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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Satellite observations and modelling of transport in the upper troposphere through the lower mesosphere during the 2006 major stratospheric sudden arming" *by* G. L. Manney et al.

Anonymous Referee #1

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General Comments:

This paper compares satellite derived trace gas measurements with output trace gas fields from a global chemistry-transport model (CTM) during the major stratospheric sudden warming (SSW) of January 2006. The dramatic changes in CO, H2O, N2O, HNO3, CH4, and O3 that occur during the SSW are shown from the upper troposphere through the lower mesosphere. This work especially highlights the descent of CO into the stratosphere during the SSW and the low O3 in the upper troposphere/lower stratosphere just prior to the SSW. It also shows that a remnant of the vortex persisted

throughout the winter in the lower stratosphere. Diagnostic fields shown include potential vorticity (PV) fields, effective diffusivity, and diabatic heating rates. Comparisons of observations with the CTM results suggest problems with current analysis temperatures near the stratopause.

This paper is well written with a comprehensive introduction and a detailed section on the data and methods used. The content is appropriate for ACPD. The abstract is concise and complete. The organization is good. It is sometimes difficult to match text descriptions of figure details with the actual figures. These occasions are noted below in the Specific Comments section and should be addressed by the authors.

Overall this is an excellent paper.

Specific Comments:

1. Lines 291-293: "The MLS species' gradients are closely correlated with the overlaid sPV fields, indicating a consistent representation of the vortex in both the MLS data and the GEOS-5 sPV." The overlaid white sPV contour in Fig. 1 are difficult to see in some regions, making the stated visual correlation between the sPV and tracer fields problematic for the reader. Is a correlation coefficient useful in this context?

2. Lines 309-311: "Decreasing H2O in the vortex and increasing values spreading through mid-latitudes indicate the strong mixing during the SSW." This is a good point - the vortex air is mixing out. However, another important feature in Fig. 1 is the dry air (gray color) associated with low PV that does not seem to be mixing much during the SSW. Some mention of this could be added to the text.

3. Lines 331-225 discuss the westward tilt with altitude between two levels on 22 Jan and 5 Feb based on examining pink (upper level, high H2O values) and blue regions (lower level, low N2O values) in Fig. 1. The reader may have difficulty seeing the vertical tilt. On Jan 22 the pink and blue regions have different patterns. In some regions (near 0o longitude) there seems to be a shift to the west with altitude, but not in

other regions, such as the blue portion of the vortex near 135o E. On 5 Feb the small blue region and the small pink region are separated by about 90o of longitude. Though possibly the two features are connected, it's not obvious that the figure is showing a westward tilting, upward propagating planetary wave. The largest vertical structure change is Fig. 1 seems to be between 10 Jan, where there is little vertical tilt, and the later more complex times, where the upper and lower fields differ considerable.

4. Lines 372-371: "?;SLIMCAT does, however, show a sudden increase in values at mid-EqLs at the end of January?" This is difficult to see in Fig. 2. There appears to be one contour line at that time in the SLIMCAT CO field. Maybe the color scale could be adjusted, or a white contour added.

5. Lines 376-381: "The decrease seen in O3 in the vortex core during January has been shown to be inconsistent with transport (note that N2O decreases at this time and place, indicating diabatic descent that would increase O3) and consistent with chemical loss?" This statement is in reference to Fig. 3, eqLs vs time plots at 520 K. There seems to be a slight (green to blue) change in O3, but there is no visible change in N2O in Fig. 3 during January in the vortex. Is a reference missing here? Would a re-plotting of Fig.3 as a line plot for the region of interest show the stated changes better? If not the paragraph needs to be re-written.

6. Lines 495-496: Some readers may find the use of the word "pole" confusing when referring to equivalent latitude based plots, as the "pole" seen in the plot is not likely to be close to the geographic pole during a warming, and quantities such as trace gases and mixing can be very different at the two points. Substituting a different term for pole is recommended (EqL pole, 90o EqL, etc.). This use of "pole" occurs at other points in the manuscript as well. In addition, while 40oN and EqL 40oN should be similar, it is probably best to be specific when discussing EqL plots.

7. Lines 503-505: "In early January, CO values begin to dramatically decrease, most rapidly at levels above ∼1700 K, with high values lingering until late January in the mid-

dle stratosphere". This sentence is in the paragraph discussing Fig.∼7, which shows CO fields at 1700K. Is the CO behavior above ∼1700 K and middle stratosphere levels mention here shown elsewhere? Should Fig.∼2 (850 K) be referenced here?

8. Lines 522-523: " Figure 7 shows slightly higher SLIMCAT than MLS CO near the pole in late January." It is very difficult to see the difference in Fig. 7. If anything, the MLS CO seems slightly higher than SLIMCAT CO near the EqL pole in late January. A line plot directly comparing the two values as a function of time may help here, or the small differences should be downplayed.

Technical Corrections:

1. Line 622: "The most ridge intense?" should be "The most intense ridge?"

2. Line 652: "The veracity of the details of this fine-scale structure are difficult to verify?" reads clearer as "The details of this fine-scale structure are difficult to verify?"

3. Line 653-654: "?however, previous studies have verified similar structure in RT calculations during periods with aircraft measurements." This statement needs a reference.

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