Local Measurements, Global Studies: The Utility of Balloon-borne Frost Point Hygrometer Measurements for Studying Global Stratospheric Water Vapor

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Despite the number density of stratospheric water vapor (SWV) being 5 orders of magnitude less than at the surface, it has an inordinate influence on global energy balance and a significant impact on stratospheric ozone chemistry. Variations in SWV on monthly to decadal scales are predominantly controlled by variations of temperature in the tropical tropopause layer that are impacted by numerous potentially interrelated phenomena such as the El Niño Southern Oscillation (ENSO), the Quasi-Biennial Oscillation (QBO), variations in the lower branch of the Brewer-Dobson circulation, and increasing amounts of greenhouse gases.

In this presentation, I will argue that understanding variability and long-term changes in SWV requires a synergy of long-term measurements from both satellite sensors and balloon-based hygrometers. Although the global coverage provided by satellites is crucial, the high vertical resolution and inherent accuracy of "local-scale" balloon hygrometer measurements provide three important aspects of global monitoring: 1) confirming and quantifying short-term variability seen in satellite records, 2) detecting and potentially correcting biases and drifts in the satellite data, and 3) bridging potential gaps in the satellite data record. I will present examples of each of these, focusing on the recent near-record breaking swings in SWV, as well as how frost point hygrometer measurements inform the interpretation of global climate models and merged satellite data records such as the Stratospheric Water and OzOne Satellite Homogeneized (SWOOSH) data set.

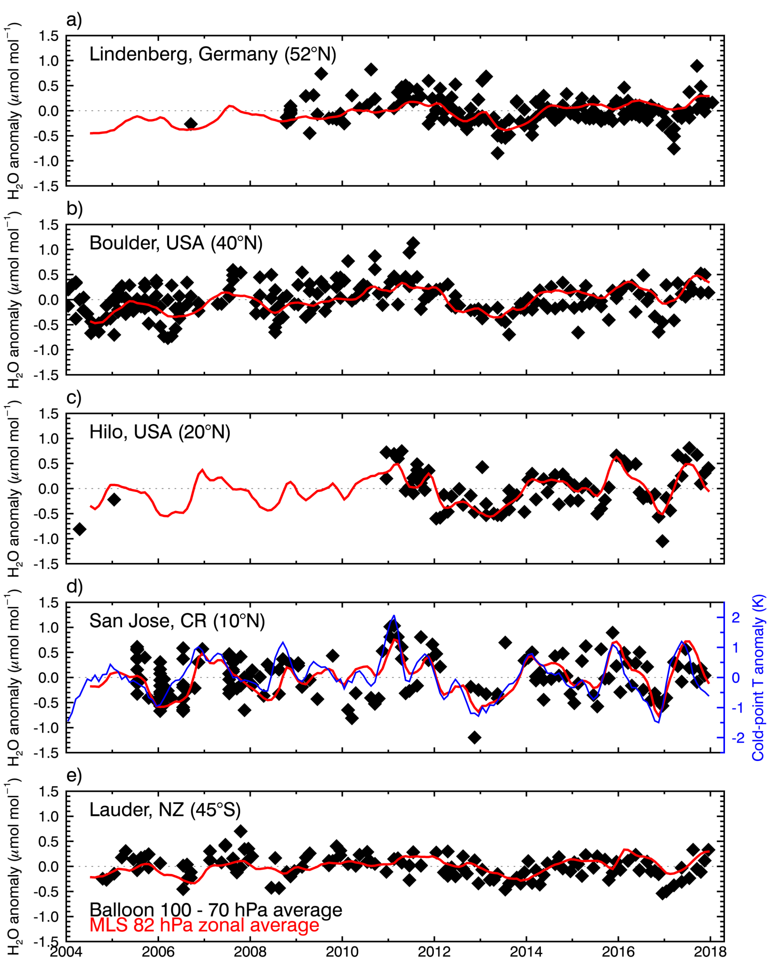

Figure 1. Lower stratospheric water vapor anomalies over five balloon-borne frost point (FP) hygrometer stations. Each panel shows the lower stratospheric anomalies of individual FP soundings (black) and of monthly zonal averages of Microwave Limb Sounder (MLS) retrievals at 82 hPa in the 5° latitude band containing the FP station (red). High-resolution FP vertical profile data were averaged between 70 and 100 hPa to emulate the MLS averaging kernel for 82 hPa. Each MLS monthly zonal mean was determined from 2,000–3,000 profiles. Anomalies for MLS and FP data are calculated relative to the 2004 – 2017 period for sites except for Lindenberg (2009 – 2017) and Hilo (2011 – 2017). Tropical cold-point tropopause anomalies based on the Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) reanalysis (d, blue curve).