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Wave-current interactions representation by coupling spectral wave and coastal hydrodynamics models

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A parallelized unstructured coupled model is developed to investigate wave-current interactions in coastal waters at regional scales. This model links the spectral wave model Simulating Waves Nearshore (SWAN; Booij et al., 1999) with the coastal hydrodynamics shallow-water equation model *Thetis* (Kärnä et al., 2018). SWAN is based on the action density equations encompassing the various source-terms accounting for deep- and shallow-water phenomena. *Thetis* solves the non-conservative form of the depth-averaged shallow water equations implemented within Firedrake, an abstract framework for the solution of Finite Element Method (FEM) problems. In resolving wave-current interactions in the proposed model, *Thetis* predicts water elevation and current velocities which are communicated in SWAN, while the latter provides radiation stresses information for the former. The numerical domain is prescribed by an unstructured mesh allowing higher resolution to areas of interest, while maintaining a reasonable computational cost. As the models share the same mesh, interpolation errors and certain computational overheads can be contained, whereas the choice to employ a sub-mesh for SWAN model is being considered to reduce the overall cost.

The model is initially validated and its performance assessed by a slowly varying-bathymetry. Predictions are compared against the analytical solutions for the wave setup and significant wave height (Longuet-Higgins and Stewart, 1964). Comparisons also extend to results from a coupled 3-D hydrodynamics model with a spectral wave model (Roland et al., 2012). The results of the proposed coupled model exhibit good correlations with the analytical solutions showcasing the same level of efficiency as the 3-D coupled model.

References

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