Attributes of Flow Structures During Turbulence Extrema in Close Proximity to Dunes

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Summary: Conditional averaging based on pre-defined events in the flow field close to dunes has been used during numerical simulations and experiments. This averaging procedure provides a unique means to characterize flow structures present during intermittent periods of elevated erosion.

Abstract: Erosion of bedform sediment via aeolian or alluvial processes is induced (and sustained) by kinetic energy fluxes transported by the above fluid (winds in the atmospheric surface layer or water in river beds). Conceptual models typically indicate that sediment flux, q (via saltation or drift), scales with imposed aero-/hydro-dynamic (basal) stress raised to some exponent, n, where $n > 1$. Since basal stress (in fully rough, inertia-dominated flows) scales with the incoming velocity squared, u^2, it follows that $q \sim u^{2n}$ (where u is some relevant component of the above flow field, $\boldsymbol{u}(\boldsymbol{x},t)$). Thus, even small (turbulent) deviations of u from its time-averaged value may play an enormously important role in geomorphic evolution of bedforms. The importance of this argument is further augmented given that turbulence in the fluid within one to two dune heights above the bedform exhibits non-Gaussian statistics (intermittent, large fluctuations). In order to illustrate the importance of these fluctuations, we have used conditional averaging predicated on turbulence extrema in close proximity to the dunes. This averaging procedure provides an ensemble-mean visualization of flow structures responsible for erosion `events'. The conditional averaging has been performed on results obtained during large-eddy simulations and high-fidelity experiments using a refractive index matching environment.