Simulation of breaking waves in a High-Order Spectral model

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We discuss the implementation of a wave-breaking mechanism into two non-linear potential flow solvers HOS-NWT and HOS-ocean. These models are computationally efficient, open source codes which solve for the free surface in a numerical wave tank and an open fluid domain, respectively, using the High-Order Spectral (HOS) method. The goal of implementing a wave breaking mechanism into the HOS solvers is to approximate the free surface as a single value. To do this, the solver identifies wave-breaking onset using the criterion suggested by Barthelemy et al. (submitted), then removes energy by adding a viscous dissipation term to the free surface boundary conditions, as introduced by Tian et al. (2010, 2012).

Unidirectional wave breaking has been validated in HOS-NWT for single and multiple breaking waves, and for irregular waves in two-dimensions, by a series of experiments conducted at the Hydrodynamics, Energetics & Atmospheric Environment Lab (LHEEA) at École Centrale de Nantes (ECN). The model has demonstrated success in calculating surface elevation and corresponding frequency/amplitude spectrum before and after breaking events, as well as wave-breaking onset time, location and energy dissipation (Seiffert et al., 2017, Seiffert & Ducrozet 2017).

The success of the wave-breaking model in a unidirectional wave field provides the basis for application of the model in a multidirectional wave field. Once a multidirectional wave breaking mechanism is validated in HOS-NWT, it can be incorporated into HOS-ocean as well as other nonlinear potential flow models. This will result in a powerful and efficient computational tool which can solve for the large scale evolution of nonlinear sea states, including breaking waves. These models provide a useful tool in the study of extreme sea states, nonlinear wave phenomena, the development of rogue waves, dynamic response of offshore vessels and marine renewable energy devices, and predicting loads on marine structures, for example.

References

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