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Quantifying competing measures of sediment dynamics on alluvial fans: implications for reconstructing past environmental change

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The effects of climate change on eroding landscapes and the sedimentary record remains poorly understood. While sediment routing systems at the Earth's surface should, in principle, record changes in past environmental boundary conditions, the extent to which landscapes are buffered to high-frequency, high-magnitude climate change is contentious. Mountain catchments and alluvial fans offer one way to address this question, as they are accessible sediment routing systems in which source and sink are closely coupled, sedimentation rates are high, and sediment budgets can be closed. Here we consider the extent to which the granulometry of sediment in stream-flow-dominated alluvial fans records changing environmental conditions. We focus on well-constrained field examples in Death Valley, California, such as the Hanaupah Canyon Fan, which have experienced hydroclimate forcing associated with recent glacial-interglacial cycles. Using field-derived measures of grain size, we compare three complementary methods that have recently been used to reconstruct sediment dynamics on alluvial fans. First, we use a self-similarity analysis of sediment calibre to reconstruct sediment mobility on the fan over time. Second, we use a downstream-fining model to evaluate the extent to which different depositional units on the fans record changing sediment fluxes from source catchments. Finally, we adopt a palaeohydrological approach to reconstruct unit discharges, bed shear stresses and instantaneous sediment transport capacities for fans in the study area, based on field measures of hydraulic geometry and grain size. We evaluate the extent to which these three methods provide consistent results, and we quantify the extent to which grain mobility, water and sediment discharge scale with documented variations in the regional climate. Our work shows that alluvial fans are highly sensitive to palaeo-environmental change, but our findings also illustrate the importance of considering which measures of past climate (particularly averages versus variance) are most relevant for landscape responses and sensitivity to climate change.