Fluid-bubble interaction and dissipation mechanisms under unsteady breaking waves

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Wave breaking entrains large volume of air in bubbles that are believed to suppress liquid phase turbulence. In addition, some part of the initial organized wave energy is lost through work done in entraining air against buoyancy forces. In this presentation, we extend work by Ma et al. (2011, 2012), on simulation of surfzone breaking waves with a poly-disperse two-fluid model, to consider an isolated, deep-water breaking event. We use a 3D VOF-based Navier-Stokes solver extended to incorporate entrained bubble populations using an Eulerian-Eulerian formulation for a poly-disperse bubble phase. Turbulence is simulated using a LES approach with dynamic Smagorinsky subgrid formulation. For the bubble induced turbulence we use a well known model of Sato and Sekoguchi (1975). We examine shear- and bubble-induced dissipation and amount of potential energy associated with entraining the air both in spilling and plunging breakers. We also study the bubble effects on the total TKE, mean and turbulence velocities in the breaking region up to 20 wave periods after breaking. Corresponding cases have been studied experimentally by Rapp and Melville (1990), Lamarre and Melville (1991) and Drazen and Melville (2009). 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.

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