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River Temperature Gradients from Foreland to High-Mountain Environments

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Temperature lapse rates are a key parameter describing how topography influences surface temperatures along elevation gradients. These rates have long been used to estimate ambient temperatures in unmonitored regions, as well as in climate and ecosystem modeling. In this work, we extend the concept of a lapse rate to alpine and peri-alpine rivers to examine variability in downstream temperature changes over steep mountains and their foreland areas.

Rivers in the Himalaya vary from glaciated to rain-fed, and have a large east-west gradient in water source, with the western regions receiving far more winter snowfall and the eastern regions monsoonal rain. Over the past decades, there has been an extreme build-up of hydropower, irrigation, and groundwater pumping infrastructure in the region, which has drastically altered the way water moves through the landscape; there remain, however, significant unmanaged and high-altitude catchments throughout the Himalaya. By comparing these diverse river reaches, we aim to decipher the role of both climate and anthropogenic influence in driving river temperature gradients at the regional scale.

Using Landsat data from 1983-2023, we first quantify how quickly temperatures change through different segments of rivers in varied geomorphic settings. We then further examine whether those downstream temperature change rates are constant through time or have shifted over the past decades, and to what degree anthropogenic influences (e.g., dams, irrigation) have changed these rates. We find that climate patterns – e.g., summer vs winter precipitation – play a strong role in controlling the rate of river temperature change along stream. We further note distinct spatial patterns in the rate of change (1983-2023), with strong differences in temperature trends between high- and low-elevation river reaches.