

## Seasonal to long-term variations of water vapor in the tropical lower stratosphere observed with balloon-borne hygrometers

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We present the results of tropical lower stratospheric in situ water vapor measurements using balloon-borne chilled-mirror hygrometers, i.e., the NOAA frost point hygrometers (FPH) and its upgraded version, the University of Colorado cryogenic frostpoint hygrometers (CFH). Measurements were made on a campaign basis at different locations in the tropics between 1993 and 2009. Major campaigns are: the Central Equatorial Pacific Experiment (CEPEX) in March 1993; the Soundings of Ozone and Water in the Equatorial Region (SOWER) in the eastern Pacific between 1998 and 2003 (mostly around March and around September) and in the western Pacific including Indonesia between 2001 and 2009 (in December or January); the TICOSONDE in Costa Rica between July 2005 and September 2008 (basically twice monthly with some intensive launches and some gaps); and others.

The water vapor profiles in the tropical lower stratosphere show a clear imprint of the seasonal cycle of tropopause temperature, the so-called tape recorder signal. The phase of the signal is generally consistent with that measured by satellite sensor, the Halogen Occultation Experiment (HALOE) on the Upper Atmosphere Research Satellite (UARS). However, its amplitude is greater than that measured by HALOE because of the much higher vertical resolution of balloon-borne hygrometers. The implications will be discussed. The profiles also show interannual variations, particularly the one associated with the Quasi-Biennial Oscillation. The time series of a 19-23-km layer average of each sounding data shows that the mixing ratios are 3-4 ppmv in the 1990s (in 1993 and in 1997-1999) and 3.5-4.5 ppmv in the 2000s; there may have been a general increasing trend in tropical lower stratospheric water vapor during the recent 20 years.