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Alluvial system records of climate forcing and their impact on depositional sinks

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It has long been appreciated that fluvial systems can modify sediment-discharge signals through transient storage and release of sediment, thus complicating our ability to reconstruct past changes in landscape dynamics from stratigraphic records. The ability of a river to faithfully transmit sediment-discharge signals to their outlets (and into depositional sinks) depends on the system response time, which is the time required for a river to reach a new steady-state profile following a perturbation. Response times that are slower than the forcing period result in either damping or amplification of the sediment-discharge signal, the magnitude of which is difficult to predict. How these dynamics of alluvial systems affect the geomorphic record of alluvial fan lobes and fluvial fill terraces, which commonly reflect climate forcing, is not well understood. Here, we present a synthesis of six field areas along the margins of the Central Andean plateau, where alluvial-channel deposits record periodic changes in past climate forcing in the form of cut-and-fill fluvial terrace sequences or alluvial-fan lobes. These systems range in length from < 10 to 150 km. We find that shorter systems record a higher frequency of forcing (20-kyr and less) compared to longer systems (100-kyr to 400-kyr), with a length-squared scaling that is consistent with diffusive functions. The alluvial systems record climate forcing with high fidelity, which is surprising considering that their theoretical response times in most cases far exceed the forcing period recorded in the field. We propose that alluvial systems comprise highly sensitive records of climate forcing, because changes in channel-bed elevation, which can occur shortly after a perturbation, can be recorded as geomorphic landforms. Moreover, we propose that that different periods of forcing among a set of superimposed forcing periods will be recorded at different downstream lengths, due to the overall diffusive nature of alluvial-channel profiles. This proposal is consistent with outputs from a newly developed numerical model of alluvial-channel long-profile evolution, and it implies that different sectors of alluvial-channel systems, from mountain-front alluvial fans to downstream alluvial rivers, will be sensitive to different forcing frequencies of climate.