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The susceptibility of large river basins to orogenic and climatic drivers

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Large rivers are known to buffer pulses in sediment production driven by changes in climate as sediment is transported through lowlands. Our new dataset of in situ cosmogenic nuclide concentration and chemical composition of 62 sandy bedload samples from the world largest rivers integrates over ∼25% of Earth's terrestrial surface, distributed over a variety of climatic zones across all continents, and represents the millennial-scale denudation rate of the sediment′s source area. We can show that these denudation rates do not respond to climatic forcing, but faithfully record orogenic forcing, when analyzed with respective variables representing orogeny (strain rate, relief, bouguer anomaly, free-air anomaly), and climate (runoff, temperature, precipitation) and basin properties (floodplain response time, drainage area). In contrast to this orogenic forcing of denudation rates, elemental bedload chemistry from the fine-grained portion of the same samples correlates with climate-related variables (precipitation, runoff) and floodplain response times.
It is also well-known from previous compilations of river-gauged sediment loads that the short-term basin-integrated sediment export is also climatically controlled. The chemical composition of detrital sediment shows a climate control that can originate in the rivers source area, but this signal is likely overprinted during transfer through the lowlands because we also find correlation with floodplain response times. At the same time, cosmogenic nuclides robustly preserve the orogenic forcing of the source area denudation signal through of the floodplain buffer. Conversely, previous global compilations of cosmogenic nuclides in small river basins show the preservation of climate drivers in their analysis, but these are buffered in large lowland rivers. Hence, we can confirm the assumption that cosmogenic nuclides in large rivers are poorly susceptible to climate changes, but are at the same time highly suited to detect changes in orogenic forcing in their paleo sedimentary records.