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The vertical structure of airflow turbulence characteristics within a boundary layer as a driver of sediment transport on a beach

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Recent studies have indicated that coherent turbulent structures, within boundary layer airflows, play an important role in driving sand transport by the wind over beaches and desert dunes. Improvements in technology have facilitated the widespread use of sophisticated instruments such as ultrasonic anemometers and high-frequency sand traps and saltation impact sensors. These technological advances have enabled a move beyond the basic monitoring of shear or average velocities and bulk sediment transport over coarse time intervals, to more detailed measurements of shear stresses at higher spatio-temporal resolutions.

The results presented in this paper are from a small-scale point-location field study of boundary layer turbulence and shear stresses conducted under obliquely onshore winds over a beach at Magilligan Strand, Northern Ireland. High-frequency (25 Hz) 3D wind velocity measurements were collected using sonic anemometry at five different heights between 0.13 and 1.67 metres above the bed, and the associated sand transport response was measured using an array of Safires and sand traps.

The wind velocity data is used to investigate the vertical structure of Reynolds shear stresses and burst-sweep event characteristics. The study explores the identification of characteristic event durations based on integral time-scales and spectral analysis, and discusses the issues involved with data rotations for yaw, pitch, and roll corrections relative to flow streamlines, and the subsequently derived turbulence parameters based on fluctuating vector components (u', v', w').

Results show how the contributions to shear stress and the average pitch of bursts and sweeps changes as a function of height above the bed, indicating the transformation of top-down turbulent eddies as they travel toward the surface. A comparison between the turbulence data and the synchronous sand transport events, meanwhile, reveals the potential effects of enhanced saltation layer roughness feedback on eddies close to the bed and the importance of careful interpretation when relating shear velocities calculated at a point above the ground to active saltation transport along a surface.