# Breaking of short-crested waves and induced vorticity

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Short-crested waves (SCWs) are doubly periodic waves in the plane. They are the simplest non-trivial three-dimensional (3D) waves. They may occur under different conditions such as reflection by a vertical wall or cliff, diffraction behind an offshore structure or island[1]. Like two-dimensional waves, SCWs can break. The longshore variations of breaking wave height, which characterize short-crested waves breaking in the surf zone, are responsible for the huge amount of vorticity creation responsible for rapid dispersion of pollutants and nutrients along the coast. They can also generate localized flows or rip currents[2].

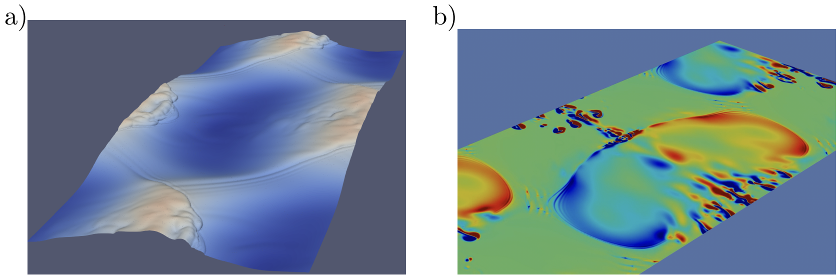

Figure 1: DNS of a breaking short-crested wave: (a) air-water interface (b) vertical vorticity at mean water level.

Simulations of 3D isolated SCWs breaking have been carried out by means of wave focusing using a LES/VOF model. One can identify the rapid generation of both spanwise and streamwise vorticity, as well as residual streamwise vorticity consisting to a great degree of organized streamwise vortex structures[2]. Recent work using two-phase DNS of 3D breaking waves has shown its ability to resolve the mixing transition in the turbulent multiphase flow with a reasonable agreement regarding available laboratory data[3]. The ERC HIGHWAVE project is a multidisciplinary project focusing on breaking waves in the ocean both numerically and experimentally (field and laboratory). We use recently developed sophisticated tools to investigate the ability of DNS to incorporate the surf zone vortex dynamics through the study of a single short-crested wave breaking event. We also investigate the dependence of the vortex structure on the three-dimensionality of the wave. We study the breaking of an unstable spilling short-crested wave solution by solving the two-phase incompressible Navier-Stokes equations with surface tension provided by the *Basilisk* library, and show that these calculations are able to accurately predict the vortex dynamics in the surfzone.

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[1]J. R. C. Hsu et al., *J. Fluid Mech.* **90**, 179-196 (1979).
[2]J.T.Kirby and M.Derakhti, *European Journal of Mechanics - B/Fluids*, **73**, 100-111 (2017).
[3]Mostert et al., *Journal of Fluid Mechanics* **942**, A27 (2022).