WEATHER AND CIRCULATION OF SEPTEMBER 1977
A Warm Month Across Much of the Country

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1. Mean circulation

A well-developed low over the Arctic Ocean was a prominent feature of the mean 700 mb circulation over the Northern Hemisphere during September 1977 (Figs. 1 and 2). Development of this system represented a significant change in the wave structure across the polar region where high-latitude blocking predominated in August (Dickson, 1977). The polar vortex was attended by fast zonal flow within an area of strong height and thermal gradients (Fig. 3) across northern Canada. As cyclogenesis occurred over the Arctic, a remnant of the August block dropped southward over the Pacific Ocean where a vigorous mean ridge replaced an almost equally strong August trough south of Alaska. Westerly flow across the ridge was displaced well to the north of its normal position (Fig. 4). Average wind speeds in the Bering Sea were as much as 8 m s$^{-1}$ faster than normal.

Fig. 1. Mean 700 mb contours (dashed) for September 1977.
Downstream, the westerlies split into two branches as they entered North America. One branch became part of the wind maximum over northern Canada while a second branch dipped southward into a trough along the West Coast of the United States. This band of winds then followed a depressed path across the northern United States and continued into a trough in the western Atlantic Ocean. Other features of the mean 700 mb circulation in the United States included a weaker than normal mid-latitude ridge over the Rocky Mountains and relatively strong subtropical ridges across parts of the South.

The subtropical ridge across the Atlantic Ocean weakened from August to September as a trough became established east of North America. A portion of the August ridge moved eastward and gave support to a ridge centered over Great Britain. Downstream, a trough stretched from the eastern Mediterranean Sea into the Arctic vortex.

A broad band of low-amplitude westerly flow spread across much of northern Asia. The core of the westerly winds was located near its normal position. Average wind speeds, however, were somewhat faster than normal in the enhanced 700 mb gradient between the polar vortex and expanded ridges across the south. Increased thermal gradients accompanied the deepening, from August to September, of the northern part of a trough near 140°E. From Sakhalin southward, the trough weakened as a ridge strengthened across Japan.

Fig. 2. Departure from normal of mean 700 mb height (m) for September 1977.

Fig. 3. Departure from normal of mean 1000-700 mb thickness (m) for September 1977.

Fig. 4. Mean geostrophic wind speed (m s⁻¹) for September 1977. Solid arrows indicate observed axes of maximum wind speed and dashed lines, the normal.

Fig. 5. Departure from normal of average surface air temperatures (°F) for September 1977 (from National Oceanic and Atmospheric Administration and Statistical Reporting Service, 1977).
TABLE 1. Record and near-record monthly mean temperatures observed in September 1977.

<table>
<thead>
<tr>
<th>Station</th>
<th>Temperature (°F)</th>
<th>Anomaly (°F)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phoenix, Ariz.</td>
<td>87.6</td>
<td>+5.3</td>
<td>Warmest September</td>
</tr>
<tr>
<td>Lakeland, Fla.</td>
<td>82.3</td>
<td>+2.1</td>
<td>Warmest September</td>
</tr>
<tr>
<td>Denver, Colo.</td>
<td>66.6</td>
<td>+3.8</td>
<td>2nd warmest September</td>
</tr>
<tr>
<td>Youngstown, Ohio</td>
<td>65.6</td>
<td>+2.9</td>
<td>2nd warmest September</td>
</tr>
<tr>
<td>Abilene, Tex.</td>
<td>82.6</td>
<td>+6.5</td>
<td>3rd warmest September</td>
</tr>
<tr>
<td>Grand Junction, Colo.</td>
<td>70.2</td>
<td>+3.0</td>
<td>Equaled 3rd warmest Sept.</td>
</tr>
<tr>
<td>Brownsville, Tex.</td>
<td>84.3</td>
<td>+2.7</td>
<td>Warmest Sept. since 1920</td>
</tr>
<tr>
<td>Pendleton, Oreg.</td>
<td>58.4</td>
<td>−5.4</td>
<td>2nd coldest September</td>
</tr>
</tbody>
</table>

2. Temperature

Low-amplitude zonal 700 mb flow across the northern part of the country and the ridges across the South contributed to above normal temperatures in much of the conterminous United States (Fig. 5). Warmest temperature departures occurred in relatively dry areas of Texas and New Mexico. Primary exceptions to the warm regime were in the Northwest and New England, where nearby troughs helped keep temperatures cooler than normal. A few record and near-record station temperatures are listed in Table 1.

Warm 700 mb ridges in the vicinity of Alaska were associated with above normal temperatures in most of the state. Temperatures also averaged above normal at four readily available stations in the Hawaiian Islands.

3. Precipitation

Short-wave cyclonic activity emanating from the mean 700 mb trough near the West Coast gave heavier than normal precipitation to much of the northern part of the country (Fig. 6). In addition, a storm track from the eastern Great Plains, through the Great Lakes and into the Northeast, produced more than the expected precipitation along its path. Part of the above normal precipitation in the Southeast was associated with hurricane Babe early in September. Record and near-record heavy September precipitation was reported by a number of stations (Table 2).

A mean ridge over the Rocky Mountains augmented by subtropical ridges in the South was related to significantly lighter than normal precipitation in much of the southwestern quarter of the country. A ridge along the East Coast inhibited precipitation in the mid-Atlantic states and southward along the coast.

Storminess accompanying the northward-displaced Pacific wind maximum gave relatively heavy precipitation to much of Alaska. Some stations in southern Alaska, nearer the Pacific ridge, were drier than normal. Precipitation was less than normal in the Hawaiian Islands, where mean 700 mb heights were higher than normal.

4. Weekly variability

a. 29 August–4 September

A subtropical 700 mb ridge moved into the eastern United States early in September, contributing to warmer than normal temperatures over most of the East and South (Figs. 7A and 7B). Below normal temperatures prevailed in the Northwest, in response to mean troughs over the region, and in Florida where precipitation was relatively heavy (Fig. 7C). Heavy precipitation also occurred in the North Central States under generally confluent 700 mb flow between the western troughs and the ridge in the East.

Heavy precipitation along some of the Gulf Coast was due to moisture associated with tropical activity, especially hurricanes Anita and Babe. Anita, born in late August, churned into eastern Mexico on 2 September while Babe intensified over the central Gulf of Mexico.

b. 5–11 September

The 700 mb wave pattern over the United States basically reversed from that of the previous week as a
moved slowly northeastward and by the 10th were located off the mid-Atlantic coast.

Ridging over the West and a lack of significant northerly drive into the country gave warmer than normal temperatures to much of the country (Fig. 8B). However, some relatively cool air associated with the eastern

ridge spread over the West and a trough moved into the East (Fig. 8A). The trough in the Southeast was associated with hurricane Babe, which struck the Louisiana coast on 5 September. Remnants of the storm

Fig. 8. As in Fig. 7 except for (A) 6–10 September 1977 and (B) and (C) week of 5–11 September 1977.
trough did penetrate into the Great Lakes and New England.

Storminess associated with Babe was responsible for most of the heavy precipitation in the Southeast (Fig. 8C). Some localities received more than 8 inches of rain and flooding was common. Chattanooga, Tenn., measured 6.62 inches of rain in a 24 h period ending 7 September, the greatest 24 h total at the station since March 1886.

The Pacific Northwest dried out as a ridge replaced a trough. Moisture advection to the rear of the western ridge brought some precipitation into the far Southwest.

c. 12–18 September

With hurricane Babe out of the way, the mean 700 mb wave pattern again reversed over the United States. Amplification of a ridge in the central Pacific Ocean led to the return of a trough to the West Coast as a ridge became reestablished along the Atlantic seaboard (Fig. 9A). Shorter wave features included a ridge over the Rocky Mountains and a trough in the Great Plains.

Mean temperatures cooled to below normal in part of the West as the trough became entrenched along the Pacific coast (Fig. 9B). New England remained relatively cool. Generally westerly and southwesterly 700 mb flow helped to maintain mostly warmer than normal temperatures elsewhere.

Short-wave cyclonic activity that accompanied the troughs in the western and central United States brought precipitation to most of the country (Fig. 9C). Heaviest amounts occurred in a swath from the central Great Plains to New England under confluent 700 mb flow around the eastern ridge. Moisture advected from the Gulf of Mexico enhanced some precipitation totals in the Southeast.

Persistent thunderstorms gave about a foot of rain to metropolitan Kansas City, Mo. in a 24 h period ending 13 September. At least 23 deaths were attributed to the storm and severe local flooding caused property damage in excess of 5 million dollars. Nearby, Independence, Mo., reported 16 inches of rain in the same period.

d. 19–25 September

Although the 700 mb circulation amplified strongly over Canada, the mean flow remained relatively flat over the United States (Fig. 10A). The western trough deepened somewhat, in connection with the general amplification, but the eastern ridge generally weakened and was located west of its previous position.

The basically persistent 700 mb pattern over the United States led to a temperature anomaly (Fig. 10B) that was similar to that of the previous week. Warming occurred under the ridge in the southern Great Plains where some daily maximum temperatures exceeded 100°F at the end of the week. Temperature departures were well below normal under the strengthened trough in the Northwest. Increased northerly drive east of the Canadian high enhanced the cool air in New England.

Cyclonic activity worked its way across the country from the western trough and south of the Canadian block and produced varying amounts of precipitation in the North and East (Fig. 10C). To the south,
e. 26 September–2 October

As blocking over Canada weakened (Fig. 11A), a ridge became reestablished east of the Rocky Mountains and a trough dropped into eastern North America. A weakening trough lingered near the West Coast of the

Fig. 10. As in Fig. 7 except for (A) 20–24 September 1977 and (B) and (C) week of 19–25 September 1977.

ever, mean ridges inhibited the development of precipitation in the Southwest and the mid-Atlantic states. Rain-shadow effects contributed to dry conditions in parts of the eastern Rocky Mountains and western Great Plains.

Fig. 11. As in Fig. 7 except for (A) 27 September–1 October 1977 and (B) and (C) week of 26 September–2 October 1977.
United States and mean ridges maintained their influence across the south.

Westerly 700 mb flow was related to a zonal temperature anomaly pattern with cooler than normal temperatures in the North and above in the South (Fig. 11B). Temperatures continued to be warm in the southern Great Plains where a number of stations experienced record daily maxima and late season warmth near the end of September. Maximum temperatures reached and exceeded 100°F at a number of places. Wichita Falls, Tex., reported a record high September temperature of 108°F on the 30th.

Storminess emanating from the trough near the West Coast was related to a precipitation pattern (Fig. 11C) similar to that of 19–25 September. Precipitation in parts of the Southwest occurred early in the week and was reportedly connected with moisture advected northward from tropical storm Glenda. Remains of the storm were situated south of Baja California on 26 September.

Two locations in Oregon reported record 24 hour precipitation totals for September. During a 24 h period ending on 28 September, Medford received 3.09 inches of rain, while Sexton Summit measured 2.46 inches.

5. Tropical activity

Tropical activity along eastern North America included hurricanes Anita and Babe, which formed over the warm waters of the Gulf of Mexico, and Clara and Dorothy which originated near Bermuda. Anita and Babe were discussed in the summaries of weekly weather. Clara sprang from a low that drifted eastward from the Carolina coast early in the month. She attained hurricane strength by the 9th near Bermuda, lingered near the island, and finally accelerated northeastward on the 11th. A deepening depression moved northeastward past Bermuda on 27 September. The storm reached hurricane strength by the 28th well northeast of the island. Extratropical remnants of the storm were located east of Newfoundland on the 30th.

Tropical disturbances in the eastern Pacific Ocean included tropical storms Emily, during 13–14 September, and Glenda on the 24th. Hurricane Florence, positioned near 17°N, 128°W on 22 September trekked northeastward toward southern California. However, the storm dissipated by 24 September before reaching the coast.

Five lows reached at least tropical storm status in the western Pacific Ocean. Three of the storms concentrated their activity in the region of the South China Sea. Tropical storm Carla brushed southern Hainan on 4 September and then struck Vietnam. Typhoon Dinah moved westward across Luzon on 15 September. She then followed a circuitous route over the sea before hitting South Vietnam on the 23rd. A low that passed north of Luzon became tropical storm Freda by 24 September. The storm quickly moved into southern China.

Typhoon Babe was a tropical storm on 2 September near 10°N, 143°E. She slowly intensified and drifted toward the northwest, reaching typhoon status by the 6th well east of the Philippines. The well-developed storm turned northward and struck Okinawa on 9 September. She then veered to the northwest and made landfall near Shanghai, China by the 11th. Tropical storm Emma tracked northward from near 20°N, 143°E on 14 September and brushed eastern Japan on the 19th. The storm continued northeastward and soon became extratropical. Remains of the storm were part of a storm system in the vicinity of Kamchatka on 21 September.

REFERENCES
