Simulation of 3D depth-limited breaking waves on a submerged bar in a fully non-linear potential flow model.

Sunil Mohanlal[1], Jeffrey C. Harris[1], Marissa L. Yates[1], Luc Pastur[2], Christophe Peyrard[1,3], Stephan T Grilli[4]

[1] LHSV, Ecole des Ponts, EDF R&D, Chatou, France
[2] UME, ENSTA Paris, Palaiseau, France
[3] EDF R&D LNHE, Chatou, France
[4] Department of Ocean Engineering, University of Rhode Island, Narragansett, RI, USA

Simulating breaking waves in Navier-Stokes models is computationally intensive, motivating researchers in the past and present, to develop efficient numerical methods. Generally, these methods are calibrated for specific cases since they are based on assumptions that do not consider the complete physics of breaking waves. We have developed a method of modelling 3D depth-limited breaking waves, based on our recent work proposing a unified 2D depth-limited wave breaking model (Mohanlal et al.) in the boundary element method, fully non-linear potential model of Grilli et al. 2001; Harris et al. 2022. The proposed wave breaking model consists of (1) a universal breaking onset criterion from Barthelemy et al. 2018 and Derakhti et al. 2020, i.e., an evolving crest, whose ratio of horizontal particle velocity at the crest, u, to crest velocity, c, exceeding a critical value, $B = u/c = 0.85$, will always break; (2) the energy dissipation in breaking crests that is determined by a non-dimensional breaking strength parameter b (defined such that wave energy dissipation rate per unit length of the breaking crest, $\varepsilon = b\rho g^{-1}c^5$) following Mohanlal et al., which is then modeled as an absorbing pressure on the free surface; (3) a termination criterion based on B to stop this dissipation. At the workshop, we will present the most recent results, including validation of the wave breaking model in comparison to the laboratory measurements of regular wave propagation over 3D submerged bar of Kamath et al. 2022.

References

1. Mohanlal, S., Harris, J., Yates, M., and Grilli, S. 2022. Unified depth-limited wave breaking detection and dissipation in fully nonlinear potential flow models. Coastal Engng. *Submitted*.
2. Grilli, S. T., Guyenne, P., and Dias, F. 2001. A fully non-linear model for three-dimensional overturning waves over an arbitrary bottom. Intl. J. Numer. Meth. Fluids 35(7), 829–867.
3. Jeffrey Harris, Emmanuel Dombre, Michel Benoit, Stephan T. Grilli, Konstantin Kuznetsov. Nonlinear time-domain wave-structure interaction: a parallel fast integral equation approach. International Journal for Numerical Methods in Fluids, Wiley, 2022.
4. Barthelemy, X., Banner, M., Peirson, W., Fedele, F., Allis, M., and Dias, F. 2018. On a unified breaking onset threshold for gravity waves in deep and intermediate depth water. J. Fluid Mech. 841, 463–488.
5. Derakhti, M., Kirby, J. T., Banner, M. L., Grilli, S. T., and Thomson, J. 2020. A Unified Breaking Onset Criterion for Surface Gravity Water Waves in Arbitrary Depth. J. Geophys. Res.: Oceans 125(7).
6. Kamath, A., Roy, T., Seiffert, B.R. and Bihs, H., 2022. Experimental and numerical study of waves breaking over a submerged three-dimensional bar. Journal of Waterway, Port, Coastal, and Ocean Engng, 148(2), p.04021052.