EGU21-3133
https://doi.org/10.5194/egusphere-egu21-3133
EGU General Assembly 2021

Moisture fluxes in the tropics dominated by deep convection up to near tropical tropopause levels

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The role played by tropical storms in the tropical tropopause layer (TTL), the transitional layer regulating the flux into the stratosphere of trace gases affecting radiation and the ozone layer, has been a long-standing open question. Progress has been slow because of computational limitations and challenging conditions for measurements and most numerical studies have used simulations over limited domains whose results must be upscaled to the tropical surface to infer global impacts. We compute the first global observational estimate of the convective ice flux at near tropical tropopause levels by using spaceborne lidar measurements from CALIOP. The calculation uses a method to convert from lidar extinction to sedimenting ice flux and uses error propagation to provide margins of uncertainty. We show that, at any given level in the TTL, the sedimenting ice flux exceeds the inflow of vapor computed from ERA5 reanalysis, revealing additional ice transport and allowing to deduce the advective ice flux as a function of altitude. The contribution to this flux of large-scale motions (resolved by ERA5) is computed and the residual is hypothesized to represent the flux of ice on the convective scale. Results show without ambiguity that the upward ice flux in deep convection dominates moisture transport up to close to the level of the cold point tropopause.