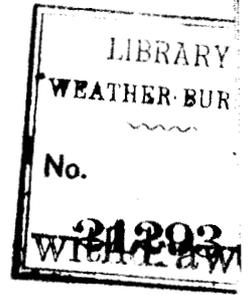


W. B. No. 206.

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU.



REPORT

OF THE

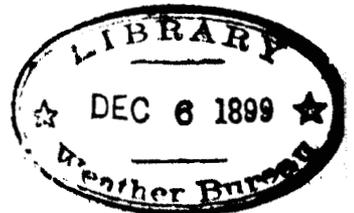
CHIEF OF THE WEATHER BUREAU

FOR

1899.

BY

WILLIS L. MOORE.



[From the Report of the Secretary of Agriculture.]



WASHINGTON :
WEATHER BUREAU.
1899.

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

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REPORT OF THE CHIEF OF THE WEATHER BUREAU.

U. S. DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D. C., August 28, 1899.

SIR: I have the honor to submit a report of the operations of the Weather Bureau during the fiscal year that ended June 30, 1899.

Respectfully,

WILLIS L. MOORE,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

WORK OF THE YEAR.

FORECASTS AND WARNINGS.

Timely and important warnings of severe storms, hurricanes, cold waves, and frost were issued on a number of occasions. The closing months of 1898 were especially stormy on the Great Lakes and the New England coast. Probably the most severe storm within the memory of the living swept along the Massachusetts coast on November 26-27, entailing a loss of at least 200 lives and many vessels. This appalling loss of life was largely due to the sailing of one vessel, the *Portland*, with a passenger list of probably 150 souls. The captain of the *Portland* left Boston Harbor at the regular time for sailing (6 p. m.), although storm signals had been flying since 11 a. m., and marine interests had been completely notified of the coming storm. The disasters of this storm will not soon be forgotten, yet what might have been the record of death and destruction if the harbors of the New England coast had not been filled with hundreds of craft which had sought a safe anchorage on the advices of the Weather Bureau?

The extension of the usual time limits of the night forecast from thirty-six to forty-eight hours marked an important change in the forecast work of the Bureau. Persons who receive the forecasts through the morning newspaper frequently wish to know the weather conditions to be expected on the coming day. Although attempts to extend the time covered by the forecasts had been made heretofore, they were not successful. In the full belief that as a result of the special study of the problem of forecasting made during the past two years such an extension was not only practicable but very greatly desired, forecast officials were directed that beginning March 1, 1899,

the period covered by the night forecasts should be increased to forty-eight hours. The success already attained has fully justified the issuance of the order.

Severe storms.—The only hurricane in the West Indies during the season of 1898 followed closely the establishment of stations in that region. At 12:40 p. m., September 10, the United States Weather Bureau observer at Bridgetown, Barbados, cabled a special report which showed the presence of a cyclonic disturbance southeast of the Windward Islands. Hurricane warnings were immediately cabled to Weather Bureau stations in the Lesser Antilles, and the officials in charge were instructed to give the widest possible distribution of the warnings in their respective districts. In the meantime, and immediately following the dispatch of his special message, the Weather Bureau observer at Bridgetown warned all local interests of the approach of the hurricane. The storm reached the island of Barbados the night of September 10, and the islands of St. Vincent and St. Lucia the morning of September 11. At Barbados 83 persons were killed, 150 injured, and property to the estimated value of \$2,500,000 was destroyed. The following are among comments made by the press in connection with this storm and the warnings issued by the Weather Bureau in advance of its arrival:

[From the Barbados Advocate, September 17, 1898.]

Saturday morning was dark and lowering, and the indications of approaching bad weather were strong. At noon Mr. McDonough, of the United States Weather Bureau, notified the public that a hurricane was fast approaching Barbados. At 6 p. m. the clouds gathered densely in the northeast, and the wind commenced to blow freshly from that point. The rain fell heavily, and the clouds continued to gather in dark, ever-wheeling columns, the higher banks forming scuds flying rapidly to various points; at 7 p. m. the barometer had fallen to 29.66, and the wind had increased in force and violence until a strong gale was blowing. At 9 p. m. the wind was blowing with hurricane force.

Fiercer and more destructive hurricanes may have visited the West Indies in years past, but taking into consideration the general condition of her industry and its gloomy prospects, never has a more appalling calamity fallen on this island since it first rose out of these western seas, than the fearful hurricane which ravaged it from shore to shore on Saturday night last.

[From an editorial in the New Orleans Times-Democrat of September 24, 1898.]

We were able to test this new service in the recent hurricane of September 10 and 11. The storm which prevailed then was first noticed in an inchoate condition near Barbados on September 10. All the other West Indian islands were notified from Washington, and it was in consequence of that notice that the Spanish vessels at San Juan de Porto Rico, which were to have sailed for Spain on that day, delayed doing so, escaping the storm and saving, in all probability, many lives by their delay. Every seaport that could be reached by telegraph was notified; the vessels remained in harbor, and the hurricane, a very severe one, swept through the Caribbean and the Gulf of Mexico without injuring a single vessel. So much for our new weather stations. There was some loss of life in the interior of the islands where the warning could not reach in time, but this was infinitesimal compared with the damage that might

have been done and would have been done had the approach of the storm not been known one or two days beforehand.

The hurricane was very severe over the smaller Antilles, and wasted most of its force before it reached Cuba. All we caught of it was a violent rainstorm. But although it was not as widespread as some other Gulf hurricanes, it was as severe in its intensity where it did rage. By the warning given by our weather service, property in value a hundred times the cost of the service was saved. The wisdom of the new stations is thus clearly proved. Louisiana ought to appreciate the improvement, for probably no part of the country is more affected and more directly interested in hearing of the approach of these hurricanes. With timely notice vessels will not leave here in the face of a storm. The thousands of fishermen along the coast can receive warning in time and escape the fate of their comrades at Cheniere Caminada. Finally, the sugar and rice plantation owners are deeply interested in knowing of an approaching blow, so as to give them a chance to care for the crops, to harvest the rice or cut the cane before the storm breaks over them.

In enumerating the benefits of the war we must not overlook the improvement it has assured us in our weather service on the Gulf and south Atlantic, an improvement that would scarcely have been made, certainly not made for years, if the safety of Sampson's and Watson's fleets and Shafter's army had not demanded the establishment of additional weather stations in the West Indies.

[From the Daily Gleaner, Kingston, Jamaica, September 16, 1898.]

Among the most notable features attending the hurricane was the action of the United States weather station at Half Way Tree. This station was only established a few weeks ago, under the scheme of the Washington Bureau for covering the meteorological observation of the West Indies more effectually than heretofore; and already the new station has more than justified its existence. From the data which, with more or less regularity, have been coming to hand, Mr. Stockman, on Saturday night, cabled hurricane warnings to Barbados, Martinique, St. Kitts, and St. Thomas. The message prognosticated a hurricane immediately, the central portion of which was south of Barbados, that it was moving north-northwesterly and increasing, with northerly winds and rains. Every one of these details has been substantiated. Fortunately, as we have seen, the warning was not required for the two more northerly of the islands notified; the hurricane abating its force somewhere in the region of St. Kitts. The Weather Bureau has distinctly shown that it can not only inform people that a hurricane has taken place after the damage is done, but can give sufficient warning before hand to prepare masters of vessels for impending danger.

[From the Galveston and Dallas Daily News, September 25, 1898.]

The new branch of the United States Weather Bureau recently established in the West Indies has already shown the wisdom of the Government's action in that direction by the excellent warnings given relative to the development and progress of the recent destructive hurricane which made its appearance in the vicinity of Barbados and moved westward, bringing havoc to several of the Lesser Antilles. The United States fleet in those waters was keptfully advised.

During the last two days of September, 1898, a storm developed in the vicinity of Santo Domingo, and moved thence northwestward to the south Atlantic coast of the United States, where it raged with hurricane violence during October 2. Conservative estimates place the damage caused by this storm in Georgia and Florida at \$1,500,000. The value of vessels and cargoes detained by the Weather Bureau warnings of Saturday, October 1, was \$880,000, and the crews num-

bered 56. These were sailing vessels, and would have doubtless suffered the fate of those caught at sea. At Savannah the warnings prompted active measures for the protection of shipping and merchandise, and credit is given the warnings by representatives of business and marine interests, for a saving of many thousands of dollars. At Charleston, S. C., vessels and cargoes valued at nearly \$1,000,000, remained in port.

Two storms of marked intensity caused dangerous gales over the upper Lakes in October, 1898. The more severe of these was centered over northern Illinois the morning of the 25th, and it moved northeastward over lower Michigan during the succeeding twenty-four hours. This storm was attended by northerly gales, which resulted in considerable damage to shipping on Lake Michigan and destroyed much property along the shore in Chicago. High winds were forecast for the upper Lakes the morning of the 24th, and the forecast for Lake Michigan, the morning of the 25th, was as follows:

Winds shifting to brisk and high northerly, probably becoming dangerous; rain to-night, possibly turning into snow flurries.

Vessel masters leaving port during the afternoon and evening of the 24th were cautioned that strong northerly winds would be encountered farther down the lake. Some remained in port, while others proceeded on their way, intending to seek shelter in some harbor on the west shore as soon as the storm should strike.

In referring to the work of the Weather Bureau during the severe gale which visited the Great Lakes from November 9-11, 1898, the Buffalo News of November 13, 1898, remarked, editorially, as follows:

The Government Weather Bureau has again demonstrated in the view of all the people of the Lake region, its great and growing importance as a factor in the commerce and travel of the inland seas. During the past ten days the Great Lakes have been swept by a continuation of severe storms, the fury of which but few vessels could withstand, although the majority of these vessels are as large, staunch, and seaworthy as any of the ocean liners; yet but comparatively few casualties occurred, which was due to the timely warnings of the Weather Bureau, and it is no exaggeration to say that in this instance alone millions of dollars worth of merchandise, hundreds of vessels, and probably many lives have been saved by the forecasts.

One of the most disastrous storms of recent years, briefly referred to in the opening paragraph of this report, visited the middle Atlantic and New England coasts November 26-27, 1898. At least 200 lives were lost, and fully 100 vessels wrecked along the New England coast, and railway traffic was blocked by snow. The morning of the 26th storm signals, for easterly gales, were ordered along the Atlantic coast from Eastport to Norfolk, and storm warnings for the lower Lakes, including a warning of snow and a cold wave. The Bureau of Navigation, Navy Department, and the Maritime Exchanges of New

York and Philadelphia, were informed of the action taken in notifying the marine interests of the impending severe storm of wind and snow. In addition to the above advices the following special warning was telegraphed to all Weather Bureau offices in New York and New England for distribution throughout their respective districts:

Heavy snow indicated for New York and New England to-night; notify railroad and transportation interests.

At the same hour the Pennsylvania and Baltimore and Ohio Railroad companies were notified, as follows:

A cold wave, with heavy snow will prevail to-night in the Allegheny Mountain districts.

Among many editorial comments made by the daily press regarding this storm, and the action of the Weather Bureau in forecasting its destructive character, the following is from the Evening Star, Washington, D. C., November 30, 1898:

The full story of Saturday night's storm may never be told. Its deadly intensity is revealed by degrees in the wreckage which floats ashore, and perhaps in a few days some approximate estimate of the havoc then wrought on the New England coast may be approachable. Meanwhile it is clear that at least one great disaster marked the gale and that many lives were sacrificed. The steamer *Portland* went to pieces some time Saturday night or Sunday morning, so far out of her course as to show that the storm was of resistless strength, and that it was the most criminal folly for the captain to put out from port. * * * At half past ten on Saturday morning the Weather Bureau in this city wired to all its observers along the New England coast the following order: "Hoist northeast storm signals; east to northeast gales, with heavy snow to-night."

Observers were also directed to warn all railroad and transportation interests of the coming of heavy snow throughout New England. The warning about the snow was particularly important. Often a ship can go to sea with comparative safety in the face of a storm if the air is not clouded, but when the snow is flying landmarks are obscured, lighthouses are useless, and the vessel is left to fate.

A severe storm for which ample warnings were given visited the lower Lakes and the middle Atlantic and New England coasts December 4 and 5, 1898. At Cleveland the storm was reported the severest of the season. The Weather Bureau observer at that point reported that the warnings were heeded, and that vessels and their cargoes, valued at upward of \$800,000 were sheltered in that port. He also reported that a disregard of the warnings would have resulted in a loss of vessels and lives. On the Atlantic coast many captains heeded the storm warnings, and upward of 100 steamers and sailing vessels sought refuge at Sandy Hook and Gravesend Bay. At Long Branch the wind reached a velocity of 70 miles an hour from the east, and heavy seas carried away 160 feet of the iron pier. The signals kept many vessels in port at New York and other harbors of the north Atlantic coast, and in view of the exceptional severity of the

storm many casualties were doubtless averted by the general regard given to the warnings.

Frost warnings.—One of the defined duties of the Weather Bureau is to issue, for the benefit of farmers, orchardists, and gardeners, warnings of impending conditions favorable for the occurrence of damaging frost. The success which attended this line of work during the last year was very marked. The first important warnings were issued October 21, 1898, for the middle and west Gulf States, Tennessee, and western Kentucky, and on the morning of October 22 the following special bulletin, showing that the warnings had been verified, was telegraphed to the yellow fever infected district of the South :

This morning's reports show frost generally throughout the infected district. In Alabama, eastern and northern Mississippi, and northern Louisiana the frosts were heavy and killing; in southwestern Mississippi and southern Louisiana light frost was reported. At Mobile the minimum temperature was 40° and at New Orleans 46°, the lowest previous record for the third decade of October being 34° at Mobile and 42° at New Orleans. November 18 is the earliest date on which freezing temperature has ever occurred at New Orleans, and November 2 is the earliest date of freezing temperature at Mobile.

In central Mississippi and northern Louisiana, and also in northern Alabama and northern Georgia freezing weather has occurred in the third decade of October. The earliest date of heavy frost at Mobile was November 2, 1874-1878. The earliest date of heavy frost at New Orleans was November 11, 1877.

The first heavy frost has occurred as late as December 29 at Mobile, while at New Orleans November and December have, in a number of years failed to show the occurrence of heavy frost. The average date of first heavy frost is November 22 at Mobile, and December 7 at New Orleans. The average minimum temperatures for the region referred to range from 50° to 55° during November, with occasional periods of freezing temperature.

The occurrence of light frost Tuesday morning, supplemented by heavier frosts and lower temperature this morning, may be considered unfavorable for the further progress of the disease. Present conditions indicate frost, and temperature 40°, or slightly below, to-night in Alabama, Mississippi, and the interior of Louisiana. The temperature will probably remain for several days below the seasonal average, which is 66° at New Orleans and 65° at Mobile.

Acting upon the information contained in this bulletin, Edmond Souchon, President of the Louisiana Board of Health, issued the following proclamation, October 22, 1898 :

Whereas, the Weather Bureau reports frosts occurring all over the State, and, whereas, it is a fact accepted by epidemiologists that no foci of yellow fever can be established in any place after frost is shown; therefore, be it ordained that all quarantine restrictions on traffic are hereby removed by the Louisiana State Board of Health, as far as it is concerned.

Referring to frost warnings issued for the sugar and trucking region about Galveston, Tex., during the early part of December, 1898, the Galveston Daily News of December 6, 1898, remarked as follows :

A heavy white frost put in its appearance yesterday morning, just as pre-

dicted by the United States Weather Bureau. While heavy white frosts occur nearly every winter on the mainland, Galveston has an average of one winter in five without frost or freezing, and even with freezing weather heavy white frosts are uncommon on the island. Everybody looked for and made preparation for this frost, because the weather service had said it would occur. The warnings of injurious weather conditions made for this section have been so accurate of late years, and consequently of so great value to the public, that they have become a great factor with the sugar planters and truck growers who care for their extensive crops as the Weather Bureau advises them. One feature which demonstrates their marked confidence in the warnings is that they take action to protect their crops as the warnings suggest. The different localities have systems in operation for the distribution of information. Some localities have distribution by telephone, others by mounted messenger service, and in others the planters distribute the information from one to his adjoining neighbor until all are advised.

There are few regions, if any, where the weather service can be of greater value than to this part of the country. The large sugar and truck farming interests use the warnings to such an extent that it saves them hundreds of thousands of dollars annually.

Cold waves.—Among the most important warnings issued by the Weather Bureau are those which give notice to agricultural and commercial interests of the approach of periods of abnormally low temperature. Warnings of this class have been particularly successful during the past year, and a not unimportant feature of the advices has been estimates of the probable continuation of injuriously low temperatures. In fact a special effort has been made, and will be sustained, to afford all interests all the information regarding future weather conditions that is warranted by modern methods, appliances, and skill in forecasting. The recognized accuracy of the temperature forecasts have caused them to be closely watched by various interests, and in the commercial centers movements of perishable goods are almost absolutely controlled by advices received from the Weather Bureau.

By far the most important cold wave, or series of cold waves, of the winter, crossed the country from the north Pacific to the south Atlantic coasts during the first half of February, 1899, damaging crops and fruits in the Southern States to the extent of millions of dollars. During the first eight days of the month the lowest temperatures on record were reported at points in the north Pacific coast States; from the 9th to the 12th many places in the central, western, and northwestern States reported the coldest weather on record. During the 13th and 14th the cold wave overspread the Southern and Eastern States, attended on the 13th by the lowest temperature on record from the southern Rocky Mountain slope to the south Atlantic coast, by zero temperature to the Gulf coast of Alabama, and by a snowstorm of unprecedented severity in the middle Atlantic States.

The Weather Bureau forecasts and warnings gave ample and timely

notice to all interests of the advance of the cold wave, and special reports and newspapers comments gave unquestionable evidence that the warnings prompted protective measures whereby crops, live stock, and perishable goods and merchandise to the value of hundreds of thousands of dollars were saved. Along the middle Atlantic and New England coasts the character of the storm called for the display of hurricane signals, the extreme warnings of the Bureau.

The detailed action taken in connection with this cold wave and storm and the numerous newspaper comments relating thereto, for which space can not be given here, will be found in the MONTHLY WEATHER REVIEW for February, 1899. All reports and comments bear witness to the fact that the work of the Weather Bureau in connection with this, the severest cold wave in the history of the Southern States, was as nearly perfect as the most approved methods of disseminating warnings would permit. The amount saved by stockmen in the west and southwest, by truck growers in the southwest, and by fruit growers, gardeners, and orchardists in the Southern States, and more especially in Florida, is incalculable. The Superintendent of the Florida East Coast Line reports that the warnings sent along his line of road, fifteen hours in advance of the cold wave, alone resulted in saving one-half of the vegetable crop, and that the value of the crop was estimated at \$1,000,000. The exceptionally severe character of the storm along the middle Atlantic and New England coasts amply justified the special warnings sent to that section.

Floods.—The River and Flood Service did not develop any features of special interest during the year on account of the absence of great floods. There has been considerable improvement made in many of the river gages, and the service has been extended by the establishment of several new special river stations, particularly in the south Atlantic States, where the additional stations are being conducted in cooperation with the United States Geological Survey.

There were several floods of minor importance during the winter in the south Atlantic and east Gulf States, and during the spring in the Missouri, Ohio, and lower Mississippi. The warnings issued for these floods were remarkably timely and accurate, and a vast amount of property was saved thereby.

During the next two years if sufficient funds are available for the purpose, it is proposed to prepare a comprehensive work on the entire navigable water régime, giving a complete history of all river stations, elevations above tide water, rate of flow of water, and data for flood forecasting. It is desired to include in one publication all matters relating to river work, and all persons experienced in river work will be invited to contribute to the same. It is also proposed to measure the discharge of water at various places along the Ohio River. No work

of this character has as yet been undertaken, although its importance has long been recognized. Data of this character is also greatly desired by the United States Geological Survey, and the work will be prosecuted in cooperation with that branch of the public service.

Several new special river stations should also be established during the coming year owing to the steadily increasing requirements of the navigation interests.

WEST INDIAN SERVICE.

In my report for the fiscal year ended June 30, 1898, reference was made to the steps that had been taken looking to the organization of a storm warning service in the West Indies. The conclusion of the war with Spain and the conditions under which the United States occupies the islands of Porto Rico and Cuba are now matters of history. The storm warning service, although primarily organized for the purpose of warning United States naval vessels of the coming of severe storms, has been continued in the interests of commerce and agriculture and strengthened wherever possible. At the close of the last fiscal year arrangements had been made for the establishment of meteorological stations at Kingston, Santiago de Cuba, Santo Domingo, St. Thomas, Barbados, Port of Spain, Curaçao, and Barranquilla, but neither men nor office equipments had been forwarded. In time of peace the sending of men and materials to the various islands upon which it was desired to establish and maintain stations would have been attended with considerable difficulty and much delay. In time of war the difficulties were greatly increased; the time at our disposal was limited, the act making appropriation for the service not being approved until July 7, 1898, about a week from the beginning of the hurricane season. The needful instruments and supplies had to be purchased, no surplus of either being on hand. By vigorously pushing the work of equipping the stations, both in this city and in New York, it was possible, in spite of many hindrances, to start a party for Kingston, Jamaica, on July 22, 1898. This party, under the lead of Mr. W. B. Stockman, Forecast Official, in charge of the West Indian Division, arrived at Kingston seven days later, but found it impossible, owing to the great number of Cuban refugees in the city, to secure office accommodations in the city proper. Suitable quarters were obtained in the suburbs, however, and an office of observation was established on August 7, 1898. On August 9 similar offices were established at Port of Spain, Trinidad; Willemstad, Curaçao; Santo Domingo, Republic of Santo Domingo; and at Santiago de Cuba, and the officials in charge began at once to forward weather reports twice daily by cable to the headquarters at Kingston.

Meteorological stations were established at Basseterre, St. Kitts,

and Bridgetown, Barbados, on August 25 and 31, respectively; at Colon, United States of Columbia, on September 17; Roseau, Dominica, and San Juan, Porto Rico, on October 20 and 31, respectively. The headquarters of the service were moved from Kingston, Jamaica, to Havana, Cuba, on February 1, 1899, and stations were established on the last-named island at Cienfuegos and at Puerto Principe on April 28 and June 24, 1899. The original intention to establish stations at St. Thomas and Barranquilla was abandoned, and the station at Colon was discontinued April 30, 1899.

Immediately after the installation of meteorological observatories in the West Indies, Mr. Stockman, the official in charge, directed all efforts to speedily get into operation a complete and comprehensive system for the display of hurricane signals and the broad dissemination of information in regard to the approach, expected direction and rate of progression, intensity, etc., of storms and hurricanes. Officials in charge of substations were called upon to report local conditions attending the approach of hurricanes and directed to correspond with all United States consuls and consular agents on the islands and in the near vicinity of their stations, and endeavor to secure their aid in disseminating these warnings to the inhabitants of the several islands and in the Spanish main at points where there are no Weather Bureau stations, the cost of transmission to be borne by the United States Government. At first it was difficult to interest the people in the warning service, since they are by nature very conservative and slow to adopt any change in their accustomed methods and mode of living. The issue of warnings of hurricanes was a most radical change, the inhabitants being accustomed to hear of these phenomena only upon their near approach. The work was unremittingly pushed forward, and resulted in the inauguration of a system capable of speedily and thoroughly disseminating storm-warning information to the uttermost parts of the several islands, enabling the general public to receive advance information in regard to the coming of hurricanes.

Many expressions of thanks and gratification have been received from local government officials and citizens for the inauguration of the service in the West Indies, and every effort has been made by those in authority to further the work of the Bureau, notably the Governor of Jamaica, who, while in London, personally called upon the honorable secretary for the colonies, with a view to obtaining the very best possible service from the subsidized British cable companies in the West Indies.

Requests have also been received from United States consular officials on the islands of Haiti, Martinique, and Guadaloupe, for the establishment of stations on those islands, and a plan is now under consideration to give these officials all information at our disposal,

to be by them distributed to insular officials, marine interests, and to the inhabitants of the several islands.

The officials of cable companies residing in the various islands extended us every courtesy, but at first it was most difficult to obtain a proper cable communication between several islands, a number of the cable managers declining to receive our reports unless prepaid; this, however, was soon adjusted, but on account of the time of closing the cable offices, generally before 6 p. m., and not opening them until between 7 a. m. and 8 a. m., it was almost impossible to get the reports within a reasonable time. By changing the time of the evening observation to 5 p. m., and by personal interviews with the manager of the West India and Panama Telegraph Company, fairly good service was obtained, yet no service could be obtained after about 7:30 p. m. Upon the personal application of his excellency, the Governor of Jamaica, the honorable secretary for the colonies wrote the directors of the West India and Panama Telegraph Company calling attention to the great detriment the early closing of the cable offices in the West Indies was to the efficient transmission of reports and warnings, particularly during seasons of unsettled conditions or the presence of storm conditions. Upon receipt of this communication the cable companies wired their Kingston official to confer with our representative and ascertain what action was necessary in order to render prompt and efficient service at all times, the result of said interview being that the manager and secretary of the West India and Panama Telegraph Company wrote the honorable secretary for the colonies as follows:

My directors * * * have instructed our general superintendent that when the Weather Report service is resumed next season, each weather report station will be advised in the terms of Mr. Stockman's remarks to keep the office open until a closing signal from Kingston is received. They believe that this will meet the case and will be satisfactory to the United States Weather Bureau in Jamaica.

Every courtesy and facility for the proper performance of the duties of this service has been accorded our representatives by the several governments of the islands where we have concluded to maintain permanent stations. There were but two islands where the local governments imposed obstacles to the installation of our observatories, and in these cases we were able to find hospitable locations in adjacent territory. But one government refused outright to allow us to place our observatory on its territory, and in this case the objection has recently been withdrawn.

The health of the men in the West Indian Division has been remarkably good, but four having at any time been incapacitated for duty, although almost all have suffered more or less from tropical fevers, and the debilitating effects of the climate, yet the continuity

of observation has been interrupted only at Santiago, due to the illness of the observer, and at Barbados on account of the blowing away of the instruments during the hurricane of September 11-12.

Climate and Crop Service of Cuba and Porto Rico.—In the latter part of October, 1898, instructions were given to the official at San Juan, Porto Rico, to establish a climate and crop service in that island, and later similar action was taken in Cuba. Sufficient instruments and shelters of standard pattern were sent into both islands and voluntary stations established as rapidly as the cooperation of efficient observers could be secured. By the opening of the new year, the issue of the Weekly Climate and Crop Bulletin had begun in Porto Rico, and similar bulletins for Cuba were first issued about the middle of May. The illness of the official in charge unfortunately interrupted the work of the Porto Rico section, which, however, was resumed in May and has since continued. Arrangements have been completed by which monthly section reports, after the standard, for both Porto Rico and Cuba, will be issued hereafter, work on the first report, that for May, 1899, for Porto Rico being well in hand. Notwithstanding the serious difficulties which were encountered in the prosecution of the Climate and Crop work in these islands, due in a great measure to the fact that the Spanish language is exclusively spoken, much has been successfully accomplished, as evidenced by the fact that both sections issued weekly bulletins with regularity after the middle of May.

From the many courteous and complimentary communications that have been received and notices published in the newspapers, both on the islands and in the United States, it is evident that the efforts to establish this service have been successful and have met a popular need. As the residents of the islands become more conversant with the aims and scope of the service, they will appreciate more fully what a great benefit it is, both climatologically and financially.

CONVENTION OF WEATHER BUREAU OFFICIALS.

A convention of Weather Bureau officials was held at Omaha, Nebr., October 13-14, 1898. In former conventions the attendance was confined mainly to employees engaged on climate and crop work, and, naturally, the deliberations of the convention were limited to that particular feature of the service. In the Omaha convention the discussions covered a wide range of subjects, all of which had an important bearing upon the practical work of the Bureau. The exchange of views and the discussion of methods indulged in were mutually helpful and stimulating. The convention was attended by eighty-three delegates, including those from the corps of voluntary observers and from the Department proper.

The beneficial results following the conventions of State Weather Service directors held in former years were so pronounced as to leave no room for doubt that such gatherings should not only be held at stated times, but that the privilege of attending them should not be restricted to officials engaged in any special line, as had been the case formerly. It was, therefore, decided that the scope of the convention should be so extended as to cover a wider range of subjects, and that the regular station officials, as well as those in charge of climate and crop centers, should have the privilege of taking part in the proceedings. The results attained were gratifying in the extreme. A complete report of all the papers and discussions was printed and extensively circulated.

DISCIPLINE.

The character of the Weather Bureau service is such as to require the maintenance of the strictest discipline. Observers, in addition to their regular observations taken twice daily at all stations at exactly the same time, must be alert to take and forward special observations when their instruments show the least premonition of storm formation. This is especially important in the new West Indian service. The officials at the Central Office must be ready to receive and chart reports at almost any hour of the day or night, and to transmit to threatened districts warnings of marine storms, cold waves, or floods. At each port or other point from which danger warnings are distributed or danger signals displayed our representative must be held to a strict accountability for the prompt receipt and distribution of the information which many times is of the utmost importance in the saving of life and property. All who are familiar with the methods of administration in the Weather Bureau recognize the fact that each employee in the service, from the humblest to the most important official, is held to a strict accountability for the proper performance of duty.

No employee removed for cause has been reinstated, and no man has been removed except for just cause and after a full investigation. It may be well to quote from my remarks before the Convention of Weather Bureau Officials, which met in Omaha in October last, as follows:

I wish to speak especially of one matter which I believe is important in maintaining a kind, yet thoroughly efficient discipline at your stations. I speak of this after an extensive experience in charge of several of the large stations of the Bureau. Allow no employee to impeach the official or personal integrity of a companion, unless the accused man is given full opportunity to answer his accuser. Do this and you will find that the harmony and efficiency of your station will be greatly improved. I desire to place all officials, both at the Central Office and throughout the extensive ramifications of the service, in such position that they may feel that they can go on with their work without fear

that their standing may be surreptitiously attacked. I feel that your discipline to-day is of a very high standard of excellence.

I do not wish you to be harsh toward those over whom you exercise authority, but I desire that such discipline be applied as will encourage the pride of the men and exalt the spirit of the officials and yet maintain completely the authority of the official in charge. It is possible to have such discipline, and I believe that we have it in the Weather Bureau.

I would encourage all to be students. I know that most of you are. I know that many (myself included) have found the best years of their lives for study while in the weather service. The Central Office has outlined a course of study in which we expect every new appointee to become proficient before he can be considered eligible for advancement. It is necessary, in writing your reports, that you express yourselves in good English; it is necessary that the local forecast officials be well versed in physics and mathematics, and it is necessary that the section directors be thoroughly conversant with the processes under which plant life has its inception and makes its growth. We carefully scrutinize the qualifications of the man, his education, moral character, and the study he has made since entering the service, before we consider him for advancement.

Several years ago the right of the Chief of Bureau to inquire into the moral character and the personal and social relations of a man before selecting him for an important trust was disputed. It was claimed that he had the right only to consider the scientific character of his work, and his standing as an official. However, the right to make such inquiry was claimed, and the Honorable Secretary of Agriculture sustained it. Especially in the matter of selecting observers for advancement to the grade of section director or local forecast official it has been insisted that the official nominated to the Secretary of Agriculture for promotion to such important trust shall not only have the necessary educational qualifications and the executive ability, but that his morals, his private character, and his social affiliations shall be such as to reflect credit upon the Government service. A rigid adherence to the foregoing regulations during the last few years has resulted in giving to the Bureau a personnel of such high character as to command the confidence and respect of the many communities through which its numerous ramifications extend.

LOSS OF LIFE AND PROPERTY BY LIGHTNING.

The collection of statistics of loss of life and property by lightning, referred to in a previous report, has been continued. The number of deaths by lightning stroke in the calendar year 1898 was 367, and the number of injuries 494. The places where the proportion of deaths to total population was the greatest were the upper Missouri Valley and portions of the Rocky Mountain region. The proportion of deaths by lightning in the United States to the total population is about five in a million, which, it may be remarked, is higher than the average of most countries.

Nine hundred and sixty-six barns, sheds, etc., 735 dwellings, stores

and office buildings, 95 churches and schools, and 70 other buildings were struck and damaged by lightning, the approximate loss being about a million and a half dollars. Of the buildings struck 40 were provided with lightning rods, 855 were not and in 952 cases it could not be ascertained whether the building was provided with rods or not.

Nine hundred and sixty-four head of cattle, 806 horses, 80 mules, 426 sheep, and 116 hogs were killed by lightning during the calendar year above referred to. The total value of the stock reported killed was \$48,257.

Lightning has caused great loss of life and property thus far during the calendar year 1899.

METEOROLOGICAL CHART OF THE GREAT LAKES.

Ten numbers of the meteorological chart of the Great Lakes were issued since the date of last report. The May and June, 1899, issues contained new and valuable material relating to the meteorology and hydrography of the Lake region. It is the present intention to publish such additional portions of the accumulated meteorological data for the Lake region as may be useful in the study of problems affecting the free and uninterrupted navigation of the Great Lakes and connecting waterways.

Two important points have been established by the investigation of fog during the season of 1898. First, that reports of fog from shore stations can not always be depended upon to show whether or not fog exists in midlake; fog was reported quite frequently in the fairway of vessels on the lakes, while very little was observed at land stations; second, that the wind direction appears to have but little influence on the formation of fog, especially on the upper Lakes. The formation of fog appears to be due primarily to changes of air and water temperatures, especially those that tend to produce a strong contrast between the temperature of the air and the underlying water. In confirmation of this belief it may be stated that fog appears most frequently on Lake Superior some distance from shore, where the water temperatures are low and the difference between air and water temperatures is the greatest. This is especially true of the region eastward of Keweenaw Point, where water temperatures as low as 89.5° have been observed during July and August.

AERIAL OBSERVATIONS.

At the close of the last fiscal year 17 kite stations were in operation and 248 ascensions had been made, in each of which the elevation attained exceeded 1,000 feet. The work was continued until about the middle of November, 1898, at which time 1,217 ascensions of 1,000 feet and over had been made.

The study of the records of temperature, pressure, and humidity thus secured was entrusted to Mr. H. C. Frankenfield, forecast official, whose first report has been submitted. For the first time in the history of meteorology we have facts instead of hypotheses, as to the average gradient of temperature up to 6,000 or 8,000 feet, free from all injurious influences, and for so many days and over such a large region of country that it has a broad significance; evidently it is the only proper gradient to be used in reducing atmospheric pressures or temperatures, up or down, from any observer's level. Notwithstanding the imperfections attending the beginnings of any such entirely novel work, these 17 stations, with their 1,217 ascensions in the course of six months, have probably added more to our knowledge of vertical gradients of temperature, humidity, and wind, in the daytime of summer, in the lower portion of the atmosphere, than the sum total of all that was previously known upon the subject.

INTERNATIONAL CLOUD OBSERVATIONS.

The report on the cloud observations, which were undertaken by the United States in cooperation with the International Cloud Committee, has been completed, and will be published as Part VI, Annual Report, Chief of Weather Bureau, 1898-1899 (quarto volume). This work was begun in May, 1896, with observations at Washington, D. C., and at 14 secondary cooperating stations quite uniformly distributed to the eastward of the Rocky Mountains; the observations were completed in June, 1897, and the computation and discussion of the observations in June, 1899.

The report was written by Prof. F. H. Bigelow; it may be briefly summarized under four heads: (1) The execution of the scheme proposed by the International Committee for the observations and publication of the results *in extenso*; (2) the application of the theodolite and nephoscope observations to the discussion of the cyclonic and anti-cyclonic local circulations over the United States; (3) the construction of a standard system of constants, barometric, thermodynamic, and hydrodynamic formulæ and tables, for the reduction of the cloud observations; (4) the computation of the pressure, temperature, and vapor pressure and the auxiliary constants in the four stages of cloud formation, viz, the unsaturated, the saturated, the freezing, and the frozen stages, the construction of the gradient tables, the formation of auxiliary pressure maps for daily forecast work at selected high levels, also the computation of the amount of heat required to convert an ideal adiabatic atmosphere into the one actually existing, which is the product of the sun's absorbed heat.

The primary object in making concerted observations of cloud heights and motions was to determine the direction and velocity of

the horizontal motions of the air over the northern hemisphere, or so much thereof as could be profitably occupied by existing meteorological services. The analysis of the cloud motions has led to a better understanding of the circulation of the air in areas of high and low pressure and materially increased our knowledge of the general circulation. It has also given us a method of constructing weather charts at various levels above the earth's surface whereby we may institute a systematic examination of the pressure and wind systems of the various sections of the atmosphere throughout the storm region.

PLATEAU BAROMETRY.

The reduction of the actual barometric pressures taken at stations located on the Rocky Mountain Plateau to sea level has always been a problem of considerable difficulty. The exact question is to discover the relation between the observed surface temperature and the mean temperature of the air column which should be substituted for the Plateau. Professor Bigelow has made a series of studies on this subject, and will make a report upon it during the next year.

CLIMATE AND CROP WORK.

At the date of last report 42 Climate and Crop sections were in operation. At the present writing there are 44, Cuba and Porto Rico having been added during the year. Improved appliances for printing the monthly reports of section directors have now been supplied in all cases, and for the first time in the history of the weather service the monthly and annual meteorological summaries for all centers are printed on a uniform plan, and in neat, attractive style.

Three hundred and twenty-two voluntary meteorological stations were established during the year, nearly all of which were equipped with standard instruments, including a thermometer shelter. The policy of the Bureau has been to improve the instrumental equipment of existing stations rather than to direct its energies toward securing a large number of new stations.

The publication of the National Climate and Crop Bulletin, Snow and Ice Bulletin, the monthly and weekly Climate and Crop Bulletins of the various sections, and the daily bulletins issued from 21 centers around which the corn, wheat, cotton, sugar, and rice stations are grouped, has continued throughout the year without material change.

MONTHLY WEATHER REVIEW.

The Monthly Weather Review has been edited, as heretofore, by Prof. Cleveland Abbe, and published regularly about six weeks after the end of each month. The average size of each number is about

fifty pages of text and tables, accompanied by from nine to seventeen charts and illustrations. The principal objects kept in mind in publishing the review are :

1. A full presentation of the climatological characteristics of the current month, for the use of every class of citizens, especially those interested in agriculture, gardening, hygiene, engineering, navigation, railroad transportation, and the study and teaching of meteorology.

2. The presentation of recent progress in the study of the atmosphere and of the ultimate physical causes of the phenomena with which we have to deal in forecasting the weather.

3. The practical art of forecasting daily weather and monthly or seasonal climatic averages.

4. The encouragement of the study of meteorology by every observer of the Weather Bureau, and by all students in schools, colleges and universities.

The recognition of meteorology as a subject worthy of laborious, profound study, not merely from the climatological point of view, but especially as a most difficult problem in dynamics, is a matter of the highest importance to the future development of the work of the Weather Bureau. No matter how perfect our system of stations and reports may be, yet the officials of the Weather Bureau will fail to derive the full advantage of this unless they keep up with every step in the progress of correlated branches of science. It is very much to be desired that some system be devised by which special opportunities shall be afforded to our best men for advanced study in meteorology and physics. In the absence of any such provision, the Monthly Weather Review will seek to respond to their needs.

There is a steady increase in the number and excellence of the meteorological papers offered for publication in the Monthly Weather Review and, if the resources of our printing office would allow it, an average of from four to eight pages might be added to each number of the Review devoted to strictly technical articles presenting summaries, or translations, of the best recent publications bearing on the laws of meteorological phenomena. Such an addition would be highly appreciated by our own employees and by the professors of physics, mechanics, and mathematics in our universities and their students, many of whom are looking to the professors of meteorology in the Weather Bureau to take the lead in this study.

CALIFORNIA RAINFALL AND ALASKAN TEMPERATURES.

During the prevalence of severe and greatly prolonged drought in California, an attempt was made by Prof. W. H. Hammon, then in charge of the San Francisco Weather Bureau office, to correlate the observed temperatures on Unga Island, Alaska, and the phenomena

of rainfall in California three months later. Professor Hammon's paper, while containing a number of interesting suggestions, was not conclusive on any point, nor did it claim to be; the subject, however, was one of very great interest, and possibly of practical importance to the people of the Pacific slope, and as such was referred to a Board at the Central Office, of which Prof. Cleveland Abbe is Chairman. Professor Abbe in his preliminary report states:

We have undertaken to collate all that is known with reference to monthly mean temperatures at stations in Alaska and its neighborhood. This extensive work is not yet complete, but is sufficiently advanced to enable me to say that the phenomena over California are not necessarily preceded by anything that happens in Alaska. In order to predict what is to happen in California a month, or even a week in advance, we must take a wide survey of the whole atmosphere. In order to get a truer comprehension of this important subject, we have, therefore, rearranged the maps of normal mean pressure and temperature for the Northern and Southern Hemispheres, and have included a study of these in our report upon long-range forecasting.

**DISTRIBUTION OF DAILY FORECASTS, COLD WAVE, FROST, STORM, RAIN,
AND EMERGENCY WARNINGS.**

Little can be said regarding this portion of the work that would not be a repetition of statements made in previous reports. The plan of distribution followed during the year was the same as in the past, and no innovation worthy of note has been introduced. There seems to be little opportunity for improvement, except by extending and perfecting the present system.

WEATHER BUREAU BUILDING AT SAULT STE. MARIE, MICH.

The sum of \$3,000 was appropriated by the Fifty-fifth Congress for the purpose of erecting a small brick and stone building on the public reservation at Sault Ste. Marie, Mich., for the use of the Weather Bureau. The building was finished on June 26, 1899, and occupied by the Bureau on July 1, 1899. It is admirably situated for the purpose for which constructed and especially convenient for vessel masters who may wish to learn of the weather conditions existing at any of the Weather Bureau stations on the Great Lakes.