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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.

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We thank the reviewer for his/her helpful 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?

The overlaid contours have been changed from white to black at the request of the other reviewer and are, we believe, easier to see. A correlation coefficient is not really that useful here: we examined scatterplots of PV versus these tracers and found very compact, but nonlinear, relationships. We have added a note to this effect to the text.

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.

We have modified the text to emphasize this point: "As seen in our Figure 1, this anticyclonic circulation transports very low H2O values towards higher latitudes where they are closely confined with little mixing as long as the anticyclone remains strong. "

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.

We have rewritten this discussion to clarify the features in the figure that it is based on, and to emphasize the change from an equivalent barotropic structure on 10 January to a baroclinic structure as the SSW develops: "The MLS trace gas signatures of vortex

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air (high H2O, low N2O) show a strong westward tilt with height developing during the SSW: Whereas the vortex at both levels shown in Figure 1 is centered near 20°E on 10 January, by 22 January it is near 45°E (0°E) at 520 K (850 K), and by 5 February the main vortex remnant is near 60°E (315°E) at 520 K (850 K). Examination of the 3D structure (not shown) confirms this to be a westward tilt of a contiguous vortex."

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.

We have re-worded (weakened) this statement to read "SLIMCAT does, however, show an increase in values at mid-EqLs at the end of January, with timing similar to that observed.", which is more consistent with what is shown in the figure.

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.

The Braathen et al (2006) reference was meant to support this. We have reworded the sentence to clarify that that citation addresses both parts of it.

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

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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.

Here, and elsewhere in the text, we have added EqL after all specific values of EqL that are given, and we have replaced phrases such as “near the pole" with, e.g., “high EqL". Where both EqL and geographic latitude are being discussed, we have been careful to be explicit as to which is being referred to.

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 middle 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.

Here, we were discussing Figure 7, but also referring back to Figure 5 (the vortex averages), in particular, for the quoted sentence – we have added “Figure 5 shows..." to clarify this, and also referred back to Figure 2 as suggested when talking about the middle stratosphere. We have restated the feature we were trying to point out in Figure 7, which is more a matter of high CO ($>$500 ppbv) lingering a few days longer in SLIMCAT than in MLS.

Technical Corrections:

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

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This was corrected in the ACPD version at proof stage.

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?"

We now use this suggested wording.

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

We have added a reference: "...(e.g., Hegglin et al., 2004)."

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