THE WEATHER AND CIRCULATION OF NOVEMBER 1961

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1. INTRODUCTION

The most prominent feature of the general circulation for November 1961 was an energetic vortex in the polar basin which followed a trajectory westward about the pole (figs. 1, 2, 3). After it left the western sector of the hemisphere, it was succeeded by a blocking regime which strongly influenced the Canadian Provinces during the latter half-month, led to an index cycle of moderate intensity, and brought about a basic shift in the North American circulation pattern. The temperature distribution for the month (fig. 4) was one of western cold and eastern warmth which favored frequent wet and stormy weather along the frontal boundary in between. A remarkably persistent snow deposit in the vicinity of Lander, Wyo. doubtless contributed to the cold weather in that region and, as a consequence, that station experienced one of the coldest temperature anomalies in the Nation.

2. CIRCULATION

The monthly mean circulation at 700 mb. for November 1961 (fig. 1) was dominated by a deep depression over the polar basin which accounted for the largest height anomaly (−470 ft.). Except for the weak center over the Hawaiian Islands it constituted the only Low, and indeed the only center of action of any strength—high or low—on the mean chart. As a result, westerly winds prevailed at 700 mb. over almost the whole region north of the Tropic of Cancer and the axis of this flow was shifted to near 50° N., about 8° north of its normal position. This broad current contained roughly three waves at middle and five at subtropical latitudes around the hemisphere, with the two wave trains mostly out of phase with each other. This was particularly true over North America where the trough in central Canada was not strongly connected either with the trough in the southwestern United States or with the one in the western Atlantic, thus permitting the flow over the Eastern States to remain confluent in nature.

At middle latitudes over the Pacific, the westerlies were well north of normal and sufficiently strong to support a long wavelength from the Japanese to the Canadian trough. Both these troughs were shallow, with positive anomalies in each, and since the ridge between was also weak, the amplitude of this flow was substantially less than normal. Blocking was prominent in the north Atlantic and in eastern Canada as indicated by the twin anomaly centers of +260 and +290 ft. in those areas. In October [1] the strongest center of positive anomaly appeared over northern Russia so that the blocking complex was displaced westward 100° of longitude from one month to the next. The reaction at lower latitudes was for heights to fall sharply and centers of negative departure from normal to appear in the troughs in the southwestern United States, the western Atlantic, and Spain.

Shortly after mid-month the flow pattern changed in a basic manner as most circulation elements retrograded. The Low in the Arctic, for example, proceeded steadily westward from its initial position north of the Beaufort Sea (fig. 2A) and finally came to rest over the Laptev Sea, almost directly across the pole, during the last half of the month (fig. 2B). Since it intensified and expanded as it went, the resulting pattern of anomalous height change in the Siberian Arctic (fig. 2C) showed a large area of strong falls, the central value of which exceeded 1040 ft. To further illustrate the regular motion and intensification of this polar depression, figure 3 has been included which depicts the evolution of the first harmonic of the mid-tropospheric flow during the month. These data were extracted from harmonic analyses about latitude circles of the 500-mb. surface as computed by the Development Branch of the National Meteorological Center and made available by Mr. Brown of that office. On November 6 (fig. 3A) the phase around the 75th parallel was such that the minimum value lay at 120° W. and its associated maximum across the pole at 50° E. The subsequent rotation of this circulation pair about the pole is evident from an inspection of the separate charts of figure 3, and by 0000 GMT, December 4 (fig. 3D), an almost complete reversal in phase had been accomplished. Over northern Canada this action permitted a blocking regime to become strongly entrenched toward the end of the month.

But the polar Low was not the only feature of the mean circulation to retrograde during this period. The central Pacific trough, which had long been a prominent and persistent feature of the circulation, was replaced by a strong ridge, and the associated change in height anomaly (+570 ft.) was exceeded only by that over the polar basin. An inspection of the individual 5-day-mean maps

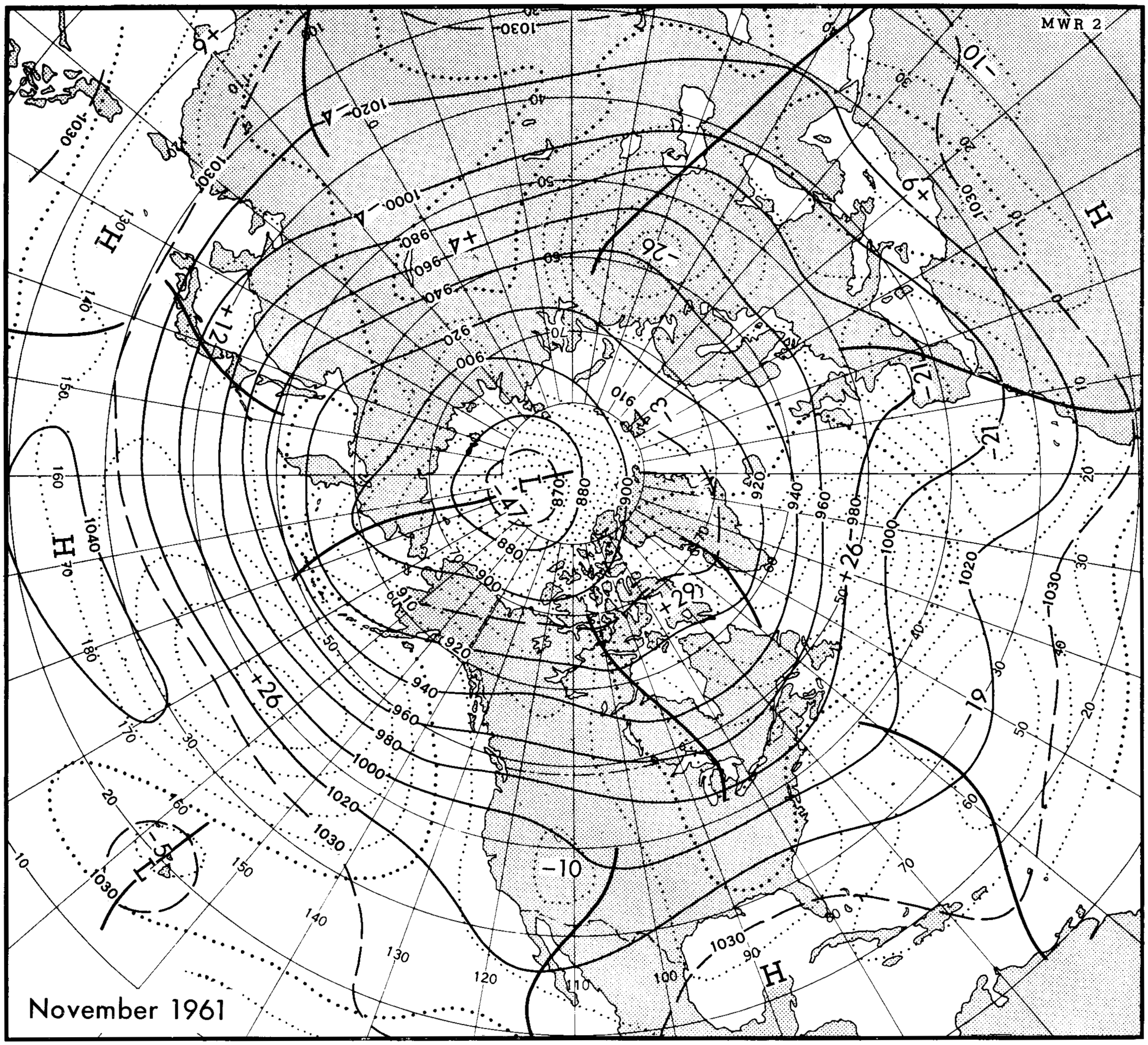


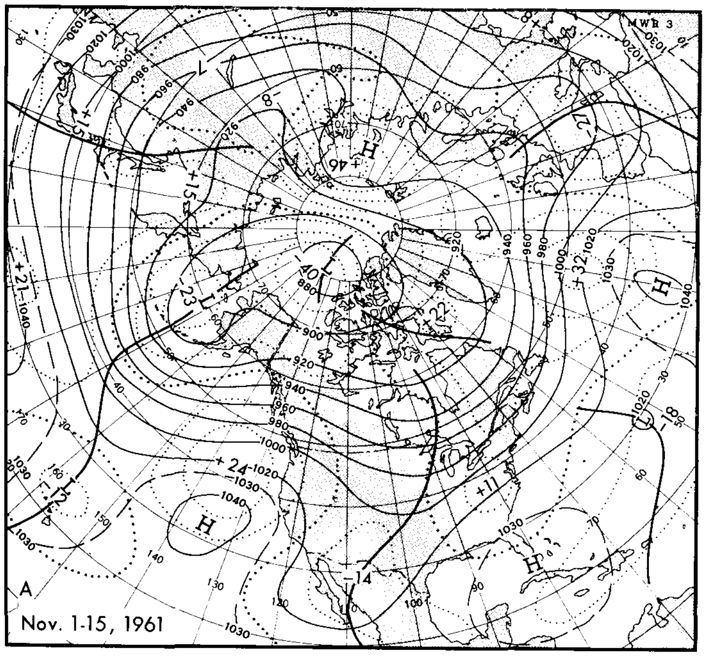
FIGURE 1.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for November 1961. The polar vortex dominated the circulation pattern with high- and low-latitude wave trains mostly out of phase.

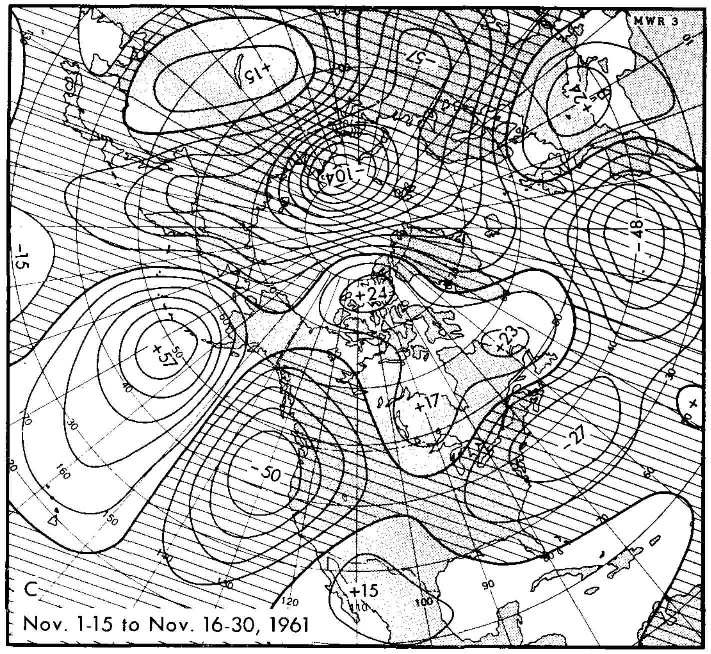
during this period indicates that the evolution was essentially a retrogression of the ridge initially along the Pacific coast of North America to the central Pacific.

Downstream, the full-latitude trough which at first occupied much of the American central plain (fig. 2A) similarly retrograded to a position just off the west coast (fig. 2B) with an accompanying sizable drop in height anomaly of 500 ft. (fig. 2C). This left the flow over the United States flat and weak compared to its earlier state and resulted in a significant change in the distribution of temperature and precipitation over the country. Subsequently the troughs in the southeastern Atlantic and over Europe also underwent a retrogression, the associated falls in anomalous 700-mb. height amounting to 270 ft. and 480 ft., respectively.

3. THE INDEX CYCLE

As has been described, when the polar Low departed from the western and migrated to the eastern part of





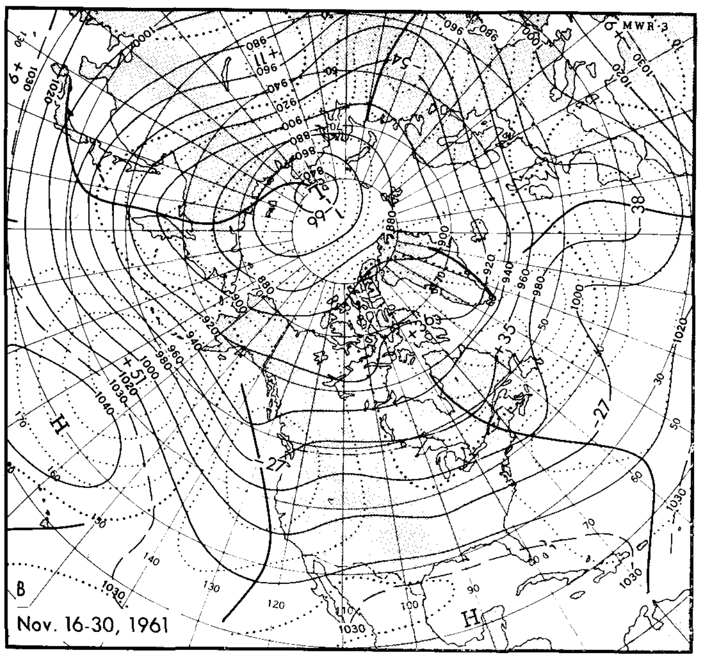
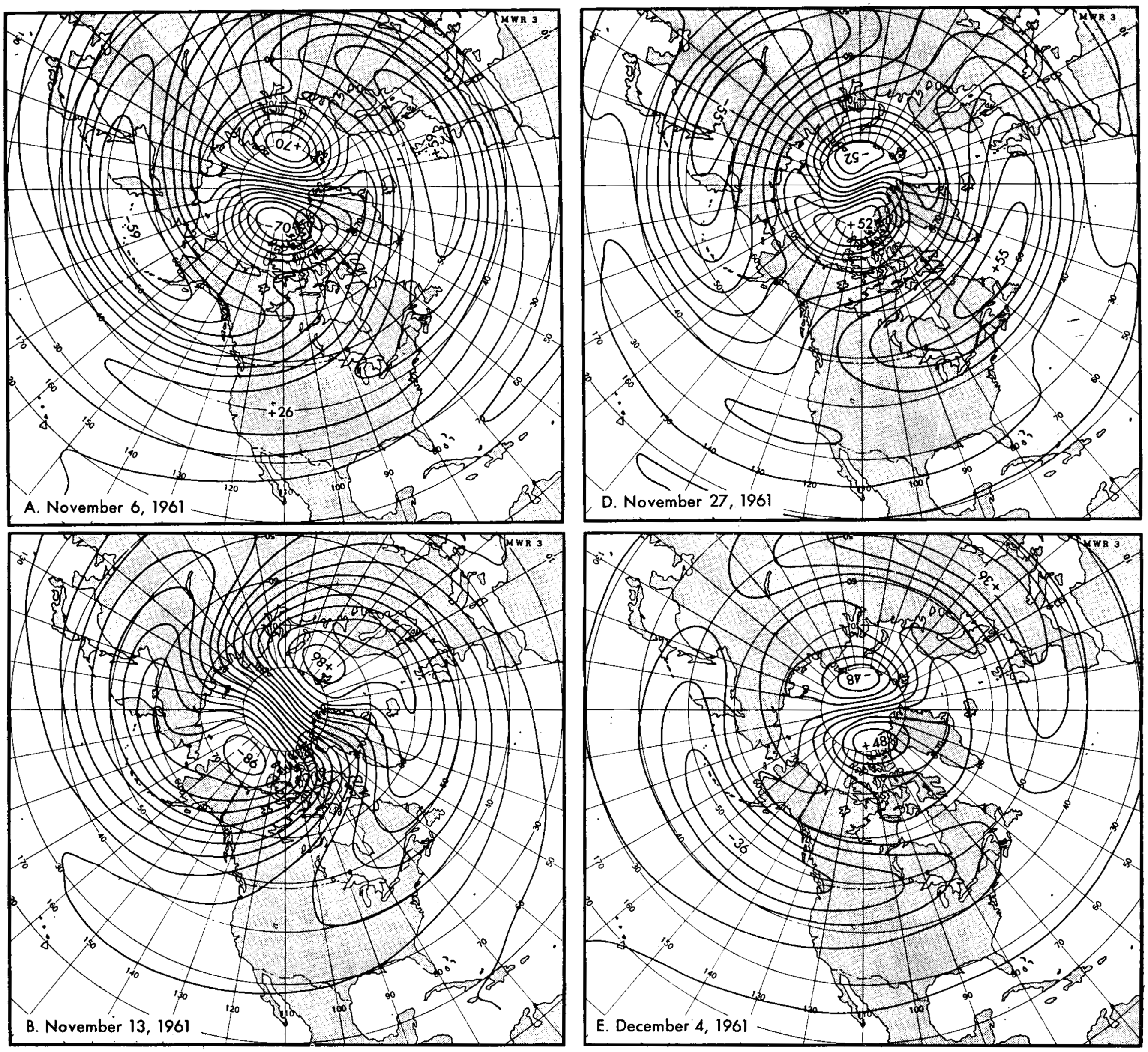


FIGURE 2.—Mean 700-mb. contours (solid) and height departures from normal (dotted) (both in tens of feet) for (A) November 1–15, 1961, (B) November 16–30, 1961, and (C) the difference between the two. As the Low in the polar basin retrograded, blocking became well established in northeastern Canada and the circulation configuration altered significantly in a manner which was essentially a retrogression of the United States trough to a position off the west coast.

TABLE 1.—*Circulation indices (meters per second) for November 1961*

Index	Northern Hemisphere					
	Western portion		Eastern portion		Whole hemisphere	
	Nov. 1-15	Nov. 15-30	Nov. 1-15	Nov. 15-30	Nov. 1-15	Nov. 15-30
Polar (55°-70° N.)	3.6	6.7	3.7	7.9	3.7	7.2
Zonal (35°-55° N.)	10.8	8.1	8.5	9.3	9.7	8.7
Tropical (20°-35° N.)	2.7	5.8	3.5	5.7	3.1	5.7

the hemisphere, it was replaced over the northern Canadian Provinces by a blocking surge. As a result the zonal index (35°–55° N.) over the western sector dropped from 10.8 to 8.1 m.p.s. from the first to the last half of the month. (See table 1.) It performed an oscillation during this time interval with a period of roughly a month and amplitude of about 4 m.p.s. The peak (10.8 m.p.s.) was reached toward the end of the first week, followed by a gradual diminution to a minimum of 7.9 m.p.s. three weeks later, and a rapid rise thereafter to above normal values by the end of the month.



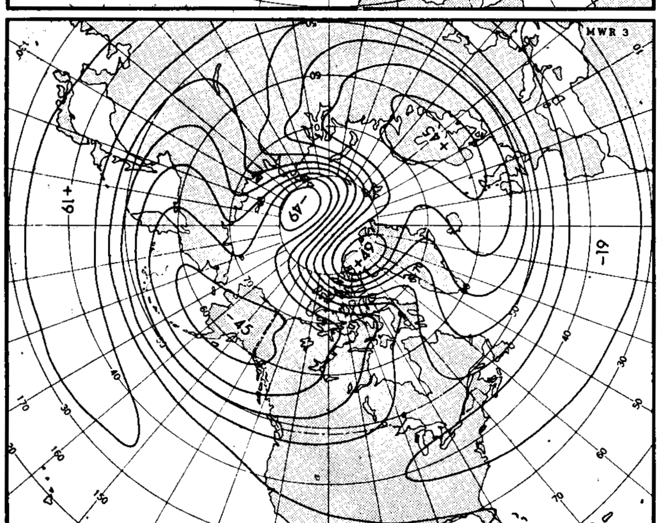


Figure 3.—Analysis of the first harmonic of the 0000 GMT 500-mb. charts for (A) November 6, (B) November 13, (C) November 20, (D) November 27, and (E) December 4, 1961. Amplitudes are shown in tens of feet. In polar latitudes the phase of wave one changed by nearly 180° during this time interval. The first harmonic was also of large amplitude at 50° N., and although the motion was not as regular as in the polar basin, in most cases the phase difference between the two was about 90°.

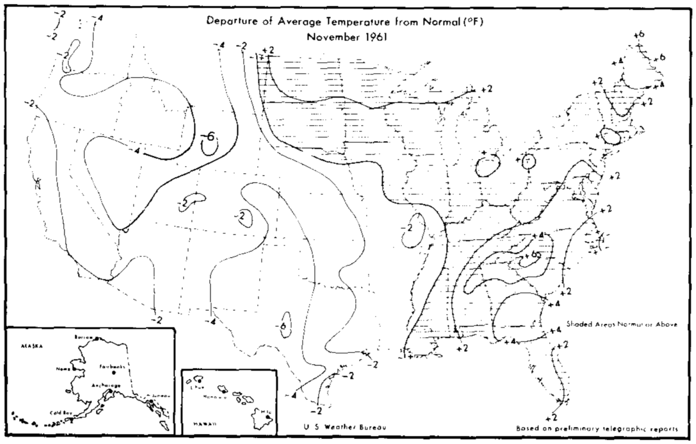


FIGURE 4.—Departure of average surface temperature from normal (°F.) for November 1961. Temperatures were generally mild in the East and cold in the West. Warmest with respect to normal was Charlotte, N.C. and coldest, Lander, Wyo. (From [5].)

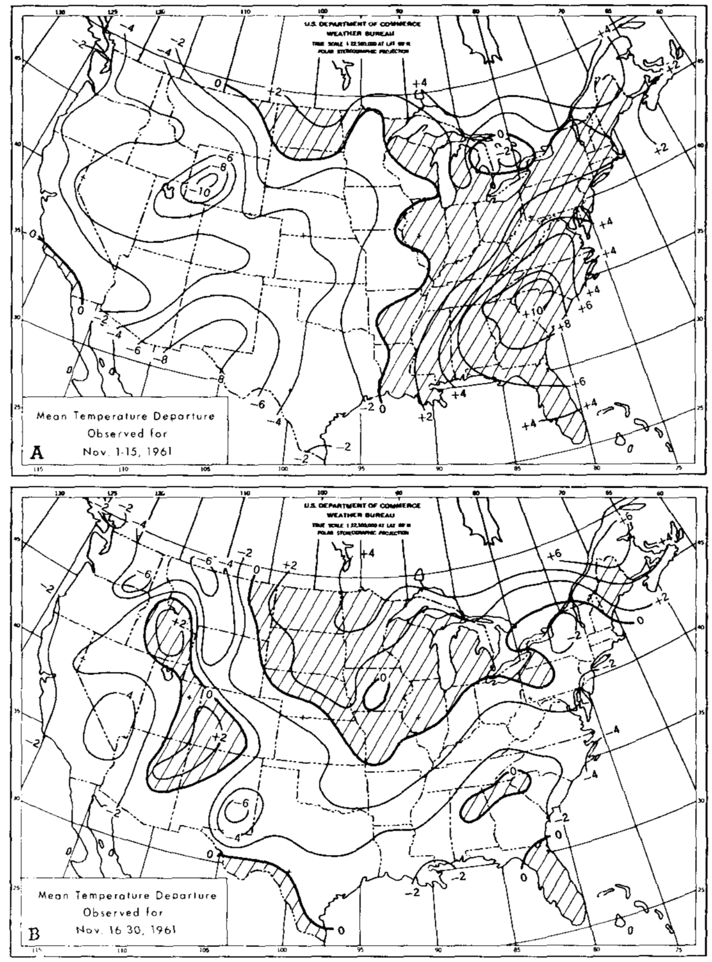


FIGURE 5.—Departure of average surface temperature from normal (°F.) for (A) November 1–15, 1961, and (B) November 16–30, 1961. Very warm conditions in the Southeast gave way to much cooler weather from the first to the last half of the month. Although some warming took place in the West, temperatures remained subnormal except over a small area extending from southern Idaho to northern New Mexico.

Although the zonal flow at middle latitudes in the western part of the hemisphere did decline as the month progressed, this was the only latitude belt over which it did so. By contrast, in the eastern portion the zonal flow strengthened over all three circulation bands (table 1). Evidently, the intensification of the polar vortex and its migration to the Asiatic side of the pole resulted in a westerly circulation of considerably enhanced vigor. Furthermore, in the western portion the indices for both the polar and tropical bands (table 1) also increased by substantial margins during the month. The suggestion is, therefore, that the zonal circulation for the hemisphere as a whole became more energetic, even though that of the western portion middle latitudes became less so.

4. TEMPERATURE

The general distribution of temperature anomaly for November 1961 (fig. 4)—cold in the West and warm in the East—closely resembled the pattern for the preceding month [1] and indeed for the fall season as a whole. From October to November, 53 percent of the stations over the country remained in the same temperature class and an additional 30 percent changed by only one class. These figures represent a remarkable persistence between October and November since it is more usual for a marked change to occur between this pair of months [2].

Coolest conditions with respect to normal occurred in the Great Basin and Rocky Mountain States in association with the deeper than normal mean trough (figs. 1, 4). Warmest weather prevailed underneath the mean ridge in the Southeast where departures ranged up to 6° F. above normal in northern South Carolina. Greenville, S.C. experienced its warmest November in over 50 years.

NOVEMBER 1–15

The break in the circulation pattern near mid-month, described earlier, resulted in a marked alteration in the distribution of temperature anomalies. The first half of the month (fig. 5A) was very cold in the West and unusually warm in the East and this pattern was sufficiently pronounced to determine the character of the field of temperature anomaly for the month as a whole (fig. 4). During this period, the cold spot of the Nation was Lander, Wyo., where the temperature averaged 10° colder than normal. Other intermountain areas did not fare much better, with most of the Rocky Mountain and Great Basin region averaging 4° or more below normal. Lander however was appreciably colder than surrounding stations. Its departure from normal was over 5° lower than at Casper, Wyo., 6° lower than at Cheyenne, Wyo., and 3°

TABLE 2.—*Some eastern stations whose maximum temperature reached record levels in November 1961*

Station	New record November maximum temperature (° F.)	Date
Jacksonville, Fla.	88	Nov. 1
Tampa, Fla.	90	Nov. 4
Augusta, Ga.	90	Nov. 2
Buffalo, N.Y.	80	Nov. 3
Youngstown, Ohio	80	Nov. 3
Pittsburgh, Pa.	82	Nov. 3
Greenville, S.C.	85	Nov. 1

TABLE 3.—*Mean temperature anomaly computed by method described in [3] compared with observed anomaly and days with snow cover at several stations in the intermountain West, November 1961*

Station	Mean temperature anomaly			Days snow on ground	
	Observed	Estimated	Error	Observed	Average (1940–59)
Lander, Wyo.	−6.9	−0.4	+6.5	30	7.6
Great Falls, Mont.	−5.2	−3.3	+1.9	14	7.0
Spokane, Wash.	−5.0	−2.1	+2.9	9	3.0
Denver, Colo.	−4.6	−1.7	+2.9	8	4.7

lower than at Salt Lake City, Utah. A clue to this unusual difference may lie in the persistent snow cover which overlay the Lander area throughout the entire 15-day period. Figure 6 shows the distribution of the number of days with snow on the ground at 5 a.m. Lander was the only station with a continuous cover and, except for Casper, all other stations were snow covered one-third of the time or less. At Cheyenne and Denver, for example, where 0 and 2 days with snow were reported, respectively, the mean temperature departures were only −3.9° and −4.9° F., certainly suggesting that the snow present at Lander played a dominant role in depressing the temperature. Of course, other factors, especially those of the scale of the general circulation, were operating to produce and maintain unseasonable cold in the intermountain region as illustrated by Salt Lake City which experienced the unusually large anomaly of −6.9° F. second only to that of Lander, despite the fact that the surface was free of snow. Thus the presence of snow can be considered only an aggravating factor, but once an anomalous snow cover is deposited and the general circulation is such as to favor cold weather anyway, then the snow and the cold become mutually supporting.

In marked contrast with the West, the Southeast was very warm during the first half-month (fig. 5A). The maximum departure from normal was centered at Charlotte, N.C., where the anomaly exceeded 11° F. and resulted in the warmest November since 1946. Also, numerous records for maximum temperature were broken during a heat wave the first few days of the month, and a few of these have been tabulated in table 2.

In addition numerous stations from Florida to New York set new record maxima for the dates involved. One interesting case was Greenville, S.C., where, in addition to a new all-time November record of 85° F. on November 1, the maximum temperature equalled or exceeded the previous high record for each of the first seven days of the month. This late-season warmth occurred in conjunction with the ridge in the southeastern United States which reached its strongest development during this period.

NOVEMBER 16–30

During the second half-month the Eastern States cooled considerably and became below normal for the most part (fig. 5B). The West, on the other hand, warmed except for stations in Washington and western Montana. The resultant pattern was a rather curious one in which two pockets of above normal temperature, one in southern Idaho and the other near the Four Corners area, were surrounded by a ring of stations with rather markedly below normal temperatures. Also in this case the distribution of snow on the terrain (fig. 6B) appeared intimately related to temperature. The stippled area, which delineates stations with 5 or more days of snow cover, coincides remarkably well with the ring of below normal temperatures previously described. The figures in parentheses on figure 6 give the average number of days with snow on the ground averaged over the past 20 years, and in almost every case where the temperature was markedly below normal, a snow blanket existed with 2 to 5 times the average frequency. By contrast, the region of warmer than normal conditions matched nicely the area where snow was either absent altogether or near its average expectancy.

Thus, although the refrigerating effect of an underlying snow layer is only one of many influences on surface temperature in a mountainous region, in this particular case there appears to have been a strong association between the two. It is difficult to separate the effect of a cold source introduced by a snow surface from the multitude of other influences which affect surface temperature. It is possible, however, to specify approximately the mean temperature distribution typical of a particular mid-tropospheric height pattern using an objective procedure devised by Klein, Lewis, and Enger [3]. Such estimated temperature values, based on the 700-mb. flow pattern for November 1961, have been computed for a few stations and are displayed in table 3. Also included are the corresponding observed mean temperature data and the difference between the two, together with the observed and the average number of days with snow cover. In each case the error in the objective estimate of temperature was positive, indicating that cooler temperatures occurred than would ordinarily characterize the particular circulation pattern observed this month. The fact that both the error and the count of days with a snow blanket were much higher at Lander than elsewhere is highly suggestive. It may be permissible to obtain a rough calculation of the average effect per anomalous snow-

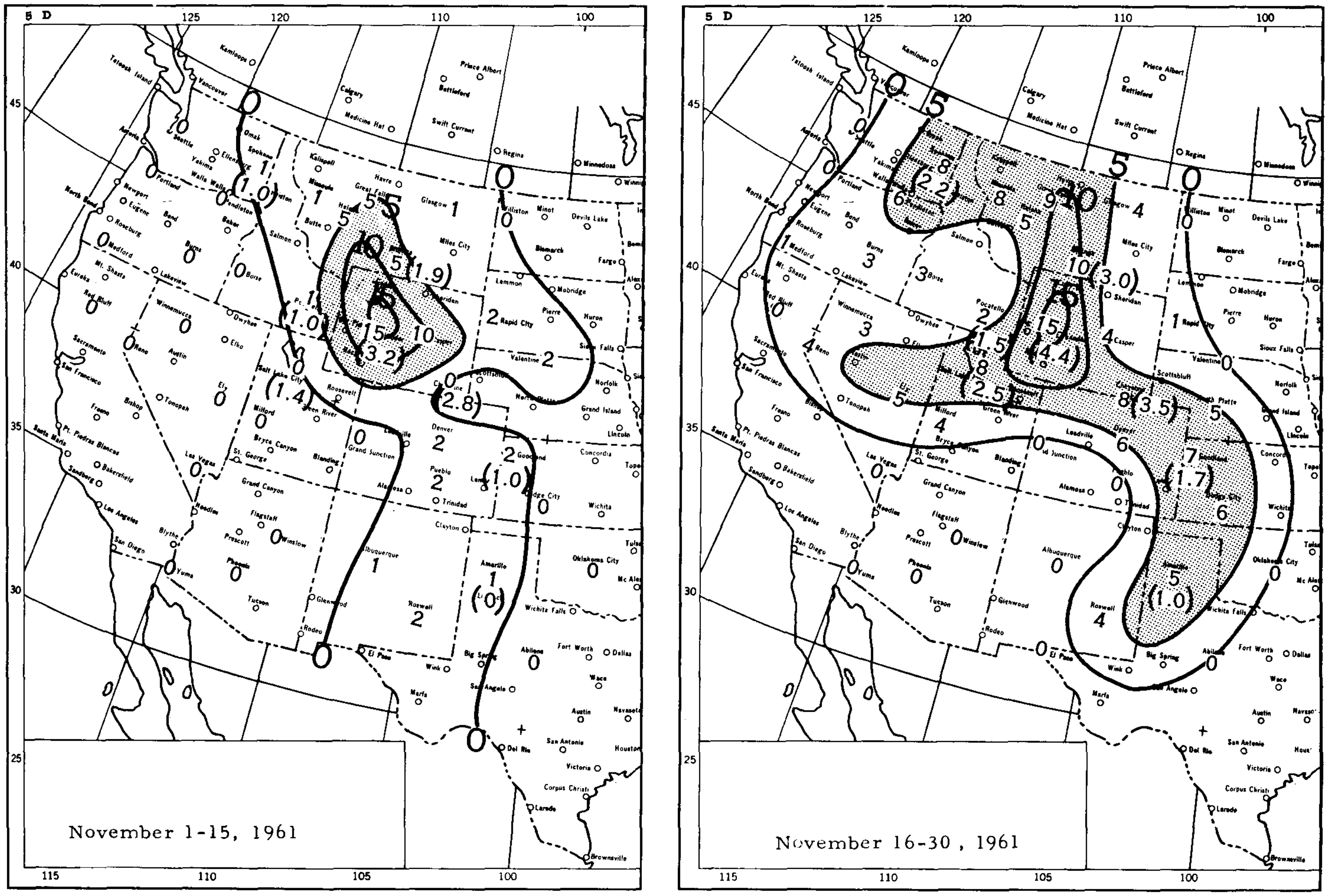


FIGURE 6.—Number of days with snow on the ground at 5:00 a.m. MST for (A) November 1–15, 1961, and (B) November 16–30, 1961. The figure in parentheses gives the average number of days with snow on the ground over the 20-year period 1940–59. The pattern of snow distribution corresponded quite well with that of the colder temperatures particularly during the latter half-month.

covered-day by multiplying the error by 30 and dividing by the total number of such days. Such a computation for Lander results in a figure of 8.8° F. which compares favorably with a similar figure quoted by Namias [4].

5. PRECIPITATION

The circulation pattern for the month as a whole, characterized by a trough in the Southwest and confluence over the central portion of the country (fig. 1), is ordinarily associated with extensive heavy precipitation over the United States, and this month was no exception. The only sizeable areas to receive less than 75 percent of the normal amount were the Great Basin, the northern Great Plains, and the Atlantic coastal plain south of New England (fig. 7). It is interesting that the driest portions of each of these areas (less than 50 percent) corresponded precisely to those which tended toward drouth during the past few months and although beneficial precipitation was received in the Dakotas and the far Southeast during the month, more is still needed in order to fully replenish subsoil moisture.

Elsewhere precipitation was adequate and over many areas excessive. It was particularly heavy over the Mississippi Basin with total accumulations as much as

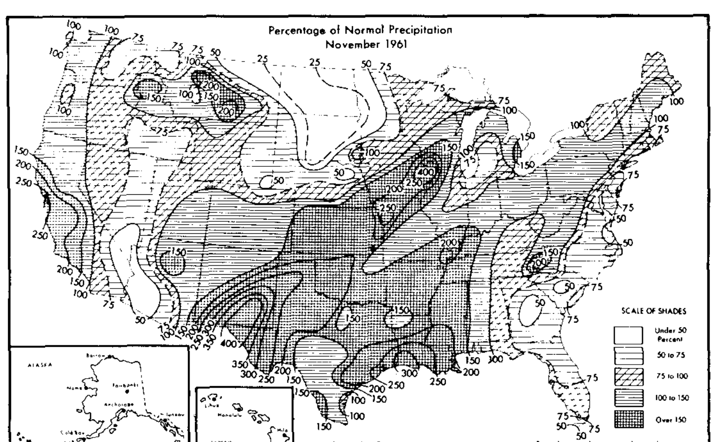


FIGURE 7.—Percentage of normal precipitation, November 1961. (From [5].)

300 to 400 percent of normal in some portions. At Lake Charles, La. the monthly total, which exceeded 14 in., fell mostly during the first of the month and gave rise to many floods and near floods along drainage streams in that area.

As has already been described, the confluent pattern was particularly prominent during the first half-month (fig. 2A) and, as a result, precipitation was heaviest from western Texas northeastward. The Far Southwest, however, because of its position to the rear of the mean trough, continued very dry. As the mean trough retrograded to its position off the west coast during the latter half of the month (fig. 2B) rainfall also extended westward. Amounts totaled 1.88 and 4.24 in. at Los Angeles and San Francisco respectively, this being the first accumulation of an inch or more at the former location since January 1961. Much of this rainfall occurred in connection with the remnants of typhoon Dot which was first reported in the Southwest Pacific on November 9, recurved on the 12th, then weakened as it crossed the Pacific at middle latitudes and finally plunged southeastward to enter the coast of southern California on the 20th. Subsequently this storm weakened as it crossed the mountains, then redeveloped over the western Gulf States, and moved out into the Atlantic where it finally lost its identity by joining a large cut-off depression off the east coast on the 26th. Before doing so, however, this remarkable storm enjoyed a life span of over two weeks, traveled roughly 8,500 miles, and spread heavy precipitation, mostly as rain, from California to New England.

In addition, the appearance of the trough near the west coast brought heavy precipitation to the Northwest and by the end of the month a deep snow pack had accumulated in the Cascades.

Another noteworthy event which took place during the last half of the month was the intense snowstorm in the Northeast on November 20 and 21. A new record for daily snowfall for the month was set at Greenville, Maine when 25 in. accumulated on the 21st. Also, at Rockland, Maine, 4.24 in. of precipitation in 24 hours on the 20th and 21st established a new November record. The storm responsible passed off shore south of New England on November 20, just as blocking became well established to its north over the Canadian Maritime Provinces. As a consequence the depression was able to progress only very slowly and had ample opportunity to acquire an abundant supply of moisture as it rapidly deepened over the ocean. The result was sustained heavy precipitation which fell continuously as snow in the interior of New England but turned to rain along the coastal strip.

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