DIRECT NUMERICAL SIMULATIONS OF AEOLIAN SAND RIPPLES

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Key words Aeolian transport. Wind ripples. Resonance

Aeolian ripples form regular patterns at the surface of sand sheets and dunes, both on Earth and Mars. Their emergence at a wavelength much larger than the grain size was unexplained. Here we report direct numerical simulations of grains interacting with a wind flow that are able to reproduce the spontaneous growth of ripples with an initial wavelength and a propagation velocity linearly increasing with the wind speed. The instability turns out to be driven by resonant grain trajectories, whose length is close to a ripple wavelength and whose splash leads to a mass displacement towards the ripple crests. The pattern selection results from a compromise between this destabilizing mechanism and a diffusive downslope transport which stabilizes small wavelengths.

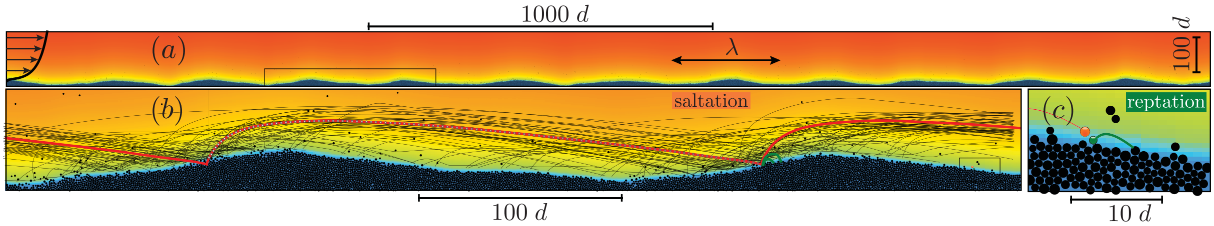

Figure 1. Ripples emerging from a flat bed in a simulation ($u_*/u_{th} = 3$). (a) Large-scale view of the system composed of 45000 grains in a quasi two-dimensional xyz box of respective dimensions $3400\,d \times 1\,d \times 1000\,d$). Periodic boundary conditions are used in the x (wind) direction. The results presented here are obtained for a density ratio $\rho_p/\rho_f = 500$, a grain Reynolds number $\mathcal{R} = d/\nu\sqrt{(\rho_p/\rho_f - 1)gd} = 22$ (ν is the air kinematic viscosity) and shear velocities in the range $u_*/u_{\rm th} = 1$–5. The colored background codes for the wind velocity, see wind profile (left). (b) Close-up view at the scale of the ripple wavelength, featuring saltation trajectories, with hop-height between 15 and $30d$. The average resonant trajectory is shown in red. (c) Zoom at the level of the interfacial. A collision between a salton (orange) and a repton (green) is sketched.

References

[1] O. Durán, P. Claudin, B. Andreotti, *Direct numerical simulations of aeolian sand ripples*, Proc. Natl. Acad. Sci. USA **111**, 15665–15668 (2014).