Is convection important for controlling stratospheric humidity?

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We investigate the role of convection on stratospheric water vapor and upper tropospheric cloud fraction using two sets of complementary transport and microphysical models driven by MERRA-2 and ERA-Interim meteorological analyses: (1) computationally efficient ensembles of forward trajectories with simplified cloud microphysics, and (2) one-dimensional simulations with detailed microphysics along back trajectories. Convective influence along the trajectories is diagnosed based on TRMM/GPM rainfall products and geostationary infrared satellite cloud-top measurements, with convective cloud-top height adjusted to match the CloudSat, CALIPSO, and CATS measurements. We evaluate and constrain the model results by comparison with satellite observations and high-altitude aircraft campaigns (e.g., ATTREX, POSIDON).

Convection moistens the lower stratosphere by approximately 0.6 ppmv (about 15% increase) and increases the cloud fraction in the upper troposphere by roughly 15%. Convection moistens the upper troposphere and lower stratospheric region mostly by saturating the convectively-influenced parcels. Including lofted ice in the microphysics has a negligible impact on lower stratospheric humidity. The highest convection has a disproportionately large impact on stratospheric water vapor enhancement. Implications of these model results on the role of convection on present and future climate will be discussed.

Keywords: tropical tropopause layer, water vapor, cirrus clouds, stratosphere, convection, climate

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