Comment on acp-2020-1253
Anonymous Referee #1

Referee comment on "The stratospheric Brewer–Dobson circulation inferred from age of air in the ERA5 reanalysis" by Felix Ploeger et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-1253-RC1, 2021

Summary:

The authors investigate the representation of the Brewer-Dobson circulation (BDC) in the new ERA5 reanalysis, as compared to the previous ERA-Interim product as well as observational estimates. To do so, they use a Lagrangian transport model (CLaMS) in order to calculate stratospheric age of air. ERA5 is found to show significantly older mean ages than ERA-Interim, by as much as 2 yr (50-75%) in the lower stratosphere, indicative of a slower mean BDC. In terms of trends, ERA5 is found to exhibit a decreasing age trend (strengthening circulation) throughout the stratosphere over the 1979-2018 period studied. In contrast, ERA-Interim shows a decreasing age trend in the SH but increasing in the NH. A closer look at the trends reveals an apparent step-change decrease in extratropical ERA5 age in the early-mid 1990s, which is less prominent in ERA-Interim. Comparison with observationally inferred ages suggests that the mean age values might be in slightly closer agreement for ERA-Interim, though the latitudinal structure may be better for ERA5. Overall, the authors conclude it is unclear whether the ERA5 stratospheric age of air climatology and trends are any better (or worse) than the previous ERA-Interim.

I found this to be a clear, interesting paper, which I very much enjoyed reading. The age of air calculations which the authors present will provide a useful comparison with the transformed Eulerian mean calculations from Diallo et al. 2020, as well as within the wider context of the S-RIP exercise. The results and their wider interpretation are very nicely discussed. I am therefore happy to recommend this paper for publication in ACP, following just a few minor comments below, which I hope the authors find useful.

General comment:
I think that the apparent step-change extratropical in age around the early-mid 1990s is an interesting result and one of the clearer differences between ERA5 and ERA-Interim. The fact that this does not appear clearly in observational data (e.g. Fig. 10) may bring into question the reliability of ERA5 trends. It’s also interesting that this step-change is not apparent in the tropical upwelling (Diallo et al. 2020, their Fig 12). I might encourage the authors to elaborate a little more on this in the paper as the result is not very prominent. In particular, do any TEM diagnostics of the circulation show this step change, or is this only seen in age calculations? Is so, could the authors speculate as to why? If this step-change is not thought to be real, do the authors have any suggestions for what change in the assimilation scheme may be responsible?

Minor comments:

L7: ‘Above’: it wasn’t clear to me what this was referring to as being above. Maybe ‘in the mid-upper stratosphere’ would be clearer?

L94: \( \theta \) (potential temperature) should be defined.

L105: along -> along with?

Fig. 2: I think this would benefit if a difference plot were also shown (ERA-Int minus ERA5) to aid with comparison of the two reanalyses and with Fig 1 e-g. It is quite difficult to pick out the differences without such a plot.

Fig. 3: This is a minor point, but I would encourage the authors to consider using a ‘perceptually uniform’ color scale for the age plots (a,b,d,e), such as grayscale, viridis etc. The rainbow scheme used here can introduce the appearance of false boundaries (where the yellow color are) in the date. The same goes for Figs 4 and 5.

L391: ‘strongly overly’. I’m not sure what this means? Perhaps ‘decadal variations are significant compared to potential long-term trends’?

L427: ‘steplike change around the year 2000’: To me it looks like the main steplike change in ERA5 is over \(~1992-1997\) rather than around 2000.

References in this review: