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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Characteristics of lower stratospheric transport as inferred from the age of air spectrum" *by* F. Ploeger and T. Birner

Anonymous Referee #1

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General comments:

This paper is very well written, enlightening, and concerns an important and timely aspect of atmospheric transport. My primary criticism is that the discussion is too terse in places. I suggest the addition of strategically placed clarifying phrases will help the reader understand the logic of the arguments. In the specific comments, I have noted a few examples where I had a particularly difficult time following the logic. In addition, the discussion of the relationship between ENSO and inter-annual variations of the age spectrum (Figure 10 and the last paragraph of Sec. 5) is not convincing. It should either be improved with some quantitative measures of the information content of that relationship or removed.

Specific Comments:

Page 2, line 17: The discussion in this paragraph could greatly enhanced if you briefly explained (1) the motivation for representing transport as a diffusion process and that for representing the age spectrum by a Green's function, (2) the assumption implicit in those representations, and (3) why the assumptions needed for such a representation are not met.

P. 2, L. 34: Changing 'using multiple pulses' to 'using multiple tracer pulses' will help clarify what you are doing.

P. 6 L. 16-19: Perhaps I am confused here. Shouldn't the mean age calculated from the age spectrum be identical to the value calculated from a perfectly linear clock tracer? Why is there a (small) discrepancy between the two calculations? Is it because, for ages approaching 10 years, the clock tracer does not capture the full range of source concentrations (i.e., the clock does not start early enough)?

P. 6 L. 26-27: It took me a while to decipher the meaning of the phrase 'coinciding with the youngest peak from spring to fall and the second youngest peak in winter'. Perhaps it would help to be more explicit, for example, 'the modal age as determined by the apex of the largest peak coincides with the youngest peak during spring, summer and fall and with the second peak during winter.'

P. 7 L. 9-12: The description of the propagation of the peak and the argument that the peaks are due to the fact that the most efficient transport from the boundary layer to the stratosphere is too terse. Perhaps another sentence or two will clarify the argument. For example, I can understand why efficient transport during winter leads to a peak in the summertime age spectrum at 6 months. However, I don't understand why the subsequent wintertime peaks are also linked to transport efficiency during winter. It seems to me that once the air is in the stratosphere (i.e., after 6 months) then an additional boundary layer to stratosphere transport boost the following winter is irrelevant; unless an important fraction of the air released during a specified winter remains in the troposphere until the following winter – when the troposphere-to-stratosphere 'transport

window' re-opens.

P. 7 L. 24-25: Vertical velocity near the tropopause is also slower during summer than during winter (W. Randel and co-authors have written papers on this) and could be important.

P. 10 L. 8-20: The connection between ENSO and inter-annual variations of the age spectra is, perhaps, believable, but is not convincingly demonstrated in Fig. 10. This could be due to the fact that, while equatorial convection patterns shift substantially as sea surface temperature patterns shift, variations of the average strength of tropical convection have relatively weak connections to ENSO. It seems the authors are trying to see make too much of patterns that appear in Fig. 10 – a problem that can arise when analysis rely too heavily on a qualitative comparison and the ability of the human eye to recognize patterns in a chaotic system (whether or not the patterns are meaningful). At the very least, Fig. 10 should be changed to make it easier to discern how well the age spectra are related to ENSO. It would be better to make the analysis more quantitative. For example, how much to the inter-annual variance of the age spectra is explained by a lag-relationship with ENSO variability? It might be best to simply remove Fig. 10 and the last paragraph of Sect. 5. Fig. 11: Did you create this plot for the global release experiment? (as opposed to 15S-15N) Does it look the same for both experiments? If so, or even if not, that is an important comparison to make.

P. 11 L. 11-12: Does the distribution in Fig. 11b mean that the particle pulses do not always have the same mass? That the rate of particle release varies? If so, how is this justified physically? Regardless, please explain this figure a bit more.

Sec. 6.1, last 3 paragraphs: This discussion could use elaboration. Please be sure that, each time the effect of some phenomenon on peaks is mentioned, the explanation for how (or why) the effect is carried out is clear.

P. 12 L. 26-7: Regarding 'This flushing . . . has implications for the chemical composition . . .'. Can you give an example?

Technical details:

P. 2 L. 16: 'Many studies of stratospheric age . . .'

P. 3 L. 2: Change 'spectra from seasonal . . .' to 'specta on seasonal . . .'

P. 8 L. 19: 'plays a dominant role' is an over-statement without further analysis. Change 'dominant' to 'important'. Better yet, use 'plays a more important role during this season than during NH winter'.

P. 8 L. 21: Change 'The isolation of tropical air through the subtropical transport barriers' to 'imposed by the subtropical transport barriers' (or some analogous change) to avoid the contradictory imagery invoked by the words 'isolation' and 'through'.

P. 9 L. 3: Change 'transit times above' to 'transit times longer than'.

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