WEATHER AND CIRCULATION OF JULY 1979
Heavy Rain and Floods from Two Tropical Storms

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1. Mean circulation

The vigorous circulation at high latitudes that became established during June (Taubensee, 1979) continued throughout most of July, with deeper than normal lows located near the North Pole and over Baffin Island (Figs. 1 and 2). The wave pattern over Asia and the Pacific deamplified as the strong ridge that had been over central Asia moved northward and took on more of the characteristics of a block near the Tamyr Peninsula. A weak band of westerlies undercut the block and confluence of this stream with a more vigorous northwesterly flow from the Arctic led to a rather deep trough east of Japan.

Loss of much of the midlatitude portion of the Asian ridge removed upstream barotropic support for the strongly amplified mid-Pacific ridge that had prevailed during June. The main band of westerlies followed a fairly straight path across the Pacific, close to the normal position and strength (Fig. 3), except for the vigorous maximum in the trough. A

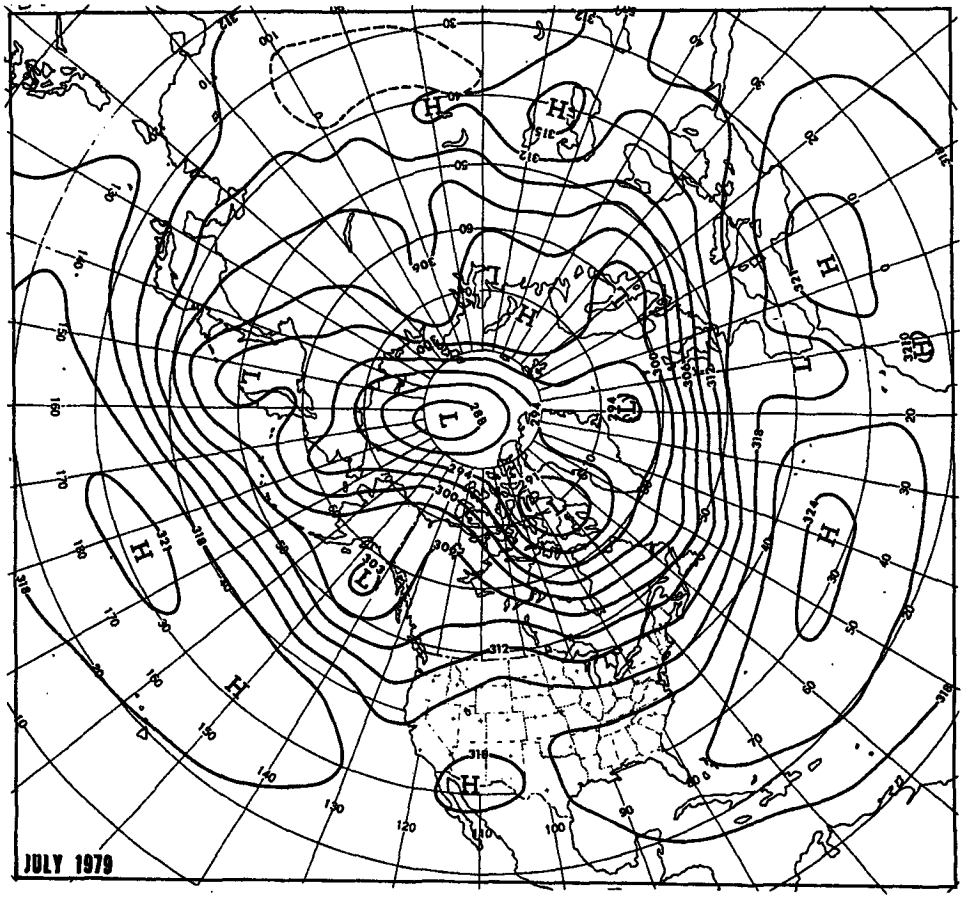


FIG. 1. Mean 700 mb height contours (dam) for July 1979.

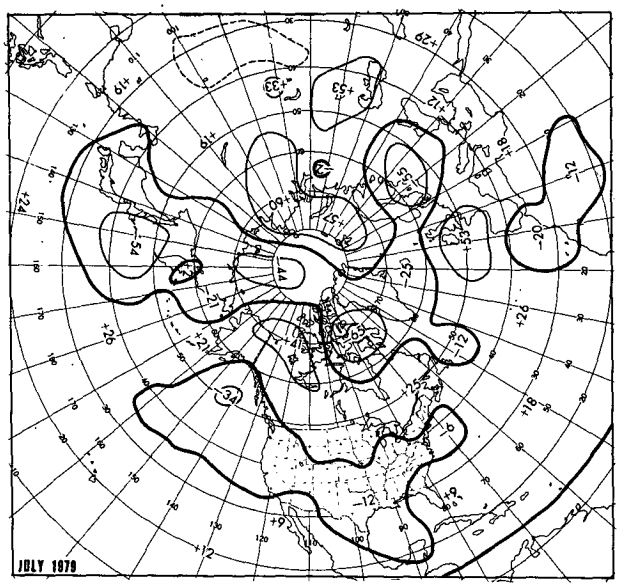


FIG. 2. Departure from normal of mean 700 mb height (m) for July 1979.

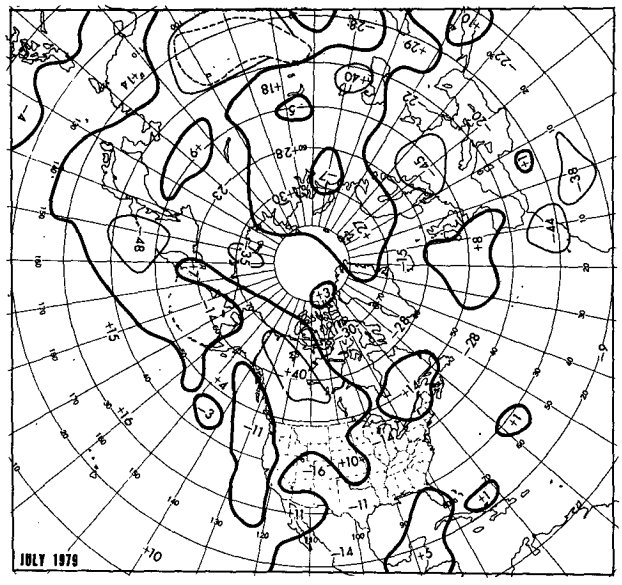


FIG. 4. Departure from normal of mean 1000–700 mb thickness (m) for July 1979.

substantially greater than normal supply of cold air advected in the northwesterly flow from the Arctic across the Sea of Okhotsk contributed to the vigor of extratropical cyclones emanating from the west Pacific trough (Figs. 1 and 4). A number of these storms curved sharply northward through the Bering Strait along the secondary wind maximum at high latitudes (Fig. 3).

The trough off the west coast of North America deepened, while strong high-latitude westerlies south of the polar low contributed to progression of a high-latitude ridge from Alaska to northwest Canada. The flat ridge components that had been over British Columbia and just east of the northern Rocky Mountains phased while progressing to the northern Great Plains and Canadian Prairies.

A variety of out-of-phase trough components south of the vigorous Baffin Island low were located over the Great Lakes, the north Atlantic coast of the United States and east of Newfoundland. Fast westerly flow with an enhanced baroclinic zone prevailed across the North Atlantic from Newfoundland to Scotland, leading to progression and deepening of a trough in eastern Europe. A strong ridge built northward from the Caspian Sea, shunting a weakened remnant of the strong trough that had been near the Ural Mountains in June eastward toward central Asia.

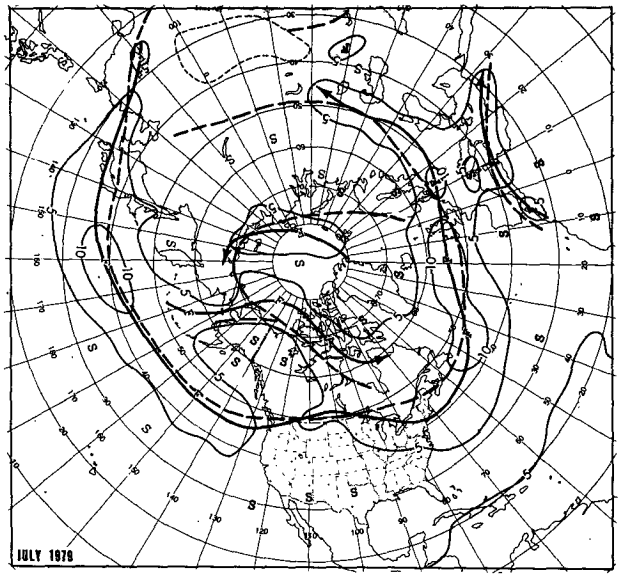


FIG. 3. Mean 700 mb geostrophic wind speed (m s^{-1}) for July 1979. Solid arrows indicate observed axes of maximum wind speed and dashed lines, the normal.

2. Temperature

July mean temperature anomalies were not extreme over most of the Nation (Fig. 5) and bore the expected resemblance to both the height anomaly and thickness anomaly patterns (Figs. 2 and 4). The coolest conditions relative to normal prevailed from the south central part of the country eastward to the middle Atlantic Coast, and were due to a combination of unusually cold air of Canadian origin early in the month, and abnormally cloudy, wet conditions for much of the remainder of the month. It was the first July since 1943 that the temperature failed to reach 90°F at Detroit, MI and the first year since 1915 that no 90°F reading had been observed this late there. It was not until 12 July that the tem-

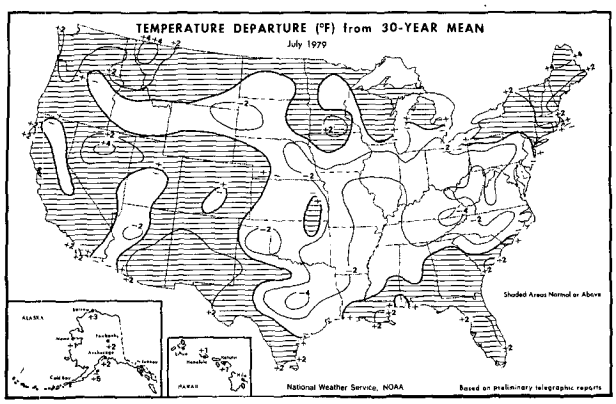


FIG. 5. Departure from normal of average surface air temperature (°F) for July 1979 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1979).

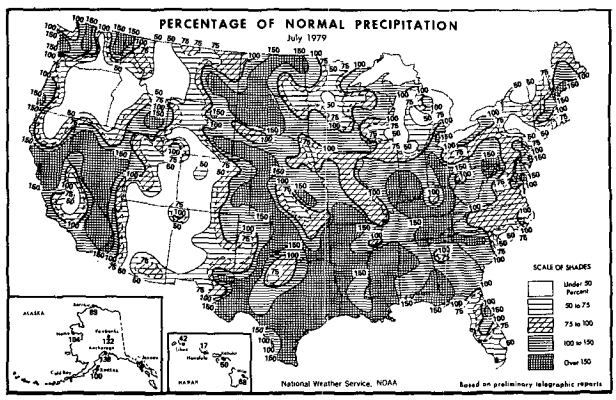


FIG. 6. Percentage of normal precipitation for July 1979 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1979).

perature reached 90°F at Washington, DC—the latest on record. Temperatures averaged a few degrees above normal over most of the West, the eastern Gulf and south Atlantic coastal areas, and across the northern border from the Pacific Coast to New England. Mean thickness anomalies indicate that somewhat warmer than normal air masses prevailed in most of these areas (Fig. 4).

Temperatures averaged above normal over Alaska under the influence of above normal 700 mb heights and southwesterly flow, continuing and expanding the area of abnormal warmth from the previous month (Taubensee, 1979). Temperatures over Hawaii ranged from near to a little above normal south of a slightly stronger than normal subtropical ridge.

3. Precipitation

Changeable circulation patterns during the month ensured that most of the Nation received at least near normal precipitation totals during July. Most of the area between the western Great Plains and the Appalachian Mountains received substantially more than the normal July rainfall (Fig. 6). Two tropical storms moving on similar paths about two weeks apart contributed to excessive rainfall of more than 16 inches along portions of the central Gulf coast from east Texas to the Florida Panhandle, as well as over 12 inches in southern Indiana. Damaging floods and record rainfall totals were observed in both areas (Table 1). Although not having a record wet July, Shreveport, LA reported it had already received its normal total annual rainfall before the end of the month. This had happened on only three previous occasions prior to the end of July. Another area of greater than normal precipitation occurred along the West Coast and portions of the southern and central Plateau, where total amounts were mostly around an inch or less in this normally dry area.

The only areas substantially drier than normal were the Rocky Mountains and the Northwest interior, as well as small sections of the Great Lakes region and the Northeast (Table 1). Several forest fires were burning in the northwestern dry area at the end of the month. Most of the agriculturally important areas of the country had ample crop moisture reserves in the topsoil (Fig. 7), whereas there were areas of severe drought in the southern Great Plains and the Southeast at the end of July the previous year (Wagner, 1978).

Greater than normal precipitation fell over most of Alaska under the influence of southwesterly flow and the Bering Strait storm track. Hawaii was drier

TABLE 1. Record and near-record monthly rainfall totals observed over the United States during July 1979.

Station	Amount (inches)	Anomaly (inches)	Remarks
Austin, TX	10.54	+8.66	3rd wettest July
San Antonio, TX	7.38	+5.69	4th wettest July
Galveston, TX	17.48	+13.07	3rd wettest July
Port Arthur, TX	15.60	+9.71	4th wettest July
Pensacola, FL	20.36	+13.03	Wettest July
Jackson, MS	13.25	+8.98	Wettest July
Chattanooga, TN	11.78	+6.64	Wettest July
Louisville, KY	10.05	+6.29	2nd wettest July
Indianapolis, IN	11.06	+7.39	Wettest July
Burlington, VT	1.23	−2.31	Driest June–July
Albany, NY	2.78	−0.34	Dry until 26th when most of month's rain fell
Sault Ste. Marie, MI	4.42	+1.82	11 consecutive rainless days early in month, 2nd longest July dry spell
Houghton Lake, MI	0.87	−2.20	Driest July since 1936
South Bend, IN	1.75	−1.92	Only 0.05 inch through 23rd
Columbia, MO	2.97	−0.92	Only 0.22 inch 4 weeks through 25th

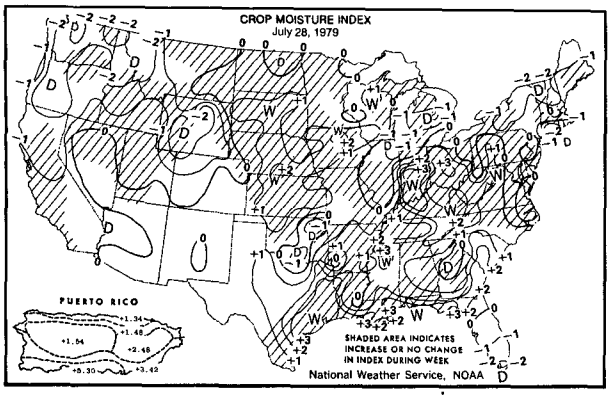
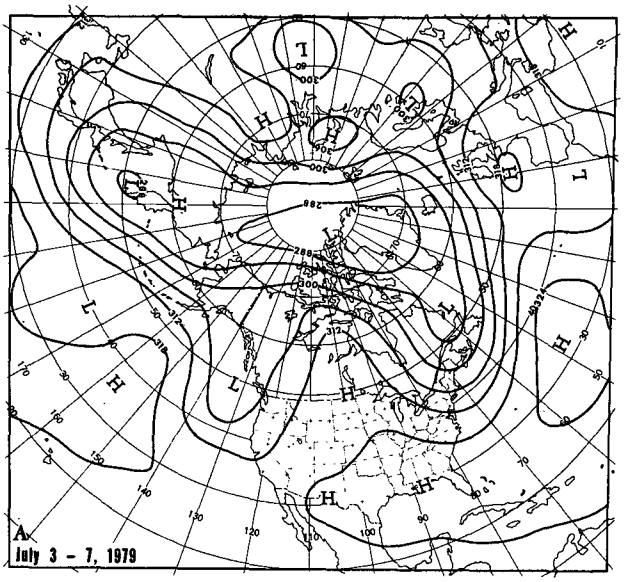
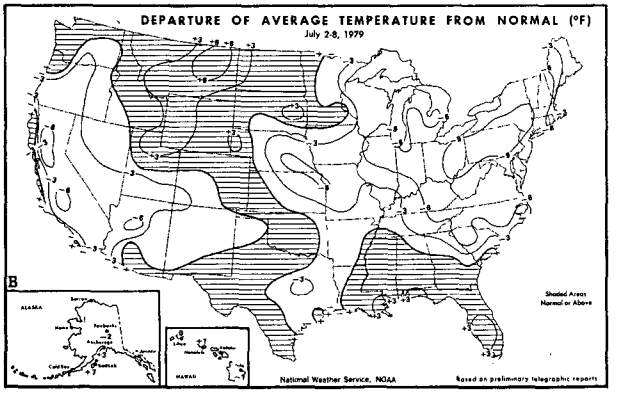


FIG. 7. Crop moisture index for the period ending 28 July 1979 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1979).





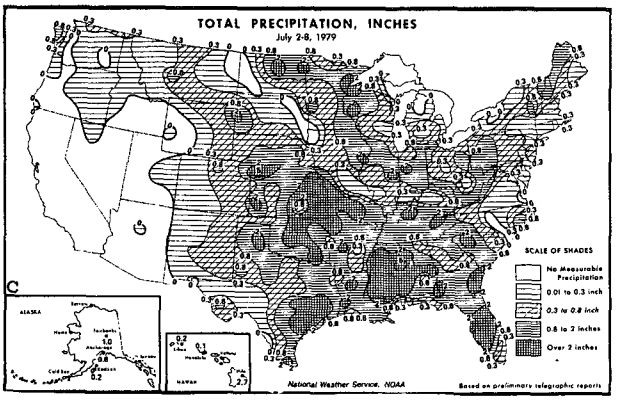


FIG. 8. (A) Mean 700 mb contours (dam) for 3–7 July 1979; (B) departure from normal of average surface air temperature (°F) and (C) total precipitation (inches) for week of 2–8 July 1979 (from National Oceanic and Atmospheric Administration and Economics, Statistics and Cooperatives Service, 1979).

than normal under the moderately strong subtropical ridge.

4. Weekly variability

a. 2–8 July

The amplification of the 700 mb flow pattern that had begun during the last week of June (Taubensee, 1979) proceeded even further during the first week of July as deep mean troughs near the Pacific and Atlantic coasts of North America flanked an unusually strong ridge over central Canada (Fig. 8A). Temperatures averaged well below normal over most of the northeastern quadrant of the United States under the influence of an extensive high-pressure system that moved slowly southeastward from the western shore of Hudson Bay (Fig. 8B). Many record-low daily minimum temperatures were observed on the 5th and 6th from the Midwest eastward to New England, and as far south as North Carolina the next two days. The cold spell was ushered in by 0.8 inches of snow at the Mt. Washington, NH observatory, and the temperature of 45°F on 6 July at Dulles International Airport west of the Nation's Capital was a new July record. The 54°F minimum at Norfolk, VA on the 7th tied the record low July minimum there.

Above normal temperatures were confined mainly to the deep South, the northern Great Plains and Alaska. All of these areas were influenced by stronger than normal 700 mb ridges. Hawaiian temperatures averaged close to normal.

Precipitation occurred over the entire country except for the Southwest, with heaviest totals in the central and southern states (Fig. 8C). Severe thunderstorms and a few tornadoes occurred in some of the heavy precipitation areas. An unusual snowfall of 5.8 inches, which was a new July record, fell at Stampede Pass, WA on the first day of the month when a deep cold low moved out of the mean trough off the coast. There was insufficient moisture for measurable precipitation in the southwestern states, even though a fairly strong cold front did bring subnormal temperatures to the area.

b. 9–15 July

Below normal 700 mb heights and fast polar westerlies continued over the Canadian side of the Arctic. Marked flattening of the flow pattern occurred in the North American sector and adjacent oceanic areas, while blocking ridges amplified over the Bering Sea and Novaya Zemlya (Fig. 9A).

The increasing westerlies across North America cut off the flow of Canadian air into the United States and pushed warmer than normal temperatures eastward across the Great Lakes to the Northeast, where some localities averaged more than 6°F above normal (Fig. 9B). Residual coolness remained over the Pacific Northwest following the final vigorous short-wave trough before the flow flattened, and below normal temperatures over the Southeast were mainly related to extensive cloudiness and precipitation. A severe heat wave was observed at El Paso, TX, which had 10 consecutive days with maximum temperatures over 100°F, five of which were daily records, culminating in an all-time record maximum of 112°F on 10 July. Albuquerque, NM had a record seven consecutive days with maxima over 100°F, and tied its record July maximum temperature with 104°F on the 13th.

Very little precipitation fell west of the Rocky Mountains, but excessive totals from the Gulf Coast northward to the Ohio Valley were largely due to Hurricane Bob, which moved inland across southeastern Louisiana on 11 July (Fig. 9C). Some of the heavy amounts were due to convective activity in the very humid air that surrounded the storm. Local flooding occurred both in the Gulf Coast states and from southern Indiana through West Virginia.

c. 16–22 July

Weakening of the troughs near the east and west coasts of North America during the last half of July was indicated by substantial 700 mb height rises centered over the eastern Pacific and near Newfoundland (Fig. 10). Marked deepening of a polar low just north of Hudson Bay is reflected by a large height fall center in that area. A more active channel for storms moving from the central Atlantic across northwestern Europe to Novaya Zemlya is also clearly evident. Heights rose across most of the Pacific at middle latitudes.

During the third week of July, a new deep low developed over Baffin Island while the original polar low remained north of eastern Siberia (Fig. 11A). A strong full-latitude ridge extended northwestward from the Great Basin to the Beaufort Sea north of Alaska. Height rose over the central Atlantic, pushing the low that had been near Iceland the previous week eastward to the North Sea.

Temperatures were generally below normal in the middle third of the United States due to the combined effects of northwesterly flow brining cool Canadian air into the north central states and rain and cloudiness lowering maximum temperatures farther south. An unusually cool high that moved slowly from North Dakota to Pennsylvania during the week caused several daily record-low temperatures across the upper Midwest on 18 and 19 July.

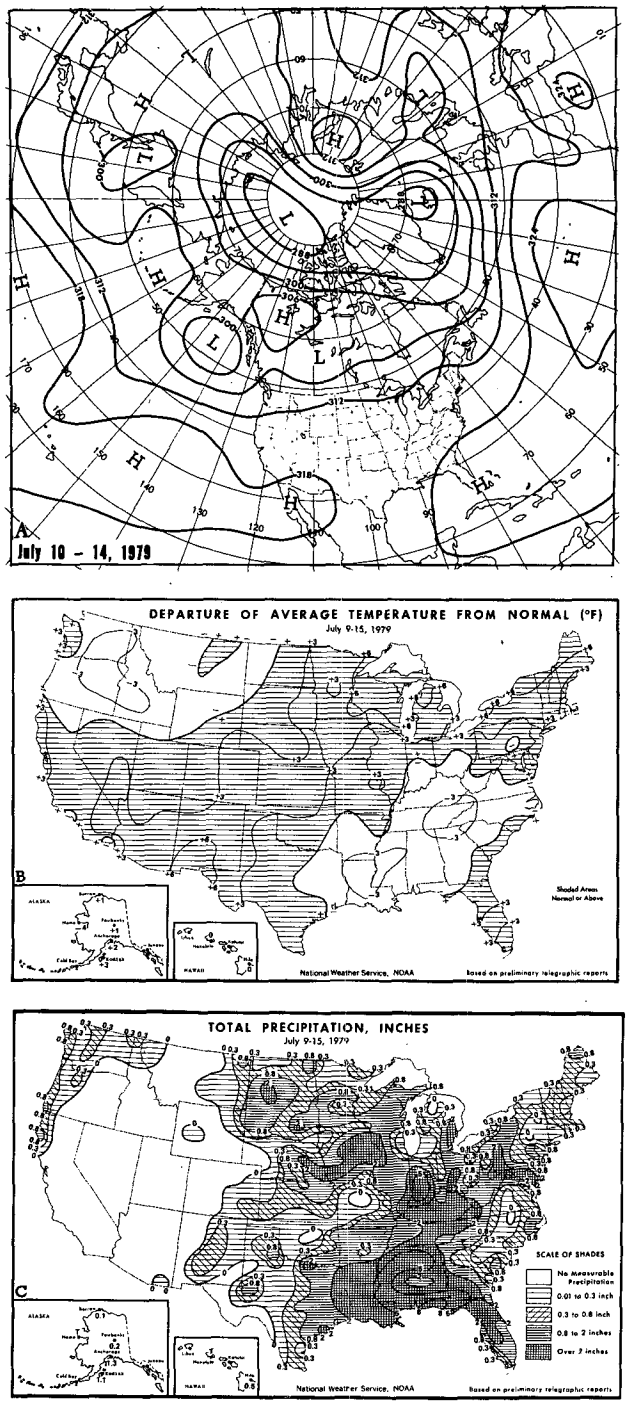


FIG. 9. As in Fig. 8 except for (A) 10–14 July 1979 and (B) and (C) week of 9–15 July 1979.

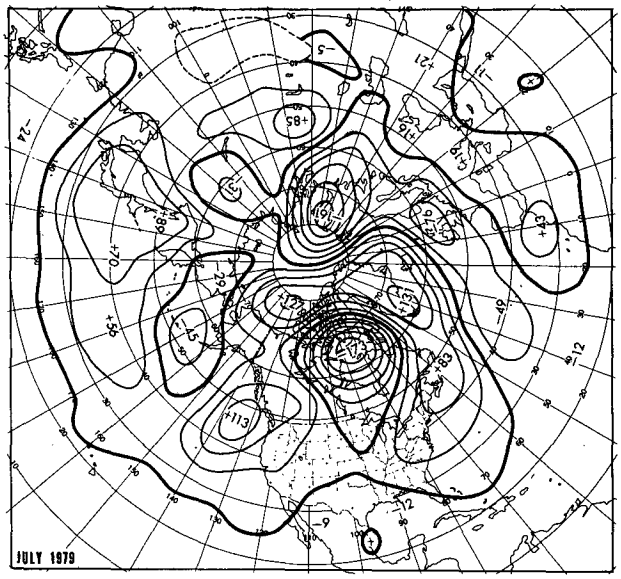
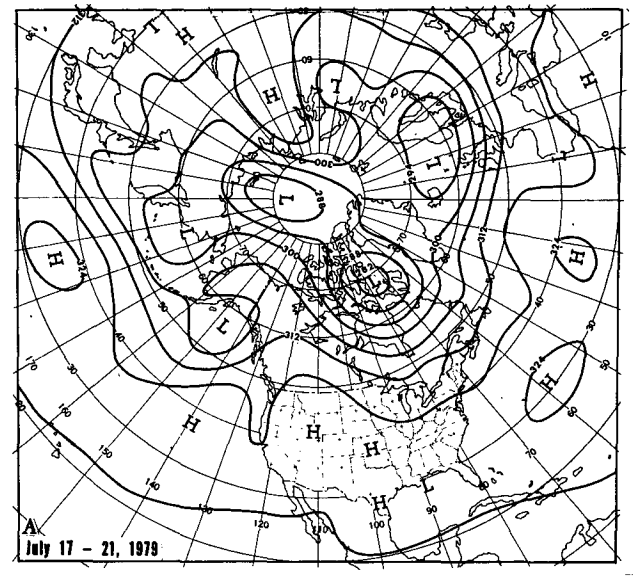
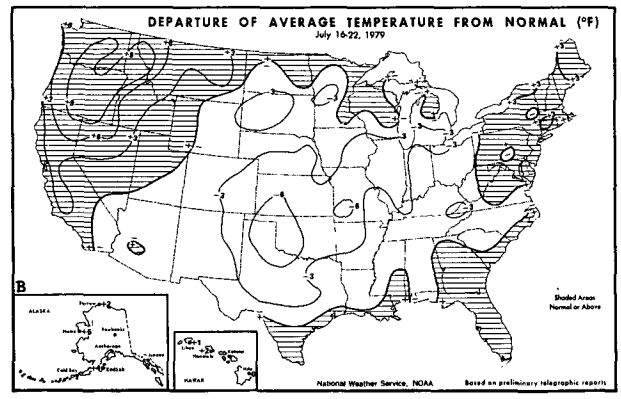


FIG. 10. Mean 700 mb height change (m) from first half to second half of July 1979.





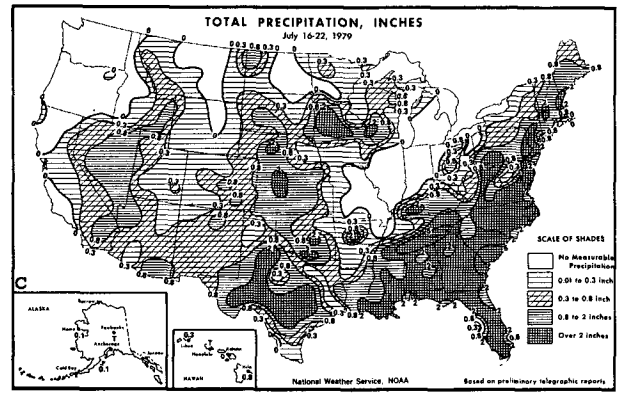


FIG. 11. As in Fig. 8 except for (A) 17–21 July 1979 and (B) and (C) week of 16–22 July 1979.

At the same time, the building 700 mb ridge over the West caused extremely high temperatures in the Northwest, some of them records. Most localities, except for the coast, reported several consecutive maxima over 100°F. The 98°F maximum on the 16th at Seattle-Tacoma Airport was the highest July temperature ever observed at that location. Farther inland, the temperature rose as high as 107°F at Walla Walla, WA on the 20th. The extreme heat and accompanying low humidities increased the forest fire danger over much of the West.

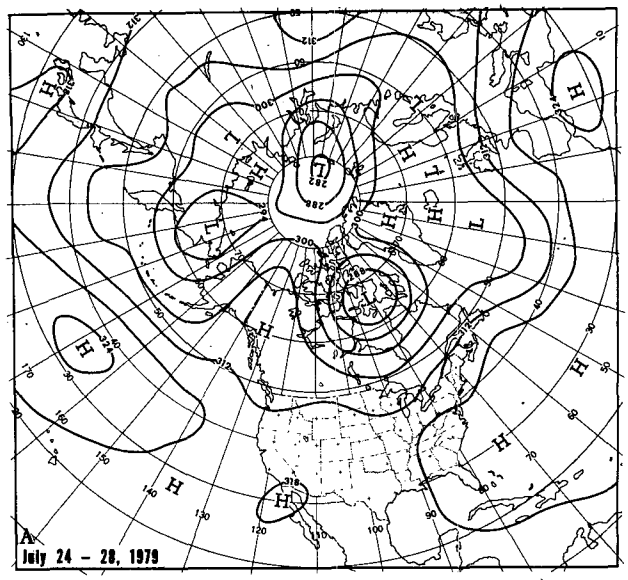
Although 700 mb heights rose over much of the country and no tropical storms directly affected it, precipitation was widespread with only the Pacific Northwest and portions of the northern Great Plains and Midwest remaining rainless (Fig. 11C). The "summer monsoon" rains began over the Southwest as a favorable circulation for advecting moisture into the area and releasing it by convective instability was set up by the phasing of a weak easterly disturbance near the Mexican border with a short-wave trough from the Pacific. Northward elongation of the heat low by the Northwest heat wave eventually drew the low-level moisture northward to southeastern Idaho. Extensive cloudiness associated with the rain led to a record-low maximum temperature of 89°F at Yuma, AZ on 20 July, and the next day was the first 21 July on record that measurable rain was observed at Fresno, CA. The onset of the Southwest summer rainy season was about two weeks later than normal in 1979.

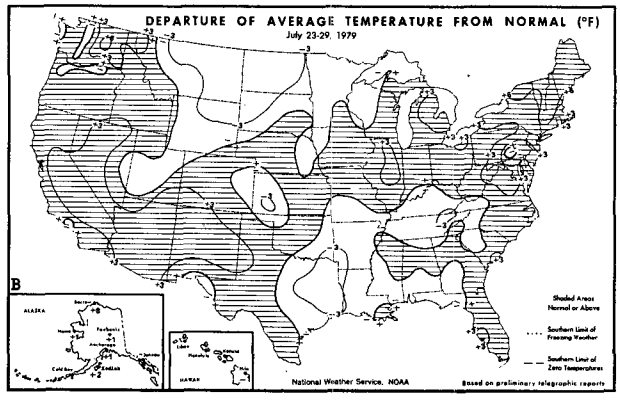
Convective activity was widespread over much of the Great Plains, where substantial rains occurred. On 16 July a rare tornado devastated part of Cheyenne, WY. Later in the week, a slowly moving frontal wave and its accompanying convective activity produced heavy rains of as much as 5 inches over the Tennessee Valley and portions of the middle and south Altantic States.

d. 23–29 July

Emergence of a strong ridge over the Sea of Japan led to progression of the trough east of Japan and eastward movement of the subtropical high. The trough in the Gulf of Alaska filled, while a strongly amplified three-wave pattern prevailed at high latitudes, with a strong ridge remaining near the Alaska-Canada border and a deep closed low situated north of Hudson Bay (Fig. 12A). At middle latitudes, moderately strong generally westerly flow prevailed from the Pacific to Europe. A pronounced split in the westerlies was evident from the Atlantic to eastern Europe.

Temperature anomalies were somewhat weakly defined over the United States, although most areas averaged a little above normal (Fig. 12B). Canadian air was limited in its influence to the north-central states, while below normal temperatures in the South were mainly caused by heavy precipitation (Fig. 12C). Most of the excessive rainfall was associated with Tropical Storm Claudette, which gave over a foot of rain to some southeast Texas localities within a day or two as the center moved very slowly northward on 24 and 25 July. Torrential rains and localized flooding occurred along much of the path of Claudette's weakening center northward through Arkansas and then eastward through the Ohio Valley to Virginia. Although not related to the tropical storm, Atlantic City measured 4.78 inches of rainfall within a 24 h period on 23 and 24 July.





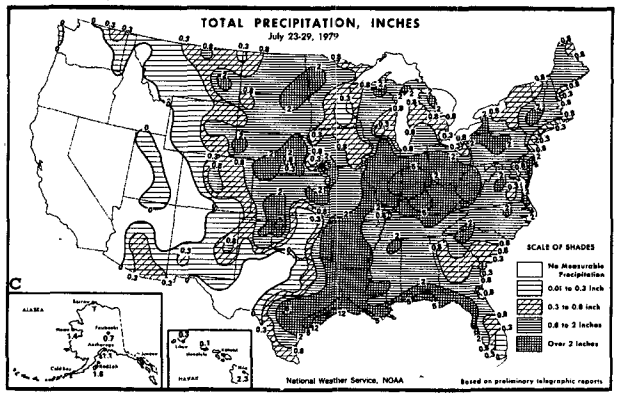


FIG. 12. As in Fig. 8 except for (A) 24–28 July 1979 and (B) and (C) week of 23–29 July 1979.

5. Tropical activity

Two tropical storms, one of which briefly reached minimal hurricane intensity, moved out of the Gulf of Mexico and struck the United States mainland during July. A weak tropical depression that took shape on 9 July in the southwestern Gulf of Mexico became Tropical Storm Bob on the 10th near 25°N, 92°W. Later that day it intensified to minimal hurricane intensity. Moving steadily north-northeastward, it made landfall just west of Grand Isle, LA around dawn on 11 July. The rapid deepening and northward motion of the storm may have been due in part to an upper trough to the west of the center.

After moving inland, Bob quickly weakened and passed close to New Orleans, producing eight tornadoes, only one of which did significant damage, in the central Gulf Coast region. Heavy rains followed the weakening circulation across Louisiana, Mississippi, Alabama, and southern Indiana and Ohio. A weak remnant of the center drifted southwestward from lower Chesapeake Bay to near Cape Hatteras on 14 and 15 July but no redevelopment occurred.

The second storm, Claudette, was identified as a tropical depression moving west-northwestward north of the Leeward Islands on 16 July. The disturbance briefly gained storm intensity near Puerto Rico before weakening again while passing in the vicinity of the larger islands. A center had again become organized north of Yucatan on 21 July and reached tropical storm intensity early on the 23rd

near 26°N, 92°W. It moved very slowly north-northwestward to the Texas coast near Port Arthur late on the 24th, weakening quickly to depression strength again upon moving inland. The storm milled around in east Texas for the next couple of days, giving widespread flood-producing heavy rains. On the 27th, the remains of the storm moved northeastward across the Ozarks into the Ohio Valley, where heavy rains over southern Indiana caused floods on the 28th. It crossed the Appalachians on the 29th, reaching the Virginia Capes area that evening, still causing scattered heavy thunderstorms and localized flooding over Virginia.

In the eastern Pacific, short-lived Tropical Storm Carlos formed late on 14 July a short distance south of Manzanillo on the Mexican coast. It moved west-northwestward and weakened to a depression the next day as it headed west toward cooler water.

Tropical storm Dolores formed near 12°N, 108°W late on 17 July. It moved west, deepening to hurricane intensity the next day. Turning more to the northwest, the storm reached peak intensity with maximum gusts near 120 kt late on 20 July. The next day it weakened rapidly and was down to storm intensity again by evening, and depression strength on the 22nd. A weak center was discernible until late on the 23rd.

Four tropical storms, two of which reached typhoon intensity, were active in the western Pacific during July. Tropical storm Ellis, which formed the last day of June, became a typhoon on 2 July shortly before grazing the northeastern corner of Luzon Island in the Philippines. It weakened to storm intensity again while turning more to the west between Luzon and Taiwan on the 4th. Landfall occurred near the border of mainland China and North Viet Nam on the 6th.

Tropical Storm Faye developed from a depression near 9°N, 143°E on 3 July. Moving west-northwestward the next three days, it weakened to depression intensity again on the 6th and dissipated the following day east of Luzon.

After being unusually inactive for the next couple of weeks, tropical activity began to increase again in the area near and east of the Philippines after 20 July. Several ephemeral circulation centers appeared between the 23rd and the 25th, and by the 26th a more definite depression developed near 20°N, 129°E while another center was becoming organized near 11°N, 143°E. Tropical Storm Gordon formed from the northern center on 27 July and moved westward, brushing the southern end of Taiwan on the 28th and continuing to the Chinese mainland the next day. Tropical Storm Hope developed near 17°N, 135°E on 29 July from the other depression, which had been drifting northwestward. It became a typhoon on the 30th and by the end of the month had become a major storm near 20°N, 127°E with winds of 130 kt and peak gusts of 160 kt.

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