Free-surface turbulence

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Abstract

Turbulent free surface flows are ubiquitous, including virtually all natural bodies of water. The interaction between the turbulence in the bulk and the free surface is crucial to determine the transport properties in terms of mass, momentum, and energy. These play a paramount role on the global scale, e.g., for the uptake of CO_2 and the aerosol generation at the air-water interface of oceans, rivers, and lakes, and for the spreading of floating plastics. Even the seemingly simple case of a virtually flat surface displays very complex dynamics: the boundary condition quenches the vertical component of the velocity fluctuations below, while the bulk turbulence leaves its footprint in the motion of floating objects. In the presence of large deformations of the surface, the problem is complicated by the mutual transfer of energy between the bulk flow and the gravity-capillary waves, and by nonlinear interactions among those. In the presence of wind, the mechanisms by which waves build up and exchange energy with the underlying turbulence are even less well understood. In this talk, I will touch upon some fundamental aspects of free-surface turbulence, ranging from cases in which the bulk flow barely deforms the surface; to cases where it corrugates it dynamically; to cases in which turbulence is created and modulated by wind shear and wind-driven waves on the edge of breaking. Those flows are investigated with a suite of experimental facilities and leveraging high-resolution imaging, in the attempt to improve our predictive understanding of the two-way coupling between the surface and the turbulence underneath.

Keywords: free-surface turbulence, particle image velocimetry, particle tracking velocimetry.

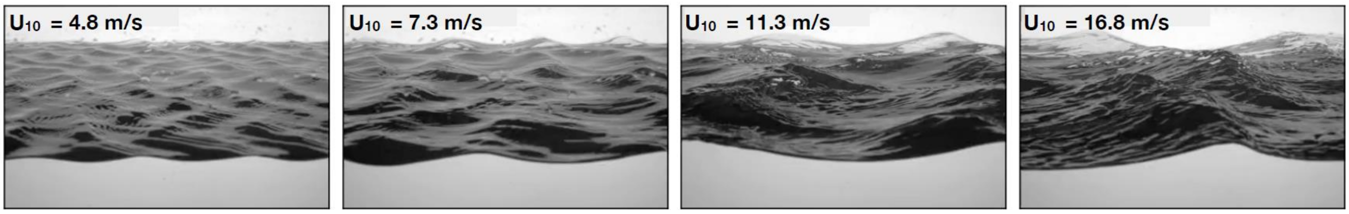

Figure 1: Wind-driven water waves under increasingly high free-stream velocity of the air.