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Dunes morphologies and superimposed bedforms in a cellular automaton dune model

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We use a new $3D$ cellular automaton model for bedform dynamics in which individual physical processes such as erosion, deposition and transport are implemented by nearest neighbor interactions and a time-dependent stochastic process. Simultaneously, a lattice gas cellular automaton model is used to compute the flow and quantify the bed shear stress on the topography. Local erosion rates are taken proportional to the shear stress in such a way that there is a complete feedback mechanism between flow and bedform dynamics. In the numerical simulations of dune fields, we observe the formation and the evolution of barchan, transverse, longitudinal and star dunes. For all these types of dunes, we observe the emergence of superimposed bedforms when dunes are large enough. Then, we use the same model under different initial conditions, and we perform the linear stability analysis of a flat sand bed disturbed by a small sinusoidal perturbation. Comparing the most unstable wavelength in the model with the characteristic size of secondary bedforms in nature, we determine the length and time scales of our cellular automaton model. Thus, we establish a link between discrete and continuous approaches and open new perspectives for modeling and quantification of complex patterns in dune fields.