U. S. DEPARTMENT OF AGRICULTURE.

REPORT

OF THE

CHIEF OF THE WEATHER BUREAU

FOR

1891.

BY

MARK W. HARRINGTON.

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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.

SIR: I have the honor to transmit herewith a report on the work of the Weather Bureau for the last six months of the year 1891.

Very respectfully,

MARK W. HARRINGTON,
Chief.

Hon. J. M. RUSK,
Secretary.

INTRODUCTORY.

In my special report, dated October 1, 1891, I submitted a statement of the administrative work of this Bureau since its transfer on July 1. In the present report I desire to refer more at length to the scientific and practical work of the Bureau and to enlarge upon some of the features of especial interest to the public. The evident intention of Congress, as expressed in the act creating the Bureau and in the appropriation bill, as well as your own specific instructions, have made it my duty to endeavor to extend the benefits of the meteorological service to agricultural interests. Under my eminent predecessors, Generals Myer, Hazen, and Greely, the commercial requirements have been met as fully as the art of forecasting the weather would permit. This was doubtless in part because their wants were more fully met by general forecasts, and partly because forecasts when made could be more easily distributed to them. The Chief Signal Officers apparently appreciated the needs of the farmers and some effort was made to meet them, especially by my immediate predecessor, who himself initiated some of the improvements which I have endeavored to put into operation.

I embrace the opportunity to express my high appreciation of the Bureau force, in and out of Washington. The employees in the meteorological service generally remained with it after its transfer. Their hours of labor have been generally increased, in some cases to an extent which I regret and would be glad to remedy; but they have in every case responded nobly to every demand made upon them. I have found them uniformly able, enthusiastic, and trustworthy, so that I have not hesitated to give them increased responsibility and freedom of action. This is a natural result of the transfer to a civilian department, and, so far from detecting evidences of deterioration, which the critics of the transfer claimed would ensue, and even its friends feared might be the result, I believe that the actual result has been an improvement in the public service.

The state of uncertainty in which the station employees (those employed outside of Washington) were left by the transfer was speedily ended by their prompt appointment under the newly organized Weather Bureau,

and, as employees of the Department of Agriculture, they are faithfully performing the duties assigned to them. I may state here that it will add to the satisfaction of the entire force, and satisfaction always means increased efficiency, if we can be enabled by the extension to this service of civil service rules so modified as to meet its peculiar needs, to provide a proper means of admission, and, what is still more difficult, a proper test for promotion, so that every man will be dependent for admission and advancement upon his own capacity and exertion, and will know that a system is in force which will accord to each full justice on this basis. I need hardly say that it is no easy matter to devise such a system specially adapted to a service like that of the Weather Bureau, but I hope to be able in a short time to submit therefor a plan for your consideration.

I take pleasure in warmly commending the force engaged on scientific work at Washington, in which I include the able and experienced commissioned officers detailed from the Army. The forecasters performed the same duty under my predecessor. The appointment of Mr. Frank H. Bigelow as professor of meteorology has been uniformly commended. I have intrusted to him a special line of investigation, which will be mentioned later. The other members of the scientific force have routine duties intrusted to them in every case, in addition to the special researches on which they are engaged.

An endeavor has been made to enlist in our work scientific men of established reputation and not regularly connected with the Bureau. This has been fairly successful, and I hope soon to place in your hands a series of reports on various features of the practical and theoretical aspects of our work which will prove to be a notable addition to our knowledge. In these reports especial attention will be paid to the applications of meteorology to agriculture.

THE FORECASTS.

Our first care, on the transfer, was to improve the forecasts and their distribution in every possible way. The time covered by the forecasts has been lengthened to thirty-six hours, and the forecasters have been encouraged to make their predictions still longer whenever they see a fair prospect of verification. At the same time the forecasters have been instructed to put their predictions in language which will be easily understood by everybody.

Both these improvements tend to reduce the technical percentage of verification, but as they make the prediction of greater value to the public, they have been introduced. So perfectly, however, has the work of forecasting been done that the verifications have not suffered. To show this, I compare the verifications for the months for which they have been made since the transfer with those for the same months for the previous year:

Month.	1891.	1890.
July	82.9	83.1
August	82.1	84.2
September	88.7	79.4
October	88.8	83.9
November	85.8	86.2
December	88.4	83.9
Average	86.12	83.45

The most exact verification possible can not express in percentages all the features of success and failure in the work of a forecaster. The feature of the forecasts which it has been my endeavor to strengthen, namely, the making of predictions which will be of the highest possible use to the public, can not receive adequate arithmetical treatment.

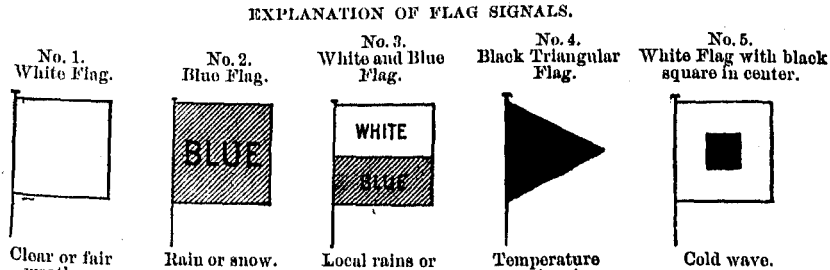
THE DISTRIBUTION OF FORECASTS AND FROST AND COLD-WAVE WARNINGS.

The value of the work of the Weather Bureau to the country depends largely upon its ability to distribute promptly the information collected at central points from its system of telegraph stations. The daily weather forecasts issued by the Bureau have always been recognized as of sufficient importance to be telegraphed by the Associated Press as items of news, and they are therefore distributed without expense to the service to the centers of population, and have appeared regularly in the daily journals of the country. Many efforts have been made to reach the more thinly settled portions of the country, and with the transfer of the Weather Bureau to the Agricultural Department renewed efforts are being made to extend the weather forecasts to agricultural communities. The most thorough distribution of the forecasts possible would be by telegraph daily to every telegraph office in the country, where means should be provided for the display of reports in bulletin form. Such a system can not at present be utilized owing to the small appropriations made for telegraph purposes, although it has been strongly urged by agricultural organizations throughout the country, and Congress has been petitioned repeatedly for appropriations to bear the expense attending such telegraph service. Those most interested in agriculture will not be satisfied without additional appropriations for this feature of Weather Bureau work, and it will be in the interest of the general public, including all classes, if arrangements can be made which will place the daily weather bulletin at every telegraph office in the country.

The Bureau not having the necessary funds for the extended distribution outlined above, every other available means has been utilized for placing before the public the information collected by this service, of which the following is a general outline:

The forecasts and frost and cold-wave warnings issued by this Bureau are disseminated as widely as possible, through the medium of the Associated Press, by special message (telegraph or telephone), by railroad wires, by train service, and by mail. They are received by the newspaper editor, the farmer, the merchant, the mariner, the miller, and others, and are by them disseminated by means of the flag or whistle signals adopted by the Weather Bureau, of which the following is a description:

EXPLANATION OF FLAG SIGNALS.



No. 1, white flag, 6 feet square, indicates clear or fair weather. No. 2, blue flag, 6 feet square, indicates rain or snow. No. 3, white and blue flag (parallel bars of

white and blue), 6 feet square, indicates that local rains or showers will occur, and that the rainfall will not be general. No. 4, black triangular flag, 4 feet at the base and 6 feet in length, always refers to temperature; when placed above Nos. 1, 2, or 3 it indicates warmer weather; when placed below Nos. 1, 2, or 3 it indicates colder weather; when not displayed the indications are that the temperature will remain stationary, or that the change in temperature will not vary more than 4° from the temperature of the same hour of the preceding day from March to October, inclusive, and not more than 6° for the remaining months of the year. No. 5, white flag, 6 feet square, with black square in center, indicates the approach of a sudden and decided fall in temperature. This signal is not to be displayed unless it is expected that the temperature will fall to 42°, or lower, and is usually ordered at least twenty-four hours in advance of the cold wave. The display of the flag during the growing season indicates that injury to vegetation may be expected from frost, and at other times that the cold may prove injurious to stock and to farm products, etc., exposed in shipment. In the State of Florida, and in a strip of country 100 miles wide on the Gulf coast, and along the Pacific coast, the cold-wave flag is known as the frost-warning flag. During the late spring and early fall the cold-wave flag is also used as a frost-warning flag in other portions of the country, to indicate anticipated frosts. When No. 5 is displayed No. 4 is always omitted. When displayed on poles, the signals should be arranged to read downward; when displayed from horizontal supports a small streamer should be attached to indicate the point from which the signals are to be read.

INTERPRETATION OF DISPLAYS.

No. 1, alone, indicates fair weather, stationary temperature.
No. 2, alone, indicates rain or snow, stationary temperature.
No. 3, alone, indicates local rain or snow, stationary temperature.
No. 1, with No. 4 above it, indicates fair weather, warmer.
No. 1, with No. 4 below it, indicates fair weather, colder.
No. 2, with No. 4 above it, indicates warmer weather, rain or snow.
No. 2, with No. 4 below it, indicates colder weather, rain or snow.
No. 3, with No. 4 above it, indicates warmer weather, with local rains or snow.
No. 3, with No. 4 below it, indicates colder weather, with local rains or snow.
No. 1, with No. 5 above it, indicates fair weather, cold wave.
No. 2, with No. 5 above it, indicates wet weather, cold wave.

A system of steam-whistle signals is also in use at a number of stations, by means of which the weather conditions are communicated in places where flags can not be seen at long distances, those within range of the sound of the whistle being supplied with the code which is used at stated hours to communicate the probable weather conditions for the coming twenty-four hours. This whistle code is intended only for use at stationary engines and is not applicable to the railway.

The flag displays here outlined may be greatly extended and become a most valuable aid to farmers, shippers, and the public generally, by a little exertion and a small outlay for flags on the part of those to be benefited. The system has been adopted and is in use by some of the principal railroads throughout the country, the symbols, made of tin or sheet iron, being displayed from the baggage cars. These roads transmit over their wires each morning, to points from which trains start, the names of the symbols to be displayed on the cars. When the symbols are thus displayed they should be placed one above the other and read downward. Many large firms and corporations are displaying the flags, and at the same time advertising their business, by printing the signals and their meanings on the back of their business cards.

There being but a limited appropriation at the disposition of the Chief of the Weather Bureau for the purchase of flags, it is necessary that the utmost care be used in their distribution, in order that they may be placed in proper hands where they will be properly cared for as Government property, and used only for the purpose for which they are intended. In many instances individuals or firms procure their own signals for such displays, and upon this office being notified that

arrangements are completed for the display of signals the forecasts and warnings are telegraphed to the proper address at Government expense.

On June 30, 1891, about six hundred and thirty weather signal display stations were in operation, to which the forecasts were telegraphed or telephoned at Government expense; ninety stations receiving cold-wave warnings only, fifty-one stations being furnished with frost warnings alone, and six stations (located in California) receiving rain warnings for the benefit of the raisin-growing sections.

Since July 1, 1891, this number has been largely increased. Before the close of the year the forecasts and warnings were telegraphed or telephoned to nearly one-thousand six hundred and fifty points, at which flag signals are displayed or whistle signals sounded for the benefit of the general public.

A system of frost warnings for the benefit of cranberry and tobacco interests in operation in Wisconsin during the past season having been so thoroughly satisfactory the State service directors in the cranberry and tobacco-growing States have been instructed to perfect similar systems for the dissemination of frost warnings. A warning of a killing frost for the cranberry district of Wisconsin, on August 24, resulted in the saving of over one-third of the cranberry crop in that State, representing over $125,000. In Minnesota and the Dakotas frost warnings were issued during August of the current year to protect the grain, and little or no damage resulted where farmers used smudges to cover their fields with a dense smoke during the period of anticipated frost. In the State of Kentucky alone nearly one hundred and fifty frost-warning stations were established and are now in operation to protect the tobacco interests of that State.

The various means employed for the dissemination of forecasts and warnings have resulted in placing the information in the hands of thousands who have been heretofore unable to reap the benefits of the work of the Weather Bureau. This, as a matter of fact, has necessitated a considerable outlay, but it is believed that in every case the expense has been justified and that the service rendered has amply compensated for the cost of distribution. In the majority of cases the plan of distribution is entirely satisfactory, although rare instances of inadequate telegraph service are reported, which, as a rule, receive prompt consideration by the proper officials.

The Railway Bulletin Service has been largely utilized for the gratuitous distribution of forecasts and should be encouraged and as widely extended as possible. If the matter is properly presented to the proper officials of the railroads coöperation invariably follows in cases where companies control their own wires. At the present writing the records of this office show that over thirty railroads are coöperating in this work and posting the forecasts at nearly two thousand stations at which the information is accessible to the general public, while a number of roads distribute the reports for the benefit of their employees only, being restricted to this action by their agreement with the telegraph companies.

The telephone, for distributing forecasts, is becoming more popular with the building and extension of new lines, and it is believed in the near future will supersede the telegraph as a means to be utilized at distributing centers for reaching every point in the sections desiring to obtain the predictions of this Bureau. The more enterprising and progressive farmers, living on the routes over which the lines are strung,

avail themselves of the opportunity presented, place private telephones in their residences, and obtain the forecasts by application to their nearest exchange. Gratuitous distribution of forecasts is allowed in some instances, and a liberal policy is pursued by all telephone companies in their dealings with this Bureau and its work. It is believed that very low rate can be obtained from every line for daily messages. The only apparent objection to this manner of distribution is the fact that in damp or wet weather the lines are grounded, in a measure, and poor service necessarily follows.

Postal facilities are made use of at distributing centers as far as possible in distributing the forecasts to near outlying points, and quite a number of individuals are now receiving the reports by mail who formerly were furnished the same information by telegraph.

It has long been the desire of this Bureau to devise some method by means of which a legible and clearly printed map could be published in the daily journals, and several attempts have been made but without satisfactory results until quite recently. Through the efforts of the forecast official at Atlanta, Ga., in coöperation with the officials of the Atlanta Constitution, a satisfactory daily weather map is now regularly issued in that journal, and a number of the more prominent journals of the country, seeing the advantage that will result from this undertaking, are preparing to do the same thing. Should this feature be adopted by the daily journals of the country it would not only add greatly to the distribution of the weather forecasts, but the appearance of the chart would doubtless create an interest in the work of the Bureau, the public would become familiar with the map and its uses, and intelligently apply to their interests the information thus given.

The majority of the means now employed in the dissemination of the forecasts and warnings present more or less difficulty, which must be overcome to secure prompt and efficient service and prevent complaints on the part of the recipients, but every effort is being made at all times to perfect the work of distribution and economize in the disbursement of the appropriation allowed for this purpose, without reflecting discredit on the Bureau or subjecting it to adverse criticism.

Great as is the practical value of the system of forecasts, it may be shown that this system, without any change of methods or amounts of observations, and equally with no diminution of territory concerned, is susceptible of marked extension, which will enable its benefits to reach several times the number of persons who now find the prediction of coming weather changes a matter of economic advantage. Hitherto the course of issuing forecasts for a period narrowly restricted to one day in advance has limited their first benefits to the urban and suburban residents. To give these benefits to a much larger and equally interested portion of the community is possible by the process of simple extension, and, being possible, may well claim consideration in behalf of the foremost producers of the wealth of the state.

Inclosed within the boundaries of our country, marked by varying influences exerted from without, the field equally varies in its interior parts. It presents the strongly marked individualities of mountain and valley, coast and insular climates, with the addition of a most important region of central plain over which it is a necessary but difficult task to follow out the combined or successive application of the many external and internal factors. The field thus constituted must be ever kept in mind by the forecasting official in order that from the

particular individualities of each storm area and the more permanent modifications introduced by the geographical physics of the land, he may issue a reliable statement of impending weather changes at such a time in advance as may secure the benefits of this knowledge to the greatest number.

To issue this information, in other words to forecast the weather, is a matter which depends upon recognizing the approach of an area of disturbance at the earliest moment, and upon watching its development most closely with equal regard to the presence in other parts of the country of other climatic elements which may affect the future path of the disturbing area and its rate of speed of translation along that path. When the development has progressed to a certain extent it becomes possible to correlate this area with others similarly originated, and thus having brought it into connection with a certain type recognized by past familiarity with these meteors, it is a legitimate process of induction to assign to the individual the average characteristic of the type as known. In proportion as it is practicable to appreciate the type relations of an approaching storm area at an early period and with certainty, so is it possible to issue warnings of its approach for the benefit of those in the line of its march of progress whose industries are so likely to be affected beneficially or injuriously by the passage of the storm as to make early knowledge of its coming a positive advantage. But as climatic physics is not as yet an exact science, it must not be forgotten that the farther from the storm front the warning runs the greater is the chance that some unforeseen modification of path or rate may interfere to vitiate to a certain degree the accurate value of the warning.

The problem is not one to be lightly approached. It has initial difficulties in the attempt to pick out of the obscure and ill-defined beginnings of an atmospheric movement the generic and specific characters of the type which must precede any estimate of its growth and movement. Along its course it is also beset with difficulties in the recognition by obscure and often almost inappreciable signs of the existence of perturbing forces, which, in the interval between two successive observations, may so divert or impede the storm progress as to bring it under a type needing different treatment. Never easy, the problem becomes more difficult when it is sought to go before the storm at any but short intervals of space and time. Likewise there is a complication of the problem introduced by the change of the seasons wherein the solar influences induce rapid or lagging movements of the storm areas. The prime essential without which the forecast can not hope to rise above an unreasoning guess is, then, to look upon the storm area as a physical entity concerning which it is possible to predicate breadth, course, and speed. This entity being exposed to perturbations in its course, a new difficulty is introduced by the fact that an area of atmospheric disturbance may so distinctly change its character while in progress as to vitiate all foreannouncements, except such as are expressed in the most general terms and for times and places removed to such a limit in advance as may allow the issuance of a second forecast, revised in accordance with the altered conditions. Nor does the difficulty end with this. In a territory so wide it is possible that storm areas may die out entirely; or, on the other hand, such meteors may develop without warning from apparently neutral conditions, and these are matters which it is as impossible to predict as it is beyond the power of mind to foresee.

Having such factors to deal with, and subject to the modification of *such coefficients of perturbation*, successful forecasts are limited within certain lines, which differ from day to day and from season to season, in a manner as yet so imperfectly understood as to make the problem presented to the forecast official on his maps night and morning more a matter of empirical essay in a long chain of individual instances than a satisfactory induction. Yet many of his difficulties lose much of their force through the operation of nature's harmony with the needs of man, which finds in the seedtime and harvest of the husbandman the meteorologist's well-recognized seasons of sluggish development and slow progress of storms; and in winter, with its conditions of danger to the mariner, finds a period when the lakes are frozen, and on the seacoast a natural absence of freight for the smaller and less seaworthy vessels, which in consequence are removed from the possibility of disaster.

In general, it may be said that the maritime interests have been abundantly conserved in the issuance of forecasts and storm warnings. The fact that great ports and great cities are the same place, and that the port shares every last advantage of publication of information which the city affords, has served to transmit to the seaman the warning of approaching gales as rapidly as it has been found possible to reach any party in interest. Beyond this general system of information the marine interest has received particular attention in the winter season, when violent conditions are of quick development and speedy translation, and are as quickly handled by the display of warning signals that respond to the telegraph and may be appreciated by a glance of the eye.

Commerce afloat and commerce ashore have been so favorably situated as to command the advantage of learning sufficiently in advance any change which may be impending. But before this information has been brought to the farmer, to whom, as representing the productive interests with which commerce must concern itself, it is of equal if not greater applicability, much time has been lost, and that, too, in a matter where time is of the utmost consequence. The delay in transmission continues irremediable, and must ever be due to the fact that time is requisite to publish the information and to distribute it where needed under the condition that, as the population is more widely scattered, the channels of transmission operate more slowly and correspondingly with less efficiency. To meet the needs of all agricultural industry, in recognition of its right to receive from the Weather Bureau a service to the full as efficient as is afforded any element of the population, this problem has been studied in detail. The delays in publication and transmission remaining constant, as they must, the remedy must accordingly be sought in some plan of extending the time predicted for by such a period as will take note of this constant factor of delay, and give to the average agricultural community its information as to the approach of weather changes at such time in advance as will allow it to take measures accordingly to protect itself.

This demand is now met by a general statement presenting useful probabilities of coming changes of the weather. The adoption of this general synopsis has been tentative in its character, both by reason of natural hesitation at entering upon a new and untried procedure, and equally by reason of the necessity of avoiding any alteration of the more positive character of the district predictions as now authorized. The present system of forecasts has been suffered to remain unmodified, but nevertheless the Weather Bureau has recognized the paramount neces-

sity of giving to agricultural communities, more slowly reached, such early information as may be of service in their varying needs. Under this system the prominent characteristics of each day's meteorological elements are discussed in popular terms, the history of each threatening meteor is narrated, and particular attention is called to the presentation of the probable path which it will follow over the country, the rate of movement which it may be expected to attain within that path, and the whole is summed up by judicious warning to those to whom the storm path and progress may be of interest and value. Thus has grown up, in addition to the official predictions, which lie under limitations of time and degree, a system of freer secondary warnings for two and three days in advance, and frequently over half a week ahead, of which the value is becoming daily more conspicuously manifest. The initiation and development of this additional system is to be laid to the credit of one of the officers of the Army retained on temporary designation for duty under the Secretary of Agriculture. This official was willing to undertake the additional care if only the advantages of the service rendered might be extended as far as possible and the usefulness of the Bureau further broadened. Its simple beginning was the making of a statement of the general weather conditions; its extension has been to present fuller details, without the sacrifice of any of the simplicity and utility which are necessarily a prime desideratum.

The same impulse has led in the official system of predictions to the presentation of forecasts for not only the ensuing twenty-four hours, but for the succeeding day as well, in almost every instance. As illustrating this endeavor to increase the range of the authorized forecasts, it is well to draw a comparison between those of the five months from July to November, inclusive, of the current year and the corresponding five months of 1890. These are not the reasonable probabilities that form the topic of the general bulletin, but are the forecasts made at night for the second day, and included in the dispatches published in the papers and sent to correspondents of the Bureau.

Number of forty-eight-hour predictions:	
July 1, 1890, to July 1, 1891	2,189
July 1, 1890, to December 1, 1890	731
July 1, 1891, to December 1, 1891	3,523
Percentage of increase:	
Five months 1891 over five months 1890	382
Five months 1891 over twelve months 1890-'91	61

The system thus devised for the extension of the benefits of weather foreknowledge has, in Washington, been of intermittent application. Beyond the central office it has hardly gone at all, except to a few metropolitan centers; and though it has received appreciative attention in the large cities, that was by no means the end which the originator of the system set before himself, namely, the improvement of the service in its relation to the industries of those who produce wealth at a distance from the cities which consume it. An organization well adapted for extending the advantages of this subsidiary system is now available without altering existing methods.

This machinery of distribution exists in a new system of local forecast officials. To avoid loss of the skill which a few have acquired in the work of weather prediction, and at the same time to afford the highest degree of practical training to those who must ultimately succeed to their work when they lay it down, a plan has been under careful

consideration of dividing the two daily forecasts between the local forecast officials and those at the central bureau. The problem thus presented has by no means been solved, but the advisability appears in full measure of apportioning the morning report to the several local officials, each in his own district, and of reserving to the professors of the Bureau and others qualified for the work the preparation of the night bulletin, with its wide circulation and valuable information of cold waves, river stages, and wind signals.

It is to be expected that the effort to institute this additional improvement will encounter the objection that it is not fairly reducible to the present mode of verification. The answer to this objection, if raised, is that the object sought is to remove the general synopsis from the domain of that which is technically known as verification. That practice of the office is not based on a legitimate footing. Without entering upon the detail of the manner in which a practice initially designed to assist forecast officials in their professional study has elevated itself into a custom of rigorous application, it is sufficient to repeat the assertion that the statement of probabilities designed for the farmer's guidance must be free from the rigid definitions of arithmetical verification. That custom has always hampered those who have worked under the constraint which it imposes, and has entailed needless criticism upon the work.

In fine, it is to be said that here is offered a method, already tried, by which the plain probabilities of American weather may be foreannounced in plain American speech in order that the farmer may know whether or not he is to have fair weather for the care of his crops, and if storms do come, that he may have some idea of what his delay is likely to be. It has also been shown that this can be done without altering a single condition of the official predictions now authorized. It has been shown that the objection which might be raised on the score of verification will never prevail against the popular verification of an appreciative community when it receives, as has long been desired, its knowledge of to-morrow's weather in season to make it useful.

THE WEATHER MAP.

The weather map is based on observations made morning and evening at 8 o'clock, seventy-fifth meridian time, at one hundred and sixty places throughout the United States and the Dominion of Canada, and is issued twice a day. Data as to the condition of the weather are thus gathered from an extent of more than 3,500,000 square miles of the earth's surface, about one-fortieth part of the whole surface of the globe. Information is also received from the West Indies at times when severe storms prevail there, and occasionally also from Bermuda Islands.

The observations taken at a place comprise the pressure of the air; the temperature at time of observation; the highest temperature of the day and the lowest; the moisture; the wind direction; the velocity of wind for five minutes at the time of observation; the depth of rainfall for the preceding twelve hours when the observation is made in the evening, and for the preceding twenty-four hours when the observation is made in the morning; the condition of the weather at the time of observation, whether clear, raining, snowy, foggy, or hazy; the condition of the sky as to clouds and the kind of clouds; the direction of their motion and the proportion of sky covered.

These observations are telegraphed to the central office of the Weather Bureau at Washington, D. C., with the aid of a cipher code designed for the purpose of saving time and expense in the transmission of the messages. As a rule, a message consists of ten words. The cipher is so constructed that a person familiar with the key can quickly translate the message without reference to the key and without consulting an index of words. As the cipher messages are received a skilled translator reads each of them in the terms expressed by the cipher. An assistant enters the data upon a map of the country near the location of the particular place.

When all the data are entered on the map, it is generalized by lines representing graphically the various conditions of the air and the changes going on.

The lines on the specimen weather maps adjoining represent pressure and temperature distribution over the country. Shaded areas show where there has been rainfall in twelve hours preceding the time of observation. Heavy dotted lines inclose areas of great temperature fall. A line of arrows indicates the path followed by the center of low pressure. Circular symbols show the condition of the weather and the sky, and the circles with arrows the wind direction.

This map, made up from observations at 8 o'clock, is issued two hours and a half later in a number of the large cities throughout the country, and is posted in post-offices, custom-houses, boards of trade, and maritime exchanges. In the aggregate 5,000 copies of the weather map are issued daily, except Sundays, at sixty-three cities. The maps given here are on a reduced scale, the actual size being 22 by 16 inches.

On the printed weather map issued at Washington the principal data for the various stations are given in figures, in tabular form, on the side of the map.

The pressure of air varies greatly at different times. The average pressure is equal to what would be exerted by a layer of water 34 feet in depth, or a depth of about 30 inches of mercury. On the weather map pressures are always expressed in equivalent heights of a column of mercury as ascertained by the observation of a barometer. The pressure may be as low as 29.0 inches, or occasionally even less. Sometimes it is as high as 31.0, the highest ever observed in the United States being 31.12 inches.

As the height of a column of mercury varies with its temperature, independently of the air pressure, on account of expansion, all observed pressures are reduced to what they would be if the temperature of the mercury was 32°.

Great and widespread changes of air-pressure are closely related to weather changes, especially high winds.

Besides the effect due to weather, the air-pressure diminishes with height in the air or altitude above sea level. The observations made throughout the country being at places situated at various heights above the sea, from 50 feet to 1,000 feet or more, it is necessary for the purpose of comparing them that they be reduced to some common plane. The plane selected for this purpose is sea level. Before telegraphing the observation, the pressure observed at any place is first reduced to what it would be at sea level; the amount of the reduction depends on the height of the place and the temperature of the air at the time. At a height of 1,000 feet the reduction amounts to about 0.90 of an inch, to be added to an observed pressure.

The corrected and reduced air-pressures are inscribed on a map and are represented graphically by lines drawn through places where the pressures are equal. These lines (called isobars, meaning equal pressures) are drawn for pressures 0.1 of an inch apart for 30.0, 29.9, 29.8 inches, etc. The 30-inch pressure line is drawn through all the points with pressures of 30 inches. There may be only a few such actually observed pressures on the map, exactly equal to 30 inches, but many such points can be determined by interpolation from the pressures above and below 30; for instance, if the pressure at Springfield, Ill., is 29.95 and at St. Louis, Mo., 30.05, it may be inferred that the 30-inch line will pass halfway between those places, and the line is drawn accordingly.

The distribution of temperature over the country is graphically shown by lines drawn through places of equal temperature. These are called isotherms, meaning equal temperatures. On the specimen weather maps the isotherms are shown by dotted lines. They are drawn for every ten degrees—60°, 50°, 40°, etc. They are located principally by interpolation, the same as in the case of the isobars. With a temperature, for instance, of 35° at Memphis and 45° at Vicksburg, the 40° isotherm is drawn halfway between them. If the temperature was 32° at Memphis and 42° at Vicksburg, the 40° isotherm would be four-fifths of the way from Memphis to Vicksburg.

On the weather-map the direction of the wind at a place is shown by an arrow flying with the wind, . This, it is to be noted, is the very reverse of a written or spoken description of wind direction. A northwest wind always means a wind coming from the northwest; on the weather map, however, it is represented by an arrow pointing southeast.

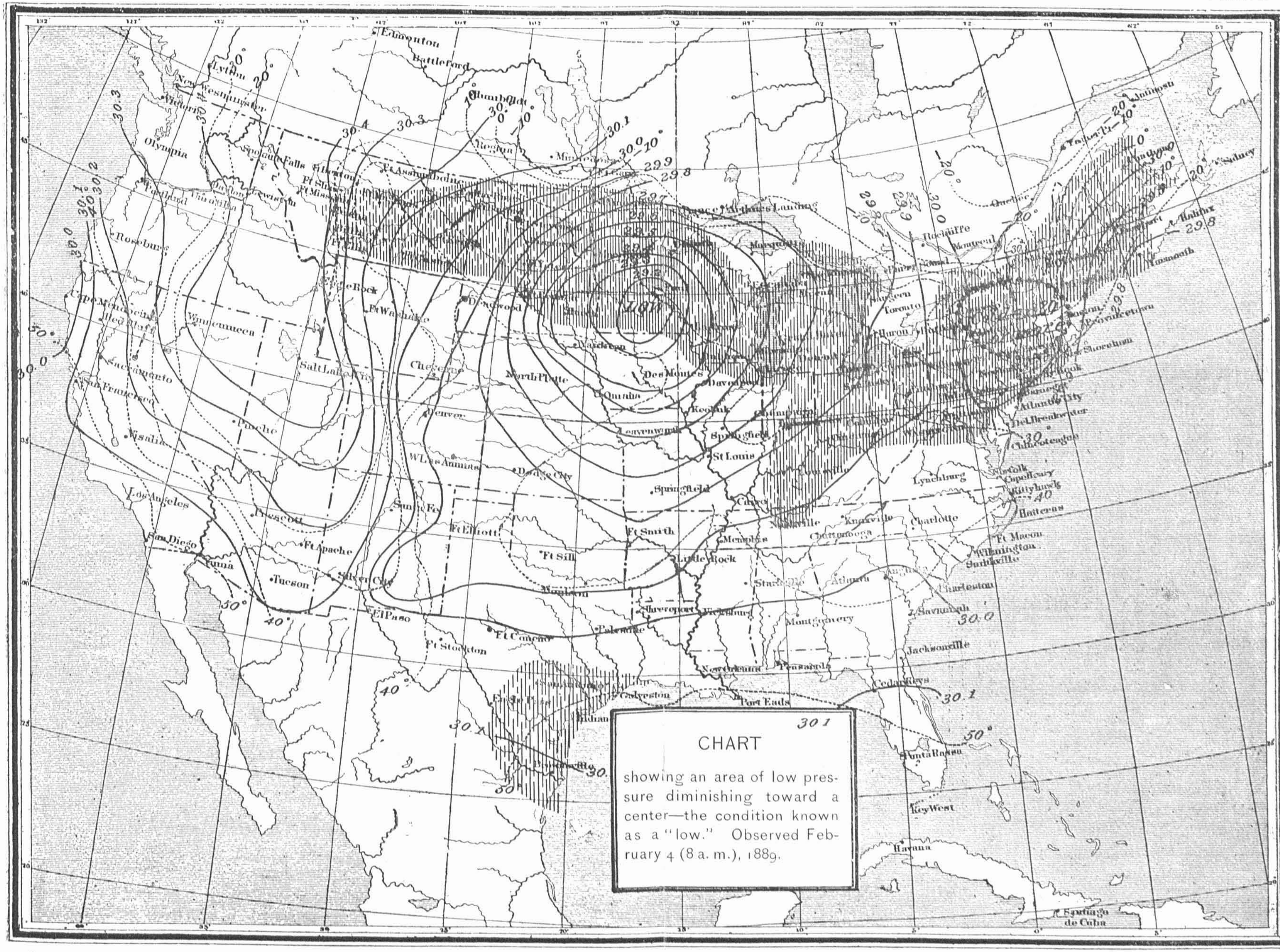
Of the symbols, a circle, ○ , at a place indicates clear sky and fair weather at the time of observation; a full black dot, , indicates that it is raining; a cross-barred dot, , indicates that it is snowing; a black dot, with a white center, , indicates wholly clouded sky; a dot with black bar, , indicates a sky half-clouded.

A series of concentric isobars, showing an area of pressure diminishing toward a center, is called a "low." Such a map is that of February 4, 1889 (Plate I), where the pressure is as low as 29.2 inches in Minnesota. This type of pressure distribution is commonly associated with the occurrence of rain or snow and high winds over a wide area of country, especially in winter. Rain is likely to occur for a distance of 500 to 700 miles to the east of a decided low center.

These areas of low pressure traverse the country from west to east and from southwest to northeast. Sometimes they move in from the northwest and, turning in the region of the lower Missouri River, move to the northeast over the Great Lakes to the Gulf of St. Lawrence; at other times they pursue a southeast course as far as the Gulf of Mexico and then turn northeast; this latter, however, is only apt to occur in winter.

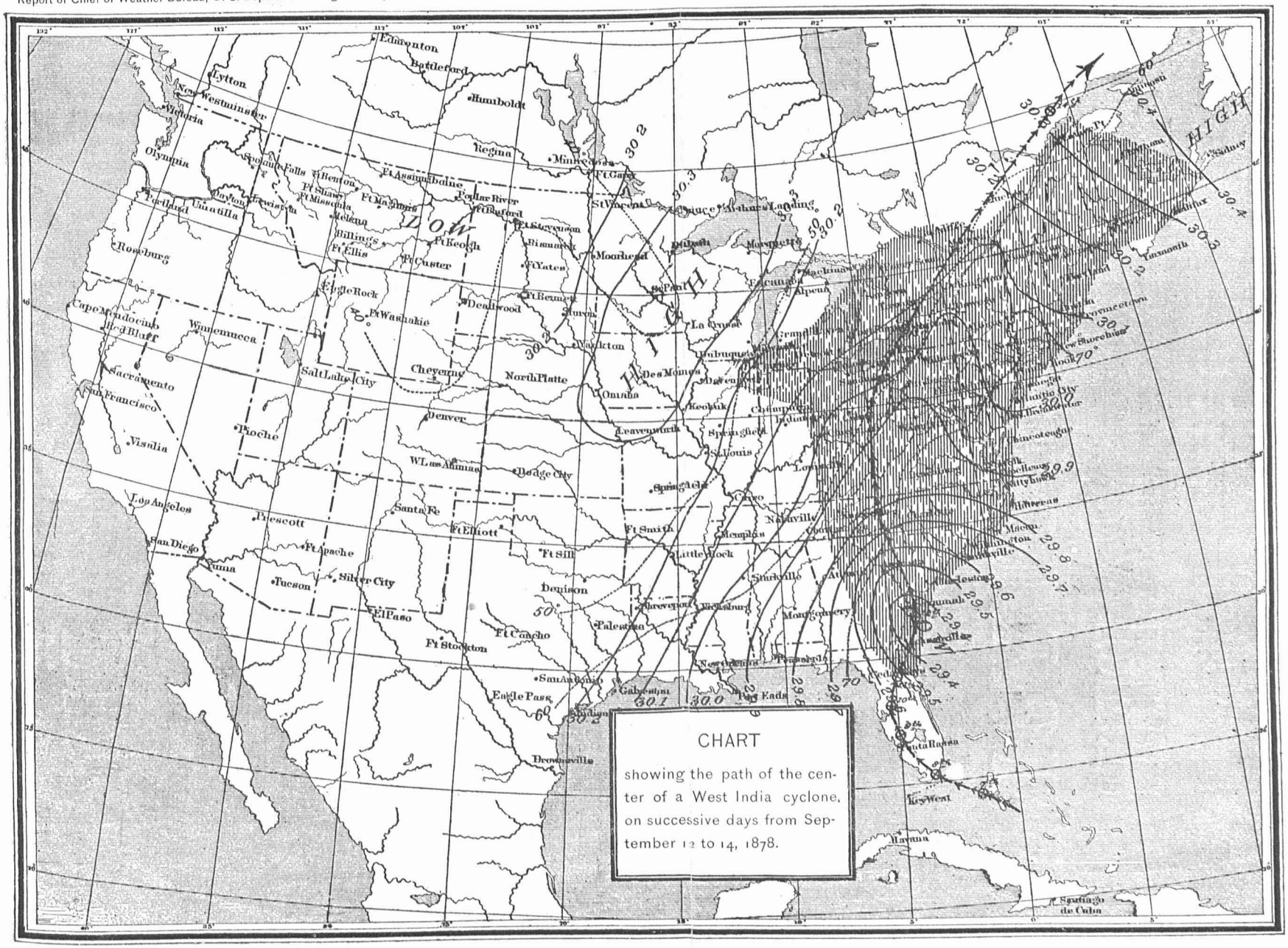
The average velocity of low centers is about 32 miles an hour. The motion is more decided and definite in winter than in summer.

There is a type of low pressure which originates in the West Indies, and, moving northwest, turns to the northeast on the south Atlantic coast or in the Gulf of Mexico. These "lows," commonly called



CHART

showing an area of low pressure diminishing toward a center—the condition known as a "low." Observed February 4 (8 a. m.), 1889.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St Vincent
Prince Albert
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Red Bluff
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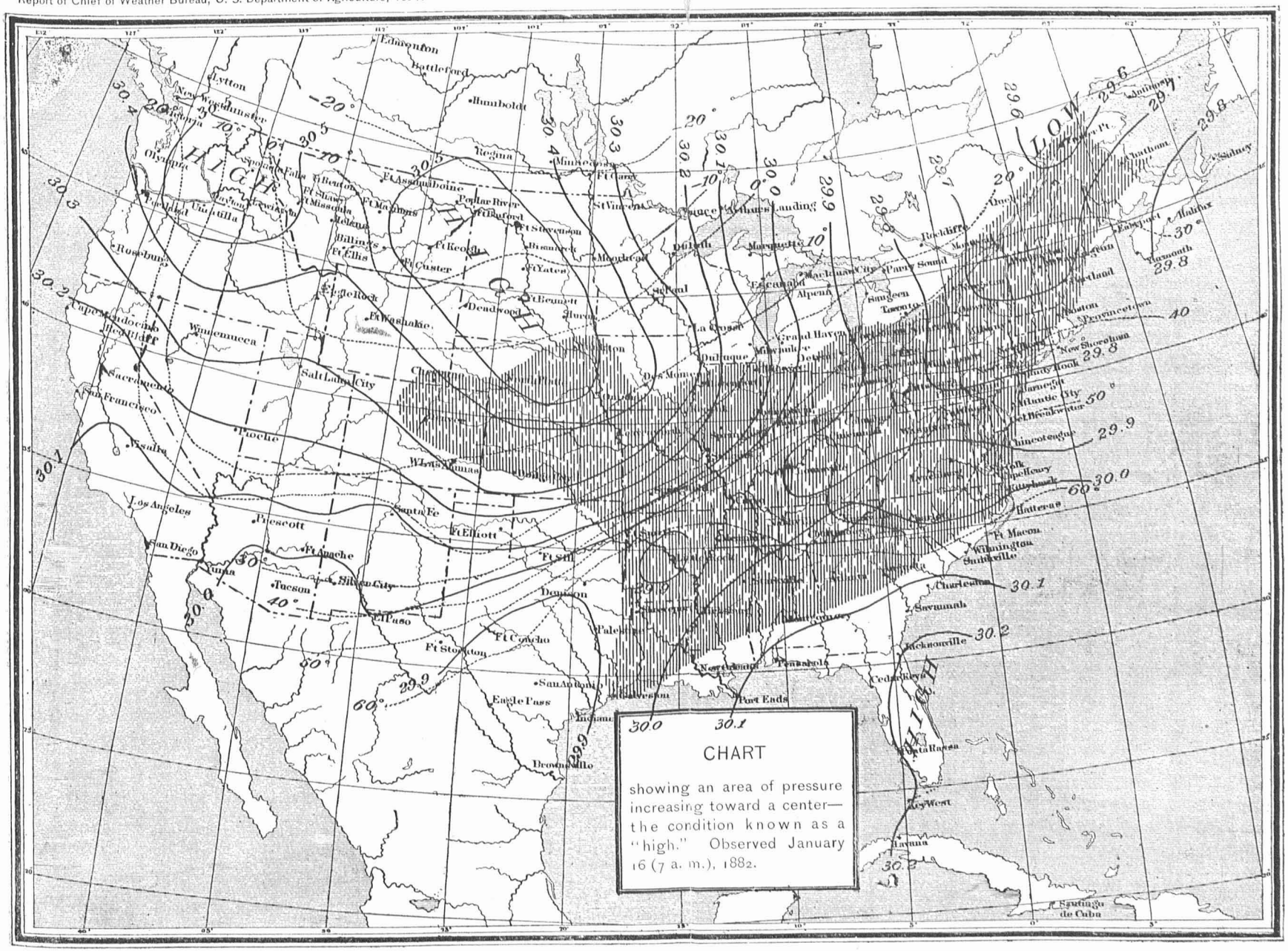
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Ft Delaware
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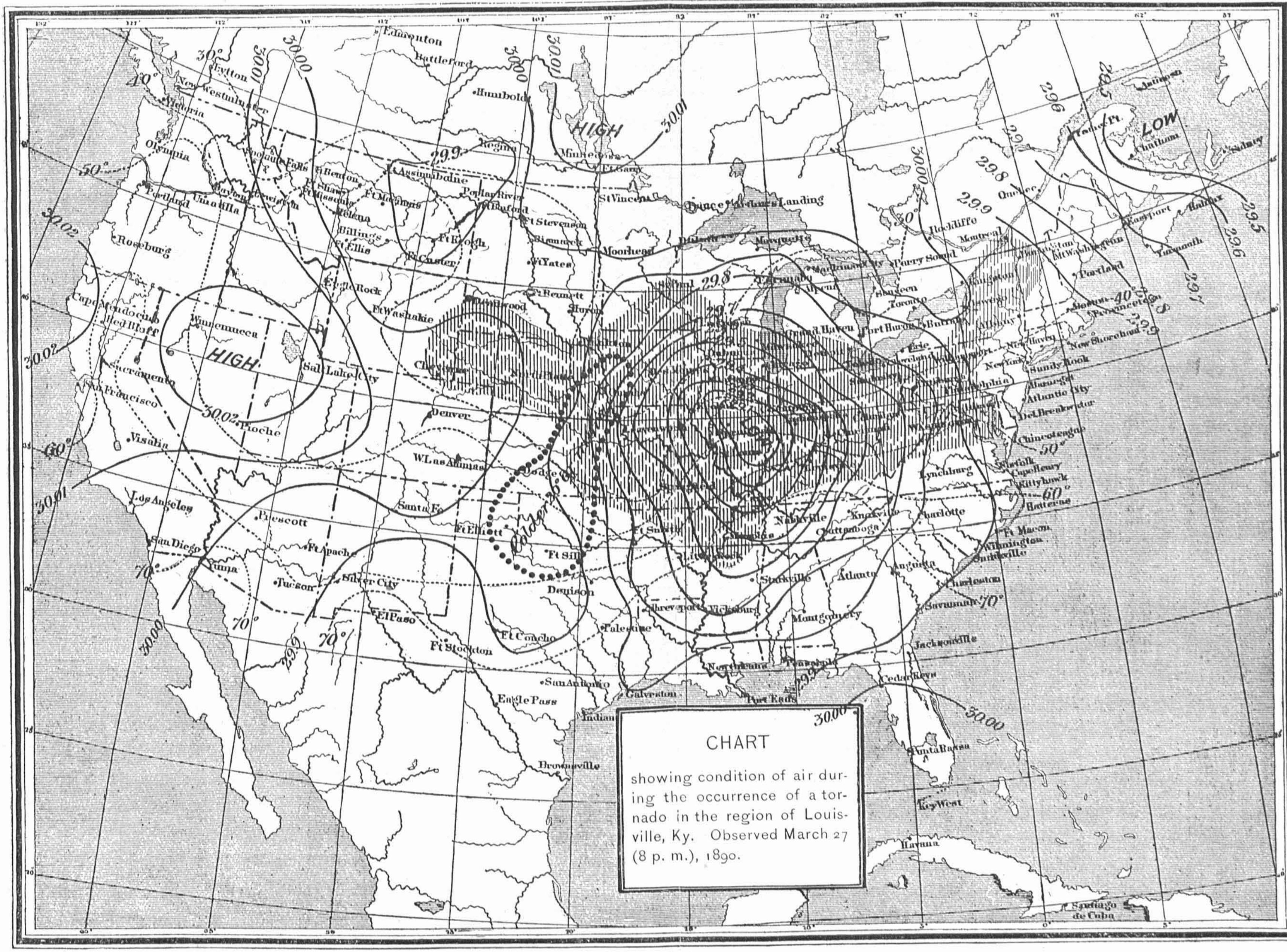
CHART
showing an area of pressure increasing toward a center—the condition known as a "high." Observed January 16 (7 a. m.), 1882.



CHART

showing condition of air during the occurrence of a tornado in the region of Louisville, Ky. Observed March 27 (8 p. m.), 1890.

cyclones, occur chiefly in August and September, and are accompanied by great downpours of rain and devastating hurricane winds.

On the weather map of September 12, 1878 (Plate II), is shown the path of the center of a West India cyclone marked by a series of arrows, and its position at 7:35 a. m. on successive days from September 12 to 14.

Sometimes the isobars over the country indicate an increase of pressure over a wide irregular area toward a center. Such a case is that on the map of January 16, 1882 (Plate III), where the pressure over Nebraska, North and South Dakota, Montana, and Wyoming is 30.5 inches. These areas of pressure are called "highs." The isobars in a "high" are not as regular as in the case of a "low." The "high" ordinarily covers a far greater area than a "low." In cases of great development it has a tendency to a triangular rather than a circular form.

The "highs" always originate in the west or northwest and generally move in a southeasterly direction, but very vaguely and indefinitely.

A "high" almost invariably marks a region of low temperature. Light snows, usually not more than the equivalent of 0.1 of an inch of water in depth, ordinarily occur to the southeast of a "high."

The whole matter of weather prediction is based on observations made at the same instant of time over a wide extent of country and on the known general progression of weather changes that have been by this means observed to take place in many cases in the past. There is a general tendency for the weather changes to advance from the west toward the east in the United States. Skill in predicting weather is gained by long familiarity with the weather maps and a close attention to the precedent conditions of pressure and temperature distribution that are observed to occur before very considerable weather changes. By long study of the weather maps there is finally gained, as it were, an intuitive perception of coming great changes.

The very great changes can be foreseen almost to a certainty in most cases by a skilled forecaster. The ordinary and slight changes, that for the most part are the ones usually occurring, it is not possible in most cases to correctly predict.

As "lows" move over the country the temperature rises to the east of the centers. There is a marked tendency for "lows" to move toward the region having the greatest rainfall in twelve hours preceding. As a "high" moves down from the northwest the temperature falls in front of it. With an opportune succession of a "low" and a "high" the temperature may fall as much as 60° in twenty-four hours, and the area covered by a fall of 20° and more in such cases may be a million square miles or more.

A great fall of temperature over an extensive area of country is called a "cold wave." Following the "low" of February 4, 1889 (Plate I), there was a fall of temperature of 54° in Minnesota, and the area over which a fall of 20° or more occurred was 658,000 square miles. Succeeding the map of January 16, 1882 (Plate III), the area of temperature fall greater than 20° was more than a million square miles.

The extent and depth of a "cold wave" depend in a measure on the extent of the "low" and "high" preceding it, and on the contrast of temperature over the region between the centers of the "low" and the "high." The temperature from the center of a "low" into a "high" may diminish from 60° to 0°, or even as low as −40°, in a distance varying, in different cases, from 400 to 1,400 miles.

The occurrence of tornadoes in many cases is associated with the presence of a low-pressure area over the country. The tornado is apt to occur about 300 miles to the southeast of the center of a "low" in which the pressure at center is lower than 29.4 inches and the isobars are very symmetrical or nearly circular.

The condition of air shown on weather map of March 27, 1890, 8 p. m. (Plate IV), was about simultaneous with the great tornado at Louisville, Ky., that occurred that day.

High winds, dangerous to shipping, are associated with the passage of "lows" and "highs" across the country. The strength of the wind over a region depends greatly on the contrast of pressure over it; the greater the difference of pressure in a given distance the stronger the wind is likely to be.

The change in pressure over a region is called the gradient. The closer the isobars are together the greater the gradient. As a general thing, winds of storm force, at least 40 miles an hour, lasting for a considerable time, do not occur with pressure gradients less than 0.4 of an inch in 500 miles.

Storm winds are preceded by a sudden fall in the air pressure. A fall of three-tenths of an inch in twelve hours over an area of at least 100,000 square miles is a common indication of a coming heavy blow.

The direction of wind around a low-pressure area is spirally inward, contrary to the direction of motion of the hands of a watch held with the face uppermost. In an area of high pressure the winds are out from the center and of slight force, except where a "high" is close to a "low" which is to the east or southeast of the "high." In this case the winds blowing out of the "high" into the "low" may be of very great intensity.

Particular attention has been given to the improvement of the maps, and the stations issuing them were informed that nothing but the most satisfactory results in this respect would be accepted. In place of the custom before existing, of only sending a copy of the map issued on Saturday, they were required to send to this office the poorest copy of every issue of the maps. By this course this office had the means of at once knowing when a poor map issue was made, so that action to correct it might be taken. At many stations complaint was made that on account of the poor quality of stencil paper furnished them the observers were unable to do better work. For this reason a better quality of stencil paper was immediately secured, at some additional expense. At the same time the observers were required to give that close personal attention to the matter without which good work can not be done with the best material. The result has been that the appearance, legibility, etc., of the maps have been greatly improved, and there is now rarely any complaint on that account. The issue of maps has also been authorized at Albany, N. Y.; Charlotte, N. C.; Charleston, S. C.; Marquette, Mich.; Green Bay, Wis.; Parkersburg, W. Va.; Eastport, Me., and Omaha, Nebr., stations not heretofore issuing them. The edition of the maps at all stations has been very largely increased, and they are distributed, without charge, to persons who will display them for the information of the public. The maps are prepared at the stations with the greatest possible speed, upon the receipt of the telegraphic reports, so as to catch all the mail trains, upon which they are dispatched to postmasters and others for display in cities and towns that can be reached in time for the information to be of benefit.

The weather maps are now issued at over sixty of the more important

stations, and are considered a most important feature of the service, as their usefulness is being appreciated by an ever-widening circle. They not only contain, as a rule, the forecasts prepared in Washington and the local forecasts, but also the data on which the forecasts are based, with a synopsis of the general meteorological conditions and probable direction of movement of storm centers, etc., so that they may be studied and personal conclusions be drawn by those engaged in any profession or calling affected by the weather, and this includes nearly all classes of business. In several of the large cities school superintendents and teachers have become much interested in these maps, hundreds of which are now furnished daily for study by the pupils. Information by lectures, etc., was given by the observers to the teachers as to data, practical deductions therefrom, etc. Several hundred agricultural newspapers and periodicals were recently put on the list and now receive the map daily. A very large edition of "Explanation of the Weather Chart" is about to be published for the information of those interested, and especially for those engaged in agricultural pursuits, to reach whom with these maps every effort is being made.

It is only when some change is made in the weather maps that it is learned how many and various are the classes of people who find it profitable to make a study of them. There is no doubt that the increasing issue of these maps is educating a constantly increasing number of persons as to their proper use. It is beginning to be realized that by study of the information contained on the maps, in connection with local weather signs, practical deductions as to coming weather changes may be made with profit by all who give the slight attention necessary to an intelligent understanding of the general principles outlined above governing the movement of storms over the United States.

Such is the growing appreciation of the maps that the total edition at all stations, which, on June 30, 1891, was 3,100, has had to be steadily increased, until at present (December), over 5,000 copies are issued daily; a total of over 1,500,000 a year, which will doubtless have to be still further increased. To meet the expense of this very large addition, saving was effected in other directions; for instance, by reducing the number of reports telegraphed to stations, without, however, materially curtailing in that direction.

FLOOD PREDICTIONS.

The stages of water at a number of important places on rivers are telegraphed with the weather report. These stages are printed on the weather map issued from Washington, D. C. A coming great rise of water is predicted for points along the lower course of a river when there occurs a rise along the upper course. The judgment of predicting officials is based on what has occurred in previous cases of high water for which there are records of the water stages. Records of daily stages of water have been kept at some places for more than thirty years.

To assist in predicting the stages of water, tables showing corresponding crests of high water at various points along the rivers have been prepared. Where the rise at a point in a main stream is the result of rises in a number of tributary rivers—as, for instance, at Cairo, Ill., where a rise is the result of rises in the Upper Ohio, the Upper Mississippi, the Tennessee, the Cumberland, and the Wabash—a special rule has to be devised for predicting the stages.

Important rises in the river are predicted three days ahead for Cincinnati, being based on the stages observed at Parkersburg, W. Va., Charleston, W. Va., and Louisa, Ky. For Cairo, Ill., predictions of river stages are made six days in advance of their occurrence, and for Vicksburg, Miss., seven days in advance.

STATE WEATHER SERVICE DIVISION.

At this time there are forty-one weather services, either in operation or in process of organization, representing every State and Territory in the United States with the exception of Idaho and the Indian Territory. The territory covered by the New England Meteorological Society embraces the six New England States, and the Maryland weather service includes Delaware. Elsewhere each State or Territory has its independent service.

In New York, Pennsylvania, New Jersey, Ohio, Michigan, Colorado, Iowa, South Dakota, local weather services have been organized, and supported by State laws; and in California and Nevada they have been supported through coöperation of State boards of agriculture. In New England the service is conducted under the auspices of the New England Meteorological Society, and has received no aid from the States forming its territory. The Maryland service, including Delaware, is in coöperation with the Johns Hopkins University; the North Carolina service is aided by coöperation of the experimental stations; the South Carolina service was supported by the State board of agriculture, but this support has been withdrawn and it is now aided only by the national service. In Georgia the service is in coöperation with the Atlanta "Constitution." In Alabama some assistance has been received from the experiment station, but the service relies largely upon such support as can be extended by the National Bureau. In Louisiana and Texas the commercial exchanges coöperate. The Arkansas weather service is in coöperation with the "Arkansas bureau of mines, manufactures, and agriculture." The Tennessee service formerly coöperated with the State board of health, but recently the local forecast official of the Weather Bureau at Nashville was made its director, and the service now coöperates with the State officials representing agricultural interests. In Nebraska the service has received much assistance through Prof. G. D. Swezey, of Doane College, Crete. The Kansas service coöperates with the State board of agriculture. In Florida a service is in process of organization, with the Weather Bureau observer at Jacksonville in charge. The Territorial service of Arizona is assisted by the experiment station. Local services in the following-named States and Territories receive no assistance other than that extended by the National Weather Bureau, viz: Colorado, Illinois, Indiana, Kentucky, Minnesota, Mississippi, Montana, New Mexico, North Dakota, Oklahoma, Utah, Washington, West Virginia, Wisconsin, and Wyoming.

The National Bureau has extended substantial aid to all the services, furnishing supplies for the crop bulletins, blank forms for meteorological records, and issuing meteorological instruments where needed, as far as possible.

The Weather Crop Bulletin, issued by this Bureau weekly, has been greatly appreciated during the current season by those interested in agriculture, as it presents truthful statements of the condition of the

staple crops at short intervals, and these statements, having been distributed throughout the country, have enabled the producer to become familiar with the exact crop prospects and, therefore, to form a correct estimate of the probable value of the product in which he is interested. The last bulletin for the season of 1891 was that for the week ended October 2. The work pertaining to this branch of the service is performed in a division known as the State Weather Service Division, which has charge of the preparation of the weekly and monthly crop bulletins and a supervision of the work of coöperating State services, reports from which form the basis of the crop bulletins.

This division also has charge of the establishment of stations for the display of weather signals and the distribution of frost warnings. Immediately upon the organization of this division correspondence was entered into with the weather observers in several States where State weather services were not organized, and this correspondence has resulted in the establishment of new State and Territorial services, so that at present almost every State and Territory in the Union is provided with a locol coöperative weather service, which forms a channel through which the benefits of the work of the National Service may be conveyed more extensively and more promptly to the people.

Since the 1st of July new weather services have been organized in Arizona, California, Florida, Georgia, Maryland and Delaware, Montana, New Mexico, North Dakota, Oklahoma, Utah, Virginia, Washington, West Virginia, and Wyoming, making the number of State services in operation on December 1, 1891, forty-one.

While the organization of new State services has been in progress much attention has been devoted to a general supervision of the work of those coöperating services previously established, the desire being to greatly increase the number of voluntary meteorological observers and crop correspondents and to effect a more thorough dissemination of current weather crop information among those classes of people most likely to be benefited thereby. More than one hundred and seventy-five voluntary meterological stations have been established and equipped with instruments at the expense of this Bureau since July 1, and nearly one hundred have been established by this Bureau but were furnished with instruments at private expense.

The reports from voluntary observers serve a twofold purpose for agricultural societies and experiment stations, giving them accurate meteorological data on which to rely in dealing with experiments on vegetation, etc., and the reports of rainfall, temperature, sunshine, etc., are utilized weekly in the weather crop bulletins as standard meteorological features for the State or Territory, while the compiled monthly conditions are utilized in various ways in establishing the climatology of the State and as a record for physicians in the study of the relations between climate and disease.

The most practical and most highly complimented portion of the exclusive work of the State services is the issue of the weekly weather crop bulletins. These are sources of reliable information for all interested in agriculture, following up the season from week to week, so that an excellent estimate can be made at any time relative to the crops of any county, State, or the country at large. These bulletins have a thorough dissemination in all the States and Territories in which State services are in operation, and are highly spoken of by the press and public. The national bulletin, published weekly by this office during the growing-season, deals with the weather of the week throughout the country,

consisting of charts showing the departures of temperature and rainfall, the table of seasonal and weekly departures of like data, besides giving a discussion of such charts and tables, with edited telegrams received from the several State services showing the actual condition of crops and the effect of the week's weather thereon.

As a practical illustration of the utility of these bulletins may be given a statement from a correspondent, Mr. F. L. Dunbar, of the New Jersey service at Union, which is as follows:

My brother farmers come to this station within an hour after the reception of the weekly crop bulletin, to hear it read. This prompt intelligence can be obtained in no other way. The condition of the crops of the whole State is known within a circle of a mile of this station in a few minutes after the bulletin arrives, and before the close of the day in a large part of our township. To obtain just this kind of information far in advance of the farmer the sharp speculator pays a high price, and too often heretofore the farmer has accepted a price for certain products far below their actual value. It is well known that the farmer gets little enough for his produce, while the consumer is made to pay a high price. I might enlarge on the usefulness of this bulletin. The point in the following "parable" is apparent to you. We do not raise grapes here extensively. One of my neighbors has an acre promising well. A dealer saw the advantage of securing this crop rather than depend on shipments from elsewhere. Yesterday he offered the farmer what might usually seem a fair price. The farmer brought him to this station and I read to him the report from south Jersey: "Concords, seven-eighths gone; Clintons, half." The result was the speculator advanced his offer $30, and the bargain closed. The farmer told me afterward that he considered the bulletin worth just $30 to him in this instance alone. Comment: the dealer was posted; so was the farmer.

To the immigration boards and societies in the various States these services will continue to be of great importance, and will contribute much toward the development of the Western portions of the country, and could be utilized in the Southern States in showing the true conditions of climate, and thus invite immigration.

The information supplied by these services is not only of interest to emigrants studying the adaptability of the various portions of the country to certain crops, but is equally important to the medical profession and to invalids in search of reliable and unbiased information as to the climate, etc. To the State health departments of Michigan, Pennsylvania, and Tennessee these services have afforded excellent facilities for the study of climate in connection with health, etc.

The benefits resulting from State weather services have been summarized, as follows, by the late Prof. George H. Cook, PH. D., LL. D., formerly director of the New Jersey service.

They will be the means of securing better predictions of weather changes and storms; they will bring the benefits of the national service into every county participating in the local organization; they will prepare for a system of storm signals that will be widely beneficial to agricultural interests; they will give to every county the Government standards for temperature and rainfall, wind velocity, humidity, etc., which are sources of useful public information; they will put within reach of local agricultural societies means of accurate observations which, in the course of years, must be valuable to any locality in the study and adaptation of cereals; they will bring the science and methods of the National Weather Bureau within reach of the high schools of the States, offering teachers and pupils alike excellent opportunity to study a wide range of the application of science to foster and protect agricultural industry; they will lead to the collection of rainfall statistics to enable engineers to better estimate the supply of canals, also the sudden downpours to guard against in the laying out of sewers in cities; they will lead to a correct knowledge of rainfall over the various watersheds, for the purpose of giving data for supplying the waterworks of towns and villages; they will lead to the forming of reliable meteorological records for use in legal cases; they will lead to a better practice of medicine when the physicians throughout the State can study diseases with reliable and accurate meteorological facts by their side—and for sanitary purposes correct meteorological statistics are invaluable to the practitioner in applying preventive remedies.

Names of States, central stations, directors, and assistant directors under charge of the State Weather Service division of the Weather Bureau.

[Persons marked thus * are employés of the Weather Bureau.]

State and central station.	Director.	Assistant director.
Alabama, Auburn	Prof. P. H. Mell*	
Arizona, Tucson	J. C. Hayden*	
Arkansas, Little Rock	M. F. Locke	F. H. Clarke.*
California, Sacramento	James A. Barwick*	
Colorado, Denver	W. S. Miller*	
Florida, Jacksonville	E. R. Demain*	
Georgia, Atlanta	Park Morrill*	
Illinois, Springfield	John Craig*	
Indiana, Indianapolis	Prof. H. A. Huston *a*	C. F. R. Wappenhans.*
Iowa, Des Moines	J. R. Sage	George M. Chappel, M.D.*
Kansas, Topeka	Prof. J. T. Lovewell	T. B. Jennings.*
Kentucky, Louisville	Frank Burke*	
Louisiana, New Orleans	Geo. E. Hunt*	
Maryland, Baltimore	Dr. Wm. B. Clark	C. P. Cronk, M. D.*
New England Meteorological Society, Cambridge, Mass.	Prof. W. M. Davis	J. Warren Smith.*
Michigan, Detroit	N. B. Conger*	
Minnesota, Minneapolis	J. H. Harmon*	
Mississippi, University	Prof. R. B. Fulton*	
Missouri, Columbia	Mr. Levi Chubbuck	J. H. Smith.*
Montana, Helena	E. J. Glass*	
Nebraska, Crete	Prof. G. D. Swezey	G. A. Loveland.*
Nevada, Carson City	C. W. Friend	Ford A. Carpenter.*
New Jersey, New Brunswick	E. W. McGann*	
New Mexico, Santa Fé	H. B. Hersey*	
New York, Ithaca	Prof. E. A. Fuertes	R. M. Hardings.*
North Carolina, Raleigh	Dr. H. B. Battle	C. F. von Herrmann.*
Ohio, Columbus	Prof. B. F. Thomas	C. M. Strong.*
North Dakota, Bismarck	W. H. Fallon*	
Oklahoma Territory, Oklahoma City	Louis Dorman*	
Oregon, Portland	H. E. Hayes *b*	B. S. Pague.*
Pennsylvania, Philadelphia	W. P. Tatham	L. M. Dey.*
South Carolina, Columbia	A. P. Butler*	
South Dakota, Huron	S. W. Gleim*	
Tennessee, Nashville	J. B. Marbury*	
Texas, Galveston	D. D. Bryan	I. M. Cline, M. D.*
Utah, Salt Lake City	G. N. Salisbury*	
Virginia, Lynchburg	Dr. E. A. Craighill	J. N. Ryker.*
Wisconsin, Milwaukee	Willis L. Moore*	
Washington, Olympia	E. B. Olney*	
West Virginia, Parkersburg	W. W. Dent*	
Wyoming, Cheyenne	E. M. Ravenscraft	

a Address, La Fayette, Ind. *b* Address, Oswego, Oregon.

PACIFIC COAST DIVISION.

Work of this division of the national service is constantly growing in importance, with increasing efficiency. By reason of the great distance from the central office at Washington, the Pacific coast has required the formation of a semi-independent service in the collection and distribution of telegraphic weather reports for the benefit of commerce and agriculture.

The area embraced by this division includes the Pacific coast States, California, Oregon, and Washington, and the western portion of the plateau regions, Arizona, Nevada, Utah, Idaho, and western Montana. This great region is brought under the influence of weather changes moving eastward from the Pacific and southward from British Columbia in such a manner that the collection of adequate telegraphic information at San Francisco has enabled the forecast official in charge there to study reports and disseminate timely warnings of atmospheric occurrences which have been received at telegraphic centers in California, Arizona, Nevada, Utah, Idaho, Oregon, and Washington under circumstances that gave results of practical value to the people.

This work, although well organized, is yet in its infancy and can be greatly enlarged with better telegraphic facilities. The extension of commercial lines of communication is progressing rapidly under the competition of rival companies. The effect of this competition has already been of service and will continue to be beneficial to the development of the work of the Weather Bureau.

The regular 8 a. m. and 8 p. m. (seventy-fifth meridian time) telegraphic reports are received at San Francisco from two Weather Bureau stations in Arizona, eight in California, two in Nevada, one in Utah, four in Oregon, six in Washington, and one in Montana. The Weather Bureau also pays for one report daily (7 a. m., Pacific time) from three railroad stations in southeastern Nevada, three in southeastern California, and four in northern Arizona. These stations cover fairly well a peculiar region of country, of little or no agricultural value at present, but from which reports are necessary in order to furnish satisfactory rain warnings to the great fruit regions of southwestern California. The establishment of these stations has already shown the value of such reports in forecasting the early rains of autumn and the occasionally heavy showers of July and August, in the mountain regions of southeastern California, southern Nevada, and northwestern Arizona.

The information from regular stations is supplemented by additional telegraphic reports, once daily (7 a. m., Pacific time), furnishing rainfall, temperature, state of weather, and direction of the wind from certain stations of the Southern Pacific Railway system, the Pacific Postal Telegraph and Cable Company, and the Western Union Telegraph Company, distributed about as follows:

The Southern Pacific Company, 90 stations in California, 23 stations in Nevada, 7 stations in Utah, 11 stations in Arizona, and 3 stations in New Mexico; the Pacific Postal, 5 stations in Oregon, 26 stations in California; the Western Union, 24 stations in California.

The voluntary railroad and telegraphic stations can not be depended upon for the same accuracy and regularity required from Government observers, yet because of the large list of active stations from these two sources information of indispensable value is always secured for daily use in connection with the more complete reports from the Weather Bureau stations. The most important data from the voluntary stations are the records of precipitation, which are in form for immediate use to serve commercial and agricultural interests in and about the large cities of California.

Oregon and Washington remain to be developed in this line of work. There are a number of railroad and telegraph stations favorably located, and the companies controlling them will doubtless coöperate with the National Weather Service, in the collection of reports which can be bulletined to advantage in the principal cities of these two great and thriving States. In this connection it is important to note that the value of precipitation data is greatly enhanced where it can be made available for daily use through the aid of the telegraph.

The natural division of the year into two seasons, the "wet" and the "dry," and their effect upon the commercial and agricultural interests of the Pacific coast, requires careful consideration by the forecast official. The "wet season" embraces the months of October to April, inclusive, and the "dry season" the remainder of the year. The seasonal year begins with July, and all averages and comparisons are made accordingly. Special attention has been given to this subject by preparing and distributing such information concerning the characteristics of each season as would prove of the greatest value to the peo-

ple. In the "dry season" the elements of temperature, wind direction, and humidity demand almost undivided attention. It is during this season that "hot northers" and "cold westers" occasionally occur in California, Nevada, and Arizona, and warm waves in Oregon and Washington.

Commercial interests in the large cities of the coast have taken advantage of timely warnings of the approach of these atmospheric changes in the purchase and sale of large quantities of produce, especially perishable fruits. During the prevalence of a "hot norther" the consumption of certain kinds of fruit is more than quadrupled in the cities of California, and the effect in the country is to greatly hasten the ripening of some fruits and retard the development of others. Knowledge of the approach and probable time of continuance of these hot winds is, therefore, of great value to horticultural interests.

The producers, commission merchants, and canning establishments of California are all deeply interested in the atmospheric changes of the "dry season," and appreciate the valuable assistance that has and can be rendered by the detailed reports and forecasts of the Weather Bureau. During the prevalence of "hot northers" many people from the interior towns of California seek the coast cities for comfort and recreation, their movements being guided more or less by the forecasts of the Weather Service. Under similar conditions people from the coast visit the interior valleys during the occurrence of warm periods, because of the advantages of a drier atmosphere and clearer sky. These facts forcibly illustrate the practical importance of weather science and the many-sided advantages of California climate.

In Arizona and Nevada weather forecasts during the dry season are not considered necessary in the present stage of agriculture and horticulture, although they will be required in the western portion of both States in the near future. In Oregon and Washington the forecasts are valued throughout the year, but especially so during the winter season. In the summer the benefits are mostly confined to commercial interests as yet, but with a greater development of the Service agricultural interests can be reached.

The character of the "wet season" measures very largely the prosperity of the entire Pacific coast and of the western portion of the Plateau regions. Normal precipitation with a uniform distribution throughout the season invigorates all classes of business and promises bountiful crops for the "dry season." During the "wet season" the attention of the forecast official has been directed almost exclusively to the study, collection, and distribution of rainfall data for the benefit of the public. The interest is such as to demand the most complete record and careful comparison of daily, monthly, and seasonal values from numerous well-selected points throughout the Pacific region. Telegraph reports obtained from all available sources have been used for the daily forecasts and otherwise placed before the people through the medium of the daily weather map and special bulletins to the press. The forecasts furnished the two press agencies in San Francisco have been telegraphed by them to over seventy daily papers published in Arizona, California, Nevada, Utah, Oregon, and Washington, thus reaching thousands of readers with practically no expense to the Government for distribution. Stronger evidence is not needed of the value of this information for the daily needs of the people.

In addition to this extensive circulation of daily forecasts at private expense, the Weather Bureau furnishes special telegrams to over one hundred well-selected points in California, Nevada, Utah, Oregon, and

Washington, where weather and temperature signals are displayed, and in some instances steam-whistles sounded to announce the probable atmospheric changes. It can readily be seen that these means of communication bring the daily work of the Weather Bureau before thousands of people, who use the information for business, pleasure, and study.

The daily weather map published at San Francisco has reached a circulation of over two hundred copies and is constantly increasing. The great interest in this publication is shown by the fact that it is distributed in Arizona, California, Nevada, Oregon, and Washington, where in many cases it arrives too late for the immediate use of forecasts, and therefore must be employed for study only. Its use is indispensable for the purpose of educating the masses of the people in a knowledge of popular meteorology and daily weather changes. Its influence has been widespread and beneficial on the Pacific coast, and it will continue to be a permanent source of the most useful information to agricultural and commercial interests.

The issue of the daily map is now confined to the morning reports, but arrangements are in course of preparation for the publication of an evening édition, which will permit of a wider and more satisfactory distribution of this valuable information.

During the "wet season," especially at its opening and near its close, forecasts of weather are of extreme value to agricultural and horticultural interests in California, Arizona, Nevada, Utah, Oregon, and Washington. Rain warnings in California for the raisin-making districts have been estimated at the value of nearly one million of dollars in a single season in the saving of crops. The effect of a heavy shower on a crop of drying raisins diminishes their value one-third by destroying the "bloom" or by making the fruit "gritty." A successful rain warning permits the trays of drying grapes to be covered with canvas, thus protecting the fruit from damage. Immediately after the rain the canvas covers are removed and the natural sun-drying proceeds. Sun-drying is decidedly preferable to drying by artificial heat, the former process securing a higher grade of fruit, while being a much less expensive system of curing, notwithstanding the expense of covering in the case of rain, which in a single instance has amounted to several hundred dollars to the largest raisin grower.

The maintenance of the Pacific coast weather service as now organized is more than justified if for no other reason than that of affording protection to the raisin-growing interests of California. In view of the superiority of the sun-drying process, the necessity and great value of daily weather forecasts to the raisin industry of California becomes at once apparent. The raisin industry embraces portions of fourteen of the largest counties in the State, and grapes are extensively cultivated in fifty-three counties. The capital invested in the vineyards of the State, according to the last census, is about ninety millions of dollars, and employment is given to over one hundred thousand people.

Forecasts of "fair but cloudy or foggy weather" have proved of practical value to the raisin districts by preventing unnecessary expense in covering the drying grapes, which, as has been shown, is a large item in the preparation of the crop for market.

As to the importance of rain warnings, Mr. A. P. Butler, of Fresno, the largest grower in the State, wrote the Daily Examiner, San Francisco, that, owing to the accuracy of the forecasts of the Weather Bureau, "not a pound of raisins has been lost in his vineyard during the season."

The Occidental Medical Times publishes the following statement:

The efficiency of the Weather Bureau on this coast has been greatly augmented, not only by the increased facilities for receiving data from a larger area of country, but also in the daily issuance and distribution of maps with the weather forecasts. Formerly reports were received only from stations of the Pacific coast and the country adjacent, but the field of observation has now been so broadened as to include much of the territory east of the Sierra Nevadas; consequently thermal waves which affect our climate secondarily can be better observed and their modifying influences predicted. This has rendered possible the announcement of approaching storms, both more accurately and for a longer period in advance than was possible before this system was adopted. Care has also been taken to properly diffuse the knowledge thus gained.

Commercial and shipping interests have been benefited at San Francisco by timely warnings of high winds, which have been published in general and special forecasts through the Merchants' Exchange and by the Board of Harbor Commissioners. Increasing the efficiency of the Point Reyes Station and the Government telegraph line connecting it with San Francisco has proved of very great value to maritime interests at the metropolis of the Pacific coast. During the past year the value of the vessels and their cargoes that have been saved from wreckage through the instrumentality of the Point Reyes Station would more than defray the expense of maintaining it, together with its telegraphic connections, for the next twenty years. The weather reports, received four times daily by telegraph at San Francisco from Point Reyes, are bulletined at the Merchants' Exchange and published in the leading shipping gazette of the city. These reports are closely watched by maritime people, especially those who are interested in traffic along the north Pacific coast. The display of storm signals on the northwest coast of California, the northwest coast of Oregon, and along the Washington coast during the "wet season" are acknowledged to be of much assistance to shipping. The trade in lumber, grain, and coal in western Washington and western Oregon requires large fleets of vessels in constant service throughout the year. They ply their vocation upon the waters of the Columbia and Puget Sound, and before departing for the ocean make close inquiries as to approaching changes of the weather off the Washington coast, which region lies directly in the path of storm movements from the Pacific.

The Morning Leader, Port Townsend, Wash., November 14, 1891, has the following:

The accuracy of the predictions of Lieut. Finley has made the Pacific coast branch of the national weather service of inestimable value to mariners, and of general interest to all people on the coast. When the office was first established the old sea captains would frequently laugh at the idea of predicting the condition of the weather in advance, but the accuracy with which Lieut. Finley has foretold of approaching storms time and again has taught the thoughtful mariner that it was no laughing matter, and now they invariably consult his reports before venturing out to sea. The absolute correctness of his predictions has been especially noticed by captains of sea tugs, who have to make frequent trips to the Cape, where the storms are usually the worst.

Communications received from the great lumber companies on Puget Sound acknowledge the benefits derived from the furnishing of storm warnings and general weather forecasts. Hundreds of loaded vessels have anxiously awaited the order "down signals" before going to sea, and their masters have admitted and appreciated the value of the warning. An important service has been rendered maritime interests at San Francisco by reporting by telegraph from Tatoosh Island, Clal-

lam Bay, and Port Angeles the arrival, departure, and passing of vessels, and also the state of the weather at these stations.

The recent organization of State weather services in Arizona, California, and Washington, coupled with those formerly established in Oregon and Nevada, has united all interested persons in systematic and useful coöperation with the National Weather Service. It has greatly encouraged voluntary meteorological observers, increased their numbers, and enlisted the sympathy and support of agricultural, commercial and educational societies and institutions. It has provided for the collection, publication, and dissemination of daily, weekly, and monthly weather and climatic reports, the value of which has been repeatedly admitted by the press and by the people.

The entire Pacific coast, with the western portion of the Plateau region, has responded with great heartiness to the development of the work of the Weather Bureau, and the press has afforded invaluable assistance in disseminating information and in instructing the public as to the advantages of coöperation with the National Weather Service. In no other part of the country have the railroads and telegraph companies given so much assistance in the collection and dissemination of weather reports.

No portion of the United States is more earnest in its appreciation or more active in its support of the highest development of the practical work of the National Weather Service. There is no better opportunity for high grade weather work. The rapid development of the Pacific Slope and the Plateau regions demands it. Questions of great moment to agricultural and commercial interests are beginning to arise, which will require the most careful investigation.

THE STUDY OF METEOROLOGY IN THE UNITED STATES.

In 1883 Dr. Frank Waldo, then in the employ of the U. S. Signal Service, presented a report on the extent to which meteorology was taught in the higher schools of Germany, Switzerland, and Austria, in which he refers to the growing need of trained meteorologists in this country, and says:

> We have a few men only who have made this subject enough of a study to be able to give instruction to young men. We have not more than two or three schools where there is any pretense of teaching meteorology, and even then the instruction is of a very elementary nature.

Of late, increased interest has been manifested in regard to meteorological education in the United States, chiefly, it is to be presumed, on account of the extension of the weather service of this country and of its practical applications. Young men of trained ability are in demand for the work of this service, and the increased distribution of weather maps and forecasts has drawn much attention to the subject. To enable the public to fully profit by the information thus conveyed, there is needed just such a widespread awakening in the matter as is now apparent.

I have repeatedly been asked within a short time past, both here and by letter from abroad, what is being done in our higher institutions of learning in the way of instruction in meteorology. To answer these numerous inquiries and to obtain definite information, which I am sure will be of general interest, I have, through the courtesy of the Commissioner of Education, caused a systematic examination to be made of

the college catalogues on file in his office, and the results are presented herewith. It should be borne in mind that the courses announced are in general of a somewhat elementary character. Original research and the work carried on by the trained meteorologist are usually freed from the restrictions of a class. In one case, however, which has come to my notice, admirable work of an advanced character is being carried on in class.

Following is a list of the universities and colleges announcing definite courses in meteorology. Such further information found in the announcements is given as is consistent with brevity:

California.—University of California, Oakland; John Le Conte, professor of physics. The physics of meteorology, lectures on the distribution of heat over the earth's surface, permanency of climate, distribution of rain, winds, etc., and on optical phenomena of the atmosphere. Twice a week during the second semester.

Colorado.—State Agricultural College, Fort Collins; Louis G. Carpenter, professor of physics and engineering. Meteorology is taken up for six weeks during the second term of the senior year, and includes a discussion of the instruments used in taking observations, barometry, thermometry, precipitation, the laws of storms, and the elements of agricultural meteorology.

Connecticut.—Yale University, New Haven, Conn. (Catalogue 1889-'90). A course in meteorology is given the seniors twice a week during the second semester. Loomis' Meteorology is used, with daily study of the current weather maps. In the Sheffield Scientific School of this university, in the course in agriculture, two hours per week (lectures) of the first half of the senior year are devoted to meteorology.

Florida.—Florida Agricultural College, Lake City. In the senior year, spring term, meteorology divides the time with logic, tactics, and astronomy.

Indiana.—Purdue University. In the second term of senior year of School of Agriculture meteorology is taught two hours a week for eight weeks.

Iowa.—Iowa State Agricultural College. Meteorology is given once a week in the second half of the senior year.

Kansas.—(1) Kansas State Agricultural College, Lake City. Physics and meteorology, two terms' work; text-books, Atkinson's Ganot's Physics and Loomis' Meteorology. This course also includes a careful study of instruments and methods employed in taking meteorological observations. (2) University of Kansas, Lawrence. Francis H. Snow, president and professor of botany, entomology, and meteorology. Meteorology: Loomis' Treatise and Lectures, one-half semester.

Massachusetts.—(1) Harvard University, Cambridge. William M. Davis, professor of physical geography. Meteorology: Lectures, recitations, written exercises, and laboratory work; three times a week during the first half year. A course of equal extent in physical geography follows during the second half-year. A second course in physical geography and meteorology consists of lectures and reports twice a week for a half-year. (2) Massachusetts Agricultural College, Amherst. Freshman year, fall term, climatology, or relations of weather and farming, two hours a week. (3) Massachusetts Institute of Technology, Boston. William H. Niles, professor of geology and geography. Climatology is taught by lectures and recitations twice a week for fifteen weeks of the senior year. The course is introduced with a general outline of meteorology, and in the physical laboratory the students have some practice with the ordinary meteorological instruments.

Michigan.—(1) Albion College, Albion. In the fall term a course of three hours a week in meteorology and the mechanics of the atmosphere is given in the department of physics. (2) Michigan State Agricultural College. R. C. Kedzie, professor of chemistry. A course in meteorology is given by lectures five times a week during the spring term of the senior year. (3) University of Michigan, Ann Arbor. A course in modern meteorology is given twice a week during the first semester; instruction is given by lectures, recitations, and practice in forecasting by means of weather maps.

Nebraska.—Doane College, Crete; G. D. Swezey, professor of natural sciences. Meteorology and mineralogy constitute a course given in the winter term (three months). In meteorology there is text-book work supplemented by observations with the instruments of the observatory, and by the tracing of weather changes from the United States weather maps.

New Hampshire.—New Hampshire College of Agriculture and the Mechanic Arts; Dartmouth College, Hanover. Second year, third term, Loomis' Meteorology.

New York.—Alfred University, Alfred Center; H. C. Coon, professor of physics. Gives a course of ten weeks in theoretical meteorology, and another of like extent in meteorology, theoretical and practical.

North Carolina.—Davidson College; H. L. Smith, professor of natural philosophy. Astronomy and meteorology are given three times a week in the senior year. After the 1st of March the class studies meteorology, and is taught to handle a full set of instruments for determining air pressure, temperature, moisture, rainfall, etc. Loomis is used as a text book.

North Dakota.—University of North Dakota, Grand Forks; Ludovic Estes, professor of mathematics, physics, and astronomy. Meteorology is taught one hour per week during the senior year of the scientific course. Loomis' Treatise, or an equivalent, is used.

Ohio.—Findlay College, Findlay; A. C. Redding, professor of chemistry and physics. In the fall term of the junior year meteorology is given in a course of lectures embracing atmosphere, winds, clouds, precipitation, theory of storms, atmospheric electricity, climatology, etc.

Oregon.—Oregon State Agricultural College. Meteorology is taught during the winter term of the junior year.

Pennsylvania.—(1) Pennsylvania State College. In the course in agriculture, meteorology (Abercromby's Weather) is given three times a week during the third term. (2) Washington and Jefferson College, Washington; James F. Ray, professor of physics and chemistry. Meteorology (Loomis) is taught during the third term of the senior year.

South Dakota.—University of South Dakota, Vermilion; Lewis E. Akely, professor of physics and chemistry. A course in meteorology is given two hours per week during winter term. Lectures and practical work.

Wisconsin.—University of Wisconsin, Madison; F. H. King, professor of agricultural physics. In the College of Agriculture a full course (five times per week) in meteorology is given during the fall term.

Wyoming.—University of Wyoming, Laramie. During the fall term of the College of Agriculture a course is given in meteorology and the use of instruments. The instruments are at the agricultural experiment station in connection with this college.

There are of course many institutions where more or less instruction in the elements of meteorology is given under some other name. In physics the topics of atmospheric pressure, vapor tension, condensation, and others, relate directly to this subject. It is not unusual for a chapter on meteorology to be added to a text-book of physics, and in a general course in physics of sufficient extent the subject may properly come in for its share of attention. In physical geography, also, no general course would be complete which did not include the subject of climatology and theoretical meteorology.

Besides the above named colleges, about twenty incidentally mention meteorology, usually as included in the general instruction in physics or in physical geography. Four have weather service stations in connection with them, and offer opportunities for practical meteorological work. Two or three other colleges announce their intention of soon including meteorology in their curricula.

It should be remembered that the Bureau is doing much in the way of popular education in meteorology by means of its maps and the work of individual employees, but allusion has been made to this elsewhere.

METEOROLOGICAL RECORDS.

The following brief sketch of the meteorological records of the United States, with particular reference to those filed in the Weather Bureau, is submitted for the information of the general public and students of meteorology.

Before entering in detail upon a description of the state of the records, it is deemed both appropriate and of interest in the present connection to present a brief résumé of the progress of statistical meteorology in the United States. Such a history must naturally differ but little, if any, from the history of statistical meteorology the world over. Here, as in older countries, much credit is due the private observer for his

untiring labor in recording facts which have contributed greatly towards the advancement of the science of meteorology. It is to private observers that we are indebted for such comparable records of the weather as were made during the early part of our country's history.

The distinction of being the first observer to make systematic record of the weather in the United States undoubtedly belongs to Dr. Lining, of Charleston, S. C., who, in 1738, eighteen years after the general distribution of the first comparable thermometer, began to maintain a record of temperature, to which precipitation was added in 1742. The Charleston observations, which were reported to the Royal Society of Great Britain, were followed by several other series in different parts of the country. The increase in the number of observers was, however, very slight. Up to the close of the eighteenth century there were but fifteen stations, so far as known, at which observations of temperature and precipitation had been made. From 1800 to 1817, which latter year may be said to mark the dividing line between systematic meteorology on the one hand and the unguided efforts of private observers without concert of action on the other hand, there was but little increase in the number of observers. Twenty-eight records have been transmitted to us; there may be still others in manuscript of which no public record has been made. Without any directing influence or medium of publication and exchange, it is not singular that so few records were made. Indeed, the wonder is that so many were kept.

The results of these observations as monthly mean values of temperature and total monthly precipitation are of record in the files of the Weather Bureau. Little is known of the originals.

What may be called the epoch of comparative or systematic meteorology in the United States begins with the efforts of Josiah Meigs, who as Commissioner of the General Land Office, issued a circular on April 29, 1817, requesting his subordinates (the several registers) to take regularly observations of temperature, wind, and weather. Meigs had previously failed to receive the sanction of Congress to a more elaborate plan of observation. He was without sufficient means to provide the more expensive apparatus; nevertheless he was still willing to do his utmost with the simple instruments at his command to secure comparative data for the study of atmospheric phenomena, and it is to be noted that with the data at his command he was able to recognize the area of several cold waves, although no clue as to their movement seems to have been discovered.

On his death, in 1822, the system which he established seems to have lapsed. No effort appears to have been made to compile the results of the observations made by the registers, nor is it known definitely what became of the original records of observation.

In treating of the meteorological observations made in the United States between the establishment of the Meigs system and the Signal Service, it will be convenient to divide them into two broad classes, viz, (1) those made by or under the directing influence of one or more branches of the public service, often as necessary adjuncts to the successful prosecution of work devolving upon them by law, and (2) those made by private individuals under the controlling influence of some central body or State organization.

Under the above heads, the observations made in connection with the work of certain branches of Government will be considered first. Foremost of these, both in point of time and in completeness, stands the series begun by Surgeon-General Lovell, in 1819. During the first few years of this series observations of temperature and wind direction were made

at 7 a. m., 2, and 9 p. m. In the year 1836 a rain-gauge was furnished to each post, and the daily fall of rain recorded in the register. No change was made in the hours of observations until January, 1841, when "sunrise" was substituted for 7 a. m. In 1842 the number of daily observations was increased to four, and the hours were "sunrise," 2 p. m., sunset, and 9 p. m. In 1843 the hours were changed to "a little before sunrise," 9 a. m., 3 p. m., and 9 p. m.

The results of the observations for 1820 and 1821 were published at the end of each year. Those of subsequent observations have been published in a series of army meteorological registers, of which the first volume, embracing the years from 1822 to 1825, inclusive, was issued by Surgeon-General Lovell in 1826. The second and third volumes of the series, comprising, respectively, the years from 1826 to 1830, and from 1831 to 1842, inclusive, were prepared and published, the former in 1840 and the latter in 1851.

With a desire to make the labors of the medical officers in the field of meteorology more useful in elucidating and defining the relations of atmospheric phenomena to the causation and development of disease, the Surgeon-General, in 1840 and 1841, applied to Congress for an appropriation to enable him to extend the system and make it more complete. With the funds appropriated for the purpose, he was enabled to equip a number of stations with barometers and hygrometers imported from Europe. The system thus extended went into effect January 1, 1843. It embraced four observations daily of the barometer, attached thermometer, thermometer (detached), clearness of the sky, direction and force of the wind, and the direction and velocity of the clouds. To these were added two daily observations of the wet-bulb thermometer and the measurement of rain and snow. Hourly observations of the barometer, thermometer, etc., were also directed to be taken for twenty-four hours at the equinoxes and solstices.

The results of the new series from 1843 to 1854, inclusive, except as regards observations of the barometer and hygrometer, were published in 1855. This volume contains the averages of temperature at each hour of observation and for the month, the monthly extremes of temperature, the number of times the wind was observed blowing from the N., NE., etc., and the sum of force from each direction, the average clearness of the sky, the number of fair days, the number of cloudy days, the number of days with rain, and the number of days with snow, and, finally, the amount of rain and melted snow. The system of wet-bulb observations was discontinued in 1849, having failed to give satisfactory results.

The hours of observation were again changed in 1855 to 7 a. m., 2, and 9 p. m., at which hours they were continued up to August, 1888. The last change was to one daily observation at 6 p. m.

The results for the period 1855 to 1859 were published in substantially the same manner as the period immediately preceding. Consolidated tables of mean temperature and total precipitation for each month and the four seasons, together with the annual extremes of temperature, were added to this volume (1855–'59).

From 1860 to 1874 the observations were turned over to the Smithsonian Institution and embodied in the reports of that institution, and later the entire series, both the original records and the office transcripts, extending from about 1860 (and in some cases earlier) to date, were turned over to the Weather Bureau.

Next in point of time to institute a series of meteorological observations was the Patent Office, which began to publish notes and memo-

randa of the weather some time in the decade 1840–'50. The Annual Report of the Commissioner for 1844 contains the following remarks:

> An attempt has again been made to estimate the influence of the season by collecting notices of the state of the weather from the earliest periods in which the various crops could be supposed to be much affected by the diversity of the same.

And again in the Report for 1847:

> It is not proposed to enter much into detail with respect to the weather. The space allotted to this portion of the report will not allow it. Still as the state of the crops is so immediately and mainly dependent on the aspect of the season, it would not be a fair exhibit of the influencing cause were we to leave this topic without notice. * * *

The foregoing remarks are given simply as indicating the trend of opinion at this period of our country's history. The Commissioner proceeds to further discuss the state of the season with respect to the condition of the crops, and follows with tables of number of days of rain, amount of rain in inches, mean temperature, all for April and May (grass season), and other statistics of like import.

Additional data were published each successive year; the volumes for 1855 and 1859, respectively, containing Joseph Henry's contributions, entitled "Meteorology in its Connection with Agriculture." Observations for the years 1854–'59, inclusive, were published as a Senate Executive Document, Thirty-sixth Congress, first session.

For the information of those unable to consult this volume, the following brief summary of its contents is given:

(1) The average height of the barometer reduced to 32°, but not to sea level.
(2) The maximum and minimum readings of the same instrument, with date of occurrence.
(3) The average temperature for the hours of 7 a. m., 2, and 9 p. m., and for the month.
(4) The highest and lowest temperature and date of occurrence.
(5) The warmest and coldest days as a whole.
(6) The average and maximum and minimum force of vapor.
(7) The relative humidity.
(8) The number of times the wind blew from each quarter.
(9) The amount of rain and snow.
(10) The average amount of cloudiness.
(11) Summaries for each year.

The results for each year are published separately. The annual reports of the Commissioner of Patents, and later the reports of the Commissioner of Agriculture, contain much climatic data extending from the beginning above noted to 1870.

While the Patent Office and the Smithsonian Institution were devoting a great deal of labor to meteorology as affecting land interests, the interests of the mariner were not neglected. The Twenty-ninth Congress appropriated, in 1847, the sum of $2,000 for the compensation of a meteorologist, and the next year $2,000 for "meteorological" observations to be conducted under the direction of the Secretary of the Navy. The services of Prof. James P. Espy were secured to discuss the observations and formulate his findings for the benefit of mariners. His several reports to the Secretary of the Navy contain the results of his investigations.

An important series of observations was begun under the direction of the Engineer Corps, U. S. Army, on the borders of the Great Lakes, in July, 1859, and continued with more or less interruption until 1876, there being but three stations in operation at that date. The greatest number of stations in existence at any time was fifteen. The results of these observations were in some cases published in the annual reports

of the operations of the Lake Survey. Transcripts from the originals are on file in the Weather Bureau.

The U. S. Coast and Geodetic Survey has also contributed to the general fund of information on meteorological topics. The results of the Survey's work will be found in Appendix No. 20, Report of 1875, "Meteorological Researches for the use of the Coast Pilot;" Appendix No. 10, Report of 1878, "Cyclones, tornadoes, and water-spouts;" and Appendix No. 10, Report of 1881, "Barometric hygrometry and the reduction of the barometer to sea-level," all by the late Prof. William Ferrel. Dr. William H. Dall, also of the U. S. Coast and Geodetic Survey, has collated and published in the Pacific Coast Pilot all meteorological observations of record for Alaska and the Bering Sea region, to which he has added a number of charts and a discussion of the observations. This collection embraces tables of atmospheric pressure, mean temperature of the air, sea temperatures, average precipitation, and prevailing direction of the winds, and other data.

The second general head embraces all observations made by private individuals, and forwarded at one time or another to the Smithsonian Institution, those made in direct coöperation with that institution, and those made by State systems which were later gradually merged in the general system of the Smithsonian Institution.

1891

The State of New York can properly lay claim to establishing the pioneer State weather service. In 1826 the university regents of New York directed that each of the academies under their jurisdiction should be furnished with a thermometer and a rain-gauge, and that the diligent report of observations should be an essential condition of their receipt of State funds. Further instructions from time to time directed observations of the wind and a variety of miscellaneous occurrences, considerable attention being directed upon phenological phenomena. The observations began in 1826, and were continued more or less completely until 1850. During this period sixty-two academies reported observations, of which three were complete for a whole term, and only three quite failed to record the precipitation. In 1849 the legislature made an appropriation for the purchase of improved instruments, in order to conform the State system of observations with the more comprehensive system recently instituted by the Smithsonian Institution. A small sum was appropriated for salary of observers. The instruments provided by this appropriation were a mountain barometer, thermometer, rain and snow gauge, wind-vane, and, to a few stations, wet and dry bulb thermometers. The system came into operation at the end of 1850, and thirty-five academies began the observations. From the first the humidity observations were a failure, owing to confusion of reduction tables and thermometric scales. In 1863 the legislature failed to make the small salary appropriation, and from that time the system rapidly declined, both from that cause and from the great weight of the Smithsonian observations covering the same ground. The reports of these observations were published in the annual reports of the regents from 1826 onward. In 1855 the observations from 1826 to 1850 were collated and published, and in 1872 appeared a similar collation of the second system of observations from 1850 to 1863.

Pennsylvania next became interested in the study of atmospheric phenomena. The legislature of that State, in 1837, appropriated $4,000 to equip one station in each county with a barometer, two thermometers, and a rain-gauge. As many as twenty-two stations reported under this system, but it lapsed as a distinct organization in less than

ten years. Some of its observers, however, continued their work under the auspices of the Smithsonian Institution.

The published results of these observations will be found in the transactions of the American Philosophical Society and the Franklin Institute.

Mr. Lorin Blodgett, of Philadelphia, whose knowledge of the climatology of the State amply fitted him for the work, has compiled a set of climatic maps, one for each month, showing average temperature and precipitation for the State.* The more important temperature and precipitation records (monthly values only) have been published in the report of the secretary of internal affairs for Pennsylvania, 1888.

In 1849 the State of Massachusetts inaugurated a system of meteorological observations, which, in a year or so, was merged with the more elaborate system of the Smithsonian Institution.

The Smithsonian Institution began its great work in the field of American meteorology in 1849 along several parallel lines of research, which appear topically as record of observations, publication of material aids to meteorological study, and forecast of approaching weather conditions. As a bureau of record the Institution, under the direction of Joseph Henry, gathered up from all sources past records of observations, assisted the few systems of observations then in existence, and instituted its own system throughout the country. Before this time the records, if published at all, appeared in most cases without corrections or reductions, and very rarely were they discussed. But the Smithsonian was in a better position than any other organization to give the rapidly accumulating data scientific treatment, and for that reason the data of other systems were at first sent to the Institution for examination, as was the case with the Patent Office series, and by natural growth the individuality of the several independent series was for greater convenience merged in the Smithsonian. Thus it came about that, in 1870, this great Institution controlled all the meteorological records of the country.

With the organization of the Signal Service, in November, 1870, the meteorological service of the country was provided for by the General Government. The efforts which the Smithsonian Institution had previously made in the establishment of meteorological stations were therefore discontinued, and soon after the Signal Service had entered fully upon its duties the active support of the Smithsonian Institution was withdrawn. The efforts of the Signal Service were largely taken up in the development of a system of weather predictions, and thus it happened that the climatological work, so ably prosecuted by its immediate forerunner, was in a great measure subordinated to weather forecasting. The number of voluntary coöperating observers decreased steadily, so that in 1887 the total number of observers was but 378. The number has increased very rapidly since that date, however, and aggregated on June 30, 1891, when the Weather Bureau was transferred to the Department of Agriculture, 2,028. The net gain during the five months just passed has been greater, it is believed, than at any other period in the history of the Bureau, being 191.

Having thus traced the development of meteorological observations in the United States, it now becomes of interest to know where and how far the results of said observations are available for the many purposes for which they can be used.

* These maps may be found in the Transactions of the Franklin Institute, Philadelphia, Pa.

THE USE OF OUR DATA.

The enormous accumulation of meteorological records now in the Weather Bureau affords an opportunity for climatal and other special studies and investigations, which should be utilized to the greatest degree possible. We have now the observations for the twenty years during which the meteorological work was in the charge of the Signal Service and also those for many years before, when in charge of the Smithsonian Institution. I propose to utilize these data by special studies by the proper officers of the Bureau. Several studies of this sort are now under way and others are being organized. But I believe that we should pursue no exclusive policy in the treatment of our records. They should be thrown open to all students of meteorology who are competent to use them, subject only to such restrictions as will preserve them from injury. I recommend that meteorologists be invited to make use of them in the Bureau. Space can be found for a limited number of such students and the necessary guidance and oversight given them.

A brief statement of the records embraced in the files of the Weather Bureau follows:

(1) The records of Weather-Bureau stations which have been in operation since November, 1870. Of such stations, 373 have been in operation at one time or another. Main dependence is of course placed upon these observations.

(2) The records of the Medical Department of the Army from 1860 to date, and the reports of voluntary coöperating observers from December, 1873, to date.

(3) As a special deposit, the records collected by the Smithsonian Institution from 1847 to 1873. This collection embraces original registers or monthly values of temperature and precipitation secured through the coöperation of the United States Lake Survey, under the Engineer Corps, U. S. Army; the U. S. Coast Survey, under the Treasury Department; the compilations of Dr. F. B. Hough from observations made under the direction of the regents of the University of the State of New York, the records made in Pennsylvania under the direction of the Franklin Institute, of Philadelphia, the transactions of various societies and periodical publications.

(4) Abstracts of monthly registers forwarded by directors of State weather services and meteorological societies.

(5) Abstracts of reports made by the Central and Southern Pacific railway agents.

(6) Records of observations at stations of the Canadian meteorological service, furnished through the courtesy of the director.

(7) Copies of many private series of observations, the originals remaining in the custody of the owners.

The condition of the records, with reference to the facility with which the data contained therein can be supplied to the public, will be considered below.

The different elements, as temperature, precipitation, etc., will be taken up separately. The word "compiled," as used throughout this report, has a certain restricted and definite meaning, to wit, that the data under consideration—as, for example, monthly averages of temperature—have been abstracted from the original reports, entered upon specially prepared forms, having, as a rule, the months of the year running horizontally across the top of the page and the years in a perpendicular line on the left-hand margin. The sums and means are generally, but not always, computed and entered at the bottom of the page.

It should also be remembered that when charts are mentioned the edition is limited, unless otherwise stated. Copies, however, can always be consulted at the office of the Chief of the Weather Bureau or at stations of the Bureau outside of Washington. The edition of the Monthly Weather Review is limited; but few copies can be secured, unless special arrangements are made beforehand.

An "Index of Meteorological Observations in the United States" has been prepared, and will shortly be sent to the principal stations.

This index will afford persons inquiring after climatological data an idea as to the number and character of records made in the several sections of the country.

TEMPERATURE.

More attention has been given to compiling temperature and precipitation data than to all of the other elements combined, since the temperature and rainfall of a place are the two climatic features which most forcibly impress themselves on the average man, and, moreover, it is with these two elements that the majority of investigations as regards the relations between weather and crop production must deal.

Daily values.—The daily extremes of temperature from self-registering thermometers for 145 Weather Bureau stations from June, 1872, or the establishment of the station when opened subsequent to the above-named date, to December, 1890, can be supplied with readiness. A set of charts has been prepared, showing for each decade of the year (three decades to a month) the highest and lowest temperature reached therein from the beginning of the record to June, 1891.

Daily readings at the several hours of observation.—These have not been compiled, but must be sought for in the original reports.

Temperature averages, daily.—Daily averages for a fifteen-year period ending with 1885 have been compiled for Weather Bureau stations only.

Temperature averages, five-day periods.—Steps have been taken to have compiled at stations of the Weather Bureau and at the central office normal temperatures for five-day periods after the international plan. It is hoped to have these data completed by July 1, 1892.

Temperature averages, ten-day periods.—Averages for ten-day periods at the hours of 8 a. m. and 8 p. m., seventy-fifth meridian time, have been compiled, and are used chiefly as adjuncts to the work of the forecast room. Charts have also been prepared.

Temperature averages, monthly.—Monthly averages of temperature for about 5,200 stations in the United States and 300 in the Dominion of Canada have been compiled in one or more volumes for each State or Territory. These data can be furnished quite readily, the only labor required being the simple copying, which, for a twenty-year record, will not take more than twenty-five minutes. The length of record varies from a single month to one hundred and twenty-five years. The average length of record will probably not exceed five years. For the information of those wishing to keep informed as to the temperature conditions which obtain in different portions of the country from month to month, it may be stated that the Monthly Weather Review contains, in addition to the charts named below, tabulated data of the average, the highest, and the lowest temperature for the month for about 2,000 stations. Charts of the monthly and annual mean temperature are published in the Monthly Weather Review. The annual report of the Chief of the Weather Bureau will also contain, it is expected, tables of monthly means and extremes of temperatures, and the annual range.

Monthly means of maximum and minimum temperature.—These data have been compiled for an eleven-year period, beginning with 1880, and can be furnished readily.

The difference between the mean maximum and mean minimum for any month gives what is known as the mean daily range. These data have been compiled for a period of twelve years for the principal Weather Bureau stations.

Extremes of temperature, monthly.—The monthly extremes for 373

stations of the Weather Bureau, including the stations not now in operation, have been compiled, and can be furnished readily.

Temperature variability.—The temperature variability, obtained by noting the changes in mean temperature which take place from one day to another without regard to the course of the temperature, whether rising or falling, has been compiled for a period of about ten years at the principal Weather Bureau stations, and can be readily furnished. These data are of value to physicians and others who desire to know the degree of equability of temperature experienced in various portions of the United States. In addition to the foregoing-named records of temperature, note should be made of the automatic records which have been accumulating from 23 stations since June, 1888; additional stations have been furnished self-recording thermographs since that date. The number now having such instruments is 73. The data of hourly temperature thus becoming available will soon be of sufficient value to warrant an examination, more in detail than has been possible heretofore, of the interesting features connected with the daily march of temperature. The results thus far accomplished under this head will be found in the publication entitled "Mean Temperatures and Their Corrections," by Alexander McAdie, A. M.

PRECIPITATION.

As in temperature, the compilations of precipitation data embrace the records of a large number of stations, including observations from the earliest times to the present day. The number of stations for which a record of precipitation has been compiled is about 5,500 in the United States and 350 in the Dominion of Canada.

Daily amounts.—The daily precipitation at 145 stations of the Weather Bureau, from the beginning of the records in 1870 to date, has been compiled on specially prepared sheets. The daily precipitation at about 300 special rainfall and voluntary stations for irregular periods has also been compiled.

Monthly totals and averages.—The monthly totals of precipitation for the whole number of stations for which records have been made (5,850) have been compiled and entered in specially prepared volumes, one or more volumes to each State or Territory. The monthly totals for any station or number of stations can be furnished with but little labor; not more than thirty minutes will be required to copy a twenty-year record.

The greatest and least monthly falls for Weather Bureau stations can also be supplied quite readily. Charts and tabulated data of monthly and annual precipitation for about 2,000 stations will be found in the current issues of the Monthly Weather Review.

Normal rainfall of the United States.—The normal rainfall of the United States, as shown by eighteen years' observations, will be found in a special publication, entitled "Charts showing the Monthly Normal Rainfall of the United States," etc. This publication contains the numerical values and charts for each month of the year.

Excessive precipitation.—The number of rainfalls of 10 inches and over per month, and the number of occurrences of 2.50 inches in twenty-four hours, or of 1 inch in an hour, from eye records beginning in 1870 and extending to date, can be supplied for Weather Bureau stations only. Automatic records of rainfall began in April, 1889, at 6 stations; the number of such stations now reporting is 34. The data of excessive rainfalls afforded by these instruments, and also given in a certain degree by the eye records of beginning and ending of precipitation which

have been maintained at all Weather Bureau stations from November, 1870, to date, are valuable, especially to engineers charged with the construction of sewers, reservoirs for irrigating purposes, etc. Data of excessive precipitation have been applied to a number of engineering problems during the past few months. Applications from municipal authorities for information as to kind and cost of automatic gauges show that the importance of the subject is being realized by cities entering upon the construction of extensive water works.

Rainy days, number of.—The number of days on which 0.01 inch or more of precipitation has occurred during each month of the year from the establishment of the stations to date has been compiled, and can be supplied for Weather Bureau stations quite readily. The mean annual deviation or variability of precipitation as expressed by the percentage which the annual excess or deficiency bears to the normal has not been deduced, neither has the diurnal periodicity been calculated, except for a few stations. Charts showing the probability of rain for each month of the year have been prepared.

SNOW.

The records of snowfall are not as complete as might be wished. The total depth in inches for each month of the season is given at the majority of Weather Bureau stations for 1884–'85 and at all stations thereafter. Charts of depth of snow on the ground at the end of the month have appeared in the Monthly Weather Review regularly since November, 1888. Data of monthly snowfall have not been collated so as to be readily supplied to inquirers, although the number of requests for such data have increased of late years. The manufacturers of rubber goods, especially foot wear, are much interested in snowfall statistics, inasmuch as it appears that the demand for rubber overshoes, boots, and the like is regulated by the quantity and prevalence of snowfall.

ATMOSPHERIC PRESSURE.

Observations of atmospheric pressure have been made at about 900 stations in the United States. Of this large number but comparatively few stations outside of those maintained by the Weather Bureau have given records which can be utilized in a comparative study of storm movement. Owing to the fact that the greater portion of the observations were purely voluntary, and that frequently no accurate determination of the elevation of the stations could be had, there has been little uniformity in the matter of reductions. Some observations have not been reduced to 32° F., and in the great majority of cases no corrections to reduce to sea level have been applied. The record of pressure observations at stations of the Weather Bureau prior to 1873 is not satisfactory, owing to a number of causes.

Hourly readings.—Hourly eye readings have been made for very short periods at the mountain stations of Mount Washington, N. H., Mount Mitchell, N. C., and Pike's Peak, Colo. These have been printed in the annual reports and special publications of the Signal Service. Hourly readings were also made at a number of Weather Bureau stations, during the day hours only, for three months in 1888, and also for a year (twenty-four hourly readings) at Washington, D. C. Automatic hourly records are now being made at fifty stations of the Weather Bureau. Such records were begun at five stations in October, 1888. The observations formerly made by the Signal Service include readings

of the barometer seven times daily. The data have not, however, been compiled.

Highest and lowest barometer during the month.—The highest and lowest barometer for each month of the year for a period of nine years (1880–'88), reduced to 32° F. and to sea level, have been compiled and entered in specially prepared books. Charts of normal monthly pressure (reduced) at 8 a. m. and 8 p. m., seventy-fifth meridian time, have been prepared for use of the officials of the Weather Bureau. They can be consulted, when reproduced, at the office of the Chief of the Weather Bureau in Washington and at Weather Bureau stations.

Average monthly pressure (at 7 a. m., 3, and 10 p. m.), Washington mean time.—The average monthly values reduced to 32°, but not to sea level, for the hours at which observations were telegraphed to Washington from 1873 to 1887 have been compiled and can be supplied readily. Monthly averages for each month of the period 1873–'87 have not been calculated. Steps have been taken to secure a continuous record of the average monthly pressure at each station of the Weather Bureau from the opening thereof to January, 1890; all pressures to be reduced to the datum point in use on that date. The numerical values of monthly and annual pressure (actual and reduced) are published in the Monthly Weather Review, a chart of reduced pressure appearing in each issue. For the daily pressure one must look to the daily weather map. The phenomenon of diurnal variation of pressure has been investigated to some extent with the data available. Curves of daily fluctuations have been drawn for a number of stations, but it has not yet been found advisable to reproduce them. The results of the work thus far accomplished will be found in the publication "Diurnal Fluctuations of Atmospheric Pressure at twenty-nine selected stations in the United States."

WIND.

The files of the Weather Bureau contain observations of the wind at over 2,000 stations. As in other elements, a lack of uniformity in the hours of observations at very many of the voluntary stations is noticeable. Generally tri-daily observations at 7 a. m., 2, and 9 p. m. were made. The Medical Department of the Army noted the direction of the wind three and for quite a period six times daily. The results of these observations from 1821 to 1860 are available in the published reports of the Department, as before noted; the original records from 1860 to date are in the possession of the Weather Bureau, but no compilation of the data has been made.

The results of the voluntary system of observations up to and including 1869 are included in Prof. Coffin's compilation, "Winds of the Globe."

The following compilations of wind data (direction) for Weather Bureau stations have been made, and are in convenient form to be readily supplied to the public.

Number of times observed blowing from the N., NE., etc., as noted at the tri-daily telegraphic series of observations for each month of the year from 1871 to 1888, and the prevailing direction as deduced from the data so recorded. The direction of the wind as given by automatic records has been compiled for a few stations having automatic recording instruments. The results, however, are not available for distribution. Automatic records of the direction of the wind are now being received from 53 stations.

The Monthly Weather Review contains charts and tabulated data

showing the prevailing direction of the wind for each month of the year.

A special series of charts have been prepared for use of the officials of the Weather Bureau, showing the prevailing direction of the wind at the morning and evening hours of observation at the principal points of observation east of the Rocky Mountains. These charts may be consulted at the central office in Washington and at stations of the Weather Bureau.

WIND VELOCITY.

The continuous records of wind velocity in the files of the Weather Bureau are without parallel as regards number of records or continuity. The records at the older stations began in 1872 and are continuous to date.

Average hourly velocity.—Average hourly velocities for about 65 representative stations have been calculated for each month of the year, and published as Appendix No. 14 to the Annual Report of the Chief Signal Officer for 1890. These data can be supplied to the public quite readily.

Total monthly wind travel.—The monthly wind travel, 1871 to 1888, for all Weather Bureau stations has been compiled in specially prepared volumes for ready reference.

Maximum velocity of wind for each month.—The maximum velocity of the wind during each month of the period 1871–'88 has also been compiled as above. Special charts showing the average *hourly* velocity of the wind for the hours ending at 8 a. m. and 8 p. m., seventy-fifth meridian time, respectively, and the average highest and lowest hourly velocity during the day for each month of the year, have been prepared for use of officials of the Bureau.

HUMIDITY.

Observations of the wet and dry thermometers have been made at about 750 stations in the United States. It is doubtful, however, if the majority of such observations will afford at best more than a close approximation to actual conditions. The New York Academy system, after thirty-five years' experience, accomplished but little. The Medical Department, after twelve years' observations, replaced the instruments in use during that period with others which it was expected would yield better results. The examination of hygrometric observations made under the voluntary system, so far as it has gone, shows the results to be unsatisfactory, as a rule.

This is regretted, inasmuch as several very important inquiries have within the past year or so been set on foot respecting the relative dryness of several portions of the country.

The hygrometric observations of the Weather Bureau were for a long period made in window (unventilated) shelters. The present form of shelter, adopted in 1885, together with the apparatus for whirling the thermometers, yields quite accurate results.

The values of relative humidity deduced from the present series of observations (8 a. m. and 8 p. m.) are not strictly comparable with the results derived from tri-daily observations, one of which was taken during the heated portion of the day.

Monthly averages.—Monthly averages of relative humidity for each month and all years from 1871 to 1888 have been compiled and can be supplied quite readily. No daily values have been collated. The absolute humidity has not been calculated except for one year (1883).

DEW-POINT.

A record of the dew-point has been made at the Weather Bureau stations since July, 1881. Monthly averages are of record and in convenient form for reference.

CLOUDS.

Record of the amount, kind, and direction of clouds for upwards of 300 stations of the Weather Bureau are on file in the original manuscript reports. No compilations have been made except as to amount. *The average monthly cloudiness*, on a scale of 0-10 determined from three eye observations per day from 1871 to July, 1888, thereafter from frequent personal observations during the day for the majority of stations, has been compiled. Twelve monthly charts have been prepared.

Automatic sunshine recorders have been in operation at about twelve stations since the early part of 1890. Many of the records at first produced were faulty, but the tendency towards better results has been apparent for some time. Twenty stations are now supplied with automatic recorders.

Cloud observations are also of record for about 2,000 voluntary stations. A lack of uniformity is noticeable in these observations, as in other elements, some observers giving only amount and direction, others kind and amount, and still others kind, amount, and direction.

No compilation has been made of the cloud data afforded by the voluntary system of observations.

WEATHER.

The number of *cloudless*, *partly cloudy*, and *cloudy days* for all months of the period 1871 to 1890 has been compiled in specially prepared volumes.

A cloudless day is one having an average of less than three-tenths clouds; partly cloudy, three to seven-tenths; cloudy, eight to ten-tenths.

A number of minor compilations have been made from time to time. It is believed, however, that but few of them would be of special interest to the general public.

Special reports have been made to both Houses of Congress on the questions of water storage and irrigation, rainfall of the Pacific slope and the western States and Territories, and on the climate of Oregon, Washington, and Nebraska.

A year's observations on evaporation have been printed and discussed, and reports have been made on a number of other subjects, due notice of which has appeared in the publications of the Bureau.

THE LIBRARY.

The work of the library falls into two distinct classes, (1) the collection, cataloguing, and arrangement of the printed literature relating to the weather and its various relations, and (2) the preparation of an index to this literature for the use of those having occasion to consult such works as the library contains relating to the subject under investigation, and also the preparation of a classified catalogue of the whole literature of meteorology, in order to present readily what has been done by investigators all over the world in certain lines of work, and to show where the results of these investigations may be found.

The library at present contains about 12,000 books, exclusive of pamphlets, relating mostly to meteorology, climatology, electricity, and magnetism, with some reference books and books on general science. They are arranged according to a simple scheme of classification, and are fully catalogued under authors' names and again under the subjects, thus facilitating ready reference.

Additions to the library are obtained by purchase and by a system of exchange of publications. Foreign weather services receiving the publications of the Weather Bureau send in return their own publications, and in this way a most valuable series of results of observations and investigation are accumulated and made available for comparative study. The collection of weather maps and bulletins thus obtained is especially valuable for comparative study in weather forecasting; practically complete sets of sixteen foreign weather services being now in the library bound in volumes convenient for reference. Some of the more valuable sets, covering long periods of daily maps, are here given: France, from 1863 to date; United States, from 1871 to date; England, from 1872 to date; North Atlantic and Europe, from 1873 to 1876 and from 1880 to 1886; Germany, from 1876 to date; Austria, from 1877 to date; Algeria, from 1877 to date; Belgium, from 1877 to date; Japan, from 1883 to date.

In accordance with the expressed purpose of Congress to develop the work of the Bureau in the interest of agriculture, especial attention will be given to the collection of the literature which is now so extensively issued by the State weather services and the agricultural experiment stations, and all publications containing climatic data relating to the various States, in order to facilitate the study of local climate in this country.

As it is the desire of the chief of the Bureau to make the valuable collection of printed literature of meteorology and climatology in the library useful to the fullest extent, the privileges of the library are extended to private investigators in any part of the country under such restrictions only as will insure the careful usage and safe return of the volumes loaned.

INDEX TO METEOROLOGICAL OBSERVATIONS.

The index to all observations made and recorded in the United States and accumulated in the Records Division of this Bureau has been of great value since its completion a year ago, under the direction of General Greely. The very valuable collection of foreign observations in the library, covering every portion of the globe and extending over long series of years in many instances, has thus far had no suitable index beyond the usual cataloguing of the volumes as they are received into the library. The usefulness of such a collection is vastly increased by the possession of an index such as that made to observations in the United States.

The frequent calls made upon the librarian by the Records Division for climatic data in foreign lands impressed upon him the importance of having prepared a complete index to all foreign meteorological data, arranged in alphabetical order under the names of the places of observation. Such an index has been begun in the library, with the coöperation of the Records Division. In its final form the index will consist of a large number of cards; each card will contain a fairly complete history of a station, giving all the information, in tabular form, which is likely to be called for, together with a reference to the

publication in the library in which all this information may be found. For example, each card will contain the name of a station, its latitude and longitude, its elevation above sea-level, the character and frequency of the observations made at the station, the date of begining and ending of each series of observations, and the reference to the book in which this information is printed. The meteorological history of any station on the globe of which there is any record in the library collection may thus be placed before the inquirer as quickly as a place may be looked up in a gazetteer.

This index to foreign observations has been in preparation for about two months, and the first draft completed for India, the East Indies, Australasia, China, and Japan, making available for ready reference histories of over 5,000 stations, each station possessing a series of observations extending on an average over a period of about twelve years, while the periods range in extent from one year to eighty years.

To the central office the value of the index, when completed for the entire globe and put into the form of a card catalogue, can not easily be overestimated. Much time will be saved which is now spent searching for records, while climatological research will be stimulated when it becomes known that there is such an index, and that access to the records in the library is allowed, under necessary restrictions, to all students of meteorology competent to use them.

GENERAL CATALOGUE OF METEOROLOGY.

It is generally recognized that one of the most useful indirect aids in scientific research is a catalogue which will show what has been accomplished in the science.

At an international meeting of delegates, representing the various meteorological services of the world, held at Rome in 1879, it was resolved to request the delegates to urge upon their governments the importance of preparing national catalogues embracing all observations and works relating to meteorology and published in their respective countries. As this recommendation was not acted upon, General Hazen, then Chief Signal Officer, recognizing the importance to the Bureau of a general catalogue of all the important meteorological publications, purchased the catalogues of two private individuals, which yielded nearly 30,000 titles. These formed the basis of a general bibliography of meteorology.

Representatives of the various foreign weather services promptly and very generously responded to General Hazen's request for assistance in the compilation of the catalogue, with the implied understanding that the work was to be completed as an official matter, and, if possible, published by the Signal Service. From 1884 to 1887 the collection of material was vigorously prosecuted. At the end of this time the number of titles on hand was about 50,000, covering the period from the origin of printing to the close of 1881. The catalogue includes all the more important contributions to meteorology, climatology, and electricity and magnetism brought to light by a careful search of the principal libraries of the world and examination of accessible catalogues. After thorough examination of the titles, they were arranged according to a carefully planned system of classification.

About half the material accumulated has come from foreign meteorologists, mostly from those who have voluntarily contributed much valuable time, and whose chief reward thus far has been a hope that they may some day receive a printed copy of the completed work.

General Hazen was unsuccessful in his efforts to secure an appropriation for printing the catalogue. His recommendations to Congress were renewed by General Greely in his annual reports when the latter became Chief Signal Officer.

In his report for 1887 General Greely strongly indorses the importance of this work as of great practical value in the current work of the office and to meteorologists in general. As long as this material remains in its present form of a card catalogue it is of value mainly to this Bureau. Its publication would not only vastly increase its usefulness by placing copies within the reach of those now actively engaged in climatological studies in all the States of the Union, but it would remove the moral obligation resting upon this Bureau to make every effort to have copies of the complete catalogue made accessible to the foreign services and individuals who so generously assisted in its preparation.

Since 1887 more than 10,000 titles have been added to the general catalogue, and the period covered has be enextended from 1881 to 1889.

In order that the most important parts might be made more generally available and to insure the safety of the catalogue, which has cost much time and effort in its preparation, a few copies of portions of the catalogue were reproduced by lithography and the milleograph process, under the direction of General Greely. These were distributed to the prominent libraries of this country and to foreign contributors to the work.

Progress in meteorological and climatological study has undoubtedly been retarded many years owing to the absence of a general index to the literature of these subjects. It is hoped that in view of the value of this catalogue as a time-saving device, if made widely and easily accessible, means may be found for its publication in proper style at an early date.

INSTRUMENTS.

The great tendency of the genius of modern times has been to devise and invent instruments and mechanisms that shall not only do all manner of work, but also very often do it much better than could be done by hand. This is as true in meteorology as in any other field of study, and to-day the greatest variety of ingenious instruments are in use for securing records of the various conditions of the atmosphere about us that go to make up the climate of a place. To ascertain this climate we must have continuous records hour after hour and day after day of all the meteorological elements. This is what the instruments secure for us. It will not be possible here to give a description of even the more important of these ingenious instruments, but since rainfall and sunshine have such a direct and immediate influence upon all plant growth and are of such importance to agriculture, brief descriptions of one or two forms of instruments for this purpose will doubtless prove of interest.

In the first place it may be said that the amount of rainfall is nearly always expressed, not in so many quarts or gallons or barrels, but in so many inches or so many hundredths of inches of rainfall, which means that if none of the water runs or soaks away the surface would be covered so many inches with water. As the rainfall is often only very light—that is, only a few hundredths of an inch—it may be wondered how such small quantities can be measured accurately. This is easily understood from what follows.

Suppose a large metal basin a foot or more in diameter be exposed to

collect the rainfall. Ordinarily the water thus collected would be only a small fraction of an inch deep and difficult to measure accurately. If, however, the bottom of the vessel, instead of being flat, be shaped like a funnel so that all the water falling within the basin may be conducted into a smaller vessel, such as a tin cup underneath, we see at once that the depth of the water will be greatly magnified. If the area of the basin is ten times that of the cup then water 1 inch deep in the cup would mean only one-tenth of an inch of rainfall. This principle is always applied in the construction of rain gauges. Such an instrument tells only how much rain fell and gives no idea as to *when* it rained or whether it rained very fast or gently.

By aid of the accompanying drawing (Fig. 1) it may be seen this additional information may also be obtained:

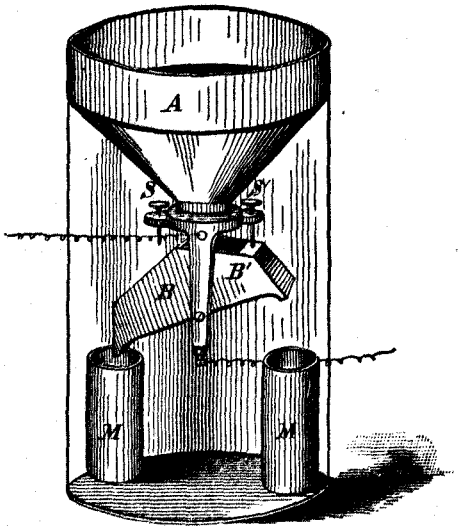


FIG. 1.—Recording rain gauge.

The large receiver *A* of the rain gauge has its bottom shaped like a funnel, and just beneath this is suspended a kind of three-sided bucket which has a partition across the middle portion so as to divide it into two equal parts, *B* and *B'*. This bucket is delicately supported upon an axis or hinge so that it can be tipped back and forth. The arms *S* and *S'* project out and prevent the bucket from tipping too far. Now, when water trickles through the funnel it is caught in the bucket, but this latter is so made that it will hold only so much water as represents, say, one one-hundredth of an inch of rainfall. When this amount has run into it, the bucket becomes top-heavy and tips over against the arm *S'*, the water at the same time running into a tall cylinder, *M*. In the new position of the bucket the side *B'* is presented underneath the funnel so as to receive the water, and when full also causes the bucket to tip. Of course, if the rain falls very rapidly the bucket will tip from side to side in rapid succession, while for very gentle rain a considerable time may be required before the bucket becomes full enough to tip. It remains now to show how it is possible to secure an automatic record of the number of times and the frequency of the tips of the bucket. That wonderful agent, electricity, useful in so many ways, serves admirably in this connection. A small spring is arranged in such a way that when the bucket tips the spring is momentarily deflected and made to close an electric circuit through wires by which the rain gauge is connected with an electric battery and the recording part of the apparatus. This recording part or register consists of a clock movement, to which a cylinder, having its surface covered with a sheet of paper, is joined in such a manner as to be turned round and round quite slowly by the clock. A pen or pencil attached to a suitable arm is mounted beside the cylinder and pressed gently against the paper so as to trace a mark as the cylinder moves under it. Moreover, the arm to which the pencil is attached has a piece of iron attached to it in such a manner that

whenever the bucket of the rain gauge tips and the electric current is made to flow, as explained above, the iron will be attracted by a magnet, thus drawing the pencil aside momentarily and making a corresponding mark upon the paper, each mark representing a tip of the bucket. The sheet of paper is divided off by lines into hours and minutes, so that we can tell exactly when the tips of the bucket occurred and how fast the rain fell at the time.

For recording sunshine a number of different instruments have been devised. The one shown in Fig. 2 is in use at several of the stations of the Weather Bureau. It consists of a metallic cylinder supported upon a frame so that it can be set up in an inclined position. This places the cylinder so that the sun shines as nearly as possible squarely against it during the whole day, both forenoon and afternoon.

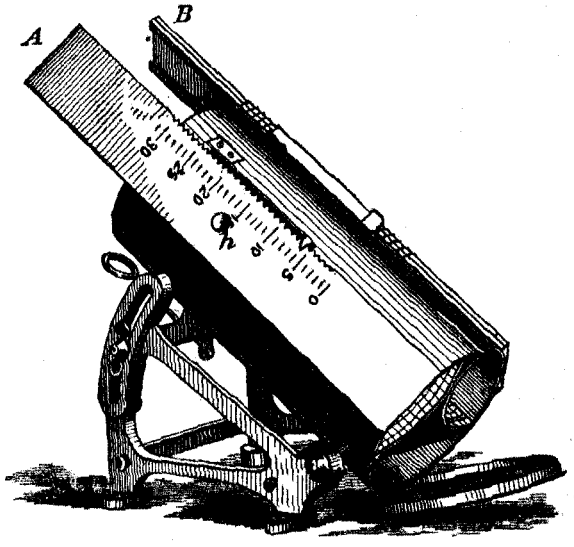


Fig. 2.—Sunshine recorder.

Two slides, *A* and *B*, are attached to the cylinder at two places and are provided with notched edges and springs so that the slides can be set in a number of different positions. In fact, a notch is provided for each day of the month, and when the instrument is in use the slides are set into a new notch for each day of the month. A long slot is cut underneath each slide, and in the middle of each slide just above the slot is cut a very small hole beveled out upon the upper surface. The beveled portion of this hole is seen at *h*. In setting up the instrument one of the slides is made to face toward the forenoon sun and the other toward the afternoon sun. Looking at the lower end of the cylinder, which is shown open in the figure, a small portion of two curved surfaces can be seen within. These surfaces extend from end to end of the cylinder, and against them are placed the sheets that are to receive the record, each sheet facing directly towards its corresponding slide. When sunshine falls upon one or the other slide a small beam of light passes through the small hole and falls in a bright spot upon the paper opposite. This paper has a peculiar chemical spread over its surface, and whenever the sunshine falls upon it the chemical undergoes a change. Afterwards, when the paper is taken out and washed in water, the parts that were affected by sunlight all turn blue while the remainder of the paper washes out nearly white. As the sun passes across the sky from hour to hour the little spot of light passes across the sheet, tracing what will afterwards become a blue line, which will be continuous if the sun shines steadily, but will be broken and interrupted whenever the sun is obscured by passing clouds. The slide being moved each day brings the spot of light to a new place upon the

sheet, and in this way a continuous and automatic record of the amount of sunshine from month to month can be procured.

METEOROLOGY AND TERRESTRIAL MAGNETISM.

These have long been studied side by side, with the object of discovering some physical relations connecting the two classes of phenomena pertaining to them, but such efforts have been on the whole fruitless. Hence these subjects are now generally separated from each other, and are regarded as distinct branches of science.

The researches carried on by Prof. F. H. Bigelow have, however, given rise to the hope that after all there may be some bond between them existing in nature, which has been missed in the discussion of the observations. Accordingly, since the appointment of Prof. Bigelow to the Weather Bureau he has been assigned to the study of this problem. Although it is too soon to have arrived at a full understanding of the question, it may be stated that such progress has been made as to render it quite certain that the two subjects are intimately associated, and that if their relations can be fully elucidated the solution will relate to those fundamental atmospheric considerations which it is most important to understand. Unless all signs fail, this field is a very promising one for securing contributions to our knowledge of the physical action of the atmosphere.

The method of analysis used by Prof. Bigelow differs from that which has been hitherto employed in this respect. Instead of making comparisons between the variations of the atmospheric elements, as displayed by the meteorological instruments, and some one of the magnetic components—that is, the declination, or the horizontal force, or the vertical force taken separately—a total deflecting force is computed from the variations of the magnetic elements, and this is compared with the meteorological changes. By this process Prof. Bigelow has been able also to disentangle several of the magnetic fields surrounding the earth, which we observe in the magnetic curves as an integrated effect.

Our thanks are due to the Navy Department, to Capt. F. C. McNair, superintendent of the U. S. Naval Observatory, and to Ensign J. A. Hoogewerff, U. S. Navy, for permission to use freely their meteorological and magnetic records, and for much practical coöperation, without which this work could not have been prosecuted in Washington.

SOIL PHYSICS.

In the conferences I held during my recent visit to several of the experiment stations, I carefully considered their wish, expressed in the last clause of the resolution adopted at the meeting of the Association of American Agricultural Colleges and Experiment Stations, held in Washington in August, to the effect that the sphere of the work of this Bureau "should be enlarged to include the physics, conditions, and changes of agricultural soils."

I find here an important field of work which they have opened up, having a direct bearing on our own work and offering an interpretation of our data, and showing their application to agriculture such as has not been attempted before. Our data are of conditions above the soil, and this stops short of the needs of agriculture, for the reason that the development of the plant is largely affected by the climatic conditions of heat and moisture under the surface of the ground. The rain which

falls does the plant little or no good until it enters the soil. It is upon the movement of the rainfall after it enters the soil that the development of the plant is largely dependent. A record of the amount of moisture in the soil would show a more direct practical bearing on agriculture than our rainfall tables have done in the past. This is what the stations wish in asking us to enlarge the scope of our work by including a study of what may be termed the meteorological conditions within the soil.

They have collected data showing the marked relation between the moisture in the soil and crop development. They think this explains the local distribution of crops; why the same crops often can not be grown with equal success upon the soils of adjoining fields. It is claimed that the relation of great soil types, or soil formations, to the distribution or development of plants is largely due to the difference in the movement of the rainfall after it enters these different soil formations.

This seems to me a perfectly legitimate field for us to occupy and that the work would be an important addition to the work at present done by the Weather Bureau. The scope of the work would include, first of all, a record of the amount of moisture in the soil in different localities. The observations could be taken at our regular observing stations, or by our voluntary observers and by coöperation with the experiment stations. The localities for these observations should be selected with care to include the principal soil formations, or soil types, best suited to the staple crops of the country. For example, it would be desirable to have a record of the actual amount of moisture in the upland cotton soils of the South, in the Sea Island cotton soils, in the several types of soils not adapted to the growth of cotton, in the soils of the great Blue Grass region, in the wheat, tobacco, and corn lands. A convenient method would have to be devised for the determination of the moisture in the soil in its natural position in the field and for the determination of the actual rate with which water can move through the soil in its natural position on the field, either when it is fully saturated or when it is only slightly moist.

It has been recently shown that the texture or structure of these soil formations or soil types differ, and that this largely determines the relation of these soils to the movement of the rainfall after it enters the ground; that it largely determines the ease with which water may be supplied to the plants. It is claimed that it is possible, from the mechanical analysis, as showing the structure or framework of the soils, to calculate the relative rate with which the rainfall will move after it enters the soil.

The area and distribution of the different soil formations are dependent upon the geology of a country. It should be possible for us to classify the soils of a country under a very few types according to the geological and botanical characteristics, and for us then to collect data to establish the relation of these soils to our ordinary meteorological conditions, and to work out a complete branch of the science in the meteorology of the soil. The practical benefit this would be to climatology and agriculture is perfectly obvious.

It is claimed that the deterioration of lands is largely due to a change in their structure, caused by a rearrangement of the soil grains, thus changing the relation of the soil to the circulation of water.

The determination of the actual rate with which water moves within the soil of any soil formation, under given conditions, will give a basis of comparison with the relative rate with which it should move, calcu-

lated from the structure or framework of the soil as shown by the mechanical analysis. Any difference between this observed rate and the calculated rate would indicate a change in the arrangement of the soil grains and suggest the direction in which the soil should be improved to better adapt it to a given crop.

It has been shown that the arrangement of the grains of soil may be varied at will with the ordinary fertilizing materials, and it is even claimed that a very important effect of fertilization is this physical action of the manures in changing the structure of the soil and its relation to the rate of movement of the soil moisture. If this be so, then our data would supply the basis for the improvement of lands. We would show the meteorological conditions of these soil formations, and particularly their relation to the movement of the rain after it falls and enters the ground. Our records would then show the actual conditions in regard to moisture and its available water supply under which the plant grows. If we thus establish the typical conditions of plant growth, any departure from these conditions in any local soil or great soil formation will indicate the changes which are desirable in the structure of the soil for a better development of the crop.

The simple record of moisture in the soil from time to time would undoubtedly have a great interest and wide practical application to agriculture. The work will also, as I have said, give a basis for the improvement of lands in suggesting changes in the relation of these soils to the meteorological conditions of a region.

The amount of water which a soil contains and the texture of the soil itself, as shown from the mechanical analysis, have an important effect upon the temperature of the soil and the amount of heat lost by radiation. It takes much more heat to raise a pound of water one degree than to raise a pound of soil one degree, so that under like conditions the temperature at midday of a soil saturated with water would be lower than if the soil were only slightly moist. The saturated soil would contain more material to be heated, and this added material is harder to heat than the soil itself.

There is another important effect of moisture upon the temperature of the soil in the rate with which evaporation takes place from the surface of the ground. On a hot, dry summer day, when evaporation is freely going on, more water will evaporate from a light sandy soil than from a clay land, and the temperature of the sandy soil will be considerably lower at midday than that of the clay land, whereas if the soils were both quite dry the sandy soil would have the highest temperature, because the sand is easier to heat than the clay. These effects of moisture on the temperature of the soil must have an important value in the development of plants.

A large amount of data on the temperature of soils has been accumulated by the experiment stations, but because of this influence of the moisture of the soil it has been difficult to give a true interpretation to the results or to show their relation to plant development. Soil-temperature observations could easily be taken on by the Bureau service at the observing stations and in coöperation with the experiment stations by the use of a few special instruments. The work should be made more general, with some broad, general plan, so that the results would give the relation of these great soil formations, or soil types, to heat. This would give a systematic study of the different soil formations, where any individual station can deal only with the soil of its immediate locality. For the reasons just given, the record of soil moisture should be an accompaniment to the soil temperature data, and

it would probably be possible, from the known texture of the soil, the size of the grains of soil, and the relation of the soil to the circulation of water, to determine also their relative relation to heat.

Another line in which the experiment stations have been working, and which might properly come within the scope of our own work, is in the study of the loss of heat from the soil or from objects freely exposed to radiation. The texture of the soil and its relation to both heat and moisture largely determine the relative rate with which the soil will lose heat by radiation, and so influence the occurrence of dew and frost. Both the solar and the terrestrial radiation thermometers should be included in this study of the meteorology of the soil, and they would probably give interesting results if the observing stations were selected in representative soil formations and in great crop areas.

This new field of investigation thus outlined appears so important and so full of promise of results of great practical value to agriculture, if the work is systematically arranged and carried out, that I think it would be well to establish a division in this Bureau devoted to the subject of meteorology in its relation to agricultural soils.

CLIMATIC LABORATORY.

The relations between the climates of the separate States and their local crops are supposed to be fully attended to by the respective agricultural colleges and the experimental stations, but there are many questions of a wider character that are proper to be discussed by this Bureau, as a part of the whole field and as a contribution to our general knowledge of the laws of the growth of plants. For instance, the question as to whether any given characteristic of a crop is due to the temperature of the air, or of the soil, the rainfall, the sun's heat, or the sun's light, or the constitution of the atmosphere, is one that belongs to this Bureau to determine. These are questions of the influence of meteorological climate, as distinguished from the influence of the soil, the fertilizers, variety of the seed, and the methods of culture. These latter questions are properly studied by the local experiment stations, but I know of no provision for studying the former by themselves. It is difficult to see how the question of climatic influence can be satisfactorily handled unless localities are provided in which crops may be grown under climatic conditions that are strictly under control as to temperature, moisture, atmosphere, and light. I therefore respectfully submit the following sketch of the conditions necessary to be fulfilled in a building adapted to this important study.

This building, which might properly be called a "climatic laboratory," should contain about ten rooms, each devoted to some one of our ten principal crops, and each room to furnish an available soil surface of about 1 square rod. Each room to be furnished with the means for completely regulating the temperature of the soil and that of the air, independently of each other; also, for controlling and altering, to a limited extent, the chemical nature of its atmosphere, its moisture, and its barometric pressure; also, a method of controlling the sunlight that enters by day and of substituting, by night, a powerful electric light in its stead. All of our present knowledge tends to demonstrate that the crop produced from any seed has its qualities and its time of ripening changed by temperature, moisture, and sunlight, and especially by the relative distribution of these during the period of growth; while the quantity of the crop—namely, the number and the size or weight—

depends on the nature and quantity of the fertilizer contained in the soil or water. The precise analysis and study of these complex relations has been attended with great difficulty in experimental work carried on in the open air or in the ordinary greenhouses. The absolute necessity of the climatic laboratory was strongly insisted on by A. de Candolle thirty years ago, and is still more evident from the data collected together in Prof. Abbe's report. The work to be conducted in this climatic laboratory is so important in its bearings on many questions that come before the Department of Agriculture, and on the general interests of the farmer, that it should give occasion for the formation of an independent division of the Department, if it is not thought proper to organize it under the Weather Bureau.

WEATHER CONDITIONS OF THE CROP OF 1891.

Prepared by H. H. C. DUNWOODY, *Acting Assistant Chief of the Weather Bureau.*

As editor of the Weather Crop Bulletin during the past four years, the writer has been associated with work having the most direct bearing upon agricultural interests and in line with that contemplated in the law transferring the Weather Bureau to the Department of Agriculture. Experience in this work has shown that the value of the information collected by this Bureau may be increased many fold by a wider distribution of the information collected by this office and an ability to utilize the same. No feature of the work of the Weather Bureau has been so highly commended by those interested in agriculture as the weather crop bulletins. These contain reliable statements of the weather conditions under which the crops of the present year were planted, cultivated, and harvested, and a summary of these bulletins has been prepared, covering the period from March 1 to October 1, in which the more important meteorological elements are presented in such form as to enable those who are interested in crop production to become thoroughly familiar with the conditions which have prevailed over the principal agricultural districts during the growing season, and this information, compared with the actual yield of the several crops, will serve as a record of comparison which, if continued from year to year, will enable those interested to form more reliable estimates of the influence of weather conditions on the more important crops. The conditions of rainfall and temperature are here represented in graphic form.

Plate V exhibits the seasonal conditions of rainfall from March 1 to September 25 throughout the United States, or during the growing period of the present year. From this chart it will be seen that more than the usual amount of rain occurred from Indian Territory and northern Texas northward over the west slope of the Missouri Valley, including the west half of South Dakota and the greater portions of North Dakota. This region of excessive rain extends to the Pacific coast, over Oregon and the greater portion of Washington. Within the limit of the shaded portion of the chart light lines indicating areas over which the rainfall ranged from 2 to 6 inches in excess of the usual amount, and the time of the occurrence of this rainfall, will be found in the weekly record of the stations, as given in the tabular statement. Small areas of excessive rainfall occurred over the eastern portion of the United States, as shown on the charts, while throughout the central valleys, including the greater portion of the cotton, corn, and wheat

regions, the rainfall was less than usual. While the deficiency was slight and ranged only from 2 to 6 inches below the average of previous years in the corn and wheat States of the central valleys and in the northern portion of the cotton region, there was a marked deficiency in the lower Mississippi Valley along the Gulf coast, where the rainfall was 8 to 20 inches less than usual, the region of greatest drought including the sugar and rice regions of Louisiana. On the Pacific coast the rainfall was generally in excess in Oregon and Washington, while over the greater portion of California it was from 1 to 2 inches less than usual.

Plate VI exhibits the thermal conditions of the season as compared with the average of previous years, the shaded portions showing that in New England, over the lake region, and along the Pacific coast it was slightly warmer than usual, while throughout all principal agricultural districts the average daily temperature for the entire period was from 1 to 3 below the average.

Plates VII and VIII show the conditions of temperature and rainfall by weeks, for selected stations, viz, Kansas City, Shreveport, Springfield, Albany, Augusta, and Huron. These diagrams will serve as types to indicate the general weather conditions from week to week for the localities represented, and similar diagrams may be constructed for each of the stations named in the table. For example, the diagram for Springfield, Ill., the heavy horizontal line marked "0" is taken as the normal (or average) for both temperature and rainfall, and figures to the left indicate degrees when referring to temperature and tenths of inches when referring to rainfall. The full black line refers to temperature and the dotted line to rainfall. The full black line being below the zero line during the month of March and the first two weeks in April, indicates that this period was colder than usual for that locality, while during the same period the rainfall was in excess during the last week in March and the second week in April. From this date until the second week of July the rainfall was less than usual in central Illinois, while the temperature varied but slightly from the normal. After this followed the excessive rain of July and August, which proved so beneficial to the corn crop in the central Mississippi Valley. The weather had been cool up to that period, and the corn crop was retarded, but the excess in temperature which occurred in September, as is shown on the curves for Springfield and Kansas City, was the condition most favorable to the then retarded corn crop, as it hastened the ripening of the crop and saved it from frosts which occurred late in September. The tabular statements contain the departures from the normal for both temperature and rainfall for each week for the season of 1891. The first column in each table contains the conditions as compared with the normal from January 1 to the first week in March, the date of the issue of the first weekly bulletin; the remaining columns give the departures for each successive week. Table I refers to temperature and Table II to precipitation.

The tables thus present the seasonal conditions for each locality named in the table, and diagrams similar to those given in Plates VII and VIII may be readily constructed, which will present the data in more graphic form and facilitate comparisons.

In the study of the weather conditions for the year, the conditions which existed before the opening of the growing season and during the winter months should not be neglected. During the late winter and spring months the temperature was abnormally high over the principal agricultural districts east of the Rocky Mountains, especially in the

Northwest, and the ground was well filled with moisture at the opening of the growing season.

With a view of securing a more detailed statement which would show the march of the season in the several States, I have secured from the directors of the several State weather services a general statement of the weather crop conditions in their respective States from the opening of the growing season until the end of September, 1891. As these statements contain much valuable information, which may be utilized by farmers interested in the study of the weather and the effects of the same upon crops, they are herewith submitted. These reports from the cotton region States, having been prepared before the close of the growing season in that section, necessarily do not give the condition of the cotton crop at maturity, but the estimates as given will doubtless closely approximate the actual state of the crop.

TABLE I.—*Temperature departures for the season of 1891 from the normal of many years.*

Stations.	From Jan. 1 to Mar. 6 inclusive.	For the weeks ending—											
		March			April				May				
		13.	20.	27.	3.	10.	17.	24	1.	8.	15.	22.	29.
New England States:													
Eastport, Me	+ 86	+ 50	−20	+16	+ 10	+ 8	+25	+ 1	− 5	+ 8	+10	− 7	+ 5
Portland, Me	+104	+ 43	−19	+12	+ 6	− 9	+32	+53	−14	−25	−21	−33	−37
Boston, Mass	+236	+ 40	−17	+11	− 2	−26	+38	+73	+ 6	−14	+10	+11	−18
Middle Atlantic States:													
Albany, N. Y	+ 25	+ 11	−25	+39	+ 16	−47	+37	+67	+11	−38	+28	−30	−28
New York City, N. Y	+217	+ 43	− 6	+21	0	−39	+49	+80	+37	−22	+34	− 4	−15
Philadelphia, Pa	+184	+ 24	−29	+10	− 15	−43	+56	+82	+32	−33	+29	− 1	−38
Washington City, D. C	+233	+ 8	−20	+ 1	− 26	−60	+49	+82	+27	−29	+ 2	− 2	−53
Lynchburg, Va	+ 46	− 18	−31	−10	− 30	−69	+58	+75	+25	−29	−19	−13	−49
Norfolk, Va	+167	+ 20	−30	−18	− 23	−56	+63	+54	+18	−24	−10	− 5	−25
South Atlantic States:													
Charlotte, N. C	+ 75	− 20	−33	−15	− 21	−71	+58	+50	+19	−16	−29	−14	−31
Wilmington, N. C	+117	+ 21	−23	+ 8	− 12	−53	+55	+31	0	−25	−17	−26	−11
Charleston, S. C	+141	+ 12	−32	+ 2	− 15	−43	+38	+30	− 4	−10	−25	−22	−20
Augusta, Ga	+ 63	− 20	−37	−12	− 23	−52	+55	+42	+10	−18	−42	−24	−28
Savannah, Ga	+ 80	0	−39	− 4	− 26	−59	+31	+14	− 5	−12	−25	−32	−27
Jacksonville, Fla	+148	+ 25	−32	− 1	− 17	−69	+26	+ 9	− 7	−14	−21	−17	−19
Gulf States:													
Atlanta, Ga	+ 13	− 46	−39	− 4	− 33	−57	+46	+42	+28	− 7	−21	−13	− 7
Mobile, Ala	+ 65	− 26	−30	+14	− 9	−66	+12	+14	− 1	−21	−25	− 8	− 3
Montgomery, Ala	+ 91	− 41	−29	+18	− 18	−62	+39	+34	+ 9	−12	−21	−13	−12
Vicksburg, Miss	+136	− 51	−45	+ 2	− 10	−49	+27	+23	+ 3	−17	−38	− 3	− 6
New Orleans, La	+122	− 45	−41	− 4	− 9	−57	+12	+ 6	+ 6	−16	−28	− 7	+ 9
Shreveport, La	+ 64	− 67	−37	−27	− 17	−36	+18	− 3	+ 3	−25	−52	−15	−32
Fort Smith, Ark	+ 54	− 84	−31	−15	− 31	−30	+24	+30	+15	−22	−40	+ 5	−32
Little Rock, Ark	− 4	− 80	−44	−12	− 23	−26	+28	+38	+ 8	−30	−33	+ 1	−23
Palestine, Tex	+ 94	−104	−52	−42	− 12	−24	+23	− 4	+ 9	− 8	−50	+ 7	−16
Galveston, Tex	+ 76	− 52	−40	−22	− 11	−28	− 1	− 4	+ 9	− 6	−30	0	−20
San Antonio, Tex	− 12	− 78	−57	−19	− 12	−13	+12	−32	−11	−14	−47	− 6	−32
Ohio Valley and Tennessee:													
Memphis, Tenn	+147	− 55	−31	− 5	− 17	−26	+43	+51	+11	−31	−26	+15	−18
Nashville, Tenn	+159	− 24	−11	0	− 41	−43	+45	+52	+12	−41	−19	− 2	−18
Chattanooga, Tenn	+101	− 28	−17	0	− 30	−56	+52	+52	+25	− 8	− 8	−14	− 1
Knoxville, Tenn	+107	− 15	−17	+ 4	− 28	−63	+53	+54	+17	−26	−28	−13	− 8
Louisville, Ky	+201	− 18	−24	− 6	− 31	−45	+60	+71	+22	−39	−12	+ 6	−36
Indianapolis, Ind	+204	− 16	−24	− 7	− 13	−44	+56	+83	+16	−41	− 3	0	−59
Cincinnati, Ohio	+136	− 20	−33	− 9	− 19	−53	+53	+76	+15	−52	−21	−10	−64
Columbus, Ohio	+196	− 7	−31	+ 2	+ 4	−57	+46	+67	+12	−46	− 8	−17	−65
Pittsburg, Pa	+237	+ 28	−16	+ 5	+ 4	−54	+41	+83	+ 9	−50	− 1	−13	−48
Lake Region:													
Oswego, N. Y	+113	+ 42	−34	+19	+ 27	−40	+34	+40	+14	−37	+12	−13	−51
Buffalo, N. Y	+252	+ 43	−18	+25	+ 43	−27	+41	+42	0	−48	+ 6	−11	−22
Cleveland, Ohio	+292	+ 23	−10	+ 5	+ 18	−36	+43	+64	+37	−39	+ 7	−14	−45
Detroit, Mich	+134	0	−37	− 4	+ 11	−46	+27	+56	+34	−32	+16	−15	−36
Alpena, Mich	+313	+ 58	−25	+32	+ 40	−29	+22	+56	+70	−21	+32	−12	−22
Grand Haven, Mich	+187	+ 1	−22	+ 9	+ 7	−44	+19	+45	+14	−47	+ 5	−16	−25
Milwaukee, Wis	+325	− 30	− 6	+12	+ 16	−46	+16	+40	+56	−13	+28	−12	−52
Chicago, Ill	+221	− 49	−23	− 3	+ 7	−67	+26	+42	+47	−33	+28	−25	−70
Duluth, Minn	+298	− 27	−57	−12	+ 3	−16	+14	+23	+44	+ 3	+39	−20	− 7
Upper Mississippi Valley:													
St. Paul, Minn	+176	− 63	−55	+15	− 15	−34	+21	+44	+56	−24	+31	+10	−13
La Crosse, Wis	+259	− 46	−33	− 1	− 9	−50	+19	+50	+61	−16	+41	+ 6	−34

TABLE I.—*Temperature departures for the season of 1891 from the normal of many years*—Continued.

Stations.	From Jan. 1 to Mar. 6 inclusive.	For the weeks ending— March 13.	March 20.	March 27.	April 3.	April 10.	April 17.	April 24.	May 1.	May 8.	May 15.	May 22.	May 29.
Upper Mississippi Valley—Continued.													
Davenport, Iowa	+256	−70	−35	−17	−13	−51	+32	+63	+47	−34	+20	−14	−40
Des Moines, Iowa	+302	−67	−29	−16	−39	−39	+25	+55	+43	−41	+3	−29	−39
Springfield, Ill	+126	−59	−13	−32	−19	−48	+37	+58	+27	−38	+10	+6	−36
Cairo, Ill	+167	−47	−10	−8	−24	−32	+41	+61	+16	−41	−16	+10	−40
St. Louis, Mo	+208	−53	−7	−24	−25	−37	+37	+62	+27	−43	+2	+6	−45
Missouri Valley:													
Springfield, Mo	+103	−76	−5	−21	−35	−38	+25	+47	+17	−39	−43	−23	−50
Kansas City, Mo	+114	−100	−26	−42	−45	−26	+25	+59	+38	−30	−15	−23	−47
Concordia, Kans	+206	−82	+15	−34	−57	−6	+48	+53	+52	−1	0	−32	−34
Omaha, Nebr	+172	−97	−12	−35	−46	−28	+24	+59	+58	−31	+5	−30	−29
Valentine, Nebr	−27	−133	−19	−23	−72	−33	+8	+48	+56	−15	−6	−9	+7
Huron, S. Dak	+314	−123	−50	−15	−38	−15	+9	+59	+52	−13	+8	−1	+11
Extreme Northwest:													
Moorhead, Minn	+318	−102	−45	−9	+15	+32	+28	+88	+79	−2	+7	+12	+23
Bismarck, N. Dak	+434	−116	−18	−22	−12	+28	+13	+71	+62	0	0	+2	+13
Fort Buford, N. Dak	+266	−107	+16	+19	−1	+40	+34	+59	+30	−11	−5	+10	+20
Rocky Mountain Slope:													
Fort Assinaboine Mont	+122	−104	+13	+6	−38	+45	+23	+45	+1	−8	+9	+3	+19
Cheyenne, Wyo	−116	−98	+6	−42	−77	−1	+1	+24	+40	+55	−4	−47	−10
North Platte, Nebr	−4	−116	+8	−46	−79	−29	+14	+41	+57	+15	+12	−27	−5
Denver, Colo	−270	−86	+6	−64	−108	−23	+7	+10	+65	+68	−6	−57	−20
Dodge City, Kans	+84	−112	−1	−79	−74	−13	+20	+36	+39	+16	−29	−25	−32
Pacific Coast:													
Olympia, Wash	−18	−9	+21	−10	−76	+3	+23	−11	−3	−10	+17	+15	+34
Portland, Oregon	−21	−23	+1	−20	−37	−4	+14	−16	−11	−1	+6	+6	+7
Roseburg, Oregon	−70	0	+18	−12	−32	−15	−1	+8	+13	+12	−10	+3	+2
Red Bluff, Cal	−39	−4	+20	−10	−12	−48	−47	+1	+14	−6	−17	+28	−30
Sacramento, Cal	−23	+6	+19	0	−11	−17	−39	−4	+21	−9	−28	+16	−34
San Francisco, Cal	+56	+4	+16	−8	−6	−35	−28	−22	+13	−1	−31	−16	−24
Los Angeles, Cal	+38	+6	+11	−1	+2	−2	−34	−11	+12	−8	−17	−24	−16
San Diego, Cal	−13	−10	+9	−3	−4	−6	−23	0	−2	−2	−10	−7	−10

Stations.	For the weeks ending— June 5.	June 12.	June 19.	June 26.	July 3.	July 10.	July 17.	July 24.	July 31.
New England States:									
Eastport, Me	−11	+7	+24	−7	−23	−20	+1	−31	−27
Portland, Me	−24	+13	+25	−24	−33	−32	−4	−25	−29
Boston, Mass	−14	+35	+17	−30	−54	−47	+12	−8	−27
Middle Atlantic States:									
Albany, N. Y	+3	+4	+22	+11	−26	−61	+4	−11	−43
New York City, N. Y	+19	−2	+18	+22	−39	−38	−3	−4	−27
Philadelphia, Pa	+14	−23	+11	+18	−30	−49	−8	−13	−35
Washington City, D. C	+6	−35	+21	+17	−28	−62	−49	+22	−20
Lynchburg, Va	−10	−47	+36	+12	−28	−76	−38	−7	−28
Norfolk, Va	−8	−25	+36	+30	−10	−37	−44	−27	−17
South Atlantic States:									
Charlotte, N. C	+10	−32	+16	+13	−6	−52	−55	−18	−27
Wilmington, N. C	+7	−28	+16	+20	+8	−28	−42	−22	−21
Charleston, S. C	+9	−5	+8	+17	+11	−12	−39	−23	−4
Augusta, Ga	+15	−11	+10	+13	+3	−28	−37	−28	−29
Savannah, Ga	+22	−4	+1	+9	+10	−26	−50	−27	−7
Jacksonville, Fla	+25	−5	−4	+2	+15	−9	−25	−18	+9
Gulf States:									
Atlanta, Ga	+37	−18	+18	+18	+14	−28	−44	−18	−24
Mobile, Ala	+3	−4	0	+21	+6	−23	−15	−6	−3
Montgomery, Ala	+27	−7	+3	+18	+8	−32	−25	−12	−7
Vicksburg, Miss	+23	−3	+7	+28	+11	−38	−21	−12	−8
New Orleans, La	+6	−5	−17	+14	+10	−37	−5	0	−2
Shreveport, La	+6	−8	0	+12	−7	−53	−32	−14	+2
Fort Smith, Ark	+24	−3	+17	+6	−12	−47	−40	−19	−44
Little Rock, Ark	+33	−5	−7	+16	+1	−41	−41	−19	−43
Palestine, Tex	+19	−4	−17	+13	−10	−49	−17	−12	+12
Galveston, Tex	.....	−8	0	−1	−8	−37	−14	−11	−2
San Antonio, Tex	+13	−3	+5	+18	−7	−1	−6	+5	+27
Ohio Valley and Tennessee:									
Memphis, Tenn	+41	−8	−2	+18	+10	−46	−35	−12	−36
Nashville, Tenn	+32	+6	+16	+19	+3	−51	−26	−24	−27
Chattanooga, Tenn	+39	+5	+16	+19	+3	−35	−28	−10	−21
Knoxville, Tenn	+30	+10	+23	+15	−5	−42	−24	−5	−20
Louisville, Ky	+16	+16	+34	+21	−2	−65	−25	−18	−24

TABLE I.—*Temperature departures for the season of 1891 from the normal of many years*—Continued.

Stations.	For the weeks ending—								
	June				July				
	5.	12.	19.	26.	3.	10.	17.	24.	31.
Ohio Valley and Tennessee—Continued.									
Indianapolis, Ind	+17	−13	+38	+26	− 2	−53	−32	− 8	−33
Cincinnati, Ohio	+ 2	−12	+30	+17	−11	−65	−39	−29	−43
Columbus, Ohio	+ 8	−10	+49	+28	−10	−69	−42	−23	−38
Pittsburg, Pa	+ 3	−14	+49	+17	−17	−70	−20	−13	−44
Lake Region:									
Oswego, N. Y	−23	+ 6	+27	+10	−13	−73	− 5	−21	−47
Buffalo, N. Y	− 4	+19	+28	+32	− 6	−60	−12	−11	−40
Cleveland, Ohio	+ 5	+ 2	+23	+26	− 2	−47	− 9	− 7	−37
Detroit, Mich	+ 6	+ 3	+27	+26	−17	−62	− 9	−22	−44
Alpena, Mich	−20	0	+27	+37	−10	−38	+21	−34	−47
Grand Haven, Mich	+ 3	+12	+42	−38	− 4	−60	−30	−30	−44
Milwaukee, Wis	−12	+ 2	+ 9	+17	−14	−58	+ 5	−21	−46
Chicago, Ill	−23	− 9	+12	+10	−28	−64	− 8	−14	−55
Duluth, Minn	−77	−17	−20	+ 1	−42	−30	−31	−58	−24
Upper Mississippi Valley:									
St. Paul, Minn	−24	−18	+ 8	+15	−41	−63	−27	−39	−42
La Crosse, Wis	+ 6	− 9	+21	+24	−35	−70	−26	−39	−44
Davenport, Iowa	0	−28	+30	+33	−20	−60	−42	−29	−37
Des Moines, Iowa	− 2	−43	+10	+14	−26	−61	−36	−40	−40
Springfield, Ill	+17	−12	+35	+26	− 4	−63	−40	−22	−56
Cairo, Ill	+39	+11	+ 6	+16	+ 7	−44	−34	−14	−31
St. Louis, Mo	+23	− 9	+12	+17	− 4	−44	− 36	−19	−35
Missouri Valley:									
Springfield, Mo	+22	− 4	−14	+ 1	− 7	−65	−55	−26	−28
Kansas City, Mo	− 4	−42	− 9	+ 5	− 9	−61	−49	−35	−34
Concordia, Kans	+12	−46	−18	+ 6	− 2	−55	−35	−14	−30
Omaha, Nebr	− 8	−49	+ 2	+12	−10	−64	−42	−38	−31
Valentine, Nebr	−14	−17	−36	− 4	−18	−48	−55	−45	−23
Huron, S. Dak	− 21	−11	− 8	+ 4	−28	−34	−18	−51	−48
Extreme Northwest:									
Moorhead, Minn	−43	− 7	+ 7	+18	−34	−24	−14	−56	−28
Bismarck, N. Dak	−66	−16	−32	0	− 36	−26	−32	−52	−51
Fort Buford, N. Dak	−76	− 35	−48	−43	−43	−21	−44	−43	−55
Rocky Mountain Slope:									
Fort Assinaboine, Mont	− 56	−36	−26	−39	− 2	+11	−31	−24	− 9
Cheyenne, Wyo	−24	+ 2	−34	−14	−25	− 31	−46	− 6	−23
North Platte, Nebr	−13	−26	−42	− 3	−18	−54	−42	−17	−19
Denver, Colo	−36	+ 7	−37	− 8	−25	−39	−41	− 9	−28
Dodge City, Kans	+14	−38	−47	+ 1	−12	−47	−33	−28	−36
Pacific Coast:									
Olympia, Wash	− 6	−25	−11	−20	+18	−29	−13	+21	+ 3
Portland, Oregon	−22	−40	−20	−28	+25	−24	+23	+25	− 6
Roseburg, Oregon	−24	−38	− 8	−27	+31	−34	+ 9	+37	+ 5
Red Bluff, Cal	−47	−24	−32	−35	+74	−51	+12	+40	+32
Sacramento, Cal	−39	−13	−23	− 6	+96	−13	+13	+47	+13
San Francisco, Cal	−18	−20	− 6	+ 1	+62	.....	− 8	+ 5	−20
Los Angeles, Cal	−26	−10	−17	− 9	+15	− 7	−12	+33	+33
San Diego, Cal	−12	− 7	− 4	−14	− 2	− 8	− 9	+22	+25

Stations.	For the weeks ending—								
	August				September				Oct
	7.	14.	21.	28.	4.	11.	18.	25.	2.
New England States:									
Eastport, Me	− 5	+ 8	− 1	+ 3	+ 5	+17	+ 9	+ 30	+45
Portland, Me	− 6	+33	+ 1	+ 9	− 3	− 2	+38	+ 66	+49
Boston, Mass	−20	+37	+ 9	+39	−17	− 8	+34	+ 55	+56
Middle Atlantic States:									
Albany, N. Y	−23	+29	+ 7	+33	−14	−13	+14	+ 72	+54
New York City, N. Y	−16	+45	+13	+38	−18	− 9	+16	+ 61	+45
Philadelphia, Pa	−19	+40	0	+33	−23	−18	+21	+ 72	+56
Washington City, D. C	− 8	+37	+ 8	+19	− 18	−25	+12	+ 55	+42
Lynchburg, Va	−18	+ 25	+ 8	0	−29	−25	+ 8	+ 66	+32
Norfolk, Va	− 2	+23	+14	+29	−20	− 7	+ 7	+ 30	+39
South Atlantic States:									
Charlotte, N. C	− 9	+20	+25	− 2	−40	−28	+ 6	+ 51	+37
Wilmington, N. C	+ 1	+15	+21	+20	−26	− 9	+ 9	+ 16	+27
Charleston, S. C	+15	+13	+26	+13	−17	−10	+ 6	+ 22	+18
Augusta, Ga	− 4	+ 5	+11	−11	−44	−35	−11	+ 26	+24
Savannah, Ga	+12	+ 2	+17	+ 1	−19	−10	+ 4	+ 13	+13
Jacksonville, Fla	+14	− 3	+14	+10	−14	− 5	+ 1	+ 3	+ 6

TABLE I.—*Temperature departures for the season of 1891 from the normal of many years*—Continued.

Stations.	For the weeks ending—								
	August				September				Oct
	7.	14.	21.	28.	4.	11.	18.	25.	2.
Gulf States:									
Atlanta, Ga	−7	+22	+38	−14	−23	−39	−4	+52	+38
Mobile, Ala	−4	+3	+18	−24	−13	−48	0	+26	+33
Montgomery, Ala	−9	+19	+31	−5	−5	−34	0	+32	+30
Vicksburg, Miss	−12	−6	+18	−58	−38	−42	+14	+40	+44
New Orleans, La	−1	+3	+16	−24	−12	−33	−1	+12	+26
Shreveport, La	−14	−21	+12	−67	−37	−45	+9	+26	+26
Fort Smith, Ark	−26	−3	+36	−60	−28	−32	+24	+42	+45
Little Rock, Ark	−22	−10	+27	−73	−44	−36	+18	+52	+45
Palestine, Tex	−13	−15	+15	−55	−24	−37	+14	+26	+43
Galveston, Tex	−8	−3	+14	−33	−5	−20	+6	−0	+24
San Antonio, Tex	+7	+15	+23	−22	−1	−2	+23	+17	+38
Ohio Valley and Tennessee:									
Memphis, Tenn	−23	+10	+36	−61	−43	−34	+25	+71	+53
Nashville, Tenn	−18	+22	+34	−51	−51	−42	+15	+63	+60
Chattanooga, Tenn	−16	+15	+36	−17	−26	−37	−8	+48	+52
Knoxville, Tenn	−4	+17	+19	−15	−23	−41	−7	+51	+58
Louisville, Ky	−15	+27	+17	−55	−42	−38	+26	+73	+48
Indianapolis, Ind	−16	+40	+29	−50	−29	−32	+58	+107	+72
Cincinnati, Ohio	−19	+22	+12	−61	−43	−48	+18	+71	+49
Columbus, Ohio	−9	+36	+19	−43	−23	−35	+25	+87	+63
Pittsburg, Pa	−23	+33	+17	−17	−26	−36	+18	+73	+58
Lake Region:									
Oswego, N. Y	−23	+22	+9	+8	−6	−18	+16	+61	+61
Buffalo, N. Y	−6	+24	+30	−19	−10	−20	+27	+71	+54
Cleveland, Ohio	−11	+46	+31	−21	−15	−20	+46	+71	+61
Detroit, Mich	0	+40	+35	−33	−24	−26	+51	+98	+63
Alpena, Mich	−8	+32	+32	−17	−16	−27	+48	+106	+75
Grand Haven, Mich	−4	+31	+39	−32	−21	−30	+44	+98	+66
Milwaukee, Wis	0	+45	+21	−50	−46	−34	+78	+121	+59
Chicago, Ill	−11	+22	+18	−62	−52	−34	+66	+110	+70
Duluth, Minn	−17	+13	+16	−43	−11	+25	+33	+105	+56
Upper Mississippi Valley:									
St. Paul, Minn	+11	+16	+24	−67	−42	−4	+61	+125	+54
La Crosse, Wis	+6	+26	+29	−56	−44	−9	+74	+134	+69
Davenport, Iowa	−10	+19	+35	−62	−37	−27	+64	+109	+74
Des Moines, Iowa	−8	+11	+25	−74	−42	−21	+67	+102	+53
Springfield, Ill	−24	+22	+36	−54	−39	−30	+61	+108	+63
Cairo, Ill	−20	+10	+24	−68	−34	−29	+35	+79	+60
St. Louis, Mo	−19	+27	+21	−58	−34	−25	+52	+99	+66
Missouri Valley:									
Springfield, Mo	−28	+16	+29	−73	−36	−17	+44	+78	+62
Kansas City, Mo	−19	+30	+30	−75	−34	−19	+53	+87	+65
Concordia, Kans	+1	+37	+40	−56	−22	−14	+51	+78	+33
Omaha, Nebr	+5	+33	+28	−64	−28	−9	+75	+93	+43
Valentine, Nebr	+20	+8	+20	−57	−3	+7	+76	+50	+15
Huron, S. Dak	−1	−2	+25	−58	−21	+16	+78	+97	+48
Extreme Northwest:									
Moorhead, Minn	+46	−1	+19	−48	−14	−3	+58	+116	+37
Bismarck, N. Dak	+10	−35	+4	−46	+3	+18	+55	+64	+9
Fort Buford, N. Dak	+3	−60	−8	−46	+1	+27	+35	+40	−35
Rocky Mountain Slope:									
Fort Assinaboine, Mont	−31	−46	−8	−13	+27	+38	+35	+26	−33
Cheyenne, Wyo	+15	+19	+7	−34	+2	+18	+46	+2	−16
North Platte, Nebr	+4	+8	+8	−55	−14	−3	+52	+49	+28
Denver, Colo	−6	+16	0	−31	−5	+15	+50	+8	+9
Dodge City, Kans	−11	+8	+26	−57	−33	−22	+46	+33	+15
Pacific Coast:									
Olympia, Wash	−21	+27	+17	+45	+3	+7	+14	−5	−25
Portland, Oregon	−28	+29	+23	+78	+36	+13	−8	−16	−28
Roseburg, Oregon	−29	+7	+22	+85	+41	+27	+13	+1	−18
Red Bluff, Cal	−21	−7	+2	+64	+55	+16	−52	−4	−14
Sacramento, Cal	−11	+12	+12	+47	+27	+15	−35	−9	+2
San Francisco, Cal	−4	−7	+24	+24	+3	−14	+2	+17	.....
Los Angeles, Cal	−14	+14	+28	+34	+23	+66	−13	+4	+18
San Diego, Cal	−1	+11	+35	+27	+33	+61	−4	−4	−4

TABLE II.—*Precipitation departures for the season of 1891 from the normal of many years.*

Stations.	From Jan. 1 to Mar. 6, inclusive.	For the weeks ending—						
		March			April			
		13.	20.	27.	3.	10.	17.	24.
New England States:								
Eastport, Me	+.19	+.12	-.60	-.98	-.62	-.75	-.21	-.41
Portland, Me	+4.75	+2.85	-.67	+.43	-.11	-.70	-.02	-.21
Boston, Mass	+.70	+.03	-.97	+.61	-.04	-.91	-.19	-.72
Middle Atlantic States:								
Albany, N. Y	+5.05	+.86	-.60	+.12	+.53	-.62	+.22	-.31
New York City, N. Y	+2.55	+1.44	-.89	+.59	+.35	-.82	-.15	-.25
Philadelphia, Pa	+1.57	+1.09	-.11	+.49	+.30	-.69	+.91	-.51
Washington City, D. C	+3.92	+1.24	-.51	+2.58	+1.59	-.74	+1.07	-.13
Lynchburg, Va	+4.92	+1.43	-.31	+.91	+1.13	-.72	+1.10	-.15
Norfolk, Va	+.94	+.17	-.53	+2.85	+.41	-.68	+.08	-.81
South Atlantic States:								
Charlotte, N. C	+1.58	+4.22	-.02	+1.65	+.30	+.06	-.41	-.09
Wilmington, N. C	-1.17	+1.15	-.98	+.37	+.52	-.80	-.38	-.40
Charleston, S. C	-4.92	-.03	+.87	+1.67	+.12	-.88	.00	-.89
Augusta, Ga	-.89	+3.24	-.40	+.22	+.06	-.95	-.89	-.82
Savannah, Ga	-3.95	+.92	+1.49	-.03	+.95	-.98	-.65	+.04
Jacksonville, Fla	-5.80	+.28	+.91	+.57	-.39	-.70	-.70	-.10
Gulf States:								
Atlanta, Ga	+4.35	+3.74	-1.00	+.07	+1.15	-.86	-.51	-.56
Mobile, Ala	+.46	+1.08	-.76	+.56	-.94	-.32	-1.24	-.63
Montgomery, Ala	+.45	+4.50	-1.39	+1.03	+.41	-1.00	-1.35	-.41
Vicksburg, Miss	+3.61	+5.60	-1.47	-1.15	-.60	-.88	-1.26	+.52
New Orleans, La	+.51	-.60	-.44	-.29	-1.26	-1.18	-1.26	-1.08
Shreveport, La	-1.78	-.02	-1.03	-.09	-.72	-1.30	-.35	+.36
Fort Smith, Ark	-1.57	+.47	-.02	-.15	+.97	-.83	-.28	+.76
Little Rock, Ark	-.03	+1.58	-1.03	+.18	-.02	-.95	+1.22	-.39
Palestine, Tex	+4.21	-.22	-.84	+.22	-.56	+.14	+2.29	+3.55
Galveston, Tex	+3.70	-.19	+.48	-.02	-.68	-.63	-.53	+.78
San Antonio, Tex	+3.05	-.42	-.03	+.05	-.72	-.68	+.51	+2.35
Ohio Valley and Tennessee:								
Memphis, Tenn	-.04	+2.20	-1.25	-.18	+.39	-.88	+.23	-.59
Nashville, Tenn	+3.80	+3.92	-.96	+.44	+.03	-.56	-.93	+.04
Chattanooga, Tenn	+4.52	+2.52	-1.39	+.34	+.40	-.20	-.82	+.15
Knoxville, Tenn	+4.52	+1.85	-1.05	+.41	-.13	-1.06	-1.15	+.30
Louisville, Ky	+.40	+.47	-.10	+1.28	+.94	-.41	-.85	-.02
Indianapolis, Ind	+.99	-.17	-.16	+1.47	+1.28	+.26	-.50	-.54
Cincinnati, Ohio	-.36	-.02	-.15	+1.17	+.64	-.18	-.37	-.41
Columbus, Ohio	+1.33	-.10	+.48	+.27	+.64	-.02	-.24	+.19
Pittsburg, Pa	+2.33	+.59	-.08	-.28	+.14	-.30	-.15	-.48
Lake Region:								
Oswego, N. Y	-.18	+1.36	+.19	+.43	-.18	-.28	+.77	-.45
Buffalo, N. Y	+.59	+.12	-.12	-.34	-.08	-.07	.00	-.54
Cleveland, Ohio	+1.57	+.23	-.04	-.43	+.56	-.16	-.20	-.37
Detroit, Mich	-.63	+.04	-.19	-.47	+.64	-.09	+1.45	-.25
Alpena, Mich	+.67	+.13	+.29	-.33	+.64	-.35	+.05	-.14
Grand Haven, Mich	+.21	-.02	-.37	-.41	+.59	-.07	+.11	.00
Milwaukee, Wis	-.06	-.10	-.37	+.24	+.41	+1.79	-.20	-.33
Chicago, Ill	-.47	-.22	-.48	-.09	.00	+.95	+.25	-.13
Duluth, Minn	+.79	+.92	-.11	+.21	+.32	-.12	-.50	+.05
Upper Mississippi Valley:								
St. Paul, Minn	+.24	+.02	-.28	-.26	-.03	+.53	-.46	-.04
La Crosse, Wis	+1.44	+.86	-.35	-.16	+.29	+.24	-.06	+.49
Davenport, Iowa	-.01	-.11	-.40	+.08	-.31	+.37	+.17	+.87
Des Moines, Iowa	+.38	+.30	+.19	+.38	-.31	+.24	-.03	+.16
Springfield, Ill	-2.74	-.18	-.30	+1.41	-.07	+.77	+.16	-.22
Cairo, Ill	-.27	+1.06	-.49	+.24	+.28	-.52	-.40	-.61
St. Louis, Mo	-1.28	-.26	.00	.00	-.42	-.36	+.16	-.10
Missouri Valley:								
Springfield, Mo	-.96	-.50	-.37	-.42	-.60	+.21	+.64	+.48
Kansas City, Mo	+1.13	+.32	+1.23	+.40	+.13	-.03	+.91	+.31
Concordia, Kans	+.91	+.34	.00	+1.78	+.11	-.70	+.80	-.09
Omaha, Nebr	+1.76	+.61	+.27	.00	-.42	-.68	+1.24	+.10
Valentine, Nebr	+2.27	-.19	-.20	-.08	+.75	-.27	+.03	+1.57
Huron, S. Dak	+.89	-.01	-.13	-.14	+.70	+.26	+.54	+.55
Extreme Northwest:								
Moorhead, Minn	+.94	-.11	-.13	+.57	+.29	+.07	+.23	-.15
Bismarck, N. Dak	-.62	+.01	-.20	+.58	-.31	+.11	+.51	+.14
Fort Buford, N. Dak	-.64	+.01	+.02	-.11	-.16	+.28	+.68	-.15
Rocky Mountain Slope:								
Fort Assinaboine, Mont	-1.55	-.13	-.09	-.10	-.07	-.07	-.13	-.11
Cheyenne, Wyo	+2.38	+.10	-.02	+.63	+.35	-.27	-.07	+.37
North Platte, Nebr	+.25	+.20	-.14	+.46	+1.01	-.38	+.19	+1.23
Denver, Colo	+.86	+.01	-.04	+.57	+2.32	-.42	-.02	+.64
Dodge, City, Kans	+.19	+.50	-.21	+2.42	-.09	-.22	+1.07	+.71

TABLE II.—*Precipitation departures for the season of 1891 from the normal of many years*—Continued.

Stations.	From Jan. 1 to Mar. 6, inclusive.	For the weeks ending— March 13.	March 20.	March 27.	April 3.	April 10.	April 17.	April 24.
Pacific Coast:								
Olympia, Wash	−6.98	−.99	−.33	+.74	−.79	+.57	−.62	−1.27
Portland, Oregon	−5.57	−.88	−1.10	−.23	−.73	+.31	−.60	+.97
Roseburg, Oregon	+4.83	+.27	−.40	+.38	−.61	+.14	−.47	−.21
Red Bluff, Cal	+3.88	−.67	−.67	−.15	−.67	+.67	+.32	−.45
Sacramento, Cal	+.73	−.49	−.57	−.50	−.70	+.42	+.27	−.63
San Francisco, Cal	−.01	+.69	−.46	−.13	−.59	+1.09	+.27	−.47
Los Angeles, Cal	+1.81	−.63	−.34	−.54	−.49	−.09	+.43	−.37
San Diego, Cal	+1.37	−.33	−.09	−.26	−.25	−.03	+.25	−.07

Stations.	For the weeks ending— May 1.	May 8.	May 15.	May 22.	May 29.	June 5.	June 12.	June 19.	June 26.
New England States:									
Eastport, Me	−.06	−.82	−.44	−.19	−.82	−.28	−.84	−.75	+.76
Portland, Me	−.57	−.39	−.52	+1.59	−.37	−.02	−.77	−.44	+.67
Boston, Mass	−.73	−.68	−.69	+.25	−.55	−.14	−.77	+.11	+.76
Middle Atlantic States:									
Albany, N. Y	−.62	−.48	−.64	+.51	−.50	−.13	−.89	+1.02	−.85
New York City, N. Y	−.76	−.25	−.54	+.60	+.49	−.55	−.35	+.25	−.71
Philadelphia, Pa	−.63	−.13	−.27	−.25	−.29	−.65	+.03	+.21	−.13
Washington City, D. C	−.76	−.23	−.16	−.75	+1.36	−.22	−.61	+.47	+1.00
Lynchburg, Va	−.78	−.71	+1.13	−.43	−.49	−.58	−.35	−.44	−.44
Norfolk, Va	−.91	−.82	+.34	−.76	+1.07	−.69	−.72	−.34	−.51
South Atlantic States:									
Charlotte, N. C	−.92	−.98	+3.66	−.80	+1.68	−.77	+1.19	−1.08	−.68
Wilmington, N. C	−.71	−.31	−.85	−1.01	−.71	−1.09	+.35	−.87	−1.00
Charleston, S. C	−.86	−.54	+.10	−.59	+.59	+.36	−.69	−1.08	−1.02
Augusta, Ga	−.78	−.62	+1.59	−.73	+1.45	−.88	+2.89	−.70	−.75
Savannah, Ga	−.72	−.40	+.11	−.52	+.21	−1.42	−.56	−1.01	−1.65
Jacksonville, Fla	+.02	−.20	−.94	−.96	+.93	−1.24	+.44	−.15	−1.14
Gulf States:									
Atlanta, Ga	−.84	−.80	−.72	+.09	+.09	−.91	+1.69	−1.02	+.90
Mobile, Ala	−.95	−.87	−.83	−.04	−.83	−1.31	+.61	+2.81	−.69
Montgomery, Ala	−1.07	−.94	−.34	+.18	+.31	−.81	+1.06	−.50	−.47
Vicksburg, Miss	−1.35	−1.22	−1.08	−.88	−.24	−1.05	+1.34	+1.00	−.82
New Orleans, La	−1.23	−1.13	−.37	−1.19	−1.30	−1.47	−1.11	+1.70	−.95
Shreveport, La	−1.20	−.99	−.99	−.42	−.75	−.93	−.63	−.46	−.48
Fort Smith, Ark	−1.19	+.54	−.93	−.36	−.39	−.73	−.38	+1.28	+.05
Little Rock, Ark	−1.13	+.24	−1.22	−.74	−.91	−1.14	−.20	+.79	−1.03
Palestine, Tex	−1.23	−.55	−1.45	−1.34	−.90	−.88	−.02	−.79	+.40
Galveston, Tex	−.78	−.75	−.79	−.99	−1.08	−1.17	−1.19	−1.12	+.59
San Antonio, Tex	−.77	−.77	−.04	−.54	+.70	−.61	+.25	−.38	+.35
Ohio Valley and Tennessee:									
Memphis, Tenn	−1.17	−.64	−.84	−.76	+.25	−1.17	+1.15	+.82	−1.00
Nashville, Tenn	−1.05	−.65	−.78	−.26	+.84	−.89	+3.46	−.52	−.13
Chattanooga, Tenn	−.67	−.97	−.94	−.58	−.43	−1.03	+1.87	+2.85	−.58
Knoxville, Tenn	−.79	−.79	−.09	−.78	−.39	−.74	+.90	+.21	−.89
Louisville, Ky	−.97	−.40	−.84	−.20	−.61	−.25	−.63	−.98	−.56
Indianapolis, Ind	−.75	−.85	−.80	+.14	−.70	+.02	−.90	−.65	−.86
Cincinnati, Ohio	−.64	−.62	−.71	−.53	−.25	+1.01	+.32	−.81	−.17
Columbus, Ohio	−.81	−.95	−1.12	+.29	+.13	+.03	+.84	−.22	+.20
Pittsburg, Pa	−.59	−.52	−.76	+.53	+.08	+.32	+.11	+.22	+.78
Lake Region:									
Oswego, N. Y	−.50	−.31	−.56	−.01	−.41	−.39	−.13	−.48	−.60
Buffalo, N. Y	−.64	−.33	−.69	−.31	−.25	−.48	−.82	−.46	+.18
Cleveland, Ohio	−.36	−.59	−.69	+.87	−.02	+1.00	+.29	−.70	−.25
Detroit, Mich	−.61	−.22	−.31	−.12	−.79	−.39	−.78	−.24	+.02
Alpena, Mich	−.57	−.81	−.83	−.74	−.86	−.35	−.81	+.80	−.82
Grand Haven, Mich	−.64	−.64	−.60	+.25	−.79	+.93	−.95	−.00	−.78
Milwaukee, Wis	−.70	−.70	−.66	+.47	−.74	+2.13	−.83	+.25	−.39
Chicago, Ill	−.75	−.35	−.64	+.54	−.90	−.09	−.77	−.19	−.86
Duluth, Minn	+.02	−.64	−.60	+1.26	−.99	−.73	−1.24	−.49	−.62
Upper Mississippi Valley:									
St. Paul, Minn	−.61	−.68	−.68	−.48	−.76	+.10	−.90	+.50	−.27
La Crosse, Wis	−.61	−.63	−.63	−.59	−.72	+.04	−.97	+1.46	−.32
Davenport, Iowa	−.82	−.70	−.42	+.60	−.94	−.08	−.45	+.05	−.79
Des Moines, Iowa	−.79	−.95	−.99	+1.54	−.91	−.85	−.80	−1.18	−.30
Springfield, Ill	−.96	−.65	−.60	−.44	−1.26	−.59	−.80	−1.29	−.33
Cairo, Ill	−.74	+.79	−.84	−.49	−.59	−.98	+.55	−.47	+.66
St. Louis, Mo	−.81	+.27	+.02	−.34	−.84	−.72	+1.82	+.02	−.10

TABLE II.—*Precipitation departures for the season of 1891 from the normal of many years*—Continued.

Stations.	For the weeks ending—								
	May					June			
	1.	8.	15.	22.	29.	5.	12.	19.	26.
Missouri Valley:									
Springfield, Mo	—1.24	—.18	—1.18	—.57	—.36	—.18	+2.08	—.23	+.74
Kansas City, Mo	—.90	—.73	+.52	+2.40	—.46	+2.70	—.70	+1.14	—.71
Concordia, Kans	—.73	—.85	—.37	+2.04	—.81	+1.43	—.80	+2.80	—.56
Omaha, Nebr	—.80	—.69	—.88	+1.48	—.64	+1.05	—.50	—.80	+3.12
Valentine, Nebr	—.35	—.35	—.83	—.27	—.91	+.30	—.57	+1.22	+2.11
Huron, S. Dak	—.31	—.67	—.77	—.61	—.62	+.04	—.84	+3.80	—.72
Extreme Northwest:									
Moorhead, Minn	—.45	—.52	—.44	+.03	—.56	+.99	—.80	—.29	+.71
Bismarck, N. Dak	—.56	—.53	—.08	+.60	—.09	+1.00	—.38	+1.09	—.40
Fort Buford, N. Dak	—.17	—.16	—.18	—.37	—.47	+1.84	+.87	—.08	+2.06
Rocky Mountain Slope:									
Fort Assinaboine, Mont	+.51	+1.81	+.13	—.05	—.09	+.15	—.12	+1.65	—.10
Cheyenne, Wyo	—.41	—.49	+1.25	+1.02	+1.00	—.27	—.40	+.53	+.44
North Platte, Nebr	—.41	—.62	—.62	+.74	—.70	+.89	—.35	+2.65	+.35
Denver, Colo	—.57	—.67	—.13	+1.76	+.63	+.07	—.32	+.80	—.04
Dodge City, Kans	—.63	—.74	—.77	+1.35	+.26	+1.33	+.08	+1.96	—.31
Pacific Coast:									
Olympia, Wash	+.67	+1.25	—.50	—.49	—.48	+.11	—.03	+1.78	+.21
Portland, Oregon	+.27	+1.03	—.55	—.55	—.37	—.28	+.71	+1.02	—.81
Roseburg, Oregon	—.40	+1.78	—.40	—.35	+.38	+.68	+.76	+.15	—.01
Red Bluff, Cal	—.48	+.09	—.26	—.21	+.36	+.27	+.18	+.09	—.11
Sacramento, Cal	—.51	+.17	—.19	—.14	—.03	+.01	—.02	—.07	—.01
San Francisco, Cal	—.36	+.36	—.14	—.14	+.51	—.03	+.04	—.07	—.07
Los Angeles, Cal	—.23	—.12	—.07	+.23	—.07	—.07	—.07	—.01	.00
San Diego, Cal	—.17	—.11	—.06	+.24	—.07	—.02	—.01	.00	.00

Stations.	For the weeks ending—								
	July					August			
	3.	10.	17.	24.	31.	7.	14.	21.	28.
New England States:									
Eastport, Me	—.51	+.66	—.92	—.48	—.50	—.77	+.46	—.64	+1.51
Portland, Me	—.50	+1.01	+.50	.00	—.09	—.74	—.84	—.66	—.04
Boston, Mass	—.77	+.56	—.72	+.09	+.54	—.32	—.67	—.60	+1.05
Middle Atlantic States:									
Albany, N. Y	—.86	—.15	—.12	+1.87	+.87	+.05	—.62	+1.07	+1.97
New York City, N. Y	—.84	+.05	—.94	+.05	+.70	—.26	—.64	—.45	+2.39
Philadelphia, Pa	—.66	+.92	—.90	—.51	+.83	—.14	—.49	—.34	+.11
Washington City, D. C	+1.44	+.60	+.39	+.64	+.08	—.88	—.66	+.07	+1.10
Lynchburg, Va	—.03	+.68	—.84	+1.99	—.31	+.91	—.82	+.01	+2.02
Norfolk, Va	—.92	+.78	+1.41	+.94	+.48	—.34	—1.31	—.31	+1.64
South Atlantic States:									
Charlotte, N. C	—.47	—.21	—.81	—.12	—.57	—.29	1.16	—.02	+3.99
Wilmington, N. C	—.60	—1.16	—.52	+.25	+.60	+3.64	1.30	—1.49	+2.81
Charleston, S. C	—.08	—1.32	—1.63	+3.35	+.66	1.40	1.24	1.63	+2.25
Augusta, Ga	—.66	—.88	—1.17	+.35	+3.05	+.03	+.26	—.32	+3.48
Savannah, Ga	—1.24	+.43	—.77	+2.86	+2.57	—.16	+.39	—1.64	+6.19
Jacksonville, Fla	—1.15	—.60	+.54	—.62	—1.24	1.32	—.09	—.85	—.26
Gulf States:									
Atlanta, Ga	—1.04	+.83	+.64	—.95	+1.45	—.56	—.57	—.05	—.68
Mobile, Ala	—.88	+2.37	—.36	—.65	—.13	+.17	—.09	—1.27	—1.40
Montgomery, Ala	+1.86	+.18	—.13	—.84	+.57	+.43	+.01	—.46	—.56
Vicksburg, Miss	—.98	+1.64	+.39	—.57	—.63	—.31	—.49	—.78	—.73
New Orleans, La	—1.44	+.98	—1.05	—.80	—.52	—.27	1.29	—1.27	—1.18
Shreveport, La	—.53	+.57	—.23	—.82	—.30	+.53	.00	—.40	—.53
Fort Smith, Ark	—.64	—.81	+.24	—.05	+7.12	—.85	+.77	—.85	—.78
Little Rock, Ark	—.84	+.29	+.63	—.74	+5.98	+.11	—.77	—.46	+.14
Palestine, Tex	—.70	+1.00	—.35	—.62	+.35	+.27	+1.79	—.25	—.58
Galveston, Tex	+.56	+2.28	+.17	—.28	—.47	—.98	—.90	—.97	+2.01
San Antonio, Tex	—.61	—.53	—.44	—.09	—.66	—.19	—.77	—.79	—.41
Ohio Valley and Tennessee:									
Memphis, Tenn	+.21	+.62	—.40	—.58	+3.65	—.06	—.82	—.33	+.18
Nashville, Tenn	—.32	—.11	—.63	—.84	—.79	—.04	—.75	+1.25	+.65
Chattanooga, Tenn	—.54	+.73	—.39	—.35	+2.83	+1.38	—.78	—.80	—.46
Knoxville, Tenn	—.94	+.83	—.02	—.57	+.50	+.10	—.53	+.04	—.61
Louisville, Ky	—.48	.00	—.89	+1.84	—.42	+2.38	—.66	—.06	—.36
Indianapolis, Ind	—.50	+.09	—.98	—.67	—.87	+.60	—.59	+2.46	—.12
Cincinnati, Ohio	—.23	+1.71	—.18	—.41	+.84	—.70	—.91	+.19	+.41
Columbus, Ohio	+.47	+.61	—.03	+.35	+.77	—.54	+.08	—.18	+.10
Pittsburg, Pa	+.83	+.45	—.07	+.91	+.09	—.68	—.23	—.30	—.29

TABLE II.—*Precipitation departures for the season of 1891 from the normal of many years*—Continued.

Stations.	For the weeks ending—								
	July					August.			
	3.	10.	17.	24.	31.	7.	14.	21.	28.
Lake Region:									
Oswego, N. Y	−.38	+.29	−.54	+.36	+.62	−.40	−.13	+.16	+.14
Buffalo, N. Y	−.13	+.70	−.37	+.06	+.21	−.60	+.75	−.06	+.15
Cleveland, Ohio	−.41	−.43	−.78	−.61	−.59	−.70	+.85	−.57	+.24
Detroit, Mich	−.04	+.20	−.39	+.09	−.77	−.70	−.03	−.06	+.15
Alpena, Mich	+.44	−.71	−.63	−.34	−.37	−.46	+2.13	+.85	+1.14
Grand Haven, Mich	−.31	+.20	−.53	−.06	−.62	−.62	−.62	−.21	−.06
Milwaukee, Wis	−.12	+.67	−.16	−.33	−.17	−.70	−.64	+.22	+.96
Chicago, Ill	+.25	+.38	−.09	−.82	−.78	−.65	−.40	+.38	+2.45
Duluth, Minn	+.43	−.91	+1.29	+.15	−.53	+.02	−.58	.00	−.61
Upper Mississippi Valley:									
St. Paul, Minn	+.56	+.53	+.37	−.53	−.55	−.84	+.42	+1.04	−.67
La Crosse, Wis	+.63	−.08	−.09	−.12	−.84	−.61	−.63	−.09	−.85
Davenport, Iowa	−.12	+1.27	−.50	−.08	−.84	+.28	+1.25	+1.01	−.60
Des Moines, Iowa	−.04	−.80	−.45	+1.49	−.70	−.16	+.48	+1.41	−.61
Springfield, Ill	−.83	+.14	+2.25	−.37	+.49	+.30	+2.00	+.44	−.15
Cairo, Ill	−.98	+.23	−.49	−.41	−.34	−.26	+.27	+2.69	−.47
St. Louis, Mo	−.81	+.20	−.43	−.69	−.65	−.15	+.43	+.58	−.38
Missouri Valley:									
Springfield, Mo	−1.02	+.15	+.33	+.15	+.50	−.71	−.67	+2.46	−.94
Kansas City, Mo	−.43	−.01	−.14	−.48	−.86	+.54	−.97	+3.73	−1.00
Concordia, Kans	+.15	+.07	−.18	+.09	+.06	−.90	−.72	−.67	−.74
Omaha, Nebr	−1.34	−.51	−.50	−.95	−.29	−.30	−.69	+.56	−.63
Valentine, Nebr	−.28	+1.51	−.48	−.16	+.67	+.59	+.41	+2.25	+.12
Huron, S. Dak	+1.56	−.90	−.69	−.08	−.82	−.50	−.07	−.56	−.35
Extreme Northwest:									
Moorhead, Minn	−.75	−.77	+1.04	−.01	−.65	+.22	−.40	+.76	−.57
Bismarck, N. Dak	−.45	+.40	+1.35	−.15	+.26	+.48	−.40	−.26	−.45
Fort Buford, N. Dak	−.21	+.31	+.80	−.40	+.44	−.35	−.29	+.26	−.04
Rocky Mountain Slope:									
Fort Assinaboine, Mont	−.05	−.43	+3.13	−.44	+.18	+1.11	−.29	−.33	−.29
Cheyenne, Wyo	−.22	−.26	−.15	−.30	−.14	−.26	−.24	+1.37	−.15
North Platte, Nebr	−.02	+.72	−.11	+.67	+.01	−.63	−.01	+.40	+.43
Denver, Colo	−.16	−.27	−.37	−.32	+.06	+.12	−.35	+1.45	−.22
Dodge City, Kans	−.51	+1.11	−.34	+.28	+1.30	−.65	+.32	−.69	−.54
Pacific Coast:									
Olympia, Wash	−.28	−.02	−.17	−.14	−.14	+.78	−.14	+.30	−.18
Portland, Oregon	−.26	−.03	−.01	−.14	−.14	+.65	−.14	.00	−.14
Roseburg, Oregon	−.25	+.62	−.06	−.07	−.07	−.13	−.06	+.16	−.07
Red Bluff, Cal	−.06	+.16	+.01	.00	.00	.00	.00	.00	.00
Sacramento, Cal	.00	.00	.00	.00	.00	.00	.00	.00	.00
San Francisco, Cal	−.01	−.09	+.01	.00	−.02	−.01	.00	.00	.00
Los Angeles, Cal	.00	.00	.00	.00	−.03	−.05	.00	.00	.00
San Diego, Cal	.00	.00	.00	.00	−.01	−.07	−.07	−.01	.00

Stations.	For the weeks ending—				
	September				Oct. 2.
	4.	11.	18.	25.	
New England States:					
Eastport, Me	−.19	+1.41	−.51	−.87	−.92
Portland, Me	−.58	+.09	+.04	−.70	−.66
Boston, Mass	−.37	+1.28	−.64	−.66	−.79
Middle Atlantic States:					
Albany, N. Y	−.50	+.02	−.23	−.84	−.75
New York City, N. Y	−.40	+.72	−.82	−.90	−.56
Philadelphia, Pa	−.20	+.75	−.79	−.76	−.47
Washington City, D. C	−.15	+1.43	−.84	−.89	−.61
Lynchburg, Va	−.83	+.06	−.79	−.54	−.73
Norfolk, Va	−.85	−.33	−.37	−1.07	−.11
South Atlantic States:					
Charlotte, N. C	−.37	−.69	−.43	−.75	−.86
Wilmington, N. C	+1.03	−1.08	−1.17	−1.50	+3.86
Charleston, S. C	+.67	+1.13	−.77	−1.39	+3.02
Augusta, Ga	+.79	−.77	−.80	−.89	−.43
Savannah, Ga	−1.32	−.77	−1.48	−1.28	+1.23
Jacksonville, Fla	−.74	+5.19	−.80	−1.89	+1.83
Gulf States:					
Atlanta, Ga	−.39	−.60	−.81	−1.01	−.70
Mobile, Ala	−.31	+.52	−.53	−.74	−.79
Montgomery, Ala	−.45	+.99	−.75	−.71	−.59
Vicksburg, Miss	−.91	−1.10	−1.00	−.76	−.56

TABLE II.—*Precipitation departures for the season of 1891 from the normal of many years*—Continued.

Stations.	For the weeks ending—				
	September				Oct. 2.
	4.	11.	18.	25.	
Gulf States—Continued.					
New Orleans, La	—1.05	— .61	—1.16	+1.36	— .62
Shreveport, La	+ .25	—1.06	—1.11	.96	+3.22
Fort Smith, Ark	— .30	— .42	— .77	— .73	— .71
Little Rock, Ark	— .08	— .91	— .82	— .72	— .56
Palestine, Tex	— .35	— .72	— .80	— .49	— .02
Galveston, Tex	—1.61	—1.85	— .64	+3.46	— .40
San Antonio, Tex	—1.01	—1.11	+ .33	+ .47	+ .27
Ohio Valley and Tennessee:					
Memphis, Tenn	+ .27	— .64	— .79	— .77	— .75
Nashville, Tenn	— .39	— .39	— .92	— .88	— .76
Chattanooga, Tenn	+ .28	— .86	— .63	— .98	— .81
Knoxville, Tenn	— .01	— .77	— .09	— .70	— .59
Louisville, Ky	+ .38	— .07	— .69	— .63	— .47
Indianapolis, Ind	— .37	— .37	— .63	— .68	— .41
Cincinnati, Ohio	+1.11	— .06	— .56	— .49	— .09
Columbus, Ohio	+ .47	— .35	— .37	— .59	— .39
Pittsburg, Pa	— .09	+ .06	— .39	— .61	— .16
Lake Region:					
Oswego, N. Y	+ .17	— .30	— .50	— .70	— .62
Buffalo, N. Y	— .38	— .62	— .02	— .76	— .32
Cleveland, Ohio	— .48	+ .53	— .50	— .88	— .77
Detroit, Mich	+ .26	+ .34	— .63	— .57	— .26
Alpena, Mich	+ .65	— .93	+ .24	— .98	— .82
Grand Haven, Mich	— .47	— .84	— .10	— .89	— .88
Milwaukee, Wis	— .24	— .68	— .70	— .70	— .54
Chicago, Ill	— .43	— .64	— .62	— .70	— .68
Duluth, Minn	+ .16	— .54	— .54	— .68	+1.50
Upper Mississippi Valley:					
St. Paul, Minn	— .45	— .76	— .70	— .73	+ .15
La Crosse, Wis	— .73	—1.22	+ .08	—1.00	+ .54
Davenport, Iowa	— .57	— .69	+ .10	— .77	— .16
Des Moines, Iowa	— .81	— .82	+ .04	— .21	— .42
Springfield, Ill	— .68	— .77	— .81	— .84	+ .46
Cairo, Ill	— .34	— .63	— .62	— .56	— .56
St. Louis, Mo	— .37	— .83	— .73	— .74	+ .30
Missouri Valley:					
Springfield, Mo	— .50	— .06	— .79	— .77	— .73
Kansas City, Mo	—1.06	— .82	—1.05	— .99	— .80
Concordia, Kans	— .16	+1.09	— .56	— .56	+1.93
Omaha, Nebr	+ .25	— .67	— .66	— .28	+1.39
Valentine, Nebr	— .28	— .24	— .32	— .05	+ .85
Huron, S. Dak	— .39	— .35	— .35	— .11	— .03
Extreme Northwest:					
Moorhead, Minn	— .40	+ .80	— .56	+ .89	+ .53
Bismarck, N. Dak	— .23	— .28	— .22	+ .05	+ .71
Fort Buford, N. Dak	— .24	— .21	— .21	— .11	+1.09
Rocky Mountain Slope:					
Fort Assinaboine, Mont	— .12	+ .41	— .28	— .09	+ .05
Cheyenne, Wyo	+ .16	+ .16	— .17	+ .94	+ .21
North Platte, Nebr	— .43	+ .16	— .27	— .31	+ .41
Denver, Colo	— .24	— .18	— .15	+ .38	— .04
Dodge City, Kans	— .37	— .20	+ .17	+1.17	+3.02
Pacific Coast:					
Olympia, Wash	— .33	— .04	+ .71	— .16	+ .25
Portland, Oregon	— .19	— .20	+ .47	— .20	+ .26
Roseburg, Oregon	— .07	— .05	+ .22	— .04	+ .04
Red Bluff, Cal	— .09	— .04	— .07	— .12	— .16
Sacramento, Cal	— .03	— .01	— .05	— .05	— .09
San Francisco, Cal	+ .02	+ .01	+ .05	+ .56	— .09
Los Angeles, Cal	.00	.00	+ .06	— .01	— .09
San Diego, Cal	.00	.00	.00	+ .06	— .07

WEATHER AND CROP CONDITIONS FOR 1891 IN VARIOUS SECTIONS OF THE UNITED STATES.

ALABAMA.

Farming operations begin in Alabama about the 1st of February, although the winters are generally mild enough for some work to be done in December and January. The soil is very seldom so hard frozen at any time during the winter as to prevent plowing and preparation for the planting of certain winter crops.

The weather crop bulletins of this service begin generally the first week in April, because farming operations and the planting of the most important crops have well begun by this time. The first bulletin issued this year was dated April 5. During February and March, however, the cold weather was so severe, following a mild winter, that a large proportion of the fruit was destroyed and but few peaches and plums remained on the trees to ripen. In the second week of April another cold wave passed over the State, and all young corn, vegetables, etc., were killed to the ground and some farmers were compelled to replant. The rainfall throughout April was below the normal, and this condition, together with the cool weather, threw farming operations backward. This drought continuing through the month of May, it was not until the middle of June that fair stands of corn and cotton were secured. During the third week in June the drought was broken by frequent and good showers in all parts of the State, that were greatly beneficial to all crops. Corn and cotton began a vigorous growth from this time, and the season remained very favorable until the 15th of August. In the southern portions of the State half-grown cotton bolls were discovered in the fields on the 20th of June.

The finest crop of corn has been made in Alabama this year that has been gathered in many years. After June 1 the season was most excellent for this crop, and, fortunately for the farmers of the State, quite a large area was planted.

From the 1st to the 15th of August the precipitation was above the normal. From the 15th of August until the middle of September rain fell very seldom; the air became very dry, and crops suffered very much for moisture. The atmosphere was also unusually warm. This dry and hot condition of the atmosphere was so severe that the cotton was badly scorched and the plant was placed in such an unhealthy condition that diseases rapidly set in, and before the 10th of September the young bolls and squares shed to such an extent that the excellent outlook of July 1 was obliterated and the chances for even a fair crop were destroyed. By the 12th it became quite evident in all sections of Alabama that the crop would be reduced fully 25 per cent, if not more. The bad season caused the plant to quit blooming sooner than usual, and a large reduction was made in this way also.

Periods of drought.—April 11 to June 15, and August 15 to September 12.

Wet weather.—June 18 to July 1.

Cool spells.—The months of May, June, and July, and August 23 to August 25.

Warm spells.—August 15 to August 22.

Comparisons between the average precipitation and temperature for certain months in 1891 and the normals for the same period are shown in the following table:

Months.	Temperature.		Precipitation.	
	Normal.	Mean.	Normal.	Mean.
March	54.1	52.9	5.76	8.05
April	63.5	63.3	5.12	1.85
May	73.3	68.3	3.95	2.20
June	77.8	78.5	4.80	4.38
July	83.9	78.6	4.40	5.77
August	78.9	78.8	4.01	2.29
September	79.9	.....	2.74	.....

ARKANSAS.

From Mr. F. H. Clarke, observer, Weather Bureau assistant director of the Arkansas weather service at Little Rock:

General farming operations began about March 21, although at that time the soil was too wet to make good plowing and too cold to germinate seeds planted.

The excess of precipitation at this date was not great, but showers were frequent, and the average cloudiness was much below the normal; this, together with the low temperature of the early part of the month, prevented the soil from drying out sufficiently to make good plowing, and in some portions seriously injured oats that had been sown.

The cool weather was advantageous in retarding the development of fruit buds and thus preventing injury by a subsequent killing frost, which occurred throughout the State on April 4, but no serious damage resulted owing to the lateness of the season.

Corn was being rapidly planted during the week ending April 11, which was favorable for all kinds of farm work.

In the southern part of the State cotton-planting became general about April 16, and in all other portions during the following week.

The mean temperature for May averaged about three degrees per day below the normal, and was injurious to cotton in most sections of the State in preventing growth and tending to bring out cut-worms, which did considerable damage.

The dry weather from the 5th to the 17th of May prevented germination of cotton seed planted, and during the following two weeks many acres were plowed up and replanted in corn. At the close of the month cotton was generally clean and well cultivated, and corn was in excellent condition.

Up to the last week of July cotton was in good condition and promised an abundant yield, but during the last five days of the month heavy rains occurred throughout the State, causing bottom lands to become overflowed and seriously damaging the crop. Rust, blight, and shedding prevailed throughout the lowlands; on the uplands, however, cotton was in excellent condition and promised a full crop.

During the week ending August 20 the temperature averaged about five degrees above the normal. Cotton and corn made rapid growth and was recuperating somewhat from the effects of the heavy rains in the latter part of July when, on the 23d, the weather turned suddenly much cooler and during the ensuing week averaged about eight degrees per day below the normal. This cold spell, which continued until the middle of September, damaged the cotton beyond recovery, causing blight, rust, and shedding to prevail to an alarming extent. This, together with the ravages of the boll and cotton worm, it is estimated, has caused the crop to be cut short about 20 per cent.

A general summary of the weather conditions shows that everything was favorable for cotton up to July 27, when the heavy rains occurred, since which time the condition of this crop has steadily fallen off. The quality of cotton is, however, good and above the average.

The weather was favorable for corn during the entire season, and the largest crop has been harvested that has been made in years.

Oats did fairly well and wheat above the average.

CALIFORNIA.

From Mr. James A. Barwick, observer, Weather Bureau at Sacramento:

The peculiarities of the climate of California leaves but little to say, because there is a wet and dry season, and all crops except grain are raised by irrigation in the summer or dry season, and consequently the weather cuts but a small figure in the effects upon crops. Will, however, say that the first part of the spring was excellent for all crops, and continued so until the begining of the hot wave in the last days of June, from which time up to September wave after wave of extreme heat passed over this State, and so continuous were they that it injured both the raisin and the wine grapes, thereby reducing the average yield of both raisin and wine per acre; but with increased acreage the amount of raisin grapes will be about the same as last year, but the wine output will be very much less in the Santa Clara Valley and somewhat less in the Sonoma and Napa valleys. The grasshoppers ruined crops in certain and scattered areas throughout the San Joaquin and Sacramento valleys and the foothill region.

The following data regarding the planting and maturing of the different crops in the great valleys of this State was taken from my annual meteorological report to the State Agricultural Society for the year 1889.

Planting and harvesting time in the Sacramento and San Joaquin valleys.

Kind of crops.	Planting.	Maturing.
Wheat	December and January	June.
Barley	do	June and July.
Oats	January and February	Do.
Corn	February and March	June to August.
Beans	do	May to July.
Peas	do	April to June.
Tomatoes	do	May to June.
Oranges		December and January.

There is very little if any difference in the time of planting and harvesting the above crops in northern or southern California, except oranges, which color and ripen in northern California before they do in southern California, thereby keeping the orange crop from each part of the State coming in competition with each other, and also preventing the glutting of the Eastern and home markets.

Crops near the coast of the Pacific Ocean ripen somewhat later than they do in the interior and warmer valleys, while some of the counties in the higher altitude have their crops ripen and mature much later than the counties that compose the great valleys of the State.

COLORADO.

From Mr. W. S. Miller, observer, Weather Bureau, director of the Colorado weather service:

The late snows and cold weather last spring retarded farm work a great deal. On account of the heavy precipitation during the winter the ground was in excellent condition. April came in with very little seeding or plowing having been done. Fruit buds were held back by the low temperature, thus saving many that would have been killed by frost later on. By April 15 seeding had been about completed and fruit was beginning to blossom; corn and potatoes were planted from April 20 to the beginning of May. Alfalfa at this time was doing extraordinarily well. Toward the beginning of May the hot dry air had crusted the surface, preventing the grain from coming up, but general rains, which fell from the 10th to the end of May, did the ground much good and placed everything in a fine condition. With the wet weather (which was so excessive in some localities as to somewhat damage alfalfa) came a cool spell, which interfered with the growth of corn. By June 5 wheat was stooling, rye heading out, corn much better color and condition, potatoes and fruits doing well, and the first alfalfa crop being cut. Heavy rains during the second decade of June damaged some hay which had been cut but not secured; about this time an immense berry crop was also being harvested. In the Arkansas Valley cutting of wheat began the last few days of June, followed the next week by harvest in eastern and northeastern Colorado. Wheat was just about ripe in northern Colorado when it was damaged by a severe hailstorm. (Of this storm a full report was rendered at the time.) Toward the end of July water was needed, especially for land not under ditch. Fortunately, general rains fell over the State the last few days of that month; there was not much suffering from drought in any section. At the beginning of August all grain had been harvested except in the San Luis Valley, where the season is normally several weeks later than in other sections of this State. The second alfalfa crop was harvested by the 5th of the month under favorable conditions and well secured. The temperature during August was about average, but the precipitation was considerable less than the average, generally; but a general rain fell during the last few days of that month, so there were no ill effects from lack of water. On August 22 and 23 we had light frosts, doing no damage. The first two weeks of September were quite cool, and had a retarding effect on corn and other standing crops, but the warmer weather since the middle of this month have about placed the crops out of danger from early frosts and they are now ripening very rapidly and will yield well. The third crop of alfalfa is now about harvested. The San Luis Valley grain harvest was completed under very favorable conditions by the 20th of September.

Taking the season as a whole the weather has been very good for agriculturists, and the farmers have had a good year in every way. For fruit we had an exceptionally good year. Sections of the State which are unfortunately located as to water supply raised good crops this year.

ILLINOIS.

From Mr. John Craig, observer, Weather Bureau, in charge of the Illinois weather service at Springfield:

Temperature.—Between the dates March 14 and September 12, 1891, the temperature was below the normal throughout the State sixteen weeks. At the central office the deficiency ranged from 2 degrees to 9 degrees daily. During the following dates the temperature was above the normal: Weeks ending April 16, 23; May 1; June 15, 19, and 26, and August 21; and normal for the weeks ending May 15 and 22; June 11, and July 3. Light frosts occurred during April, but did no damage. Frosts again occurred on May 6, 7, 17, and 27, and did considerable damage to small fruits and tender vegetables.

Rainfall.—The rainfall generally was badly distributed throughout the State during early part of season. During July the drought was unusually severe in the central and southern counties, but after that time the precipitation was generally well distributed over the counties where it was so badly needed.

Wheat.—The seeding of wheat begins during September and is generally harvested about the end of June. The condition of this crop from the first has been good and the weather conditions affected it very favorably, little damage being done by the drouth or fly. Wheat seeding has commenced in the central and southern counties, the ground being in fairly good condition.

Corn.—The seeding of corn begins during May and it is generally ready to harvest between October 15 and November 1. At the present time it is safe to say that at least 70 per cent of it is out of danger from frost, and the remainder will be by October 1. This crop has been retarded by the continued cool weather of the present season. If a killing frost does not come before October 1 the corn crop of the State will be one of the largest ever raised.

Oats.—The planting of oats begins about May 1 and it is generally ready to harvest by July 15. The grain suffered somewhat from insects and the drought which prevailed during July, and considerable of it was damaged by heavy rains which caused it to lodge. This crop will be lighter than usual, but the quality is good.

Fruits.—Strawberries were badly nipped by the frosts which occurred during May, but the crop raised was up to the average. With the exception of apples, the fruit crop was above the average.

INDIANA.

From Prof. H. A. Huston, director, and C. F. R. Wappenhans, Weather Bureau, assistant director, Indiana weather service:

The winter was mild and open throughout, and wheat wintered well. During March, when exceedingly cold weather occurred, wheat was protected by a covering of snow, but the cold weather retarded the development of fruit buds. The heavy rains during the latter part of March and the early part of April delayed plowing, the seeding of oats, rye, potatoes, and tobacco. The latter part of April was more favorable to farm work and crops, and at the close of the month peaches, pears, and plums were in full bloom. The light frosts during the early part of May caused no injury, and fruit and crops did well. About the middle of the month some corn was planted, although the ground was very dry, but during the latter part of the month the weather was more favorable and nearly all the corn crop was planted and oats had improved. In early June much rain fell; wheat was in fine condition, clover ripened, corn grew rapidly, and fruits promised a great yield; strawberries were abundant, but oats seemed almost a complete failure. About middle of June smut and the grain aphis made their appearance in some localities; wheat matured rapidly, and harvesting began in the southern portions of the State on the 13th. By this time oats had improved and was heading, corn was growing rapidly, clover was cut, and berries were plentiful. At the end of June all wheat was in the shock; thrashing had commenced, and oats and rye were being harvested; corn continued to grow rapidly. At the beginning of July farmers began to secure a good hay crop; the oat crop proved short; the peach crop was very heavy. The rain and cool weather about the middle of July retarded the growth of corn, but tobacco grew well. At the end of July potatoes and watermelons were in fine condition; there was an absence of destructive insects.

During the early part of August corn, potatoes, and pastures needed rain, and fears were entertained of serious injury, but the copious rains of the middle of the month benefited all crops and placed the soil in better condition for plowing. There was an abundant melon crop. The rains that fell toward the end of August benefited the crops and the ground continued in excellent condition for plowing; at the close of the month most of the fields were ready for seeding. September began with dry cool weather. At this time the corn planted in the latter part of May was still green and milking; pastures were in excellent condition; and an increased acreage had been prepared for wheat seeding, but little wheat had been sown. About the middle of September hot and dry weather prevailed and proved very favorable to corn, which matured so rapidly that by September 20 most of corn was safe from injury by frost, and in a few days after the date mentioned the entire corn crop was safe. Tobacco was cut about the 20th of September. The quantity, quality, and perfect condition of the tobacco crop of 1891 has not been equaled in past years.

Upon the whole the weather during the crop season of 1891 was very favorable, and, with the exception of oats, there was an abundant yield of an excellent quality of all crops, and in consequence great prosperity prevails in Indiana.

IOWA.

From Mr. J. R. Sage, director of the Iowa weather and crop service, Des Moines:

Despite its many drawbacks and periods of discouragement, the season of 1891 brought the most bountiful crops ever garnered by the farmers of Iowa.

March was unusually cold and wet, and though the moisture was greatly needed, the roads were well-nigh impassable and the fields were generally too wet for plowing and seeding until about the 6th of April. The season was two to three weeks late at the outset, and the same conditions continued until its close.

During the first half of April the weather was cool and cloudy, but the latter half brought more favorable conditions of heat and moisture, giving a remarkable impetus to plant growth and greatly improving the crop situation. The temperature and precipitation of the month averaged somewhat above the normal. Considerable seeding of small grain was done during the month, and in some sections corn-planting was begun about the 25th. Grass was well started, and the month was favorable for meadows, pastures, winter wheat and rye, and small grain crops.

May was cool and dry. There were frequent light frosts in nearly all sections of the State, but no damage resulted except a general retarding of the crops. There was very little precipitation until about the 20th, and the drought quite seriously affected timothy and early-sown oats. At the close of the month, however, the crop outlook was much better than at the corresponding period in 1890. Corn-planting was generally completed before the 1st of June, but considerable replanting was necessitated by the depredations of cut and wire worms.

June was characterized by extremes of temperature and local excesses of rainfall, causing floods and damage to crops; but on the whole it was favorable to grass and small grain, and corn made fair progress. The average temperature was about normal, and there were no damaging frosts. In many localities the excessive moisture interfered greatly with the cultivation of corn, and the weeds gained a temporary advantage. The crop was two weeks late at the close of the month.

The daily average temperature of July was about 6° degrees below the normal, making it the coolest July within the past twenty years. The average rainfall was about normal, and it was fairly well distributed. A very damaging hailstorm on the 1st passed over a narrow belt from Cherokee to Decatur counties, the area of destruction being at least 100 square miles. Despite frequent showers and an unusual degree of cloudiness, fair progress was made in securing the hay and ripened grain crops, and the yield was exceptionally heavy in nearly all parts of the State. The condition of corn, however, was not promising at the close of the month, the cool weather being unfavorable to its rapid growth. But it made a good stand and its color was good.

The first half of August was warm, and growing crops made fair progress. The last week in the month, however, was abnormally cold, and light frosts were reported in every county in the State, but the resultant damage was light. The cool weather checked the ripening of corn, and the prospect at the close of the month was not promising.

September, by an average daily excess of 5° grandly compensated for the deficiency of temperature during the summer months. It was the warmest and altogether the finest September ever known in Iowa, and at its close every acre of corn was practically safe and sound. The first killing frost occurred on the morning of October 5.

All in all, the year of grace 1891 gave the farmers of Iowa the best all-round crop season ever known since the soil was turned by the plowshare of civilized man.

KANSAS.

From Mr. T. B. Jennings, observer, Weather Bureau at Topeka, in charge Kansas weather service:

The cold weather and large amount of snowfall in March, although generally beneficial to wheat and rye, prevented preparation of the ground for spring crops. The month of April opened cool, with much cloudiness, the first week giving much rain in the central and western counties, while the northern and southern remained deficient.

By the 10th of April much plowing had been done, oat sowing was in progress, and the prairie grass had made a good start. By the 18th the oats were generally sown, and in the south the corn was generally planted, while the wheat and rye had their excellent progress. This week gave us some warm weather, which continued through the following week, by which time the oats were making a fine start all over the State; cherry and peach trees were in full bloom, and all vegetation had made a phenomenal growth. In the extreme southern counties corn was 6 inches high, wheat 10 to 15, while rye was heading out.

By May 1 the prairie grass was furnishing good pasture for all stock. The large rainfall during the first half of April, followed by the warm weather in the last half, made a rapid growth in all crops, which, however, received quite a check during the dry weather of the first half of May. In the southern counties the wheat began

heading the first week in May, while strawberries ripened the second week; this week the drought was broken by abundant rains in the west and northwest counties, which became general over the State during the succeeding week. On account of the dry weather during the first of the month the cool weather proved beneficial to all crops, but during the last half it was a detriment. The abundant rains and cool weather continued through the rest of the month, giving great impetus to wheat, rye, oats, grass, and fruits, but retarding corn and the vegetable garden. Home-grown strawberries began supplying the tables of the central counties during the fourth week of May, and the tame grasses were ready for the first cutting.

The first week in June gave us a continuation of the wet weather, but with the temperature much more seasonal, and corn commenced making a rapid growth; wheat harvest began in the southern tier of counties this week. The second week in June the farmers were enabled to get into their cornfields in a large part of the State. Rains stopped the wheat harvest in the central counties the third week, while the crop conditions in the western counties were most excellent; during this week a "dry spell" extended through the southern tier of counties west of Chautauqua, and during the week ending July 4 moved into the counties east of Harper, yet through the greater part of the State the first week in July was the great corn week of the season, the weather having become more nearly normal in all its departments. Rye harvest ended in the eastern counties. During the second week in July peaches and apples were marketed in abundance in central and southern counties; small fruits abundant in all parts except the newest, and corn grew rapidly. The third week the dry weather narrowed to Elk, Wilson, Montgomery, Labette, and Cherokee; the State generally was well watered, especially in the central counties; corn in tassel, much of it in silk. The next week was a good one for general purposes; wheat harvest over, oats harvest nearly so, flax harvest begun, haying in progress. The drought continued in the southeast the rest of the month, with cool, cloudy, and wet weather in the rest of the State, and corn growing rapidly.

The first week in August gave an entire change over the State, a greatly diminished rainfall and much more sunshine, yet a lower temperature; the drought in the southeastern counties extended over the larger part of the southern half of the State, but during the second week was reduced to the counties south of Miami, Coffey, and McPherson and east of Stafford, Kingman, and Comanche; high temperature and much sunshine this week. In the western counties rains put the ground in good condition for fall plowing; in the southeastern counties the long-continued drought (this being the seventh week), coupled with the high temperature, began to affect not only the corn, but also the shade trees; hay crop is proving the best for some years. Hot, dry weather prevailed during the third week of August, until the last two days, when the temperature rapidly fell, snow falling for some minutes during the middle of the afternoon of the 21st near the central part of Ottawa County. The dry, hot weather this week was favorable for the early corn, but unfavorable to the late corn, the former being nearly matured. The drought was broken this week in Labette and Cherokee, but too late to benefit except fall plowing and renew stock-water.

Cold, dry weather characterized the fourth week in August, except in the western and extreme eastern counties, where good rains fell; frosts occurred on Sunday and Monday, but too light to do damage. The continued dry weather began to shorten the late corn crop by too early maturing; at the close of the week the hay crop had been very generally secured.

The first of September was a continuation of the dry, cool weather of the preceding week; corn-cutting was vigorously pushed to save the fodder. Good rains in the western and northwestern counties during the second week in September gave new life to the late corn there, and enabled fall plowing to be successfully pushed.

KENTUCKY.

From Mr. Frank Burke, observer Weather Bureau at Louisville. In charge Kentucky weather service:

The mildness of the winter 1890-'91 greatly favored the condition of fall grains and grasses and left the fruit trees of all kinds in excellent order at the opening of the present season. Plowing was generally commenced about March 10, though the heavy rains which fell for some time previous to that date rendered the ground unfit for cultivation in the bottom lands. The season was, upon the whole, very unfavorable up to May 10. Excessive rain and lack of sunshine retarded all farm work. To these detriments were added heavy, and in many parts of the State damaging, frosts from May 4 to 7. Though the injury from these was not so great as was at first anticipated, they served as a setback to all crops, particularly to fruits. Unfavorable weather conditions delayed the completion of corn-planting until May 10.

Following these conditions came a period of excessive dryness. For a time it

operated to the advantage of crops, but by the 1st of June it had assumed the character of a serious drought, from the results of which the small grain crops never fully recovered. The seasonal precipitation, which on May 1 showed an excess of 0.87 inch, was on May 31 1.37 inches less than the normal. This deficiency was gradually increased until July 15, when it attained a maximum of 5.01 inches. From that date to the present time (September 15) the seasonal deficiency has diminished to 1.64 inches. The seasonal temperature has throughout the season shown a large excess. This is attributable, in the main, to the unusual clemency of the earlier months of the year. The crop season was, upon the whole, uncommonly cool, and during the months of July and August abnormally so. There were no protracted periods of excessive heat, the highest temperature of the season being 93°, on August 10. The amount of sunshine received during the season was probably in excess of the normal, and it was the one condition entirely favorable to crop progress.

The effect of the weather conditions outlined was, except in the cases of a few crops, very deleterious. The exceeding dryness prevailing at the usual time for the setting out of tobacco, about June 10, compelled growers to keep the plants in their original beds until in many cases they became too large for safe transplanting, and in consequence the crop was not in the ground before June 30. This fact, combined with the failure of the young plants to take root rapidly, has been a serious drawback to the crop, and at the present time it is probably ten days late and promises only a fair harvest. Corn-planting was likewise delayed through the dryness of the weather, and for some time after it sprouted the outlook was far from promising. Since then it has recovered from this drawback, and will doubtless be the largest crop ever harvested in the State, barring damage from early frost, to which it is more than usually exposed, owing to the cool damp weather of August retarding its progress towards maturity.

The crop of small grains was considerably smaller than the average. This is particularly true of oats, which in many sections was a total failure. The harvest was completed July 15, and the period of dry weather preceding this time cut the grain short and withered it before it had attained its normal size. The outlook for wheat early in the season, and for a month previous to harvest time, June 20 to 30, was most excellent. The same causes which operated against the success of the oat crop injured this grain, but owing to the earlier date of the harvest their effects were not so serious. Generally speaking, less than an average crop was harvested, though the reports as to the amount in the different parts of the State are by no means uniform; some sections, which had been favored by local thundershowers during the early part of June, reporting more than an average yield, while in other districts deficiencies as great as 50 per cent existed.

Fruits and vegetable crops are generally very fine. The former suffered some injury from the early frosts, but the yield indicates that the effects were not serious.

It is yet too early to predict accurately the character of the hemp crop, but from all indications it will be excellent.

The past season has been unusually free from destructive insects. Apart from some few reports early in the season of the presence of bugs in tobacco, no complaints have been made.

The existing weather conditions are the most favorable of the season for the crops yet unharvested; tobacco has been vastly improved in the past ten days, and corn is making rapid strides toward maturity. In all probability, the latest planted of the former crop will be cut and housed by October 12; the latter is practically out of danger from frost, and by the 25th instant will be fully harvested.

LOUISIANA.

From Mr. George E. Hunt, local forecast official Weather Bureau director of the Louisiana weather service at New Orleans:

The weather as related to crops in Louisiana from March 1 to September 12, 1891, was divided into three distinct periods: The first, embracing the months of March, April, and May, decidedly unfavorable; the second, from first week of June to August 22, decidedly favorable; while the third, from August 22 to September 12, was unfavorable, but to a less marked extent than the first.

The protracted drought which affected the entire State from the beginning of March to the first week in June came perilously near causing a complete failure in all crops. Cotton and rice planting were delayed, much replanting made necessary, and complaints of poor stands of cotton were general. Sugar cane and corn, having been planted previous to March, were not affected as to stands, but suffered severely for moisture. Sugar cane never entirely recovered and the plant is still small and backward, not yet having attained its proper growth. Temperature and sunshine conditions were generally favorable during the drought period, and planters took advantage of the absence of wet weather to keep their crops in an excellent state of culti-

vation. There were several rather notable cool spells during March and April, but beyond slightly retarding the growth of young cotton there is no evidence that they caused any damage.

The drought was broken during the first week in June by general rains, which were succeeded by well-distributed showers of almost daily occurrence over all portions of the State, and these conditions, accompanied as they were by warm weather and sufficient sunshine and extending up to August 22, were the salvation of the crops; and but for the unfavorable turn of affairs that was ushered in with the phenomenal cool wave of August 22 would have turned what promised to be a most disastrous farming year into one of the most prosperous ones that the State has ever known.

The extent of the injury to crops from the cool and dry weather of the period from August 22 to September 12 is yet problematical, but that there will be a serious falling off in the yield of cotton and sugar is beyond doubt.

Conditions have been all that could be desired for harvesting rice, and planters have been enabled to gather their cotton as rapidly as it opens, thus avoiding dirt and stain in the latter crop.

MARYLAND.

From Dr. C. P. Cronk, observer Weather Bureau in charge of the Maryland weather service:

The opening of the agricultural season of 1891 was not propitious. March was a cold wet month. The minimum temperature of the winter, 15.6°, occurred on the 2d, and on the 15th there was another drop to 21.1° The total precipitation, 7.94 inches, was in excess of any previous record for the same month, and the snowfall itself, 20.5 inches, was the maximum monthly fall for the winter. Snow or rain fell on twenty-one days. Spring work was retarded and general farming operations did not begin until March 30. The cool weather checked the rapid development of fruit and the growth of all other vegetation.

The first part of April was also cold, and minimum temperatures of 30° and 32° were recorded on the 5th and 6th, respectively. The season thus far was about three weeks late and apparently unfavorable, but it was doubtless beneficial in preventing the too rapid development of fruit and its subsequent injury from the cold weather and frosts. After the cold weather of April 5 to 9 farming operations proceeded. Ground was prepared without interruption and seeding progressed rapidly. The doubt in regard to the peach crop of Maryland and Delaware was over by April 25, the petals by that time having fallen away, leaving the embryo peaches in a condition to withstand a considerable frost without serious results. There was every indication at the close of the month that the crop would be a full one.

During the last part of April and the first part of May the rainfall was very slight and crops suffered somewhat from drought. The early part of May, besides being dry, was cold, and northwest winds prevailed. Frost occurred on the morning of the 6th, and though harmless in most sections it did considerable damage in some. In eastern Maryland Irish potato tops were on some lands killed to the ground. Over considerable territory strawberries, pears, beans, cucumbers, and melons were reduced to half crops. On the 17th another light frost occurred in favorable localities, but no damage resulted. Light rains fell every day from the 20th to the last of the month and did a great deal of good, but they came too late for oats, which at the close of the month were estimated at a half crop.

During June the rainfall was in excess of the normal, and not well enough distributed to be of the greatest good. At the close of June there was promised a heavy yield of peaches, except in portions of the "Lower Peninsula," where growers attributed the failure to frosts, which injured the stamens in their weakest moment. The high temperature of the 15th, 16th, and 17th had a tendency to damage the wheat before it matured fully, but the rains which followed, from the 18th to the 22d, caused it to ripen nicely. The rain, however, ruined considerable cured hay, and caused the wheat of many fields to lodge badly. In places it was estimated that a loss of 5 bushels in 100 would result from this lodgment of the wheat. This trouble seemed to be confined to northern central Maryland. Tobacco planting began about the 15th, and was nearly finished by the end of the month. The wheat harvest began about the 22d, and was nearly half over by the 30th. The harvested wheat was somewhat injured by the rain of the 26th and 27th, but the general outlook at the close of the month was good for wheat, tobacco, fruit, and other crops.

The first part of July was too wet for the wheat harvest, then being completed, and much grain not housed was injured by the soaking rains, particularly the storm of the 8th. Harvesting was generally finished by the 15th. The almost continuous wet weather from the 22d to the end of July retarded farm work, injured unhoused wheat, and was damaging to all crops. Wheat thrashing was "rushed" during the fair-weather intervals. The peach harvest was begun by the 20th, and the yield bade

fair to be the greatest for several seasons. The crop was somewhat injured by the cold rains of the 28th, 29th, and 30th, but the damage was not material in most sections. The temperature during July was rather too low for the proper development of plants, but taking into consideration the heavy rains of the month, it was doubtless of greater benefit than injury.

During August the temperature and precipitation followed the normals pretty closely, and, generally, beneficial results were the consequence. Heavy rains, however, fell on the 4th and 18th, with the usual detrimental sequelæ. Considerable wheat was thrashed in a damp condition. The yield was large, in some places averaging as high as 39 bushels per acre, but the quality was perhaps a little below the average, owing to the damage by rain. Corn and tobacco did fairly well. August was essentially a peach-harvesting month, the crop, as to quantity, being almost without parallel. At the close of the month some wheat yet remained in the field unthrashed, and, on account of the wet weather, in bad condition. Corn was generally doing well; pasture was excellent, and fall plowing had commenced. The weather had not been favorable to the proper maturing of the tobacco crop, and there were some fears that the crop would be considerably injured. Vegetables and fruit, though so plenty, rotted quickly.

The peach harvest continued in September, and the crop in Maryland was one of the largest in the history of the State. The quality of the fruit was also good. The wet weather continued till the 6th, and ended on that day with one of the greatest rainfalls in the history of the station, 4 inches falling in nine and one-half hours at Baltimore. Reports from other portions of the State indicate that the excessive precipitation was general. From the 6th to the 12th the rainfall was inappreciable and the temperature above the average. Much tobacco was cut, and the late tobacco and corn matured so rapidly that injury from frosts was not probable.

At the time of finishing this report (October 1) both the corn and tobacco crops have in the main been secured, the warm sunshiny weather of the geater portion of the month having exercised a hothouse-like effect in bringing them to rapid maturity. The corn crop is said to be the largest and best in several years, and the tobacco crop about two-thirds of the average yield. The quality of the tobacco crop, however, is much above the average. The greater portion of it has been cut and housed in excellent condition.

Taken as a whole, the season now drawing to a close has been a prosperous one generally to the Maryland and Delaware agriculturist.

MICHIGAN.

From Mr. N. B. Conger, local forecast official, Weather Bureau, director of the Michigan weather service:

The crops came through the winter in very fair shape, wheat wintering very well, and at the close of March was fully up to the average for the season. There was a fair catch of clover and the crop promised well. During the fore part of April the weather was too wet for wheat, but it took the frost out of the ground in good shape and left the ground in favorable condition to receive the spring seeding. The month was cool until the last week, when the temperature was high, and the previous wet conditions placed the crops in average shape; the growth of all crops during the latter part of the month was rank. On account of the wet weather during the fore part of the month, spring seeding was delayed quite a good deal. Oats were above the ground the last week of April in the southern tier of counties.

During the first part of May the weather was too cool and dry for all crops, and fruit suffered considerably from the hard freezes of the 4th and 5th, but not as much as was at first feared. A frost-warning was sent to all parts of the State in time to save much fruit. The dry conditions of the weather at this period did much to save a greater portion of the fruit in the fruit belt of the State. The weather conditions during May were too cool and dry for crops, and consequently the crops made but slow progress; warm rains were badly needed during the month. In the northern section there was very little rainfall and the consequent effect on the hay crop was quite serious, cutting down the average fully 50 per cent. Apple trees did not bloom as full as usual this year, and the orchards were very badly spotted as to fruit-bearing trees. Corn-planting was in full blast during the middle of the month. During the last half of the month light rains occurred in the south half of the State, which tended to greatly revive the crops. A heavy frost occurred on the 17th, which cut small fruits seriously. In the southern section corn was up during the last week of May, and the cut-worms were getting in steady work on the young shoots.

The general conditions during the month of June were unfavorable to the growing crops, being too dry and cool during periods when copious warm showers were needed to create a rapid and healthy growth in the crops, yet the wheat in most sections of the State did fairly well and the yield was better than was anticipated

from the retarded growth during most of the month. No damaging frosts were reported during the month. Local showers were the rule during the month, and many sections of the State suffered considerably from the lack of sufficient moisture. In St. Clair and Sanilac counties the drought in sections was very serious to the hay crop and it was materially shortened. The southern portion of the State did not suffer so much from the drought, as local showers kept the crops in condition during the month. The continued light rainfall, and at times the cool weather, had an unfavorable effect on the crops during July, and the effect begins to show on the corn and potato crops.

Wheat cutting began in the southern section during the first week of July and was general by the middle of the month. Pastures began to suffer from the drought during the latter part of the month, but were relieved by copious showers during the fore part of August. Corn was touched by frost in different sections of the State, especially on the lowlands, but mostly in the interior counties; the damage was light. The light rainfall continued until after the middle of the month, when general rains occurred, which greatly improved the corn, potato, and bean crops, and placed the ground in excellent condition for fall seeding. Oats cutting began in the southern section during the first week of August, and was general during the last half; but some was not secured until the fore part of September, owing to the continued wet weather. The cool weather continued until the middle of the month, when a warm wave set in, which continued until nearly the end of the month, and which was the practical saving of the corn and potato crops, as the warm weather materially improved the corn crop and placed it beyond the danger of frost. The ground being in excellent condition for fall seeding, a large acreage of wheat was sown, and the crop was appearing above the ground in very promising shape at the close of the crop season.

The following estimate of the wheat crop in the State, taken from the September crop report published by the secretary of state, is compiled from reports from several hundred correspondents, and shows that the yield was very satisfactory:

"The returns from thrashings indicate that wheat in this State is yielding far better than estimated earlier in the season. On the 5th of this month, from the returns then in, the approximate yield in the State was placed at near 27,000,000 bushels. More complete returns show that the total yield will exceed this amount. It now seems certain that it will reach, and it may exceed, 28,000,000 bushels. The present uncertainty respecting the output is due to the fact that the acreage is not yet definitely determined, and also to the fact that very many farmers have not as yet thrashed only a part of their crop; hence they themselves do not know, accurately, the average yield on their own farms.

"The oat crop is better than for several years, and barley is yielding well per acre.

"Potatoes will yield about 85 per cent of an average crop. The crop has been injured by the drought, but the recent rains will improve it. If there are no frosts until late, the very late potatoes may be materially improved.

"Winter apples will yield about 30 per cent and late peaches 82 per cent of an average crop."

MINNESOTA.

From Mr. J. H. Harmon, observer, Weather Bureau, director of the Minnesota weather service:

Owing to the heavy snows during the latter part of winter, which kept the ground well covered, the season opened most propitiously for the unusually large crop of this fall.

The rainfall for the latter part of March was in excess of the normal and the temperature normal, except in the extreme northeast portion of the State. A little seeding was reported in two or three southern counties, but the season was generally considered backward nearly two weeks.

In the early part of April seeding was commenced north and about the middle became general throughout the State, except in the lowlands and in some southeastern counties. The ground was in excellent condition to receive seed, and the last of April saw about all the wheat in, with some sprouting.

The 1st of May rye, oats, flax, and some barley were being put in the ground and winter wheat showing above in promising shape; corn was being planted south. About this time grain out of the ground was damaged by frosts and high winds, but nowhere near such a serious extent as was anticipated. Rain was much needed; light showers had fallen in the northwest, but with that exception the ground was suffering from drought.

Later in the month copious rains fell north and south and the drought was temporarily relieved, but more rain was desired. For May the temperature was in excess of the normal, but not to be compared with that of April. The precipitation further widened from the average required to insure good crops.

In early June rains occurred, which broke the drought temporarily relieved in May and improved the prospects for a large yield. Rains were again general during the last half of the month, advancing the crops materially and making June a progressive month for the crops. The heavy rainfall of the month was well distributed. Corn was retarded somewhat by the cool weather, which, however, advanced small grains and allowed them to head out well.

The continued cool weather in July lowered the condition of corn, but was exceedingly beneficial to wheat. The temperature for the month showed a daily deficiency of from 6 degrees to 8 degrees; the rainfall was also below the normal. The last of July saw harvesting in progress in the southern part of the State and haying completed.

With August harvest began north, and the warm weather which ushered in the month proved of great advantage to corn. More rain was required for buckwheat, potatoes, flax, and corn. During the month serious damage from hailstorms was reported. By the 20th harvesting was well under way in the central counties and nearly finished south. Rain set in the latter part of the month, proving of incalculable good to corn, potatoes, and late flax. On the 23d a frost occurred, doing some slight damage to uncut grain in the north and central sections, with but little hurt south except to corn in low places.

September saw harvesting nearly completed over the entire State and thrashing being pushed rapidly. Warm weather setting in early advanced corn, and the excessive hot spell from the 14th to the 25th either matured or placed the entire crop out of danger from frosts.

MISSISSIPPI.

From Mr. R. B. Fulton, observer, Weather Bureau, director of the Mississippi weather service:

In 1891 weather conditions were nearly normal, as to temperature, in January and February. Excessive rains prevailed. The weather was almost continuously cool, the occasional warm spells not lasting over a few days each. Vegetation remained quite dormant and was not affected by the five marked cold waves that came during these months.

The first half of March was characterized by marked changes in temperature. Frosts occurred over all the State about the 5th, 10th, and 15th, and in the northern part it was near the frost point during all this period. Very heavy rains prevailed, being unprecedentedly heavy in the central parts.

The cool weather and frost of the first week in March was seriously injurious to fruit and early vegetable interests, especially in the south, where vegetation had begun to bud.

Up to the 15th very little progress had been made in farm work, the ground having been continuously wet since the 1st of January.

In consequence of unfavorable weather a small planting of oats was made.

The latter half of March was favorable for planting, the ground having dried out rapidly under the increased sunshine and light rainfall. Farming operations were begun over the State, and corn-planting was well advanced in the south. The ground became too dry for the germination of corn in the southwest.

Rains occurred generally during the first week in April, sufficient for the needs of planted crops.

The cold weather on the last days of March, and especially on the 5th of April, was quite injurious to sprouted vegetation everywhere.

The market gardeners in the southern part of the State lost heavily, having been tempted to put out into the fields their tomato and other plants during the mild weather in the latter part of March. Peaches and strawberries were largely killed where they were budding, the crop being nearly ruined in the central and southern sections. Corn was killed down by the frost in the south. But little damage occurred in the northern part, where vegetation was dormant.

From the 8th to the 18th of April conditions were very favorable for spring vegetation. Sufficient showers fell, and both soil and air were in fine condition. Farming operations were pressed, and planted crops and forest growth responded with remarkably rapid development. Cotton-planting was pushed in the south, and in the north corn-planting, with preparation of land for cotton. Early vegetables were replanted in the south.

These favorable conditions continued to be improved up to the 25th of April. Generally good stands were obtained and a vigorous start was made by all staple crops. Cool, dry weather prevailed from April 25 to May 20, and was decidedly injurious. Sunshine was abundant, but cool nights and dry soil and atmosphere checked the growth of crops and caused much cotton to die after sprouting. The stand of cotton was rendered irregular almost everywhere. Corn was not permanently injured.

The last week in May afforded sufficient rain and favorable conditions nearly everywhere. Lack of moisture was again seriously felt during the first week in

June, but rains and warm cloudy weather gave an impetus to all crops between the 6th and 13th. Crops were well cultivated. Excessive rains, doing some damage, occurred between the 13th and 20th. The end of June showed good progress and rapid growth, the rainfall and sunshine having been sufficient and the temperature slightly above the normal during the latter part of the month.

July was remarkable for excessive rains, cloudiness, and low temperature. The rainfall averaged about twice the usual amount, being 6.98 inches. The temperature averaged 78.5, fully 3° below normal for the month. Rain and wind storms did considerable damage about the 7th, particularly in the south. Corn was much injured by these, and cotton was everywhere forced to make too much weed on rich lands.

On the 1st of August a fine corn crop was well assured nearly everywhere, and cotton, though late, was fruiting well. Excessive shedding did not generally follow the July rains. Probably this was prevented by the vigorous condition of the plant, and the fact that hot sunshine did not immediately follow the rains.

By the 15th of August cotton was needing more sunshine and warmer weather to force it to maturity. These conditions came from the 15th to the 22d, the warmest week of the season. The average temperature for that week was 84°, fully 4 degrees above normal. Some shedding of fruit occurred, but cotton responded generally with rapid development. This week of warm weather was succeeded by a continued period of almost unprecedentedly cool weather, the temperature averaging only 68° from the 22d to the end of the month. On four nights it was as low as 48°.

This remarkably cool weather, beginning on the 22d of August and continuing to the 12th of September, has proved disastrous to the cotton crop, decreasing by from 20 to 50 per cent the prospect of August 10. The plant, under the influence of the cool dry weather, ceased to develop new fruit. The blooms and forms fell off, many leaves were shed, rust attacked many fields, and the plant seemed to give its strength to the maturing of the lower and older bolls, which began to open very rapidly, and afford a fine quality of cotton.

Caterpillars have done but little work outside the Delta region, and loss from this cause is small compared with that from unfavorable weather. The boll-worm is still at work, but probably doing less damage on account of the prevailing dry weather. Injury from rust has been widespread and large in the uplands.

A fine crop of corn has been made, both early and late corn doing well. The former was injured by rainstorms in the south on July 7. Irish potatoes did fairly well in the spring, but the second crop is generally a failure. Peas have lately suffered much from drought. The first planted did well. Sweet potatoes have been retarded by drought, but may yet do fairly well. Sorghum was somewhat cut off by drought, especially in the south. Sugar cane has also suffered. Peaches afford a fair half crop in the north, with almost none in the south. Apples are yielding well in the north. Pears have been scarce. Fall vegetables will have small chance on account of drought. The hay crop saved is quite large. On the whole, food crops have given over an average yield. Cotton will probably fall below the average for the State at large, and much below the fine promise of the first part of August. The southeastern and northwestern parts of the State have had the most favorable conditions, and the southwestern section has had the worst.

May seems to be the most uncertain month as to rainfall and temperature, and it is an important problem to decide in what stage of advancement the cotton crop should be in order best to weather vicissitudes of that month. The season is generally long enough for corn to mature if planted any time from February 15 to July 1, and many chances may be taken on that crop as to the date of planting.

Cotton needs for its proper maturing a mean temperature of about 80° for a period of at least two months. The mean temperature in Mississippi in June was 80.5°, or 1.04° above normal; in July it was 78.7°, fully 3° below normal, and in August 78.2°, about 2° below. The seasonal temperature has thus been considerably below the needs of the crop, especially in the northern part of the State. The deficiency of temperature has been accompanied by lack of rain in August and September, and a general abundance of sunshine, excepting in July.

The cool dry weather in the latter part of August virtually ended the growing season for cotton, excepting in a few sections where local rains fell later.

MISSOURI.

From Mr. Levi Chubbuck, director of the Missouri weather service:

For the crop season of 1891 in Missouri the meteorological conditions were unusual; the precipitation was excessive every month from March to September, although very unevenly distributed, and the temperature for the months, excepting only April, was below the normal.

March was a wet, disagreeable month; while the rainfall was only one-half inch above the normal, it came in light showers, making the number of rainy days very

large. The month was unfit for farm work, and the ground plowed in February for oats was not seeded until April.

At that date some corn was also planted in the extreme southern counties. Seeding was about completed in the southeast during the second week of April and commenced in the extreme northwest, but in the remainder of the State excessive rain delayed all work.

After April 23 the conditions were favorable and farm work was pushed.

The temperature for May was 3 degrees below the normal; a cold wave passed over the State on the 6th, with general frosts and light ice, cutting melon vines and doing slight injury to fruit and garden vegetables. Light frost also general on the 11th and 27th, but no damage done.

Warm wave on the 20th and 31st, accompanied by excessive rain and general and severe hailstorms in many sections.

The first twenty days of June rain fell nearly every day, the distribution being very irregular, the greatest excess being in the central and northwest sections, while in the extreme eastern portion there was a deficiency.

The last ten days of the month were seasonable and the heavy growth of hay was everywhere secured, most of it in prime condition; the quality only of clover being slightly damaged by too rank growth.

Wheat, which had been from seeding until June 1 in a condition rarely equaled in the State, was injured by the winds and rains of the month, but the conditions for harvesting were fine in most counties and the yield per acre, determined from thrasherman's returns to date, has been above the average, of a fair quality, although the heads were not perfectly filled and some was ruined in the shock and stack in the northwest by rain. Insects were reported from several counties, but did no perceptible injury.

Oats was not a profitable crop this season, for in the southeast, the only section which produced a fair crop, the area was very limited, owing chiefly to the price of seed and fear of the grain aphis.

Corn was not benefited greatly through the month of July, for the temperature was uniformly below the normal and the rainfall continued unevenly distributed, the deficiency in the southeast amounting to a drought, which affected both corn and pastures disastrously, while in the northwest and west central the excess amounted to 3 inches.

For August the same irregularity in the precipitation continued, although very slightly above the normal for the State.

The temperature was also subject to extremes, the week ending with the 22d being the warmest of the season.

The month was not seasonable for growing crops; the very high temperature and lack of rain permanently injuring corn in the southeast counties, while the heavy rains of the last week caused a material decline in the northwest.

The weather conditions for the month of September have been a seasonable average, very favorable to maturing corn, the bulk of which is now beyond danger from frost.

Notwithstanding the continued unfavorable conditions, the season's crops already secured insure a period of prosperity unknown in Missouri for years.

NEBRASKA.

From Mr. G. D. Swezey, director of the Nebraska weather service:

The season opened very late, a snowstorm occurring early in April and snowdrifts remained on the ground as late as the middle of the month in northern Nebraska.

In the central and southern parts of the State seeding was well advanced by the middle of April, but in the northern part frost was not wholly out of the ground at this time.

There was plenty of moisture in the ground at this time, but the soil was too cold for the ready germination of seed. This was followed during the last half of April by warm wet weather, so wet indeed as to retard farming operations. The last half of May and the month of June were favorable to the growth of small grain, but detrimental to the germination and growth of corn, and which hindered the cultivation of the ground, so that corn became generally very weedy.

During the first half of July the rainfall was below normal, and the period gave good opportunity for the cultivation of the corn and the commencement of the harvesting, but was too cool for the proper growth of the corn. The last half of July was a period of heavy rainfall, with low temperature, unfavorable for the growth of corn and interfering seriously with the gathering in of the small grain.

The third week of August was a period of warm weather and abundant rainfall, which hastened the growth of the corn, which, owing to the prevailing cool weather

of the season, was at this time two or three weeks behind in average condition. This was followed by an abrupt fall in temperature, with the first frost of the season on the 23d and 24th of August, which, however, did no damage except to the tenderest vegetation.

The three weeks following were cool and dry, and the corn, which had already attained a rank growth, made hardly its normal progress.

The third week in September was very hot and dry, with south winds, which hastened the ripening of the crop, which is now out of danger from frost, with the exception of a few late pieces and in the northern counties.

NEVADA.

From Ford A. Carpenter, observer, Weather Bureau, assistant in charge State weather service:

The growing season started out warmer than usual, but with about the average precipitation. The ground being thoroughly saturated with the excessive rainfall of the preceding month, the water ran off and filled the lakes, ponds, etc., thus storing a good deal for use during the coming months. Cooler weather prevailed during April, accompanied by an abundance of rain, causing the alfalfa fields to look fresh and green. The next month, like all preceding, was chiefly characterized by long and continued rains throughout the whole State. Apple, pear, plum, and peach trees and all berries in full bloom about the 10th instant. May was reported from all portions of the State to be more favorable for the growth of all crops of grains and fruit than any other such month for thirty years. June was cloudy, cool, and, like May, very wet; but the weather turned warmer toward the latter part, making all vegetation grow wonderfully. July being normal in both precipitation and temperature, it was expected that the grain and fruit crops would exceed the yield of previous years. August was almost a perfect month for all grains, fruits, grasses, and vegetables. The wheat crop on the Truckee meadows was struck with rust and badly injured, but aside from this single instance other crops have turned out all right. The potato crop has, so far as can be learned, exceeded anything ever raised in this State. By the middle of September all grains were cut and harvested; some few late varieties of apples are yet upon the trees. Taking the growing season all in all, it has been one very satisfactory to the farmers and ranchmen.

NEW ENGLAND.

From Mr. J. Warren Smith, observer, Weather Bureau, assistant to director, New England Meteorological Society, Cambridge, Mass.:

Several heavy snowstorms occurred in New England during the month of March, 1891, and all the northern section was covered with snow at the end of the month. The maple-sugar industry was carried on to considerable extent in that section, but no work whatever was done on the land. In southern New England some plowing and gardening was done in the most favorable localities, and a few peas and early potatoes planted. The temperature and precipitation were slightly above the normal.

On April 1 the season was about ten days ahead of the average, but one of the heaviest snowstorms of the winter occurred on the 3d and prevented further work for several days. It left the ground in good condition in southern New England and farm work was rapidly pushed, the early crops being put in from seven to ten days earlier than the average. In Massachusetts and southern Vermont and New Hampshire the work on the land began about the 20th, but in the northern part of the latter States and in Maine very little had been done at the end of the month. The precipitation for the month was below the normal and the average temperature was slightly above. During the last week of the month the weather was very variable, cold windy days, with threatening weather and snow squalls, alternating with days of intense heat. The weather was generally favorable for farm work, but too cold to put seed into the ground. Heavy frosts occurred on the 29th and 30th, but little damage was done. Rain was much needed at the end of the month, the dry weather continuing over the greater part of New England until May 16. The weather was very cool during the first week in May, and that, coupled with the dryness, made the ground very unfavorable for seed and very little was put into the ground in any section. Heavy frosts occurred on the 5th and 6th, doing great damage to strawberries and to other crops that were above the ground. It was somewhat warmer in the second week in May, and at the end of that time the greater part of the early grains were sown and potato-planting was well under way in the south and well begun in the north, although seeds germinated slowly in the dry soil. A hard freeze

occurred over New England on the morning of the 19th, again doing much damage to strawberries and to fruit and all vegetation. All crops that were above ground, especially in the northern States, were cut down and grass was somewhat injured. Considerable rain fell on the 16th, but the ground was quite dry during the last of the month, the total precipitation being over 1¼ inches below the normal. The mean temperature was over 1 degree below. Planting was not generally completed in the northern States until nearly the end of May—several days later than the average—and all crops started slowly.

During the first week in June heavy rains fell over the greater part of New England, but generally cool weather prevailed, with frosts on the 5th and 6th doing some damage. Dry weather, with steadily increasing heat, prevailed from the 5th to the 16th, accompanied by strong drying winds and much sunshine, and on the 15th and 16th a degree of heat was felt which is seldom ever experienced so early in the season. The effect was very unfavorable on all crops, excepting perhaps corn and tobacco. Grass was much injured and cutting was begun immediately, in the south. Heavy rains fell on the 16th-19th and on the 22d, and more favorable weather prevailed during the last half of the month, although a little too cool. Crops grew well, and grass on lowlands and in the northern States was much improved. Both temperature and precipitation were below the normal during the month.

Much hay was cut in southern New England during the last of June and the first week in July, many farmers completing the harvest. The hay was of excellent quality, but only about 75 per cent of an average crop. Hay-cutting was begun in southern Vermont, New Hampshire, and Maine during the first week of July, and in the northern part of those States it was not general until the second week. The precipitation for the month of July was about the normal and was well distributed. The maximum and minimum temperatures were both considerably lower than is usually registered during the month and the mean for the month was over 3 degrees below the normal. At New Bedford, Mass., the mean temperature was the lowest since 1816. Crops generally grew quite well, but more warmth and sunshine were needed for corn and similar crops.

The mean temperature during August was slightly above the normal, with no extreme ranges. The precipitation was below the normal and a slight drought was experienced over most of southern New England, especially during the first half of the month. In southeastern Massachusetts and Rhode Island and in the southern Merrimack valley dry weather prevailed until the first week in September, but in other places a sufficient quantity of water fell after July 16, and all crops were favorably affected. Corn and grain made a luxuriant growth and will yield large crops. The former was ready for harvest on the 12th (September) and in the south cutting had begun. In the northern States a week or two more of warm weather and sunshine are needed to perfect the growth. The ears have set well and are well filled. Grain was mostly cut before the middle of August, and where thrashed has yielded much above the average. Haying was mostly completed in the northern States by August 25, and more than an average crop was secured. The tobacco harvest was begun during the last part of July, and was generally completed by September 1. A large crop was secured, and of excellent quality. Potatoes were affected by disease during the last of August, but not seriously.

Heavy rains fell on August 28, and on September 8 and 9, doing some damage to crops, but putting the ground in most excellent condition for fall plowing and seeding. Favorable weather was experienced during the first of September for the ripening of crops and harvesting. A large part of the cranberry crop was picked during the week ending September 12. The crop is slightly below the average.

Cambridge, Mass., September 16, 1891.

NEW JERSEY.

From Mr. E. W. McGann, observer, weather bureau, director of the New Jersey weather service, New Brunswick:

The State of New Jersey is in area 7,526 square miles, or 5,263,641 acres. Its climate partakes of the continental type, and is marked by extreme features, but softened to a degree by its close proximity to the ocean. That portion of the State south of Trenton, its capital, is known as southern New Jersey, and is particularly adapted to agricultural uses. The soil is a sandy loam, free from stones, and is well adapted for the raising of all varieties of early truck. The chief crops are potatoes, both round and sweet, sweet and field corn, melons of all kinds, tomatoes, squash, and orchard fruits (peaches and pears). Plowing in this section was possible during a portion of every month during the year, but during the early spring months both it and the planting of early truck were greatly retarded, except on very high ground, by the excessive rains.

The weather conditions which prevailed during the month of April were more favorable, and plowing and planting were pushed rapidly along. All crops did well until the cold spell of May, when severe frosts on the mornings of the 4th, 5th, and 6th did considerable damage to early potatoes and strawberries along the seacoast. The absence of rain now began to be seriously felt and all crops were suffering for the want of it, until near the close of the month, when copious showers relieved and greatly benefited all vegetation. Fruits were then in a most promising condition. The cool nights which prevailed during the first half of June retarded all growth, especially corn, and the maturing of the earlier varieties of strawberries; but the warmer weather which followed helped along all crops. Haying was commenced about the 15th of June and the yield was not more than one-half of the average yield, owing to the frequent droughts during the spring months. At the close of June all crops in this section were in a promising condition, as the heavy rains which fell during the preceding week revived all growth.

Small fruits were in marketable condition on the 20th of July, and the frequent light showers which fell during the picking time were of great benefit in putting this crop to market in good condition. At the close of July the melon crop was about ten days late, owing to cool nights and a deficiency of rainfall.

The early part of the month of August was unfavorable to all crops, except orchard fruits. Cloudy and wet weather prevailed, which was injurious to tomatoes, potatoes, and sweet and field corn, these crops needing more warm sunshine. These unfavorable conditions continued almost during the whole month, and injuriously affected the early peach and truck crops as well as tomatoes, the latter cracking badly on the vines; but the warm and bright sunshiny weather which prevailed during the entire month of September brought all crops rapidly on to maturity to such an extent that the picking of tomatoes, the digging of potatoes, and the cutting of corn was well under way at the close of this month.

The central portion of the State differs very materially from the southern as to climate, soil, and the crops produced. The soil is largely red shale, loam, or clay, and the principal crops are winter grain (wheat and rye), corn, oats, late potatoes, a little garden truck, and orchard fruits (principally apples and peaches). The wheat and rye gave indications early in the spring that no serious damage was done during the winter months by the frequent freezing and thawing. Plowing was commenced early in March, but owing to the reavy rains very little progress was made with this work until the last three days of the month.

During April the planting of potatoes, corn, and oats was quite general, and the weather conditions being favorable, satisfactory progress was made. The growth of all crops, however, was seriously checked by the dry weather and brisk winds which followed the planting and sowing. In many sections the replanting of corn and potatoes was necessary. The severe frosts which occurred on the mornings of the 4th, 5th, and 6th did great damage to early potatoes, which were well above ground, and also to the early varieties of strawberries and tender vegetables. The orchard fruits, which were in full bloom at this time, escaped. The close of May saw no change in the existing conditions, the dry spell still continuing and the cool nights which prevailed making the conditions even more unfavorable to the general growth of all field and garden crops. About the middle of June the condition of all crops was not highly encouraging. Although there was an increased acreage of corn and potatoes planted over the preceding year, the drought and late frosts had made corn come up poorly and necessitated much replanting. Fruits of all kinds continued in a most promising condition. The harvesting of wheat, rye, and hay commenced about June 24 and was completed by July 3, having been favored by excellent conditions.

During the months of July and August rains were more frequent and, aided by the warmer weather, corn made a remarkable growth, as did all field crops. Early fruits matured well and were marketable by July 24. The high temperature which prevailed during the last week of August and during all of September was most beneficial to all crops, especially corn. The cutting of this crop commenced about September 15 and was quite general on the 22d. The digging of potatoes generally took place from September 1 to 3 and continued until the crop was all housed. Fall plowing in this section was delayed by reason of the dry condition of the ground, owing to the absence of rain. In the northern section of the State the principal crops raised are wheat, rye, oats, and orchard fruits (principally apples and peaches) and a little late truck. Dairy farming, however, is the principal feature and is given especial attention.

In this section during the early spring months all farm work was well advanced, and by the middle of May wheat and rye obtained a most promising stand; but grass, which was so promising a few weeks earlier in the season, was suffering from want of moisture. The heavy frosts on the mornings of May 4, 5, and 6 did considerable injury to early fruits and vegetables. The frequent light showers during the last week of May greatly stimulated all growth. At this time oats were very backward,

owing to the cool dry weather, and grass was too far gone to be benefited by the rains. The yield of this crop was far below the average and the lightest harvested for a number of years. The warm nights which prevailed during the middle of June caused all crops to make a rapid growth and wheat and rye to ripen rapidly. The harvesting of wheat, rye, and oats commenced during the last week of June, and by July 5 these crops were safely housed in better condition than for a number of years. The abundant rains which fell during July and August greatly benefited all crops, especially grass, and the meadows again afforded ample pasturage for the cattle. The weather conditions which prevailed during the month of September were all that could be desired for growth and maturing of the late crops. The cutting of corn was commenced about the middle of the month, as also the sowing of winter wheat and rye, but the latter was retarded somewhat by the very dry weather which prevailed during this month.

At the time of closing this report (October 4), the winter grain which was sown during the early portion of September is growing well and has a very promising appearance.

NEW YORK.

From Prof. E. A. Fuertes, of the New York meteorological bureau:

The crops of New York wintered well, and the unusually cool and cloudy weather, while retarding general farm produce, checked the development of fruit buds until the danger of serious injury from frost had passed. By the middle of March, notwithstanding the continued cold and wet weather, the prospects for fruits and grains were good. Plowing had become general in the southern portions of the State, but owing to excessive moisture the soil was in bad condition for working, while north of the Mohawk Valley this work had scarcely commenced. During the last week of March potatoes had been planted and gardening was well advanced on Long Island. The maple-sugar industry was well under way in the southern counties, while in the most northern section little sap had as yet been collected.

During the first part of April abnormally cold weather and heavy snowstorms caused a general suspension of plowing, seeding, and other farm work. Although excessively cold weather prevailed, the deep snows of the 2d, 3d, and 4th protected grains from damage, while fruit buds were not sufficiently developed to sustain serious injury. In the western counties, generally, grass and grains were slightly damaged by the alternate thawing and freezing of the ground, causing upheaval; but over the greater part of the State reports were still favorable concerning these products. The production of maple sugar had begun in the northernmost counties, and large amounts were being made. The middle of the month was characterized by unusually warm weather, with about the average rainfall. Grasses and grains had a vigorous growth, spring sown oats were above the ground in the warm southern valleys, peach trees were in bloom in the southern Hudson Valley, and in many localities the season was stated to be from one to three weeks in advance of the average year. Plowing was being pushed rapidly forward and the soil fitted for corn in the southern sections, while in the northern counties the warm weather had brought the frost out of the ground; but in general, the soil was too wet for working. In the hop regions of the north, hops, which appeared to have wintered well, were uncovered and rooted. Fruit trees were heavily budded, and the prospects for fruit and berries were unusually favorable. Some tobacco was being planted in Oswego County. During the latter part of April the temperature was below the normal, and this, added to the general deficiency of rainfall, somewhat checked the growth of vegetation; but, owing to the very favorable preceding weather, the season was still well advanced. Soil hitherto too wet for working was plowed, and much spring sowing was done.

During the first two weeks of May the continued dry and unusually cool weather retarded vegetation, and crops dropped back to their average seasonal growth. Trees were in full leaf and fruits had blossomed by the 3d and 4th in all sections except the colder parts of the northern counties. On the 5th and 6th severe frosts occurred all over the State, the minimum temperatures ranging from 1 degree to 5 degrees below the freezing point; but owing to the dryness of the atmosphere and the prevailing cloudiness little damage was done excepting on portions of the western highlands. During the middle of the month copious rains in the eastern sections of the State revived the parched vegetation, but in the western part the ground had become too dry almost for cultivation, and crops, especially grass, were supposed to have sustained serious and permanent injury. The germination of corn and seeds recently sown was greatly delayed. Many vineyards and fruit trees were reported ruined by the frosts of the 16th and 17th. General but insufficient rains fell on the 22d and 26th, and this, with the continued cold weather, kept the crops back. Severe frosts occurred on the 26th and 27th, which did considerable damage in the northern

counties. Many early potatoes and strawberries and other tender plants were reported killed.

During the first part of June crops over the State were very much in need of rain. The hay crop was generally estimated at a half or less; and winter wheat, while in better condition than other grains, was becoming discolored and thin. Many farmers plowed up their oats and planted buckwheat; and corn, while doing well in the eastern part of the State, was elsewhere replanted to a considerable extent. Tree fruits in general promised a fine crop, although less than an average yield of apples was expected. Cherries, with strawberries and other small fruits, were reported to have suffered severely by the drought. Rains on the 11th, 16th, and 17th, and a good general rain on the 18th, broke the drought, and fruits and cereals were greatly revived; but the hay crop was generally too far advanced to receive much benefit. Haying began about this time in scattered sections, with prospects of one-half to three-fourths of an average yield; while oats and other spring grains, although growing well, were generally thin, owing to the fact that much of the seed did not sprout. Corn and potatoes, although backward, were making rapid growth, and hops were in fine condition in the northern counties. At the close of June the crops were doing well, although needing rain. Oats, corn, late barley, and the condition of pastures had greatly improved. During the last week haying was begun in the southeastern sections. The rye harvest had also commenced in the lower Hudson Valley, with prospects for an average yield. The temperature and rainfall were below the normal, and a drought prevailed over the eastern part of the State, which seriously injured pastures and potatoes. Hudson Valley grapes, however, were bearing well.

Unusually cool, cloudy weather, with normal rainfall, obtained during the first part of July, which somewhat retarded the growth of corn, potatoes, and garden truck; but the prospects for grass had greatly improved. During the first week wheat, rye, and barley harvesting began in the Hudson Valley. Peaches, pears, plums, and cherries were in fine condition, and an average yield of apples was expected. By the middle of the month considerable portions of the hay, wheat, and rye crops were secured in excellent condition, but in the northern portions this work had scarcely begun. Wheat and rye were of a good color and well filled, and the hay was of an excellent quality. Oats and potatoes were well advanced and in fine condition; corn, although growing well, was still backward. A drought prevailed in the southeastern section, which seriously damaged early potatoes and caused increased injury to crops that had not recovered from the prolonged lack of rain in May and June. Tree fruits were in good condition. Showers during the latter part of June delayed the harvesting. The oat harvest was well advanced in the southern Hudson Valley. Corn was still retarded by the cool nights, but promised a good yield. Apples were unusually sound, although the yield was not large. Pears and peaches continued in good condition, although the peaches were undersized, which fact was attributed by some observers to the excessive yield. In a few peach orchards in Orleans County the "yellows" was noticed. Although the potato blight was reported in a few sections, the crop in general was in excellent condition, especially the late planting.

During the beginning of August heavy local rains occurred and the temperature was considerably below the normal. The wheat and rye harvests were completed, wheat giving more than an average yield and the rye less. The oat harvest became well advanced, with large yield of grain and straw. In general, the crop was free from rust. Buckwheat blossomed and was growing finely. Tobacco, while backward in some localities, promised well. Pears, peaches, and plums were an abundant yield, although the peach "yellows" showed a tendency to spread. The rainfall during the middle of August was very unevenly distributed, and the temperature was above the normal. In general, the ground was in good condition for plowing, excepting in the lower Hudson Valley, where continued drought rendered the soil unfit for working and greatly damaged such products as had not matured. More than the usual amount of bright weather prevailed over the State, however, giving an impetus to late crops as well as checking the potato rot and blight, which had developed to a small extent in various localities. The harvesting of oats progressed rapidly, the yield being much above the average in quantity and quality. Corn grew well and reached an average maturity, excepting in the cool northern sections or where retarded by heavy local rains. Tobacco was growing finely; hops were in good condition in Franklin County, although elsewhere the outlook was not so favorable as a short time previous, principally on account of the ravages of the hop aphis. The temperature for the last part of the month was about normal, while severe local storms distributed the rainfall very unevenly over the State. Pastures and meadows were in fine condition. The ground was excellent for working, and a considerable acreage of wheat and oats had been sown by the end of the month. The oat harvest was not quite completed, and some grain had been slightly damaged by moisture. Corn was still backward. The potato crop was not as promising at the beginning of September as it had previously been. The blight, although not

existing generally, was locally reported from many sections. The outlook for buckwheat was very favorable, and a portion of the crop had been harvested in Chautauqua County. In Franklin County hop-picking began on the 1st of September. The hops were found to be somewhat damaged by moisture. The tobacco harvest began during the first week of September, with prospects for a large yield, of excellent quality.

The temperature and rainfall for the first part of September were about normal and very favorable for vegetation, especially grass, buckwheat, and fruits. The ground remained in excellent condition and fall seeding progressed rapidly and was well advanced. The sowing of wheat and rye was nearly completed in many portions of the State. The potato blight still continued in some few sections, but the tubers were generally in a sound condition and a large crop was being marketed. Owing to the cool nights, corn was still backward, excepting in a few localities, but the harvesting of the crop was expected to be general by the 14th in the Hudson Valley. Buckwheat harvest was well under way by the 10th, and the crop promised well. Owing to the prevailing cloudy and wet weather in the northern part of the State, considerable quantities of oats and other grains remained still in shock on the 9th. Franklin County hops, on account of excessive moisture, are estimated to be below the average yield. The quantity of grapes is below the average, but the quality of such as have ripened is reported very good. Tree fruits in general are abundant, and apples, although the yield is not as great as usual, more than make up for the deficiency by their fine quality and sound condition. Corn is reported as well filled, and an average crop is expected.

NORTH CAROLINA.

From Dr. H. B. Battle, director North Carolina weather service:

Average dates of planting and harvesting of crops:

Preparation of soil generally completed by end of March.
Cotton planted April 1 to April 30; harvested August to January.
Tobacco transplanted April 1 to May 10; harvested July to October.
Corn planted about April 1; harvested in September.
Wheat planted October 10; harvested June 1. Oats and rye planted September 10; harvested June 15.

Dates of planting and harvesting of crops in 1891:

Preparation of soil begun April 1; done very hastily.
Cotton planted April 15 to May 22; picking, not general, September 15.
Tobacco transplanted during May; curing commenced August 28.
Corn planted early in April; harvested average date.
Harvesting wheat and rye progressing June 19; planting September 10.

Normal mean temperature, and rainfall and departures for 1891.

Months.	Temperature.	Departure, 1891.	Rainfall.	Departure, 1891.
January	41.5	−0.2	4.64	+0.20
February	44.7	+3.2	4.10	+1.50
March	48.8	−3.5	4.83	+2.50
April	57.9	+1.2	4.00	−1.78
May	67.5	−3.3	4.10	+1.26
June	74.9	+0.5	4.64	−1.25
July	78.6	−4.1	5.24	+1.50
August	76.4	−0.7	6.09	+1.91
September	71.1	.....	5.20	.....
October	60.7	.....	4.17	.....

The weather crop conditions during the season of 1891 have been unfavorable from the beginning in the State of North Carolina. Owing to the continued cloudy weather and excessive rains during the first three months of the year the usual preparation of the soil, which begins early in March, was delayed fully three weeks. March was the coldest and wettest month, with a departure from the normal of −3.5°, and an excess in precipitation of 2.50 inches. The soil became soaked, roads were so muddy as to be nearly impassable, and outdoor work was impossible. At the beginning of April the "rainy season" suddenly ended with a cold snap, sending the temperature below freezing on the 5th, with heavy frost. Drought prevailed during the latter part of April and the first half of May, causing the soil to become rapidly dry and hard.

Planting was done chiefly during April and early part of May, and was done too hastily, without proper preparation of the soil, resulting from the start in a poor

stand of the chief crops, especially cotton. The stand was further injured by the late killing frosts of May 5, 6, and 7, which greatly damaged truck crops and injured cotton in many places so as to necessitate replanting, some of which was done as late as May 22. Fruit generally escaped serious injury. The transplanting of tobacco, which generally begins April 1, was commenced a month later this year. The weather conditions during May were unfavorable because of the drought during the early part, broken about the 12th, and on account of the decided deficiency in temperature, the departure from the normal being —3.3°. This was the chief cause of the subsequent poor and late condition of the cotton crop.

June was the most favorable month of the season, being slightly in excess in temperature and deficient in rainfall. Crops grew rapidly and farmers were enabled to cultivate and destroy weeds and grass, which had made unusual headway. The favorable conditions continued until the 10th of July, at which date cotton was blooming freely and crops were cleared of grass and well cultivated. But the remainder of July was unusually cold and wet, making it the coldest July for the past twenty years. The deficiency in temperature for the State was 4°, with an excess in precipitation of 1.50 inches. The condition of all crops except corn rapidly deteriorated, especially cotton, the growth of which was delayed and blooming stopped. The first three weeks of August were favorable for all crops, but excessive rains fell again during the latter part. September was drier, with cool nights, which were decidedly unfavorable.

The condition of crops during the latter part of the season is as follows:

Cotton is from three to four weeks late, bad stand, very weedy, but not fruiting well; is shedding upper squares and is suffering materially from rust. An early frost would do very great damage, but with very late fall a conservative estimate would not place the yield higher than 70 per cent of a full crop. Cotton is opening very slowly and picking is progressing at but few places, while at this time last year the greater part of the unusually large crop had been picked and marketed.

Tobacco is being cured rapidly, but the damage by excessive rains during July and the latter part of August is now seen to have been considerable. Curings are too frequently poor both in color and quality, but the yield will be good.

Corn was in excellent condition throughout the year, and a full crop gathered. The uniformly good condition of corn as compared with cotton, even in unfavorable years, should serve as a warning to farmers to place more dependence on food crops and less on cotton, which seems always the first to suffer from the effects of bad weather.

Trucking was very successful in the southeastern part of the State. The yield of fruit is excellent and abundant. The yield of grain and minor crops has been somewhat below the average.

A special characteristic of the season was the unusual number of destructive hailstorms occurring during May, June, and July, which have inflicted thousands of dollars damage to crops in this State during the season.

The crop season of 1890 was so excellent, the yield of the staple crops (except fruit, which was a failure) being the largest obtained for many years, that the following comparison of the departures during the first half of the years 1890 and 1891 is instructive:

Months.	Departure in temperature, 1890.	Departure in rainfall, 1890.	Departure in temperature, 1891.	Departure in precipitation, 1891.
January	+9.0	—3.21	—0.2	+0.20
February	+6.9	+0.10	+3.2	+1.50
March	—0.8	—1.43	—3.5	+2.50
April	+0.8	—1.25	+1.2	—1.78
May	+0.0	+0.69	—3.3	+1.26
June	+2.7	—1.81	+0.5	—1.25
Total	+18.6	—6.91	—2.1	+2.43

OREGON.

From Mr. B. S. Pague, observer, Weather Bureau, assistant director of the Oregon weather service:

Farming operations in Oregon are almost continuous. The harvest of 1890 was finished, and immediately plowing and seeding were begun. The fall plowing and seeding depends upon the commencement of the autumn rains. The almost rainless period from June 20 to September 20 allows the earth to become very dry, and it is not until the rains begin that extensive plowing can be prosecuted. Hence favorable climatic conditions are of paramount importance. The period from July 1, 1890, to January 1, 1891, was unusually dry, the precipitation in those six months

being from 15 to 70 per cent below the normal amount. The temperature was about 2 degrees above the normal. During December and January much of the land was prepared for seed. Almost uninterrupted outdoor work was done during January. Spring was apparent during the month, buds swelled, leaves broke forth, and an open winter seemed imminent. There was an absence of frost in the ground up to the 1st of February. February was cold and wet. In western Oregon the ground was thoroughly saturated with moisture; in eastern Oregon snow covered the ground. The backward conditions commenced February 1 and continued up to March 21, when warmer and drier weather prevailed. There was little farm work done during the month of March. In western Oregon the soil was too wet, except on the uplands; in eastern Oregon the snow was melting; by close of month the snow was gone, but the soil was too wet to be worked. Up to April 1 there was little spring seeding done. The winter wheat was, however, in excellent condition; the mildness of the winter prevented any freezing out; it had a good color, and was well rooted and well stooled. April opened cool, with freezing temperature and frost, and closed with springlike temperature and weather. The April night temperature was higher than usual. There were no warm days; only one maximum was reported above 80°. During April spring seeding progressed very well, especially in southern and parts of eastern Oregon, in Umatilla and Morrow counties particularly. The cool weather checked rapid growth and allowed vegetation to gather root, strength, and vigor. Toward the close of April winter wheat had good growth. Oats were healthy and had an equal growth with wheat. By April 20 fruit trees were blooming and leafing; hops were above the ground and in a very thriving condition; sheep shearing was in progress and the best clip for years was being secured. Owing to the mild winter, stock wintered remarkably well and the range grass was very good. There were frosts in March and April which at the time were not considered damaging, yet during May it was found that the fruit was considerably injured by them, not sufficiently injurious, however, to make a marked shortage in the total yield of fruit, for fruit trees bear so heavily that unless frosts prune out the superfluous fruit it must be done by hand, otherwise the fruit trees would bear themselves out or break down. Seeding continued during April, first on the uplands; then, as the soil gradually dried out, seeding was done on lower land. By May 10 seeding was practically over and the weather conditions were very favorable to the growth of all crops. The entire spring was backward; April weather was favorable to the life and vigor of vegetation, May to the growth and advancement, up to the 23d, 24th, 25th, and 26th, when hot dry winds prevailed along the upper Columbia River basin, doing considerable damage to cereals. During June cool, partly cloudy weather, with general and frequent rains, prevailed. There was an absence of any injurious climatic conditions and the presence of all favorable ones. The ripening period was delayed, but the certainty of fine crops improved each day. Haying was in progress during the month, and never before were there such hay crops secured. Strawberries and cherries yielded well, although both were injured by the rain. Hops thrived, and the hop-louse made its appearance. The weather conditions kept the codling-moth and kindred insects in embryo. July was favorable to the ripening of cereals, fruit, etc. There were no injurious conditions except an extremely hot period from the 22d to the 25th. In Wasco and Sherman counties the grain was somewhat injured; in other sections it was too far advanced to be injured, considerable fall wheat having been cut. During August harvesting was in fine operation. Rains on the 4th, 5th, and 6th delayed harvesting, but did no damage. Harvesting continues on September 12, and will continue until about October 1, when practically all the grain will have been thrashed.

To summarize, it might be said the dry autumn of 1890 delayed fall plowing and seeding, the warmth of December and January advanced vegetation, the cold and wet of February and March delayed spring operations and advancement of vegetation. April, May, and June were very favorable to the growth of vegetation, July and August to the ripening and harvesting of products.

Frequently in June the weather becomes very dry and a hot period comes along, which does great damage to the grain, drying it up, shriveling the berry, etc. This year the only injurious climatic condition was the hot wind in the latter part of May, which did slight damage in the upper Columbia River basin. The June rains, however, repaired about all the damage that was done.

The harvest of all cereals and fruit in Oregon this year was never better. The wool clip was large and most successful. Stock wintered well, the loss was practically nothing, and they were in prime condition for sale in May and June. Hops bore well, but the hop-louse did damage. Corn never yielded so well. Melons were plentiful and of immense size. Garden truck was late in developing, but all gardens were successful. Potatoes are so plentiful that many acres will not be dug, as they won't pay for the digging. Good prices prevail, debts and mortgages are being paid off, and the Oregon farmer is happy and prosperous over the successful harvest of 1891.

OHIO.

From Mr. Charles M. Strong, observer, Weather Bureau, secretary of the Ohio meteorological bureau:

Excessive rainfall during the month of March and deficiency in temperature during the first half of April prevented farming operations on any large scale from taking place.

During the latter part of April and the first few days in May farming operations were in general progress in all sections of the State, and advanced rapidly under favorable auspices, although the ground being rather hard made plowing difficult and delayed the work.

The temperature and sunshine, both above the normal, favored plowing and the development of wheat and grass, which grew rapidly. The rainfall was deficient and was badly needed to soften the ground. From the 2d to the 9th of May the temperature was much below the normal; killing frosts, with ice forming, being reported generally from all sections of the State on the mornings of the 5th, 6th, and 7th. The wheat plant was badly touched in localities in the northeast section. Tender plants and fruit were seriously injured north of Columbus, and grape shoots were badly nipped in many localities south. A peculiar haziness and dryness of the atmosphere contributed largely toward preventing serious effects from frost south of the center of the State. The drought that began during the month of April continued until the 19th in the northern and middle sections, when copious showers fell, reviving the vegetation, which was begining to suffer seriously. Despite the drought the wheat continued to improve under the influence of the dry cool weather to the 17th, when another killing frost injured it somewhat on low grounds in some localities. This frost also killed garden vegetables, fruit, potato vines, and corn in the northern and middle sections. The effects of the frost on fruit were noticed in the latter part of the month, in the general falling off from trees. The month closed with excessive cloudiness and lack of warmth, but was beneficial on account of continued excess in rainfall, which further relieved the droughty conditions and placed ground in better condition for working.

During the first of June excess of rainfall and alternate sunshine and cloudiness produced excellent growing weather. Cereals were doing well, although the corn was retarded in growth by the cool nights. Increased warmth, with deficiency in cloudiness and rainfall, formed very favorable conditions throughout the balance of the month, and were evidenced in the rapid development of all growing crops, especially corn, potatoes, and tobacco, and the maturing of the wheat, which was being harvested in the middle and southern sections at the end of the month. The rapid development, with accompanying high temperatures, proved injurious in only one thing, that is, in the rapid growth of weeds in the corn and baking hard of the ground.

During the month of July the temperature was considerably below the normal, but injurious effects that would naturally result from this condition were overcome in a large degree by deficient cloudiness and opportune rainfalls. As a whole, conditions continued favorable, and the development of all crops, except the corn, which was hindered by the cool nights, were in proportion. In the northwest portion of the State droughty conditions prevailed during the latter part of the month; also, grasshoppers proved very destructive to oats and pasturage. At the end of July the wheat was generally secured, oats were ready for harvesting, and fall plowing was ready to begin.

During the first week in August the deficiency in temperature, with excessive cloudiness, rendered conditions unfavorable for corn and potatoes. The farmers of the northwest section were cutting their oats to save them from the grasshoppers. Fall plowing was also commenced. During the second and third weeks corn, potatoes, and pastures were affected unfavorably by continued dry conditions, but the oat harvesting was facilitated. The drought was especially severe in the northwest portion of the State. During the week ending the 29th the drought was generally relieved by copious showers; corn, potatoes, and pasturage were revived, and fall pasturage saved. Fall plowing continued during the month under generally favorable conditions, the only difficulty encountered being dryness of soil.

Deficiency in temperature, excessive cloudiness, with only normal rainfall, rendered conditions unfavorable at the commencement of September, but this was relieved by the second week by return to more seasonable conditions, followed the third week by summer heat and dryness, which, at the present writing, has placed all crops in a secure state and matured the corn, tobacco, and potatoes.

The fall plowing is about finished, also wheat seeding, with largely increased acreage.

Fall pastures are again suffering from droughty conditions.

Periods of drought, wet weather, or normal conditions:

March 1 to 10, normal rainfall.
March 10 to 20, excess in rainfall.
March 20 to April 9, normal rainfall.
April 9 to May 19, deficient rainfall.
May 19 to June 8, excess in rainfall.
June 8 to 28, deficient rainfall.
June 28 to July 8, excess in rainfall.
July 8 to 18, normal rainfall.
July 18 to 28, deficient rainfall.
July 28 to Aug. 7, excessive rainfall.
Aug. 7 to 27, normal rainfall.
Aug. 27 to Sept. 12, deficient rainfall.

Cool and warm spells:

March 1 to 30, warm.
March 30 to April 9, cool.
April 9 to 29, warm.
April 29 to June 8, cool.
June 8 to 28, warm.
June 28 to Aug. 7, cool.
Aug. 7 to 27, warm.
Aug. 27 to Sept. 12, cool.

PENNSYLVANIA.

From Mr. L. M. Dey, observer, through Mr. Ball, assistant observer:

A State large as Pennsylvania must necessarily be divided into several areas, in each of which general farming operations—the planting and raising of crops and their final harvest—occur at different periods of the year. Local farming operations depend upon both the latitude and the altitude of a given place, so that we find farm work either more advanced or behindhand according to location, whether in a higher or lower latitude, in the valley or upon the mountain side. Spring farm work properly begins with plowing for spring wheat, oats, and early potatoes. The date of commencement depends upon the character of the past winter and the condition of the ground during March and April. As soon as the ground thaws sufficiently the plow is put in and the work occupies the greater part of March and April. The plowing season of 1891 in Pennsylvania was unfavorable.

In many places the ground was hard and dry, and farm work and plant growth were backward. Corn-planting usually extends from about May 1 to June 10. This season the planting was late and slow. Much of the early planting failed to germinate, owing to the insufficient moisture. Frosts and some freezing weather occurred during the last week in April, but only slightly damaged fruit trees and tender plants. The trees were heavily laden with bloom, and some declared that the frost was beneficial, as it caused many of the blooms to fall, thus relieving the weighted trees.

From May 1 to 15 plowing for corn was still in progress in the northern counties, while in the southern the planting was well advanced and some of the corn was above ground. The season was still backward. Cold dry weather continued, yet little damage was done to wheat, grass, and fruit trees. Considering the unseasonable weather, the fine appearance of vegetation and growing crops at this time was remarkable. After May 15 the outlook grew serious, the drought continued, and all crops were suffering. Corn planting was delayed and wheat and grass showed the lack of moisture. The temperature at this time was nearly normal, which was exceedingly fortunate.

By June 1 crop planting, except tobacco, was nearly over. Weather still unfavorable, and but little rain had fallen. During the week ending May 29 general rains had fallen, and these in many sections saved the crops from serious injury. Cool weather continued, yet, notwithstanding all, the condition of the crops was encouraging.

A hot spell occurred from the 8th to the 17th of June, and the crops advanced rapidly. The warm weather and generous rains lent renewed energy to plant life. Corn especially improved wonderfully, and correspondents stated that wheat never looked better than at that time. Enormous crops of tobacco and potatoes were planted, the warm showery weather being especially favorable for tobacco planting.

By July 1 haying had commenced and tobacco had been about all planted. All crops were in fine condition and the weather propitious. Wheat harvest began about July 3 and was soon in full blast. Rarely before has such an enormous yield of wheat been seen in Pennsylvania. Everywhere farmers were rejoicing at the luxuriant fields of waving grain. Other crops were also in fine condition. The

weather was cool and retarded the growth of corn, but the outlook for a large crop was very promising.

Hailstorms on July 3 did some damage to corn, tobacco, and fruit in the central portions of the State. Thus far the season had been without destructive storms of any kind.

Wheat harvest was nearly over by July 20, and still greater satisfaction was expressed at the prospects of a splendid yield.

A protracted cool spell occurred during the whole of July and the early part of August. On three days only did the temperature rise above the normal. No serious damage resulted, other than to delay the growth of corn. From August 12 to about the 25th the weather was generally warm and sultry. In the extreme northeast section the drought remained unbroken and the crops suffered greatly. Wells, springs, and small streams were dry, and it seemed that the season would be disastrous. Copious rains fell during the latter part of August and greatly revived vegetation.

The week ending August 28 was characterized by destructive and terrific rain floods in the interior counties of the State east of the Allegheny Mountains, and especially in the Schuylkill and Lebanon valleys. In many places the rain was the heaviest ever recorded, but fortunately the crops on the whole were too far advanced to be seriously injured. The period of wet weather continued until September 7. Since then the days have generally been fair and cool, affording excellent opportunity for farm work. Corn needs more sunshine and warmth to mature it before frost. Preparations are making and fall seeding will begin properly about the middle of September. Farmers are rapidly pushing the cutting of tobacco, the cool weather causing them to fear the approach of frost.

On the whole the year has been singularly prosperous, and well illustrates the proverb, "A bad beginning makes a good ending." The early season was unfavorable. Cool weather and dry soil retarded farm work and the growth of crops. Notwithstanding all, the outlook was at all times favorable. A brief period of drought darkened the bright horizon, but generous rains and plenty of sunshine dispelled the gloom. The extreme northeast section, it is true, suffered a protracted drought, but rain came in time to save most of the crops and the yield was very fair.

In conclusion, it can be said that few years within the memory of man have yielded more abundant harvest, few have given more pleasant weather for farm work, and few have given less cause for complaint of floods, droughts, insects, or the many other evils so well known to agriculturists.

SOUTH CAROLINA.

From Mr. A. P. Butler, observer, Weather Bureau, at Columbia, director of State weather service:

The general farming operations began about the 1st of March, but were attended with but little success. The excessive rains prevented the proper preparation of the soil and greatly retarded the planting of the corn crop, so that at least half of April was consumed before the farmers could prepare any portion of the lands for the cotton crop. About that time the rains ceased and the soil became so hard that it was impossible to plow and plant the remainder of the crop until about the month of June, and much of that which was planted late did not germinate, and it was not until the latter part of June that it could be said that the crop was fairly up, and not until early in July was the crop reduced to a stand. Much of the land was so overrun by grass that came up before the plant that the stands were made imperfect by the choppers, and in some instances the crop was abandoned, so that about one-third of the crop was very late, and the continued rains caused that part of the crop to grow unusually fast, taking on and holding but little fruit.

The early cotton, while it grew very slow in June and the first part of July, had fruited well, when the rains, the want of sunshine, and the low temperature in July and August and the two weeks in September caused the plant not only to shed, but to rust, the seed to sprout in the open bolls, thereby destroying much cotton and badly injuring the staple, so that the prospects of a fair average cotton crop is not encouraging, and will certainly fall far below the crop of last year.

SOUTH DAKOTA AND NORTH DAKOTA.

From Mr. Samuel W. Glenn, observer, Weather Bureau, director of the South Dakota weather service:

The winter of 1890-'91 was milder than usual until after February 1. The greater portion of February was warmer than the seasonal average. Stock fed and fattened on the range most of the winter, thereby enabling stock men to carry them through on what would otherwise have been a serious shortage of feed.

A little seeding was done at favorable opportunities in the early part of March, but this work was not general until the latter part of the month, when it was prosecuted under favorable conditions of soil, due to the melting of recent snows. Interruptions were frequent during the month from frost, cold, and snow.

In the first half of the month of April seeding was interrupted by windy, cool, and rainy weather in most sections, but every favorable day was utilized. The latter part of the month warmer and more favorable weather prevailed, and by the 24th much of the grain was well sprouted and growing under most favorable conditions of both moisture and temperature, inducing a much larger acreage to late wheat than was anticipated. The month closed with the sprouted grain in South Dakota in luxuriant growth, and most of the seeding done; while in North Dakota, latitude considered, as favorable conditions prevailed, but work not so well advanced. Frosts occurred in North Dakota and portions of South Dakota the latter part of the month, but no serious damage reported.

The first week of May was unusually cool, and frosts did slight but temporary damage to staples in North Dakota and northern South Dakota, and considerable injury to berries and early vegetables. The temperature was below the average most of the month, and showers were local, some localities feeling the need of rain very much during the last week, especially for corn, and some specially late small grain that had lain in the ground unsprouted for some time. Frequent high winds added to the effect of the droughty condition. This condition was, however, permanently relieved by general showers on the 28th and 29th. Corn planting was general during the month. The month closed with North Dakota in better condition in point of moisture than South Dakota, with crop advancement correspondingly satisfactory. In South Dakota corn was doing fairly well, but needed warmer weather.

The temperature of June was below the average, as also the amount of sunshine. Unusually heavy and opportune rains occurred over both States, stimulating all crops to phenomenal growth. High winds were slightly detrimental, and local hailstorms inflicted some injury, but the general conditions were exceptionally favorable to small grain and grasses. Corn, already behind the seasonal condition, would have done better with warmer weather. In localities where the droughty conditions of May had seriously injured crops the ground was reseeded to something of later maturity. The conditions during June converted the fears of May that there would be a repetition of former unfavorable seasons into rejoicing, and the month closed full of promise for a most bountiful crop of small grain and grasses. June practically made the wonderful small-grain crop produced by the Dakotas during the season.

The temperature of July was below the average, while the rainfall was about the average over North Dakota and below over South Dakota. The amount of sunshine was about the average. The conditions highly favored small grain in South Dakota, but in North Dakota the growth was most too rank; considerable complaint was made of "lodging," and fears were entertained that grain would not mature before possible early frosts might injure it. By the 25th the harvesting of small grain was well advanced in South Dakota, and progressing under most favorable general conditions. Localities in North Dakota had reported light frosts, but no serious damage. Local hailstorms did some damage in both States. The month closed with the harvesting of small grain in southeast South Dakota practically completed and elsewhere well advanced, while in North Dakota most of the rye and barley was cut, with indications that general harvest would begin about August 10.

During August the absence of general rains, the abundant sunshine, and higher temperature all combined to produce the most favorable weather for the completion of the ripening, harvesting, a limited amount of thrashing, and late hay-making in South Dakota, and pushing toward completion of the harvest in North Dakota. Corn (not a staple in North Dakota), considerably behind the seasonal condition at the close of July, made marked advancement, and garden stuffs and grass crops developed finely. Unfortunately, a frost occurred over most of North Dakota and northern half of South Dakota on the 22–23d, doing considerable damage to small grain in North Dakota (in quality more than quantity) and killing vines and vegetables, and damaging corn considerably in South Dakota in areas, many localities in the frost belt escaping with little or no injury. Timely warnings from the Weather Bureau doubtless did much good, as "smudges" were general in both States. Some damage was done in both States by local hailstorms. The month closed with South Dakota busy successfully garnering the most bountiful and highest quality small-grain crop that she has ever produced, and North Dakota pushing to completion the harvesting of a very heavy crop, inferior only to that of South Dakota in that some of it has been damaged by frost.

The temperature of September (1 to 12) was below the seasonal average over both States. Rain is needed generally for fall plowing. Heavy frost occurred over North Dakota and the greater portion of South Dakota on the 2d and 3d, but no special damage reported from North Dakota, the bulk of the small grain being harvested; but in South Dakota, taken in connection with the effect of the August frost,

in many localities corn suffered considerably, and the frost injured vegetables farther south than in August. Corn will mature in southeast South Dakota, elsewhere the frost injury is permanent, and as a whole the corn crop can be called but "fair." The crop season is practically ended in both States, and it remains for the Dakota farmers but to convert the surplus of their overflowing granaries into other necessaries and comforts of life.

TENNESSEE.

From Mr. J. B. Marbury, observer, Weather Bureau, assistant in Tennessee weather service:

General farm work was commenced in Tennessee about the middle of March, nearly one month later than the usual time, owing to the unseasonable weather, which was cold and wet. Very little progress was made in general farm work until about the second week in April.

During the latter part of March the weather continued so cold and wet that farmers were delayed in preparing the land for planting, and what seed had been previously planted was greatly damaged. These conditions culminated in a cold wave and heavy frost about the 6th of April, which did some damage to fruit and killed a good deal of young clover.

During the third week in April the weather was about normal and generally favorable to farm work. During this period large areas of corn were planted and preparations made for the planting of cotton, which was commenced about the middle of the month. The area planted in cotton this season was somewhat smaller than usual, as many farmers have turned their attention to clover, grasses, and live stock.

The area sown in oats was also small, owing to the delay in getting the land ready for planting.

A large area of Irish potatoes was planted, and although the early part of the season was rather cold and unseasonable a splendid crop was made.

Wheat continued in good healthy condition during the entire season, except a slight damage by rust in the northern sections, and a very fine crop was harvested and saved.

Tobacco plants were rather small, but in good condition when planted during the latter portion of May and first of June. Soon after the first plantings a short drought set in and many of the plants died, but the second planting made a good stand, and an average crop is assured unless destroyed by an early frost.

A drought set in about the 3d of May and continued till the 18th. This was accompanied by unseasonably low temperature, which greatly retarded the maturing of nearly all crops.

A good deal of cotton was killed outright, and the land had to be replowed and a second planting made, and this crop will not be saved unless there should be no frost till late.

Good seasonable weather continued through the months of July and August, and crops of all kinds did well, except cotton, which was somewhat injured by the abnormally cold nights during the last week in August.

During the first two weeks in September the lack of rain caused a drying and hardening of the soil to such an extent that plowing for wheat and other fall seeds had to be suspended, and these conditions exist at the close of the week ending September 12.

The early corn crop was the largest that has been raised in this State for years, but the late crop is not at all encouraging, and unless good rains occur in a short time there will not be more than a third of the usual crop.

Cool nights and warm dry days are now rendering the cotton outlook rather gloomy.

TEXAS.

From Dr. I. M. Cline, local forecast official, Weather Bureau, Galveston:

During the month of January the precipitation was in excess over all portions of the State, the average above normal being over 3 inches. That this excess did not fall in heavy rains is shown by the fact that the number of rainy days during the month averaged about 12 per cent above the normal, and consequently the greater part of the precipitation was absorbed and retained by the soil. The temperature averaged 2 degrees above the normal, which, with the showery weather, was very favorable for the wheat crop of the northwestern part of the State. During the months of February and March the precipitation was generally deficient. During February it was less than 50 per cent of the normal, and the number of rainy days was about 20 per cent below the normal; while during March the amount was from 1 inch to 1½

inches deficient, except over north Texas, where it was above normal, but the number of rainy days was generally about normal. General farming operations began in February, when plowing for cotton, corn, and other crops was entered upon in all portions of the State. The rainfall of January, with what rain fell during February, kept the ground in unusually good condition for cultivation, while the exceptionally fair weather enabled rapid progress in farm work. During March and until the 10th of April the same favorable conditions as prevailed during February continued, and farming operations progressed rapidly. Frost from April 3 to 5 did some damage to the fruit crop. By April 10 the corn crop had been planted and was generally coming up; the greater part of cotton had been planted over the southern portions of the State and planting was under good headway over other portions. From April 10 until the 1st of May the rainfall was above the average and the temperature was about the average, which brought up corn and cotton generally, the planting of cotton having been completed in the southern and central portions of the State by April 20, and in all sections by May 1. During the latter part of April the Brazos River overflowed its banks and did some damage, which necessitated replanting a few thousand acres of cotton and corn; this, however, was replanted by May 7, and came up and grew off rapidly. The precipitation for May averaged about 2 inches below the normal, but it fell on about the average number of days and was well distributed throughout the month, except along the coast and over the eastern portions of the State, where the number of days as well as the amount was deficient. On May 17 considerable damage was done by hailstorms in the northern and eastern portions of the State, and slight damage in one or two of the western counties; about 25,000 acres in cotton, corn, wheat, and oats were badly damaged, and about 4,000 acres were entirely ruined; this was, however, all replanted in cotton. The temperature during May averaged about 2 degrees daily below the normal, and this had the effect of retarding the growth of both cotton and corn. The cotton plant on the 1st of June was small in consequence of the cool weather, but was generally healthy, and the crops were unusually clean and well cultivated and the general outlook was better than the average at this season of the year; in some sections there had been a large increase in acreage, while in a few there had been a falling off, yet the average for the State over last year showed an increase of about 7 per cent, which makes the total cotton crop of the State this season about 5,000,000 acres. There was also an increase in the acreage cultivated in corn; the growth of corn had not been materially retarded by the cool weather and the crop was very promising. The weather throughout the season had been favorable for small grain, of which there was also a much larger acreage than last season; the weather during June was favorable for harvest, and the largest yield of wheat per acre was made that has been produced for some years. The oat crop was slightly injured in some sections by the cool weather and deficiency of rain during May, but the crop was generally about the average.

During June and July the weather was showery, with about normal temperature. The rainfall was from 1 to 1½ inches deficient, but the number of rainy days was nearly normal, and as a result crops did not suffer to any great extent from the deficiency, which from May 1 to July 31 amounted to nearly 5 inches. The cultivation of corn was completed by June 30, and of cotton by July 15. With an average season after August 1 the cotton crop would have been heavy. The previous deficiency in rainfall would have been considered beneficial, as it had given good opportunity for work, and crops had never been better cultivated. At this time, however, the cotton plant was putting forth blooms and bolls at a rapid rate, and it required at least an average amount of rainfall, particularly on account of the previous deficiency, but a large deficiency continued during August, and by the middle of August prospects had fallen off materially on account of drought. Worms, which had appeared in a few sections about the 1st of August, spread rapidly between August 10 and 20 and threatened a great deal of damage. However, unusually cold weather for August occurred from the 23d to the 25th, which checked the spread of worms, and this was followed by another cool spell between the 1st and 10th of September, which stopped them entirely, before material damage had been done. The temperatures throughout the State, while decidedly below the average, were in no instance low enough to injure the cotton plant. Some claimed that the cool weather had caused rust, but on close examination what appeared to be rust was found to be leaves turning yellow from dry weather.

The deficiency in precipitation did not injure the corn crop except in some parts of southwest Texas, where the drought was most severe; taking the State as a whole, the corn crop was slightly above the average. The good yield of corn can be accounted for from the reason that the crop was made before the middle of July and that the season in the ground at the time of planting was sufficient, with the current rainfall, to keep all crops in a flattering condition until toward the last of July. During the latter part of August and the first of September drought continued generally throughout the State and cotton suffered severely, and the prospects for

cotton continued to become more unfavorable, and by the 1st of September the plant had stopped growing over southwest Texas and in a few localities over eastern Texas, yet in other portions the top crop continued to stand the drought very well, and it is believed that the showers since the first of the month, with favorable weather from this time on, will make an average top crop over at least two-thirds of the State. The bottom crop was excellent throughout the State, and the middle crop will make a fair yield. Cotton-picking is much further advanced than at a corresponding time in any previous season, and the staple is longer and much cleaner than is generally the case.

Some have estimated that the effects of the drought since August 1 would result in a decrease ranging from 20 to 25 per cent per acre from last year's yield. This, however appears to be greater than would result with the loss of the entire top crop; since in 1882, the best yield ever produced in the State, the top crop was placed at less than 15 per cent of the entire crop. Up to the 1st of August the crop looked as well over the greater part of the State as it did in 1882, and the top crop now gives promise of a fair yield in the greater part of the State; consequently, if the cotton is picked as clean as it was last season, and with favorable weather from this time on, the yield per acre will hardly fall more than 12 per cent below that of last year, which would give a yield of about thirty-eight hundredths of a bale per acre; and this, with the increased acreage, would give an aggregate yield of about 1,800,000 bales for the State.

VIRGINIA.

From Mr. J. N. Ryker, observer, Weather Bureau, assistant director of the Virginia weather service, Lynchburg:

The date of beginning of general farming operations in this State in 1891 was very much delayed by reason of continued and excessive rains in February and March, with temperature generally below the normal until about the 4th of April, so that little preparation for spring crops could be made before the latter date. This was followed by eighteen to twenty days of favorable weather, excepting frosts on April 7, 8, and 9, that slightly damaged fruit which was then in bloom; all kinds of fruit were in bloom between April 10 and 20. Some corn was planted and oats seeded during last ten days of April, though the last week of the month was too dry for plowing. Tobacco beds were not made this year until in April in most sections. Serious drought continued from April 25 to May 16 in all portions of the State, and, in the north and northeast portions until about May 25 to 30, stopping corn planting and plowing, causing almost an entire failure of the first crop of clover and damaging the oat crop more than 50 per cent, and killing the greater part of the new grass crop. After June 1 the conditions proved generally very favorable to all crops, especially to tobacco, and everything improved; these conditions continued until about July 25, followed by continued rains and too much cloudiness, with excessive rains in south and southeast sections, that damaged the melon, tobacco, peanut, and potato crops, with cool weather the last week of August and first week of September, that retarded corn and tobacco. Since September 11 the conditions have been very favorable; fall plowing is probably nearly all finished, under favorable conditions, and prospects are bright for fall seeding.

The following data will prove to be a tolerably correct statement for the crops of the State:

Oats: Usual time of seeding, about March 1; this year, from April 1 to 25, and the amount cut off by dry April and early May.

Tobacco plant beds: Usually from in winter up to March 1; this year, nearly all after April 1.

Corn planting: Usually about April 15; this year some from April 20 to May 1, but mostly from May 20 to June 20.

Clover crop harvesting: Usually about June 1; this year very little of first crop harvested, and second crop cut from June 20 to July 20.

Tobacco plant setting: This year, about the usual time, May 20 to June 20 or 25.

Wheat harvest: Usually about June 20 to July 10, and this year about the same time.

Oat harvest: Usually about July 10 to July 25; this year, July 15 to August 1, with very short crop.

Hay harvest: This year, about the usual time, from July 20 to August 20, with a fairly good crop.

Corn-fodder pulling: Usually begins about August 20; this year, September 1.

Corn-cutting: Usually about September 1, but this year will be near October 1.

Tobacco cutting: Usually August 20 to October 1; this year, September 7 to October 15, if frost should not occur sooner.

The fruit crop has proved an abundant one.

Oats was about one-third to one-half an average crop.
Wheat probably about three-fourths crop.
Hay crop about an average.
Pastures have been good since June 1, and are in excellent condition.
Corn promises a large and good crop.
Tobacco, a fair to large crop, though the quality has been injured by rains and cloudy weather and the cool weather from August 25 to September 9.

WISCONSIN.

From Willis L. Moore, local forecast official, Weather Bureau, director of the Wisconsin weather service:

April 1 found about 2 feet of snow on the ground in the northeast part of the State, 2 to 6 inches in central and northwest portions of the State, and the southern part uncovered. Plowing and seeding began in southern part about April 15. At this time it was considered that winter grains had come through in excellent condition, and that winter wheat especially was in fine shape; but the season was thought to be about two weeks late. The last half of April was warm enough to advance the season fully up to the average. Spring plowing and seeding completed in the southern counties the last week in April, and also finished in the northern section by May 10.

The Crop Bulletin of May 2 said, in reference to the high temperature of the two previous weeks: "The weather has been too warm for the cranberry vines, starting them too early and thereby making them liable to be frosted later on." This premonition was fully justified, for before the expiration of another week severe frost occurred in all parts of the State, with minimum temperatures ranging from 19° to 35°, and the prematurely developed cranberry shoots were considerably touched. However, the effects of this cold were greatly mitigated by the fact that little or no rain had fallen for eighteen days previous and all vegetation was comparitively dry. Winter wheat, pastures, and spring-sown grain were but little injured.

This drought condition continued up to about May 20, the ground being so dry as to cause farmers to hold off in planting corn. Corn, therefore, entered the ground late and under very unfavorable circumstances. An average of about 1 inch of rain now fell over the State, but its good effect was transitory and the drought remained unbroken. Severe frosts occurred on the 25th and 26th, ice forming one-fourth to one-half an inch in thickness in the interior counties. Again the dry and backward condition of vegetation made the effects of the frosts but slightly apparent.

The rosy prospects of April slowly but surely deteriorated as the season advanced without material rainfall, until on the 1st of June the parched ground and the withered leaf of vegetation promised anything but a bountiful yield for the crops. Corn and hay were particularly unpromising, and many fields of wheat were nearly as bare as when sown, four to six weeks before. But the temperature during May was 4° below the normal, which tended greatly to preserve the vitality of plant life during the drought period. Had abnormally high temperature been coincident with the May drought its severity would have been greatly increased and the power of the growing crop to recuperate with the coming rains of June been considerably lessened.

But what a change occurred during the month of June. While the rainfall was below the normal in the northern portion, it was heavy enough to break the drought, and in the southern and west-central part it was from 1 to 3 inches in excess. The temperature during the month was also all that could be desired, averaging 1° above the normal. It may be said that the wheat, rye, and potato crops were made by the rainfall and temperature of the month of June. Everything seemed to take a new lease of life; fields that were considered hopeless came forward with such astonishing rapidity that at the end of the month all crops promised well except hay. While more rain of a slow, soaking nature would have been beneficial, still there was enough moisture stored in the ground during the month to carry wheat, potatoes, and oats through the extremely dry months of July and August to a successful maturity and a good yield. But not so with the hay crop. The question at once presents itself: If the rainfall were sufficient to produce a fair crop of cereals, why should not the meadows produce their proportionate quota of hay? The answer is probably found in the fact that the grass stocks grow much closer than those of the cereals and that the roots are matted and many-fold more numerous, and therefore consume a greater amount of moisture. To be sure, the sod protects the undersoil and retards evaporation, but this probably does not compensate for the great draft made upon the moisture of the soil by the numerous roots. The crop was about one-half the average, and was entirely harvested during July.

July was cool and dry, the rainfall being 1 to 3 inches below the normal and the temperature 5° to 10° below, conditions very unfavorable to corn.

August opened with the hay crop all in, barley and spring wheat being harvested in eastern counties, corn small and unpromising from the effects of the continued cold dry conditions; tobacco looking well, and cranberries promising fairly well. It will be remembered that the tobacco district of the State was thoroughly saturated during the June rainfall. Bountiful rain fell in the northeast portion of the State during the first week, and relieved all anxiety in regard to the principal crops this season in that district, so far as rain was concerned. In the remaining part of the State the drought affected pasturage to such an extent that in many counties farmers were feeding nearly as much hay as they do in winter. By the middle of August the early-planted tobacco and all grains were being harvested, with a good yield. On August 20 a very beneficial rain fell over the whole State, but not enough to permanently relieve the drought. The low-pressure area that caused this rain was followed by a high-pressure area and a cold wave, which caused killing frost in the cranberry region and light frost on the northwest border of the tobacco belt. Warnings were telegraphed twenty-four to forty-eight hours in advance of the frost, but owing to the drought condition which had prevailed during most of the season many marshes could not get water, and two-thirds of the crop was totally destroyed. Corn and buckwheat in the north-central and northwest counties were also severely damaged. Tobacco was unhurt, and the rain of the 20th was just what was needed to save the late fields from the drought, which now began to seriously threaten them.

The cool wave and frosts of the last week of August were followed by another cool wave and much heavier frosts on September 4, which froze and destroyed many fields of buckwheat and corn in the central and northwest counties and caused frost over nearly the entire tobacco belt. No serious damage was done, however, to tobacco. Warnings were sent forty-eight hours in advance of the frost. The abnormally low temperature and deficiency of rainfall during July and August—the principal time for making the corn crop—combined with the severe blight by frost in the northwest half of the State, tells the story of the short corn crop. During the severe frosts of the latter part of August and the first of September the protecting influence of the lake in keeping up the night temperature was such that no frost occurred in the coast counties.

Altogether the year was a fairly successful one for the farmers of Wisconsin. Wheat, rye, oats, potatoes, tobacco, and barley, good crops; with corn, hay, and cranberries very light. It is, indeed, surprising that such bountiful products could come from the soil with so little rain. In this connection it should not be forgotten that, with one exception, the periods of least rainfall were accompanied by moderately low temperature. This gave but little evaporating power and left to vegetation the full measure of all moisture in the soil.

THE INTERNATIONAL CONFERENCE.

By Prof. CLEVELAND ABBE.

The International Conference of Meteorologists held in Munich in August, 1891, was an occasion of much importance both for meteorology and for agriculture as one of its practical applications. As the Chief of the Weather Bureau and myself had been commissioned to represent the Department of Agriculture on this occasion, it was deemed by us especially important to give as much attention as possible to the bearing which the discussions should have upon agricultural matters. The fact that at this conference representatives of this Bureau were present occasioned many congratulatory expressions, and has, we believe, served to arouse a lively interest in the work that is being undertaken in this country. The selection of the Chief of the Weather Bureau as one of the two vice-presidents of the conference, and also as a member of the permanent international committee, will demonstrate to you the appreciation in which our weather service is held by foreign meteorologists.

As the resolutions adopted by the agricultural conference held at Vienna in 1880, as well as those of the Rome congress in 1879, are intimately connected with those adopted at the present Munich congress of 1891, they should all be carefully considered in laying out the work of our agricultural stations and our State weather services, and it

is hoped that they may be printed elsewhere in full. These numerous resolutions are the official expression of the best conclusions that could be agreed upon by large bodies of men who have the widest knowledge upon these subjects. To those who, by local experience, have arrived at the positive conclusion that a special style of instrument or method of using it is the best, or that a special climatic influence is the most important, some of these resolutions may appear, at first thought, wanting in precision and force, but the fact is that owing to the extreme complexity of the subject of meteorology and climatology and the conservatism of human nature, these generalized resolutions express all that it has been practicable to agree upon as fundamentally important and practically attainable. From this point of view we must hail many of these resolutions as indorsing the present practice and policy of the Weather Bureau, so that, as it would seem, our methods are not only free from the criticism of being different from those of other countries, but are in many respects recognized as a step in advance, and therefore praiseworthy.

Among the resolutions adopted at these various conferences it is proper to dwell upon a few that are of general interest to this Bureau. That which affects us most directly is the assignment, at the request of the Chief of this Bureau, to the international committee of the duty of drawing up a special report on the relations of meteorology to agriculture. It will possibly be several years before such a report can be completed, and meanwhile my report already on hand on this subject may serve as an earnest of what is to be hoped for from the committee. The dependence of crops and all agricultural operations upon the climate and the weather occupied much attention during our rapid run through Europe. We found the north of Europe still suffering from cloudy, cold, wet weather up to the 1st of September, and although during the first half of that month we enjoyed dry clear weather in southern Germany, Austria, France, and England, yet the crops were backward and deficient.

Agricultural interests seem to be especially studied by the weather bureaus of France, Austria-Hungary, Bavaria, and Saxony; in the last two the study of local thunderstorms and hail during the growing and the harvest seasons has made such progress that it would seem to be possible to predict the general path of a storm during its growth and its dissolution when once its existence has been recognized in the morning. Doubtless a similar result can be attained in the United States, or in any portion thereof, whenever a system of thunderstorm observers, at an average distance of 5 miles apart, can be secured. The efforts made in this direction in former years, by the coöperation of Gen. Hazen and the Post-Office Department, deserve to be renewed. As an illustration of what may be done in this respect, it is proposed that this Bureau surround the city of Chicago as soon as practicable, and possibly other cities, such as New York and Washington, if practicable, with such a minute system of reports that the arrival of every thunderstorm, with its short squall of wind and rain, shall be regularly predicted. The successful working of such a system during the Columbian Exposition will undoubtedly lead Chicago and other cities to make similar and permanent arrangements at their own expense, for it is hardly probable that such expenses for all the principal cities of the country can be borne by this office.

Among the European meteorologists who have shown great sympathy with the needs of the farmer is Dr. Paul Schreiber, director of the Meteorological Institute at Chemnitz, Saxony, and from his recent

address to the farmers' convention the following, which is equally applicable to our own country, is quoted:

The price of subscription to the daily weather map is only $2 annually, and it is remarkable that this important aid in judging the future weather is so little used by the farmers. That which is most necessary in order to give the predictions their full value is the more rapid distribution of the weather map, so that at 6 p. m. every farmer would receive notice of the weather to be expected the next day. Perfectly accurate predictions are not to be expected, but very useful indications of the probable character of the weather can be derived by the farmer from the weather map, and especially as to whether it is likely to rain or not, and 75 per cent of the predictions of rain in Saxony are found to be completely verified and only 9 per cent entirely fail. Perhaps many of you think that you can do as well by glancing at the sky and at the "weather glass;" but, however this may be, you will often have experienced how easily you are deceived. You would have made a very different prediction if you could have gone up high in a balloon and have taken a general view of the atmospheric conditions all over Europe.

This bird's-eye view is accomplished by means of our weather charts which show us whether causes are approaching us far beyond the narrow limits of our horizon that can bring about a change in the weather. The weather chart shows that no matter how pleasant the weather is in our own locality, an area of rain is approaching; on the other hand, when it is raining in our locality, whether it will soon pass by or continue for a long time. It oftens happens that a long period of fine weather or of rainy weather is interrupted by one or two rainy or clear days, respectively. I believe that for outdoor work it is principally important to know whether there will be a series of rainy days or dry days. One rainy day in the midst of many dry ones can scarcely be of much influence in farming operations. Here we see the inestimable value of weather reports, and especially of weather charts; they show why it is raining or dry, and why it is warm or cold; whether the existing weather will last a long time, or is only temporary. We often see in the charts the evidence of a coming change in the weather a long time before there is the slightest sign in our sky or our instruments.

But we can attain skill in anticipating the weather only by a thorough, earnest, and pertinacious study of the weather reports. I can not too earnestly recommend to every one to begin at once to study the weather charts, and not to relinquish it even although they do arrive late every day and though there may be some difficulty at first in understanding them. They will at least arrive early enough to enable you to understand the weather of the day that is past, and from *that* you will be enabled to conclude, from the present aspect of the sky and readings of your local instruments, what the next change will be.

A more intimate connection between the meteorological office and the farming population will be a benefit and a blessing to both.

The short time at our disposal allowed us to visit only one agricultural experiment station—namely, the celebrated establishment of Sir John Lawes, Rothamsted, Herpendon, Hertshire. It is a pleasure to be able to record that by a special clause in his will Sir John has provided for the maintenance of this important work during all future time. Of course, the results attained in the climate of Rothamsted can not be directly applied to the climate of any part of the United States, and indeed the same may be said of results obtained in the special climate of any other locality.

This suggests mention of the fact that the study of climate has been carried by European meteorologists to a degree of refinement that is not yet attained in America. We are apt to speak of the climate of a State, whereas we should speak of the climates within a State, or the climate of a special farm, or even of a small field, because each individual plant prospers or languishes according as the temperature and moisture of its own locality is favorable or not. Thus an eminent German climatologist criticised in our hearing the location of some instruments amid trees on a slight rise of ground and possibly a hundred feet above the surrounding plain, objecting that these instruments could not properly represent the climate of the surrounding country, but that they should have been placed in the open flat fields near at hand. If this person be correct, it is evident that the demands of agricultural cli-

matology are very different from those of dynamic meteorology, or the study and prediction of daily weather. This latter has been the object of the Weather Bureau in its past history, and has led to the establishment of its instruments as high as possible above the ground, and generally within larger cities. These stations, established in the interest of meteorology proper, have given the service its present high standing, and of course can not be relinquished. On the other hand, climatological studies must be made near the earth's surface and in the open country, as is done at most of our voluntary stations, and it will be an important result of our inspection of European institutions if we shall have received a decided stimulus in the direction of minute climatology.

It was a very pleasant surprise to European meteorologists to learn that we had so large a number of stations of the first order, at which, namely, continuous records are kept. The general resolution of the conference would require that these observations, as well as those at all our other stations, should be published in accordance with a system that has been drawn up for the guidance of European governments. Although this publication will consume much labor and involve much expense for printing, yet it will be eventually a decided saving, as these climatic records are in continual demand and must be distributed to those who study climatology in its relation to agriculture and manufactures, and especially to all State agricultural colleges and experiment stations. The so-called "international form" of publication should begin with the present lustrum, 1891–'96; it is adapted to pages of the quarto size, and is undoubtedly as economical as in any way consistent with the proper presentation of the data.

The Chief of this Bureau was pleased to be able to represent to the congress the fact that the exposure of a rain-gauge on the roof of a large building, as is generally necessary in our city stations, is not necessarily very objectionable, provided the gauge be placed near the center of a large flat roof, and the resolution passed by the congress on this matter has finally removed a criticism that has often been made upon the American observers. It is very desirable that in this place, and by the wide distribution given to the Annual Report of the Department, the attention of every citizen be called to the fact that there is still a lamentable need of more records of rainfall. The Bureau is prepared to coöperate heartily with everyone, whether in the city or in the country, who will keep a proper record of the time and amount of rainfall at one or more localities.

At the present time meteorological observations are probably weakest in that which would seem to be one of the simplest matters of observation, namely, the study of the clouds. On this point the conference has expressed an especial desire that every country should awaken to the importance of this subject. Through its special committee it proposes to superintend the publication of an atlas showing the forms and varieties of clouds, with appropriate nomenclature; and, on the other hand, it hopes to secure a large number of stations at which the heights and actual movements of the clouds will be carefully observed. This latter work, owing to the skill required, must almost necessarily be largely left in the hands of special meteorological observatories and the professors of meteorology at our universities, agricultural colleges, and experiment stations, who can do much for meteorology by entering upon this class of work. The various methods of measuring altitudes will be communicated to anyone who makes inquiry of this office.

The resolutions of the conference calling upon all nations to compare

their instruments with each other, and with those of the international bureau of weights and measures; the resolution to adopt the air-thermometer in all temperature work, and to compare all thermometers at very low temperatures; to adopt the reduction of the barometer to standard gravity; to adopt a steady ventilation in the use of the psychrometer, and to introduce everywhere the registration of sunshine, are, it is gratifying to state, all more or less completely carried out by this Bureau.

The international bibliography of meteorology, as begun by Gen. Hazen and published in part by Gen. Greely, seems to have attracted the greatest interest among European students, as it attempts to satisfy a want that has long been recognized. We were so fortunate as to enjoy a prolonged interview with Dr. Hellmann, at Berlin, and Mr. Symons, in London, but missed seeing Mr. Lancaster in Brussels, the three Europeans who have probably done the most work in connection with the bibliography of meteorology. Evidently the general sentiment in Europe is to the effect that the great work thus far done by the Signal Office is too important to be left unfinished, and that the interests of meteorology and of climatology alike demand that the Weather Bureau shall publish the complete work in proper style, after obtaining from European colaborers all possible corrections to the manuscript that has already been milleographed.

The resolution of the conference urging the desirability of publishing as velocities of the wind only the corrected readings of the anemometers will, if carried out, involve this service in considerable extra work, and its execution may not prove to be practicable; yet the propriety and desirability of this improvement is generally acknowledged, as it seems likely that all velocities as measured by the ordinary Robinson anemometer are from 15 to 25 per cent too large. On the other hand, the office will be glad to increase the accuracy of its results if possible by the introduction of any better form of anemometer, if such can be devised.

The conference decided, as on previous occasions, that the introduction of zonal time, or any departure from the customary local mean time in meteorological matters, would be very regrettable; but as the system of standard times adopted in this country can not be changed, and is in fact very beneficial to the work of this office, there seems to be no reason to change our customs in this respect. Considered as a great popular convenience, there is no doubt that the zonal system makes friends wherever it is introduced, and strong demonstrations have been made on many occasions in Europe in favor of its introduction there. The original records of this service are kept on the seventy-fifth meridian time, which is the standard in Washington, and its uniform adoption simplifies our work. Experience has shown that since the adoption of uniform standard time the innumerable errors of five, ten, or even twenty minutes in the watches and clocks of voluntary observers have been avoided, and it is only by the help of this great accuracy that we shall be able properly to study thunderstorms, auroras, meteors, earthquakes, and other interesting phenomena.

Many of the members of the conference expressed to us, as has so often been done before, the great value attached by European students to observations on high mountain stations, and regretted exceedingly that the stations at Pikes Peak and Mount Washington should have been given up without securing from each a complete determination of the diurnal variations of the meteorological elements. Our station on Pikes Peak and the one temporarily occupied on Mount Whitney have

always enjoyed the reputation of being by far the highest of any in the world, and if the expense is not too great and local sentiment supports the movement, we surely may hope to reëstablish these and many other mountain stations, furnishing them with self-recording instruments and publishing the results, thus materially contributing to the progress of meteorology.

The committee of the conference to which the question of terrestrial magnetism was referred, besides going into certain details as to instruments and methods, expressed the general desire that the subject of terrestrial magnetism should be provided for by the national weather bureaus when practicable and when not otherwise specifically provided for in each country. It would seem that this important subject may be considered from the view of the needs of the navigator, of the surveyor, and of the meteorologist, and as the relations between magnetism and meteorology have lately assumed a very interesting shape, considerable attention should, with your permission, be devoted to this subject.

After the close of the conference at Munich there was held a conference of delegates from the Governments interested in the international polar work of 1882–'83, at which your representative was present as a guest, and received the request to coöperate as far as possible in encouraging and developing the magnetic investigations of our fellow-countryman, F. H. Bigelow, since appointed by you as professor of meteorology in the Weather Bureau, with a view to the further development of the relation between these two subjects.

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