Atmos. Meas. Tech. Discuss.,
doi:10.5194/amt-2016-157-AC3, 2016

Atmospheric Measurement Techniques Discussions

AMTD

Interactive comment

Interactive comment on "Recent divergences in stratospheric water vapor measurements by frost point hygrometers and the Aura Microwave Limb Sounder" *by* Dale F. Hurst et al.

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Received and published: 8 August 2016

The authors would like to thank the referees for their constructive comments, as these were helpful in improving this manuscript. Below, we provide reviewer's comments, our detailed responses to each comment and any manuscript changes warranted by the reviewer's comments.

Reviewer Comment: This is an easy paper to review. The focus is on comparisons of water vapor measured by balloon sondes at five different locations versus MLS satellite retrievals for the time period 2004-2015. Time series of differences show changes over time, with a recent divergence of the two measurement types that is similar at the different sounding locations. The details of the calculations seem reasonable: the comparisons are based on vertically averaging the balloon measurements for appropriate comparisons to the satellite retrievals, and there is substantial care in handling the statistics of deriving piecewise trends to the difference time series. Although the time series are short, the results are shown to be statistically robust, and the similarity of results among vertical levels and among stations is convincing. The net results suggest a possible recent drift in the satellite measurements; having an expert on the MLS water vapor retrievals as one of the lead authors helps convince that the comparisons are done correctly. Overall the analyses seem straight-forward, and the paper is concise and well-written (although describing all of the statistical results in words gets a little tedious). These results are interesting and I recommend publication basically as-is.

My only comment regards the convolution with MLS averaging kernels: I expect the calculations involve using the MLS a priori and calculating quantities in log (H2O), as appropriate for comparisons to MLS. This should be stated explicitly in Section 2.

Author Comment: Admittedly, we took a shortcut here and did not include details of how the FP profiles were convolved with the MLS averaging kernels because this was presented in detail in Hurst et al., 2014. To be more complete we have added a few sentences to the manuscript that describe this process.

Author Revision: This revision required the re-ordering and slight re-wording of existing paragraphs before the new information was included. The revised text now reads:

"Evaluations of biases and drifts in coincident FP and MLS measurements of water vapor require that their profiles are matched in space and time. The same spatial criteria presented as "coincidence criteria set #1" in Hurst et al. (2014), within $\pm 2^{\circ}$ latitude and $\pm 8^{\circ}$ longitude, were employed to identify MLS profiles proximate to the five FP sounding sites. The spatially coincident MLS retrievals are plotted as time series along with the FP mixing ratios at 68 hPa over each site (Figure 1). Note in Figure 1 that, towards the end of each record, many of the markers representing FP mixing ratios reside near the lower limits of the MLS data envelope.

For this work a criterion of ±18 hours was used to identify temporally coincident MLS and FP profiles. This enabled MLS profiles to be compared with 94-100% of the FP soundings at each site. Employing the spatial and temporal criteria together, an average of 4-6 spatiotemporally coincident MLS overpass profiles were identified per FP sounding at each of the 5 sites (Table 1). As in Hurst et al. (2014) the multiple MLS profiles coincident with each FP flight were distilled into a single "median" coincident profile composed of the median MLS mixing ratio at each pressure level. Our choice to use median rather than mean mixing ratios reduces the potential for any anomalous MLS retrievals to skew the values used for this comparison.

Before FP-MLS differences were computed, each FP profile was convolved with the MLS averaging kernels to degrade its high vertical resolution to the ∼3 km resolution of lower stratospheric MLS retrievals and place the FP mixing ratio "retrievals" on the MLS pressure grid (Read et al., 2007; Lambert et al., 2007). Each convolution employed a forward model, operating in log(P)-log(H2O) space, that ingests both the FP profile and an a priori profile (Read et al., 2007). We used the MLS median profiles as a priori profiles because they produce convolved profiles equivalent to those generated using the actual MLS a priori profiles (Hurst et al., 2014). FP profiles were independently convolved with the MLS v3.3 and v4.2 averaging kernels for 8 MLS retrieval pressure levels: 100, 83, 68, 56, 46, 38, 32 and 26 hPa. FP mixing ratios were not retrieved at pressures <26 hPa because the averaging kernels require data above the typical maximum altitude of high-quality FP measurements. Although convolved FP retrievals at pressures >100 hPa are feasible, the coincidence criteria applied to FP and MLS retrievals at pressure levels 100-26 hPa produced very noisy comparison results at >100 hPa, presumably due to the much greater variability of water vapor at pressures >100 hPa, especially in the tropics. Applying more stringent coincidence criteria to improve the spatiotemporal matching of FP and MLS data below 100 hPa severely reduces the number of coincident profiles at each site and diminishes the value of the statistics generated by this type of comparison."

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-157, 2016.