DIRECT NUMERICAL SIMULATIONS OF AEOLIAN SAND RIPPLES

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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 \( \frac{u_*/u_{th}}{= 3} \). (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 \( R = d/\nu \sqrt{(\rho_p/\rho_f - 1)gd} = 22 \) (\( \nu \) is the air kinematic viscosity) and shear velocities in the range \( u_*/u_{th} \) = 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 30\( d \). 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