HOT WAVES: CONDITIONS WHICH PRODUCE THEM, AND THEIR EFFECT ON AGRICULTURE.

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GENERAL REMARKS ON DAMAGE CAUSED BY HOT WAVES.

Of all adverse weather conditions, those accompanying periods of long-continued high temperature are perhaps the most detrimental to man's mental, physical, and financial welfare. A summer hailstorm may destroy considerable property over a limited area, a high wind may cause damage of more serious nature, and a tornado is still more destructive to property and is usually accompanied by loss of human life; but all these are local in their effect, and their duration is only for a short period. Even a hurricane sweeping up from the West Indies, carrying death and devastation in its path, affects but a relatively small portion of the United States; a general hot wave, however, with its blighting and death-dealing temperatures, leaves a trail of ruin so widespread and so great that it can not be accurately measured. To be sure, estimates can be made of the injury to growing crops, and these alone make an astounding figure. The loss to the State of Iowa on account of a hot wave which visited that section in the latter part of July and early portion of August, 1894, amounted to over $50,000,000,[1] a property loss nearly twice as great as that caused by the Galveston hurricane in 1900; and these are the figures for only one State.

As for the suffering undergone by the millions of humanity day after day in these hot-wave periods, there is no record, nor is one possible. Statistics may be secured as to the number of sunstrokes, but no data are obtainable regarding the sick whose deaths are hastened by the abnormally heated atmosphere.

Of the great crops of the country, corn and cotton are most liable to injury through overheating. The damage that results from this cause is at times appalling. In most cases the mere lack of rain is but partially responsible for the blight, as it is found that the cooking, firing effect of the intensely heated atmosphere is the source of much irretrievable damage. When affected by drought alone most crops will

[1] The average value of Iowa crops for the three years prior to 1894, as reported by J. R. Sage, in the Iowa Climate and Crop Reports for 1891, 1892, and 1893, was $181,926,432; while for the year 1894, according to the same authority, the value of Iowa crops was $121,284,696, or more than $60,000,000 below the average. The hot wave coming at a critical period was almost wholly responsible for this diminished production.

rapidly revive if favorable weather follows in a reasonable time, but once the life-giving properties are destroyed by excessive heat no amount of properly distributed rainfall or sunshine can repair the injury. Conservative farmers in the West estimate that during a summer of average heat the damage resulting on account of occasional seasons of high temperature, covering a period of from three to six or more days, reduces the yield fully 20 per cent below what it would be under favorable circumstances.

PERIODS OF OCCURRENCE OF HOT WAVES AND CHARACTER OF INJURY CAUSED.

In this discussion a hot wave is regarded as a period of three or more consecutive days, during which the maximum temperature reaches or passes 90°. With but a few minor exceptions, these periods are found to occur in the months of June, July, August, and September.

JUNE PERIOD.

In June, as a rule, the hot waves are less frequent and not as severe as later in the season. The heat is less intense, as the cumulative effect of the summer season has not reached its maximum. In the farming districts of the West it is generally a month of abundant moisture. For most cereals an excess of heat at this time is the one thing most needed, corn and kindred crops being especially benefited. The oat crop, however, is frequently endangered and often seriously damaged by rust caused by a combination of excessive precipitation and too much heat. Under these conditions the oats fail to fill and the yield is light and its value greatly impaired. Fruits which ripen during this month, if superheated, are also greatly injured.

JULY AND AUGUST PERIODS.

In the latter part of July and early August, crops which mature in the fall are most susceptible to permanent injury. It is at this time that the summer excess of heat is greatest and such precipitation as occurs falls during thunderstorms or in showers, so that the heat of the atmosphere is not materially lowered thereby. It can readily be seen that this is a most critical time with the farmer. When for any reason the cumulative heat tendencies are exaggerated above the naturally high normal, the result is most disastrous to the agriculturist. The corn withers and fires, the leaves curl up and become lifeless, the growth of the ear is stopped in its infancy, and the efficacy of the pollen is destroyed. No amount of favorable weather after such a period is effective in revivifying the blighted crop. Nubbins and small ears are the best that may be expected. The effect on cotton is equally injurious. After passing through a period of abnormally hot temperature at this season, the yield is of such poor quality and such

small quantity as scarcely to pay for the picking, and many fields are abandoned on that account. Pastures, and grass products in general, suffer even more. If the hot wave is unusually severe it is found that the life has been baked out of the roots, and it is often necessary to plow under an otherwise good pasture, because the grass was killed the preceding summer by the torrid weather. The severe drought with its evil effects on vegetation is not lost sight of, but investigation lends color to the belief that the drought is only a contributing influence and not the principal factor in the damage caused. When the temperature reaches a point where the leaves on the trees begin to curl up and drop, despite the moisture supply of the roots, the cause must be assigned to other reasons than a mere lack of rainfall. Such results frequently follow, or are coincident with, hot waves.

SEPTEMBER PERIOD.

During September the principal deteriorating effect of a hot wave is to push crops too quickly to maturity, thus causing an injury to the soundness of the grain and lowering its keeping qualities. Apples and other fruit drop to the ground or begin to rot while still on the trees. However, a hot wave in September is not always detrimental. It is sometimes the means of the salvation of a large portion of a crop which may need a great deal of heat in order to properly mature it before frost arrives. The absence of a hot wave at such a time amounts to almost as great calamity as its presence earlier in the season.

SUMMARY OF HOT WAVE RECORDS.

Taken as a whole, the harvest returns for years during which hot waves were unusually severe show a production of one-fourth less in quantity, the quality being quite inferior to the standard. However, during the years immediately following such seasons the yield frequently reaches a maximum for the decade. Frequently the hot weather of one summer is of material benefit in preparing the soil for an unusually large crop the following season. It seems to have the effect of making the ground mellow and putting it in an ideal condition for the reception of seed.

A careful study of the records of the Weather Bureau covering a period of thirty years fails to reveal the regular recurrence of summers of excessive heat, or that hot waves occur on the same days in succeeding years. The table following (p. 328) gives the departures from the normal temperature of the four summer months, June, July, August, and September, at eight widely separated stations of the Weather Bureau, thus showing representative conditions over the entire country.

Departures from the normal temperature during June, July, August, and September for a period of twenty-nine years, reported from eight stations, as shown by the records of the Weather Bureau.

Year.	Boston.	Washington.	Charleston.	Memphis.	Cincinnati.	Denver.	Santa Fe.	Omaha.	Average.
	°	°	°	°	°	°	°	°	°
1872....	+2.1	+3.5	+1.6	+0.8	+1.7	−0.4	+0.4	+0.7	+1.3
1873....	+0.3	+1.9	−1.0	−0.6	+1.5	+0.2	−0.2	+0.4	+0.3
1874....	+0.1	+1.8	−0.4	+2.1	+3.8	+2.0	+2.8	+1.8	+1.8
1875....	−1.0	+2.7	−2.2	−1.4	−1.9	−0.2	−0.7	−2.0	−0.8
1876....	0.0	+1.3	+1.8	−0.5	+1.3	+0.7	−1.1	−1.8	+0.2
1877....	+0.3	+1.1	+1.6	−0.6	+0.5	+0.4	+1.2	−0.4	+0.5
1878....	−0.4	+0.1	+0.8	+1.2	+1.0	−0.1	+0.1	+0.8	+0.4
1879....	−1.7	−0.7	+3.1	−1.0	+0.3	+1.3	+2.0	+0.6	+0.5
1880....	+0.4	+0.5	+0.8	−1.5	+1.1	−0.4	−1.4	+0.3	0.0
1881....	−0.7	+2.1	+2.5	+3.7	+4.1	+2.3	+0.2	+3.4	+2.2
1882....	+0.2	+0.1	+0.5	−1.4	−0.7	0.0	−0.3	−0.8	−0.3
1883....	−0.5	−1.0	+0.3	−1.0	−0.8	+0.3	.....	−0.4	−0.5
1884....	−0.3	+0.1	−0.7	+0.6	+1.7	+0.9	.....	−0.2	+0.3
1885....	−0.9	−1.0	+0.4	+0.9	−2.1	−1.5	−0.1	−1.1	−0.7
1886....	−1.2	−1.5	−1.3	−0.6	−1.7	−0.1	−1.3	+0.5	−0.9
1887....	−1.1	−0.4	−1.0	+0.2	+1.7	−0.2	−0.1	+0.1	−0.1
1888....	−1.5	−2.3	−4.0	−2.0	−3.1	−1.0	+0.2	−1.8	−1.9
1889....	−0.1	−1.9	−1.2	−1.4	−2.4	0.0	+1.6	−1.1	−0.8
1890....	−0.5	−0.3	0.0	+0.5	0.0	+1.0	+0.2	+0.1	+0.1
1891....	+0.4	−1.0	+0.2	−0.4	−1.3	−1.1	+0.5	−0.9	−0.3
1892....	+1.5	+0.5	−0.7	−0.6	+0.3	+1.0	+2.2	+0.6	+0.3
1893....	−0.9	−0.6	+0.3	+0.2	+0.9	+1.3	+0.2	+0.8	+0.3
1894....	+1.5	+1.1	−1.1	+0.2	+1.8	+1.3	−0.8	+3.2	+1.0
1895....	+0.9	+1.1	+0.9	+1.4	+1.9	−1.3	−0.3	+1.0	+0.7
1896....	+1.1	−0.2	+0.8	+1.2	−0.8	+0.8	+1.2	−1.1	+0.4
1897....	−0.7	−1.1	+0.4	+2.2	+0.4	+0.3	−0.1	+2.9	+0.5
1898....	+1.9	+1.9	+1.0	+1.3	+2.5	+1.0	+0.3	+2.1	+1.5
1899....	+1.1	−0.2	+1.0	+1.2	+1.0	+1.0	+1.8	+1.0	+1.0
1900....	+1.1	+2.9	+2.0	+1.7	+2.7	+2.5	+0.0	+2.0	+1.9

The conclusion then is that these visitations may be expected at irregular intervals, the number and intensity of which vary greatly from year to year. It is also found that the extreme maximum occurs within a day or two after the first 90° is recorded. This extreme temperature in regions north of the thirty-seventh parallel sometimes passes the 100° mark, and almost always approximates that point. The number of successive days of abnormal heat varies, and may range as high as sixteen or seventeen. Again, two or more periods may come in close succession, and in the popular mind these are associated as one long spell, as, for example, the month of August and first part of September, 1900. It is the exceptional summer when at least one of these hot waves does not sweep across the country, but the number to be expected in any one season is uncertain. As before stated, fewer hot waves occur in June than in any other of the summer months. July furnishes the greatest number, while

August and September are not far behind. In the last two the period covered is likely to be longer than in the earlier part of the season.

SECTIONS AFFECTED BY HOT WAVES.

At times only one section of the country is affected; on other occasions large areas, covering half the United States, are held in the grasp of the hot wave. No section entirely escapes, although the conditions vary in different portions. In central California, eastern Oregon, and eastern Washington the local surroundings are favorable for long-continued periods of excessive heat, as ideal "summer conditions" exist in these places. There is an almost total absence of rain, and the summer drought brings with it temperatures that frequently pass the 100° mark on several consecutive days. On the Great Plains of the Middle West the most severe effects of the hot wave are noticed. It is in this section that the hot wave frequently has its birth. It is often attended by hot winds, which bear a relation to the hot wave not unlike that of the tornado to the general cyclone. These hot winds are a constant menace to the crops of the Western prairies. In many instances fields which promised abundant yields have been injured beyond recovery in a single day. To the eastward of the Great Plains the hot wave is not so severe with regard to its extreme temperatures, but it is usually of longer duration. The effect on vegetation is less marked, although on account of the higher relative humidity the discomforts to man are much greater. In the South the conditions are of a semi-tropical nature, the changes being less frequent and the diurnal range less. This is partly due to geographical position and partly to the fact that the storm tracks pass far to the north, and their influence is but little felt in this region. The South does not entirely escape, however, and at times suffers severely from the abnormal heat.

In the Ohio Valley, Tennessee, and the Atlantic coast States the duration of the hot wave reaches a maximum, at times embracing a period of two and even three weeks. The extreme temperature is lower than on the Western prairies, but the mean is higher and the diurnal range much less. During these periods, when the maximum temperature is above 90° daily, the minimum rarely registers lower than 70°, and frequently not that low. To this latter fact may be traced the intense suffering of those who are compelled to live in the large Eastern cities, where the street temperatures are higher than those recorded in the Weather Bureau observatories. On account of the proximity to large bodies of water the region surrounding the Great Lakes, as well as New England, is largely free from severe hot waves. The frequent passage of storm centers over these sections keeps the air in circulation and prevents stagnation, which latter seems to be an essential factor in the evolution of a hot wave. Along the

coast line hot waves are practically unknown, due, no doubt, in a large measure to the land and sea breezes which tend to keep the temperature lower than farther inland.

METEOROLOGICAL CONDITIONS PRODUCING HOT WAVES.

A study of the meteorological conditions under which hot waves occur reveals a certain type of influences which may be said to be characteristic of this phenomenon. This is the so-called "summer type," under ideal surroundings, existing over a series of days, that is, it is the ideal summer conditions in a state of stagnation, and it is only when there is this stagnation that the hot wave manifests itself. When the normal circulation of the atmosphere is resumed the heated term comes to a close. It should be understood, however, that this stagnation, while marked, is but relative, as the area of high temperature usually slowly drifts from west to east and is finally driven off to sea by the advent of a marked area of high pressure, causing a complete change in barometric and thermal conditions.

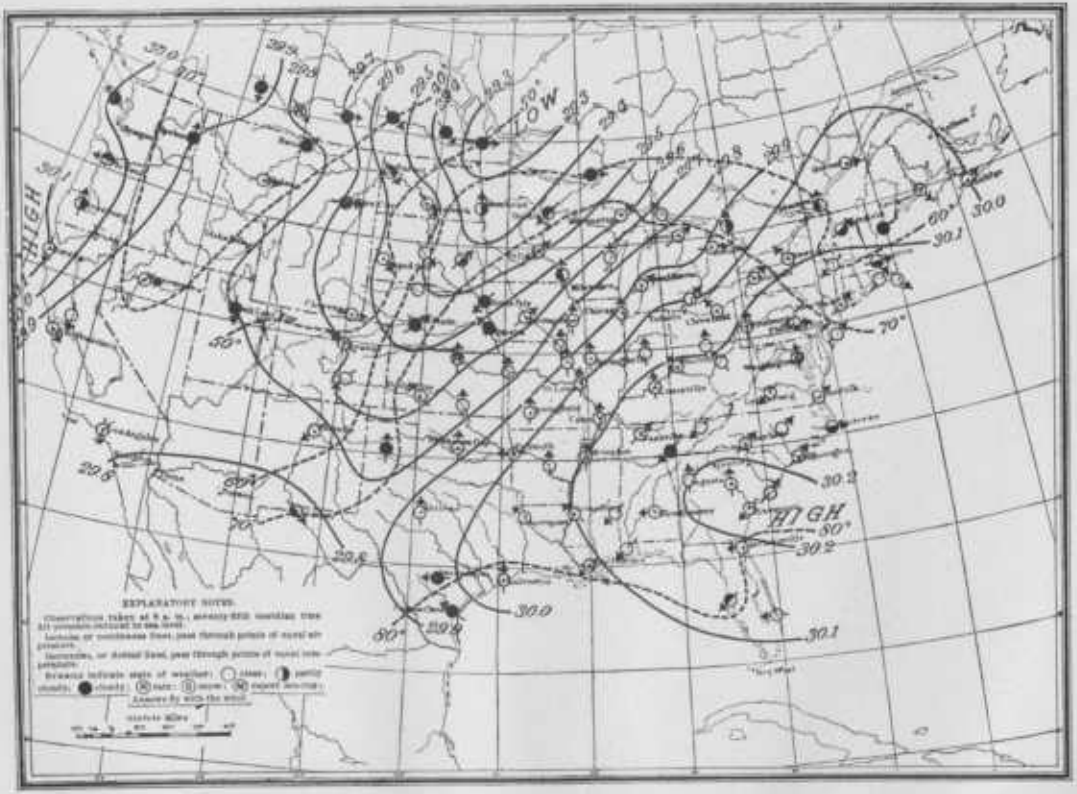
WEATHER CONDITIONS DURING A JUNE HOT WAVE.

From June 20 to 30, 1890, the Mississippi Valley and the Gulf States were visited by a well-marked hot wave. In fact the entire central portion of the country was within the circle of its influence. During this period a high pressure was constantly present off the north California coast, and during most of the time a second high hung over the South Atlantic and Gulf States. Situated in the Great Plains was an almost stationary trough of low pressure, with an average reading of 29.7. Over the region most affected occurred a series of clear days and cloudless nights, attended by a uniform but light wind from a southerly direction. In the neighborhood of the Lakes the temperature remained quite moderate, the weather being cloudy, with occasional showers, and the winds generally from a northerly direction.

During the continuance of this hot period the 80° isotherm, as shown by the 8 a. m. observation, frequently extended above the Ohio River, and at times as far north as central Iowa. The barometric changes from day to day were inconsequential and the general stagnation of the air was plainly evident. No general storm moved across the country, although several skirted the northern edge and affected somewhat the conditions over the Great Lakes. While the low pressure remained over the Great Plains and the high was located to the southeast over the South Atlantic States, the hot wave continued. It was only when an area of high pressure appeared in British Columbia and drifted southeastward into the United States that the stagnation was broken up and the temperatures were reduced to their normal stage.

Pl. XXXV is a chart of the weather conditions as observed at 8 a. m., June 25, 1890, which will give an idea of the conditions prevalent during this period. On the day previous to the one on which

WEATHER MAP OF 8 A. M. JUNE 25, 1890.



WEATHER MAP OF 8 A. M. SEPTEMBER 20, 1895.

these observations were taken the maximum temperature registered 90° or more at almost all of the stations situated in the Ohio, Mississippi, and Missouri valleys and the Rocky Mountain plains. This is what might reasonably be expected in view of the season and the distribution of barometric pressure.

WEATHER CONDITIONS DURING A SEPTEMBER HOT WAVE.

A severe hot wave which occurred late in the season was that of September, 1895, which prevailed over the central and eastern portions of the country from the 10th to the 23d of that month. On account of the approaching winter season the gradients were steeper than usual during hot waves and the movements of the atmosphere not so sluggish. For several days prior to the commencement of the excessive temperature a high pressure of moderate intensity was present over the Southeastern States, its stagnated condition indicating that it formed a part of the great permanent South Atlantic high. The weather was generally clear over the territory east of the Rocky Mountains and south of parallel 45. The direction of the wind was from the center of the high northward and northwestward. After forty-eight hours' continuous flow of this warm stream of air from the south a low area began to form near the Canadian line. This increased rapidly in intensity, attaining a pressure of 29.1 at its center, at that time located over the Dakotas. During the ensuing week this depression drifted slowly eastward, followed closely by a high area, which had appeared over the Puget Sound region. In the van of the low, temperatures were from 10° to 20° above normal. The center of extreme heat was first located in the West, but it slowly moved eastward, keeping slightly in advance of the low area. Although the Pacific coast high was well marked and the temperature range sharp, its action was not as vigorous as would be expected. After several days, however, it had reached northern Texas, bringing with it temperatures close to the freezing point, while in the East the thermometer registered well into the nineties. From Texas northeastward the movement of this anticyclone was greatly retarded, the influence of the high in the Southeast being still strongly felt. The severity of the hot wave was increased by the absence of precipitation, the records showing little or no rainfall during this period in the region affected. The absence of this disturbing element permitted the heat to accumulate from day to day and made the dissolution of these conditions difficult to accomplish.

In Pl. XXXVI, which is the 8 a. m. weather map for September 20, 1895, may be seen characteristic conditions for this period. The official synopsis for that day contained the following statement:

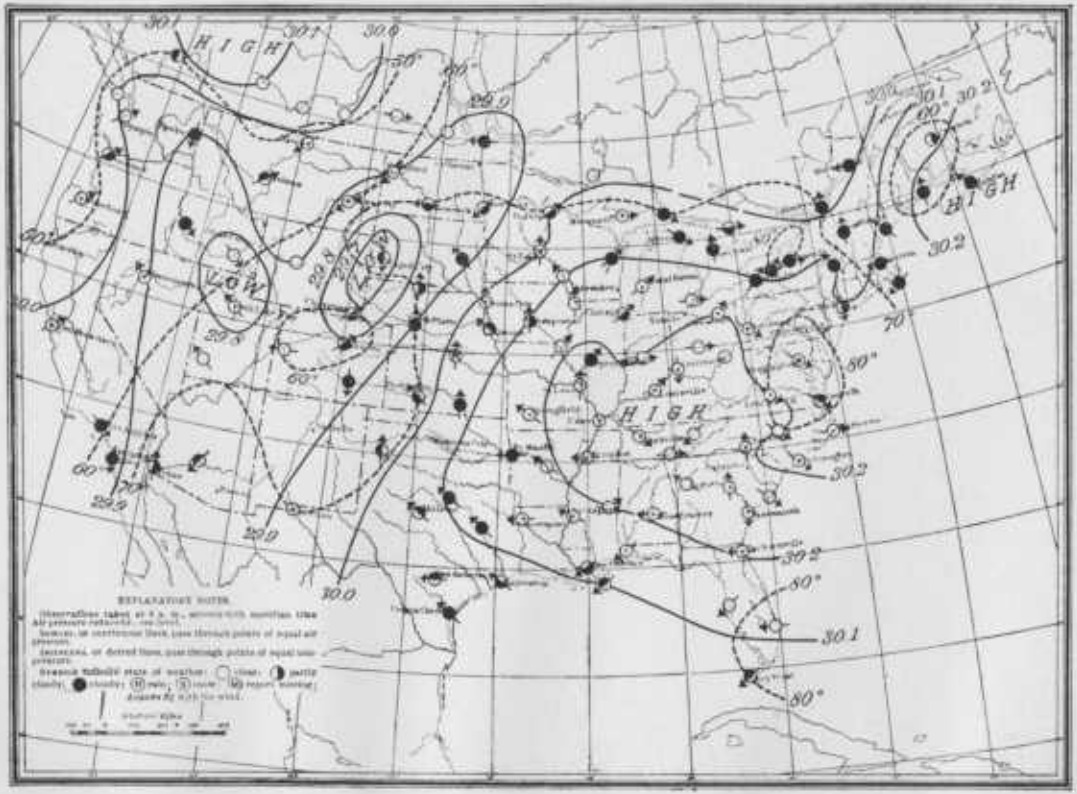
The excessive heat which has prevailed during the past week throughout the central and western portions of the country continued yesterday, with maximum temperatures generally above 90°, although the extremes were slightly lower than on

the preceding days. Heated conditions have extended eastward over North Carolina, Virginia, and the District of Columbia, maximum temperatures of 96° occurring at Charlotte, N. C., and Washington, D. C.; 98° at Raleigh, N. C., and 100° at Norfolk and Lynchburg, Va. These temperatures were from 2° to 9° above the record in any previous year for the second ten days of September.

WEATHER CONDITIONS DURING THE HOT WAVE OF AUGUST–SEPTEMBER, 1900.

The hot wave of August–September, 1900, will long be remembered on account of its length and intensity. In the East it was especially severe, although its influence extended westward beyond the Mississippi River. From the 5th of August until the 10th of September there were but three or four days when the maximum temperature did not equal or exceed 90°, so that this entire period may be regarded as continuous, so far as its effect on mankind is concerned, although in a meteorological sense it was divided into at least two distinct periods. The conditions were not unusual, the lack of movement of the South Atlantic high being the most marked feature. The hot wave had its inception in the wake of a high area, which dropped down from northern New York over Virginia and the neighboring States. Here it seemed to join forces with the permanent high over the ocean and remained nearly stationary for a number of days. Its center was further inland than ordinarily, indicating the presence of an unusually large high to the eastward. This oceanic high doubtless acted as an insurmountable barrier to the eastward flow of the atmosphere, thus closing the outlet for the escape of warm continental air, which, thus confined, maintained its high temperature for a long period. The fact that the minimum temperatures were the highest of the year lends color to the theory that the introduction of new and fresh air had almost ceased, thus preventing the cooling of the air at night.

The winds blew out radially from the center of the high, their velocity being quite low. In the Upper Mississippi and Missouri valleys was located a low area into which the hot winds from the high constantly poured. The precipitation was much below the normal during the greater portion of the time, except along the Canadian border from Minnesota eastward, where cloudy weather with heavy showers predominated. In western California and Oregon the oceanic high pressed slightly into the interior. As the days passed the energy of the South Atlantic high slightly diminished, a tendency to drift southward being manifest. While the high was passing over Washington, D. C., moderate temperatures prevailed, but as soon as the pressure began to fall temperatures began to rise. After the area of high pressure came the period of high temperature from the 6th to the 12th. During this time the skies were mostly free from clouds. A few ragged cumuli formed and hung listlessly around the horizon, disappearing by sunset. The barometer rose and fell with the regularity of the tide, its action on this occasion being not unlike that in the calm



WEATHER MAP OF 8 A. M. AUGUST 8, 1900.

and tranquil atmosphere of the Tropics. On the approach of the tropical storm from the West Indies about September 1, the anticyclone was still of such strength as to act as a barrier to the northward progress of the hurricane, which was deflected into the Gulf of Mexico and finally reached Galveston, bringing with it death to thousands of people and destruction to millions of property. Leaving the Texas coast, the storm passed rapidly northward into Iowa and from thence northeastward over the Great Lakes and the St. Lawrence Valley. It carried with it much of the stagnant heated air which had accumulated in the Eastern States and most completely brought to an end the insufferably hot weather of the preceding six weeks.

Pl. XXXVII shows the conditions existing at 8 a. m. August 8, 1900, and is a typical map for this period. Temperatures ranging from 96° to 100° were recorded the day previous, as well as on that particular day and the several following, in North Carolina, Virginia, District of Columbia, Maryland, and Pennsylvania.

GENERAL WEATHER CONDITIONS TO BE EXPECTED DURING HOT WAVES.

From the above three periods, a general idea of weather conditions to be expected during hot waves can doubtless be obtained. The location of the center of extreme heat will generally be found on the northern and western outskirts of the high pressure. The distribution of pressure will be about such as has been described. The longevity of the hot wave seems to depend upon a slacking up in the general circulation. Aside from the direct heating from the sun, dynamic heating and lack of radiation have an important influence in maintaining the temperature at an abnormal figure. At such times the atmosphere becomes heated to a much greater altitude than usual, the heat being retained at night by conditions explained further on in this article. The air which flows eastward across the Rocky Mountains and into the low has been bereft of its moisture, and on descending into the lowlands gains heat dynamically. The air emanating from the high in the southeast goes through much the same process. The clear days warm up the atmosphere and at night the radiation is greatly impeded. Ferrel and other meteorologists of repute have determined that the increase in heat of descending currents of air is at the rate of 1° C. for each 100 meters, which is equivalent to 1° F. for each 183 feet. When it is considered that there is a steady flow of air outward from the center of the high, the presence of this descending current is clearly demonstrated. In the case of the high over the South Atlantic States, at such a time it forms part of the great subtropical high, which is composed largely of relatively highly heated air which has drifted northward from the equatorial region. As long as this unfailing source of heat supply is uninterrupted, the stream of hot air continues to flow out from the center until the advent of an anticyclone of superior energy sufficient to bring about new conditions.

Professor Bigelow, in Bulletin No. 20 of the Weather Bureau, "Storms, storm tracks, and weather forecasting," says:

> The excessively hot spells of weather that cover the Atlantic States during certain intervals are attended by a high area on the South Atlantic coast, being a portion of the great subtropical high. Aside from the transportation of warm air from Southern to Northern latitudes, there must be a downpouring of dry hot air in the high itself, due to the excessive "potential" temperature of the upper strata.

Speaking of the hot waves of August, Professor Bigelow says:

> These come from two sources: They originate in a mass of heated air on the Rocky Mountain plains and gradually move eastward from thence; on the other hand, a high area settling over the South Atlantic and Gulf States has the effect of charging the stagnant air with heat, as if the eastward circulation in the upper air was suspended for quite long intervals of time.

One of the peculiar features of the hot-wave period is that, notwithstanding the cloudless nights ordinarily favorable for radiation, the air retains its heat in a manner that seems little short of remarkable. For some reason the normal radiation is greatly impeded and almost totally suspended. The exact cause of this cessation of normal action has not been definitely determined, although the investigations of Professor Very have shed much new light on the subject. In his report on "Atmospheric radiation," recently published by the Weather Bureau, he states that this condition is brought about by the gradual accumulation of water vapor in the upper air, which, although not sufficient to form clouds, is of such a nature as to transmit the rays of the sun with greater readiness than the reflected rays from the earth. This has the effect of accumulating the heat in the lower strata, causing the night temperature to be unseasonably high. At such times the diminution of the daily range of temperature with a clear sky, as saturation approaches, is probably due to a change in the quality of aqueous absorption, and also to the increase of water vapor and its ascent to exceptional heights in considerable quantity, whereby the escape of radiation is impeded by the strong aqueous absorption of the infra-red rays between 5μ and 8μ (that is, the invisible heat rays of the spectrum between which the absorption of water vapor is greatest) not far from the point where the maximum energy in the radiation from bodies at ordinary temperature resides. The presence of large masses of water vapor in the upper air may not always be indicated by high relative humidity at the surface any more than by clouds, but it is evidenced by the strengthening of the rain band, as seen in the spectroscope, as well as the diurnal range of temperature. Professor Very states that—

> The heat entrapped through the differential transmission of solar and terrestrial radiation by aqueous vapor and carbon dioxide is mainly stored in the lower layers of the atmosphere, and because the absorption by air heavily loaded with moisture is nearly complete for its own radiation, this stored-up energy continues for a long time as a controlling balance wheel in the mechanism of the weather. As long as

the mantle of water vapor remains unbroken thermal fluctuations are kept within narrow limits. Storms may make inroads upon the continuity of this aqueous atmospheric envelope, but evaporation of moisture restores the rents. Rolled up in great bosses covering hundreds of thousands of square miles of territory, the thickened mantle of vapor brings hot waves. The gradual accumulation of moisture in higher and higher atmospheric layers during the summer clothes the temperate regions with so deep a protective covering of moist air that summer conditions are prolonged in the autumn to a time which is astronomically the correlative of late winter. The absence of this protective layer, whose formation can only be effected gradually, permits late frosts in the spring, long after the sun has resumed his ascendancy. In the middle of a sunshiny day, by the evaporation of moisture from the earth's surface and its ascent in convection currents, the vapor of water is carried up to high levels, but during the night most of this accession of moisture is diffused into colder or drier regions of the upper air, where it is either condensed and no longer exists in the air as vapor or is so diluted and reduced in relative humidity as to be of slight absorptive value when the sun next rises.

The kite observations at Pierre, S. Dak., reveal the fact that just prior to and during periods of hot waves the upper atmosphere in the early morning is several degrees warmer than the layers adjacent to the surface of the earth, showing that the cooling process has extended upward but a short distance. There are a number of facts which seem to warrant the belief that the warm ascending air in the low is carried with but slight loss of heat to the center of the high, whence it descends, its temperature when it reaches the ground being quite high. The presence of a large number of dust particles in the upper air during such periods, attended by hazy conditions, seems to support this theory, although these phenomena may be due solely to local conditions caused by dry, dusty weather. On the other hand, it is held by some meteorologists that there is little actual interchange of air between adjacent highs and lows, that is, that the air which ascends in the low is not the same which later descends in the high, but that this descending air comes from other sources.

In the case of the South Atlantic high the source of supply is believed to be from the superheated air of the equator, which, upon being heated, rises and flows down the slope thus created, and is piled up in the region bordering on the thirtieth parallel. When a high drifts across the continent and settles over Virginia or the Carolinas it becomes a part of the greater high just described, and the descending currents of air in it are fed from the accumulated masses of relatively warm air in these upper strata. Thus, the great heat of the air blowing out from the high at the surface is satisfactorily accounted for. Whatever may be the cause, it seems certain that the upper air in the high is relatively warm, and that during hot waves radiation is retarded in the high by reason of the descending currents of warm air, and in the low by reason of the accumulation of water vapor. Thus, the temperature over the affected region is kept at a high point because the conditions which bring about increased heat are at a maximum and those which permit its dissipation are at a minimum.

SUMMARY.

To sum up, it may be said that, with the present fragmentary knowledge of the basic cause of meteorological changes, we are confined to the statement, that during a hot wave the eastward circulation of the atmosphere, both upper and lower, is for the time being almost totally suspended, and that radiation is at the same time at a minimum. A careful study of the weather charts covering such periods leads to the belief that it is quite practicable to forecast high temperatures for a period of from four to five days, but predictions for a longer time are, for the present at least, the merest guesswork and not entitled to credence.