Data Set Description:
PI: Dr. Belay Demoz, Dr. Ricardo Sakai
Instrument: Cryogenic Frostpoint Hygrometer (CFH)
Sites: Howard University, Beltsville, MD, 39.0541°N, 76.8775°W, 53 msl
Measurement quantities: pressure, temperature, relative humidity, geopotential height, frost point temperature, water vapor mixing ratio, mixing ratio uncertainty, vertical resolution, ozone mixing ratio, ozone partial pressure, GPS altitude, latitude and longitude, horizontal wind speed and direction. Simultaneous ozone measurements on the payload of some soundings are considered ancillary data.

Contact Information:
Name: Dr. Belay Demoz
Address: University of Maryland, Baltimore County. Department of Physics, room 424
1000 Hilltop Circle
Baltimore, MD 21250
Phone: (410)455-2715
Email: bdemoz@umbc.edu

Name: Dr. Ricardo Sakai
Address: Howard University, Beltsville Campus
7501 Muirkirk Rd,
Beltsville, MD 20705
Phone: (301)419-9035
Email: ricardo.k.sakai@Howard.edu

Data quality information:
Name: Dr. Holger Vömel
Address: National Center for Atmospheric Research, Earth Observing Laboratory
3090 Center Green Drive, Boulder, CO 80301, USA
Phone: (303)497-8837
Email: Voemel@UCAR.EDU

Reference Articles:

Vömel, H., T. Naebert, R. Dirksen, and M. Sommer, (2016): An update on the uncertainties of water vapor measurements using Cryogenic Frostpoint Hygrometers, Atmos. Meas. Tech., 9, 3755-3768, doi:10.5194/amt-9-3755-2016.

Vömel, H., D. E. David, and K. Smith (2007), Accuracy of tropospheric and stratospheric water vapor measurements by the cryogenic frost point hygrometer: Instrumental details and observations, J. Geophys. Res., 112, D08305, doi:10.1029/2006JD007224.

Vömel, H., J. E. Barnes, R. N. Forno, M. Fujiwara, F. Hasebe, S. Iwasaki, R.Kivi, N. Komala, E. Kyrö, T. Leblanc, B. Morel, S.-Y. Ogino, W. G. Read, S. C. Ryan, S. Saraspriya, H. Selkirk, M. Shiotani, J. Valverde Canossa, D. N. Whiteman, (2007), Validation of Aura/MLS Water Vapor by Balloon Borne Cryogenic Frostpoint Hygrometer Measurements, J. Geophys. Res., 112, D24S37, doi:10.1029/2007JD008698.

Instrument Description:

The Cryogenic Frostpoint Hygrometer (CFH) is the first lightweight digital balloon-borne hygrometer based on the original NOAA analog Frostpoint Hygrometer. The CFH uses the chilled-mirror principle, in which a water condensate is formed on a small temperature-controlled mirror, which is exposed to ambient air flowing across the mirror. An optical detector senses the condensate by measuring the amount of light that is reflected off the mirror and a digital controller regulates the temperature of the mirror in order to maintain a constant reflectivity of the condensate covered mirror surface. To the extent that the reflectivity is constant, the condensate on the mirror is assumed to be in equilibrium with the gas phase. The temperature of the mirror is measured using a small individually calibrated thermistor. Under the condition of equilibrium, it is considered to be equal to the ambient dew point or frost point temperature, depending on whether the condensate phase is liquid or ice.

Algorithm Description:

The partial pressure of water vapor (ew) is calculated directly from the measured frost point temperature using the Goff-Gratch equation, which relates the saturation vapor pressure over ice or over liquid to the condensate temperature. The Goff-Gratch equation corresponding to the correct phase of the condensate (liquid or ice) has to be used to calculate the partial pressure. The water vapor mixing ratio (H2O) in dry air is calculated from ew using

H2O (ppmv) = ew/(P-ew) (x1e^6)

where P is the measured atmospheric pressure.

Frost point temperatures are converted to relative humidity values by dividing the water vapor partial pressure by the saturation water vapor pressure (es) at the measured atmospheric temperature.

RH = ew/es (x100%)

The uncertainty of RH values calculated in this way depends on the uncertainty of the frost point temperature measurements and the radiosonde measurements of temperature that determine es.

Expected Total Uncertainty of Instruments:

- Vaisala RS80 Radiosonde Measurements of Pressure, Temperature and Relative Humidity

  Pressure: Total uncertainty +/- 1 hPa (at 100 hPa)
  Total uncertainty +/- 0.1 hPa (at 10 hPa)

  Air Temperature: Total uncertainty +/- 0.3 K
  Relative Humidity: Total uncertainty +/- 5% RH

- InterMet iMet-1-RSB Measurements of Pressure, Temperature and Relative Humidity (PTU)

  Pressure: Total uncertainty +/- 2 hPa (at 1000 hPa)
  Total uncertainty +/- 1 hPa (at 100 hPa)
  Total uncertainty +/- 0.1 hPa (at 10 hPa)

  Air Temperature: Total uncertainty +/- 0.3 K
  Relative Humidity: Total uncertainty +/- 5% RH

  Geopotential Height: Calculated using radiosonde PTU measurements.

- Vaisala RS41 Measurements of Pressure, Temperature and Relative Humidity (PTU)

  Pressure (> 100 hPa): Total uncertainty +/- 0.4 hPa (at 1000 hPa) (k=2)
  Pressure (< 100 hPa): Total uncertainty +/- 0.3 hPa (at 10 hPa) (k=2)

  Air Temperature (>16 km): Total uncertainty +/- 0.4 K (k=2)
  Relative Humidity: Total uncertainty +/- 4 % RH (k=2)

  Geopotential Height: Calculated using radiosonde PTU measurements.

- CFH Frost Point Temperature:

  Total uncertainty +/- 0.1 K

  Water Vapor Mixing Ratio:
  Total uncertainty typically +/- 2 % (1 sigma)
  The total uncertainty is provided as additional column within the data.
  The vertical width of the smoothing kernel for which this uncertainty applies is also provided as part of the data.
  For the algorithm to estimate the water vapor uncertainty see Vömel et al., (2016)

Measurement History:

Campaign based soundings using Vaisala RS80 radiosondes:	July 2006 through Aug 2007
	Mar 2009 through April 2009
Campaign based soundings using Intermet Imet-1-RSB radiosondes:	May 2011 through June 2011
Routine soundings using Intermet Imet-1-RSB radiosondes:	Oct 2014 through Oct 2019
Routine soundings using Vaisala RS41 radiosondes:	Nov 2019 through present