Development of a Brazilian Operational Forecast Model for Coastal Waters

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Introduction

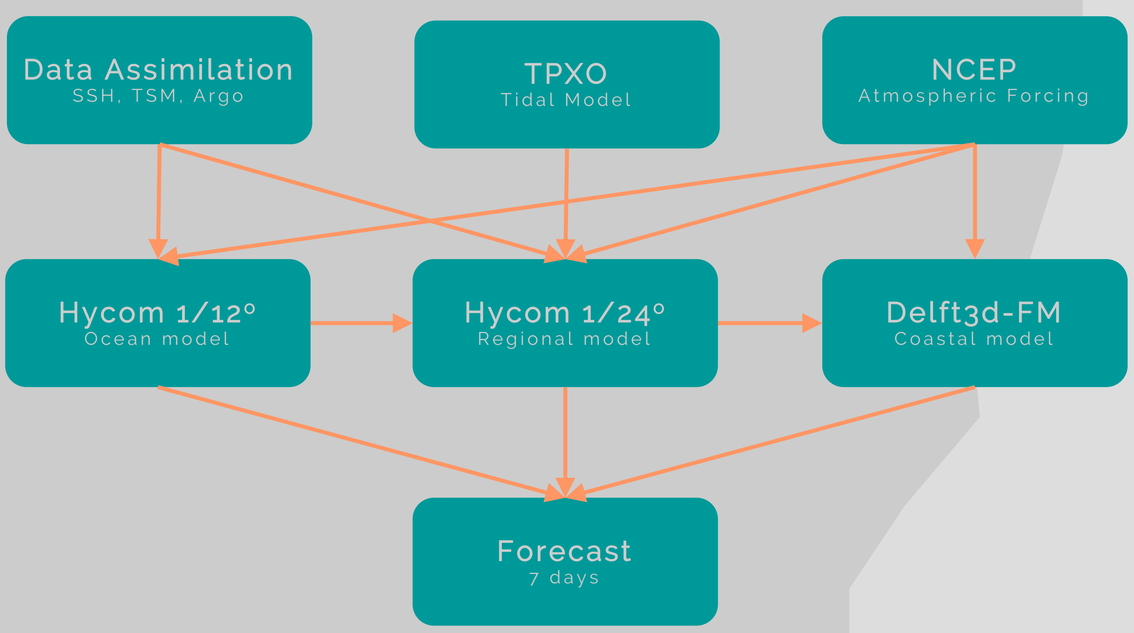
The Brazilian oil industry has experienced a fast growth in recent years caused by the discovery of new offshore reserves and technological development allowing prospection at deeper waters inaccessible until recently. This expansion means higher economic dependence on the sea, higher environmental impact and higher probability of accidents, such as oil spills.

Oil spill models constitute an essential element in contingency plans. These models should be able to reproduce and predict ocean and coastal physical processes. The main challenge in producing an effective oil spill forecast model is to develop a hydrodynamic model that solves processes at different scales. Ocean models have difficulties in solving smaller scale processes and coastal models need to be correctly forced by offshore conditions to reproduce local processes.

Despite the importance of the marine operational forecast to improve oil spill modelling in the Brazilian coast, few initiatives have been made so far. These studies are usually done using climatological data and focus in specific events without a systematic modelling approach.

Methods

This study is part of REMO, a Brazilian effort in physical oceanography and operational oceanography, started in 2006, to develop a real-time modeling forecast system for Brazilian waters. The aim of this study is to expand the ocean model developed by REMO to coastal waters.



REMO uses a set of nested HYCOM models. This study will be based on a downscale of HYCOM model for the Brazilian coast (METAREA5) with spatial resolution of 1/24 degrees and domain 45°S-10oN, 58oW-18oW which is nested in the HYCOM 1/12 degrees for the entire Atlantic Ocean. The 7-day ocean forecasts are forced with atmospheric forecasts from the NCEP/NOAA Global Forecast System (GFS) with horizontal resolution of 0.5o each 6 hr.

Large-scale meteorological and oceanographic forecasts will be obtained from the ocean model and used to force a coastal model (Delft3D-FM). Delft3D-FM yields fully baroclinic three dimensional hydrodynamic fields. Atmospheric forecasts from the NCEP/NOAA will be imported to force the surface (wind and air pressure) and REMO results will be used to force open boundaries (water level, flow, temperature and salinity). The hydrodynamic results from the ocean model and the set of coastal models will be integrated to generate the hydrodynamic fields necessary for the oil spill models forecast or contingency.

Research Questions

> What is the dynamical link between the estuarine outflow and the coastal ocean?

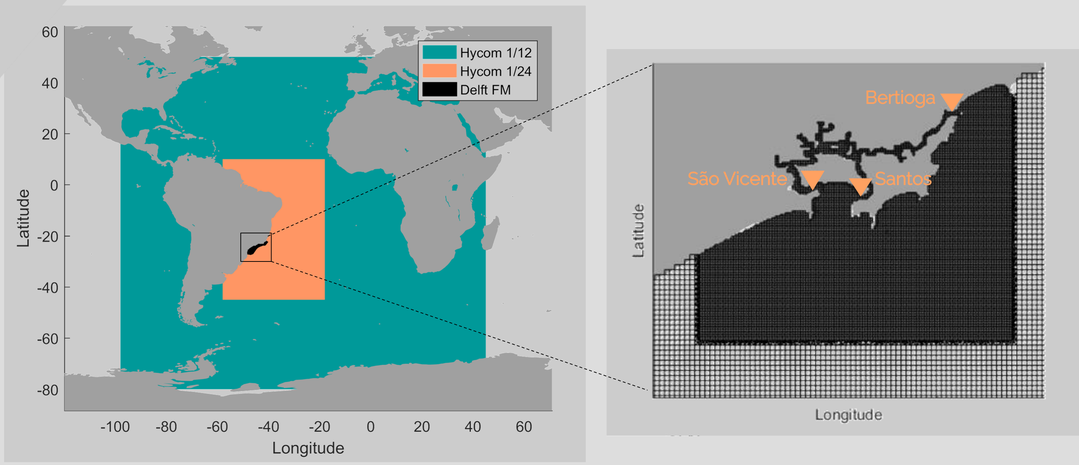
> What are the scales of the processes that drive the estuarine processes?

> Which are the most efficient coupling methods between the coastal and ocean models?

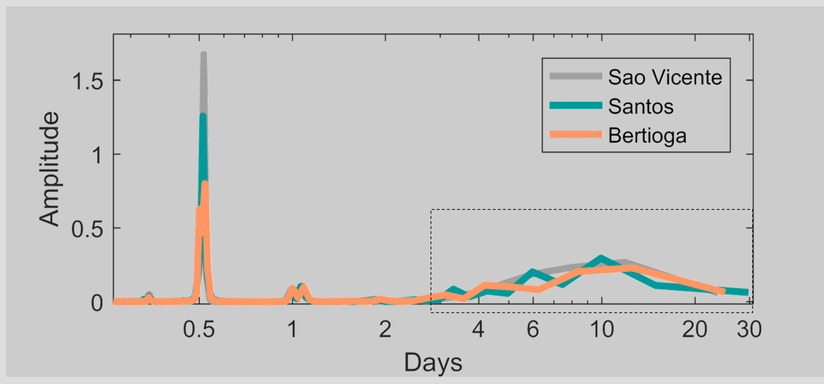
> What is the sensitivity of the coupling methods in the representation of the observed processes?

Results

The selected pilot area to test the methodology is the Santos estuary. Santos Estuarine System is located on the coast of the State of São Paulo and hosts the most important port in Brazil. The grids used in the pilot experiment are represented in the figures bellow.



Preliminary results show the importance of large-scale processes in the coastal dynamics. Water Level and current data available for Santos estuary show signals with periods higher than 2 days, associated with low frequency waves that propagates along the Brazilian coast. In order to reproduce and predict these waves, it is of prime importance to include large-scale processes in coastal models.



In preliminary tests Rienman Boundary shows the best calibration against measured data. This boundary is used to simulate a weakly reflective boundary and uses both velocity and water level.

The next steps are the following:

> Finish the calibration and validation of the coastal model at Santos Estuary.

> Calibrate the coastal model for at least two more important estuaries with available data: Guanabara Bay and Sepetiba Bay.

> Extend the domain of the coastal model to the entire Brazilian coast.