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Quantifying alluvial fan sensitivity to climate in Death Valley, California, from field observations and numerical models

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A quantitative understanding of landscape sensitivity to climate change remains a key challenge in the Earth Sciences. The stream-flow deposits of coupled catchment-fan systems offer one way to decode past changes in external boundary conditions as they comprise simple, closed systems that can be represented effectively by numerical models. Here we combine the collection and analysis of grain size data on well-dated alluvial fan surfaces in Death Valley, USA, with numerical modelling to address the extent to which sediment routing systems record high-frequency, high-magnitude climate change.

We compile a new database of Holocene and Late-Pleistocene grain size trends from 11 alluvial fans in Death Valley, capturing high-resolution grain size data ranging from the Recent to 100 kyr in age. We hypothesise the observed changes in average surface grain size and fining rate over time are a record of landscape response to glacial-interglacial climatic forcing. With this data we are in a unique position to test the predictions of landscape evolution models and evaluate the extent to which climate change has influenced the volume and calibre of sediment deposited on alluvial fans.

To gain insight into our field data and study area, we employ an appropriately-scaled catchment-fan model that calculates an eroded volumetric sediment budget to be deposited in a subsiding basin according to mass balance where grain size trends are predicted by a self-similarity fining model.

We use the model to compare predicted trends in alluvial fan stratigraphy as a function of boundary condition change for a range of model parameters and input grain size distributions. Subsequently, we perturb our model with a plausible glacial-interglacial magnitude precipitation change to estimate the requisite sediment flux needed to generate observed field grain size trends in Death Valley. Modelled fluxes are then compared with independent measurements of sediment supply over time. Our results constitute one of the first attempts to combine the detailed collection of alluvial fan grain size data in time and space with coupled catchment-fan models, affording us the means to evaluate how well field and model data can be reconciled for simple sediment routing systems.