DESCRIPTION OF THE 50-MB. PATTERNS OVER ANTARCTICA IN 1958

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ABSTRACT

Seasonal variations in the 50-mb. circulation over the Antarctic during 1958 are discussed and the features observed in 1957 are compared with those found in 1958. Both years exhibited similar patterns in the fall and winter seasons but differed somewhat in spring and summer. In 1957, the polar vortex of winter began to weaken in early October and by November 21 a closed anticyclone at 50 mb. encompassed the continent. In 1958, the breakdown of the polar vortex was more gradual and by the end of November the 50-mb. circulation was characterized by an irregular pattern of closed cyclones and anticyclones rather than a dominant anticyclone.

1. INTRODUCTION

Although it is too soon to receive the full amount of checked data from the Antarctic stations participating in the IGY program, it is felt that a sufficient number of reports are available from the radio broadcasts in 1958 to permit a preliminary analysis of the 50-mb. level over the continent (fig. 1).

The present work is more or less a continuation of the series of daily 50-mb. charts prepared by W. B. Moreland of the U.S. Weather Bureau during his tour of duty as chief of the Antarctic Weather Central at Little America in 1957. A comparison of the circulation patterns for the two years reveals some significant differences in the spring and early summer seasons. A more detailed discussion of these differences will be attempted later in this paper.

The series of charts for 1958 was plotted and analyzed at 10-day intervals with data for one day on either side of the 10th day added as an aid in analysis. These charts were based on 0000 GMT data, although 1200 GMT data were used as an aid in analysis. Extrapolations, by thickness techniques, from levels between 100 mb. and 50 mb. were carried out whenever practicable to obtain better coverage of the 50-mb. heights and temperatures. This method of analysis is similar to that employed by Austin and Krawitz [1] in their Northern Hemisphere study, and by Teweles and Finger [2] in their higher stratospheric analyses.

The area covered by the analysis is, of necessity, confined to the Antarctic Continent and adjacent waters, since 50-mb. data from the islands in the Southern Oceans are quite meager. The contours are drawn at 100-meter intervals and the isotherms for every 5° Celsius. The maps included in this paper are excerpts from the series for the whole year which will be checked and completed as the final data become available.

2. SUMMER 1957–1958

The 50-mb. chart for January 15, 1958 (fig. 2), is fairly representative of the summer pattern at the beginning of this year although the circulation had been predominantly anticyclonic from the middle to the end of December 1957. The flat contour gradient and relatively uniform temperatures over the entire continent persisted until early March 1958.

The Low centered at about 80° S., 100° E. apparently had moved into this region from the western coast of Queen Maud Land. It remained over East Antarctica but exhibited a variable intensity and occasional breakoff of secondary cells until the middle of March, when a single pronounced vortex and strong cyclonic circulation developed over the whole continent.

The ridges along the coastal areas fluctuated in shape and extent, sometimes forming separate small high cells over the continent. There appeared to be some general westward drift to these ridges during the summer.

The chart for February 5, 1958 (fig. 3), depicts the variations in the systems discussed above. The Low over the Ross Sea seems to have been a part of the larger system centered over East Antarctica. Rather prominent ridges appeared over the coast near D'Urville and over the Ellsworth Highland with the possibility of a small closed High in the latter area at about 74° S., 85° W. It should be recognized, however, that trying to maintain continuity of these factors on charts drawn for 10-day intervals may not be too satisfactory.

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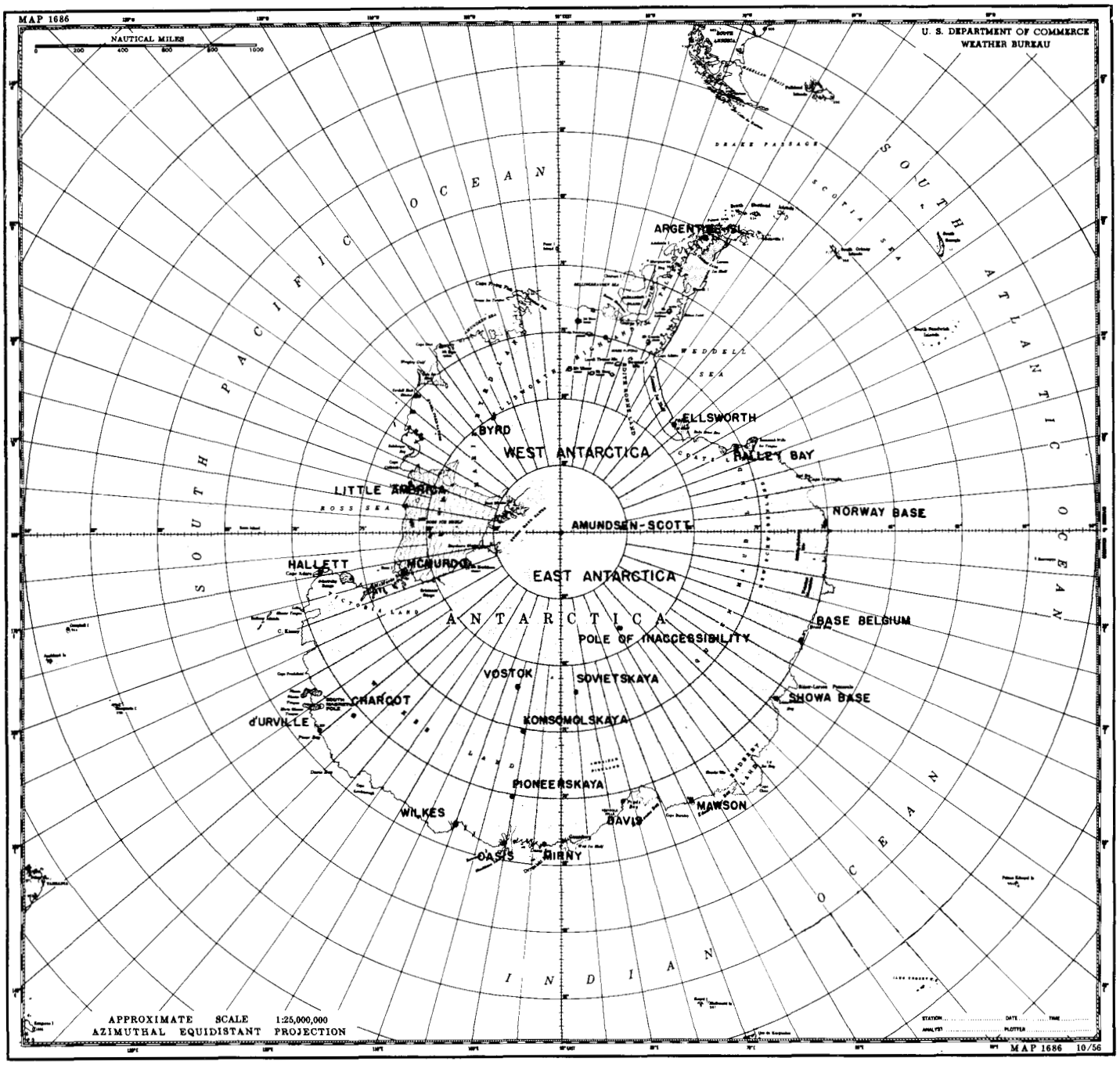

FIGURE 1.—Antarctica and stations established during the International Geophysical Year.

3. AUTUMN 1958

The transition from summer is first observed on the chart for March 15, 1958 (fig. 4). The development of this single prominent vortex appeared to be rather gradual. The first area to indicate a strengthening of the cyclonic circulation was the coastal region from D'Urville to Little America with winds of 30 to 40 kt. reported at stations in this part of the continent in the period March 14–16.

By April 15 (fig. 5), the circulation was stronger over the coast of the entire continent and the band of highest winds (40 to 50 kt.) extended from Mirny to Little America. The center of the circulation at about 85° S., 40° W. had a tendency to drift about the geographic pole in a general west to east direction but was most often located between the South Pole and the Weddell Sea and between the South Pole and the Pole of Relative Inaccessibility (82° S., 59° E.) during the year.

The large-scale features which developed by the middle of April were retained without much change throughout the fall season.

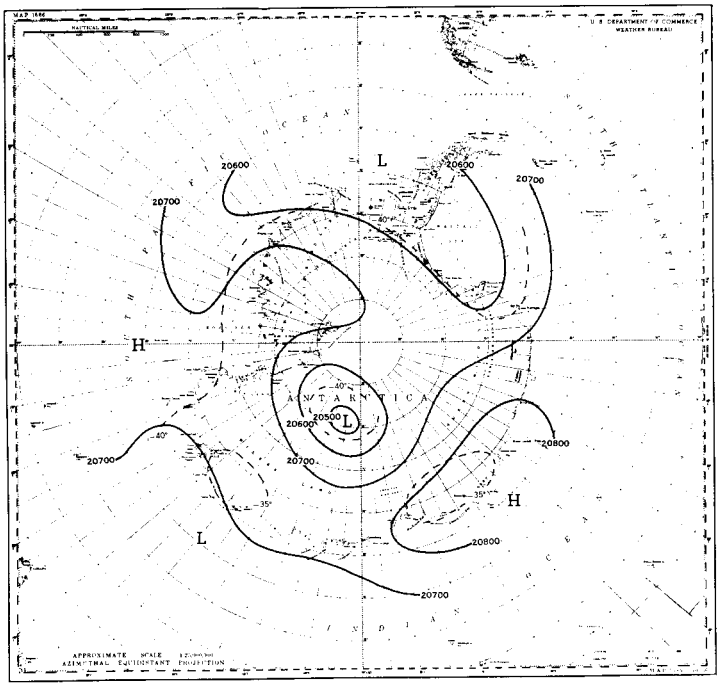

FIGURE 2.—50-mb chart, January 14–16, 1958.

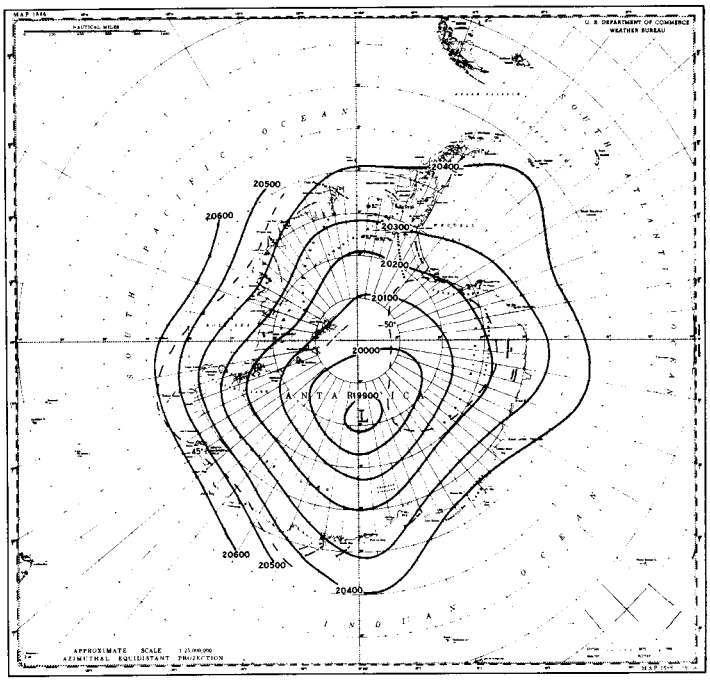

FIGURE 4.—50-mb. chart, March 14–16, 1958.

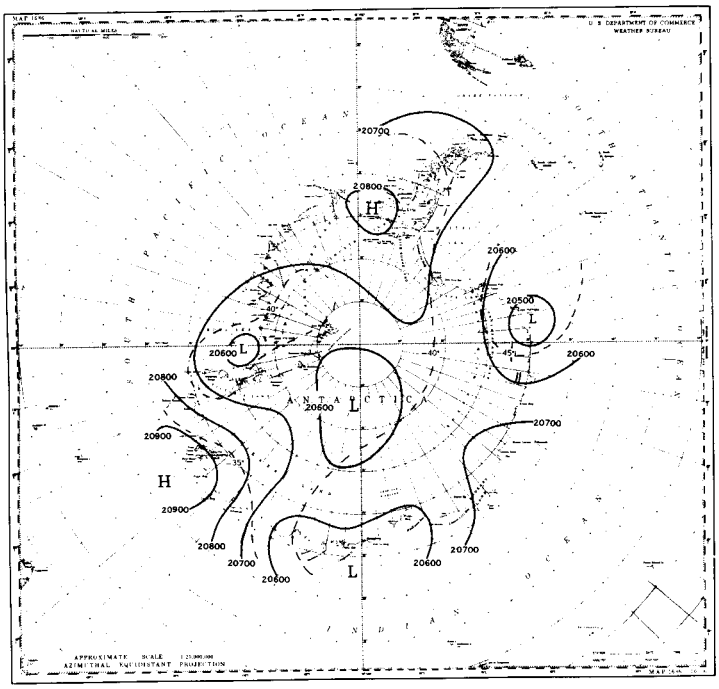

FIGURE 3.—50-mb. chart, February 4–6, 1958.

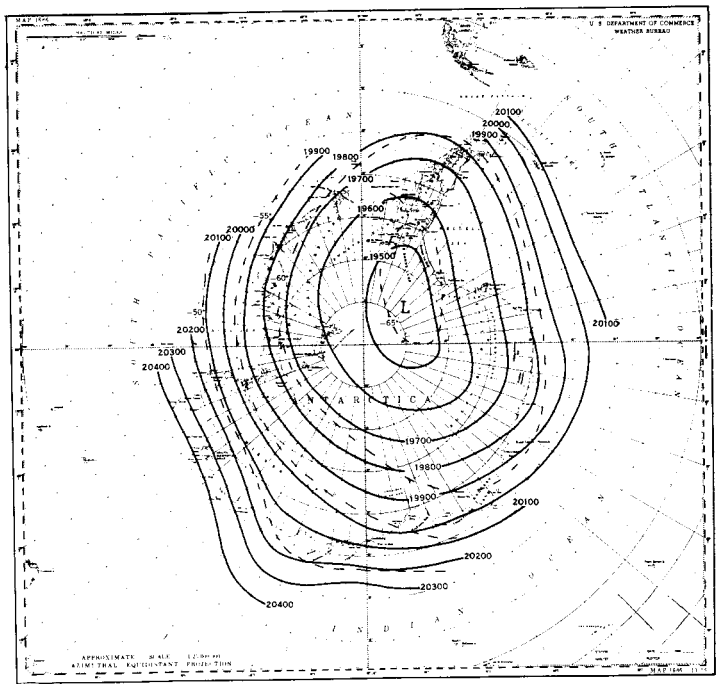

FIGURE 5.—50-mb. chart, April 14–16, 1958.

Cooling at 50 mb. over the continent was most pronounced over the Weddell Sea sector, but the decrease in all regions was fairly smooth.

4. WINTER 1958

A pattern typical of this winter season is shown on the chart for July 15, 1958 (fig. 6). It is characterized by a single center near the South Pole and strong zonal circulation with a weak three-wave pattern over the continent. At times during this month winds over Mirny and McMurdo reached speeds of over 100 kt. at 50 mb. Although the circulation had intensified over the coast of the entire continent it appears that the coasts of Wilkes Land and Victoria Land had consistently stronger winds during late fall, winter, and early spring. This may be attributed to the temperature contrasts resulting from the

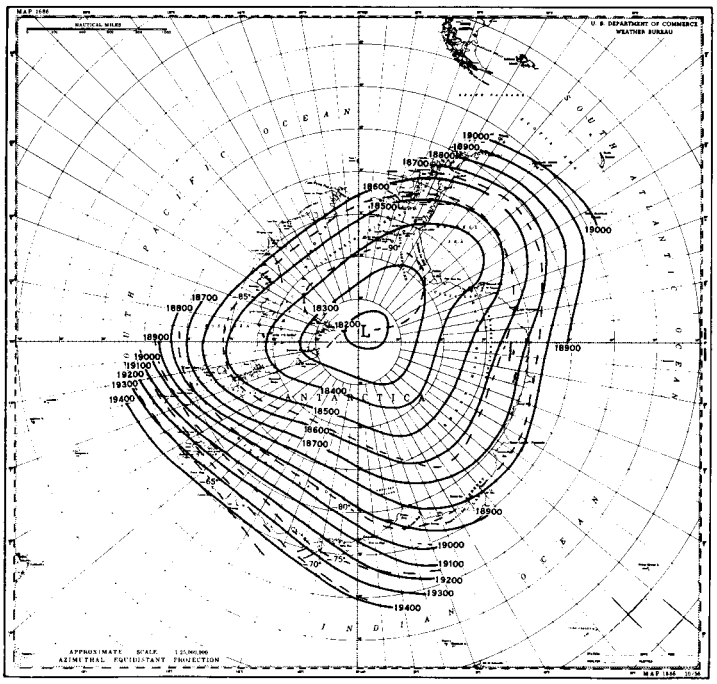

FIGURE 6.—50-mb. chart, July 14–16, 1958.

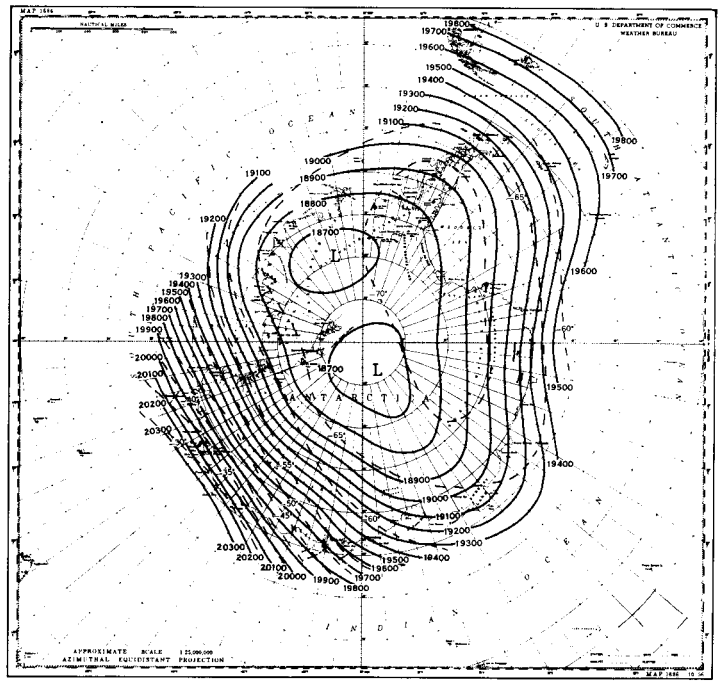

FIGURE 8.—50 mb. chart, October 14–16, 1958.

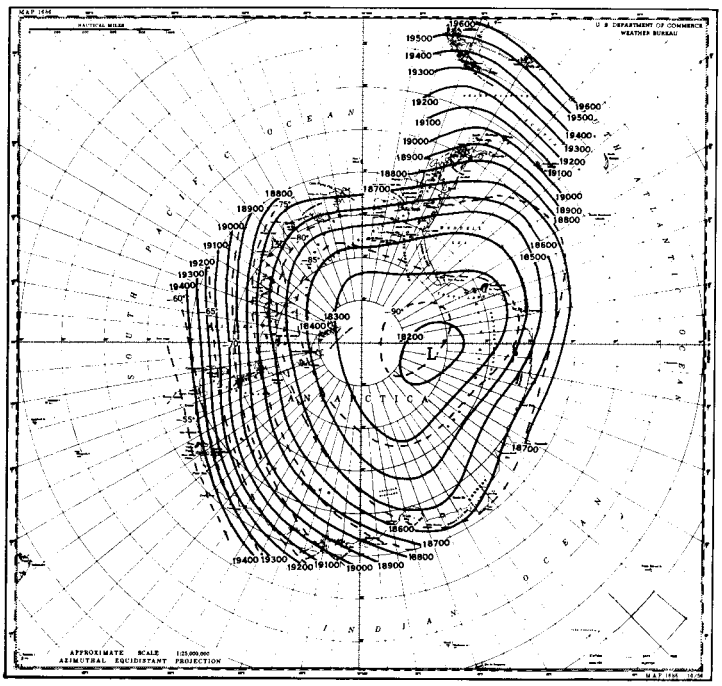

FIGURE 7.—50-mb. chart, August 14–16, 1958.

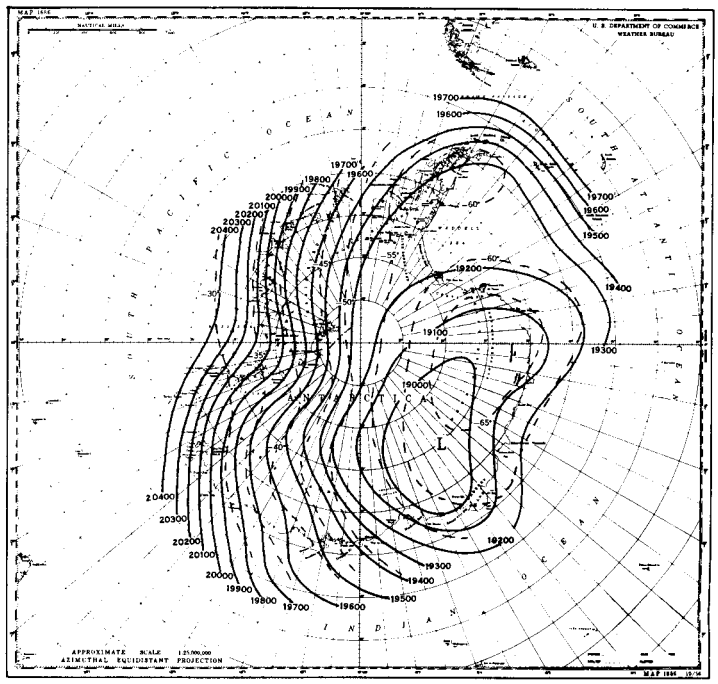

FIGURE 9.—50-mb. chart, October 24–26, 1958.

fact that the boundary of the polar night zone at 50 mb. was about 68° to 69° S. Unfortunately, no wind reports for this level are available at comparable latitudes on the Palmer Peninsula to check the validity of this hypothesis.

The three-wave pattern shown on this chart seems to be a representative feature of the maps for July and August 1958, whereas the maps for the spring and fall seasons indicate that four, and occasionally five, major troughs were more common.

By the middle of July the temperatures over the interior were between −85° C. and − 90° C., while the temperatures over the coastal areas ranged from −81° C. at the Belgian station, on the Atlantic side of the continent, to −65° C. at D'Urville, on the Pacific side. Again, it might be noted that while the isotherms did not exactly

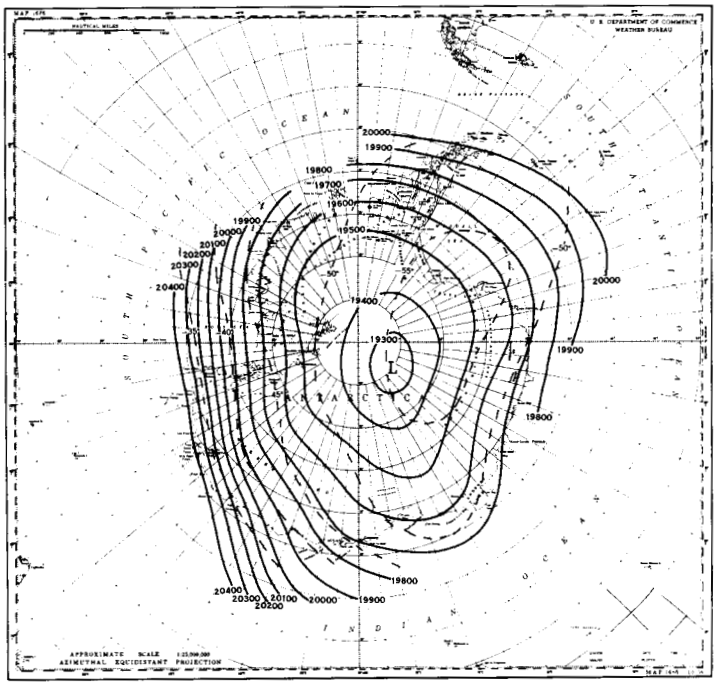

FIGURE 10.—50-mb. chart, November 4–6, 1958.

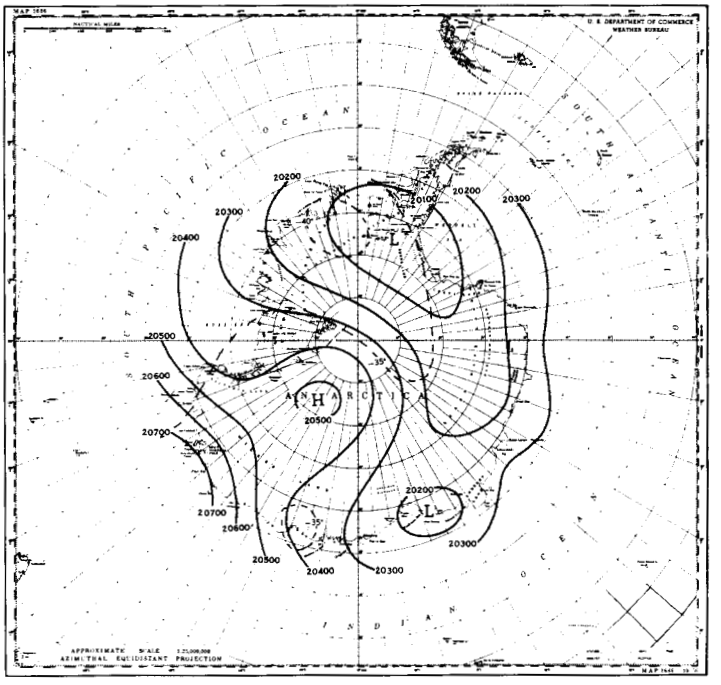

FIGURE 12.—50-mb. chart, November 27, 1958.

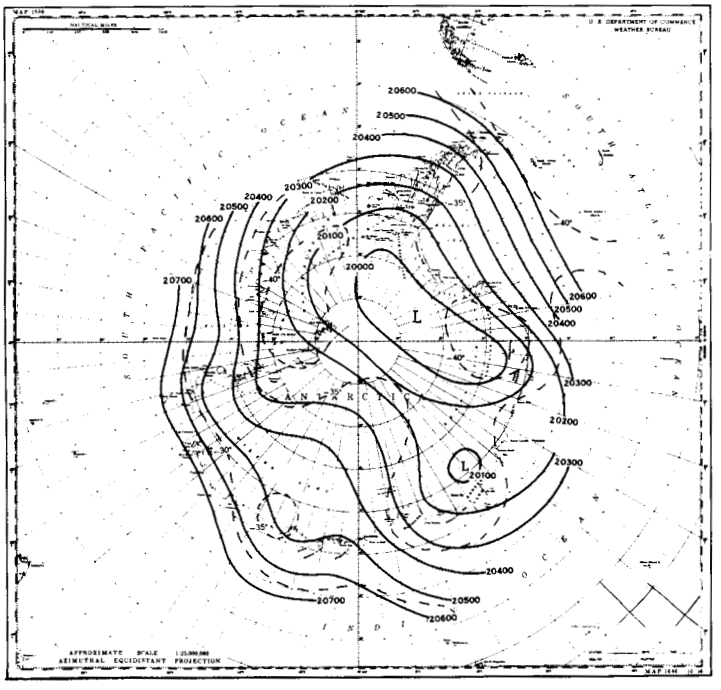

FIGURE 11.—50-mb. chart, November 24–26, 1958.

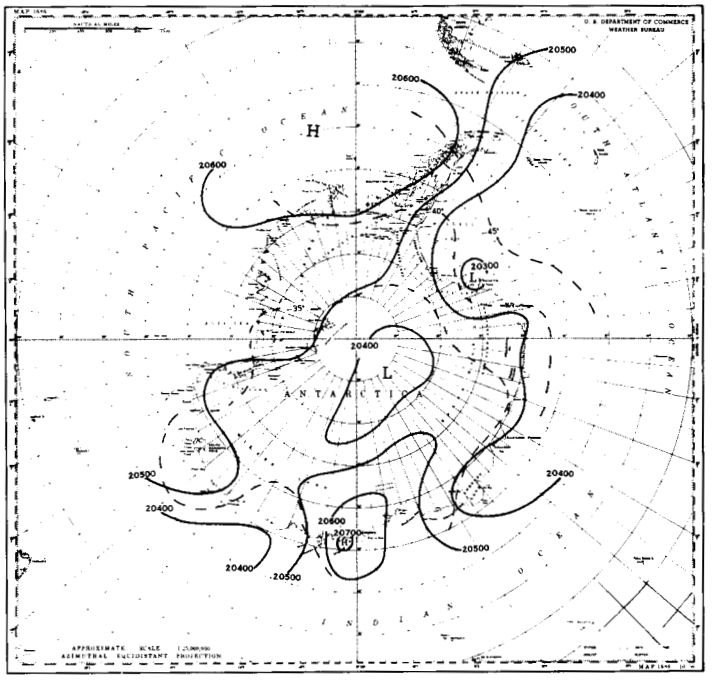

FIGURE 13.—50-mb. chart, December 4–6, 1958.

parallel the contours there was only a slight cross-contour orientation and, therefore, very little advective temperature change in the winter months.

The chart for August 15, 1958 (fig. 7), shows rather well-defined jets on opposite sides of the continent with winds of 50 to 60 kt. over the coast of Queen Maud Land and winds over 100 kt. (at 67 mb.) at D'Urville on the 16th. On the 14th McMurdo reported a wind of 145 kt. at 50 mb.

Although the band of strong winds over the coasts of the continent varied in intensity and lateral extent during the winter months, the winds over the coast of Wilkes Land and Victoria Land were rarely reported as less than 25 to 30 kt. at 50 mb.

5. SPRING 1958

It is in the spring season that the most radical changes take place in the Antarctic stratospheric circulation. The rapid warming at very high levels in 1958, described by Hanson [3], was also noticeable at 50 mb. and helped to produce the eventual breakdown of the winter cyclone.

The rate of warming at 50 mb. appears to have been about the same at both the coastal and interior stations in early October and this acted to maintain the band of high winds encircling the continent from the coast of Queen Maud Land to Wilkes Land and the Ross Sea shown on the chart for October 15, 1958 (fig. 8). Winds of 80 kt. were reported at the Norwegian station, over 100 kt. at Mirny and D'Urville, and 100 kt. at Hallett in the period October 14–16, 1958.

It might be noted in passing that the double center configuration of the polar vortex (fig. 8) was not a common occurrence although a similar pattern was evident on October 5, and once in each of May, June, and August.

On October 25, 1958 (fig. 9), the center of the polar vortex had shifted to about 75° S., 50° E. and a ridge had developed over the western Ross Sea and inland to near the South Pole. The band of high winds had moved inland over Wilkes Land and the Ross Ice Shelf. The apparent warm air advection and subsidence accompanying this change in circulation caused a rise in temperature to −37° C. at Wilkes and to −35° C. at McMurdo as contrasted with temperatures of −60° C. to −65° C. on the other side of the continent. The temperature at the South Pole rose from −68° C. to −53° C. in this 10-day period with a 6° increase taking place from the 24th to the 25th as a result of the change in circulation.

The relatively colder air associated with the polar vortex spread eastward and apparently acted to inhibit the warm air advection and help produce a breakdown of the developing ridge. The modification of the temperature gradient allowed a circumpolar flow to be re-established. The chart for November 5, 1958 (fig. 10), shows the center of the Low near 84° S., 40° E. with a circulation similar to the winter pattern. The temperatures had decreased somewhat over the coast of Wilkes Land and remained about the same over the Pole and coast of Queen Maud Land. The jet over Wilkes Land and the Ross Sea persisted until the 25th (fig. 11) when the pattern began to weaken and a ridge formed over East Antarctica.

A series of daily charts was analyzed from November 27 to December 1 to determine if a radical change in circulation occurred which might not have been detected in the usual 10-day map interval. This series showed that the ridge over East Antarctica continued to develop and there was a possibility of a closed High about 80° S., 125° E., while the Low was displaced to a position just south of the Palmer Peninsula with a trough extending over Queen Maud Land toward Mawson (fig. 12). These

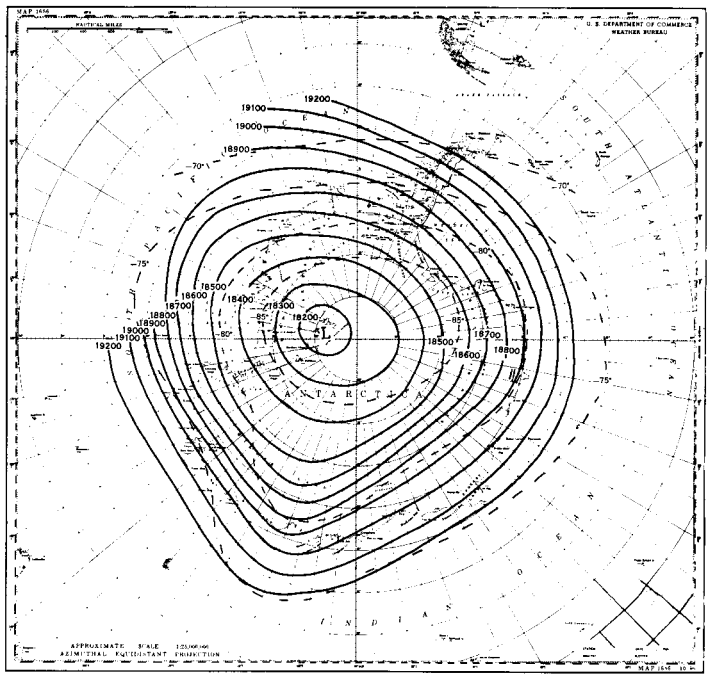

FIGURE 14.—50-mb. chart, July 15, 1957.

two features weakened gradually and appeared to move around the continent from west to east until a rather irregular pattern of isolated Lows and ridges was established by December 5, 1958 (fig. 13). This type of circulation was characteristic of the remainder of December 1958.

6. COMPARISON OF THE 50-MB. PATTERNS IN 1957 AND 1958

There is quite a bit of similarity between the 50-mb. charts of the fall and winter seasons of 1957 and 1958. The polar vortex over the continent developed rather gradually and was well established by the end of April of each year. A comparison of the charts for July of both years (fig. 6 and fig. 14) shows very little difference in the character of the winter circulation. It should be noted that differences in detail, such as the positions of troughs and ridges, occur on most of the charts for the two years.

It is in the spring and summer that a pronounced difference in the 50-mb. patterns is observed. In the first part of October 1957, a ridge developed over the coast of Wilkes Land and the major low center was displaced toward the Palmer Peninsula. The movement of these systems was accompanied by a shift of the jet across the South Pole with an orientation from about 20° E. to 160° W. long. By November 17, 1957 (fig. 15), the ridge was more firmly established over East Antarctica, and on November 21, 1957 (fig. 16), a closed anticyclone was centered about 78° S., 110° E. with easterly winds observed at all coastal stations. This pattern was substantially retained until January 1958.

In 1958 there was no major change in the winter type

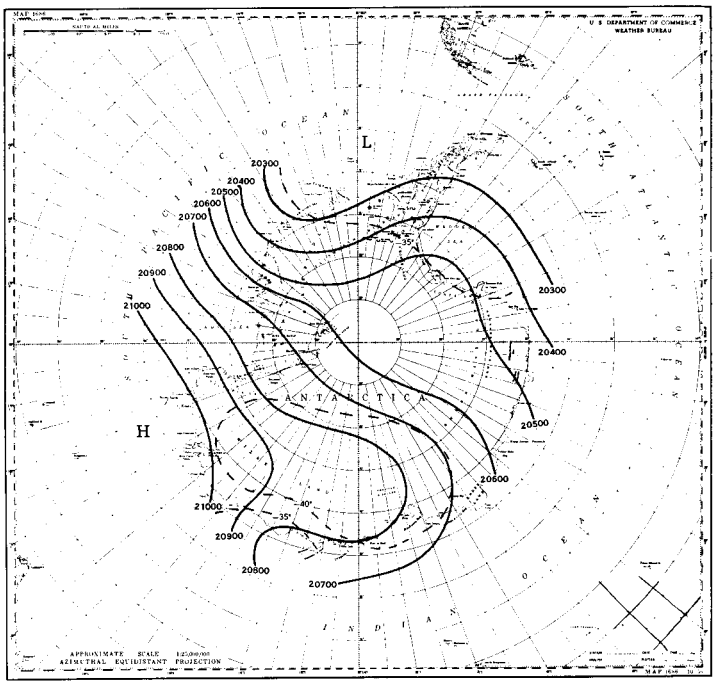

FIGURE 15.—50-mb. chart, November 17, 1957.

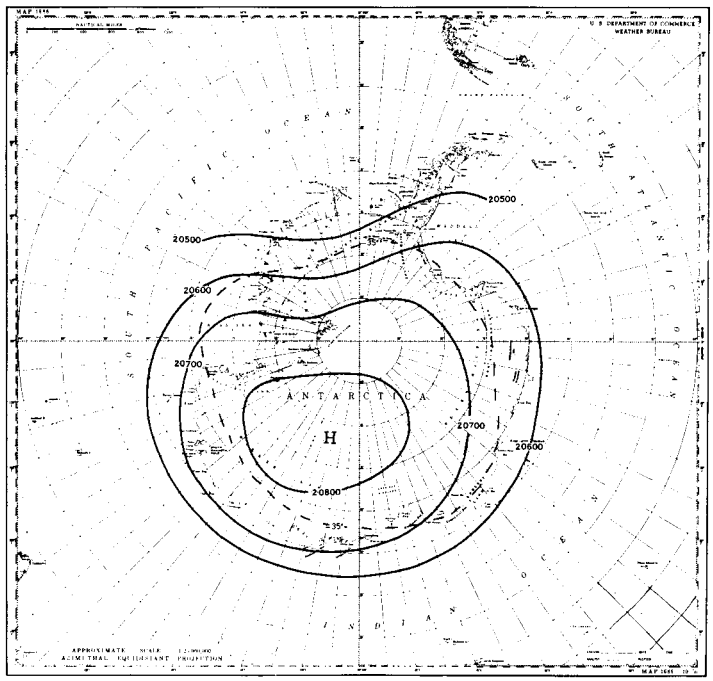

FIGURE 16.—50-mb. chart, November 21, 1957.

circulation until October 25, 1958 (fig. 9), when a ridge developed over the Ross Sea area and the jet was diverted across Wilkes Land directly toward Byrd Station. However, in this case, the low center was displaced to about 75° S., 50° E. as the major ridge built over the Ross Sea. The colder air associated with the Low apparently spread to the east inhibiting the continued development of the ridge. The consequent modification of the temperature gradient over Wilkes Land and the Ross Sea area helped to produce a more uniform circulation centered near 84° S., 40° E. (fig. 10).

The permanent breakdown of the pronounced circumpolar flow apparently was well-established by November 27 (fig. 12) with the build-up of a high cell over Wilkes Land at about 80° S., 125 °E., and the movement of the low center to just south of the Palmer Peninsula. By December 5, 1958 (fig. 13), as was noted before, the circulation pattern became rather unorganized and remained this way throughout the month.

The significant difference between the spring and summer patterns in the two years was that: (1) at no time in the spring and summer of 1958 did an anticyclone dominate the circulation over the entire continent as happened in 1957, and (2) the final breakdown of the strong polar vortex took place almost a month later in 1958 and at a more gradual rate than was observed in 1957.

As a point of interest in the comparison of the two years, a graph of the 50-mb. temperatures at three stations (South Pole, Mirny, and Hallett) was prepared (fig. 17). These temperatures, for both years, were plotted at 10-day intervals on the same basis as the maps for 1958.

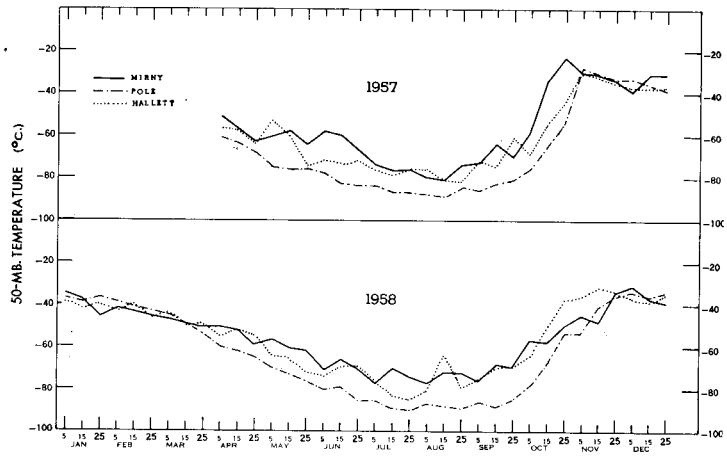

FIGURE 17.—50-mb. temperatures (° C.) at 10-day intervals, 1957 and 1958, at Mirny (solid line), South Pole (dashed-dotted line), and Hallett (dotted line).

Here again the two years were rather similar in the relatively gradual decrease of temperature beginning in the fall and continuing to a minimum reached in late July to mid-August. As was observed in the circulation patterns, a significant difference appeared in the temperatures for the spring and early summer seasons. In 1957, all three stations exhibited a sharp rise of temperature from the first of October with the maximum reached at Mirny about October 25 and at the South Pole and Hallett about November 5. From this point the temperature began falling slowly. In spring and early summer 1958 the temperature rose rapidly in October at the South Pole and Hallett but by about October 25 the increase had

stabilized and the warming was gradual until the maximum was reached in mid-November at Hallett and early December at the South Pole. The temperature at Mirny increased relatively gradually during this period to a maximum in early December.

ACKNOWLEDGMENTS

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New Weather Bureau Publication

The Cooperative Weather Observer, U.S. Weather Bureau, Washington, D.C., 1960, 116 pp. For sale by Superintendent of Documents, U.S. Government Printing Office, price 65 cents.

A booklet recognizing and honoring the voluntary services of the cooperative weather observers over the United States. It contains an explanation of early weather observational programs in the United States and the part played by the volunteer observers. Biographical sketches of observers with long service records are included and many examples of devotion to duty are cited. Institutions and organizations with long records of observations are also recognized.