

Interactive comment on “Atmospheric tracers during the 2003–2004 stratospheric warming event and impact of ozone intrusions in the troposphere” by Y. Liu et al.

Anonymous Referee #1

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The authors use the MOZART-3 model to investigate the distribution and transport of ozone and N₂O in the northern hemisphere stratosphere during an intense stratospheric warming event (SSW) in winter 2003/04. They compare the temporal evolution of the trace gas fields during this event with results of a MOZART-3 simulation for a more "typical" SSW event that took place in winter 2002/03. In addition, qualitative comparisons with corresponding trace gas fields obtained from the MIPAS instrument onboard the ENVISAT satellite are used to underline the capability of MOZART-3 to realistically capture the most important transport effects associated with both SSW events. The study shows that the 2003/04 SSW led to the occurrence of exceptionally large "low ozone pockets". In addition, reduced planetary wave activity (BD circula-

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tion) is observed as a result of long lasting easterly wind. The authors show that the poleward flux of ozone in the stratosphere is decreased in this situation as well as the downward flux of ozone into the troposphere (in particular over East Asia). The paper presents a very interesting example of the influence of disturbed dynamical conditions on the distributions of ozone, ozone flux into the troposphere, and stratosphere-troposphere coupling. The material presented should be of great interest for the ACP readership. The paper should be published after some minor revision.

The first general comment concerns Section 4.1., where temporal changes of ozone and N₂O associated with the SSW are qualitatively described on the basis of zonally averaged values (Figures 3, 4). The description in the text should be more precisely, because some of the discussed features cannot directly be seen in the 2D fields presented in the figures (see also detailed comments 8, 9).

The second general comment concerns the diagnosis of the downward flux of ozone into the upper troposphere. It is not immediately clear how Figure 11 (weaker vertical flux in 2003/04 over the whole period) and Tables 1, 2 corroborate each other.

Other comments:

1. Introduction, p13637, line5: A detailed investigation of the effects of the EPP event in late October / early November 2003 on ozone is given in a recent paper of Vogel et al. (ACP, 8, 5279-5293, 2008). This paper could be added to the references.
2. Chapter 3, p 13639, line 26: It is stated that "Several small and shallow downward intrusions, however, were observed after January 2003 (lower panel of Figure 1)". I assume that this can be seen by the wave-like contour line just below 30 km in Figure 1. Unfortunately, the pattern above this line is not so easy to identify (at least in print outs), as a result of the colour code.
3. Chapter 3, p13640, line 1: "The major differences between the two events are highlighted by the white circles appearing in Fig. 1". Comment: I guess that you mean

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Fig. 2. Moreover, what do you mean by "white circles"? I guess that you mean the areas that indicate negative wind speeds (easterlies).

4. In the next sentence, it is stated that a prolonged reversal of the zonal wind occurred near 10 hPa (Fig.2). Since it is obvious from Fig. 12 that this reversal occurred over a wide altitude range, the sentence should be replaced by something like " ... the zonal-mean wind exhibited a prolonged reversal at high latitudes between ... hPa, as illustrated in Figure 2 for the 10hPa level.

5. Same page, line 23: I suggest to replace "vertical distribution" by something like "latitude-height cross-section" or just say "Zonal mean N2O and Ozone distributions".

6. Page 13641, line 4: I suggest to replace " ...is represented realistically. The calculated N2O concentrations are low inside the polar vortex, ..." by something like "... is represented realistically by the model results. Before the occurrence of the SSW, the calculated N2O concentrations are low inside the polar vortex, ..."

7. Page 13641, line 21: "The intrusion of high N2O concentrations into the polar region occurs through the tongues of high N2O concentration". This section should be formulated more precisely to avoid confusion. The reader could get the impression that the tongues can be seen somewhere in the 2D presentation of Figure 3, 4. However, Figure 3 just shows that the area of low N2O values (originally associated with the vortex) is filled by higher values after the SSW event. One could mention that this is related to (3d) tongues that have been previously observed by MLS.

8. In line 28, you use again the expression "ozone-rich tongue". However, you refer to the meridional gradient of the mixing ratio maximum of the ozone layer. This may cause confusion. In the following text, expressions like "a high ozone tongue" should be replaced by something that is more appropriate to describe the modelled and observed ozone changes in the 2D presentation of Figures 3 and 4.

9. Page 13642, line 26: It is stated that "For example on 10 January 2004 the already

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elongated vortex on the 10 hPa surface splits into two parts". From my point of view, the situation shown in Figure 7 is better described by something like "On 10 January 2004 two remnants of the diluted vortex can be seen"

10. Page 13643, line 22: You could add (if appropriate) something like "In addition, part of the difference in the strength of the structures in ozone and N₂O may be attributed to the MOZART-3 transport scheme".

11. Page 13645, line 3: You could add a sentence that the decline in wave amplitude during period 2 and 3 is also reflected in the temporal development of the shape of the polar vortex (Figs. 7 to 10).

12. Figure 3: There is an inconsistency between the figure legend (7 January) and the figure caption (10 January).

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