

Author comments in reply to the anonymous referee on “Inter-comparison of stratospheric mean-meridional circulation and eddy mixing among six reanalysis datasets” by K. Miyazaki et al.

We thank the referee for the helpful comments. We have revised the manuscript according to the comments, and hope that the revised version of the manuscript is now suitable for publication. Below are the referee comments in italics with our replies in normal font.

Reply to Referee #1

Minor comments:

I am not sure how to interpret the K_{yy} results. The authors argue that the K_{yy} mixing estimate agrees with the results of Haynes and Shuckburgh (2000), but this does not seem right to me. In particular the strongest mixing in Figure 6 of the present manuscript is found just in the region of strongest zonal winds within the polar vortices, and not in the surf zone. This result is also at odds with theoretical expectations. The authors should be aware of this discrepancy and clarify what information does the K_{yy} diagnostic provide. These concerns regarding the mixing diagnostic make me skeptical about the interpretation of the results in the following Sections.

To clarify the limitations and usefulness of K_{yy} , the following paragraph has been added:

“We should note that, even after eliminating the influence of apparent diffusion in K_{yy} estimates, there are limitations in elucidating eddy mixing from these estimates. As discussed by Nakamura (2008), whilst a part of the Eulerian eddy diffusivity (e.g., K_{yy}) can be attributed to instantaneous, irreversible mixing in a way similar to effective diffusivity, the Eulerian eddy diffusivity and eddy diffusivity are fundamentally different, both qualitatively and quantitatively. This is because of difficulties associated with representing eddy advective transport in the Eulerian formulation. Meanwhile, the results of the K_{yy} analysis and related variables are presented here in the geometric latitude coordinate system (where a zonal average is taken for air parcels with different PVs), whereas effective diffusivity is presented in the equivalent latitude (EL) coordinate system (based on the latitude circle that encloses the same area as the PV contour). Latitudinal variations of zonal-mean eddy mixing and associated fields (e.g., strong eddy mixing outside the polar vortex) are more clearly presented in the EL coordinate system.”

- The authors should discuss the statistical significance of the linear trends and correlations throughout the manuscript. Significance information is only found in some tables but not mentioned in the text or

shown in the figures.

Information on statistical significance has been added to the figures and discussed in more detail in the revised manuscript.

Some of the results in the present manuscript are already shown in the recent publication Abalos, M., B. Legras, F. Ploeger, and W. J. Randel (2015), Evaluating the advective Brewer-Dobson circulation in three reanalyses for the period 1979–2012. J. Geophys. Res. Atmos., 120, 7534–7554. doi: 10.1002/2015JD023182. The authors should discuss their results in light of published work.

The results of Abalos et al. (2015) are discussed in the revised manuscript. The following sentences have been added:

In Section 1:

“Recently, Abalos et al. (2015) compared the MMC in three reanalyses (ERA-Interim, JRA-55, and MERRA) using three different estimates: from the transformed Eulerian mean (TEM) residual circulation and based on momentum and thermodynamic balances. They showed a relatively large spread (around 40%) among the estimates of the magnitude of tropical upwelling.”

In Section 3.1:

“Abalos et al. (2015) revealed that the acceleration in the MMC is a qualitatively robust result across different estimates (from the TEM residual circulations and based on momentum and thermodynamic balances).”

“Abalos et al. (2015) demonstrated that, across nine estimates using three reanalyses (ERA-Interim, JRA-55, and MERRA) and three approaches (derived from the TEM residual circulation and based on momentum and thermodynamic balances), only the residual circulation derived from ERA-Interim shows negative trends in annual mean tropical upwelling.”

In Section 4.2:

“Abalos et al. (2015) showed that the DJF trends make a major contribution to the overall structure of the annual mean trends of BDC in the NH.”

Minor comments:

- L16 P27750: *showed* → *show*

Corrected.

- L12 P27755: $w^* \rightarrow w$

Corrected.

- L1-5 P27755: *Mention if the absolute value change to follow the argumentation.*

An example of the absolute difference information is given in the revised manuscript as follows:

“For instance, Miyazaki et al. (2008) found a significant (>30%) difference in the mean vertical velocity around the Antarctic polar vortex between the TEM residual vertical velocity and the MIM MMC analysis, which can be attributed to the assumptions applied for the TEM Stokes corrections.”

- L11 P27756: *Is there a reason why w^* is estimated from w but v^* from the stream-function?*

v^* is calculated from meridional wind data. The mass stream function is calculated from integrating meridional velocity v . Then, w^* is estimated from the mass stream function. The revised manuscript presents the methodology more clearly.

- L 11-12 P27757: *The mentioned paper does not estimate K_{yy} as done in the present manuscript.*

Removed.

- Table 1. *The value for JRA-55 at 560 K is highlighted as significant but it is not.*

We have confirmed that the trend is statistically significant for the 95% confidence level using the Mann-Kendall test. The revised manuscript describes this approach more clearly.

- L22-24 P27763: *Could you explain how “decadal scale changes in the mixing trends seem to be consistent with those in the tropical upward mass flux”?*

Although the reason is unclear, the variations in wave forcing may lead to decadal scale changes in both the mean and eddy transports, as suggested in the manuscript.

- L14 P27765: *Relative importance of mean and eddy transport -> ... meridional eddy transport*

Corrected.

- L11 P27772: *strictly -> accurately -*

Corrected.

- L13-16 P27775: *Which unrealistic variations and discontinuities have been found?*

The sentence has been rewritten as follows:

“However, there still seem to be problems that cause unrealistic atmospheric variations (e.g., large differences in long-term variations between ERA-Interim and JRA-55) associated with discontinuities in the assimilated measurements and large uncertainties in the forecast models.”