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Using heating rates derived from CALIPSO measurements to diagnose transport pathways through the tropical tropopause layer

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It has been recognized that trace gas concentrations at the tropical tropopause serve as a chemical boundary condition for the stratosphere. As a result, there has been considerable recent interest in the transport pathways through the Tropical Tropopause Layer (TTL), typically defined as the layer between the main convective outflow layer (about 13 km) and the lowermost stratosphere. CALIPSO provides unprecedented information about the properties, regional distribution, and height distribution of clouds in the TTL. This information has recently been used in radiative transfer calculations to calculate the spatial distributions of radiative heating in the TTL. We use these radiative heating rates, along with diabatic trajectory calculations to determine the pathways of air parcels that ascend through the TTL and ultimately enter the stratosphere. We specifically address the following two science questions: (1) What fraction of air parcels detrained from the main convective outflow level actually make it to the tropical tropopause? (2) What convective outflow levels (ranging from the main outflow level near 13 km to the rare extreme convective systems that extend to near the tropopause (16-17 km)) dominate the flux of air into the stratosphere? (3) How well is transport through the TTL represented in large-scale models?