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Scale effects for air entrainment in quasi-steady breaking waves[1]

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Quasi-steady breaking waves are prominent and highly observable features in civil, environmental, ocean and naval engineering applications with direct impact on turbulent dissipation and air-sea interaction. We use high-resolution 3D direct numerical simulation of quasi-steady breaking waves to study the air entrainment characteristics as a function of resolvable features within the wave. The numerical method utilizes conservative Volume of Fluid (cVOF) to capture the interface on a Cartesian grid. A submerged body generates the quasi-steady breaking wave. Our particular interest lies in developing parameterizations and models that relate the entrainment due to quasi-steady wave breaking to underlying flow characteristics. For different Froude numbers Fr, we observe two flow regimes: a periodic-wave-breaking and a metastable regime. For the periodic-wave-breaking regime we show that the bubble-size distribution (above the capillary length scale) for each entrainment period achieves an expected slope of $r^{-\beta}$, β=10/3 and the mean volume of entrained air scales linearly with Fr^2. We also observe a direct correlation between strong underlying vertical vorticity flux events and surface entrainment. The behavior and scaling in the metastable regime is different and

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