Smithsonian Institution was making observations of the total moisture content of the air above Mount Wilson; also of insolation and nocturnal radiation at Mount Wilson in the early part of the period, at Mount Whitney in the latter part. The records obtained by the pyrheliometers sent up have been discussed by Mr. Abbot in Science, March 6, 1914. The observations of insolation and of nocturnal radiation are being prepared for publication by A. K. Angström, under whose direction they were made. The data obtained in the aerial soundings

have been reduced and prepared for publication. They will appear in the July, 1914, number of the Monthly Weather Review.

**TRANSFER OF AERIAL WORK TO THE MIDDLE WEST.**—In order to increase the effectiveness of the aerological investigations by means of kites and balloons, steps were taken toward the close of the year to transfer this work from Mount Weather to a point in the Middle West, and the bureau was peculiarly fortunate in this connection in securing the temporary use of the valuable hydrogen generating and aeronautic equipment belonging to the Signal Corps of the Army, located at Fort Omaha, Nebr.

The request of the Secretary of Agriculture to utilize this elaborate plant was generously granted by the Secretary of War, May 11, 1914, and action was immediately taken to generate hydrogen for the purpose of making a large number of balloon ascensions, both for purely meteorological purposes and also in cooperation with the Astrophysical Observatory of the Smithsonian Institution, for the purpose of securing measurements of intensity of solar radiations at great elevations in the free air.

Incidental to the foregoing, search was made for the best possible site in the vicinity of Omaha for the location of a kite-flying station, but no selection was made before the close of the year.

The influence of the wind in lowering the barometer readings at Mount Weather was briefly studied, and certain quantitative results were obtained.

**MEASUREMENT OF SOLAR RADIATION.**—Certain general, rather definite, conclusions having been reached from the investigations of solar radiation, it appears appropriate to mention briefly some of these presented in the report of Prof. H. H. Kimball, in charge of this work.

The observations have been conducted not only at Mount Weather but also at Madison, Wis., Lincoln, Nebr., and Santa Fe, N. Mex. Some of the dust thrown into the atmosphere by the eruption of the Katmai Volcano, Alaska, early in June, 1912, still affected radiation intensities until about December, 1913, and air temperatures over the whole Northern Hemisphere seem to be appreciably lowered thereby.

From the extensive studies of total solar and sky radiation received by a horizontal surface it is found that on the average with the clearest sky the heat received per square centimeter varies from 250 calories per day on December 20 to 765 calories on June 10. On March 20 it is 605 calories, and on September 20 it is 510 calories. In general, the radiation received on clear days during the first half of the year exceeds that received on clear days during the second half by about 8 per cent. This is principally because of the increased water-vapor content of the atmosphere during the latter period.

The total radiation received with the clearest sky during an hour in the middle of the day varies from 45 calories per square centimeter of horizontal surface in December to somewhat over 90 calories in June. It exceeds 60 calories per hour, or 1 calorie per minute, from early in February to the middle of October. The maximum radiation per minute does not occur when the sky is clearest, but when there are clouds near the sun, which, while not obscuring it, reflect its rays toward the earth. A rate of 1 calorie per minute has been recorded in every month except December, a rate of 1.50 calories from early in April to early in September, and a rate of 1.65 calories in May and June.

The photometric measurements with the clearest sky give a midday intensity of 4,500 foot-candles in December and 9,500 foot-candles in June. About one-fourth of this illumination is received diffusely from the sky, while only about one-fifth the radiant heat received at noon is from this source.

Expressed in units of work, the receipt of 1 calorie of heat per minute per square centimeter of area represents 697 watts per square meter, or 0.78 horsepower per square yard; and 1.5 calories per minute, or 90 calories per hour, which is not an uncommon rate at midday in summer with a clear sky, represents over 1 kilowatt per square meter, or nearly 1.2 horsepower per square yard.

During the summer months at Mount Weather the average daily insolation is about 70 per cent of what would be received were the sky continuously clear.

A detailed study of these various radiation measurements has been prepared for publication in the Monthly Weather Review.

NOCTURNAL RADIATION.—Closely related to the subject of insolation, or the heat received by radiation, at the surface of the earth, is that of irradiation, or the heat lost by radiation from the earth outward. Measurements of the loss of heat from a blackened surface when freely exposed to the sky at night have been made at Mount Weather since May 14, 1914. The maximum rate measured is 0.22 calories per minute, or 13.2 calories per hour, which was obtained on a clear night early in June. The rate has been found to be very uniform during a clear night. Assuming that this rate is maintained during the day, the loss of heat by radiation during 24 hours of clear weather in June may reach 317 calories, or about 40 per cent of the insolation. The average nocturnal radiation during June was less than 60 per cent of this maximum rate, however, and fell off steadily as the water-vapor content of the atmosphere increased with the advance of summer.

