

Vertical and Horizontal Mixing in the Tropical Tropopause Layer

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Nearly all air enters the stratosphere through a single layer in the tropics. The tropical tropopause layer (TTL) is a transition region between the troposphere and stratosphere and its roles include regulating stratospheric chemistry and surface climate. Multiscale dynamics existing in the TTL range from transient convection to the hemispheric wave-driven circulation and the relative influences of these processes still remain unclear. This study pays special attention to vertical and horizontal mixing which are associated with breaking gravity waves and Rossby waves, respectively. We quantify the roles of these dynamics by taking advantage of the conservative nature of water vapor in the lower stratosphere. Unable to change concentration in the lowermost stratosphere after passing through the cold point, water vapor becomes a tracer for total transport and its signal is known as the tape recorder. This tape recorder is studied using observations, reanalysis data, a chemistry-climate model (CCM), and simple idealized modeling. Modifying past methods, we are able to capture the seasonal cycle of effective transport in the TTL and we introduce seasonally-dependent dynamics to a one-dimensional model and perform a parameter-sweep to test all possible dynamical combinations. Simulating with annual mean transports results in bimodality where either vertical advection or vertical mixing dominate. The solutions that depend on unrealistically large vertical advection disappear when seasonally-dependent transports are used. Overall, all datasets show that vertical mixing is as important to TTL transport as vertical advection itself even during boreal winter when advection peaks. The reanalysis and CCM have increased effective transport compared to observations, however, they rely on different dynamics. The reanalysis has amplified vertical mixing while the CCM has amplified vertical advection. This hints at the possible influence of spurious diffusion from data assimilation and its role in amplifying TTL transport.