

Analytical mesoscale modeling of aeolian sand transport

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The mesoscale structure of aeolian sand transport determines a variety of natural phenomena studied in planetary and Earth science. We analyze it theoretically beyond the mean-field level, based on the grain-scale transport kinetics and splash statistics. A coarse-grained analytical model is proposed and verified by numerical simulations resolving individual grain trajectories. The predicted height-resolved sand flux and other important characteristics of the aeolian transport layer agree remarkably well with a comprehensive compilation of field and wind-tunnel data, suggesting that the model robustly captures the essential mesoscale physics. By comparing the predicted saturation length with field data for the minimum sand-dune size, we elucidate the importance of intermittent turbulent wind fluctuations for field measurements and reconcile conflicting previous models for this most enigmatic emergent aeolian scale.