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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Gravitational separation in the stratosphere – a new indicator of atmospheric circulation" *by* S. Ishidoya et al.

Anonymous Referee #2

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Overall, I think this is a novel approach, and an interesting study. The data analysis is the strongest aspect of the study; the modeling could use some more description and discussion of the results. Also useful would be a paragraph describing how a change in the del values shown corresponds to an age of air change. Also, I don't understand how the history of small-scale wave breaking impacting a given parcel might alter the vertical mixing and change the ratios measured, and whether any such processes are included in the model.

Note: I can't type out the Greek d like character used in the paper. . .so I've called it del in this review.

Page 4840

Line 12: change "air age" to "age of air"

Line 14: change "the gravitational separation" to "gravitational separation" Actually. . .do this throughout the paper. Change "the gravitational separation" to simply "gravitational separation" in most cases. Minor copyediting would help.

Line 19: delete "the" at the end of the line"

Line 24: delete "the" before "gravitational separation"

Page 4841:

Line 1 : delete "a" before "new concrete" and "the" before "gravi-"

Line 3: Is this an effect on O2 concentration, or on the O2/N2 ratio?

Page 4842:

could you explain in the text what your reference sample is? (i.e., is it like Standard Mean Ocean Water used to compute depletions for HDO?)

Page 4843:

Discussion of Figure 1: The model shows a smooth decrease with altitude (and I assume age of air). Why do the observations show coherent oscillations about the model line? Does that oscillation reflect seasonal variation in the strength of the BDC? Or seasonal variations in something about the input airmass or eddy mixing strength?

Page 4846:

Line 18: (and Figure 3) I'm still confused what "corrected for the gravitational separation" means." Why does CO2 need a correction? And are the corrected values for del(O2/N2) what you think the surface ratio would be?

Figure 3:

why does the tropospheric value decrease with time?

Page 4847, first paragraph:

How is the age calculation with the del(O2/N2)? Are you just shifting the solid line to match the dashed line? And, don't you then have to assume than the upper tropospheric value given here matches what is seen in the tropics at the tropopause?

Page 4848:

In the model, do you look at the gravitational separation for the species measured with the cryogenic sampler? Why do you model with a different ratio?

Model discussion:

You need a reference for the model. Is a BDC somehow imposed, or calculated by the model through some imposed eddy parameterizations. How does eddy mixing impact the ratios being examined? And, why is the model circulation "too fast"? Can you show that is the case (i.e., via examining propagation of the water vapor tape recorder. . .comparison with other estimates of BDC upwelling in the tropics?)

Page 4849 (and figure 5)

Could you explain how you did the average del profile? Is that done by averaging all the values shown in Figure 1 at a given level?

Figure 6:

Is the del value shown here from the model based on the CO2 ratio shown in equation 6? Does that give the same del you have calculated from O2, N2 and AR and I assume is what is plotted with the data points on figure 6? And, why is 2002 considered an outlier but 2000 is not?

Figure 6 (and Page 4850)

Could you explain why the gravitational separation is enhanced when the BDC is faster? Are the parcels getting to an age of 4.25 years (where the lines split) following

a drastically different path (possibly going much higher)? Is your imposed enhanced BDC anything like what is modeled in 3D climate models?

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 4839, 2013.