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Incision in alluvial piedmonts indirectly records climate forcing after modulation by glaciation in the E. Tian Shan high range

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Rivers flowing on alluvial piedmonts can abandon high resolution terrace records by incising fast in unlithified conglomerate. Fluvial entrenchment can have an autogenic origin but more often it is driven by climatic forcing and terraces record this forcing. The climatic cause for incision is generally due to a modification in the ratio of sediment flux over water discharge Q_s/Q_w and it is often assumed to be directly driven by a change in precipitation.

We show here, with an example from the Eastern Tian Shan (Northwest China) that the state of fluvial incision is not necessarily directly reflecting a climatic forcing. The north and south piedmonts of the range undergo the same climatic and tectonic forcing. Yet their alluvial piedmonts stand in sharp contrast: the north is incised by 100 to 300 m at the alluvial fan apex while the south is barely incised at all.

In the north, where glaciers carved U-valleys in the upper half of the catchments, incision is primarily driven by a fast drop in the sediment flux out of the high range after glacial sediments are flushed out of the high range. The drop in Q_s lags behind the initial forcing that is the onset of deglaciation and the terraces mainly record the postglacial internal routing of sediments en route to the basin. All rivers of the north piedmont are similarly entrenched, but the timing of the incision onset differs from one river to the next (between 13 and 5 ka), precluding a unique external forcing. Vertical incision rates can be further modified by autogenic processes and changes in water discharge.

In the south, glaciation is restricted to cirque glaciers or long glaciers that reached the piedmont. As a result there is no important accumulation of loose sediment up in the range to be flushed out and starved. The fully aggraded southern piedmonts reflect the current Central Asian aridity in the absence of a postglacial alluvial readjustment.

A sediment routing system with accumulation of sediment high in the mountain can amplify environmental signals instead of dampening them. The same climatic forcing can result in widely different morphological expressions depending on the extent of the glacial overprint. Strategies to study past climate can take advantage of exacerbated signals to measure climatic trends provided that the local sediment routing is understood.