THE WEATHER AND CIRCULATION OF JUNE 1964

Reversal of a Long-Standing Trend Over the Pacific

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1. INTRODUCTION

An important feature of the 700-mb. circulation during June was the return to more nearly normal height values in the mid-Pacific from a persistently anomalous condition. Despite the radically changing circulation over the Pacific, however, June's temperature anomaly pattern over the United States was quite similar to that of May. In the United States most newsworthy weather items stemmed from the precipitation distribution which brought floods to Montana and drought to parts of the Mid-West and East.

2. MONTHLY CIRCULATION

The greatest readjustment of the large-scale circulation in the Northern Hemisphere from May to June occurred in the mid-Pacific area (fig. 1). Monthly mean 700-mb. heights had been above normal over the eastern Pacific since February and over much of the Pacific since mid-March. By May heights had reached record levels [1] with the Pacific anticyclone at 700 mb. displaced northward to its normal midsummer location. Thus, the large Pacific height fall from May to June represented a sharp return toward normal from an extremely anomalous circulation pattern which had been developing over a period of several months. A comparison of the 700-mb. height anomaly change from May to June (fig. 1) with the departure from normal of the monthly mean 700-mb. height during May 1964 [1] reveals a similar, though less striking, change toward normal of most circulation features.

The framework within which these height changes took place was, to a large extent, one of retrogression of major circulation features at middle and high latitudes. Intermediate mean maps (not shown) reveal that the mid-Pacific trough in June (fig. 2) was essentially the result of retrogression of a May trough along the western coast of North America. Remnants of the May blocking ridge in mid-Pacific built northward in June and combined with a westward-moving ridge from the high latitudes of North America to produce a strong blocking ridge centered over northeastern Siberia.

Over North America circulation changes from May to June were generally less dramatic. At high latitudes, retrogression of the trough from Davis Strait to the continent was consistent with upstream retrogression. To the south, May to June changes were minor as slightly below normal 700-mb. heights were maintained in the western United States and a moderately strong ridge continued over the East (fig. 3). Relative motion of of high- and low-latitude circulation features in North America resulted in a strong confluence area near the Great Lakes (fig. 2) which was associated with a well-developed wind speed maximum.

The Atlantic ridge, which was quite weak in May, built northward in June and was accompanied by deepening of the trough south of Great Britain and a strengthening of the western European ridge. The eastern European trough of May intensified as it moved eastward and joined the retrograding high-latitude trough in mid-Asia.

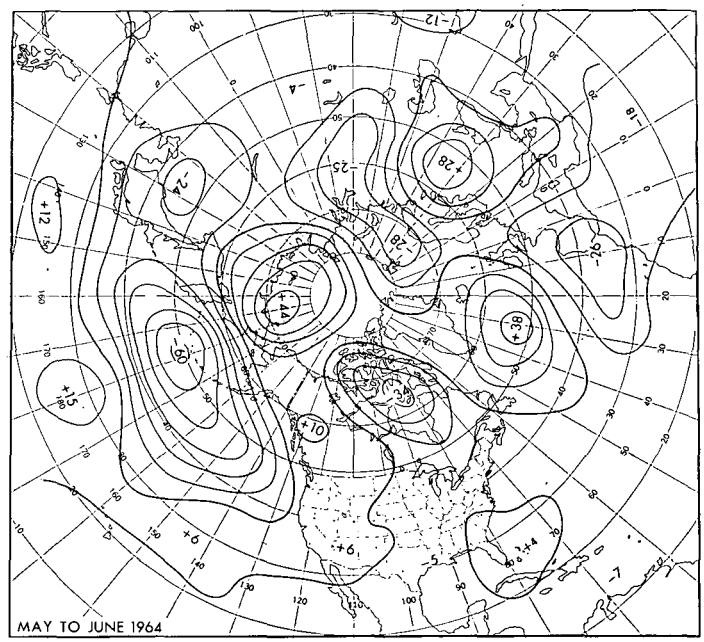

FIGURE 1.—Change of mean 700-mb. height anomaly from May to June 1964, drawn at intervals of 100 ft. with centers in tens of feet and zero isopleth heavy.

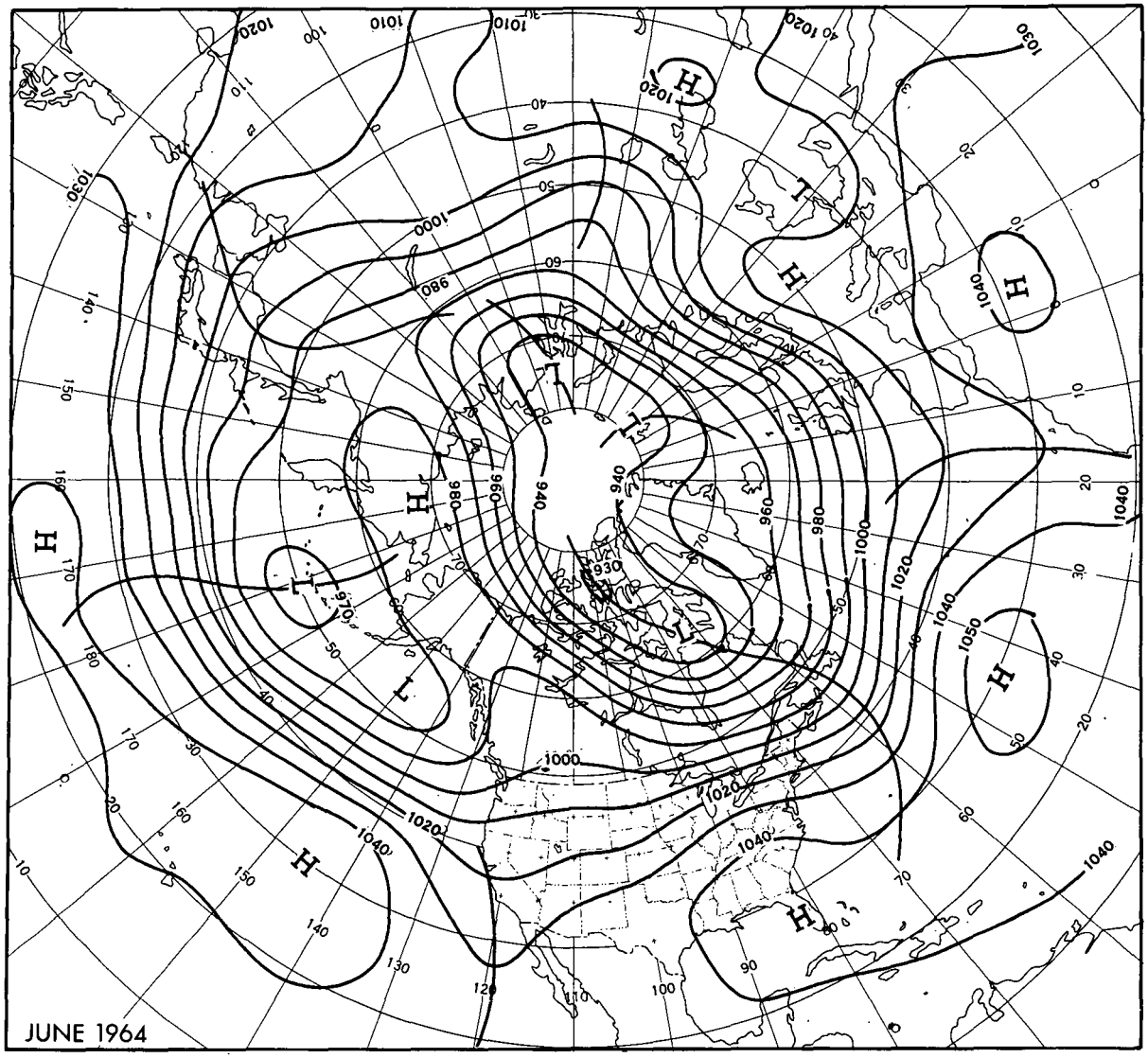

FIGURE 2.—Mean 700-mb. contours (tens of feet) drawn at intervals of 100 ft. for June 1964.

Reference to half-monthly mean 700-mb. maps (figs. 4A and 5A) reveals that in the Pacific, site of the May to June circulation upheaval, all of the striking height fall took place during the first half-month when May's blocking ridge was replaced by a deep Low with heights well below normal. Indeed, during the latter half of the month strong height rises were evident and 700-mb. heights again rose above normal over much of the Pacific. Thus, there is a suggestion that the circulation-molding factors which had fostered the persistent mid-Pacific height anomaly for several months were still effective during the latter half of June. Typhoons during the month were concentrated in this latter period when both Winnie and Alice were observed east of the Philippines. The former, striking Manila on June 29, was of major proportions.

Further examination of the half-monthly circulation patterns confirms that, over most of the Northern Hemi-

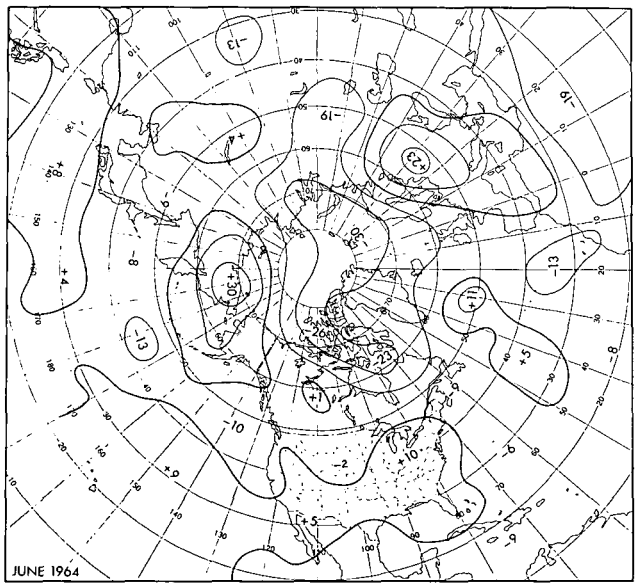

FIGURE 3.—Mean 700-mb. height departures from normal for June 1964 drawn at intervals of 100 ft. with centers in tens of feet and zero isopleth heavy.

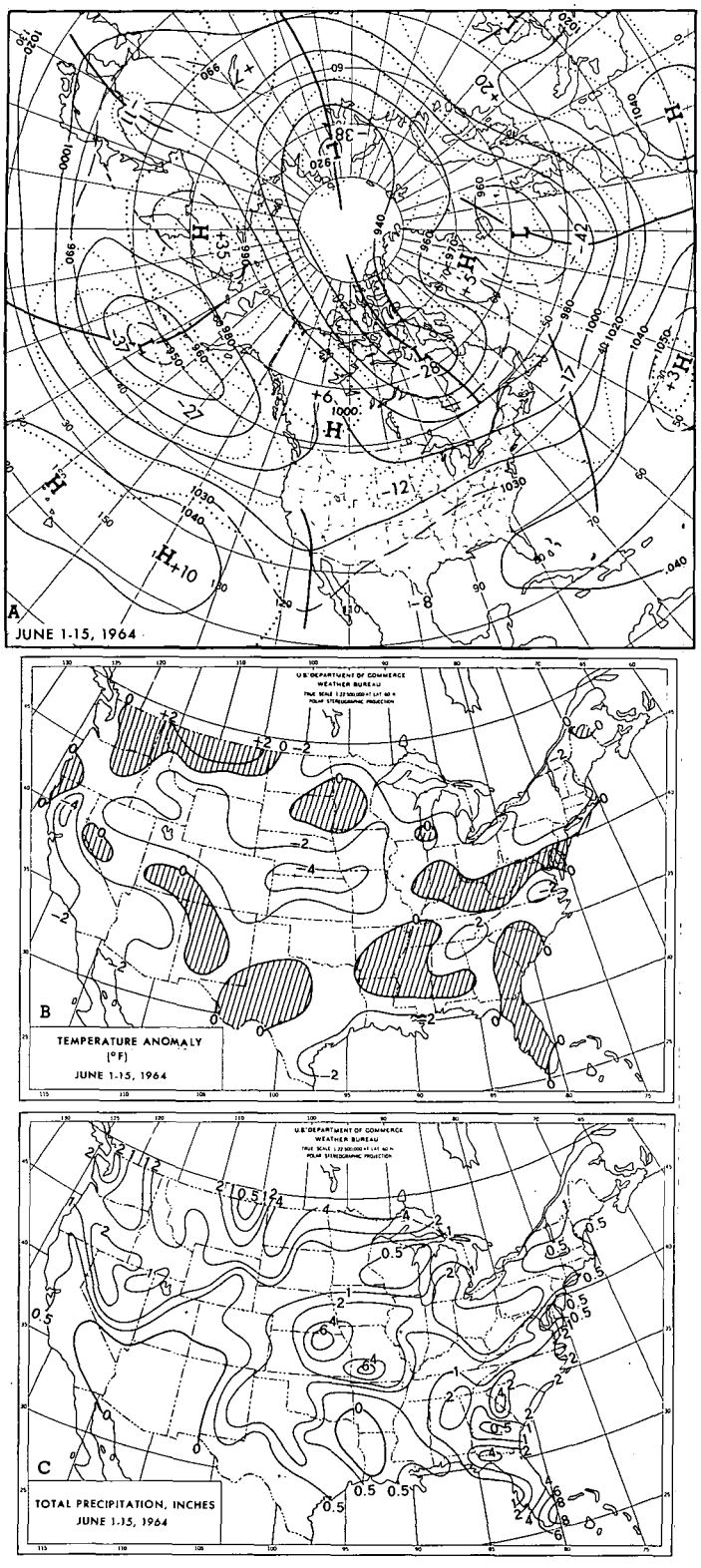

FIGURE 4.—(A) Mean 700-mb. height and departure from normal (both in tens of feet); (B) Departure of average temperature from normal (°F); and (C) Total precipitation (inches) for June 1–15, 1964.

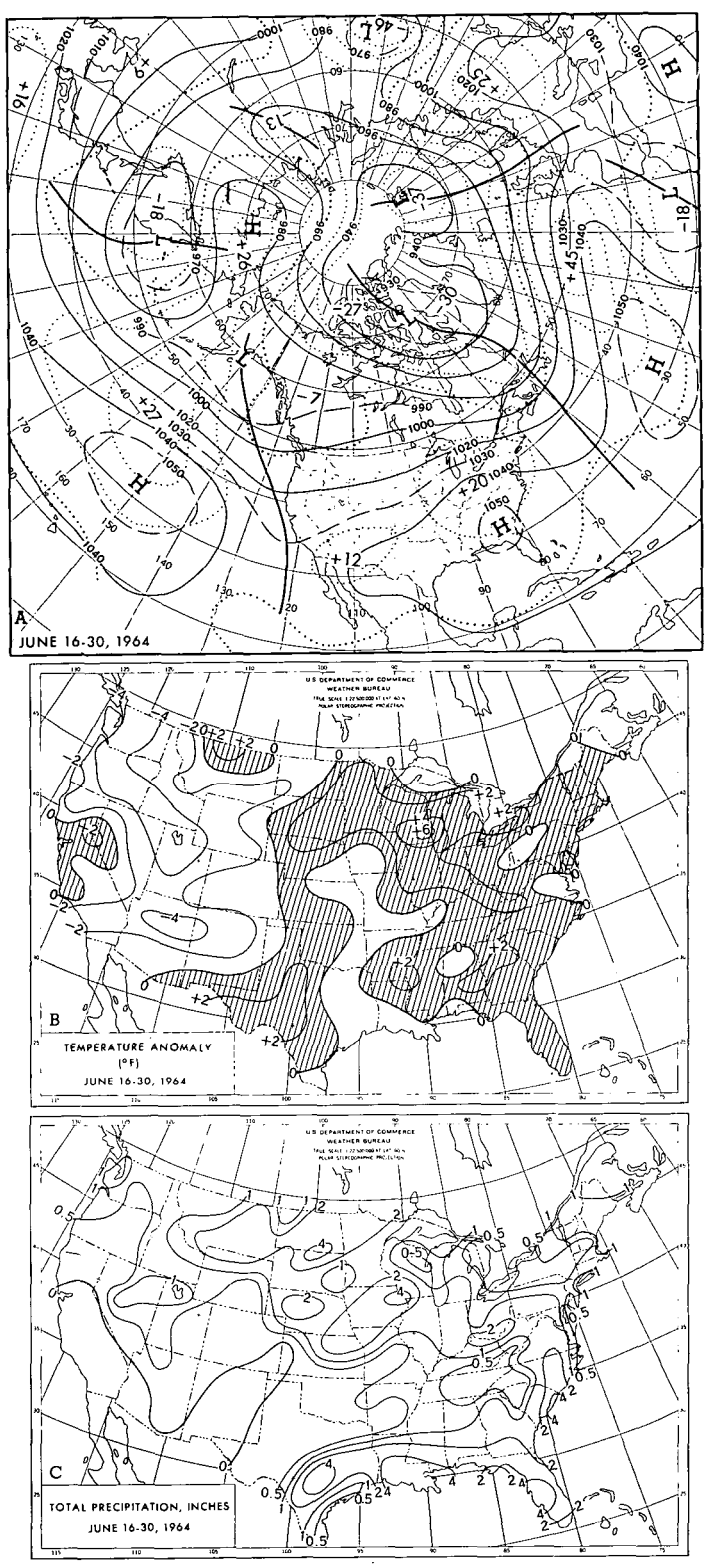

FIGURE 5.—(A) Mean 700-mb. height and departure from normal (both in tens of feet); (B) Departure of average temperature from normal (°F); and (C) Total precipitation (inches) for June 16–30, 1964.

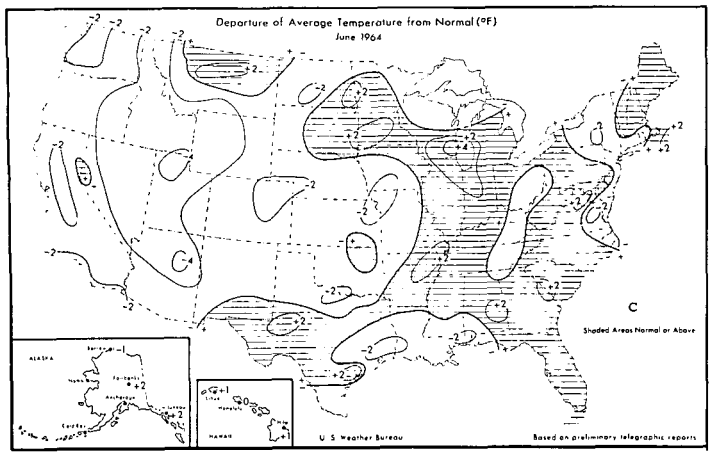

FIGURE 6.—Departure of average surface temperature from normal (°F) for June 1964 (from [2]).

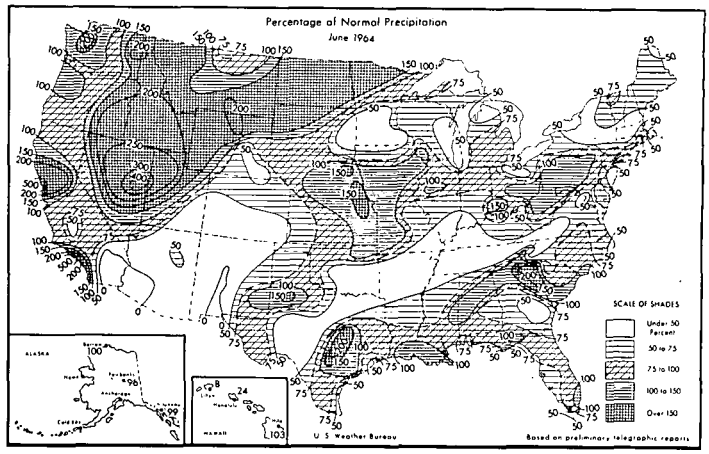

FIGURE 7.—Percentage of normal precipitation for June 1964 (from [2]).

sphere, this was a month encompassing widely varying circulation regimes. Over the Atlantic, for example, the vigorous trough and below normal heights of early June gave way to a strong ridge with heights well above normal in late June. Relatively stable features, on the other hand, included the European ridge, the closed High over northeastern Siberia, and the trough in northeastern Canada.

3. TEMPERATURE

Depressed and accelerated Pacific westerlies with below normal 700-mb. heights over western United States (figs. 2 and 3) resulted in the influx of cool Pacific air well into the United States during June (fig. 6). Despite wide differences in circulation during the two halves of June, both half-monthly patterns were accompanied by cool weather in the West, as shown in figures 4B and 5B. During the first half of June both circulation and temperature anomalies were similar to those of the full month. During the latter half of the month ocean-to-continent transport of air remained above normal, as indicated by the height anomaly pattern, but eastward penetration of the cool air was limited by the strong ridge over the eastern United States.

Cool weather in the West during June was a continuation of cool conditions prevailing in that area since February 1964. Prior to June, this persistent temperature anomaly was due, in large part, to the persistently above normal mid-troposphere heights over the eastern Pacific which maintained a flow of relatively cool air into the West.

In the eastern half of the Nation anticyclonic conditions with above normal 700-mb. heights resulted in generally above-normal temperatures (fig. 6). However, divergent circulation regimes during the month resulted in a somewhat chaotic pattern. During the first half of June (figs. 4A and 4B), below normal heights in northern portions were accompanied by below normal temperatures. To the south, where heights were only slightly below normal, temperature departures from normal were also small. In the latter half of June (figs. 5A and 5B), with above normal heights predominating, temperatures were above normal in most areas.

4. PRECIPITATION

June was a month of great precipitation contrasts in the United States (fig. 7). In the West, a succession of upper-level troughs entered the continent bringing unusually heavy precipitation to a large area from the Great Basin through the northern Great Plains. Over much of this area June was the wettest in many years, and at Wendover, Utah, it was the wettest month of record (since 1911).

In general much of the precipitation in the West was observed during the first half-month when blocking was well established in western portions of the continent (figs. 4A and 4C). During this period heavy rains, augmented by snowmelt runoff over western and central Montana, brought record stages to tributaries of the upper Missouri River and to the upper Flathead River in Montana. Flooding was severe on the latter river near Kalispell, Mont., and also on the Sun River at Great Falls, Mont.

Throughout much of the month the upper-level troughs and accompanying surface systems moved eastward across the Nation giving a belt of precipitation from the Central Plains to Pennsylvania. As was the case with precipitation in the West, this mid-continent precipitation was more favored by the circulation during the first half of the month when a channel of below-normal heights extended from northern California to Nebraska. A notable feature of the precipitation from western Texas to Pennsylvania was that it occurred mainly south of and parallel to the axis of the monthly mean wind speed

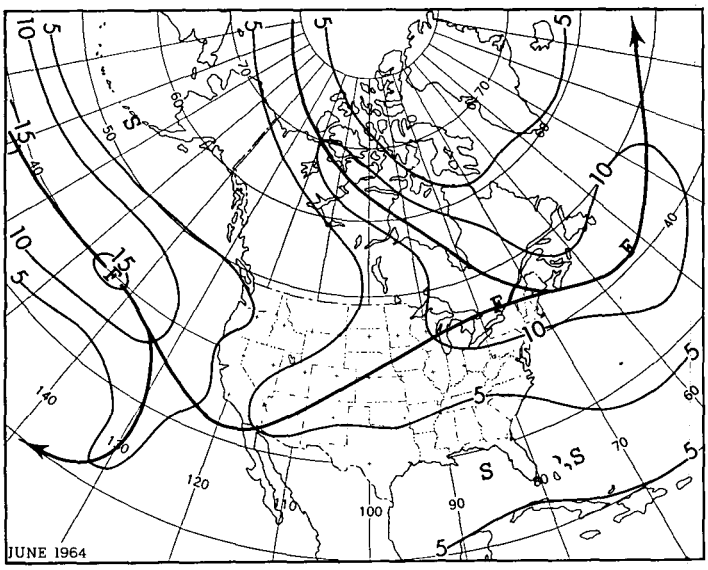

FIGURE 8.—Mean isotachs (meters per second) at 700 mb. for June 1964. Heavy solid arrows indicate principal axes of maximum wind speed.

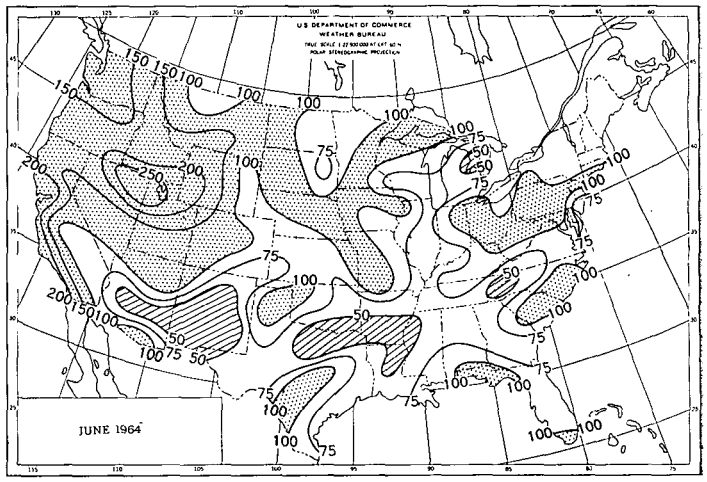

FIGURE 9.—Percentage of normal number of days with 0.01 inch or more precipitation for June 1964.

maximum at 700 mb. (fig. 8) and in the accelerating phase of this current. To the extent that the 700-mb. mean flow depicted the salient flow characteristics at jet stream level, this precipitation fell in the southwestern quadrant of a jet stream maximum which was centered in the confluent zone east of the Great Lakes. Qualitatively, this portion of the jet stream can be identified as an area where relative vorticity in the upper troposphere decreases downstream, a condition conducive to cloudiness and precipitation in daily circulation patterns [3].

Precipitation was well below normal in a narrow strip stretching from central Texas through the Tennessee Valley and also in much of the Northeast (fig. 7) where June was the driest in many years. It was of record dryness at Asheville, N.C., Lynchburg, Va., and Concord, N.H. Following a dry May, this represented a serious problem to many areas. The combined May-June period was driest of record at Wilmington, Del., Philadelphia, Pa., Hartford, Conn., and Albany and Binghamton, N.Y. At Boston, Mass., June was the fourth consecutive month with below normal precipitation. In the East the dry regime was associated with an amplified ridge over the Appalachians at 700 mb. coupled with a deeper-than-normal trough to the east (figs. 2 and 3). This resulted in northerly anomalous wind components over the drought area, a pattern unfavorable for precipitation. The eastern ridge reached its greatest strength during the last half of June (fig. 5A) but even in early June (fig. 4A) northwesterly anomalous wind components prevailed over the dry coastal area.

The dry zone from central Texas to western Virginia paralleled the 700-mb. reflection of the mean jet stream, discussed earlier, and was located approximately 500–600 n. mi. to the southeast. This dry strip possibly represents an area of mean descending motion compensating for the upward motion just south of the jet stream discussed in connection with the observed precipitation in that area.

Precipitation in the extreme Southeast occurred on a few days early in the month when westerly troughs aloft affected that area and on several days late in the month when a deep layer of easterlies overlay the region.

Percentage of normal number of days with 0.01 inch or more precipitation is shown for the month of June in figure 9. Comparison with figure 7 reveals a fair relation between percentage of normal precipitation and percentage of normal number of days with precipitation. However, in areas of heavy rainfall such as the Great Basin and the Central Plains the former appears to be consistently higher. Thus it appears that the average precipitation on days with precipitation in these areas was greater than normal. For this month over the entire Nation (excluding areas where there are normally less than 5 days with precipitation during June) the two variables show a 70 percent correlation. It is worthy of note, also, that the pattern of percentage of normal number of days with precipitation exhibits about the same scale of variations at that of percentage of normal precipitation.

REFERENCES

1. R. A. Green, "The Weather and Circulation of May 1964—Large Weekly Variations," *Monthly Weather Review*, vol. 92, No. 7, Aug. 1964, pp. 374–380.
2. U.S. Weather Bureau, *Weekly Weather and Crop Bulletin, National Summary*, vol. LI, No. 27, July 6, 1964.
3. H. Riehl, K. S. Norquest, and A. L. Suggs, "A Quantitative Method for the Prediction of Rainfall Patterns," *Journal of Meteorology*, vol. 9, No. 5, Oct. 1952, pp. 291–298.