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Turbulent Flow Interactions with Complex Topography: From Multi-Scale Roughness to Barchan Dunes

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ABSTRACT:

This talk will highlight on-going studies of interactions between turbulence and complex topography. One such scenario is multi-scale surface roughness commonly encountered on flow surfaces, such as turbine blades and hulls of ships, as well as in nature (gravel river beds, for example). The present effort is devoted to identifying the impact of multi-scale roughness replicated from a turbine blade damaged by deposition of foreign materials (but reminiscent of a broad range of multi-scale topographies in industry and nature) on wall turbulence. Both particle-image velocimetry (PIV) and hot-wire anemometry measurements were conducted for flow over this surface, both within and outside the roughness sublayer, to explore its impact on the canonical statistical and structural nature of smooth-wall turbulence. The latter portion of this talk will highlight on-going experiments of flow over barchan dunes – crescent-shaped bedforms that form in aeolian and sub-aqueous environments with a limited sediments supply and relatively unidirectional flow. Fixed-bed barchan models are utilized in a new refractive-index-matched (RIM) flow facility to study interactions between dunes arranged in various alignments using PIV. The optically-unimpeded access afforded by the RIM methodology provides unique views of the rich flow dynamics associated with these turbulence–complex topography interactions.

BIOGRAPHY:

Kenneth T. Christensen is a Professor and the Collegiate Chair in Fluid Mechanics at the University of Notre Dame, with a joint appointment in the Departments of Aerospace & Mechanical Engineering and Civil & Environmental Engineering & Earth Sciences. He also presently serves as the Department Chair of Aerospace & Mechanical Engineering and as a Provost's Fellow at Notre Dame. He joined the ND faculty after ten-plus years on the faculty at the University of Illinois at Urbana-Champaign. Christensen directs a research group that pursues experimental studies of turbulence, geophysical flows and microfluidics and is a WPI Principal Investigator in the Carbon Dioxide Storage Division of the International Institute for Carbon-Neutral Energy Research (I2CNER) based at Kyushu University in Japan. He is a Fellow of both APS and ASME, an Associate Fellow of AIAA and has received the AFOSR Young Investigator Award (2006), the NSF CAREER Award (2007), the Francois Frenkiel Award for Fluid Mechanics from APS-DFD (2011) and the Gustus Larson Memorial Award from ASME (2016).