Introduction

Dehydration within the TTL regulates the amounts of water vapor entering the tropical lower stratosphere. It should not be assumed that dehydration is always 100% efficient; some air masses exiting the TTL are supersaturated or even subunaturated. Consequently, high accuracy water vapor measurements in the TTL are required to accurately quantify the efficiency of dehydration. A growing number of TTL water vapor data sets exist, but important discrepancies between them continue to limit our understanding of dehydration in the TTL. Here we demonstrate how small water vapor measurement biases between frost point hygrometers (FPs) and the Aura Microwave Limb Sounder (MLS) can lead to significant disparities when evaluating the efficiency of dehydration within the TTL.

Hurst et al (2014) reported agreement greater than 1% between the NOAA frost point hygrometer and MLS from 68 to 26 hPa over three sites, including Hilo, Hawaii. Below 68 hPa, at 83 and 100 hPa, statistically significant biases of 0.1 to 0.3 ppmv (3 to 8%) were found. Here we extend the comparison to upper tropospheric pressure levels 121 and 147 hPa, and augment the analysis with FP data from San José, Costa Rica.

The Instruments

MLS

- Near-global coverage
- 830 profiles per day
- Low vertical resolution (3 km)
- Operational since August 2004
- Using MLS v3.3 retrievals

FPs

- 7 routine launch sites worldwide
- Only 2 sites are tropical: Hilo, Hawaii and San José, Costa Rica
- 3-2 soundings per month at each site
- From the surface to ~20 hPa
- High vertical resolution (3-30 m)

The Approach

Water Vapor Losses to Dehydration in the TTL

Figure 6. The losses of water vapor to dehydration in the TTL \(\chi_{\text{WV}}\) implied by each data set are (intuitively) proportional to the amount of water vapor entering the bottom of the TTL near 147 hPa. The water vapor losses inferred from the FP and MLS data are very different; MLS losses average 58 ± 8% of the FP losses. These disparities lead to substantial uncertainties in our understanding of dehydration processes in the TTL.

FP-MLS Measurement Biases

Figure 3. (a) Markers show FP-MLS differences for individual FP soundings while curves depict moving averages and 95% CIs of the moving averages. (b) Mean FP-MLS biases for the combined FP data sets over the full record interval. Though statistically significant, none of the mean biases exceed the combined instrument measurement uncertainties.

Example Profiles

Figure 4. The water vapor loss to dehydration in the TTL \(\chi_{\text{WV}}\) determined from FP profiles at both sites are approximately twice those based on MLS data. MLS-based RH values at the CPT are almost always greater than those based on FP measurements.

FP and MLS Frequencies of Saturation and Supersaturation at the CPT and 147 hPa

Figure 5. The FP-MLS measurement biases biases produce very different frequencies of saturation and supersaturation at the CPT over San José and at 147 hPa over both sites.

Conclusions

- Statistically significant biases exist between water vapor measurements by the Aura MLS and two frost point hygrometers (NOAA FPH and CFH) at 83, 100, 121 and 147 hPa over Hilo, Hawaii and San José, Costa Rica.
- The biases make the MLS-based frequency of supersaturation at the CPT over San José but does not significantly reduce the discrepancy between MLS- and FP-inferred water vapor losses to dehydration in the TTL.

References