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Debris flow sensitivity to glacial-interglacial climate change – supply vs transport

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Numerical models suggest that small mountain catchment-alluvial fan systems might be sensitive to climate changes over glacial-interglacial cycles, and record these palaeoclimate signals in the sedimentology of their deposits. However, these models are still largely untested, and the propagation of climate signals through simple sediment routing systems remains contentious. Here, we present detailed sedimentological records from 8 debris flow fan systems in Owens Valley, California, that capture the past $\sim$ 120 ka of deposition. We identify a strong and sustained relationship between deposit grain size and palaeoclimate records over a full glacial-interglacial cycle, with significantly coarser-grained deposits found in warm and dry periods. Our data show that these systems are highly sensitive to climate with a rapid response timescale of < 10ka, which we attribute to rapid transfer from source to sink. This sensitive record might be explained by changes in sediment supply and/or changes in sediment mobilisation, and we evaluate these mechanisms quantitatively. We find little evidence that changes in catchment hypsometry, weathering patterns, past glaciation or sediment production can explain the grain size changes we observe on the fans. However we do find that grain size has increased exponentially with rising temperatures, at a rate that matches the intensification of storms with warming. As these debris flows are triggered by surface runoff during intense storms, we interpret that enhanced runoff rates in warm and stormy conditions are responsible for entraining larger clasts during debris flow initiation. This implies that debris flow fans might record signals of past storm intensity. Our study utilises field sedimentology and focuses on short transport distances ($\sim$ 10 km) and climate changes over $\sim$ 1-100 ka timespans, but could additionally have important implications for how eroding landscapes might respond to future warming scenarios. We address the importance of extreme events (such as storms and debris flows) for determining how sensitive landscapes are to climate variability.