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3D HOS simulations of extreme waves in open seas, and of their reproducing in a wavetank.

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In open seas, ships and marine structures are periodically exposed to extreme waves, which constitute a major problem for both structure integrity and human safety. These extreme physical events are both three-dimensional and highly-nonlinear phenomena, making their numerical study challenging. Their occurrence may be related to a wave energy focusing which derives from a number of factors: wave-current interaction, bathymetry, wind effects, self-focusing instabilities, directional effects, etc. In the proposed work, we mainly interest ourselves in long-time evolutions of a given wavefield in deep water or finite constant depth without wind or current.

Historically, sea-spectra evolutions have been studied through approaches where a limited number of wave-component nonlinear interactions are accounted for. More recently, fully-nonlinear simulations of such evolutions have been handled in time domain by using the Higher-Order Spectral technique proposed by [1] and [2]. With respect to classical time-domain models such as the Boundary Element Method, this spectral approach presents the two assets of its fast convergence and its resolution quickness (by means of FFTs), allowing to accurately simulate long-time 3D evolutions with fine meshes. The initially proposed HOS method is limited to unbounded domains, modelled with periodic conditions applied on the sides of the numerical domain. It allows the reproduction of open-sea evolutions once an initial sea-state has been adequately defined. Several studies of long-time evolutions have thus been carried out (see *e.g.* [3] for apparition of ‘natural’ freak waves in a 2D spectrum, and propagation of 2D regular waves with 3D modulational instabilities; or [4] for a study of the nonlinear evolution of a 3D spectrum). However, the definition of adequate initial fields to start the computations is not an easy task, and can lead to numerical instabilities [5]. Moreover, in this initial HOS formulation, no wave generation or absorption is possible, making difficult experimental validations. Indeed, sea evolutions reproduced in wavetanks present the additional difficulties of wall and beach reflections, generation of spurious free waves, and of starting from the rest.

To overcome the limitations of the original HOS method, significant efforts have been made to develop and validate a new fully-spectral model able to reproduce a wavetank (see [6]). The obtained NWT model *HOST* (for HOS Tank) reproduces all the characteristics of a physical wavetank such as the ECN one: generation through a snake-wavemaker driven as the physical one, experimentally-calibrated absorbing layer, etc. Dedicated validation experimental campaigns have evidenced the capabilities of *HOST* to reproduce long-time evolutions in the wavetank (see [7]). Thus, we have at our disposal two different formulations: a periodic one, able to model propagation in open seas, and a NWT, able to fully reproduce sea evolutions in wavetanks. It must be noted, in addition, that the HOS formulation we employ has been enhanced with respect to the order-consistent one by [1] on which it is based. In particular, a specific care is paid to the dealiasing of nonlinear products in physical space, which is crucial to the code stability and precision. By the way, all the stability and accuracy tests present in literature have been redone, showing the efficiency of this enhanced technique. Consequently, both our periodic and our NWT models present the specific and attractive spectral features: a fast resolution and a high accuracy.

At the meeting, two complementary kinds of results will be presented. Firstly, simulations of extreme wave events appearing in 3D open-sea evolutions will be shown and discussed. To obtain these events using our periodic-domain HOS model, different options are possible: (i) a 3D wavefield defined by a directional wave spectrum can be let evolve until 'natural' emergence of extreme events; (ii) in such a directional wavefield, the wave phases can also be initially artificially adjusted to obtain a 'forced' focusing event after a while; finally (iii), 3D modulational (class II) instabilities can be superimposed to a regular wavefield. Secondly, such events, recorded, will be numerically reproduced in the $50m \times 30m \times 30m$ ECN wavetank by using *HOST*. The key point in this process is to adjust the wavemaker motion characteristics, in order to obtain the best fit between the target freak wave previously obtained in open sea conditions, and its reproduction in laboratory conditions. Different possible strategies will be investigated and presented at the workshop. The proposed combination of open sea and wave tank simulations is intended to provide useful informations on freak waves formation mechanisms.

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