Bubble-induced dissipation under unsteady breaking waves

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Wave breaking is a highly dissipative process, and also a source of turbulence in the ocean surface layer. It entrains a large volume of air in bubbles that rapidly evolves into a distribution of bubble sizes, which interacts with fluid turbulence and organized motions. The liquid-bubble interaction, especially in the complex two-phase bubbly flow under breaking waves, is still poorly understood. In this presentation, we perform a large-eddy simulation (LES) using a Navier-Stokes solver extended to incorporate entrained bubble populations, using an Eulerian-Eulerian formulation for a polydisperse bubble phase, to consider an isolated, unsteady breaking event. The volume of fluid (VOF) method is used for free surface tracking. We examine momentum exchange between dispersed bubbles and liquid phase as well as shear- and bubble-induced dissipation, both in spilling and plunging breakers. Comparison of mean and turbulent velocities, void fraction distributions and integral properties of the bubble plume show that the model is capable of capturing the large scale of turbulence and bubble plume kinematics and dynamics fairly well, and the inclusion of bubbles gives better results in terms of total dissipation and turbulent velocities. We find that the total bubble-induced dissipation accounts for more than 50% of the total dissipation in the breaking region. All of the simulations are repeated without the inclusion of dispersed bubble phase, and it is shown that the integrated TKE in the breaking region is damped by the dispersed bubbles about 20% for the large plunging breaker to 50% for the spilling breakers. In the plunging breakers, TKE is damped slightly or even enhanced during the initial stage of active breaking.

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