UDC 551.506.1:551.513.1(73)"1969.10"

THE WEATHER AND CIRCULATION OF OCTOBER 1969

Widespread Cold With High-Latitude Blocking Over North America

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1. WEATHER SUMMARY

Midautumn this year seemed like early winter over much of the conterminous United States with record cold and widespread snowfall, especially in the northern and central Rockies and nearby Great Plains. In contrast was the unseasonable warmth created by blocking in high latitudes over western Canada and Alaska. At Fairbanks the temperature reached an October record of 65°F on October 13 with a daily average temperature 24°F above normal. On the same day at Denver, Colo., the average temperature was 38°F below normal with a minimum temperature of 3°F. This kind of inverted temperature gradient is typical of blocking.

Heavy precipitation associated with repeated convection caused flash flooding in parts of Texas, the Central Plains States, and Florida. Record snowfall and record precipitation were reported by a few stations in the Midwest and in New England.

Tropical disturbances were plentiful in this very active season, but none struck the United States with hurricane force or with destructive tides in October 1969.

2. MEAN 700-MILLIBAR CIRCULATION

Most principal waves in the midtropospheric flow (fig. 1) appeared to be of greater amplitude this month than in September, yet the temperate-latitude index in the western portion of the Northern Hemisphere was about normal. This suggests that the easterly 700-mb anomalous "flow" that accompanied blocking was more than compensated for by the strengthened westerly anomalous flow (fig. 2).

In the Atlantic, 700-mb heights in the broad trough were only slightly less than normal except from Spitzbergen to the south of Greenland. In this area, heights were 30–100 m lower than normal. This represented little change in the depth of the main vortex east of Greenland; but about 10° latitude south of Greenland, heights fell by as much as 100 m from September to October (fig. 3). This occurred as the ridge near the Azores in September diminished and retrograded by some 15° latitude. At the same time the ridge over Europe strengthened by more than 80 m to become the strongest ridge in the Northern Hemisphere. This very strong ridge caused unseasonable warmth over Europe as the position of the polar jet averaged above 60° N. latitude (fig. 4).

This amplification over the eastern Atlantic and Europe was accompanied by a very deep trough for this time of year over Russia and western Siberia where heights fell as much as 190 m from September to October between Novaya Zemlya and the Aral Sea. The monthly mean wind speed maximum was south of 50° N. here, some 10° farther south than normal and more than 10 m sec^{-1} faster than normal from the Aral Sea to Lake Balkhash. Over the rest of Asia, changes were slight with the greatest deepening in the trough along the Asian coast.

In the Pacific, westerlies were near the October normal latitude with a mean wind maximum close to 40° N. and speeds to 9 m sec^{-1} above normal. Strong deepening in the east-central Pacific with heights some 100 m below normal was related to high-latitude blocking that became established as the ridge over western North America increased by at least 90 m this month.

As 700-mb mean heights increased over northwest Canada and Alaska, the principal mean jet stream split. The northern branch reached the Beaufort Sea while the southern branch went as far south as northern Baja California. This was an example of the typical effect of high-latitude warming on the westerly currents. The difluence thus created caused anticyclonic curvature to replace cyclonic off the Northwest Pacific coast and encourage deepening in the Southwest and West where heights were 50 m or less below normal. Another response to the blocking was retrogression of the trough formerly over eastern North America and deepening by some 80 m over Hudson Bay. The strengthened northwesterly flow and the flow from the southwestern United States to the Middle Atlantic States caused a confluent zone to appear near the Great Lakes. These changes in the circulation produced major changes in the weather.

3. MEAN MONTHLY WEATHER

TEMPERATURE

Temperatures averaged below normal over most of the Nation with maximum departures of 6°–12°F over much of the northern Rockies and parts of the Northern Plains States (fig. 5). Below-normal heights prevailed here in the mean trough discussed above. Temperatures were normal to a few degrees above normal east of the southern Appalachians and the coastal areas of the Gulf of Mexico and of California.

This distribution of anomalous temperatures represented a reversal from September when the West was above normal and the East below normal. This nonpersistence can be attributed to marked changes in the circulation and to a transport of quite cold air into the United States as amplification progressed. The tempera-

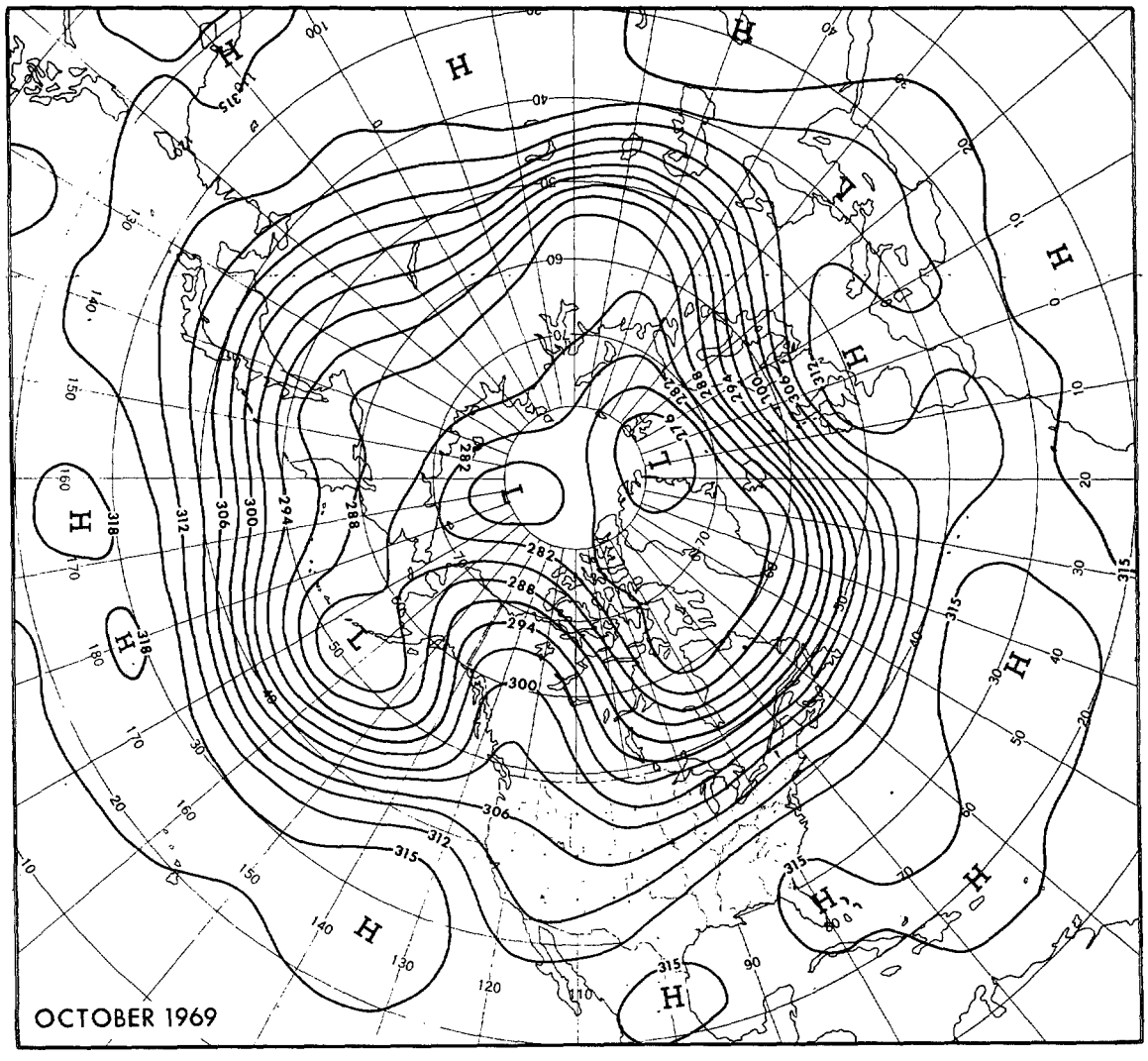


FIGURE 1.—Mean 700-mb contours (decameters) for October 1969.

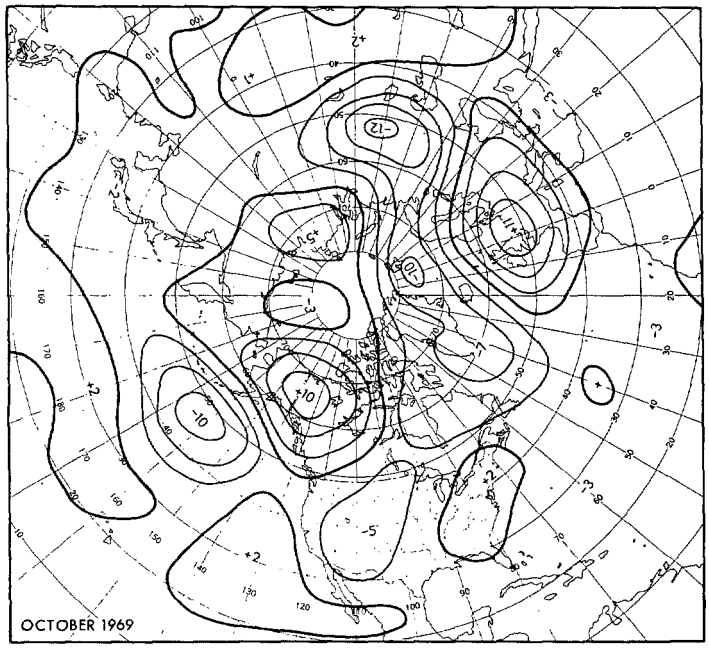


FIGURE 2.—Departure from normal of mean 700-mb height (decameters) for October 1969.

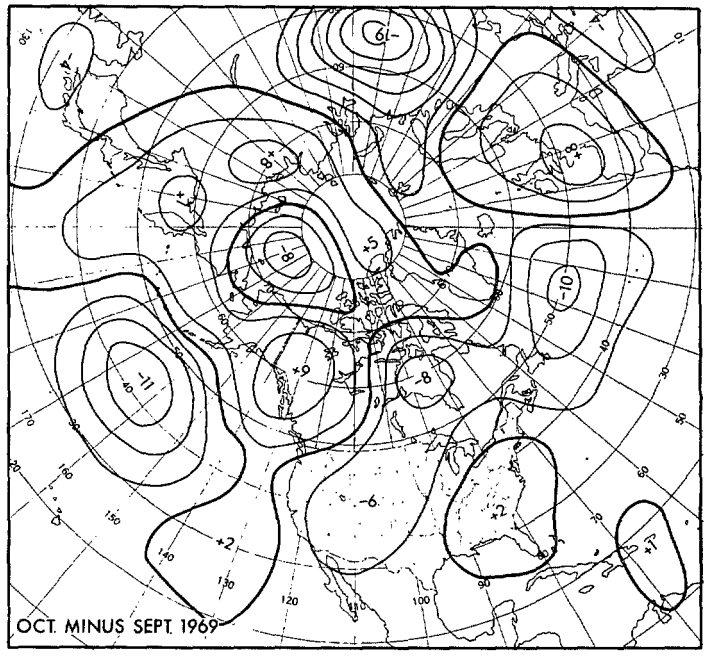


FIGURE 3.—Mean 700-mb height anomaly change (decameters) from September to October 1969.

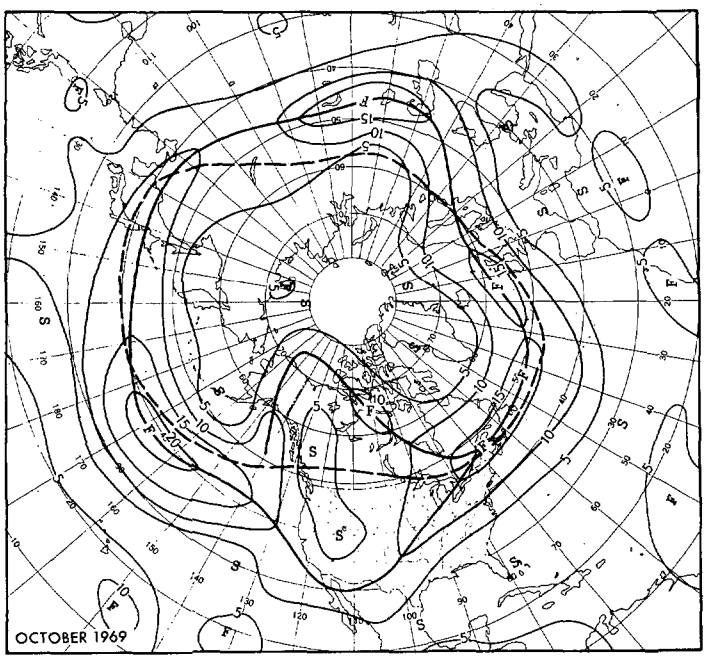


FIGURE 4.—Mean 700-mb isotachs (meters per second) for October 1969. Heavy solid lines show principal axes of maximum wind speed and dashed lines the normal.

ture reversal resulted in three to four temperature class changes over most of the West. This meant that above- to much above-average temperatures were lowered to much-below from September to October. The warming in the Southeast that accompanied the slight ridging caused only four stations to warm by as much as two classes while 48 stations in the western half of the Nation cooled by two classes or more. Numerous minimum daily temperature records were reported as a result of the frequent polar outbreaks. A few monthly records were established (table 1). Many other stations reported the coldest October since 1925, at which time several polar outbreaks occurred with at least one surface High of 1040 mb.

PRECIPITATION

Very heavy precipitation fell this month (fig. 6) along and to the south of the monthly mean jet at 700 mb (fig. 4). The jet was much farther south than normal and reflected a flow that transported positive vorticity advection throughout the southern branch of the westerlies and a source of moisture from the Gulf of Mexico.

Numerous storms came across the central and southern Rockies followed by very marked cyclonic activity in the Great Plains and Great Lakes. This caused record snowfall in Nebraska (table 2) and heavy precipitation from the southern Rio Grande Valley to the Ohio Valley. Here, amounts averaged 4 in. generally with locally heavy rainfall of 8–10 in. in strong convection. These heavy rains generated flash flooding in Oklahoma, Missouri, and Illinois. In southern Texas, another area of flash flooding occurred early in the month between Del Rio and San Antonio. Uvalde, Tex., reported over 12 in. in 24 hr.

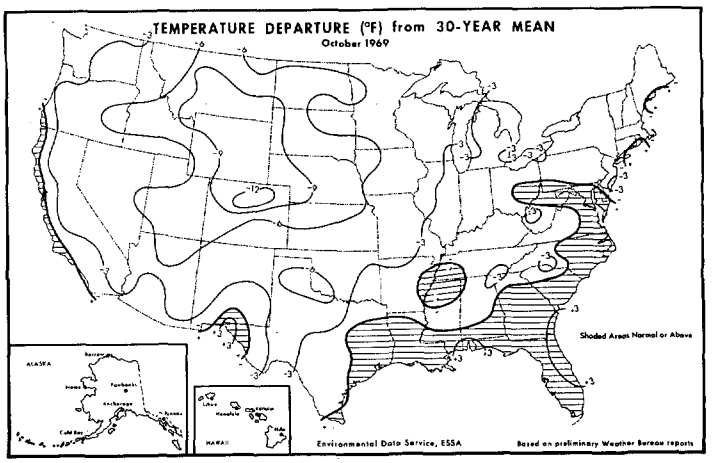


FIGURE 5.—Departure from normal of average surface temperature (°F) for October 1969 (from Environmental Data Service 1969).

TABLE 1.—*Low monthly mean surface temperature records established in October 1969*

City	Temperature (°F)	Departure from normal (°F)
Cheyenne, Wyo	37.1	−10.4
Casper, Wyo	37.9	−10.4
Goodland, Kans	45.2	−7.9
Grand Junction, Colo	47.4	−7.6
Clayton, N. Mex	47.7	−7.6
Fresno, Calif	59.7	−4.9
Stockton, Calif	60.5	−3.5

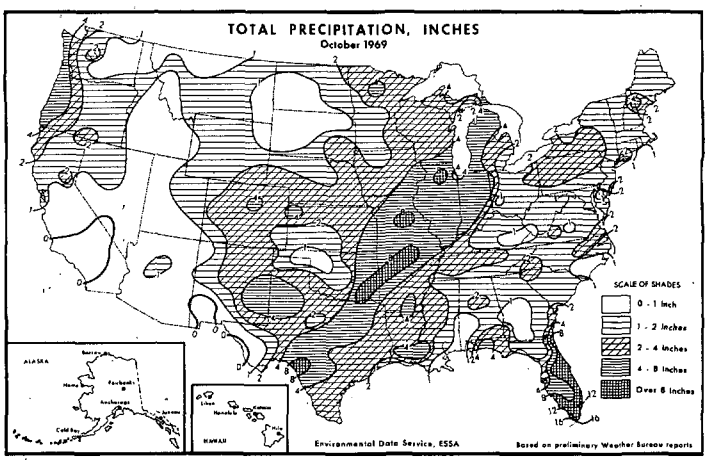


FIGURE 6.—Total precipitation (inches) for October 1969 (from Environmental Data Service 1969).

Greatest precipitation of the month fell in southern Florida where Key West had over 21 in.

Snowfall this month brought a touch of winter and a few new records as shown in table 3. Snow came to the Northwest and to the central and northern Rockies early in the month and to New England late in the month. Precipitation this month was fairly well related to the circulation and circulation anomaly and was heavier than

TABLE 2.—*Monthly total precipitation records established in October 1969*

City	Amount (inches)	Departure from normal (inches)
Rockford, Ill.	8.02	5.62
Muskegon, Mich.	6.56	4.01
Sault Ste. Marie, Mich.	6.29	3.47
Scottsbluff, Nebr.	3.02	2.33

TABLE 3.—*Snowfall records established in October 1969*

City	Amount (inches)	Date	Remarks
Grand Island, Nebr.	2.4	12	Earliest measurable
Scottsbluff, Nebr.	21.6	.....	October total
Concord, N.H.	2.1	.....	October total
Burlington, Vt.	5.1	.....	October total, 24-hr total
Portland, Maine	3.8	22/23	Greatest amount so early

normal in and near the long-wave trough; lighter than normal precipitation, in most instances, fell in areas of anticyclonic flow.

4. INTRAMONTHLY CHANGES

Mean 700-mb circulation features the first half of October 1969 (fig. 7) resembled those of the full month. The Gulf of Alaska Low was 140 m below normal near the Aleutians. The ridge over western Canada was about the same as that of the full month, the principal difference being the positive height anomaly center 20° farther east. The trough in the Northern Plains was somewhat deeper with much greater shear suggested.

The ridge in the East was much stronger than the monthly ridge, with heights some 80 m above normal. The flow, thus defined, created a strong thermal gradient at the surface with temperatures 2°–4°F above normal in the eastern half of the country. In the western half, cold air dominated with temperatures 9°–15°F below normal over the Great Basin and central and northern Rockies. This cold air resulted from two strong upper level daily perturbations that moved into the West from the mean trough in the eastern Pacific and became cut-off as blocking increased in high latitudes.

The first major storm brought heavy snow to higher elevations of the Pacific Northwest and to the central and northern Rockies. Heavy rain fell over southern Texas with amounts of 4–8 in. that caused local flash flooding. The second major storm developed on the trailing front of the first storm as a 500-mb Low was cut off over the Great Basin. Very strong cold advection occurred as a surface ridge extended to Texas from a 1040-mb High in Alberta. Precipitation fell over the Plains and eastern portions of the Rocky Mountains with 4–8 in. in a narrow band from western Texas to Illinois. As much as 10 in. fell in heavy

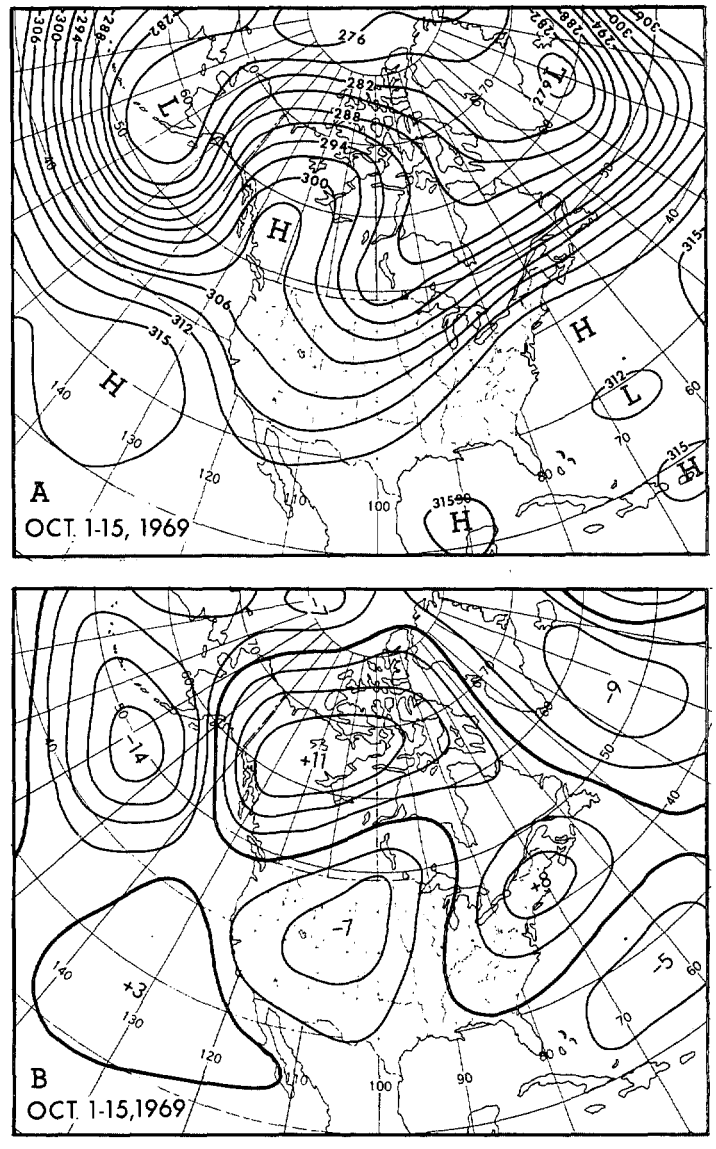


FIGURE 7.—(A) mean 700-mb contours and (B) departure from normal of mean 700-mb height (both in decameters) for Oct. 1–5, 1969.

showers near Baton Rouge, La. New snow fell from Nebraska (8 in. at North Platte) to Wisconsin as a storm of Pacific origin deepened in the mean trough.

Much change occurred in the 700-mb mean circulation from the first to the second half of October (fig. 8). As the trough moved eastward from the Northern Plains, the ridge formerly off the west coast of the United States moved inland (fig. 9), and the portion in higher latitudes retrograded and extended westward across Alaska, where heights increased by as much as 170 m. Height decreases of 210-m maximum over northern Hudson Bay and 130-m maximum over the Maritime Provinces show the eastward motion taken by the mean trough and the weakening of the ridge that had been over the Northeast.

Temperatures the last half of October were lower than normal over most of the conterminous United States, but

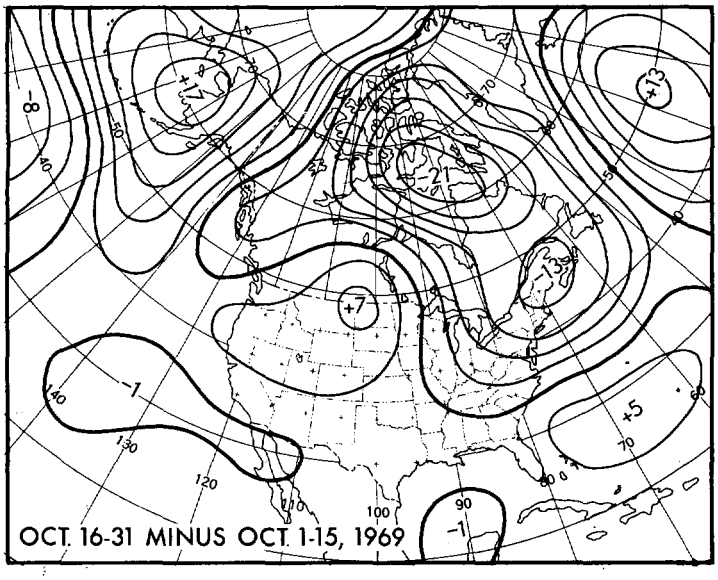
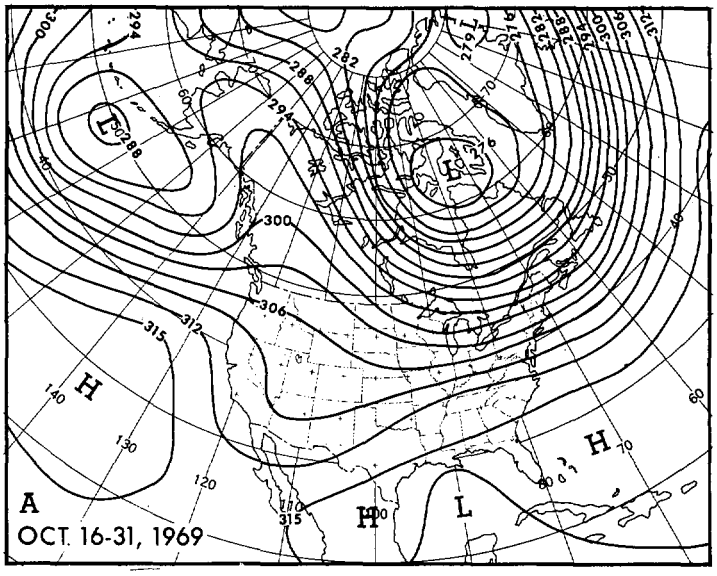


FIGURE 8.—Mean 700-mb height anomaly change (decameters) from Oct. 1–15 to Oct. 16–31, 1969.



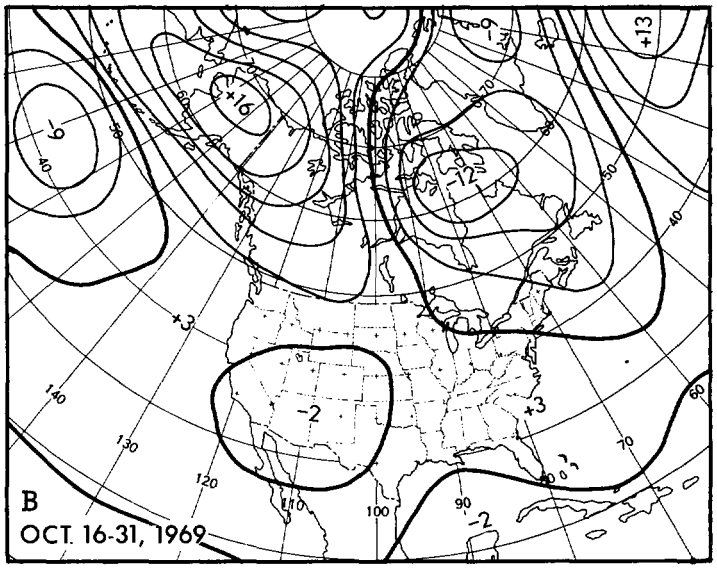


FIGURE 9.—(A) mean 700-mb contours and (B) departure from normal of mean 700-mb height (both in decameters) for Oct. 16–31, 1969.

the warming trend in the West brought increases of 4°–8°F over most of the area; temperatures decreased 4°–8°F over the East. Gulf Coast areas and Florida warmed by a degree or two. The cooling in the East caused new minimum temperatures for the month at Concord, N.H. (10°F), and Bridgeport, Conn. (26°F).

A new 500-mb daily trough was deflected south of normal during the third week, but only light precipitation fell as the surface Low moved from the west coast to the central Rockies. The upper level Low became two Lows, the northern portion being absorbed in a westerly trough as the southern Low over southern California migrated slowly south and east out of the principal belt of the westerlies. This brought heavy precipitation to the desert Southwest. Meanwhile, one of the heaviest snows of record for October fell in parts of New England with as much as a foot in New Hampshire. During the last few days of October, a new Low moved from off the west coast to Colorado, then to eastern Nebraska. This was accompanied by heavy precipitation from the Rio Grande to the Northern Plains. Southern Florida received heavy precipitation in the last half of October which accounted for most of the month's total of 21.57 in. at Key West, 13.57 in. at Miami, and 11.03 in. at Fort Myers. Some of the heavy precipitation was related to tropical activity, but most was caused by convective and frontal processes.

5. TROPICAL ACTIVITY IN THE NORTH ATLANTIC AND GULF OF MEXICO

Only two tropical disturbances entered the United States this month. On October 1, a tropical depression crossed the coast of northwestern Florida and produced widespread precipitation northward to the Ohio River. A remnant of this Low moved to New Jersey, then became absorbed in a deepening extratropical storm off Nova Scotia.

Jenny was short-lived and reached only tropical storm intensity. From south of Cuba, Jenny struck southern Florida on the 2d and weakened on the 3d and 4th, having spread rain to Jacksonville. On the 5th, Jenny

reappeared over the Gulf of Mexico, a very weak, poorly organized Low that dissipated the same day.

Laurie moved northwestward across the tip of Yucatan, intensified for 2 days, and reached hurricane strength on the 21st about 200 mi south of New Orleans. This storm moved slowly and threatened much of the Gulf Coast and Florida. Daily flow at 500 mb suggested that the hurricane would be forced eastward as it entered the low-latitude westerlies and in response to the eastward motion of the strong daily perturbation moving out of the Baja California area, but the hurricane weakened as it turned south and westward and lost its circulation in the southwestern Gulf of Mexico. Mean 700-mb flow during this period (fig. 9) only reflects the track of this hurricane and provides little explanation.

Hurricane Kara threatened the Middle Atlantic coastline for several days during the first half of October. Its slow erratic path from the 8th to the 14th took the storm from the southeastern Bahamas generally northward to the latitude of Cape Hatteras, then southwestward for 2 days. This part of the track may have been related to the blocking effect of the positive height anomaly over the Northeast (fig. 7). From its most westward position south of Cape Hatteras, Kara became imbedded in the westerlies and sped off to the northeast, no longer a threat to the United States.

Inga was a hurricane the first few days of October but remained 20°–30° east of Florida. This storm turned southward and weakened as Kara went northward and intensified. Inga finally circled back and became diffuse in the same general area where it was first detected.

Many factors probably contributed to the unusual tracks of these storms. In addition to any effects of the general circulation, sea-surface temperature anomaly may have been relevant. Inga changed course abruptly from northeastward to southeastward at the boundary of a negative sea-surface temperature anomaly, averaged over the first decade of October, near 55° W. Kara reversed its course toward the northeast from a southwesterly heading at the boundary of a pool of cool water off Cape Hatteras the second decade of October. Laurie had been moving northwestward but turned northward and eastward as it approached the area of cooler than normal sea surface in the northern Gulf of Mexico in the third decade of October.

REFERENCE

Environmental Data Service, ESSA, *Weekly Weather and Crop Bulletin*, Vol. 56, No. 45, Nov. 10, **1969**, pp. 1–12.

U.S. GOVERNMENT PRINTING OFFICE: 1970 O—370-724