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Impact of atmospheric convection on the isotopic composition of Tibetan precipitation using a combination of satellite data and atmospheric general circulation modeling

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Past precipitation isotopic composition recorded in natural archives from the Tibetan Plateau may provide valuable information about past variations of Indian monsoon intensity. However, the distribution of hydrological processes related to monsoon activity and how these processes change the isotopic composition of precipitation need to be characterized before these data can be used for this purpose. This study investigates how atmospheric convection affects the isotopic composition of Tibetan precipitation and water vapor at the daily time scale using isotopic data from precipitation samples, isotopic measurements of water vapor by satellite (TES, GOSAT) and satellite based cloud information (NOAA OLR, CALIPSO) with isotopic modeling using the general circulation model LMDZ.

A cluster algorithm was implemented to analyze the backward trajectories arriving at Lhasa in June-September and three kinds of backward trajectories were selected. Profiles of observed and simulated humidity, cloud fraction and water vapor isotopic composition along trajectories were analyzed and their sensitivity to convective activity along trajectory was investigated. To better understand the processes at play, isotopic variations simulated by LMDZ were decomposed into physical contributions from large-scale dynamics, large-scale condensation, boundary layer mixing, convective detrainment, rain evaporation and convective updrafts and downdrafts.

We show that convection upstream Lhasa, especially over Northern India and in the Bay of Bengal, has a major influence on the precipitation isotopic composition at Lhasa. Convection in these regions depletes the mid-tropospheric water vapor and this depleted anomaly is then transported up to Lhasa. A final depletion is associated with precipitation on Himalayan slopes. LMDZiso captures the first order convective effect on the isotopic composition but fails to reproduce the vertical structure of humidity and isotopic depletion. Comparison with humidity, isotopic and cloud data suggests that LMDZiso detrains too much water too high in the troposphere, and this affects the way LMDZiso simulates the precipitation isotopic variability over Lhasa.