

## WEATHER AND CIRCULATION OF OCTOBER 1976

## Record Cold over the South and Midwest

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The 700 mb circulation was characterized by an amplified wave number 5 at middle latitudes during October, with troughs located over the sea of Japan, the central Pacific, eastern North America, the eastern Atlantic and western Asia (Fig. 1). The zonal westerlies increased rapidly across the central Atlantic to as much as  $8 \text{ m s}^{-1}$  stronger than normal in response to rapid deepening of the Icelandic low as intense storms formed in the enhanced baroclinic zone between the warm ridge which had occupied the area in September

(Taubensee, 1976) and increasingly cold air moved eastward from the Canadian Arctic.

The ridge progressed to Scandinavia while the associated positive anomaly moved northeastward to Spitzbergen (Fig. 2). Storms approaching Europe were deflected strongly northward over and near the British Isles in the northern branch of the 700 mb wind maximum (Fig. 3), giving another extremely wet month to the area which had severe drought last summer.

The Asian coastal trough deepened, especially over the Sea of Okhotsk. Even though stronger than normal westerlies continued across the western Pacific (Fig. 2),

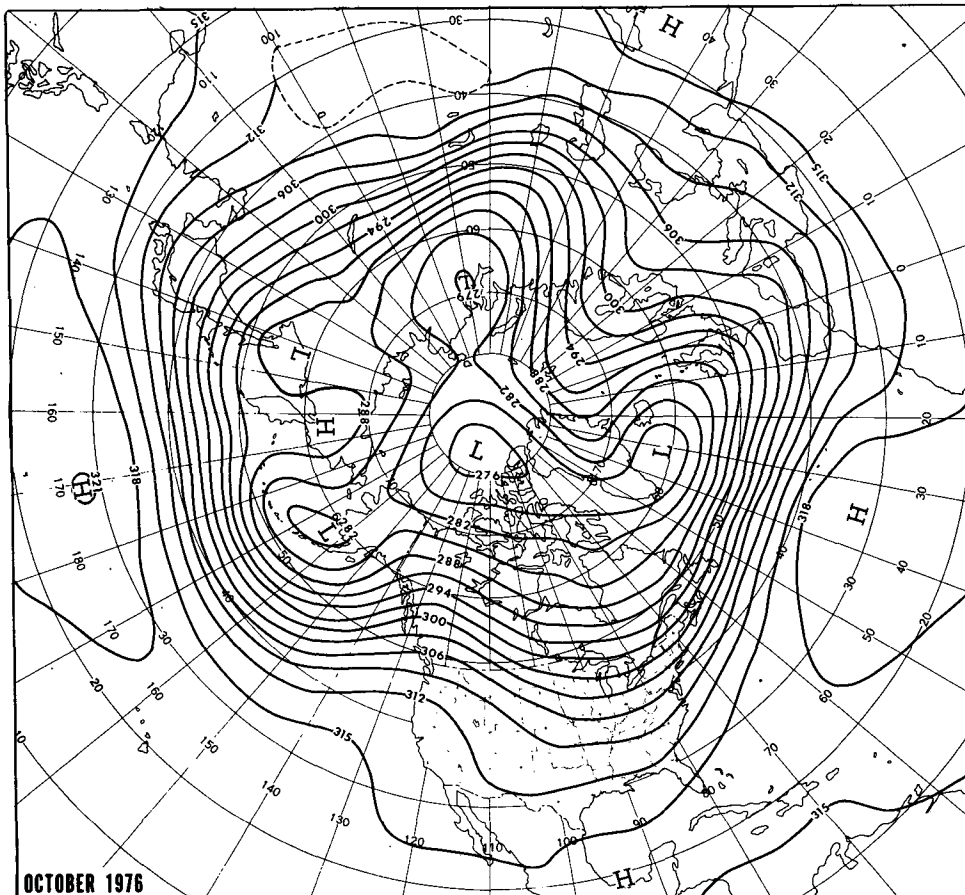


FIG. 1. Mean 700 mb height contours (dam) for October 1976.

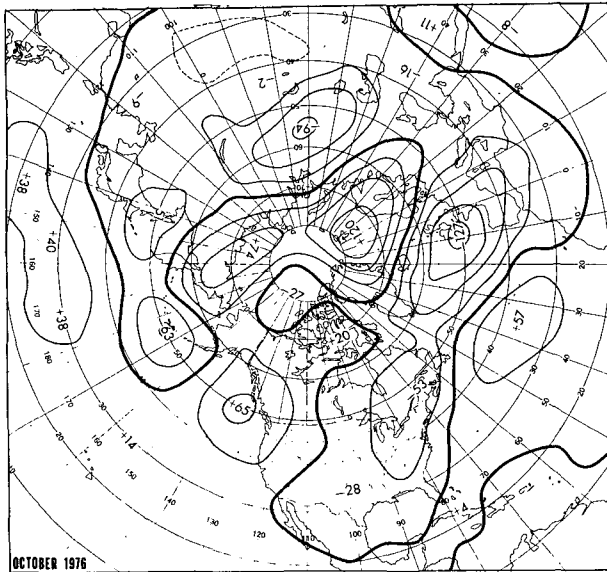


FIG. 2. Departure from normal of mean 700 mb height (m) for October 1976.

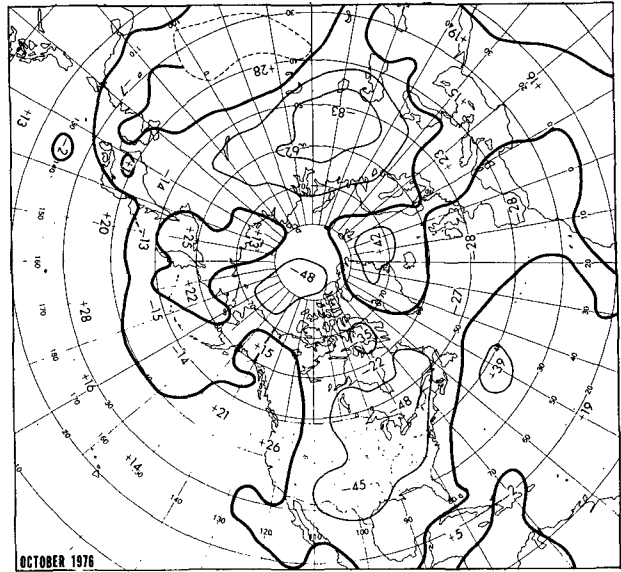


FIG. 4. Departure from normal of mean 1000-700 mb thickness (m) for October 1976.

the trough over the eastern Pacific retrograded somewhat, as did the downstream ridge over western North America. As a result, the 700 mb flow had a northerly anomalous component nearly everywhere from the West Coast to the Appalachian Mountains and colder than normal air masses occupied most of the United States east of the Rocky Mountains (Fig. 4).

The 700 mb wind maxima were stronger than normal over the middle of both oceans, where strong subtropical ridges were located south of deep lows (Figs. 1 and 4). The wind maxima were close to their normal positions

except over the eastern Atlantic and Eurasia where the flow divided into two branches in response to the Scandinavian block. At the 200 mb level, an anomalously strong subtropical jet stream extended across northern Mexico and the southern United States.

## 2. Temperature

In agreement with the thickness anomaly (Fig. 4), most of the country except for the Far West was colder than normal (Fig. 5). Stronger than normal northerly flow from Canada to the United States (Fig. 2) favored repeated outbreaks of Canadian air which kept tropical air confined to the Gulf of Mexico most of the time and limited the duration of occasional mild bursts of Pacific air crossing the country. Temperatures averaged from 6° to as much as 10°F below normal over the United States between the Rocky Mountains and the Ap-

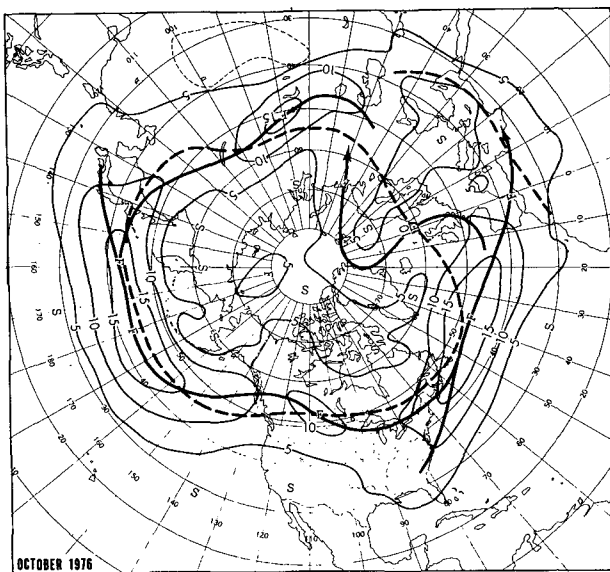


FIG. 3. Mean 700 mb geostrophic wind speed ( $m s^{-1}$ ) for October 1976. Solid arrows indicate observed axes of maximum wind speed; dashed lines show the normal.

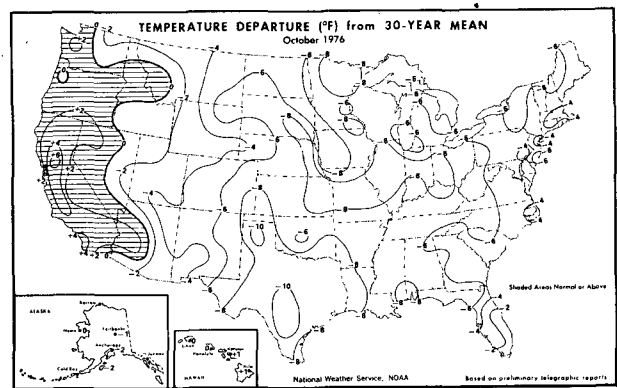


FIG. 5. Departure from normal of average surface temperature (°F) for October 1976 (from National Oceanic and Atmospheric Administration and Statistical Reporting Service, 1976).

palachian Mountains, and many new records were set (Table 1).

Temperatures in Alaska were near or slightly below normal over most of the state, while Hawaii ranged from near to slightly above normal under the moderately strong subtropical ridge (Figs. 1 and 2).

It is interesting to note that temperatures over the eastern equatorial Pacific have remained above normal (National Oceanic and Atmospheric Administration, 1976) following the onset of El Niño conditions along the South American Coast in early Summer 1976. Recent years in which strong El Niños have been recorded during the Northern Hemisphere spring or early summer have had widespread and unusually cold weather over the United States in October (Frazier, 1957; Taubensee, 1973), even though several aspects of the mid-latitude circulation were different. In some areas where the current October failed to break the record, the coldest October on record was in 1925 (Table 1). It is noteworthy that Sverdrup (1943, p. 191) cited a particularly strong El Niño occurring in 1925 as a classical example of the phenomenon.

**3. Precipitation**

Most of the southern and eastern portions of the country had greater than normal precipitation (Fig. 6). Several storms developed over the eastern Gulf of Mexico or off the South Atlantic coast in the enhanced lower tropospheric baroclinic zone (Fig. 4) with the aid of the unusually strong subtropical jet stream in the upper troposphere. Although some areas had more than

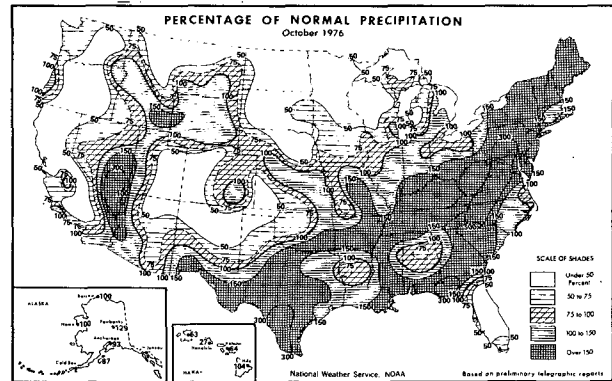


FIG. 6. Percentage of normal precipitation for October 1976 (from National Oceanic and Atmospheric Administration and Statistical Reporting Service, 1976).

three times the normal rainfall, no records were set. Tallahassee, Fla., and Avoca, Pa., both had their second wettest October, with 11.79 and 8.12 inches, respectively. Slightly above normal precipitation at South Bend, Ind. brought the 1976 total to 48.84 inches, 17.82 inches above normal and already a new annual record.

Much of the Far West and the north central states had less than half their normal precipitation in response to stronger than normal ridge conditions (Figs. 1 and 2). Only 0.04 inches precipitation at Helena, Mont., equaled the least ever recorded there in October, and Minneapolis, Minn., had its fourth driest October. Muskegon, Mich., which had less than half its normal October precipitation, concluded the driest June–October period on record with only 5.19 inches total precipitation.

**4. Weekly variability**

*a. 4–10 October*

Fast westerlies over the Pacific in late September and early October [see Fig. 11A of Taubensee (1976)] helped to push a vigorous cyclonic system inland into southern Canada where it developed into a strong, full-latitude trough by the first full week of October (Fig. 7A) in response to amplification of the flow over the eastern Pacific.

Temperatures averaged well above normal in the West under the amplified ridge, where Medford, Oreg., reported a record high temperature for so late in the season of 90°F on the 7th. Under the deep trough in the middle of the country, weekly temperatures averaged from 6° to 12°F below normal (Fig. 7B), while the Atlantic Coast remained a few degrees warmer than normal due to a prolonged flow of tropical air ahead of a slow-moving cold front. A number of cities in the southern Great Plains reported record low temperatures for so early in the season, with readings close to freezing.

TABLE 1. Record and near-record monthly mean temperatures observed during October 1976.

Station	Temperature (°F)	Anomaly (°F)	Remarks*
El Paso, Tex.	58.5	-5.5	
Port Arthur, Tex.	61.9	-8.0	
Galveston, Tex.	65.3	-7.8	
New Orleans, La.	63.9	-6.9	
Fort Smith, Ark.	55.1	-8.1	
Mobile, Ala.	61.4	-7.5	
Tallahassee, Fla.	63.4	-5.9	
Columbia, S. C.	58.6	-5.6	
Wilmington, N. C.	60.5	-4.8	Equaled 2nd coldest October
Greensboro, N. C.	53.2	-6.0	
Norfolk, Va.	57.7	-4.0	5th coldest October
Buffalo, N. Y.	46.3	-5.2	2nd coldest October in 50 years
Youngstown, Ohio	45.9	-6.7	
Toledo, Ohio	45.6	-7.4	Coldest October since 1925
Dayton, Ohio	47.6	-7.9	Coldest October since 1925
Pittsburg, Pa.	45.8	-7.4	
Houghton Lake, Mich.	42.3	-5.3	
Indianapolis, Ind.	48.7	-7.0	3rd coldest October
Rockford, Ill.	45.1	-7.6	3rd coldest October
Sioux City, Iowa	45.1	-8.0	3rd coldest October
Omaha, Neb.	48.5	-7.4	4th coldest October
Topeka, Kans.	50.3	-7.3	2nd coldest October

\* All are coldest October on record except as otherwise indicated.

Several weak waves moving northward along the front produced heavy precipitation in Texas and the Mississippi River Valley (Fig. 7C). As much as 8.50 inches of rain fell at Wortham, Tex. Later in the week

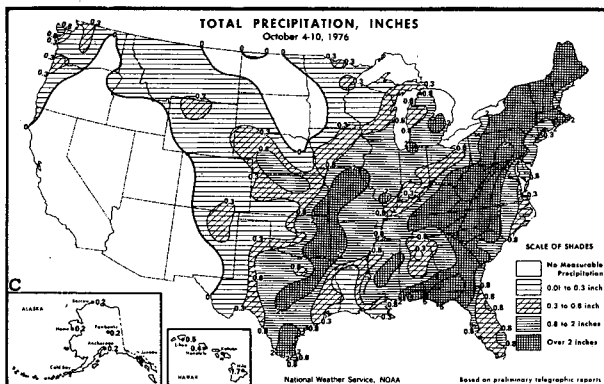
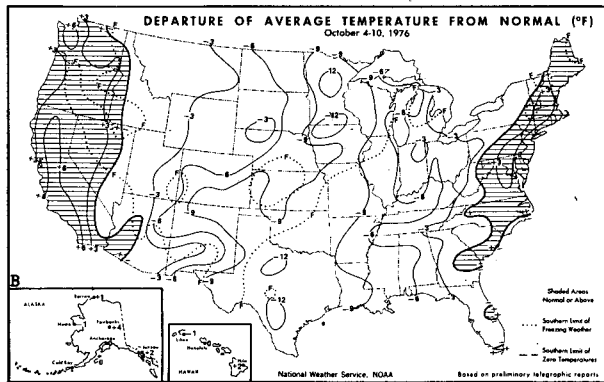
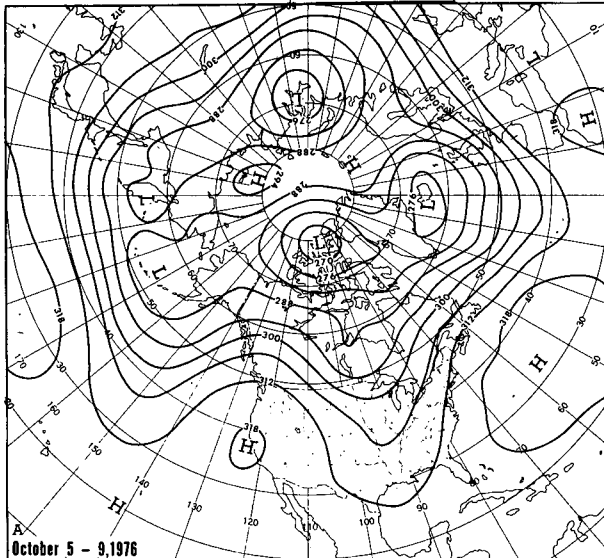


FIG. 7. (A) Mean 700 mb contours (dam) for 5-9 October 1976; (B) departure from normal of average surface temperature (°F); and (C) total precipitation (inches) for week of 4-10 October 1976 (from National Oceanic and Atmospheric Administration and Statistical Reporting Service, 1976).

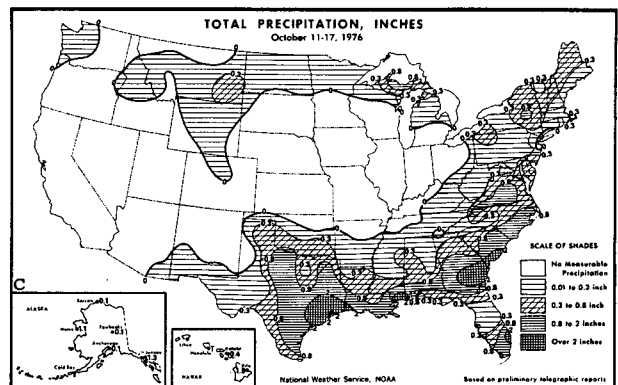
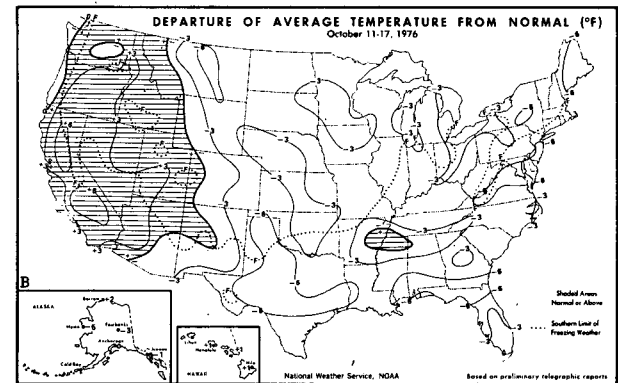
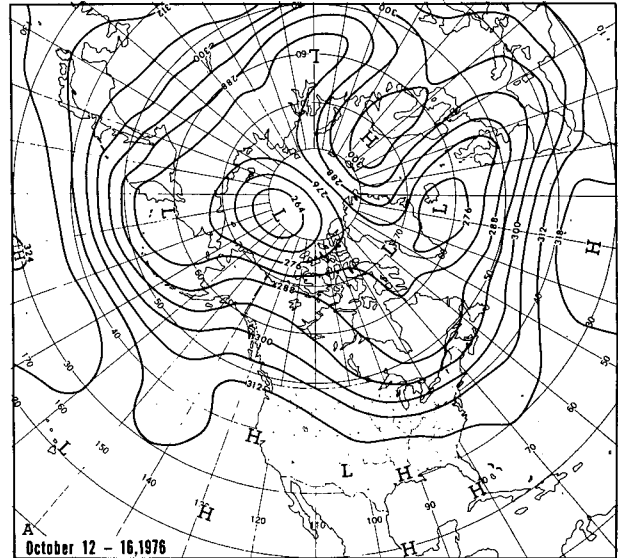


FIG. 8. As in Fig. 7 except for (A) 12-16 October 1976 and (B) and (C) week of 11-17 October 1976.

a final, rapidly deepening wave formed over Georgia and moved northeastward just east of the Appalachian Mountains. This storm produced heavy rains of 2-6 inches from Georgia through Pennsylvania as it moved rapidly northeastward. Flooding occurred along some rivers in South Carolina and along the Potomac in Maryland and Virginia.

*b. 11-17 October*

The 700 mb circulation pattern flattened somewhat over the Pacific and North America with the sharp trough which had been over the Mississippi River Valley broadening and moving eastward to the western Atlantic (Fig. 8A).

The Continental Divide marked the boundary between mild air to the west and cold air to the east (Fig. 8B). Due to the reduced amplitude and progression of the North American trough, temperature extremes were not so pronounced as in the previous week, but colder than normal weather spread to the East Coast.

Storms were fewer and less intense, and most of the western and central portions of the country were rainless (Fig. 8C). Very little precipitation fell anywhere in the conterminous United States until the end of the week when a low formed off the Texas Coast and produced a narrow band of heavy precipitation from southeastern Texas to the south Atlantic Coast. The first snow of the season fell in high elevations of the central Appalachians along the northern fringe of the storm.

*c. 18-24 October*

The main band of westerlies tended to move southward somewhat more rapidly than usual from the first to last half of October as strong height falls occurred over Manchuria, the east-central Pacific, and a broad area of North America and the western Atlantic centered over the Gulf of St. Lawrence (Fig. 9). Large height falls over southern Europe signified an early activation of the Mediterranean storm season. Strong height rises at high latitudes over most of the Northern Hemisphere

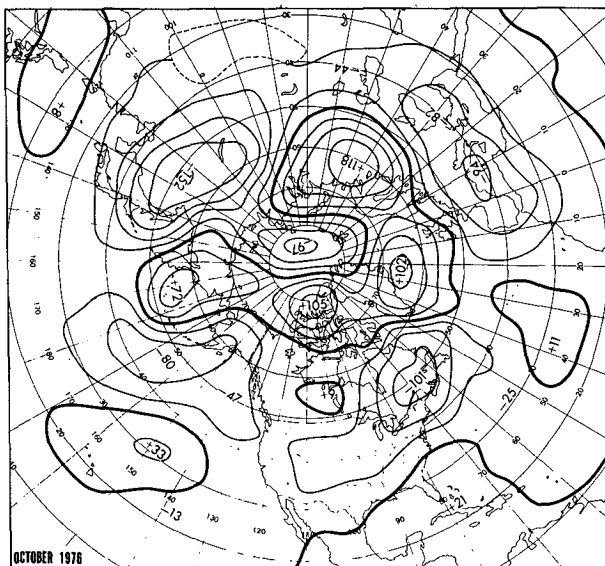


FIG. 9. Mean 700 mb height change (m) from first half to second half of October 1976.

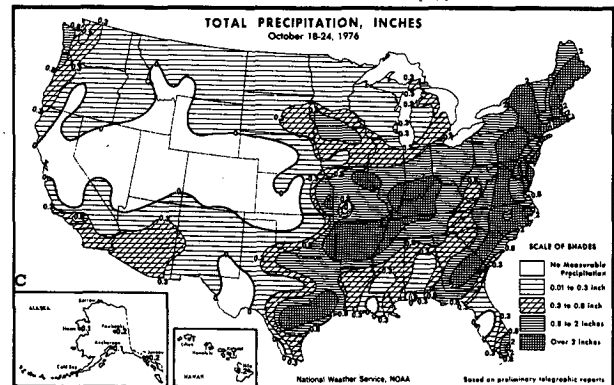
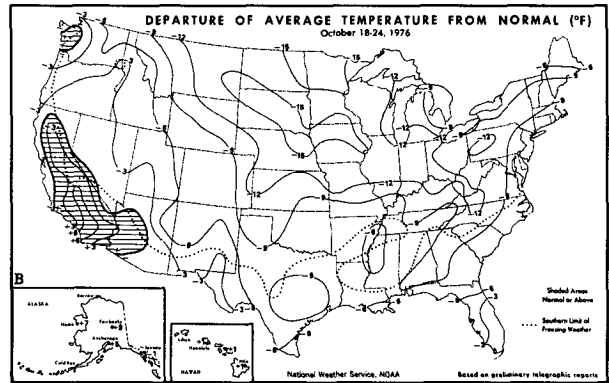
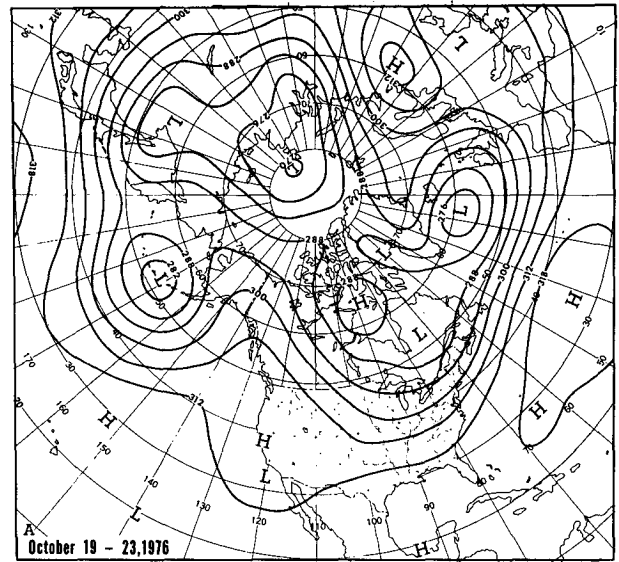


FIG. 10. As in Fig. 7, except for (A) 19-23 October 1976 and (B) and (C) week of 18-24 October 1976.

indicated a pronounced trend toward blocking in the mean circulation.

The aforementioned developments, together with strong deepening of a low just south of the Aleutians, led to a reamplification of the circulation pattern over the eastern Pacific and North America (Fig. 10A).

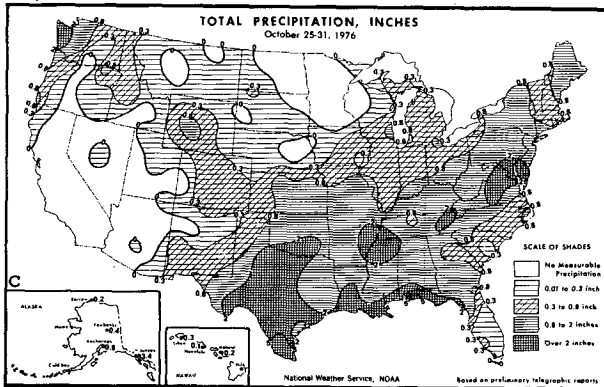
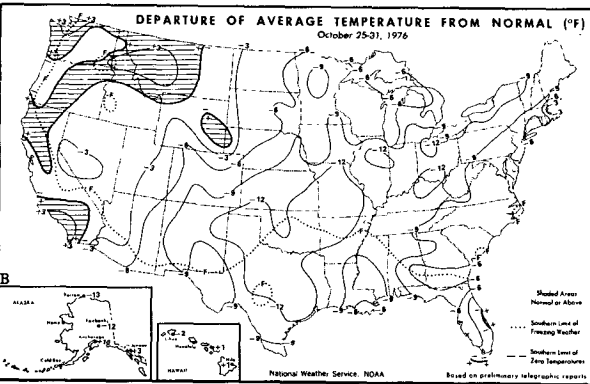
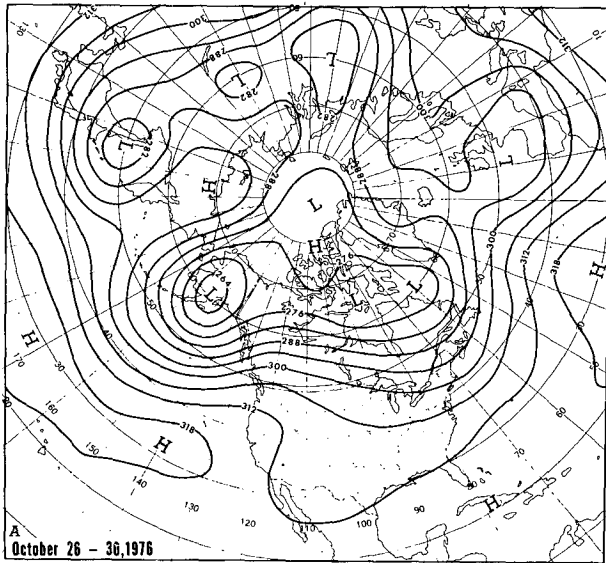


FIG. 11. As in Fig. 7 except for (A) 26-30 October 1976 and (B) and (C) week of 25-31 October 1976.

As a result, cold air again plunged deeply into the United States and temperatures over nearly the whole country averaged below normal (Fig. 10B). An extensive area from the Northern Great Plains to the central Appalachians averaged 12-16°F below normal. Record cold temperatures for so early in the season were observed at one or more stations somewhere in the

eastern two-thirds of the country every day from 17 to 22 October. The growing season came to an end everywhere except along the coastal and southern areas of states bordering the Gulf of Mexico or the Atlantic south of Cape Hatteras.

Precipitation was more widespread again, and another rapidly deepening storm produced heavy amounts in the East as it moved up the Atlantic coastal plain (Fig. 10C). A week trough over southern California produced significant rainfall over the Southwest which had been rainless the previous two weeks. A storm early in the week dropped 1.4 inches of snow on Omaha, Nebr., the most ever observed there in October.

d. 25-31 October

The Aleutian low moved slightly eastward to the Gulf of Alaska, resulting in progression and deamplification of the circulation features over North America and the western Atlantic (Fig. 11A).

Temperatures remained cold over most of the country, but mild air began spreading into the Northern Great Plains in response to increasing westerly flow from the deepening low in the Gulf of Alaska (Fig. 11B). The cold remained intense over the south-central states and the Midwest, where the week averaged 8-12°F below normal. Several additional cities in the Midwest, New England and the Southeast reported new record low temperatures for so early in the season.

In response to flow around the Gulf of Alaska low, precipitation increased to fairly heavy amounts, but about normal for the time of year along the Pacific Northwest coast (Fig. 11C). Rather intense impulses moving through the mean trough in the Southwest (Fig. 11A) triggered heavy rains through Texas and across the South to the middle Atlantic coast. The Brownsville, Tex, area reported as much as 6 inches of rain. Snow fell over the Texas High Plains area, and totals were the most ever recorded during October at some places in the Panhandle.

5. Tropical activity

Two hurricanes occurred in the Atlantic during October. Gloria was moving northward east of Bermuda at the beginning of the month and weakened a few days later as she moved into a frontal zone. Hurricane Holly formed on the 24th from a tropical depression northeast of the Windward Islands. She moved northeastward and weakened to tropical storm intensity a few days later before being caught up in a front and dissipating.

Over the eastern Pacific, tropical storm Kate was moving northwestward a few hundred miles northeast of Hawaii at the beginning of the month. She weakened and dissipated a few days later, but apparently contributed energy to an extratropical wave which deepened rapidly and moved into the Gulf of Alaska.

Also at the beginning of the month, Hurricane Liza

struck the southern tip of Baja, Calif., with torrential rains causing severe flash flooding and a large number of casualties. Two other storms, Madeline and Naomi, both of tropical storm intensity, moved into the Mexican southwest coast on the 8th and 29th of October, respectively.

The western Pacific was unusually quiet, perhaps due to the strong low-latitude ridge occupying much of the area where typhoons usually form (Figs. 1 and 2). There were no named storms until the last day of the month when Tropical Storm Louise formed near 10°N, 140°E.

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