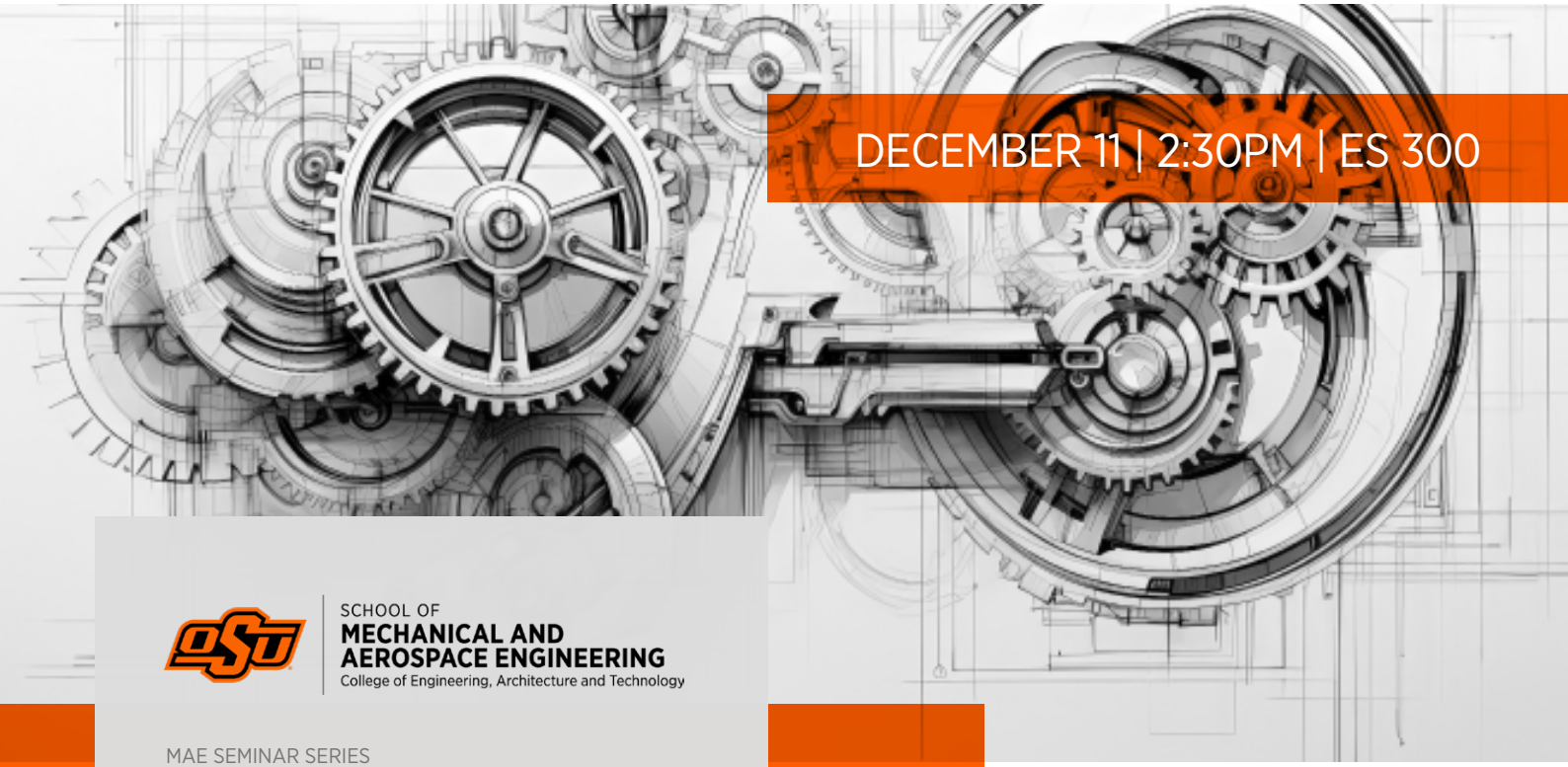


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College of Engineering, Architecture and Technology

MAE SEMINAR SERIES

Small-scale turbulence over surface waves: From experiments to multi-scale AI modeling

KIANOOSH YOUSEFI, PH.D.

Kianoosh Yousefi is an Assistant Professor in the Department of Mechanical Engineering at the University of Texas at Dallas. He received his PhD in Mechanical Engineering from the University of Delaware in 2020. Prior to joining UT Dallas, he was an Associate Research Scientist in the Department of Civil Engineering and Engineering Mechanics at Columbia University. Dr. Yousefi's research focuses on understanding the physics of turbulent flows across scales, with a particular emphasis on turbulent air-sea interactions, wave-structure interactions, and multiphase/interfacial flows. He is the recipient of multiple awards, including the ONR Young Investigator Program (YIP) and the Computing Innovation Fellowship from the Computing Research Association (CRA), as well as several awards recognizing early-career scientists. His work has been supported by multiple grants from NSF, ONR, and DOE.



ABSTRACT

About two-thirds of the surface of the Earth is covered by the ocean. The air-sea exchanges of mass, momentum, and energy that take place at the ocean surface over such a huge area play an integral role in determining the sea state, weather patterns, and climate and thus significantly impact many aspects of human life. In particular, surface waves, which most of us are familiar with from going to the beach, are crucial in connecting the atmosphere and ocean by generating turbulence, airflow separation, and breaking events. Although we know that surface waves are critically important, we do not yet fully understand the fundamental physics of ocean waves and their associated processes that couple the turbulent boundary layers above and below the ocean surface. This prevents us from making accurate predictions of extreme wind events such as tropical storms and hurricanes.

Over the last several years, we have investigated the influence of surface waves on the structure of airside turbulence and flux transfers across the air–sea interface through a combination of controlled laboratory experiments and data-driven modeling. In this presentation, I will highlight our recent progress in characterizing small-scale turbulence above/below wind-generated waves using high-resolution particle image velocimetry (PIV) and laser-induced fluorescence (LIF). Building on these measurements, we have developed supervised machine learning (ML) surrogate models capable of reconstructing skin-friction drag and turbulence structure over waves that will provide physics-informed wall-layer representations for high-fidelity numerical simulations. These ML models are trained directly on our experimental datasets, enabling them to capture the multiscale dynamics that mediate momentum and energy exchange at the ocean surface.