IMPROVED HIGHER-ORDER BOUNDARY CONDITIONS FOR WAVE GENERATION IN THE NON-HYDROSTATIC MODEL SWASH

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INTRODUCTION

The increase in computational power in recent years has made it feasible to apply the non-linear phase-resolving wave propagation model SWASH to investigate long sea states in large coastal regions and port environments. One of the key requirements for phase-resolving models is the ability to generate and maintain a homogeneous wave field throughout the entire area under examination. However, a well-known challenge associated with non-linear wave models is related to the generation and propagation of spurious free waves, leading to wave fields that lack homogeneity.
Within the present study, we illustrate that by imposing the derived exact mathematical solutions of SWASH at the model's wave generation boundaries, the aforementioned numerical issue can be entirely resolved.

NUMERICAL MODEL AND IMPLEMENTATION

SWASH is an open-source non-hydrostatic wave propagation model (Zijlema et al., 2011). The governing equations of the model are based on the Navier-Stokes (or Euler) equations for an incompressible fluid with a free surface and a constant density.
In Vasarmidis et al. (2024), exact higher-order solutions (up to third order) for all dependent variables of SWASH were derived. This was achieved by performing a Stokes-type Fourier analysis on the model's governing equations while considering one to four vertical layers. In Figure 1, the second-order derived amplitude of the surface elevation for one, two, three, and four vertical layers is compared with the theoretical solution obtained from Stokes wave theory, and the relative error is presented.

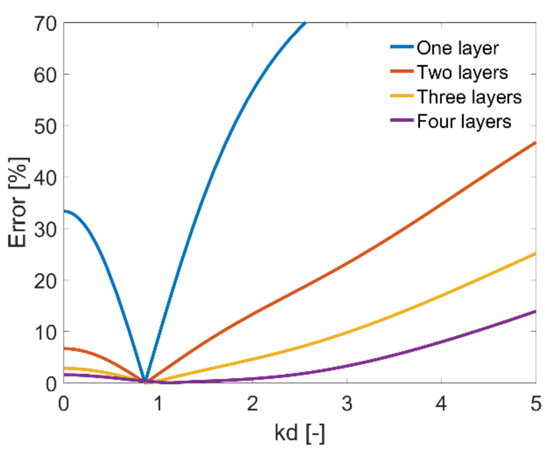

Figure 1 - Relative error for second-order derived amplitude of the surface elevation.

It is observed that as the number of layers increases, the dimensionless depth (kd) range over which SWASH can accurately represent the Stokes second-order surface component is getting larger.
Within the present study, the derived solutions for horizontal velocities and surface elevations are used to develop higher-order boundary conditions for regular and irregular waves.

VALIDATION

Figure 2 shows the computed surface elevation profiles in SWASH when waves are generated at the boundary of the computational domain by imposing either the first-order solutions (blue dashed lines) or both the derived first- and second-order solutions (red dashed lines).

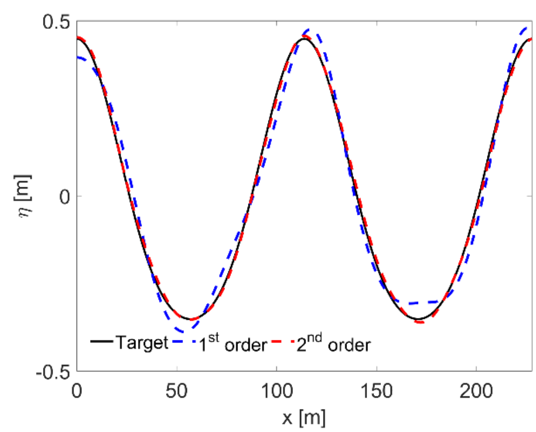

Figure 2 - Computed surface elevation profiles by SWASH using first-order and second-order boundary conditions.

CONCLUSIONS

The results demonstrate that when the derived high-order solutions are also imposed at the generation boundary of SWASH, the spurious waves are eliminated, resulting in homogeneous wave fields. More details regarding the validation results and further discussion will be provided in the conference presentation.

REFERENCES

Vasarmidis, Klonaris, Zijlema, Stratigaki, Troch (2024): Non-linear properties and wave generation for a multi-layer non-hydrostatic model (in press)
Zijlema, Stelling, Smit, (2011): SWASH: An operational public domain code for simulating wave fields and rapidly varied flows in coastal waters, Coastal Engineering, vol. 58, pp. 992-1012.