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Cascades of bubbles in turbulent breaking waves[1] WAI HONG RONALD CHAN, PERRY JOHNSON, JAVIER URZAY, PARVIZ MOIN, Center for Turbulence Research, Stanford University — Turbulent breaking waves entrain air cavities that break up and coalesce to form polydisperse clouds of bubbles. A bubble-tracking algorithm is developed to identify bubble breakup and coalescence events in interface-capturing two-phase numerical simulations, and to quantify the resulting transfers of air between bubbles of different sizes. The time evolution of the volume- and ensemble-averaged bubble size distribution resulting from imbalances of the averaged transfer fluxes is described by a population balance equation with models for breakup and coalescence kernels. The formalism resembles the phenomenology of the Richardson-Kolmogorov energy cascade in single-phase turbulence. In order to demonstrate the presence of a bubble cascade, the transfer of air mass in bubble-size space by breakup and coalescence is examined for an ensemble of simulations of turbulent breaking waves. For breakup, a quasi-local transfer is observed in which the net transfer of air across a certain bubble size primarily depends on the number and breakup frequency of bubbles of similar sizes. This quasi-locality suggests that the statistics of bubble breakup at intermediate sizes are largely independent of the smallest and largest bubbles, in support of the idea of a bubble breakup cascade.

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