Congregation of Vapors: Towards a Synoptic View of Water Vapor in Support of Airborne IR Astronomy

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The Stratospheric Observatory for Infrared Astronomy (SOFIA) airborne astronomical observatory operates at the physical boundary between the troposphere and stratosphere, and at the intellectual boundary between atmospheric science and infrared astronomy. Planning and calibration at water-sensitive wavelengths, either in narrow bands at wavelengths < 28 μm or throughout the 28-300 μm range, requires the prediction and measurement of the total precipitable water (TPW) above the aircraft when observing at altitudes between 10.7 and 13.7 km. Nadir sensors, limb sensors and *in situ* radiosonde measurements cannot simultaneously provide the sensitivity and temporal, spatial and vertical resolution required to calibrate SOFIA data. Thus, SOFIA has an on-board 183 GHz radiometer (WVM) to measure TPW. Yet using atmospheric models to convert WVM TPW to infrared radiation (IR) absorption corrections is not straightforward. Even cross-calibration between different bands of the same SOFIA instrument give inconsistent results (Guan et al., 2012). In search of additional data or model insights, we looked for correlations between mass mixing ratio (MMR) and TPW in NOAA frost point hygrometer (FPH) data to assess the degree to which MMR at a given altitude is a good predictor of TPW above that altitude. FPH MMR data is sampled every 0.25 km at altitudes up to 25 km, and collected during monthly balloon flights over Boulder (Colorado), Hilo (Hawaii), and Lauder (New Zealand) under mostly clear sky conditions. TPW is then simply the integral over pressure of MMR, with a small constant offset for the contribution above 25 km. We combined an empirical power-law with the Haas & Pfister (HP98) model to jointly fit data from all 3 launch sites, examples of which are shown in Figure 1. We conclude that an automated atmospheric science research package containing an aircraft FPH (Buck Instruments CR-2) and possibly other instruments, similar to the successful IAGOS-CARIBIC package for commercial airliners, would allow SOFIA to serve atmospheric science as well as astronomy.

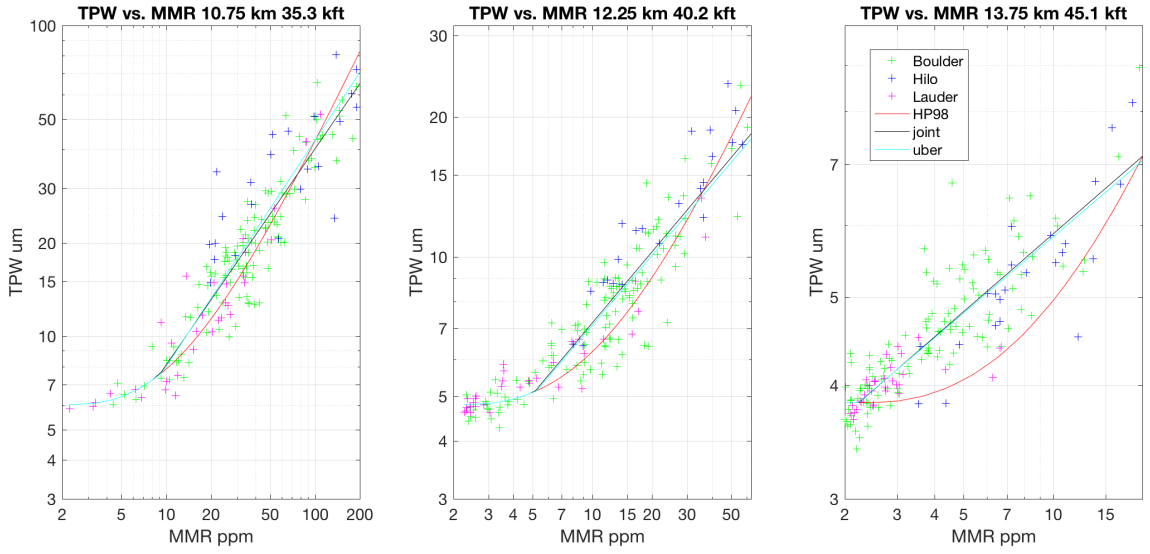

Figure 1. Example plots for various altitudes showing correlation of TPW above altitude vs. Mass Mixing Ratio (MMR) at altitude for all FPH descent data from all 3 stations. The uber fit lets the power-law prefactor and exponent themselves be simple functions of altitude. At the lowest MMRs, the uber, joint, and HP98 fits are indistinguishable.