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Water isotopic composition above the North American and Asian Summer Monsoons provides a tracer of strong convective activity

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Moisture transport of Earth's monsoon systems into the upper troposphere and lower stratosphere is poorly constrained, with implications for stratospheric chemistry and radiative budget. Water isotopes provide information on moisture transport pathways in Earth's atmosphere, and both satellite and in situ measurements of δD show enhancements of up to 50 per mille in the 15-19 km range above the North American monsoon relative to the Asian monsoon. This is indicative of differences in the life cycle and fate of convectively lofted ice in the monsoon system. Here we use data from the Chicago Water Isotope Spectrometer (ChiWIS), which flew aboard high-altitude aircraft in the Asian Monsoon center during the StratoClim (2017) campaign out of Nepal, in monsoon outflow during ACCLIP (2022) out of South Korea, and in the North American Monsoon in 2021 and 2022 out of Houston, to show that in situ measurements of the HDO/H2O isotopic ratio in these systems trace strong convective activity, which is processed differently between the monsoon systems after detrainment. Both campaigns sampled a broad range of convective and post-convective conditions, letting us trace how convective ice sublimates, reforms, and leaves behind characteristic isotopic signatures. We additionally use other tracers, isotopic models, along with TRACZILLA backtrajectories and convective interactions derived from radar and cloud-top products, to follow the evolving isotopic composition along flight paths in both campaigns and to asses the origins of the difference in isotopic signature.