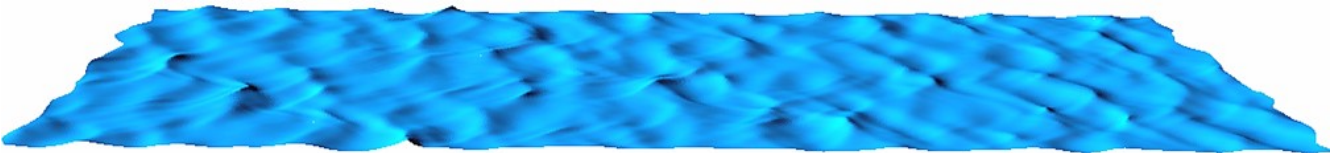# Numerical Wave Simulators
- When steep waves and statistics matter

Ocean waves can be responsible for significant loads on offshore and coastal structures. Their magnitude and probability of occurrence must be estimated accurately to ensure a good design and safe operational conditions.

Most numerical tools for the design and analysis of offshore structures are based on wave simulations. Depending on applications, the quality of the analyses strongly relies on the accuracy of the generated wave data.

Due to the nonlinear characteristics of the equations describing the propagation of waves at the water surface, no closed mathematical solution exists to model wave properties in a general way. Simplified and fast models, such as linear or second-order wave theory, assume low steepness and consequently fail at reproducing steep wave events, which are often the primary ones of interest for design purposes.

At SINTEF Ocean, we are developing capabilities to couple our numerical analysis tools to high accuracy numerical wave models that can efficiently generate 3-hour realizations of steep sea-states defined in terms of a wave spectrum.

SINTEF OCEAN'S NUMERICAL WAVE SIMULATORS

Two Numerical Wave Simulators (NWS) are currently being developed at SINTEF Ocean. Both are one-phase potential solvers that provide surface elevation and wave kinematics in the whole computational domain at any simulation time. Depending on the targeted application, the most suitable code is selected in terms of efficiency and capabilities.

HOS:

- Constant water depth

- Two- and three-dimensional domains

- Bounded (tank, with or without wave maker) or unbounded periodic (open ocean) domain

- Improved model for very steep waves

FEM-MEL:

- Any bottom topography

- Bounded domain (tank) with various wave makers: piston, single or double hinged flaps

In cooperation with NTNU, much focus is put on validation to ensure the accuracy of the numerical models, even in the challenging cases of steep and breaking waves.
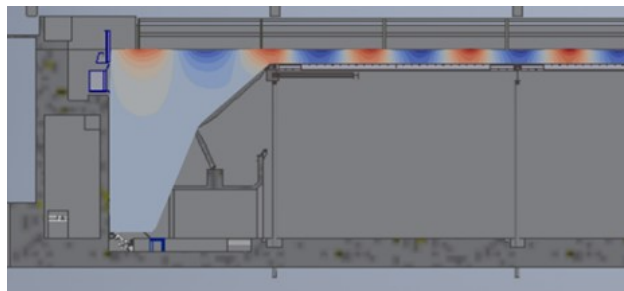
APPLICATIONS FOR AN NWS

- Digital twins of experimental wave basins to review laboratory designs and explore their range of capabilities.

- Identification of dangerous wave events along with their probabilities of occurrence for a given structure prior to model testing.

- Investigation of statistical properties of steep waves.

- Generation of three-hour nonlinear wave realizations for numerical analysis tools:

    - Surface elevation and kinematics of incoming waves for marine operations and ship simulators including SIMO, RIFLEX, VeSim, SIMA, VARUNA .

    - Coupling to CFD simulations to reduce computational cost and improve the quality of the numerically generated waves.

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TECHNOLOGY FOR A BETTER SOCIETY