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Hydroclimate controls alluvial fan aggradation and incision in the southwestern United States

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Alluvial fans are common landforms that record source-to-sink sedimentation in terrestrial basins. In the semi-arid southwestern United States, it has long been thought that episodes of fan aggradation and incision might be related to past climate changes, but this link has been difficult to demonstrate empirically. Here, we compile and update 10Be exposure ages for 15 alluvial fan surfaces in Death Valley and nearby basins. Rather than focus on the average ages of aggraded surfaces we instead introduce a new probabilistic approach to determining when aggradation ended and the fans switched to incision. Across the region, we find that alluvial fans aggraded and incised with a periodicity of ∼23 kyr, suggesting an orbital control involving changes in hydroclimate. We explore past changes in the regional hydroclimate using a new palaeoclimate model for the southwestern United States. Our climate modelling spans the entire last glacial-interglacial cycle and reveals that fan aggradation coincided with drier intervals and fan incision coincided with wetter intervals. Periods of wetter climate in the Death Valley area were driven by both orbital variations in insolation and the waxing and waning of ice sheets, which displaced Pacific storm tracks southward and increased wintertime rainfall. Our observations imply that temporary increases in water flux were the primary trigger for the abandonment of fan surfaces, so we identify the threshold precipitation rate at which fans switched from aggradation to incision. We find that this threshold itself reacts to climate variability, and quickly adjusts to changes in the mean precipitation state within an insolation cycle. Together, our findings demonstrate that alluvial fans in the southwestern United States preserve a record of high-frequency climate changes spanning at least the past 200 kyr.