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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Three-dimensional simulation of stratospheric gravitational separation using the NIES global atmospheric tracer transport model" *by* Dmitry Belikov et al.

Anonymous Referee #2

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The authors conducted numerical simulation of carbon dioxide isotopes, 12C16O2 and 13C16O2 by using the NIES global tracer transport model (CTM), and clarified its gravitational separation (GS) due to the difference in the molecular diffusion. The CTM, which is an offline 3-D passive tracer transport model based on isentropic vertical coordinates, was driven by the reanalysis dataset, JMA Climate Data Assimilation System (JCDAS). Results of the 3-D CTM were found to be much more realistic than the results of a 2-D transport model. The CTM showed the GS apparently increasing with increasing altitude and latitude in the stratosphere, and also suggested a unique relationship of GS with the age of air (AoA). This work made an important progress in understanding of the 3-D distribution of GS in the stratosphere. However, there are many incomplete

discussions, particularly of physical interpretations of simulated results. I recommend to publish the manuscript in ACP after addressing the following comments.

1. Generally speaking, the turbulent eddy diffusion is much greater than the molecular diffusion in the troposphere. The eddy vertical diffusions may be enhanced by the large wave activity in the extratropical stratosphere. The authors should describe how the CTM treats the eddy vertical diffusion in the troposphere and stratosphere, and discuss how they affect the GS distributions in the stratosphere.

2. The CTM adopts isentropic vertical coordinates, where the diabatic heating assessed in the reanalysis is used to estimate the vertical velocity. I think the choice of isentropic coordinates is adequate, because its vertical motions are free from the gravity wave noises. Note that conventional pressure coordinates tend to overly express the vertical mixing due to gravity wave noises. A problem in this work is that the vertical velocity was assessed from the seasonal mean diabatic heating. It neglected the short-term temporal variation of actual instantaneous diabatic heating, and underestimated their contributions to the vertical diabatic mixing.

3. The characteristics of Brewer-Dobson circulation in a reanalysis have been recognized to vary significantly depending on the reanalysis, and to be subject to systematic errors of the reanalysis. In this experiment, the CTM was driven by using a reanalysis. The systematic errors of reanalysis may degrade the simulated GS. How do the authors think about this problem?

4. Figure 4 showed that the geographical distribution of $<\delta>$ value is significantly different between the northern and southern hemispheres. According to the authors, the stronger polar vortex enhances the GS in JJA-SH compared with DJF-NH. Furthermore, the GS differences may be caused by the Brewer-Dobson circulation and horizontal diffusions on isentropic surfaces. The authors should clarify major mechanisms causing the actual differences in GS distributions.

5. Figure 10 showed that the $<\delta>$ value decreases very rapidly after the age exceeding

4 years. It means that the GS is highly nonlinear to the residence time of “Age” in the stratosphere. We would like to know the mechanisms for the GS acceleration in layers with an age of 4 or more years in the model.

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