WEATHER AND CIRCULATION OF JULY 1978

Hot and Dry over the Southern Great Plains

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1. Mean circulation

Rather fast westerly flow continued across the Pacific in July as the subtropical ridge remained north of its normal position and generally stronger than normal, particularly over Japan and the eastern Pacific (Figs. 1 and 2). Stronger than normal troughs extended southward from northeastern Siberia into the Sea of Okhotsk, and southward from the Aleutians into the central Pacific. Below-normal heights, persisting from June over the area south of Japan, continued to be associated with typhoon activity. With the exception of tropical activity, most storm tracks over the Pacific were north of 45°N, in agreement with the northward-displaced 700 mb wind maximum (Fig. 3).

The fast westerly flow across the Pacific led to some progression of the strong eastern Pacific ridge from its June position (Taubensee, 1978), and the trough that had been just off the northern

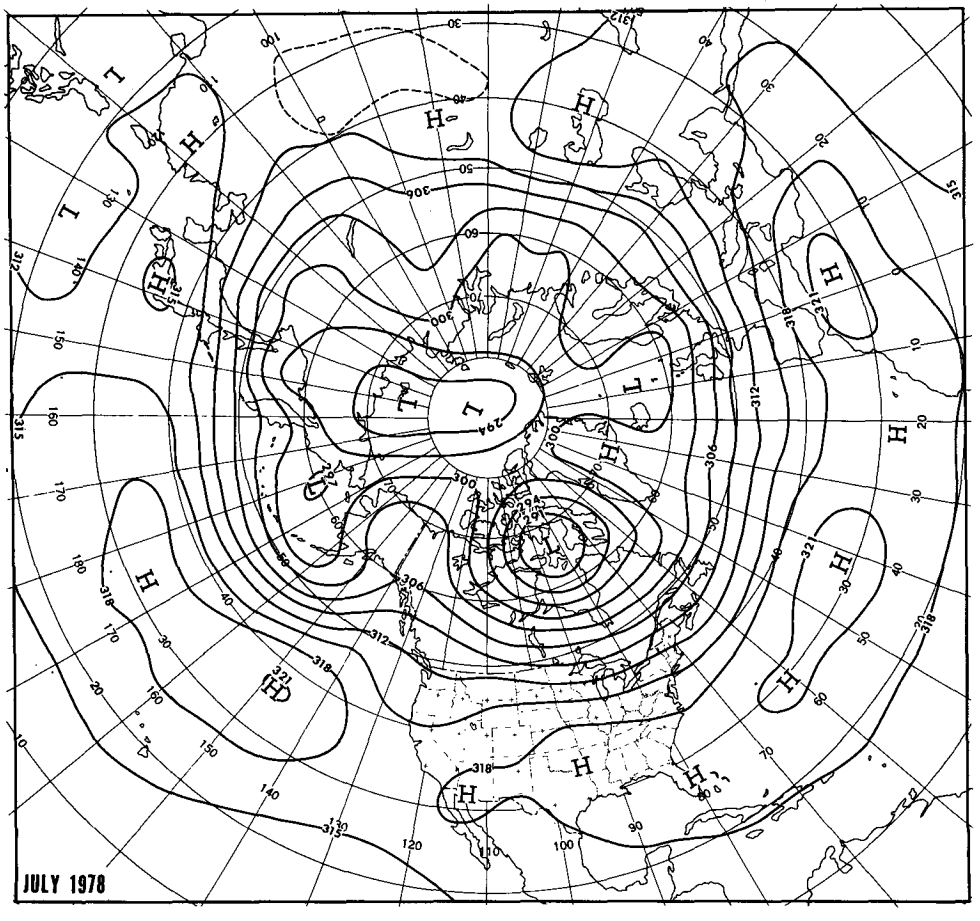

FIG. 1. Mean 700 mb height contours (dam) for July 1978.

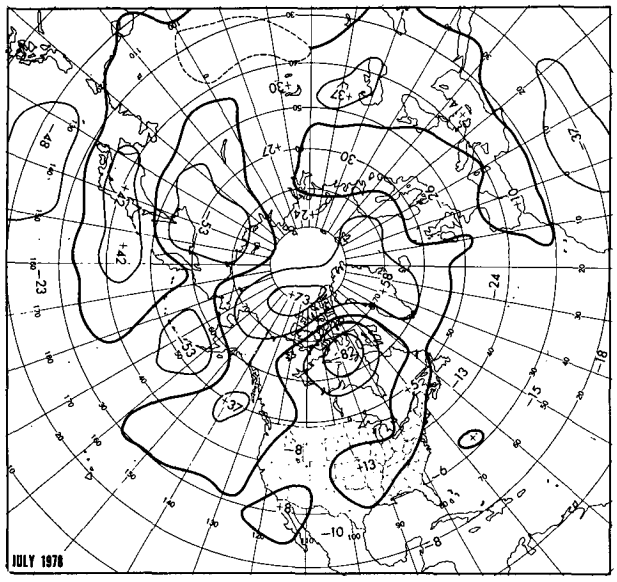

FIG. 2. Departure from normal of mean 700 mb height (m) for July 1978.

Pacific Coast moved inland. The stronger than normal ridge remained over the central United States, while slight slowing of the westerlies over the Nation, in keeping with the seasonal trend going into the midsummer, allowed retrogression of the lower part of the western Atlantic trough to near the Atlantic Coast.

Although the Atlantic subtropical high strengthened between June and July, the increase was less than the usual seasonal trend and the zonal flow was weaker than normal over the North Atlantic in July, in contrast to the highly amplified but unusually fast flow during June. Contributing to this decrease in speed and a south of normal displacement of the westerlies over the Atlantic (Fig. 3) was the development of a strong blocking high over Greenland (Figs. 1 and 2). An extensive area of higher than normal 700 mb heights over high latitudes resulted from the Greenland block and strong high-latitude ridge components extending northward from eastern Alaska and central Asia. The polar westerlies (55–70°N) index declined rapidly to below-normal values from its record-fast value in June (Taubensee, 1978).

The lower troposphere became warmer than normal in much of the region affected by the high-latitude blocking (Fig. 4). Although some warming was also evident over the eastern Mediterranean, cooler than normal weather continued to prevail over much of Europe and the western portions of the Soviet Union due to the high-latitude blocking and southward displaced midlatitude westerlies and their associated prevailing storm tracks (Fig. 3). Cooler than normal conditions also persisted over northern and central Canada in response to the deeper than normal mean cyclonic center over northern Hudson Bay.

2. Temperature

July averaged warmer than normal across most of the southern half of the United States and near or cooler than normal over the northern half (Fig. 5). The mean thickness pattern (Fig. 4) does not completely reflect the degree of coolness which actually occurred; this is probably due to the fact that much

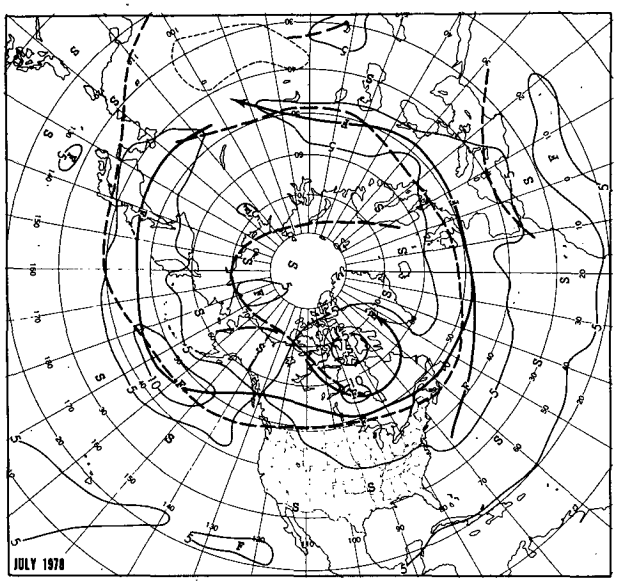

FIG. 3. Mean 700 mb geostrophic wind speed (m s^{-1}) for July 1978. Solid arrows indicate observed axes of maximum wind speed and dashed lines, the normal.

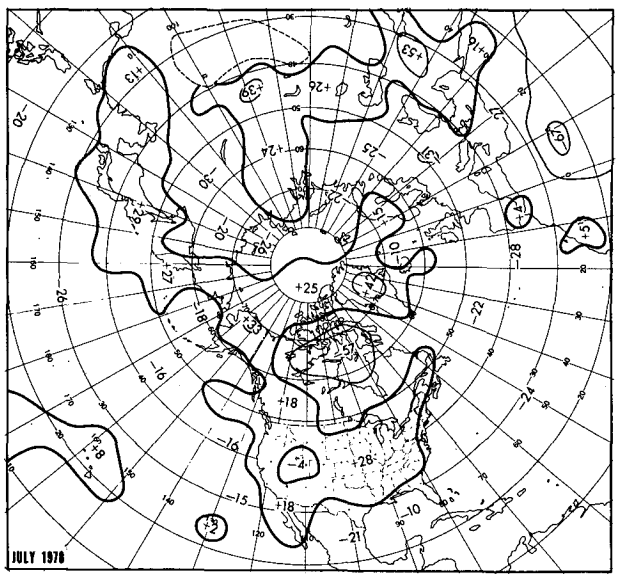

FIG. 4. Departure from normal of mean 1000–700 mb thickness (m) for July 1978.

of the cool weather was associated with shallow surface highs from the Canadian cold source and with cloudiness and relatively heavy precipitation which helped to cool the lowest layers of the atmosphere over the north-central states.

The largest negative temperature anomaly occurred over Montana just east of the Continental Divide, while the greatest positive anomalies of temperature were located over the Southwest and the southern Great Plains, in an area of increasing drought.

Even though the heat was prolonged and severe, with many Texas and Oklahoma stations recording maxima of 100°F or higher for more than half the month, only two stations reported the hottest July on record. These are Albuquerque, NM with 81.6°F, 2.9°F above normal, and Abilene, TX with 89.0°F, 5.1°F above normal. Oklahoma City averaged 87.0°F, 5.5°F above normal, for its hottest July since 1954 and Phoenix had its sixth hottest July on record, averaging 94.6°F, 3.4°F above normal.

Temperatures over most of Alaska averaged above normal under the influence of the high-latitude ridge and easterly (continental) anomalous flow, which is relatively warm in the summer, although the Aleutians were cooler than normal in response to cyclonic activity associated with the central Pacific trough. Most reporting stations in Hawaii also averaged warmer than normal.

3. Precipitation

Except for the southwest quarter of the country, most of the Nation had precipitation totalling near or greater than normal (Fig. 6). Active frontal systems, augmented by upslope precipitation over the northern Great Plains, swept across the northern half of the country and produced generally beneficial rains at intervals throughout the month. Most of the agriculturally important Corn Belt was enjoying a good growing season, with slight or moderate moisture excesses (Fig. 7). The combination of heat and drought over northern Texas, Arkansas, Oklahoma and New Mexico led to an increasing crop moisture deficit in soils in these areas. A limited area in the Southeast, mainly over Georgia, also had a substantial moisture deficit by the end of July. This pattern stands in sharp contrast to the extensive areas of drought prevailing at the end of July last year (Wagner, 1977).

Excessive rainfall led to flooding in parts of southeastern Minnesota and southwestern Wisconsin. More than 12 inches of rain, over three times the normal July total, fell in and near Rochester, where July 1978 was the wettest July on record. The only other locality reporting a record wet July was Charleston, WV where 9.83 inches, 4.79 above normal, was measured. Heavy rains of 8–12 inches fell over much of Florida and the eastern Gulf Coast from tropical airmass thundershowers, but no records were set.

The only localities reporting near-record dryness

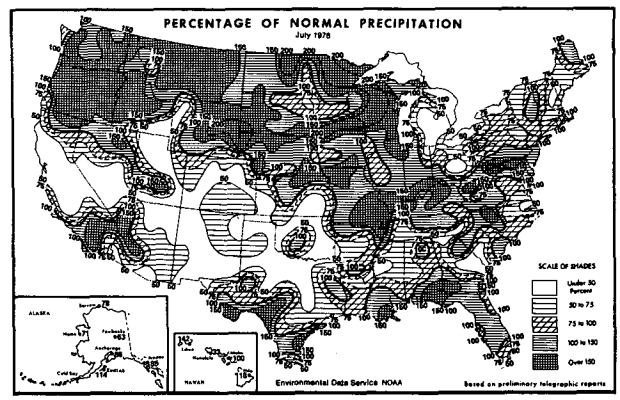

FIG. 6. Percentage of normal precipitation for July 1978 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1978).

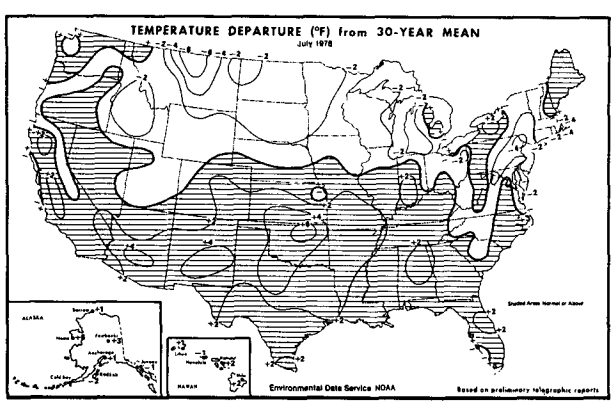

FIG. 5. Departure from normal of average surface air temperature (°F) for July 1978 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1978).

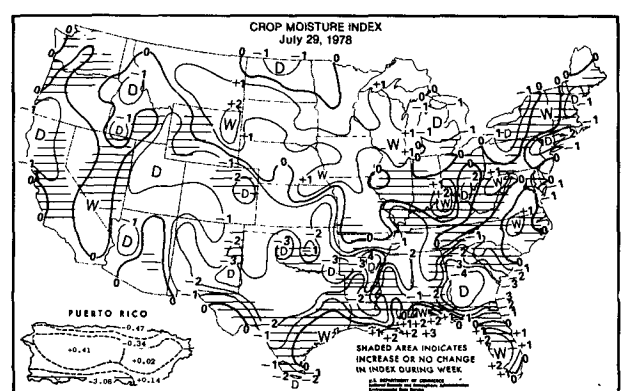

FIG. 7. Crop moisture index for the period ending 29 July 1978 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1978).

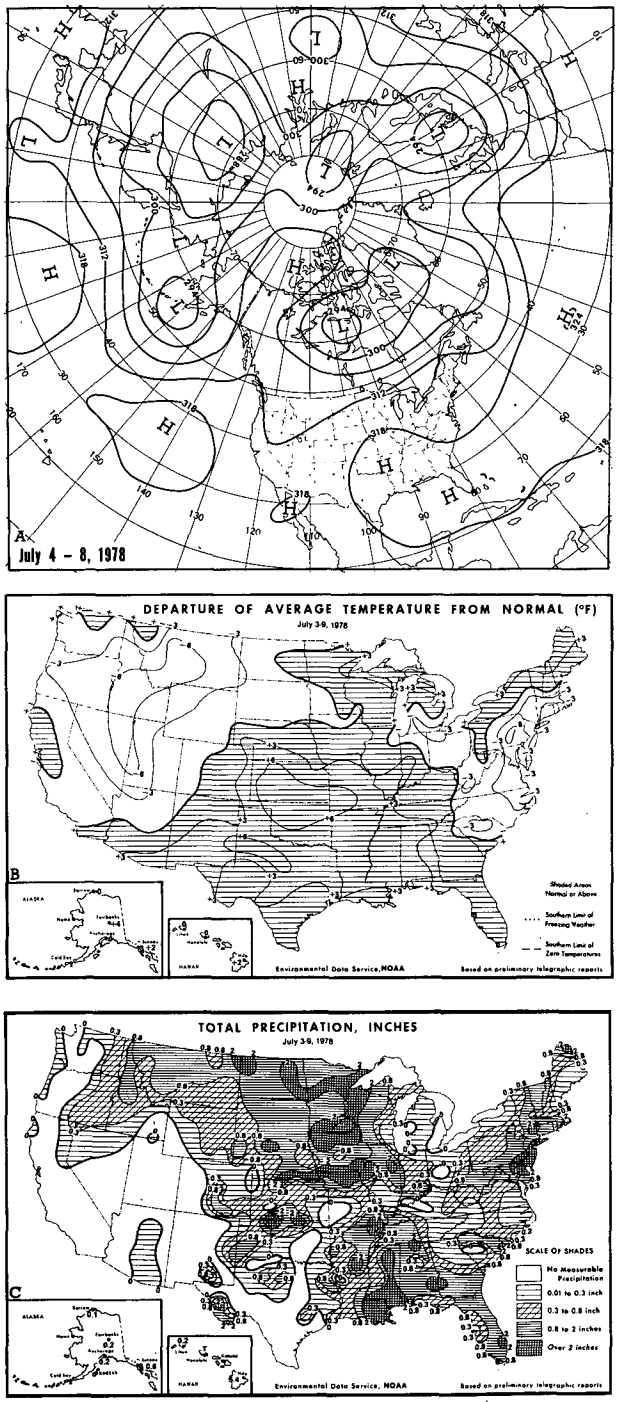

FIG. 8. (A) Mean 700 mb contours (dam) for 4–8 July 1978; (B) departure from normal of average surface air temperature (°F) and (C) total precipitation (inches) for weak of 3–9 July 1978 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1978).

were in the Great Lakes area. Houghton Lake, MI reported its driest July since 1936 with 0.91 inches of rain, and Erie, PA reported its driest July since 1916 and second driest on record with only 0.65 inches. No new precipitation records were reported in the southern Great Plains drought area.

Precipitation averaged below normal over most of Alaska under the influence of the strong mean 700 ridge; storminess associated with the mean trough over the north-central Pacific brought somewhat above-normal rainfall to the Aleutians. Precipitation in Hawaii was quite variable but averaged near normal at the available reporting stations.

4. Weekly variability

a. 3–9 July

Deepening of a 700 mb low over northeastern Siberia strengthened the westerlies over the northwestern Pacific, causing the mean trough that had been just east of Kamchatka the previous week (Taubensee, 1978) to progress to the Aleutians (Fig. 8A). Deepening of this feature in that locality contributed to slight retrogression and marked amplification of a high-latitude ridge over the western Canadian Archipelago, in effect transferring the center of arctic blocking from near Novaya Zemlya to the Western Hemisphere. A deep mean vortex formed near the northwest shore of Hudson Bay, completing an "omega" blocking pattern along with the Aleutian low and the arctic ridge.

Over the United States, the West Coast trough moved inland and weakened, the ridge over the middle of the country was quasi-stationary, and the trough off the Atlantic Coast weakened and sheared under the influence of increasing westerlies over Canada.

Temperatures in the northwestern quarter of the United States cooled with the arrival of the trough, with precipitation ending over most coastal regions as the trough moved inland (Figs. 8B and C). The advection of tropical moisture northward through the Great Plains to the strengthening baroclinic zone over the northern Mississippi Valley set off heavy thunderstorms and flash flooding over southeastern Minnesota and western Wisconsin. Rochester, MN reported a record 24 h total of 6.74 inches during 5–6 July. Other localities in the area were struck by severe thunderstorms, hail and tornadoes.

The heat wave increased its intensity over the southern Great Plains. Dodge City, KS tied its all-time record high temperature with 109°F, the hottest in 35 years, while 103°F at Springfield, MO was the hottest in 22 years.

In sharp contrast, the East Coast states averaged unseasonably cool for the week, mainly due to an unusually cool and wet Fourth of July weekend. Harrisburg, PA reported 14 heating degree days during this cool spell, which was the greatest July total on record. A minimum of 40°F on 2 July at Albany, NY was the lowest temperature over observed in July. The same reading set daily records on both

the 2nd and 3rd at Burlington, VT and Concord, NH set a daily record minimum of 38°F, also on the 2nd.

Greatest weekly mean temperature anomalies were observed over the middle Atlantic States, where a slowly moving coastal storm produced several days of cloudiness and some heavy all-day rains that kept maximum temperatures far below normal. On 3 July, 3.83 inches of rain chilled vacationers at Atlantic City.

b. 10–16 July

The Aleutian trough weakened, resulting in a flattening of the flow pattern downstream over the eastern Pacific and most of North America (Fig. 9A). Some redeepening of a trough near the East Coast occurred. The blocking ridge over the Canadian Arctic retrograded somewhat but the deep mean low remained close to the northern shore of Hudson Bay. A blocking high also developed west of Scotland with a portion of the westerlies undercutting it and forming a mean low to the south.

Temperatures rose to a few degrees below normal over the Pacific Northwest, but the Northeast cooled while it remained cool in the middle Atlantic States (Fig. 9B). Weekly mean temperatures were as much as 6°F below normal in Michigan, where scattered light frost was observed on 12 July. Many localities reported record daily low temperatures on the 12th and 13th. The temperature at Concord, NH dropped into the upper thirties for the second time this month on the 12th, and the following day a minimum of 54°F at Norfolk, VA was the lowest ever observed there in July.

The heat wave continued unabated over the southern Great Plains and Southwest, with most places averaging at least 3–6°F above normal. Many daily maximum temperature records were broken with readings well over 100°F throughout the area, and the 114°F maximum on 15 July at Wichita Falls, TX was the highest temperature ever observed at that locality.

Precipitation fell over all areas except for the Texas Plains, California and the Great Basin (Fig. 9C). As is typical of summer, precipitation amounts varied widely over limited areas. Heaviest totals of 2–5 inches fell over Missouri and portions of the Southeast. Birmingham reported 3.50 inches in less than an hour on the 14th and Charleston measured 3.19 inches within a 24 h period on the 15th and 16th. Tornadoes, hail and high winds were observed in several states in the Great Plains, Midwest and Southeast.

c. 17–23 July

Both the blocking ridge over the Canadian Arctic and the Aleutian low weakened considerably after

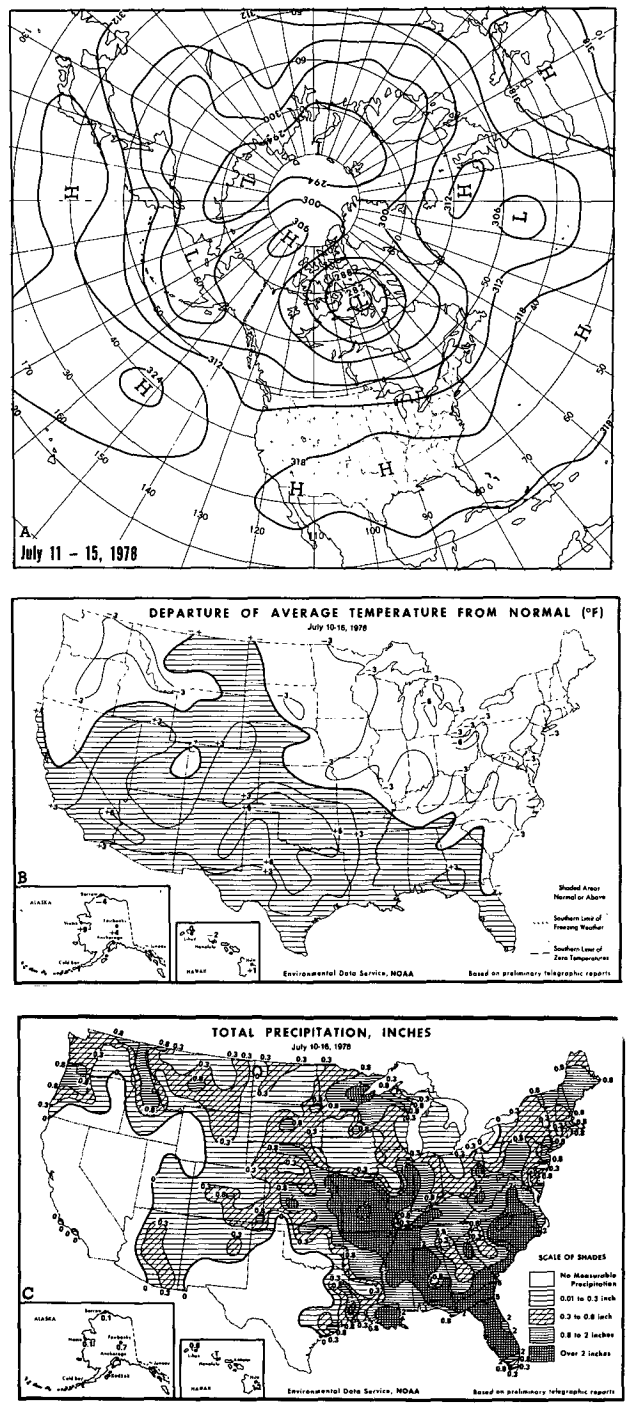

FIG. 9. As in Fig. 8 except for (A) 11–15 July 1978 and (B) and (C) week of 10–16 July 1978.

the middle of the month, while ridges tended to dominate the West Coast (Fig. 10). The trough near the East Coast weakened and was replaced by a strong westward extension of the Bermuda high during the third week of the month (Fig. 11A). As a result, both the West and East Coast states had a generally cool first half and hot last half of July.

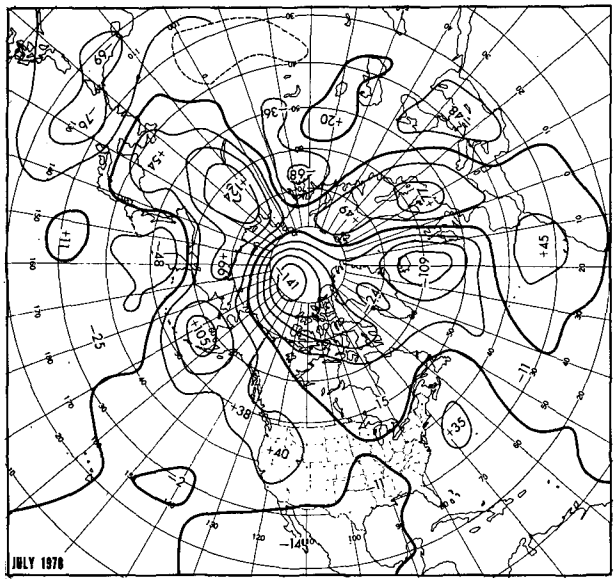

FIG. 10. Mean 700 mb height change (m) from first half to second half of July 1978.

The northward building and retrogression of the eastern Pacific ridge advected very cool Canadian air circulating around the Hudson Bay low southward into the northern portions of the Rocky Mountains and the Great Plains, where temperatures averaged more than 9°F below normal in Montana (Fig. 11B). The strong westward extension of the Bermuda high, however, limited the southward and eastward spread of the cold air so that temperatures remained above normal over the southern Great Plains and rose above normal in most areas east of the Mississippi River. Temperatures rose to the highest levels since the previous summer on 23 July over most of the East Coast states. Daily records were set with readings as high as 100°F at Concord, NH, 99°F at Hartford, CT and 100°F at Washington, DC. At the latter location the record high minimum of 81°F for the date was tied.

Temperatures of well in excess of 100°F continued to bake the southern Great Plains, and a reading of 110°F at Abilene, TX on the 17th equaled the highest ever recorded in July there. Hot weather also developed in the California interior valleys with maximum temperatures rising well above 100°F.

Precipitation fell over most of the country except for the West (Fig. 11C). Heaviest amounts were observed in the northern half of the Great Plains and Mississippi Valley, where frequent frontal activity occurred in the region of temperature contrast. A weak easterly disturbance south of the subtropical ridge axis also produced heavy showers and thunderstorms along much of the Gulf Coast. Showers, mainly light, broke out in Texas at the end of the period when a weak cold front penetrated the area.

d. 24–30 July

The sharply amplified trough that had been over the Aleutians the previous week progressed, with some weakening, into the Gulf of Alaska (Fig. 12A). The eastern Pacific ridge flattened and retrograded, allowing the subtropical ridge over the Southwest

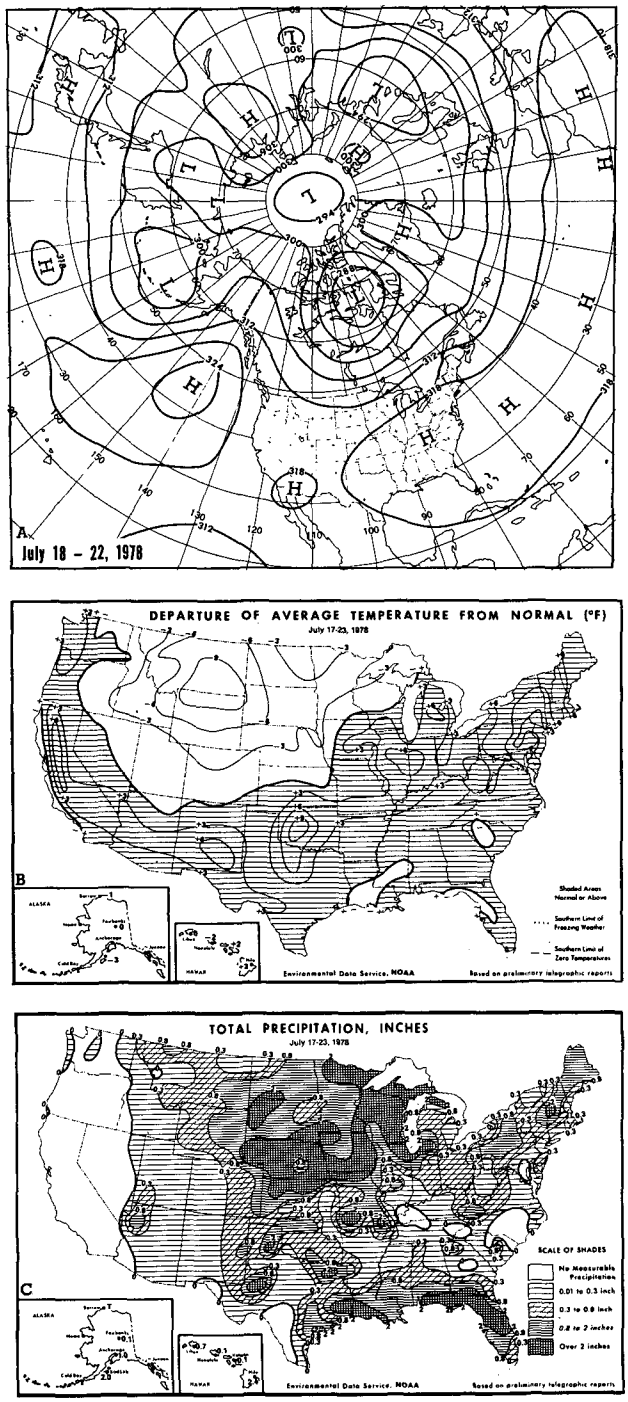

FIG. 11. As in Fig. 8 except for (A) 18–22 July 1978 and (B) and (C) week of 17–23 July 1978.

to amplify and build northward over the Rocky Mountains. With low pressure developing over the Arctic Ocean, the high-latitude westerlies strengthened and the Hudson Bay low moved eastward to southern Baffin Island. The associated trough extending southward from this low also progressed from the northern Great Plains to the Great Lakes and extended its influence southward to the southern Appalachians.

Temperatures rose well above normal over the entire western third of the country in response to the ridging, and fell to below normal over the north central and northeastern states as cool Canadian air once again penetrated the area (Fig. 12B). Record low daily temperatures were observed at several localities. Sault Ste. Marie and Detroit observed 39°F and 48°F, respectively, on the 28th, and Concord, NH had a reading of 43°F on the 29th.

Although weekly mean temperatures were not quite so hot, some daily records were still set in the heat wave area near the end of the month. Albuquerque had 102°F on the 20th and 103°F on the 29th. Oklahoma City observed its highest temperature of the month on the 26th with 106°F, and the reading of 103°F at North Little Rock, AR on the 30th also was a new daily record high.

Precipitation was distributed over most of the country with heaviest amounts falling in the Ohio Valley and the South (Fig. 12C). Several localities reported exceptionally heavy totals for short periods. Phoenix measured 0.50 inches in 5 min on the 24th, which was over one-third of the total for the whole month. Midland, MI reported 3.50 inches in 15 min on the 26th, and Lexington, KY had 4.33 inches on the 30th. On the last day of the month, substantial rains from Tropical Storm Amelia moved into the lower Rio Grande Valley, giving some relief from the drought.

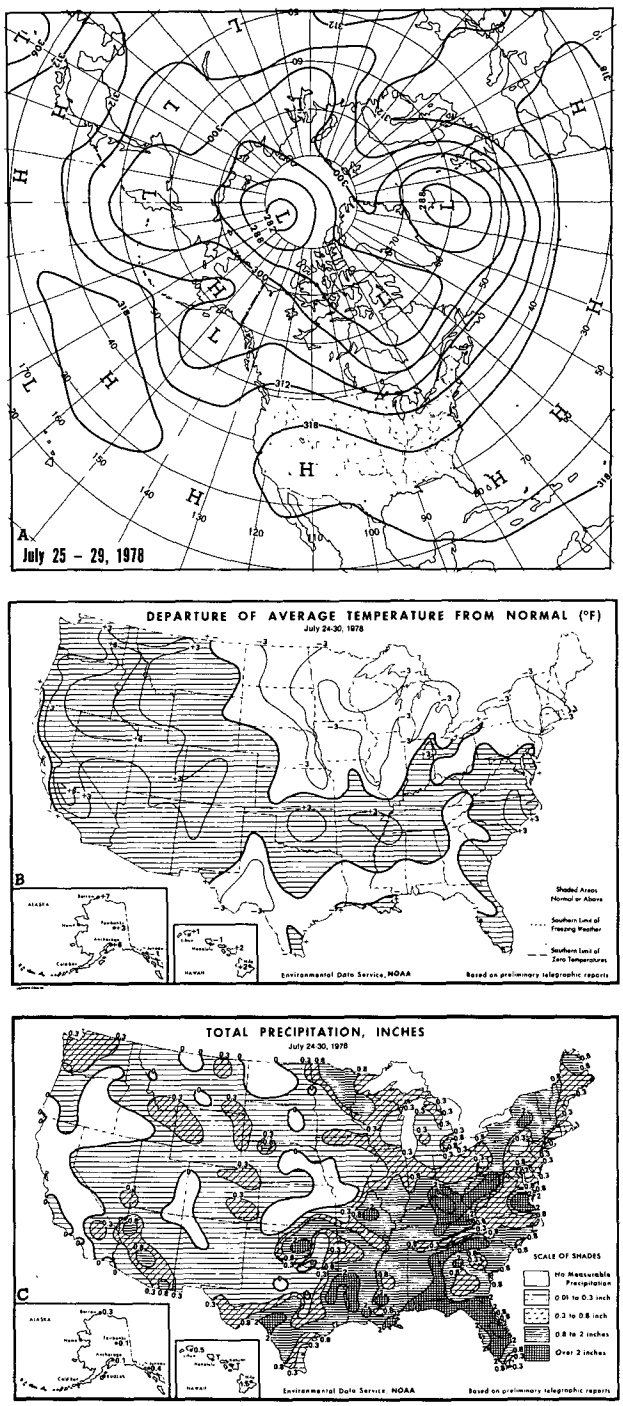

FIG. 12. As in Fig. 8 except for (A) 25–29 July 1978 and (B) and (C) week of 24–30 July 1978.

5. Tropical Activity

There were no named storms in the Atlantic or adjacent waters until 30 July, when Tropical Storm Amelia formed from a weak depression in the southern Gulf of Mexico, where water temperatures had been somewhat above normal. She moved northwestward and crossed the lower Texas coast near Brownsville that evening. All signs of a surface circulation disappeared by the end of the 31st, but heavy rains from the moisture brought inland continued over central Texas for the first several days of August.

The lack of tropical storm activity over the Atlantic proper continued the trend of recent years but appeared unusual this year since the lower tropospheric subtropical easterlies were stronger than normal in July 1978. There were, however, extensive areas of below-normal sea surface temperatures over the eastern Atlantic at low and middle latitudes that may have suppressed development of the African "seedling" disturbances.

There were five tropical storms active over the eastern Pacific during July, and four of these reached hurricane intensity. Hurricane Daniel formed during

June and moved westward near 16°N, weakened to a tropical storm on 2 July, diminished to a depression on the 3rd, and dissipated near 140°W on the 4th.

Tropical Storm Emilia formed on 6 July just north of the ITCZ near 15°N, 113°W. She moved westward and then northwestward, finally dissipating near 22°N, 125°W on 10 July while turning northward over cooler water.

Fico was an unusually long-lived and long-path hurricane, forming as a tropical storm on the ITCZ near 12°N, 109°W on 9 July. He became a hurricane the next day and commenced a steady but slow west-to-west-northwestward trajectory. He passed south of Hawaii, bringing heavy surf but nothing unusual in the way of rain or wind. He weakened to a tropical storm on 26 July near 25°N, 175°W after turning northward over cooler water. By the 28th Fico was classified as an ordinary low. The remains accelerated northward between a strong ridge to the east and a trough to the west, and eventually redeveloped as an extratropical system south of the Aleutians on the 30th.

Tropical Storms Gilma and Hector both formed near 12°N, 102°W, on the 13th and 22nd of the month, respectively. Both storms were briefly hurricane intensity—Gilma for a day and Hector for three days. They followed similar trajectories, with Gilma dissipating on the 21st near 24°N, 136°W and Hector dying on the 31st near 25°N, 140°W.

There was no tropical storm activity over the western Pacific until just before the middle of the month when a depression formed near 20°N, 148°E. Tropical Storm Trix developed from this center on the 15th and became a typhoon the next day. After moving on an irregular path, she weakened again to a tropical storm on the 19th, moving northwestward and then turning to the west a short distance south of Japan. She weakened to a depression on the 22nd before going ashore on the Chinese mainland south of Shanghai on the 23rd.

Three tropical storms formed within a few days of each other between the 23rd and 25th. Virginia developed near 17°N, 151°E late on the 23rd, Wendy formed near 21°N, 135°E on the 24th, and Agnes intensified from an active depression in the South China Sea on the 25th. All three storms showed signs of interacting with one another, and the first two became typhoons.

Virginia followed the most straightforward path, moving first westward, then northwestward, and finally turning north on the last day of the month east of Japan. Wendy became a rather large storm and moved very slowly at times. She moved northwestward and then northward to near 30°N, 125°E by the 29th, where she became quasi-stationary midway between southwest Japan and mainland China through the end of the month. Agnes grazed the south China coast near Hong Kong on the 26th, then milled around just off the coast through the 29th, finally weakening to a depression and dissipating on the 30th.

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