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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Composition changes after the "Halloween" solar proton event: the High-Energy Particle Precipitation in the Atmosphere (HEPPA) model versus MIPAS data intercomparison study" *by* B. Funke et al.

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We thank Referee #1 for helpful comments and suggestions. The "Referee's Comments" are noted first and then we give our "Reply:" to the comment.

Specific Comments:

Page 9425, B3dCTM: What happens at the vertical boundaries?

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Reply: In B3dCTM, concentrations at the lower model box are kept constant from the initialization. No transport over the lower and upper vertical boundary into and out of the model boxes is considered. This has been added to the model description in Section 4.2 of the revised manuscript.

Page 9426, CAO: What Radiative scheme is used with the dynamical core?

Reply: The radiative scheme used in the dynamical core below 60 km is based on parameterizations described in Chou and Suarez (1994, 1999). Above, parameterizations from Kutepov and Fomichev (1993); Fomichev et al. (1998); Kockarts (1980); Strobel (1978) are applied.

Chou, M.-D. and Suarez, M. J.: An Efficient Thermal Infrared Radiation Parameterization for Use in General Circulation Models, Technical Report Series on Global Modeling and Data Assim- ilation NASA/TM-1994-104606, Vol. 9, Goddard Space Flight Center, Greenbelt, Maryland 20771, 1994.

Chou, M.-D. and Suarez, M. J.: A Solar Radiation Parameterization for Atmospheric Studies, Technical Report Series on Global Modeling and Data Assimilation NASA/TM-1999-104606, Vol. 15, Goddard Space Flight Center, Greenbelt, Maryland 20771,1999.

Fomichev, V. L., Blanchet, J.-P., and Turner, D. S.: Matrix parameterization of the 15 μm CO2 band cooling in the middle and upper atmosphere for variable CO2 concentration, J. Geophys. Res., 103, 11 505–11 528, http://dx.doi.org/10.1029/98JD00799, 1998.

Kockarts, G.: Nitric oxide cooling in the terrestrial thermosphere, Geophys. Res. Lett., 7, 137– 140, http://dx.doi.org/10. 1029/GL007i002p00137, 1980.

Kutepov, A. and Fomichev, V.: Application of the second-order escape probability approximation to the solution of the NLTE vibration-rotational band radiative transfer problem, Journal of Atmospheric and Terrestrial Physics, 55, 1 – 6, doi:10.1016/0021- 9169(93)90148- R, http://www.sciencedirect.com/science/ arti-

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cle/pii/002191699390148R, 1993.

Strobel, D. F.: Parametrization of the Atmospheric Heating Rate from 15 to 120 km due to O2 and O3 Absorption of Solar Radiation, J. Geophys. Res., 83, 6225, 1978.

This information has been added to the model description of CAO in Section 4.3.

Page 9433: How does underestimating the background HOCl lead to apparent better agreement? It seems confusing because lowering (underestimating the background) would seem to give lower modeled HOCl values while the figure show high HOCl values than observed.

Reply: There was a mistake in the wording at page 9433 (line 2): “In the latter case” should read “In the former case”. We have re-worded the corresponding paragraph in order to clarify this: “Figure 6 compares HOCl zonal mean distributions at 40–90N, averaged over the period 29 October to 4 November 2003, as observed by MIPAS and as modeled by WACCM with and without application of averaging kernels. In the former case, the vertical distribution is broader and slightly shifted towards lower altitudes compared to the original model data, similar to the retrieved MIPAS profiles.” We also make this clearer in the corresponding figure caption of the revised manuscript: “ Effect of application of averaging kernels (AKs) to the model data on the example of MIPAS and WACCM4 HOCl zonal mean distributions (40–90N) averaged over the period 29 October to 4 November 2003. Left: MIPAS, middle: WACCM4 with MIPAS averaging kernels applied, right: WACCM4, original model results.”

Page 9435, discussion of Fig. 9: Would a Potential Vorticity Area diagnostic show stronger gradients in the lower mesosphere, more consistent with gradient above and below, if planetary waves are responsible for the reduced gradient?

Reply: A PV or equivalent latitude analysis would indeed help to understand whether the weakening of meridional gradients in the lower mesosphere is related to either planetary wave activity or small-scale mixing. Unfortunately, however, PV output is

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not available from the models. Alternatively, we have looked at the zonal anomalies of observed and modeled CH_4 at vertical levels belonging to the lower mesosphere and above or below. It turned out that more pronounced zonal anomalies (i.e., planetary waves) occur in both observations and models in the stratosphere compared to the lower mesosphere. Therefore, it is more likely that the weakening of meridional gradients in the lower mesosphere is related to small-scale mixing (i.e., a weakened vortex boundary) rather than planetary wave activity. Therefore, we state in the revised version: "The vertical distribution of the observed CH_4 meridional anomaly shows a broadening in the stratopause region (1–0.1 hPa). Spatial CH_4 distributions at these vertical levels (not shown) indicate that this broadening is related to a weakened transport barrier at the vortex top rather than to increased planetary wave activity in the mesosphere."

Page 9435, discussion of Fig. 10: Other than changes in values from the initial conditions (in most models) and varying rates of descent (in most models), there is not much agreement in the Ch4 fields. Is there an explanation for such poor agreement of the models with MIPAS?

Reply: Figure 10 compares CH_4 changes with respect to 26 October rather than actual vmrs. It thus highlights differences in the temporal variations of CH_4 vmr distributions (i.e., descent, or variations in meridional redistribution). Conclusions about the agreement of the CH_4 fields themselves cannot be drawn from this figure.

Page 9441, discussion of Fig. 14: Has there been speculation as to why the MIPAS NO_y seems to have much larger zonal asymmetry during the main SPE than the models?

Reply: Referring to the relatively high NO_y in the 120-180W sector (i.e., about 20% higher than at other lngitiudes), it would be very speculative to think about possible physical or chemical reasons. Given that the precision of the displayed MIPAS NO_y averages (2nd panel from the left) at this location is about 3 ppbv (i.e., 10%) and

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hence poorer than at other longitudes, at least a large fraction of the apparent zonal asymmetry in the MIPAS data could be linked to random artefacts.

Page 9459, discussion of Fig. 34: Any speculation on why the FinROSE shows such a large response, and why two models: B2dM and CAO show very little response?

Reply: FinROSE includes the additional catalytic cycle Cl+NO2+M -> ClNO2+M and ClNO2 +OH -> HOCl+NO2, leading to a net HOCl production in the presence of NO2 (being available after the SPE event). In the case of B2DM, the smaller response seems to be related to the small latitudinal extent of the HOCl enhancements (as comes clear from Fig. 35), resulting in relatively low averages for the 70-90N region. The small latitudinal extend in B2dM is related to a very strong but small vortex, which is also fairly obvious in Figure 14. This is probably a result of the poor horizontal resolution. The small HOCl response in CAO is related to the unrealistic fast conversion of ClO to ClONO2, compensating the increased HOCl buildup via R14 (ClO+HO2) by reduced ClO abundances. The faster ClO -> ClONO2 conversion (compared to the observations) is most likely related to the use of a family approach for Cly and NOy in this particular model.

These explanations have been added to the discussion of Figures 34 and 35 of the revised version.

Page 9459, discussion of Fig. 35: Why is there almost no response in the CAO model?

Reply: See reply above.

Technical Corrections:

Figs. 1, 3, 25, and 26 are very small on my printer.

Reply: We agree that Figures 1, 3, 25, and 26 are very small and difficult to read in the ACPD version. These Figures will be significantly enlarged in the final version (ACP formatting).

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Page 9433, Fig. 6 discussion: The case with the averaging kernel is broader and slightly shifted to lower altitudes. Is this the former not the latter case?

Reply: The Reviewer is right. See the reply to the comment above.

All typos encountered by the Reviewer have been corrected.

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 9407, 2011.

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