MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE.

VOL. XXIV. ANNUAL SUMMARY. No. 13

INTRODUCTION.

The SUMMARY for the year 1896 is based upon data received from about 3,000 stations occupied by regular and voluntary observers of the Weather Bureau, Canadian data received by the cooperation of Prof. R. F. Stupart, and Mexican data received by the cooperation of Dr. M. Bárcena, the Director of the Central Meteorological Observatory of Mexico. The statistical tables have been generally prepared by the Division of Records, and Meteorological Data, A. J. Henry, Chief of Division. The text and editorial work are by Prof. Cleveland Abbe unless otherwise specifically noted.

GENERAL CLIMATIC CONDITIONS.

ATMOSPHERIC PRESSURE.

The mean pressure for 1896 is shown numerically in Tables I and II. The method of reduction to sea level and the omission of the correction for gravity, as explained by Prof. H. A. Hazen in the MONTHLY WEATHER REVIEW for 1894, Vol. XXII, page 538, have continued in use in the Weather Bureau during 1896, and the figures given in Tables I and II, as also those on Chart I, accord therewith. Owing to the variations of gravity with latitude and altitude, the readings of the mercurial barometer, after being corrected for instrumental temperature and index error, need a further correction or reduction to standard gravity in order to represent the true atmospheric pressure, as measured by a uniform standard. As the international conferences of meteorologists have uniformly urged the application of the reduction to standard gravity and the further reduction to sea level by the tables and methods of the International Meteorological Committee, the Editor has requested Mr. Park Morrill to make the corresponding corrections and reductions. The general method of doing this is explained in the MONTHLY WEATHER REVIEW for 1895, Vol. XXIII, pages 492–494; the results for 1896 are shown in the accompanying table and on Chart IV.

These charts cover the stations of the United States and Canada and can easily be extended over Mexico when the annual mean values for stations in that country become available.

As the general motions of the lower atmosphere depend intimately upon those of the upper atmosphere, it is important to study the isobars and temperatures at elevations of 10,000 feet or more. Assuming a general average decrement of temperature at the rate of 2° F. per 1,000 feet (0.37° C. per 100 meters), the reduction upward can easily be made by using Table B, MONTHLY WEATHER REVIEW, for 1895, page 494, as computed by Mr. Morrill. By a slight change in the first column, which gives the temperature argument, this table becomes applicable to reduction upward to 10,000 feet for any rate of diminution of temperature with altitude and is reprinted as Table F of the present SUMMARY. The resulting isobars are shown on Chart V. On the other hand, with any adopted rate of diminution of temperature, pressures may be reduced upward to the level of 5,000 meters, or 16,404 feet, by means of the table on page 419 of the MONTHLY WEATHER REVIEW for November, 1896, as computed by Koeppen.

The data on Chart I show that the reduced barometric means not corrected for gravity were highest in the east Gulf and South Atlantic States and lowest in southern Arizona, but nearly as low in Newfoundland.

The data on Charts IV and V show that the true pressure gradients at sea level differ appreciably from the apparent pressure gradients on Chart I. They also show that the high-level gradients are steeper and that, therefore, the currents of air are swifter than at sea level. Both the high-level and sea-level gradients and winds and temperatures represent the result of the interaction of ascending and descending currents. If there were no such vertical interchange of air the contrasts between the upper and lower systems would be still stronger. The resultant surface winds are shown on Chart I, and should be compared with both the sea-level and the upper-level isobars. It is very desirable that the wind currents at the 10,000-foot level should be brought under observation in order to compare these directly with the isobars. The observations of cloud motions are only approximately satisfactory, and the true wind directions obtained by kites or free balloons are preferable.

AREAS OF HIGH AND LOW PRESSURE FOR 1896.

The location of an area of high or low pressure is, to a limited extent, affected by the method adopted in the reduction of the barometer to sea level. The following summary, therefore, holds good, especially in connection with the method adopted by the Weather Bureau for the past few years. The average daily and hourly movements of the centers of the areas are given by paths and by days in the individual tables of the successive MONTHLY WEATHER REVIEWS, and the monthly sums are collected together in the following table for the purpose of taking the annual means by paths and by days.

These averages show the same peculiarity as do those for the year 1895, namely that the means taken by days are in both cases smaller than those by paths; that is to say, when each path is given the same weight, no matter whether it is

a long one or a short one, the numerous paths of rapid movement and short duration, outweigh those of slow movement and long duration. If the movement of a center of high or low pressure depends upon the general movement of the upper layers of atmosphere, or is in any way a partial index to the velocity of the general circulation, then from that point of view, the averages taken by days are to be preferred. The average daily movement in 1895 was 556 miles for the high areas and 598 for the low, or an average of 577; in the current year the above table shows average daily velocities in both cases 5 miles larger than the preceding year, giving an average of 582, or about 24 miles per hour. This average undoubtedly gives us a first approximation to the annual average velocity of the wind at some upper level, probably between 5,000 and 10,000 feet, but nearer the latter. If studied in connection with a system of upper isobars such as that shown on Chart VII, of the November REVIEW, they seem to harmonize with the general statement that our high and low areas and weather changes form part of the system of circulation around the north Polar Region of low pressure.

TABLE A.—*Movements of areas of high and low pressure for* 1896.

Month.	High areas.				Low areas.			
	By paths.		By days.		By paths.		By days.	
	No.	Movement.	No.	Movement.	No.	Movement.	No.	Movement.
		Miles.		*Miles.*		*Miles.*		*Miles.*
January	10	5,317	45.5	21,880	9	5,435	38.0	21,830
February	14	9,931	50.0	33,950	7	4,447	34.5	20,260
March	8	4,512	39.0	22,460	10	6,693	42.0	26,760
April	6	3,036	36.0	13,430	9	5,093	36.5	20,330
May	7	3,941	33.0	18,520	10	5,075	41.5	19,960
June	7	3,965	44.5	24,470	8	4,620	35.0	20,350
July	7	3,734	22.0	11,660	11	6,302	38.5	22,550
August	6	3,234	39.0	20,950	10	6,617	34.0	22,360
September	7	4,148	39.0	22,900	11	6,631	39.0	22,320
October	10	5,244	44.0	22,530	9	4,832	35.0	18,060
November	5	3,307	22.5	13,810	8	6,491	33.5	25,250
December	8	4,754	32.5	18,390	12	9,171	43.0	31,530
Sums	95	55,123	437.0	244,950	114	71,407	450.5	271,560
Mean daily velocity	580		561		626		603	
Mean hourly velocity	24.2		23.4		26.1		25.1	

TEMPERATURE.

The mean annual temperature is shown by the isotherms on Chart I. These temperatures relate to the surface of the ground, and the individual figures are given in Table I of the annual meteorological summary of data for Weather Bureau stations. The lowest annual averages within the United States were: Williston, 37.6; Moorhead, 37.7; Bismarck, 38.9; Sault Ste. Marie, 39.5; Duluth, 39.6; Havre, 39.7. For Canada: Prince Albert, 30.5; Battleford, 31.1; White River, 31.2; Minnedosa, 31.6. The highest averages were: Key West, 76.4; Jupiter, 73.4; Yuma, 73.1; Tampa, 71.4; for Canada, Halifax, 43.2; Charlottetown, 43.1; Yarmouth, 43.0.

The mean annual temperature was above the normal at nearly all stations. The largest departures were in the middle Slope and the west Gulf States. The annual temperatures were below normal in the Florida Peninsula and on the north Pacific Coast and in portions of New England.

The maximum temperatures are shown both by the figures in Table I and the full lines on Chart II; the minimum temperatures of the year are shown by the figures in Table I and the dotted lines on the same chart. The absolute range of temperature during the year is easily obtained by comparing the full and dotted lines on this chart. In general maximum temperatures exceeding 105, occurred as follows: Yuma, 117; Phœnix, 115; Fresno, 111; Red Bluff, 109; Fort Smith, 107; Shreveport and Wichita, 106. The absolute maximum for the whole country was 117 at Yuma. Minimum temperatures of —25 or more occured at: Havre, —33; Lander, —31; Northfield, —30; Moorhead, —28; Williston and Idaho Falls, —26; Sault Ste. Marie, Duluth, Miles City, —25.

The regions of large annual ranges of temperature were, as usual, the north, middle, and south Pacific slopes and the Missouri Valley. The stations of small annual range were: Hatteras, 76; Key West, 38; Tatoosh Island, 48; Eureka, 45; Point Reyes Light, 51.

The accumulated departures of average monthly temperatures from the normal values are given in Table III, and show that there was a steady diminution in the deficit with which the year began in the Atlantic and Gulf States, generally turning into a surplus before the end of the year. In other sections of the country the year began with an excess of temperature which generally increased steadily until the close. The greatest deficits for the year were: —0.77, Florida Peninsula. The greatest excesses for the year were: the middle Slope, +2.07; Abilene, +2.19.

MOISTURE.

The mean temperature of the dew-point and of the mean relative humidity are given in Table I.

For the sake of certain studies in hygiene the mean temperature of the wet-bulb thermometer has been given each month. The thermometer from which this temperature is read is whirled at the rate of about 10 feet per second within the light wooden shelter that protects from direct radiation. The average wet-bulb for the year can be easily inferred from the mean temperature and dew-point of Table I as the wet-bulb reading is approximately midway between these two.

The total quantity of moisture in the air for the current year can be found by the table given on pages 539–540 of the ANNUAL SUMMARY for 1894, and does not differ to any important extent from the figures there given for that year.

PRECIPITATION.

The total annual fall of rain and melted snow for 1896 is shown on Chart III. The greatest precipitation was: Tatoosh Island, 100.8; Astoria, 94.8; Fort Canby, 78.6; East Clallam, 78.1. The least was: Yuma, 2.6; San Diego, 8.7; El Paso, 9.3; Pueblo, 10.8.

An annual rainfall above 60 inches occurred on small portions of the coast of Florida and Alabama, Nova Scotia, and Newfoundland, as also along the entire coast of Oregon and Washington. An annual rainfall of less than 10 inches occurred in southern California, Nevada, Utah and Colorado, western New Mexico, and northern Arizona.

The accumulated departures of total monthly precipitation from the normal values are shown in Table IV, from which it appears that a steadily increasing deficit has prevailed over the Atlantic States, Ohio Valley, and Lake Region; but elsewhere a slight excess has accumulated. The large total annual deficits are the west Gulf States, 12.50; South Atlantic States, 10.70. The largest accumulated excess was north Pacific, 10.10.

WIND.

The prevailing direction of the wind, namely that which occurred most frequently at the two hours of regular observations for telegraphic report, 8 a. m. and 8 p. m. (eastern time) is given in Table I. The annual resultant wind deduced from these same observations without taking into account the force of the wind (which is equivalent to attributing a uniform force to all winds) is given in Table V. These resultants are also presented graphically on Chart I in connection with the barometric means. They should also be compared with the pressures on Charts IV and V to which they are intimately related.

Owing to the great labor of computation the resultant