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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.

**J. C. Wilson et al.**

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Response to Reviewers: We appreciate the reviewers' careful reading of the manuscript and their comments. We respond to each comment in order.

Anonymous Reviewer 1: The first comment deals with the relative size of the residual and the rate of change of the aerosol abundance plotted in Figure 7. The reviewer is concerned that for some values of $X_{N2O}$ (for $X_{N2O}$<225 ppbv), the residual is not small compared with the rate of change of the abundance and therefore, a significant amount of this parameter remains unexplained. Since we make our interpretation of this data over the $X_{N2O}$ range from 75 to 225 ppb, it seems appropriate to aggregate the data rather than to disaggregate it. The average value of the residual over this



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range is -0.22e-9 ppbv/s. The average value of rate of change of the abundance is -2.1e-9 ppbv/s or 9.5 times larger. Thus, on average, our simple model does a pretty good job of explaining the rate of change of aerosol abundance. Given the limitations of the model, greater statistical sophistication is probably unwarranted. We feel that the visual impression given in Figure 7 is a reasonable representation of this fact. We prefer not to add error bars or convert to the axes to percentages. The text remains unmodified in response to this comment.

The second comment discusses limitations of the data set. We will modify the second sentence of the abstract to read: "After September 1999, the oxidation of OCS and sedimentation of particles in the extra-tropical overworld north of 45 N are found to maintain the aerosol in a steady state." Figure 1 leaves the reader with the clear impression that measurements made in the overworld are dominated by measurements made at high latitudes. Figure 3 and Table 2 show clearly that the lower values of $X_{N2O}$ are only reachable by the aircraft in winter. We feel that the limitations of the data set are clear. The comparisons made with the SPARC models are within the range of the measurements. With the tables and graphs showing geographical distribution, we do not think that reemphasis is necessary.

The reviewer proposes that a steady state is defined as dAA/dt=0. We define steady state in the second sentence of section 3.2.2 (lines 3, 4). "In a steady-state, the aerosol properties are similar in air parcels having the same age-of-air and $X_{N2O}$." As the reviewer points out, as the air ages, AA changes. We point out that as the air ages, it also moves. If this circulation was unchanging with season and from year to year, we would find the same value of age-of-air and AA at the same locations in space as air flows through the stratosphere. This condition is probably closer to the most common interpretation of steady state. However, the circulation will never meet that condition. So we define a steady state with respect to $X_{N2O}$. When you find the same values of $X_{N2O}$, you will find the same aerosol properties. We do not propose changes in the text in response to this comment.



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The reviewer comments on the vertical axis in Figure 3. We prefer the altitude to potential temperature for this axis because it shows clearly the seasonal limitations in the values of $X_{N2O}$ that can be reached with the aircraft. The reviewer addresses the limitations of the data set in various comments and Figure 3 makes those limitations evident to the reader. We propose no changes in response to this comment.

The reviewer suggests replacing the lines in Figure 4 with plots of the lognormal fits and proposes that the vertical axes be adjusted to so that all have the same maximum value. We believe that Figure 4 contains much information in a small space. It represents a trade-off between density of information and clarity. We plot the median values and the error bars because they reflect a critical experimental finding (that aerosol properties depend on $X_{N2O}$) and we sacrifice uniformity in the y axis scale to spreading the cures maximally in the vertical direction permitting the differences to be clearly seen. We believe those to be the right choices given the role played by figure 4. Therefore we do not propose any changes in response to this comment.

The reviewer suggests further dividing the measurements into 1999-2000 and 2001-2004. We point out that in Fig 4 and Table 2, the data are divided into the smallest, reasonable time groupings (June 1996- Sep 1997, Sep 1999- March 2000, Dec 2002-Feb 2003, Jan 2004). These groupings are used to demonstrate the existence of the steady state. In Fig 1 and Fig 5, all the steady state data are plotted and distinguished from the volcanic data. We believe that this is the appropriate choice for the purposes of the narrative and do not propose any changes in response to this comment.

The reviewer proposes changing the x axis on figures 4 through 7 from $X_{N2O}$ to Age-of-air. We prefer to display these measurements in terms of the measured quantities (aerosol properties and $X_{N2O}$). The reader can translate into age-of-air as needed. We propose no changes in response to this comment.

3669.23-25: The reviewer asks for the basis of the statement (3699.23-25). In lines 9, 10 of this page, we state that that our description of the circulation follows Tuck et



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al and Holton et al. Those references cover the comments specifically addressing the circulation including the one mentioned by the reviewer in this comment. We propose no changes in response to this comment.

3672.14: The reviewer's comment beginning 3672.14 does not call for any change. We propose no changes in response to this comment.

3672.23: The reviewer asks for the basis of the statement in 3672.23. We appreciate the correction. The sentence will be revised to read "Measured number distributions of these smaller particles show that this is certainly the case for $X_{N2O}$>250 ppbv."

3672.27-28: The reviewer asks for a list of other processes leading to the decrease in aerosol abundance as $X_{N2O}$ decreases for the time period (3672.27-28). In the sentence above, the non-uniformity of the volcanic injection and subsequent mixing are mentioned in terms of the variability of AA with $X_{N2O}$. These factors may have contributed to the decrease of AA with $X_{N2O}$ as well. We conclude that this is a bit speculative and does not add to the discussion. Thus we propose no changes in the text in response to this comment.

3677.20-22: The reviewer questions the mention of aerosol surface area. Aerosol surface area concentration comparisons (satellite vs model) receive considerable attention in the SPARC report. We briefly, and we believe appropriately, provide the reader with information concerning this comparison. We propose no changes in the text in response to this comment.

Style suggestions: We appreciate the reviewer's careful reading and suggestions. In each case, we have reviewed the suggested change and chose to maintain the original text.

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