Seasonal variability of the tropical tropopause dehydration

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The concentration of stratospheric water vapor is largely controlled by the freeze drying processes taking place at the tropical tropopause. However, these processes are quantitatively not well understood and large uncertainties exist in the historic analysis and prediction of stratospheric water vapor.

The only long-term observations of water vapor in the tropical tropopause layer and the tropical lower stratosphere are conducted at San Jose, Costa Rica, in cooperation between NASA, the Universidad de Costa Rica and NCAR. This record currently spans 10 years, with approximately monthly is situ soundings of water vapor profiles between the surface and about 25 km.

These data show the tropical tape recorder at high vertical resolution and record changes occurring over this time period.

The tropical tropopause at Costa Rica exhibits a well understood seasonal cycle with warmest temperatures and highest water vapor mixing ratios during the northern hemispheric summer. Campaign based observations at San Cristobal, Galapagos, during the summer and winter, as well as campaign based observations in the Western Pacific region during northern hemispheric winter are consistent with this seasonal cycle.

The climatology of relative humidity over ice (RHi) at the cold point tropopause, on the other hand, does not show any strong seasonal cycle. Mean RHi values at the tropopause are within a few percent of saturation over ice throughout the year, indicating that on average the tropical tropopause temperature at Costa Rica is a good proxy for the amount of water vapor at the cold point.

The frequency distribution of RHi at Costa Rica shows a broad distribution roughly centered at 100% with supersaturation reaching up to 160% and sub-saturated values as low as 20%. These observations are not able to distinguish between in cloud and out of cloud observations and supersaturated observations may be in cloud free air prior to cloud formation and sub-saturated observations may be within evaporating clouds. At this point it is not obvious, why the mean value should be at 100% within the uncertainty of the measurement. Due to the inaccessibility of this region, there is little to no understanding of the longitudinal variation of these processes.

Soundings at Costa Rica may be well suited for validation of other in situ observations in particular of long duration balloon observations.