THE WEATHER AND CIRCULATION OF JUNE 1966

A Month With Variable Weather and Several Extremes

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1. MEAN CIRCULATION AND HIGHLIGHTS

The mean 700-mb. circulation at high latitudes for June (figs. 1 and 2) was characterized by an intense polar vortex and two areas of high-latitude blocking, one over northeastern Siberia and the other over Scandinavia. These areas of above-normal height experienced warm and generally dry weather. Below normal heights south of Iceland and the Aleutians surmounting stronger than normal subtropical Highs led to frequent storminess over the oceans. The monthly mean 700-mb. wind speed was greater than normal across the Pacific from the coast of China to Oregon, reaching 14 m.p.s. above normal near the 180° meridian (fig. 1). The monthly mean thickness gradient across the central Pacific (not shown) was also considerably above normal.

Below normal heights over the southeastern United States, the Gulf of Mexico, and the Caribbean Sea were associated with frequent showers which produced a record June total of 31.53 in. at Swan Island and gave birth to two tropical disturbances, the first of which became Alma, the earliest hurricane on record to cross the United States coastline. The cloudy and rainy conditions accompanying the tropical activity, following a record-breaking cold spell the first 2 days of the month, produced monthly mean temperatures as much as 6° F. below normal in the Southeast (fig. 4).

The monthly mean 700-mb. circulation changed markedly from May [1], especially at middle and high latitudes of the western half of the Northern Hemisphere. The polar vortex remained stronger than normal, but shifted toward the North American side of the Arctic Ocean. As a result the departure of 700-mb. height from the monthly normal was 380 ft. lower over Baffin Island in June than in May (fig. 3), when blocking had prevailed in that area. At the same time, height departures decreased as much as 500 ft. from May to June over the central Pacific, while blocking increased over Alaska and eastern Siberia. Over the United States, heights fell with respect to normal over the West while rising strongly in the Great Lakes area.

2. TEMPERATURE AND PRECIPITATION

As a result of these circulation changes, temperatures increased rapidly from the northern Mississippi Valley to the mid-Atlantic coast, with greatest departures in Minnesota and Pennsylvania (fig. 4). Daily maximum temperature records were set at Harrisburg, Pa., on 3 days toward the end of the month, and at Newark, N.J., twice. The weather cooled relative to normal in the Pacific Northwest and the Rockies, although it was still warmer than normal over the Southwest and the Plateau. Lower than normal temperatures, a feature of the past several months, persisted in the Southeast and along the Gulf Coast. Several cities, such as Macon and Savannah, Ga., and Brownsville, Tex., reported the coldest June of record, while Charleston, S.C., had its coldest June since 1884.

Precipitation was generally deficient over the eastern half of the country (fig. 5) leading to fears of a reintensification of the Northeast drought after near-normal precipitation during the spring had alleviated dry conditions. Huntington, Parkersburg, and Charleston, W. Va., and Avoca, Pa., had the driest June of record, while Trenton, N.J., and Elkins, W. Va., reported their second driest. The 0.07-in. rainfall on the 16th at Harrisburg, Pa., was the only measurable rain the whole month, a new record for June dryness.

An anomalous component of flow from the south in the middle of the country (fig. 2) was associated with a belt of above normal rainfall from southern Wyoming to eastern Iowa. To the south of this area, however, drought conditions appeared in some sections. Concordia, Kans., reported the driest first half-year of record, with only 6.90 in. of rain. Parts of California, Oregon, and Nevada were also experiencing a lengthening dry spell.

Although the departure from normal of the monthly mean 700-mb. height (fig. 2) does not indicate any abnormal component of flow from the Gulf extending beyond southern Texas, the monthly mean surface pressure in the area (not shown) indicated a stronger than normal southeasterly flow from the Gulf to New Mexico, in the area of abnormally heavy precipitation (fig. 5). Albuquerque, N. Mex., had the wettest, and El Paso, Tex., its second wettest June of record. Two tropical disturbances, one of which reached hurricane intensity, in addition to frequent showers and thunderstorms, gave copious rainfall totals to the southeastern coast and most of Florida. Miami reported 21.37 in. of rain, also a new June record.

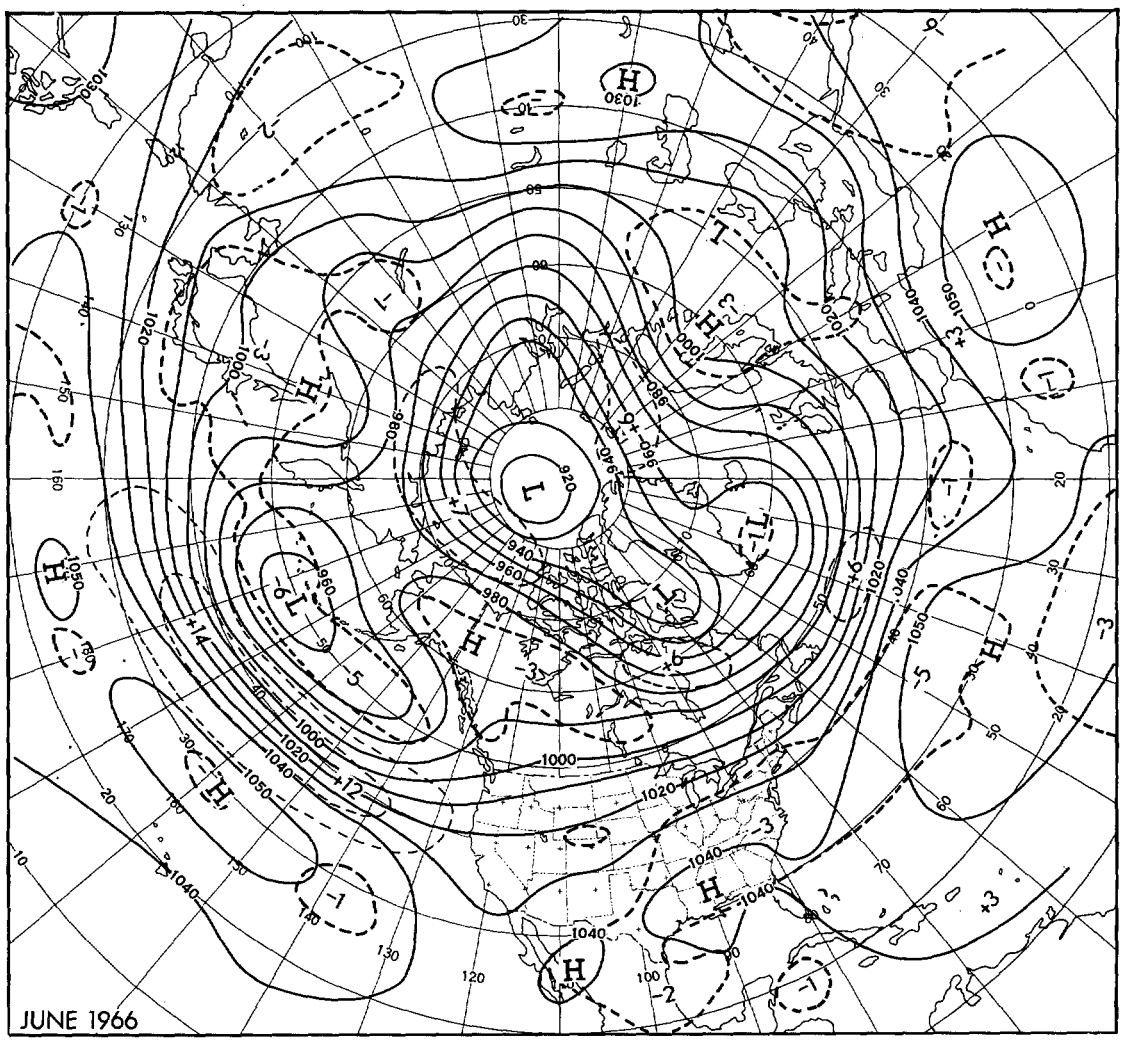


FIGURE 1.—Mean 700-mb contours (tens of feet) (solid) and *wind speed departure from normal* (meters per second) (dashed) for June 1966.

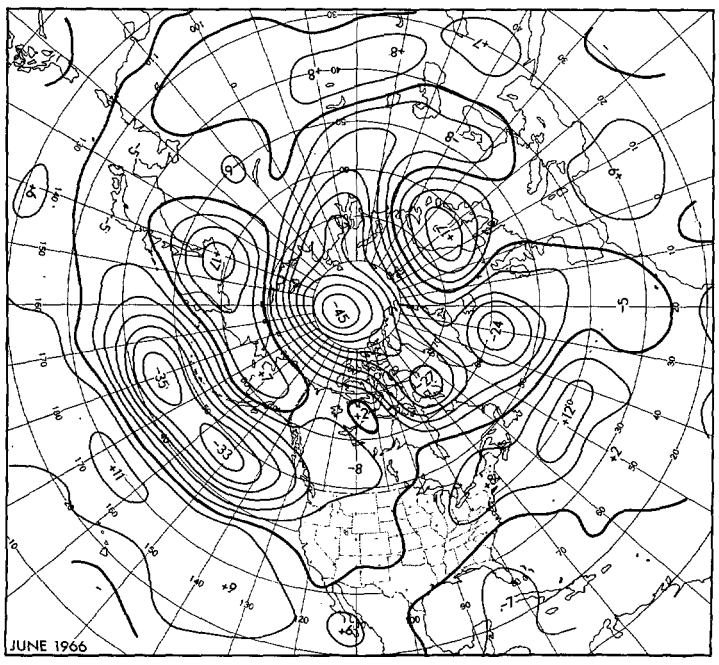


FIGURE 2.—Departure of mean 700-mb. heights from normal (tens of feet) for June 1966.

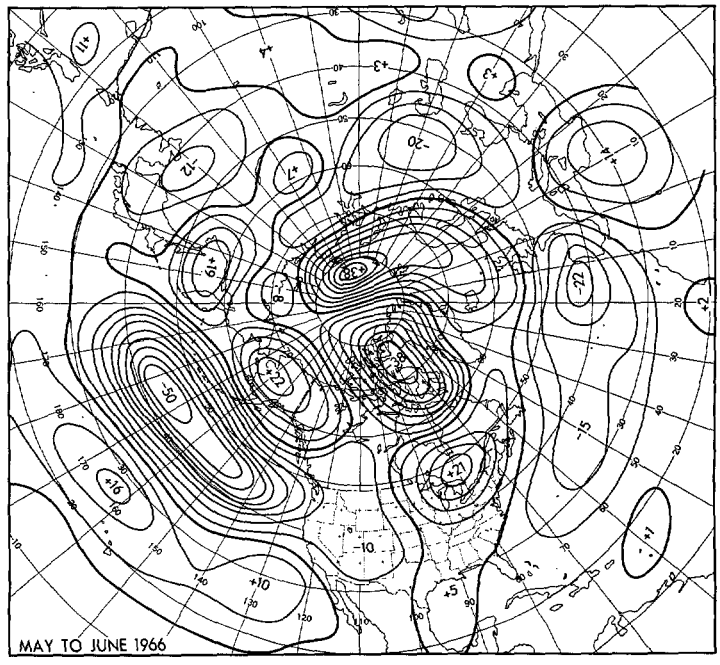


FIGURE 3.—Change of departure from normal of mean 700-mb. height (tens of feet) from May to June 1966.

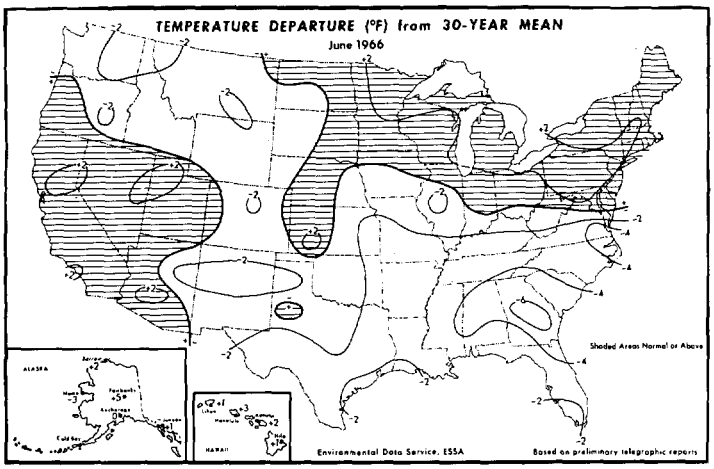


FIGURE 4.—Departure of average surface temperature from normal (° F.) for June 1966 (from [2]).

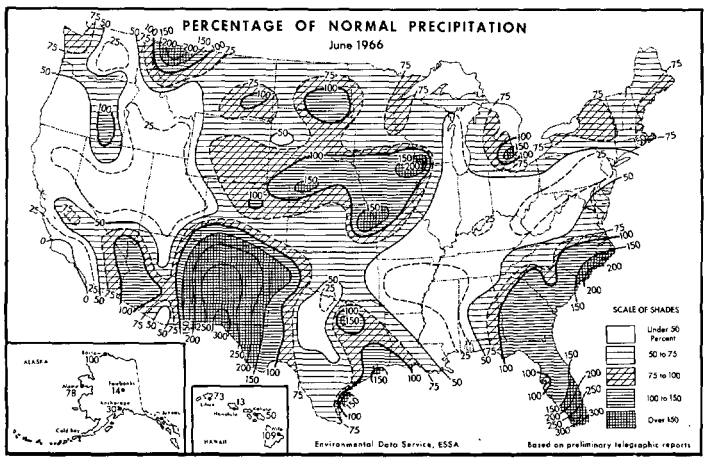


FIGURE 5.—Percentage of normal precipitation for June 1966 (from [2]).

Precipitation was deficient over most of Alaska, in connection with the blocking conditions and above normal heights in that area. For instance, Fairbanks reported only 0.19 in. of rain, which was 14 percent of normal and the least of record for June. At the same time it was the third warmest June on record there (fig. 5).

3. INTRA-MONTH VARIABILITY

The first half of June was relatively cool over most of the country, with no extended spells of hot weather appearing until the second half. The change in mean 700-mb. height between the two halves of the month (fig. 6) shows a rise center of 250 ft. over the Great Lakes. This represented the early stages of growth of a persistent continental anticyclone which gave record heat in July. This development may have been related to the large area of falls just upstream over Alaska and northwestern Canada. Heights fell 240 ft. in the Gulf of Alaska between the first and last halves of June while extremely low heights across the Central Pacific rose to near normal values.

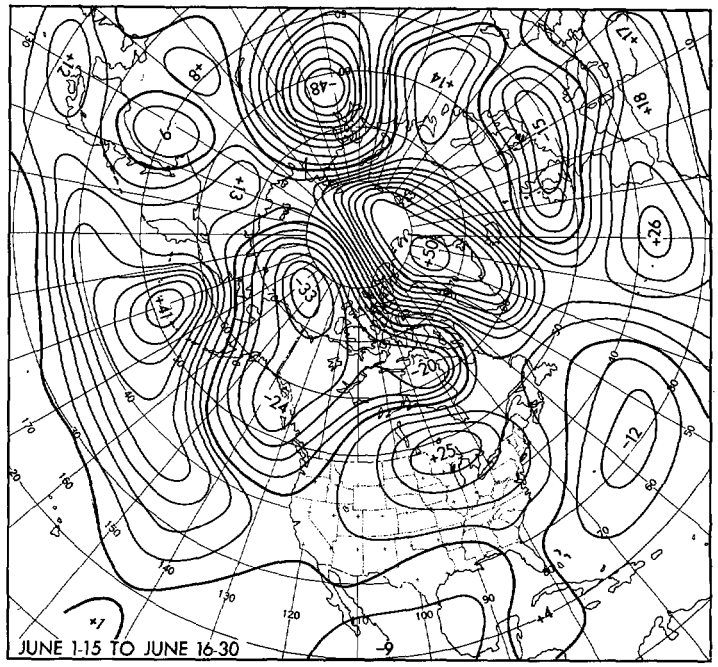


FIGURE 6.—Change in 700-mb. height (tens of feet) from first half to second half of June 1966.

Intra-month height changes in other parts of the Northern Hemisphere were also related to significant weather changes. Rise centers of 140 ft. over western Russia and 500 ft. over Greenland indicated the tendency of the Scandinavian block to weaken and split during the latter part of the month. Cyclonic activity worked eastward under the block, as shown by the area of height falls across central Europe.

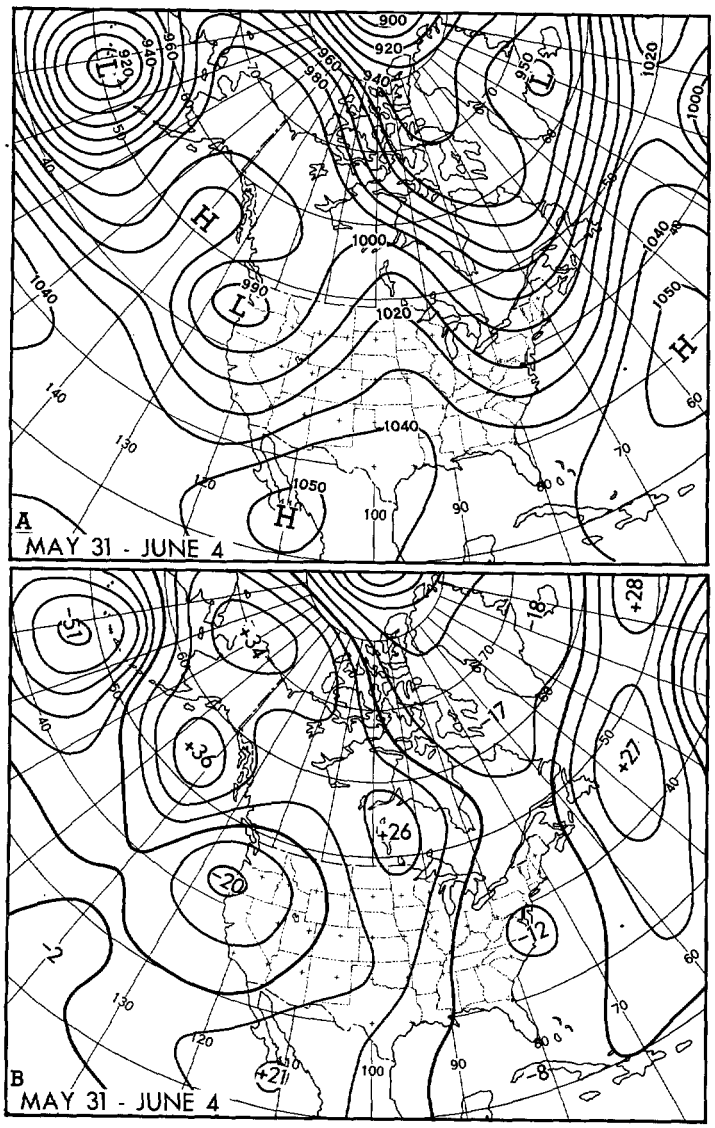
At lower latitudes, the height rises over North Africa show the establishment of the Saharan summer upper-level anticyclone. A belt of height falls (off map) in northern India was associated with the onset of the monsoon around the middle of June. During the first half of the month heights were above normal over northern India, while a heat wave took the lives of 353 persons, according to press reports.

4. WEEKLY WEATHER AND CIRCULATION

MAY 30–JUNE 5, 1966

At the beginning of the month, abnormally strong ridges were located over the central United States and from the Gulf of Alaska to the Arctic Ocean north of Point Barrow (figs. 7A and 7B). A deep full-latitude trough extending from the polar vortex to the southeastern United States just east of the ridge served to draw cool air directly southward from the still ice- and snow-covered northern Canada and Hudson Bay areas.

The polar air produced record low temperatures over an extensive area of the country on June 1 and 2. Table 1 lists the cities and temperature readings which broke or tied the record for June cold. It can be seen that the area of record cold, which was centered somewhat south-



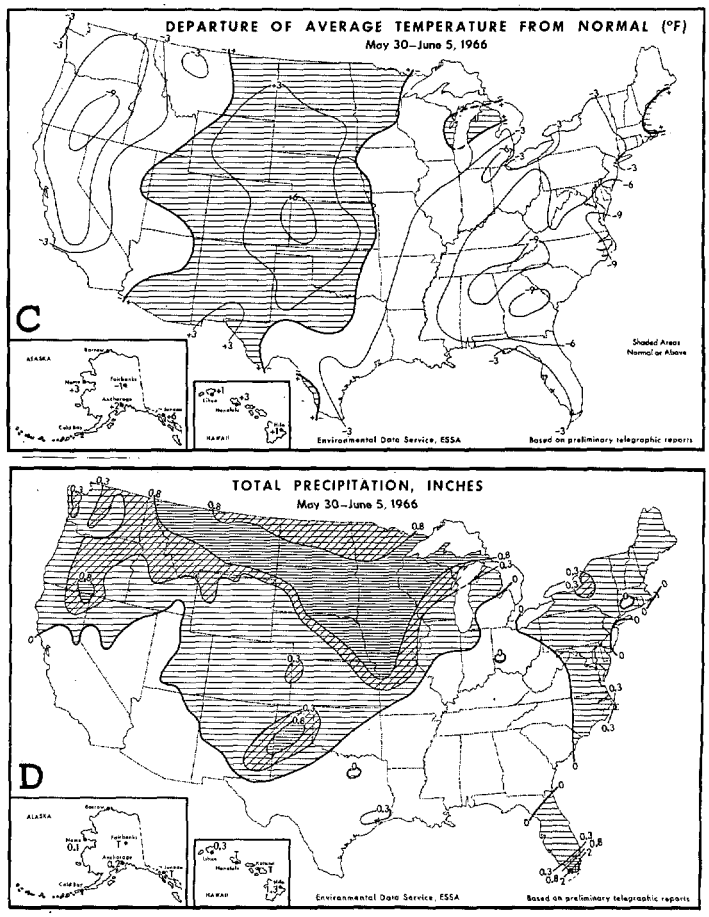


FIGURE 7.—(A) Mean 700-mb. contours and (B) 700-mb. height departures from normal (both in tens of feet) for May 31–June 4, 1966; (C) departure of average surface temperature from normal (° F.) and (D) total precipitation (in.) for week of May 30–June 5, 1966 (from [2]).

east of the region similarly affected in May (see table 1 of [1]), extended from the Great Lakes to the Gulf of Mexico and from Missouri to the Atlantic Coast. The temperature dipped below freezing in central Michigan and the northern Appalachians. Weekly temperatures were as much as 10° F. below normal in parts of the Southeast and also in eastern Oregon (fig. 7C), where there were large negative height departures (fig. 7B) associated with a closed Low trapped by blocking at higher latitudes.

The anomalous component of flow from the southeast contributed to widespread precipitation over the Upper Plains (fig. 7D) while little or no rain fell in the subsiding Canadian air in the East.

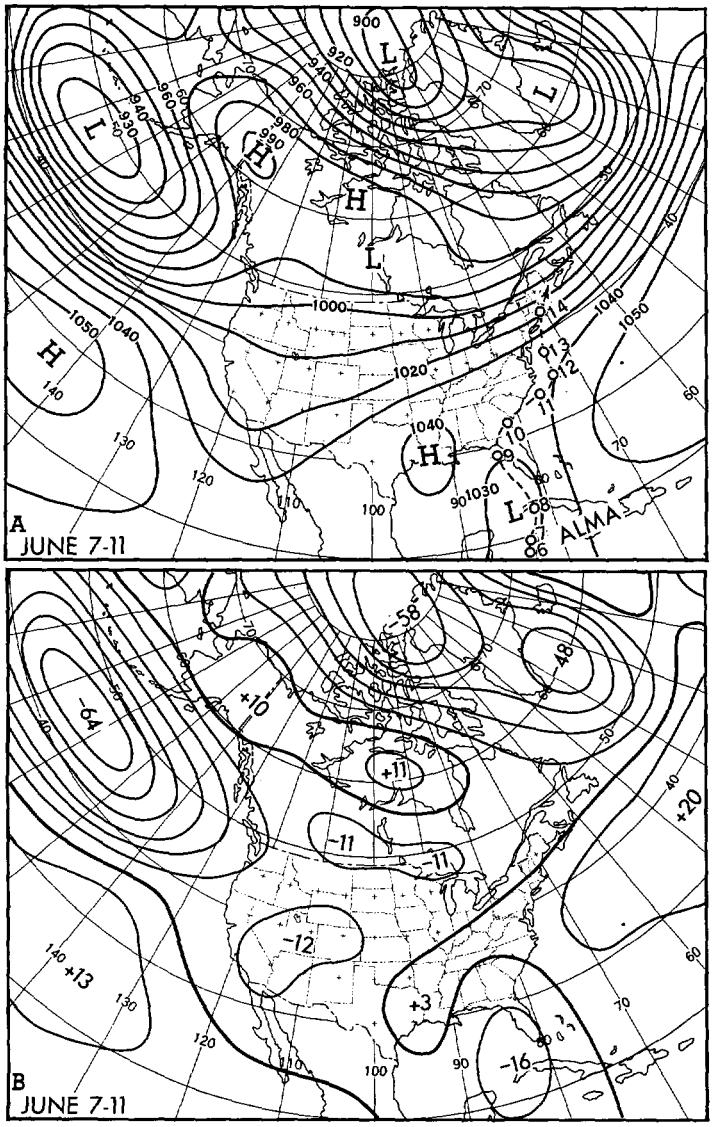
JUNE 6–12, 1966

During the second week of June heights fell over the central United States and rose in the East, as a broad confluence zone was established from the Central Plains to New England (figs. 8A and 8B). Temperatures fell rapidly in the Central and Northern Plains and rose to above

TABLE 1.—*Record low temperatures for June established or equaled during June 1966*

City	Date	Temperature (° F.)
Greensville-Spartanburg, S.C.	1, 2	49, 46
Lynchburg, Va.	1	*42
Baltimore, Md.	1	*42
Pittsburgh, Pa.	1, 2	36, *36
Erie, Pa.	1	37
Lansing, Mich.	1	30
Detroit, Mich.	1	36
Evansville, Ind.	1	41
Lexington, Ky.	1	39
Louisville, Ky.	1	42
Nashville, Tenn.	1	*42
Memphis, Tenn.	1	48
Springfield, Mo.	1	42
West Plains, Mo.	1	41
Birmingham, Ala.	1	42
Little Rock, Ark.	1	49
Alexandria, La.	1	49
Pendleton, Oreg.	1	*36
Olympia, Wash.	1	31
Bridgeport, Conn.	2	43
Youngstown, Ohio	2	33
Toledo, Ohio	2	*38
Charleston, W. Va.	2	35
Elkins, W. Va.	2	29
Roanoke, Va.	2	40
Norfolk, Va.	2	*48
Hatteras, N.C.	2, 3	45, 44
Wilmington, N.C.	2	50
Raleigh-Durham, N.C.	2	43
Charleston, S.C.	2	*51
Rome, Ga.	2	43
Tallahassee, Fla.	2	54
Lake Charles, La.	2	*58
New Orleans, La.	2	55
Brownsville, Tex.	2	*92

*Equaled previous record.



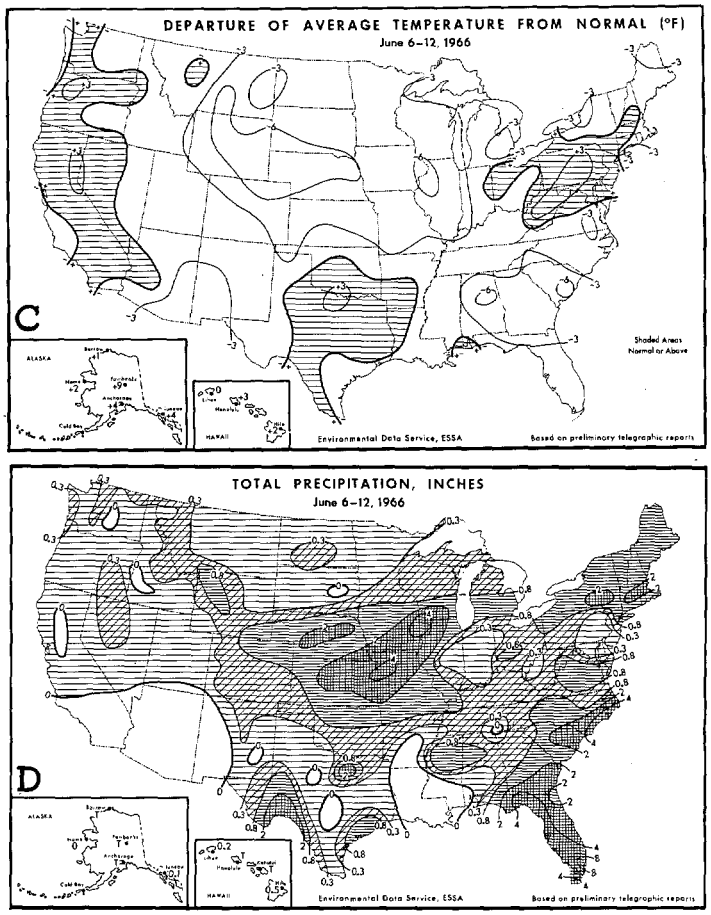


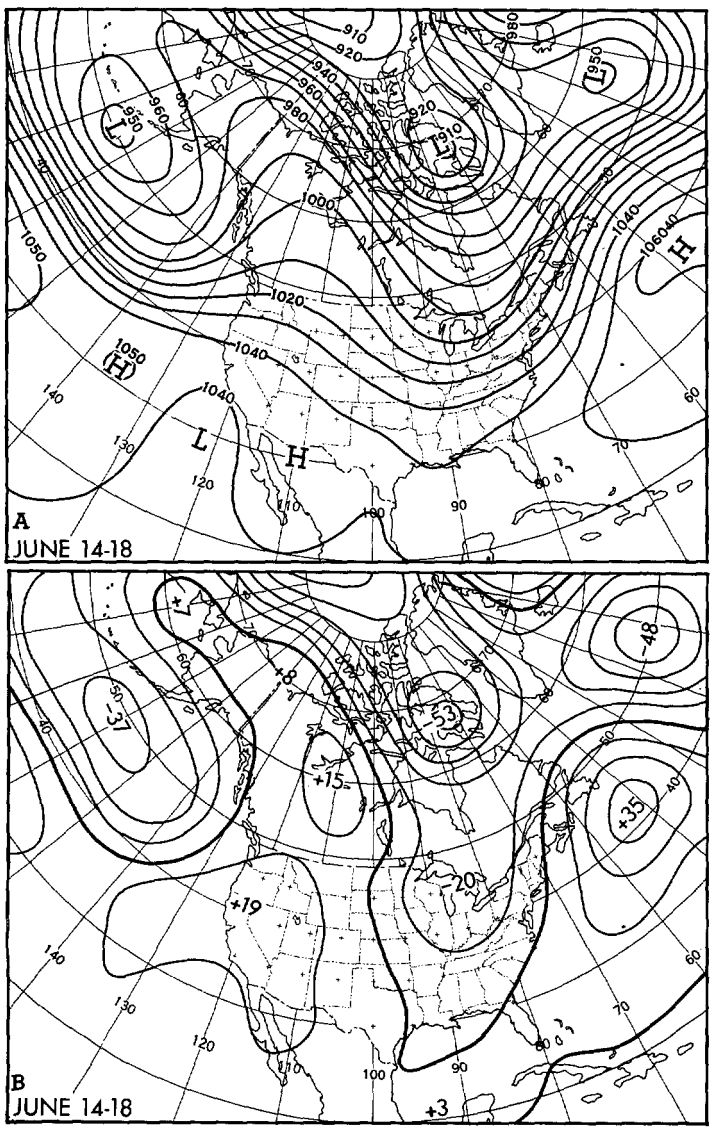
FIGURE 8.—Same as figure 7, (A) and (B) for June 7–11, 1966; (C) and (D) for June 6–12 (from [2]). Path of hurricane Alma is superimposed on (A). Numbered dots give dates of 7 a.m. EST storm positions.

normal over most of the Mid-Atlantic States (fig. 8C). An extensive belt of rainfall in excess of an inch extended from Colorado to the New England coast (fig. 8D) in response to the confluence of warm humid air from the Gulf and cool Canadian air.

Daily rainfall amounts up to 3 in. were recorded over parts of Kansas, Nebraska, and Iowa on June 8 and 9. The heavy convective activity in this area was marked by an outbreak of tornadoes, the most severe of which passed through the center of Topeka, Kans., where 17 people were killed and over 500 injured. Preliminary damage estimates were around $100 million.

The second week of June was also marked by another unusual and destructive weather event. Hurricane Alma, the first of the 1966 season (fig. 8A), and the earliest hurricane of record ever to cross the United States coastline, did considerable damage along the Gulf coast of Florida, although inland the rains were beneficial for the citrus crop. Alma probably had its origin just south of the polar trough over the eastern United States at the beginning of the month. The cold air introduced into low latitudes contributed to added instability in an area of showers covering a large part of the western Caribbean, where the thickness has been below normal most of the spring. The injection of fresh cool air and cyclonic vorticity aloft into the Tropics from higher latitudes is a mechanism suggested by Namias [4] for initiating tropical cyclogenesis. Sea temperatures were near the seasonal normal in the area, which is just above the minimum criterion suggested by Palmén [3] for tropical storm formation.

After dumping up to 30 in. of rain in Honduras during its formative days, Alma moved more or less northward across western Cuba and then parallel to the west coast of Florida, finally making landfall 20 mi. east of Apalachicola early on June 9. The storm weakened after turning sharply to the east-northeast over southern Georgia. As it again moved over the ocean, Alma produced heavy rains over the Carolinas. Wilmington had almost 8 in. within 24 hr. on the 10th and 11th, the greatest 24-hr. rainfall



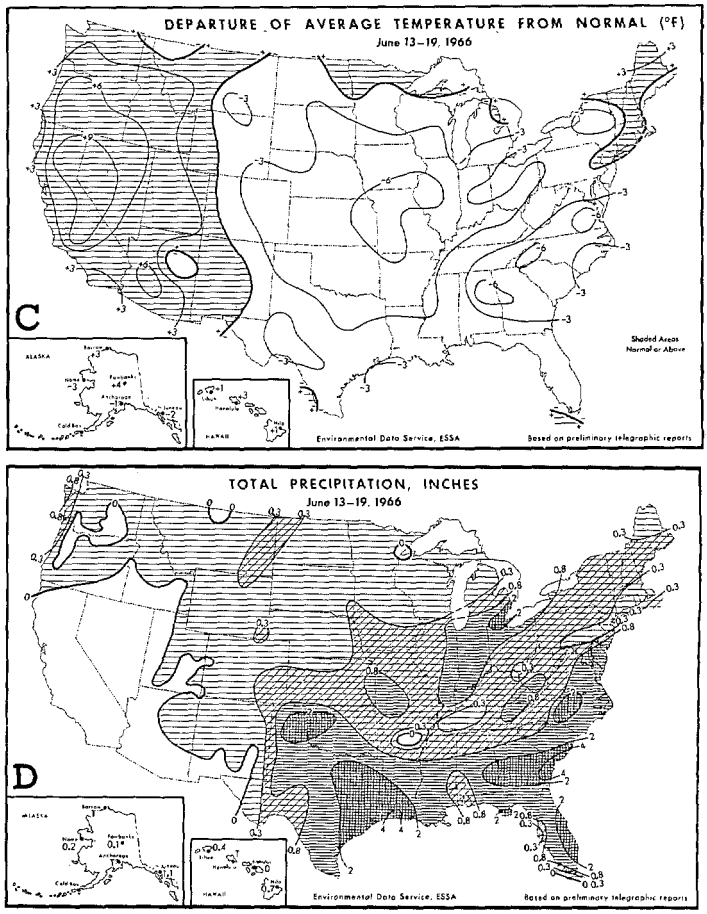


FIGURE 9.—Same as figure 7, (A) and (B) for June 14–18, 1966; (C) and (D) for June 13–19 (from [2]).

since records began there in 1871. Alma briefly regained hurricane intensity off Cape Hatteras before turning northward. As soon as the storm moved over the cold waters east of Delaware (10° F. below seasonal normal) Alma rapidly lost strength and became a weak extratropical storm.

JUNE 13–19, 1966

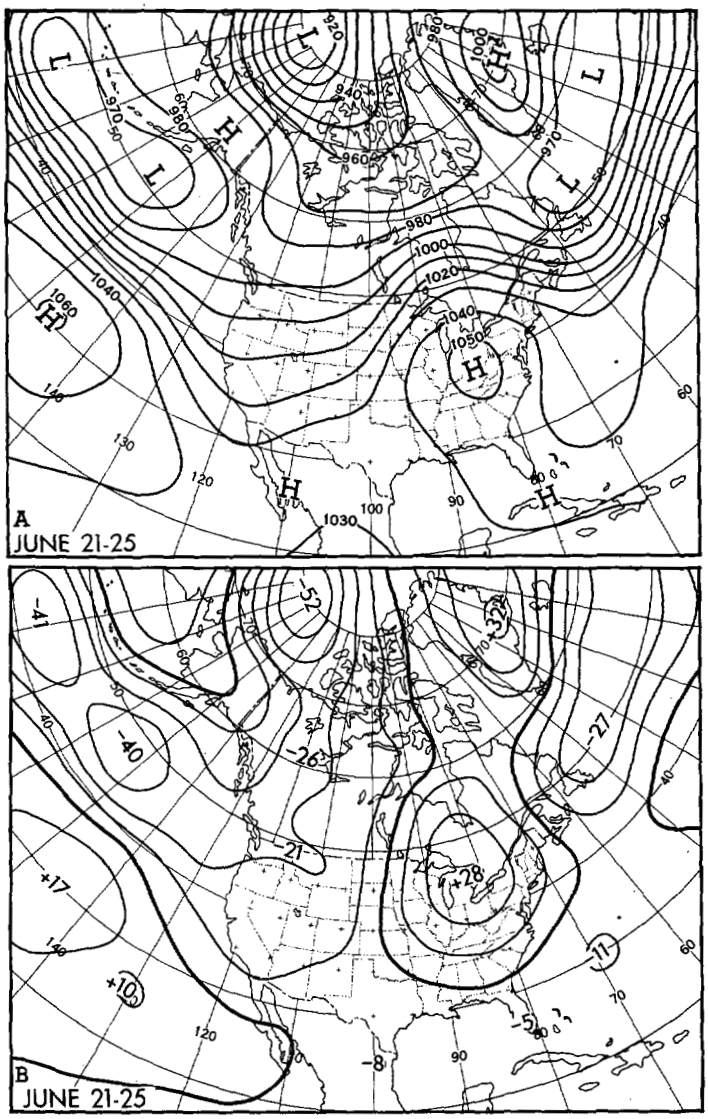
This week's weather was similar to that at the beginning of the month as another full-latitude trough was established from Baffin Island to the Gulf of Mexico (fig. 9A). Weekly temperatures were more than 6° F. below normal over the central Mississippi Valley and in sections of the Southeast, while they rose to as much as 10° F. above normal in Nevada under a 190-ft. positive 700-mb. height anomaly center (fig. 9B and 9C). A reading of 100° F. in Salem, Oreg., on the 15th was the highest there so early in the season.

Unlike the first week of June, when the trough was nearer the coast, precipitation was fairly heavy over much of the South and East under the broad cyclonic flow aloft (fig. 9A and 9D). Tornadoes were observed in Illinois, Iowa, and Texas, and hailstorms occurred in Kansas, New Mexico, Oklahoma, and the Texas panhandle.

JUNE 20–26, 1966

This week was marked by the first appearance of the persistent continental anticyclone (fig. 10A) which was to produce a long heat wave and many individual record high temperatures. Heights over the Great Lakes rose to 280 ft. above normal (fig. 10B). The building of the eastern ridge was related to large height falls to more than 200 ft. below normal over western Canada and the western United States where heights had been above normal the previous week.

An idea of the marked temperature reversal accompany-



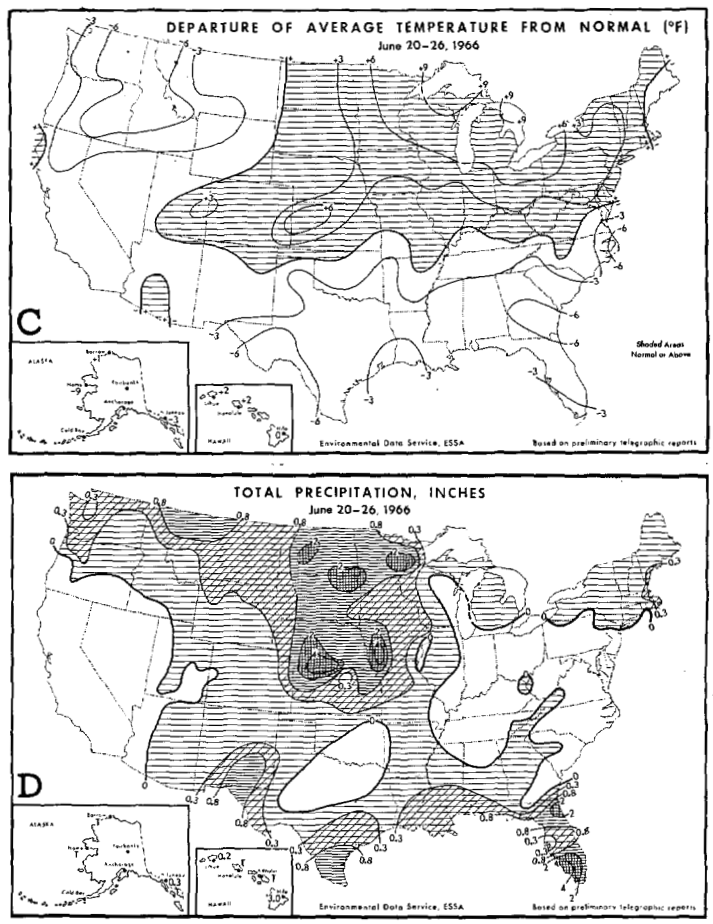


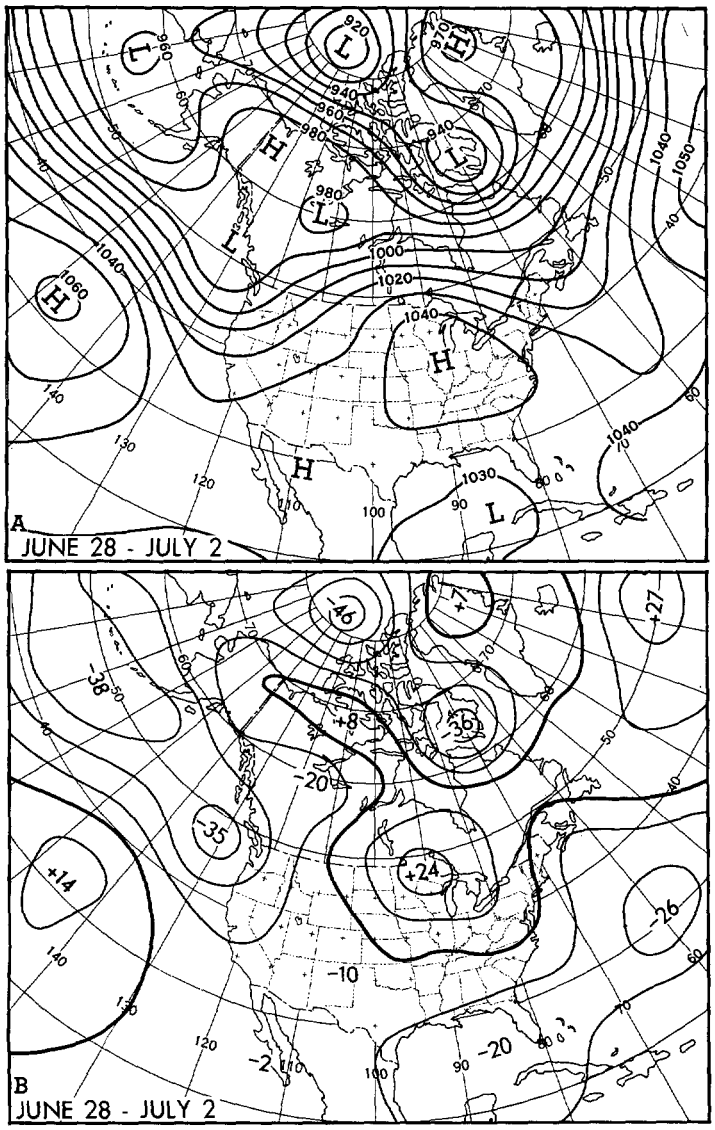
FIGURE 10.—Same as figure 7, (A) and (B) for June 21–25, 1966; (C) and (D) for June 20–26 (from [2]).

ing the circulation change may be obtained by noting that on June 21, Norfolk, Va., had a temperature of 54° F., and on June 25, Boise, Idaho, reported a minimum of 38° F., both record lows for so late in the season. The change in temperature may be further seen by comparing figure 10C with figure 9C. The entire northeastern third of the country (except for New England, which remained near or slightly above normal) warmed rapidly to as much as 9° F. above normal in part of the Great Lakes area. At the same time, the western plateau area cooled from 3° to 10° F. above normal to 2° to 7° F. below normal. Temperatures remained low in the Southeast.

The East was generally dry under the strong anticyclone, but heavy showers and thunderstorms occurred in the Northern and Central Plains as abnormal flow from the south (fig. 10B) brought warm, humid air north from the Gulf. 24-hr. rainfall amounts up to 5 in. were observed in Minnesota and Iowa (fig. 10D). The Plateau had little rain in the north and none in the south, even though below normal heights and relatively cyclonic flow aloft prevailed.

JUNE 27–JULY 3, 1966

As the month ended, the continental High drifted somewhat farther westward (fig. 11A) and as a result the area of above normal temperatures expanded (fig. 11C). Only the Southern States and the Pacific Northwest remained below normal. A temperature of 100° F. at Allentown, Pa., on June 27, was the highest ever observed during June, and 101° F. on the same day in New York City's Central Park equaled the monthly record. The next day 102° F. at Billings, Mont., also tied the June record as the heat wave grew both in area and severity. The climax of the heat in the East came on July 3 when New York's La Guardia Airport and



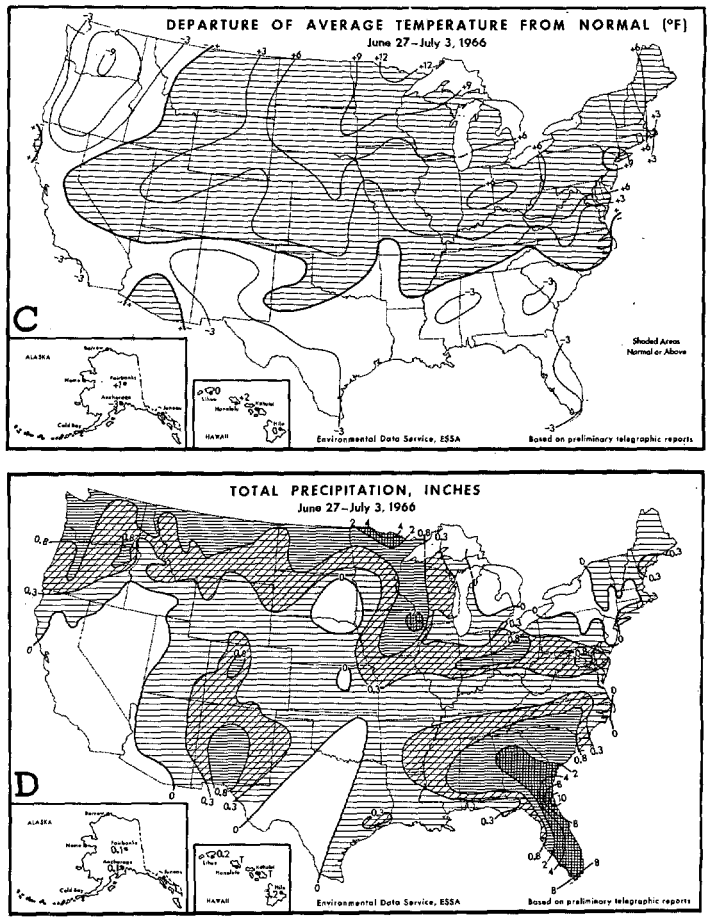


FIGURE 11.—Same as figure 7, (A) and (B) for June 28–July 2, 1966; (C) and (D) for June 27–July 3, 1966 (from [2]).

Harrisburg, Pa., broke their all-time records with readings of 107° F.

The 700-mb. height anomaly pattern (fig. 11B) shows three areas of above normal height located in the eastern Pacific, the Great Lakes, and the eastern Atlantic. This is rather similar to the three-cell anticyclonic pattern which Namias [5] found to be associated with the persistent hot, dry weather over the central United States during the summers of 1952–54.

A tropical depression formed over the western Caribbean and moved northward on a path quite close to that taken by Alma earlier in the month. Although this disturbance failed to reach tropical storm intensity, it did produce torrential rains over eastern Florida and southern Georgia (fig. 11D). Jacksonville, Fla., recorded 10.09 in. of rain within a 24-hr. period on June 30–July 1.

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