KEYNOTE

Bedform dynamics: interaction, attraction and repulsion of dunes

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ABSTRACT In desert landscapes, we observe individual sand dunes of different sizes, with a characteristic length scale of up to kilometers, which seamlessly interact with each other and their environment. Can we capture the interaction behaviour of these large objects with simple physical laws? Processes in the field occur over long times and are difficult to investigate in detail, but we are able to scale the physics down to the laboratory. During the presentation, we will explore a unique, recirculating laboratory experiment in which we create and trace aqueous dunes over long times, and investigated three distinct research questions.

We explore the interaction between two dunes of different sizes, leading to either coalescence (merging) or ejection (repulsion) of bedforms and present a phase-space diagram outlining the possible interaction outcomes derived from experiments and cellular automaton simulations [1,2].

An interesting question is what happens in the long-time behaviour [3]: will the system obtain a perfect symmetry in all configurations, or are there certain initial conditions which produce a stable non-symmetrical long-time outcome? We find that the secret ingredient is “turbulence”: for slow flows with a low level of turbulence, the dunes will display fast-slow dynamics before equilibrating symmetrically, but for high levels of turbulence in fast flows, we find an asymmetric attractor. This indicates that dune-dune interactions can either stabilize or destabilize the size and spacing of large dune fields.

Lastly, we place objects in the path of our model dunes and explore the outcome. We observe that both object size and shape matter whether a sand dune is blocked or able to overcome an obstacle and reform on the other side [4]. We discover that a modal decomposition of the flow field (without sediment or dunes present!) can predict the collision outcome, which has interesting applications for reducing and halting dune encroachment.

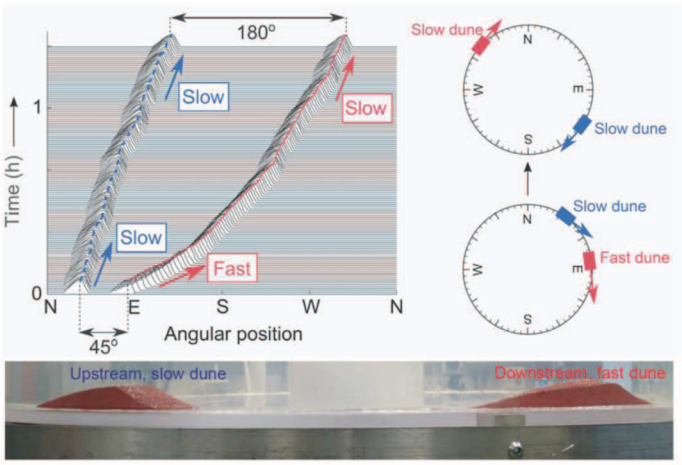

Figure 1: Two equal size dunes, placed 45 degrees apart, drift to antipodal positions over long times.

The central mystery of this research topic is the interplay between small-scale granular physics and large-scale landscape features. The fascinating observation is that certain length-scales change by an order of magnitude or more, but the underlying physics remains the same.

KEY WORDS: subaqueous dunes, sediment transport, dune interactions

REFERENCES

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