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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Kinematic and diabatic vertical velocity climatologies from a chemistry climate model" *by* C. M. Hoppe et. al.

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We acknowledge the reviewers for the helpful comments on our manuscript. All comments were taken into account in the revised version and we feel that the manuscript has improved greatly through these revisions. Below, we reply point-by-point to the referee comments:

- I wonder why the authors show the results for the vertical velocity, which are expressed in pressure-based units (Pa/day), on isentropic coordinates. Equation 9 gives the diabatic velocity on pressure coordinates, which can be directly compared to the vertical velocity given by Eq. 3. This comparison would be simpler than then interpolating both vertical velocities to isentropic levels. A related concern is how the inter-

polation of the residual circulation to isentropic surfaces is done. In order to evaluate the mass transport across an isentropic surface both the meridional and vertical components of the residual circulation should be considered since pressure and isentropic surfaces are not parallel. Could you clarify how the interpolation is done and if this issue could have any effect on the comparison? Indeed, comparing the results directly on pressure surfaces could avoid having to interpolate the residual circulation.

We agree with the reviewer that showing the velocities on pressure levels is straightforward and more consistent than potential temperature coordinates. Therefore, we changed the vertical coordinate from potential temperature to pressure levels in Fig. 1, and Fig. 3-7 (Fig. numbers of old manuscript).

- The age of air results should be explained more carefully. It is an important point to what extent the different vertical velocities affect the age of stratospheric air calculations. More discussion on this point is highly desirable. For instance, the hemispheric pattern appears mostly below 800 K while the latitudinal shift of the tropical pipe (in boreal summer) is mainly observed above that level.

We have rewritten the age of air section in the paper. We added the analysis of residual circulation transit times (RCTT) to distinguish between residual circulation and mixing effects, which allows the differences like the hemispheric pattern to be explained in more detail.

- L11 P29944 ”although their results are also affected by assimilation effects ”: could you explain this? This sentence means that these studies are based on reanalysis data. Thus, their results are not pure model results, instead they also include information from observations.

- L11 P29945 “it shifts the pressure boundaries of the grid boxes” –> the pressure boundaries of the grid boxes are not fixed This has been changed as suggested by the reviewer.

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- L27 P29945 remove “towards each other” This has been changed as suggested by the reviewer.

- L9 P29946 Planetary waves that propagate on isentropic surfaces: what do you mean? We agree that the formulation was confusing, so we changed the sentence in the following way: Planetary waves may induce upwelling and downwelling in the Eulerian zonal mean ω in different latitudes which is not related to net tracer transport.

- L19 P29946 remove TEM This has been changed as suggested by the reviewer.

- Figure 2: It would be convenient to express in the same units as the other figures (Pa/day) This figure is shown to demonstrate the general difference between w and w*, using the ‘original’ units of the TEM [m/s]. As explained in the test, it is not useful to calculate the zonal mean of w (i.e. upwelling in the polar regions.) Therefore, it is not necessary to compare the zonal mean of w directly to any other vertical velocity. In case of the TEM, the units are changed to Pa/day in the following figures.

- L17 P29949 This problem can be avoided if the transformation is applied to the data on pressure instead of hybrid coordinates. This has been changed as suggested by the reviewer.

- Figure 3. Fix the figure caption. Also remove “grey”. The figure caption has been fixed.

- Figures 4 and 5 Perhaps it could be considered to select one representative month per season and have only one figure instead of showing the 24 panels. We agree that the discussion of the monthly figures is too detailed for the main part of the paper. Though, we like to keep it for completeness and moved this part to the appendix.

- Figure 6 Perhaps it would be clearer to have lines at different levels, it is not easy to compare the magnitude on a contour plot (e.g. L7-8 P29953) We tried different ways of plotting but came to the conclusion that the figure in its present way is most clear.

- L12-13 P29953 This is only true above 800 K To be more precise in this sentence, we

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have added the height (∼15hPa in pressure coordinates).

- L22 P29953 “more dispersive” this is known from previous works but it is not a result seen here It is seen in e.g in Ploeger 2010, Schöberl 2003. We removed this part here.

- L25 P29953 The southward shift is only seen in summer To be more precise, we changed the text: a∼southward shift of maximum upwelling in the diabatic vertical velocity in NH summer.

- L25 P29953 What about the difference in the latitudinal extension of the upwelling? The upwelling region is wider in the kinematic vertical velocity field, and wider in the diabatic vertical velocity field. We added this point to the list.

- L9-12 P29954 Could you discuss the contribution of the different velocities versus the different transport schemes in the models (ClaMS versus EMAC)? We address this point by adding the RCTT analysis to the age of air discussion.

- Figure 7 bottom: The color scheme is confusing (blue is usually used for negative values) We chose the color scheme similar to the plots in the rest of the paper. (Red: negative, blue: positive). To make it clearer, the last sentence of the figure caption specifies the meaning of the colors in this plot: Blue colors indicate younger air in EMAC-FFSL, while red colors indicate younger air in EMAC/CLaMS.

- L5 P29955 Add reference The work has not been submitted or published. We deleted the sentence, since there is no proper citation available.

- L14 P29955 Remove “In summary, the discussion above showed that” (This is discussed in this paragraph, not above) This has been changed as suggested by the reviewer.

- L4 P29956 Remove “for the example of the EMAC/CLaMS model” (redundant) This has been changed as suggested by the reviewer.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 29939, 2015.