SECTION III.—FORECASTS.

FORECASTS AND WARNINGS, JANUARY, 1918.

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GENERAL PRESSURE DISTRIBUTION OVER NORTH AMERICA AND THE ADJACENT OCEANS.

Reports from Midway Island and Honolulu were missing from January 7 to 26 inclusive. Over the northeastern Pacific Ocean and Alaska there was a regular series of low and high pressure areas, each three in number, none especially marked except the first low and the following high area, the latter extending in marked form into Alberta. The high area during the closing days of the month was also quite marked, with an extension into Alberta.

Over the United States pressure was generally low, abnormally so during two periods which are discussed in some detail below; and it was not until the closing days of the month that there was a decided rise in pressure, which, however, did not maintain its pronounced character over the eastern portion of the country, except over Newfoundland. There abnormally low pressure prevailed during the greater portion of the month, indicating the persistence of a strong area of high pressure to the north and northeast. No reports are received from this latter section, but it is believed that the erratic movement and general behavior of several of the western disturbances after they reached the eastern portion of the country may safely be attributed to such an extensive and sluggish high area as that above mentioned, as low pressure also ruled over the northern and middle North Atlantic Ocean as indicated by the reports received from Bermuda.

STORMS AND WARNINGS.

The first 23 days of the month of January, 1918, were remarkable for the persistence of a type of pressure distribution that resulted in the most severe period of winter weather over that portion of the United States lying east of the Rocky Mountains that has ever been recorded within the 47 years of the history of the Weather Bureau.[1] Snow and ice storms, notable because of their frequency, intensity, and wide extent covered the entire area from Canada to Mexico, the Gulf and Florida, and low temperatures were equally widespread, the line of zero temperature extending into northern Texas and that of freezing temperature to the southern limits of the Florida mainland. While the temperatures were not as low, as a rule, as on some previous occasions and the records for the month of January were equaled or exceeded over very large areas, yet the outstanding feature was the persistence of the cold weather, and in this respect the record over a large portion of the East and South stands without a parallel. For instance, at Washington, D. C., during the first 24 days of January the average daily deficiency in temperature was 10.5 degrees, while for the 30 days from December 26, 1917, to January 24, 1918, both dates inclusive, it was 11.6 degrees, a hitherto unprecedented occurrence.

[1] Appropriate divisions of the Central Office have been charged with the preparation of a detailed discussion of the meteorological conditions characteristic of this almost unprecedented winter, together with the conditions leading up to it, and a comparison with other severe winters of this continent.—C. A., jr.

The low temperatures were also associated with unusually frequent snowfalls, that often proved heavy, especially in the region of the Great Lakes and the great Central Valleys, and in two instances the southern limit of snow extended to the western coast of the Gulf of Mexico.

The persistence of any type of weather depends, of course, on the equal persistence of a reasonably uniform type of pressure distribution. The pressure type may vary considerably as to details of intensity and direction and rapidity of movement, yet the general type presents certain characteristics that are—in the main—uniform when once definitely developed. During this month of January, 1918, the type was that of low-pressure areas from the extreme Southwest moving in a general northeasterly direction, with high-pressure areas of great magnitude to the northwest that were naturally accompanied by low temperatures.

The localities of origin of these southwestern low-pressure areas were not often the same, yet, once they had reached the extreme Southwest and had begun their northeastward movement, their behavior was quite uniform and in keeping with the well-known tendencies of this class of storms. Whether they continued in a true northeasterly direction or whether they were deflected to the northward or eastward, depended almost entirely on the changing pressure over the western Atlantic Ocean, and the character of this change was not always apparent when the storms began their northeastward march.

As a whole, the history of one of these storms is the history of all, and intimate discussion of each can be justified only by a desire to preserve a record of minute details. This work has been accomplished so frequently in the past that it seems hardly necessary to again attempt it, and therefore only one of the greatest storms will be treated in extenso.

This storm appeared off the extreme southern coast of California on the morning of January 8, 1918. During the ensuing 36 hours it moved slowly, but with greatly increased intensity, to southwestern Colorado (at Durango its central pressure was 29.44 inches), with a strong and cold high-pressure area to the northward (central at Edmonton, Alberta, pressure = 30.84 inches, −22° F. on the evening of Jan. 9). It then turned southeastward and on the evening of the 10th was central over extreme southern Texas (Corpus Christi, pressure = 29.42 inches), the high-pressure area closely following with snow, strong northerly winds and a cold wave (Amarillo, Tex., −2° F.). Here the storm turned northeastward by way of the extreme lower Mississippi Valley and on the morning of the 11th it was central over southeastern Louisiana (New Orleans, 29.32 inches), with heavy snow to the northward and snow and ice storms in eastern Texas. At 10:30 p. m. of the 10th southeast storm warnings were ordered on the Gulf coast from Bay St. Louis to Cedar Keys, Fla.; and southwest warnings on the following morning over the remainder of the eastern Gulf coast and along the Atlantic coast from Miami, Fla., to Georgetown, S. C., while the remaining Gulf warnings were changed to northwest. Advisory warnings for strong north winds and snow were also sent to open ports on Lake Michigan.

On the evening of the 10th cold-wave warnings had also been ordered for Tennessee, Alabama, Mississippi,

western Georgia, and extreme northwestern Florida, and extended on the morning of the 11th to central and northern Florida, eastern Georgia, the Carolinas, the Ohio Valley, lower Michigan, and the western upper Lake Region. Warnings of heavy snow were also ordered for the lower Lake Region, the upper Ohio Valley, the Middle Atlantic States, and southern New England. By the evening of January 11 the storm center was over extreme eastern Tennessee (28.98 inches at Knoxville), the general disturbance extending from southern Florida to Lake Superior, with heavy snows to the northward and northwestward and heavy rains in the east Gulf States and western Georgia. The cold wave had reached extreme northwestern Florida and severe gales had occurred where storm warnings had been displayed, as well as over the interior district. At 10.30 p. m. southeast storm warnings were extended along the Atlantic coast to Boston, and cold-wave warnings ordered for the Middle Atlantic States. On the morning of the 12th the storm was central over Georgian Bay, with a barometer reading of 28.70 inches at Saugeen, Ontario, and all conditions—snow, gales, and cold—had occurred over the interior districts and in the South Atlantic States, the cold wave reaching New England by the morning of the 13th.

During this storm the wind reached a velocity of 60 miles an hour from the northwest at Pensacola, Fla., 56 miles an hour from the south at Jacksonville, Fla., 72 miles an hour from the southwest at New York City, and 80 miles an hour from the southwest at Buffalo, N. Y. The line of 0° F. extended into northern Alabama on the morning of the 12th and the line of 18° to the Middle Gulf coast, while on the following morning the line of freezing temperature extended southward as far as Fort Lauderdale, Fla. Temperature records for the month of January were lowered over many of the central and southern districts east of the Rocky Mountains, and heavy snow fell from northeastern Texas northeastward through the Lakes Region and northern New England. Gales continued along the New England coast until the night of the 13th, and warnings were continued accordingly.

The next storm was also a very severe one, and it was first observed on the morning of the 12th over extreme northern British Columbia, appearing as an offshoot from a general depression over the Aleutian Islands. This was also the time of greatest development of the preceding storm over Georgian Bay. The second disturbance moved rapidly down the western slope of the Rocky Mountains, and by the morning of the 14th was central over northwestern Louisiana (Shreveport, 29.52 inches). It then turned northeastward with somewhat increased velocity of progression and passed into the Gulf of St. Lawrence on the morning of the 16th, having reached its maximum intensity on the previous evening over extreme eastern Maine (Eastport, 28.72 inches).

A recital of the storm's history would merely be a repetition of that of the previous one except as to specific details, and only the rapid approach of the third storm, which was over eastern Texas on the evening of January 15, prevented another cold wave in the South. Other less violent storms followed in rapid succession, although the type sequence was temporarily interrupted from the 22d to the 26th by a northwestern disturbance that moved eastward over the northern portion of the country.

In addition to those mentioned above, storm warnings were ordered on the following dates: 14th, 15th, 18th, 19th, 21st, 22d, 26th, 27th, and 28th. The major portion were verified, either wholly or in part, while several failed on account of erratic movement and decreasing intensity.

Cold-wave and frost warnings were ordered also on the following dates: 15th, 18th, 19th, 20th, 22d, 23d, 25th, 26th, 27th, 28th, and 31st. Quite a number of these failed of verification on account of the persistence of high pressure over the middle and southern North Atlantic, which could not be anticipated.

Heavy-snow warnings were issued for the Middle Atlantic States and southern New England on the 22d, the only ones except those of the 11th previously mentioned.

A warning of strong northwest to north winds for the Panama Canal zone was issued on the 11th, and a maximum wind velocity of 27 miles an hour from the northwest was recorded on the 14th. The Chief Hydrographer of the Panama Canal reported that "it is probable that the winds may have reached gale force at no great distance seaward."

Special bulletins regarding cold weather and snow were issued on the 10th, 12th, 14th, 24th, and 30th, and were prepared with special reference to their effect upon railroad activities and the distribution of food and fuel.

WARNINGS FROM OTHER DISTRICTS.

Chicago, Ill., forecast district.—A storm of marked intensity moved northeastward from Texas to the southern Lakes Region during January 5–6, and at the same time an area of high pressure and low temperature developed over Manitoba and moved southward. Accordingly cold-wave warnings were ordered for the upper Mississippi and middle Missouri valleys. These warnings were only partially verified on account of the rapid eastward advance of a disturbance from the far Northwest.

Warnings were issued well in advance of the severe cold wave which overspread Montana on the 9th and moved rapidly southeastward, reaching Illinois during the night of the 10th-11th. Warnings of strong northerly winds and snow were also issued for the benefit of the cattle interests in Wyoming and the Plains States.

No further warnings were issued until the evening of the 18th, when cold-wave warnings were ordered for eastern Wyoming and cattle warnings for southwestern Nebraska and western and central Kansas. The former were fully verified, but the weather conditions in the Western Plains States were not severe on account of the filling up of a disturbance which moved southeastward into Texas.

On the evening of the 24th the pressure-change chart showed a marked fall in pressure over the northern Plateau and northern Pacific States, with a marked rise over northern Manitoba and Saskatchewan. Such conditions are usually quite favorable for the development of an area of high pressure and low temperature over the Northwest, accordingly cold-wave warnings were issued for the northern border States and as far south as Iowa, Nebraska, and Wyoming. The following morning warnings were ordered for Kansas and western and central Missouri, and on the evening of the 25th and morning of the 26th for eastern Missouri and Illinois. The warnings were fully verified in practically all sections.

The next cold-wave warnings of importance were ordered for western Montana on the evening of the 28th and for Wyoming, Kansas, western Iowa, and western and central Missouri on the 29th. These warnings were fully verified.

Heavy-snow warnings were issued for northern and central Illinois and southeastern Wisconsin on the evening of the 27th.—*Chas. L. Mitchell, Assistant Forecaster.*

New Orleans, La., forecast district.—Periods of cold weather, mostly following barometric depressions that developed in the southern ends of troughs of low pressure moving eastward from the Rocky Mountain Region, were unusually frequent during January, 1918; and marked activity was shown by the cyclonic disturbances.

On indications of the 8 p. m. chart of January 4, southeast storm warnings were issued for the Louisiana coast and the east coast of Texas; but the disturbance moved farther inland as it gained intensity and the warnings were lowered the next morning.

Intense weather conditions prevailed over the western half of the country on the 10th, and midday special observations showed that a depression over the Southwest had been forced southward over Texas by a large area of high pressure. The following warning was issued:

Hoist northwest storm warning 2 p. m., Morgan City, La., to Brownsville, Tex. Disturbance over southern Texas, with high pressure to northward, will cause moderate to fresh northerly gales to-night and Friday. Rain turning to snow and much colder Thursday night and Friday.

At 3 p. m. southeast warnings were ordered for the Louisiana coast east of Morgan City and changed to northwest the next morning. The warnings from Velasco, on the east coast of Texas, to Morgan City, La., were continued at 2 p. m. of the 11th, with orders to lower at sunset. The warnings were verified. The maximum velocities exceeded 40 miles an hour along the Texas coast and reached 56 miles at Galveston.

Because of a marked disturbance over New Mexico, shown on the 8 p. m. map of the 13th, southeast storm warnings were ordered for the Texas coast and extended the following morning over the Louisiana coast. The disturbance moved eastward across the Gulf States, attended by strong winds to moderate gales, as forecast.

A disturbance over Texas, on the morning of the 19th, gave some promise of development. Small-craft warnings were issued for the Louisiana and Texas coasts and were changed to northwest storm warnings for the east coast of Texas at 2 p. m. Small-craft warnings were again displayed on the Texas coast on the 20th, being changed from storm warnings on the east coast. These warnings were verified, the highest velocities occurring during the night of the 19th–20th on the east coast of Texas.

A large area of high pressure was moving southward on the 26th, as shown by the 8 p. m. map, and northeast storm warnings were ordered for the Texas coast. A moderate gale occurred on the west coast and fresh winds on the east coast.

On the morning of the 2d, colder weather was predicted for the interior of the district, with freezing in Oklahoma and Arkansas, near freezing in northern Louisiana, and frost nearly to the coast in Louisiana and Texas. No marked area of high pressure appeared on the map, but a depression central over Kentucky was moving in an unusual southeastward course. A marked change to colder followed, reaching the proportions of a cold wave in eastern and central Oklahoma and northwestern Arkansas.

On indications obtained in special observations, on the 5th, cold-wave warnings were issued for central and northeastern Oklahoma and northwestern and central Arkansas. At night the warnings were extended over the northern portion of east Texas and the remainder of Arkansas, and on the morning of the 6th were ordered for the southern portion of east Texas. The warnings were timely and were verified except on the west coast of Texas, where the temperature fall was slightly less than was expected.

Cold-wave warnings issued for Arkansas on the 9th proved to be premature, although a change to colder occurred. In the early afternoon warning of a cold wave with snow and strong northerly winds was issued for the Texas Panhandle and northwestern Oklahoma, and was verified. The warning was extended eastward and southward, at night and the following morning, to include all of Oklahoma, northwestern Arkansas, and the northern portion of Texas. The approach of severely cold weather was now apparent and special observations were called for. Early in the afternoon of the 10th, cold-wave warnings were ordered for the remainder of the forecast district, with forecasts of northerly gales, snow in the interior, rain turning to snow on the coast, and temperatures below freezing to the coast by the following morning. The cold wave reached the Texas coast on the morning of the 11th, bringing a fall of 30 to 40 degrees to a temperature of 22° at Corpus Christi and Galveston. Snow and winds occurred as forecast. Although temperatures were already much below freezing in Arkansas on the morning of the 11th, warning of a cold wave was repeated for eastern and southern Arkansas as well as for Louisiana, with zero temperatures in Arkansas, zero to 10° in northern Louisiana, and 10° to 16° in the sugar and trucking region of southern Louisiana. Temperatures slightly below zero were recorded in Arkansas, and temperatures in Louisiana occurred as forecast. At New Orleans the temperature on the 11th fell from 67° at 7 a. m. to 24° at 7 p. m., and reached a minimum of 17° in the early morning of the 12th. Previous low-temperature records in Arkansas were broken. Plumbing was extensively damaged in southern Louisiana, and many young citrus fruit trees were killed. The forecasts contained a special warning to protect live stock and vegetation and to drain water pipes. Losses, though considerable, were diminished by precautions taken.

On January 14, a well-defined area of low pressure was over extreme eastern Texas. The high-pressure area over the central Plains States was small and only relatively high, while a considerable depression overspread the far Northwestern States. Midday special observations were called for and cold-wave warnings were ordered for the southern portion of eastern Texas, and for Palestine in northeastern Texas. The cold wave occurred in the area named and also at Muskogee, Okla., Fort Smith, Ark., and Shreveport, La. At Muskogee and Fort Smith, continued cloudy and cold weather during daytime of the 14th was followed by an ordinary temperature fall at night.

A cold wave occurred in the central and southeastern portions of the district on the 20th–21st, for which warnings were issued on the morning of the 19th. For western Texas, no warnings were issued in this instance and no cold wave occurred except in the southwestern portion, where (El Paso) the temperature was high at 7 p. m. of the 19th and fell decidedly in the following 24 hours, as an area of low pressure in that vicinity was displaced by the western edge of an area of high pressure.

On the 26th–27th and 30th–31st, respectively, extensive areas of high pressure moved southward over the district, causing cold waves over the interior, for which timely warnings had been issued. Due to unsettled conditions over the Gulf, the temperature along the Gulf coast was not as low as was expected in either instance.

Forecasts of frost, or temperatures of freezing or lower, to or nearly to the coast, were made on two-thirds of the days of the month and were nearly all verified. Special attention was given to conditions affecting live stock and the shipment of perishable commodities. The scarcity of fuel enchanced the importance of the forecasts.

Fire-weather warnings were issued for the forested regions of Oklahoma and Arkansas on the 5th and for Oklahoma on the 9th, and conditions occurred as forecast except that snow continued to fall in western Arkansas somewhat longer than predicted. The fire hazard was lessened during the greater part of the month by the snow covering.—*R. A. Dyke, Assistant Forecaster.*

Denver, Colo., forecast district.—While January, 1918, in the Denver Forecast District was colder and stormier than common, severe conditions were confined principally to the region east of the Continental Divide. The storm activity on the eastern slope resulted, for the most part, from the abnormal paths taken by several northwestern low-pressure areas, which instead of moving eastward were deflected southward, following closely the Continental Divide to southwestern Texas. In the wake of each of these LOWS there followed strong anticyclonic conditions from the Canadian Northwest and severe cold spread over the Plains Region to the lower Rio Grande Valley and adjacent parts of Mexico and the Gulf districts.

In addition to these depressions having their origin in the distant north a low-pressure area, followed by the lowest temperatures of the month, developed in the southern Plateau States during the night of January 8. Its front reached the Plains Region in advance of the northern anticyclone whose front thereafter moved rapidly southward along the east side of the Continental Divide. Cold-wave warnings were issued the evening of the 9th for eastern Colorado and eastern New Mexico. The warnings were fully verified. At Roswell, N. Mex., the 24-hour temperature-fall on the 10th was 51 degrees.

At 1 p. m. of the 25th cold-wave and live-stock warnings were issued for northeastern and middle eastern Colorado; at night these warnings were extended to include southeastern Colorado, and on the morning of the 26th to include eastern New Mexico. During the afternoon of the 25th the low center overlay north-central Colorado with an elongation of the depression northwestward to British Columbia and southeastward to central Texas. At this time the crest of the high-pressure area was north of the Dakotas. During the following 12 hours fresh LOW centers formed in Oklahoma, southeastern Colorado and northern Arizona while a general increase of pressure occurred over the northeastern Rocky Mountains slope. Temperatures fell rapidly, justifying the warnings issued. At Denver the 24-hour temperature fall was 56 degrees. In the afternoon of the 28th a low-pressure area was central in northern Idaho and 12 hours later in central Wyoming with loops extending northwestward to Washington and southward to southeastern New Mexico. Anticyclonic conditions overlay Alberta and Assiniboia. Cold-wave warnings and live-stock warnings were issued for eastern Colorado with the morning forecasts and in the afternoon were extended to include eastern New Mexico. On the morning of the 30th temperatures had fallen to zero, or lower, throughout eastern Colorado and 24 hours later to zero in northeastern New Mexico and 16° in southeastern New Mexico.

Rain in southern Arizona on the 13th and again from the 25th to 27th, inclusive, was accurately forecast. On the morning of the 28th killing frost was reported from Yuma; later reports indicated that no damage resulted from the temperature of 30° reported. Notice of freezing temperature in central Arizona on the morning of the 29th was included in the forecast of the 28th.—*Frederick H. Brandenburg, District Forecaster.*

San Francisco, Cal., forecast district.—Like the two preceding months, the storms passing eastward from the north Pacific during January, 1918, entered the continent at a high latitude. As a result of this storm movement the northern portion of the San Francisco forecast district received ample precipitation, which was well distributed throughout the montn while the southern portion was abnormally dry. No excessive daily amounts of precipitation were reported. There were a large number of rainy days in Washington, Oregon, and Idaho, but the precipitation fell in such moderate amounts that it nearly all penetrated the soil and there was only a moderate run-off. The only rains of any consequence in California occurred in the northern portion on the 12th, 13th, and 14th, when the amounts were moderate; and in the southern portion on the 13th and 14th and again on the 25th and 26th, when moderate amounts fell at most stations, with quite heavy rains in the extreme south and at some foothill stations.

Taking the record at San Francisco, which extends over a period of 69 years, as a basis, there has been less rain this season to date than any previous record, and there is practically no snow in the mountains except on the high isolated peaks. At Summit, where the Southern Pacific Railroad crosses the Sierra Nevada Mountains, elevation 7,017 feet, the average depth of snow on the ground at the end of January is a little over 125 inches, but this year there were only 2 inches on the ground. These comparisons illustrate the seriousness of the drought condition in northern California, and in the south it is about the same.

The temperature was above the normal throughout the entire district. In the northern portion both day and night temperatures were high, while in the southern portion the nights were comparatively cool and the days warm. There were but few sudden and marked changes in temperature during the month, the transitions to colder or warmer weather in most cases being gradual. Frosts occurred frequently in California, but they were not of marked severity, and little or no damage resulted, and there were but few nights when it was necessary for the citrus growers to smudge.

Storm warnings were ordered from the Columbia River northward on January 1, 3, 4, 6, 17, and 28; from Port Harford to San Diego on the 9th; from Point Reyes to Eureka on the 25th; and at Point Reyes on the 12th. While the warnings were not verified in all cases, it is believed that they were warranted by the conditions and appreciated by the marine interests.—*G. H. Willson, District Forecaster.*