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Development and assessment of dynamic water-surface roughness model for large-eddy simulation of winds blowing over water waves[1]
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Large-eddy simulation (LES) has become a useful tool for the study of turbulent winds blowing over water surfaces. The surfaces are usually covered by waves with various lengths, interacting with the wind turbulence over a wide range of scales. In the LES, in addition to the subgrid-scale (SGS) stress in the flow, the SGS surface roughness also needs to be modeled. In this study, following the work by Anderson and Meneveau (JFM, 2010) on the dynamic modeling of the SGS roughness of stationary surfaces, we have developed a new dynamic model for the water-surface SGS roughness based on the physics of surface waves. The roughness is quantified by an integral of the SGS wave spectrum weighted based on the wind-wave kinematics, with an unknown model coefficient as prefactor. This coefficient is determined dynamically based on the first-principles constraint that the total surface drag force must be independent of the LES filter scale. This new roughness model is assessed by *a priori* and *a posteriori* tests, and is found to successfully capture the effects of SGS surface waves on the wind turbulence without *ad hoc* prescription of model parameters.

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