Wave Influence on Cirrus Clouds in the Tropical Tropopause Layer

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The tropical tropopause layer (TTL) is an important region for stratosphere-troposphere interactions, by serving as a transport gateway of air and equatorial waves entering the stratosphere. Waves propagating through the TTL to the stratosphere contribute to driving the mean tropical upwelling and quasi-biennial oscillation (QBO) of stratospheric wind. The chemical and physical processes in the TTL determine transport of atmospheric constituents into the stratosphere. Along with the wave-mean interaction, wave temperature variations affect TTL cloud formation that regulates water vapor and ozone depleting substances entering the stratosphere. Changes in these have significant impacts on the global radiation budget. Therefore, proper representations of TTL waves in climate models will be critical to simulate stratospheric water vapor, cirrus clouds in the TTL, and wave-driven mean circulation.

We will present characteristics of waves in the TTL observed in radiosondes, COSMIC GPS, and NASA's aircraft measurements during the Airborne Tropical TRopopause Experiment (ATTREX) mission. The ATTREX data also provide useful information on cloud occurrence in the TTL in relation with waves. We will show that thin layers of cirrus clouds are highly related to vertical structures of waves. Vertical wavelet analysis reveals that a significant wave spectrum is contributed by shallow waves at vertical wavelengths shorter than ~3 km. Our results suggest that coarse vertical resolution of current (re)analysis and climate models will underrepresent the wave impacts on the TTL processes, and will prohibit proper propagation of waves into the stratosphere.

Key words: cirrus clouds, tropical tropopause layer, equatorial waves, dehydration, stratosphere-troposphere exchange