

# THE WEATHER AND CIRCULATION OF APRIL 1962

## A Month with Persistent Blocking in the Pacific

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### 1. INTRODUCTION

The most anomalous feature of the general circulation at 700 mb. for April 1962 (fig. 1) was a pronounced and persistent blocking complex in the Central Pacific. The dominant pattern over the United States featured a warm ridge in the West and a cool trough in the East, a regime which was prominent during the first three weeks, but underwent a fundamental reversal in the final week of the month. During the latter period, the West cooled as the East warmed, and east of the Rockies temperatures rose to values more typical of summer than spring. From the standpoint of severe storm activity, most of April was comparatively mild for a spring month, though a rash of tornadoes during the last few days sufficed to bring the storm total to near normal incidence.

### 2. GENERAL CIRCULATION

As mentioned above, blocking in the Pacific was perhaps the most striking aspect of the mean 700-mb. chart for the month (fig. 1). The associated positive anomaly overspread all of the Bering Sea and a large area of the northwestern Pacific, and its maximum, located near the end of the Aleutian Chain, exceeded the normal by 640 ft. In absolute magnitude, this was nearly twice as large as the next largest center, the 350-ft. negative anomaly which accompanied the depression in the polar basin. The mean ridge in the Pacific does not appear exceptionally strong in the monthly contour field, but it is significant that it was located in a region normally occupied by a trough. This remarkable feature persisted for almost the entire month and it is indeed interesting that such circulation regimes, so out of keeping with the normal, are often so long lived and dominant.

In the preceding month [1] blocking activity was concentrated mainly in the vicinity of the Davis Strait. Its shift westward to the Pacific during April accounted for the two largest 700-mb. anomaly change centers between the two months, namely a fall of 780 ft. over the Davis Strait and a rise of 730 ft. over the North Pacific (fig. 2). As is usual with large height increases in high latitudes, 700-mb. heights fell away to the south, and reductions up to 300 ft. from the preceding month (fig. 2) led to average heights 100 ft. below normal in the mean

trough west of Hawaii. As can be noted from the mean circulation (fig. 1) this trough was directly south of the mean ridge and was associated with the southern branch of the westerly flow.

The split in the westerlies is also evident from figure 3 which shows the mean axes of maximum west winds at 700 mb. for April 1962. The stronger northern branch proceeded into the southern Bering Sea before again dropping southward to join the southern branch in the eastern Pacific. Normally in April the westerlies blow across the Pacific in a well organized single maximum whose axis lies just about between the two branches which characterized the April circulation. In fact the normal location of the center of maximum speed in the mid-Pacific corresponds almost exactly to the region of slowest winds this month. The core of the blocking ridge averaged very warm for its latitude as evidenced by the extensive area of greater than normal thickness shown on figure 4. The central value of 190 ft. above normal (the largest value on the map) was situated just to the west of the corresponding 700-mb. anomaly maximum (fig. 1).

Downstream from the blocking region the two branches of the westerlies again joined in the confluent zone to the south of the Gulf of Alaska. Wind speeds increased to a maximum of 16 m.p.s., which is 8 m.p.s. above the normal for that location, and the axis of the flow returned to a path more in accord with normal (fig. 3). The position of the Bering Sea ridge favored a trough in the Gulf of Alaska which, though much weaker than the ridge (anomaly only  $-150$  ft.), was equally persistent. Although the northern portion of this trough was fairly constant, its extension equatorward was not, and its affiliation first with the subtropical trough west of Hawaii and then with the one over Lower California accounted for the only major reversal in the Nation's weather during the month.

Over North America the ridge in the West and trough in the East were near their normal location but stronger than normal. Consequently, the jet core (fig. 3) followed near its usual path but with somewhat larger amplitude. In addition, a weakly confluent flow prevailed over the States bordering the eastern Gulf of Mexico.

Partly as a result of this confluence, the westerlies increased again over the western Atlantic and reached

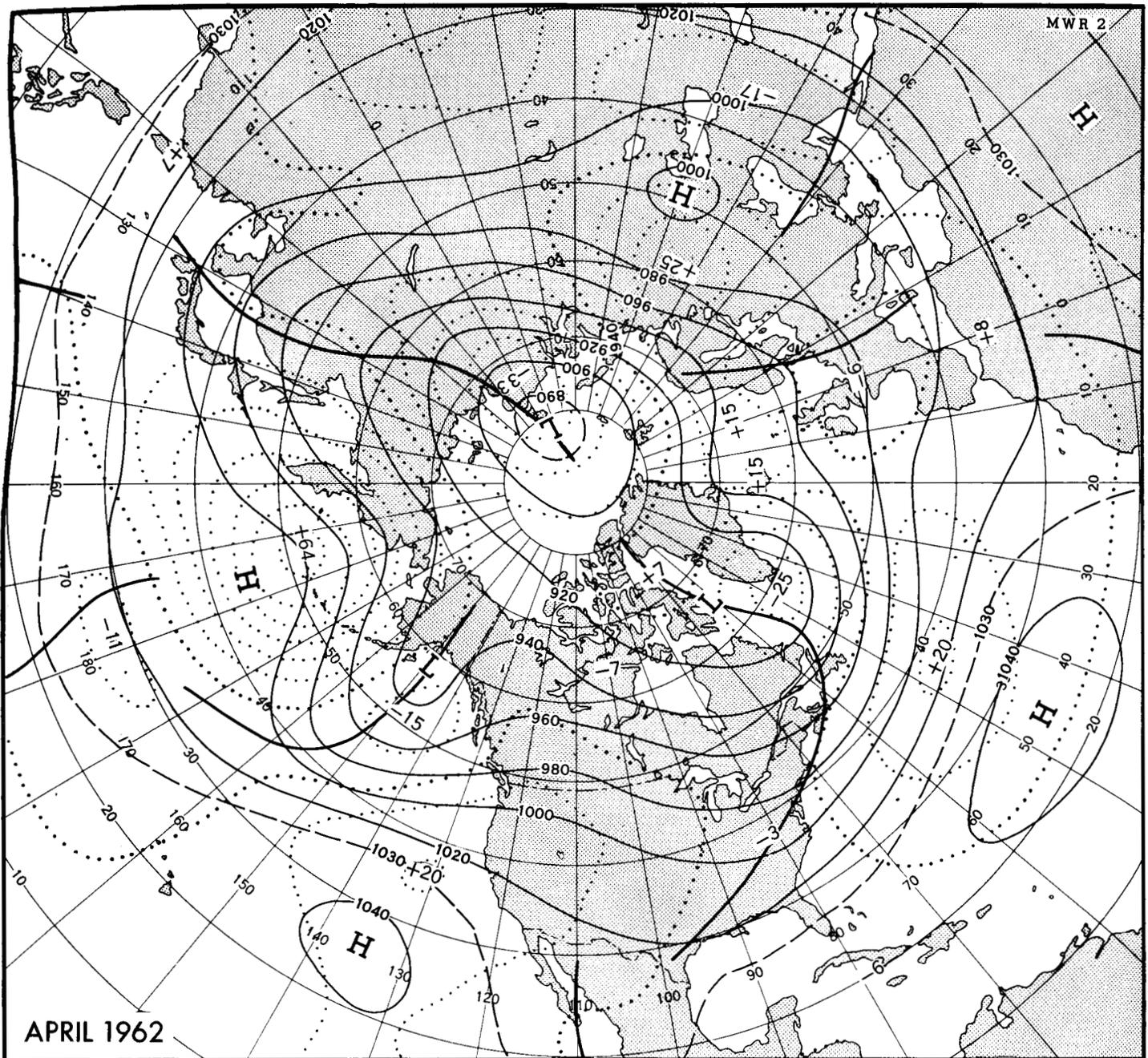


FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for April 1962. A blocking pattern dominated the central Pacific and the flow over North America featured a ridge in the West and trough in the East.

speeds up to 7 m.p.s. above normal in the area of fastest flow. However, the westerlies separated once again into two parts in the eastern Atlantic and assumed a diffluent nature over Europe. This tendency toward blocking was not discernible during the first portion of the month (fig. 5A) and did not become well entrenched until the last week (fig. 5B). Accordingly, the associated positive anomaly in northern Russia averaged only 250 ft. on the monthly mean chart (fig. 1), substantially less

vigorous than the Pacific anticyclone, but nevertheless effective in shunting the northern branch of the 700-mb. jet (fig. 3) well north of normal.

Reference to figure 2 will show that this fast zonal circulation in the Atlantic represents almost an exact reversal from the flow pattern of the previous month [1]. It appears that the increase in westerly momentum at middle latitudes in the Atlantic was balanced to some degree by the decrease in the Pacific.

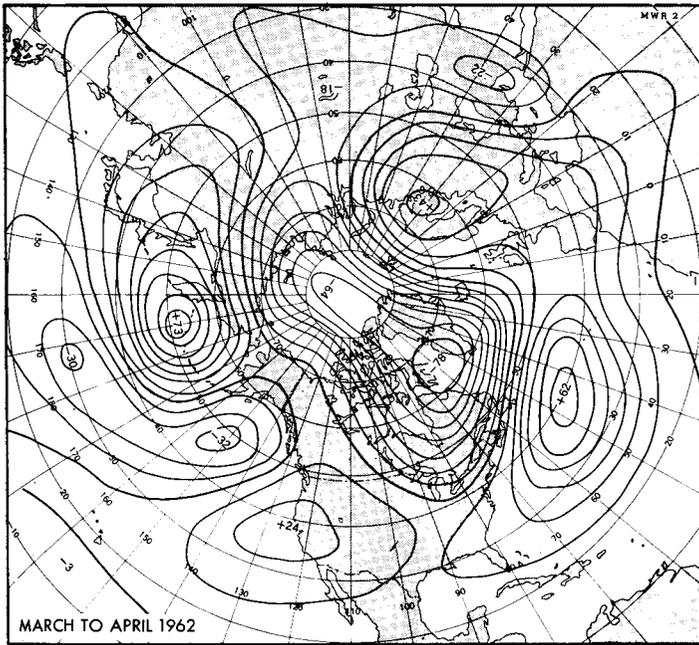


FIGURE 2.—Anomalous 700-mb. height change (tens of feet) between March and April 1962 with zero line heavier. The change in the seat of blocking from the Davis Strait in March to the central Pacific in April accounted for the largest changes (-780 ft. in the former and +730 ft. in the latter case) which occurred between the two months.

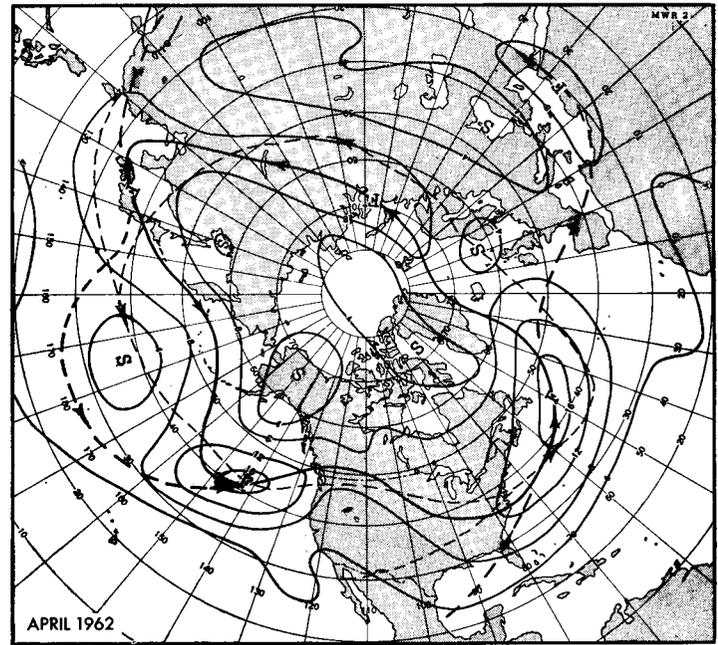


FIGURE 3.—Mean 700-mb. isotachs in meters per second for April 1962. The heavy solid arrows indicate primary, and the heavy dashed arrows secondary, axes of maximum winds. The light solid line shows the normal April axis. The westerlies were diffluent in both the western Pacific and eastern Atlantic. Over North America the axis of maximum winds was roughly in accord with the normal but of slightly larger amplitude.

### 3. TRANSITION WITHIN THE MONTH

#### A. FIVE-DAY MEAN PERIOD APRIL 10-14

To illustrate the principal evolution of the circulation during the month, two 5-day mean 700-mb. charts have been selected and are reproduced as figure 5. By the end of March (fig. 10A of [1]), there was little to suggest blocking in the central Pacific. The westerlies were very strong at middle latitudes, and 700-mb. height anomaly values were mainly negative in the north and positive in the south. Subsequently, however, a mean ridge moved eastward across Kamchatka, developing enroute, until by April 10-14 (fig. 5A) the situation was almost exactly the reverse with height anomalies strongly positive (+850 ft.) and the flow anticyclonic in the north, but with negative anomalies (-340 ft.) and cyclonic flow in the south. At the same time, the trough previously in the Bering Sea moved eastward and became well established from the Gulf of Alaska southward to the Hawaiian Islands. Downstream over North America, these changes were reflected in a resonant ridge in northwestern Canada and trough in the eastern United States. However, the flow over northern and particularly eastern Canada was further complicated by blocking as indicated by the closed mean High over Hudson Bay and its sizeable departure from normal of +500 ft. (fig. 5A). This blocking was a contributing factor to the abnormally deep trough to its south over the eastern United States.

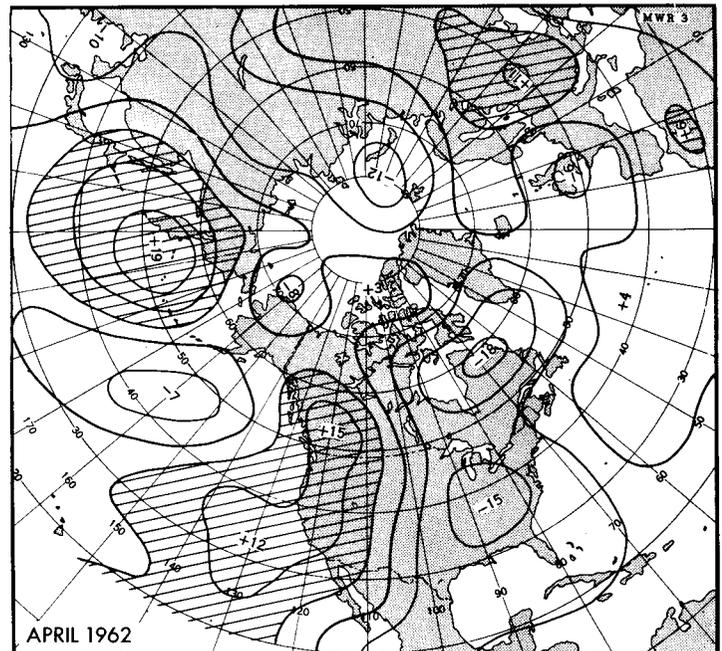


FIGURE 4.—Mean 1000-700-mb. thickness departure from normal (isopleth interval 50 ft.) for April 1962 with areas greater than +50 ft. cross hatched. In North America the western ridge was warm and the eastern trough cool. Also the blocking High in the Pacific was quite warm for its latitude.

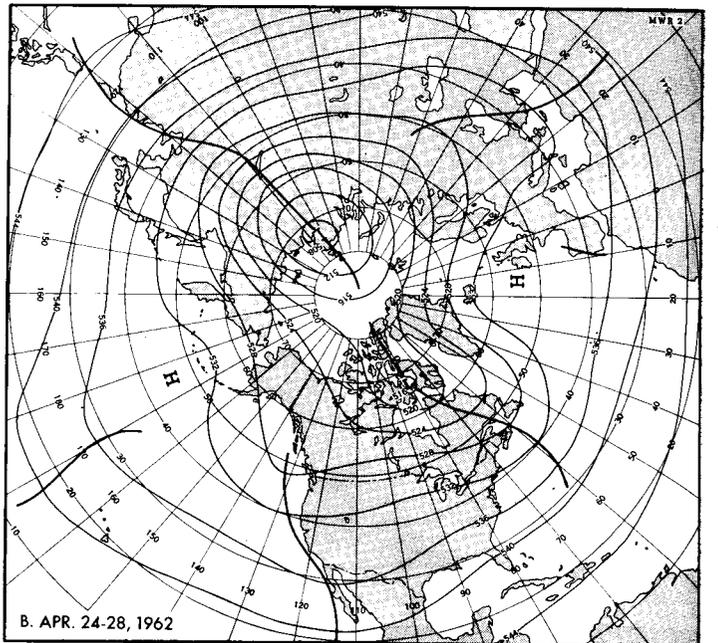
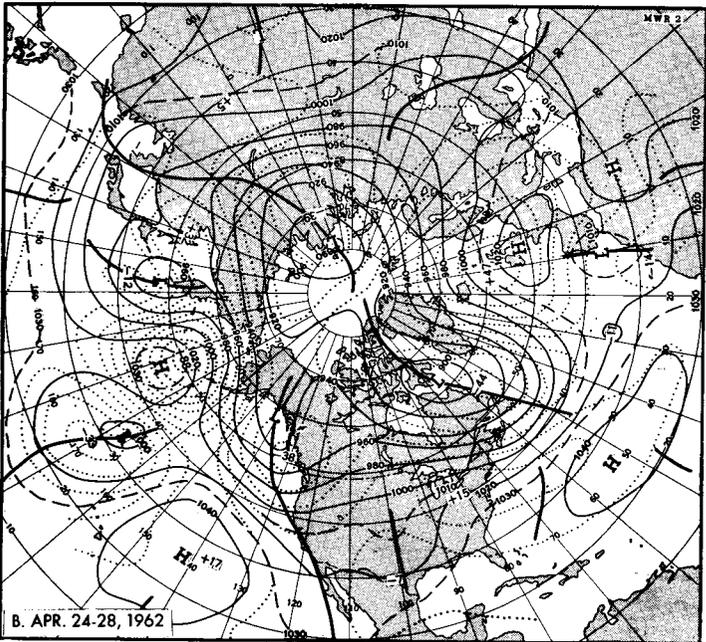
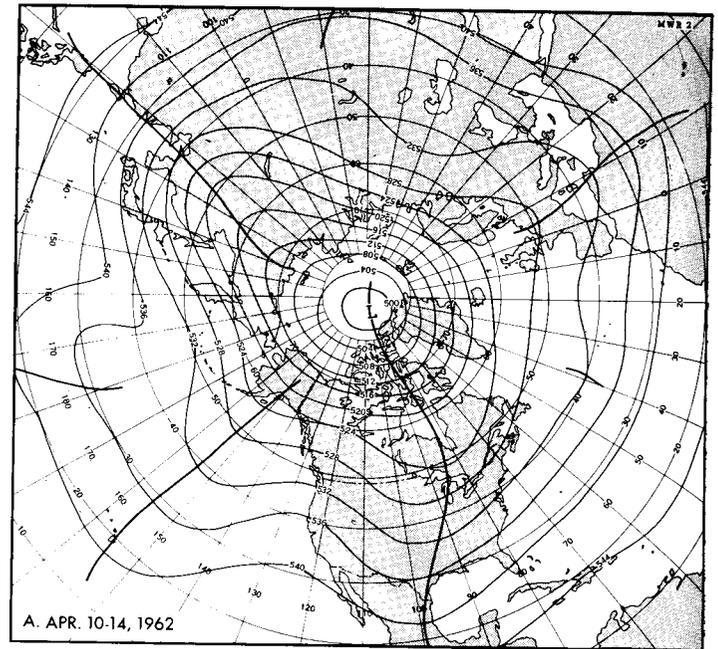
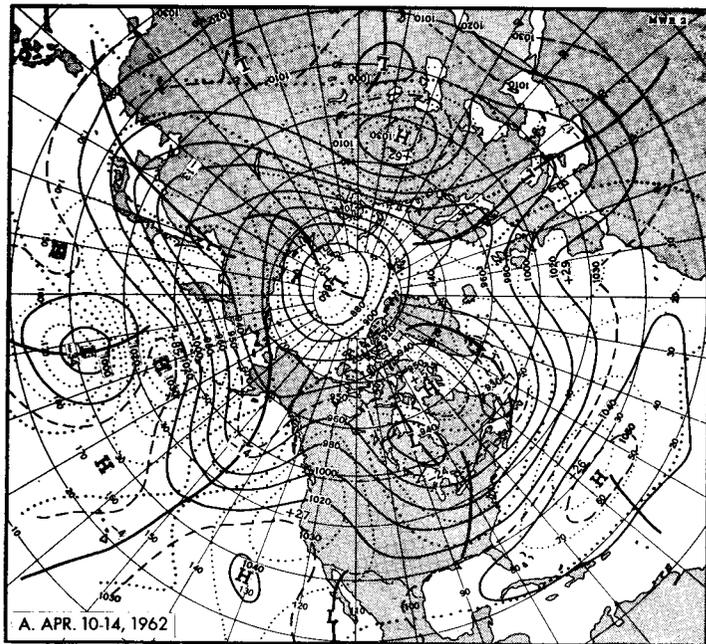


FIGURE 5.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for (A) April 10–14, and (B) April 24–28, 1962. The blocking anticyclone near the Aleutians remained nearly constant in position and intensity in each period but the cut-off depression to its south moved eastward late in the month resulting in progression of low-latitude features and a complete change of phase over the United States.

FIGURE 6.—Mean 100-mb. contours in hundreds of feet with a contour interval of 400 ft. for (A) April 10–14 and (B) April 24–28, 1962. In the Pacific a blocking pattern was still in evidence on each map as high as the 100-mb. level.

In order to study the vertical extent of the circulation features discussed above, a 5-day mean 100-mb. chart was prepared and is included as figure 6A. A number of authors have commented on the coupling between the flow at 100 mb. and that at lower levels. Julian, Krawitz, and Panofsky [2], for example, found a close correlation between the heights at 500 mb. and 100 mb. The cor-

relations were a function of the scale of the oscillation concerned, with the larger-scale tropospheric features having the best chance of being preserved at the upper level. This applies particularly to the polar Low which is well known to be a feature of the stratospheric circulation, especially in winter. These characteristics are well illustrated by the flow during this period. It is striking

that the polar vortex, though also well developed at 700 mb. (anomaly  $-530$  ft.), assumed an almost overwhelming dominance at 100 mb. Most of the other large-scale features were also reflected at 100 mb. though with a westward displacement of  $5^{\circ}$  to  $10^{\circ}$  of longitude. However, except for the intense polar depression, all closed centers at 700 mb. disappeared at the higher level. It is of interest, nonetheless, that the split in the westerlies in the Pacific was still very real at 100 mb. Apparently blocking systems of this magnitude extend at least to the 100-mb. level.

#### B. FIVE-DAY MEAN PERIOD APRIL 24-28

This general pattern represented by figure 5A proved remarkably stable during the middle two weeks of the month. However, by the last week some extensive changes took place. Though the blocking ridge in the Pacific changed relatively little either in location or intensity, the cut-off depression to its south moved eastward south of the blocking High and attempted to amalgamate with the Gulf of Alaska trough. This connection was never accomplished, but rather a markedly confluent pattern ensued which in effect forced the Gulf of Alaska trough eastward to join with the trough which had previously persistently occupied Lower California. Thus a full-latitude trough of negative tilt and below normal 700-mb. height appeared off the west coast of North America for the first time during the month and introduced cooler and wetter weather. On the other hand, the trough which had previously dominated the East gave way to ridging and a record-breaking hot spell. According to Beebe [3] this pattern of figure 5B, with a trough in the southern Plains States and a ridge in the Southeast is an ideal producer of tornadoes, and this period was no exception. Numerous tornadoes were reported in the last few days of the month, mostly in eastern Texas and Oklahoma.

The circulation evolution over the Atlantic during this period is also of interest. Corresponding to the progression of North American features, the trough initially near the Appalachians on April 10-14 (fig. 5A) also moved eastward into the Atlantic (fig. 5B). It deepened considerably, particularly in the southern Davis Strait where a cut-off Low appeared, and, since it was blocked in the north by the warm ridge east of Greenland, the trough acquired a negative tilt. The closed High associated with this new blocking surge overlay the British Isles during this interval and, although the central contour value differed from that of its Pacific counterpart only by about 100 ft., its anomaly was much weaker, only 470 ft. compared to 880 ft. for the Pacific anticyclone.

The evolution of the British anticyclone can be traced to the large High just north of the Caspian Sea during the 5-day period April 10-14 (fig. 5A). This system moved irregularly but with an overall retrograde tendency and by the last week of the month was situated over the British Isles (fig. 5B). At one stage, when the anomaly center was over central Scandinavia on the 5-day mean

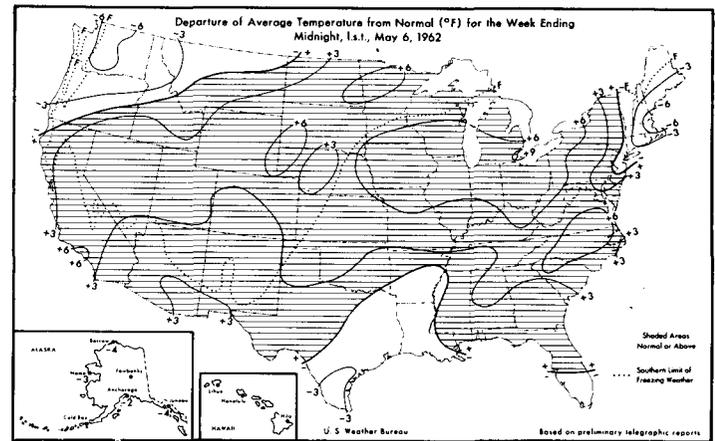


FIGURE 7.—Departure of average temperature from normal ( $^{\circ}$  F.) for April 1962. Except for a small region from the southern Great Lakes eastward, temperatures averaged warm for the western and cool for the eastern half of the country.

map for April 14-18 (not shown), its value exceeded 700 ft. above normal.

At 100 mb. the polar depression, so prominent previously (fig. 6A), divided into two centers by April 24-28 (fig. 6B) at subpolar latitudes, each an image of its counterpart at 700 mb. The stronger center lay over the northern Siberian coast and the weaker over northeastern Canada. Again most major systems at 700 mb. were also discernible at 100 mb. and most closed systems were not observed at the upper level. The diffluent flow at 700 mb. in both the Pacific and the Atlantic, however, was preserved at 100 mb., again suggesting that such large warm blocking systems in the troposphere also extend well into the stratosphere. The westward displacement of troughs and ridges from 700 to 100 mb. also prevailed in most instances during this period, though it is noteworthy that the blocking ridge in the Pacific, the cut-off Hawaiian trough, and the trough along the west coast of North America all represent nearly vertical systems.

#### 4. TEMPERATURE

The temperature pattern for April 1962 (fig. 7) was one of warm conditions in the West and mostly cool in the East, the one exception being an area of above normal temperatures extending from the lower Great Lakes eastward to the Atlantic coast. This warm pocket was in large measure the result of an unusually hot spell the last week of the month. The warmth in the West was a welcome change from the cold regime of March, and a large area in the Southwest experienced a warming of four temperature classes, from much below in March to much above normal in April. The cool weather in the Southeast on the other hand, was a continuation of the March pattern.

The April temperature regime became established early in the month and persisted in its general aspects

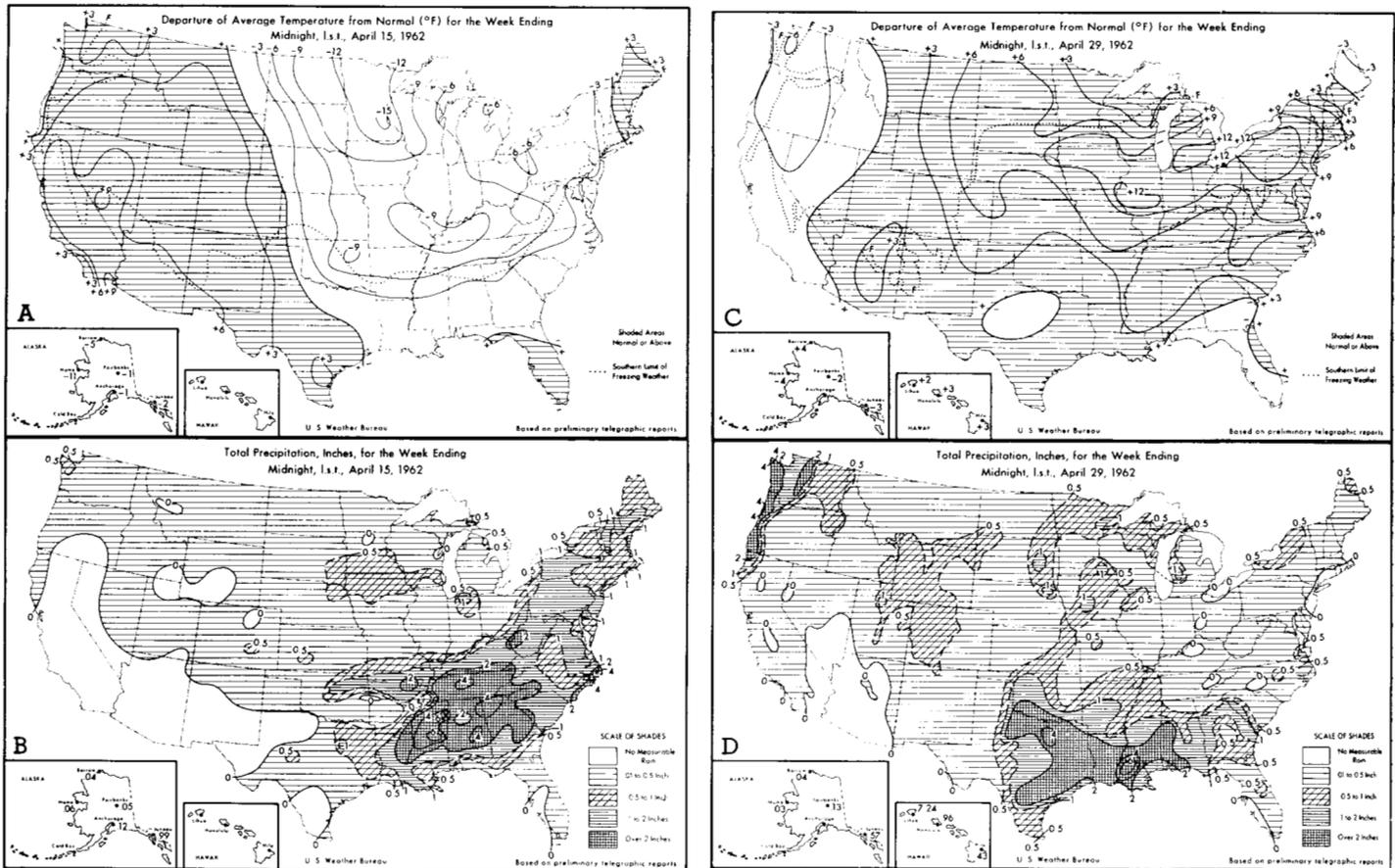


FIGURE 8.—Departure of average temperature from normal ( $^{\circ}$  F.) for week ending midnight (A) April 15, 1962, and (C) April 29, 1962, and total precipitation in inches for week ending midnight (B) April 15, 1962, and (D) April 29, 1962. The temperature departure from normal averaged mostly warm in the West and cool in the East but altered significantly the last week as the warm air spread eastward to the Atlantic Seaboard and was replaced in the West by cooler conditions. Rainfall during the first portion was generally adequate in the eastern third of the Nation and heavy in the Southeast, but was very light or nonexistent in the West. However frontal activity the final week of the month brought increased shower activity to the West and particularly the Far Northwest. (From [4]).

for three weeks. Largest anomalies, however, occurred during the week ending April 15 (fig. 8A). Coolest conditions during this interval prevailed over Minnesota where temperatures averaged  $12^{\circ}$  to  $15^{\circ}$  F. cooler than normal. The mean flow into this area (fig. 5A) followed a northerly trajectory from over the snow fields of the Canadian prairies.

Temperatures in the West during this period rose to new highs for the year with readings over  $90^{\circ}$  F. in the interior of California and in the Southwest desert region. At Yuma, for example, the maxima exceeded  $100^{\circ}$  F. from the 12th through the 15th and reached  $106^{\circ}$  F. on Friday the 13th. During the following week the pattern remained similar except that the warm air pushed eastward to include the Plains States from the Dakotas to Texas. Denver reported a high of  $83^{\circ}$  F. on the 20th, the highest ever recorded on that date.

As previously mentioned, the anticyclogenesis in the East during the last week of the month effectively spread

the warm air rapidly eastward to the Atlantic coast (fig. 8C). Largest positive temperature anomalies for this 7-day period occurred in the States bordering the southern Great Lakes. Binghamton, N.Y., and Detroit, Mich., each averaged  $14^{\circ}$  F. warmer than normal. This hot spell produced new record high temperatures for April 27 at several locations, the most notable of which were:  $94^{\circ}$  F. at Binghamton, N.Y.,  $91^{\circ}$  F. at Boston, Mass., and Concord, N.H., and  $83^{\circ}$  F. at Buffalo, N.Y. Although each of the previous three weeks averaged cooler than normal over most of the area around the southern Great Lakes, it is of interest that the warmth of this last week was sufficiently pronounced to offset the previous period and resulted in a warmer than normal pattern for the month as a whole (fig. 7).

In the Far West, however, the trough development along the west coast (fig. 5B) previously described, introduced a much cooler regime and brought an end to a rather prolonged period of warm weather.

## 5. PRECIPITATION

For the most part, precipitation was subnormal over a large portion of the United States during April 1962 and much of the Southwest received no rain at all (fig. 9). The only regions where rainfall totals substantially exceeded the normal were the Gulf States and the coastal strip of the Pacific Northwest. Total accumulations ranged from 4 to 10 inches in each area and exceeded 150 percent of normal in the regions of heaviest precipitation. The Appalachian and Atlantic Coastal States also received adequate moisture with totals ranging from 2 to 6 inches, while showers in the Rockies were sufficient to account for near normal amounts. Reference to figure 1 suggests that the rainfall in the Gulf States and the East occurred in conjunction with the mean trough in the eastern States, while the precipitation in the Northwest was associated with abnormally strong on-shore flow.

Otherwise very dry weather prevailed over the Nation, with some areas approaching drought conditions by month's end. At Las Vegas, Nev., no rain fell in April, the first time in the period of record. Other stations in the Far Southwest also reported no rain, and the dryness which was also characteristic of March was prolonged throughout April. The arid conditions in the Southwest occurred under the mean ridge with anticyclonic flow and above normal heights. The northern Plains States were also very dry as much of the area received less than 50 percent of normal rainfall. The driest April in 50 years was recorded at such widely separated points as Dayton, Ohio, Burlington, Iowa, Topeka, Kans., and Billings, Mont., and in some areas winter wheat was beginning to show the effects of soil moisture deficiencies. This dry weather was related to the ridge over the West and the drying effects of downslope flow east of the Rockies. It is of interest, in this connection, that the axis of maximum westerly flow (fig. 3) coincided closely with the region of driest weather.

The precipitation distribution for the first three weeks of the month roughly followed the pattern of figure 8B. Dry conditions characterized the West under the mean ridge and wet conditions the East under the mean trough. Heaviest precipitation occurred in the States bordering the central Gulf as trailing fronts set off thunderstorms upon encountering moisture-laden Gulf air. Hail accompanied a number of these storms and hailstones of "golf to baseball" size were reported in northern Louisiana and central Mississippi.

As the circulation pattern altered during the last week and the trough developed along the west coast (fig. 5B)

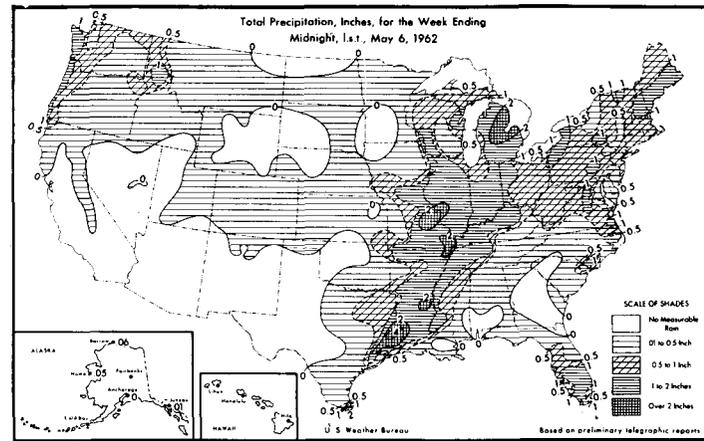


FIGURE 9.—Total precipitation in inches for April 1962. Largest amounts accumulated in the Southeast and the Pacific Northwest. Driest regions occurred in the Southwest and the northern Plains. (From [4].)

the first substantial rains of the month fell in the Northwest and, though amounts were low, shower activity also occurred over most of California, the northern Great Basin, and particularly the central Rockies. Accumulations of 2 inches or more were general along the coastal strip of Washington and Oregon with some reports of over 4 inches.

The trough in the southern Plains States (fig. 5B), was also an effective rainfall producer during the last week of the month and the central Gulf States again experienced heavy downpours, mostly as showers and thunderstorms along frontal systems. One such storm at Baton Rouge, La., produced nearly 7 inches of rain accompanied by 60 m.p.h. winds and minor flooding. Similarly, locally heavy amounts occurred in eastern Texas. Shamrock, for example, totaled 6.05 inches and Dallas 4.92 inches during this week.

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