WEATHER AND CIRCULATION OF JUNE 1981
A Return to Coast-to-Coast Warmth and Continuing Drought in the West

ROBERT E. LIVEZEY

Climate Analysis Center, NMC, NWS, NOAA, Washington, DC 20233

1. Mean circulation

The upper air circulation for June 1981 bore little resemblance to that in May (Wagner, 1981). In place of a strong polar vortex and an amplified mid-latitude wave pattern, the hemisphere was dominated by a pronounced wave 1 flow asymmetry[1] (Fig. 1). This was principally manifested in the western half of the hemisphere by extremely fast westerlies at middle latitudes and weaker-than-normal zonal winds at higher latitudes (Fig. 2), with somewhat the opposite over Eurasia. For example, winds near the jet stream level (i.e., 200 mb) at 40°N latitude above the east-central Pacific were over double their usual strength.

Accompanying the high winds aloft was a stronger-than-normal subtropical ridge (Fig. 3) that extended from the western Pacific to the western Atlantic with only one important break over Mexico and the

[1] According to calculations by R. Quiroz of the Climate Analysis Center (for 500 mb height data at middle latitudes) wavenumber 1 amplitude anomalies from May to June reversed sign from negative to positive while just the opposite reversal took place for wavenumbers 2 and 3.

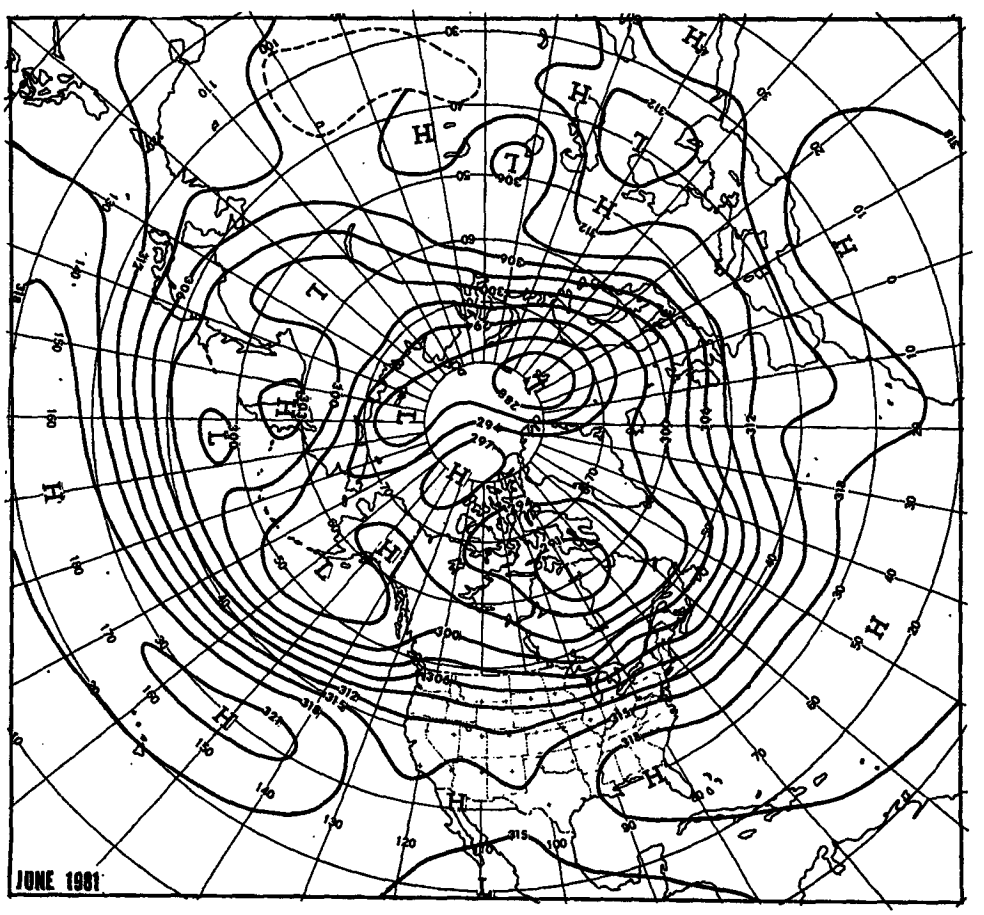

FIG. 1. Mean 700 mb height contours (dam) for June 1981.

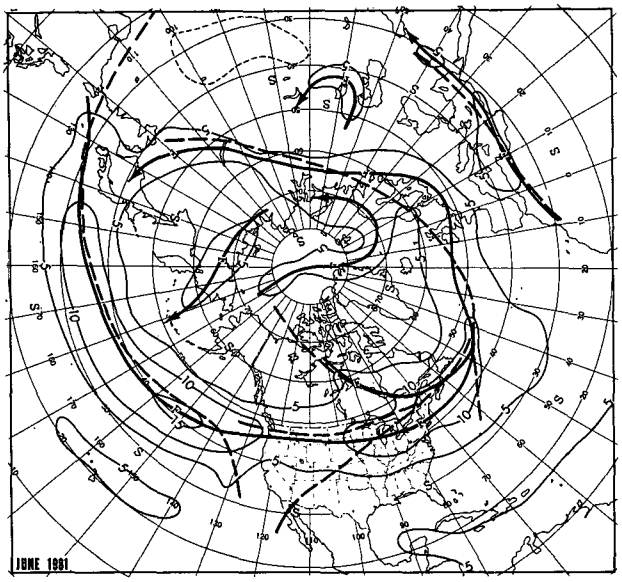

FIG. 2. Mean 700 mb geostrophic wind speed (m s^{-1}) for June 1981. Solid arrows indicate observed axes of maximum wind speed and dashed lines, the normal.

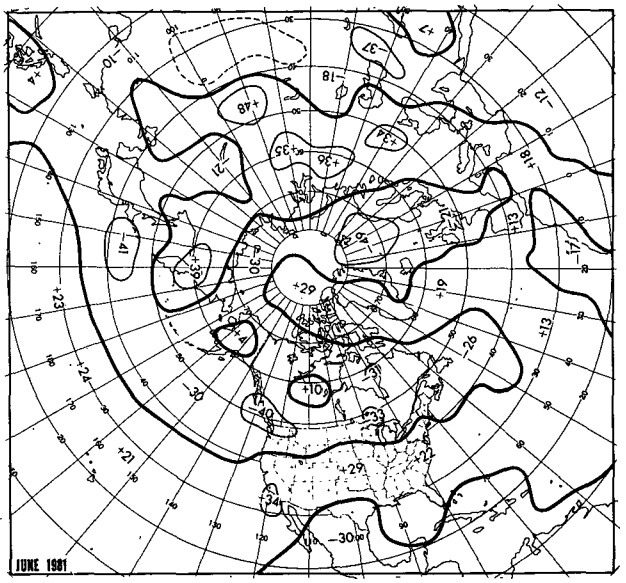

FIG. 4. Departure from normal of mean 1000–700 mb thickness (m) for June 1981.

south-central United States. Two effects of this were the confinement of the subtropical jet to south of 25°N latitude as far east as Baja California and substantial weakening of the West Coast trough.[2]

The fast wind current was associated with strong baroclinity along most of its length (Fig. 4). This was in turn maintained by cold air supplied principally by an Arctic blocking high north of the Canadian Archipelago and one over Kamchatka. The former helped effect the removal of the vast cell of warm air that overlay western Canada and Alaska in May.

In direct contrast to the North American side of the hemisphere, Eurasia was mainly influenced by a cold Arctic trough and a warm mid-continental ridge (Figs. 1, 3 and 4), again illustrative of the dominance of wave 1 asymmetry. The ridge and its associated positive height anomaly around 60°E longitude appeared to result from amalgamation or ridges situated both to the east and west the previous month. The eastern component apparently split with its progressive half moving to near

[2] Contrast this with June of last year when the Summer 1980 heat wave began. At that time the central Pacific westerlies were weak and a strong subtropical branch from the southwest fed the extratropical jet arching over the northern half of the United States.

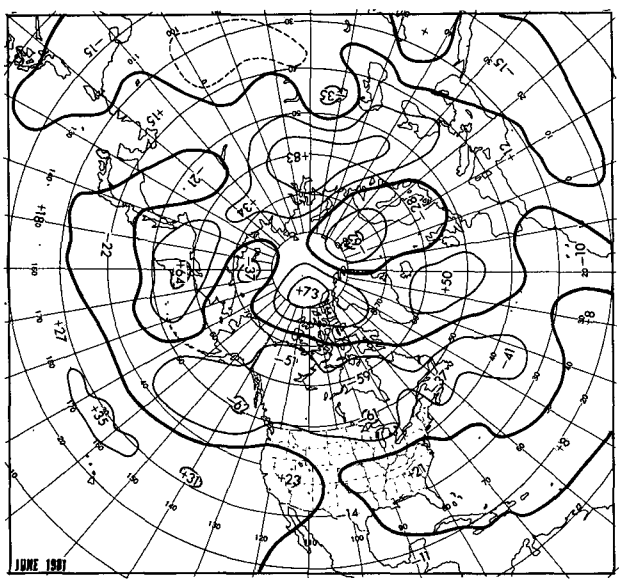

FIG. 3. Departure from normal of mean 700 mb height (m) for June 1981.

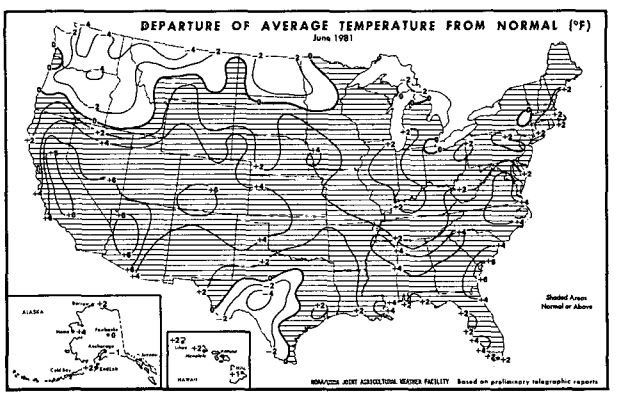

FIG. 5. Departure from normal of average surface air temperature (°F) for June 1981 (from National Oceanic and Atmospheric Administration and Economics and Statistics Service, 1981).

TABLE 1. Temperature records and near records (°F) for June 1981 in the southwestern United States.

Station	Date	Temperature	Anomaly	Remarks
Fresno, CA		82.8	+8.9	Hottest June*
Phoenix, AZ		93.4	+8.8	Hottest June
Sacramento, CA		79.2	+7.9	Hottest June**
San Diego, CA		72.9	+7.4	Hottest June
San Francisco, CA		65.0	+3.4	Second hottest June
Los Angeles, CA	16	104.0		Highest for June

* Record days in June with maximum temperatures greater than or equal to 100°F, 17.

** Record days in June with maximum temperatures greater than or equal to 100°F, 12. All time record consecutive days for same, 9.

Kamchatka. Over Scandanavia a reversal in the sign of the height anomaly occurred in the wake of the advancing western component.

Upstream the ridge in the eastern Atlantic primarily reflects a major blocking event that occurred in the second half of June in conjunction with a considerable deceleration of the westerlies and the subsequent demise of the negative anomaly near the Gulf of Alaska. This last feature has been a fixture of charts like Fig. 3 (with the exception of April) since October 1980.

2. Temperature

The change to mostly cooler than normal weather in the United States in May after a long warm period (cf. Wagner, 1981) apparently was only temporary (Fig. 5). With pumped-up subtropical highs dominating both the Southeast and Southwest and fast westerlies across the top of the nation shearing off troughs and confining cooler air to the north, over three-fourths of the country had positive temperature departures from normal.

The only exceptions were central Texas and the Rio Grande Valley, as well as the Pacific Northwest and scattered locales along the Canadian border. In the former, preexisting wet conditions (Wagner, 1981) and a weakness in the subtropical ridge with attendant cloudiness and precipitation were responsible for lower-than-normal temperatures, while in the latter a combination of maritime

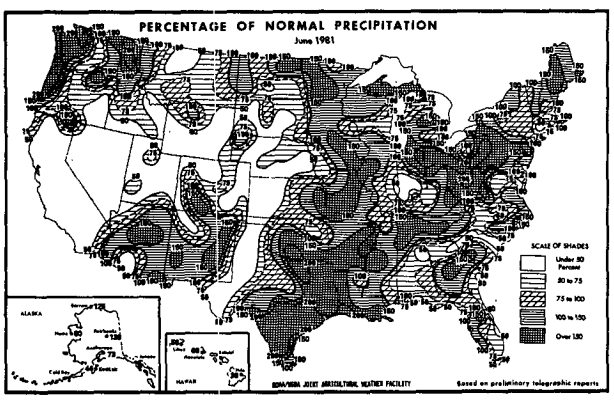

FIG. 6. Percentage of normal precipitation for June 1981 (from National Oceanic and Atmospheric Administration and Economics and Statistics Service, 1981).

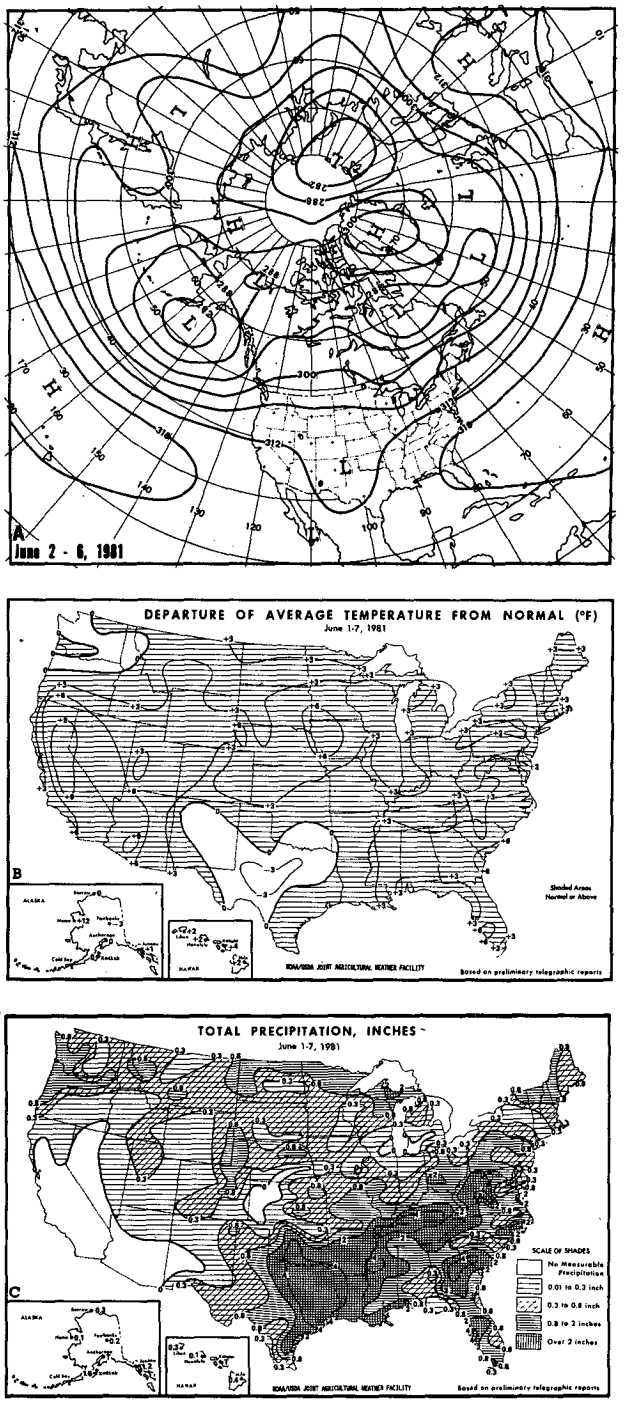

FIG. 7. (A) Mean 700 mb contours (dam) for 2–6 June 1981, (B) departure from normal of average surface air temperature (°F), and (C) total precipitation (inches) for week of 1–7 June 1981 (from National Oceanic and Atmospheric Administration and Economics and Statistics Service, 1981).

air and Pacific disturbances moving eastward in the strong current aloft were involved. At least twice during the month, near the middle and near the end, the mean circulation depicted in Fig. 1 buckled sufficiently to permit incursions of daily record-smashing cold air along and near axes of minimum positive anomalies from Idaho to West Texas and from northwest Ohio to central South Carolina.

Nevertheless, departures from normal were quite large in a number of areas in the deep South and along the Atlantic coast and over a wide area of the Southwest and West (Table 1). Western Arizona and California's central valley, shut off from the moderating effects of southwesterly flow aloft and, in the cast of the latter, topographically isolated as well, were particularly torrid (see entries for Fresno, Phoenix and Sacramento in Table 1).

Elsewhere in the hemisphere the most noteworthy surface temperature anomaly was the heat wave that covered virtually the entire European territory of the Soviet Union as well as western Siberia. It is well reflected in the lower tropospheric thickness field (Fig. 4) and can be directly attributed to the unusually broad and strong ridge over Eurasia (Figs. 1 and 3).

3. Precipitation

The gross distribution of percent of normal precipitation in Fig. 6 for June over the United States reflects the accessibility of areas to either Pacific or Gulf of Mexico sources of moisture and disturbances suggested by anomalous flow configurations in Fig. 3.

Notwithstanding this, the pattern of precipitation in the eastern half of the country is quite spotty, a characteristic of episodic convective events against the backdrop of a mean anticyclonic cell aloft. Periodic breakdowns of this circulation pattern characteristic of the month, accompanied by either a strong frontal passage or one of two tropical disturbances, led to reports of flash floods and severe weather in every week of the month. Yet interspersed throughout the region are a number of excessively dry locations.

In fact, overall the long-term drought severity (measured by the Palmer Index as of 27 June) in the eastern half of the United States didn't change substantially. This was not the case in the West where drought worsened in Southern California, in the northern Great Plains, and near the Colorado-New Mexico border. In arid areas like the latter, greater-than-normal precipitation does not necessarily imply large rainfall depths. This fact, coupled with a large potential evaporation rate (Fig. 5), is consistent with the suggested depletion of water supplies in southern Colorado and northern New Mexico.

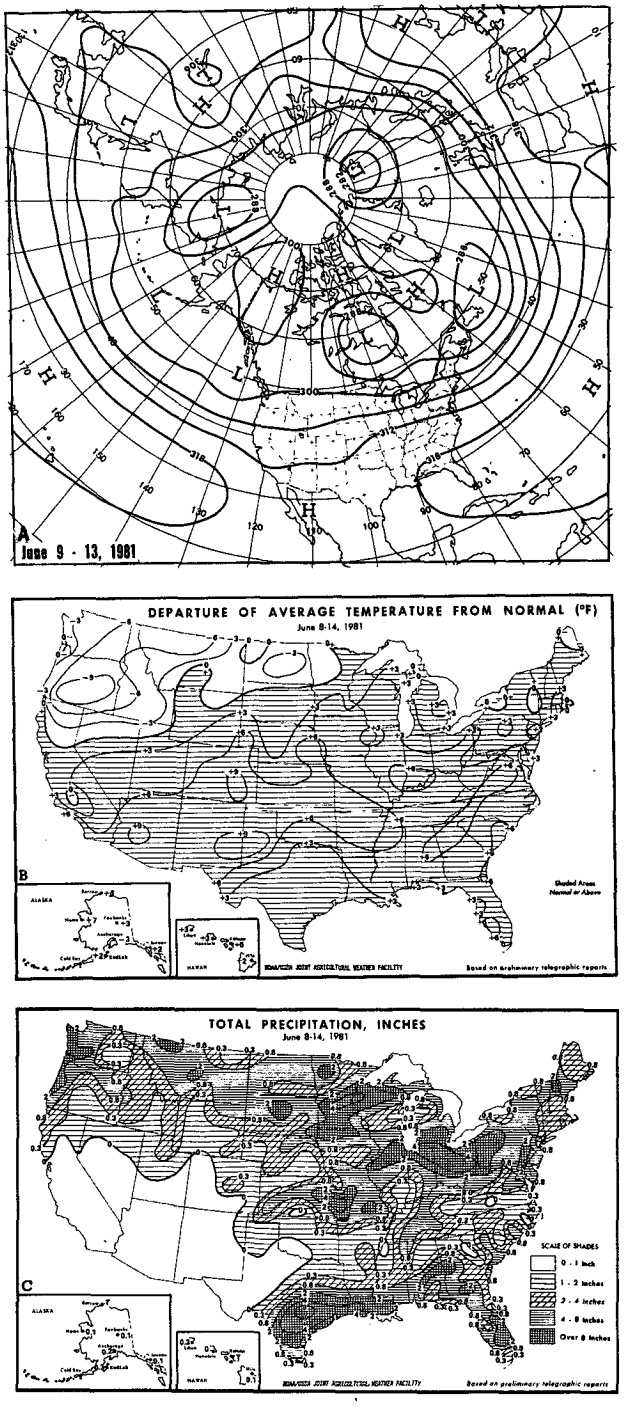

FIG. 8. As in Fig. 7 except for (A) 9–13 June 1981, and (B) and (C) week of 8–14 June 1981.

In sharp contrast, Austin, Texas experienced its wettest June on record (14.96 inches with 3.13 inches normal) after suffering a destructive flood just the previous month (Wagner, 1981). Over 13 inches of rain fell at Austin from 10–16 June.

Outside the continental United States several major precipitation anomalies were reported. Hilo,

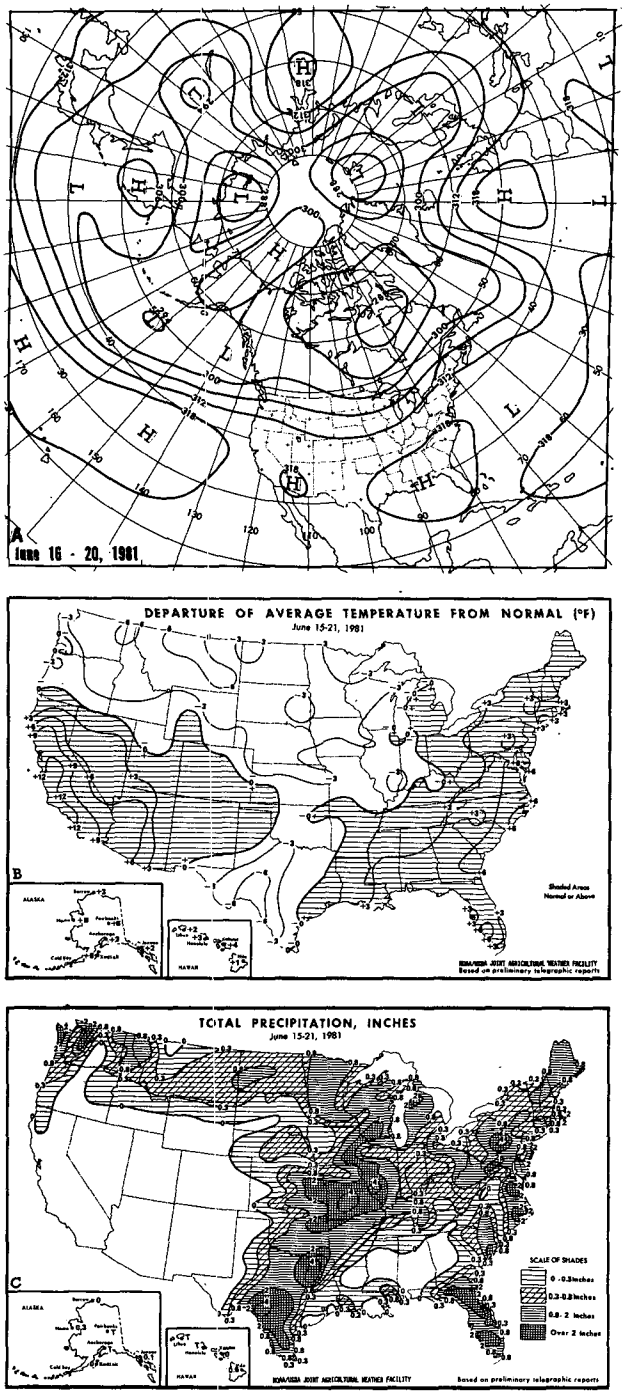

FIG. 9. As in Fig. 7 except for (A) 16–20 June 1981, and (B) and (C) week of 15–21 June 1981.

Hawaii had a record dry June (2.43 inches with 6.61 inches normal) under the strong subtropical ridge, while further west torrential rains fell at nearby land stations as Tropical Storm Ike tracked its way slowly (it was nearly stationary for two days) across the South China Sea. Its transit is responsible for the negative 700 mb height anomaly in that area (Fig. 3).

Finally, while western Europe was mostly wet during June, much of the area in the Soviet Union that was hot (see Section 2) was also dry.

4. Weekly variability

a. 1–7 June

At both high latitudes and over the breadth of Eurasia a general retrogression of 700 mb wave features took place between the last week in May [Fig. 12a in Wagner (1981)], and the first week in June (Fig. 7a). This permitted a new ridge to emerge over Sakhalin and lows over the North Pacific to consolidate into one large vortex near 155°W longitude. Consequently, accelerated westerlies drove over North America building the ridge to the south and eroding the one to the north. Over the Atlantic the flow also flattened somewhat as a lobe of the subtropical high built westward to meet the trough advancing from the southwestern United States.

The remains of the western ridge and rising 700 mb heights in the Southeast and especially in the Southwest contributed to higher than normal temperatures for most of the United States (Fig. 7b). The only important exception was over Texas just to the east of the mean trough position.

Only the Southwest was excluded from the effects of a stormy, chaotic week (Fig. 7c) in which flooding, hail and tornadodes were commonplace. Short waves riding the fast current driving into the continent from the Pacific triggered a complex frontal system that was closely followed by a tropical depression moving northward from the Gulf of Mexico into Texas and then northeast. These disturbances were almost continually fueled at low levels by moisture-laden onshore flow along the southern Gulf Coast, accounting for the copious rainfall amounts from Texas to Virginia.

The Hawaiian Islands, as they would consistently be throughout the month, were warm and dry beneath the expanding subtropical ridge.

b. 8–14 June

Retrogression of 700 mb height centers generally continued in the Arctic in the second week of June (Fig. 8a). Although the continuity is uncertain, middle to high latitude phasing of ridges over eastern Asia seemed to be associated with the deepening of the low near 170°E longitude and the reappearance of a ridge near the Alaska-Canada border. At lower latitudes the transport of lower heights from the Gulf of Alaska to over North America may have contributed to the westward retreat of the low near Hudson Bay and the amplification of the ridge near Labrador. Far downstream the European ridge was pushed east of the Black Sea by strong westerlies allowing a new ridge to swell near the British Isles.

Over the United States continued buildup of heights across the southern half of the country again blanketed most of the nation with warmer than normal air (Fig. 8b). The principal exception was in the Pacific Northwest, where the end of the week extent of a cold outbreak and record daily minimum temperatures is approximately delineated by the zero anomaly line through Nevada (Fig. 8b). This outbreak was associated with a continental-scale baroclinic development as the fast zonal current across the country buckled in response to a wave perturbation from the Pacific (the low off the Coast in Fig. 8a) that pushed inland in the latter part of the week. This development is also reflected in the temperature anomaly maxima along the Appalachian ridge and the southeast coast. Northern Alaska, under strong southerly flow aloft, was also warm during the second week of the month.

Much of the precipitation shown in Fig. 8c along with hail and tornadoes was associated with the major wave development alluded to above, especially in the central Great Plains and the upper Midwest. However, earlier in the week overrunning and interaction with an east-west front also produced large amounts of rain as well as flooding and severe weather. Additionally, intense moisture flux convergence along the Gulf Coast was responsible for the torrential rains there. Note finally that the rain-free area in the Southwest expanded from the previous week.

c. 15–21 June

The rapid 700 mb wave retrogression at high latitudes that so characterized changes for the previous two weeks seemed to come to an abrupt halt in the third week (Fig. 9a). Instead the principal centers around the pole remained quasistationary as a tremendous amplification of the wave pattern at lower latitudes took place from the eastern Atlantic east to at least the northwestern Pacific.

The key event may have been the growth of the ridge south of Iceland; the difference in 700 mb height at 50°N and 20°W between Figs. 8a and 9a is ~200 m. The effects of this development may have been felt as far east as the central Pacific where a low deepened somewhat, thereby continuing the fast westerlies across North America and the ridge building in the eastern Pacific.

The infusion of vorticity into North America and subsequent wave growth that began the previous week is evidenced by the broadening of the trough across the north central United States. Both the influence of this mean trough and the surge of cold air in the wake of the storm were responsible for making the third week of June the coolest of the month (Fig. 9b). Excessively high

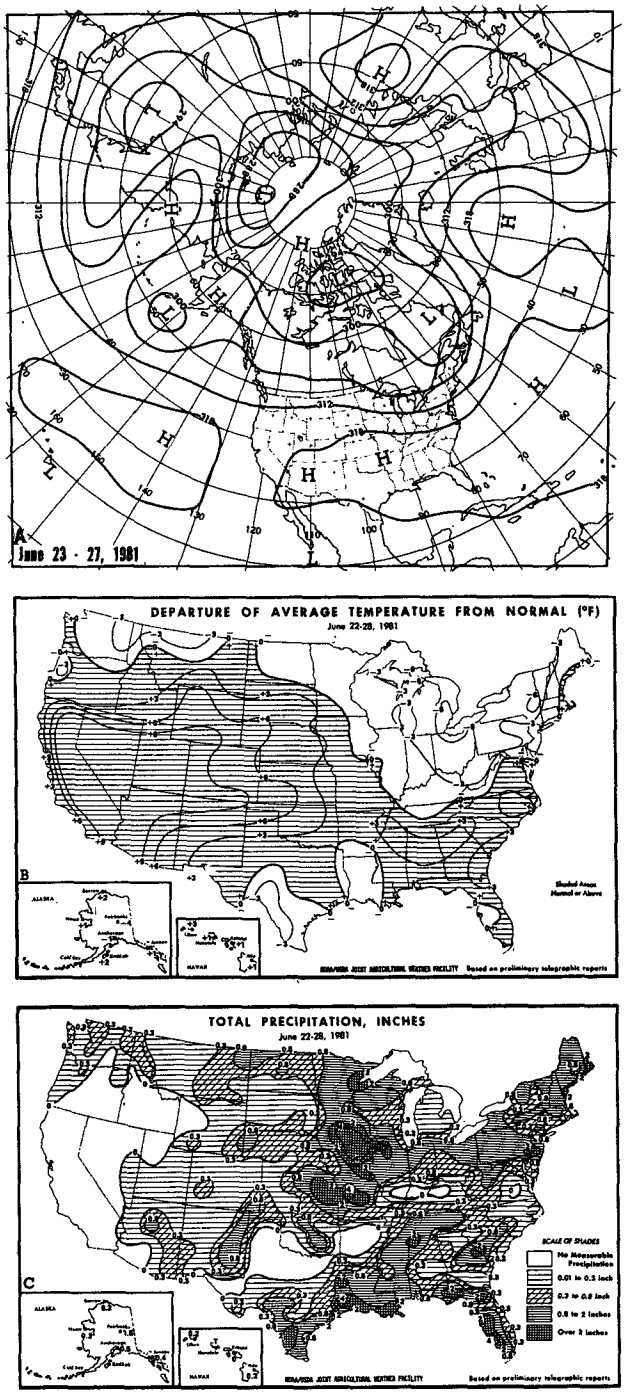

FIG. 10. As in Fig. 7 except for (A) 23–27 June 1981 and (B) and (C) week of 22–28 June 1981.

mean temperatures were confined to both coasts despite the continued strengthening of the highs over the Southeast and Southwest.

The influence of these ridges were instead apparent in the precipitation pattern (Fig. 9c), the driest of the month. The rain-free area over the Southwest expanded again from the previous week

while such an area developed in the formerly rainy Deep South. A lobe of the Atlantic subtropical high moved over Alabama and intensified, effectively cutting off flow from the Gulf. Flooding and severe weather, however, were again common in many areas influenced by the major cyclogenesis and a second weaker disturbance that followed it as the circulation aloft flattened once more into a fast zonal current. Alaska remained warm and dry under an anticyclone aloft.

d. 22–28 June

In the last week of the month the blocking high over the eastern Atlantic began to move westward (Fig. 10a), portending major changes in the weather over North America. Simultaneously, retrogression of circulation features to the east of the block and responsive adjustments at high latitudes took place. These include retrogression of the Arctic low north of northeastern Siberia, collapse of the high over Alaska, and a split in the Hudson Bay low with a lobe dropping down over Labrador ahead of the advancing block. Over the Pacific the low south of the Aleutians filled considerably, thus depriving the eastern Pacific westerlies of much of their former strength. Along with this a significant weakness in the subtropical ridge developed over California as the ridge over the Southwest edged eastward to partially amalgamate with the southeastern United States ridge. Both high centers increased in strength and moved toward each other.

With the shift of the trough to eastern North America, and the loss of a vigorous influx of moisture and vorticity from the Pacific, the locus of cool air finally shifted to the Great Lakes and the Northeast (Fig. 10b). Not coincidentally, temperatures soared over a huge area in the Southwest to values in excess of 9°F above normal. In the former area at least 10 daily minimum temperature records were broken on 27 June, while in the latter daily maximum records were set throughout the week.

Much of the eastern half of the United States had generous precipitation in the final week of the month (Fig. 10c), but most of the severe weather occurred in the north central region. Moisture from Mexico fed the precipitation-producing processes that led to the appearance of the "moist tongue" in the Southwest, a common event in the summer in this region.

Finally, Alaska returned to near-normal conditions because of the collapse of the upper air ridge over it while Hawaii ended the month the way it started—warm and dry.

5. Tropical activity

Tropical Storm Ike (see Section 3) was followed in June by two more major western Pacific tropical disturbances. June (not the month) developed east of Luzon and grew to typhoon strength on 18 June as it moved northwest. As it passed the northern tip of Taiwan on 21 June, it lost strength before finally achieving landfall a day later on mainland China. Tropical Storm Kelly appeared off the southeast coast of Luzon on the last day of the month.

In the eastern Pacific, the month began with Tropical Storm Adrian moving northeast to the Mexican coast southeast of Acapulco on 4 June, and ended with the appearance of Beatriz near 12°N, 107°W on 29 June.

REFERENCES

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