# Unstructured-mesh Modelling of the Hydrodynamics of the Congo River Estuary and Adjacent Coastal Zone

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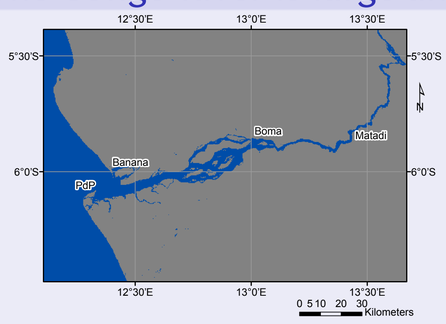
## The Congo River is large and quite remote



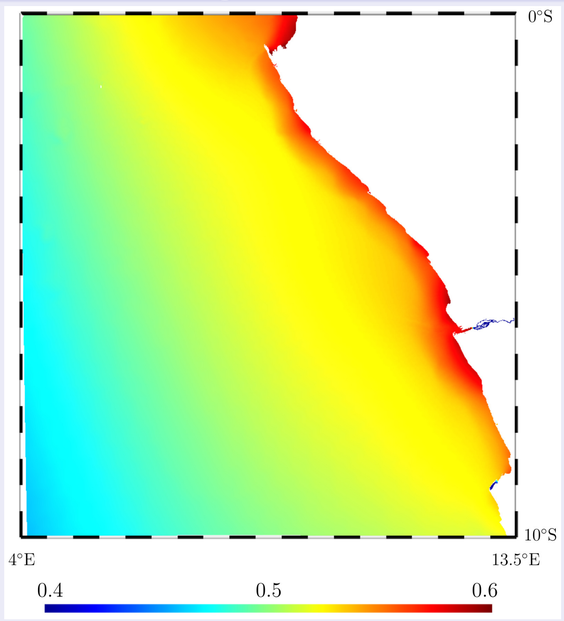

*Overview of the Congo river-to-sea continuum. Matadi is located about 10 km downstream of rapids that prevent navigation. On the map, PDP stands for Ponta do Padrão. Image courtesy of Julien Radoux.*

The Congo River discharge is the second largest in the world (average flow $\sim$ 41,000 $m^3\ s^{-1}$). The area of its drainage basin is about $3.7 \times 10^6$ $km^2$ wide. It is characterised by a deep canyon which directly connects the river with the deep ocean through hundreds of kilometres.

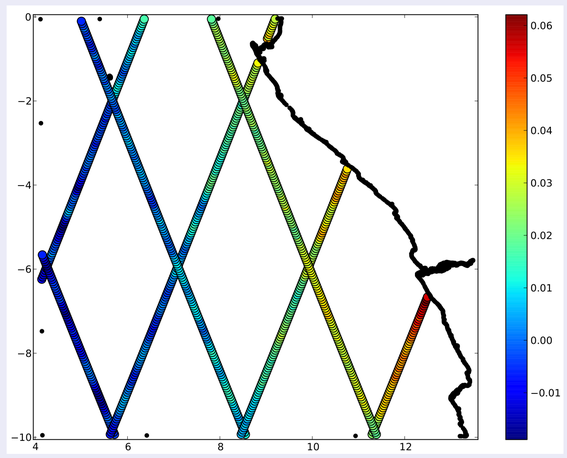
For our modelling, we have chosen SLIM (sites.uclouvain.be/slim), a 2D and 3D hydrodynamical unstructured mesh multi-rate time-stepping model. Its 2D mode uses discontinuous Galerkin finite element method.

To force the model, we are imposing upstream discharge using daily observations. Flather conditions are prescribed on open ocean boundaries, provided by a global ocean tidal model (FES2012) and a global circulation model (HYCOM). On land boundaries, we are using a no-slip condition. Winds are provided by ECMWF and prescribed as a surface stress.

## Validation using altimetric data



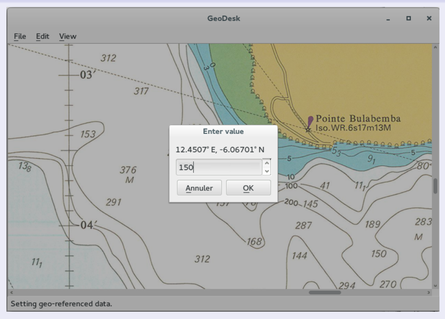

$M_2$ amplitude (in m). As expected, it is amplified by the shelf break.



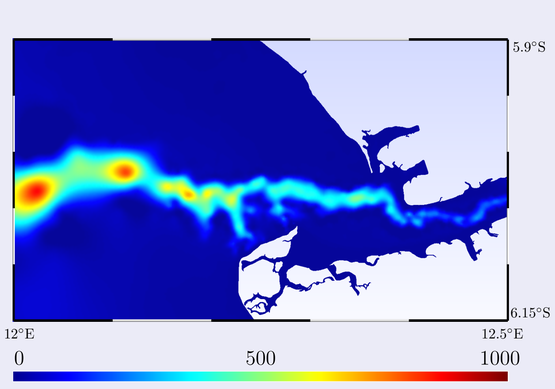

Absolute error on $M_2$ amplitude with regard to altimetry (in m). Mean error is 1.26 cm (2.53 %), RMS is 2.09 cm (4.09 %).

## Data from various sources

As a basis for the bathymetry, we have used GEBCO2008 and GSHHG for coastlines. However, these data bases do not provide a precision suitable for numerical modelling in rivers and estuaries. To complete them, we have collected several nautical charts describing the Congo River.




*ylebars.github.io/GeoDesk*



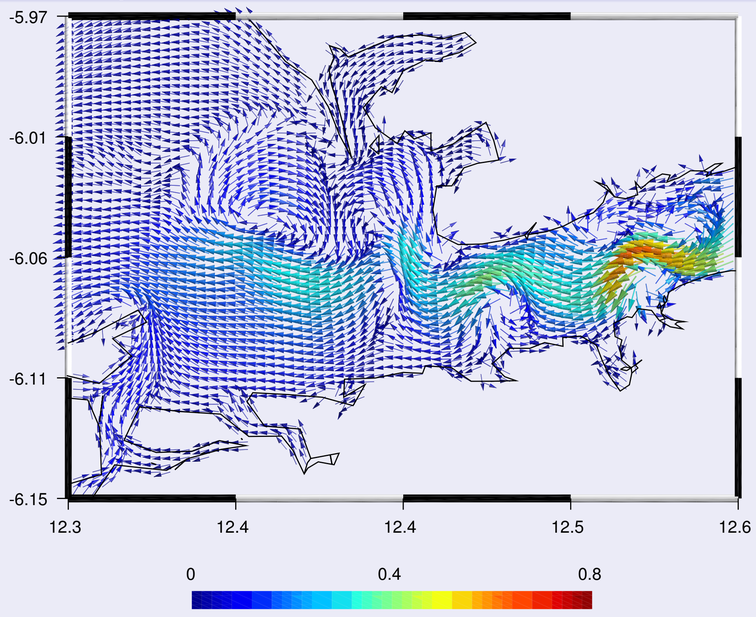

*Close-up view of our bathymetry (in m). The canyon is clearly visible.*

To join together these data sources, we have developed one piece of software, namely GeoDesk, a tool able to georeference images and map. It works as a point-and-click software and can open any image file format. All isobathymetric lines, sound points or coastlines can then be easily extracted and merged together.

The steps are the following:

- digitalise charts;
- use GeoDesk to obtain georeferenced data;
- interpolate data point;
- merge data from the diverse sources.

## Barotropic currents



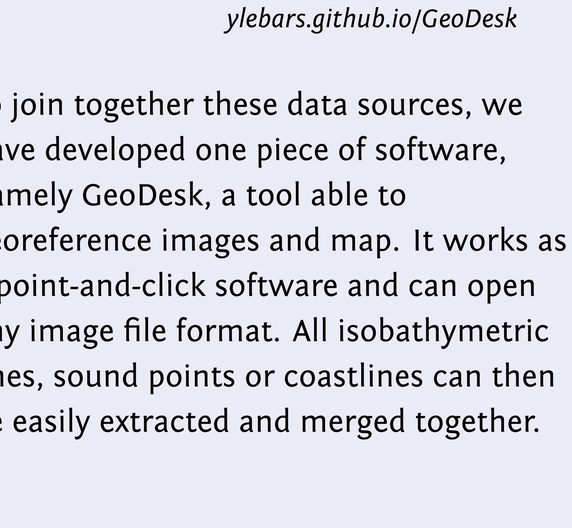

*Instantaneous currents (in m $s^1$) for mean river flow and spring tides.*

Our model suggests gyres are created along the river course and in the adjacent coastal sea. According to our sensitivity analysis, they are quite stable and are a consequence of the river flow.

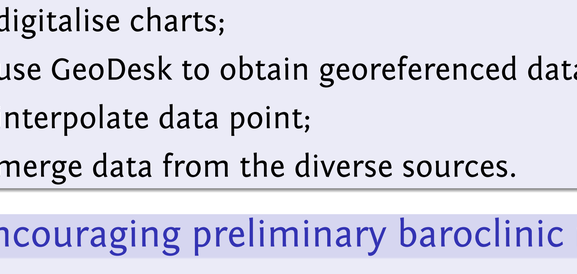
## Encouraging preliminary baroclinic modelling

Uses a shaved cells z-layers mesh:

- arbitrary number of layers (13 here);
- each layer is given an arbitrary thickness;
- number of layer varies with depth.




*3D mesh side view (magnified depth)*




*Salinity (magnified depth).*

- The model uses mode-splitting, the barotropic model being the external mode;
- turbulent closure using GOTM.

## Water age

The water age ($t - t_{in}$) is the time elapsed since entering the domain through the upstream boundary, which is located at Matadi.

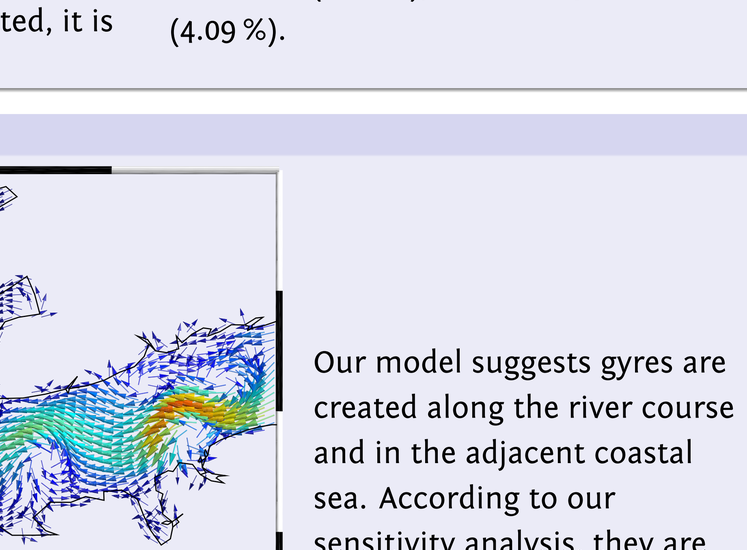



*Figure courtesy of J.M. Delhez*




*Water age downstream Matadi (in h).*

On some places, such as the "Chaudron d'enfer" near Matadi, water stagnates and water age in such places is significantly greater than in the main current channel. However, it takes less than a day for water to flow from Matadi to Boma, located 60 km away.

It takes a couple of days to reach the river mouth. But the flow is then slowed down by tides entering and leaving the estuary and it takes a few more days to reach Banana at the ocean limit.


*Water age in Congo River mouth (in days).*

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