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Towards multiscale green sea loads simulations in irregular waves with Naval Hydro pack

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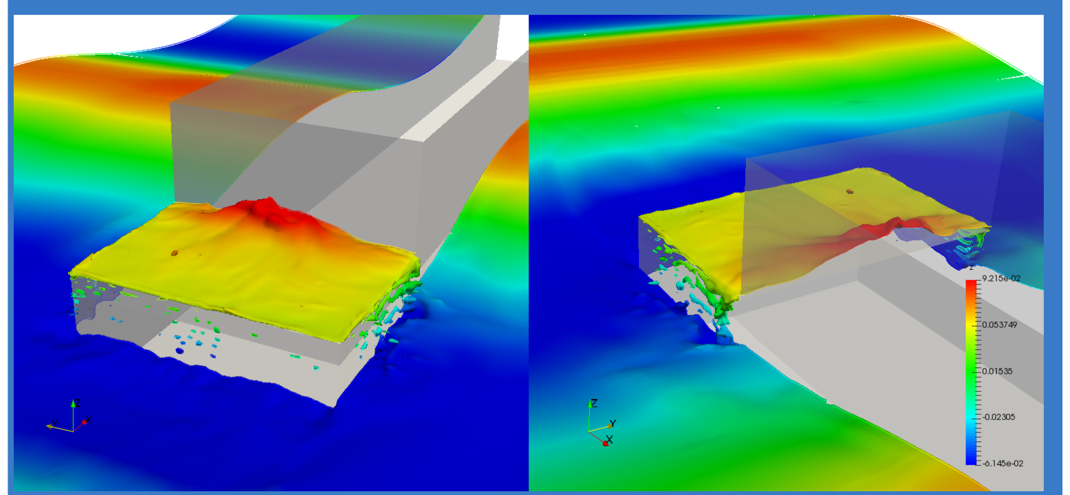


ABSTRACT

A comprehensive multiscale procedure for determination of green sea loads on ships and offshore structures is developed, with the aim of assessing deterministic green water loads on arbitrary deck structures and equipment that corresponds to the stochastic nature of the sea states which the naval object encounters.

The procedure is implemented within Naval Hydro pack and it employs several methods, such as linearised free surface CFD solver, Higher Order Spectral method for irregular wave propagation, SWENSE method for coupling CFD and potential flow methods, enhanced 6–DOF–fluid flow coupling algorithm, and geometric VOF interface capturing method called isoAdvector.

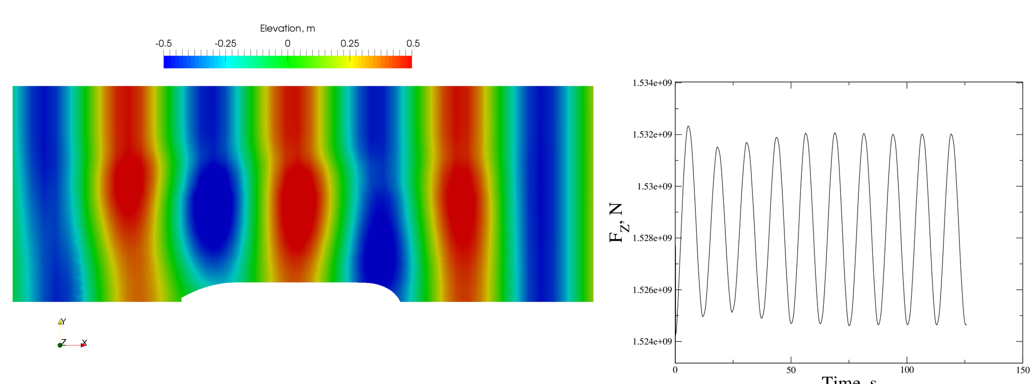
Introduction

The issue of green water loads on deck structures of naval objects is an important and complex problem. Green water phenomenon, or water on deck, is caused by wave–structure interaction which is highly nonlinear, where detailed flow features around intricate geometries on deck have to be resolved. On the other hand, being a phenomenon related to ocean waves, it has a stochastic character that needs to be taken into account, in order to assess realistic operational loads. Hence, it is the aim of this study to devise a procedure which will envelop both deterministic loads due to green water, as well as the probability of their occurrence.

Stochastic methodology

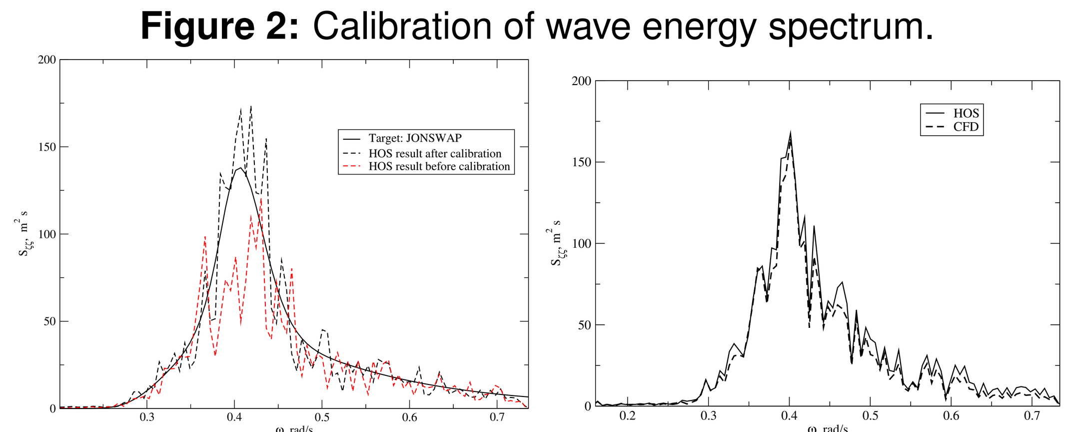
First, a linear seakeeping method is used to calculate ship seakeeping characteristics in frequency domain, where linearised free surface CFD solver is used to obtain hydrodynamical coefficients in very efficient single–phase simulations.

Figure 1: Wave diffraction simulation using linearised free surface solver.



Using linear seakeeping method, the sea state related to the highest green water probability is selected, which will be used to conduct a fully nonlinear, two–phase three hour CFD seakeeping simulation in order to detect deterministic green sea phenomena. Before the CFD simulation, the selected wave spectrum needs to be calibrated so that the waves occurring in CFD correspond to the wave spectra. Higher Order Spectral method is used for the calibration, where dozens of realisations are simulated and the initial wave energy spectrum is calibrated. The spectrum also needs to be properly propagated in CFD.

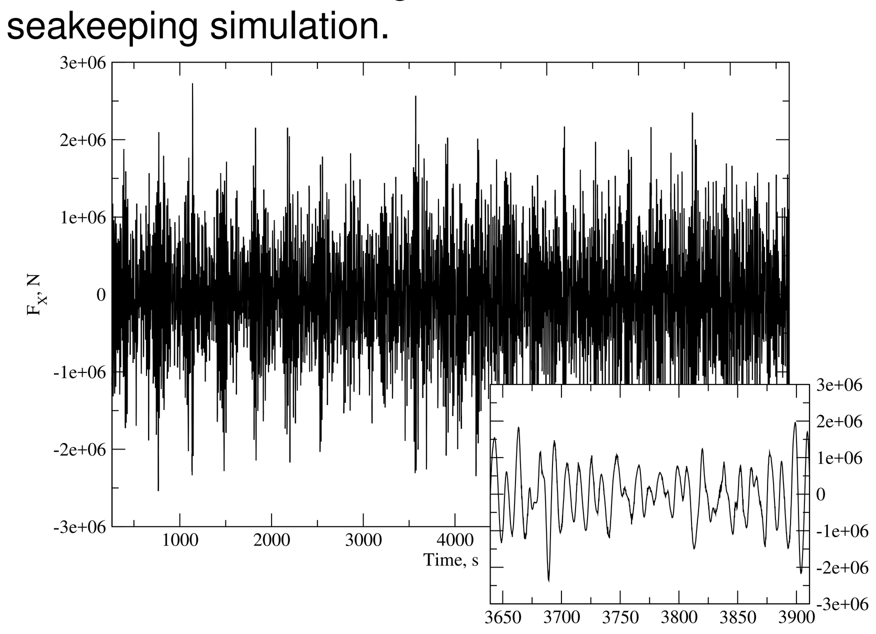
Figure 2: Calibration of wave energy spectrum.



Deterministic methodology

Using the calibrated spectrum, a global performance CFD simulation is performed. The theoretical wave spectrum is imposed in CFD using SWENSE method, while the enhanced 6–DOF–fluid flow algorithm is used, both providing a very efficient CFD seakeeping simulation, rendering the three–hour simulation feasible even on a small (<100 cores) cluster.

Figure 3: Total resistance signal of a full–scale KCS in a three–hour seakeeping simulation.



Once the three–hour seakeeping simulation is performed, post–processing methods are applied in order to find the most adverse green water event based on a case–dependent design criteria (e.g. forecastle deck structure load, overhanging life–boat load etc.). Next, the selected single green water event is re–simulated in a CFD simulation with fine spatial and temporal resolution, where even the most intricate geometries can be modelled. At this stage, isoAdvector method is used for interface capturing, which is a geometric VOF based method, enabling high interface resolution.

Figure 4: VOF field in simulation with isoAdvector (left) and with algebraic VOF (right).

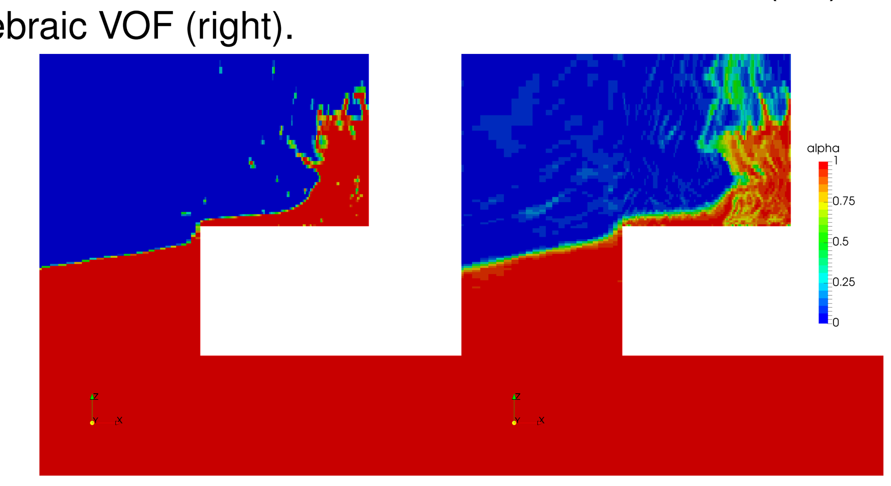
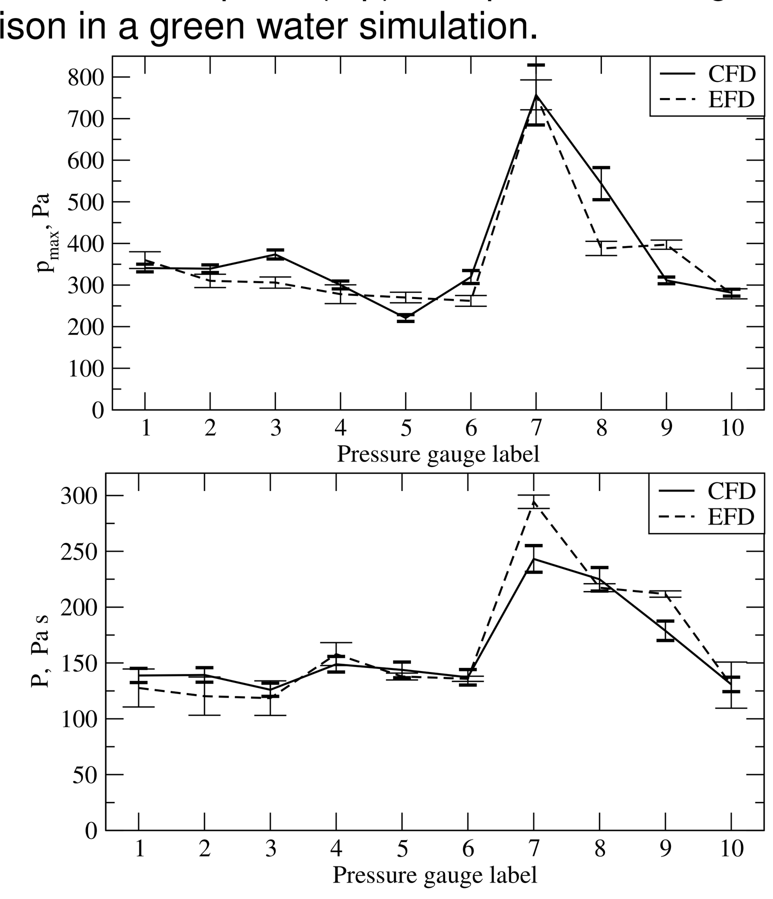


Figure 5: Pressure peak (top) and pressure integral (bottom) comparison in a green water simulation.



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