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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Steady-state aerosol distributions in the extra-tropical, lower stratosphere and the processes that maintain them" *by* J. C. Wilson et al.

Anonymous Referee #1

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This manuscript presents a broad set of in situ aerosol size distributions from aircraft measurements in the lower stratosphere. The measurements are ordered by N2O, a surrogate for the age of the air. Thus aerosol evolution can be presented. A simple model of the time dependence of aerosol abundance (AA) in layers stratified by N2O in the lower stratosphere, in volcanically quiescent conditions, is developed and compared with observations during 1999-2000. The model assumes the only aerosol source is the photolysis of OCS, with subsequent oxidation and condensation of the sulphur released, and the only sink is gravitational sedimentation of aerosol through the N2O layer. The completeness of the model is evaluated by comparing the measured source and sink terms with the measured derivative of aerosol abundance to calculate the residual, or unexplained portion of the processes controlling aerosol abundance.

I recommend publication after the following questions/comments/suggestions have been considered.

For air older than 3 years, XN2O $<$ 250 ppbv, the sink (source) are in the range of -4 to -8 (2 to 5) ppbv/s compared to the measured change of abundance of -2 to -3 ppbv/s, leaving a residual fluctuating around zero in the range of -2 to 1 ppbv/s. The immediate conclusion is that the model does quite a reasonable job of capturing the measurements using only OCS as a source and gravity as a sink; however, even though the residual is usually quite a bit less than 50% of the source and sink terms, the residual ranges from 0 to 90% of dAA/dt. Thus at certain N2O levels is not a significant fraction of dAA/dt left unexplained? This uncertainty may be clearer if error bars were added to Fig. 7, or the estimates presented as a percentage?

The observations presented here are made by aircraft, thus limited to altitudes below 21 km. The depth of penetration into the stratosphere thus depends on latitude. Only in the polar winter are stratospheric depths equivalent to XN2O $<$ 100 ppbv achieved. Thus the model is tested against observations in the descending winter leg of the Brewer Dobson circulation. All observations of air older than 3 (4) years were made pole ward of 43 (60)ž N. This fact could be mentioned a little more explicitly in the abstract and conclusions and must be kept in mind for comparisons with broader ranging models.

Abstract and last paragraph, page 3675, is steady state the correct phrase? Would that not imply that dAA/dt = 0, rather than R=0? The implication of R=0 is that the model source and sink explain the time dependence of AA, but does not imply that AA is constant. In fact AA should not be constant since the observations/model are focused on the aerosol exit leg of the Brewer-Dobson circulation.

Figure 3. Although it is not really stated, I assume that the point of Fig. 3 is to show the altitude dependence of N2O. If that is the purpose then potential temperature should

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be used for the ordinate instead of geopotential height. The comparison figure (Fig. 1) uses potential temperature.

Figure 4. The authors could show how well the bimodal/unimodal lognormal fits, indicated in Table 2, capture the data by replacing the lines connecting the median bin values with lines showing the fitted distributions, to be compared with the median values. The basis for the statement, 3673.19-20, would be easier to see if a common ordinate scale were used in Fig. 4.

Figure 5. It would be nice to show the measurements which form the primary test bed for the model. This requires the data to be further subdivided into measurements 1999-2000 and 2001-2004. Note from Fig. 4 that there are no measurements at XN2O $<$ 250 ppbv after 2000.

Figures 4-7. These all show the dependence of some quantity on XN2O, but XN2O is only a surrogate for the age of the air in the stratosphere which then provides the evolution of the quantity of interest. To make this clear, either the XN2O axes should be replaced with age of air, or a second abscissa should be added for age of air to figures 5-7. In Fig. 4 the age of air should be added to the legend in all panels.

3669.23-25: What is the basis for this statement? It should have a reference or some supporting documentation?

3672.14: The altitude of large values of XN2O depends on the latitude and season. Only in polar winter does the aircraft reach XN2O $<$ 100 ppbv.

3672.23: What is the basis for the statement beginning, This is …? It is not obvious from Fig. 4.

3672.27-28: Perhaps the other processes leading to the decrease in aerosol abundance could be mentioned.

3677.20-22: I do not see the reason for this statement. There has been no mention of aerosol surface area up to this point, and there are other issues which are also not addressed. Why single out one to say it will not be addressed?

Style/clarity suggestions:

3668.22-23: gases to molecules that condense —, condensation of vapors alters —

3668.27: — of particle more than —

3670.18: integrated over

3671.13: mass of particles

3672.13: Confusing. How about, Larger particle are more —

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 3665, 2008.