Numerical simulation of landform/atmosphere coupled evolution

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Predicting sediment transport and bed evolution in severe wind conditions depends on accurate computations of flows past complex boundaries, evolving with the flow itself. We employ a variant of the nonhydrostatic atmospheric numerical model EULAG that couples the internal flow with a lower boundary developing in response to the sand saltation and/or dust storms.

The key prerequisite facilitating this development is the use of time-dependent curvilinear coordinate transformation that accommodates rapid changes of the boundary shape. In consequence of the adopted severe wind scenario, the geometric difficulty of the two-phase coupling is enhanced by the ubiquity of the turbulence and separating surface planetary boundary layers, requiring an adequate modelling of the details of the local surface stress field.

The flux-form PDE for the interface profile — accounting for saltation, sand avalanches and mobilised sediment fluxes from and to the ground — is formulated as a forced advection-diffusion equation. This novel formulation not only facilitates finite-difference integrations, but it also aids understanding of landform propagation. Theoretical considerations are illustrated with numerical experiments that explore the landform/atmosphere system. In particular, we investigate the dune/flow response to the character of the underlying surface, the development of dunes via instability of sand ripples and the associated dust phenomena.