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Observations of TTL water vapor and cirrus properties from the NASA Global Hawk during the Airborne Tropical TRopopause EXperiment

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Despite its very low mixing ratios relative to the troposphere, water vapor in the lower stratosphere (LS) plays a significant role in Earth's radiative balance and climate system and is an important constituent in stratospheric chemistry. The low H_2O content of air entering the LS is established to first order by dehydration processes controlled by the cold temperatures of the tropical tropopause layer (TTL), especially over the western Pacific. Cirrus clouds occur with high frequency and large spatial extent in the TTL, and those occurring near the thermal tropopause facilitate the final dehydration of stratosphere-bound air parcels. Uncertainties in aspects of the nucleation and growth of cirrus cloud particles and the sparseness of in situ water vapor and cirrus cloud observations with sufficient spatial resolution limit our ability to fully describe the final stages of the dehydration process before air enters the LS in the tropics.

The NASA Airborne Tropical TRopopause EXperiment (ATTREX) measurement campaign has yielded more than 140 hours of sampling from the Global Hawk UAS in the Pacific TTL during deployments in winter 2013 and 2014, including more than 30 hours sampling TTL cirrus. Cirrus clouds were encountered throughout the TTL, up to the tropopause (17-18 km), with ice water contents (IWC) down to the detection limit of 3 μg m^{-3} and water vapor mixing ratios as low as 1.5 ppm. Most TTL cirrus sampled had particle number concentrations of less than 100 L^{-1}, but some had concentrations ranging up to more than 1000 L^{-1}. The mean value for relative humidity with respect to ice within cirrus was near 100%, but encompassed a range from $< 50\%$ to higher than 150%. The high spatial and temporal resolution in situ measurements of water vapor and cirrus cloud properties made during ATTREX provide an outstanding dataset by which to characterize the Pacific TTL environment and evaluate our current understanding of the dynamical and microphysical processes that result in the dehydration of stratosphere-bound air in this region. Here we present an analysis of the ATTREX water vapor, relative humidity and cirrus cloud ice crystal measurements and IWC data to investigate cirrus cloud formation in the TTL and the resulting potential for dehydration.