Physical processes controlling the spatial distributions of relative humidity in the tropical tropopause layer over the Pacific

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Abstract
The spatial distribution of relative humidity with respect to ice (RHI) in the boreal wintertime tropical tropopause layer (TTL, ≃14–18 km) over the Pacific is examined with the measurements provided by the NASA Airborne Tropical TRopopause EXperiment. We also compare the measured RHI distributions with results from a transport and microphysical model driven by meteorological analysis fields. Notable features in the distribution of RHI versus temperature and longitude include (1) the common occurrence of RHI values near ice saturation over the western Pacific in the lower to middle TTL; (2) low RHI values in the lower TTL over the central and eastern Pacific; (3) common occurrence of RHI values following a constant mixing ratio in the middle to upper TTL (temperatures between 190 and 200 K); (4) RHI values typically near ice saturation in the coldest airmasses sampled; and (5) RHI values typically near 100% across the TTL temperature range in air parcels with ozone mixing ratios less than 50 ppbv. We suggest that the typically saturated air in the lower TTL over the western Pacific is likely driven by a combination of the frequent occurrence of deep convection and the predominance of rising motion in this region. The nearly constant water vapor mixing ratios in the middle to upper TTL likely result from the combination of slow ascent (resulting in long residence times) and wave-driven temperature variability. The numerical simulations generally reproduce the observed RHI distribution features, and sensitivity tests further emphasize the strong influence of convective input and vertical motions on TTL relative humidity.

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