Atmos. Chem. Phys. Discuss., 8, S6136–S6140, 2008
www.atmos-chem-phys-discuss.net/8/S6136/2008/

Atmospheric
Chemistry
and Physics
Discussions

Interactive comment on “Mesospheric N_2O enhancements as observed by MIPAS on Envisat during the polar winters in 2002–2004” *by* B. Funke et al.

B. Funke et al.

Received and published: 19 August 2008

We thank Reviewer #2 for his/her very helpful comments and suggestions. The "Reviewer Comments" are noted first and then we give our "Reply:" to the comment. We are submitting a revised manuscript that includes all the actions noted below.

It seems that authors should give more details (page 6, line 159-162) to the explanation of stratospheric warming influence on chemical composition due to rather complicated transformation of temperature and wind fields during these periods. It should be mentioned that motions and temperature changes in the stratosphere and mesosphere are not similar.

Reply: The NH stratospheric warmings in 2002-2004 led, in first instance, to a distortion and weakening of the upper stratospheric and mesospheric (USM) polar vortex (e.g. Manney et al., 2004; Funke et al.,2005). As a consequence of these warming events, the chemical composition of the USM polar regions was affected by intrusions and /or in-mixing of tropical air. This is already mentioned on page 10568, l7-12. The response of temperature and wind fields in the USM to these warming events, though a very interesting topic, is of minor importance for the discussion of the temporal evolutions of N2O and CH4 abundances in the context of mesospheric N2O productions. To our opinion, the inclusion of details on this response in the text would lead to confusion and should thus be avoided for the sake of clarity. It should be noted that there is a typo in the manuscript on page 6, l 159/160 (page 10568, l17 in the ACPD version): January 2002 should read January 2003. This has been corrected in the revised version.

Possible more details also are needed for the explanation of the influence of tropospheric sources on N2O increase in the lower mesosphere (page 6, line 258).

Reply: Since apart of the mesospheric source proposed in this paper, the only known N2O source is located at the surface, any N2O observed at 58 km which is not produced in the mesosphere must be of tropospheric origin and must have ascended to 58 km by dynamics. We have clarified that by including on page 10572, l21: "tropospheric N2O transported up to 58 km".

Authors didn’t show calculated ionization rates (fluxes only) caused by precipitating electrons. Narrow peak (Fig. 7, bottom) caused by SPE of October 2003 doesn’t describe the situation. The better comparison is produced molecular of NOy by protons and electrons.

Reply: We agree that ionization rates at the altitude of interest would be a better choice for correlating them to the observed N2O abundances. Unfortunately, ionization rates due to electron fluxes, relevant to this paper, are not available to us. Nevertheless, the MEPED electron fluxes of different energies (30, 100, and 300 keV), used instead, are in first order proportional to the ionization rates at different altitudes, so that they describe rather well the temporal evolution of atmospheric ionization due to precipitating electrons. In order to clarify this point we state now on page 10573, l17: "Fluxes of precipitating electrons of energies 30 keV, 100 keV and 300 keV included in Figures 7and 8 cause ionization peaks at altitudes around 85, 75, and 60 km, respectively (Callis,1998a).Therefore, they can be used as indicator for EEP-induced atmospheric ionization at these altitudes." Since our paper focuses on EEP-related (and NOT on SPE-related) N2O productions (the latter was already analyzed for the "Halloween" SPE event in Funke et al., 2008), we use proton-induced ionization rates (bottom panel of Figure 7) only in order to verify that no further SPE events apart of the October-November 2003 event could have been responsible for the polar winter N2O enhancements observed during 2002-2004. This is already clearly stated in line 10573, l5.

Calculation of N2O production (Fig. 10) is not enough, because we should also need calculate the losses.

Reply: Chemical losses of N2O (photolysis and reaction with OH and O(1D)) at polar winter conditions are very small (chemical lifetime in the order of several months) due to the faint illumination conditions. Thus, N2O losses are dominated by dynamical processes, i.e. mixing across the vortex boundary and vertical redistribution (advection and diffusion), which are extremely difficult to quantify accurately for the particular dynamical conditions of the polar winters under investigation. Based on typical vertical and meridional advection velocities at polar winter conditions, we estimated the N2O dynamical lifetime around 60 km to be in the order of several weeks and concluded on p. 10579, l 22 that, under consideration of these losses, the calculated N2O production would generate mesospheric N2O enhancements in the order of those observed by MIPAS. Figure 10 was included in order to allow for the identification of the altitude regions where N2O is produced by the proposed processes, to compare their magnitudes, and to analyze their dependence on different atmospheric conditions. For this purpose, the calculated altitude-dependent chemical productions are well suited.

It would be interesting to have a look on MIPAS scans up to 170 km (page 3, line 64).

Reply: In the context of this paper, upper atmospheric (UA) observations of MIPAS are of interest for searching possible thermospheric N2O emissions related to reaction R2 (N2+O2). Unfortunately, UA observations of MIPAS were performed only occasionally during 2002 - 2004 (see page 10564, l20) and are thus not suited for an analysis of the N2O temporal evolution during this period. Nevertheless, we searched for thermospheric N2O emissions in MIPAS UA1 observations (tangent heights from 20 to 100 km) taken on 11 June 2003 (page 10579, l11), however, without detecting them in the 90 - 100 km altitude range. Although it is rather unlikely that there is a detectable N2O contribution in MIPAS spectra at higher tangent heights (N2O production due to R2 would peak at 100 km and drops rapidly at higher altitudes, see Figure 10), we now have looked into UA4 observations (40 -170 km tangent heights) taken on the same day. As expected, no N2O signal has been found above 100 km. Accordingly, we modified the sentence at page 10579, l11 to "We thus have looked at MIPAS spectra taken in the upper atmospheric observation mode on 11 June 2003, which includes tangent heights up to 170 km. No evidence for N2O emissions at tangent heights above 90 km was found in any of the N2O bands included in the MIPAS spectra."

Authors should give explanation to readers, what does it mean "equivalent latitudes".

Reply: Equivalent latitudes are widely used to express tracer distributions as a function of potential vorticity (PV) by assigning the highest (lowest) PV values encountered in the NH (SH) an equivalent latitude of 90N (90S). Equivalent latitudes between 90S and 90N are then determined such that the area enclosed by an 1 degree increment in equivalent latitude corresponds to the area enclosed by the same increment in geographical latitudes. A detailed description on the use of equivalent latitudes is given by Nash et al. JGR 101, 9471, 1996 which is referred now in the manuscript.

Is not clear really what kind of correlation were found and is a final interpretation (page 15, lines 490-493).

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Reply: We found a correlation between the inter-annual variations of polar winter averages of mesospheric N2O and those of precipitating electron fluxes as measured by the MEPED instrument. This correlation hints at an implication of EEP on the observed mesospheric N2O enhancements. In order to clarify this, we have rewritten page 10582, l3-4 by "Further, the inter-annual variations of polar winter averages of mesospheric N2O correlate well with those of precipitating electrons fluxes as measured by the MEPED instrument, which hints at an EEP-related N2O source."

It would be useful to have an "Altitude" on the Figure 1 as a vertical scale (as on Figure 2).

Reply: The reason for choosing potential temperature rather than geometric altitude as vertical scale on Figure 1 is that meridional transport generally occurs on isentropic surfaces. Hence, it can be easier identified on the actual vertical scale which, in turn, helps to distinguish between transport-related and chemically produced N2O enhancements. Nevertheless, in order to relate certain potential temperature levels to geometric altitudes, we have included mean altitude contours in Figure 1.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 10561, 2008.