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Preliminary results of a finite element model of the ecohydrodynamics of the Scheldt estuary and the adjacent Belgian/Dutch coastal zone

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ABSTRACT

A fundamental problem in estuarine and coastal modelling is the need to simultaneously consider large- and small-scale processes, especially when local dynamics or local environmental issues are of interest. The approach widely resorted to is based on a nesting strategy by which a coarse grid large scale model provides boundary conditions to force fine resolution local models. This is probably the best solution for finite difference methods, which need structured grids. However, the use of structured grids leads to a marked lack of flexibility in the spatial resolution. Another option is to take advantage of the potential of the more modern finite element methods, which allow the use of unstructured grids in which the mesh size may vary over a wide spectrum. With these methods only one model is required to describe the whole range of scales.

Such an unstructured-mesh model is used herein, namely the Second-generation Louvain-la-Neuve Ice-ocean Model (SLIM, http://www.climate.be.SLIM). For one of its first realistic applications, the Scheldt estuary area is studied. The hydrodynamics is primarily forced by the tides and the neatest way to take it into account is to prescribe them at the shelf break. This results in a multi-scale problem since the domain boundary lies at the shelf break, and covers about 1000 km of the North Sea and 60 km of the actual estuary, and ends with a 100 km long section of the Scheldt river until Ghent where the river width does not exceed 50 m. Such a broad spectrum of characteristic length scales is an ideal test case for a multi-scale model.

Two-dimensional triangular elements are used to simulate the hydrodynamics from the shelf break to Antwerp (80 km upstream of the mouth - see Fig. 1) and one-dimensional elements are implemented for the riverine part between Antwerp and Ghent, including the major tributaries.

Due to the significant tidal range in the Scheldt estuary, wetting and drying processes are taken into account, which raises numerical issues. A variety of methods are found in the finite difference literature. Unfortunately for finite element models the situation is more obscure. Several finite element models do use a wetting-drying method, but a rigourous description thereof is often lacking.

The model and the wetting-drying method will be described in detail and the simulation results will be discussed. The results of a first ecological application will also be shown, in which the dynamics of one fecal bacteria indicator (*Escherichia coli*) is considered. This modelling exercise illustrates the combined effect of hydrodynamics, mortality and sedimentation on the abundance of *E. coli* in the study domain with a resolution that is impossible to achieve by sampling alone.

This work falls within the framework of the interdisciplinary project TIMOTHY (http://www.climate.be/TIMOTHY) dedicated to the modelling of ecological indicators in the Scheldt catchment basin, estuary and adjacent coastal zone.

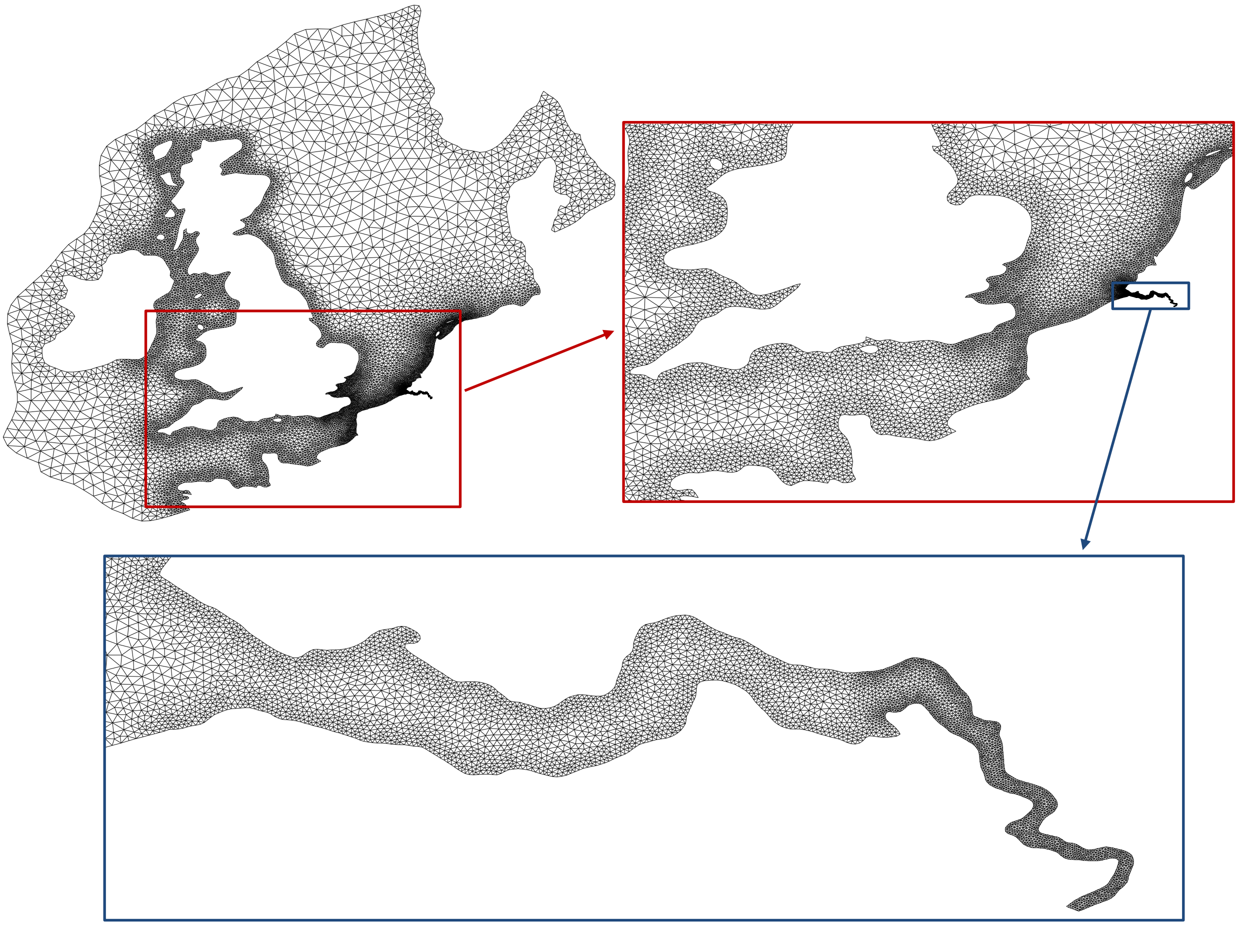

Figure 1: Multi-scale two dimensional mesh of the Northwestern European continental shelf, containing the Scheldt estuary. It is made up with almost 30,000 triangles with a characteristic length going from about 200 m in the Scheldt estuary up to more than 30 km in the deep North Sea and on the shelf break.