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Scaling of Aeolian and Subaqueous Bedform Dynamics

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The understanding of the origin, evolution and dynamics of bedforms in flowing water and air is fundamental for model development and for identifying constraints on experimentation. Some aspects of bedform dynamics may be considered the same at the level of representing emergent, self-organised features arising within the complex system of sediment transport. Fundamental differences in bedforms arise because different bedforms represent organisation of different fractions of the total transport load, and because there are physical differences in the transporting fluids. Wind ripples originate with the reptation and creep of surface grains under the largely bypassing saltation load. Aeolian dunes develop in an adjusting atmospheric boundary layer driving a saltation load in which a sandy patch may grow owing to the loss of momentum of saltating grains upon striking a sandy surface. This grain-trapping mechanism implies a minimum survival size of the patch, which should scale with a characteristic grain saltation jump length or the fetch effect (saturation length). While there appears to be a clear and fundamental difference between aeolian dunes versus ripples, subaqueous bedforms of varying scales may be the result of one single universal mechanism. Subaqueous ripples and dunes represent the organisation of the entire traction load and, progressively with larger bedforms, significant portions of the intermittent-suspension load. Because saltation jump lengths are short in water and a slipface occurs with initial grain clusters, slipface development may be the sediment trapping mechanism for the organisation of both subaqueous ripples and dunes. An apparent continuum in scale between ripples and dunes argues that both features are fundamentally the same and represent development stages of the bedform and local volume of sediment in transport, as limited by water depth.

This paper explores the arguments for and against treating subaqueous bedforms

(dunes and ripples) as equivalent to aeolian dunes and possibly ripples, both from the perspective of self-organising complex systems as well as the physical processes and non-dimensional scales involved.