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Insights into monsoon rainfall in Singapore by interpreting high-resolution isotopic data of precipitation and water vapour

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Stable isotopes (δ18O and δ2H) of precipitation and water vapour are valuable tracers of the hydrological cycle and have the potential to reveal insights into convective activities and overall atmospheric processes. Data from tropical regions are scarce, limiting our understanding of the drivers of stable isotopic variability in precipitation and vapour and the proper interpretation of isotope enabled general circulation models. We present laser spectroscopy generated high-resolution isotopic measurements of both precipitation and water vapour over two monsoon seasons (between 2016 and 2017) in Singapore located at $\sim$1.3°N. The results of 94 events captured by our analytical system during the sampling campaign are classified into different categories according to their vapour δ-evolution (increase or decrease of vapor isotopes with the onset of rainfall). Each category corresponds well to the magnitude of convection. For instance, the category characterized by considerable isotopic depletion of precipitation and vapour during rainfall is associated with strong convective activities over Singapore and down-drafts. During such heavy rainfall events, vapour δ18O can drop by 3‰ while larger declines for precipitation of up to 6‰ have been observed. We found that precipitation and vapor are not in isotopic equilibrium during the rainfall stage and are up to a range of 1‰ away from equilibrium for δ18O, possibly controlled by a strong evapotranspiration flux. Moreover, the isotope enabled general circulation model ECHAM-5 overestimates the measured isotopic composition when compared to 8 months of in-situ data (r2=0.29). The integration of radar retrievals with fine spatial and temporal resolution can reveal the microphysics in the clouds and their relationship with the evolution of stable isotopes of precipitation and vapor during rain events.