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Decadal record of monsoon dynamics across the Himalayas using tree ring data

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The temporal variability of the Indian monsoon penetrating through the Himalayan range and into the southern Tibetan Plateau is poorly understood. Intermittent ingress of wet monsoon air masses into the otherwise arid and deserted landscapes beyond the orographic barrier can have consequences for erosion and flooding, as well as for water availability. Furthermore, the latitudinal rainfall distribution across the mountain range is crucial to better understand the hydrological cycles of rivers originating there.
Because instrumental measurements are rare in the High Himalayas and on the Plateau, hydro-climatic sensitive proxies, such as oxygen stable isotope ratios in cellulose of tree-rings, are a valuable source of data covering decades to centuries. Here we present new findings on how often and how far the Indian monsoon penetrated into trans-Himalayan region over the last century. To cope with the lack of direct measurements, we strive to reconstruct a record of intense monsoon years based on tree-ring width chronologies along a latitudinal gradient. Thus, we need to answer whether water availability is the main driver of tree growth in the trans-Himalayan region and how dendro-isotopic data relate to seasonal precipitation inputs and sources.
In order to study the monsoon dynamics, we selected four sites along the Kali Gandaki River valley in the central Himalayas (Nepal). This valley connects the very wet, monsoon dominated south Himalayan front with the arid trans-Himalayan region and the southern Tibetan Plateau. Our study area covers the sensitive northern end of the precipitation gradient, located in the upper part of the catchment. Water availability, which drastically varies at each site, was explored by using the climate signal- and isotope-transfer within arboreal systems composed of Juniperus sp., Cupressus sp. and Pinus sp. Results from continuous dendrometer measurements for the entire growing season (Mar-Oct) allowed us to assess the link between tree growth and precipitation, confirming the sensitivity of the trees to water availability.
A set of cores from at least 20 individual trees was collected at each site. Dating revealed records with lengths from 80 to 500 years. Tree-ring width measurements were detrended to minimize the ecological influence on growth, and analyzed against local climate parameters such as temperature and precipitation. The site chronologies were compared to highlight the propagation of the monsoonal events along the latitudinal transect. Additionally, 80-year tree-ring oxygen isotope records from the lowest site (Lete, 2500 m a.s.l.) of the transect were compared with precipitation patterns derived from historical rain gauge and satellite data. This study provides first insights into the relationship among tree-ring width, cellulose isotopes and monsoon signature, shedding light on decadal variations of precipitation in the high-elevated arid area of the High Himalayas.