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Data Article

High-resolution hydrodynamics and TS structure database of the Brazilian continental shelf and adjacent waters



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ABSTRACT

This data set was obtained from two ROMS model simulations in the region of Brazil located at 60°W–15°W / 25°S - 15°N. One of the simulations takes into account the tide (obtained from the TPX07 product) and the other one does not. The rest of the configuration was similar for both simulations, taking bathymetry from ETOPO2 and surface forcings from COADS climatology. Moreover, all boundaries were considered open and lateral conditions were taken from SODA, while initial conditions are derived from WOA09 and the river discharge climatology was obtained from Dai and Trenberth. In both experiments the KPP parameterization was used as vertical mixing scheme. The output files are in NetCDF format and are separated by months with a frequency of daily averages, containing 12 files for the simulation with tide and 12 for the simulation without tide, which are organized in two directories: Tide and

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noTide. This dataset is hosted at <https://www.scidb.cn/en/detail?dataSetId=e1f188c4684048459823aaec4f168cc3>.

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Specifications Table

Subject	Oceanography.
Specific subject area	Physical oceanography.
Type of data	NetCDF files
How the data were acquired	The data were obtained by simulation of hydro-thermodynamics using the ROMS model.
Data format	Raw
Parameters for data collection	The parameters were obtained through hydro-thermodynamic simulation with the ROMS model with output of monthly and weekly means and geospatially distributed in two-dimensional and three-dimensional grids.
Description of data collection	The original datasets were downloaded directly from the official websites.
Data source location	<ul style="list-style-type: none"> • Country: Brazil • Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: Limited region by 60.5°W-24°W/5°S-16°N.
Data accessibility	<p>The collection of NetCDF files is published at the following address:</p> <p>Title: High-resolution Ocean Hydro-thermodynamics of the Brazilian Tropical Atlantic (HOH-BRAT)</p> <p>Repository name: Science Data Bank</p> <p>Data identification number: https://doi.org/10.11922/sciencedb.01370</p> <p>Direct URL to data: https://www.scidb.cn/en/detail?dataSetId=e1f188c4684048459823aaec4f168cc3</p>
Related research article	<p>T. A. Capuano, M. Araujo, M. Silva, H. L. Varona, G. Cambon, A. Koch-Larrouy, T-S and hydrodynamical structures within the deltaic regions and continental platforms adjacent to two northeastern Brazilian rivers, <i>Regional Studies in Marine Science</i>, Elsevier BV, 102219, 2022, doi:https://doi.org/10.1016/j.rsma.2022.102219, [1].</p>

Value of the Data

- This dataset contains numerical simulations of the hydro-thermodynamics of the waters off Brazil, which is useful for physical oceanographers studying the behavior of ocean currents and the T-S structure of the ocean, both on the continental shelf and in the deep waters of the Atlantic Ocean off Brazil.
- Chemical and biological oceanographers can use this dataset to analyze the impact of physical processes on the distribution and variability of pH, nutrients, chlorophyll concentration, primary productivity and the behavior of marine species.

1. Data Description

The “High-resolution Ocean Hydro-thermodynamics of the Brazilian Tropical Atlantic (HOH-BRAT)” dataset is a ROMS model output of daily mean hydrodynamic parameters and the TS structure of the region located at 60°W - 15°W / 25°S - 15°N. It is composed of 24 files of which 12 are in the “**Tide**” directory and the remaining 12 in the “**noTide**” directory, these directory names correspond to 2 ROMS model simulations, one made taking into account the tide and the other not. The names of all files are according to the standard AVG output names of the ROMS model, defined with the pattern “**roms_avg_Y<Month_number>.nc**” (in NetCDF format

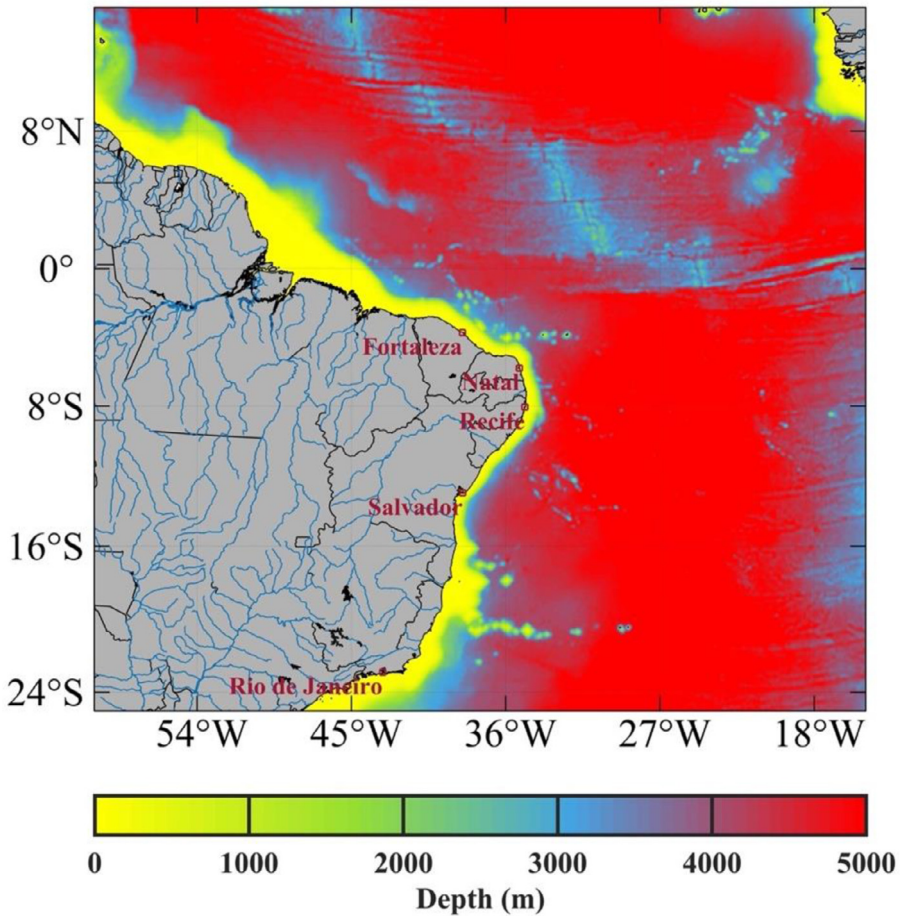


Fig. 1. Geographic location and bathymetry of the Dataset region: 60°W – 15°W / 25°S – 15°N (Adapted from [1]).

particular to the ROMS model), where **Month_number** varies from 1 to 12. Both simulations are performed with $1/12^\circ$ horizontal resolution, have a grid of 541×494 nodes, 50 vertical levels, a frequency of daily averages and each month was considered to be 30 days. The ROMS AGRIF model is a freeware developed in FORTRAN language by [2–4] for numerical simulations of hydro-thermodynamics and is available at https://data-croco.ifremer.fr/CODE_ARCHIVE/Roms_Agrif/Roms_Agrif_v3.1.1_07_07_2014.tar.gz. To prepare the model input files (surface forcing, initial and boundary conditions, and river discharge), the **ROMSTOOLS** tool developed by [5] is used; it is a set of MATLAB scripts and is distributed as freeware; as an integral part of it, **ROMSTOOLS** also contains several scripts for visualization of the input data and numerical outputs. **ROMSTOOLS** is available for download at https://data-croco.ifremer.fr/UTILITIES/Utilities_ROMSTOOLS_v3.0_21_12_2012.tar.gz (Fig. 1).

This dataset has stored grids in two, three and four dimensions. A detailed description of the dimensions and parameters of the ROMS model output was made by [6]. In the HOH-BRAT dataset, the coordinate system of the current components is different from the rest of the parameters, where **lon_u** and **lat_u** are the longitude and latitude respectively of the zonal component of the ocean current and **lon_v** and **lat_v** are the longitude and latitude respectively of

Table 1
Hydro-thermodynamic parameters simulated in the ROMS AGRIF model.

Variables	Description	Unit
lon_rho	Horizontal nodes longitude	Degree east
lat_rho	Horizontal nodes latitude	Degree north
lon_u	Horizontal nodes longitude	Degree east
lat_u	Horizontal nodes latitude	Degree north
lon_v	Horizontal nodes longitude	Degree east
lat_v	Horizontal nodes latitude	Degree north
H	Bathymetry	m
mask_rho	Land mask (1 to ocean, 0 to land)	-
temp	Potential temperature	°C
salt	Salinity	psu
u	Eastward-momentum component	m/s
v	Northward-momentum component	m/s
w	Vertical momentum component	m/s
zeta	Sea surface height	m
ubar	Vertically integrated u-momentum component	m/s
vbar	Vertically integrated v-momentum component	m/s
f	Coriolis parameter	s ⁻¹
bostr	Kinematic bottom stress	N/m ²
wstr	Kinematic wind stress	N/m ²
sustr	Kinematic u wind stress component	N/m ²
svstr	Kinematic v wind stress component	N/m ²
diff3d	Horizontal diffusivity coefficient	-
hbl	Depth of planetary boundary layer	m
hbbl	Depth of bottom boundary layer	m
shflux	Surface net heat flux	W/m ²
swflux	Surface freshwater flux (E-P)	cm/day
swrad	Short-wave surface radiation	W/m ²

the meridional component of the ocean current (Table 1), for the remaining parameters **lon_rho** (for longitudes) and **lat_rho** (for latitudes) are used.

The only parameters with two dimensions are the Coriolis parameter (**f**), the bathymetry (**h**) and the mask (**mask_rho**), the latter is a binary parameter and is used to differentiate land from sea, taking the value 0 for land and value 1 for ocean. All other parameters have three or four dimensions and are described in Table 1. In the case of the three-dimensional parameters are the ocean surface parameters and those at a fixed depth. All hydro-thermodynamic parameters have four dimensions with the exception of the sea surface height (**zeta**), which is three-dimensional because it is only dependent on geographic position and time (time parameter).

2. Experimental Design, Materials and Methods

The numerical code used for our scientific purpose, ROMS [2,3] descends from the evolution of the original code 'Semi Spectral Primitive Equation Model' (SPEM), developed in the University de Rutgers and characterized by the rigid lid assumption in classical sigma coordinates. Afterwards, an improved version of SPEM, called "S-Coordinate Rutgers University Model" (SCRUM), was designed, integrating a free surface and generalized, sigma coordinates allowing an increase in the vertical resolution of the model both at the surface and at the bottom. Thanks to this technical improvement, the model has been able to better represent both the upper and lower boundary layers, acquiring a more homogeneous resolution in the near-surface.

ROMS has been employed in many regions of the world ocean by a broad, international community and offers as well the possibility of implementing passive tracers and Lagrangian floating particles within a given experiment. In addition, it is also possible to integrate modules of disciplines depending on the hydrodynamics, like the interaction waves-mean current, sedimentology

and biogeochemistry. In the present numerical experiments we employed the ROMS version designed at the 'Institut de Recherche pour le Développement' (IRD) by Patrick Marchesiello (IRD Toulouse), Pierrick Penven (IRD Brest), Gildas Cambon (IRD Brest) and Laurant Debreu (INRIA, Institut National de Recherche en Informatique et en Automatique). In it the ROMSTOOLS package [5] was implemented and allows any user to easily create, within the Matlab environment, the initial conditions of a given simulation and as well to analyse/ visualise its output. Furthermore, this version enables the nesting of various grids ones into the others, which allows an increase of their individual resolutions, thanks to the AGRIF library (Adaptative Grid Refinement in Fortran) [4] adoption.

It is also remarkable that ROMS has already been extensively used in our geographic area of interest [7–12] and tested by a team of Brazilian modellers placed at the Federal University of Recife, some of which areco-authors of this paper greatly contributing to the choice of the best configuration of the model (in terms of advection, dissipation and turbulent mixing schemes). ROMS has the important advantage of having been designed for runs at regional scales, both within an idealised and realistic frameworks. In fact, sensitivity runs can be easily set and carried out with this model by differently tuning a wide range of parameters and this allows to realize process-oriented studies.

The IRD version of ROMS was originally designed for parallelization, thus all our experiments have been compiled through the MPI (Message Passing Interface) library. And given that this numerical code was already satisfactorily implemented on the IDRIS clusters (Ada, Turing, etc.), we chose to run our simulations on these supercomputing facilities.

In [1] we have tested the tides' effect on the local ocean dynamics, running a series of numerical simulations with and without the input of tides ('Tidal' and 'No-tide' setups). In both configurations, we used a mesoscale-resolving, horizontal resolution of $1/12^\circ$ (~ 7.3 km) and a geographical domain encompassing the whole North-eastern Brazilian coast (10°N to 20°S of latitude and 30° to 60°W of longitude). On this squared domain, we adopted 100 vertical levels, aiming at a fair representation of the physical processes happening along the water column, and test the sensitivity of the model to the study region by modifying the tuning parameters that regulate their distribution along the vertical.

Indeed, by default ROMS tends to stretch these levels towards the ocean surface, in order to acquire an enhanced resolution in the upper layers. However, it is also possible to set a more homogeneous distribution of the vertical levels in order to gain further resolution in the subsurface and at specific depths of interest. The choice of the latter was in our case directly related to the interest of investigating tidal mechanisms of generation, mixing, breaking and dissipation. These simulations were integrated for a period of 10 years, storing the output at a daily frequency, with the aim of evaluating not only the initial adjustment of the model but also the spin-up period required to reach a statical steady-state of the simulated energy budget.

The establishment of this equilibrium was explored through the Eulerian analyses of classical variables (potential vorticity, kinetic energy, properties and volumes of the water masses, heat and salt fluxes). Moreover, we reckon necessary to check the sensitivity of the model to other initial parameters: wind forcing and surface fluxes from climatology; different values of the slope parameter controlling the smoothness of the bottom topography and the inclination of the continental slope; a realistic or idealised stratification of the water column; the eventual activation of the diffusive component of the advection scheme, designed to reduce artificial effects of spurious diapycnal mixing that could appear in the tracers fields (T and S).

In the interest of comparability, in both the '**Tidal**' and '**No-tides**' configurations the following datasets and conditions were used to create the grid file, forcings at the open boundaries and the initial state:

- Bathymetry is derived from the ETOPO2 dataset [13] and smoothed under the constraint that:

$$\frac{\Delta h}{2h} < 0.2 \quad (1)$$

with the minimum depth represented at 10 m;

- At the surface, wind forcing, heat and fresh waters sources are extracted from the COADS climatology [14];
- At the lateral open boundaries, an active, implicit, upstream biased radiation condition connects the model solution to the surrounding ocean [15] and forced with Simple Ocean Data Assimilation dataset (SODA) release 2.1.6;
- The ocean is initially at rest, with temperature and salinity fields taken from the World Ocean Atlas 2009 dataset (WOA09) at 1° of resolution;
- For the river discharge, the climatology of [16], which includes monthly means' values for the biggest South-American rivers' runoff, has been adopted;
- The 9 tidal components were obtained from the TPXO7 product [17], encompassing altimetry data from several satellites in order to validate the results derived from the hydrodynamic model;
- The vertical mixing scheme is based on the **KPP parametrization** of [18], while the horizontal mixing is parametrized as a linear combination of Laplacian and biharmonic mixing scaled with the grid size.

As already mentioned, both configurations have been run for 10 years and the steady state was statistically achieved after a spin-up period of about one year. In order to evaluate the impact of the domain extension, but also of other background values as the horizontal Laplacian diffusivity number or the bottom drag coefficient, as well as the topographically influential slope parameter ' r ', several simulations were run at very low resolution (1/4°). This allowed to indeed test the sensitivity of the model to slight alterations in its initial parameters and to subsequently address the choice of the best configuration to use for running higher resolution simulations.

Ethics Statements

Not applicable.

CRediT Author Statement

T. A. Capuano: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing- Original draft, Visualization. **H. L. Varona:** Methodology, Validation, Visualization, Writing- Reviewing and Editing. **M. Araujo:** Conceptualization, Methodology, Validation, Visualization, Writing- Reviewing and Editing. **A. Koch-Larrouy:** Conceptualization, Visualization, Writing- Reviewing and Editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that there is no conflict of interest regarding the publication of this article. The authors also declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

Data Availability

[High-resolution Ocean Hydro-thermodynamics of the Brazilian Tropical Atlantic \(HOH-BRAT\) \(Original data\)](#) (Science Data Bank).

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