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From LES to Radar:

Advancing Surface Wind Estimation in Internal Boundary Layers During Hurricane Landfalls

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Hurricane landfalls are associated with extreme wind hazards and cascading compound impacts. Accurate estimation of near-surface winds during landfall is crucial for risk communication, community preparedness, and post-storm response and recovery. However, reliably estimating coastal surface winds remains a major challenge, partly due to limited understanding of wind profiles within the internal boundary layer (IBL), which forms in response to abrupt water-to-land roughness transitions or spatial heterogeneity in overland surface roughness.

To address this challenge, this study employs semi-idealized large-eddy simulations (LES) to examine how different land surfaces influence vertical profiles of sustained near-surface winds and turbulence properties within the coastal IBL. Given the IBL's partial decoupling from the flow aloft, the ability of coastal radars and radiosondes to capture this feature is evaluated, and, for the first time, uncertainties in 10-m wind estimates derived from several observation-based methods are quantified. Motivated by these findings, a recent Doppler analysis of hurricane landfalls proposes an IBL-based approach for improved surface wind estimation. The uncertainty of this approach is further assessed through a synergy between LES and the newly developed radar simulator AOSPRE at NCAR. Finally, future research directions in hurricane boundary layer dynamics and wind-hazard predictions are discussed. Event Website