Time: Friday, December 4th, 2020, 9:00-11:30 AM

Event: Ph.D. Dissertation Defense of Meng Li from Mechanical Engineering

Faculty Advisor: Di Yang

Committee Members: Ralph Metcalfe, Dong Liu, Rodolfo Ostilla Monico, Mostafa Momen

Defense will be held online via Zoom:
https://uofh.zoom.us/j/94299255470?pwd=eE9zcU1yMjNQQlRyaWxOQXBHTmcyQT09

Title: Wave-Resolving Numerical Simulations of Langmuir Circulations

Abstract: In open-water environments, the interaction between progressive surface waves and shear turbulence driven by surface wind stress causes the generation of Langmuir circulations – a flow phenomenon frequently occurring in the surface layer of oceans and large lakes. Understanding the dynamics of Langmuir circulations is vital for accurate prediction of mass, momentum, and scalar transfer in air-sea interaction. In this study, the generation and development of Langmuir circulations by the wave-turbulence interaction is systematically studied using a high-fidelity wave-resolving direct numerical simulation (DNS) model. The complex flow field in Langmuir circulations is decomposed into a rotational turbulent flow field and an irrotational wave velocity field based on the Helmholtz decomposition theorem. With the desired wave condition being prescribed, the evolution of the shear-driven turbulence under the modulation of the progressive surface waves is simulated by solving the rotational turbulent flow velocity field. This DNS model is found to successfully capture the incipient generation and evolution of the Langmuir circulations caused by wave-turbulence interaction. In this study, both the time evolution of the instantaneous flow field obtained from the wave-resolving DNS model and the statistical analysis results are presented. For comparison, a reference simulation of Langmuir circulations based on the classical Craik-Leibovich equations (CL2 model) is also performed, in which only the averaged effect of waves is modeled using the wave-induced Stokes drift current. While the simulated Langmuir circulations from the two models are qualitatively similar, noticeable quantitative differences are observed in the statistics of the velocity and vorticity fields. A detailed comparison of the turbulent kinetic energy (TKE) budget reveals some fundamental difference in the mechanism of TKE generation between the wave-resolving model and the CL2 model.