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A quantitative approach to understanding dated dune stratigraphies

Richard Bailey and Dave Thomas
School of Geography and the Environment, University of Oxford, UK

Attempts to reconstruct past changes in climate-related forcing of dryland landscapes are hampered by the lack of an adequate quantitative framework for understanding the production and interpretation of dated sedimentary records. In drylands, as in other environments, information on past forcing conditions is progressively modified, degraded and removed from the available stratigraphic record by a series of 'filters' involving changes in the primary forcing factors themselves, geomorphological processes and the sampling/dating procedures. Here we describe a quantitative model that includes these effects, and use the model to examine the nature of preserved dryland sedimentary records and their relationships to primary forcing conditions: thicker preserved sedimentary records reflect periods of more intense aeolian activity; localized switching between erosion and deposition results in discontinuous and highly variable stratigraphic sequences; a preservation bias towards younger deposits is observed, potentially leading to a continuum of accumulation that decays approximately in proportion to 1/sqrt(age) . Time periods not represented by deposition can in some cases be interpreted as periods of higher precipitation and/or lower wind energy. An asymmetry exists between the efficiency with which past 'drier' and 'wetter' episodes can be identified, which relates to the time-separation of depositional periods and the correct distinction between hiatuses due to forcing conditions and those due to under-sampling. Relevant to this is the effect of random dating errors (statistical uncertainty), which (increasingly which age) filter-out higher frequency events from the record. A new data treatment method (termed Accumulation Rate Variability) provides an efficient proxy for accumulation rates, and therefore the intensity of aeolian activity, with significant improvements over existing date-frequency methods. The filtering problem discussed applies to all attempts at understanding the timing and nature of past events, independent of the proxies and dating methods employed.