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# Structures of turbulent boundary layer in a wind-driven gravity-capillary surface wave

Wu-ting Tsai

National Taiwan University, Department of Engineering Science and Ocean Engineering, Taipei, Taiwan (wttsai@ntu.edu.tw, +886-2-2392-9885)

Numerical simulation of a wind-driven non-breaking gravity-capillary wave and the underlying turbulent flow is conducted to identify the characteristic signatures of various surface parameters, including temperature, gas flux, velocities and roughness; and to explore the potential correlations among these surface quantities. Three characteristic surface signatures and the corresponding flow processes are identified: the carrier gravity wave, the parasitic capillary wavelets, and the elongated streaks. The elongated streaks are induced by both the coherent streamwise vortices formed within the turbulent shear layer and the Langmuir circulations arising from nonlinear interaction between the carrier gravity wave and the drift current. Streaks attributed to Langmuir circulations are more intensified than those of turbulent coherent vortices. All three surface signatures can be observed in the distributions of various quantities, though some are more visible than the others. Image processing techniques, employing empirical mode decomposition and phase averaging, are developed to decompose the distinct signatures thus to quantify the contributions by the responsible flow processes. It is found that elongated streaks prevail the distribution of surface temperature and gas flux, indicating Langmuir cells and the coherent eddies contribute to the major interfacial heat and gas transport. These eddies induced strong cross-stream velocity strain at the water surface which reveals resemblant elongated signatures as that the interfacial tracer properties. High correlation between the surface distributions of temperature and gas flux is observed, suggesting that the spatial and temporal distribution of surface temperature is a good proxy tracer of interfacial gas transfer.