CORRESPONDENCE

Remarks on 'The Disturbed Circulation of the Arctic Stratosphere'

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In his discussion of possible interactions of the Ferrel and the polar-night westerlies [1], Mr. Hare mentions that I had suggested to him that a connection exists between the so-called primary index cycle of the Ferrel system and the breakdown of the stratospheric polar-night vortex. The purpose of this note is to clarify this suggestion.

In the course of a study on the polar-night vortex breakdown phenomenon, I undertook an examination of the sea-level pressure changes (on the time-scale of a month or so) in an effort to ascertain whether any consistent behavior from winter to winter occurred. The following results were obtained from analysis of three winters—1956–57, 1957–58 and 1958–59.

First, a definition of the vortex breakdown was formulated. As Mr. Hare and others, notably Godson and Lee [2], have pointed out, the so-called sudden-warming phenomenon is characterized in the lower and middle stratosphere by the change from a highly baroclinic Arctic stratosphere to a barotropic one. This change, to be indicative of a true hemispheric vortex breakdown, should occcur both over the Canadian arctic and in Siberia. Figs. 1, 2 and 3 show the 50-, 100-, and 500-mb height differences between Alert or Resolute and Columbia, Missouri; and figs. 4 through 6 show the 100- and 500-mb height differences between a Siberian station and Tashkent for the three winters.

Examination of these figures indicates that 1 February 1957, 10 January 1958 and 1 March 1959 were approximately the dates on which the vortex breakdown commenced in the Canadian arctic. These dates also approximate the vortex breakdown beginnings over Siberia, although the rate of disappearance of the polar vortex was apparently much slower than over Canada.

Winter courses of 100- and 50-mb heights at a number of Arctic stations confirm these dates, as do the analyses by various authors of the particular winters involved [3; 4; 5].

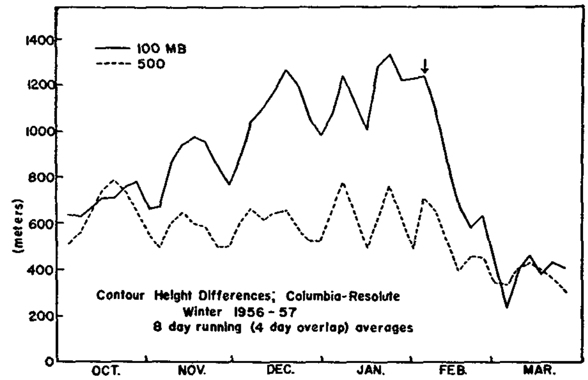

FIG. 1. 100- and 500-mb height differences; Columbia, Missouri-Resolute, winter 1956–57.

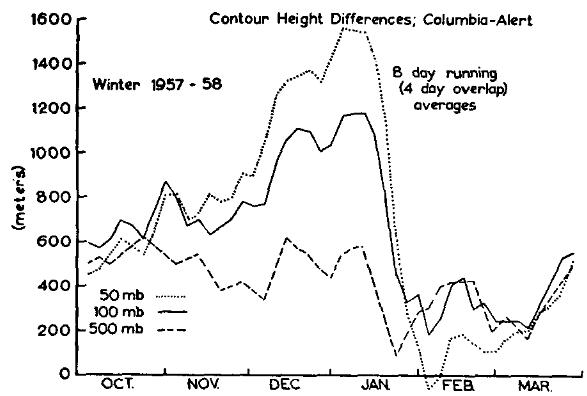

FIG. 2. 50-, 100-, and 500-mb height differences; Columbia-Alert, winter 1957–58.

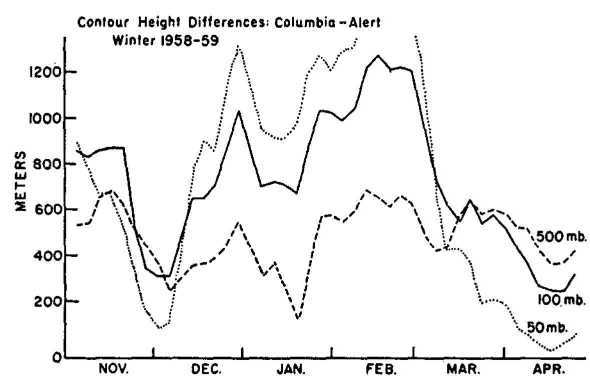

FIG. 3. 50-, 100-, and 500-mb height differences; Columbia-Alert, winter 1958–59.

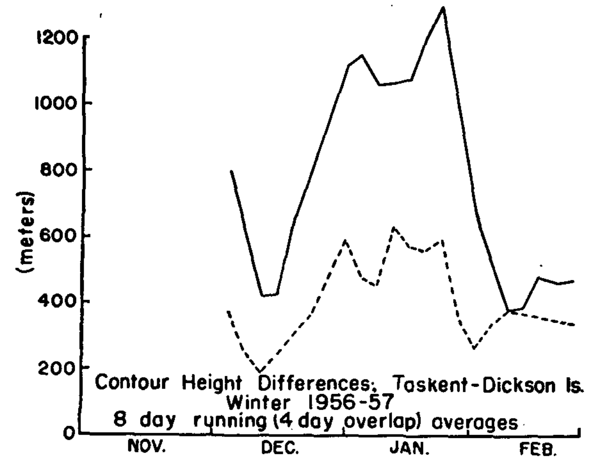

FIG. 4. 100- and 500-mb height differences; Tashkent-Dickson Island, winter 1956–57.

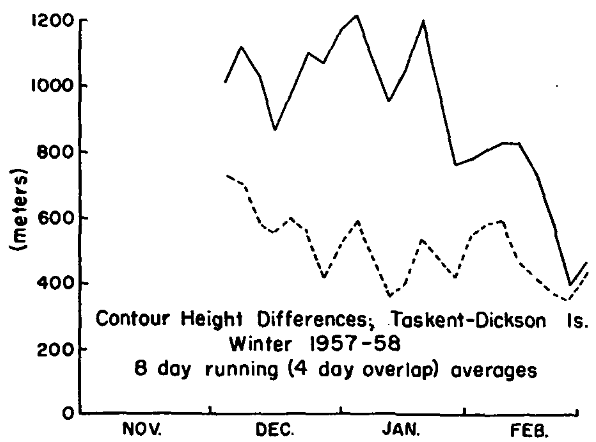

FIG. 5. 100- and 500-mb height differences, Tashkent-Dickson Island, winter 1957–58.

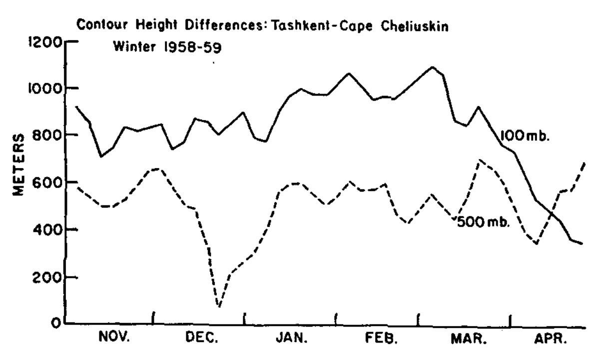

FIG. 6. 100- and 500-mb height differences, Tashkent-Cape Cheliuskin, winter 1958–59.

The next step in this analysis was to approximate these dates by 1 February 1957, 15 January 1958 and 1 March 1959 for computational convenience and to compute sea-level pressure-change charts from monthly-mean charts straddling these dates. These are shown in figs. 7, 8 and 9. All three years exhibit similar polar-region pressure rises following the breakdown dates, although not in all cases circumpolar in orientation. These rising pressures commenced as nearly simultaneously with the rising stratospheric pressures as these broadscale changes can be determined. Craig and Hering [3] have pointed out the strong rising polar pressures in the 1957 case.

Large pressure rises are not in evidence for the 1958 or 1959 cases over Siberia in the figures shown. Since the vortex collapse was apparently slower in that region, sea-level pressure rises might be expected to have been delayed, if some connection between the vortex collapse and the tropospheric circulation exists. Examination of the change charts for January to February 1958, and for March to April 1959, indicate that, indeed, sea-level pressure rises occurred over northern Siberia.

The 40-yr average monthly-mean sea-level charts [6] show an increase in polar pressures from January to February and from February to March. Therefore, change charts covering the other winter months for the three winters were also examined. No other 30-day pressure-change patterns in the three winters showed large-scale increases in the polar regions and falls in middle latitudes except those coincident with the polar-night vortex breakdown.

The relation between broad-scale pressure rises in the polar regions and the primary index cycle has been discussed by Namias [7]. In the first two winters, the primary index cycle was pronounced and was easily related to the large polar pressure rises. In the 1958–59 winter, however, the connection was not as clear, and it was difficult to define a primary index cycle.

Although no data from Siberia are available, an examination of the 1951–52 winter corroborates the suggested relationship. A very pronounced primary index cycle began on about 1 February which is also the date on which the stratospheric polar-vortex collapse began in the Canadian arctic [8].

In conclusion, I feel that a quotation from Craig and Hering's article [2] on the events of the 1957 stratospheric warming and associated events is particularly appropriate: "It is clear, however, that the radical stratospheric variation is only one manifestation of a sizeable variation in the entire general circulation."

I wish to express my appreciation for the support provided by the Geophysics Research Directorate, Air Force Cambridge Research Center, and to Mr. Jerome Namias for his suggestions and the sea-level pressure data. This work was part of a larger study done at the Pennsylvania State University under the direction of Dr. Hans A. Panofsky.

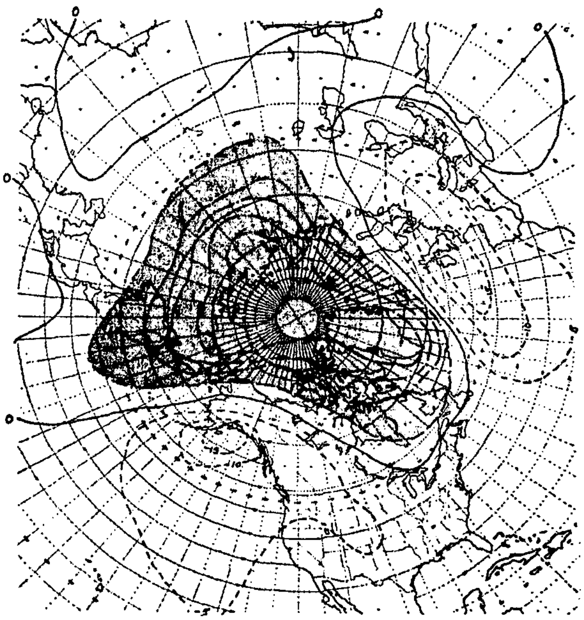

FIG. 7. Sea-level pressure change, January to February, 1957. 5 mb isallobar interval. Area greater than +5 mb shaded. Plus ——·——·; Zero ————; Minus - - - -.

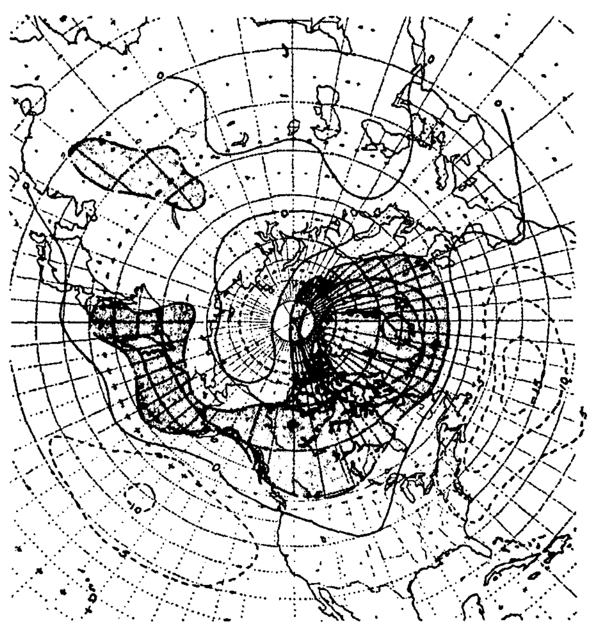

FIG. 8. Sea-level pressure change, Mid-December–Mid January to Mid-January–Mid February, 1958. Legend same as fig. 7.

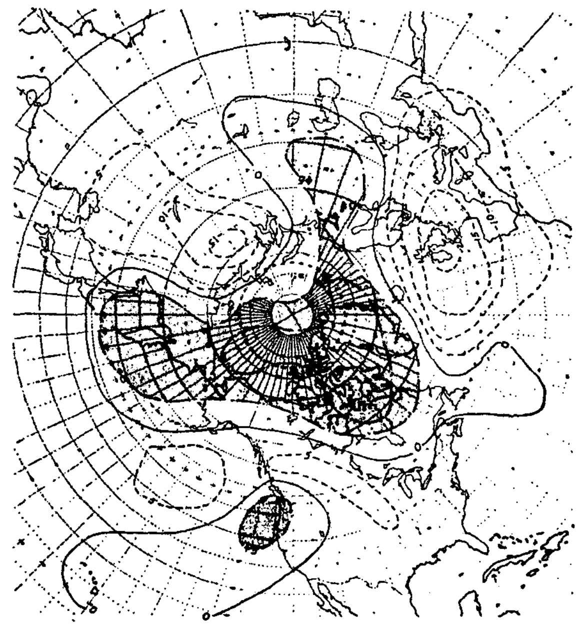

FIG. 9. Sea-level change, February to March, 1959. Legend same as fig. 7.

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