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Size of giant dunes limited by the depth of the atmospheric boundary layer

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Eolian sand dunes, created by the interaction of wind-driven sediment transport and bed shape, usually have scales on the order of tens of meters, although kilometre-scale dunes also exist. The length over which eolian sediment transport achieves equilibrium determines the smallest scales at which a sand surface is unstable to dune formation. However, the processes limiting the largest sand dunes scales, and the mechanisms by which dunes grow to giant scales, have remained open questions. Here we present field observations indicating that nonlinear interactions between elementary dunes build larger-scale structures, and numerical modelling showing that interactions with the free surface of the atmospheric boundary layer ultimately halts this growth. These results elucidate a fundamental relationship between eolian and subaqueous dunes, and may serve as a starting point for modelling the long term evolution of bed forms common in many river, desert, and coastal environments, and on Titan.