

THE WEATHER AND CIRCULATION OF APRIL 1964

A Stormy Month in the Midwest

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1. SEVERE WEATHER IN APRIL 1964

Frequent storms swept through the West this month and intensified in the Plains States (Chart IX of [1]). Deepening was favored in the baroclinic environment created by the contrast between cool air from the Pacific and warm, moist tropical air from the Gulf of Mexico. The monthly mean sea level chart (fig. 1) shows the long fetch of tropical air from low latitudes to southern Canada and the opposing northerly flow west of the Continental Divide.

A succession of storms began early in April when a Low from the northern Rockies moved into the Central Plains on the 2d. This storm was responsible for snow from the Rocky Mountain States to New England with 13 in. at Casper, Wyo. Hail and gusts of 100 m.p.h. in the vicinity of St. Louis, Mo., caused estimated damage of \$10 million. The worst tornado of record at Wichita Falls, Tex., on the 3d accounted for 7 deaths and an estimated \$15 million damage. Heavy rains occurred in the South along the cold front as it retarded and extended east-west. On April 5 and 6 Meridian, Miss., received 6.36 in. of rain.

On April 6 another storm deepened in the Plains, followed by one of the few continental polar outbreaks this month. Snow and sleet in the North and rain along the front in central and southern portions were followed by cold air that lowered temperatures to the 30's in the Gulf States. At Dallas, Tex., the daily mean temperature was 8° F. above normal on the 6th; two days later, behind the strong cold front, the average temperature was 12° F. below normal.

The third storm deepened more than 20 mb. in the Central Plains from the 12th to the 13th. On the 13th, Minneapolis, Minn., recorded the lowest sea level pressure in its history as the barometer fell to 973 mb. Several tornadoes occurred in eastern Kansas, western Missouri, and southern Iowa, and high winds caused damage elsewhere from the Dakotas to Texas.

Storm number four, which arrived in the Dakotas on the 16th, was less severe than previous ones, although there was considerable convective activity along the front and in the warm air. In the strong southerly flow preceding the cold front, rainfall amounts were small, but

Ville Platte, La., reported that 14.55 in. of rain fell there in a 14-hour period on the 17th and 18th.

During the last third of April two rather intense storms emanated from the long-wave trough in the West (see sec. 4). The first Low deepened in the Panhandle of Texas after depositing rain in southern California and rain and snow in the Plateau. Thunderstorms and heavy rain occurred from the central Rockies to the Atlantic coast on succeeding days as the Low moved through the western Great Lakes area to James Bay. Flooding was locally serious in Indiana where some rainfall totals were more than 7 in.

The last storm of the month migrated from the Gulf of Alaska through western Canada into the Great Basin. This is an uncommon track since such Lows usually move from west to east [2] instead of southward. The Low then moved across the western Plateau, deepened in the lee of the Rocky Mountains, and recurved northeastward

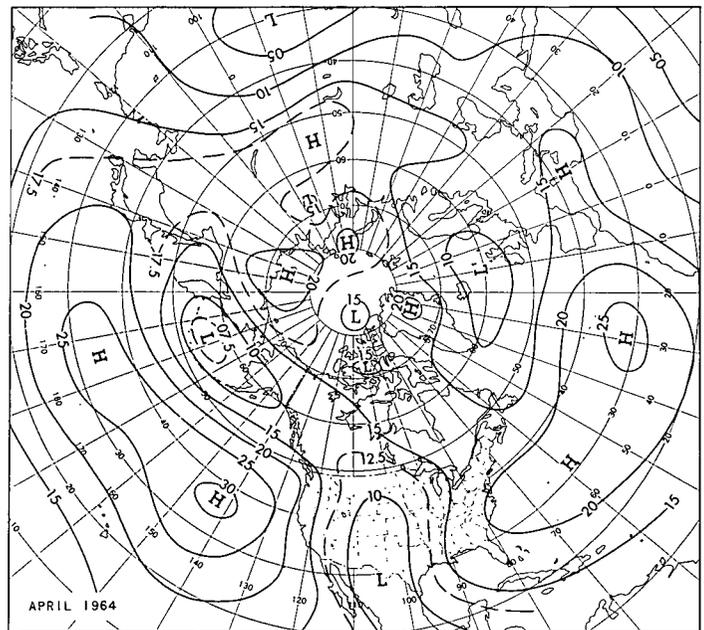


FIGURE 1.—Mean sea level pressure (in millibars) for April 1964. Vigorous northerly flow in the West and southerly flow east of the Rockies helped maintain a cyclogenetic zone in the Plains States.

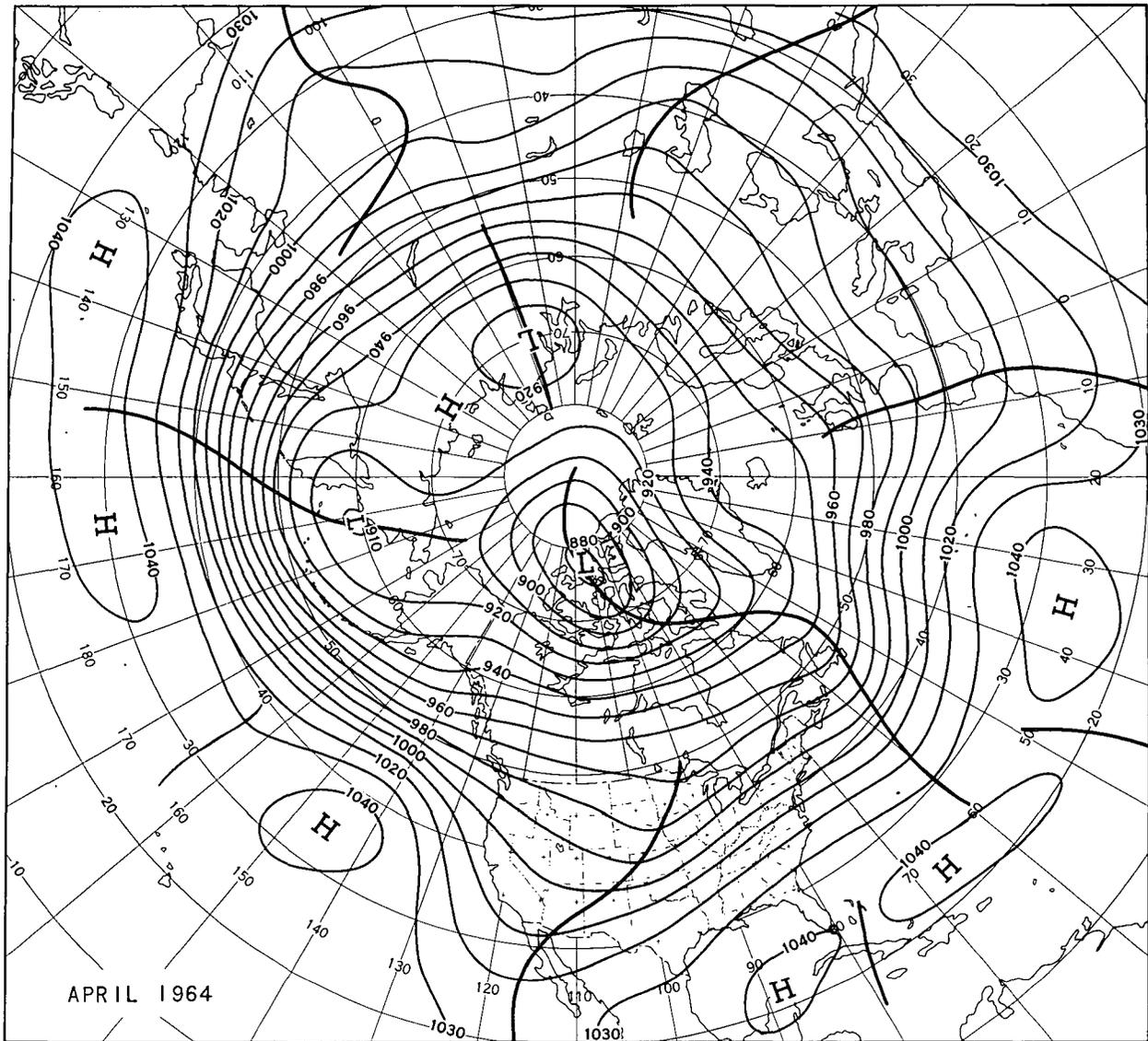


FIGURE 2.—Mean 700-mb. contours (tens of feet) for April 1964. Short-wave spacing from central United States to western Europe typifies transitional state from zonal to blocking regime.

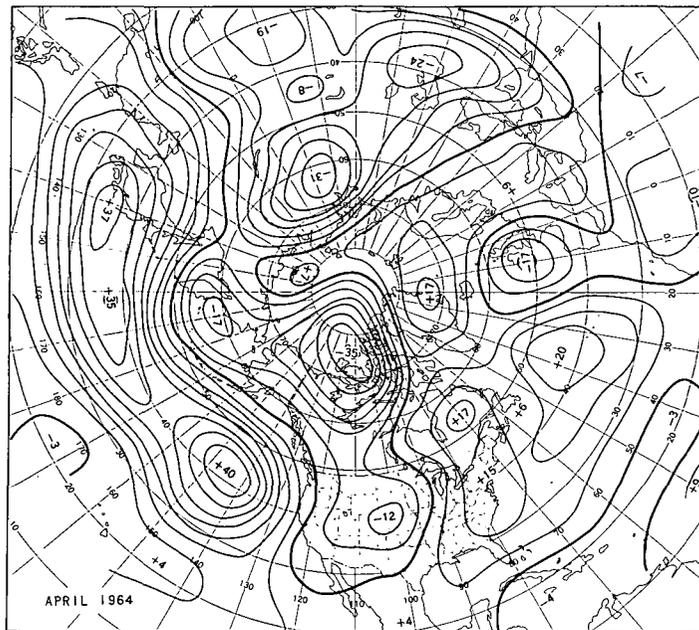


FIGURE 3.—Departure of mean 700-mb. heights from normal (tens of feet) for April 1964. Flow was zonal in the Pacific and meridional over the United States.

to the western Great Lakes. The slow motion of the storm (7 days from the Northwest to Wisconsin) accounted for heavy rainfall over the eastern two-thirds of the Nation. There were cloudburst rains and tornadoes along the cold front in the Plains and parts of the South as the cold front progressed to the southeastern Atlantic coast.

2. PRINCIPAL FEATURES OF THE CIRCULATION

Pronounced ridging in the eastern Pacific Ocean in April 1964 (fig. 2) was a major feature of the circulation in the mid-troposphere. 700-mb. anomalous heights were as great as +400 ft. about 1000 mi. off the coast of Oregon. Long term averages [3] show a ridge along 115° W. at 50° N., but in April 1964 the ridge was some 30° of longitude farther west. The position and strength of this ridge were decidedly important factors governing the circulation and weather in the United States.

Flow at 700 mb. was fast and zonal over the Pacific in April, but over the United States low-index conditions prevailed. The 700-mb. height contours suggest the latter characteristic, but the anomalous height pattern (fig. 3) indicates the disturbed flow more clearly. Northerly anomalous flow off the west coast and southerly anomalous flow in the Plains States imply a mean pattern that was amplified most of the month over the United States. Further evidence is found in figure 4, the mean 700-mb. isotach chart. The dashed lines show that on the average there are two principal jets during April, but this year the northern branch of the westerlies was notably absent, principally because of the strong ridge in the eastern Pacific.

Blocking affected North America and the Atlantic Ocean during April, but since it spread westward only in the last 10 days of the month, its net impact on the circulation was not prominent, at least in the accustomed sense of a large positive height anomaly in northern latitudes and negative height anomaly to its south. However, blocking this month was evident in the displacement northwestward of the vortex normally over Baffin Island [3]. Note also that the trough from Davis Strait southward was very weak. While blocking was not dominant over most of the Atlantic and eastern North America during April, it was sufficient to complicate the 700-mb. flow such that the pattern is difficult to categorize. The flow averaged neither zonal nor meridional but transitional from the former to the latter. This was true also at sea level (fig. 1) where there were no large abnormalities and the configuration of the contours resembled the normal [3].

Europe was subject to a 700-mb. flow that was westerly but not exceptionally so (figs. 2 and 3). The trough over western Europe was quite weak with some blocking activity from Greenland to the United Kingdom. Over Asia 700-mb. heights were lower than normal (figs. 2 and 3) except in parts of China and eastern Siberia. Despite the strength of the Low near Novaya Zemlya, the westerlies were only a few meters per second faster than long-period

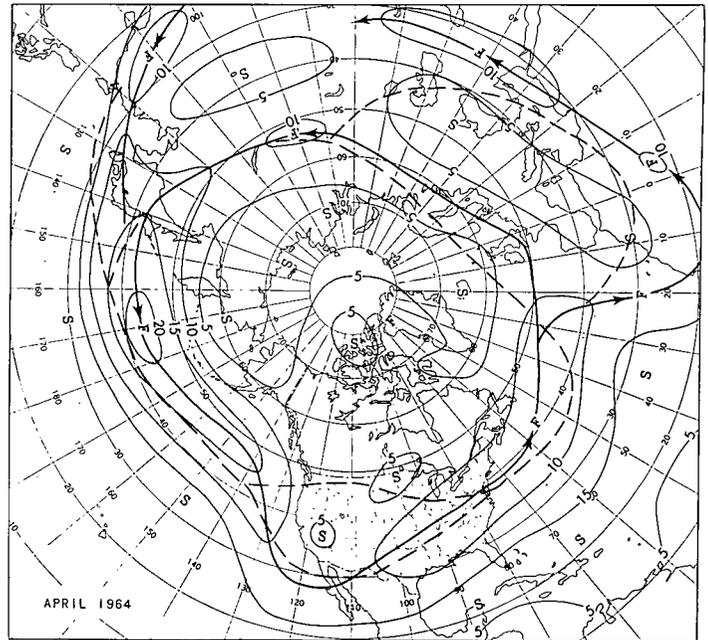


FIGURE 4.—Mean 700-mb. isotachs (meters per second) for April 1964. Solid arrows are principal axes of maximum west wind speed and dashed lines are the normal April positions. Absence of the northern branch of the jet over the United States was associated with the deeper-than-normal trough in the Great Plains.

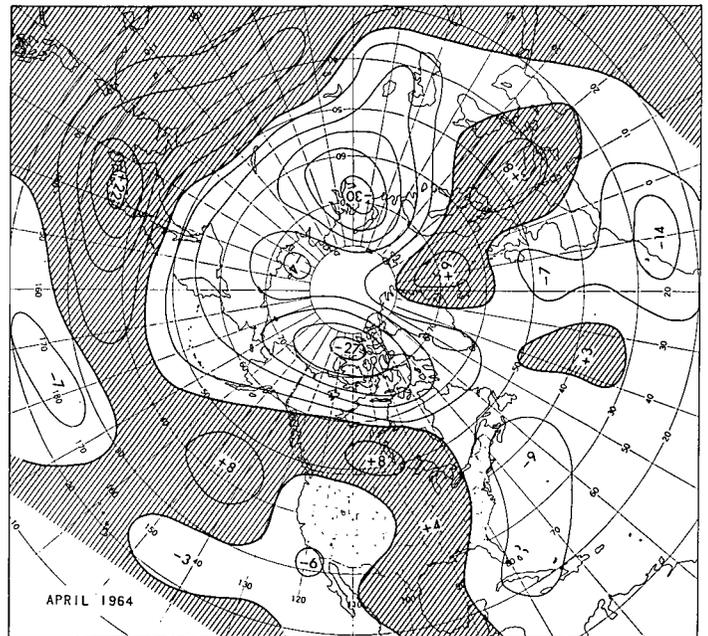


FIGURE 5.—Departures of mean 1000-700-mb. thickness from normal (tens of feet) for April 1964. Relatively small values over the United States suggest few extremes of surface temperature.

averages and the mean jet was displaced little (fig. 4). Below normal thickness (fig. 5) was very extensive, and it is probable that surface temperatures also were lower than normal over a wide area in Asia north of 50° N.

In the Pacific, 700-mb. height departures were remark-

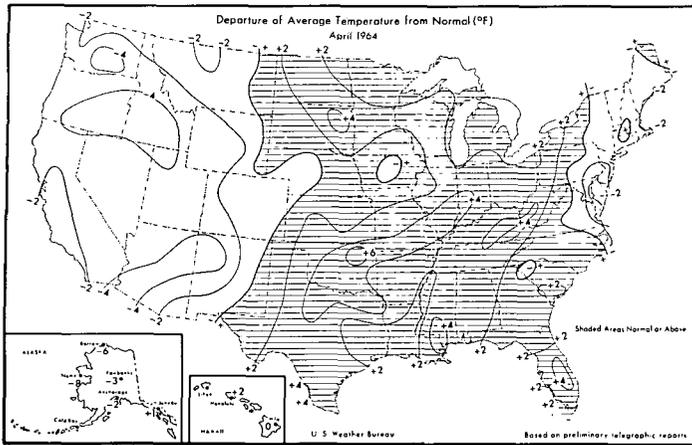


FIGURE 6.—Departure of average temperature from normal (°F.) for April 1964. Range of temperatures was rather small since repeated polar outbreaks were inhibited by the strong upper-level vortex over northern Canada. (From [4]).

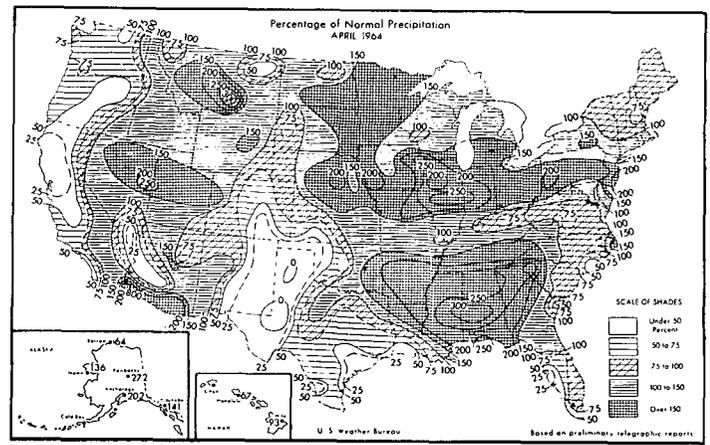


FIGURE 7.—Percentage of normal precipitation for April 1964. Excessive rainfall caused major flooding in Mississippi, Alabama, Georgia, and part of the Ohio Valley. (From [4]).

ably positive from eastern China to the west coast of the United States. This was also true at sea level (fig. 1) as pressures were 5 to 10 mb. greater than normal from Japan to the eastern Pacific at middle latitudes. There was some northward displacement of the mean jet (fig. 4), but this was limited to some degree by the cyclonic nature of the flow at higher latitudes and the negative height anomaly in the Bering Sea. Average wind speeds in the westerly flow from 40°–50° N. were 5–10 m.p.s. faster than normal. A compensating decrease of the same magnitude in the speed of the westerlies occurred between 25° and 35° N.

3. MONTHLY WEATHER

TEMPERATURE

April was without extremes in average temperature across the country (fig. 6). Mean temperatures were 2°–4° F. below normal from the Rocky Mountains to the west coast. The largest departure was –5.2° F. at Boise, Idaho. In the first week an outbreak of polar continental air moved into the West with the apparent amalgamation of polar and Pacific ridges. Thereafter only cool Pacific air masses affected the West. The flow at 700 mb. (fig. 2) and on the monthly mean sea level chart (fig. 1) shows that the average trajectory of air was from the higher latitudes of the Pacific Ocean. Cooler weather than normal also was observed from New England to central Virginia, even though the heights were above normal and the sea level flow was southerly most of the month.

The balance of the Nation was somewhat warmer than normal from the Gulf of Mexico to the Canadian border. Temperature anomalies were small and ranged generally from 2° to 4° F. above normal. Greatest departures were in the Southern Plains where some temperatures averaged 4°–6° F. above normal.

Record monthly temperatures were few and circulation features of the month were not of particularly large ampli-

tude. It is also of interest that there was considerable variability of circulation and temperature on time scales shorter than two weeks. New records established include the lowest April minimum (10° F.) at Cleveland, Ohio, and new maximum temperatures for April at International Airport, Los Angeles, Calif. (93° F.) and at Long Beach, Calif. (98° F.).

PRECIPITATION

Precipitation was abundant this month over most of the United States (fig. 7). Amounts ranged from one to two times normal, equivalent to 1/2–2 in., over the Rocky Mountain States. In the Upper Mississippi Valley, the Ohio Valley, and in most of the South, amounts were in excess of 4 in. with totals of 10–16 in. from Alabama to Arkansas.

Precipitation fell in record amounts in several cities in April 1964 (table 1). The largest amount was 16.82 in. at Meridian, Miss., 11.49 in. in excess of normal; this was principally the result of thunderstorms and repeated periods of instability showers. Record 24-hr. rainfall at Appalachicola, Fla., totalled 7.76 in. on April 27–28.

Slight precipitation was confined to those areas that are normally quite dry with the exception of eastern Oregon and northern California where amounts were less than half of normal. In Red Bluff, Calif., precipita-

TABLE 1.—Monthly precipitation records established in April 1964

| Location | Amount (in.) | Percentage of normal |
|-------------------|--------------|----------------------|
| Montgomery, Ala. | 15.64 | 320 |
| Meridian, Miss. | 16.82 | 316 |
| Billings, Mont. | 4.11 | 314 |
| Waterloo, Iowa | 8.11 | 300 |
| Ely, Nev. | 2.77 | 292 |
| Greenville, S.C. | 11.30 | 287 |
| Springfield, Ill. | 9.91 | 276 |
| Rockford, Ill. | 8.17 | 268 |

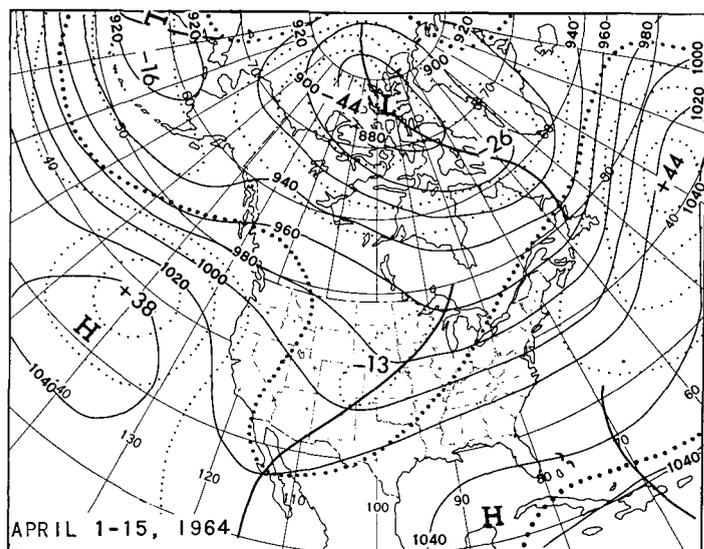


FIGURE 8.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for April 1-15, 1964.

tion from late November 1963 through April 1964 amounted to only 4.50 in., a drought-producing deficiency of 12.48 in. San Francisco received 0.01 in. this month, the smallest amount in April since 1916. Pueblo, Colo., also had the driest April of record with but 0.03 in., 1.15 in. below normal.

Comparison of the precipitation chart (fig. 7) with the 700-mb. circulation (figs. 2 and 3) shows a northerly anomalous flow over the West Coast States where precipitation was less than normal. Over the Plateau, cyclonic curvature of the 700-mb. contours was almost coincident with the heavy precipitation. Most of the eastern half of the United States was subject to a southerly anomalous flow. Sea level flow (fig. 1) was also quite southerly; thus lower-level heat and moisture were transported to the north from the Gulf of Mexico. Activity related to the mean trough resulted in widespread instability, severe storms, and heavy rains.

4. HALF-MONTHLY CIRCULATION AND RELATED WEATHER

APRIL 1-15

During the first 15 days of April 700-mb. flow in the eastern Pacific (fig. 8) was fast between the ridge to the south and cyclonic conditions in the Gulf of Alaska. Instability of this flow was manifested downstream as diffluence in the contours and a trough from the western Lakes to Baja California. The strong cyclonic vortex in northern Canada produced fast flow to its south and contributed to the isolation of a cut-off negative height anomaly center over the Central Plains States. In the Atlantic the subtropical ridge was farther north than usual with 700-mb. heights more than 400 ft. higher than normal in mid-ocean.

Temperatures averaged 2°-5° F. below normal in

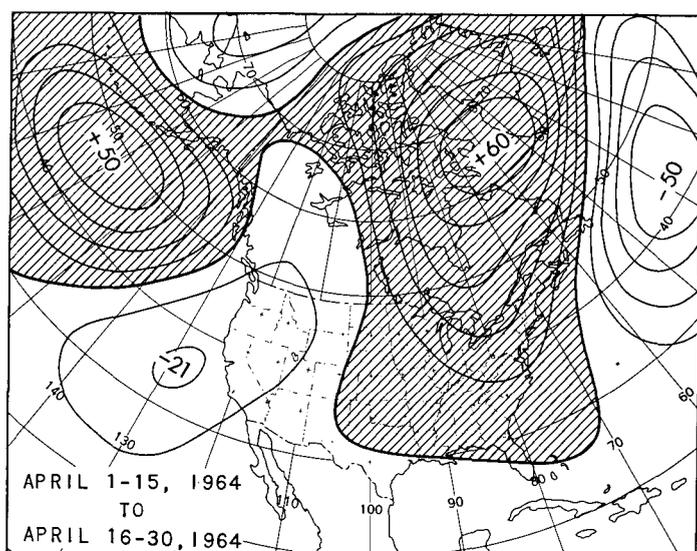


FIGURE 9.—Mean 700-mb. height change (tens of feet) for April 1-15 to April 16-30, 1964. Large height rises in the north-eastern Pacific and in eastern North America depict the increased meridional flow.

Atlantic Coast States north of Florida the first 15 days of the month. This is an apparent contradiction to the westerly upper-level flow and the southerly direction of the anomalous height contours. However, the circulation was fairly weak and its potential for warming was not realized. At the surface a polar High from northern Canada moved through the Eastern States early in the period. Minimum temperatures were less than 20° F. in New York State and Pennsylvania, with freezing temperatures observed into Virginia. Another cold air mass lowered temperatures in the East late in the period behind a deepening Low in the Gulf of St. Lawrence. Frequent cloudiness and rain also contributed to below-normal temperatures.

In the Central States temperatures were generally a degree or two above normal, but in the Northern Plains departures of 4°-5° F. above normal were common. Maximum temperatures at times were in the 60's and 70's. Most of the West was relatively cool with temperatures generally 2°-4° F. lower than normal in the Plateau. This coolness was consistent with the northerly anomalous flow that prevailed over the area.

Precipitation in the first half of April was widespread, even in the usually dry Southwest. In the Rocky Mountain States heavy snow fell on the 3d and again on the 6th and 7th. From the Mississippi Valley eastward, precipitation totals were 1-3 in., except in the South where Montgomery, Ala., reported 10.58 in., Jackson, Miss., 6.95 in., and Chattanooga, Tenn., 7.21 in.

APRIL 16-30

Circulation changes from the first half of April to the last half were substantial over North America and ad-

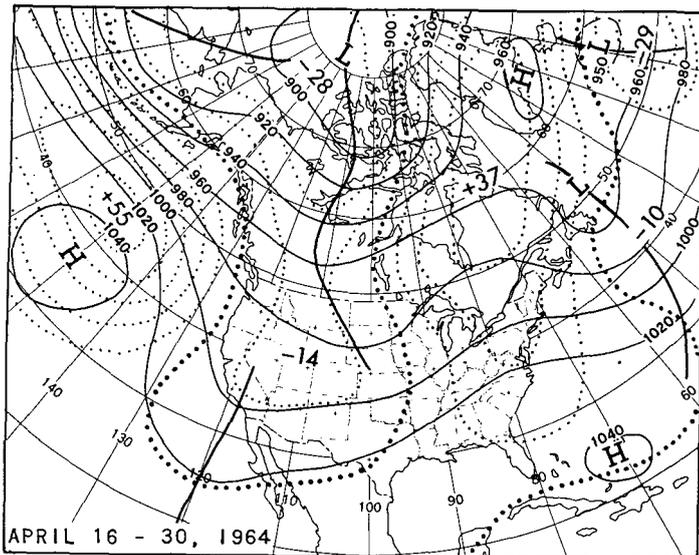


FIGURE 10.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for April 16-30, 1964.

adjacent oceans (fig. 9). Heights at 700 mb. increased in and near the Gulf of Alaska as cyclonic conditions were replaced by a strengthening ridge (fig. 10). This amplification spread into North America and produced several notable changes. Heights decreased 100-200 ft. over the West as the trough retrograded. The weak ridge from the Gulf of Mexico to the Ohio Valley in the first half amalgamated with the blocking wave that appeared in eastern Canada in the last half. Largest positive changes were in Davis Strait where 700-mb. heights increased by a maximum of 600 ft. Meanwhile in the central Atlantic 700-mb. heights decreased by some 500 ft. in a manner typical of blocking in these longitudes.

Temperatures during the last half of April were below normal from the Rocky Mountains to the Pacific Coast. Largest departures were 6°-8° F. from Utah to southern Washington. Cool Pacific air masses dominated the West as the ridge in the eastern Pacific retrograded and strengthened, accompanied by northerly anomalous flow to its east. Pocatello, Idaho, recorded an average temperature departure of -14° F. for the week ending April 27, the coldest city in the Nation relative to normal.

From southern New England to the Middle Atlantic States temperatures were 2°-3° F. below normal. This is somewhat surprising since the ridge in the East was so strong. However, anomalous flow was northeasterly, suggesting some weakening of the westerlies during the period. In fact, there was considerable onshore flow in this area at sea level (fig. 1), the effect of which was to transport air over nearby ocean waters that have been unusually cold in recent weeks.

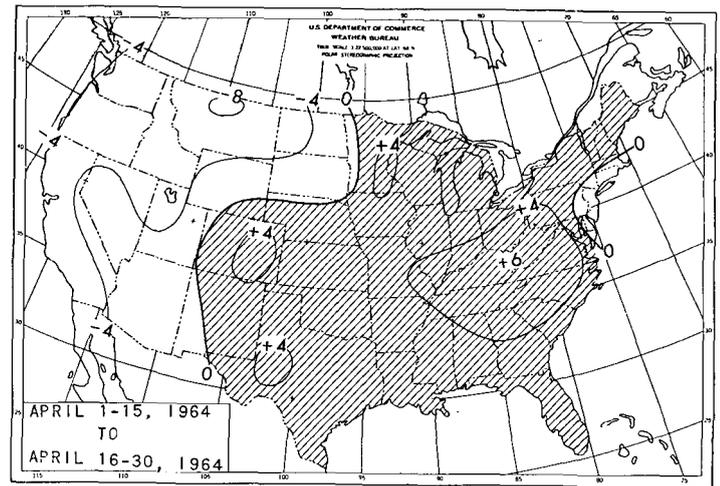


FIGURE 11.—Change in temperature anomaly (°F.) from April 1-15 to April 16-30, 1964. Cooling in the West and warming in the East were responses to amplification and some retrogression of the long-wave pattern.

The remainder of the Nation east of the Rocky Mountains was warm, especially from the Ohio Valley westward where anomalous flow was southerly.

Changes of anomalous temperature from the first half of April to the last half (fig. 11) reflect the changes in the 700-mb. circulation (fig. 9) to some extent. Decreased heights over the West were accompanied by temperature anomaly decreases of 4°-8° F. Over the eastern two-thirds of the United States, where heights increased, departures of average temperatures from normal increased 2°-4° F., with a maximum increase of 6° F. in the Ohio Valley.

Precipitation during the last two weeks of the month continued heavy with 4-8 in. from northern Florida to Arkansas, while 2-4 in. totals were common from the mid-Atlantic States to the Central Plains. Little precipitation fell in southern Colorado or New Mexico, or in northern California, but the rest of the West received quite heavy precipitation compared with normal.

REFERENCES

1. U.S. Weather Bureau, *Climatological Data, National Summary*, vol. 15, No. 4, April 1964, Chart IX.
2. W. H. Klein, "Principal Tracks and Mean Frequencies of Cyclones and Anticyclones in the Northern Hemisphere," U.S. Weather Bureau, *Research Paper No. 40*, Washington, D.C., 1957, 59 pp.
3. U.S. Weather Bureau, "Normal Weather Charts for the Northern Hemisphere," *Technical Paper No. 21*, Washington, D.C., Oct. 1952, 74 pp.
4. U.S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. LI, Nos. 18 and 19, May 4 and 11, 1964.