File Revision Date:
10 Aug 2023

Data Set Description:

PIs:	Dr. Ryan Stauffer, Dr. Holger Vömel
Instrument:	Cryogenic Frostpoint Hygrometer (CFH)
Sites:	Universidad de Costa Rica, San Pedro, San Jose, Costa Rica
	9.93955 N, 84.04234 W, 1231 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.

San Jose, Costa Rica is also a SHADOZ site. Simultaneous ozone measurements on the same payload are considered ancillary data.
All ozone profiles should be accessed through SHADOZ (https://tropo.gsfc.nasa.gov/shadoz/CostaRica.html/).

Contact 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

Name: Dr. Ryan Stauffer
Address: NASA/GSFC
8800 Greenbelt Rd, Greenbelt, MD 20771
Phone: (301)614-5552
Email: ryan.m.stauffer@nasa.gov

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Not at this time.

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.

Fujiwara, M., H. Vömel, F. Hasebe, M. Shiotani, S.-Y. Ogino, S. Iwasaki, N. Nishi, T. Shibata, K. Shimizu, E. Nishimoto, J. Valverde-Canossa, H. B. Selkirk and S. J. Oltmans (2010), Seasonal to decadal variations of water vapor in the tropical lower stratosphere observed with balloon-borne cryogenic frost point hygrometers, J. Geophys. Res., 115, D18304, doi:10.1029/2010JD014179.

Selkirk, H. B., H. Vömel, J. M. Valverde Canossa, L. Pfister, J. A. Diaz, W. Fernández, J. Amador, W. Stolz, and G. S. Peng (2010), Detailed structure of the tropical upper troposphere and lower stratosphere as revealed by balloon sonde observations of water vapor, ozone, temperature, and winds during the NASA TCSP and TC4 campaigns, J. Geophys. Res., 115, D00J19, doi:10.1029/2009JD013209.

Schoeberl, M., H. Selkirk, A. Douglass, and H Vömel (2015): Sources of Seasonal Variability in Tropical UTLS Water Vapor and Ozone: Inferences from the Ticosonde Dataset at Costa Rica, J. Geophys. Res., 120, 9684–9701, doi:10.1002/2015JD023299

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.

<u>Expected Total Uncertainty of Instrument:</u>
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

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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.

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:

Start at Alajuela, Costa Rica (9.98 N, 84.21 W) using Vaisala RS80 radiosondes:	July 2005
Moved the site to Heredia, Costa Rica (10.0 N, 84.109 W)	October 2005
Moved the site to Alajuela, Costa Rica (9.98 N, 84.21 W)	May 2007
Moved the site to Heredia, Costa Rica (10.0 N, 84.109 W)	December 2009
Upgrade to InterMet iMet-1-RSB radiosondes	Sep 2010
Moved the site to San Pedro, San Jose, Costa Rica (9.94 N, 84.042 W)	March 2011
Upgrade to InterMet iMet-4-RSB radiosondes	Jul 2020