

Interactive comment on “Assessing the ability to derive rates of polar middle-atmospheric descent using trace gas measurements from remote sensors” by Niall J. Ryan et al.

Anonymous Referee #4

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First review of Ryan et al. entitled “Assessing the ability to derive rates of polar middle-atmospheric descent using trace gas measurements from remote sensors” for publication in ACP. The authors use the SD-WACCM model to argue that processes other than vertical advection of CO are important in the calculation of polar winter descent rates in the upper stratosphere and mesosphere. The paper is well written and the results will be of interest to the scientific community. I recommend publication after the following revisions.

—General comments— I echo here a comment made by another reviewer that the authors need to first show consistency between the CO measurements and the evolution

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of CO in SD-WACCM. If the CO tendencies between the obs and the model do not agree then it's not appropriate to use the obs to calculate w-corrected.

Overall, both in the abstract (maybe even the title), throughout the paper, and in the conclusions, the authors need to emphasize that these results are based on SD-WACCM. Report quantitative error estimates to vertical motions derived from tracers instead of using provocative language like “found to be invalid”.

Figures 1, 3, and 4 are too small, bordering on illegible. In many cases all of the figure panels shown are neither introduced nor discussed. Please reduce the content of each of these figures to simply support the key point being made in the text.

Figures 3, 4, and 8: swap the color bar to be blue for negative values and red for positives. Whenever possible, hold fixed the color bar range so that comparisons between winters and between tendency terms can be made.

—Line-by-line comments— Abstract Line 16 - “the relative importance of vertical advection is lessened. . .” – by how much? Give %

1 Introduction Page 2, lines 25-35: “. . .defining the edges of the polar vortex is not straightforward.” – cite Harvey et al. (2009) and Harvey et al. (2015)

2.1 KIMRA, Page 3, line 29: does “average precision” mean daily average?

2.2. MLS, Page 4 line 7 - Does “highest pressure level” refer to the pressure level at the highest altitude? Line 8 - Does “averaged to produce daily profiles” in some spatial region?

2.3 SD-WACCM – Given the fallibility in MERRA winds (mentioned in the intro) in the upper stratosphere and their inability to properly model the elevated stratopause in February of 2009, what (if any) impact does this have on SD-WACCM and the conclusions?

2.4 CO VMR comparison, Page 5 Figure 1 is inadequate. Please compare the model

and measured CO in a comprehensive way that convincingly demonstrates that CO tendencies are in agreement.

Figure 2 – increase panel size and symbol size. Reword last line of the caption to be “Parcel positions on Jan 28th (start of the 2009 SSW) is indicated by black asterisks.”

3.3 Tendencies of CO during Arctic winter Page 6, line 28 – “. . .in depth analysis is not made as it is not the focus of the study.” – Then can the results be summarized in fewer than 36 panels? Page 6, line 31 – “. . .decrease in CO VMRs” add “in the upper mesosphere” – Does this mean air is ascending there? Page 7, first paragraph – Mention different color scales. Give relative magnitudes wrt w^* , i.e., chem is 10% of w^* . Can we interpret negatives = ascent/poleward and positives = descent/equatorward (or is it not that simple)? Page 7, first paragraph, line 7 – “. . .because of proximity to the edge of the polar vortex.” – No, both are well inside the vortex core. Page 7, line 14 – “There is also a brief change to a positive” – do you mean negative? Page 7, lines 19-20 – This is very useful. Please do this for all tendency terms.

4 Rates of vertical motion with KIMRA and MLS Page 7, lines 30-31 – “. . .the concentration is adjusted using the tendencies of the continuity equation. . .” add “from WACCM”. This section will gain credibility after showing that the model and observed tendencies are in agreement. Page 8, lines 17-20 – please reword. Are derived descent rates stronger because they need to counteract the opposing terms? Page 8, line 23 – “. . .around the time of SSW is decreased. . .” could use an arrow in the figure to highlight this location.

Figure 4 – can any of this information be shown using a scatter plot with w^* along one axis and w^* -corrected along another? The points could be colored by altitude. It is currently very difficult to look at the panels and understand the comparisons quantitatively. How often would you get points with opposite signs? Is it more likely to get different directions up high or down low?

Figure 5, 6, and Page 9 – refer to 60-90 as the “polar cap” – not the pole.

6 Discussion, Page 10 line 2 - "...not a valid one." Add "according to SD-WACCM" line 30 – Reword "...are representative for the complete mesospheric air..."

7 Conclusion, Page 11, line 17 – "...no months during polar winter when vertical mean advection dominates the budget of CO to such an extent that vertical mean velocity can be accurately derived." – This statement is too strong. Instead, give error estimates as a function of altitude and time over the winter.

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