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Interactive Comment

Interactive comment on "Evaluation of CLaMS, KASIMA and ECHAM5/MESSy1 simulations in the lower stratosphere using observations of Odin/SMR and ILAS/ILAS-II" *by* F. Khosrawi et al.

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The most important point to be made regarding the remarks by referee 1 on the comment by Dr. Tilmes is that they are not really relevant to our paper discussed here. Our paper employs the method introduced by Proffitt et al. (2003) and extended by Khosrawi et al. (2004, 2006, 2008). This is *not* the method commonly referred to as "tracer-tracer correlations", the two methods are fundamentally different! Nowhere in the discussion paper is an attempt being made to quantify chemical polar ozone loss in terms of mixing ratio or column ozone, which are the fundamental products of a tracer-tracer correlation analysis (see explicit reply to the referee's comments for fur-

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ther details).

Nonetheless, from a more general point of view, it is of interest to respond in more detail to the points raised in the comment. First, we agree with the referee that in the paper by Huck et al. (2007) there is no independent evidence provided for the validity of the tracer-tracer correlation method; however, we also agree with the comment by Dr. Tilmes, a coauthor of the Huck et al. (2007) paper, that this paper does not give any counterarguments against the use of the tracer-tracer correlation method, a point raised originally in the review of referee 1. Below, there is a detailed discussion of the arguments put forward by referee 1; although they have been made in several recent papers (e.g., Tilmes et al., 2004; Müller et al., 2005; Tilmes et al., 2006a,b; Lemmen et al., 2006; Müller et al., 2007) they might be worth repeating here briefly. We would also offer to include this discussion in the paper if the editor recommended doing so.

Plumb and Ko (1992): We agree that this is a seminal paper on tracer-tracer correlations. However, it does not really discuss the method of deducing polar ozone loss from ozone-tracer relations; most of the papers on ozone tracer-relations have appeared after 1992. Further, in this paper an important aspect for polar ozone-tracer relations is not discussed in depth, namely the fact that different correlations develop in- and outside of the polar vortex, see e.g., Plumb (2007) for a detailed discussion on this issue.

Sankey and Shepherd (2003): The CMAM model used by Sankey and Shepherd (2003) is incapable of producing a strong polar vortex in the Arctic: "there is virtually no barrier at all in the CMAM Arctic vortex" (Sankey and Shepherd, 2003). This model feature is in contrast to observations. It means that compact tracer-tracer correlations can not develop in the CMAM Arctic vortex. Further, in the CMAM Antarctic vortex, for which a transport barrier is simulated, a compact ozone-tracer relation develops in the model. In CMAM it takes months for the compact correlation to develop; a truly compact correlation is established in August. An analysis of ILAS II measurements in Antarctic winter 2003 indicates that a compact relation had developed by the end of June (Tilmes

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et al., 2006a,b). Thus, very likely, the too strong permeability of the Antarctic vortex edge did not allow the correct time scale for the establishment of compact tracer-tracer correlations to be simulated in CMAM.

Michelsen et al., 1998: This issue has already been discussed in detail by Müller et al. (2005). In short, out-of-vortex ozone-tracer relations (as used by Michelsen et al. (1998) but never in the tracer-tracer correlation method) are characterised by greater ozone mixing ratios for a given tracer value than vortex relations. This leads to a erroneous over-estimation of ozone loss in the Michelsen et al. (1998) analysis which is thereafter 'corrected' by introducing a mixing-line reference. The reference relation for deducing ozone loss that are derived from mixing lines yield results for the deduced chemical ozone loss comparable to those obtained by using an 'early vortex' relation from within the vortex as it is done in the tracer-tracer correlation method. Nonetheless, we consider an 'early vortex' relation as a more reliable reference than one derived from mixing lines. In any event, the mixing line introduced by Michelsen et al. (1998) can only be an approximation to mixing in reality as is considers instantaneous mixing between air-masses at 20 and 40 km.

Therefore, it is incorrect to interpret the findings of Michelsen et al. (1998) as "mixing could produce about half the changes in the O_3/N_2O relation" as Plumb et al. (2000) did.

Plumb et al., 2000: This paper is indeed often cited as making the point that mixing across the vortex could lead to a significant overestimate of polar ozone loss. As just argued above (see Müller et al., 2005, for further details) such citations are misleading insofar as they rely on a misinterpretation of the Michelsen et al. (1998) study.

Moreover, Plumb et al. (2000) use a conceptual model to discuss the impact of mixing across the vortex edge on tracer-tracer correlations. However, the cross vortex edge diffusivity in this model is likely to be substantially greater (by about two orders of magnitude) than in the stratosphere. Therefore, conclusions based on the results of

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this conceptual model do not carry over directly to stratospheric conditions. A further caveat for the application of conclusions from this conceptual model to the behaviour of ozone-tracer relations in the stratospheric polar vortex is that Plumb et al. (2000) assume the same tracer-tracer relation inside and outside the vortex; an assumption which is not valid for the ozone-tracer relation in the polar region.

Intrusions of upper stratospheric/ mesospheric air: This issue is discussed at length in a recent paper (Müller et al., 2007). We quote here from the abstract of this paper "...the impact intrusions of mesospheric air into the polar stratosphere have on estimates of chemical ozone loss based on the ozone-tracer technique has not hitherto been studied. Here, we revisit observations of an intrusion of mesospheric air [...] in the Arctic. [...] The measurements influenced by mesospheric air show ozone mixing ratios ranging between 3.6 and 5.6 ppm, which are clearly greater than those found in the 'early vortex' reference relation employed to deduce chemical ozone loss. Thus the impact of intrusions of mesospheric air into the polar vortex on chemical ozone loss estimates based on ozone-tracer relations are likely small; the correlations cannot be affected in a way that would lead to an overestimate of ozone depletion."

Ray et al., 2002: We consider this a very important paper; for example its relevance on ozone-tracer relations in the polar vortex has been discussed by Müller et al. (2005). However, it can not be cited as a "counter-example to the assertion that ozone loss can only be underestimated ...". Rather, the last sentence of the abstract of this paper reads: "The results indicate that mixing of mid-latitude air into the winter vortex is not a significant contributor to the observed ozone changes in the 1999/2000 season".

References

Huck, P. E., Tilmes, S., Bodeker, G. E., Randel, W. J., McDonald, A. J., and Nakajima, H.: An improved measure of ozone depletion in the Antarctic stratosphere, J. Geophys. Res., 112, D1110, doi:10.1029/2006JD007860, 2007.

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Khosrawi, F., Müller, R., Proffitt, M., and Nakajima, H.: Monthly averaged ozone and nitrous oxide from the Improved Limb Atmospheric Spectrometer (ILAS) in the Northern and Southern Hemisphere polar regions, J. Geophys. Res., 109, D10301, doi:10.1029/2003JD004365, 2004.
Khosrawi, F., Müller, R., Proffitt, M. H., and Nakajima, H.: Monthly averages of nitrous oxide and ozone for the Northern and Southern Hemisphere high latitudes: A "1-year climatology" derived from ILAS/ILAS-II observations, J. Geophys. Res., 111, D11S11, doi:10.1029/2005JD006384, 2006.
Khosrawi, F., Müller, R., Proffitt, M. H., , Urban, J., Murtagh, D., Ruhnke, R., Grooß, J.-U., and Nakajima, H.: Seasonal cycle of averages of nitrous oxide and ozone in the Northern and Southern Hemisphere polar, midlatitude, and tropical regions derived from ILAS/ILAS-II and Odin/SMR observations, J. Geophys. Res., 113, D18305, doi:10.1029/2007JD009556, 2008.
Lemmen, C., Müller, R., Konopka, P., and Dameris, M.: Critique of the tracer-tracer correlation technique and its potential to analyse polar ozone loss in chemistry-climate models, J. Geophys. Res., 111(D18), D18307, doi:10.1029/2006JD007298, 2006.
Michelsen, H. A., Manney, G. L., Gunson, M. R., and Zander, R.: Correlations of stratospheric abundances of NO_y, O_3, N_2O, and CH_4 derived from ATMOS measurements, J. Geophys. Res., 103, 28 347–28 359, 1998.
Müller, R., Tilmes, S., Konopka, P., Grooß, J.-U., and Jost, H.-J.: Impact of mixing and chemical change on ozone-tracer relations in the polar vortex, Atmos. Chem. Phys., 5, 3139–3151, 2005.
Müller, R., Tilmes, S., Grooß, J.-U., Engel, A., Oelhaf, H., Wetzel, G., Huret, N., Pirre, M., Catoire, V., Toon, G., and Nakajima, H.: Impact of mesospheric intrusions on ozone–tracer relations in the stratospheric polar vortex, J. Geophys. Res., 112, D23307, doi:10.1029/2006JD008315, 2007.
Plumb, R. A.: Tracer interrelationships in the stratosphere, Rev. Geophys., 45, RG4005, doi:10.1029/2005RG000179, 2007.
Plumb, R. A., Waugh, D. W., and Chipperfield, M. P.: The effect of mixing on tracer relationships in the polar vortices, J. Geophys. Res., 105, 10 047–10 062, 2000.
Proffitt, M. H., Aikin, K., Tuck, A. F., Margitan, J. J., Webster, C. R., Toon, G. C., and Elkins, J. W.: Seasonally averaged ozone and nitrous oxide in the northern hemisphere lower stratosphere, J. Geophys. Res., 108, 4110, doi:10.1029/2002JD002657, 2003.
Sankey, D. and Shepherd, T. G.: Correlations of long-lived chemical species in a middle atmosphere general circulation model, J. Geophys. Res., 108(D16), 4494, doi:10.1029/

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2002JD002799, 2003.

Tilmes, S., Müller, R., Grooß, J.-U., and Russell, J. M.: Ozone loss and chlorine activation in the Arctic winters 1991–2003 derived with the tracer-tracer correlations, Atmos. Chem. Phys., 4(8), 2181–2213, 2004.

Tilmes, S., Müller, R., Grooß, J.-U., Nakajima, H., and Sasano, Y.: Development of tracer relations and chemical ozone loss during the setup phase of the polar vortex, J. Geophys. Res., 111, D24S90, doi:10.1029/2005JD006726, 2006a.

Tilmes, S., Müller, R., Grooß, J.-U., Spang, R., Sugita, T., Nakajima, H., and Sasano, Y.: Chemical ozone loss and related processes in the Antarctic winter 2003 based on Improved Limb Atmospheric Spectrometer (ILAS)–II observations, J. Geophys. Res., 111, D11S12, doi:10.1029/2005JD06260, 2006b.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 1977, 2009.