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Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Effects of tropical deep convection on interannual variability of tropical tropopause layer water vapor" *by* Hao Ye et al.

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Specific comments:

The regression model, based on BDC, QBO and ΔT parameters, is an extension of Dessler et al., 2014 (D14). The accurate simulation of H_2O in the trajectory model is evidence that tropopause temperatures primarily control H_2O (as acknowledged here), and the regression model then accounts for variability of tropopause temperature. This is why the BDC accounts for most of the H_2O variance, as the BDC (heating rates) are closely proportional to temperature. The component of H_2O variance tied to tropospheric temperatures (ΔT) is relatively small in the regression model, with larger relative uncertainties (the corresponding H_2O variations for ΔT in Fig. 4 are < 0.1

ppmv, versus $\sim$ 0.5 ppmv for the BDC in Fig. 2). Time series of ΔT (Fig. 4 in D14) show that ΔT is mainly a proxy for ENSO variability, which explains the see-saw spatial structures in Fig. 4 (consistent with the patterns in Figs. 5-6). This ENSO spatial structure was discussed recently in Konopka et al., 2016, JGR, which should be referenced.

Response: The reference (Konopka et al., 2016) has been added (page 6, line 11 and page 9, line 1).

The key points of this paper relate to the small differences between the ΔT regression fits for MLS observations (or GEOSCCM model) and trajectory model results. To be convincing, the authors need to explain why the convection effect (persistent moistening) is associated with the ΔT (ENSO) regression, and demonstrate links to observed convection. Is there in fact more convection (in a global sense) when the troposphere is warm?

Response: To demonstrate the correlation between convection and the tropical warming, we added a scatter plot of tropical average convective cloud occurrence frequency at 370 K from observation and 500 hPa ΔT (Fig. 6a); it shows that that the convective cloud occurrence frequency in the TTL increases with ΔT.

This also occurs in the models. Dessler et al. (2016) (their Fig. 2) showed that convective ice in models' TTL increases in response to long-term warming. In this paper, we have also added a plot showing that IWC and net ice evaporation both increase with ΔT in response to interannual variability (Figs. 6b and 6c).

We also tested the correlation between convection and other regressors, i.e. BDC and QBO, and there is no apparent correlation like what found between convection and the tropical warming.

Overall, we view this as a reasonable assumption.

The ΔT regression differences (e.g. Fig. 4a vs. 4b) are likely within the uncertainty estimates of the regression fits, although this is not discussed.

Response: We have added a discussion about statistics testing of how confidently we can conclude that the tropical average coefficients are different (page 6, lines 16-20 and page 7, lines 13-14).

Furthermore, scatter plots (Figs. 4c,f,i) suggest an overall shift of the coefficients that is not dependent on location, and in particular the differences are not evidently related to regions of deep convection. Given these uncertainties, the argument that the differences are due to the neglected effects of deep convection are unconvincing.

Response: The reviewer makes a good point. While the hydration due to convection is localized, the impact is indeed spread throughout the tropics. That was not clear in the previous version and we have made changes throughout the paper to better reflect this.

My suggestion for revising the paper: 1) The authors could keep the present analysis, but provide more convincing discussion regarding the physical relationship between convection and ΔT, and in addition demonstrate statistical significance of the ΔT regression differences, and show clear physical links to observed convection.

Response: As discussed above, we have added new figures to connect ΔT and convective ice in observations and models (Figs. 6b and 6c). We also show that the ice evaporation rate in the GEOSCCM also increases with ΔT (Fig. 6c). While somewhat circumstantial, we feel the case we've made is nonetheless convincing.

2) A more convincing argument could be made by systematically analyzing the differences between observations and trajectory model results, and demonstrating that

these differences are consistent with convective influence (e.g. using their spatial and temporal characteristics, and links with observed convection).

Response: This is not a new idea. One of us (AED) tried to do something like this about 10 years ago and it just didn't work. We know that other groups (such as one at JPL) also tried doing this. The main problem is that the TTL is relatively close to saturation, so any individual convective event doesn't add that much water. As a result, it's hard to pull the signal of that out of the background noise, which is considerable due to trajectory uncertainty and noise in the individual MLS measurements. Because of this prior experience, we do not judge this is a profitable course of research.