Atmos. Chem. Phys. Discuss., 9, S1044–S1046, 2009
www.atmos-chem-phys-discuss.net/9/S1044/2009/

Atmospheric Chemistry and Physics Discussions

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9, S1044–S1046, 2009

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.

A. Plumb

rap@rossby.mit.edu

Received and published: 25 March 2009

While the comments regarding the appropriateness of using tracer-tracer (TT) relationships is somewhat peripheral to the paper under discussion, some remarks that have been made cannot be allowed to pass unchallenged. Moreover, statements made in section 4 of the paper ignore almost everything that has been learned about stratospheric transport over the past couple of decades.

First, regarding the method itself, while it is true that the approach taken by Khosrawi et al. differs in detail from some earlier TT methods, is remains essentially the same in its basic assumptions. What is wrong with the approach is succinctly summarized

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by the sentence (p1986, lines11-12): "This method helps to separate O_3 variability due to latitudinal transport from photochemical changes." No, it does not: it eliminates the effects of reversible transport, but not of mixing, and mixing is crucial to the whole existence of the TT relationship.

Just on an historical note, the Plumb and Ko (1992) paper was, contrary to Rolf Mueller's comment, entirely motivated by the appearance of TT methods as an attempt to quantify ozone depletion. The issue raised there was the non-compactness of the O_3 - N_2O relationship because of the short lifetime of ozone in the middle stratosphere. Subsequently, we have come to appreciate the importance of mixing barriers (at the vortex edge and in the subtropics) and the role of mixing itself in the compactness, and the shape, of the TT relationships. (I have discussed the basis of TT relationships at length in Plumb (2007)).

Mixing alone tends to straighten TT curves. In the tropics and middle latitudes, replenishment by chemical sources or sinks maintains curvature in the relationships. Once the vortex forms in winter, air within the vortex is mostly cut off from this replenishment, and the relationships evolve away from the midlatitude curves, always migrating to the concave side of the original relationship. Note that mixing across the edge of the vortex is not crucial here: mixing within the vortex has the same effect (and it can take some subtle analysis, such as Ray et al. (2002) to separate them). The effects of interior mixing are large because vortex descent produces strong vertical gradients of tracers in the lower stratosphere, upon which diabatic dispersion (horizontal mixing plus differential descent) acts. Given vortex descent rates, the lower stratosphere would be flushed clean of tropospheric source gases during the course of the winter if it were not for such mixing.

A few years ago, I reviewed a paper that included the claim, made on the basis of the TT relationships, that CH_4 must be chemically destroyed within the vortex. And there is the rub: if one wants to associate changes in the O_3 - N_2O relationship with chemical loss, one also has to do the same for CFC-11, NOy, CH_4, and all the other tracers that show

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evolving TT relationships within the vortex through the winter. Of course, they do so because of mixing: one cannot accept this on the one hand and, on the other, ascribe the evolution of the O3 - N2O relationship to chemical loss unless one first eliminates the effects of mixing (and I for one do not know how to do that). Because mixing straightens the curves, ignoring it will tend to overestimate the chemical loss. (I don't follow the arguments that it will be an underestimate.) Comparison with other methods does not carry much weight: these objections are not restricted to TT methods, but apply to any method that does not properly account for the influence of mixing on the ozone budget.

Plumb, R. A., and M. K. W. Ko, 1992: Interrelationships between mixing ratios of long-lived stratospheric constituents. J. Geophys. Res., 97, 10145-10156.

Plumb, R. A., 2007: Tracer interrelationships in the stratosphere. Rev. Geophys., 45, RG4005, doi:10.1029/2005RG000179.

Ray, E. A., et al., 2002: Descent and mixing in the 1999-2000 northern polar vortex inferred from in situ tracer measurements. J.Geophys. Res., 107, 8285, doi:10.1029/2001JD000961.

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