From grains to bedforms: direct numerical simulations of aeolian ripples

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In contrast to sand dunes which arise from the coupling of hydrodynamics and topography, aeolian ripples result from the interaction of sediment transport and topography. Current theories of their formation have been unable to explain recent field and laboratory measurements. In order to understand the dynamical mechanisms responsible for this instability, we performed direct numerical simulations of ripples using a two phase model coupling a discrete element method (DEM) for particles to a Reynolds averaged description of hydrodynamics. We find that ripples result from the competition between the resonance of grain trajectories with the modulated surface, which destabilize the granular bed, and gravity-induced downslope transport which stabilize small wavelengths. Crucially, the details of a gas-like collisional boundary layer at the interphase between the transport layer and the static bed select the scaling of ripples wavelengths and migration rates with the wind speed.