From regional to local scale modelling on the south-eastern Brazilian shelf: Case study of Paranaguá estuarine system

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Introduction

This work presents the setting and validation of a numerical model for the south-eastern Brazilian shelf (regional model) and Paranaguá estuarine system (local model) through a downscaling approach. The model results were validated with tidal gauges data, Argo floats profiles and Sea Surface Temperature (SST) from satellite measurements. The regional model can provide open boundary conditions for other important estuarine systems located at the south-eastern Brazilian shelf, such as Guanabara Bay and Santos Bay, by following the same methodology.

Study Area

The south-eastern Brazilian shelf is known by the resonance of the third-diurnal principal lunar tidal constituent (M3) due to its geometry features, with the largest amplitudes found in the Paranaguá estuarine system. The bathymetries of the regional model were generated from the GEBCO One Minute Grid, version 2.0. For the local model, the bathymetries were generated by using digitalized nautical charts from the Brazilian Navy. The intertidal zones in Paranaguá estuary were obtained from Landsat satellite images.

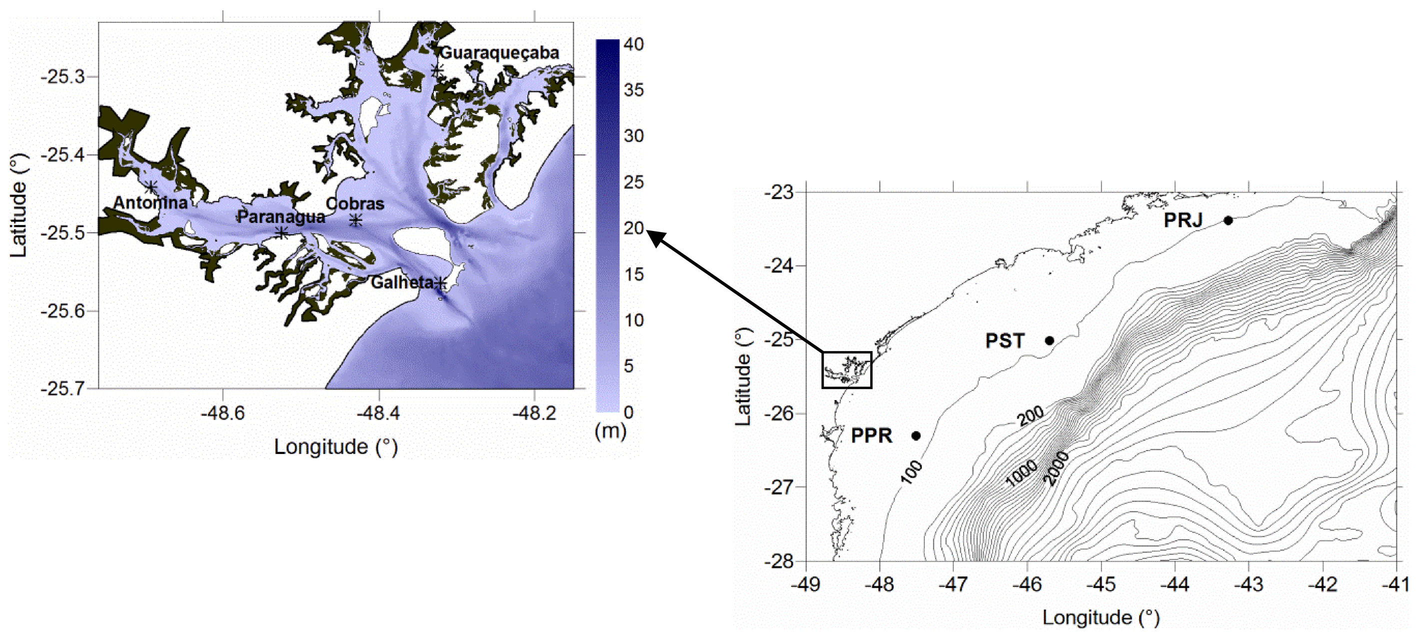

Figure 1 - Geometry features of the south-eastern Brazilian shelf (right) and Paranaguá estuarine system (left) with wetlands, showing the tidal gauges sites used for model validation.

Model Setup

In this study, we have used the MOHID water modelling system. An extensive bibliography concerning this system can be found at:

http://wiki.mohid.com/wiki/index.php?title=Mohid_Bibliography

The model was implemented by using a multi-nesting approach and with tools that allow automatic simulations in a perspective of nowcast/forecast, which can be useful to important activities, such as navigation and emergency response (e.g., oil spill). At first, three domains were nested in an online one-way for modelling the Brazilian south-eastern shelf (regional model). Then other two domains were nested in an offline way to study the tidal propagation into Paranaguá estuarine system (local model).

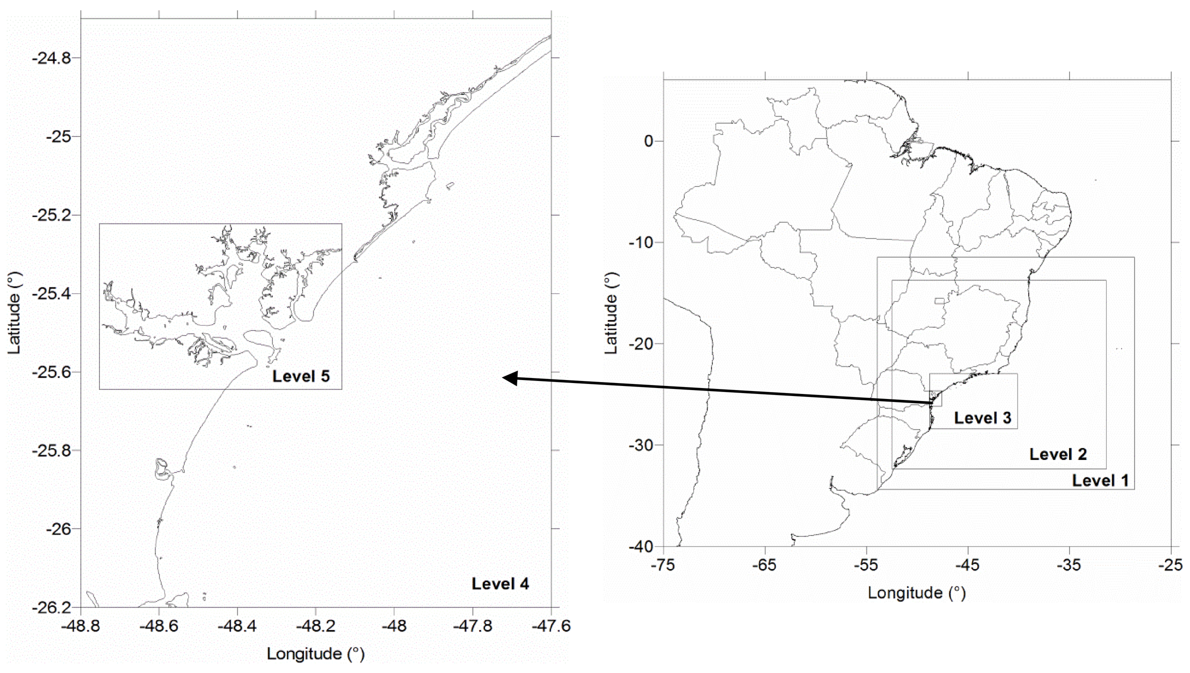

Figure 2 – Area covered by the local (left) and regional (right) scale models

Name	Horizontal Cells	Horizontal Resolution	Vertical Layers	Vertical Resolution	Maximum Depth
Level 1	191 x 211	12 km	1	-	5902 m
Level 2	156 x 177	12 km	49	447 m – 1 m	5503 m
Level 3	182 x 288	3 km	47	421 m – 1 m	4552 m
Level 4	132 x 175	600 m	18	7 m – 1 m	50 m
Level 5	385 x 540	120 m	16	5 m – 1 m	38 m

Table 1 – Features of the domains

Open Boundary Conditions

- FES2012 (Finite Element Solution) tidal atlas, which includes 32 tidal constituents. The tide was propagated into the nested domains using the Flather radiation scheme.
- MyOcean model results (water level, velocity, temperature and salinity) were used to constrain the open boundary condition via a relaxation scheme in a ten cells band.

Atmospheric Boundary Conditions

- GFS (Global Forecast System) reanalysis, with 0.5° resolution and 3 hours frequency. The water level oscillations caused by atmospheric pressure fluctuations were estimated on the open boundary based on the inverted barometer effect.

Local Tidal Potential

This local forcing interacts with the tidal propagation from the open boundary, which can amplify or attenuate the tidal constituents' amplitude and change their phase. In shelf seas where resonance occurs, as observed in the south-eastern Brazilian shelf for M3, the local tidal potential can greatly affect the tide. MOHID was developed to take into account the second degree tidal potential for the most important long period (Mf, Mm, Ssa), diurnal (K1, O1, P1, Q1) and semidiurnal (M2, S2, N2, K2) tidal constituents. The third degree tidal potential is usually neglected due to its small contribution. In this study, it was considered to take into account the local tidal potential of M3.

Results

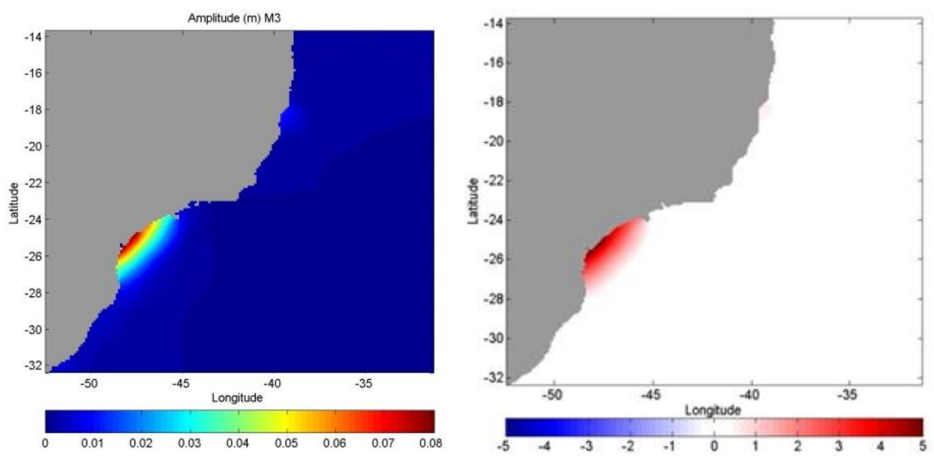

Figure 3 – Amplitudes (m) of M3 tidal constituent from model results (left) and differences (cm) from FES2012 tidal solution (right)

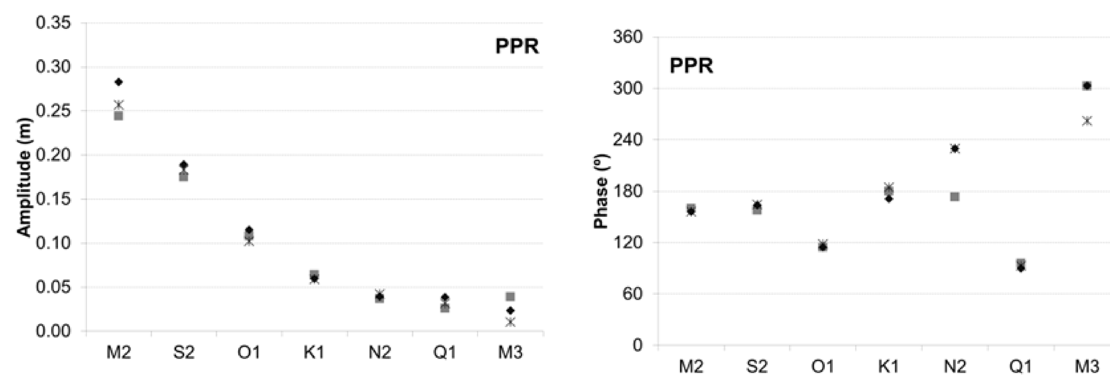

Figure 4 – Amplitudes and phases of the most important tidal constituents on the south-eastern Brazilian shelf.
■ Data ∗Fes2012 ◆Model

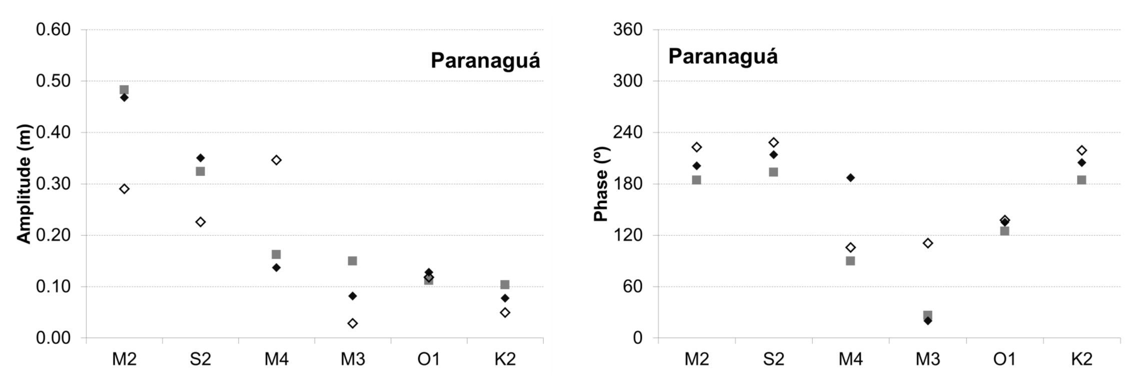

Figure 5 – Amplitudes and phases of the most important tidal constituents in Paranaguá estuary.
■ Data ◆ Model ◇ Without local tidal potential

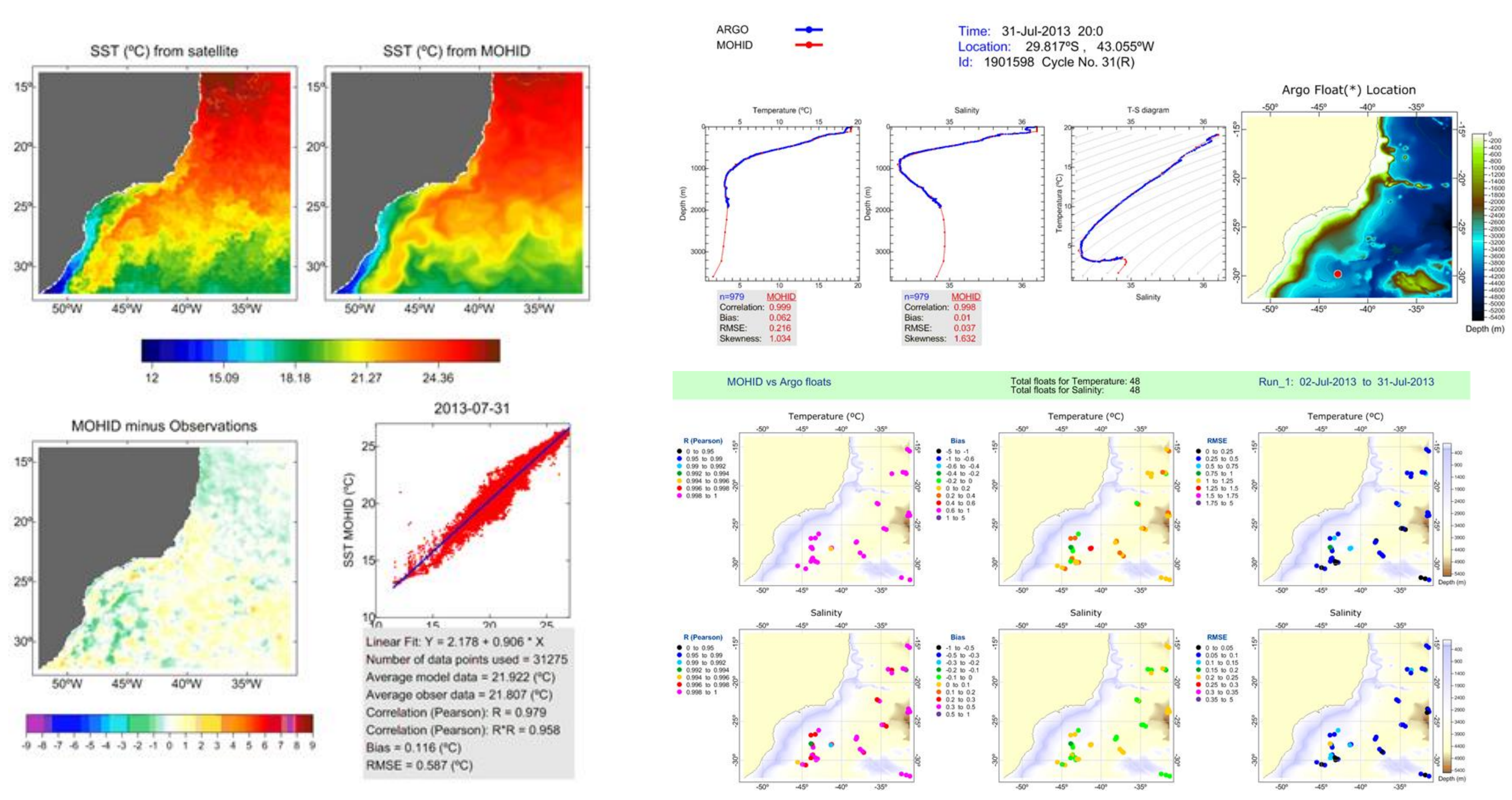

Figure 6 –Validation of SST with satellite measurements (left) and of salinity and temperature with Argo floats profiles (right)

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