WEATHER AND CIRCULATION OF JULY 1980
Climax of a Historic Heat Wave and Drought over the United States

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1. Introduction

The continued presence during July 1980 of the upper air circulation pattern that was established in the latter part of June (Dickson, 1980) had enormous social impact on the United States. High air temperatures and drought exacted a heavy economic and human toll over the southern and central Plains and the deep South. The highest cost was in human lives; initial surveys in affected areas found that mortality rates were substantially higher than a year ago, suggesting that press reports of well over 1000 heat-related deaths accurately characterized the emergency. These increases were apparently well-distributed over different age groups.[1] Additionally, the persistent extreme heat was responsible for large losses in poultry and livestock and, in conjunction with continued low rainfall amounts, feed grains like sorghum, as well as spring wheat, cotton and other crops.

In comparison to other memorably hot Julys since 1881 for the continguous United States as a whole, especially 1901, 1934, 1936 and 1954, this July could well rank as the second warmest. Certainly, it is at least comparable to all but July 1936. These points are qualitatively illustrated (because normals are not uniform) in Fig. 1 where the relative size of areas with average temperature departures from normal in excess of several arbitrarily selected values are shown. Charts (not shown) with uniform normals for Julys 1901, 1934 and 1954 (produced by the British Meteorological Office) are quite similar in location, extent and magnitude of large temperature anomalies. Thus, July 1954 is used to represent the Julys cited above that are not shown in Fig. 1.

Clearly, July 1980 weather over the United States constitutes a notable meteorological event. A long list of daily and monthly, July and all-time high-temperature records were set, of which only some of the more impressive are shown in Table 1. Only observers in New England (except Rhode Island), West Virginia and Michigan officially failed to note 100°F temperatures, while at least this value was reported for Dallas, TX every day in the month!

In subsequent sections, the circulation, temperature and precipitation patterns for the month, as well as the variability within the month, will be discussed in more detail.

2. Mean circulation

The pattern of 700 mb heights (Fig. 2) was again dominated in July in middle latitudes by three stronger than normal highs positioned over both oceans and over the south-central United States with troughs near both coasts (Figs. 2 and 3). With some adjustment this configuration is substantially the same at these latitudes and meridians as that for June and, as pointed out by Dickson (1980), that described by Namias (1955) in his discussion of the United States drought of the early fifties.

Important differences from June, however, include, in middle latitudes, strengthening (in an absolute not departure from normal sense) of the three key 700 mb anticyclones, an expansion of the North American cell longitudinally and to the north, and a shortening of the three-cell wavelength. The latter was apparently compatible with the establishment upstream of an important East Asian ridge and trough south of Kamchatka.

At higher latitudes a general retrogression of wave features took place from June to July. This is true of the blocking ridge over northern Europe and the low southeast of Iceland, the ridge in western Canada, and the far eastern Siberian trough. The retrogression is especially evident in the zonal wave 2 pattern around and near the pole where a reversal from mostly negative height anomalies to mostly positive also took place (note particularly Fig. 3).

This last change is reflected by the general demise of the circumpolar vortex at 700 mb (Fig. 4) and a strengthening of the zonal current at middle latitudes at least in the western half of the hemisphere. Over

[1] Personal communication with Dr. Joel Greenspan, Center for Disease Control, Atlanta, Ga.

the northeast Pacific the strong flow helped isolate the low off the California coast and maintain the fast zonal westerlies near their normal position along the United States-Canadian border.

The straighter, faster wind core conforms with the appearance of substantially colder air (and enhanced north-south baroclinity to the south) over much of the northwestern Pacific and Atlantic Oceans and over the northwestern Soviet Union (Fig. 5). In the case of the latter two locations, the transport of smaller 1000–700 mb thicknesses was in some part assisted by retrogression of high-latitude circulation features while in the former it was probably a consequence of the swelling of the ridge over eastern Asia. The strong baroclinity encouraged frequent cyclonic activity over both oceans that tracked generally south and east of climatologically expected paths. Both the westerlies and storms over the Atlantic drove far south of their normal positions into western Europe.

3. Temperature

With the exception of the northern Intermountain region in the west and eastern Maine, virtually all of the contiguous United States experienced above-normal temperatures in July (Fig. 6). Weak southwesterly flow aloft (Fig. 2) allowed sufficient penetration inland of cool maritime air to keep temperatures in the Northwest mostly below normal, while the location of the mean trough over the Northeast permitted occasional incursions of Canadian air resulting in near-normal temperatures.

Otherwise the large and intense ridge aloft and the fast westerlies just to its north conspired to produce strong subsidence, heating and drying of the air, suppression of clouds and precipitation, increased isolation, baking of dry ground, and further heating of the air, with little challenge from disturbances out of the north or south.

The focus of the anticyclone aloft and the highest mean temperature anomalies were within a few hundred kilometers of each other, the latter close to the Kansas-Missouri border. While the string of 100°F or higher daily maximum temperatures at Dallas was quite impressive (see Sections 1 and 5e), the severity of the heat wave in the central Plains is perhaps better characterized by Witchita, KS. With daily maximum and high minimum records falling almost continually, temperatures there averaged close to 10°F above normal during the month (see Table 1), soaring to 112°F on July 12. Outside of the desert Southwest, this was the highest reported temperature for the month.

Elsewhere, not surprisingly (from Figs. 2–5), western Europe had a particularly cool July. In Hawaii temperatures were near normal on the north islands and above normal on the main island. Barrow, AK, was vulnerable to Arctic air because of the ridge to its northwest, while Nome enjoyed southwesterly flow (albeit weaker) as it did in June.

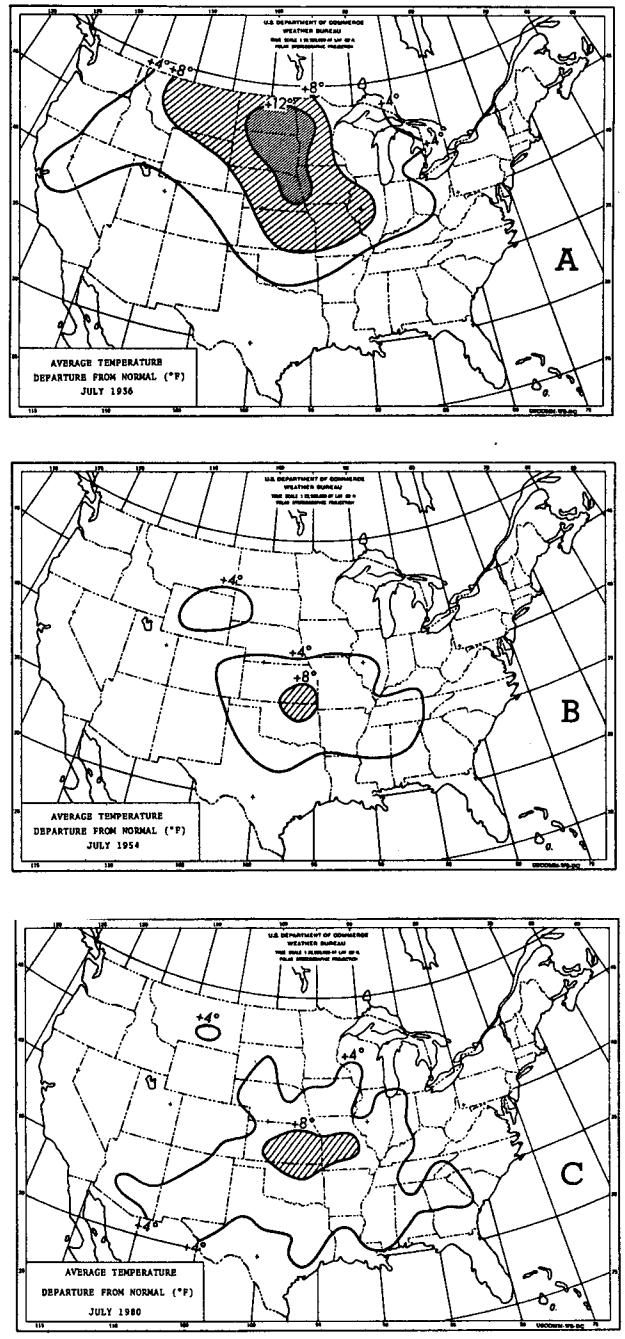


FIG. 1. Average temperature departures from normal (°F) for July 1936 (A), July 1954 (B) and July 1980 (C). Only +4, +8 and +12°F lines are shown. Light shading denotes areas with departures between +8 and +12°F, and dark shading areas greater than +12°F. Because normals are different in (A)–(C), only qualitative distinctions should be made.

TABLE 1. Temperature records equaled or exceeded in July 1980.

Station	Date	Temperature (°F)	Anomaly (°F)	Remarks
Dallas, TX	2	110		Highest for July
	18	110		Equaled highest for July
Little Rock, AR	13	108		Equaled highest for July
	14	108		Equaled highest for July
	16	108		Equaled highest for July
Macon, GA	12	105		Equaled highest for July
	13	108		Highest for July
				Equaled highest all time
Memphis, TN	13	108		Highest all time
Augusta, GA	13	107		Highest all time
Meridian, MS	14	107		Highest all time
West Plains, MO	12	107		Highest for July
Jackson, MS	14	105		Highest for July
	15	105		Equaled highest for July
	16	106		Highest for July
				Equaled highest all time
Pueblo, CO	29	106		Highest for July
				Equaled highest all time
Atlanta, GA	12	103		Equaled highest all time
	13	105		Highest all time
	15	105		Equaled highest all time
Albuquerque, NM	18	105		Equaled highest all time
Port Arthur, TX	17	103		Equaled highest for July
Lake Charles, LA	17	102		Equaled highest for July
New Orleans, LA	15	100		Equaled highest for July
	16	101		Highest for July
South Bend, IN	20	100		Highest all time
Ely, NV	25	96		Highest all time
Phoenix, AZ		95.6	+4.4	Hottest month
Tulsa, OK		91.7	+9.6	Hottest month
Wichita, KS		90.5	+9.8	Hottest July*
Little Rock, AR		88.6	+7.2	Hottest month
Austin, TX		87.9	+3.3	Hottest July
Columbia, MO		87.0	+9.7	Hottest month
Cairo, IL		85.8	+5.1	Hottest month
Jackson, MS		85.8	+4.1	Hottest July
Albuquerque, NM		82.7	+4.0	Hottest July

* Record daily maximum temperature equaled or exceeded on 15 days and record daily high minimum temperature equaled or exceeded on 11 days in July.

4. Precipitation

With the dominance aloft over most of the United States of an abnormally strong center of high 700 mb heights, perhaps three-fourths of the country had below normal precipitation in July (Fig. 7). Consequently, the monthly mean pattern of percent of normal precipitation is somewhat chaotic exemplifying well the relatively small scales of summertime rain. Many of the areas with above-normal July amounts, with the exception of the eastern Ohio Valley and parts of the Northeast, were mostly the result of quite transient, isolated events. For example, the relatively heavy amounts in the Intermountain region condensed out of moisture from the remnants of Hurricane Celia.

On the opposite side of the Atlantic during July, Europe was generally wet with eastern Europe receiving the largest amounts. This was the result of the deep trough aloft over most of the continent surmounted by the blocking ridge over Scandanavia, the consequent vulnerability to Atlantic lows, and the abnormally large thermal gradients north of the Black Sea. Many locations from the German Democratic Republic east to the Ukraine and south to Romania had 200% or more of July normal precipitation, while vast areas of Polish farmland were under water part of the month.

In the non-contiguous United States percentages of normal precipitation were generally unexceptionable for summer except perhaps at Kodiak, AK, which reported 23%.

5. Variability within the month

A review of Dickson's (1980) Fig. 10a and Figs. 8a–12a below clearly reveals (over the zonal band of the United States from mid-ocean to mid-ocean)

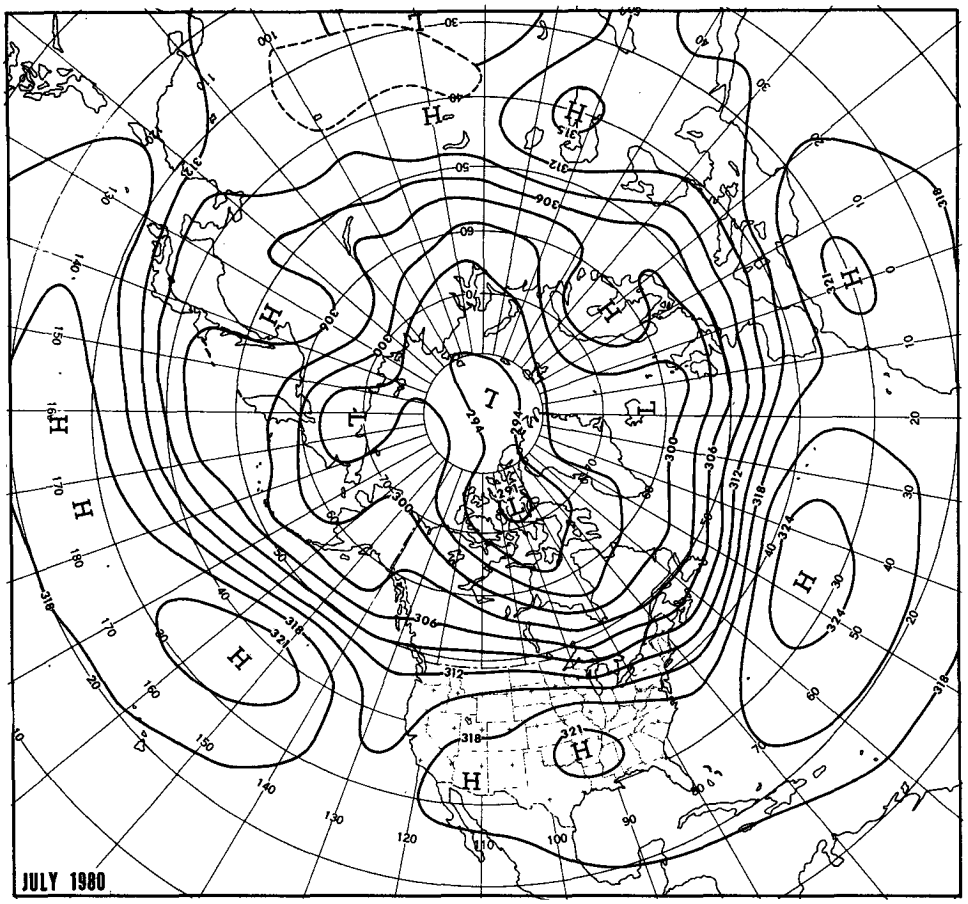


FIG. 2. Mean 700 mb height contours (dam) for July 1980.

how stationary the upper air pattern shown in Fig. 2 was from week to week in July. Only one break is apparent (Fig. 11a) and that period brought important relief to many scorched areas. At higher latitudes the month began with general retrogression of waves, but toward the middle of the month a trend toward progression began upstream of North America that reached its peak at the abovementioned break.

It is interesting to note from the figures, and perhaps germane to the understanding of teleconnective relationships, that vacillation in the position of the Atlantic ridge was large during the time the central United States cell was most stationary and quite small when it was the most transient. On the other hand, the position of the Pacific ridge was relatively constant with the exception of the break week when it was displaced several degrees of longitude to the south.

a. 30 June–6 July

In the first week of the month the 700 mb ridge (Fig. 8a) over the United States expanded dramatically to the east, giving the Southeast its first real exposure to the heat wave (Fig. 8b). To the north a deep trough consolidated itself over Hudson Bay. This, along with a substantial retrogression of the Atlantic ridge, flattened the flow over the Atlantic but permitted the westerlies upstream to penetrate into the northeast quadrant of the country, bringing some relief from the previous week's above-normal temperatures. Disturbances in the westerlies brought substantial amounts of rain (Fig. 8c) to a zone across the center of the nation near the mean position of mostly stalled fronts.

The West Coast and the Pacific Northwest continued to enjoy cool maritime air as the trough aloft opened up further in response to the weakening of the western Canada ridge and the retrogression and strengthening of the Pacific ridge. Much of the precipitation in the Plateau and Rocky Mountain regions came from moisture pumped in by the fading vestige of Celia.

Elsewhere aloft the low near the Taymyr Peninsula weakened as a high grew in the Sea of Okhotsk and the western Pacific trough broadened.

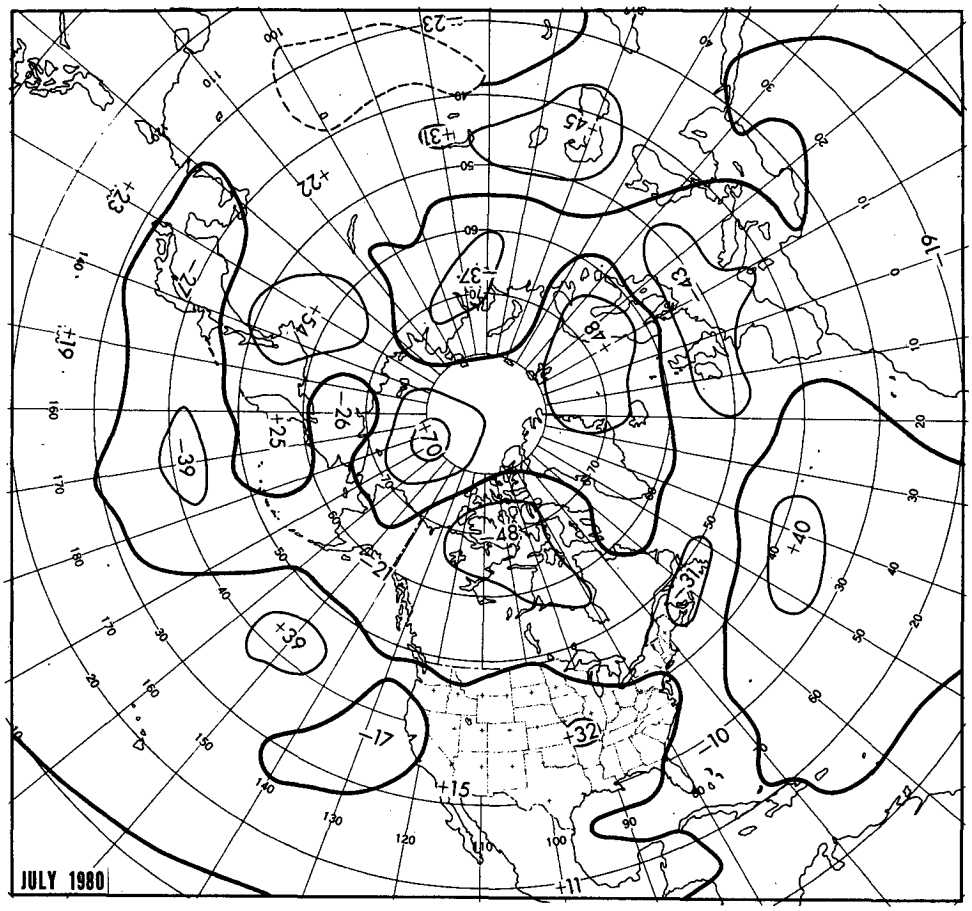


FIG. 3. Departure from normal of mean 700 mb height (m) for July 1980.

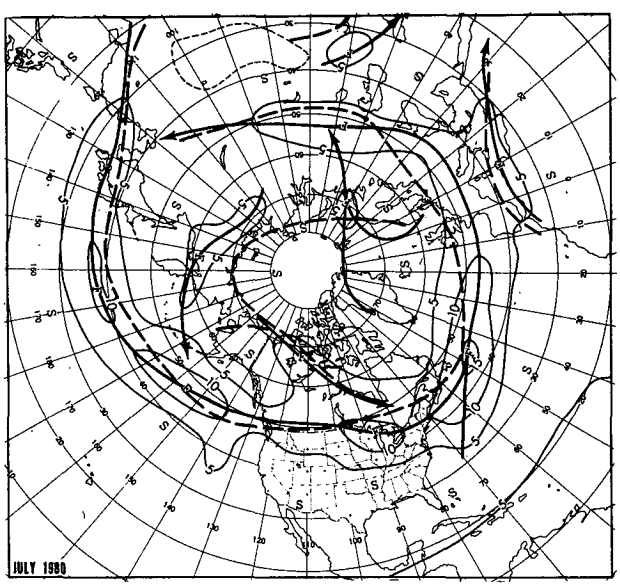


FIG. 4. Mean 700 mb geostrophic wind speed (m s^{-1}) for July 1980. Solid arrows indicate observed axes of maximum wind speed and dashed lines, the normal.

b. 7–13 July

In terms of intensity the heat wave probably reached its climax in this week as the anomalously high central value of the cell centered over Arkansas persisted into a second week (Fig. 9a) and the ridge expanded to encompass two-thirds of the United States. Temperature departures from normal exceeded 6°F for the week (Fig. 9b) from the Gulf of Mexico to Lake Superior and from the Continental Divide to the Atlantic, with areas in Kansas and Missouri averaging over 15°F above normal! The bulk of the high temperature records listed in Table 1 were set in this week or the following.

Meanwhile, however, the Northeast and Northwest remained unseasonably cool. Even though the Atlantic ridge advanced to close to its position two weeks ago, the trough over Hudson Bay remained stationary and was reinforced by a lobe of low heights that retrograded from the southern tip of Greenland. With the growth of the ridge over the center of the United States the northwesterly component of the flow into the Northeast

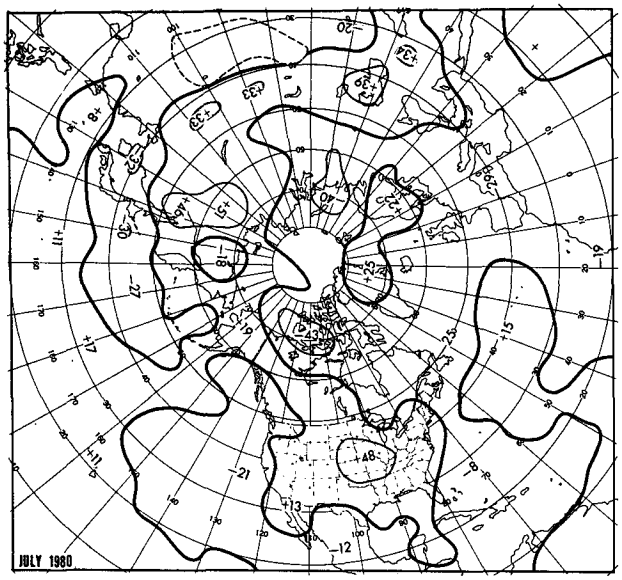


FIG. 5. Departure from normal of mean 1000–700 mb thickness (m) for July 1980.

was greatly enhanced. This set the scene for the month's most violent weather as a vigorous short wave moving across Canada drove a frontal system south and east bringing heavy rains (Fig. 9c) and tornados to the upper Ohio Valley and central Appalachians.

Upstream at 700 mb, as the Taymyr low rapidly retrograded, the ridge over the Sea of Okhotsk split with one cell advancing to Kamchatka. This promoted both the sharpening of the trough near the dateline and a small shift eastward of a weakened Pacific high. Near the end of the week the trough near the West Coast had begun a definite progression inland.

c. 14–20 July

For the second time in the month the Atlantic 700 mb anticyclone (Fig. 10a) moved west to 50°W longitude. This, coupled with retrogression of the Hudson Bay low to the Canadian Archipelago and the eastward expansion of the high over the United States, drove the main westerly current in a mostly zonal path from Minnesota across the Atlantic. With the partial retreat northward of the strong flow aloft the heat wave finally began to invade the Northeast (Fig. 10b), only moderating slightly in the center of the country.

Meanwhile, general retrogression was taking place near the Pole and the westward movement of the Arctic high center may have been instrumental in the development of the vortex west of the Bering Strait. South of this feature the weak ridge that was near Kamchatka and the trough to its east

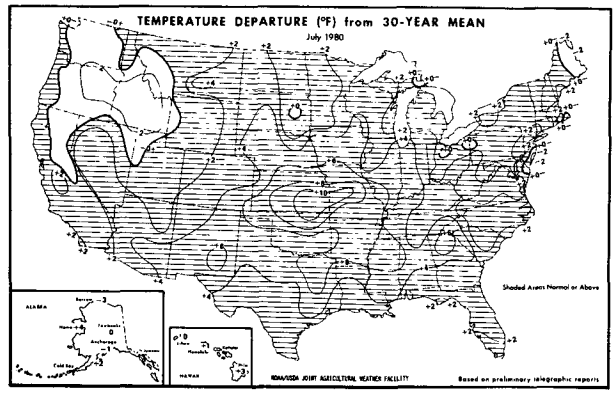


FIG. 6. Departure from normal of average surface air temperature (°F) for July 1980 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1980).

both advanced eastward, leaving in their wake a developing ridge in East Asia and an expanding western Pacific trough. The trend toward a less amplified, more zonal westerly pattern was assisted by the continued advancement of the West Coast trough inland. Its progress can be marked by the shift in the focus of cooler temperatures into Idaho and Montana, and the spread of higher temperatures north through California and Nevada.

Ample rain fell across the northern part of the United States (Fig. 10c) from both mid- and late-week storms as disturbances from the Pacific continued to feed the advancing western trough. To the south heavy rains resulted from an easterly disturbance from the Atlantic that moved into the Gulf and subsequently north. The West was extremely dry and for the third straight week little or no rain fell over Texas or Oklahoma.

d. 21–27 July

A major but brief respite from the extreme conditions in the south and central Plains occurred

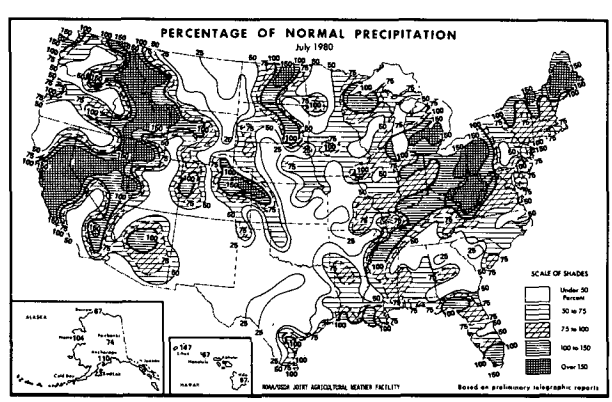


FIG. 7. Percentage of normal precipitation for July 1980 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1980).

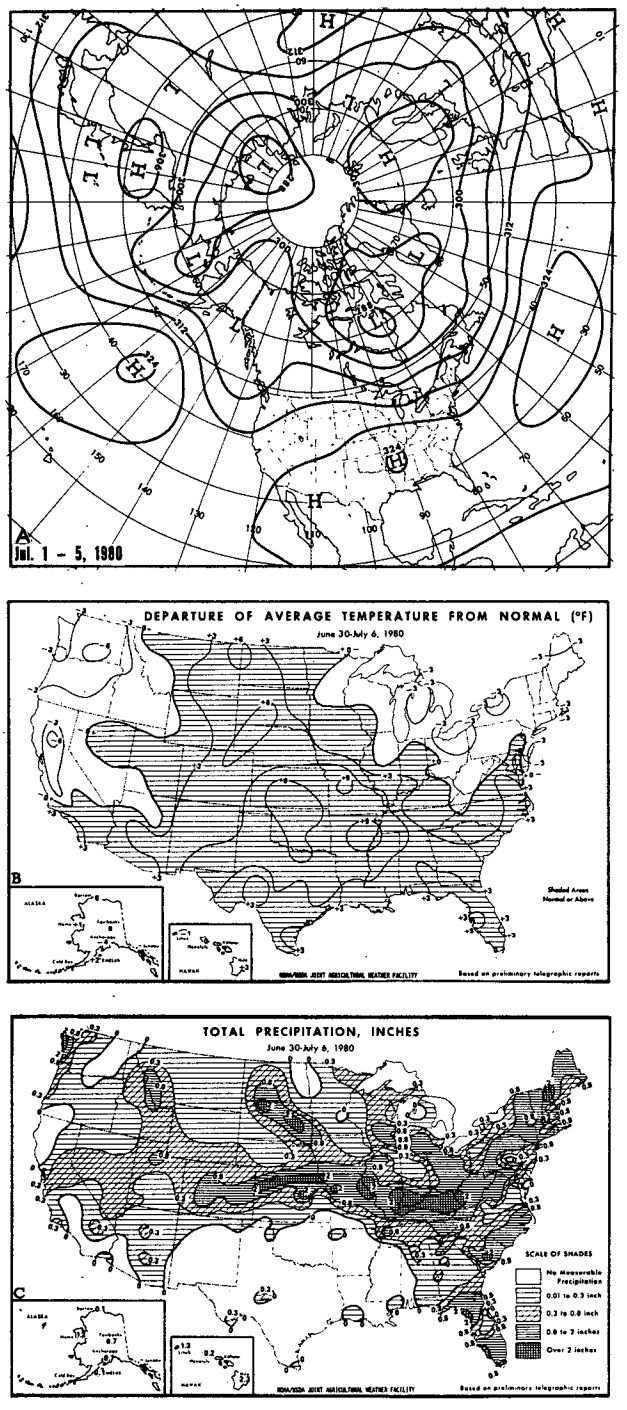


FIG. 8 (A) Mean 700 mb contours (dam) for 1–5 July 1980, (B) departure from normal of average surface air temperature (°F) and (C) total precipitation (inches) for week of 30 June–6 July 1980 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1980).

as 1) the western Pacific trough (Fig. 11a) moved eastward and completely supplanted the Pacific anticyclone north of 35°N latitude, and 2) the ridge over the Southeast retrograded smartly to the Southwest. Extensive areas with extreme positive average temperature departures the week before enjoyed below normal temperatures (Fig. 11b). Moreover, most of the eastern half of the country received generous amounts of rain (Fig. 11c).

Above-normal temperatures did continue for a second week in the Northeast and, ironically,

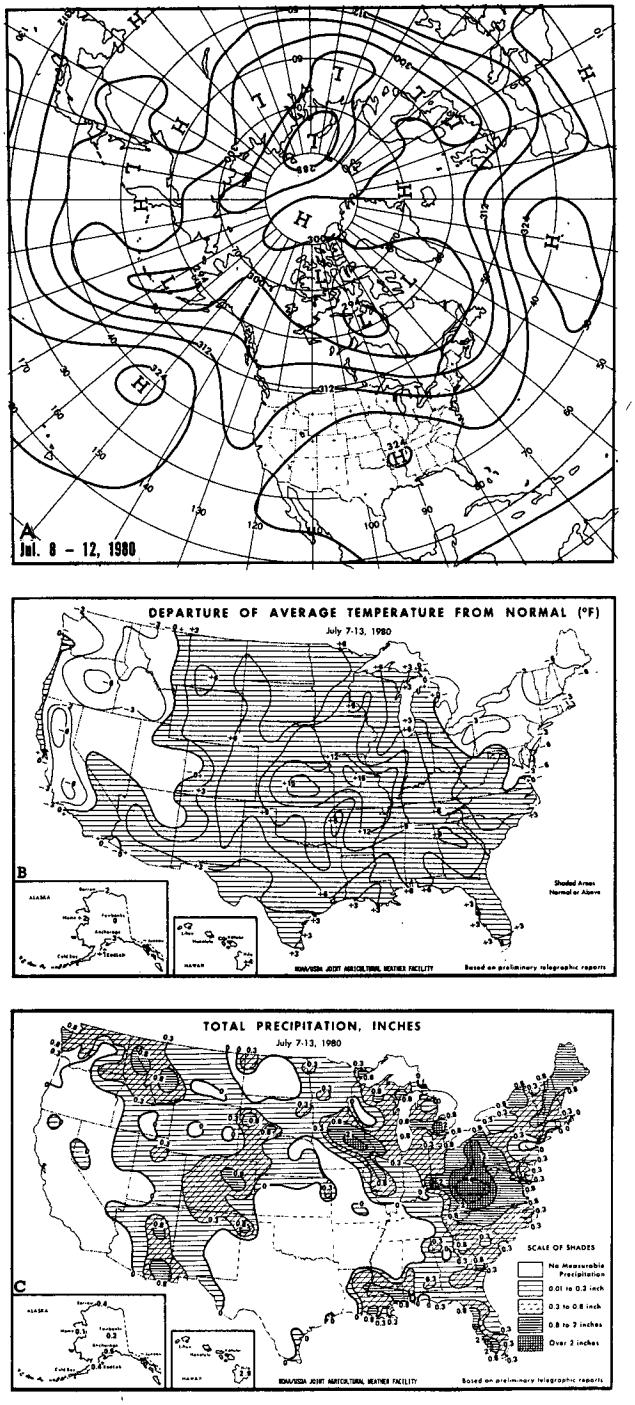
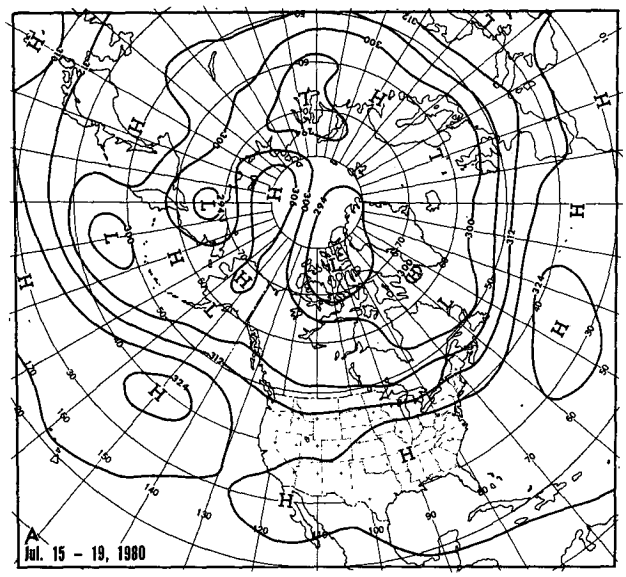
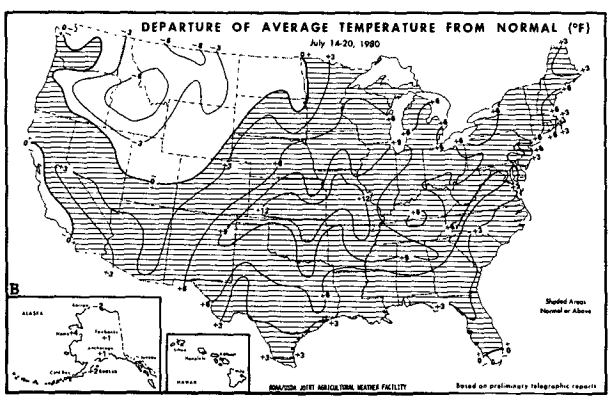


FIG. 9. As in Fig. 8 except for (A) 8–12 July 1980, and (B) and (C) week of 7–13 July 1980.

tenaciously persisted in Texas. Dallas continued to add to its string of consecutive 100°F or higher days. Much of the rain was produced in association with a strong front that moved rapidly southeastward in advance of the western trough driving eastward. A second frontal advancement in the latter part of the week lacked the potency of the





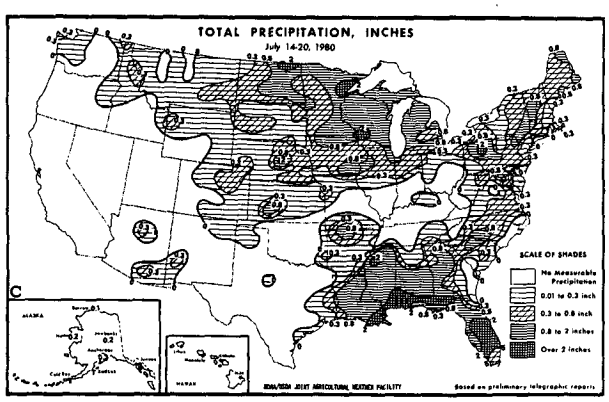
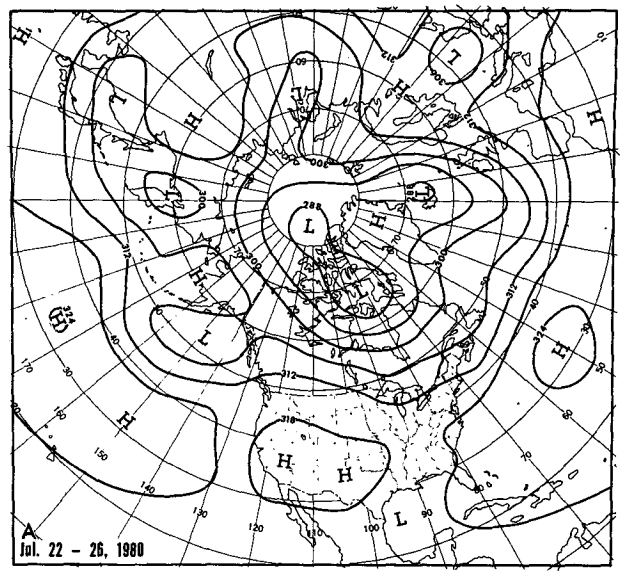
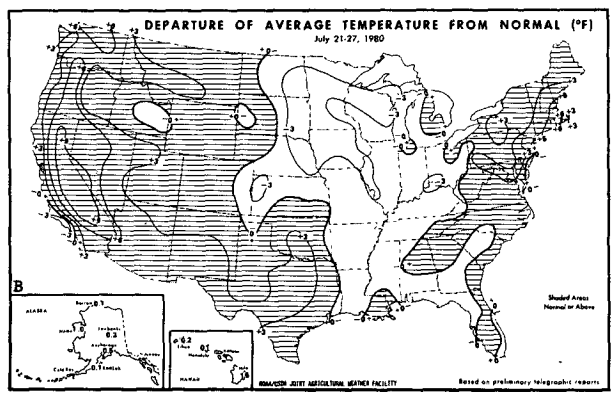


FIG. 10. As in Fig. 8 except for (A) 15–19 July 1980, and (B) and (C) week of 14–20 July 1980.





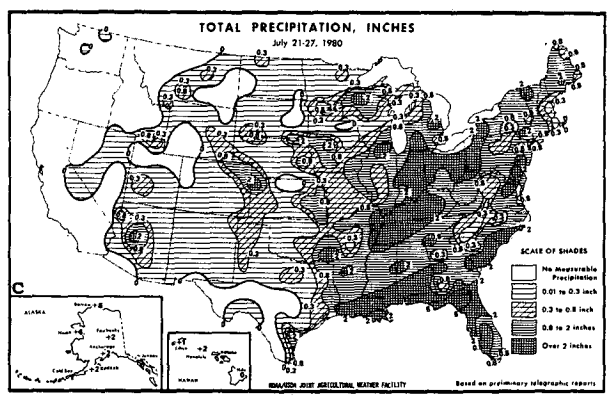
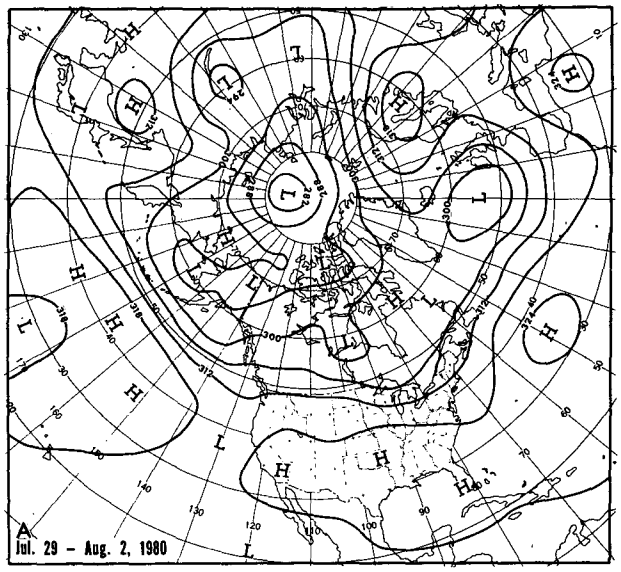
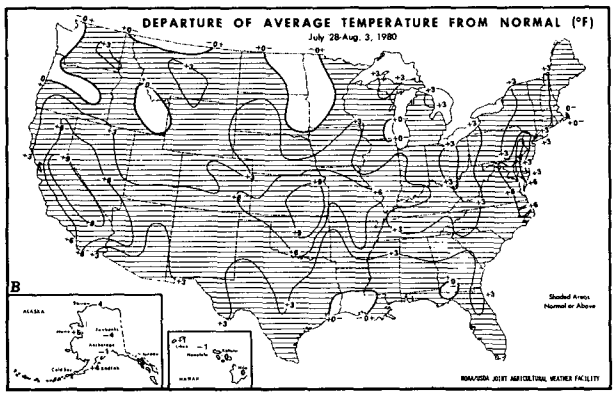


FIG. 11. As in Fig. 8 except for (A) 22–26 July 1980 and (B) and (C) week of 21–27 July 1980.

first. Some flooding occurred in the South either in conjunction with the strong frontal passage or the tropical disturbance described in the last section.

The rest of the hemispheric upper air pattern underwent major adjustments as well. With the notable exception of the North American anticyclone and the slight westward movement of the Atlantic high, virtually all waves and centers of





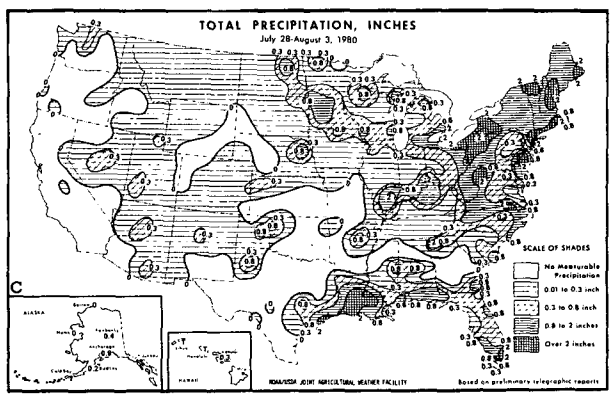


FIG. 12. As in Fig. 8 except for (A) 29 July–2 August 1980, and (B) and (C) week of 28 July–3 August 1980.

action from East Asia around almost to Europe advanced from their positions a week ago. Over northern Europe a new block that appeared the week before retrograded as it continued to grow, while west of the Black Sea a trough strongly developed.

Ominously, over the United States the upper high showed signs of a resurgence to the east as a ridge over the Pacific west of the dateline steadily approached the position north of Hawaii previously occupied by the main Pacific ridge.

e. 28 July–3 August

As the trough over the eastern United States moved off the coast (Fig. 12a) a ridge built behind it near the former central Plains location, abruptly returning the nation to a now familiar temperature anomaly pattern (Fig. 12b). Two important differences to note are that the departures from normal are not as large as before, but that positive values cover practically the entire nation.

Over both oceans the upper air pattern described by Namias (1955) is weakly indicated; the Atlantic ridge is still in place and the Pacific ridge is experiencing a comeback as the trough moves to the West Coast and a reinforcing ridge continues to approach from the west. Further upstream and to the north, eastward wave progression is still common as major hemispheric mass rearrangements continue to take place.

Most of the rainfall in the Northeast (Fig. 12c) fell in connection with a wave development in the Upper Ohio Valley and a weak coastal low at the beginning of the week. Throughout the rest of the week, as the ridge built in the east and later sagged, a stationary front that stretched across the midsection of the country sporadically encouraged showers. On 3 August, the last day of the week, Dallas had its forty-second and final consecutive day with high temperatures equal to or greater than 100°F.

6. Tropical activity

Four tropical storms—Darby, Estelle, Frank, and Georgette—formed over the tropical east Pacific in July. All were short-lived and only Georgette briefly attained hurricane intensity. In contrast, four typhoons formed in the well-developed easterlies in the western Pacific. Typhoon Ida reached the South China coast on 11 July, Joe crossed Luzon, passed Hainan and finally hit Vietnam on 23 July, and Kim (perhaps the most dangerous with sustained winds of 110 Kt before hitting Luzon) crossed Luzon and reached land near Hong Kong on 27 July. Typhoon Lex was well southeast of Japan at the end of the month.

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