

Interactive comment on “Mixing and ageing in the polar lower stratosphere in winter 2015/2016” by Jens Krause et al.

Anonymous Referee #1

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The paper uses aircraft tracer measurements from the POLSTRACC campaign combined with simulations with the CLaMS model to derive conclusions on the characteristics of transport in the high-latitude boreal lower stratosphere for the winter of 2015-16. The results show an increase of the mean age in the region from January to March 2016, which seems at odds with the increase in CO concentrations. The authors argue that this is due to a change in the age spectrum, which exhibits an increase in both old and young air by the end of the winter.

The article is well written and presents an interesting analysis motivated by in situ observations and nicely complemented with modeling tools. I recommend publication in ACP after the following few minor comments and technical corrections are addressed.

- The main point that should be addressed regards the high values of CO observed

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during phase 1, seen in Fig. 5a at about 70 degrees and 330-340K, and in Fig. 7 (CO values above 45 ppbv). Although these values are not the main focus of the paper, they stand out, and there are a few parts in the paper where I miss some explanation of their origin. For instance, in the description on Page 13 Lines 25-29 it is mentioned that the 'direct tropospheric impact was greater in phase 1 than in phase 2' referring to these points. What do you mean by 'direct tropospheric impact'? Is this transport across the ExTL or did the high CO values originate in the TTL? Also in Section 5.2, you could look separately at the age of air spectrum for those air masses, instead of showing the results for all measurement points in phase 1 together. Does that help in interpreting the origin? Finally, some measurements in phase 1 were taken at lower latitudes (over Italy) compared to the rest of the campaign. Does that latitude difference have an impact on the CO values?

- P1 L22: 'adiabatic descent [...] adds to the adiabatic downwelling of the Brewer-Dobson circulation'. It seems to me you are referring to the same thing twice?
- P2 L29: tropical pipe
- P3 L23: The McPhaden reference is not about the 2015 ENSO event. A better option could be perhaps L'Heureux et al. (2017).
- P3 L24: The impact of the 2015-16 ENSO event on the polar vortex has been analyzed by Palmeiro et al. (2017).
- P6. Only flights that were used for the analysis are shown.
- P8 L1: take → taken
- P8 L20: remove 'respective'
- P8 L27: remove respectively?
- P9 L7-8: is this a hypothesis or do you have an argument to support this statement?
- P9 L14: Are the physical altitude ranges the same for both phases?

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- P9 L18: The mean increase of 0.29 is just below the precision of the mean age estimate from SF6. Do you still consider it a robust change?
- P9 L27: “with an variability” → an interannual variability?
- P9 L3: chapter → section
- P12 L4: [...] general picture of enhanced downwelling of the Brewer-Dobson circulation [...]
- P12 L9: despite the
- P13 L4-13: Could you refer to the individual panels of Fig. 6 as you describe the figure?
- P13 L21: an CO → a CO
- P13 L25-29: This description is unclear. What you mean by ‘shows higher CO relative to N2O?’. Perhaps it would make it easier to follow if you referred to the isentropic levels approximately corresponding to the N2O values when you describe Fig. 7 (it is hard for the reader to combine mentally Figs. 4, 5 and 7).
- P17 L4-5: would it be more accurate to refer to these figures as ‘scatter plots’ rather than ‘correlations’? Also on Fig. 9 caption.
- P17 L18: remove ‘which is’
- P18 L8: Green’s function
- P21 L1: what do you mean by ‘mass balance systems of transport pathways’?
- P22 L27: Eventhough → Although
- P24 L8-10: This sentence is unclear. Do you mean that the high fraction of young air reaches higher latitudes in 2015/16 as compared to the climatology? If so, what is the variability (e.g. standard deviation) around the climatology? Is this winter statistically different from the climatology?

C3

References:

- L’Heureux, M.L., K. Takahashi, A.B. Watkins, A.G. Barnston, E.J. Becker, T.E. Di Liberto, F. Gamble, J. Gottschalck, M.S. Halpert, B. Huang, K. Mosquera-Vásquez, and A.T. Wittenberg, 2017: Observing and Predicting the 2015/16 El Niño. *Bull. Amer. Meteor. Soc.*, 98, 1363–1382, <https://doi.org/10.1175/BAMS-D-16-0009.1>
- Palmeiro, F. M., M. Iza, D. Barriopedro, N. Calvo, and R. García-Herrera (2017), The complex behavior of El Niño winter 2015–2016, *Geophys. Res. Lett.*, 44, 2902–2910, doi:10.1002/2017GL072920.

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