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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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This paper explores variability of TTL water vapor from satellite observations, trajectory model calculations and GEOSCCM results, aiming to make a convincing argument for a direct effect of deep tropical convection. The calculations are based on multiple regression analysis of the different data sets, and the key points regarding convection are deduced from the regression coefficients related to tropospheric temperature (500 hPa zonal average temperature). The trajectory model does an excellent overall job of simulating interannual changes in water vapor, which is due to the accurate tropical tropopause temperatures input to the model. However, there are small systematic differences between the regression of the observed MLS water vapor onto tropospheric temperature and the results from the trajectory model, and the authors interpret this difference as evidence for the impact of deep convection. The results are

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Discussion paper

repeated using GEOSCCM model simulations with similar results, and further analyses of the GEOSCCM model with parameterized convective ice are used to estimate the ice contribution to stratospheric water vapor. While the different results point to possible effects related to deep convection, a convincing argument is not made based on the tropospheric temperature regressions (which I believe are mainly reflecting ENSO variations, as discussed below). In fact, there is no clear discussion of why the effects of deep convection should show up primarily in the tropospheric temperature regressions, as opposed to the other regression terms. My recommendation is that the authors provide more convincing evidence before the paper is acceptable for publication.

Specific comments:

The regression model, based on BDC, QBO and dT 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 (dT) is relatively small in the regression model, with larger relative uncertainties (the corresponding H_2O variations for dT in Fig. 4 are < 0.1 ppmv, versus ~ 0.5 ppmv for the BDC in Fig. 2). Time series of dT (Fig. 4 in D14) show that dT 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.

The key points of this paper relate to the small differences between the dT 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 dT (ENSO) regression, and demonstrate links to observed convection. Is there in fact more convection (in a global sense) when the troposphere is warm? The dT regression differences (e.g. Fig. 4a vs. 4b) are likely within the uncertainty estimates of the regression fits, although this is not discussed. 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.

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 dT, and in addition demonstrate statistical significance of the dT regression differences, and show clear physical links to observed convection. 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).

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