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LES OF WIND AND WAVE FORCED OCEANIC TURBULENT BOUNDARY LAYERS USING THE RESIDUAL-BASED VARIATIONAL MULTISCALE METHOD AND NEAR-WALL MODELING

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Large-eddy simulation (LES) of wind and wave forced oceanic turbulent boundary layers is performed using the residual-based variational multiscale method (RBVMS) [1, 4] and near-wall modeling [2, 3]. Wind and surface gravity wave forcing generates Langmuir turbulence characterized by Langmuir circulation (LC) with largest scales consisting of stream-wise vortices aligned in the direction of the wind, acting as a secondary flow structure to the primary wind-driven component of the flow. Our LES is representative of a shallow water continental shelf flow (10 to 20 meters in depth) far from lateral boundaries in which LC engulfs the full depth of the water column and disrupts the bottom log layer. Field measurements indicate that occurrence of full-depth LC is typical during the passage of storms. The RBVMS method with quadratic NURBS (Non-Uniform Rational B-splines) and near-wall modeling is shown to possess good convergence characteristics for this flow. Furthermore, the use of near-wall modeling facilitates simulations with expanded domains over horizontal directions (on the order of hundreds of meters in the downwind and crosswind directions). Thus, these simulations are able to resolve multiple Langmuir cells permitting analysis of the interaction between the cells for the first time. Results are compared from simulations performed with distinct near-wall treatments: 1) the classical treatment reviewed in [3] based on a stress bottom boundary condition and 2) a recent treatment presented in [2] based on weak imposition of the no-slip bottom boundary condition.

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