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Scaling and modeling of air entrainment volume from vortex interactions with a free surface[1] KELLI HENDRICKSON, XIANGMING YU, DICK YUE, Massachusetts Institute of Technology MIT — Understanding air entrainment from vortex interactions with a free surface is a critical component for predicting air entrainment 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 individual vortex interactions with a free surface to study the air entrainment characteristics as a function of the vortex parameters. The numerical method utilizes conservative Volume of Fluid (cVOF) to capture the interface on a Cartesian grid and informed component labeling (ICL) to quantify the entrainment characteristics. Our particular interest lies in understanding the total volume of air entrainment due to underlying vortical interactions. By varying the vortex Froude number, Weber number, Reynolds number, and incidence angle, we establish the dependence of the initial onset entrainment volume as a linear function of the vortex circulation flux Froude number. We define a critical value and relative depth below which vortex interactions with a free surface do not entrain air. Finally, we show the applicability of the scaling and model within the context of quasi-steady breaking waves generated by a fully-submerged circular cylinder.

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