Abstract

Numerical modelling of coastal zone dynamics provides basis for solving a wide range of hydrogeological, engineering and ecological problems. A novel three-dimensional unstructured-mesh model is applied to simulate the dynamics of the density field and turbulence characteristics. The model is based on a finite-volume discretization and works on mixed unstructured meshes composed of triangles and quads. Although triangular meshes are most flexible geometrically, quads are more efficient numerically and do not support spurious inertial modes of triangular cell-vertex discretization. Mixed meshes composed of triangles and quads combine benefits of both. In particular, triangular transitional zones can be used to join quadrilateral meshes of differing resolution. The main aspects of this approach determining its reliability are discussed. The results of several simulations showing the performance of the model with regard to modelling wetting and drying, internal waves, and tidal dynamics are presented.

Strategy of mixed meshes

The advantage of mixed meshes is that quads are more efficient computationally. Indeed, compared to triangular meshes with the same number of scalar degrees of freedom, they have twice less elements and 1.5 times less edges. This leads to shorter cycles and a reduced computational burden. Clearly, in close proximity to coast one may need the versatility of triangular meshes for geometrical reasons. Outside these areas, the triangular part may only be needed to provide smooth transition between quadrilateral meshes of differing resolution. This is very similar to the idea of nesting, and is perhaps more value of modeling for large-scale ocean circulation than for applications on the coastal scale.

For many wave applications, the approach may work just fine. However, if nonlinear effects are significant, or, in other words, the grid-scale Reynolds number is sufficiently high, transitional zones may be vulnerable to noise, especially on the triangular part. For this reason, the reliability of mixed meshes depends on whether we are able to control the noise in the case it is generated. That said, it should be clear that the transition we are dealing with here is much more gradual than the jump in resolution in traditional nesting, and fields are always consistent across the coupling zone if dissipation operators are properly adjusted (Danilov and Androsov, 2014).

Model

- The Finite-Volume Ocean Model (FVOM) model solves three-dimensional primitive equations for the momentum, continuity, density-constituents, and turbulence-characteristics equations.
- FVOM uses a θ-coordinate in the vertical; it is coupled with GOTM turbulence closure sub-model, employing the Smagorinsky formulation for the horizontal viscosity and is equipped with a wetting and drying algorithm.
- FVOM uses a mode-splitting technique to solve the momentum equations with two distinct time steps: external and internal mode time steps to accommodate the faster and slower barotropic and baroclinic responses, respectively.

Future developments

- Sediment transport model
- Wind-surge model
- Ice model
- Coupling with global models

References