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Discontinuous Galerkin modelling of the Congo River's coupled estuary-shelf dynamics

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With the second largest river in the world by discharge volume of water, the Congo River strongly affects the sea surface salinity in the Eastern Atlantic Ocean. The Congo River estuary is also the location of several vulnerable ecosystems (e.g. Mangroves National Park). Despite its importance, there are very few published studies about the dynamics of the area.

The river estuary is characterized by a very deep canyon that directly connects the river to the the deep sea. This unique feature strongly impacts the plume dynamics and the shelf circulation. From a numerical modelling perspective, the variation of the water column depth over a wide range of values and the steep slopes require flexible vertical coordinates and multiscale horizontal resolution. Modelling the baroclinic circulation along Congo river-to-sea continuum therefore represents a very challenging test case for any numerical ocean model.

In this study, we show that the multi-scale coastal ocean model SLIM (http://www.climate.be/slim/) correctly represents the main features of the shelf and estuarine dynamics. SLIM solves hydrostatic equations under the Boussinesq approximation on an unstructured mesh with the Discontinuous Galerkin finite element method. For numerical efficiency, the riverine part is simulated using depth-integrated shallow water equations, whilst the rest of the domain is dealt with by SLIM 3D, the baroclinic module of SLIM. The model takes into account the major forcings, i.e. tides, surface wind stress, river discharge and the large-scale deep-ocean circulation, on a single multi-scale mesh.

Beside assessing the model skill and its ability to capture the multi-scale processes that drive the shelf circulation, we assess the impact of different vertical coordinates. We show that they have to be carefully selected in order to correctly reproduce the canyon dynamics. We also analyse how the horizontal mesh anisotropy can help improve the model results. Our results compare very favourably with in-situ data on the shelf and in the estuary. They are the first high-resolution model results for this very remote and under-studied region.