SLIM: A multi-scale model of the land-sea continuum

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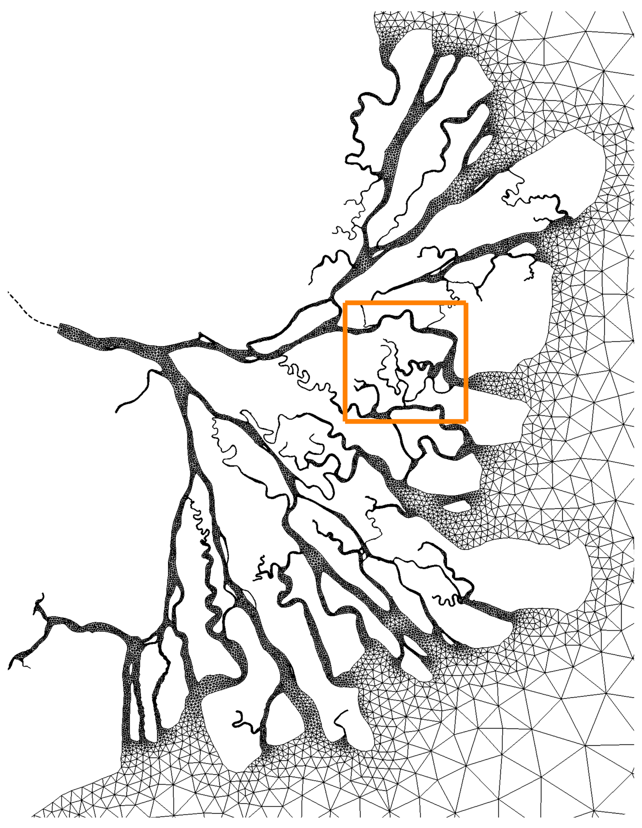
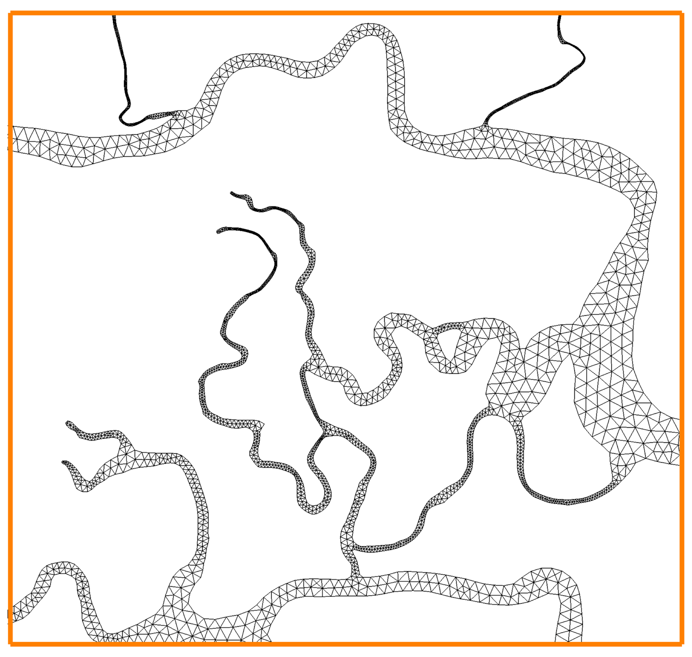
SLIM in a nutshell...

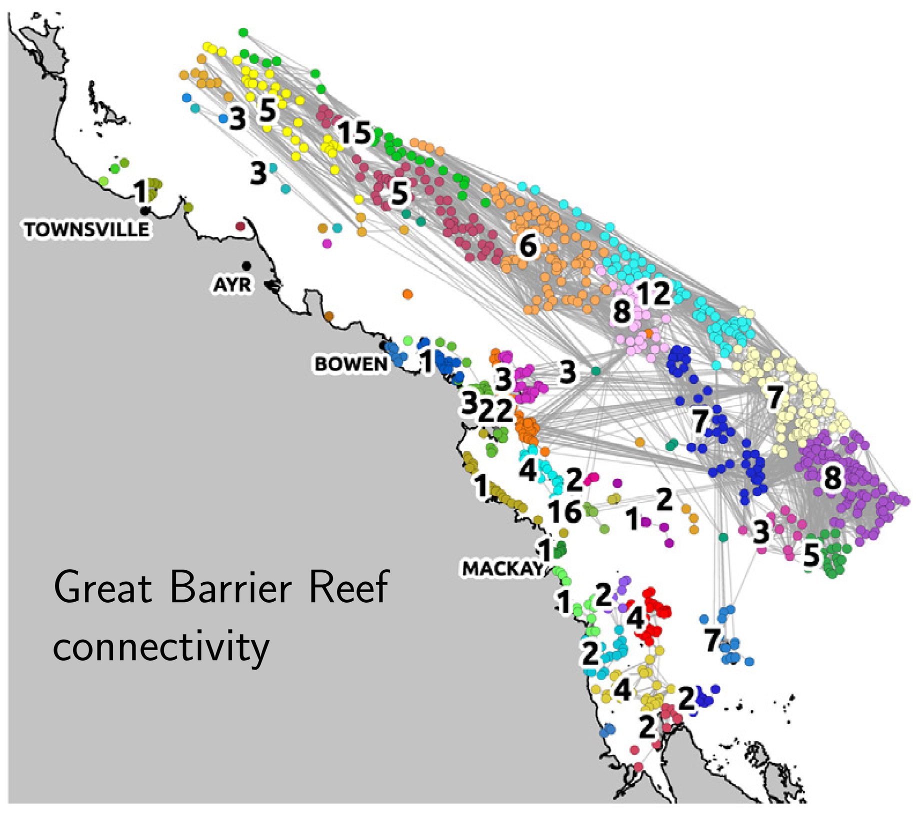
SLIM is an unstructured-mesh hydrodynamic model that can seamlessly simulate flows from the river to the coastal ocean. It relies on the Discontinuous Galerkin finite element method to achieve unprecedented accuracy, especially for very complex coastlines and bathymetry. SLIM includes the following modules to model a range of different water environments:

- SLIM1D for flows in branching river networks;
- SLIM2D for shallow barotropic flows with or without wetting and drying;
- SLIM3D for more complex barotropic or baroclinic flows where the vertical structure cannot be neglected;
- A Lagrangian particle tracker to simulate the transport of larvae or plastic debris;
- A Eulerian transport model to simulate the dynamics of passive and active tracers, such as sediments.



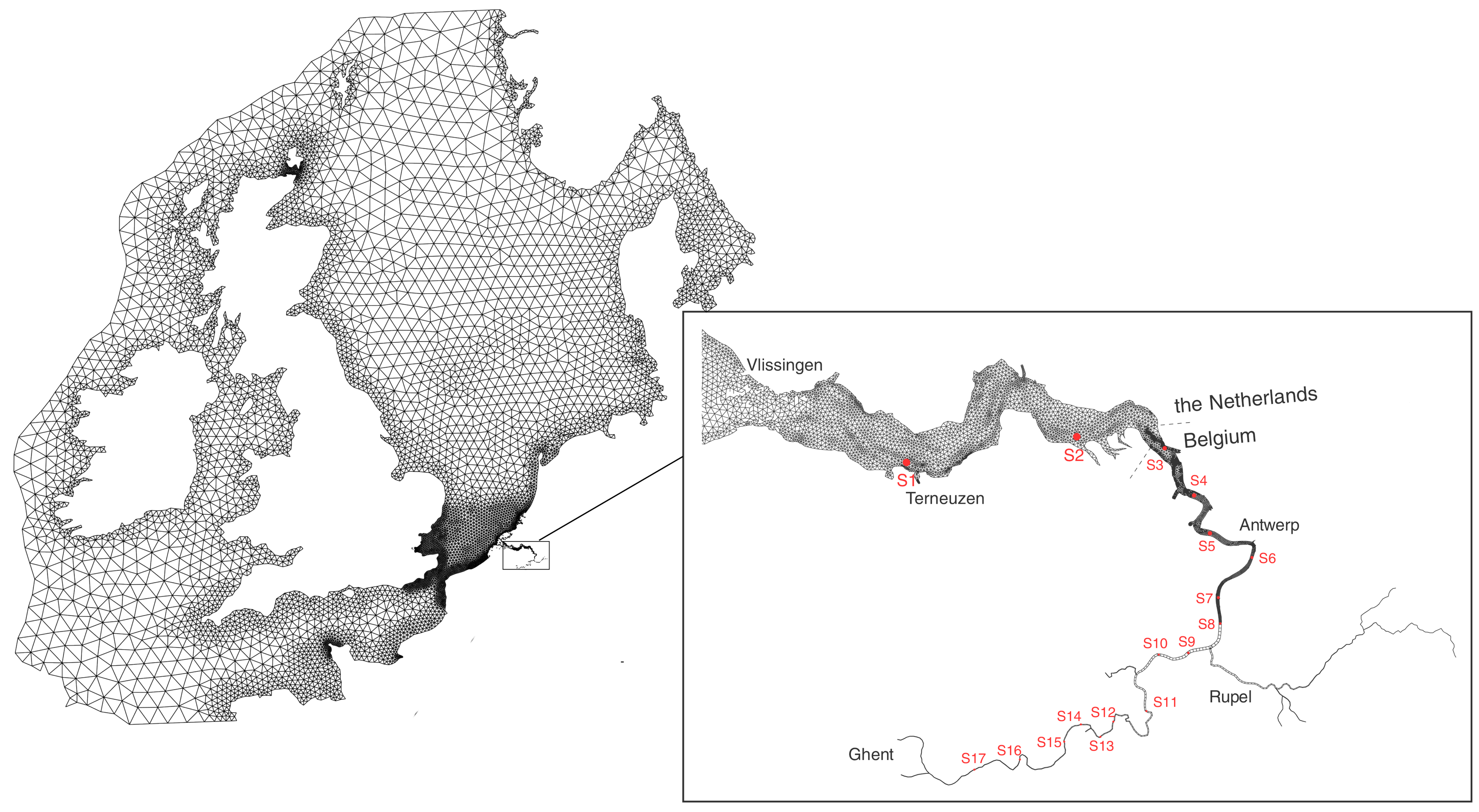
Mahakam River Delta





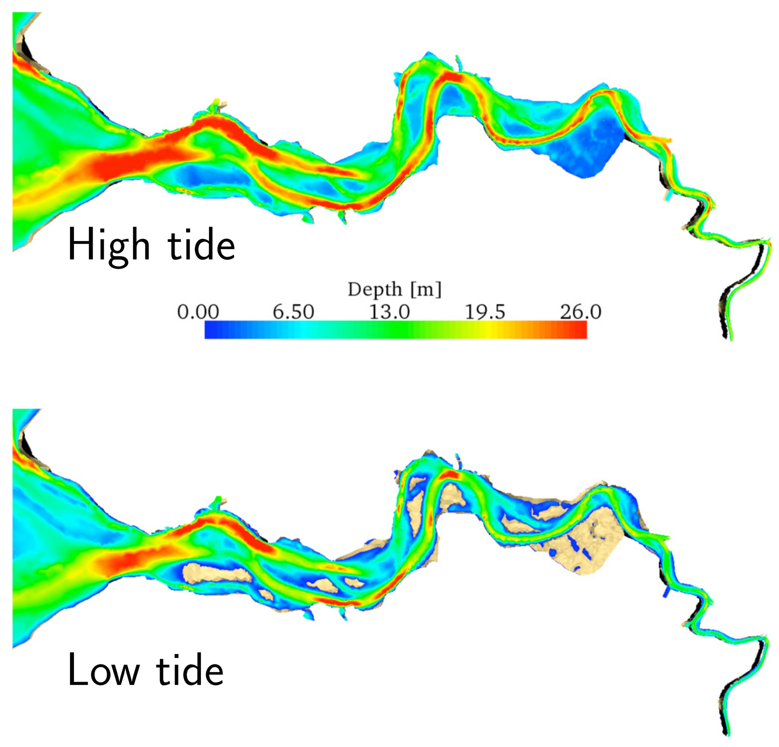
Great Barrier Reef connectivity

The Scheldt estuary with SLIM1D and SLIM2D



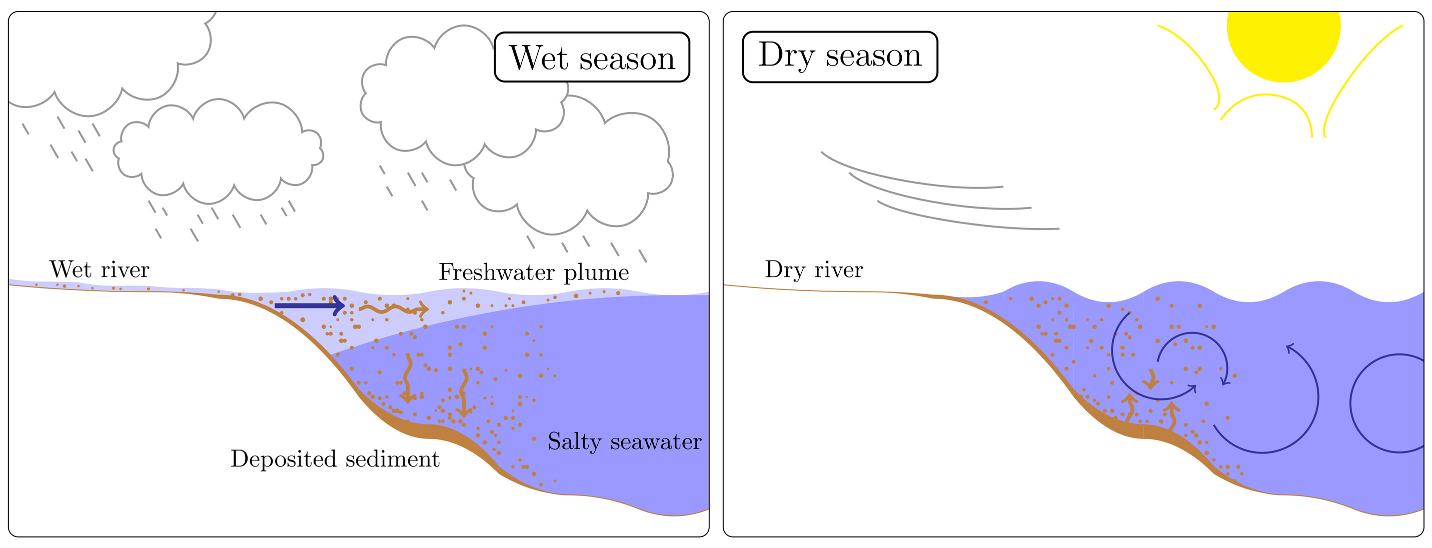
As the Scheldt Estuary is generally well-mixed with little vertical structure and small salinity gradients due to a small residual flow, SLIM2D is sufficient for capturing the dominant dynamics. The width of the estuary ranges from 8km near the mouth (at Vlissingen) to 1.5km near the Dutch/Belgian border narrowing down to 50 meters in Ghent. As it is fairly impractical to use a 2D model on such narrow channels, the rivers upstream of Hemiksem are described with a 1D model. The following model applications have been considered:

- Hydrodynamics from Gent to the North Sea through a seamless 1D-2D coupling using a wetting and drying algorithm to simulate emerging sandbanks in the estuary;
- Water quality and the transport of the E.coli bacteria through the river network;
- Age, exposure and residence times dynamics;
- Transport of fine-grained sediments;
- Risk of metal contamination;
- Phytoplankton dynamics with a coupled ecosystem model;
- Impact of radioactive releases.

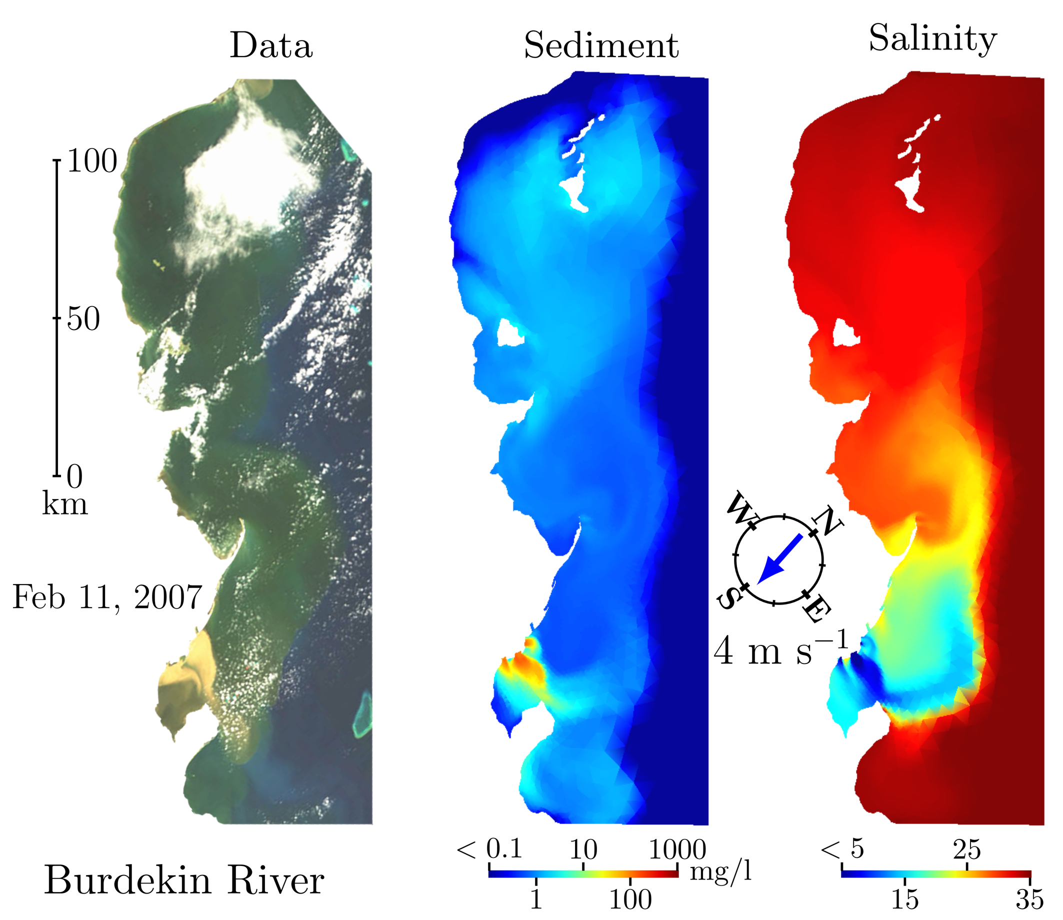


The Burdekin river ROFI with SLIM3D

The Burdekin River region (Australia) is characterised by its coastline shape (numerous capes and headlands) and its strong seasonal cycle (wet and dry seasons). Sediment transport and fate can vary considerably depending on the geophysical characteristics of the coastal environment.



The model reveals that, for such a system, most of the sediment load is deposited and retained in the bay near the river mouth while the suspended sediment that travels longer distances is transported within freshwater plumes during flood events. Wind resuspension processes only redistribute the sediment within the embayments and do not move it from bay to bay.

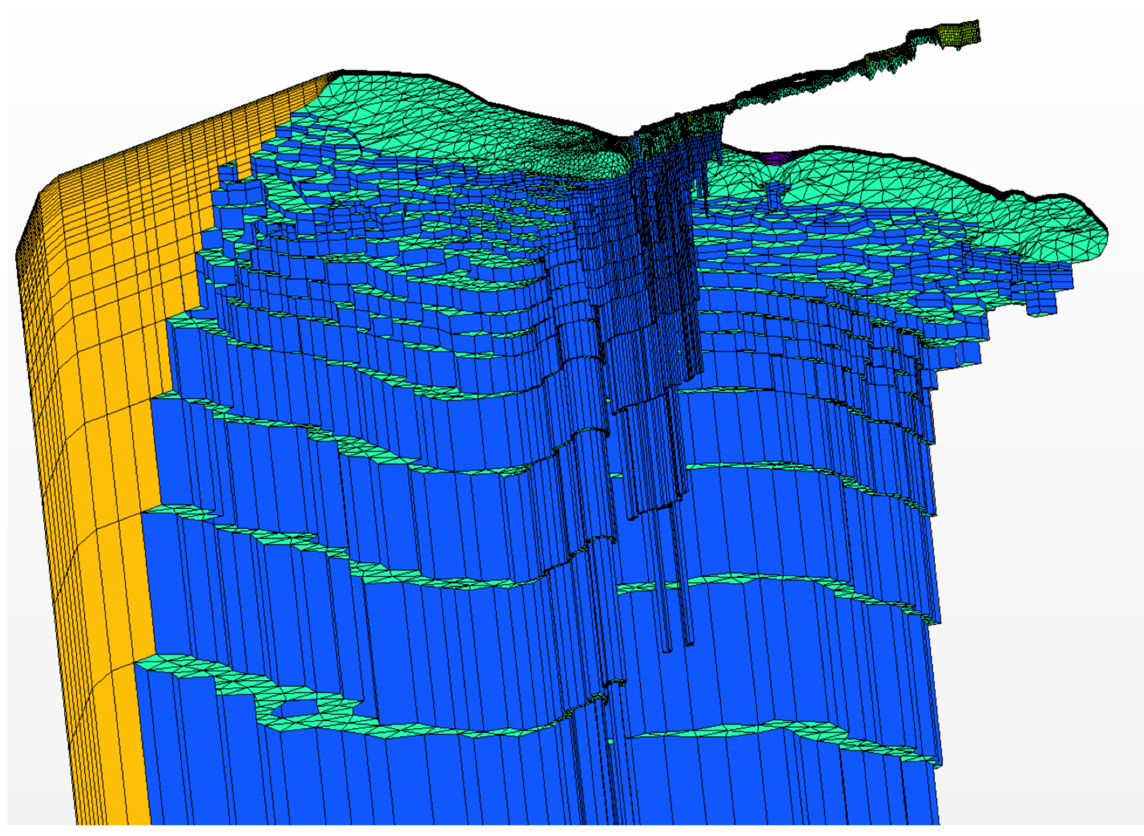


Burdekin River

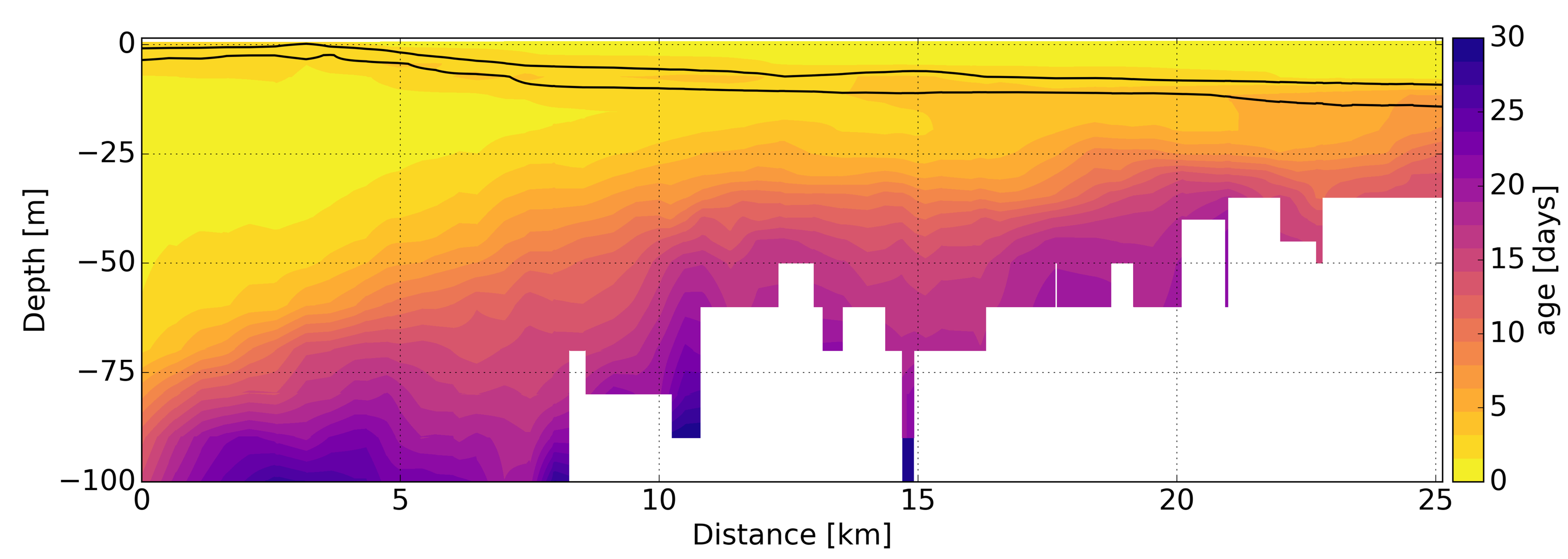
The Congo estuary with SLIM3D

The Congo River is the second largest river in the world in terms of both watershed and mean river discharge, after the Amazon River. The river mouth is characterised by a deep submarine canyon cutting through the shelf, which directly connects the estuary with the deep ocean.

The presence of this deep canyon strongly constrains the mesh generation. Hence, we use an anisotropic mesh on the horizontal combined with a mix of σ layers in the first 10 meters and z layers below. These z layers had to be built very carefully to correctly approximate the canyon and hence accurately model the 3D dynamics.



The estuarine dynamics is characteristic of a strong exchange flow, with a thin layer of freshwater moving downstream on top of a thick layer of saline waters going towards the river. The small tidal energy input and the large depth of the canyon induce a strong stratification between both layers. There is very little water renewal at the bottom of the estuary because of the low vertical mixing. This is confirmed by the renewing water age, which supports the hypoxic conditions observed near the bottom of the canyon.



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