

Interactive comment on “Age of Air as a diagnostic for transport time-scales in global models” by Maarten Krol et al.

Anonymous Referee #1

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The manuscript presents a diagnostic for inter-hemispheric transport in global models. The method is very useful to analyse model's transport bias and to link these biases with the model parameters (convection, resolution, data). The results compare very well with observations.

Although the paper contains some interesting material, which should be published, the manuscript itself could be improved qualitatively in some parts. Some paragraphs and sections need revisions by enhancing the discussion with regard to the scientific content as well as to the models differences (used resolution, convection schemes, data). Particularly, the difference in the reanalyses (JRA-25 and ERAI) could be emphasize. The work should be published after major revisions. In the following here are my major points and general concerns:

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Major points:

- 1. Mainly, I am missing a critical discussion and the connection between the model's difference with the different set-up, such as vertical and horizontal resolution, nudging and reanalyses-driven models. How different configurations in Table 4 affect the results. Convective parameterisation may play the biggest role but one should not neglect the differences induced by the difference in the reanalyses, vertical resolution, nudging.***
- 2. My other major point concerns the organisation of the figures. Some of them could be grouped to allow an easy reading and inter-comparison. I would suggest to regroup on same panel figures 3 and 4; fig. 5 and 6; Fig. 8 and 9.***
- 3. Section 5 (Conclusions) provides mostly a brief summary of things which have been stated before.***

Minor points:

- 1. Page 2, line 12: ". . . is only broken down in the upper stratosphere . . ." Please add citation after "stratosphere" about stratospheric SF6 photo-dissociation***
- 2. Page 2, line 32: ". . . upper-tropospheric equatorial westerly duct,. . ." Please cite Waugh and Funatsu, 2003 after "duct"***
- 3. Page 3, line 1: please replace "again" by "also"***
- 4. Page 3, lines 9: ". . . troposphere-stratosphere exchange . . ." please cite Holton et al., 1995 which is the suitable reference for STE***

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5. **Page 3, line 12:** “Stratospheric age of air and its temporal trend have been determined from SF6 measurements from the MIPAS satellite (Stiller et al., 2012)” and from balloon observations (Engel et al, 2009).
6. **Page 5, line 21-23:** The tracers that are not used in this study don’t need to mentioned or listed in this paper. Please remove this sentence. “Note that we also included a 222 Rn simulation with monthly varying emissions over Europe during 2006–2010, based on the high resolution emissions maps presented in Karstens et al. (2015). The current paper will, however, not analyse these simulations.”
7. **Page 9, lines 2:** “ For this inter-comparison . . .” coma after “inter-comparison”
8. **Page 9, lines 5-7:** “Recent analysis (Tsuruta et al., 2016) shows that the mass fluxes produced with the ERA-interim data set (Dee et al., 2011) lead to faster inter-hemispheric transport compared to the old model version using the Tiedtke (1989) scheme that was used in the earlier TransCom study (Patra et al., 2011).” Sentence should be revised “According to Tsuruta et al., 2016, the mass fluxes . . .”. There is also an over citing Dee et al., 2011 in this page.
9. **Page 10, line 28:** “. . . (Austin and Houze Jr, 1973; Belikov et al., 2013a) A modified . . . “ there is a missing dot before the “A . . .”
10. **Page 12, line 7:** “. . . signalling stratosphere-troposphere exchange. ” Please add Holton et al., 1995 at the end of the sentence.
11. **Page 12-13, line 12/line 1:** “ Here, all models agree on an interesting asymmetry: AoA derived from “SHsurface” around the North Pole is older than AoA derived from “NHsurface” around the South Pole.” Why?

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12. **Page 13, line 1:** What the cause of the differences between TOMCAT and NIES results?
13. **Page 13, line 12:** “. . . emission from the NH.” Please replace by “. . . from the NH emissions.”
14. **Page 14, line 1:** “Indeed, the lowest CH4 concentrations on the Earth’s surface are found at NOAA site Eastern Island (EIC) (Patra et al., 2009b), which was attributed to “old” air in combination with strong removal of CH4 by OH at tropical latitudes”. Please rephrase this sentence.
15. **Page 14, line 6:** How Louis (1979) scheme would impact the transport? Please be more explicit.
16. **Page 14, line 10:** “Here it should be noted that the TOMCAT and NIES AoA is already systematically older at the tropopause (see Figure 2).” But in the stratosphere, the AoA from LMDZ, TM5, EMAC are even older than TOMCAT and NIES. Therefore, the sentence is not useful here.
17. **Page 15, line 9:** “Further analysis on the stratospheric AoA in this model ensemble is left for future exploration.” Before this sentence please discuss Garny et al., 2014; Ploeger et al, 2015 concerning the impact of the aging by mixing which play important role.
18. **Page 17, paragraph 2, line 5-15:** Please combine fig. 8 and 9 and rephrase the paragraph. This will make this paragraph easy to follow. Please improve the ticks and legend of actual fig. 8. Enumerating the panel would be helpful.
19. **Page 23, line 21-22:** Please rephase this “. . . five AoA tracers...”

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References

- Holton, J. R. and Haynes, Peter H. and McIntyre, M. E. and Douglass, A. R. and Rood, R. B. and Pfister, L. (1995), Stratosphere-troposphere exchange, *rev. Geophys.*, *33*,403-440, doi:10.1029/95RG02097.
- Engel, A., T. Möbius, H. Bönisch, U. Schmidt, R. Heinz, I. Levin, E. Atlas, S. Aoki, T. Nakazawa, S. Sugawara, F. Moore, D. Hurst, J. Elkins, S. Schauffler, A. Andrews, and K. Boering (2009), Age of stratospheric air unchanged within uncertainties over the past 30 years, *Nature Geoscience*, *2*, 28–31, doi:10.1038/ngeo388.
- Garny, H., T. Birner, H. Bönisch, and F. Bunzel (2014), The effects of mixing on age of air, *J. Geophys. Res. Atmos.*, *119*, doi:10.1002/2013JD021417.
- Ploeger, F., M. Abalos, T. Birner, P. Konopka, B. Legras, R. Müller, and M. Riese (2015b), Quantifying the effects of mixing and residual circulation on trends of stratospheric mean age of air, *Geophys. Res. Lett.*, *42*, doi:10.1002/2014GL062927.

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