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Multiscale variability of tropical tropopause layer characteristics during the 2011 DYNAMO field campaign

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The tropical tropopause layer (TTL) is a transition region that shares characteristics of both the troposphere and stratosphere. It is considered a gateway to the stratosphere and sets the boundary conditions for atmospheric tracers such as water vapor. Observations in this region show time variations across multiple scales that are not fully understood. In this study, we investigate the evolution of TTL properties and their vertical structure during the Dynamics of the Madden-Julian Oscillation (DYNAMO) field campaign from October-December 2011. This time period is particularly interesting in that two prominent MJO passages were seen over the tropical Indian Ocean. We use multiple datasets, including high vertical resolution observational data from three-hourly atmospheric soundings over the entire three month period. Cloud characteristics are determined from CALIPSO satellite data in addition to ground-based radar. We focus on Gan Island, Maldives (0.69S, 73.15E) to better understand the response of the TTL to MJO dynamics at the equator in the region of MJO initiation.

Observations show that the increase in deep convection and higher cloud top heights during the active phase of the MJO are associated with a significant lowering of the level of zero radiative heating. Furthermore, we find that thin tropopause level cirrus identified from CALIPSO data are present during periods of upper level cold anomalies prior to the active phase of the MJO, and may have a significant impact on TTL radiative heating rates. Characteristics of the observed background wave structures are also analyzed, and suggest convectively coupled equatorial waves with downward phase propagation. Bandpass filtering is used to isolate Kelvin wave activity, and shows a quadrature phase relationship in the temperature and zonal wind anomaly fields, with cooler temperatures co-varying with easterly anomalies. On shorter timescales, we investigate higher-frequency gravity waves excited by MJO convection.