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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A convolution of observational and model data to estimate age of air spectra in the northern hemispheric lower stratosphere" *by* Marius Hauck et al.

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This paper extends the work of a previous study by the same lead author on deriving age of air spectra in the stratosphere based on modeled and measured trace gases. The primary addition in this study is a refined treatment of the extratropical lowermost stratosphere by the inclusion of upward extratropical cross-tropopause entry into the stratosphere. This aspect of transport has been known for some time but this is the first study that has included non-tropical tropopause upward mass flux to obtain age spectra based on trace gas measurements in the NH lowermost stratosphere. This is important because most of the stratospheric in situ trace gas measurements we have

available now, and likely in the future, are in the lowermost stratosphere.

Overall this paper is a really nice piece of work. This study combined with the previous one by the same lead author has significantly advanced our ability to derive many aspects of the age of air and transport in the lower stratosphere from trace gas measurements. The use of the CLaMS model output to inform and validate the results derived from the trace gases is excellent and helps to understand the strengths and limitations of the inverse technique.

I recommend publication in ACP with consideration of the specific comments listed below. I have two main issues with the paper that should be easily resolved. One is the overall length of the text is too long and there are numerous grammatical errors such that I likely didn't find them all. The second issue is the discussion of the seasonal scaling that needs an additional figure and some more clarity in the text.

Specific comments:

Pg. 1, line 13: I have a preference to use 'output' when referring to models rather than 'data'. This clearly delineates the observational data from model output.

Pg. 1, line 29: add 'the' before 'extratropical', remove 'has' before 'peaked'

Pg. 1, line 30: 'The ratio of moments for all retrieved age spectra for PGS and WISE is found to range between 0.52 years and 2.81 years.'

Pg. 1, line 31: 'We conclude that. . .'

Pg. 2, line 2: '. . .stratosphere are determined by the global mean. . .'

Pg. 2, line 3: add 'the' before 'Brewer'

Pg. 2, line 6: 'recognized'

Pg. 2, line 13: change 'succumbs' to 'has' or 'shows'

Pg. 2, line 19: '. . .BDC will strengthen due to enhanced wave drag. . .'

Pg. 2, line 29: add ‘the’ before ‘strength’

Pg. 2, line 33: remove ‘linked’

Pg. 3, line 9: ‘The basis of many past studies has been measurements. . .’

Pg. 3, line 19: change ‘matching’ to ‘matched’

Pg. 3, line 22: ‘We extend the inverse method described therein to the. . .’

Pg. 4, line 20: change ‘an’ to ‘a’

Pg. 5, line 12: add ‘a’ after ‘as’

Pg. 5, line 14: add comma after ‘stratosphere’

Pg. 5, line 15: change ‘steers’ to ‘affects’

Pg. 6, line 1: ‘. . .referring to transport through the tropopause section i.’

Pg. 7, line 5: change ‘extent’ to ‘extend’, add comma after ‘choice’

Pg. 7, line 14: When you say ‘now with 0.1% tolerance’ does that mean in comparison to your previous study?

Pg. 7, line 28: In equation 13 why did you switch the symbol for the seasonal scaling from S in your previous paper to omega here? Just curious since I kind of liked S to stand for seasonal or scaling.

Section 2.2.2: I got unexpectedly hung up on this section even though I thought I knew what the scaling should look like. Your discussion of the seasonal scaling in the 2019 paper for tropical tropopause entry was very clear and I was expecting something similar here. After reading this a few times and staring at Figure 1 compared to your 2019 paper discussion I think I identified a couple of things that are missing here that would help. The main one is something equivalent to Figure 1a from your 2019 paper. You really need the visual of the mass flux seasonal cycle in each hemisphere to help make quick sense of the seasonal scalings. In this case the inverse Olsen flux would

likely be most appropriate. You might even want to include a latitude-height schematic of some kind. In the caption of Figure 1 you also need the sentence you had in the caption of Figure 1 from your 2019 paper, ‘Increasing transit time means backward in time.’

You mention a couple of times here that the maximum scaling is in late spring and the minimum in late fall. And yet, we know that the maximum upward mass flux in the extratropics is in the summer and fall. Later in the paper it does seem to work out that you get peaks in the spectra in summer and fall but I don’t follow how that works from this discussion. In your discussion of the tropical entry scaling it was clear that upward mass flux peaked in winter and there was a corresponding peak in the scaling curves. I’m left not confident that I understand this discussion and the scaling curves very well.

I would recommend rethinking this section from the point of view of a reader who hasn’t read your 2019 paper and the seasonal scaling is all new.

Pg. 9, line 9: add ‘a’ after ‘as’

Pg. 10, line 15: add ‘a’ after ‘as’

Pg. 10, line 19: change ‘perturbate’ to ‘perturb’, add ‘a’ after ‘As’

Pg. 10, line 31: change ‘strongest’ to ‘most’

Pg. 11, line 3: I’m not sure what ‘weakly regard the effective character’ means. I would reword it somehow.

Pg. 11, line 5: change to ‘approximations’

Pg. 11, line 7: ‘. . .tropopause consists of 10%...’

Pg. 11, line 12: change ‘get’ to ‘were’

Pg. 12, line 8: add ‘a’ after ‘as’

Pg. 13, line 13: add ‘the’ before ‘troposphere’

Pg. 13, line 20: ‘programmed’

Pg. 15, line 5: change ‘their’ to ‘each’ and ‘sections’ to ‘section’

Pg. 15, line 7: add ‘a’ after ‘as’

Pg. 15, line 8: ‘. . .setup is consistent overall, as the fractions at each location sum up. . .’

Pg. 15, line 13: add ‘450 K’ after ‘Below’

Pg. 15, line 14: remove ‘start to’

Pg. 15, line 16: Here and everywhere else I would recommend abbreviating southern and northern hemispheres to SH and NH. This will help shorten the text a bit.

Pg. 15, line 17: remove ‘also’

Pg. 15, line 18: remove ‘quite’

Pg. 15, line 27: add ‘tropospheric’ after ‘fresh’

Pg. 15, line 28: ‘. . .maximum downward forcing through the 380 K level is. . .’

Pg. 15, line 31: change ‘that’ to ‘which’

Pg. 16, line 19: change ‘referring to the’ to ‘for’

Pg. 16, line 20: change ‘section’ to ‘entry’

Pg. 16, line 27: remove ‘that also’

Pg. 17, line 2: Why not adjust the seasonal scaling to better match the pulse secondary peaks?

Pg. 17, line 14: add ‘an’ after ‘on’, remove ‘fairly’ and ‘as well’

Pg. 17, line 16: remove ‘largely’

Pg. 18, line 4: change ‘using always’ to ‘with’

Pg. 18, line 6: remove ‘in general’

Pg. 18, line 10: change ‘find’ to ‘found’

Pg. 18, line 11: ‘. . .bias both above and below a threshold of 1.5 years. . .’

Pg. 18, line 18: Did you mean red shading here? Add ‘the’ after ‘on’

Pg. 18, line 20: change ‘find’ to ‘found’

Pg. 18, line 22: ‘. . .the sign appears different.’

Pg. 18, line 24: add ‘tropospheric’ after ‘fresh’

Pg. 18, line 28: remove minus sign in front of 30S.

Pg. 18, line 31: add ‘a’ after ‘as’

Section 4.3.1: You should restate the tracers used in these observational age spectra inversions. It would also be very helpful to restate the seasons of each mission at the beginning of this section since that’s the most critical element in comparing them.

Pg. 19, line 11: add ‘entry’ after both ‘NH’ and ‘tropical tropopause’

Pg. 19, line 13: change ‘appears’ to ‘appear’, add comma after ‘general’

Pg. 19, line 16: add ‘regions’ after tropopause’

Pg. 19, line 19: ‘. . .scattered bins of mean age older than 3 years. . .’

Pg. 20, line 1: It would be interesting to see the tropical – NH ages, maybe in a third row of plots in Figure 6.

Pg. 20, line 9: add ‘the’ before ‘season’

Pg. 20, line 23: change ‘datapoints’ to ‘locations’ or something similar

Pg. 20, line 30: '. . .WISE rapidly decreases after. . .'

Pg. 21, line 10: add 'is' after 'This'

Pg. 21, line 33: add 'the' before 'right'

Pg. 22, line 12: change 'succumbs' to shows'

Pg. 22, line 13: add 'a' after 'as'

Pg. 22, line 30: change 'gained' to 'measured'

Section 5: The first nearly three pages of this section could be shortened considerably. The text of the paper is already quite long and the summary does not need to be so detailed. Just include the main points so it's easier for the reader to get the take home messages. In general, I would look for ways to shorten the text throughout the paper, it's a pretty long read.

Figures 6 and 7: Add somewhere prominently a label of the season of each mission since that's the most relevant comparison to be made between the plots.

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