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 #2

Starting from the well-known 2d picture decomposing the Brewer Dobson circulation (BDC) into the mean meridinal circulation (MMC) and eddy mixing (EM) the authors use the method of mass-weighted zonal means (MIM) to quantify both, the MMC and EM contributions, for six reanalysis data sets. Overall, this is an important contribution in the ongoing discussion of the uncertainties of the reanalysis data, especially in their ability to represent stratospheric trends. The paper is well-written and contains results which are worth to be published. The most novel results are related to the analysis of eddy mixing (in terms of the meridional diffusivity Kyy) and of the relative importance of eddy mixing in relation to mean meridional circulation. However, there are some (partially major) critical points listed below which should be addressed before publication:

Many thanks for your positive assessment of our manuscript. The revised version discusses the analysis results more clearly, as described below.

Major points:

- The recently published paper, Abalos et al., JGR, 2015 is not included into the discussion of the results. Especially the discussion of the trends in tropical up-welling, weakening trends in MMC in the NH only for the ERA-Interim reanalysis (for the deep branch of the BDC) are some of the main results mentioned in the abstract which are not compared with the Abalos et al. publication who clearly demonstrates that ERA ($\bar{v}^*\bar{w}^*$) is an outlier compared to the other estimates.

The results of Abalos et al. (2015) have been included 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."

- The study does not show any simulation of the Age of Air (AoA). On the other side, some speculations on the possible impact of the results on AoA are given in the abstract. Because AoA is not the focus of this paper, I would recommend to reduce such speculations to some discussion in the last chapter.

Some sentences in Section 4.2 have been removed.

- There are two definitions of the mean meridional circulation: by using eq (3) with $\bar{w}^*$ describing the TEM vertical velocity in the log pressure coordinate and eq (6) with the cross-isentropic PV flux $\bar{q}^\theta$. To me both quantities are different, or if these quantities are the same you should prove that. Consequently, I expect also different streamfunctions resulting from these different definitions. This point should be clarified.

The revised manuscript explains the definitions and approaches more clearly. The relationship between w^* and θ^* is given by Eq. (10) in the revised manuscript.

Minor points:

1. *P 27751, L 9 ...of the mean meridional circulation...*

Corrected.

2. *P 27752, L10-15 Maybe you should include the Wright and Fueglistaler, ACP, 2013 paper discussing the large differences in diabatic heating rates for all reanalysis data*

The following sentence has been included:
"Wright and Fueglistaler (2013) showed large differences in the simulated diabatic heat budget in the tropical upper troposphere and lower stratosphere in five reanalysis models (NCEP-NCAR, NCEP-CFSR, JRA-25, ERA-Interim, and MERRA), with substantial implications for representation of transport and mixing."

3. *P 27752-3 "may upset this balance and degrade the expression of momentum budget" - maybe you should explain it in more details*

The sentence has been replaced by:
"Data assimilation analysis increments, introduced by using conventional data assimilation techniques such as the three-dimensional variational (3D-VAR) one, may upset this balance and degrade the expression of momentum budget and wave structures. This is because they introduce an additional force, without maintaining physical balance, as a result of its isotropic and instantaneous analysis increment."

4. *2.2 Analysis framework In this chapter I miss some connection to the isentropic TEM formalism described in the standard text books like Andrews 1987. Your chapter makes necessary to look into all the citations. However, you should try to argue what is different in your formalism if compared with the text book formulations.*

The revised manuscript explains the analysis framework more clearly.

5. *Mean meridional circulation In your paper you use 2 definitions of MMC: The first one uses the mass stream function and the mean continuity equation (Eqs. (3) and (4)). The second definition uses equation (6) to quantify MMC. Are these definitions exactly the same? If yes, can you proof that?*

Please see my reply above.

6. *P2775L7 I would say, you estimate the ratio of mean eddy and mean total meridional transport*

fluxes and not of "mean and eddy meridional transport fluxes".

Corrected throughout the manuscript.

7. *P 27759 L 15 Level 560 K is too high to be influenced by the subtropical jet stream. Please reformulate*

The sentence has been rewritten to:
"They are relatively suppressed at the polar vortex edge."

8. *Figure 6-9 contain the most novel results, especially if compared with Abalos et al, JGR, 2015. Maybe you should move these results more into the foreground.*

The revised manuscript presents eddy mixing first (in Section 3.1), followed by the MMC (in Section 3.2).