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Scaldis-Coast: An Integrated Numerical Model for the Simulation of the Belgian Coast Morphodynamics

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In the present study, state-of-the-art numerical modelling tools are employed for the prediction of the long-term evolution of hydrodynamics and morphodynamics, in order to contribute to the strategic decision-making for the protection of the Belgian Coast from (extreme) sea level rise and climate change. To this end, a complex coastal model, which is referred as the Scaldis-Coast model, is being developed by use of TELEMAC-MASCARET, an open source suite of solvers for free surface flows. The Scaldis-Coast model consists of three coupled modules, i.e. the hydrodynamic module (TELEMAC2D), the wave module (TOMAWAC) and the morphology module (SISYPHE). Prior to the coupling, the individual modules are evaluated through an extensive analysis of the effect of various model parameters on the numerical predictions.

The computational grid, constructed using the finite element grid generator GMSH (Geuzaine & Remacle, 2009), consists of a broad range of element sizes, from kilometres (offshore) to a few meters (nearshore), which makes it suitable for the complex geometries of our study area. The automatic local mesh refinement is based on the geometry of the coastline (including coastal structures) and the bathymetric slopes. The latter attribute allows for the better representation of gullies and sand banks.

The Scaldis-Coast hydrodynamic simulations are performed by means of TELEMAC2D module, which solves the shallow water equations (Saint-Venant) on unstructured triangular meshes using the finite element method. The offshore boundary conditions come from a regional model of the southern North Sea (the so-called ZUNO model), through nesting. More specifically, the nesting procedure consists of simulations conducted in two levels: First a continental shelf model (CSM) is run to provide the boundary conditions of the second-level nested model (ZUNO). The model is validated by comparison of the numerically predicted water levels and velocities against measured water levels, stationary velocities and velocities along transects at several locations at the Belgian coast and the Western Scheldt estuary.

The wave modelling is performed by the TOMAWAC module which solves the balance equation of the action density directional spectrum. The wave module has been validated by reproducing successfully the wave propagation and transformation at the western part of the Belgian coast, where sand banks parallel to the shoreline are encountered.

The sediment transport and morphology simulations are conducted by means of SISYPHE module. In SISYPHE, bed load transport is calculated by using classical formulas from the literature, while the suspended load is determined by solving a transport equation for the depth-averaged suspended sediment concentration. Then, the bed evolution equation (Exner equation) is solved by use of finite element formulation. The validation of the morphology module is based on the comparison of the predicted sand volumes moving along the eastern part of the Belgian coast against measurements. Hindcasting is also performed based on historical maps from the period when the coastal port of Zeebrugge was constructed.

REFERENCES

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