**NOAA Frost Point Hygrometer (FPH) Comparisons, Measurement Uncertainties and Recent Instrument Improvements**

E. Hall[1,2], A.F. Jordan[1,2], D.F. Hurst[1,2], S.J. Oltmans[3], H. Vömel[4], B. Kühnreich[5,6], V. Ebert[7,6], S. Khaykin[8], S. Davis[1,9] and L. Kalnajs[10]

[1]Cooperative Institute for Research in Environmental Sciences (CIRES), University of Colorado, Boulder, CO 80309; 303-497-4288, E-mail: Emrys.Hall@noaa.gov
[2]NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO 80305
[3]Retired from NOAA Earth System Research Laboratory, Global Monitoring Division (GMD), Boulder, CO 80305
[4]National Center for Atmospheric Research (NCAR), Earth Observing Laboratory, Boulder, CO 80307
[5]Physikalisch-Technische Bundesanstalt, Braunschweig, Germany
[6]Center of Smart Interfaces, Technische Universitat Darmstadt, Germany
[7]Physikalisch-Technische Bundesandstalt PTB, Braunschweig, Germany
[8]LATMOS, CNRS, Université de Versailles St. Quentin, Guyancourt, France
[9]NOAA Earth System Research Laboratory, Chemical Sciences Division (CSD), Boulder, CO 80305
[10]University of Colorado, Laboratory for Atmospheric and Space Physics (LASP), Boulder, CO 80309

Accurate measurements of upper tropospheric and lower stratospheric water vapor contribute to many processes and feedback mechanisms and play an important role on the radiative forcing of our climate. The NOAA frostpoint hygrometer (FPH) is a balloon-borne instrument flown monthly at three sites to measure water vapor profiles up to 28 km. The ongoing 37 year FPH record from Boulder, Colorado is the longest continuous stratospheric water vapor record.

The NOAA FPH has an uncertainty in the stratosphere that is < 6 % and < 12 % in the troposphere (2-σ). In 2008, a digital microcontroller version of the instrument improved upon the older versions by incorporating sunlight filtering along with better frost control. A new thermistor calibration technique was applied in 2014. This decreased the error in the thermistor calibration fit from 0.06 °C to less than 0.01 °C over the full range of frostpoint or dewpoint temperatures measured during a profile (-93 °C to +20 °C).

Atmospheric chamber comparisons between the NOAA FPH and the direct tunable diode laser absorption spectrometer MC-PicT-1.4 during AquaVIT-2 in Karlsruhe, Germany are presented. Dual instrument balloon flights comparing vertical profiles between the NOAA FPH and the cryogenic frostpoint hygrometer (CFH) as well as the Lyman-alpha fluorescence hygrometer (FLASH-B) also show good agreement providing confidence in the accuracy of the FPH measurements.

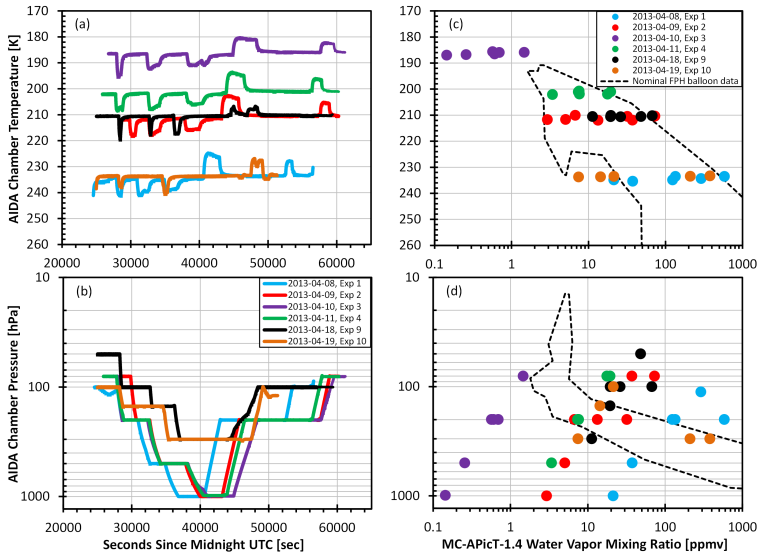


**Figure 1.** Daily time series of temperatures (a) and pressures (b) for all data during the six non-blind AquaVIT-2 experiments are shown. The relationship between chamber temperature and pressure with 36 individual stable water vapor mixing ratio segments is shown in panels (c) and (d), respectively. Areas contained by dashed lines indicate the range of water vapor and temperature in the actual atmosphere.