THE WEATHER AND CIRCULATION OF OCTOBER 1960[1]

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1. INTRODUCTION

Generally fine fall weather prevailed throughout most of the United States during October 1960. The days were pleasantly warm and the nights cool. There was very little severe storm activity, and no tropical storms were observed in the Atlantic, Caribbean, and Gulf of Mexico.

Principal exception to the good weather occurred over the Southwest where Arizona, New Mexico, and Texas reported record or near record amounts of precipitation for the month, with flash flooding a frequent occurrence in Texas.

2. MONTHLY MEAN CIRCULATION AND WEATHER

MEAN CIRCULATION

The most anomalous feature of October's average circulation pattern at 700 mb. (fig. 1) was strong blocking over the North Atlantic, where heights averaged as much as 390 ft. above normal. During September [1] blocking had been centered just north of Scandinavia. As the blocking moved westward, it increased in strength and was associated with development near Ireland of a deep mean Low both at 700 mb. and sea level (figs. 1 and 2). The presence of a cyclonic center on a monthly mean map in this area is most unusual, none previously having been observed during our period of record (since 1932). Average sea level pressures in this Low were as much as 12 mb. below normal (not shown), while heights at 700 mb. were 400 ft. below normal.

Retrogression and intensification of the block was also associated with development of a deep full-latitude trough over central Asia (fig. 1). Perhaps as a result, the mean troughs near the Asiatic coast, over the mid-Pacific, and off the California coast moved eastward from September to October. The full-latitude trough near the east coast of North America during September deepened at middle latitudes as its lower portion moved slowly eastward in October. At higher latitudes, however, this trough weakened and retrograded as blocking from the North Atlantic spread into eastern Canada, the trough assuming more of a negative tilt.

Wind speeds at 700 mb. also reflected the blocking character of the circulation over the Atlantic. Note in figure 3A the characteristic split jet stream over the Atlantic and Europe, with wind speeds up to 7 m.p.s. above normal at high latitudes and as much as 9 m.p.s. above normal at lower latitudes (fig. 3B). An extensive area of subnormal wind speeds, as much as 7 m.p.s., was observed at middle latitudes. The axis of maximum west winds across the Atlantic was displaced south of normal (normal position is shown by dashed line) as a result of the blocking. Elsewhere around the hemisphere, the jet axis appeared as a well defined current, north of its normal position over eastern Asia and the western Pacific, and near its normal position over the eastern Pacific and across North America (fig. 3A). Wind speeds in the latter two areas were close to their normal values (fig. 3B). This is also implied by small departures from normal of 700-mb. heights (fig. 1).

AVERAGE UNITED STATES WEATHER

October was generally warm over most of the contiguous United States, with below normal temperatures observed only in the Plateau States, the Northeast, and in portions of the Upper Mississippi Valley (fig. 4). Temperature departures were rather small, 2° F. or less over most of the Nation, although positive departures of as much as 4° F. were observed in southeastern Montana (fig. 4).

The predominantly mild weather can be related to the weaker than normal ridge over western Canada (fig. 1). As a result of the weakness of this ridge, relatively mild Pacific air masses dominated the Nation's weather. Over the Great Basin, however, strong radiational cooling in the mean sea level High (fig. 2) resulted in below normal temperatures. The cool conditions in Arizona and New Mexico can be related primarily to southward advection of Pacific air masses into a stronger than normal trough aloft (fig. 1), and also to cloudiness and precipitation from a very slow moving storm near mid-month. In the Northeast below normal 700-mb. heights and northerly, anomalous flow resulted in cool conditions (figs. 1 and 4). From the Middle Atlantic States to the Gulf of Mexico this flow diminished in strength, and, combined with a weak confluence zone over the middle United States, tended to prevent the southward intrusion of cooler conditions.

[1] Articles on the weather and circulation of November 1960, December 1960, and January 1961 will appear in the February, March, and April 1961 issues, respectively, of the *Monthly Weather Review*.

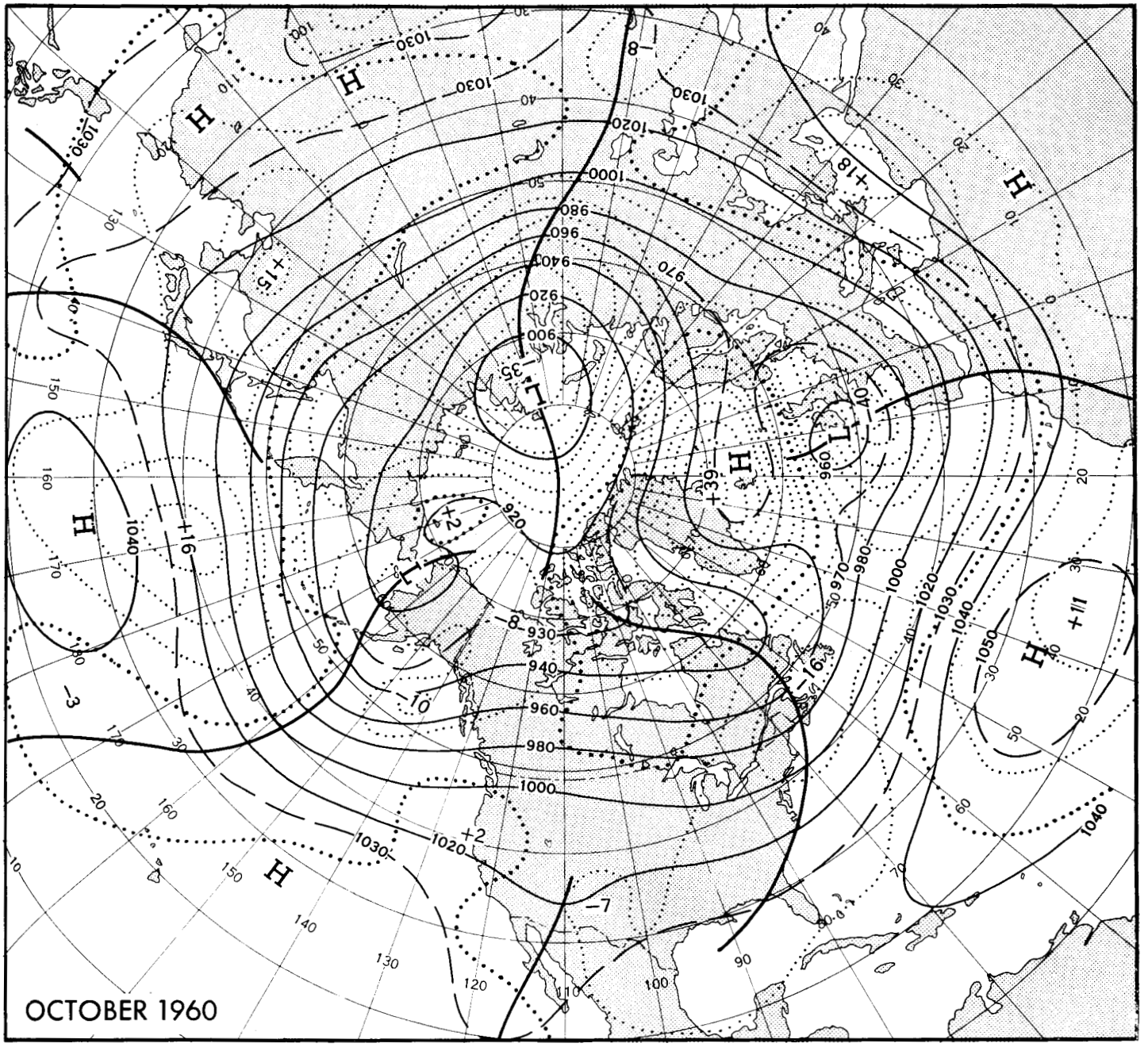

FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for October 1960. Blocking pattern in the Atlantic was the outstanding circulation feature of the month.

The outstanding feature of the precipitation pattern for October was the large area in the Southwest where amounts were far in excess of the monthly normal (fig. 5). As much as six times the normal amount of precipitation fell in portions of southeastern Texas. Victoria reported 17.25 inches, an all-time record for any month, while Corpus Christi, with 10.66 inches at the airport and 15.49 inches at the Weather Bureau city office, had its rainiest October in a period of record dating back to 1887. At Austin, Tex., rainfall of 12.31 inches was the second heaviest on record for October. The heavy precipitation in the Southwest was related to the deeper than normal trough in that area (fig. 1) and to cyclonically curved southeasterly flow of Gulf moisture at the surface (fig. 2). This weather pattern replaced the upper level anticyclone and generally dry conditions which had prevailed during September [1].

Near normal amounts of precipitation fell over much of the East. This was related primarily to cyclonic curvature of the contours and below normal 700-mb. heights in the mean trough along the east coast.

Less than half the normal amount of precipitation fell

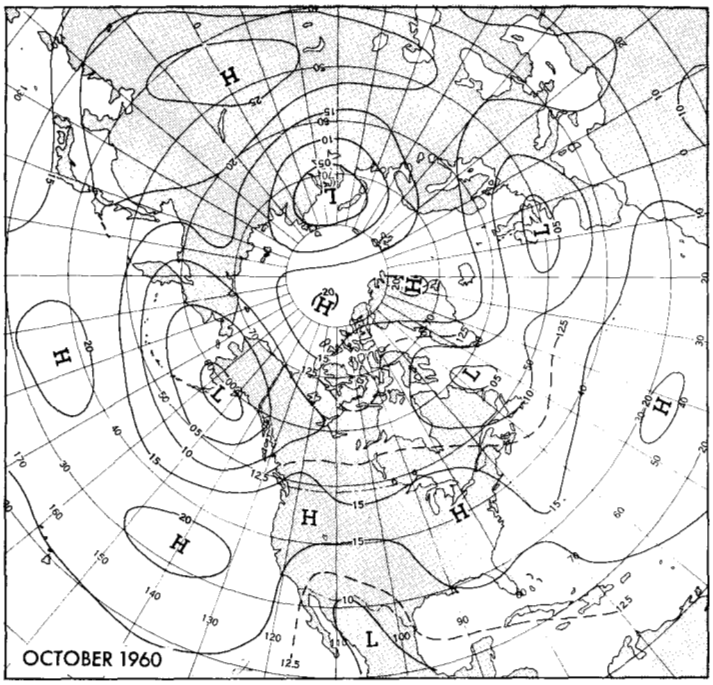

FIGURE 2.—Mean sea level isobars (millibars, hundreds omitted) for October 1960. Low cells and storm track in the North Atlantic were displaced well south of normal.

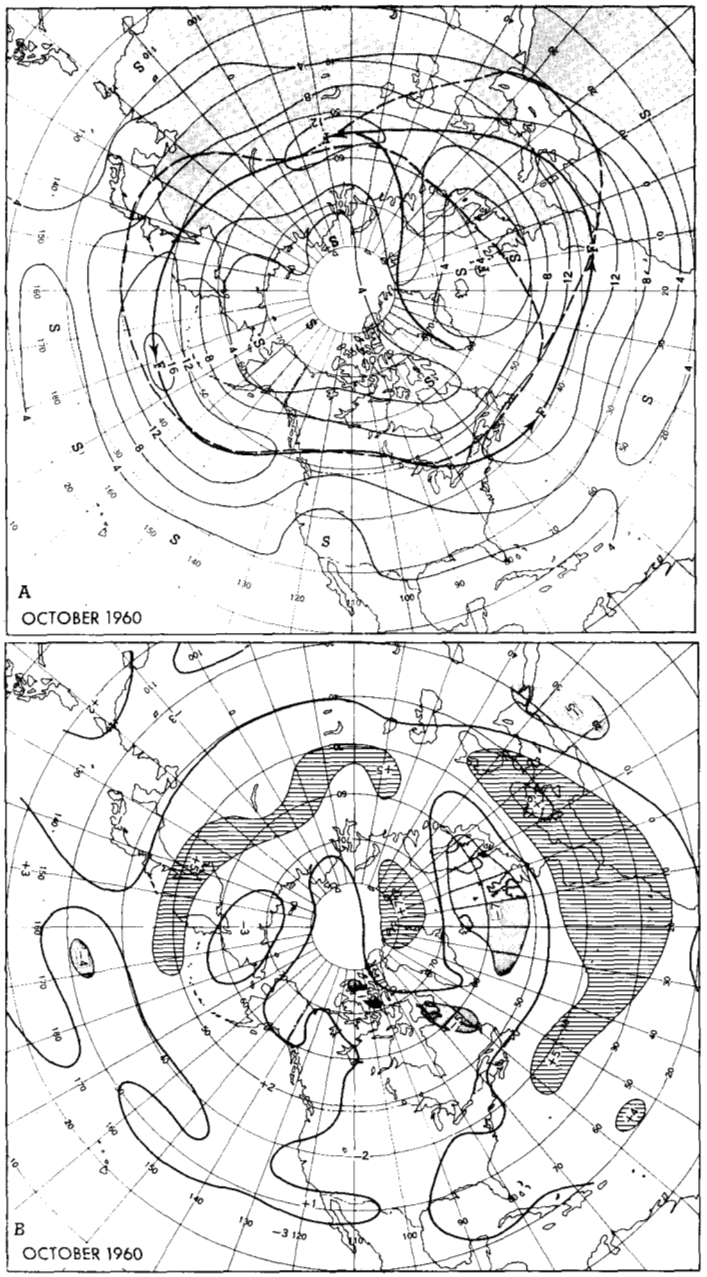

FIGURE 3.—(A) Mean 700-mb. isotachs and (B) departure from monthly normal wind speed (both in meters per second) for October 1960. Solid arrows in (A) indicate axes of primary wind speed maxima with the normal position dashed. Areas of departures in (B) greater than +4 are hatched, those greater than −4 are stippled.

in the Great Basin, most of California, and the northern Great Plains (fig. 5). No measurable precipitation fell at Rapid City, S. Dak. during October; none had fallen since September 22. Anticyclonic curvature and a weak ridge aloft (fig. 1) contributed most to this precipitation deficiency.

SOME CHARACTERISTICS OF EUROPEAN WEATHER

In this section special attention will be devoted to October's weather in Europe because of the unusual nature of the monthly mean circulation observed in that area. The average weather observed in Europe during October can be divided roughly into three regimes: cool and dry in the north, cool and wet in the south, and warm and wet in the middle countries. In figure 6A is shown the average surface temperature and its departure from normal for selected European cities during October 1960, while figure 6B gives the total precipitation and percentage of normal for the same cities. These data are from [2]. Normals used are based on a 30-year average (1901–30 when available) as recommended by the World Meteorological Organization.

Unusually heavy amounts of precipitation fell in most areas, with only the northern portions of the British Isles and Scandinavia receiving substantially less than normal amounts. Many countries received more than twice their normal rainfall for the month, while much of Spain had more than three times the normal. In general, the greatest falls and percentages were found in areas closest to the Atlantic Ocean. La Coruna, Spain received 10.63 inches, and Brest and Bordeaux, France 8.66 inches each. In many areas this was the wettest October in several decades, and flooding was reported throughout much of western Europe.

The unusually wet weather was well related to October's mean circulation pattern. Of most importance was the deep mean trough along the coast of western Europe and the intense cyclonic center of action near Ireland (figs. 1 and 2). Abnormally strong Atlantic westerlies, aided by orographic lifting, dropped much of their moisture near and

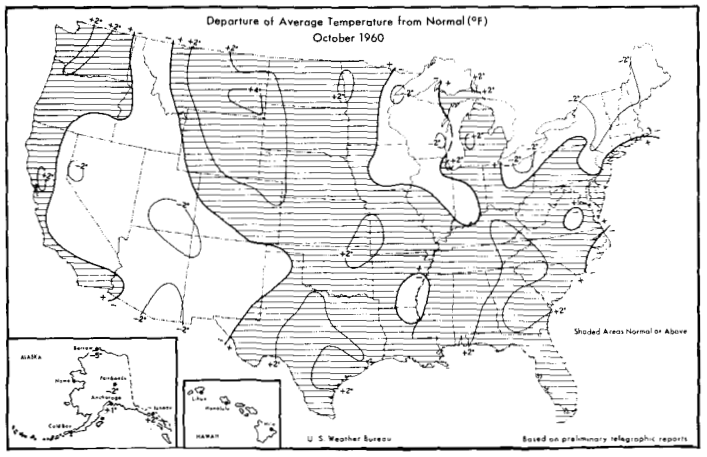

FIGURE 4.—Departure of average surface temperature from normal (° F.) for October 1960. Departures were generally small for the month. (From [6].)

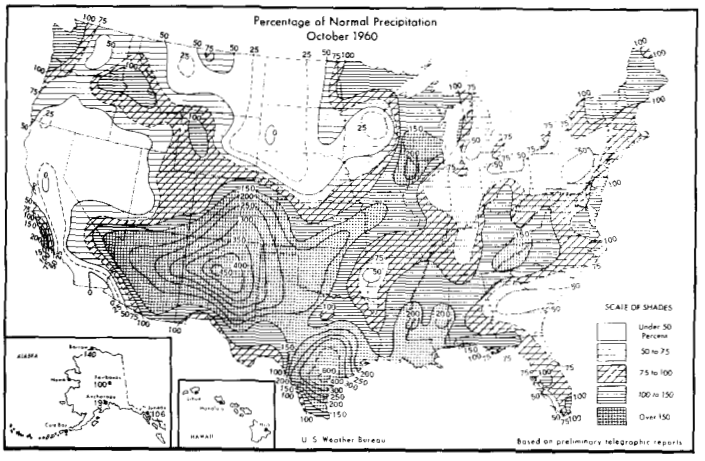

FIGURE 5.—Percentage of normal precipitation for October 1960. Far more than normal amounts fell in the Southwest. (From [6].)

along coastal areas, with somewhat lesser precipitation amounts farther inland. Much of the band of heaviest precipitation fell near or to the north of the primary jet axis at 700 mb. (fig. 3). At sea level, storms moving across the Atlantic reached their maximum intensity near the coast before moving inland and weakening. The path of these systems was well defined by the zonal trough on the mean sea level chart (fig. 2).

The strong upper level ridge near Greenland and the accompanying lack of cyclonic activity were related to above normal temperatures and a precipitation deficiency in Iceland, while stronger than normal northerly flow resulted in below normal temperatures and subnormal amounts of precipitation throughout most of Scandinavia (figs. 1, 2, 6). A strong onshore flow of relatively cool Atlantic air, combined with persistent cloudiness and precipitation, produced cooler than normal conditions in southwestern Europe, where Madrid, Spain, reported a temperature departure of −4°F. In central and southeastern Europe prevailing southerly flow at sea level and aloft resulted in generally warmer than normal conditions.

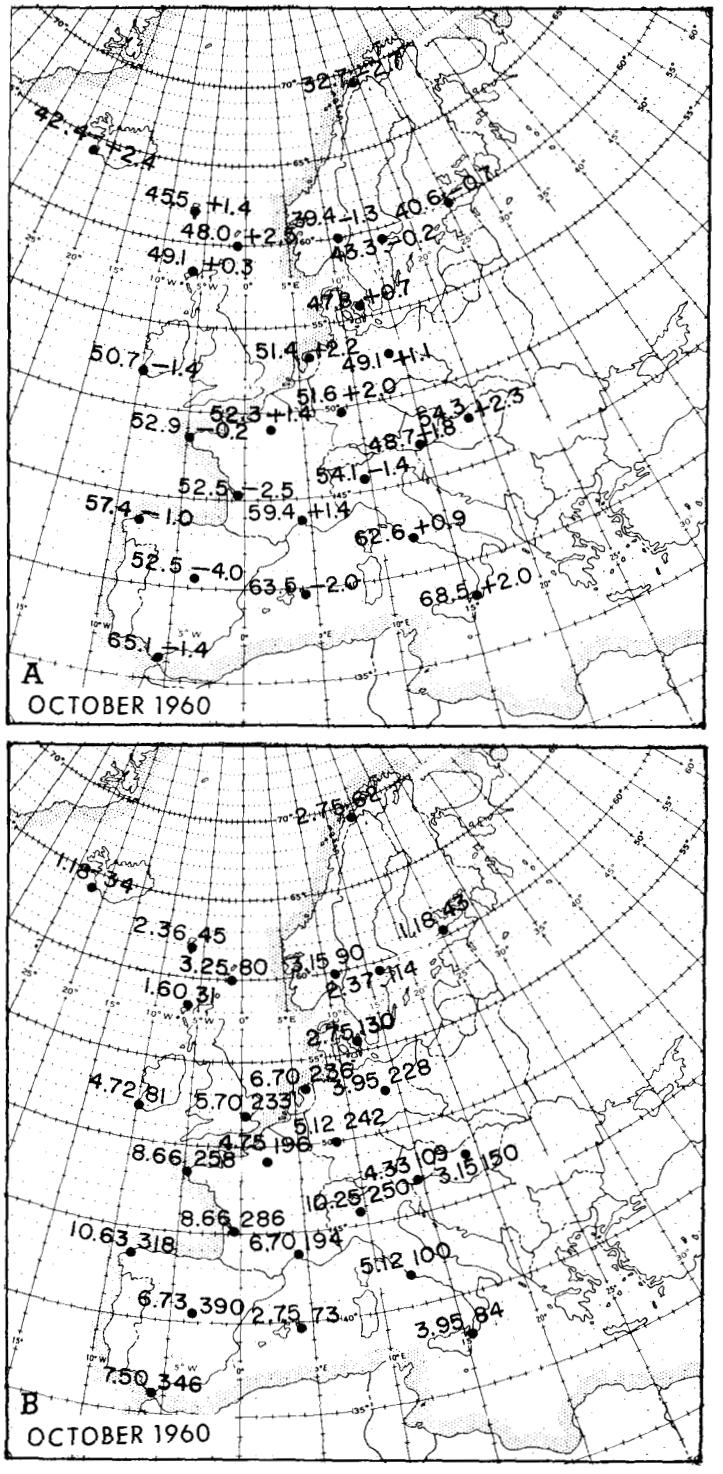

FIGURE 6.—(A) Average surface temperature and departure from normal (° F.), and (B) total precipitation (inches, approximate) and percentage of normal for October 1960 at selected European stations.

3. WEEK-TO-WEEK VARIABILITY

Rather marked week-to-week changes occurred in the circulation and weather over the contiguous United States during October. These changes will be described

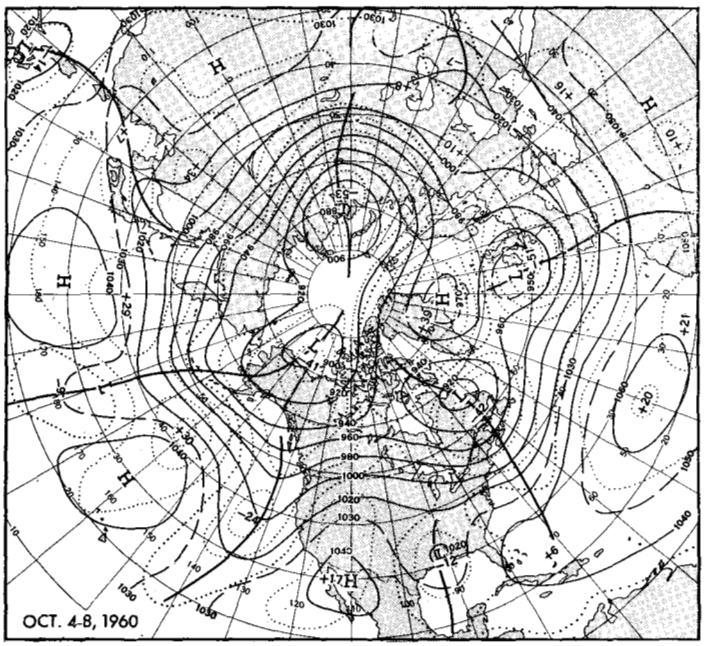

FIGURE 7.—Five-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for October 4–8, 1960.

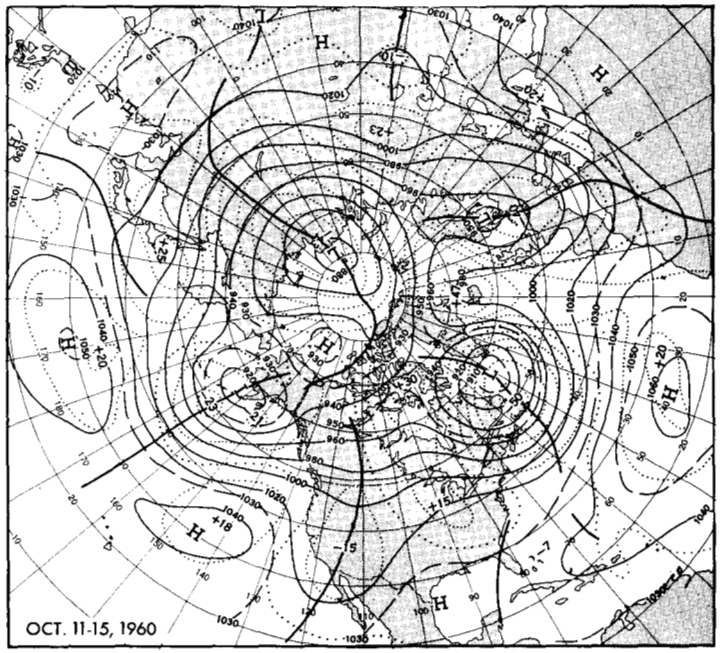

FIGURE 8.—Five-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for October 11–15, 1960.

using a series of 5-day mean 700-mb. charts centered one week apart. The reader is referred to the corresponding maps of weekly temperature departure from normal and total precipitation published in the *Weekly Weather and Crop Bulletin* [3].

WEEK ENDING OCTOBER 9

The month began with the westerlies stronger than normal, troughs off both east and west coasts of the United States, and a strong ridge over the West (fig. 7). Another trough, seemingly out of place because of high zonal index conditions and short wavelength, was found over the Gulf of Mexico. The circulation in the Atlantic was strikingly similar to the mean pattern for the month (compare figs. 1 and 7).

Mild Pacific air masses dominated the United States and resulted in above normal temperatures over all but the extreme northwestern and northeastern sections of the country [3]. Greatest weekly departures, as much as 9° F. above normal, were observed in the northern Great Plains. A temperature of 91° F. at Bismarck, N. Dak. on the 4th equalled their previous record high for so late in the season. This unseasonable warmth was related to the strong upper level ridge over the West, and to the extensive area of negative 700-mb. height anomaly over western Canada (fig. 7). It has long been known that negative height anomalies over western Canada during the cooler seasons are associated with above normal temperatures over most of the United States, with the converse also true. Cool weather in the Northeast was related to stronger than normal northerly circulation around the deep center of action over eastern Canada (fig. 7).

Little if any precipitation fell in the area from the Rockies to the Great Lakes, under the influence of dry, northwesterly flow aloft (fig. 7). The heaviest and most frequent precipitation fell over the southeastern quarter of the Nation, with amounts of 2 inches or more quite general. These heavy rains were related to a slow moving trough and cyclonic center over Louisiana and Mississippi. Precipitation in the Far West was associated with the approach of the deep trough off the coast. As this trough moved eastward, a storm developed over the Far Southwest late in the week, bringing heavy precipitation to that area.

WEEK ENDING OCTOBER 16

Eastward motion of all trough-ridge systems occurred from the first to the second weeks under the influence of continuing fast westerlies. The trough over the Gulf of Mexico and Gulf States filled considerably as it moved eastward (fig. 8). As a result little if any rain fell in the Southeast.

Eastward motion was also observed in the temperature patterns between the two weeks. Cold Pacific air masses accompanied the eastern Pacific trough into the Far West, where temperatures for the week averaged as much as 9° F. below normal in southern Nevada and southeastern Idaho.

Abnormally warm weather overspread the East to include all but northern New England, where a persistent northerly circulation kept temperatures below normal (fig. 8). Escanaba, Mich., reported its highest tempera-

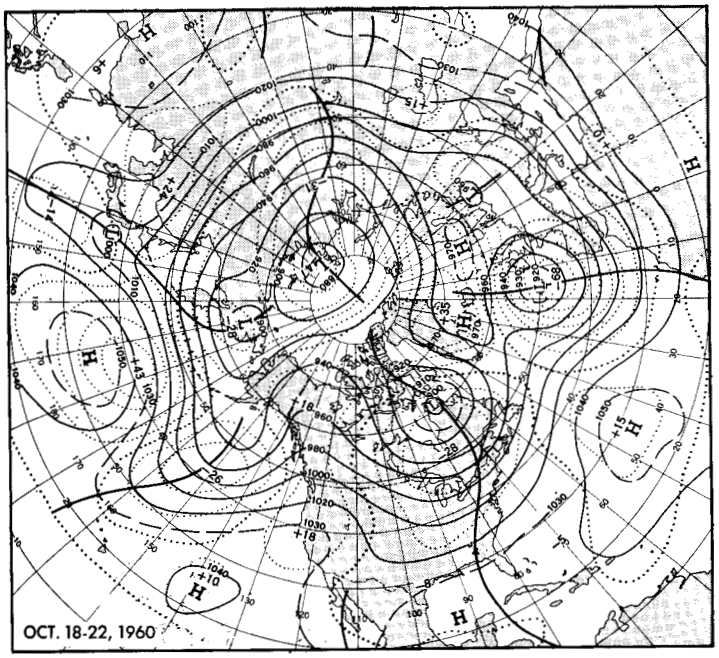

FIGURE 9.—Five-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for October 18–22, 1960.

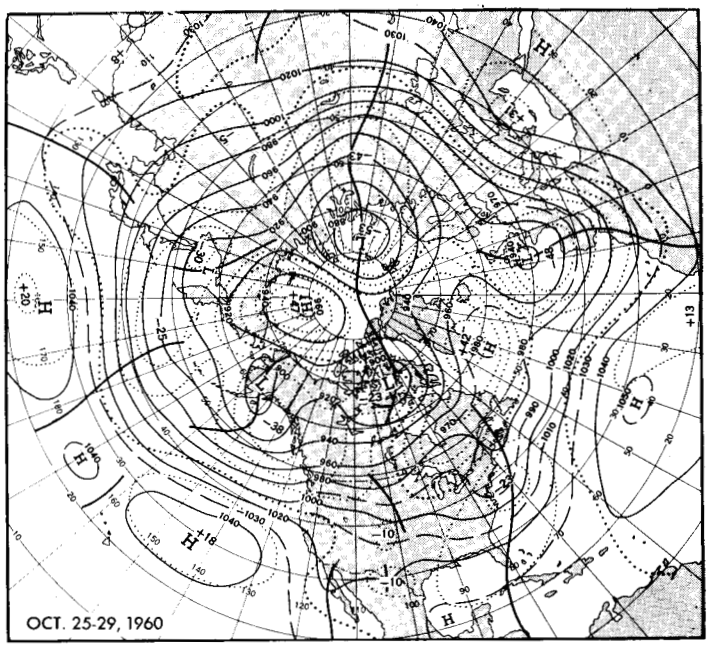

FIGURE 10.—Five-day mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for October 25–29, 1960.

ture so late in the season, 82° F. on the 10th. Daily temperature records were established at Des Moines, Iowa (86°) and Topeka, Kans. (87°) on the 11th, Detroit, Mich. (81°) on the 13th, and Providence, R.I. (81°) on the 15th.

The deep trough in the West spread heavy rains from the lower Great Plains to the Great Lakes, with greatest amounts in Texas. As much as 12 inches fell in the southern part of that State. Precipitation at Denver, Colo., on the 13th ended a 20-day period without measurable precipitation and the driest August 1–October 12 period of record. The rainfall occurred as a storm system developed over the Far Southwest and became trapped by a massive high pressure area to the north. As a result, precipitation persisted in the southern Rocky Mountain States for four to five days, carrying over into the following week. Roswell, N. Mex., reported a near record 24-hour amount on the 16th–17th. The cutting off and stagnation of this storm was related to amplification of the circulation in the eastern Pacific near the end of the week.

Western Europe had its most favorable weather of the month during the second week as the trough near the coast moved eastward into central Europe (fig. 8).

WEEK ENDING OCTOBER 23

A complete reversal of circulation and temperature regimes occurred between the second and third weeks in the United States. This change was effected primarily by amplification and eastward motion of the trough-ridge system in the eastern Pacific. As a result a strong full-latitude ridge developed over the coast of western North America, with positive height anomalies replacing the negative field of the previous week (figs. 8, 9). At the same time the trough over the West moved eastward to the Appalachians, where ridge conditions had prevailed the week before. Marked changes also occurred downstream, with the circulation reverting to the same general pattern as observed during the first week (figs. 7, 9).

Stronger than normal northwesterly flow over western North America (fig. 9) deployed cold, continental polar air masses into the eastern two-thirds of the United States, thus bringing to an abrupt end the warm regime of the week before. Early season minimum temperature records were established on the 19th at Bismarck, N. Dak. (5°) and Huron, S. Dak. (11°), and on the 20th at Sioux City, Iowa (16°) and Topeka, Kans. (22°). The circulation reversal in the West was also accompanied by a reversal in temperature regimes, with some areas averaging 10° F. warmer than the previous week.

Continuation of trough conditions in the Southwest brought additional heavy rains to the Southern Plains, with Texas again receiving the heaviest amounts. Up to 10 inches fell in the middle Texas coastal region, resulting in considerable flash flooding. Eastward motion of the trough in the West also brought substantial amounts of precipitation to the Atlantic Coastal States.

WEEK ENDING OCTOBER 30

Intensification and retrogression of North Atlantic blocking dominated the circulation changes toward the end of the month. Heights at 700 mb. rose as much as 500 feet over southeastern Canada, while an increase of 700 feet was observed north of the Siberian Peninsula

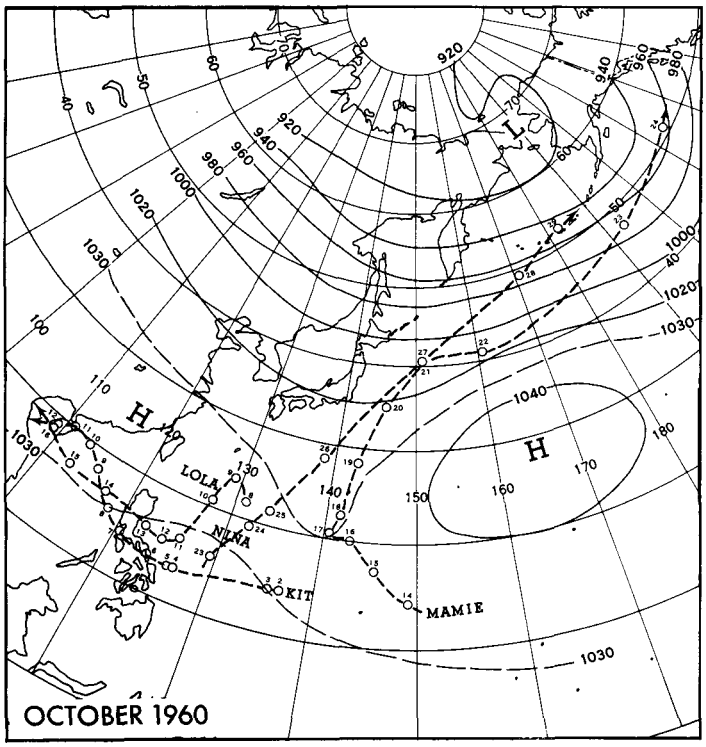

FIGURE 11.—Tracks of Pacific typhoons superimposed upon mean 700-mb. height contours (same as fig. 1) for October 1960. Open circles and dates indicate 1200 GMT positions.

(figs. 9, 10). As a result, the middle-latitude westerlies diminished in strength, with the circulation pattern characterized by a series of truncated trough-ridge systems with relatively short wavelengths.

Collapse of the ridge over western North America resulted in milder Pacific air and above normal temperatures spreading eastward to the Mississippi Valley. Most of the East continued cool because of stronger than normal northerly circulation (fig. 10).

For the third consecutive week heavy rains fell in central and southeastern Texas, causing major flooding along several streams. Amounts of 5 to 10 inches fell south of San Antonio on the 25th and from 7 to 10 inches in the Austin area on the 28th. Heavy amounts also spread northward into the western Great Lakes region. Much of this precipitation can be related to a developing lee trough east of the Rockies and to maintenance of the southwestern trough.

Several slow moving storm systems, deepening in the trough off the east coast, brought heavy precipitation to the Middle Atlantic coast and the Northeast. Some of this was in the form of an early season snowfall in Pennsylvania, New York, and New England. Amounts were generally light, but up to 6 inches was reported in New Hampshire.

4. TROPICAL ACTIVITY

ATLANTIC

There was a complete lack of tropical storm development in the Atlantic during October 1960. This compares with an average frequency of two such storms for October for the period 1887–1956. This absence of tropical activity was quite well related to the anomalous character of the circulation over the Atlantic, i.e., westerlies and subtropical ridge south of normal (figs. 1, 3), and is in agreement with the findings of Ballenzweig [4].

PACIFIC

Four typhoons were observed in the Pacific during October 1960. Tracks of these storms superimposed upon the 700-mb. monthly mean circulation (same as fig. 1) are shown in figure 11. It may be recalled that during September 1960 [1] four tropical storms were observed in the western Pacific, none reaching typhoon intensity. However, during October all storms were of typhoon strength. Normally tropical activity in the western Pacific decreases from September to October [5]. The relative increase between these two months during 1960 was probably related in part to the northward displacement of the mid-tropospheric westerlies and subtropical ridge (fig. 1). As a result the axis of maximum west wind at 700 mb. was some 10° north of normal over eastern Asia and the western Pacific (fig. 3A).

Typhoons Kit and Lola developed during the first half of the month. Both followed similar westward courses, south of the subtropical ridge axis, as they passed through the Philippines into the South China Sea before dissipating over land. Note how closely their paths followed the 10,300-ft. contour (dashed) of the monthly mean 700-mb. chart (fig. 11). Typhoons Mamie and Nina, on the other hand, developed during the latter half of the month and recurved northward into the westerlies. Here they became severe extratropical systems as they moved rapidly eastward, Mamie reaching a minimum sea level pressure of 952 mb. in the Gulf of Alaska on the 24th, while Nina deepened to 968 mb. on the 29th and 30th.

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