Atmos. Chem. Phys. Discuss., 13, C12199–C12204, 2014
www.atmos-chem-phys-discuss.net/13/C12199/2014/

Atmospheric Chemistry and Physics Discussions

Open Access

ACPD

13, C12199–C12204, 2014

Interactive Comment

Interactive comment on "Impact of tropical land convection on the water vapour budget in the Tropical Tropopause Layer" *by* F. Carminati et al.

Anonymous Referee #2

Received and published: 14 February 2014

This manuscript presents an updated and refocused version of the analysis performed by Liu and Zipser (2009). The results are interesting, but the presentation is not always clear and the technical justification is incomplete in some areas. Several of the assertions in the text require additional supporting evidence, and I hope that the authors will expand their discussion to include more contextual information (e.g., how the MLS-derived diurnal cycles compare with other metrics of overshooting convection, what the results mean in a global context) – see comments below for details. Overall, the core of the study is solid and there is enough new material to justify publication. I recommend that the manuscript be reconsidered for ACP after major revisions.

Major Comments

1. Like the first referee, I have some questions regarding uncertainties and the robustness of the results at higher levels (especially at 56 hPa). The differences shown in Fig. 2 and Fig. 6 are quite small, while the MLS retrievals for each layer are somewhat dependent on the water vapour profile at other levels. This dependence on other layers can be positive (in phase) or negative (out of phase). Have you been able to confirm that the diurnal cycles at these higher levels are not artifacts of the averaging kernel dependence on the diurnal cycle at lower levels? Are there any systematic day–night differences in the a priori profiles that might propagate into the retrievals? I recommend including a discussion of these issues in the revised manuscript.

2. I recommend slightly refocusing Section 3 ("Water vapour seasonal variations over land areas") to emphasize covariability in water vapour, temperature and IWC. One option would be to replace the current Figs. 4 and 5 with composite time–height seasonal cycles of (a) day–night differences (in MLS water vapour, temperature and IWC) and (b) anomalies from the climatological mean (in MLS water vapour, temperature and IWC). It might be helpful to include the western Pacific region in these plots for additional context. By relating the annual and diurnal cycles of water vapour, temperature and IWC, you may be able to make clearer arguments regarding the importance of overshooting convection relative to other TTL processes at different times of year and over different regions. This approach would allow you to replace at least the top row of plots in Figs. 6 and A1, and might enable a more detailed look at your argument regarding the effects of El Niño/La Niña. I cannot identify these ENSO effects in the current figures (see minor comment below); perhaps showing difference plots relative to the composite annual cycle would highlight the differences you are reporting? Relative to the current manuscript, this change would eliminate the annual cycle in water vapour (shown many times previously) and the interannual variability (only currently used with respect to the impact of ENSO phase).

3. I would like to see more in the discussion regarding how seasonal changes in the diurnal cycle of UT/TTL water vapour relate to seasonal changes in the properties of

ACPD
13, C12199–C12204, 2014

convection (particularly overshooting convection) based on previously published work (e.g., TRMM, CloudSat, etc.), as well as what (if anything) the results imply for the importance of overshooting convection to global stratospheric humidity.

4. The text of the manuscript requires substantial editing. In particular, there are a number of sentences that could be reworded or split to improve clarity and readability. It may be helpful to engage the services of a professional editing service prior to submitting a revised manuscript.

Minor Comments

p.33057, l.7-8 : Sherwood (2000) showed that vertical motion derived from sounding data over the “stratospheric fountain” region is actually downward; see also Hartmann et al. (2001) for an explanation of how radiative cooling can exist at the tropopause in this region despite cold temperatures.

p.33057, l.25-26 : If possible, you should refer back to the TROPICO campaign in the discussion or conclusions. How has this study helped to inform or provide a baseline for TROPICO?

p.33058, l.3 : I’m not sure that I would say that water vapour is a “source of” photochemical reactions – it’s a source of OH and a key player in stratospheric photochemistry.

p.33058, l.13-14 : The wording of the beginning of this sentence (“If the process is well-captured by cloud-resolving models”) is confusing. I think that you mean “Although this process is well-captured in cloud-resolving models” – is this correct?

p.33061, l.2-4 : How different is this qualitative definition of the TTL from the definition based on MLS pressure levels? The locations of the LZRH and CP change by region – are the results in any of the study regions sensitive to the definition of the TTL?

p.33061, l.8 : AURA is not an acronym – it should be replaced with Aura.

p.33061, l.15 : The wording of this sentence is difficult to follow. Is it that the precision

ACPD
13, C12199–C12204, 2014

varies from 40% at 220 hPa to 6% at 31 hPa and the accuracy ranges from 25% at 220 hPa to 4% at 31 hPa. Should these values be preceded by $\pm$?

p.33061, l.23 : v3.3 is biased relative to v2.2 – does this bias represent an improvement in MLS estimates of IWC? Is it clear at this point which version is more accurate?

p.33063, l.4-5 : The 100 hPa day–night differences only appear to be out of phase with the 177 hPa differences over portions of south tropical South America and south tropical Africa, and over Africa the region that is out of phase doesn't line up with the largest signal at 177 hPa. Over other regions (and during JJA), the variations seem to be small or in phase with the UT.

p.33063, l.11-14 : Are relative humidities sufficiently high at 56 hPa in this region to support a diurnal cycle in thin cirrus / sublimation?

p.33064, l.17-19 : Is the amplitude of the diurnal cycle in temperature quantitatively consistent with the diurnal variation of H2O, or only qualitatively? More specifically, can the amplitude of the diurnal cycle in temperature fully account for the amplitude of the diurnal cycle in water vapour? Does the MLS temperature data agree with COSMIC in sign / magnitude?

p.33064, l.21 : Does "such event" refer to the diurnal cycle of COSMIC temperature? Please clarify.

p.33066, l.19 : The vertical location of the hygropause appears to vary substantially by season.

p.33067, l.8-10 : It's difficult to tell from the figure whether the vertical propagation of the TTL summer maximum is any faster than the vertical propagation of the TTL winter minimum (also, shouldn't these be "winter maximum" and "summer minimum" since Fig. 4 shows the southern hemisphere?).

p.33067, l.23 : "6% weaker"; "3% weaker" – are these relative or absolute differences? Specifying the amplitude or maxima/minima (e.g., "xx% relative to yy% in the southern hemisphere") may help to avoid confusion here.

p.33068, l.4-25 : I can't clearly identify the weakening/strengthening of the amplitude in the UT/TTL that is supposed to be related to ENSO in these figures. It looks like the amplitude in the TTL strengthens in both 2008–2009 and 2009–2010, while the amplitude in the UT weakens in both years. . .

p.33069, l.10 : No sign of diurnal variation in what? Water vapor? Tropopause temperature/vertical location? Please clarify.

p.33069, l.19-22 : I don't follow the two implications here. My understanding is that the two possible effects should be (1) drying by condensation occurring because of the relatively low temperatures in cold overshooting air, or (2) moistening by the subsequent sublimation of ice crystals injected by overshooting convection.

p.33070, l.12-13 : Does a greater efficiency of moistening necessarily mean more intense convection? How does the background RH compare among these regions? By many measures (lightning, radar reflectivity), convection over south tropical Africa is more intense than convection over south tropical South America, especially during DJF (e.g., Petersen and Rutledge, 2001). If the amplitude of the diurnal cycle in water vapour is entirely attributable to the intensity of overshooting convection, how is this consistent with the amplitude being greater over south tropical South America than over south tropical Africa?

p.33070, l.16–18 : What do these results mean, if anything, regarding the global impact of deep continental convection in the TTL/LS? For instance, Fig. 6 suggests that the amplitude of the diurnal cycle over the convective regions is very small (less than 5%) relative to the amplitude of the typical seasonal cycle in the TTL/LS; on the other hand, MLS may substantially underrepresent the diurnal cycle in water vapour at these levels (cf. Fig. 1). Do you feel comfortable making any statements about this at this point?

p.33071, l.18-21 : Is there any indication from previous work that ice crystals from

ACPD
13, C12199–C12204, 2014

overshooting convection can moisten the atmosphere at 56 hPa? At the very least, it needs to be shown that these diurnal cycles are not artifacts of the retrieval (e.g., averaging kernel, a priori profiles, covariability with temperature).

p.33072, l.15-19 : This argument regarding the diurnal cycle of water vapour at 56 hPa over the Asian monsoon region requires further discussion and support. Is there any published evidence of cirrus clouds at this altitude (e.g., SAGE II, CALIPSO)?

p.33072, l.25 : Should "daytime" at the end of this line be "nighttime"?

p.33073, l.5-16 : As mentioned above, I recommend integrating this appendix with the main text of the manuscript.

References

Hartmann, D. L., J. R. Holton, and Q. Fu, The heat balance of the tropical tropopause, cirrus, and stratospheric dehydration, Geophys. Res. Lett., 27, 1969–1972, 2001.

Liu, C. and E. J. Zipser, Implications of the day versus night differences of water vapor, carbon monoxide, and thin cloud observations near the tropical tropopause, J. Geophys. Res., 114, D09303, doi:10.1029/2008JD011524, 2009.

Petersen, W. A. and S. A. Rutledge, Regional variability in tropical convection: Observations from TRMM, J. Climate, 14, 3566–3586, 2001.

Sherwood, S. C., A stratospheric "drain" over the maritime continent, Geophys. Res. Lett., 27, 677–680, 2000.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 33055, 2013.

ACPD

13, C12199–C12204, 2014