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Thermal characteristics of the tropical tropopause layer in the CMIP5 models: the cold-point temperature

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The climatology, seasonality, and intraseasonal to interannual variability of the tropical tropopause layer (TTL) are examined primarily in terms of the 100-hPa temperature, using the state-of-the-art climate models that have participated in the Coupled Model Intercomparison Project Phase 5 (CMIP5). Both historical simulations and future projections based on the Representative Concentration Pathway (RCP) 8.5 scenario are used to evaluate model performance and to identify potential changes in the TTL temperature. It is found that historical simulations successfully reproduce the spatio-temporal structure of the TTL temperature in comparison to the reanalysis. The interannual variability associated with El Niño-Southern Oscillation (ENSO) and intraseasonal variability associated with equatorial waves are also reasonably well captured. However, the models show non-negligible biases in several aspects : 1) most models have a warm bias around the cold-point tropopause; 2) large inter-model differences occur in the amplitude of the seasonal cycle of the upper-tropospheric and lower-stratospheric temperature; 3) many models overestimate lower stratospheric warming in response to volcanic aerosols; 4) temperature variability associated with quasi-biennial oscillation (QBO) and Madden-Julian oscillation (MJO) are almost missing; 5) waves in the TTL exhibit wide range of variations among the models with unrealistically persistent Kevin waves in several models.

In a wam climate, the models robustly predict warming at 100 hPa but cooling at 70 hPa. A weakened seasonal cycle in the TTL temperature is also predicted in most models at both 100- and 70-hPa levels. Implication of these findings is briefly discussed in the context of the cross-tropopause water vapor transport and the related global climate change and variability.