Deciphering river water source contributions from seasonal moisture pathways and latitudinal stable isotope signatures across the Central Himalayas

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The Himalayan orographic barrier is one of the steepest and largest rainfall gradients on Earth. Rain associated with the Indian Summer Monsoon (ISM) contributes more than 80% of the annual rainfall of this hydrologically unique region. However, the relative contribution of moisture sources from the ISM stored in snow and groundwater, westerly disturbances, and continental recycled moisture to rivers throughout the rest of the year is not as well constrained. Here we present novel field data from the Kali Gandaki, a trans-Himalayan river, and employ stable water isotopes to deconvolve the individual contributions of different moisture sources on temporal and spatial scales. To analyze the variability in water source contributions to rivers, we collected samples from rain, spring, snow, glacier and river locations along the Annapurna Himal during different seasons. Additionally, we present a 4-year time series of river and rain isotopes, river discharge, GPM snow and rain amount at daily to monthly resolution in an effort to constrain hydrological variability. We compare our findings to simulations from isotope-enabled general circulation and1D stable isotope model results. This study highlights the importance of pre-monsoon precipitation to water isotope variability in the central Himalayas, and lays the groundwork for using isotopic measurements to track changes in precipitation sources during the pre-monsoon in this key region of orographic precipitation.