Response of the Mesopause Region Dynamics to the February 2001 Stratospheric Warming

Ch. Jacobi¹, D. Kürschner², H.G. Muller³, D. Pancheva⁴, N.J. Mitchell⁵, B. Naujokat⁶

1. Institute for Meteorology, University of Leipzig, Stephanstr. 3, 04103 Leipzig, Germany
2. Institute for Geophysics and Geology, University of Leipzig, Collm Observatory, 04779 Wermsdorf, Germany
3. Department of Aerospace Power and Sensors, Cranfield University, Swindon SN6 8LA, U.K.
4. University of Wales, Aberystwyth, Ceredigion SY23 3BZ, U.K.
5. The Department of Electronic and Electrical Engineering, The University of Bath, BA2 7AY, UK.
6. Stratospheric Research Group, Free University of Berlin, Carl-Heinrich-Becker-Weg 6-10, 2165 Berlin, Germany

Summary

Mesopause region horizontal winds have been measured over three stations (Castle Eaton, Collm, ESRANGE) in Europe during winter 2000/2001 to investigate the response of the mesosphere/lower thermosphere region to a major stratospheric warming. Although different measuring methods have been applied (LF D1, meteor radar) the measured temporal and vertical wind structure was very similar. Also the stratospheric warming effect was visible, and very similar, in both midlatitude and high-latitude sites. The warming resulted in a reversal of both the zonal and meridional wind. In the zonal component, this reversal was due to a planetary oscillation with period 10 days, which was even more pronounced in the vertical gradients, so that the stratospheric warming effect on the mesopause was owing to the superposition of an intensifying planetary wave and a slow overall decrease of the zonal prevailing winds.
The February 2001 stratospheric warming as seen at 30 hPa

Figure 1:

Northern hemisphere geopotential height distribution during January and February 2001 at 30 hPa.

The stratospheric warming is well visible in February, when the polar vortex is strongly disturbed.
**Time series of zonal prevailing winds**

Figure 2:

Zonal prevailing winds over

Castle Eaton \( (52^\circ N, 2^\circ W) \),
Collm \( (52^\circ N, 15^\circ E) \) and
ESRANGE \( (68^\circ N, 21^\circ E) \)

at two different heights, respectively.

Wave structures as well as changes in vertical gradients are visible. The peak effect of the warming is seen around day \( \text{No} \ 50 \).
Time series of meridional prevailing winds

Figure 3: Meridional prevailing winds over Castle Eaton (52°N, 2°W), Collm (52°N, 15°E) and ESRANGE (68°N, 21°E) at two different heights, respectively.

Well-defined wave structures are not clearly visible. During the warming, strong southward winds are found.
Figure 4: Vertical gradient of the zonal prevailing wind. Over Collm and Castle Eaton (lower curves) clear wave structures are visible.
Figure 5:

Amplitude spectra of the zonal prevailing wind and the vertical zonal wind gradient, calculated using the data from January 15 through February 24, 2001.

10-day wave is only visible in the gradients.
Figure 6: Height-time cross-sections of the zonal wind over ESRANGE. During February (right part of the figure) a clear upward propagating 10-day wave is visible.
Vertical structure of the 10-day wave

Figure 7:

Amplitudes and phases of the 10-day oscillation over ESRANGE, and change rate $du/dt$ of the zonal prevailing winds at the different height gates.

Over ESRANGE a clear decrease of the zonal winds during the entire stratospheric warming period is found.
Results and Conclusions

During February 2001 a major stratospheric warming occurred. This warming was visible in the mesosphere/lower thermosphere:

1. A clear 10-day wave was measured during the warming.

2. The warming results in a decrease of the zonal prevailing wind, which is superposed by the wave.

3. The meridional prevailing wind was negative, which is due to a residual circulation above the region of wave-mean flow interaction.

Acknowledgements: This study was partly supported by BMBF within the AFO2000 programme under 07 ATF10 (MEDEC).