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A Real-Space Cellular Automaton Laboratory for the modeling of complex dunefields

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Using applications in the physics of sand dunes, we explore the capabilities of a Real Space Cellular Automaton Laboratory (ReSCAL), a generator of 3D stochastic cellular automaton stochastic cellular automaton models with continuous time. The objective of this software is to develop interdisciplinary research collaboration to investigate the dynamics of complex systems. In the vast majority of numerical models, any point in space is entirely characterized by a local set of physical variables (e. g. temperature, pressure, velocity) that are recalculated over time according to some predetermined set of fundamental laws. However, there is not always a satisfactory theoretical framework from which we can try to quantify the overall dynamics of the system. For this reason, we prefer concentrate on features of organization and ReSCAL is entirely constructed from a finite number of discrete states that represent the different phases of matter involved in the system under consideration. Then, an elementary cell is a real-space representation of the physical environment. Pairs of nearest neighbor cells are called doublets and each individual physical process is associated with a set of doublet transitions and a characteristic transition rate. Using a modular approach, we show how it is possible to model and combine a wide range of physical, chemical and/or anthropological processes. As an example, we discuss different dune morphologies with respect to rotating wind conditions.