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Comment

***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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Overall, this paper is interesting and presents new results on transport in the atmosphere during an SSW. The language is generally clear, although there are a few places where it is not, and I have indicated these. However, I find that there is an overwhelming amount of information, so much so, that at times it is hard to see the “forest for the trees” so to speak. In some cases there is just a lot of information (and in some of these cases it seems that more information is given than is necessary), and in other cases it seems that information is repeated (not as succinct as it could be). For

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instance, the fact that the SSW was triggered by a tropospheric ridge is repeated many times. I have tried to point out some of these places throughout the paper. I have also pointed out a few places where the wording seems awkward and suggested alternative wording.

We thank this reviewer very much for his/her careful reading and very helpful comments aimed at improving the clarity of the paper. As detailed below, we have tried to address each of these suggestions.

On a technical note, it seems that UK and US spellings are used interchangeably. Also, there are many sentences that use semi-colons or colons to continue the train of thought. In some cases, these are appropriate, but in others, this seems to be an over use of the semi-colon, and does not help in the reading of the paper.

We have changed some UK spellings in the model description section (written by our UK coauthors) to US. The only other instances we have found of what might be considered UK spellings are the use of “modelling” and “grey” rather than “modeling” and “gray”; both are cases where either is a correct US spelling but the latter is more commonly used. Our usage is simply a matter of personal preference and we will be glad to change it if it is contrary to ACP style guidelines.

In addition to editing the specific instances noted below by the reviewer, we have gone through the entire paper examining compound sentences, and simplified or broken up several of these.

Specific comments:

1. P 9697, L15 and L22: The use of “Even more critically” twice in the same paragraph reduces its impact. At least the second use of this should be removed, since it is made clear that the use of new satellite data available has actually been critical in this paper, whereas the coupling, while an important point, has not been.

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We have replaced the second instance of “Even more critically” with simply “Also”.

2. P 9697, L24: The reference to both Shepherd 2007 and 2008 seems inappropriate. These are review papers that do pull together important points, but were not specific in showing the coupling of the whole atmosphere. There are a great many papers that study this more specifically. This should be changed to reference a study that deals specifically with coupling of different atmospheric regions, such as one of the Baldwin-Thompson studies (Baldwin and Dunkerton, 2005, JSATP or Thompson et al., 2005, JAS), a Kushner et al study, or even the Shepherd 2002 paper already referenced in this paper, which is specifically on this topic. For stratosphere-mesosphere coupling, there is also Karlsson et al (2007), or Pancheva et al (2008, JGR).

We have added a reference to a more general Thompson et al paper (2006, JAS) and the Pancheva reference suggested here. The reference to Shepherd et al (2008) has been deleted, but we have retained the Shepherd et al (2007) citation because of its discussion of *transport* in relation to middle/lower atmosphere coupling.

3. P 9698, L 21: change “The conditions for a major warming (...) were fulfilled on 21 January, with a preceding strong major warming....” to “The conditions for a major warming (...) were fulfilled on 21 January, and were preceded by a strong minor warming which started around January 8.

We have rewritten this sentence as:

“The event fulfilled major warming conditions (zonal mean zonal wind and temperature gradient reversal north of 60°N at 10 hPa) on 21 January, and was preceded by a strong minor warming that started around 8 January.”

4. P 9699, L 5: it is not clear here whether the transport is anomalous due to the existence of an SSW, or if the transport is anomalous even compared to years with SSWs.

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We have added “associated with the SSW.” at the end of this sentence.

5. P 9699, L11: comma after “Chipperfield, 2006)” L12: move “in the UTLS” to the end of the sentence.

We have reworded this sentence: “Observed transport is compared with simulations using the SLIMCAT Chemistry Transport Model (CTM) (Chipperfield, 2006); in the UTLS, additional comparisons are made with high-resolution Lagrangian calculations.”

6. P 9700, L 12: change “before that date” to “before February”

Done.

7. P 9703, L 2 to 17: Is all this discussion really necessary?

We have condensed this paragraph as follows:

“The SLIMCAT model run used in this paper was initialized at 00:00 UTC on 15 November 2005 using fields from a run started at Aura launch, but replacing O₃, H₂O, HCl, HNO₃ and CO in the long-term run with values derived from MLS v2.2 data at the new initialization time. O₃, H₂O, HCl, HNO₃ and N₂O were replaced by v2.2 MLS data gridded as described above for the maps and interpolated to the model grid. Because of vertical oscillations in MLS CO data (albeit much less severe in v2.2 than in v1.5, Pumphrey, et al., 2007), these data were smoothed in the vertical and then zonally averaged equatorward of 45° and in EqL poleward of 45° for the initialization. More details of the model configuration are given by Santee et al. (2008).”

8. P 9705, L 4: change “10 hPa” to “850K”

Done.

9. P 9705, L 9: delete “on”

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Done.

10. P 9705, L10: change "consisting of normally tropical values of PV" to "consisting of PV values normally associated with the tropics"

Done.

11. P 9705, L 13: change "off the pole, with the..." to "off the pole. Consequently, the anticyclone containing very low H₂O values (indicative of air drawn up from low latitudes) moved near the pole, and by 27 January, was centered above it (not shown).

We have reworded this sentence: "By 22 January, when zonal mean winds had reversed, the vortex had shrunk into a crescent shape and shifted off the pole. Consequently, the anticyclone (containing very low H₂O values indicative of air drawn up from low latitudes) moved near the pole and by 27 January was centered over it (not shown)."

12. P 9706: L 29: change "with low N₂O and CH₄ spreading" to "with areas of low N₂O and H₄ spreading"

Done.

13. P 9707, L 2: change "High CO" to "High CO values"

Done.

14. P 9707, L 20: change "At 520K in the lower stratosphere...and O₃." to "We show MLS N₂O and O₃ in the lower stratosphere (520K) in Figure 3." or similar.

Done.

15. P 9708, discussion on Figure 4. - Figure 4 does not seem illuminate the picture of transport before, during or after the SSW. Vertical descent and transport barriers

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are seen in the previous figures, and the vortex evolution is also demonstrated in the previous figures. Given the amount of information already in the paper, I would suggest that it be removed in the interest of lightening the load of information.

We agree, and have deleted Figure 4 and the accompanying discussion.

16. P 9709, L 1-4: This paragraph seems out of place. It seemingly has nothing to do with transport linked to the SSW.

This has been deleted with the rest of the Figure 4 discussion.

17. P 9711, L 19: "in the upper stratosphere and into the mesosphere" - sounds as if the transport is ascent. Change to "in the mesosphere and upper stratosphere."

We have changed this to "in the lower mesosphere and upper stratosphere."

18. P 9712, L 29: change "weaker/later" to "weaker and later".

Done.

19, P 9713, L 21: Rename section to "USLM descent" or "USLM descent calculations". It is more about these than it is a discussion since it introduces the heating rate calculations.

Done.

20. P 9714, L 17: change "at this time" to " at the same time"

Done.

21. P9716, L 5-7: delete "This strong ridge was... trigger the 2006 SSW."

Done.

22. P 9716, L 22: delete "further"

Done.

23. P 9717, L 1: delete "apparent in, or"

Done.

24. P 9717, L 2: delete comma after "resolution of"

Done.

25. P9717, L 3: change "in absence" to "in the absence"

Done.

26. P9717, L 6: change "of fine" to "of the fine"

Done.

27. P9717, L 7-8: change "... January paralleling the southern edge of the high NHO3 region: examination..." to "January (paralleling the southern edge of the region of high NHO3). Examination..."

Done.

28. P9717, L 10-11: change "the quality of and resolution realized in .." to "the quality and resolution of ..."

Done.

29. P9717, L 25: No need to remind the reader of the resolution of SLIMCAT. Simply state that the modelled is sampled in the same way that the MLS samples the atmosphere.

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Done.

30. P 9722, L 17: change "High vortex CO.." to "High CO values in the vortex, existing before the warming from the mesosphere to the middle stratosphere, were mixed with..."

Done.

31. P 9722, L 23: add comma after "...lower stratosphere"

Done.

32. P 9722, L 25: delete "small" Done.

33. P 9722, L 29: change "in meteor.." to "in the meteorological"

Done.

34. P 9723, L 4: delete ", driven by ECMWF winds,"

Done.

35. P 9723, L 6: delete "slightly"

Done.

36. P 9623, L 7; delete "quite"

Done.

37. P 9623, L 21: delete ", especially," - since the winds and temperatures in the driving models are closely related, there is no justification for stating that the temperatures are more responsible for the wrong descent in the CTMs. Vertical winds and diabatic calculations are a different story; small errors can lead to very different results since

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the winds themselves are small.

Done.

Figures:

In general, many of the figures and labelling is far too small to make out the level of detail necessary to see some of the features that are pointed out in the text. I would also suggest that the abbreviation SLM not be used for the SLIMCAT calculations; it is too close to MLS.

We believe that most, if not all, of the difficulty with figure size is because of the way they were printed in the ACPD format, especially in the "printer-friendly" version, where most of the figures were *much* smaller than their intended size. We intend (old numbering) Figures 1, 6, 8, 10, 11, 12 and 13 (now Figures 1, 5, 7, 9, 10, 11 and 12) to be published in ACP at the full width (spanning two columns) of the page. Figures 2, 3, 5 (now 2, 3, 4) should also span two columns, and be at least about 3/4 of the width of the page. Figures 7 and 9 (now 6 and 8) will be single-column figures. We will work with the production staff to ensure that these sizing recommendations are followed. Instead of using SLM, we have spelled out SLIMCAT.

Figure 1: White lines are very hard to make out. Black lines would be easier to see.

We have replaced white overlays with black.

Figure 2: "EqL-Time" should be changed to "EqL/time" to be consistent with text and other figure captions.

Done.

Figure 4: While this is a nice plot, it is unclear that it adds anything new to the picture of transport. Vertical descent is discussed in detail based on the previous figures (see

above).

Deleted.

Figure 6: too small.

See above.

Figure 10: much too small - This figure is so small I gave up trying to see anything in it. I would suggest in this case that less is more. One isentropic level is sufficient to show, especially since the "curtains" are shown in the next figure for the vertical picture.

As per above, Figure 10 (now 9) will be printed at full page width. We went through the text and carefully considered deletion of one level in this figure, but concluded that, because much of the discussion is contrasting the behavior at the two levels in a way that is not illustrated in the following figure (curtains), it was helpful to retain both levels.

Figure 11: labelling is too small and overlaid lines are difficult to see (esp. solid white line).

In addition to requesting that this figure be printed at full page width, we have increased the size of the labels and thickness of overlaid lines. We have also corrected the windspeed contour interval so what is plotted is consistent with the caption, resulting in fewer windspeed contours.

Figure 12: No mention of equivalent length calculation in the caption.

This has been added to the caption.

Figure 13: Very nice summary figure but: polar plots are too small, yellow is not a good choice for contour lines, and grey lines are too light to make out.

In addition to requesting that this be printed at full-page width, we have increased the

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size of the hemispheric maps, and substituted brown for yellow and green for the light grey.

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