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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 #3

Received and published: 13 April 2013

This manuscript presents observations and model simulations of the gravitational separation of isotopes of several gases within the stratosphere, and proposes that this separation can be used as an indicator of changes in the stratospheric circulation. This is an interesting and, as another reviewer states, provocative idea, and I think the manuscript will be of great interest to many readers of ACP. However, some changes are required before the manuscript is suitable for publication. In particular, how delta could be used to detect changes in the circulation (and improve on what can be gained from CO2) needs to be expanded (see further comments below).

MAJOR COMMENTS

1. I am confused about how the authors propose to use delta to detect a change in the BDC. Do they propose an analysis as shown in Fig 6? This requires measurements of

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CO2 (and CO2 age), which is itself one way to detect changes in the BDC. If we have CO2 age what is added from delta (i.e. what can we learn from delta that we can't learn from CO2)?

I agree that delta could respond differently than CO2 to a change in BDC, but it is not clear to me how one would infer something about the change in BDC from changes in delta. As the idea of the use of delta as an indicator of circulation change is the point of the paper, how it would actually be used needs to much clearer.

I think a relatively straight forward way to do this would be more analysis of the SOCRATES model. For example, how do the vertical profiles of delta (and may be similar for CO2 age), at a couple of different latitudes, vary between the CONTROL and Enhanced BDC simulations? This is likely what we can get from observations, so should show that this would show.

Analysis of the 2 model simulations is likely enough, but paper would be improved if additional simulations with other circulations were included. By changing mixing in the model you can likely get different changes in the circulation. Do CO2 and delta detect these changes?

2. I am also confused about some the observed ages that are presented, and further information and discussion is needed.

First, The CO2 age in Fig 5 is not consistent with time lag shown in figure 3, and quoted mean value from that figure 3 (4 yrs). Is this because of different tropospheric time series or different stratospheric values? Either way this inconsistency needs to be removed.

Second, From fig 3 it appears that there is trend in the delta(O2/N2) age, i.e. smaller time lag at beginning of the time period. I think rather than just quoting mean values you should plot the time series of the age from two tracers.

Finally, and perhaps most importantly, why is the idea of a delta(O2/N2) age not pursed

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13, C1251–C1253, 2013

beyond figure 3? If you claim this gives a similar age to CO2 then why not examine this in the 2D model. Is the delta(O2/N2) age not a way to examine changes in the circulation?

MINOR COMMENTS

Pg 4840, line 21: Might help to put approximate altitude of turbo pause.

Pg 4841, line 11: "intrusion from the troposphere"? How about "after it enters the tropical stratosphere from the troposphere"

Pg 4842, I think the equations should be at the start of the paragraph when delta(15N) first used.

Pg 4844: Can you include the equation 33 from Lettau (1951)? Accessing very old articles is not always easy.

Pg 4845, line 6: "will be described somewhere" is not very useful. If a publication on measurements not at least submitted then I think there needs to be some information in this manuscript (Appendix?).

Section 3.3 on: I found it a bit confusing to have "delta" as the average because easily confused with "delta" for different gases. I would suggest using delta with an overbar or "<delta>", as overbar or < > often used to indicate averages.

Pg 4846 line 17-19: I am bit confused about the correction for gravitational separation. "using the above-mentioned equations" is a bit vague. I think this needs to be better described.

Pg 4849: What is meant by "magnitude depends on observation"?

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