U. S. DEPARTMENT OF AGRICULTURE

# REPORT

OF THE

# CHIEF OF THE WEATHER BUREAU

FOR

# 1896.

BY

WILLIS L. MOORE.

[FROM THE REPORT OF THE SECRETARY OF AGRICULTURE.]

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# 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., September 20, 1896.*

SIR: I have the honor to submit a report of the operations of the Weather Bureau during the year ended June 30, 1896.

Respectfully,

WILLIS L. MOORE,
*Chief of Bureau.*

Hon. J. STERLING MORTON,
*Secretary.*

## PRINCIPAL DUTIES OF THE BUREAU.

The foremost duties of the Weather Bureau are briefly summarized in the following:

To collect twice daily, by telegraph, meteorological observations made at about one hundred and fifty stations advantageously situated throughout the United States; to forecast the coming weather from the charted meteorological conditions, as shown by these observations; to disseminate immediately and as widely as possible the forecasts and special warnings thus made; to issue danger warnings to mariners on the seaboard and Great Lakes whenever impending storms threaten the destruction of life and property; to collect twice daily, by telegraph, at certain river centers, reports of rainfall over watersheds, and water stages in the main rivers and their tributaries; to deduce therefrom, for the benefit of commerce and navigation, forecasts of height of water and warnings of impending floods; to collect and publish at designated State centers, in State bulletins, weekly reports of crop conditions; to issue, weekly, national climate and crop bulletins, showing by text and charts the effect during the preceding week of weather conditions on the growing crops of the country; to collect, monthly, by mail, temperature and rainfall observations made daily with about 3,000 sets of standard instruments distributed throughout the country, and to collate and publish the same in order that the climatic features of the different parts of the United States may be accurately defined.

## ECONOMICAL EXPENDITURES.

Notwithstanding the rapid extension of the work of the Weather Bureau, the advancement given to old and deserving observers, and the improvements made in old methods, as shown in detail in the following pages, the expenditures were less than during any year of the

last fifteen, except one, and in that one, although the distribution of forecasts and the beneficial results attained were much less than during the year just ended, the expense was substantially the same.

## FORECASTS AND WARNINGS.

Special care has been exercised at all times in assigning officials to the important duty of making weather forecasts, and it is gratifying to report that the forecasts have attained a high standard of accuracy, whether we measure them by the official markings, by the comments of the press, or by the testimony of those whose interests are greatly affected by a foreknowledge of the weather. The average percentage of verifications of forecasts during the year was 82.4 per cent, an improvement of 2.4 per cent over that of the previous year. It should be stated, however, that no system of markings will fully determine the comparative value of weather forecasts. Occasionally there are times when the meteorological conditions during the twenty-four to thirty-six hours covered by the forecasts change so rapidly and to such a marked degree that neither the changes nor the sequence in which they happen can be foretold with even a fair degree of accuracy. Doubtless much of the criticism of the forecasts which has been made at times results from the fact that our officials have claimed, and probably the public has expected, more than science is able to do. The defects of a system should be as well understood as its possibilities. In the great majority of cases, however, the atmospheric conditions are such that it is possible to make forecasts and issue danger warnings that are not only almost certain of full verification, but also of incalculable benefit to the marine, agricultural, and commercial interests of the country if properly disseminated.

In a great measure the merits of a forecaster are determined by his ability quickly to comprehend the meaning of the charted meteorological data, to discern a portentous condition when it appears, and to confidently yet conservatively issue warnings to the many property and industrial interests concerned. It is believed that the methods of discipline which have been instituted and the assignments of officials which have been made are such as will reduce to a minimum the liability of storms dangerous to mariners reaching sea or lake ports without being heralded by storm signals, or of the rivers in the fruitful central valleys reaching the danger line without due notice having been given to shippers and to residents of lowlands contiguous thereto, or of cold waves of any considerable extent sweeping eastward unannounced to those interested in interior commerce.

Three West Indian hurricanes swept the Atlantic coast line from Florida to New England, and two passed northward offshore, but near enough to the coast line to seriously endanger craft about to leave port. Danger signals were displayed at all ports well in advance of the storms, and as a result no lives were lost and but little property destroyed. Not many years ago, before the Weather Bureau system was fully and efficiently developed, one of these terrific tropical storms might have damaged and destroyed shipping to the extent of several millions of dollars, and hundreds of precious lives might have been sacrificed. To-day, although these storms sweep our Gulf and Atlantic coasts with all their wonted fury, and storms of somewhat less force cross our Great Lakes from the West, it is seldom that the country is shocked by the news of a great marine disaster.

The forecasts for the territory east of the Rocky Mountains were

issued from the central office, except that in the morning the forecasts for Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, Kansas, Nebraska, North and South Dakota, Montana, Wyoming, and Colorado were issued exclusively by the Weather Bureau office in Chicago.

The forecasts for California, Arizona, Nevada, and Utah were issued by the Weather Bureau office in San Francisco, and those for Oregon, Washington, and Idaho by the Weather Bureau office in Portland, Oreg.

Marine storm warnings were telegraphed to the lake and seacoast stations and to the director of the Canadian meteorological service at Toronto; warnings of frosts to fruit, cranberry, tobacco, cotton, and sugar regions, and warnings of severe local storms, cold waves, northers, and dangerous floods to the threatened regions.

Local forecasts of weather, temperature, and in some instances of wind (for the station and vicinity) were issued at 66 stations other than the district forecast centers above named.

## COLD WAVE AND FROST WARNINGS.

The great value of these warnings to the general welfare and comfort of the people of the country at large has been manifested during the past year. No cold wave or frost of unusual intensity has occurred without ample forewarning, and there are numerous specific instances of record where these warnings have resulted in saving from destruction thousands of dollars' worth of property.

Particular attention is called to the cold wave of unusual severity that overspread nearly the entire United States east of the Rocky Mountains on January 2–5, 1896. Warnings of this wave were sent at least twenty-four hours in advance to nearly every station in its path. The Weather Bureau observers, at the stations visited by the cold wave, report an estimated saving on account of the warnings of over $3,500,000. This estimate, from the nature of the case, could be a partial one only. The total value of property saved must seem almost incredible to one who has given but little thought to the vast extent of territory often swept by one of these large bodies of cold air. It is interesting to note the variety of industries benefited. Owners and shippers of perishable produce protected their property from injury by frosts or freezing. Owners of residences, factories, and distilleries, and custodians of hospitals and public buildings protected water pipes to prevent bursting. Railroad officials regulated the size of trains. Florists and truck growers protected their hothouses and growing crops. Owners of skating rinks and ice harvesters saw that the water was in the best condition for freezing. Farmers in the South slaughtered their cattle and hogs. River men protected their boats, and stock raisers their cattle. In the State of Florida, alone, where a large quantity of early garden truck was above ground, the actual figures given by the truck raisers themselves showed a saving by this warning of over $300,000, and this was necessarily only a partial estimate.

A pamphlet prepared by Mr. W. H. Hammon, forecast official, Weather Bureau at San Francisco, suggesting new methods for protecting fruit trees and growing crops from injury by frost was published by the Bureau and extensively circulated in the fruit districts of California. During the severe frosts that visited that region in the spring of this year, and of which ample warnings were given, these methods of protection were tried and found quite successful, the savings being estimated at several millions of dollars.

Warnings of frosts in the early spring to the truck growers in the Gulf and South Atlantic States resulted, as shown by reports of our observers, in savings aggregating hundreds of thousands of dollars.

The local forecast official at Galveston, Tex., is authorized to make and distribute special forecasts when frost or freezing weather is anticipated in the sugar and truck-growing region in the vicinity of that city. During the past winter every dangerous temperature in this region was forecast. Many acknowledgments of the benefits derived from these warnings were received; the savings were very large, aggregating upward of $100,000.

Another marked instance of the direct pecuniary value of weather forecasts occurred in connection with the raisin crop of California, an industry representing an immense sum and quite liable to serious damage if not protected from rain during the drying season. The Weather Bureau forecasts of rain for the raisin districts during last season were successful, no rain having fallen without warning, and no unnecessary warnings having been issued. The Weather Bureau observer at Fresno, Cal., under date of November 8, 1895, reports that "of the 30,000 tons of raisins cured in the sun thus far not a single pound has been reported damaged by rain."

## SEVERE LOCAL STORMS AND TORNADOES.

A large number of destructive local storms occurred during the spring in the lower Missouri and central Mississippi valleys. These storms generally were predicted in the morning forecast in the terms, "conditions are favorable for severe local storms," or "severe local thunderstorms."

## MARINE STORM WARNINGS.

Timely warnings of all severe storms likely to cause injury to shipping were sent to our maritime stations and resulted in almost incalculable benefit. In the harbor of Buffalo alone during six of the most severe storms of the past winter a total of over 150 vessels, aggregating in value upward of $17,000,000 and having on board about 1,800 persons, were detained in port by reason of the Weather Bureau warnings. During the unusually severe and long-continued northeast storm on the New England coast of December 11–13, 1895, 37 vessels, including 7 large steamships, valued with their cargoes at about $2,000,000 and having on board 500 persons, were detained in the port of Boston by the warnings, and probably a large percentage saved from destruction. During the severe storm of February 5–7, 1896, at Charleston, S. C., 22 vessels, valued at $95,000, remained in port two days as a result of the warnings.

The hurricane signal recently adopted by the Bureau as a warning of tropical hurricanes and of extremely severe and dangerous storms was displayed on five occasions during the year, twice on the South Atlantic coast for approaching hurricanes during the fall of 1895 and three times for dangerous storms on the Middle Atlantic and New England coasts during the spring of 1896. This signal calls for a widely extended display; extraordinary efforts were made to disseminate the warnings thoroughly, and on each occasion when it was displayed it was of great benefit to the interests affected. Many expressions of commendation were received after the passage of the tropical hurricane that moved from south of Cuba northeastward between the Bahamas

and the Florida coast to the Bermudas, October 18–24, 1895. About 120 vessels, varying in size from a fishing smack to an ocean steamer, and valued with their cargoes at upward of a million dollars, remained in port on our Southern coasts as a result of the warnings sent out. Twelve seagoing vessels were detained in port at Nassau, New Providence, by the warnings that were telegraphed the authorities there by the Weather Bureau. The records of the stations near which the hurricane passed show it to have been one of great violence, velocities of 55 miles an hour being reported from Jupiter and Key West and 80 miles at Habana. Exceptionally high tides occurred on the South Atlantic coast. It is probable that if these vessels had gone out a large number of them would have been exposed to the fury of the storm with a possibility of total loss or serious damage. Two instances are also cited where the Bureau was able to be of assistance to stranded vessels, viz, on March 19, 1896, in the case of the steamer *Craigmore*, which stranded on the Florida coast, 8 miles south of Jupiter. The observer at Jupiter opened communication with the vessel and established a temporary telegraph station on the shore, and thus was able to summon assistance. The American liner *St. Paul*, valued at several million dollars, stranded near Long Branch about February 2, 1896. Information of anticipated favorable winds was given and materially aided in floating the steamer.

## OPINION OF THE MARITIME ASSOCIATION OF THE PORT OF NEW YORK AS TO THE VALUE OF STORM WARNINGS.

Mr. F. W. Houghton, superintendent of the Maritime Association of the Port of New York, by letter of September 5, 1896, speaks of the enormous tonnage that annually leaves our Atlantic ports and of the great value of the Weather Bureau storm warnings. He states, in part, as follows:

To fix with any degree of accuracy their money value is, of course, impossible. The damage caused by a storm might with much labor be reduced to figures, but not the amount saved by timely warning. Data are lacking to make more than an approximate estimate.

Your warnings of the approach of storms obviously are useful chiefly to craft outward bound. Their number, tonnage, and value are estimated as follows:

In the year ending June 30, 1895, there cleared for foreign countries, at the various ports of the Atlantic Coast, from Maine to Florida, the following vessels:

| Kind. | Number. | Tonnage. |
|---|---|---|
| Steam | 5,622 | 10,076,148 |
| Sailing | 5,848 | 2,105,688 |
| Total | 11,470 | 12,181,836 |

| | |
|---|---|
| Value of vessels reported at each clearance (estimated) | $1,060,257,000 |
| Cargoes of merchandise | 590,392,743 |
| Specie and bullion | 95,626,064 |
| Aggregate | 1,746,275,807 |

The value of the coastwise commerce of the Atlantic Coast for the same period is more difficult to arrive at. In the absence of official data, it can only be judged of proportionately. The only figures we have actually obtainable regarding it are the number and class of vessels arriving annually at the port of New York, and the number and tonnage of craft owned on the Atlantic Coast.

From these the following is estimated as the vessels of over 100 tons which cleared coastwise from Atlantic ports during the year, viz, 17,228 sailing vessels

of 8,407,156 tons, and 3,439 steamers of 2,355,639 tons. At a minimum it is safe to estimate their value, including their cargoes, at $660,998,700. This added to the estimated foreign commerce, $1,746,275,807, makes an aggregate of 32,137 sailings, and 22,944,631 tons, valued at $2,407,274,507, or more than $6,500,000 a day.

This is not evenly divided along the coast, about 54 per cent of the outward ocean commerce of Atlantic ports being dispatched at New York.

Your warnings, therefore, are probably of value to a greater number here than elsewhere. Navigators, however, do not always heed them, but are governed largely by their own judgment of local indications. Those indications are not always apparent at this port, owing probably to its peculiar situation, at an angle with the coast, say 120 miles inside the Gulf Stream, where the axis of tropical storms curves offshore, leaving comparatively slight disturbance here.

The large regular-line steamships, built to withstand the heaviest weather, and the time when mails are on board being counted by minutes, sail in all weathers, excepting only the most extraordinary storms.

These facts may reduce the number of instances in which your warnings are availed of, yet there can be no question as to their great usefulness. If only one in a hundred of the ships were saved from extraordinary damage, it would many times exceed the annual appropriation for your valuable operations. General appreciation of your work is especially shown by the frequent inquiries made of us by captains going to sea regarding your predictions.

## WIND-SIGNAL DISPLAY STATIONS.

Many persons are willing to display the signals without compensation other than the benefits that accrue to local interests by the display. Seventeen wind-signal display stations were established during the past year, at fourteen of which the displaymen serve without pay. There are in operation at present 173 wind-signal display stations, 109 of which are in charge of paid displaymen. In addition to the above, 135 stations, 32 Government vessels, and 30 lines of steamers display hurricane signals alone.

## TROPICAL HURRICANE REPORTING STATIONS.

Daily observations were taken from July 15 to October 15, 1895, at Kingston, Santiago de Cuba, and St. Thomas, by paid observers of the Weather Bureau, and arrangements were made with Mr. Felix Gomez Merdicuti, of Merida, Yucatan, to report threatening conditions by telegraph. Such conditions obtained but twice during the season, but reports of these were of great value. The same arrangement is in effect during the current year.

## RIVER FORECASTS AND FLOOD WARNINGS.

The special work of the Weather Bureau in connection with the rivers of the country is to facilitate commerce on navigable streams by publishing information daily as to water stages along the course of each river, and to issue timely warnings of floods so as to effect the saving of life and property.

As yet the rules of flood forecasting are largely empirical. The official in charge of a river center is familiar with the main river and its tributaries, the area and topography of the catchment basin, the frequency and intensity of the rainfall—especially the intensity—the average time of passage of flood crests between one station and another, and the history of past rises. A knowledge of low-water conditions, especially where bars and shoals exist, is perhaps of equally great importance as a knowledge of high water.

The official in charge of a river center is expected, with the data at his command, to give information to those interested in navigation,

during low or medium stages of water, that will be of great pecuniary value; but his chief and foremost duty is the dissemination of warnings when floods threaten.

The volume of water passing a station in a given time is known only at a few places, and varies, of course, with high and low water. Nor can simple rules be based upon the rainfall, as the absorptive condition of the soil is not constant and the distribution of precipitation over the drainage area is not always determinable.

The principal rivers concerned in the Weather Bureau system are the Allegheny, Monongahela, Ohio, Kanawha, Wabash, Illinois, Tennessee, Cumberland, Mississippi, Missouri, Arkansas, and Red rivers, of the central valleys; the Columbia, Sacramento, and San Joaquin, of the Pacific Coast, and the Hudson, Susquehanna, Potomac, Savannah, Chattahoochee, and Alabama rivers, of the Atlantic and East Gulf coasts.

Each forecaster in charge of a river center has a definite section of the river system of his district assigned to him. He receives the necessary telegraphic reports of rainfall over the tributaries to his river district, and also the necessary telegraphic data as to gauge readings nearer the source of the main river than his own station, and the gauge readings of many of the tributary streams.

Some idea of the vast destruction of property due to floods may be gathered from the statement that the floods of the spring of 1881 and 1882 caused a loss of not less than $15,000,000 to the property interests of the Ohio and Mississippi valleys. It may also be noted that the flood of the spring of 1882 caused a loss of 138 lives in the region from Cairo southward to New Orleans. The flood of 1884, in the region about Cincinnati, caused an estimated loss of over $10,000,000.

In the spring of 1890 the Lower Mississippi Valley was flooded for a distance of 40 miles back from the river in the States of Louisiana, Arkansas, Mississippi, and Missouri. Special warnings, which were amply confirmed by subsequent stages of the water, were issued from Washington in advance of the flood, and, in several cases, far in advance of the flood crest.

Instances are numerous showing the vast utility from a commercial standpoint of a thoroughly equipped Government flood-warning system, notwithstanding the fact that the forecasts are based partly upon empirical reasoning and are, therefore, subject to some error.

The past year has not been marked by any disastrous floods. The sudden melting of snow at the head waters of the Allegheny caused a moderate flood in the Ohio during the latter part of March and beginning of April. Ample warnings were issued by our river officials, and, from reports received, not less than $75,000 worth of property was saved thereby. At the same time the Tennessee reached a flood stage from heavy mountain rains. Of this rise also full warning was given, which resulted in a considerable saving. Early in July there were unusually heavy rains in the South and Middle Atlantic States, which caused floods in the Carolina, Virginia, and West Virginia rivers. The saving in stock, crops, and merchandise in the South Carolina lowlands was reported as $165,000, while preparations were made, upon receipt of flood warnings, to raft out some $3,000,000 worth of logs, which was subsequently done. It is evident that, even in a year unusually free from floods, the slight expense of the system of river forecasts and flood warnings is many times repaid by the saving of exposed property.

## THE DISTRIBUTION OF DAILY FORECASTS AND COLD-WAVE, FROST, STORM, RAIN, AND EMERGENCY WARNINGS.

More than 1,000 places have been added each month to the forecast distribution lists during the year. Many villages and out-of-the-way places not having communication with the large towns by means of the telegraph or telephone are now supplied with weather forecasts by means of the logotype cards. The extension of the logotype card system has not only resulted in a gratifying increase in the number of places receiving the daily forecasts, but also materially reduced the expense of a paid telegraph service. At the close of the year the number of stations receiving forecasts by telegraph at Government expense was 339 less than at the date of last report; the number receiving daily forecasts by mail without expense to the Government was 10,910 greater.

As a means of securing more prompt and satisfactory service the distribution of emergency warnings was placed under the supervision of officials at regular telegraphic centers in July, 1895.

The distribution of forecasts to the Executive Departments and the more prominent business houses of Washington, D. C., was begun during August of 1895, and continued throughout the year.

In January, 1896, the telegraphic distribution of forecasts and special warnings for the fifteen Northwest States, prepared by Prof. E. B. Garriott at Chicago, was transferred from the distributing centers to the Chicago station. As a result of the change and the admirable system of distribution originated by Professor Garriott, the forecasts are now received at display stations and mail-distributing centers from forty-five to fifty minutes earlier than by the old system of distribution.

Arrangements with the managers of local telephone companies at a number of our larger Weather Bureau stations have been perfected whereby special cold-wave and storm warnings are given the widest possible distribution. Nearly 44,000 telephone subscribers have been listed thus far to receive warnings of this character. Nearly 1,400 public schools are furnished with the daily forecasts by the logotype card system alone. In some instances, in addition to being posted in the corridors of the school buildings, the forecasts are read to the pupils by the teachers each day before the schools are dismissed.

While every effort has been made to extend the distribution of forecasts in every possible way, more attention has been given to mail distribution by the logotype card system than by any other means. Considering the small expense attached to the method and the small amount of labor required to give satisfactory results, it is believed to be the best plan for disseminating forecasts in rural communities yet devised.

The display of weather signals on the New Orleans, Fort Jackson and Grand Isle Railroad, a line passing through a rich agricultural section, was undertaken during the year. The results are encouraging, although the general display of weather signals from railway trains does not promise well, owing to serious difficulties for which there seems to be no remedy. A rapidly moving train will often pass over the entire section covered by a single forecast within an hour, and while a system could be devised that would provide against many of the emergencies likely to arise, it would be useless by reason of its complexity.

During the past winter the sounding of cold-wave and frost-warning signals by means of locomotive whistles was begun by the Florida

Central and Peninsular Railroad, and the system used with good effect on several occasions.

The statement below shows the number of places in each State and Territory receiving forecasts and special warnings by the various methods of distribution, as well as the increase over last year:

| States and Territories. | By telegraph or telephone, at Government expense. | | | | Without expense to the United States, by— | | | |
|---|---|---|---|---|---|---|---|---|
| | Daily forecasts. | Cold-wave warnings. | Frost warnings. | Emergency warnings. | Mail. | Telegraph or telephone. | Railroad telegraph. | Railroad train service. |
| Alabama | 20 | ..... | ..... | 63 | 332 | 6 | 38 | 12 |
| Arizona | 2 | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Arkansas | 30 | 4 | ..... | 58 | 259 | 22 | 7 | ..... |
| California | 5 | 1 | 2 | 3 | 432 | 76 | 378 | ..... |
| Colorado | 11 | 8 | ..... | 47 | 242 | 7 | 4 | ..... |
| Connecticut | 11 | 3 | 3 | 32 | 454 | 48 | 15 | 151 |
| Delaware | 4 | ..... | ..... | 6 | 30 | ..... | 21 | ..... |
| District of Columbia | ..... | ..... | ..... | ..... | 1,029 | 17 | ..... | ..... |
| Florida | 35 | 39 | 2 | 52 | 337 | 1 | 26 | ..... |
| Georgia | 48 | 36 | 1 | 82 | 222 | 2 | 138 | 41 |
| Idaho | 3 | ..... | ..... | ..... | 46 | 1 | ..... | ..... |
| Illinois | 64 | 22 | 2 | 383 | 910 | 45 | 347 | 459 |
| Indiana | 83 | 2 | ..... | 98 | 408 | 1 | 322 | 284 |
| Indian Territory | 7 | 1 | ..... | ..... | 72 | 1 | ..... | ..... |
| Iowa | 103 | 4 | ..... | 183 | 800 | 14 | 11 | ..... |
| Kansas | 35 | 3 | ..... | 142 | 370 | 29 | 113 | 3 |
| Kentucky | 43 | 2 | 42 | 76 | 588 | 28 | 26 | ..... |
| Louisiana | 28 | 9 | 14 | 6 | 208 | 14 | 3 | ..... |
| Maine | 24 | 1 | ..... | 13 | 651 | 8 | 17 | 77 |
| Maryland | 21 | ..... | 2 | 17 | 503 | 33 | 79 | 10 |
| Massachusetts | 20 | ..... | 16 | 32 | 408 | 22 | ..... | 332 |
| Michigan | 68 | 16 | ..... | 167 | 1,137 | 18 | 319 | 5 |
| Minnesota | 45 | 7 | 4 | 87 | 472 | 42 | ..... | ..... |
| Mississippi | 30 | 13 | 3 | 62 | 190 | 39 | 63 | ..... |
| Missouri | 77 | 6 | ..... | 191 | 1,599 | 67 | 104 | 60 |
| Montana | 14 | ..... | ..... | 16 | 32 | 4 | ..... | ..... |
| Nebraska | 64 | 4 | ..... | 147 | 401 | 2 | 11 | ..... |
| Nevada | 2 | ..... | ..... | ..... | 10 | 1 | ..... | ..... |
| New Hampshire | 10 | ..... | ..... | 13 | 247 | ..... | 9 | 31 |
| New Jersey | 24 | 8 | 19 | 70 | 681 | 52 | 150 | ..... |
| New Mexico | 5 | ..... | ..... | ..... | 24 | 3 | 2 | ..... |
| New York | 98 | 20 | 5 | 201 | 1,872 | 206 | 235 | 161 |
| North Carolina | 52 | 5 | 9 | 114 | 491 | 17 | 1 | 16 |
| North Dakota | 15 | 12 | ..... | 96 | 5 | 26 | ..... | ..... |
| Ohio | 107 | 33 | 81 | 197 | 2,039 | 79 | 83 | 17 |
| Oklahoma | 2 | 1 | ..... | 8 | 35 | ..... | ..... | ..... |
| Oregon | 18 | ..... | ..... | ..... | 272 | 9 | ..... | 104 |
| Pennsylvania | 59 | 12 | 1 | 105 | 938 | 365 | 765 | 7 |
| Rhode Island | 3 | ..... | ..... | 5 | 14 | ..... | ..... | 27 |
| South Carolina | 49 | 4 | ..... | 65 | 261 | 62 | 45 | 10 |
| South Dakota | 31 | 26 | ..... | 76 | 249 | 11 | ..... | ..... |
| Tennessee | 22 | 16 | ..... | 93 | 470 | 45 | 29 | 2 |
| Texas | 51 | 21 | 10 | 184 | 495 | 133 | 64 | ..... |
| Utah | 7 | ..... | ..... | ..... | 47 | 8 | 10 | ..... |
| Vermont | 11 | 1 | ..... | 16 | 490 | 6 | 11 | 4 |
| Virginia | 34 | 4 | 7 | 91 | 518 | 81 | 56 | 93 |
| Washington | 24 | ..... | 2 | ..... | 106 | 4 | ..... | 29 |
| West Virginia | 16 | 9 | 1 | 44 | 243 | 28 | 48 | ..... |
| Wisconsin | 44 | 13 | 1 | 134 | 879 | 26 | ..... | 11 |
| Wyoming | 2 | 5 | ..... | 6 | 4 | 3 | ..... | ..... |
| Total | 1,581 | 371 | 227 | 3,481 | 22,642 | 1,712 | 3,550 | 1,939 |
| June 30, 1895 | 1,920 | 198 | 419 | 3,494 | 11,732 | 1,239 | 2,346 | 1,218 |
| Increase | ..... | 173 | ..... | ..... | 10,910 | 473 | 1,204 | 721 |
| Decrease | 339 | ..... | 192 | 13 | ..... | ..... | ..... | ..... |

Grand totals:

| | |
|---|---|
| June 30, 1896 | 35,573 |
| June 30, 1895 | 22,636 |
| Total increase, past year | 12,937 |

## CLIMATE AND CROP SERVICE.

The work of the Climate and Crop Division (formerly the State Weather Service Division), the general character of which has been

outlined in the annual reports of previous years, was continued during the year practically without change.

The designation "State Weather Service" as applied to the majority of the local meteorological services, being inappropriate to the character of the work performed by these services, the term "State sections of the climate and crop service of the Weather Bureau" was substituted in all cases where the local service was wholly supported by the Weather Bureau. In making this change it was also desired to emphasize the difference between the terms "climate" and "weather." The titles of the weekly and monthly publications of the various climate and crop services, both at the central office and at outlying centers, were also changed. The former designation, State weather service, is retained by the few States in which legislative enactments have been considered such as not to warrant the adoption of a more suitable designation. In some States, however, where the local services are supported by State appropriations, the titles were changed in accordance with the suggestions of the Chief of Bureau.

The great desideratum of local climate and crop services is uniformity of style and matter in their monthly publications. The subject has been discussed at several conventions of the American Association of State Weather Services, but no satisfactory conclusion has been reached. Since the organization of local climate and crop services their results have been published in a variety of sizes and forms, some quarto, some octavo, some as periodicals containing advertisements and conducted as private enterprises, and still others by one of the many duplicating processes. The monthly bulletins were issued as a private enterprise only as a last resort, and, in some instances, at a considerable personal loss to the Weather Bureau official in charge. As a direct result of the equipment of the more important stations with small plants for the printing of daily weather maps it will be possible eventually to publish all of the section climate and crop bulletins in a uniform and attractive style. The size of bulletin best adapted for general use, arrangment of data, construction of charts, and other details were given the careful personal attention of the Chief of Bureau. The bulletin finally adopted is an 8-page quarto, and the first issue under the new process was that of the New England section for March, 1896. The Pennsylvania section was next equipped with printing facilities, and at the close of the fiscal year the Illinois, Ohio, Wisconsin, Tennessee, and Louisiana sections had also been provided with the necessary printing plants. At this writing provision has been made for the equipment of 18 of the 42 climate and crop sections with printing facilities. It is intended that all sections shall be similarly equipped. When this has been done a set of bulletins for a given month will be uniform both as to size and matter, convenient for reference, and easily filed. The equipment of all climate and crop sections with printing plants will enable the officials in charge to issue their bulletins at an earlier date, as well as relieve a number of them of the annoying and embarrassing features involved in conducting a private journal.

### CLIMATE AND CROP BULLETINS.

The publication of the National Climate and Crop Bulletin and the weekly bulletins of the various climate and crop services throughout the country met with the same high appreciation noted in former years. It was necessary to increase the edition of the National Bulletin 68 per cent in order to meet the demands for this publication.

There was also a corresponding increase in the editions of the section bulletins. But while the circulation of the State and national bulletins has largely increased, the press is relied upon as the chief means of conveying the information they contain to the public.

The climate and crop service of the Weather Bureau furnishes the public from week to week with trustworthy information concerning climate and crop conditions. Reports from 8,000 special correspondents concerning the effects of the weather upon crops are summarized by experts at State centers and studied in connection with the prevailing weather conditions. The information thus obtained is often the means of correcting erroneous impressions that have been created by the circulation of false reports. The rainfall and temperature conditions have been charted with greater precision than heretofore as a consequence of the increased number of reports made available by the organization of a corn and wheat service. A file of the weekly bulletins for each State forms a most thorough and complete history of the climate and crop conditions of the year.

### COTTON, SUGAR, AND RICE SERVICE

A very decided improvement was made in the service conducted for the benefit of the cotton, sugar, and rice interests by changing the hour of observation from 6 p. m. to 8 a. m., seventy-fifth meridian time. This change went into effect September 1, 1895, since which date the daily bulletins for the 24-hour period ending with the time of observation have been issued soon after 8 a. m. As a rule they now reach the public nearly as early as when issued in the evening, and since they contain later information by twelve hours the value of the bulletins is greatly enhanced.

### CORN AND WHEAT SERVICE.

The great value of the system of observations and reports conducted for the benefit of the cotton, sugar, and rice interests led to the recommendation of an appropriation for the maintenance of a similar system covering the principal corn and wheat producing States of the central valleys and the Northwest. The appropriation for this service was made as recommended and the new service was duly inaugurated. The region covered embraces the States north of the Ohio and Missouri rivers, Kentucky, southern Missouri, Kansas, and Nebraska. There are 131 substations which report the rainfall and temperature of the growing fields to a district center each morning. The substations are grouped under nine district centers, as follows: Chicago, Ill., 22; Columbus, Ohio, 14; Des Moines, Iowa, 13; Indianapolis, Ind., 10; Kansas City, Mo., 15; Louisville, Ky., 16; Minneapolis, Minn., 19; Omaha, Nebr., 12; St. Louis, Mo., 10.

The corn and wheat service has proved one of the most popular and useful features added to the work of the Weather Bureau in recent years.

### SNOW AND ICE CHARTS.

A chart showing graphically, and by means of text and tables, the depth of snow on the ground at 8 p. m. of the preceding day is published each Tuesday from December to March. The thickness of ice in rivers and harbors is also shown in the tables. The interest manifested in these charts continues as in former years, and the mailing

list has been increased considerably. The influence of a covering of snow upon winter wheat is such as to render these charts a source of useful information, and the ice data given are of considerable importance to lake marine interests. During the early spring especial attention is devoted to the collection and publication of information relative to the ice on the Great Lakes. The ice reports are not as satisfactory as might be desired, owing to difficulties in securing measurements at some stations, but notwithstanding the defects of the present system it serves a useful purpose.

## MONTHLY WEATHER REVIEW.

The Monthly Weather Review has become the principal medium of communication between the meteorologists and observers of this country, and by reason of its large circulation it has become a desirable journal for the publication of everything bearing on meteorology and its applications. That section of the text entitled "Special contributions" has, therefore, increased in extent and interest, and is, of course, open to receive communications from all observers and colaborers. The Review fills an important place as a means of popular education. The climatological tables have received wide recognition as one of the most valuable publications of current data. In general, our Review compares well with those published by other Governments, including that published by the Government of India, whose meteorological office has devoted much attention to the practical work of long-range, seasonal forecasts. This latter subject also has received special notice from time to time in our Monthly Weather Review, in hopes that seasonal forecasts will eventually become practicable for the United States notwithstanding the great vicissitudes of our climate. The popular but erroneous idea that these irregularities constitute permanent changes in local climates, due to such local matters as the clearing of forests, the cultivation and drainage of the ground, the planting of trees, and other marks of the progress of civilization, has been combated on several occasions in the "Notes by the editor," in the hope that the attention of the public may be more strongly directed toward the true explanation of the irregularities in daily weather and seasonal climates.

## CLIMATE AND HEALTH.

The purpose for which Climate and Health was designed was stated in the introduction to the first number of the publication to be "to collect the meteorologic and hygienic statistics that might be considered by sanitarians and medical climatologists of the greatest correlative importance, and to publish them in the forms most acceptable and useful to those professions, that from its pages all persons interested in the influence of climate and weather upon health might obtain the data for making comparisons of the relative therapeutic and hygienic merits of different climates, and for the prosecution of such original researches and studies as they might find the data suitable for." With the issuance of the March number the publication of the periodical was suspended indefinitely, owing to a change in the appropriation bill for the current year, and the consequent uncertainty as to the existence of authority needed for its continuance. Altogether nine numbers, having a total of 266 pages of text and statistical tables and about 80 pages of charts, were issued. The average edition was about 1,900 copies.

Although the publication was in every detail experimental, and occupied a field which had been relegated by recent changes in medical thought more or less to the background, yet Climate and Health met with fair consideration from the medical and scientific professions.

The time necessarily consumed in the preparation of the various statistical tables, charts, and editorial matter published in Climate and Health precluded the making of any considerable progress in studying the different statistics with a view of determining the correlation of the hygienic and meteorologic states. This line of work will be pursued during the current fiscal year, and if knowledge is acquired which is thought may be useful to the medical profession or to others it will be published in the form of special bulletins.

## TELEGRAPH SERVICE.

The aggregate length of the seacoast telegraph lines operated by the Weather Bureau remains the same as at the date of last report, viz, 485 miles, divided into seven separate and distinct sections, each in charge of a chief operator. Three of these, namely, the Hatteras section (161 miles), the Block Island section (29 miles), and the Nantucket section (98 miles) are on the Atlantic Coast. The Alpena section (31 miles) connects Alpena, Mich., with Middle and Thunder Bay islands, in Lake Huron. The remaining three sections are on the Pacific Coast and are known as the Tatoosh Island section (80 miles), the Fort Canby section (28 miles), and the Point Reyes section (58 miles), respectively. In addition to these sections, a telephone line of 2 miles serves for the transmission of wind-signal orders from Huron City to Point Aux Barques, Mich.

The several sections were maintained in very good condition except in two instances, when breaks in submarine cables interrupted communication for a time.

The British steamer *Cambay* went ashore at False Cape, Virginia, at 9 a. m. of October 15, 1895. The chief operator at Cape Henry summoned assistance from Norfolk immediately, and the vessel was released from her dangerous position by 1.30 p. m. of the same day.

The telephone lines and submarine cables from Alpena, Mich., to Middle and Thunder Bay islands, in Lake Huron, were operated throughout the year without interruption. Their maintenance is chiefly of value as a means of conveying danger warnings to vessels passing those islands or seeking shelter there during severe weather. On September 29, 1895, assistance was procured for the disabled steamer *Keystone*, of Cleveland, coal laden. No commercial (paid) business is accepted on this section.

The line from Port Angeles to Tatoosh Island, Washington, passing mostly over an exceedingly rough and densely wooded country, without either wagon roads or bridle paths, is the most difficult and expensive to maintain and also one of the most important to maritime interests. Six intermediate repair stations have to be maintained in the course of the line. This line is also chiefly valuable in reporting inward and outward bound vessels, summoning aid in times of distress, and displaying storm signals. The number of vessels reported each year is shown below:

| | |
|---|---|
| 1891-92 | 1,080 |
| 1892-93 | 1,383 |
| 1893-94 | 1,862 |
| 1894-95 | 2,245 |
| 1895-96 | 1,891 |

Another line of value to the shipping interests of the Pacific Coast is that from Astoria, Oreg., to Fort Canby, Wash.; the latter station reports all vessels entering or leaving the mouth of the Columbia River, and also the condition of the bar at stated intervals each day. On August 21, 1895, the Weather Bureau operator at Fort Canby observed the American ship *Drummond*, from Astoria to Liverpool, flying signals of distress and drifting ashore near Tillamook Head. He immediately telegraphed for assistance and the vessel was safely towed out to sea.

The third section of the Pacific Coast, built under special act of Congress, is that from San Francisco to Point Reyes Light, California. Vessel and weather reports, wreck messages, and other maritime information from Point Reyes, all highly appreciated in shipping circles, justify the comparatively small expense involved in maintaining this section. This line carries no paid business.

The following statement shows the amount of tolls collected and covered into the Treasury on account of commercial (paid) messages passing over the seacoast lines:

| | |
|---|---|
| Nantucket section | $2,674.11 |
| Block Island section | 708.09 |
| Hatteras section | 315.24 |
| Fort Canby section | 517.94 |
| Tatoosh Island section | 143.02 |
| Total | 4,358.40 |

In addition to the Government tolls proper, $4,330.72 was collected by the operators on account of connecting commercial lines.

The services rendered the Bureau by telegraph companies during the year were entirely satisfactory. More efficient service and a saving of $4,000 per annum was effected by a rearrangement of several of the telegraph circuits in January, 1896.

## INSTRUMENT DIVISION.

The work of the Instrument Division pertains to the maintenance of the instrumental equipment of stations established for the purpose of securing meteorological observations. This includes the preparation of drawings and specifications required for the purchase of instrumental supplies, accessories, etc.; the inspection, test, and adjustment of all new instruments; their issue to stations; the supervision, by correspondence, of their erection, exposure, and operation while on station; and the monthly inspection of all automatic records, comparative readings, etc., for the purpose of detecting neglect or improper care or the defective performance of instruments.

The importance of a high standard of instrumental accuracy is apparent. A dozen bad barometers and thermometers in use at as many stations, giving erroneous measurements, might lead to an entire misrepresentation of existing meteorological conditions.

The diversified interests of every city which can make good use of continuous automatic records of wind, temperature, pressure, sunshine, and rainfall are too numerous to be mentioned here. With an economical disbursement of the funds allotted to this purpose much can be done during the coming year to remedy defects in equipment.

The stations of the Bureau are visited by citizens in general, and especially by teachers (often with classes) in search of special and technical meteorological imformation purely for educational purposes.

In this connection the station equipment of instruments may be a most important and valuable lesson. Two years ago the Chicago station was completely equipped, and the result has fully justified the small expenditure necessary.

INSPECTIONS.

The Chief of Bureau has made three tours of inspection, in all visiting about 30 stations of the service. He was especially struck with the lack of uniformity in the equipment of the Government meteorological offices that are supposed to serve the interests of the people efficiently and impartially. To be sure, the importance of the interests served should have much to do with the expenditure authorized in equipping and maintaining the different local services. Instructions have been issued to the Supplies, Instrument, and Accounts divisions which will secure in the future the adoption of many standard appliances.

Formerly four inspectors were employed by the Bureau. It is now thought that with an occasional inspection by the Chief, for the purpose of keeping well informed as to the details of the work throughout the country, one inspector will suffice. It is hoped that during the coming year the Chief of Bureau may be able to personally visit nearly all of the remaining stations. In performing his executive functions he finds that a thorough knowledge of the local offices and of the officials on duty at each is almost indispensable to an intelligent and efficient administration of the Weather Service. With a trusted official in charge of the central office, he has been able to make these investigations, and at the same time to direct important operations of the Bureau by telegraphic communication with the central office. While the duty of personally examining each station and the interests subserved by each local service entails much arduous labor, it is hoped that the Chief of Bureau will be able to continue until all stations have been visited and a thorough personal knowledge acquired of the many diversified interests served by the Weather Bureau throughout the entire country.

REQUESTS FOR WEATHER BUREAU STATIONS.

Thirty-three urgent requests were received from as many cities for the establishment of Weather Bureau stations. These requests bore the indorsements of Senators, Representatives, boards of trade, and leading citizens. Many cities of large population and important industries are so situated that the Bureau has no need of observations from them in its work of making forecasts and issuing warnings. Again, towns of small commercial importance are so situated geographically as to give valuable observations for studying the movement of atmospheric disturbances. Nevertheless, it is believed that, for the benefit of its local interests, every city of over 50,000 population, even though meteorological observations therefrom may not be needed at Washington, should have a station recording automatically each climatic element. Such stations would require the services of but one observer, and he would become the distributing agent in sending out forecasts and warnings to surrounding towns.

SPECIAL IMPROVEMENTS.

During the year that ended June 30, 1896, the distribution of weather forecasts was greater than in any previous year in the history of the

Bureau. The forecasts were sent daily to all places that formerly received them only when exceptional conditions were forecast; there was an increase in the number of towns, hamlets, and farming settlements receiving forecasts of about 10,000.

Important printing devices have been introduced at nine of the principal stations of the service for the purpose of issuing daily weather maps, weekly crop bulletins, and monthly meteorological reports in a more legible manner than heretofore. These improvements made possible the compilation and publication of uniform climatic data of the various States where the improvements were introduced. The attainment of this object has been sought for years. Ten more offices, which are also headquarters for State climate and crop services, will be equipped during the next three months, and it is intended to extend these improvements during the coming year until all important stations are equipped. These printing devices include chalk-plate and logotype outfits, enabling the official in charge to print the daily weather map at comparatively small cost, instead of preparing it by the imperfect milliograph process heretofore in use.

### STATION WEATHER MAPS.

A total of 3,512,597 weather maps were issued at 75 stations during the year, an increase of 363,702 maps and one station over and above the preceding year. The increase in the number of maps issued has been made possible largely by the perfection and adoption of the logotype and chalk-plate process at 9 of our largest stations. The services of Mr. John W. Smith, local forecast official at Boston, Mass., are specially commended in connection with these improvements.

### REVISION OF FORMS.

A thorough revision of all forms, with a view to simplifying and reducing the work of the observing force, was made during the year. Much good has already resulted from the reforms instituted in this respect. A careful and much needed revision was also made of the book of Instructions for the Weather Bureau Observers.

### SENSIBLE TEMPERATURES.

The telegraphing of the readings of the wet-bulb thermometer, popularly known as the "sensible temperature," was begun on September 20, 1895. This is about the temperature felt by animal life, and may be many degrees below the air temperature, the difference between the two temperatures depending upon the relative humidity of the air—the drier the atmosphere the lower the sensible temperature when compared with the air temperature; the damper the air the higher the sensible temperature. This will be better understood when it is stated that in case the air be saturated the readings of the dry and wet bulb thermometers will be the same, and the sensible and air temperatures equal. In the arid regions of the West cases can be cited where the sensible temperature was 38 degrees less than the air temperature, due to the extreme dryness of the atmosphere. In the more humid regions of the eastern part of the country such extreme differences do not occur. Both the air temperatures and sensible temperatures are now published on all charts issued by the Weather Bureau.

## AERIAL INVESTIGATIONS.

Prof. Chas. F. Marvin, in charge of the Instrument Division, was directed by the Chief of Bureau in November, 1895, to take up, in addition to his other duties, the study and development of means and appliances for sustaining automatic meteorological instruments at high elevations in the upper free air. A detailed report of his investigations was published in the Monthly Weather Review for November, 1895, and April, 1896. The work during the past seven months was confined to experiments with kites. On one occasion an altitude of 7,000 feet was attained, and but 9,000 feet of wire was played out from the reel. The Chief of Bureau believes this to be the greatest height attained by any experimenter with kites, and that Professor Marvin is deserving of special commendation. He has applied to the problem the ideas from a well-trained mechanical and analytical mind.

Much time was consumed in devising, constructing, and perfecting various accessories and appliances required in the management of the kites and in testing materials used in conducting the investigations. It was found that both the form of the body of the kite and the action of the forces that affected it demanded a much fuller analytical consideration than they had hitherto received. The work has, therefore, consisted in developing and perfecting the kite so as to secure the highest attainable efficiency of action. It is seen that for meteorological purposes the condition of maximum efficiency consists in lifting the greatest weight.

From the results of the kite work thus far it has been demonstrated that for readily attaining elevations exceeding say 1,000 feet wind velocities exceeding 10 to 15 miles per hour must prevail. With kites of light construction good results may be obtained in lighter winds, yet gusts of strong winds are extremely liable to be interspersed with light winds, and unless the kites have a considerable margin of strength damage to the kites and failure of experiments are almost certain to result. When favorable winds prevail, it has been shown that one or two kites of the improved forms, produced as a result of Weather Bureau investigations, suffice for reaching elevations of from 3,000 to 7,000 feet, depending upon the force and steadiness of the winds and the load carried. While such results are attainable when favorable winds prevail, experience has shown that at many stations it would often be necessary to wait several days for a single occasion of favorable winds.

There appears to remain but one other means of exposing meteorological instruments at approximately fixed points in the free air, namely, the use of devices sustained by the action of propellers which either lift the apparatus directly or give to it a spirally ascending or descending motion. Many devices of this character have been proposed by ingenious inventors, and several models of small size have proved that the desired effects on a large scale are within the range of possibilities.

The frequency with which kites may be successfully employed for reaching very high elevations will no doubt be greatly increased as the kite is brought to a more perfect state of construction and the art of its management more completely developed. There must always be, however, times when upper air observations can not be obtained by such means. However good kites may be, therefore, meteorology needs for its free air observations something that may be used on any

and every occasion and in any locality. Captive balloons, which have been so repeatedly tried for military purposes, prove to be of little value for reaching lofty elevations. From the great amount of surface which must necessarily be exposed, it results that the balloon is blown far away from the zenith point over its anchorage by even moderately strong winds. Combinations of the kite and balloon have also been tried. This, in turn, possesses but little advantage over the balloon alone, and in many respects is inferior to the kite. Free balloons may reach great elevations, but they drift with the currents of air and their return is uncertain.

Perfected appliances of this character will prove of such great value to meteorology that their development requires a share of the attention to be given to the greater problem of securing meteorological observations in the free air. Such observations are now generally conceded by meteorologists to be the means by which further and more complete knowledge is to be gained of the mechanism of storms and the sequence of atmospheric phenomena. The idea may seem visionary now, perhaps, but it is a possibility that important meteorological stations of the future will be dual in character. One portion will remain, as at present, at the surface of the earth; the other portion will be poised at a great height in mid air, riding at anchor to the base station, as it were, much in the same fashion as light-ships now ride at anchor at sea, sustained, however, by the operation of other forces than the bouyant action of the air. Simultaneous observations from a system of widely distributed stations of this character would enable the future forecast official to map out the atmospheric conditions, both horizontally and vertically, and arrive at a more exact knowledge of the gradients of temperature, pressure, moisture, etc., than is possible at present with a limited knowledge of surface conditions only.

The complete solution of so great a problem is only attained gradually and by steps. It is hoped that from the small beginning here made results of inestimable benefits to commerce and agriculture will be achieved in the not far distant future.

### HUMIDITY OBSERVATIONS AND THE SPINNING OF COTTON.

A report upon the relative humidity of southern New England and other localities, published as Weather Bureau Bulletin No. XIX, by Alfred J. Henry, chief of division, was prepared during the year. The report describes the conditions of atmospheric humidity in localities where the spinning and weaving of cotton are carried on, the special object of the paper being to compare the conditions where successful spinning is carried on with those in localities where it is proposed to establish and develop the industry.

One of the conditions essential to the greatest degree of success in the spinning and weaving of cotton fabrics is a humid state of the atmosphere, and the more constant the degree of humidity the greater is the measure of profitable spinning, especially as regards the finer numbers. The average spinning of England is finer than that of the United States, and the average of the latter varies greatly with the geographic location, the finer spinning being done almost wholly in New England.

The attention of the Weather Bureau having been called to the importance of the subject, and to the probable extension of the manufacture of cotton over a much wider area than it has yet occupied, a comparison was instituted with a view of ascertaining how the natural

humidity of certain portions of the United States, particularly the South, where the extension of the art is most pronounced, compared with that of the southern shore of New England.

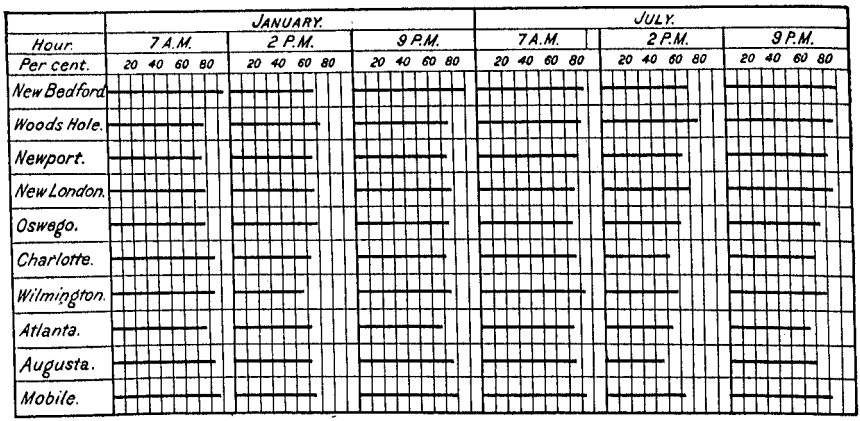
It appears that thus far in the development of the cotton manufacturing industry little account has been taken of climatic conditions as affecting the quantity or quality of the output. It is also apparent that the relative humidity of the atmosphere depends not only on the quantity of vapor present in the air, but also on the temperature which determines the point of saturation, and that these elements vary, both as regards time and geographic situation.

It is believed that the place where the spinning of the finer fabrics of cotton can be profitably done is where the relative humidity of the atmosphere undergoes the least change during the working hours of the day.

The control of both temperature and humidity by artificial means seems to be the final solution of the problem in all cases where the establishment of mills in a relatively dry climate is contemplated.

The following table is thought to be of sufficient importance, as showing the relative hygrometric conditions at four cities in New England, one on Lake Ontario, three on the South Atlantic Coast, and one on the Gulf Coast, to be reproduced here:

*Relative humidity at 7 a. m., 2 and 9 p. m. for January and July.*




The percentage of relative humidity at the hours named is proportional to the length of the heavy black horizontal line.

## MAGNETISM AND METEOROLOGY.

Studies into the relations between the solar magnetism and meteorological phenomena were carried on by Prof. Frank H. Bigelow as the other duties assigned to him have permitted. He is of the opinion that the atmospheric conditions which culminate in the storms traversing the United States are in part dependent upon the solar energy that reaches the earth in the form of magnetic influences; that there are synchronous fluctuations in the pressures and temperatures of the northwestern regions of the American Continent in the neighborhood of the magnetic pole and the auroral belt; that a train of storms, "highs" and "lows," advance from that quarter eastward in well-defined tracks; that the position of the tracks and the intensity of the

storms change along with the strength of the solar magnetic field; that there are many other forces at work to produce storms, such as the general circulation of the atmosphere and the local convection of heat and aqueous vapor, but that among them all must be included the magnetic forces in order to obtain a correct understanding of the mechanism of cyclones and anticyclones.

Unfortunately, magnetic force is not so easy to analyze as gravitation on account of its dual nature, the so-called positive and negative action, according to the properties of the material upon which it acts. Inversion of force is the characteristic of this agent, and it will be of great importance to the science of meteorology if Professor Bigelow is able to fully demonstrate that in the pressures and temperatures of storms there is such an inversion. Professor Bigelow believes that the law is periodic semiannually and not fortuitous, and is so conformed to the position of the earth in its orbit as to bear definite relations to the axes of the sun and the earth, regarded as great magnets. These subtle and delicate signs of the operation of the magnetic forces are such as to require much caution and deliberation in prosecuting the researches, in order not to arrive at unsound conclusions.

The sequence of cause and effect is rather loosely shown, and the existence of such fundamental laws as will enable the practical meteorologists to improve on the old methods of forecasting has not been as yet demonstrated. However, the problem is one worthy the fullest investigation.

## INTERNATIONAL CLOUD OBSERVATIONS.

The progress of practical meteorology, especially forecasting, has been greatly impeded by the lack of information regarding the general circulation of the atmosphere in the upper strata and throughout the cyclones and anticyclones, of which the current observations give data on the ground only. In order to overcome this defect and to reach conclusions as to the merits of the two great rival theories of the formation of storms, namely, the convectional and the general circulation theories, meteorologists have declared in favor of concerted work upon the movements of the upper strata, as given by the drifts of the clouds contained in them. At the international conference, Munich, 1891, a committee was appointed to consider the question of concerted observations of the direction of motion and the height of clouds. At a meeting of the international meteorological committee held at Upsala, August, 1894, it was agreed that these observations should commence May 1, 1896, and continue for a year. In the early part of 1896 it was found that the installation of the instruments at some stations could not be completed by May 1, and the cloud year was therefore extended to August 1, 1897.

In order that the United States might bear its share in this important international meteorological work, a board of cloud work was appointed, consisting of Prof. Frank H. Bigelow and Mr. A. J. Henry, chief of the Division of Records and Meteorological Data, to establish the stations and to conduct the operations and computations. The observing stations have been selected so far as possible from those most favorably located in reference to the principal storm tracks. The final list is as follows: Primary station, Washington, D. C. (Other independent primary stations were established at the Blue Hill Observatory, Readville, Mass., by Mr. A. L. Rotch, director, and at Toronto, Canada, by

Prof. R. F. Stupart, director Canadian Meteorological Service.) Secondary stations, Washington, D. C., Buffalo, Detroit, Louisville, St. Paul, Kansas City, Abilene, Vicksburg, Key West, and Baker City. Secondary stations are also maintained at the Blue Hill and Toronto observatories; at Cleveland, Ohio, by Rev. F. L. Odenbach, S. J., St. Ignatius College; and at Waynesboro, N. C., by Mr. Frank W. Proctor, making a total of 2 primary and 14 secondary stations in the United States. It is also to be noted that many of the Weather Bureau observers, appreciating the importance of such studies, volunteered their labor, and are making the observations in addition to their regular station duties, thus showing a commendable zeal in the interests of meteorology. The voluntary observers at Blue Hill, Waynesboro, and Cleveland deserve the thanks of the Weather Bureau.

### CLIMATE UNCHANGED.

The extraordinary period of drought which reached its culmination in the autumn of 1895 created a feeling of apprehension in many localities in regard to the stability of climatic conditions over a large extent of territory. A feeling of unrest was also created by the attempt to show that the changed conditions were a result of man's agency in the breaking up and the cultivation of the soil. In order to meet the call for information on the subject, a brief study of the rainfall records collected and preserved in the files of the Weather Bureau was made. It was clearly shown from the investigation made that periods of alternating wet and dry weather were characteristics of the seasons forty and fifty years ago, and that there was no general law governing the recurrence of years of drought or abundant rainfall. Increased interest has been manifested in the Weather Bureau records of rainfall, but whether or not as a direct result of the discussion is unknown.

### OBSERVATIONS AT PIKES PEAK AND COLORADO SPRINGS.

We are indebted to mountain observatories for much definite information concerning the movement and other physical characteristics of the upper strata of the atmosphere. The Signal Service established and maintained for a number of years, at great expense, observing stations on the summits of Mount Washington and Pikes Peak, and the attempt was made to utilize observations at these elevated points in daily weather predictions. The observations were found to be of comparatively little value for forecast purposes, and although the stations were continued for some time afterwards, they were finally abandoned in the fall of 1888. The station at Pikes Peak, however, was reestablished by the Weather Bureau in September, 1892, with a much more elaborate equipment than it had under the Signal Service, some of the instruments being devised especially to meet the exigencies of service on a high mountain peak.

A base station at Colorado Springs, 12 miles distant, and 8,036 feet below the peak, was also fully equipped with self-recording instruments of approved pattern, and observations were begun in November of the same year. These stations were maintained until September 30, 1894, at a cost to the Government of not less than $7,000. The observations of pressure, temperature, and wind were published in extenso in the reports of the Chief of the Weather Bureau for 1893 and 1894,

respectively, but no effort appears to have been made to draw therefrom conclusions that might be of possible benefit to the Weather Bureau. Although the location selected was not in the immediate track of the great storms that traverse our northern borders, or even in close proximity thereto, yet it was believed that some useful information could be had from the mass of data collected during the two years' occupancy of the peak and base stations. Mr. Park Morrill, forecast official, was instructed to make a study of the observations with special reference to the conditions which prevail on the peak during the passage of atmospheric disturbances. His report, which will be found in Part VI, Report of the Chief of the Weather Bureau (quarto volume), 1895–96, is commended to the careful study of those who forecast weather changes in the Rocky Mountain region. Mr. Morrill shows, among other interesting facts, that the notable rise of pressure at these elevated stations, in summer, is an effect of the expansion of the air upward from the increased heat. It is also shown that the law of decrease of temperature with altitude is not linear; that there is a considerable layer at the lower limit of the atmosphere, possibly extending to a height of 4,000 feet, which is somewhat uniformly heated, but that above this warm lower layer a more rapid and steady decrease of temperature occurs. This conclusion has an important bearing upon the determination of elevations by the usual hypsometric methods.

Particular attention is invited to that portion of Mr. Morrill's report which deals with the pressure distribution at an altitude of 5,000 feet above sea level. Since the general level of the Rocky Mountain and plateau regions is not far from that elevation, the pressures reduced thereto are free, in a great measure, from the errors commonly introduced in reductions to sea level. The upper isobars, as will be seen by an examination of the charts reproduced in Mr. Morrill's report, differ very considerably at times from sea-level isobars. The former conform more closely to the surface winds, both as to direction and velocity. Some meteorologists assume that the location and movement of barometric areas in this elevated region can best be studied by reduction to a surface 5,000 feet above sea level. However true this may be, the method fails of application to the practical work of the Bureau since the reduction of the pressures at low-level stations to an altitude of 5,000 feet above sea level involves the same difficulties that beset the present reduction of pressures at elevated stations to sea level. As the majority of stations are under 1,000 feet in altitude, it seemed wise to attempt to find a method of reduction for elevated stations that shall be superior to the present method rather than to seek a reduction to a 5,000-foot level. Accordingly a board, consisting of Profs. C. Abbe, H. A. Hazen, C. F. Marvin, Mr. Park Morrill, forecast official, and Mr. A. J. Henry, chief of division, was appointed to consider the question in all its details. The board has submitted a report which will serve as a basis for further investigation and study.

## TORNADOES.

On the night of May 27, 1896, the nation was startled by a report that St. Louis, Mo., had been partly destroyed by a tornado. To those familiar with the havoc caused by these destructive storms, the message caused the greatest concern, and additional details were anxiously sought. The full story of the storm was told in subsequent press dispatches, and although later developments showed that it had

not been as severe as first reported, the loss of life and destruction of property were unprecedented. So great a disaster coming so quickly after the occurrence of destructive storms in Iowa, Kansas, Illinois, and Michigan tended to create a feeling that the severity and frequency of these violent disturbances were increasing. It is not believed that there has been an increase either in the frequency or severity of tornadoes. Unfortunately, those of the present year have swept through populous sections of the country, occasionally through the midst of small villages and towns, and once through the heart of one of our great cities. Three hundred and six persons lost their lives in the storm of May 27, 1896; more than the aggregate loss by violent wind during the two years 1891 and 1895, and more than during any single year of which we have authentic records, except 1893.

If we exclude the storm of May 27, the loss of life thus far during 1896, though above the average of previous years, is not so great as in 1892 or 1893.

In almost all cases of great disaster there is a pronounced tendency to exaggerate the actual facts, and thus it happens that press accounts of tornadoes, especially those first sent out, are generally misleading. In consequence, the general conception of the frequency and severity of these unwelcome storms is more or less erroneous. According to a statement recently compiled and published in a reliable newspaper, 676 persons lost their lives by tornadoes during April and May, 1896. An investigation of the cases cited in the published list shows that 515 persons were actually killed by severe thunderstorms and tornadoes during the months named. Of the remaining deaths accredited to tornadoes, 21 were due to drowning in the flood waters of small streams; 11 were drowned at Cairo, Ill., by the capsizing of a ferryboat in a wind squall; 2 were killed by lightning, and 127 reported deaths were fictitious.

The unusual destruction of life and property has doubtless been the means of awakening general interest in tornadic phenomena and also of stimulating the business of tornado insurance throughout the great interior valleys. Direct application has been made by several companies now writing tornado insurance for statistics of the loss of life and property occasioned by tornadoes. Since the compilation of such statistics is a matter involving considerable labor, and since it would appear that the purchasers of tornado insurance should also be supplied with whatever information might be furnished to the companies, it was decided to review the tornado records of the last seven years with a view of determining the frequency and the destruction caused by these storms so far as past records throw light upon the subject. The revised list appears in the Annual Report of the Chief of the Weather Bureau (quarto volume), 1895–96. It contains a statement of what is known concerning the loss of life and property, the length and breadth of areas of great destruction, and the direction in which the tornadoes moved. The location of each storm is also shown by years, each year's record being on a separate chart. These data, it would seem, should serve a useful purpose in connection with the fixing of rates for tornado risks.

## STATE WEATHER SERVICE CONVENTION.

The American Association of State Weather Services held its fourth annual meeting at Indianapolis, Ind., October 16 and 17, 1895, and its proceedings were published as a bulletin of the Bureau.

That more than thirty officials engaged in the climate and crop work of the Bureau should volunteer to attend this convention at their personal cost manifests a most commendable interest on the part of those engaged in the climate and crop work of the Bureau. The great extension of the work of the Weather Bureau in recent years renders of great importance the assembling of section directors and other prominent officials in convention for the purpose of discussing ways and means that would likely prove successful in furthering the work of the Bureau; but it is not thought that the zeal of these earnest and devoted public officials should be allowed to operate to their pecuniary loss, and it is doubted that it will be feasible or proper to hold such conventions in the future unless arrangements can be made to allow to those in attendance a sum equal to their actual expenses.