THE WEATHER AND CIRCULATION OF OCTOBER 1961

Retrogression of Planetary Waves in the Western Hemisphere

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1. INTRODUCTION

Pleasant fall weather prevailed over many areas of the United States during October 1961, with mild Indian summer weather in the Northeast, and cool weather in the West. California was an exception, particularly near mid-month, when the highest or second highest daily temperatures for any month were reported at many places principally along the southern coast. Some of the most notable were 111°F. at Long Beach on the 15th, 106°F. at Los Angeles and 107°F. at San Diego on the 14th.

Drought conditions were aggravated by deficiencies of precipitation in some areas of the country, particularly parts of the Southeast, the middle Mississippi Valley, Pennsylvania, the western Dakotas-eastern Montana area, and in the extreme Southwest, especially southern California.

The heaviest snows for so early in the season were reported in some sections of the West. New October records there included 8.2 inches at Winslow, Ariz., and 47.9 inches at Stampede Pass, Wash. Several Alaskan raeas also reported heavy early snows including 24.2 inches at Fairbanks compared with an average monthly total of 9.1 inches. In the East, record early snows of 4.1 inches at Caribou, Maine, on the 15th and 2.8 inches at Charleston, W. Va., on the 20th were also notable.

This was one of the wettest Octobers on record in parts of the Central Plains including Rockford, Ill., Topeka, Kans., Omaha, Nebr., and Huron, S. Dak. In the East, parts of Virginia and West Virginia were the wettest areas where, for example, Richmond reported its greatest 24-hour accumulation of rain on record, 6.5 inches on the 20th and 21st. In the West, parts of the north central Rockies also reported this was the wettest October in many years.

Abnormally high tides with some flooding of low-lying areas along the coastal sections of the mid-Atlantic seaboard resulted from a slow-moving storm which was blocked by a stationary anticyclone over the Maritime Provinces between the 20th and the 25th.

The principal weather disaster of the month was the devastation of Belize, British Honduras, by hurricane Hattie on the 31st, with immense loss of life and property.

2. AVERAGE MONTHLY CIRCULATION

October 1961 was very similar to the preceding month [1] in many of the large-scale circulation features and height anomalies. Some of the principal characteristics of the 700-mb. circulation (fig. 1) were the strong positive height departures from normal in the northeastern Pacific and in southeastern Canada, together with lower than normal heights over western North America. Figure 2 shows the changes in height departure from normal from September to October. Rises in the western United States reflect some filling of the trough in that area while falls in the East indicate a weaker ridge in October.

Elsewhere in the hemisphere, figure 1 shows that the eastern Atlantic and western European areas were dominated by a deeper than normal trough reflecting abnormal storminess there. Over central Europe an intense ridge prevailed, undoubtedly a dynamic response to an abnormally intense North Atlantic Low. Figure 2 shows that heights rose over 400 feet in excess of normal over northern Russia between September and October, while heights fell over western Europe.

The strongest meridional flow relative to normal prevailed in the Atlantic and European areas where northerly components as much as 7 m.p.s. above normal prevailed at 700 mb. on the average near southern Greenland, and 8 m.p.s. near the Urals. Southerly flow averaging 8 m.p.s. above normal prevailed over southern Norway at 700 mb.

The westerlies at mid-latitudes (35°–55°N.) averaged 10.3 m.p.s. at 700 mb. in the western sector of the Northern Hemisphere this October, or 0.8 m.p.s. above normal, about the same relationship to normal as in September. As shown in figure 3, the axis of maximum winds was near or north of normal throughout this sector of the hemisphere, with maximum speeds in the eastern Pacific and Atlantic as much as 6 m.p.s. stronger than normal.

3. AVERAGE TEMPERATURES

The average temperature regime which prevailed over the United States during October is shown in figure 4. In response to abnormally strong northerly flow aloft off the coast of the Pacific Northwest (as much as 6 m.p.s. above normal), temperatures inland over the western

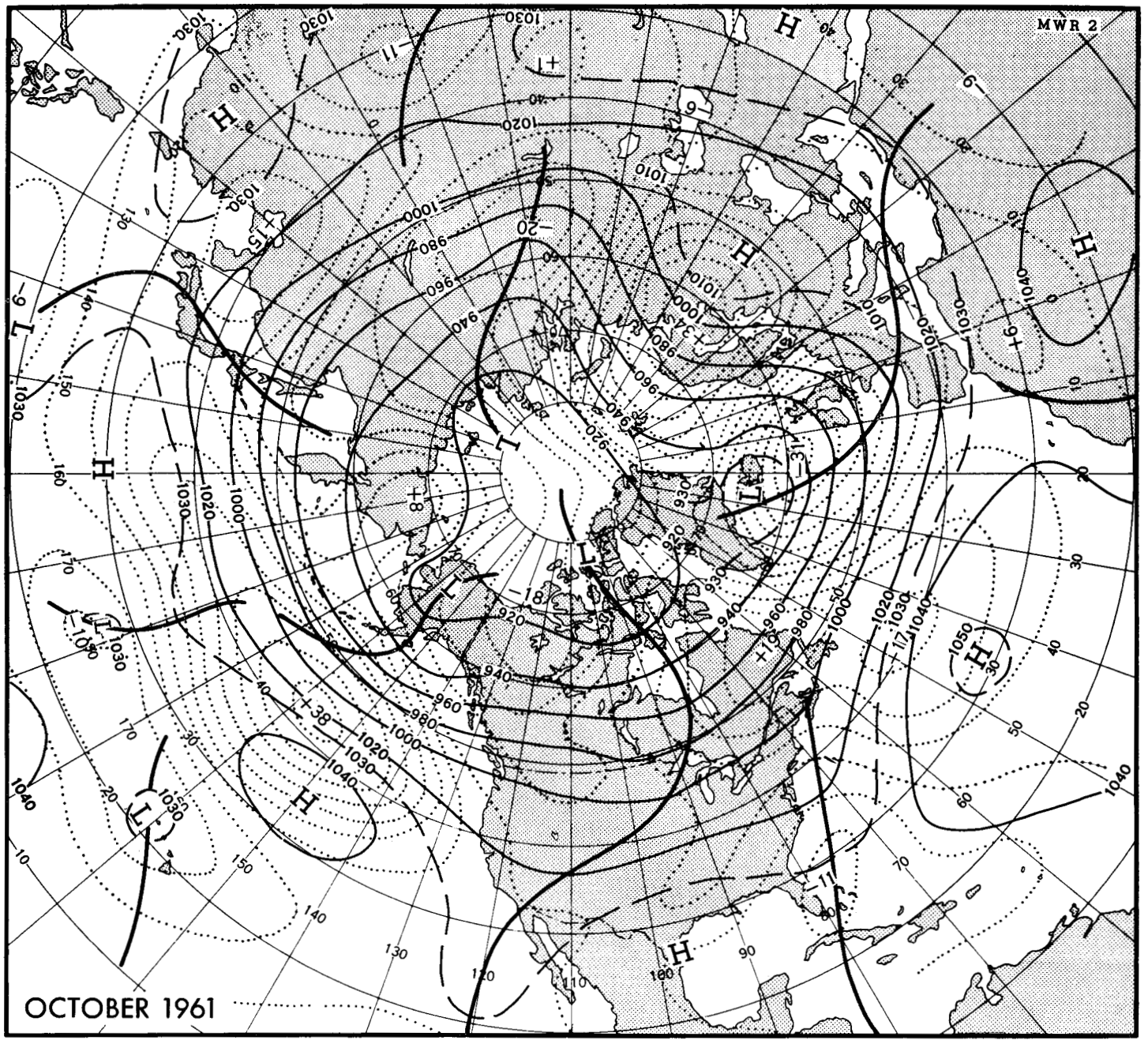


FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for October 1961. The strong positive height anomaly in the eastern Pacific was an important factor in the maintenance of below normal heights in the West.

United States averaged mostly below normal. Abnormally strong southerly flow over the north-central areas, and easterly flow over the northeastern sections produced above normal temperatures in those areas. In the Southeast, unseasonably cool temperatures were due to northerly flow of 2 m.p.s. above normal associated with an area of negative 700-mb. height anomaly near the east coast of Florida. The warmer than normal average temperatures over a large part of California in figure 4 resulted mainly from the overwhelming heat during the 5 days from the 13th to the 17th when close to all-time record temperatures were observed at some places.

A comparison of the September temperature regime with October over the United States is shown in figure 5. The predominant characteristic of this temperature class change pattern was one of persistence, since 76 percent of 100 stations changed no more than one class (out of a possible four). However, temperatures did warm one to three classes west of the Mississippi, except in the Southern Plains, and cooled one to two classes in the East.

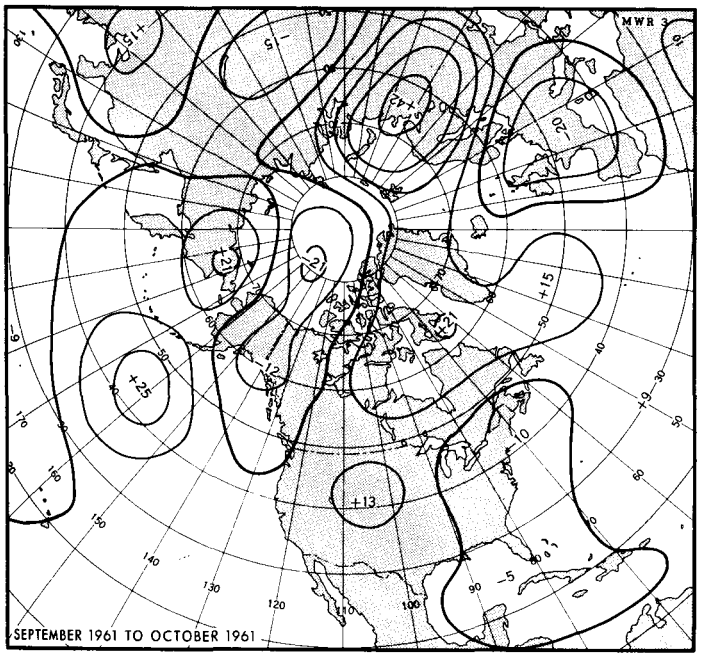


FIGURE 2.— Change in 700-mb. height departures from normal (tens of feet) from September to October 1961. Rises in the West and falls in the East resulted in some diminution of the weather contrasts between the two sections that prevailed a month earlier.

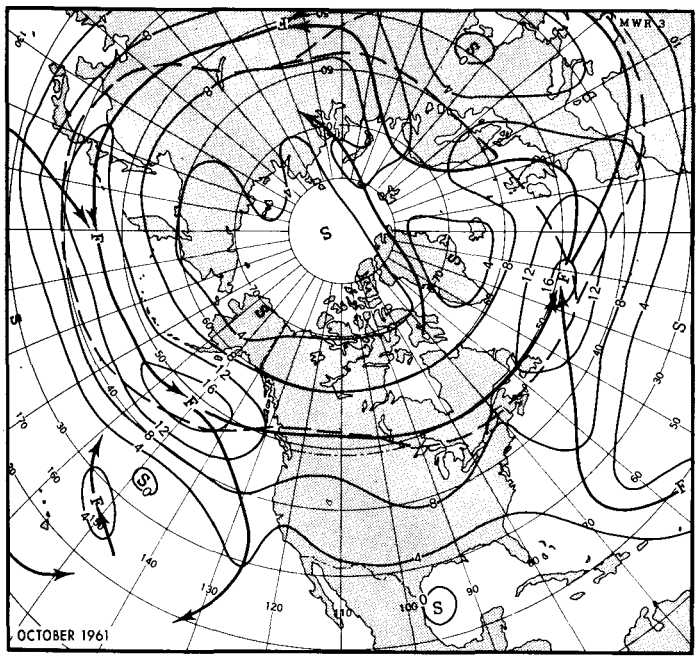


FIGURE 3.—Mean 700-mb. isotachs (meters per second) for October 1961. Solid arrows are axes of wind speed maxima with the normal dashed. Abnormally strong maxima occurred in the eastern Pacific and central Atlantic.

FIGURE 6.—Mean thickness (1000–700 mb.) departure from normal (tens of feet) for October 1961. Areas of thickness greater (warmer) than normal (by more than 50 ft.) are hatched, and less (cooler) than normal are stippled.

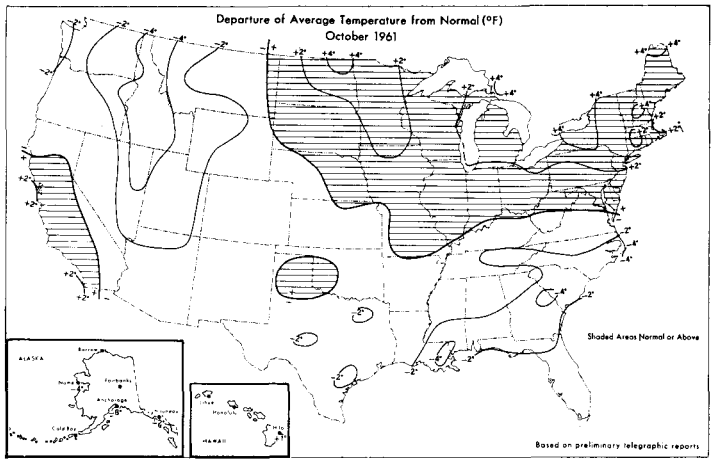


FIGURE 4.—Departure of average surface temperature from normal (°F.) for October 1961 (from [3]). Pattern was similar to September except in the Southeast and in north central sections.

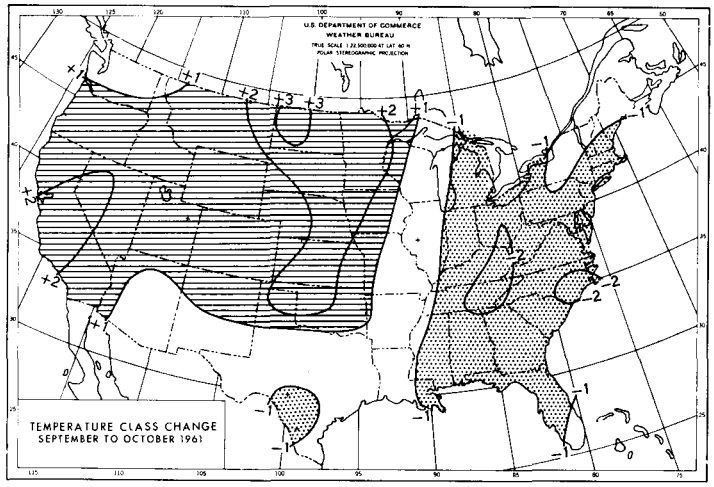
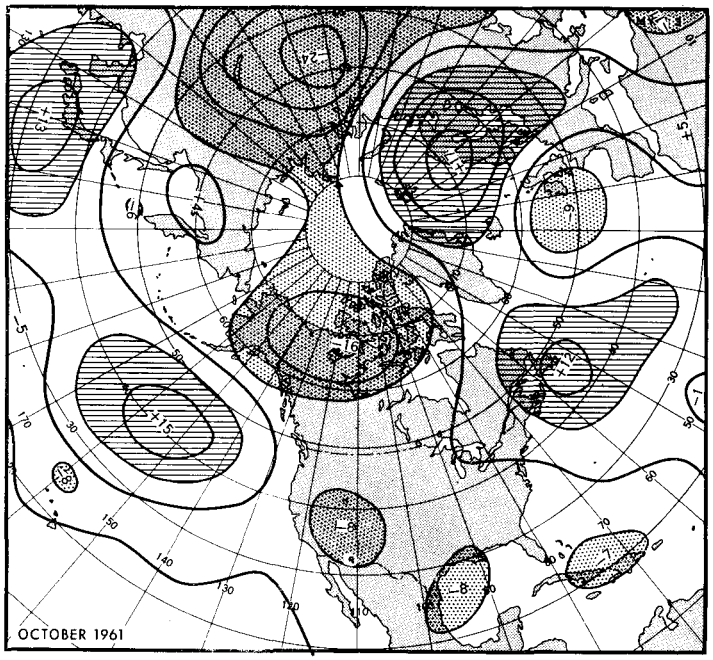


FIGURE 5.—Number of classes the surface temperature changed from September to October 1961. The pattern was one of considerable persistence since only 24 percent of the country changed by more than one class (out of four possible).



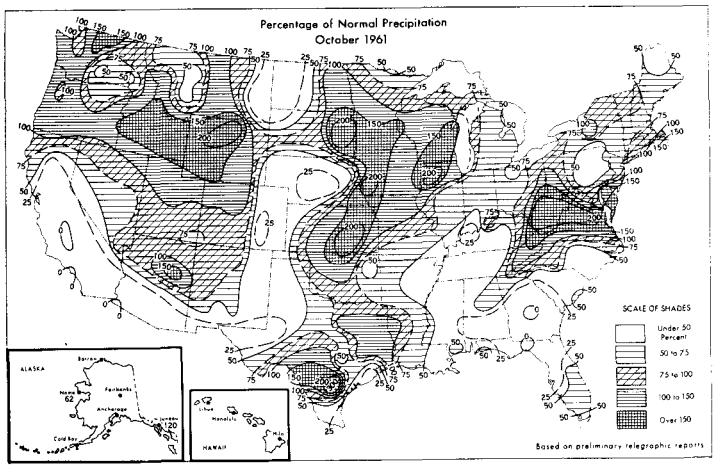


FIGURE 7.—Percentage of normal precipitation for October 1961 (from [3]). Little or no precipitation in the Southeast, western Dakotas, and southern California aggravated drought conditions there.

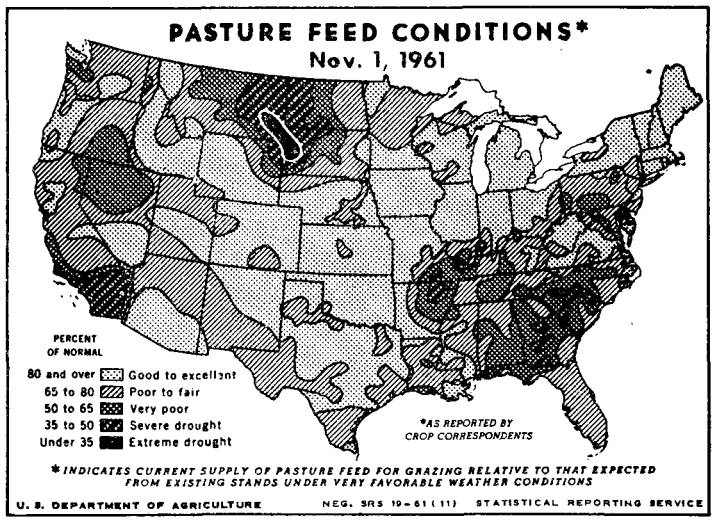


FIGURE 8.—Pasture conditions as of November 1, 1961 highlight the drought areas (from [3]). Compare with precipitation pattern of figure 7.

Over the rest of the hemisphere the approximate temperature regime is implied by the 1000–700-mb. thickness departures depicted in figure 6. In the Northwest Territories of Canada, and in Alaska, temperatures were below normal due to negative height departures and northerly components of average flow as much as 5 m.p.s. in excess of normal near the Bering Strait. In eastern Canada temperatures were warmer than normal because of the stronger than normal southerly flow and positive height departures at 700 mb. over central and eastern Canada. Most of Europe and especially northern Europe was dominated by excessive southerly flow which produced above normal thicknesses over Europe, especially northern Scandinavia.

4. MONTHLY PRECIPITATION AND DROUGHT

The precipitation regime over the United States this October is shown in figure 7. Excessive precipitation occurred mainly in central sections including parts of Texas, Kansas, Illinois, South Dakota, and Iowa; in the East primarily over the Virginias; and in the West over Arizona, Wyoming, Idaho, and parts of the Pacific Northwest. These were favored areas for cyclonic activity, both at the surface and at upper levels.

Deficiencies of precipitation approaching, or aggravating already-existing, drought conditions were reported generally in the lee of the Continental Divide, the Southeast, western Tennessee, western Kentucky and Mississippi, and in the extreme Southwest including most of California. In the Southeast, especially in Georgia, Alabama, Florida, and South Carolina, and in parts of the Northeast, particularly in Pennsylvania, many stations reported that this was the driest, or near driest, October on record. Macon, Ga., for example, received no rainfall compared with a normal expectation of 2.27 inches. Other stations reported dry periods of record duration, notably Tallahassee,

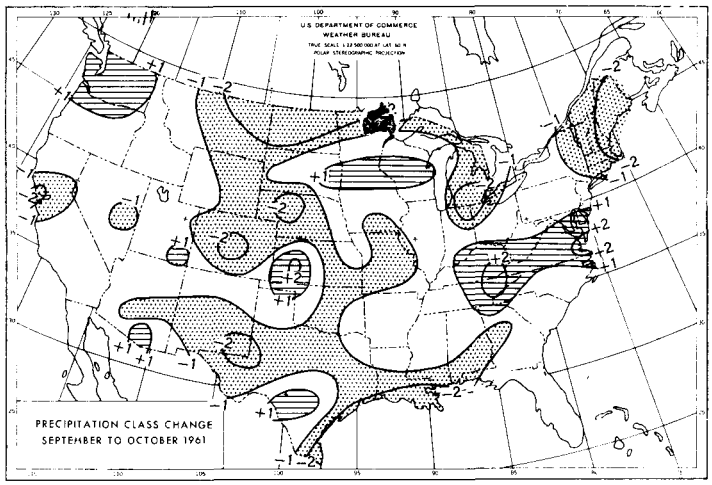


FIGURE 9.—Number of classes the total precipitation changed from September to October 1961. The pattern is one of persistence since only 23 percent of the country changed by more than one class (out of two possible)

Fla., with 46 days without rain as of the end of October. In the Southwest, a lengthy series of months of below normal precipitation continued unbroken at Yuma, Ariz., which reported only a trace this month compared with an average expectancy of 0.32 inches, making October 1961 the 16th consecutive month of below normal precipitation.

It may be of interest to compare the October precipitation (fig. 7) with the drought areas, so designated as of November 1961 by the U.S. Department of Agriculture, depicted in figure 8.

In comparison with September, rainfall patterns over the United States this October were similar in their large-scale aspects, as many of the abnormally wet as well as dry areas of September persisted into October. Of the

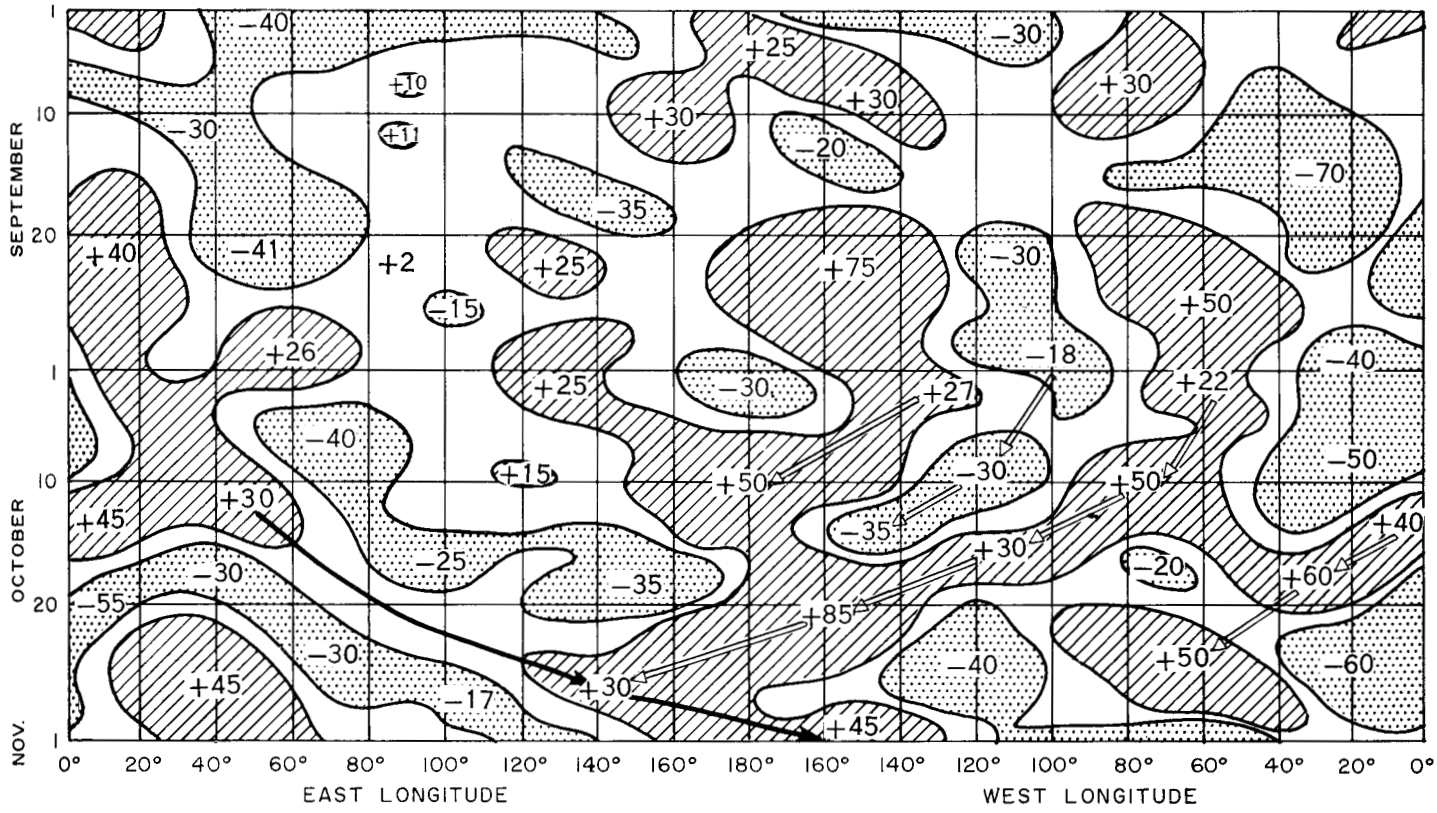


FIGURE 10.—Continuity at 50° N. of the 5-day average 700-mb. height departures from normal (tens of feet). Areas of positive departure over 100 ft. are hatched and of negative departure are stippled. Double-shafted arrows show some of the important retrogressions, and single arrow shows one of the progressions. This pattern highlights the retrogressive nature of October's circulation evolution in the western sector in contrast to the progressive character in the eastern sector.

23 out of 100 stations reporting significant changes (i.e., 2 classes, or from one extreme to the other), 20 changed from the "heavy" category in September to the "light" class in October (fig. 9). One of these was the severe drought area in the western Dakotas-eastern Montana area.

5. INTRA-MONTHLY VARIABILITY

RETROGRESSION IN THE WESTERN SECTOR OF THE HEMISPHERE

Despite the rather striking persistence of the average October circulation and weather patterns from September, this month's pattern was composed of shorter periods of considerable variability. There was frequent "cutting-off" of deep cyclonic vortices aloft over the United States during the month, both in the Southwest on the 8th–10th and 29th–31st, and in the East where a Low became cut-off over the Ohio Valley on the 19th and migrated slowly across the middle Atlantic coast and then northeastward during the following week.

Figure 10, which depicts the continuity of 5-day average 700-mb. height departures around the hemisphere at 50° N., clearly shows that the primary characteristic of the intra-monthly large-scale evolution was retrogression, mainly in the western sector, while progression was predominant in the eastern sector.

As was true also in September, figure 10 shows that at 50° N. the persistent ingredients of the large-scale circulation this month were the above-normal heights in Europe, the western Atlantic, and the eastern Pacific, with negative height departures in Asia, western North America, and the eastern Atlantic.

In the western sector of the hemisphere in October, successive retrogressive waves of both positive and negative height departure centers are clearly evident in figure 10, the double-shafted arrows delineating some of the most prominent retrogressive surges. At the same time, alternating progressive surges of both positive and negative height anomaly are also evident in figure 10, traveling eastward across Asia, with one such surge delineated by a single-shafted arrow.

Of the retrogressive waves perhaps the most dramatic was the positive anomaly or "blocking" surge which started from near the Maritime Provinces (50°–60° W.) near the beginning of October, and retrograded across North America into the Pacific by late in October when it joined with a progressive surge approaching from the Asiatic coast. This retrogression totaled about 160° of longitude

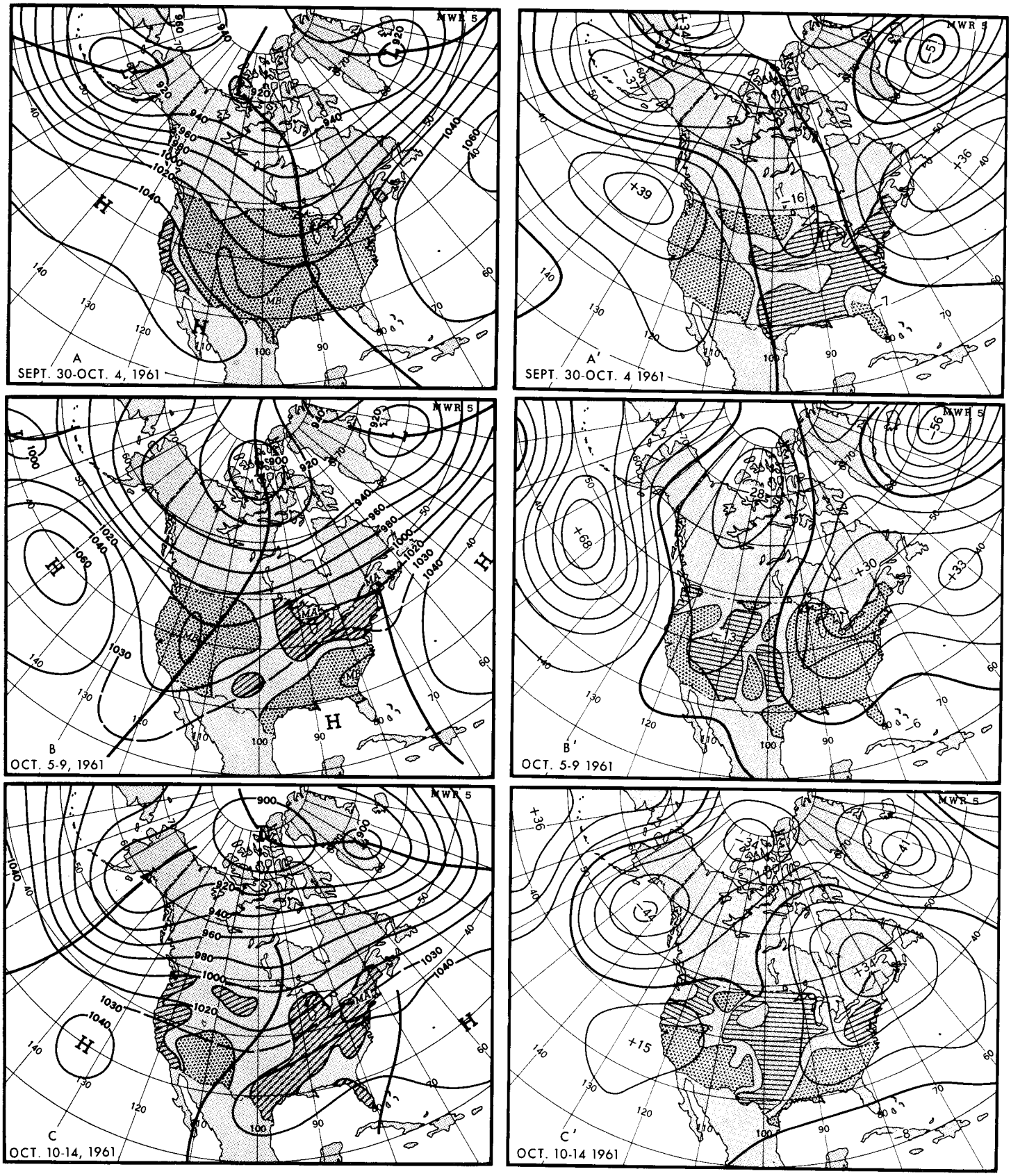


FIGURE 11.—(A–F) Mean 700-mb. contours (tens of feet) and observed temperature anomaly classes (above normal hatched, below stippled) for consecutive 5-day periods in October 1961. (A′–F′) Departures from normal (tens of feet) of the contours of maps A to F with observed precipitation classes (light or no precipitation hatched, heavy stippled). These charts show that despite considerable persistence of the average monthly pattern, almost complete reversals occurred between some successive 5-day periods. This was associated with a retrogressive evolution especially of the height anomalies.

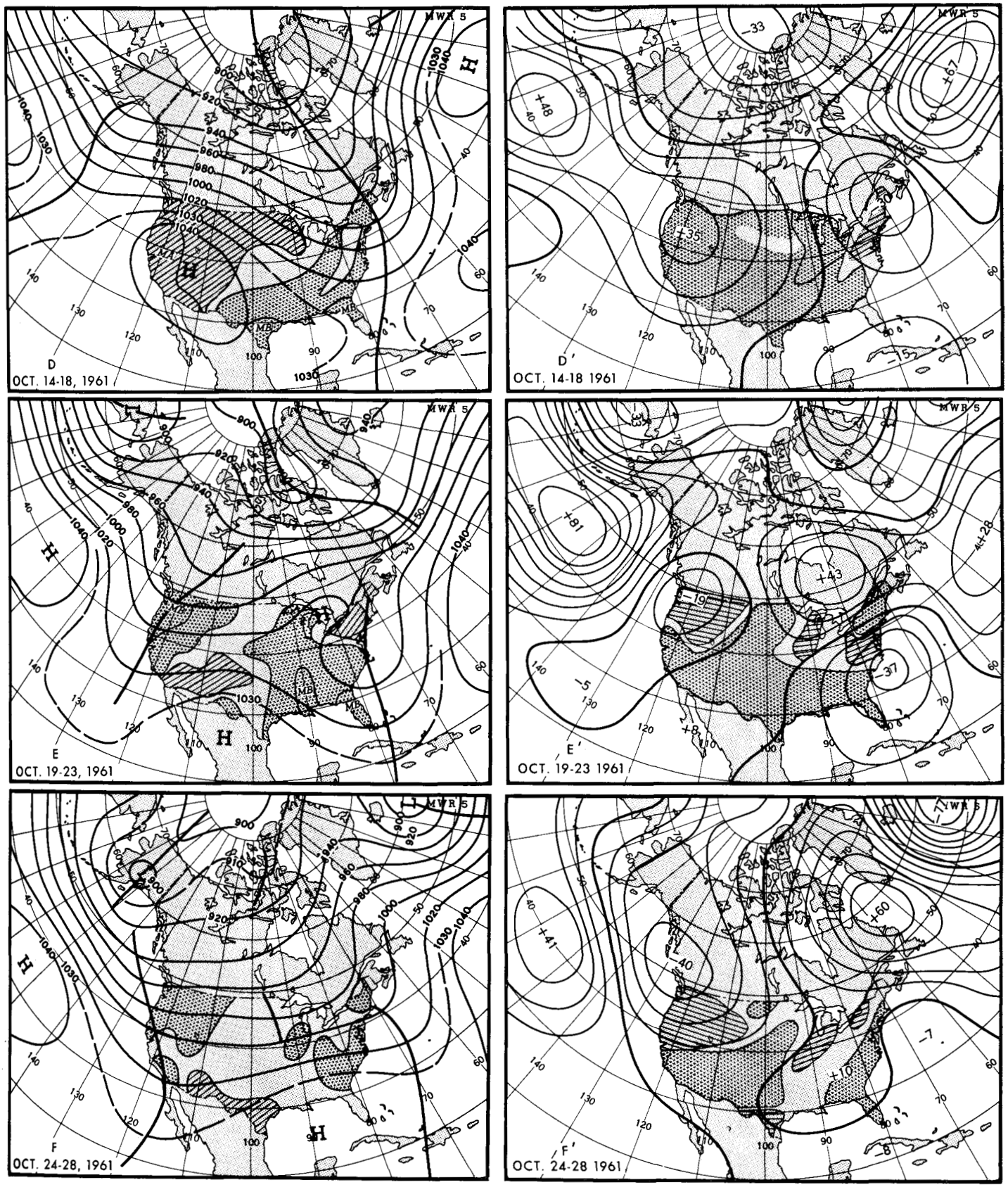


FIGURE 11.—Continued.

in about 22 days, averaging about 6.5° of longitude per day, or somewhat slower than the 60° per week estimated by Namias [2]. Simultaneously another wave of positive anomaly was retrograding from eastern Europe across the Atlantic, arriving in eastern North America in the latter part of the month.

To examine these evolutions and the associated weather changes over the United States in more detail, a series of six 5-day average maps is presented in figure 11. Charts A to F show the 5-day 700-mb. contours and observed temperature anomaly classes over the United States, while charts A′ to F′ show the 5-day 700-mb. height departures and the observed precipitation classes.

September 30–October 4 (fig. 11, A and A′).—The month commenced with a deep trough in the Mississippi Valley flanked by strong positive height departures off both coasts. Most of the United States was unseasonably cold with many new daily minimum temperature records established, especially across Texas and in the upper Mississippi Valley where Duluth, Minn., reported a minimum of 17° F. on the 2d. During this period heavy precipitation associated with a strong cold front swept across practically all sections of the country from the Continental Divide to the east coast. This was the last precipitation during the month in parts of the Southeast.

October 5–9 (fig. 11, B and B′).—During this time a marked retrogression (about 20° of longitude) of the large-scale waves occurred in the circulation. The positive height anomaly off the east coast spread westward over eastern North America bringing much above normal temperatures to parts of the Northeast and to the upper Mississippi Valley where Minneapolis-St. Paul reported a record maximum of 85° F. on the 6th. At the same time the deep trough and associated negative height anomaly retrograded from the Mississippi Valley to the western United States in the wake of the retrograding ridge in the eastern Pacific.

In response to this retrogression, the heavy precipitation also shifted westward, while the East became relatively dry under the developing mean ridge there. On a daily basis, as the eastern Pacific ridge retrograded it diverted strong cyclonic vorticity and cold air southeastward from the Gulf of Alaska into the southern Rockies; this air subsequently became cut off from the westerlies in that area. This system produced 18 inches of snow at Lander, Wyo., on the 7th and 8th. Early in this period more daily minimum temperature records were set in parts of the East and South, while in the Pacific Northwest record minima accompanied this new influx of cold air.

October 10–14 (fig. 11, C and C′).—The negative height anomaly retrograded during this period from western North America to the Gulf of Alaska and intensified considerably because of the well-known Gulf of Alaska cyclogenetical effect when abnormally cold air from Alaska is diverted southward over the relatively warm waters of the Gulf. This deepening offshore produced warming and rising heights over the western United States resulting in a flat flow over the country favorable for a trough in the lee of the Continental Divide, a pattern frequently observed with rising index and warmer than normal temperatures, especially in the East. This lee trough gave rise to heavy precipitation from Texas northward to the upper Mississippi Valley, principally as a result of a deepening storm which emerged from the southern Rockies on the 10th and 11th as the cut-off Low aloft was expelled from this area. Some highlights of this storm were a record 24-hour rainfall of 4.20 inches at Huron, S. Dak., damaging winds in parts of Wisconsin, and hail in parts of Iowa. Daily temperature maxima were approaching record levels all along the California coast on the 14th, with one of the highest readings 111° F. at Long Beach. Some stations in the East also reported record maxima, notably Evansville, Ind., with 86° F. on the 12th and Syracuse, N.Y., 81° F. on the 13th.

October 14–18 (fig. 11, D and D′).—In this period an anticyclone of near record intensity for this time of year developed over the Great Basin resulting in persistently strong offshore and downslope flow over California, a wind sometimes referred to in that area as a "Santa Ana". Simultaneously, a sharp reversal in the height anomaly pattern occurred over the Northeast as the deep Atlantic trough discontinuously retrograded to the east coast of North America, followed by an intense ridge which retrograded to the central Atlantic from western Europe. The associated sharp change in the direction of the average flow in the East and Gulf States sent temperatures tumbling to unseasonably low readings in these areas. Numerous record daily minima were observed in the East and Gulf areas from the 15th to the 17th, for example, Providence, R.I., with 32° F. and 31° F., and Augusta, Ga., with 37° F. and 38° F. on the 15th and 16th, while Corpus Christi, Tex., reported record lows of 48° F. and 49° F. on the 16th and 17th. By way of contrast, the intense anticyclone over the Great Basin produced unseasonably warm temperatures from the upper Mississippi Valley westward and southwestward to California, where a record-shattering heat wave resulted in part from the offshore flow associated with the intense anticyclone inland. New record maximum temperatures were recorded on as many as five consecutive days at some stations in California from the 14th to the 18th, notably at Sacramento where temperatures rose above 90° F. on each day of this period, while temperatures over 100° F. were recorded at many coastal points. Record maxima were common elsewhere in the Midwest and West. Norfolk, Nebr., for example, recorded 89° F. on the 17th. Precipitation was light over most sections during the period, except in the Northeast.

October 19–23 (fig. 11, E and E′).—A marked intensification of the eastern Pacific ridge into the Gulf of Alaska during this time probably resulted from amalgamation of the retrogressing positive height anomaly from the western

United States with the progressive Pacific anomaly. This strong ridge produced a deepening mean trough along the west coast of North America, while blocking again developed over southeastern Canada. At the same time the negative height anomaly was displaced to near the Carolina coast. The lowering of heights in the West resulted in cooling from the Great Lakes southwestward, the greatest change occurring in the Far West where the record heat wave gave way to temperatures much below seasonal normals in some places; e.g., at Great Falls, Mont., the average daily temperature on the 21st was 27° F. below normal.

Precipitation was heavy in the Northern Rockies as well as in parts of the East, especially in the Virginias. Both areas were under the influence of intense Lows aloft and similarly vigorous surface counterparts during the period. Richmond, Va., a notable example, reported 6.5 inches of rain on the 20th and 21st, the greatest 24-hour amount on record there.

October 24–28 (fig. 11, F and F').—The trough along the west coast of North America deepened considerably during this time while the trough in the East filled and a strong blocking ridge developed over the Labrador Sea and Davis Strait. This ridge produced an extremely deep vortex, both surface and aloft, near Ireland, reflecting a very stormy period in that area.

The deepening trough along the west coast produced heavy precipitation which helped to alleviate the drought of the recent summer in parts of the Pacific Northwest, particularly near Medford, Oreg. Heavy snows developed on the 28th over Montana, Wyoming, and parts of Utah and Idaho, as a strong surface ridge developed over British Columbia and cut off a deep surface Low over Colorado. Some of the more exceptional accumulations were 6.3 inches at Salt Lake City, Utah, the second heaviest on record there so early in the fall; 5.9 inches at Billings, Mont.; and drifts 3 to 4 feet deep at Sheridan, Wyo., on the 28th.

In the extreme East at the same time many cities again reported record minimum temperatures. At Portland, Maine, a low of 19° F. was registered on the 28th.

October 29–31.—On the remaining days of the month, an extremely strong vortex became cut-off over northern Lower California. Simultaneously a surface Low over Colorado was forced southward into Mexico by a building ridge to the north. A strong ridge over the Southeast was associated with widespread record maximum temperatures on the 31st. Little Rock, Ark., for example, reported 86° F., while Augusta, Ga. had 89° F. and New Haven, Conn., 75° F., all new records for that date. In the West unseasonably cold temperatures were highlighted by numerous record low readings on the last few days of the month, notably 13° F. at Casper, Wyo., on the 28th and 30° F. at Prescott, Ariz., on the 30th, while Sheridan, Wyo., reported its average temperature on the 29th was 24° below normal.

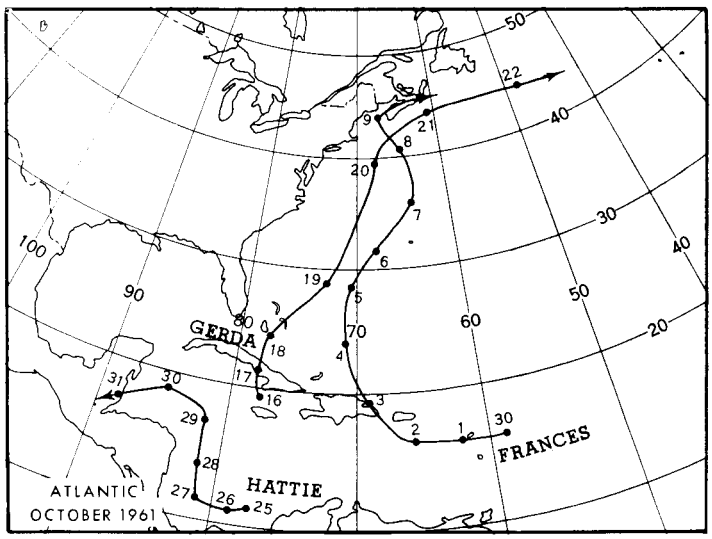


FIGURE 12.—Tracks (preliminary) of tropical storms during October 1961 in the western Atlantic. Dates indicate 0000 GMT positions.

During this time heavy precipitation spread across the country from the southern Rockies to the Northeast as the result of a strongly confluent flow. Some highlights were 6.6 inches of snow at Winslow, Ariz., on the 30th, a record 24-hour amount; Rapid City, S. Dak., 0.83 inches of precipitation, including 4 inches of snow, on the 28th and 29th, ending a prolonged dry period; and at St. Joseph, Mo., a cloudburst with 2.73 inches of rain, one-quarter-inch hail, and wind gusts to 81 m.p.h. on the 29th.

6. ATLANTIC TROPICAL CYCLONES

Tracks of the three principal Atlantic storms of the month are shown in figure 12. Early in the month, tropical storm Frances reached hurricane strength north of the Antilles. It drifted slowly northward, being blocked throughout its journey by a strong anticyclone over the Maritime Provinces (see fig. 11B′). It diminished to a weak extratropical Low in that area on the 10th, after which it moved rapidly eastward and redeveloped into a severe storm in the North Atlantic on the 12th.

Near the middle of the month tropical storm Gerda formed south of Cuba as a large cyclone with weak vorticity near the center. It drifted slowly northward until the 19th when it accelerated and deepened rapidly as it was expelled from the subtropics by events over the mid-Atlantic States. There a deep cut-off polar vortex approaching the coast from the Ohio Valley increased the southerly flow in the vicinity of Gerda and accelerated the latter northward into the westerlies on the 21st (see fig. 11E).

Near the end of the month tropical disturbance Hattie formed along the South American coast near Colombia.

Reaching hurricane intensity on the 29th it veered sharply to the west and hit Belize, British Honduras, with devastating force on the 31st. Over 300 people lost their lives and the city of Belize was all but leveled.

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