

THE WEATHER AND CIRCULATION OF MARCH 1967

A Mild Month Associated With Confluent Flow Over Mid-North America

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1. MEAN CIRCULATION

Major changes occurred in the circulation as fast westerly flow and long wave spacing in February were replaced in March by meridional flow and short wave spacing. The greatest month-to-month change was in the east-central Pacific as 700-mb. heights increased by more than 700 ft. The strong ridge accompanying this change (figs. 1, 2) represents a retrogression of the principal ridge which had been near the west coast of North America in February [1]. This ridge was flanked by two new troughs, one in the central Pacific and the other off the Pacific coast of the United States. The latter trough represents a fall in 700-mb. height anomaly of 500 ft. as the ridge in February was replaced by a trough in March. Southwesterly flow ahead of this trough and northwesterly flow over western Canada resulted in a pronounced confluence zone near the Canadian border. This feature is also indicated by the departure from normal of mean monthly thickness (1000 mb. to 700 mb.) (fig. 3) which shows below normal thickness over all of Canada and above normal thickness dominating the United States. The new trough in the eastern Pacific was accompanied by progression and weakening of the trough from the Central States to the western Atlantic. At the same time the flow over the United States became westerly with the principal ridge in the Southeast. Unusually warm dry weather in the South in March may have contributed to the abnormal strength of this ridge and hastened the normal northward migration of the westerlies.

The subtropical Atlantic anticyclone was displaced far to the northeast of its usual March position and was much stronger than normal. An intense cyclonic center prevailed over the Norwegian Sea. Heights at 700 mb. in the Low were 580 ft. below normal while sea level pressures were as much as 25 mb. below normal. The axis of maximum west wind at 700 mb. was near its usual position across the Atlantic, but was 13 meters per second stronger than normal. Migratory cyclones associated with this jet axis were frequent and intense, particularly during the first half of the month.

The ridge over north-central Russia was stronger than normal while the trough over the eastern Mediterranean

Sea was deeper than usual. Across Asia these features were accompanied by a split westerly flow which was unusually pronounced. The downstream response to the Asiatic ridge was a deeper than normal coastal trough at higher latitudes. The strong mid-Pacific ridge effectively split the Aleutian Low into two cells, one centered near Kamchatka, the other off the coast of British Columbia.

After reaching record strength in February [1] the westerlies diminished sharply in March. The zonal index, a measure of the speed of the westerlies between latitudes 55° and 35° N. in the western half of the Northern Hemisphere, fell to 10.1 m.p.s. in March from 12.7 m.p.s. in February. This was still 1.2 m.p.s. above normal but represents a marked reversal of the upward trend in this monthly index which had been observed since November 1966. Much of this decrease was related to the major circulation changes in the Pacific. The index fell throughout March, reaching a value slightly below normal (8.2 m.p.s.) during the last 15 days.

2. TEMPERATURE

The new trough off the west coast and the stronger than normal westerly upper flow across the 48 States brought mild, windy weather to much of the Nation in March. Temperatures were above normal over most of the country, except for below normal averages in the Northwest and Northeast (fig. 4). This was the warmest March of record at Dallas, Tex., and Oklahoma City, Okla. In many of the Southern States and Central Plains the month ranks as one of the warmest Marches of record. An extensive area of much above normal temperature covered this region.

March surface temperature anomaly was closely related to the mean circulation patterns. Note the good correspondence between the anomaly patterns of 700-mb. height (fig. 2) and surface temperature (fig. 4). Warm conditions were also favored at sea level by stronger than normal southerly flow from the Appalachians to the Rockies. Below normal temperatures in the Northeast were associated with northerly anomalous flow at 700 mb. and were enhanced by a persistent snow cover. In addition,

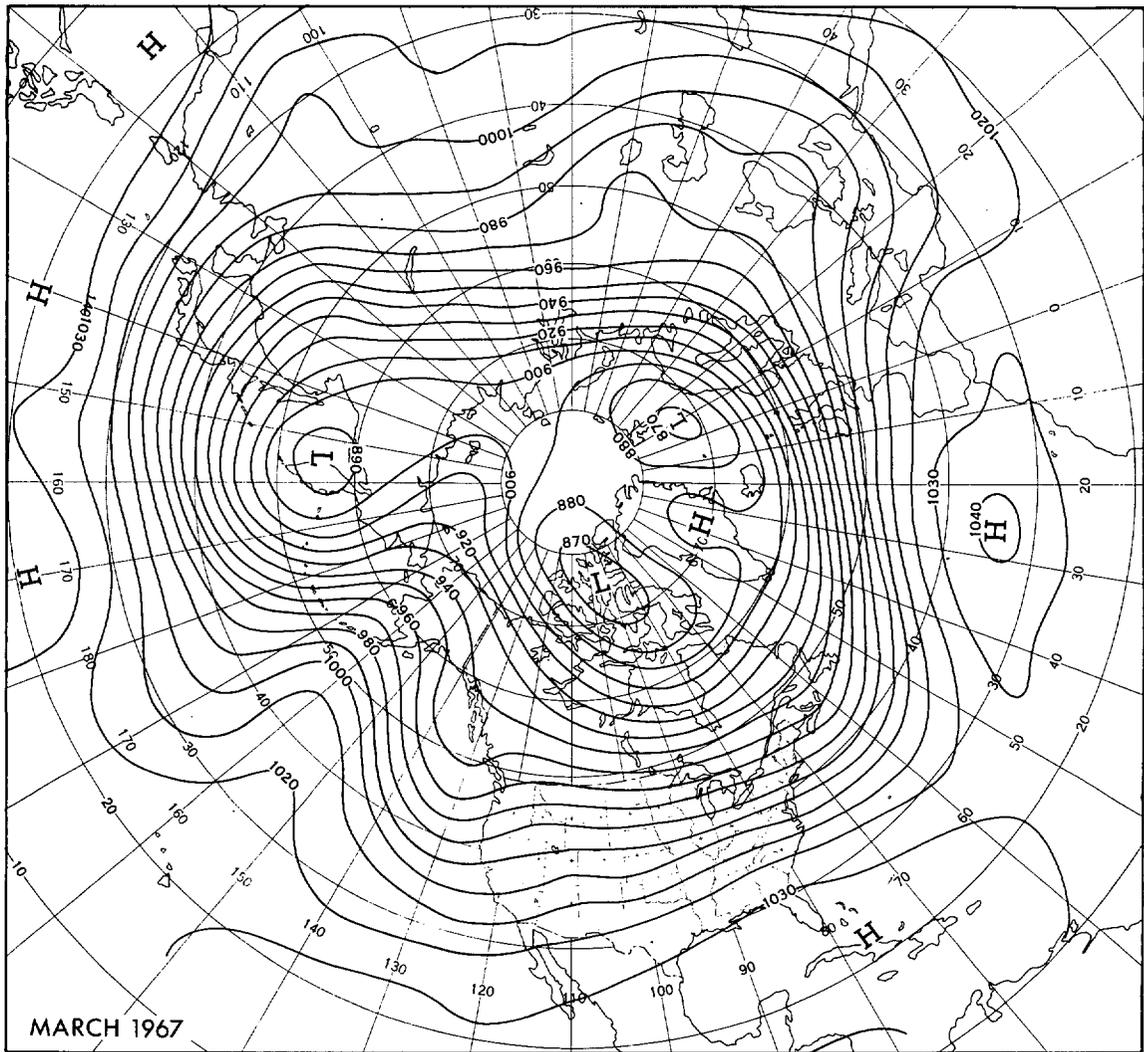
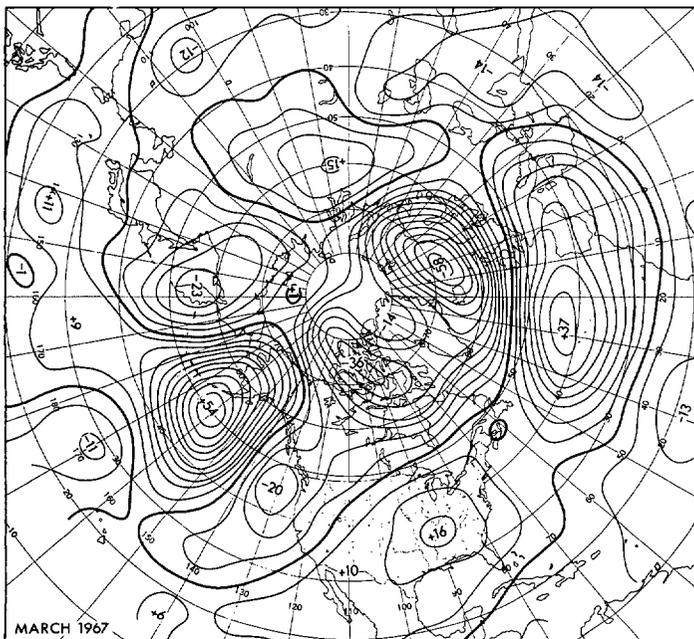


FIGURE 1.—Mean 700-mb. contours (tens of feet) for March 1967.



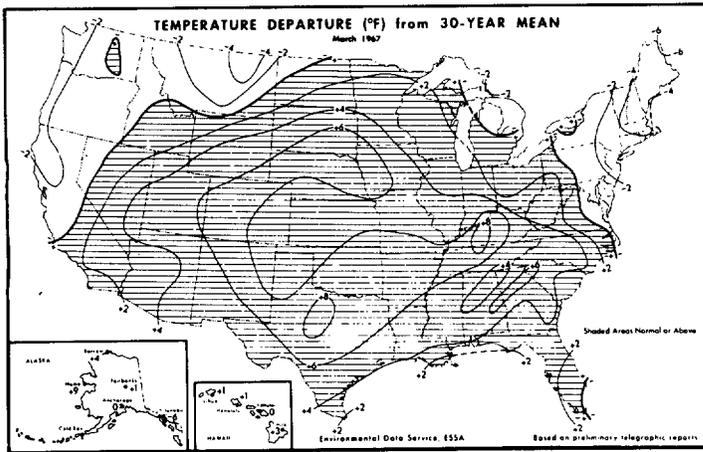


FIGURE 4.—Departure of average surface temperature from normal (°F.) for March 1967 (from [4]).

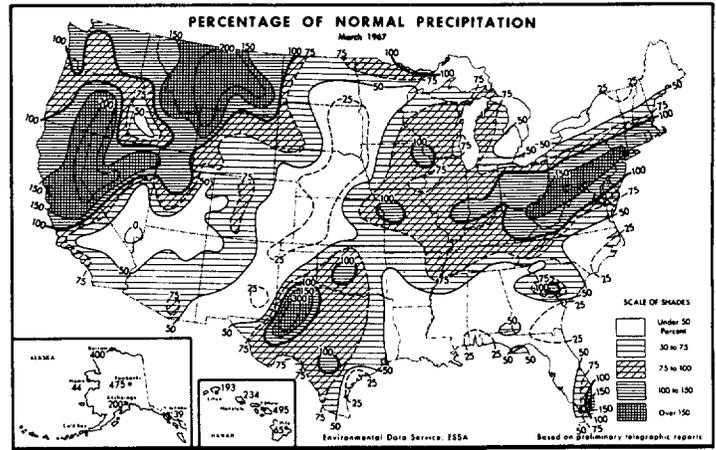


FIGURE 5.—Percentage of normal precipitation for March 1967 (from [4]).

Canadian air masses moving over the Northeast came from a source region that was abnormally cold (fig. 3).

Mild weather in March was in contrast to that of February [1] when a northwesterly circulation over western North America brought below to much below normal temperatures to the eastern half of the Nation. Of 100 representative cities, 76 warmed by one or more temperature classes while only 15 became cooler. The most pronounced change was in the Central States and Great Plains where most cities warmed by 2 to 3 classes.

3. PRECIPITATION

Abnormal dryness accompanied the mild weather over much of the Nation in March. Areas of greatest precipitation deficiency were the Central and Northern Plains, the South, and the extreme Northeast where amounts were less than half normal (fig. 5). In such widely separated cities as Mobile, Ala., Aberdeen, S. Dak., and Greensboro, N.C., this was the driest March of record. Near-record dryness for the month prevailed in other cities in the Northern Plains and South. Heavy precipitation in the previously severe drought areas of the Northeast is further evidence that the long drought may have ended with the heavy rains of September 1966 [2]. The heavy precipitation in March followed two months of abnormally dry weather. At the end of March the area of most intense drought, as indicated by the Palmer Index [3], continued to be in portions of the Southern Plains States. Moderate to heavy rainfall in March, however, was beneficial in some sections.

Dryness this month continued a trend of recent months. Much of the Nation had a deficiency of precipitation during the 6-month period ending this March (fig. 6). The area of greatest deficiency was in the Southern Plains and Lower Mississippi Valley. Major areas of an accumulated excess of moisture were in much of the Great Lakes region, Pacific Coast States, and Northern Plains.

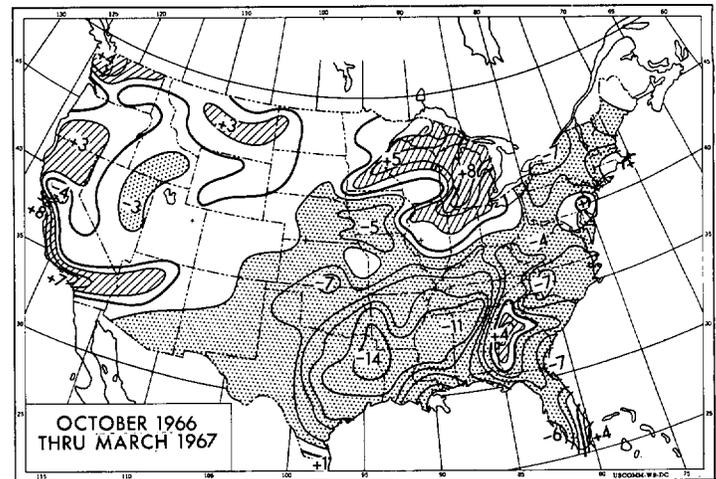


FIGURE 6.—Accumulated precipitation departure from normal (inches) for October 1966 through March 1967. Areas with a deficiency of 2 in. or more are stippled; those with an excess of 2 in. or more are hatched.

Dry weather in March was related to an upper-level circulation which was more anticyclonic than usual, as shown in figure 2 by the extensive area of positive 700-mb. height anomaly. Downslope motion over the Rockies favored dryness in the Plains States. Dryness in the South was related to the strong ridge with principal storminess passing to the north.

Moderate to heavy precipitation from storms associated with the deep trough off the coast accompanied cool conditions in the Northwest. Amounts in some areas were as much as twice normal. Total snowfall at Glasgow, Mont. (14.8 in.) was a record for any March. A second major area of above normal precipitation extended from the Ohio Valley eastward across southern New England. This was associated primarily with wave disturbances along the

polar front. Three major snowstorms struck southern New England bringing record or near-record total March snowfall to some areas. Winter 1966-67 was the snowiest winter of a 62-yr. record at Hartford, Conn., as a March fall of 33 in. brought the seasonal total to 81.4 in. Precipitation in the Southern Plains was primarily the result of cold fronts and squall lines.

4. INTRAMONTHLY VARIABILITY

Weekly changes in amplitude and position of the major Pacific ridge (fig. 1) were largely responsible for changes in circulation and average weather in the United States during March. Gradual retrogression of this ridge and formation of the new trough along the west coast occurred during the first half of the month. Weekly temperatures remained above normal over most of the Nation, except in the Northern States where there were frequent changes and departures were near to below normal. A slow-moving cold front spread heavy precipitation from the Middle

Mississippi Valley to the Middle Atlantic States and southern New England from the 4th to the 7th. Some of this precipitation was snow with record or near-record 24-hr. totals in parts of a narrow band from southern Illinois to southern New England. The largest totals were 8 to 10 inches. Severe flooding followed the heavy precipitation in portions of the Ohio Valley, and also in Pennsylvania, West Virginia, and New Jersey. Though mild weather dominated the Nation there were occasional sharp temperature changes. For example, at Dodge City, Kans., -1° F. on the 8th (lowest for winter 1966-67) was followed by 71° F. the next afternoon. At Tulsa, Okla., the temperature rose from 5° F. on the 8th to 94° F. on the 11th, the highest for so early in the season.

A large-amplitude, blocking circulation became established over the Pacific by mid-month as a strong anticyclone appeared over the eastern Aleutians with a deep trough off the west coast of the United States (fig. 7A). In response, the wave pattern also amplified over North

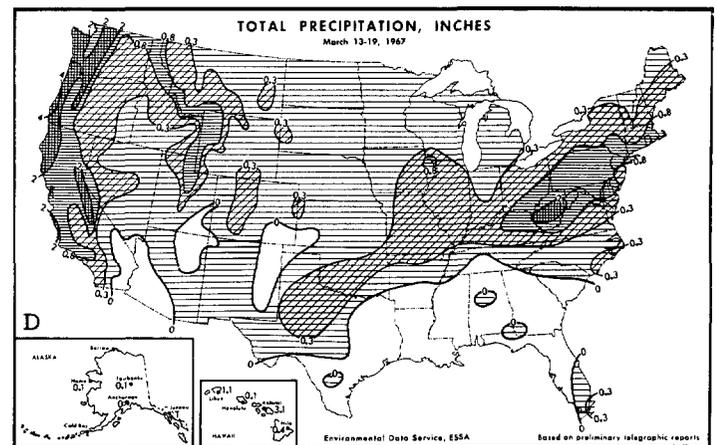
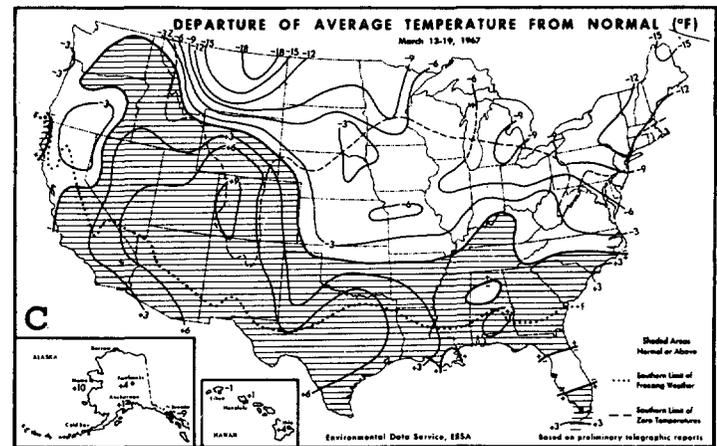
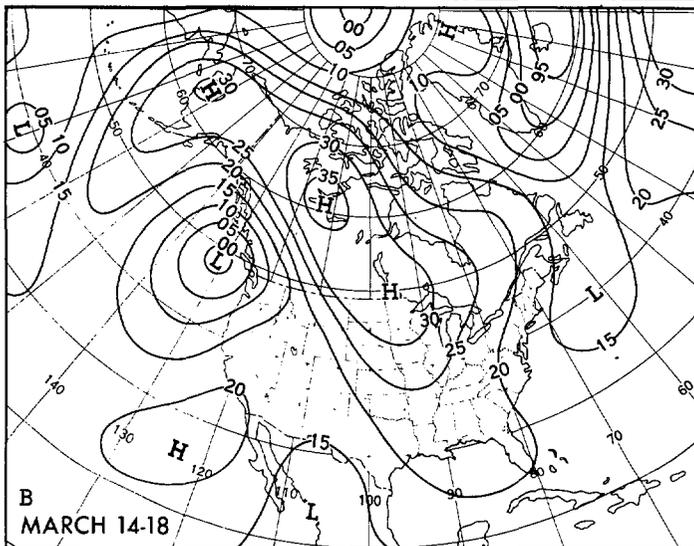
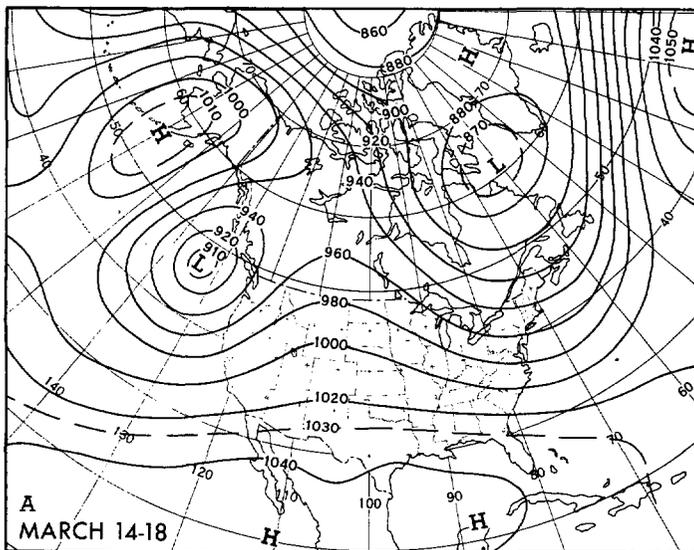


FIGURE 7.—Week of March 13-19, 1967: (A) 700-mb. contours (tens of feet), and (B) sea level isobars (mb.), both for March 14-18, 1967; (C) surface temperature departure from normal (°F.); (D) total precipitation (in.). (C) and (D) from [4].

America with a ridge over the Rockies and a trough off the east coast. An abnormally strong component of flow from the north at 700 mb. (fig. 7A) and sea level (fig. 7B) brought the coldest weather of the month during the third week as temperatures averaged below normal in the Northern and Central Plains and eastward to the Atlantic Coast (fig. 7C). The change was quite abrupt in some areas as record early season warmth, particularly in Kentucky, West Virginia, and North Carolina, was replaced by record cold. Numerous eastern cities reported daily minimum temperature records on some or all days from the 17th to the 19th. The coldest weather occurred on the 18th as average temperatures were as much as 30° F. below normal in the Northeast. The cold also moved into the Southeast where a hard freeze caused heavy damage to orchards and crops in the Carolinas and Georgia. By contrast the ridge over Alaska brought unusual warmth there to all but the Alaskan Panhandle. Greatest temperature departures from normal were along

the Arctic Coast where Barrow and Barter Island reported departures of +44° F. and +42° F., respectively, on the 15th. Temperatures of 33° F. and 36° F. were the highest ever recorded in March at these stations.

The deepening trough off the Pacific Coast brought increasing amounts of precipitation to the Far West with greatest totals along the coast (fig. 7D). Heavy snow fell in the Sierras of northern California where accumulations were as much as 15 ft. in some places. Severe thunderstorms occurred early in the week along a strong frontal zone from the Ohio Valley through the Middle Atlantic States. Later in the week a developing disturbance on this front produced the second major snowstorm of the month in parts of southern New England, southeastern New York, northern New Jersey, and northeastern Pennsylvania.

Progression of the long waves over and adjacent to North America characterized changes in circulation during the last half of the month. This occurred as a portion of the Aleutian anticyclone moved northward into the Arctic

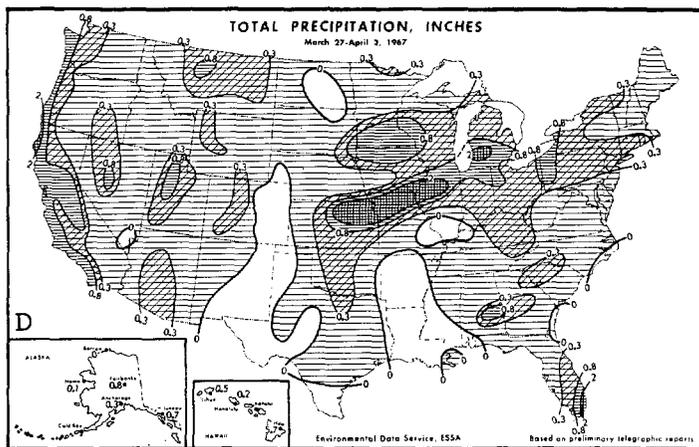
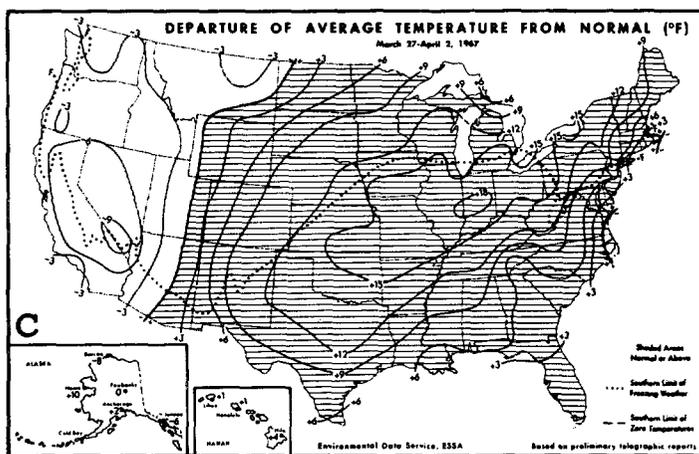
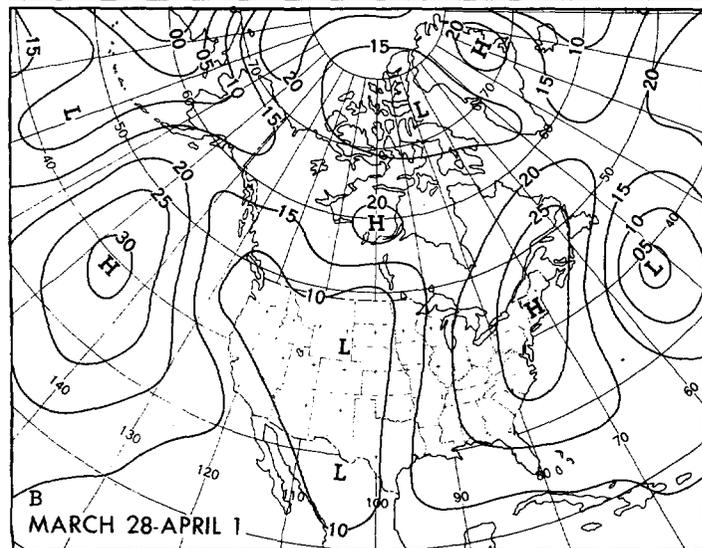
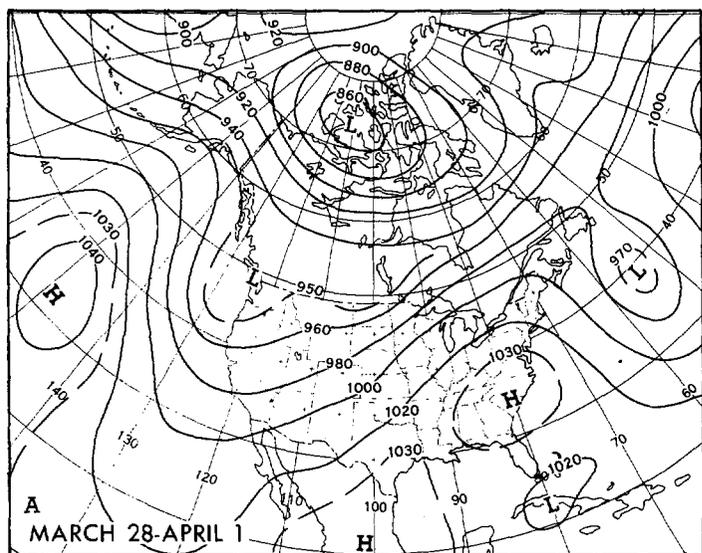


FIGURE 8.—Week of March 27–April 2, 1967: (A) 700-mb. contours (tens of feet), and (B) sea level isobars (mb.), both for March 28–April 1, 1967; (C) surface temperature departure from normal (°F.); and (D) total precipitation (in.). (C) and (D) from [4].

while the principal High developed at lower latitudes (figs. 7A, 8A). As the Pacific westerlies increased, the trough off the west coast advanced to the coast while the ridge which had been over the Rockies progressed to the East Coast States and strengthened. Heights increased sharply from the third to the fifth weeks over eastern North America, in part as a result of blocking in eastern Canada and the Atlantic manifested by the deep trough with cut-off Low in the western Atlantic at the end of the month (fig. 8).

The long fetch of southwesterly upper flow over the Nation and strong southerly flow at sea level (fig. 8B) brought springlike weather to the area from the Great Plains to the Appalachians. Temperatures during the last week averaged 15° F. or more above normal in the Middle Mississippi and Ohio Valleys and adjacent areas (fig. 8C). Some cities in the Northern Plains and Great Lakes Region reported record daily maximum temperatures at month's end with average daily temperature anomalies as much as +32° F. There were several days when strong southerly winds raised dust clouds in the Northern and Central Great Plains. A third major snowstorm struck

parts of the Northeast on the 22d-23d as a coastal storm deposited from a few inches to a foot of snow from Maryland to southern New England. Precipitation in the Pacific Coast States decreased as the trough progressed, but moderate to heavy amounts fell elsewhere in the West (fig. 8D). Below normal temperatures accompanied the trough in the Intermountain Region with greatest departures in the Central Plateau and interior valleys of California.

REFERENCES

1. J. W. Posey, "The Weather and Circulation of February 1967—Cold in the East but Continued Warm in the West," *Monthly Weather Review*, vol. 95, No. 5, May 1967, pp. 311-318.
2. R. A. Green, "The Weather and Circulation of September 1966—Large-Amplitude Flow Over North America and Heavy Rain in the East," *Monthly Weather Review*, vol. 94, No. 12, Dec. 1966, pp. 715-719.
3. W. C. Palmer, "Meteorological Drought," U.S. Weather Bureau *Research Paper* No. 45, Feb. 1965, 58 pp.
4. Environmental Data Service, ESSA, *Weekly Weather and Crop Bulletin, National Summary*, vol. 54, Nos. 12, 14, 15, Mar. 20, and Apr. 3, 10, 1967.