WEATHER TYPES AND PRESSURE ANOMALIES[1]

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INTRODUCTION

Students of weather phenomena in temperate latitudes are familiar with the fact that similar weather conditions, cyclones and anticyclones of like characteristics and paths frequently follow one another in succession for a fortnight, or a month or longer, and then quickly give way to weather of quite a different character. These persistences of indefinite duration commonly called, "weather types", are spoken of by Kendrew (1) as "weather units of the second order."

Familiar examples of such weather persistences are the cold winters and the warm winters of central and eastern United States and Canada; the wet and the dry winters of California; and the occasional prolonged droughts in the eastern half of the United States, such as occurred in the summer of 1930. These are illustrations of the persistence of type for several months, and Henry (2) remarks that "a single type of cyclonic movement occasionally dominates the weather for 2 months in winter and marked temperature anomalies may continue for 3 or 4 months." This continuance for several months is also shown by such sequence relationships between one month and the following month or months as have been found by Reed (3) at Des Moines and by Weeks (4) at Baltimore. But such correlations are never perfect and the type frequently changes abruptly in the midst of a season.

Similar conditions obtain in temperate South America. Hessling (5), speaking of Argentina, says that the forecaster "is struck by the remarkable tendency of certain types of pressure distribution and weather to repeat themselves in some years or seasons, while in other years the opposite types are more frequent." On the other hand, while such types are a prominent feature of the weather of the British Isles and central Europe, their duration there is commonly much shorter. Kendrew (1) says of England, "The spell lasts perhaps for a fortnight, then suddenly the sequence is broken and a different type of weather sets in."

It is generally agreed that this sort of variability of the weather is connected with alterations in the general circulation, and it is customary to say that such alterations result in changes in the position and intensity of the seasonal, semipermanent, centers of high and low pressure and consequent changes in the paths and frequency of traveling cyclones and anticyclones. But there is less agreement as to the way in which modifications in the general circulation are brought about.

There are at least three lines of thought in this connection. First, there is much evidence of the existence of waves or oscillations in the atmosphere, resulting in correlations between weather elements in distant parts of the world, either contemporaneously or with succeeding seasons. In connection with these correlations A. Wagner (6) emphasizes the importance of persistence, saying, "The value of these correlation factors for forecasting purposes appears to rest solely on the fact that the general circulation shows a considerable tendency to maintain its condition." Another group of students finds latitudinal displacements of the pressure belts and ascribes such movements to variations in the intensity of solar radiation. A third explanation of the variability of seasons is found in the movement and continued separate existence of air masses, as developed since the announcement of the Bjerknes polar front theory.

Observational data are inadequate to permit a physical analysis of the observed changes or completely to confirm or refute any one of these explanations. There appears no reason why all three of the processes may not be simultaneously at work producing the existing complex situation at any moment.

The accompanying short series of maps illustrates one method of representing changes in the general circulation with particular reference to its tendency to maintain its condition. It is thought that they give some indication of the natural processes which result in the persistence of weather types. Perhaps they are most intelligible in terms of displacements of air masses. In this view the maps may be considered as illustrations of the never-ending conflict between the prevailing westerlies and the cold currents blowing out of the polar anticyclones.

The maps show mean pressure departures in millibars in the Northern Hemisphere in successive, overlapping, 3-month periods from the autumn of 1913 to the summer of 1914. They are based on data for only 48 stations and, accordingly, can do no more than indicate roughly the major pressure conditions. They are chiefly of interest with reference to that region in which seasonal variability is of the greatest practical import, that is, in middle temperate portions of the Northern Hemisphere, in which the world's population is largely concentrated.

DISCUSSION OF THE MAPS

Figure 1, September-November.—Beginning with the autumn months of 1913, we find that pressure is deficient throughout polar regions but that more than the normal mass of air has accumulated in middle and lower latitudes, especially in eastern America and the western Atlantic. Does this deficiency of dense air in polar regions point toward a winter warmer than normal in middle latitudes?

Figure 2, October-December.—Dropping September and adding December, we find the deficiency has increased in intensity but is being closely pressed by wedges of high pressure over the continents, in Siberia, Europe, and eastern North America. Evidently the type of weather we have here is that of frequent cyclones taking the northern route across both continents. The British Isles are on the dividing line and subject to frequent changes of type.

Figure 3, November-January.—The deficit continues to become greater in polar regions and now shows a tendency to separate into three distinct centers, over Alaska, Iceland, and Russia, respectively. Both the Alaskan and Russian centers have moved slowly eastward as compared with the previous map, and the Siberian excess has spread eastward into the middle Pacific region. As winter develops the type of weather certainly remains the same for Asia. In Great Britain and the southern half of Europe the weather is influenced by the excess pressure from Ireland to Portugal, and the January temperature at Milan was 2.5° F. below normal. In North America note the northward bending of the lines in the center of the con-

[1] Read at the meeting of the American Meterorological Society, Chicago, June 19-21, 1933.

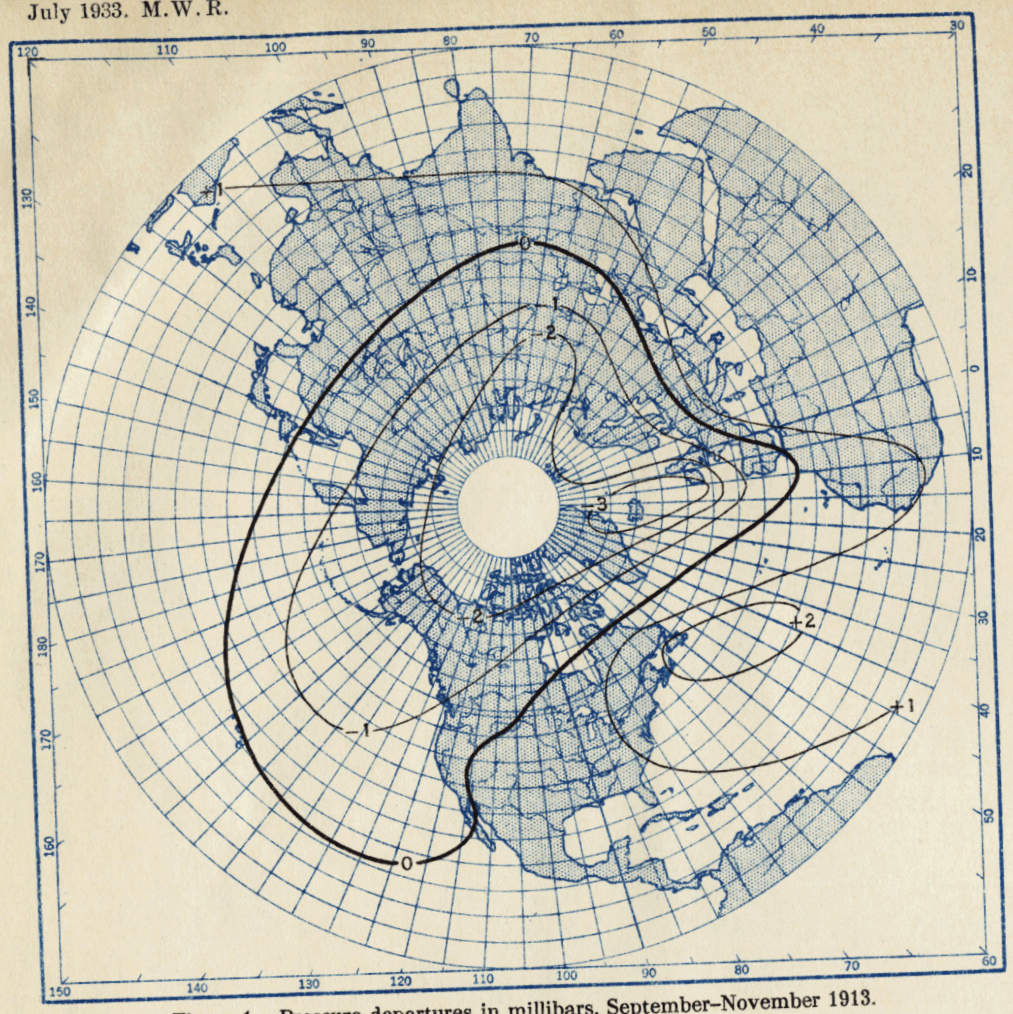

Figure 1.—Pressure departures in millibars, September–November 1913.

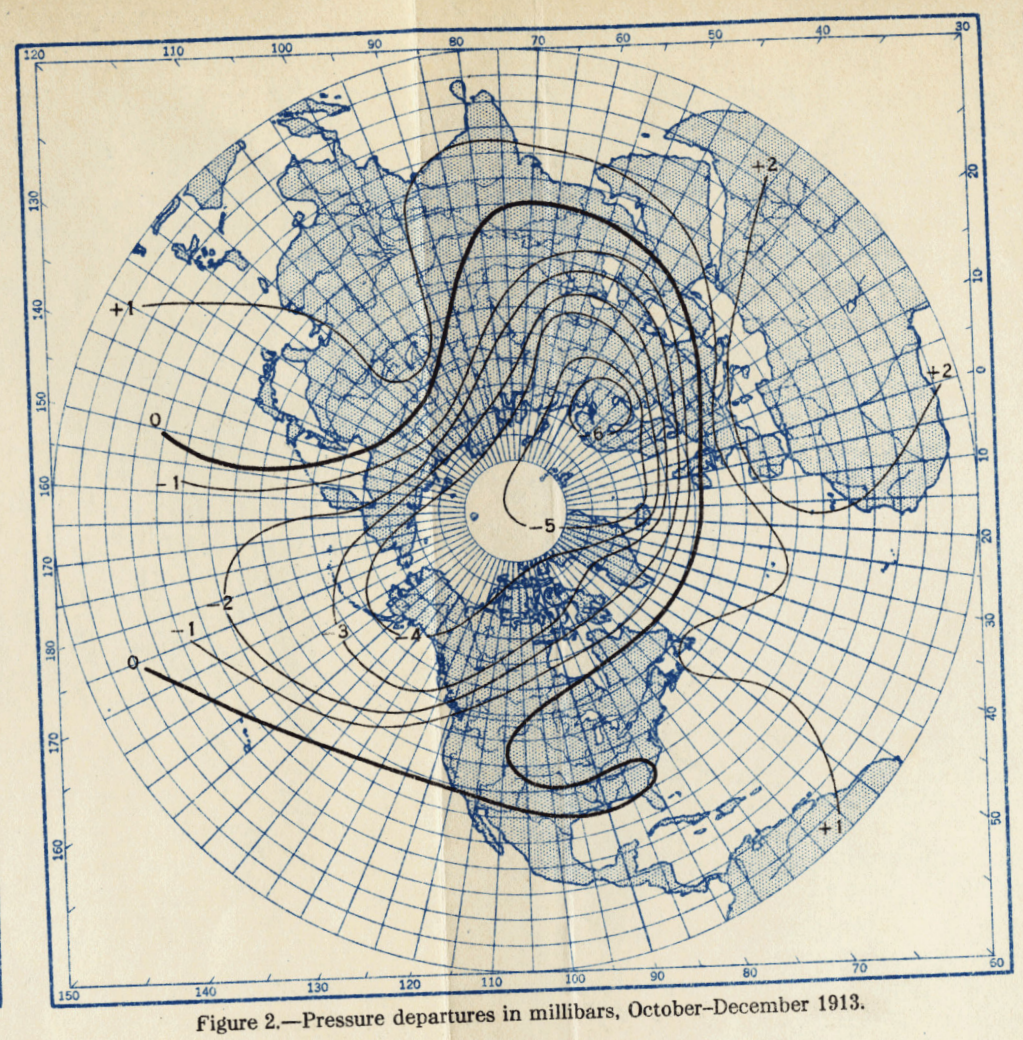

Figure 2.—Pressure departures in millibars, October–December 1913.

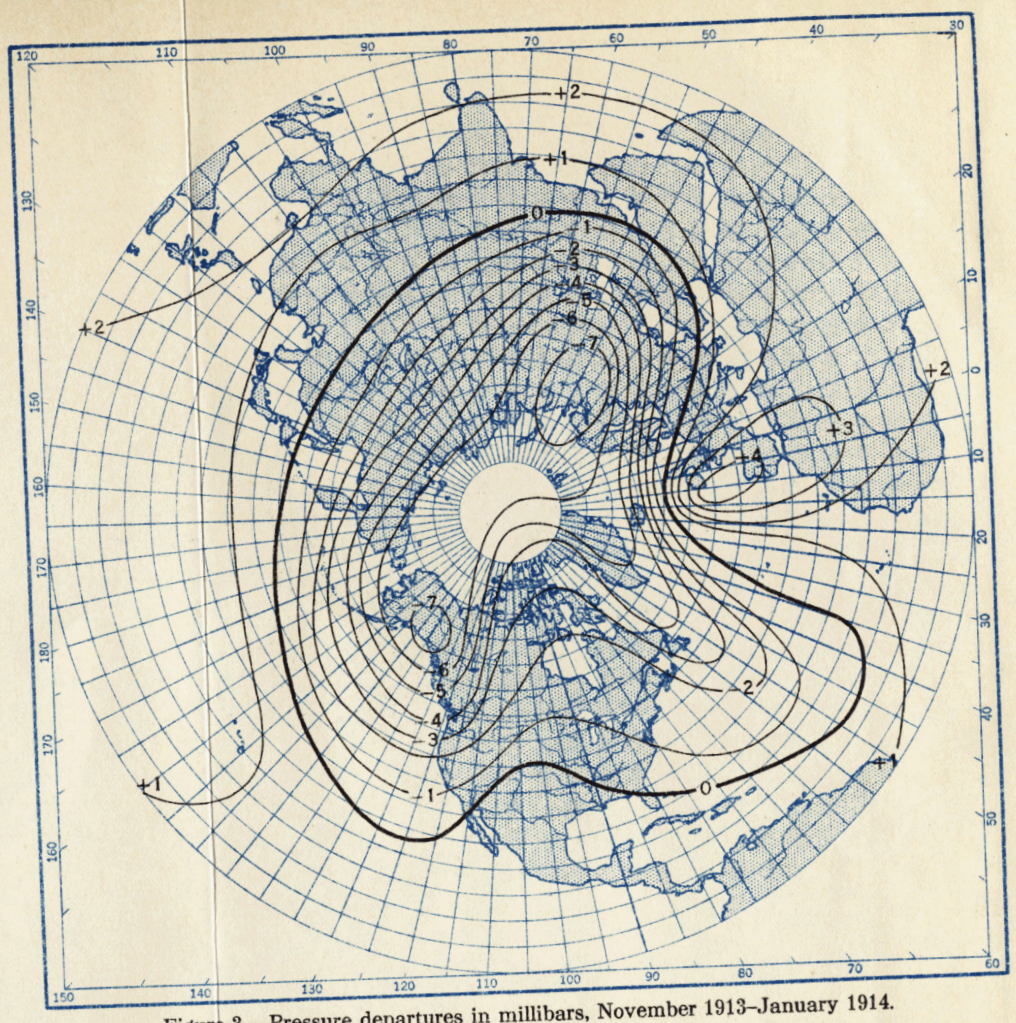

Figure 3.—Pressure departures in millibars, November 1913–January 1914.

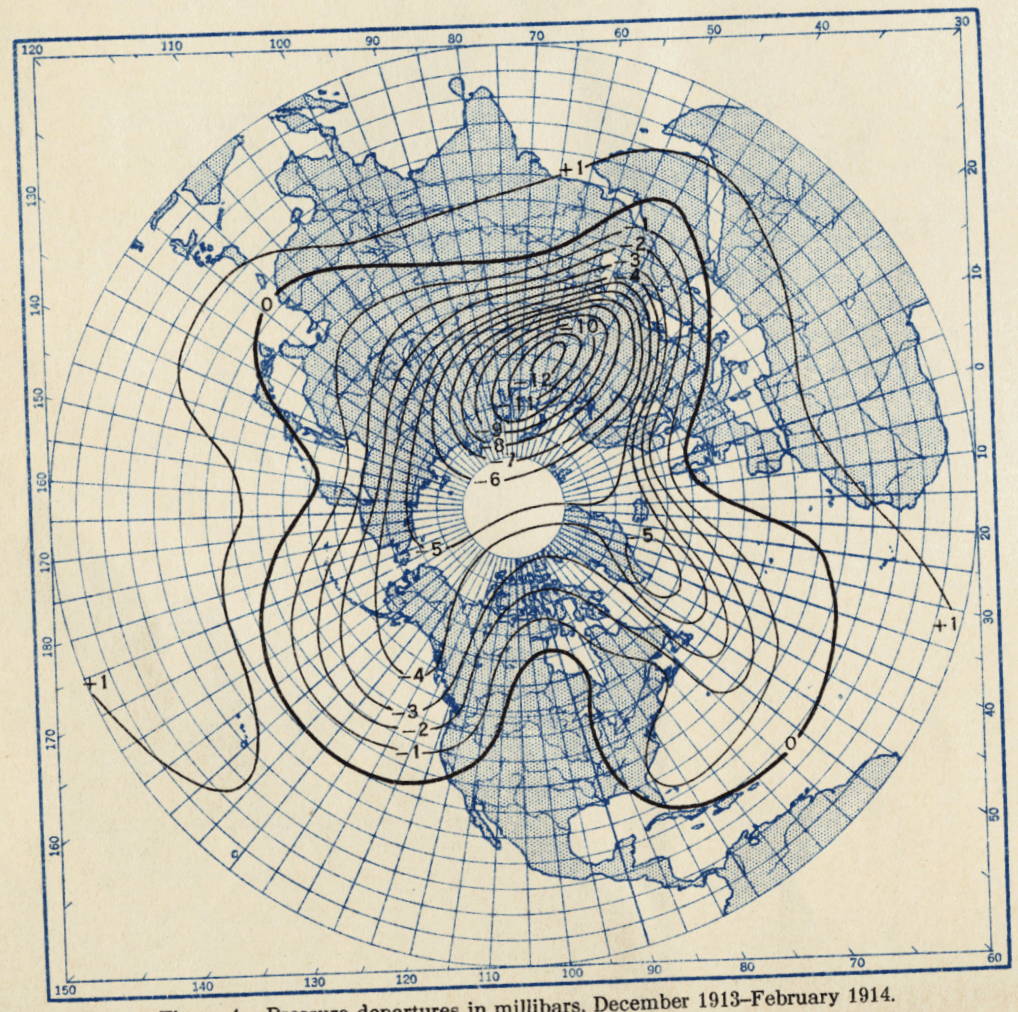

Figure 4.—Pressure departures in millibars, December 1913–February 1914.

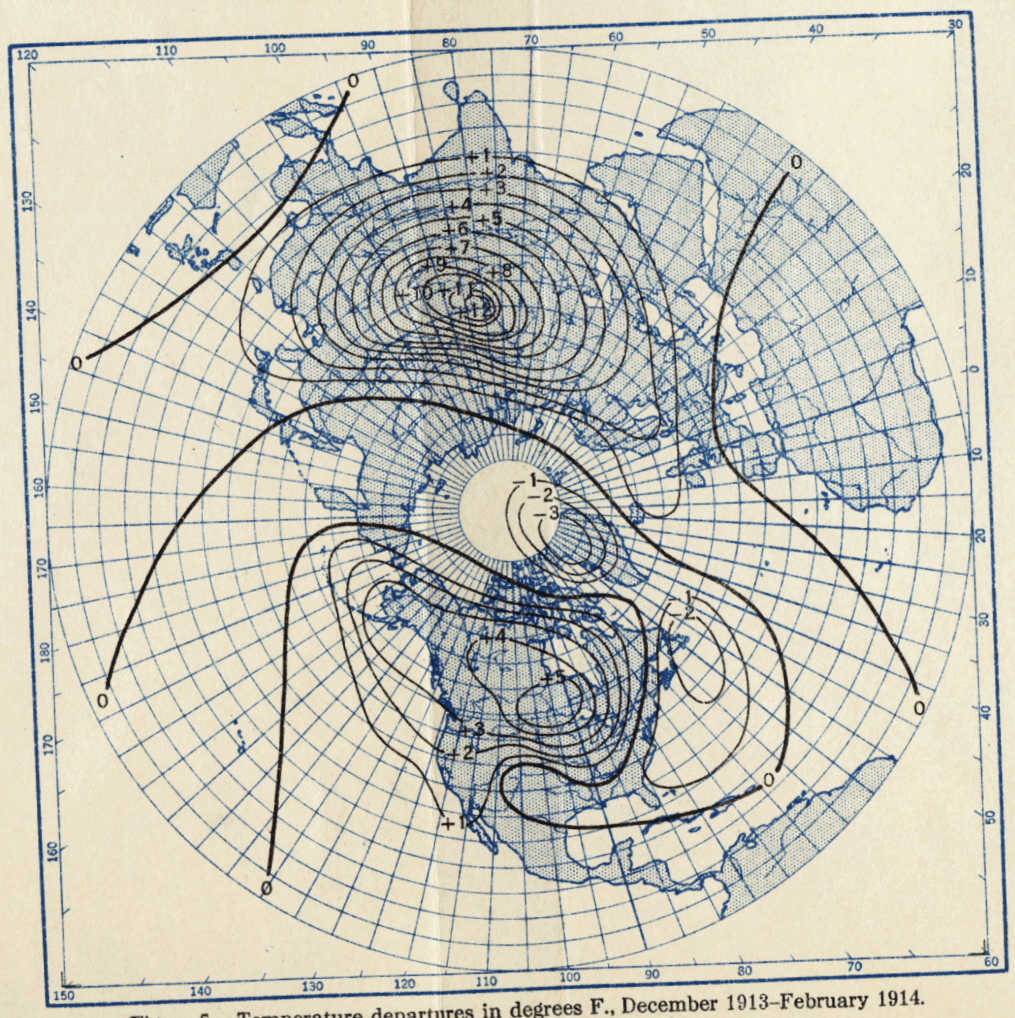

Figure 5.—Temperature departures in degrees F., December 1913–February 1914.

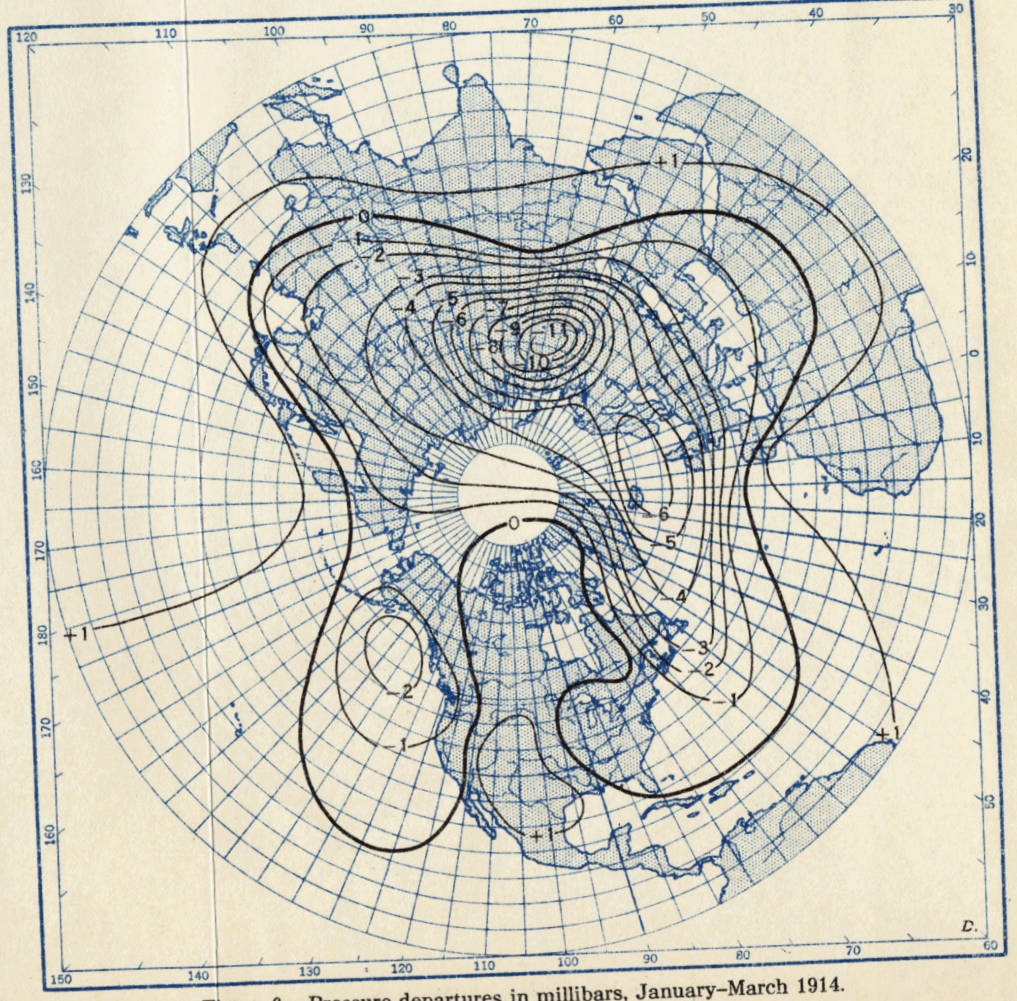

Figure 6.—Pressure departures in millibars, January–March 1914.

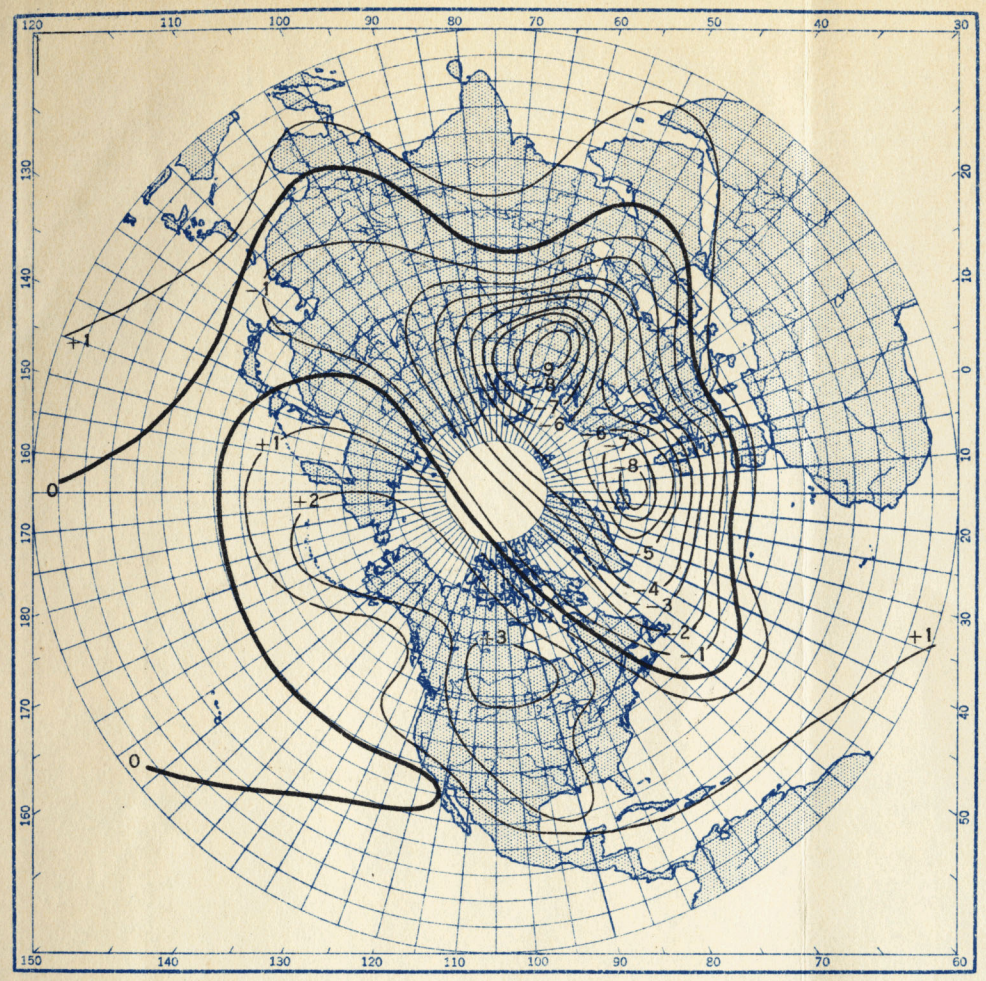

Figure 7.—Pressure departures in millibars, February–April 1914.

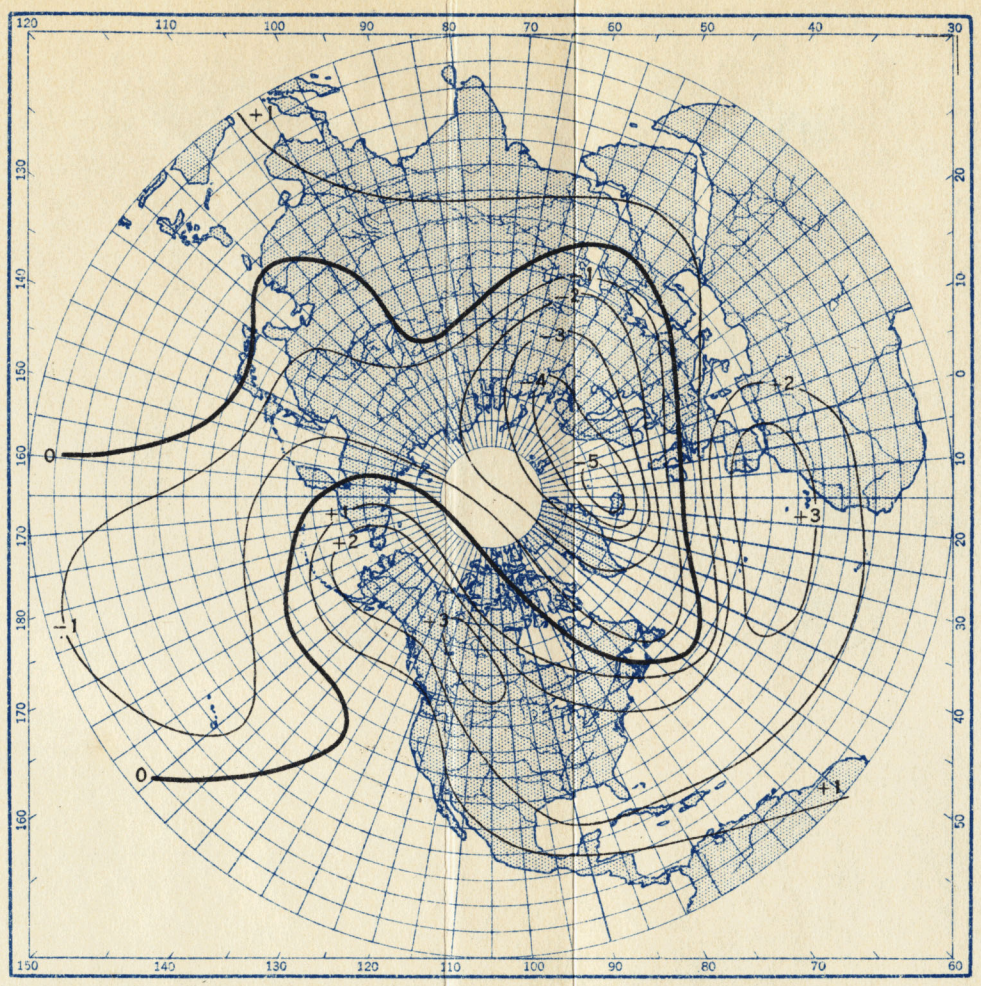

Figure 8.—Pressure departures in millibars, March–May 1914.

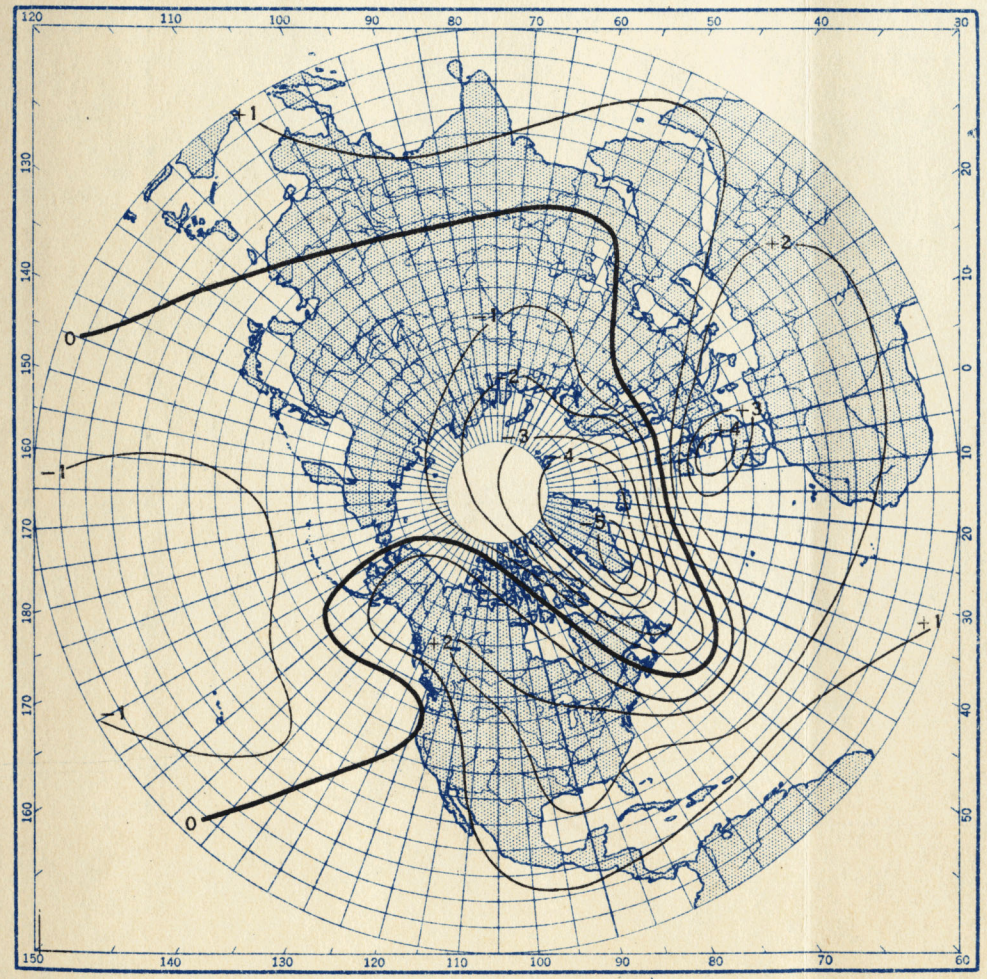

Figure 9.—Pressure departures in millibars, April–June 1914.

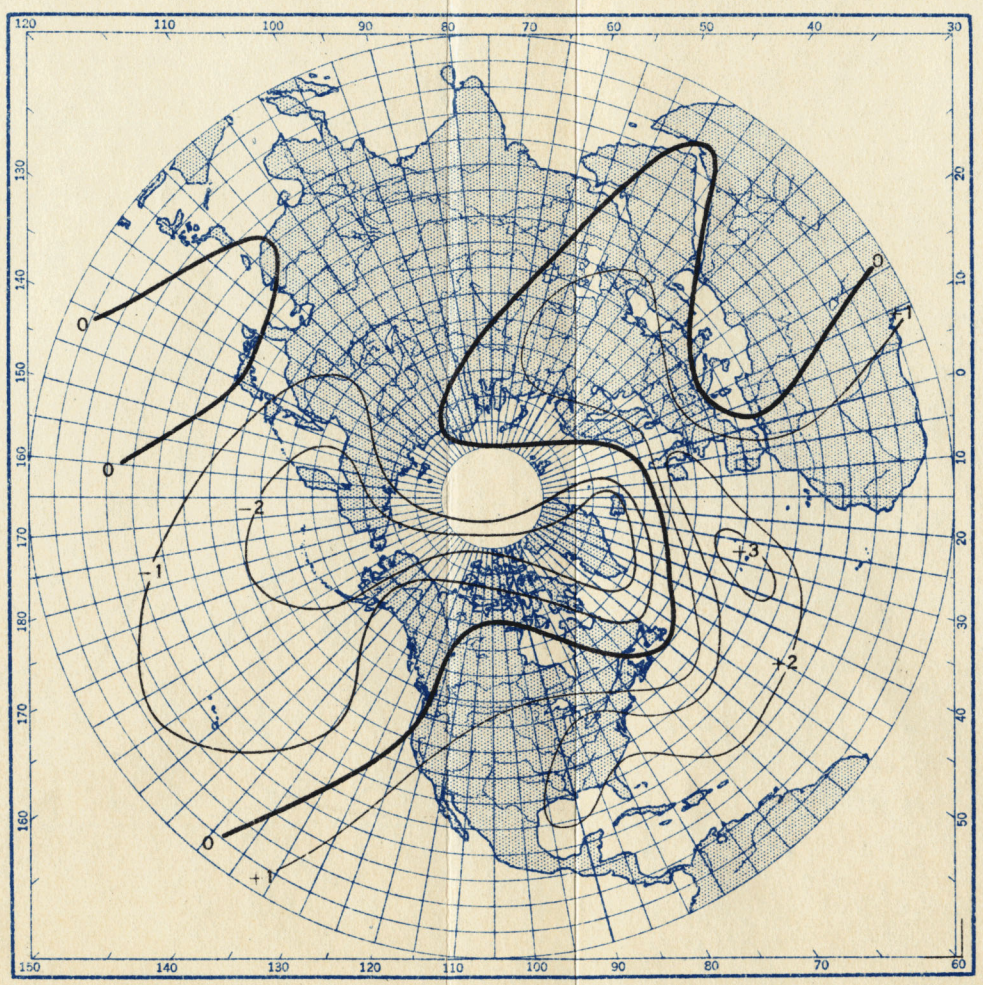

Figure 10.—Pressure departures in millibars, May–July 1914.

tinent, which may portend a change of type in the eastern half.

Figure 4, December–February.—Here are the three winter months. There are still wedges of high pressure over the continents and now a fourth has appeared over Japan and Kamchatka. The Russian center of low pressure continues to intensify and to drift slowly eastward. The American wedge has pushed northward and brought a different type of weather to central and eastern portions of the United States and Canada. The temperature records clearly show this abrupt change of type. The charts of temperature departures published in the MONTHLY WEATHER REVIEW **(7)** show that December was decidedly warm throughout the United States and southern Canada east of the Rockies, with a departure of 15° F. at Winnipeg. January likewise was warm over nearly the whole area with departures of 12° F. in the Great Plains. But February was decidedly cold east of the Rocky Mountains, parts of the Lake region and the St. Lawrence Valley having departures of −9° F.

The more detailed temperature records **(8)** give the exact day on which the change of type occurred, the first cold spell beginning on February 4th in the Missouri and Mississippi Valleys and reaching the Eastern States on the 7th. Thereafter, the month was almost continuously cold, marked by a rapid succession of surges of cold air from the Canadian interior. On the other hand, February continued abnormally warm on the west coast of America and in Asia and northern Europe. There is clearly a close correspondence between the 3-month average pressure departures as shown by this map and attendant weather conditions, both in those regions showing a marked change in type and in those showing a persistence of type. Evidently such maps have some elements of validity as pictures of atmospheric processes. There was, moreover, in the preceding map some indication that such a change as occurred in America was impending.

Figure 5, Winter temperatures.—This is a map of the average temperature departures for the 3 winter months, showing abnormally warm weather in middle latitudes over the continents, especially southeastward of the Alaskan and Russian centers of deficit, and confirming the significant relation between seasonal pressure departures and seasonal temperature departures.

Figure 6, January–March.—Rising pressure continues over the interior of North America, and the Pacific excess is pressing eastward toward Alaska, where negative departures have decreased considerably. It appears that the Alaskan depression is about to fill up or to be separated from the main area of deficit and pushed southward. If this happens, there will be another change in the paths of highs and lows across America. Great Britain and most of Europe are now distinctly under the influence of the Iceland low.

Figure 7, February–April.—The indicated realinement of pressure in North America has taken place rather rapidly and the daily weather maps of March and April show the accompanying weather changes. The number of cyclones entering the United States from the northwest was 8 in March and fell to 4 in April; the number from the southwest was none in January, 1 in February, 2 in March, and 5 in April, showing a distinct change from northerly to southerly lows with the change of pressure here indicated. March and April on the average have about the same distribution of northerly and southerly types. **(9)**. The spread of the central high pressure area northwestward to Alaska and eastward to the Atlantic is first shown on the daily weather map of March 21. Marked deficits continue over the north Atlantic, northern Europe, and Asia.

Figure 8, March-May.—Positive departures are increasing in the Atlantic and Europe while the adjoining negative area is decreasing both in extent and depth, but increased dficiency is developing in the Pacific. As this Pacific deficit reaches the coast of British Columbia, there is an increased number of northerly lows across the United States during May. The type of weather has again changed in England and central Europe.

Figure 9, April-June.—The changes in process in the previous map continue. The area of excess is moving northward in Europe and Asia and receding from Alaska, as the Pacific negative area moves eastward. For 3 months there has been a continuous filling up of the Asiatic low.

Figure 10, May-July.—Again the changes continue in the same sense and changes of weather type are indicated for both the eastern and western hemispheres. We have returned to subnormal pressure over Alaska and northern Canada, and we have for the first time in this series excess pressure over Russia.

CONCLUSION

1. The maps show that, superposed on the daily changes of pressure, there are units of pressure of a second order, large and persistent areas of positive and negative depatures, closely related to types of weather.

2. They appear to give a rather definite picture of the character and extent of the changes in pressure distribution which accompany changes in weather types.

3. They give an indication of the degree to which an established type will predominate in a given area, and of the completeness and probable duration of a change, once it has taken place. The extent of territory in which an established type will continue or in which a change of type is likely to occur is also indicated.

4. In some cases at least they afford some warning of impending changes.

5. If data were available promptly, the use of such maps in connection with the daily weather maps would help the forecaster to decide at the time of examining his synoptic charts whether the cyclones and anticyclones would follow the same paths as in the recent past, or be temporarily deflected to other paths, or show a definite and persistent change of track and character.

6. For the particular period studied they showed a long persistence of type in Asia, somewhat less stable conditions in America, and frequent changes of type in Great Britain and Europe. These conditions, as partially indicated in the intorduction, are more or less typical of these three continents.

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(4) J. R. Weeks: What Will the Winter Be? Bul. Amer., Metl. Soc., 14: 17–18.
(5) N. A. Hessling: Variable Features of Barometric Depressions and Anticyclones as a Basis for Seasonal Forecasting, Mo. Wea. Rev., 55: 184–186.
(6) A. Wagner: Investigation of the Oscillations of the General Circulation. Translation in Mo. Wea. Rev., 57: 383.
(7) Mo. Wea. Rev., vols. 41 and 42.
(8) Climatological data for various States, Feb. 1914.
(9) Bowie, E. H., and Weightman, R. H.: Types of Storms of the United States and Their Average Movements. Mo. Wea. Rev., Sup. No. 1.

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