Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2017-392-RC3, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "An "island" in the stratosphere – On the enhanced annual variation of water vapour in the middle and upper stratosphere in the southern tropics and subtropics" *by* Stefan Lossow et al.

Anonymous Referee #3

Received and published: 9 June 2017

Review of: An "island" in the stratosphere – On the enhanced annual variation of water vapour in the middle and upper stratosphere in the southern tropics and subtropics

by Stefan Lossow et al.

Recommendation: Minor revision.

The paper discusses a peculiar maximum in annual variability found for H2O and other tracers in the tropical upper stratosphere of both hemispheres, and the inter-hemispheric differences in this maximum (which is much stronger in the SH). I agree

with the authors that this feature may be telling us something important about transport, although, from the results presented, it is not clear what. The authors do demonstrate that mean vertical advection is the main factor that produces the annual variation (mean vertical advection has a large annual cycle, as shown for example in Figs. 9 and 10) but do not go further than this.

For example, it is not clear what processes produce this behavior (extension into the summer hemisphere of the deep branch of the BDC driven by Rossby waves in the opposite (winter) hemisphere? The details of the circulation associated with the stratopause semiannual oscillation? Something else?) Why does the EMAC model perform better when constrained by observations up to 1 hPa than when it is constrained only to 10 hPa? What might this tell us about missing or poorly represented dynamical processes in EMAC (and by extension, in other chemistry-climate models)? I would not make the elucidation of these points a requirement for publication, but the authors should try to address them insofar as possible, as this would add much value to the paper.

Specific comments (page, line number):

(2,10) "indicating an equilibrium": I don't understand why a maximum in water vapor indicates an equilibrium between sources and sinks. Wouldn't equilibrium obtain anywhere sources and sinks are balanced, regardless of whether there is a maximum in the vmr distribution? I would have thought the maximum in H2O occurs in the upper stratosphere/lower mesosphere because one runs out of CH4 to oxidize and is not yet in the range of altitude where Lyman-alpha photolysis is an efficient sink.

(3,24) "large variability close to the tropopause": I would have thought the main source of variability in this region is the effect of annually-varying tropical cold-point temperature on dehydration; that is, the tape recorder signal.

(4,5) "distinct variation": Does this refer to the maximum in the SH or the NH, or both?

(4,14) “a clear inter-hemispheric difference”: How does this work? What induces these differences?ÂăIn any case, I am not sure what the purpose of this figure is, other than to show that variability in the mesosphere has a different spatial distribution than in the stratosphere, which should not be a surprise, as the circulation and photochemistry are different in the two regions. If you decide going to keep this figure, then you need to explain what accounts for this pattern of variability and how that sheds light on the variability in the stratosphere. Otherwise, I would suggest you delete this material.

(5,12) “both chemical and dynamical”: I don’t see how chemistry is going to do thisâĂŤwhy would chemistry (i.e., strictly speaking, reaction or photolysis rates) be different between the hemispheres?

(5,21) “importance of . . . trace gas gradients”: More likely this points to the importance of photochemical sinks at higher altitude, specifically how quickly the sink increases with increasing altitude.

(6,1) “hint towards vertical advection”: The conclusion “hinted at” here is not immediately obvious, as these tracers also have strong meridional gradients in the Tropics/subtropics. You later show that vertical advection is most important, but you have not done so at this point.

(6,25) “some coherent behavior”: This is neither clear nor quantitative. If total hydrogen is being conserved, then neither H2O nor CH4 are responding directly to transport, although the ratio of H2O to CH4 will depend on the origin of the parcels transported. Or are you arguing that the transport lifetime is always shorter than the chemical lifetimes of CH4 and N2O at these altitudes?

(7,24) “other tendencies have some importance”: I find Fig. 9 much more useful than Fig. 8, which is too qualitative. You might consider omitting Fig. 8 altogether, assuming that the results of Fig. 9 typify what goes one throughout the SH variability maximum. Or you could make a couple more plots like Fig. 9 at other altitudes to confirm that this is the case.

(7,29) “the total tendency”: Are the tendencies in Fig. 10 also composites over 2008-2012, like Fig. 9? If so, please indicate this in the figure caption and also in the text.

(8,16) “Based on the discussion so far”: One thing that you have not discussed is how the semiannual variation seen in the top panel of Fig. 10 arises. It is not due to vertical advection, and it is not clear how the combination of the other term manages to produce it. Could you comment on this?

(8,21) “panel a”: The panels in Fig. 11 are not labeled. Please correct.

(8,28) “eddy transport . . . residual tendency”: It is an assumption, unproven as far as I can see, that the residual can be ascribed solely to (resolved or parameterized) eddy transport. This need not be the case. Numerical diffusion, for example, could play a role here.

(8,31) “yields almost the identical structure”: Perhaps I have misunderstood this remark, but shouldn’t this be the case, by construction?

(9,2) “relation . . . is obvious”: This is not quite obvious to me. This statement refers to the circulation in the winter hemisphere at mid- and high latitudes, but here you are considering behavior in the Tropics. It is not altogether clear how the circulation in this region is driven (e.g., the relative importance of PW and GW, possible influenece of the QBO, etc.)

(9,19) “panel a”: There are no panel labels in Fig. 13.

(9,29) “where the annual variation is substantial”: I think you mean “where the annual variation is largest”, no? That is, you compare the locations where the variation is largest in the NH and in the SH individually.

(10,34) “panel a”: Again, there are no panel labels in the figure.

(11,11) “much better agreement”: Please comment on why you think this is so. One possibility could be the representation of tropical dynamics, which has often been a problem for high-top chemistry-climate models. In particular, the SAO and QBO, and their secondary circulations are not always well simulated in these models. There is not enough detail given about the model used here (EMAC), and I did not have the time to consult the literature. Perhaps some details of how tropical dynamics are handled in EMAC (in particular, the tropical GW parameterization) should be summarized briefly in Section 1.

Typos, etc.

(2, 6) "are most" are the most

(2,35) "Institut für Meteorologie"... : There is no need to put the names of these institutes in quotes.

(3,27) "provoking": I think "motivating" or "suggesting" might be better.

(4, 3) "Northern Hemisphere, however distinctively" Northern Hemisphere; however, it is distinctively...

(4,24) Figure 4: The caption of Fig. 4 reads "The latitudinal cross-section..." but does not say of what. It should be "The latitudinal cross-section of water vapor".

(5,17) "The existence in methane..." The existence of this feature in methane...

(6,14) "a tendency that" a tendency for

(7,20) "is best resembled by that" best resembles that

(8,14) "combined by" produced by the combination of

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2017-392, 2017.