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Two independent dune growth mechanisms: from laboratory to landscape-scale experiments

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Using laboratory subaqueous experiments, we show that a single bidirectional flow regime can lead to two different dune orientations depending on sediment availability. The erodibility of the bed selects the overriding mechanism for the formation of dunes. Then, dunes may either (1) increase in height from the destabilization of a sand bed with no restriction in sediment availability or (2) grow by extension away from a localized sand source in zones of low sand availability.

These results are used to develop a new set of landscape-scale experiments in the Tengger desert (Inner Mongolia, China). Exposed to bimodal winds, this site is unique because it allows multiparametric analysis of dune morphodynamics in a natural environment (16 hectares) under well-controlled initial and boundary conditions. The orientation of dunes as a function of the wind regime and the coupling between flow and topography are currently investigated in three experiments that provide empirical support for the coexistence of two independent dune growth mechanisms.

In both laboratory and landscape scale experiments, we find that dunes that are transport-limited select an orientation that maximizes the normal to crest components of transport. In zones of limited sand supply, dunes elongate in the direction of the resultant sand flux at the crest. We show how these results can be used to quantitatively predicts the orientation of primary and secondary dune patterns in modern terrestrial sand seas but also on Mars and Titan.