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The impact of cirrus clouds on tropical troposphere-to-stratosphere transport

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Although it is well known that air enters the stratosphere preferentially through upwelling in the tropics, the exact mechanisms of troposphere-to-stratosphere transport (TST) are still unknown. Previously proposed mechanisms have been found either to be too slow (e.g., clear sky upwelling) to provide agreement with in situ tracer measurements, or to be insufficient in mass flux to act as a major supply for the Brewer-Dobson circulation (e.g., convective overshooting).

In this presentation, we show how clouds influence the radiative energy balance and trigger vertical motion in the Tropical Tropopause Layer (TTL). We evaluate whether the lofting of air via cirrus cloud-radiation interaction might offer an alternative path for TST, which is responsible for a significant fraction of the observed air mass transport. We find that a combination of deep convection from the planetary boundary layer into the TTL and subsequent upwelling associated with cirrus clouds and clear sky can explain the supply of air for the Brewer-Dobson circulation. Thus, upwelling associated with cirrus clouds offers a mechanism for the missing second stage, which links deep convection as first stage to the Brewer-Dobson circulation as third stage of TST.