

NEW ORLEANS FORECAST DISTRICT.*

[Louisiana, Texas, Oklahoma, and Arkansas.]

Temperature was above normal and precipitation was deficient thruout the district. Storm warnings issued on two dates were justified and no general storm occurred without warnings. Cold waves occurred in some parts of the district from the 5th to 7th, 9th to 12th, and on the 29th and 30th, for which warnings were issued for portions of the district, and warnings for all frosts and freezing temperatures that occurred in the sugar and trucking regions were issued.—*I. M. Cline, District Forecaster.*

LOUISVILLE FORECAST DISTRICT.*

[Kentucky and Tennessee.]

Temperature averaged above and precipitation was below normal. From the 20th to 28th temperature was remarkably high, while the last two days were quite cold with minimum temperatures about zero, and high winds and snow. Cold-wave warnings were issued on the 4th, 5th, 6th, 10th, and 29th in advance of decided changes to colder.—*F. J. Watz, District Forecaster.*

CHICAGO FORECAST DISTRICT.*

[Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas, and Montana.]

The severest cold wave of the present season advanced over the district from the 4th to 6th with temperature 20° to 30° below zero in the northwestern States and zero temperature as far south as southern Kansas and a minimum of 9° below zero at Chicago. This was the lowest temperature recorded at Chicago in nearly four years. Timely warning was given to all sections of the approach of the cold wave. The second cold wave of the month crost the district from the 10th to 12th. This cold wave had covered the northwestern States for several days and warning of its advance over the eastern portion of the district was given. A disturbance that crost the district on the 13th and 14th was followed by a cold wave in the more northern States. In this instance warnings were issued somewhat beyond the southern limits of the cold wave. Following a disturbance that moved eastward over British America during the 15th and 16th there was a period of mild temperature that culminated on the 23d with a maximum of 65° at Chicago, this being the highest January temperature recorded at that station since 1876. The weather continued mild and fair until the 28th when a storm advanced from Kansas eastward over the district attended by general precipitation, gales, and a decided fall in temperature. In connection with this storm warnings of gales were sent to open ports on Lake Michigan, heavy snow warnings to lower Michigan, forecasts of decidedly colder weather to northwestern States, and cold-wave warnings for southern and eastern portions of the district.—*E. B. Garrriott, Professor and District Forecaster.*

DENVER FORECAST DISTRICT.*

[Wyoming, Colorado, Utah, New Mexico, and Arizona.]

Except in northeastern Wyoming, temperature was much in excess of the normal. At intervals heavy precipitation occurred in the Plateau and Rocky Mountain districts, and in the Rocky Mountain districts snowfall was the heaviest in January since 1895. A storm that occurred on the 28th was notably severe and was accompanied by high wind that drifted the snow and interfered seriously with mountain railroads. The cold waves of the month were erratic in movement and were accurately forecast.—*F. H. Brandenburg, District Forecaster.*

In a letter to the district forecaster at Denver dated February 3, 1909, Mr. Howard Gamble, of Sheridan Lake, Colo., states that three persons at that place owe their lives to the prompt and reliable cold-wave warnings issued by the Weather Bureau during the present winter.

SAN FRANCISCO FORECAST DISTRICT.†

[California and Nevada.]

The month as a whole was one of the stormiest experienced

on this coast in many years. The rainfall was unusually heavy and continued thruout a longer period of time than any of which there is a record since January, 1849. At San Francisco, in a record covering sixty years, the total rainfall has exceeded that of the present month but three times—in 1862, 1866, and 1878. In the number of rainy days, however, the present year breaks all records, as there were 26, the average number of rainy days in January being 11. In the first decade of the month heavy rains in the valleys and melting snow in the mountains caused floods, and on the 11th killing frost occurred. Following this date storms continued practically until the end of the month, causing floods and washouts, and near the close of the month railroad communication in almost every part of the State was seriously interrupted. Storm-warnings were ordered on 19 dates.—*Alexander G. McAdie, Professor of Meteorology.*

PORTLAND, OREG., FORECAST DISTRICT.†

[Oregon, Washington, and Idaho.]

The weather was unusually stormy. Cold north to east winds continued with scarcely any interruption from the 4th to 15th, attended by heavy snow as far west as the coast line. Rivers froze that had not been frozen for many years, and the cold was intense from British Columbia to the sea. The break in the cold spell was followed by a succession of low-pressure areas that were attended by heavy rains, high winds, and mild temperatures that resulted in a breaking up of ice in the rivers. The smaller streams became bank full and the lower portion of the Willamette River was above flood stage for several days. Storm-warnings were ordered for all important storms of the month.—*E. A. Beals, District Forecaster.*

RIVERS AND FLOODS.

There were no great floods during the month except in California, and as these continued with a brief intermission, until after the end of the month their description will be delayed until the February issue of the MONTHLY WEATHER REVIEW.

Owing to the warm weather, the ice in the Hudson River at Troy and Albany, N. Y., moved out late in the afternoon of the 25th, and by the morning of the 26th there was a considerable rise in the river to within about 2 feet of the flood stages. Warning of the probable breaking of the ice and the high water was issued on the morning of the 25th.

The same general conditions prevailed in the upper watershed of the North Branch of the Susquehanna River, and the ice moved out on the morning of the 25th. Warning of the coming warm weather and rains, with consequent high water, was issued on the 21st and again on the 22d and 23d, and on the morning of the 25th the river at Binghamton, N. Y., reached a stage of 10.8 feet, 3.2 feet below the flood stage. The damage amounted to between \$3,000 and \$4,000, and was confined principally to the loss of a portion of the first ice crop.

Nothing of interest occurred along the other rivers, except that the rains of the 5th and 6th over the upper Ohio watershed caused a barge stage at Pittsburg, permitting the coal fleet to start southward with about 15,000,000 bushels of coal that had been awaiting this opportunity for several months.

Navigation at St. Louis, Mo., was suspended on the 1st on account of low water.

The use of the new river gage at Knoxville, Tenn., began on January 1, 1909. The zero of this gage is set at the same elevation as that of the old gage, but owing to differences in the channel at the old and new locations, the readings above the zero mark do not agree exactly, and at a stage of 16 feet on the new gage the reading on the old gage will be 17.7 feet. It is not thought that the difference (1.7 feet) will be much greater above the 16-foot mark and comparative readings will be made as soon as the first high water arrives.

* Morning forecasts made at district center, night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

ICE.

The Missouri River at Omaha, Nebr., closed for the second time on the 8th, and at St. Joseph, Mo., on the 7th. It remained closed at Omaha at the end of the month, with ice about 8 inches in thickness, but opened on the 22d at St. Joseph. The river was also closed at Kansas City, Mo., from the 9th to the 16th, inclusive, and at Boonville, Mo., from the 11th to the 21st, inclusive.

The Mississippi River was frozen as far down as Hannibal, Mo., on the 8th, opening at Hannibal on the 23d, when the gorge above the Wabash Bridge broke. A gorge also existed above the Eads Bridge at St. Louis from the 13th to the 16th, inclusive. No ice of consequence was observed below the mouth of the Ohio River.

There was a decided increase during the month in the thickness of the ice in the Missouri and upper Mississippi rivers and in the Red River of the North, the increase amounting to more than 100 per cent. At the end of the month there was somewhat more ice than at the end of January, 1908.

There was also considerable ice in the Columbia River during the first half of the month, and at times the river was closed almost to the mouth of the Willamette River.

In the MONTHLY WEATHER REVIEW for December, 1908, mention was made of the floods of that month in the rivers of Arizona, and the following brief report thereon was made by Mr. L. N. Jesunofsky, official in charge of the local office of the Weather Bureau at Phoenix, Ariz.:

Heavy precipitation occurred generally over the northern and central sections of the Territory on December 15, 16, and 17, 1908, resulting in a rapid run-off in the Verde, upper Salt, and Little Colorado rivers. The precipitation over their drainage areas averaged about 1.85 inches during the three days mentioned. During the twenty-four hours ending with 8 a. m., December 16, the Salt River at Tempe, Ariz., had risen 6 feet and was still rising rapidly. The Gila River rose slightly. At 8 a. m., December 17, the gage at Tempe read 11.5 feet,

and the river was then falling after reaching a crest stage of 12 feet at 5:30 a. m. of that date. The crest past Roosevelt, on the upper Salt River, at 1:30 a. m., and over the lower Verde River at about 2:30 a. m., December 17. During this entire period the Gila River rose only 2 feet.

On the 16th warnings were sent out by telegraph that a flood stage of 12 feet would be reached by midnight of the same date, and the crest of exactly 12 feet past at 5:30 a. m., December 17. By 8 a. m., December 18, the river at Tempe had fallen to 6 feet, and by 8 a. m., December 19, to 3.5 feet, the Gila River remaining at a low stage.

About the same time the heavy rains in the upper watershed of the Little Colorado River congested that stream and its tributaries to such an extent that on the 16th the water rose rapidly some 25 or 30 feet in the vicinity of Winslow and St. Joseph, Ariz., washing away the railroad tracks for some miles. The damage resulting from these washouts amounted to about \$8,000. Very little, if any, damage resulted from the floods in the Salt and Gila rivers, and the total damage did not amount to more than \$10,000 or \$12,000. The property saved thru the warnings was valued at about \$3,000.

These floods in the Salt River Valley, altho not of great extent, were the greatest since the establishment of the Arizona River and Flood Service in May, 1907, and thus far excellent results have followed the forecasts of floods and marked rises in the streams whose beds are practically dry during six months of the year.

The highest and lowest water, mean stage, and monthly range at 207 river stations are given in Table IV. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

THE PRESSURE OF SATURATED VAPOR FROM WATER AND ICE AS MEASURED BY DIFFERENT AUTHORITIES.

By CHARLES F. MARVIN, Professor of Meteorology. Dated December 10, 1908.

Dr. Nils Ekholm has recently published (1)¹ the results of a very notable study by him of the maximum pressures of aqueous vapor at different temperatures, as deduced from the observations of all the best authorities. While the present short article on the subject is essentially a review of Doctor Ekholm's paper, yet some details are added from a desire to set forth briefly the present status of our knowledge of this subject. Ekholm has not himself attempted to directly measure vapor pressure, but has brought together the results of the work of many others and has endeavored to eliminate as far as practicable various recognized as well as heretofore neglected minor errors. After harmonizing certain discrepancies and correcting all known errors as far as possible, Ekholm reduces the observations to a homogeneous series of vapor pressures for the whole range of temperature from -50° C., where the pressure is so small it can scarcely be measured, to 365° C., with a corresponding pressure of 200 atmospheres. Ekholm then seeks to represent this long series of observed temperatures and pressures by a single mathematical equation, the form of which is based upon the recognized thermo-dynamic relations between temperature and vapor pressure, as far as these have been set forth by various writers.

The following summary gives briefly the observational data utilized by Ekholm:

¹ Heavy-faced numbers in parentheses refer to the bibliography at the end of this article.

Regnault.—The measurements by this great authority (2) were made at the College of France between 1840 and 1845, at a time when exact thermometry was almost unknown outside of Regnault's own laboratory, and when the instruments of precision and the multitude of conveniences commonly found in modern laboratories were quite unknown. Nevertheless, Regnault's classic work still constitutes the basis of all vapor pressure tables in common use. He covered a range of temperatures from -30° to $+230^{\circ}$ C., making in all nearly one thousand separate determinations that in point of skill and care bestowed upon them and in general accuracy of the results are unsurpassed. A similar work done independently by Magnus in Germany fully confirmed the observations by Regnault.

Broch.—Regnault did not escape the commission of certain technical errors in his work, which have been pointed out by Moritz and others, and later, when modern thermometry and manometry had been precisely defined, it became necessary to apply certain small systematic corrections to Regnault's observations. A recomputation with this object in view was very carefully effected by Broch (3) in 1881 at the International Bureau of Weights and Measures, and his tables of pressures from -30° to $+101^{\circ}$ C., are now probably in more general use by meteorologists than any other tables.

The principal source of trouble in Regnault's observations results from the fact that below 100° C. all his temperature readings were made on the so-called normal-mercury-in-glass thermometers. Regnault himself knew that the scale of temperatures thus obtained differed slightly from that of the air thermometer, and from the hydrogen scale, but the corrections between 0° and 100° doubtless seemed small to him, and more