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# Towards an integrated and multi-scale model of the land-sea continuum

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The land-sea continuum is home to a rich and complex system, controlled by strong exchanges of material and energy between land, sea and atmosphere. All the elements of such a system have to be taken into account to understand the whole process, which means explicitly linking together the watersheds, rivers, estuaries and coastal seas. A central issue is that the involved processes take place at very different scales in space and time. To overcome this issue, we consider an integrated model using a multi-scale framework, based on the finite element method (FEM) and unstructured meshes.

In this presentation we focus on surface and subsurface models which are both fully-explicit for optimal scaling on parallel architectures. These models have been coupled with the hydrodynamical model SLIM[1] which is currently able to model the river-estuary-coastal sea continuum. All these models use the discontinuous Galerkin (DG) FEM and include a tracer transport module. The 3D variably saturated groundwater model is based on the Richards equation, the 2D surface water model uses the diffusive wave approximation of the shallow water equation and the 1D river model is based on the full shallow water equation. As the overall model is designed for large scale simulations, we assume that small rivers are included in the surface model.

Explicit methods in time allow for perfect parallel scaling and easy coupling. Our explicit model for the saturated-unsaturated subsurface water is robust and fully conservative. It is based on a mixed formulation, using both the pressure head $h$ and the water content $\theta$. On the one hand, $\theta$ is used for the unsaturated zone, where it is know to be more efficient. On the other hand $h$ is used for the saturated zone, where $\theta$ is constant. To produce an explicit formulation of the Richards equation, we use the false transient method in the saturated zone, where the hydrodynamics is described by an elliptic equation. To allow physical discontinuities between different types of soils, we make use of a modified jump term in the DGFEM formulation for the variable $\theta$. The surface flow model includes runoff, lakes and small rivers. The surface-subsurface and river-subsurface couplings are ensured by setting physical continuity of mass and pressure by appropriate boundary conditions (BC). The surface-river coupling is set by a weak Dirichlet BC.

We will present each component then the coupled model, with details on original aspects. Some simple test cases showing the performances will be displayed.

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[1] Second-generation Louvain-la-Neuve Ice-ocean Model (http://www.climate.be/slim)