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Multi-scale statistical characterization of migrating dunes

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The evolution of alluvial river beds is a strongly nonlinear process which is affected by the mutual interaction of near-bed turbulence and sediment dynamics. The characteristics of the flow field , on the other hand, are strongly conditioned by the formation and development of sediment waves which arise as a consequence of inherent instability of the sediment bed.

In this paper, we present some results aiming to quantify the inherent nonlinearity and complexity in sand bed dynamics though the analysis of temporal series of bed elevation fluctuations collected in controlled laboratory experiments. The data, measured via submersible sonar transducers at 0.1 Hz frequency, refer to experimental settings characterized by different flow discharges.

Spectral and multiscale analyses are used to investigate the presence of characteristics scales related to the migration of sand waves formed during the experiments. We also employ surrogate series analysis and the transportation distance metric in the phase-space to test for nonlinearity and the finite size Lyapunov exponent (FSLE) methodology to test for complexity. Knowing the typical scales that characterize the temporal evolution of sand beds, as well as the degree of nonlinearity and complexity in the temporal dynamics of bed elevation fluctuations, one can provide insight towards the formulation and parametrization of physics based stochastic models of sediment transport.