

LARGE-SCALE WINTER-TIME DISTURBANCES IN METEOR WINDS OVER
CENTRAL AND EASTERN EUROPE

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As it is well known, in winter a predominant westerly circulation exists in middle and high latitudes from the stratosphere up to the mesopause region (80-100 km), driven by the stratospheric polar west wind vortex. Sudden stratospheric warmings lead to disturbances or even to a breakdown of this vortex with occurrence of easterly winds (LABITZKE, 1981). Such large-scale circulation disturbances can be seen in pressure maps up to mesospheric heights (NAUJOKAT et al., 1983). Moreover, in the mesopause region similar circulation disturbances in periods with stratospheric warmings are also known for a long time from meteor wind and ionospheric drift results (PORTNYAGIN and SPRENGER, 1978). In the present report we investigate daily zonal wind data of the four Pre-MAP-winters 1978/79 to 1981/82 obtained over Central Europe (station Kuhlungsborn, 54.1°N/11.8°E) and Eastern Europe (state Obninsk, 55°N/38°E) by the radar meteor method (D2). Available temperature and satellite radiance data of the middle and upper stratosphere are used for comparison, as well as wind data from Canada (SMITH et al., 1982). The existence or non-existence of coupling between the observed large-scale zonal wind disturbances in the upper mesopause region (90-100 km) and corresponding events in the stratosphere is discussed.

An analysis of wind disturbances in the 90-100 km level above Central Europe in the first Pre-MAP-winter 1978/79 has been already published on the basis of D2 wind results of the station Kuhlungsborn and ionospheric drift (D1) results of the station Collm (GREISIGER et al., 1979). These results will be summarized here only with inclusion of D2 wind data from the station Obninsk in Eastern Europe. As shown in Figure 1 in January and February 1979 three distinct large scale reversals of the zonal prevailing wind (V_z) in 90-100 km took place as measured by the D2-method at Kuhlungsborn and Obninsk as well as by the D1-method at Collm (3-days running means are used for smoothing, applied to all winters). In the stratosphere an intense warming of the polar region started after 21 January, proceeding in three pulses and leading to a total breakdown of the circumpolar vortex ("major stratospheric warming") on 23 February (LABITZKE, 1979). The three wind reversals at 95 km occurred some days in advance of the peaks of the warming pulses at the 4 mbar level (SSU Ch 26 data), which in turn occur a little earlier than the peaks in 10 mbar temperature above the North Pole (cf. Figure 1). The period of strongest East wind in the 90-100 km level around 25 February coincided rather well with the breakdown of the polar vortex in the stratosphere, suggesting a strong coupling between the stratosphere and the mesopause region during this major stratospheric warming event.

As reported by SMITH et al. (1982), the zonal circulation in the mesosphere and mesopause region in this winter above Canada, observed at Saskatoon (52°N, 104°W) by the D1-method (partial reflection), did not show a close coupling. There was no reversal near 25 February. Such different behaviour on large scale, however, can be understood through the longitudinal asymmetry in the

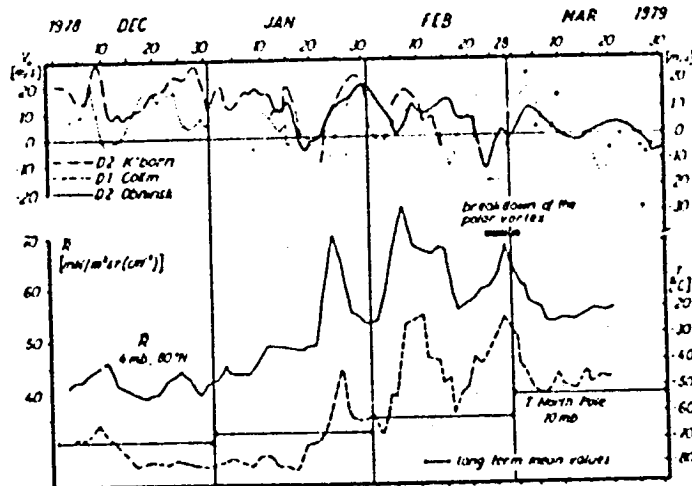


Figure 1.

vertical propagation of planetary waves, which very probably are the primary cause of the coupling.

In winter 1979/80 several circulation disturbances took place again as seen in the zonal prevailing wind data V_0 of Obninsk and Kuhlungsborn (Figure 2). For comparison the situation in the stratosphere is characterized in Figure 2 by the temperature of the 10 mbar level and satellite IR radiance data of 4 and 1.7 mbar over the North Pole (LABITZKE et al., 1980). From 10 January up to 20 February 1980 in the upper stratosphere (4 and 1.7 mbar level) several "minor warmings" occurred, whereas in the middle stratosphere (10 mbar) the temperature above the North Pole was nearly equal or lower than the long-term mean values (Figure 2). At 95 km wind reversals were observed above Central and Eastern Europe around 12 and 24 January followed by a recovery of the West wind circulation and a new weakening after 10 February. Simultaneous D1-wind measurements at Saskatoon also show several wind disturbances but not with such a close temporal connection as for the European region. The mesopause region above Europe seems favorable to indicate large scale winter-time disturbances of the pressure field and corresponding wind field, as already shown for the major stratwrm effect in the first Pre-MAP-winter. At the end of February a "major warming" of the whole stratosphere took place, as seen in Figure 2 by sharp peaks of the radiances and the temperature above the Pole. The zonal wind in the mesopause region now seems to be disturbed simultaneously over the whole Northern Hemisphere with East winds over Europe (Obninsk, Figure 2) and also above Canada around 29 February.

In the third Pre-MAP-winter 1980/81, the stratosphere showed an extreme behaviour (LABITZKE et al., 1981). Beginning with the end of November, strong cooling took place in the polar middle stratosphere, reaching temperatures in December and in the first half of January substantially below the long-term mean values, as shown in Figure 3 for the 10 mbar level. By the end of January a sudden and very strong warming began first in the upper polar stratosphere and a few days later in the 10 mbar level (cf. Figure 3). So the winter 1980/81 in the stratosphere can be clearly divided into two parts, viz., a quiet period up to 20 January and a highly disturbed period after 20 January. In the mesopause

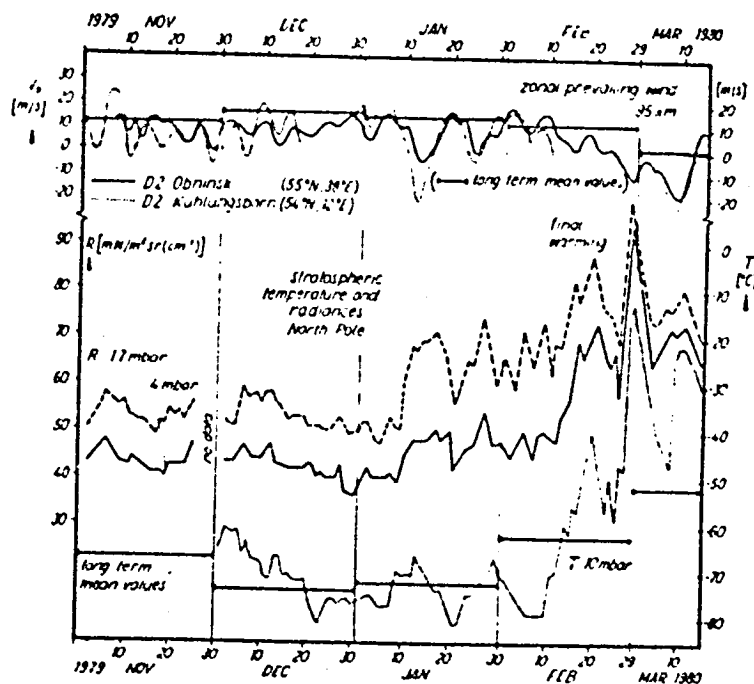


Figure 2.

region, as could be expected from earlier winters, the zonal wind in this second part of the winter was also very disturbed.

During the maximum of the stratospheric warming at the end of January/beginning of February 1981 the strong zonal westerlies at 95 km decreased rapidly and reversed to East wind, practically simultaneously above Central and Eastern Europe (Figure 3), and also above Canada. This confirms the large-scale character of the disturbance and the close coupling with the stratospheric warming event. The first part of the winter 1980/81, though rather quiet with extremely low temperatures in the polar stratosphere showed several disturbances of the zonal wind in the mesopause region, not less intense as during the major stratospheric warming. As shown in Figure 3, simultaneous reversals to East wind above Central and Eastern Europe occur in November and December, and a rapid weakening of the West wind shortly before 20 January. Even stronger disturbances with reversals were observed at Saskatoon at 93 km at about the same periods. That means that in the first part of the winter 1980/81 the zonal circulation in the mesopause region is highly disturbed in a large-scale manner, though the polar stratosphere was rather quiet. One can conclude that these disturbances are probably connected with processes in the mesosphere or in the mesopause region itself. Some indication we have from the radiance data (Figure 3), which show from November to January some little warming peaks which are higher at 1.7 mbar (44 km) than at 4 mbar (38 km).

In January and beginning of February 1981, remarkable wave-like variations of the zonal wind at 95 km with large amplitudes, very similar at both stations, were observed. They seem to be connected with corresponding variations of the

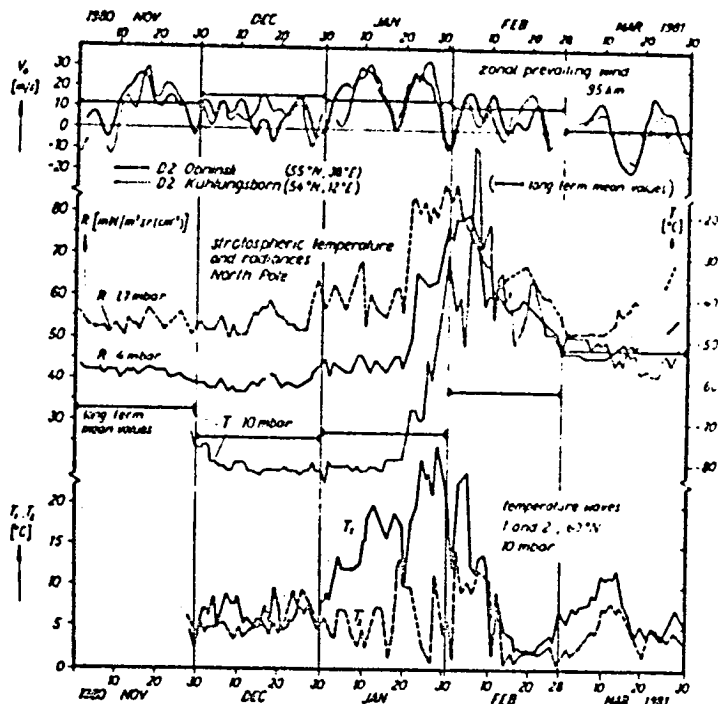


Figure 3.

dominant stationary planetary temperature wave T_1 in the stratosphere at 60°N (cf. Figure 3). In this respect the stratospheric temperature field was disturbed already before the major warming event (amplification of wave 1 as a precondition of a major stratospheric warming, LABITZKE (1981), and an influence up to the 95 km level at medium latitudes seems to exist.

The fourth Pre-MAP-winter 1981/82 is in some respects similar to the second one. In mid-December a warming in the upper stratosphere (4 and 1.7 mbar) with simultaneous cooling in the middle and lower stratosphere was observed (NAUJOKAT et al., 1982) (cf. Figure 4). The zonal wind at 95 km over Europe is strongly disturbed in December with values below the long-term mean values and some short periods of East winds. In January in the polar stratosphere a strong "minor warming" occurred (NAUJOKAT et al., 1982) with two pulses in the radiances (1.7 and 4 mbar) and 10 mbar temperature around 10 and 25 January (Figure 4). In coincidence with the stronger second pulse we observe an almost simultaneous reversal of the zonal wind above Central and Eastern Europe with an East wind period up to the beginning of February. At Saskatoon at the same time a reversal down to 62 km was recorded which shows the large-scale character of this wind disturbance in connection with the strong "minor warming".

Summarizing our results one can say that in winter during "major warmings" obviously a close coupling exists between the stratosphere and the mesopause region. The temporal and spatial relation between the events in both atmospheric layers can be understood only with informations about the vertical propagation of the pertinent planetary waves as a primary cause of the coupling.

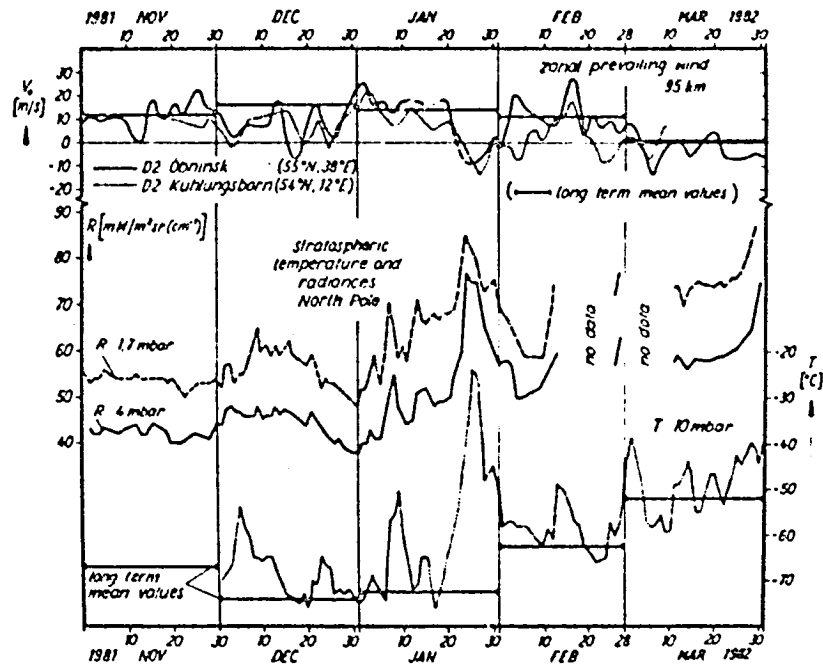


Figure 4.

Not much less intense large-scale zonal wind disturbances in the mesopause region were observed during periods of relatively quiet or even extremely typical winter conditions in the stratosphere. The cause of these disturbances is not clear; it has probably to be sought in the mesosphere or in the mesopause region itself.

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