THE WEATHER AND CIRCULATION OF JANUARY 1963

One of the Most Severe Months on Record in the United States and Europe

JAMES F. O'CONNOR

Extended Forecast Branch, U.S. Weather Bureau, Washington, D.C.

1. INTRODUCTION

January 1963 was memorable for the extreme severity of the cold weather which simultaneously gripped North America, Europe, and the Far East.

In Europe it was one of the coldest months ever recorded, resulting in shortages of coal and food due to paralysis of land and water transport as snowdrifts blocked roads and ports and waterways were blocked by ice or were completely frozen over. Shortages of water and gas also occurred as a result of damage by frost to exposed pipelines in normally milder climates. Many died or were hospitalized from exposure to the cold. Average temperatures for the month were in excess of 9° F. below normal from southern England across Europe to the Urals.

One of the coldest regions, in terms of departure from normal, was in Poland, where Warsaw reported an average temperature of 9.7° F. for the month, or 18.5° F. below normal. Farther west in Europe, Paris averaged 26.8° F., or 9.9° F. below normal. Not even the usually milder Mediterranean regions escaped the low temperatures, which averaged about 5° F. below normal, or the snowstorms which sometimes reached blizzard proportions, resulting in isolated villages and hardships in many places.

In the Far East, abnormal cold was accompanied by blizzards, notably in western Japan, where snowdrifts of 12 ft. in some districts paralyzed transportation and collapsed roofs. Soldiers and students were pressed into service to dig out trains and remove snow from roofs to save schools and other structures.

2. HIGHLIGHTS OF WEATHER IN THE UNITED STATES

In this country, heavy snows and blizzards contributed to the severity of the weather in some areas, though the most notable aspect was the persistent and extreme cold. It damaged or killed fruit trees in the West and citrus and vegetable crops in the Southwest. Many died or were hospitalized from frostbite and exposure.

In Alaska, after 9 days of cold early in the month, the remainder of the month was extremely warm. Fairbanks had the warmest January in 26 years and Kotzebue the warmest on record.

In Hawaii, the weather was stormy, with the lowest average pressures on record at some locations. New January records were set at Honolulu for total rainfall, number of days with rain, and minimum temperature.

Precipitation in the western United States continued the pattern of severe drought of the cold season. In Los Angeles, the winter produced only 0.72 in. of rain to the end of January, compared to a normal 6.73 in. San Francisco had the longest dry period, 25 days, of any January on record. In the Pacific Northwest precipitation was also considerably below normal, with the least snowfall in the mountains for any January in some places, and snowpack considerably below normal in all sections. Yakima, Wash., had its only snow on the last day of the month, 13.6 in., a record amount for a 24-hr. period.

In northern California, Nevada, Idaho, and Oregon, heavy rains in the last few days of the month helped alleviate the drought but brought destructive flooding to some localities, especially Reno, Nev., where the Truckee River overflowed and frozen ground contributed to flooding of the downtown district. Flooding also occurred in southeastern Idaho for the second time within a year.

Heavy snowfall occurred in a number of regions. Record amounts for January fell in parts of Montana, notably 28 in. at Billings and 42 in. at Missoula, the second heaviest for any month in 71 years of record. In Wyoming, Sheridan received 24 in., also a record. It snowed almost every day in those localities after the weather turned cold on the 9th.

Blizzards of varying intensity occurred with each of five outbreaks of Arctic air in the northern Rockies, while farther east they accompanied at least three. At Grand Rapids, Mich., for example, the first blizzard from the 12th to the 14th brought 18 in. of snow. Another, on the 23d and 24th at Muskegon, Mich., climaxed a 6-day period of heavy snow totaling about 35 in., following a fall of over 18 in. during a 5-day period after the first outbreak. The monthly total of 42.6 in. at Grand Rapids was the heaviest since 1918, and the 64.7 in. at Muskegon was second only to the record 66.6 in. in January only a year ago. Snowfall occurred on almost every day in the last 3 weeks at those cities.

The blizzard of the 23d and 24th hit other regions farther east, especially in New York where Albany received over 10 in., the second 10-in. snow in 4 days and the first such occurrence since 1891. Another blizzard on the 27th and 28th brought heavy snows again to many parts

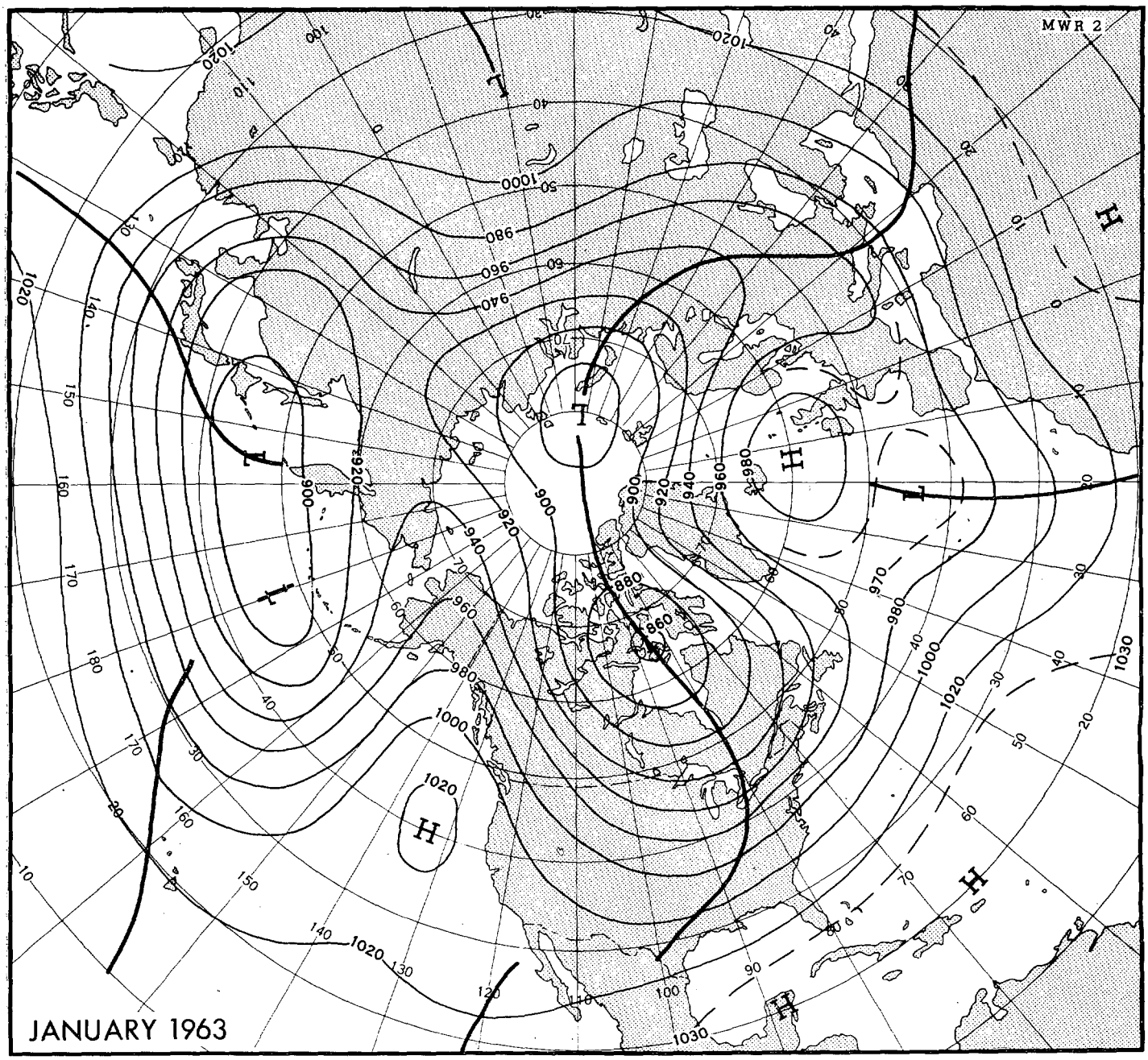

FIGURE 1.—Average contours of 700-mb. surface (tens of feet) for January 1963. Troughs (heavy solid lines) indicate minimum latitudes of contours. Outstanding features were the strong ridges in eastern Atlantic and Pacific.

of the Northeast, such as Allentown, Pa., 7.4 in., and Pittsfield, Mass., and Syracuse, N.Y., 12 in.

In parts of Ohio, January snowfall was more than twice the normal although the monthly precipitation (water equivalent) was one of the lowest on record for January.

3. COMPARISON OF JANUARY 1963 WITH OTHER COLD MONTHS

January 1963 was one of the coldest months on record in the United States. The cold spell this month came on the heels of a severe cold wave in December, when the lowest temperatures of record occurred on the 12th and 13th in Georgia and Florida, and the second coldest temperatures since February 1899 occurred elsewhere in that region [1]. The −6° F. temperature at Asheville, N.C., in December, which equaled their alltime record low of 1905 was, however, exceeded this month by 1° F.

This was the second consecutive January that temperatures averaged well below normal from coast to coast, although this month was far colder nationwide. It is

rare to have any month with cold weather from coast to coast, much less two in succeeding years. In January 1962, the most severe cold wave since February 1899 occurred in the South [2] where new records for cold in January were established at Roswell, N. Mex., Midland, Tex., and Baton Rouge, La. These were not exceeded in January 1963, but the January mean temperature this year was lower at all three locations.

On the basis of monthly mean temperatures, averaged for about 100 evenly distributed cities with records back to 1893, January 1963 tied with January 1940 as the second coldest month in 70 years, with an average temperature of 27° F. from coast to coast. Only January 1918 was colder with 26.7° F. Since parts of the Far West in both 1918 and 1940 were warm (with respect to normals for those periods as well as the present), but were cold this month, January 1963 might be considered the coldest month in 70 years on a countrywide basis. Nevertheless, on a local and regional basis, this January ranked well behind other historic cold months especially January 1918 and 1940 east of the Continental Divide.

In the Midwest, this January ranked no higher than the 3d or 4th coldest month, behind January 1912 and 1918, and February 1936. However, much of that region this month had the greatest or second greatest number of days on record with 0° F. or lower. Only the historic cold spells of January 26–February 14, 1899 at Green Bay, Wis., and January 13–February 21, 1936 in Nebraska, South Dakota, and Minnesota were colder or longer.

In the Central Plains, where Grand Island, Nebr., had one of the largest average temperature departures from normal (−13.7° F.), January 1963 ranked no higher than the 5th coldest month on record, behind January 1930, 1937, 1940, and February 1936. In the Northern Plains, it was considerably warmer than in February 1936, the coldest month, and several others. In the Southern Plains it was the 5th coldest month, behind January 1918, 1930, 1940, and February 1929; while farther east in the Tennessee Valley it was not as cold as in January 1918 and 1940. In the Ohio Valley where a number of cities established new low temperature records on January 24, the average temperatures for this month ranked well behind most of the historic cold months mentioned above.

In the West, the coldest region relative to normal was in Colorado, where Grand Junction had an average January temperature of 12.1° F., or 13.9° F. below normal, the coldest month during its record of 71 years. At Pueblo this was the second coldest since 1888. Elsewhere in the West the average temperatures this January ranked no better than 3d lowest, behind at least two historic cold months in that region, January 1937 and 1949. Near the west coast one of the coldest regions was in northern California and Oregon, where Medford, Oreg. averaged 6.1° F. below normal.

In the Northern Rockies and Pacific Northwest this January was not as extreme as the Januarys of 1930, 1937, 1949, and 1950, the coldest months on record in various localities in that region. In coastal sections of the Northeast this January was considerably warmer than February 1934, the coldest month in that section.

It is noteworthy that of all the historic cold months mentioned above, almost 25 percent of the alltime record low temperatures (for any day) which still stand today were established on the 12th and 13th of February 1899. But on the basis of average monthly temperatures countrywide, that month does not appear as the coldest month at any of those cities. In fact, February 1899 now ranks behind the Januarys of 1918 (coldest), 1940 and 1963, 1930, 1912, and February 1936, in that order, as the 7th coldest month from coast to coast.

4. THE CIRCULATION PATTERN IN MID-TROPOSPHERE

The average circulation at 700 mb. in January 1963 (fig. 1) was one of extreme amplification. The Low in the Pacific was far southeast of its usual position in the Sea of Okhotsk, and the trough normally about 10° west of Hawaii was much deeper and closer to the Islands. This produced unusually stormy conditions with record low average pressures farther south near Hawaii.

In harmony with the deep Hawaiian trough, an enormously amplified ridge was observed in the eastern Pacific, west of the usual position over western Canada. The eastern cell of the Pacific High was located farther north than normal by about 20° of latitude. Strong southerly flow from Hawaii northward, in contrast to the usual westerly flow there, brought the unusual warm spell to Alaska in the last 3 weeks.

East of the strong Alaskan ridge, a deep trough was located over eastern North America. The resulting northerly flow over western North America was not only abnormally strong but also west of the normal position, a very efficient pattern for cooling off lower latitudes. Accordingly, repeated surges of Arctic air in rapid succession drove deep into the southern United States. Four distinct cold waves reached the Texas Gulf coast, the first time that was observed in one month.

Downstream in the eastern Atlantic, the ridge was so strongly amplified that a blocking High prevailed throughout the month between Iceland and Britain. To the south a deep Low and trough occurred near the Azores, an almost complete inversion of the usual pattern. This remarkable blocking pattern diverted one branch of the westerlies sharply northward from Newfoundland, toward a ridge over Greenland. This southerly current produced unseasonable warmth over Greenland analogous to that over Alaska, then turned into an abnormally strong northwesterly flow across the Norwegian Sea and northwestern Europe. This flow penetrated well into Europe, carrying successive outbreaks of Arctic air deep into southern sections, producing cold of a severity rarely paralleled in weather history there.

To the south of the Icelandic block another branch of abnormally strong westerlies for that region occurred

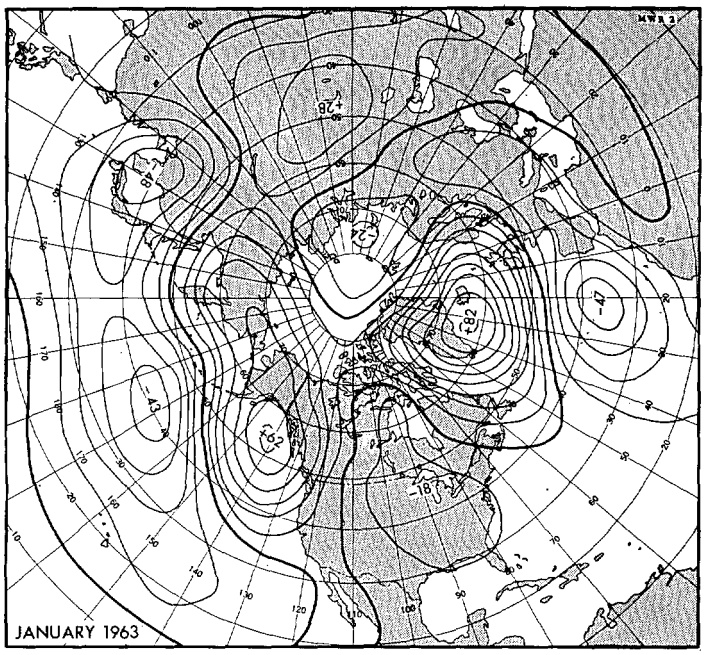

FIGURE 2.—Average height departures from normal at 700 mb. for January 1963 drawn at intervals of 100 ft. with center labeled in tens of feet and zero line heavy. Outstanding features were strong positive departures at high latitudes in Atlantic and Pacific.

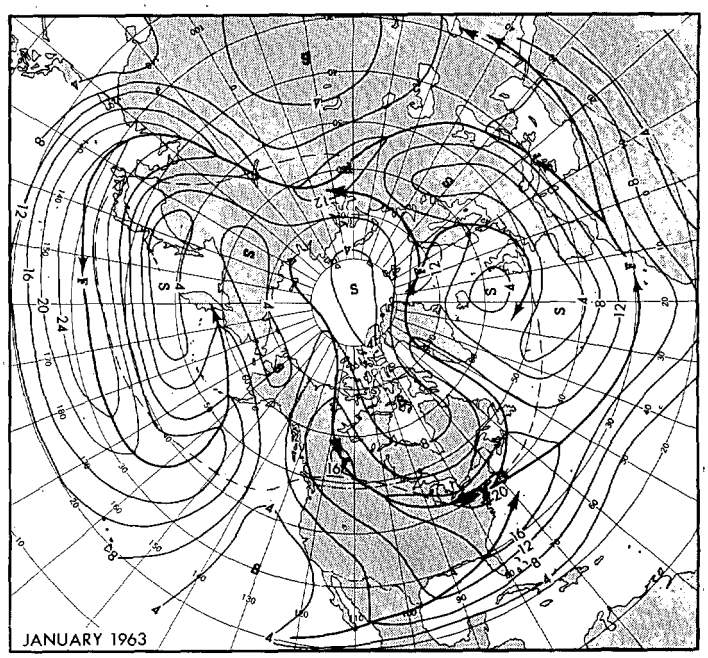

FIGURE 3.—Average geostrophic wind speeds (m.p.s.) at 700 mb. and axes of speed maxima (heavy arrows) with centers of maximum speed (F) and minimum speed (S) for January 1963. Normal positions of axes of maximum speed are dashed. Meridional orientation of axes of maximum wind speed (jet axes) was in sharp contrast to the zonal orientation of the normal.

south of the deep cutoff Low near the Azores. This was accompanied by a drastic shift of storms from the usual track, northeastward across the Atlantic to Iceland, to one much farther south across the Azores and into the Mediterranean.

Farther east over Asia, the deep European trough assisted in building a strong ridge over central Asia and a deep Asiatic coastal trough. In that region also, cold continental air was persistently transported far southeastward over Japan and China, resulting in heavy snows and blizzards in western Japan as the cold air moved over the Sea of Japan and then struck the elevated land areas.

5. CIRCULATION DEPARTURES FROM NORMAL

The magnitude and extent of the hemispheric circulation abnormalities are illustrated in figure 2. Below normal heights extended across the entire Pacific, with maxima of over 400 ft. near Korea and northeast of Hawaii. Together with positive height departures of up to 620 ft. in the Gulf of Alaska, the total gradient of height departure at 700 mb. totaled over 1,000 ft. in the eastern Pacific. This corresponds to a departure, from the normal southwesterly flow, of about 30 kt. from the southeast.

Over North America, heights were below normal over a large part of the continent, with a maximum in Wisconsin where temperatures were near their lowest relative to normal. The total height departure difference between mid-continent and the Gulf of Alaska totaled 700 ft. or more on the average. This indicates the abnormal strength of the southward drive from the Arctic source region toward lower latitudes.

The largest abnormalities, however, were in the Atlantic where heights averaged as much as 820 ft. above normal near Iceland, an intensity unequaled in at least 30 years. To the southeast, heights were as much as 470 ft. below normal near the Azores. Between Iceland and the Azores the total height departure difference averaged almost 1,300 ft. for the month, corresponding to easterly geostrophic departure of as much as 30 kt. This reflected a reversal of the usual flow in January from westerly at about 20 kt. at 700 mb. to the observed easterly flow of about 10 kt. west of Britain.

As a result of the extreme positive departures near Iceland and low heights in eastern and southern Europe, the northerly flow over northern Europe was strongly augmented, veering to easterly flow over southern and western Europe. This was the mechanism by which that region was persistently flooded with Arctic and Siberian air.

In Asia, a similar, though less intense, couplet of positive departures in western Asia and negative departures near Japan was symptomatic of the cold weather in that region.

All the height departure centers were extremely persistent throughout the month. Of the two principal

centers, the one in the northeastern Pacific drifted slowly northward from off the California coast early in the month to Alaska at the end of the month. The Icelandic center looped eastward from the Denmark Strait to the Faeroe Islands and back to the Strait at month's end.

6. THE JET STREAM

The average position of the axes of the jet stream at 700 mb. this January, in comparison with the usual position, and the associated average wind speeds are shown in figure 3.

Over the western and central Pacific, the axis of the westerlies was much stronger and farther south than normal. Average wind speeds were as much as 22 kt. above normal near Midway Island, with even greater departures over the East China Sea. The average storm track was about 5° of latitude north and west of the jet axis, in the region of cyclonic shear, the usual relationship [3].

In the eastern Pacific the mean jet was almost completely fractured, since it turned northward north of Hawaii and became a strong easterly stream over the Bering Sea. Accordingly the usual axis of strong winds across the northwestern corner of the United States was largely nonexistent.

Over western Canada the unusual axis of strong northerly winds, originating in the Arctic Ocean, coincided with the track of Arctic anticyclones southward into Alberta, which was the gateway for repeated outbreaks of cold air into the United States. Surprisingly, in the United States the wind speed axes were not dramatically different from normal, although the westerlies averaged as much as 10 kt. below normal in southeastern Canada and New England. Elsewhere in the Nation, the westerlies were about 5 kt. stronger than normal as far south as the Gulf of Mexico.

As noted in the previous section, the North Atlantic region was the most abnormal. The usual axis of winds across the central Atlantic was replaced by two westerly branches, one far to the north from Greenland to Scandinavia, and the other far to the south near the Canary Islands. The most dramatic departure occurred near Britain where the usual westerly jet was replaced by an easterly stream.

In the Mediterranean, the strong jet axis was far north of its usual position over the Sahara desert. This produced a close juxtaposition of deep disturbances, which moved eastward across the Mediterranean in rapid succession with Arctic outbreaks from northern Europe, and thus resulted in heavy snows, often of blizzard proportions.

In Eurasia an unusual jet axis extended from the Balkans northeastward to a speed maximum east of the Urals and north of its normal position. This axis indicated the locus of disturbances which brought heavy snows to eastern Europe from the Balkans. In eastern Asia the mean jet axis turned sharply southeastward across Lake Baikal into eastern China, considerably west of its usual position in January and much stronger than normal.

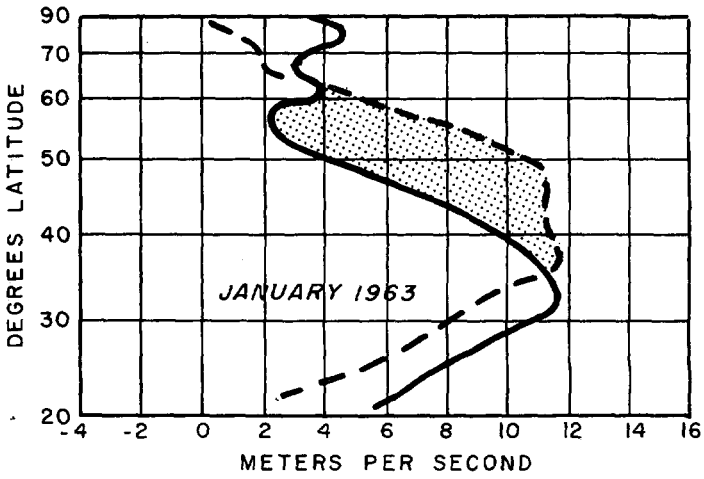

FIGURE 4.—Variation with latitude of average wind speed at 700 mb. in western half of Northern Hemisphere, for January 1963 (solid) and normal variation in January (dashed). Stippled area indicates latitudes where average winds were weaker than normal. Weak winds at mid-latitudes were associated with strong blocking in north Atlantic and Pacific.

The variation of the average wind speed with latitude for January 1963 for the western half of the Northern Hemisphere is shown in figure 4, together with the normal for comparison. The mid-latitude westerlies were much weaker than normal, as shown by the stippled area, due to strong blocking in both the Pacific and Atlantic in combination with below normal heights at mid-latitudes. The increased pressure gradients in subtropical latitudes were reflected in stronger than normal westerlies at those latitudes. As a result the westerlies this January reached a sharp maximum of about 24 kt. on the average near 32° N. at 700 mb., considerably south of normal. The polar westerlies were also stronger than usual due to the increased pressure gradients north of the Pacific and Atlantic blocks.

7. THE INDEX DECLINE

The variations in the speed of the westerlies at 700 mb. are shown in figure 5 for both the mid-latitude and subtropical zones in the western half of the Northern Hemisphere. The graphs show the variations as far back as November 1962 when the temperate westerlies were at maximum speed about the 24th. Subsequently the index declined sharply, falling well below normal in the first part of December, near the time of the first cold wave of the winter in the United States. After a recovery to near normal speeds, an abrupt decline again occurred late in December to speeds far below normal for temperate latitudes, and even below the normal for subtropical latitudes. These weak westerlies were associated with the

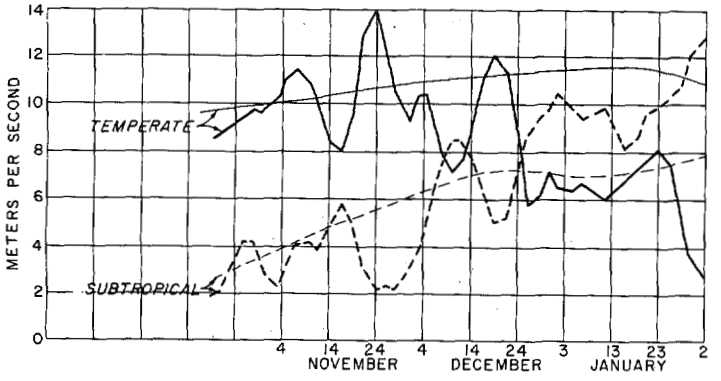

FIGURE 5.—Variation of 5-day average wind speeds (m.p.s.) at 700 mb. for western half of Northern Hemisphere, from 35° N. to 55° N. (heavy solid) and from 20° N. to 35° N. (heavy dashed) from November 1962 to February 2, 1963, with corresponding normal variations for 35° N. to 55° N. (thin solid) and 20° N. to 35° N. (thin dashed). Most notable feature was declining trend at mid-latitudes, with speeds remaining far below normal throughout January.

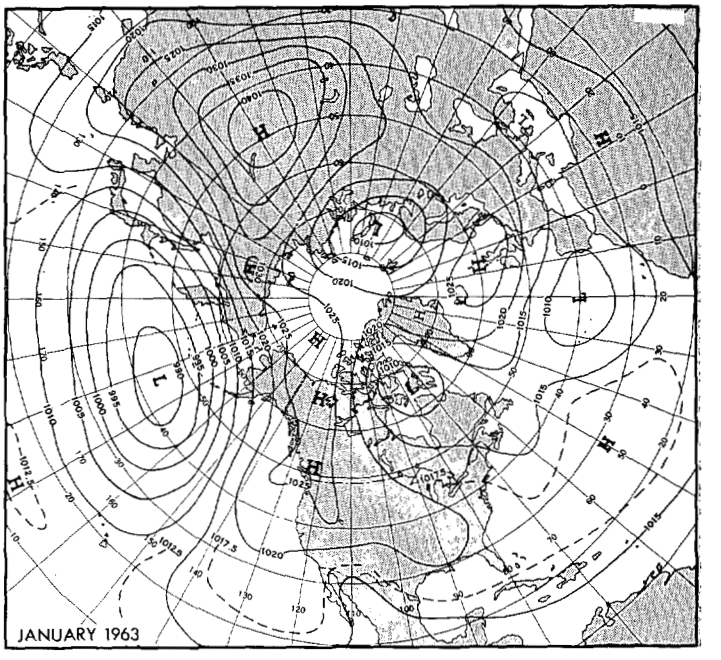

FIGURE 6.—Average pressure (mb.) at sea level for January 1963. Outstanding feature was the Low near the Azores and the High near Iceland, the reverse of the normal pattern.

persistent blocking at higher latitudes that prevailed throughout the month of January. There was no significant recovery at any time during the month, but instead the index declined sharply again during the last week to a minimum of 2.8 m.p.s., about 8.0 m.p.s. below normal. The mid-latitude westerlies thus remained far below normal during the entire month, averaging 6.3 m.p.s. for the month (about 5.0 m.p.s. below normal), lower even than the normal subtropical index in January.

The subtropical westerlies, on the other hand, maintained a rising trend after late November. As might be expected in the winter season, when the circumpolar westerlies diminish at mid-latitudes they migrate in part to lower latitudes [4]. Thus the subtropical westerlies at 700 mb. this January rose above normal in late December with no decline below the normal speed during the entire month. Late in the month they increased to their highest speed, 12.8 m.p.s. This was not only well above the normal subtropical wind speed, but even above the normal mid-latitude value. Thus at month's end the subtropical westerlies were 10.0 m.p.s. faster than those at mid-latitudes. The subtropical westerlies for the month of January averaged 9.9 m.p.s., about 2.5 m.p.s. above normal.

An index decline of this magnitude at mid-latitudes, sustained over the month without appreciable recovery, has not been observed before in the compilations of Extended Forecast Branch.

8. THE AVERAGE CIRCULATION AT SEA LEVEL

In the central and western Pacific an enormous cyclonic circulation prevailed throughout the month, about 900 miles southeast of its usual position near Kamchatka (fig. 6), with pressure averaging as much as 21 mb. below normal near the center.

In the northeastern Pacific, pressures as much as 15 mb. above normal precluded the existence of the usual Gulf of Alaska Low. A very strong ridge of high pressure from the northwestern United States to the Arctic Ocean connected with the Siberian High, which averaged as much as 11 mb. stronger than normal for the month. The locus of the Arctic outbreaks is clearly depicted in this extensive pressure ridge from western Canada into the southeastern United States.

In the Atlantic, the subtropical ridge was weaker than normal and the Azores High was completely absent from its usual location. In its place was a deep Low whose pressure was 15 mb. lower than normal for that location. Farther north near Iceland, where a deep Low usually prevails, an enormous High occurred, with pressures as much as 27 mb. above normal for that area, averaged over the entire month. This was the strongest blocking High for any winter month in the Iceland region since 1932. The Atlantic circulation thus displayed a complete inversion of the relative positions of the Iceland Low and the Azores High that normally exist in January. This reversal had drastic consequences for the weather in Europe.

East of the Azores Low an extensive channel of lower than normal pressure across Spain reflected the procession of disturbances which moved into the eastern Mediterranean south of the abnormally high pressure in Europe.

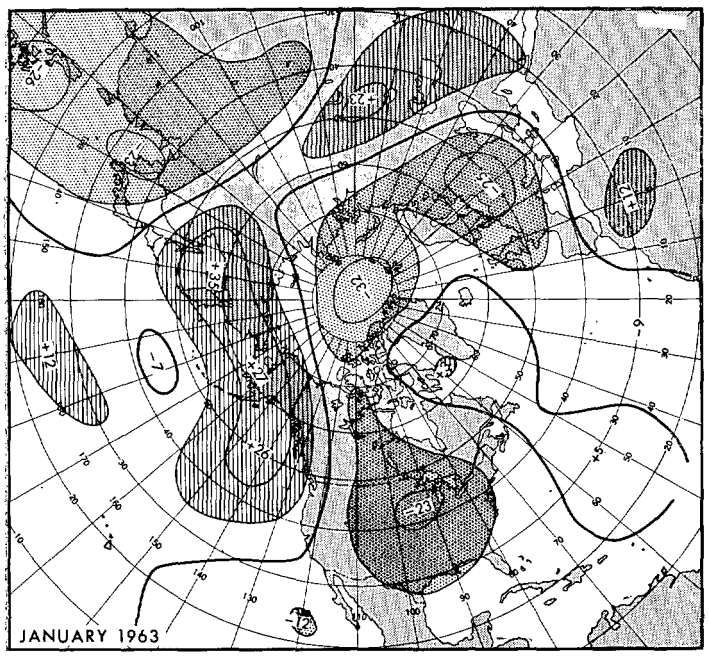

FIGURE 7.—Average 700–1000-mb. thickness departures from normal (tens of feet), with zero anomaly heavy, for January 1963. Departures in excess of 50 ft. below normal are stippled and 50 ft. above normal are hatched. Outstanding feature was the simultaneous cold (stippled) in the Far East, North America, and Europe.

9. THE TEMPERATURE REGIME ABROAD

The hemispheric temperature regime may be inferred from the 700–1,000-mb. thickness departures shown in figure 7. The stippled thicknesses are roughly equivalent to monthly average temperatures of more than 4° F. below normal, and the coldest areas relative to normal are in the vicinity of the maximum thickness departures. In the European sector, for example, there were two centers of maximum thickness depression, one near the North Pole, where Franz-Josef Land reported temperature departures averaging over 19° F. below normal, and another near Poland where temperature departures were of about the same magnitude.

In the Far East, average temperature departures were not so extreme, although averages of over 7° F. below normal were reported from many localities as far south as the northern Philippines.

The hatched areas, on the other hand, are roughly equivalent to monthly average temperatures in excess of 4° F. above normal. The largest region of mild temperatures extended from Manchuria northeastward across the Bering Sea to Alaska and the northeastern Pacific. In that region departures averaged as much as 16° F. above normal in many places.

Another warm area, though much smaller, was along the west coast of Greenland, where temperatures averaged as much as 19° F. above normal. Another mild region was in Central Asia, where average January temperatures as much as 16° F. above normal were reported near Novosibirsk, USSR.

10. TEMPERATURE IN THE UNITED STATES

Details of the average temperature regime in the United States, in terms of average departures from normal are shown in figure 8. Temperatures were below normal from coast to coast, and the only significant areas which were above normal were Maine and southeastern Florida. The coldest localities relative to normal were near Grand Junction, Colo., with an average departure of 13.9° F. The second coldest area was near Grand Island, Nebr., with a departure of 13.7° F., and the third was near Moline, Ill., with a departure of 13.4° F.

THE EARLY WARM SPELL

Strong westerlies associated with a persistent Basin High during the first nine days of January brought very warm weather to the northern Rockies and North Central States, sometimes reaching record levels. Temperatures were as much as 32° F. above normal in North Dakota on the 7th, and more than 43° F. above normal across the Canadian border. This warm spell made its way to the east coast producing some record maxima enroute on the 11th and 12th when it was as much as 20° F. above normal. The warm spell ended on the 9th in Montana, followed by 22 consecutive days of subzero temperatures in parts of the Northern Plains. The cold spell was made up of five surges of Arctic air which plunged southward across Montana into the United States, as shown in figure 9.

THE FIRST COLD WAVE

The first outbreak of cold air entered Montana on the 9th in advance of a Yukon High of 1056 mb. On the 10th, the temperature at Great Falls, Mont., fell to 42° F. below normal, while to the south Little Rock, Ark., was recording 77° F., the highest on record for that date. On the 11th the accompanying blizzard spread record cold for the date into the Far West, where Meacham, Oreg., had −23° F., its lowest on record, and into the central Rockies where Cheyenne, Wyo., recorded 49° F. below normal. On the 12th, record cold spread over large areas of the Rockies as far west as California and eastward over the Plains as far south as western Texas. On this day West Yellowstone, Mont., had a temperature of −56° F., and Raton, N. Mex., had −31° F., the lowest ever recorded there. By the 13th Arctic air had driven deep into the Southwest with record cold from California, where Long Beach reached 25° F. for the first time in 23 years, to the Texas Gulf coast, where Brownsville was 29° F. below normal. On this day occurred alltime record low temperatures of −23° F. at Grand Junction, Colo., 8° F. at Las Vegas, Nev., and −37° F. at Maverick, Ariz., the lowest ever observed in that State. On the 14th severe cold stretched from coast to coast, as part of the original Yukon High in the lower Mississippi Valley chilled the Gulf States

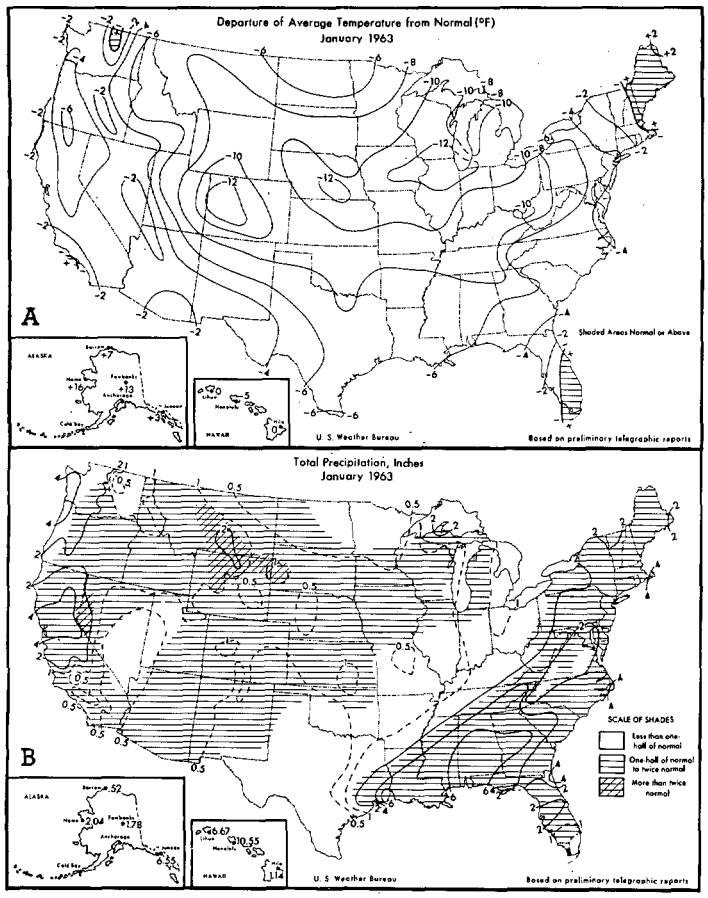

FIGURE 8.—(A) Average temperature departure from normal (° F.) and (B) total precipitation (inches) for January 1963. (From [5].)

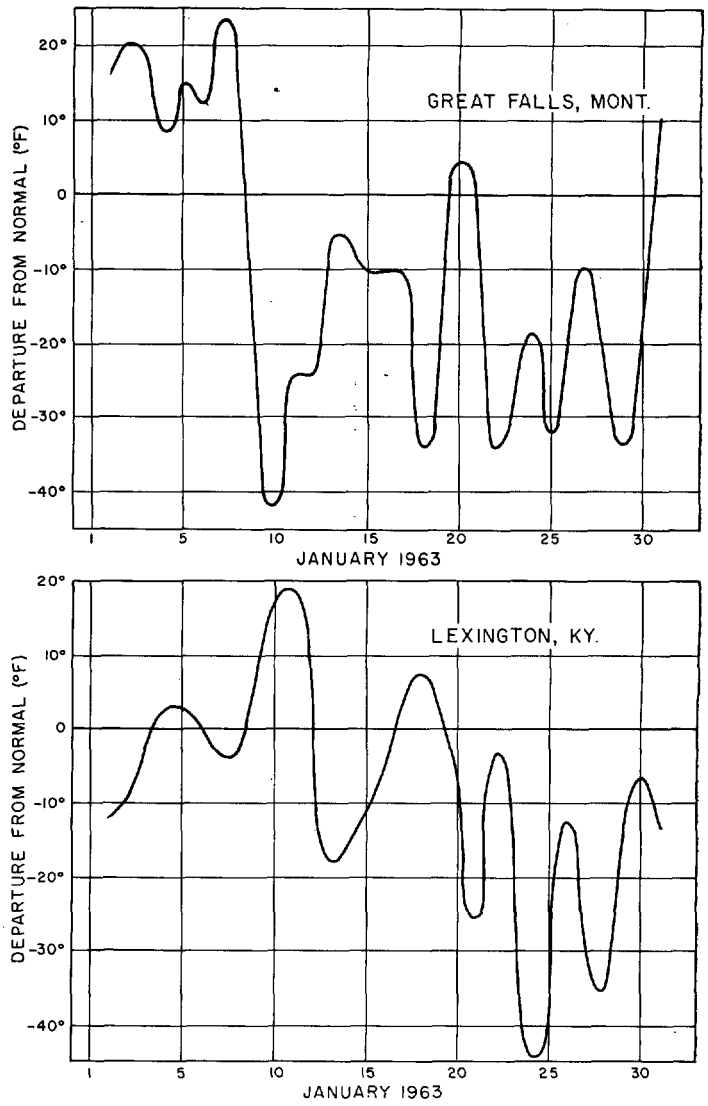

FIGURE 9.—Variation of departure from normal of average daily temperature (° F.) in January 1963 at Great Falls, Mont., and Lexington, Ky. The well-defined oscillation in temperature was associated with each of the five Arctic outbreaks during the historic cold spell. Note the record minimum (44° F. below normal) reached at Lexington, Ky., on the 24th.

with record low temperatures as much as 25° F. below normal. Meanwhile another High entered the Upper Mississippi Valley, lowering temperatures in Wisconsin to 31° F. below normal at La Crosse. On the 15th, record temperatures occurred in the Great Lakes region including −24° F. at Milwaukee and as low as −50° F. elsewhere in Wisconsin. On the 16th and 17th record minima continued in lower Michigan, although temperatures moderated elsewhere in the country as the two Highs merged and moved off the New England coast. Meanwhile another intensifying cold High was plunging southeastward from northwestern Canada.

SECOND COLD OUTBREAK

This outbreak drove temperatures in Montana far below normal again on the 18th, reaching 38° F. below normal at Billings. On the 19th, record cold spread from Salt Lake City, Utah, with a temperature of −15° F., as far south as western Texas, where temperatures were 33° F. below normal at Amarillo. By the 20th, record cold stretched from California, where Bakersfield reported the lowest temperature in 26 years of record, throughout the Southwest as far east as Texas, where Houston reported a record 24° F. below normal. Meanwhile, parts of the east coast warmed to 17° F. above normal with a record 84° F. at Daytona Beach, Fla. On the 20th the Arctic air in the Upper Mississippi Valley was again reinforced in the wake of a rapidly deepening storm, and record minima occurred there again on the 21st. This outbreak spread to the east coast on the 22d, while another intense High was plunging southward in western Canada.

THIRD COLD OUTBREAK

The third cold outbreak, and the most severe in the East, entered Montana on the 22d with temperatures 34° F. below normal at Great Falls (fig. 9). With great speed the Arctic air overspread most of the country east of the Continental Divide on the 23d and 24th, in the

wake of the second blizzard to sweep the Great Lakes region. On the 23d record temperatures occurred eastward from the Continental Divide to the Appalachians and southward from Lake Superior to the Mississippi delta, with the lowest about 36° F. below normal near Chicago, in advance of a 1045-mb. High moving into the Southern Plains. On the 24th, the strong High helped break previous temperature records for the date from Texas to the Atlantic Coast. Alltime record lows were established at a number of cities in the Ohio and Tennessee Valleys, as temperatures averaged over 39° F. below normal over almost the entire area. At Lexington, Ky. (fig. 9), an alltime record low temperature of −21° F. was recorded, with average temperature for the day of 44° F. below normal.

TABLE 1.—*New record low temperatures reported in January 1963 (° F.)*

City	New low temperature
Meacham, Oreg.	−23
Raton, N. Mex.	−31
Grand Junction, Colo.	−23
Las Vegas, Nev.	*8
Maverick, Ariz.	−37
Nashville, Tenn.	−15
Lexington, Ky.	−21
Louisville, Ky.	−20
Akron, Ohio	−21
Cleveland, Ohio	−19
Cincinnati, Ohio	−19
Toledo, Ohio	−17
Youngstown, Ohio	−18
Macon, Ga.	6

*Equaled earlier record.

FOURTH COLD OUTBREAK

On the 25th, the fourth surge of severe cold entered Montana, while intense cold still gripped the East with record low temperatures in many places. Cold air stretched from coast to coast on the 26th; the temperature was as much as 32° F. below normal at Valentine, Nebr. On the 27th the extreme cold dominated the Central Plains and Mississippi Valley as a blizzard swept the Northeast with heavy snow and strong winds. It also produced record temperatures in its wake including −15° F. at Evansville, Ind., as the Arctic anticyclone advanced into eastern Oklahoma. On the 28th, the record cold spread eastward to the Appalachians. Louisville, Ky. had a temperature of −15° F. as the associated Arctic High intensified to more than 1040 mb. in the Ohio Valley.

THE FIFTH OUTBREAK

On the 29th the last outbreak of this record cold spell again brought temperatures as much as 34° F. below normal to Montana, while in the Southwest the first substantial warming of the month occurred. Record low temperatures from the previous outbreak were common in the eastern States on this date. Severe cold continued on the 30th in the northern Rockies while also spreading eastward again into the Mississippi Valley. In the Southwest, temperatures continued as much as 18° F. higher than normal from Nevada to New Mexico.

On the closing day of the month the last cold surge spread across the Ohio Valley into the Northeast. At the same time warm air from the southern Rockies spread northeastward into Wyoming, where temperatures rose to 22° F. above normal at Casper, the first substantial warming since early in the month.

Some of the new record low temperatures are given in table 1.

11. PRECIPITATION

The precipitation regime in the United States is shown in figure 8. Most of the above normal precipitation in the Southeast occurred on the 18th, 19th, and 20th in connection with frontal disturbances in advance of the second cold wave of the month. Another area of heavy precipitation occurred in Montana and Wyoming, where as much as four times the normal amount fell at Billings, Mont. Some precipitation occurred on almost every day after the beginning of the cold spell on the 9th with the larger amounts occurring with each new Arctic outbreak, including record amounts of snow for the month at the localities referred to earlier.

The third area of major precipitation was in central and western California and western Nevada, associated almost entirely with a deep storm on the last few days of the month. Most notable was 8.7 in. of rain at Blue Canyon, Calif. on the 31st, the greatest 24-hour amount in January on records dating back to 1921. On the last four days of the month Blue Canyon received 15.7 in. of precipitation, including 7.4 in. of snow, following the first 27 days of January without any precipitation.

In most of the remaining regions, precipitation ranged from below normal to almost dry. It was relatively dry from Texas, where soil moisture was critically low in some places, northeastward to Ohio. There some localities like Cleveland and Akron received above average snowfall. Due to the extreme cold, however, the water equivalent of the snow was well below average.

In the Far West, precipitation was critically short, especially along the coast and in the mountains, where it was one of the driest Januarys on record, aggravating one of the driest winter seasons ever observed. The deficiency of snow in the mountains all the way up the west coast to Washington resulted in one of the thinnest snowpacks on record.

This historic dryness was the result of a deficiency of storms which normally strike the west coast in rapid succession in the winter season when the prevailing circulation is westerly in the eastern Pacific. However, this year, as discussed in detail earlier in this article, the normal strong westerly flow was largely absent in the eastern Pacific due to persistent high pressure there, especially in the Gulf of Alaska. This was closely associated with the abnormalities farther west in the

Pacific, with the result that the Pacific storms, instead of proceeding as usual to the west coast, were persistently diverted north of Hawaii on a retrograde track northwestward toward the Bering Sea, along and about 5° of latitude west of the jet axis in figure 3.

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4. J. Namias, "The Index Cycle and Its Role in the General Circulation," *Journal of Meteorology*, vol. 7, No. 2, Apr. 1950, pp. 130–139.
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CORRECTION

Vol. 91, No. 2, Feb. 1963:

Page 69: In paragraph 2, delete the words "rawin target."
In caption to figure 1, end of line 2, change "radar" to "GMD–1B rawinsonde."

Page 70: In caption to figure 2, line 3, delete "radar."
In column 1, line 2, change "radar" to "GMD–1B rawinsonde."

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