

A Brazilian Effort Towards Ocean Model Forecast in the South Atlantic – The Oceanographic Modeling and Observation Research Network (REMO): An emphasis to remotely sensed products



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Federal University of Rio de Janeiro (UFRJ)

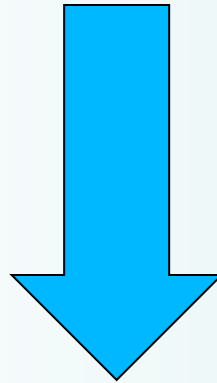
BRASIL



UN workshop

UN-SPIDER in Riyadh – Saudi Arabia:

Oil spill detection system via remotely sensed data



Our concern now is to know where *more precisely* the oil goes.

OUTLINE

- **Motivation**
- **Introduction**
- **Remotely sensed products (SST and SSH)**
- **Modeling approach**
- **Results**
- **Remarks and following work**

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MOTIVATION



Rio de Janeiro

800 tons of oil were spilled into Guanabara Bay from Petrobras refinery on **January, 2000.**



Campos Basin

- Petrobras P-37 Accident on **March, 2001**
- Oil spill of approximately ~1.2 tons occurred
- Its value was U\$ 430 millions

MOTIVATION



Mexico Gulf oil Spill - 2010



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Main goals of REMO are:

- 1) To develop an assimilative ocean forecast system for the Brazilian continental shelf and slope regions and
- 2) To help environmental authorities in case of oil disasters.



The Team

Ph.D: 18

M.Sc.: 8

Bachelor: 9

Technicians/

Administrative: 7

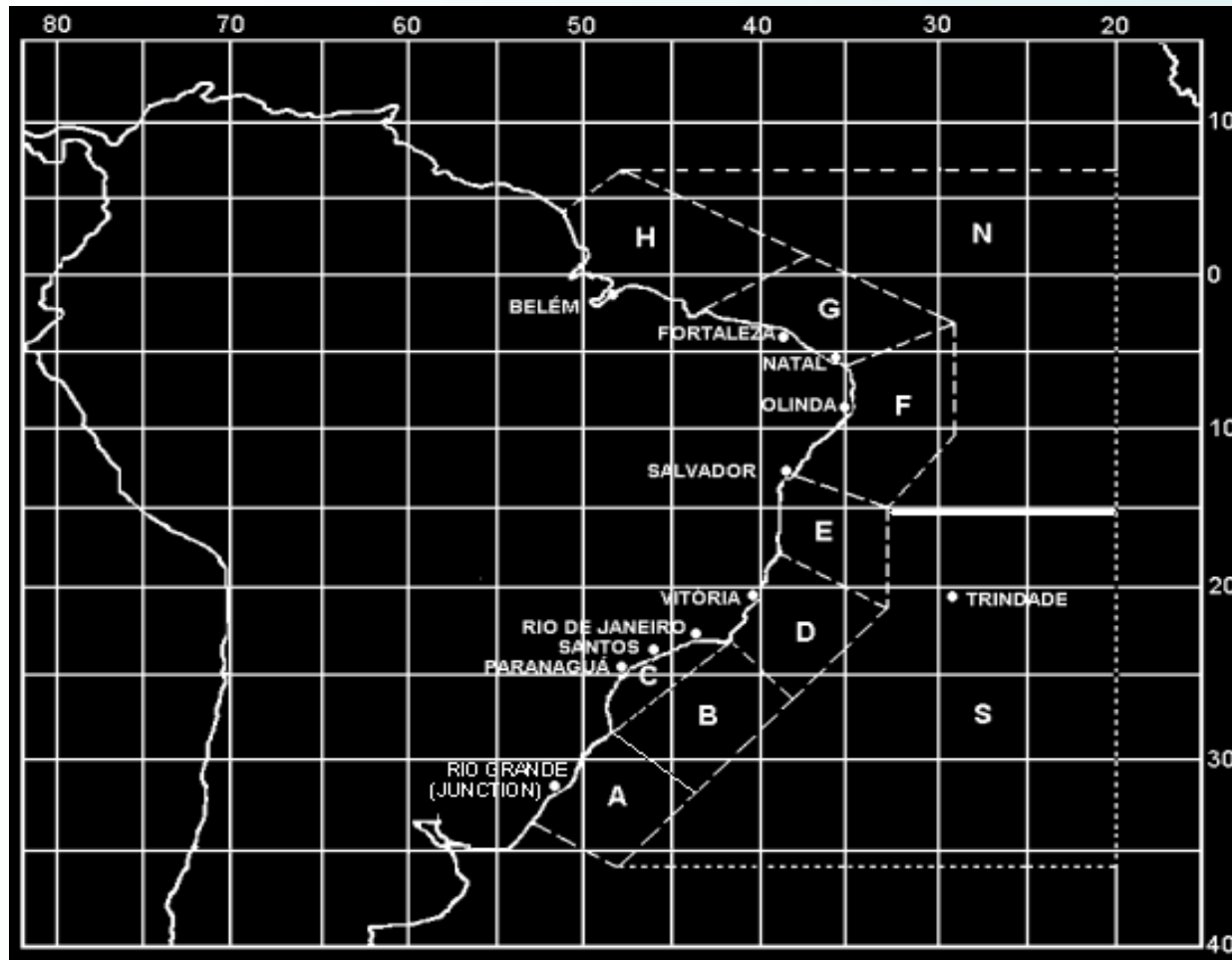
Students: 8

≈ 50 people



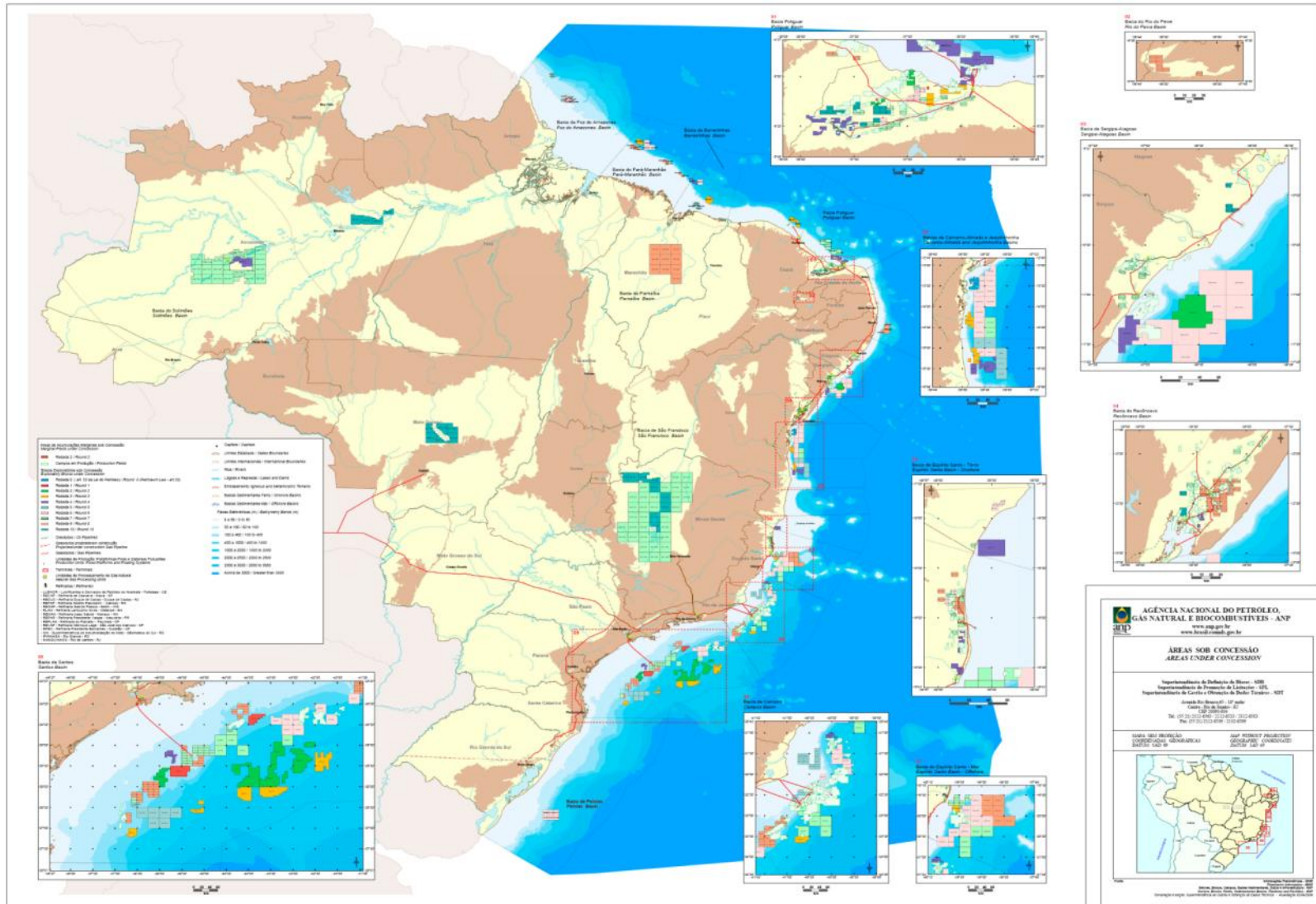
The Region of interest

- METAREA V - Maritime area under Brazilian Navy responsibility for weather and ocean forecast

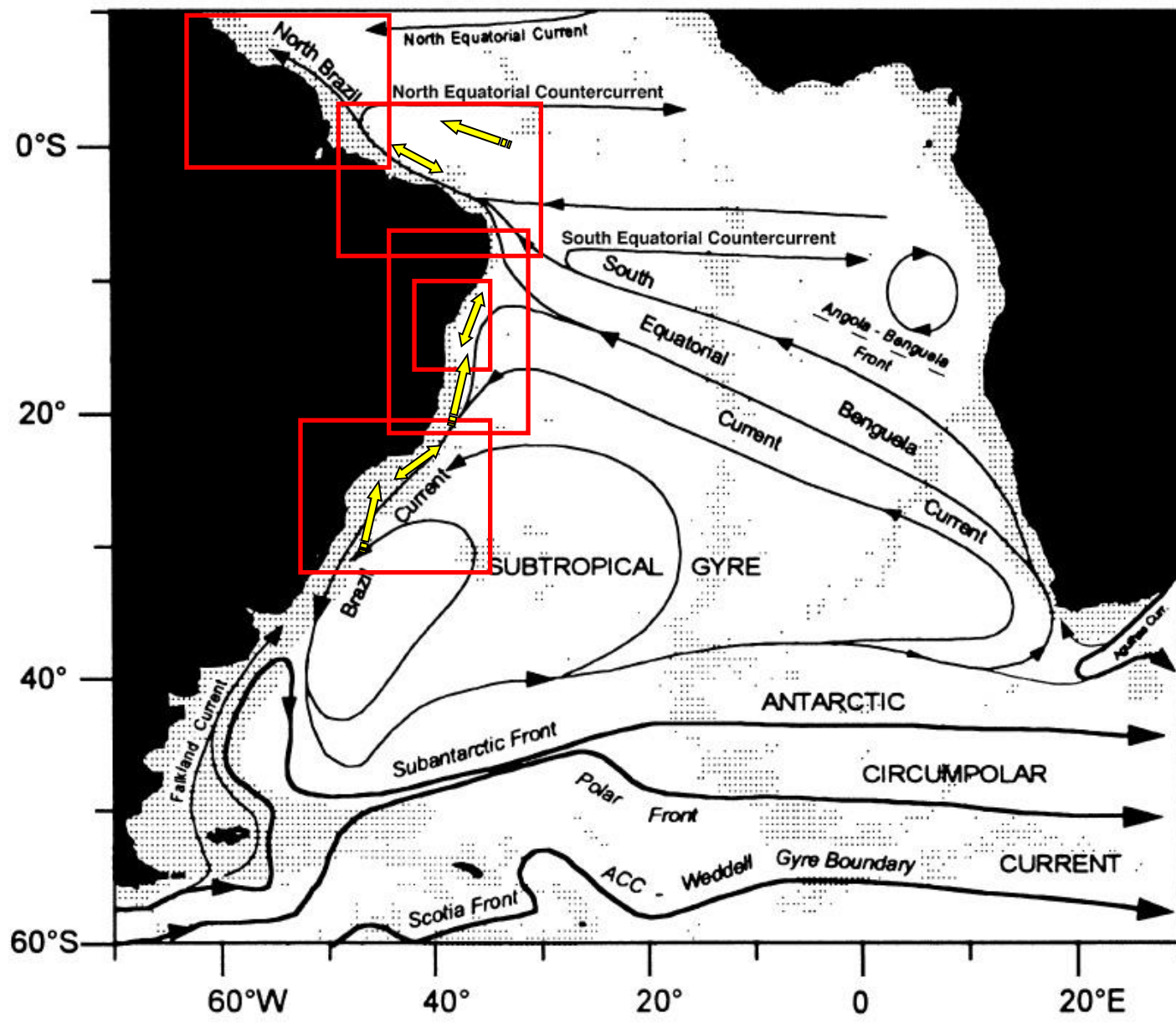


The Region of interest

- Oil and gas industry activities



The region of interest – The oceanographic challenges



South Atlantic Surface Circulation extracted from Petterson e Stramma (1991)

Computational Resources

High Performance Computer

NETUNO – NCE/UFRJ

Dell Server 256 nodes (2 processors Xeon Quad-core 2.6 GHz e 16 MB RAM) Total: 2048 processor units



High Performance Computer

SGI Altix ICE 8200 – CHM/Brazilian Navy

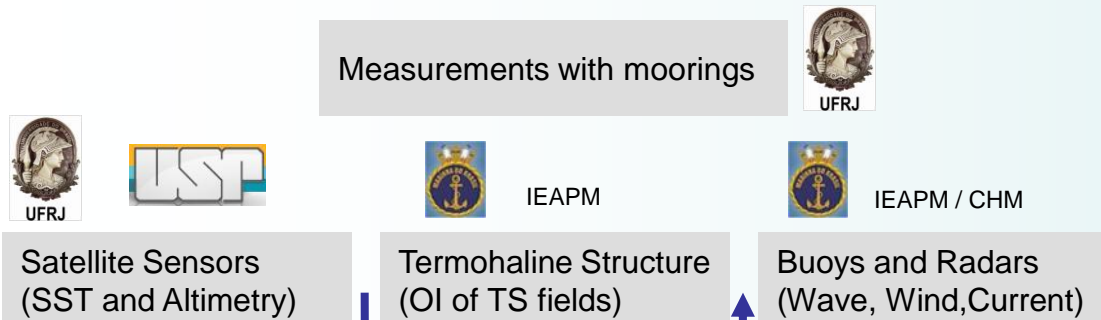
SGI Server 32 nodes (2 processors Xeon Quad-core 3 GHz e 16 MB RAM) Total: 256 processor units



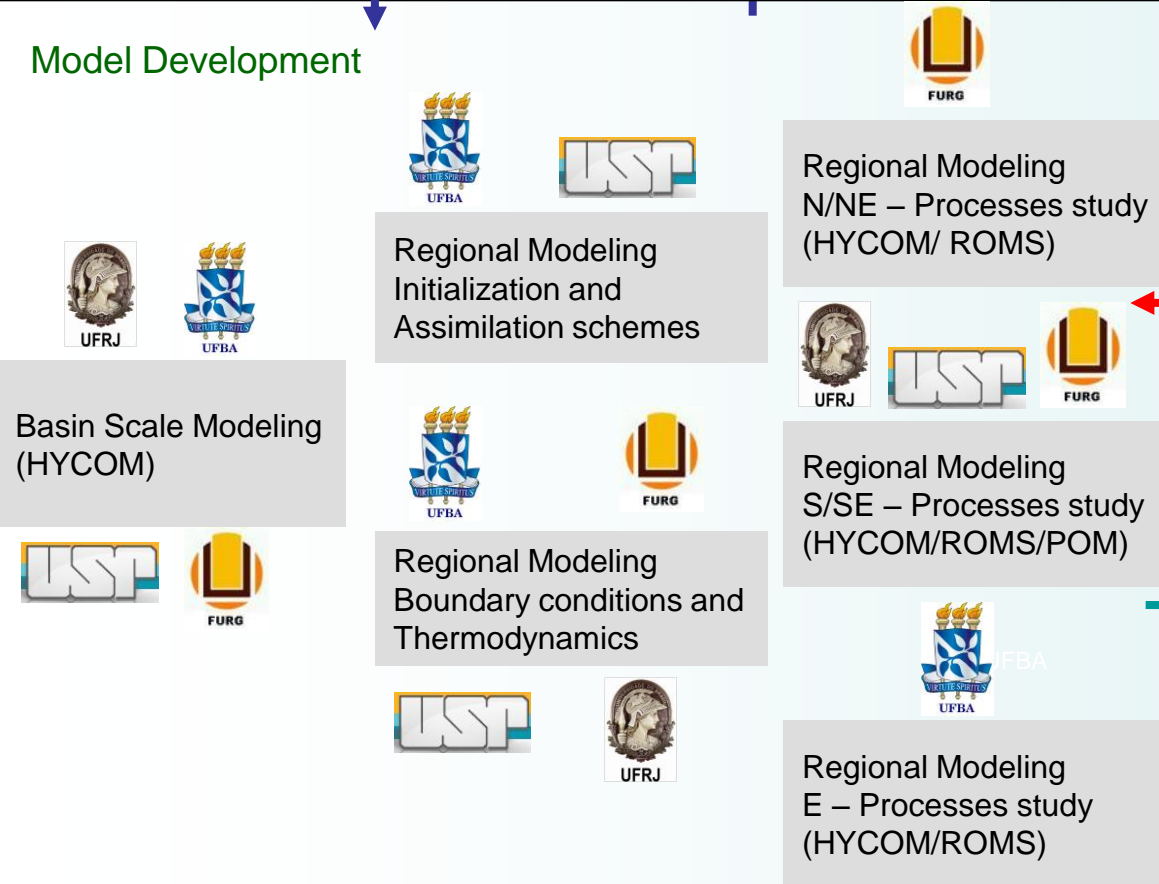
REMO Ocean Modeling and Observation Network



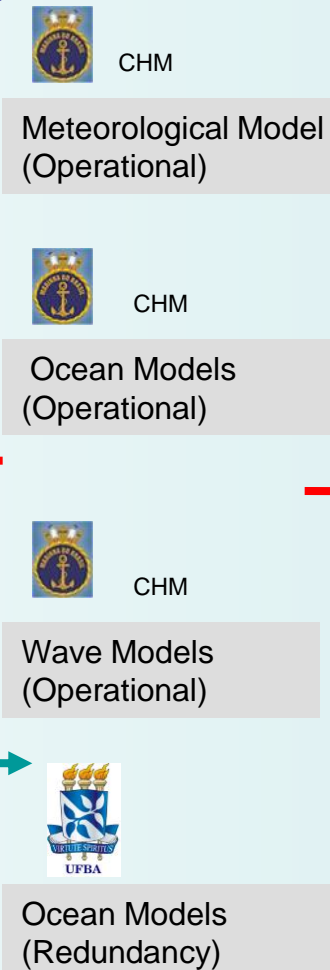
Observations (Remote Sensing and Metocean Measurements)



Model Development



Modeling Operation



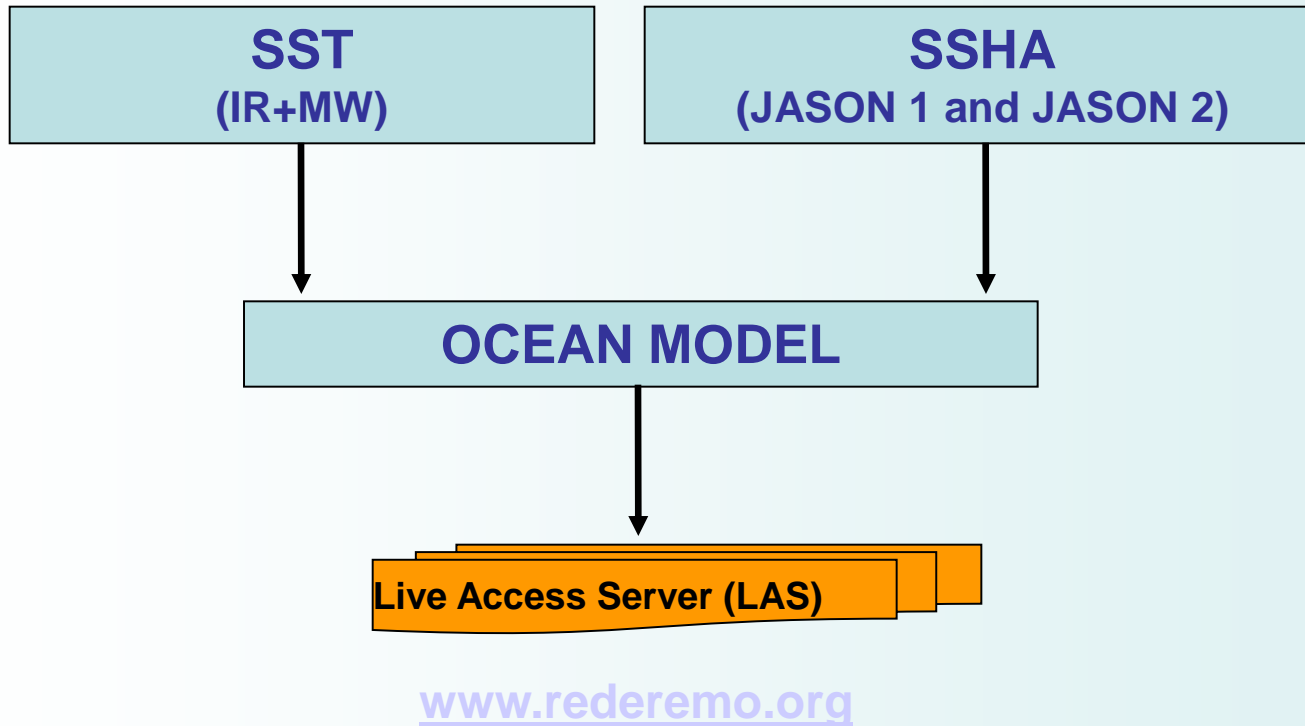
Products

- Satellite SST,SSH
- Ocean Forecasting (T,S,U,V,EL)
- Meteorological Forecasting
- Wave Forecasting
- Support to Search & Rescue
- Support to Oil Spill Models
- Scientific Papers
- Academic Support

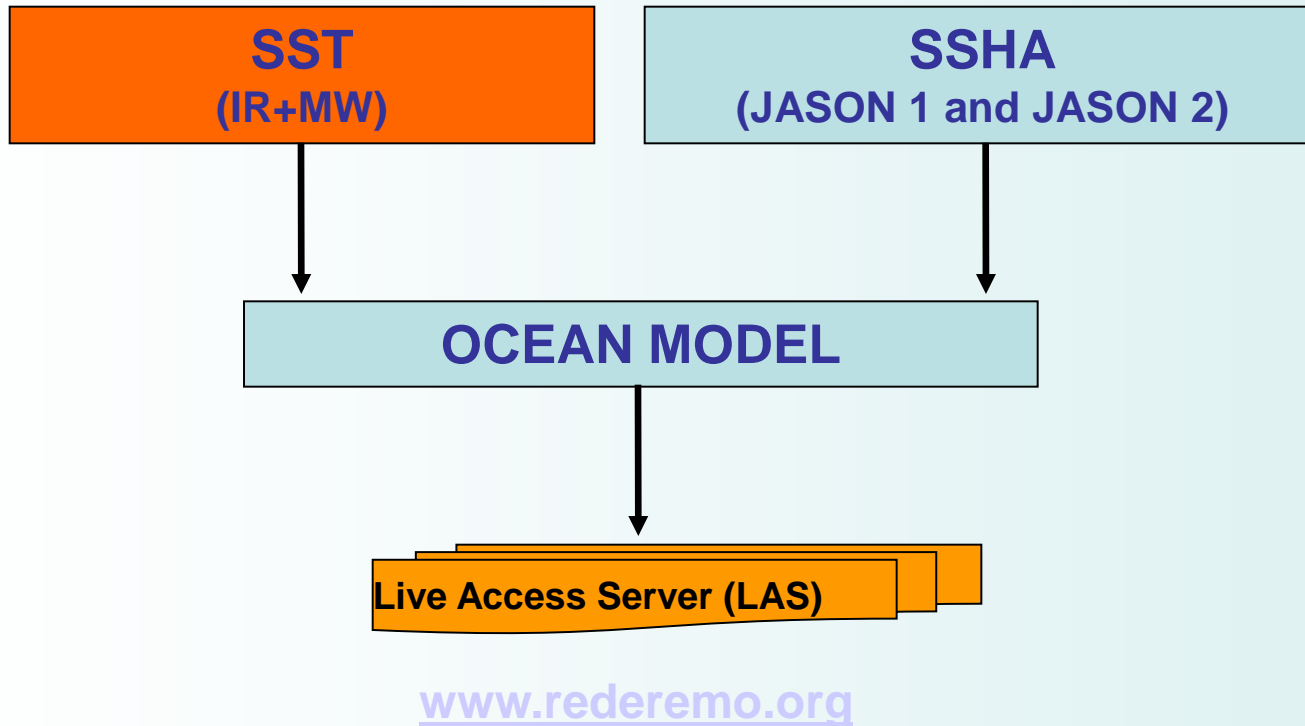
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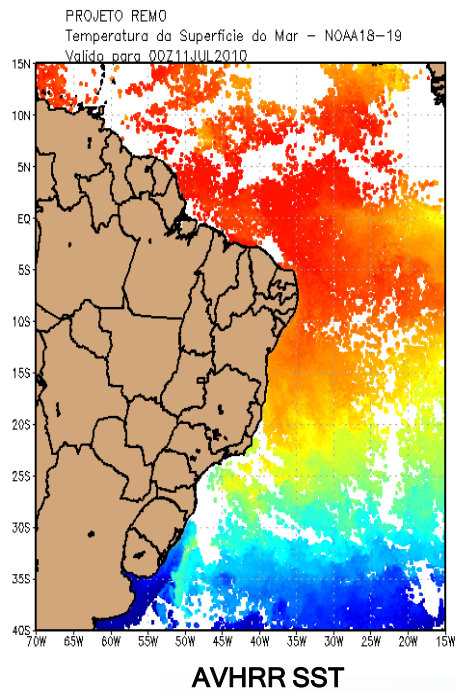
Remote Sensing Product - Ocean Model Input



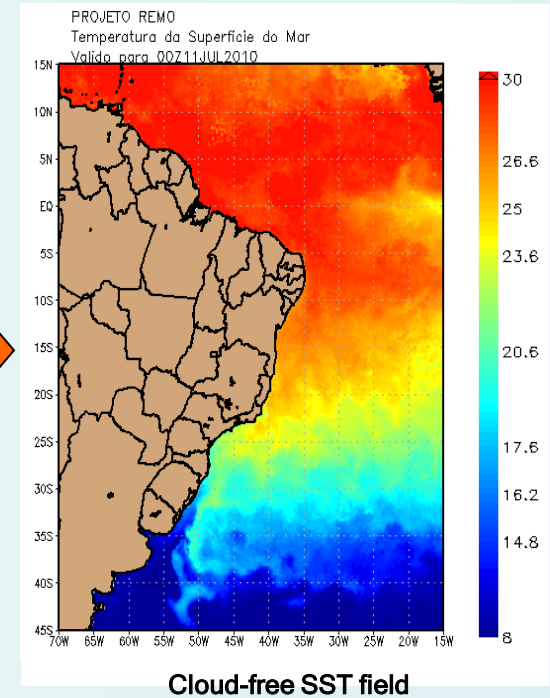
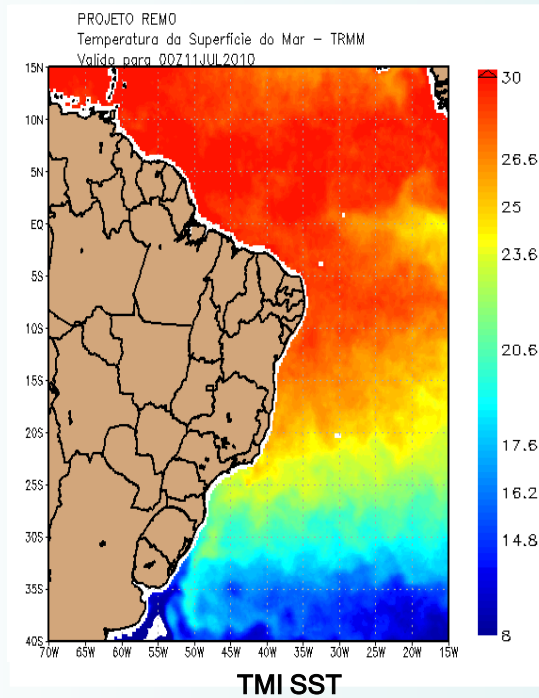
Remote Sensing Product - Ocean Model Input



SST



+



Barnes Sub-optimal interpolation technique:



$$f_i^{(1)} = \frac{\sum_{j=1}^M w_{ij} f_j^0}{\sum_{j=1}^M w_{ij}}$$

$$f_i^{(n+1)}(f_j^0, w_{ij}) = f_i^{(n)} + \frac{\sum_{m=1}^M w_{ij} (f_j^0 - f_j^{(n)})}{\sum_{j=1}^M w_{ij}}$$

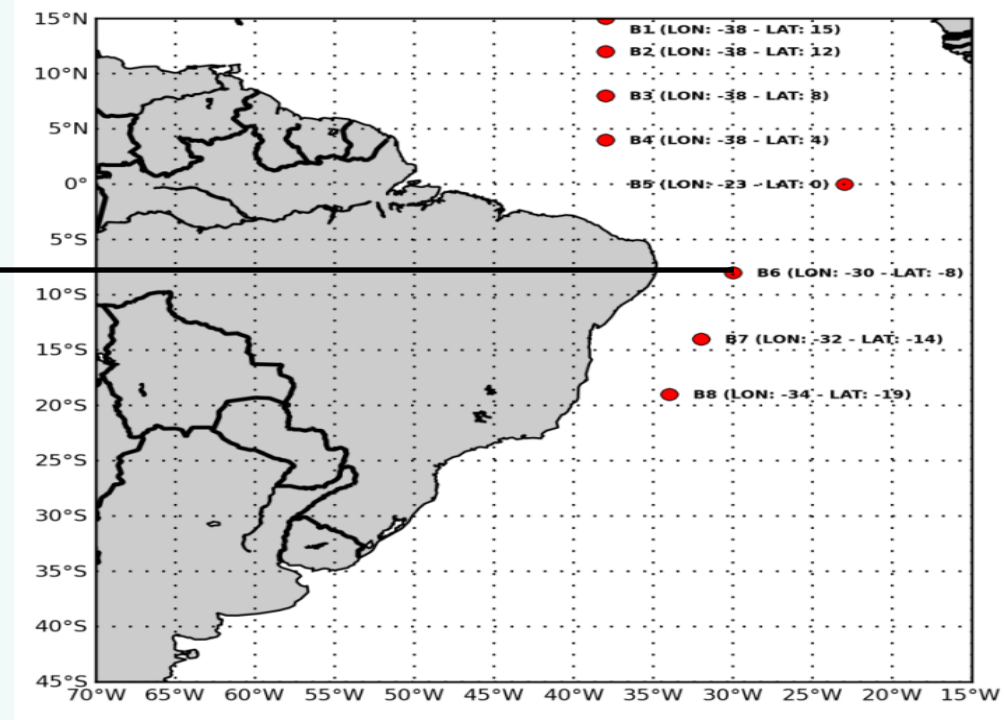
Weight Function

$$w_m^{(0)} = \exp\left(-\frac{r^2}{k} - \frac{\tau^2}{v}\right)$$

$$w_m^{(1)} = \exp\left(-\frac{r^2}{\alpha k} - \frac{\tau^2}{\alpha v}\right)$$

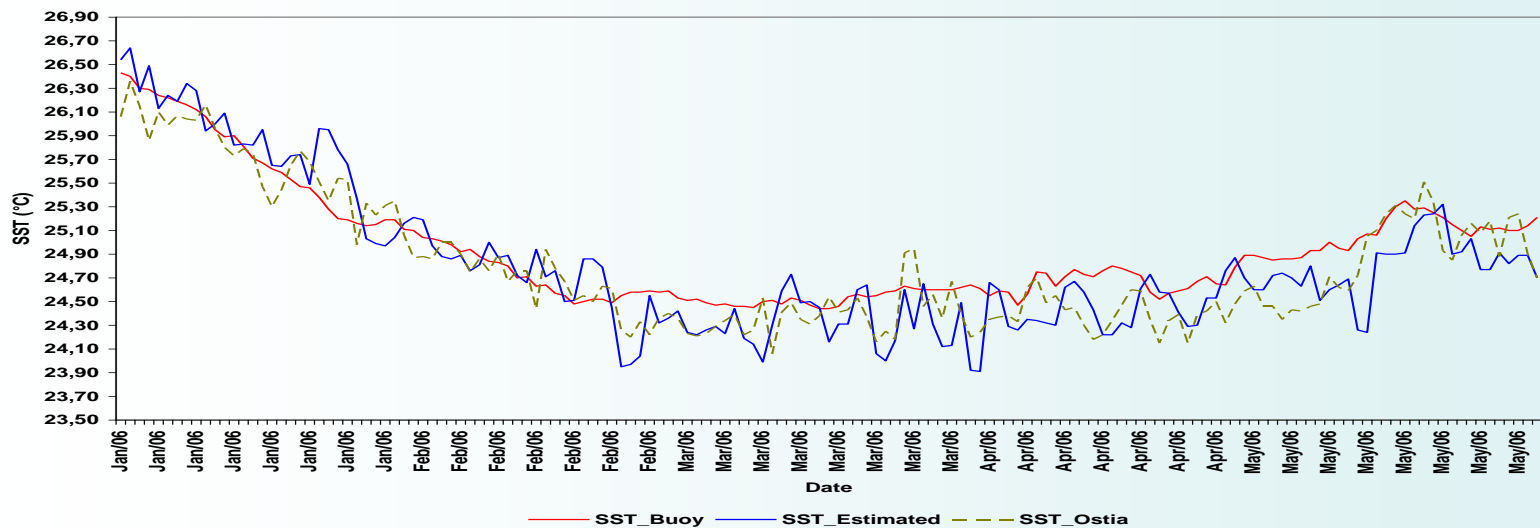
FURG

SST - Validation



Buoys locations

Location: 15°N 38°W

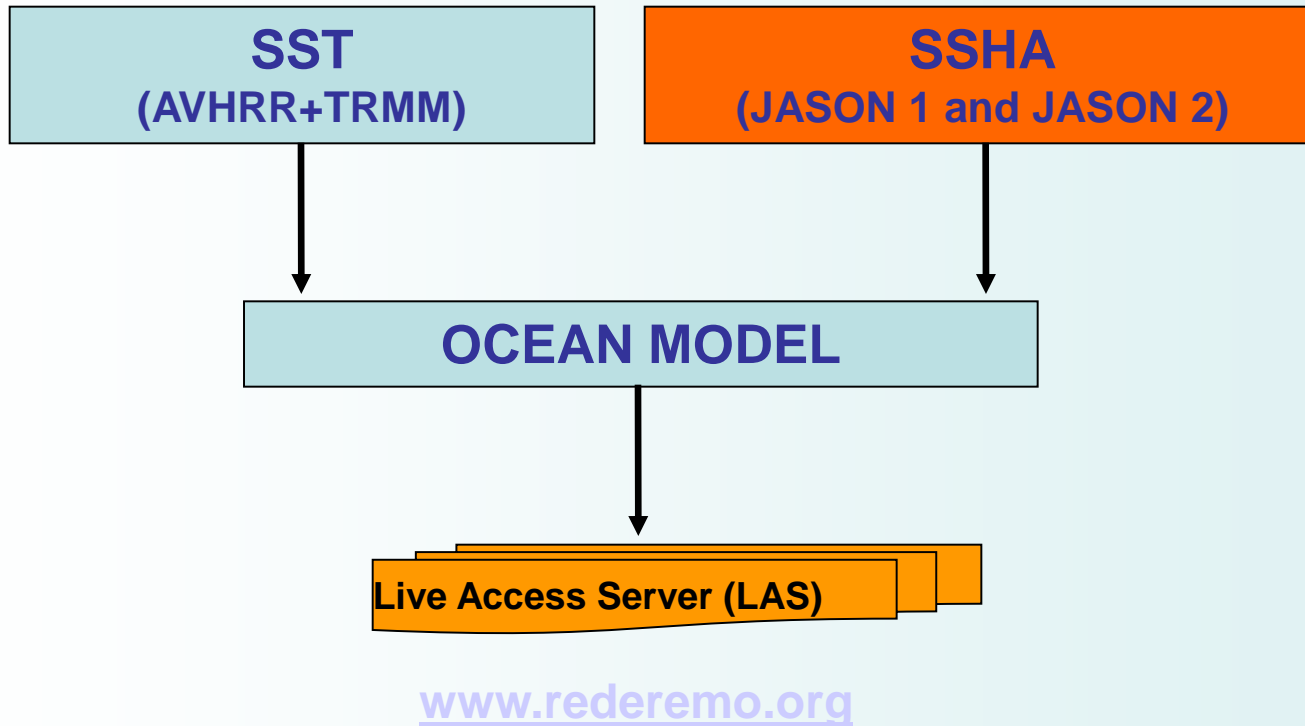


SST - Validation

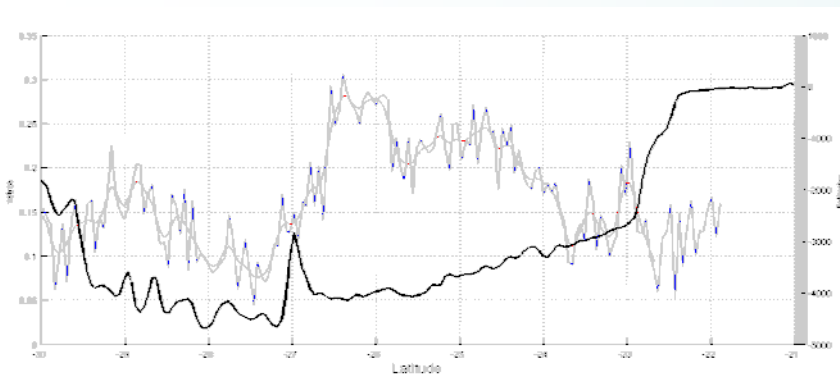
Table - Comparison statistics between daily SST composition and average daily *in situ* SST collected from eight buoys of PIRATA's project from August 01st,2005 to July 31st, 2006.

Buoy Location	RMSE		MAE		MBE		CORRELATION	
	(*)	(**)	(*)	(**)	(*)	(**)	(*)	(**)
15°N – 38°W	0.37	0.35	0.28	0.26	–0.16	–0.15	0.96	0.97
12°N – 38°W	0.50	0.49	0.39	0.38	–0.32	–0.29	0.92	0.95
8°N – 38°W	0.33	0.31	0.27	0.25	–0.17	–0.16	0.91	0.94
4°N – 38°W	0.28	0.26	0.22	0.20	0.05	–0.06	0.85	0.86
0°N – 23°W	0.31	0.28	0.26	0.23	–0.20	–0.18	0.96	0.97
8°S – 30°W	0.25	0.22	0.21	0.18	–0.13	–0.10	0.97	0.99
14°S – 32°W	0.35	0.32	0.29	0.25	–0.19	–0.15	0.94	0.96
19°S – 34°W	0.31	0.29	0.25	0.23	–0.13	–0.10	0.96	0.97
(*) without restriction of wind speed				(**) with restriction of wind speed (≥ 5 m/s)				

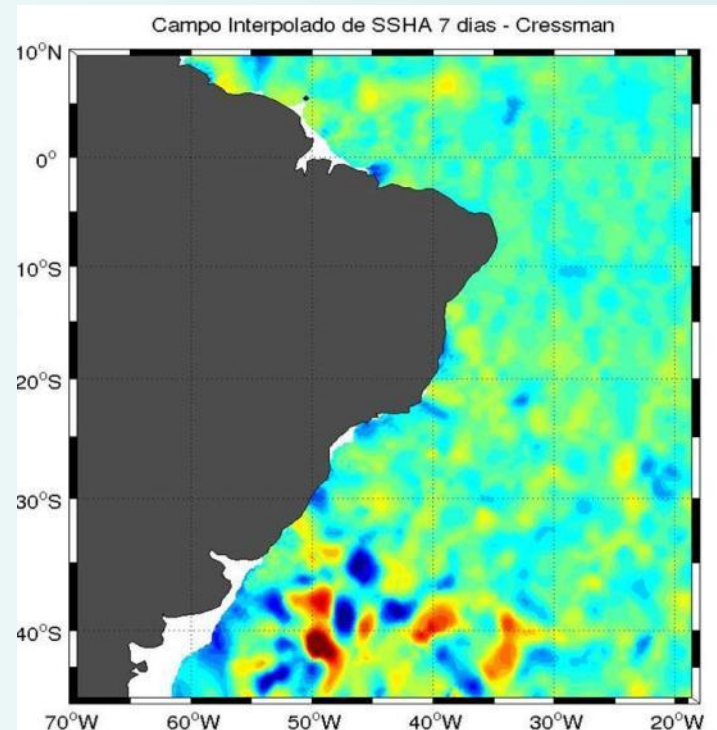
Remote Sensing Product - Ocean Model Input



SSHA



This figure represents track 202 of the 276th cycle from Jason1 where raw data (blue line), filtered data (red line) and bathymetry (black line).



SSHA interpolated field

The system:

- a) Atmospheric and geophysical corrections and SSHA estimation
- b) Redundant data elimination

Local tidal correction

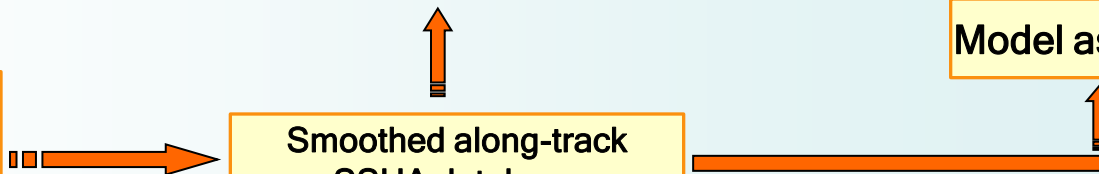
Cross calibration

- a) Spurious data elimination
- b) 7-point Gaussian convolution filter (with wavelengths smaller than 40 km)

Cressman's Method is used to create SSHA field based on 7-day long track SSHA data ($1/4^\circ$ grid)

Smoothed along-track SSHA database

Model assimilation

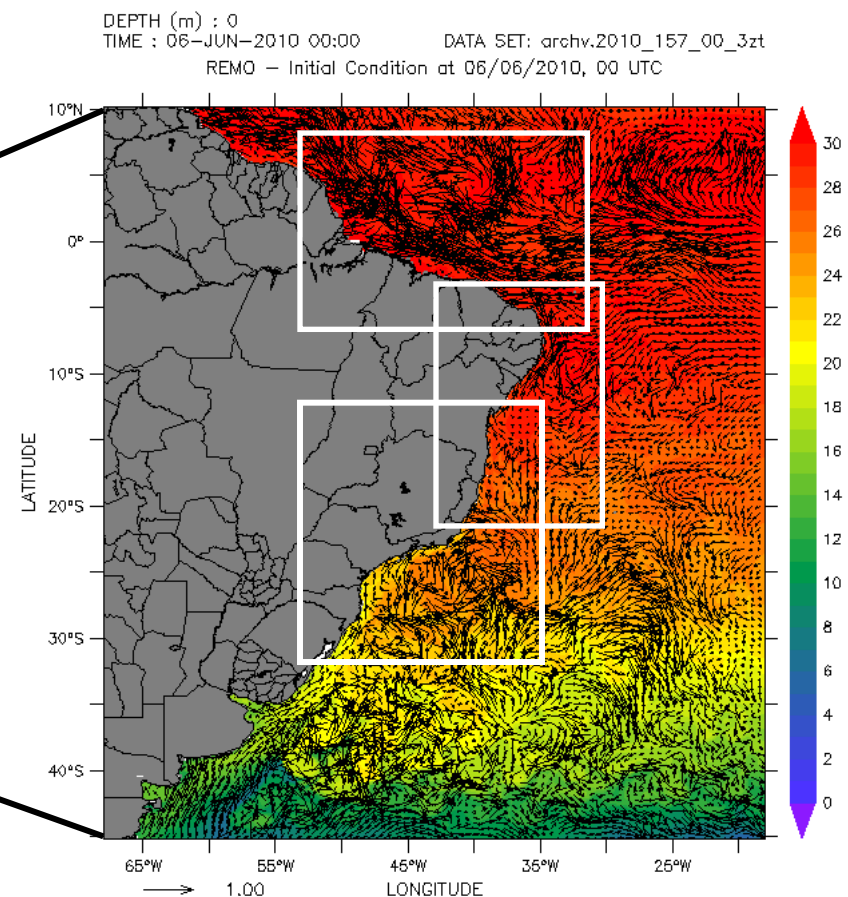
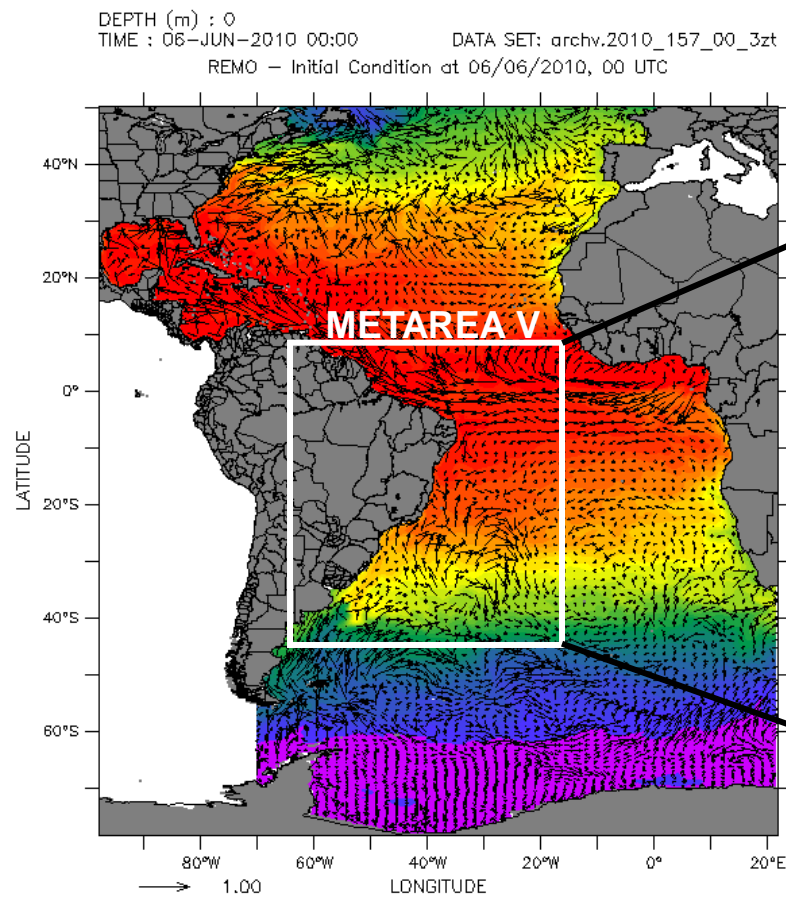


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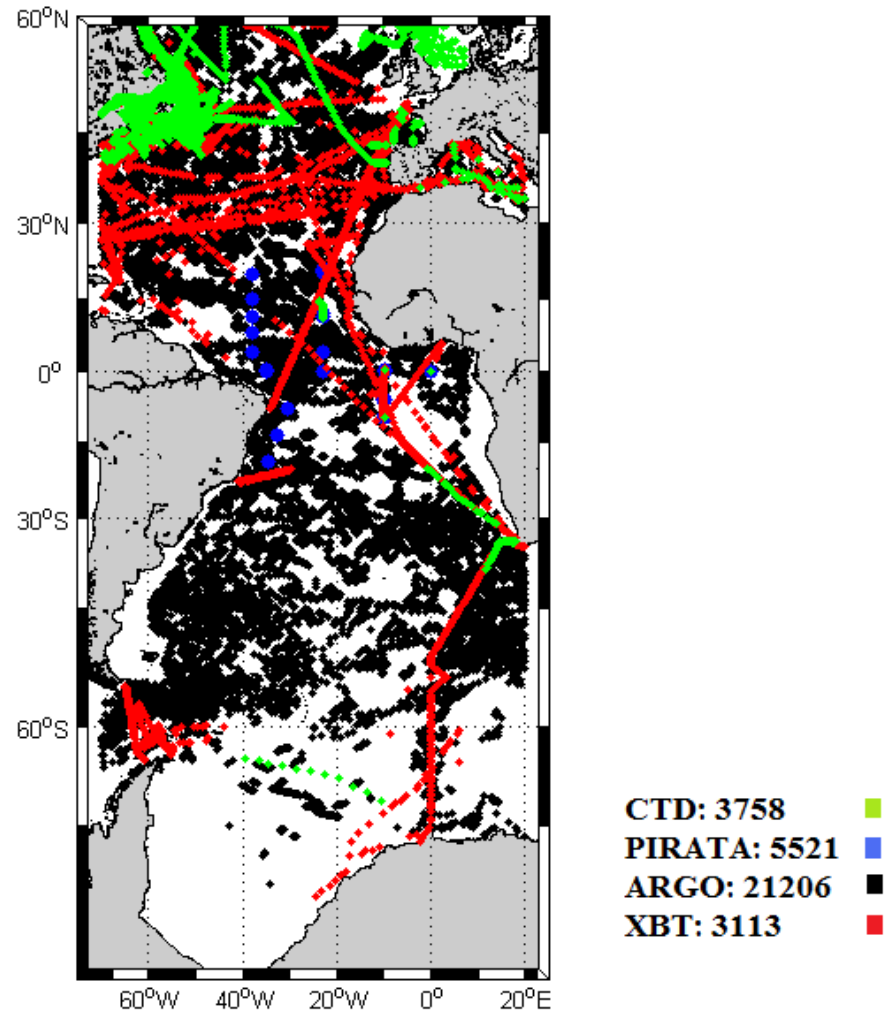
Modeling Approach

- To develop nested models from the Atlantic large scale circulation to regional circulation
 - With Data Assimilation



Data Assimilation

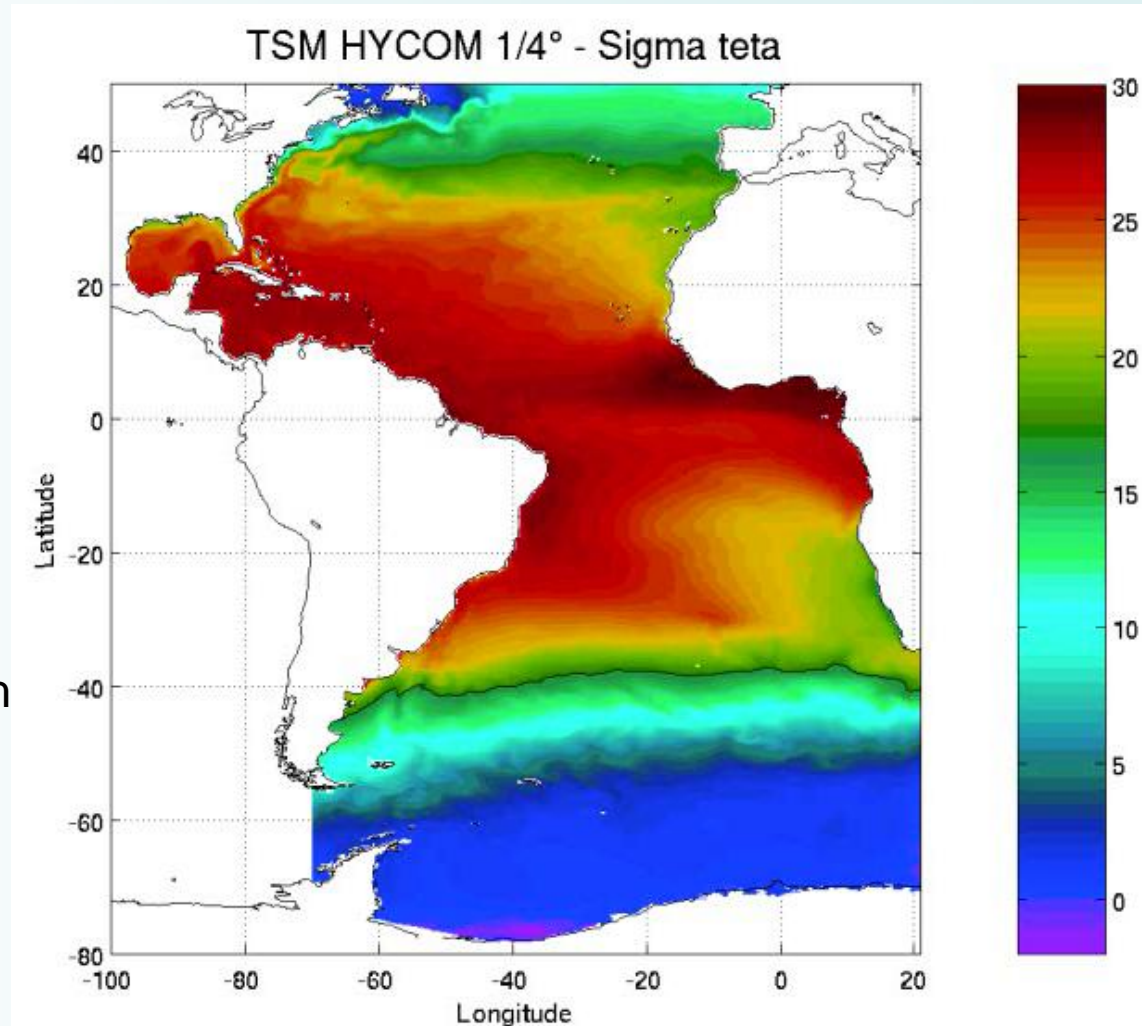
- In situ data
 - Argo
 - XBT
 - CTD
 - Pirata Buoys
 - Drifters



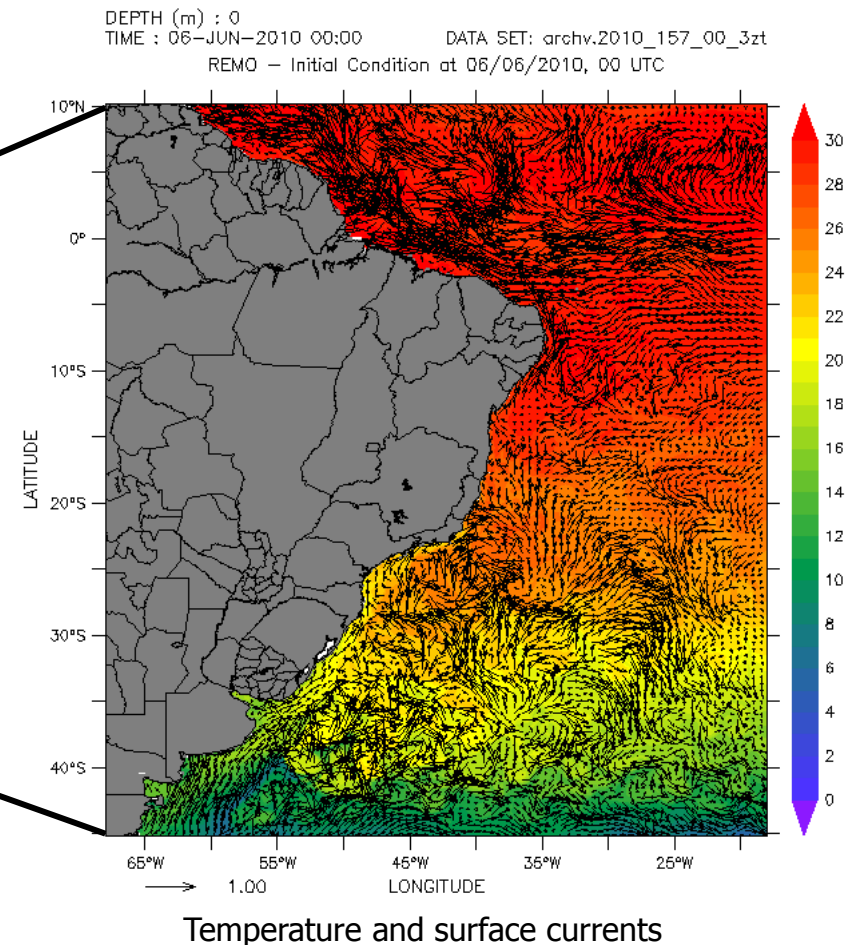
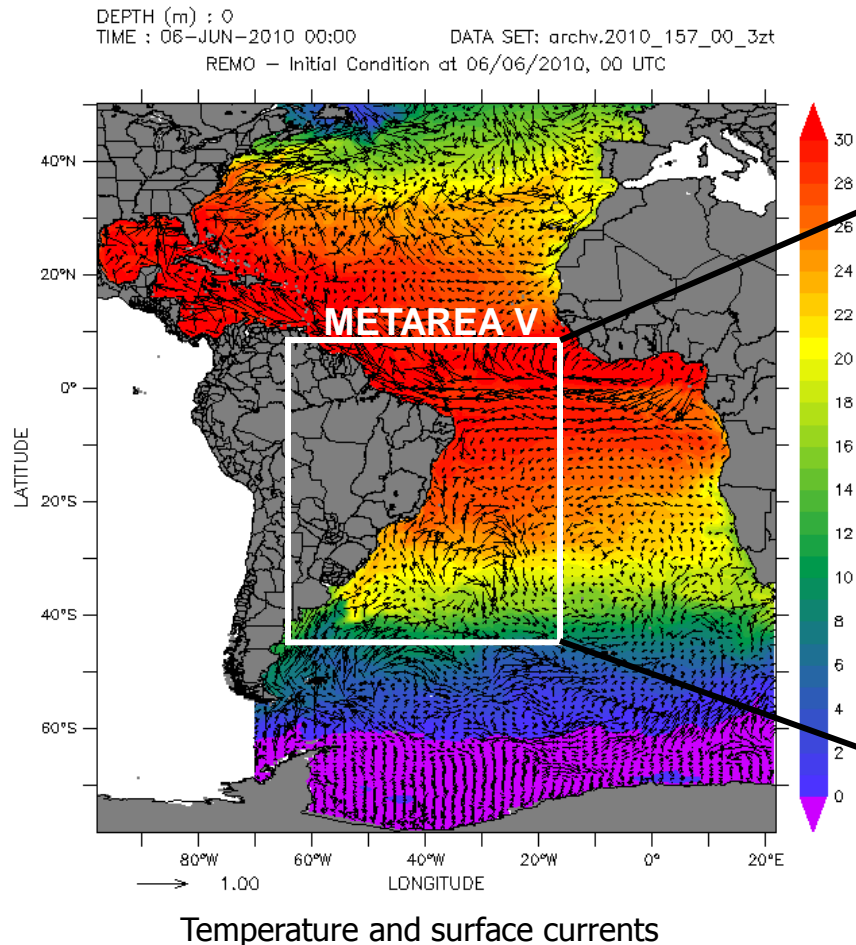
Atlantic Large Scale Circulation Model

Climatologic and Synoptic Runs

- Model: HYCOM
- Domain: Atlantic Ocean
78°S – 50°N
- Resolution: 1/4° and
21 vertical layers σ_θ
- 40 years simulation with climatological forcings:
 - Heat, mass and momentum fluxes from COADS monthly means
- 6.5 years simulation with synoptic data, from 2003 to 2009
 - Synoptic atmospheric fields in 6h interval from NCEP reanalysis 2
- Operational daily forecast: from 2009 until now

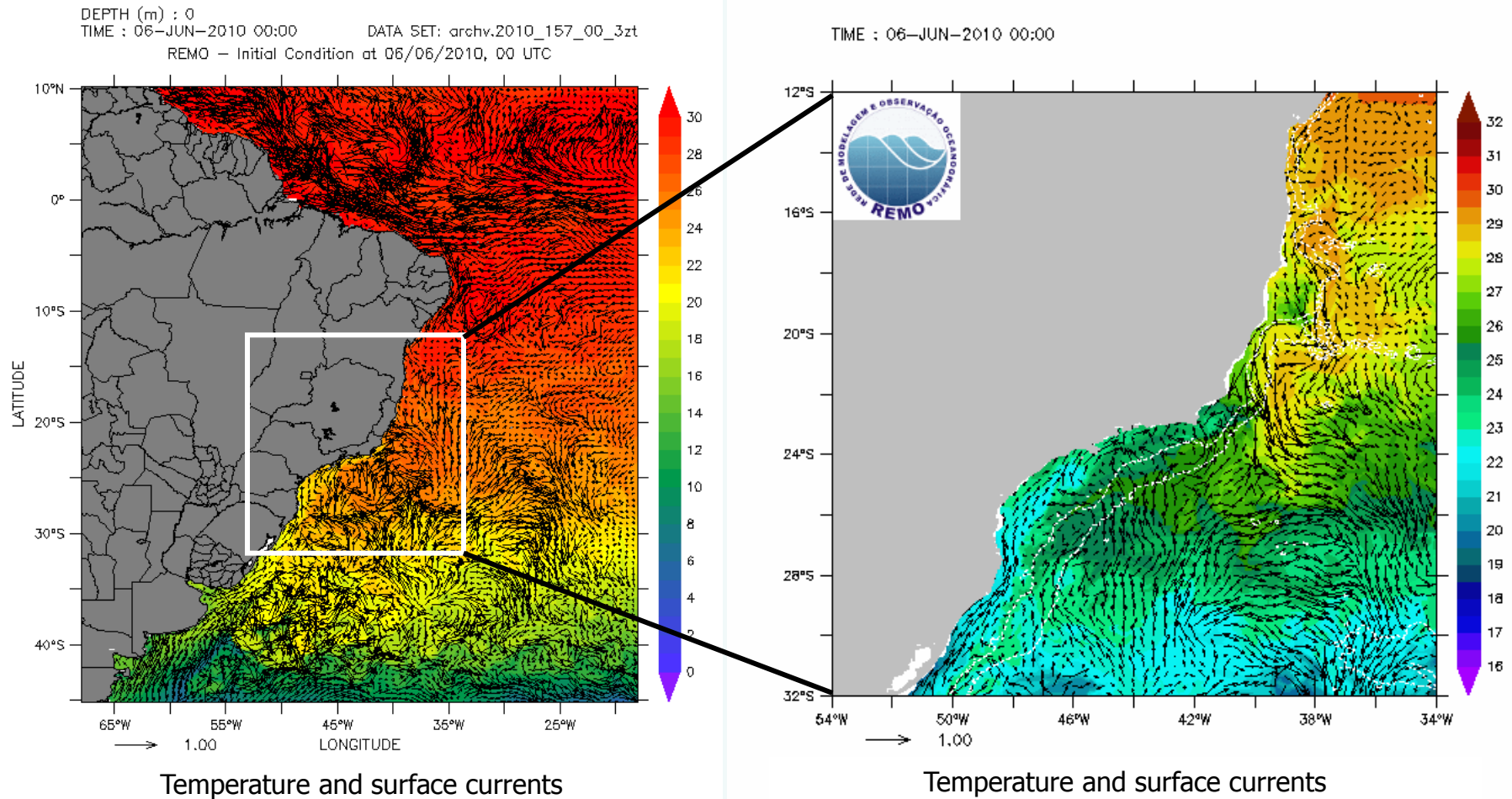


METAREA V domain nested in the Atlantic model



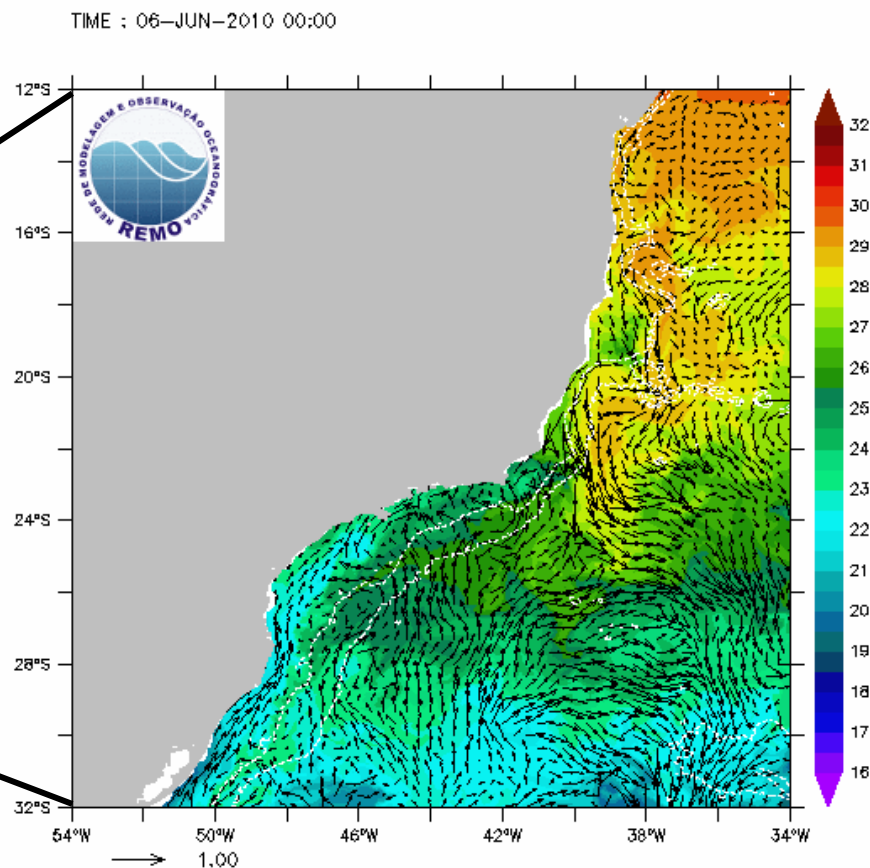
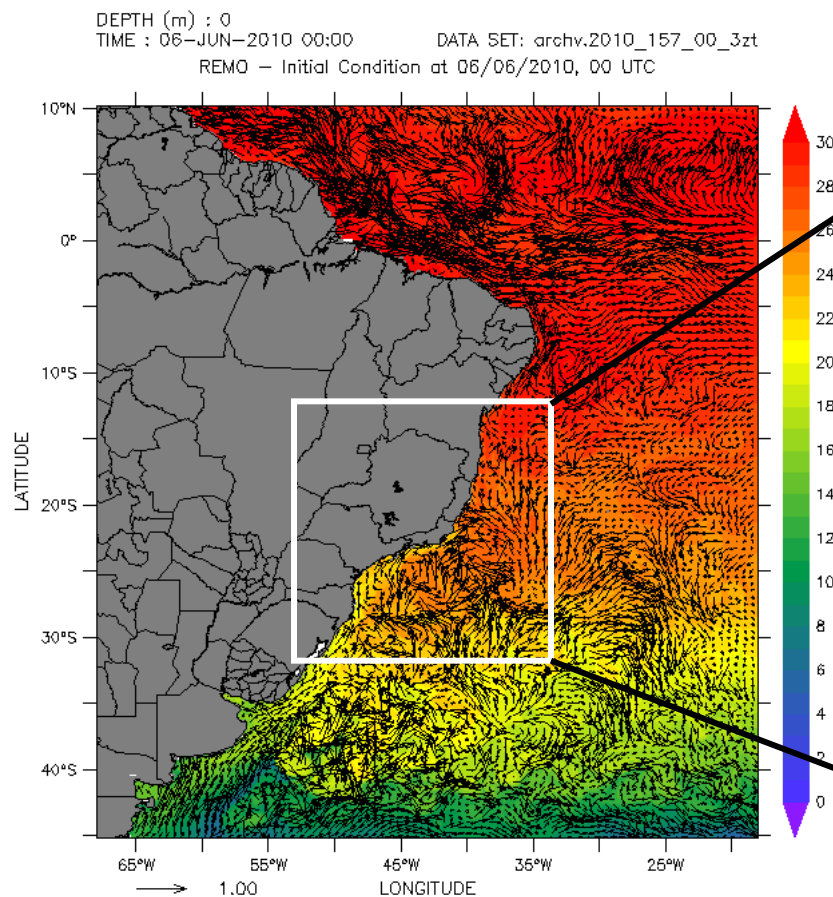
- Model: HYCOM
- Domain: **METAREA V**
- Resolution: $1/12^\circ$ and 21 vertical layers σ_θ
- 10 years simulation with climatological forcings (COADS)
- 6.5 years simulation (2003 to 2009) with synoptic atmospheric forcings (NCEP)
- Operational forecast: From 2009 until now
- Cooper & Haines scheme (SSH data)

SE region model nested in the METAREA V model



- Model: HYCOM
- Resolution: $1/24^\circ$ and 21 vertical layers σ_θ
- Cooper & Haines scheme (SSH data)
- Operational forecast: 2010
- Tidal forcings (work in progress)

SE region model nested in the METAREA V model



Work in progress

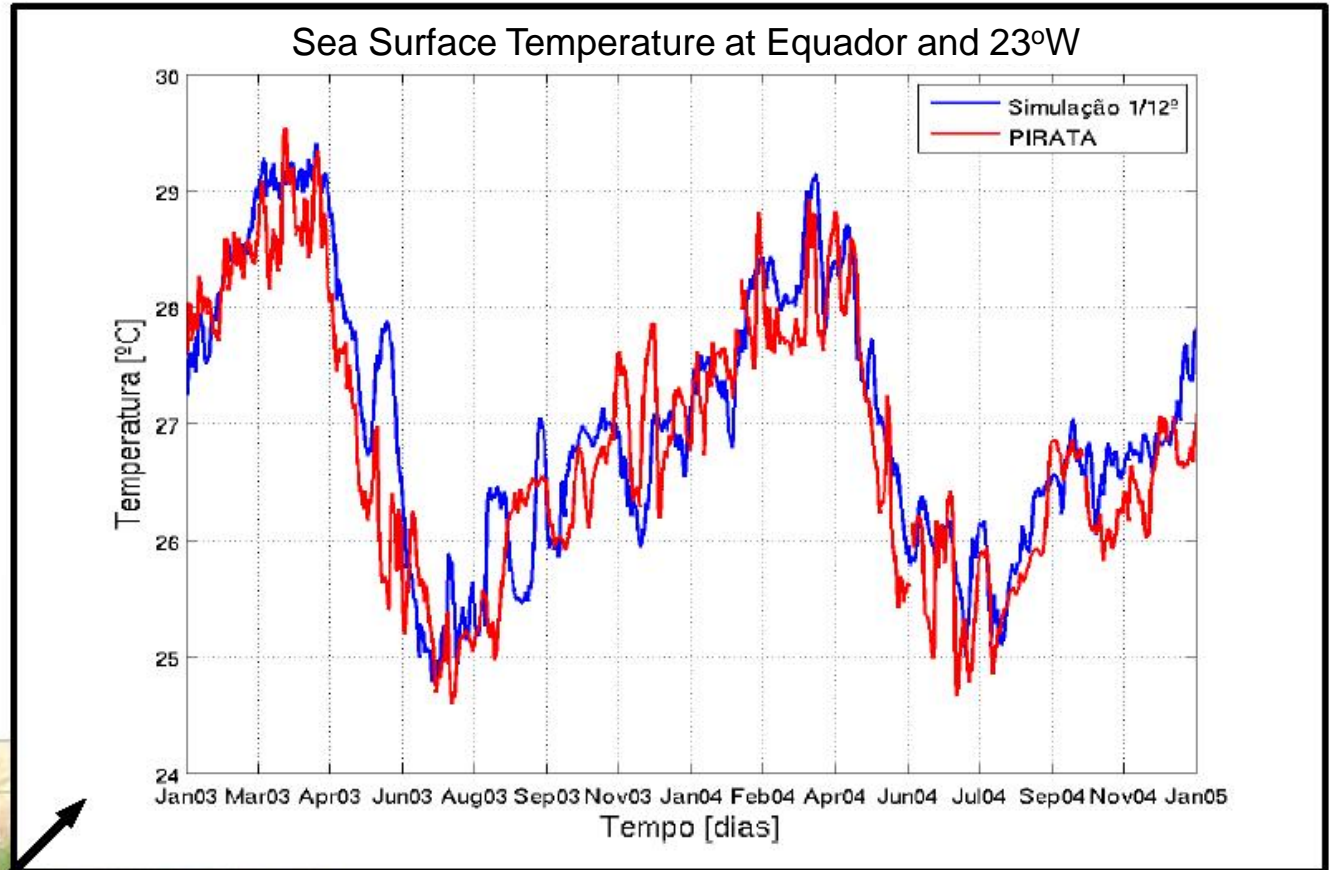
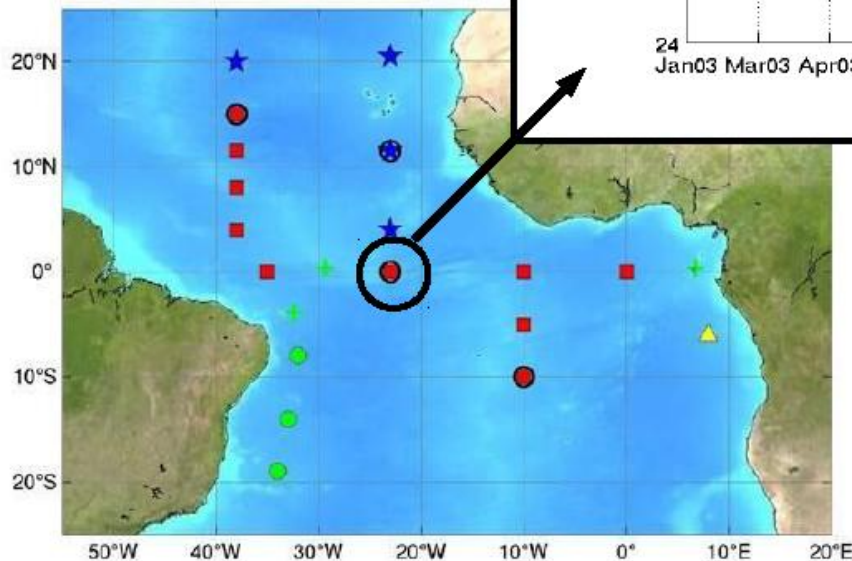
- Model: ROMS
- Resolution: 1/24°

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Model results assessment

Sea Surface Temperature (SST)



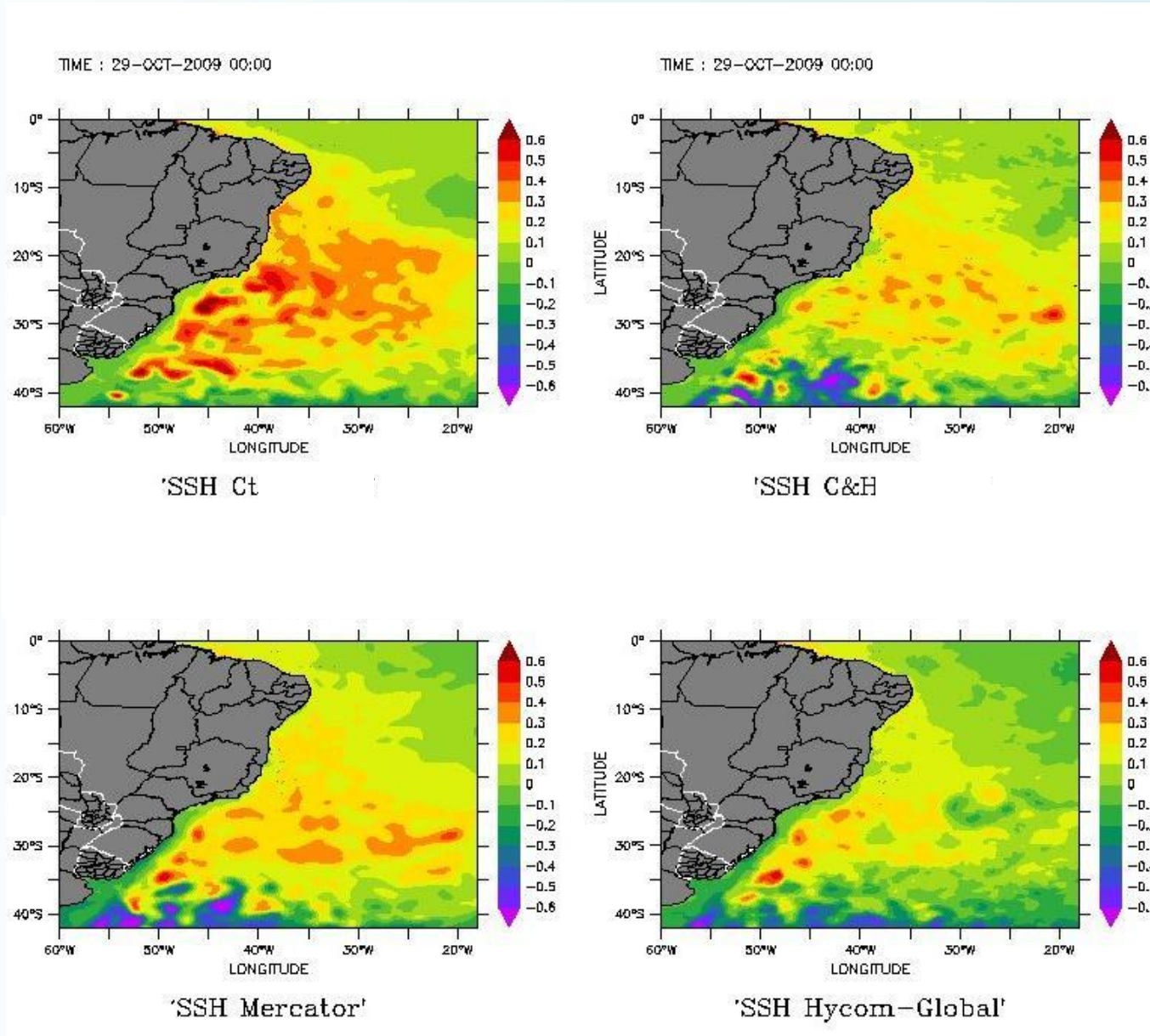
Preliminar comparison: Pirata Buoy data and model results without data assimilation

Model results assessment

Data Assimilation

Simulation
1st july to 31st
october 2009

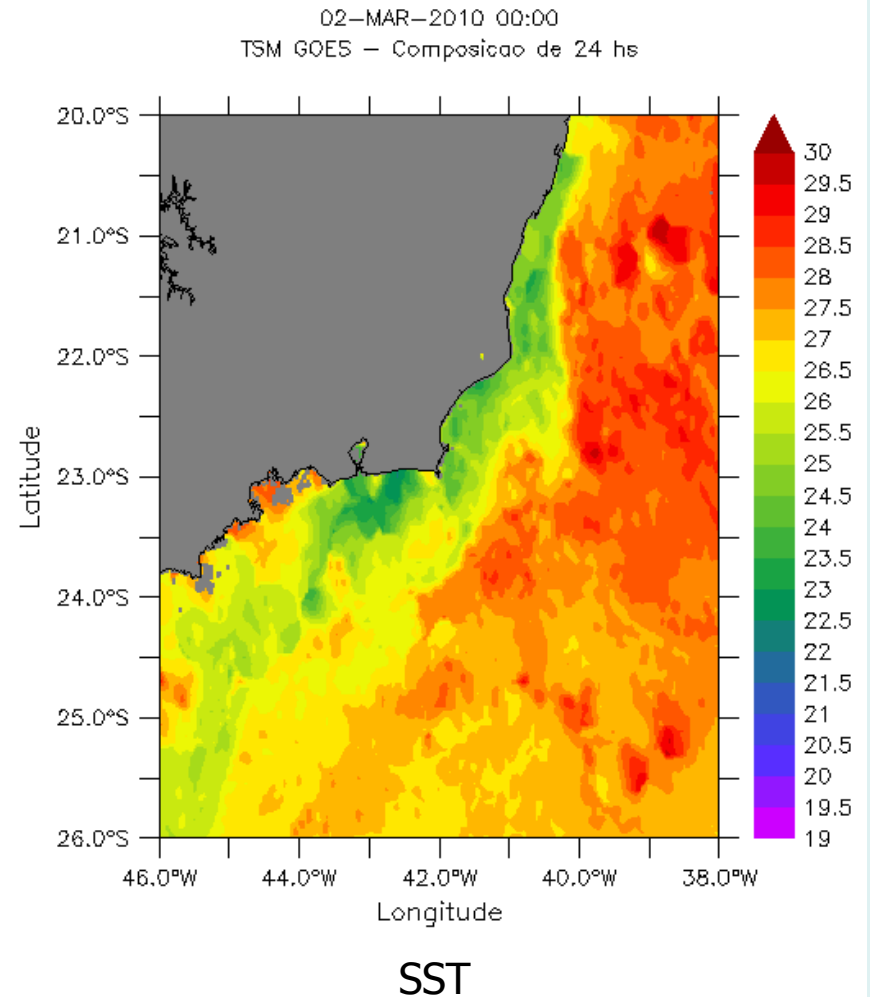
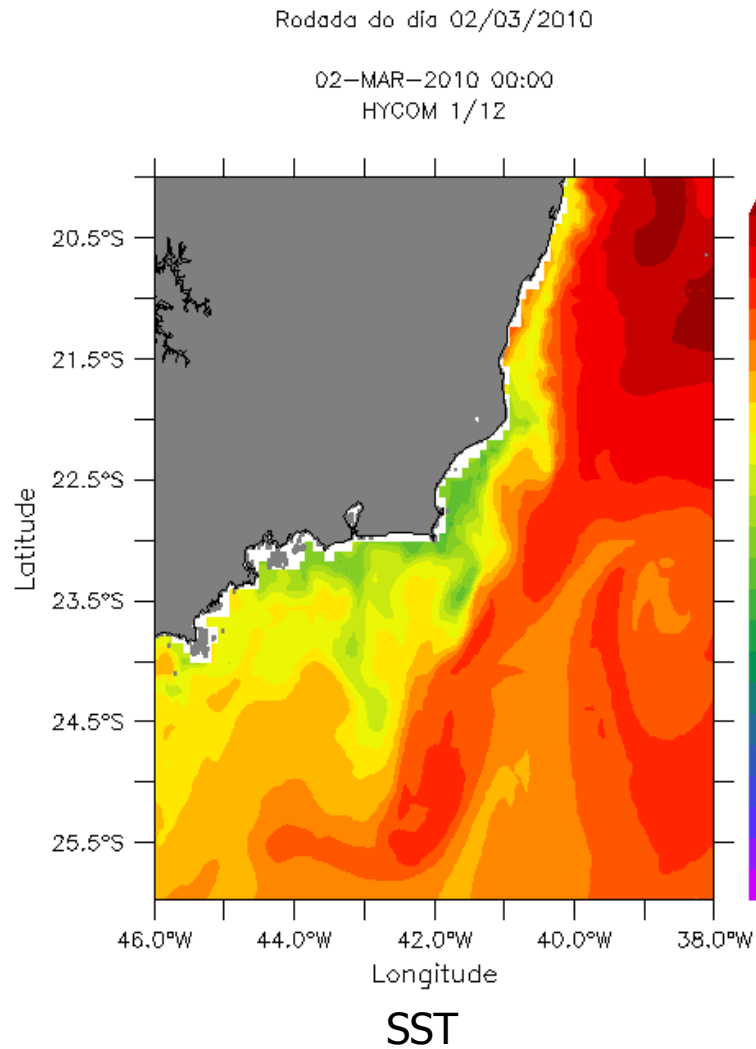
SSHA data
assimilation from
Jason-1 and Jason-2
with Optimal
Interpolation and
Cooper and Haines



(Tanajura, Ramos da Silva, Ruggiero, Daher, Belyaev, Martins, Lima, CBO 2010)

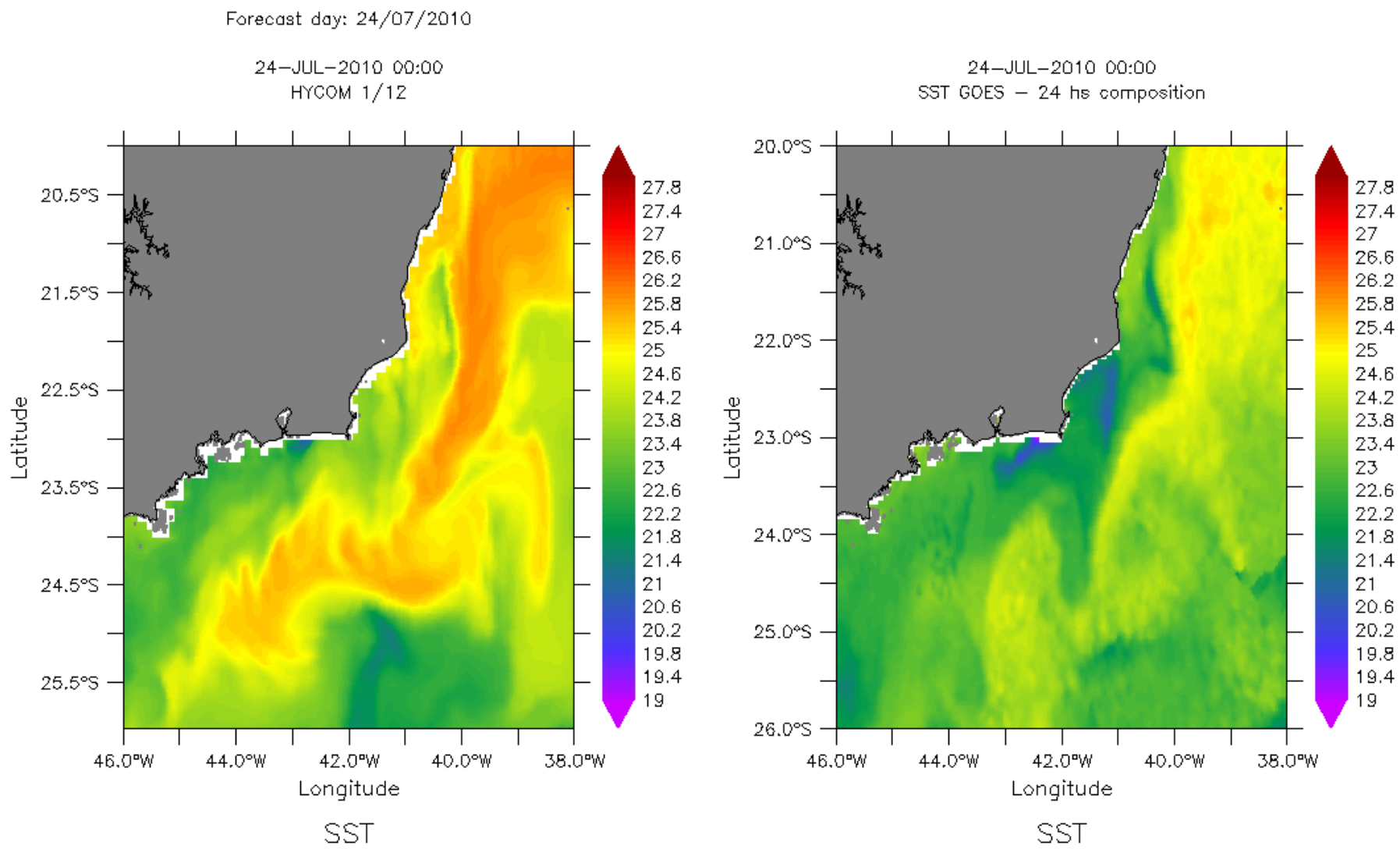
Model results assessment

Model results X remote sensing SST - METAREA V Model



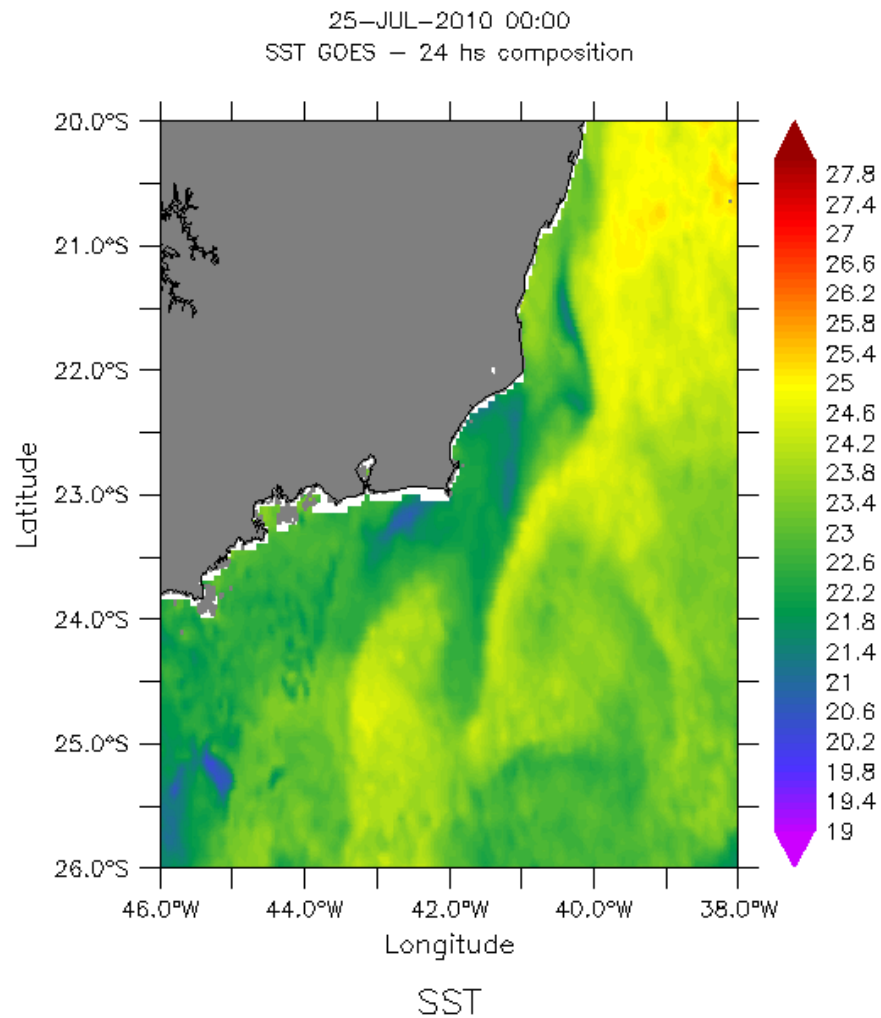
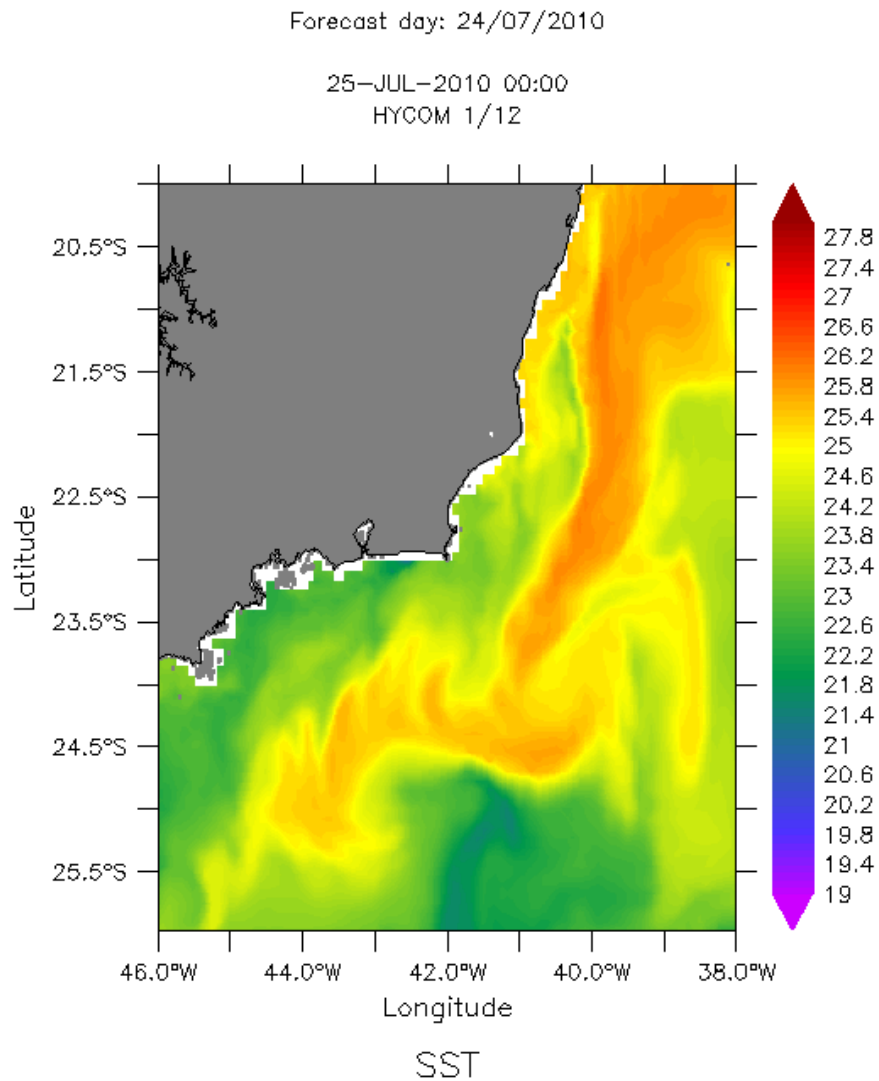
Model results assessment

Model results X remote sensing SST - METAREA V Model



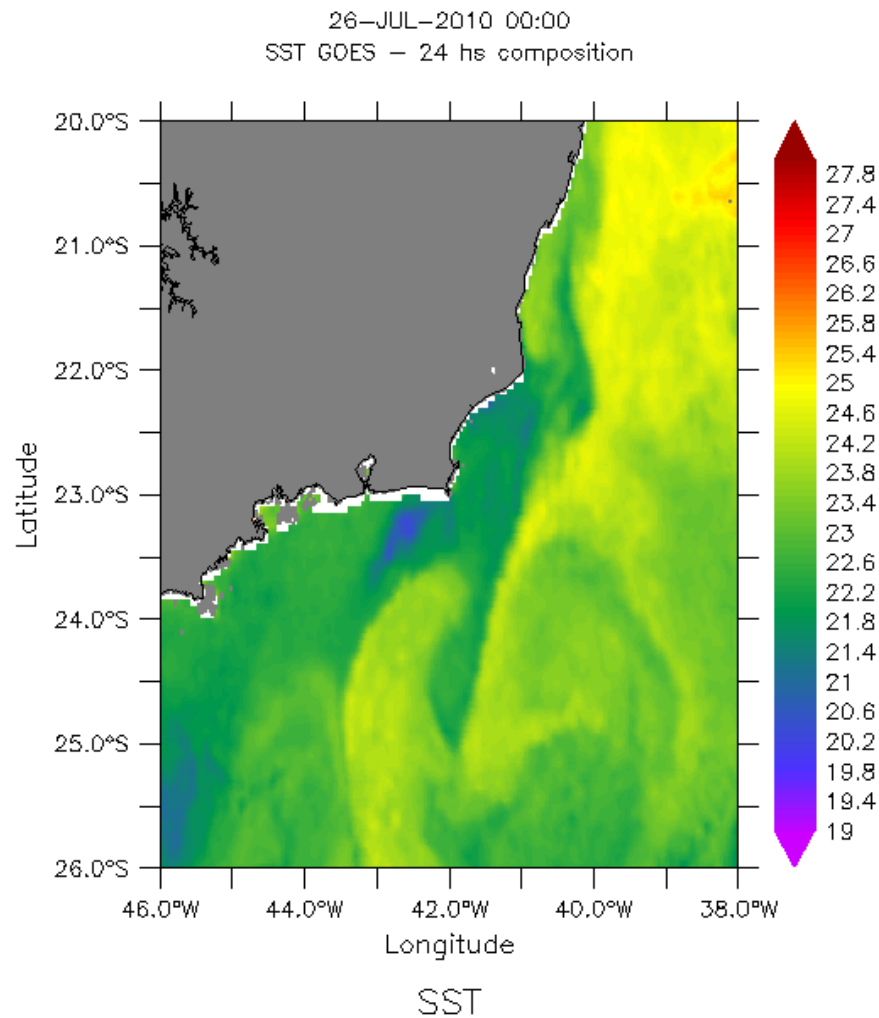
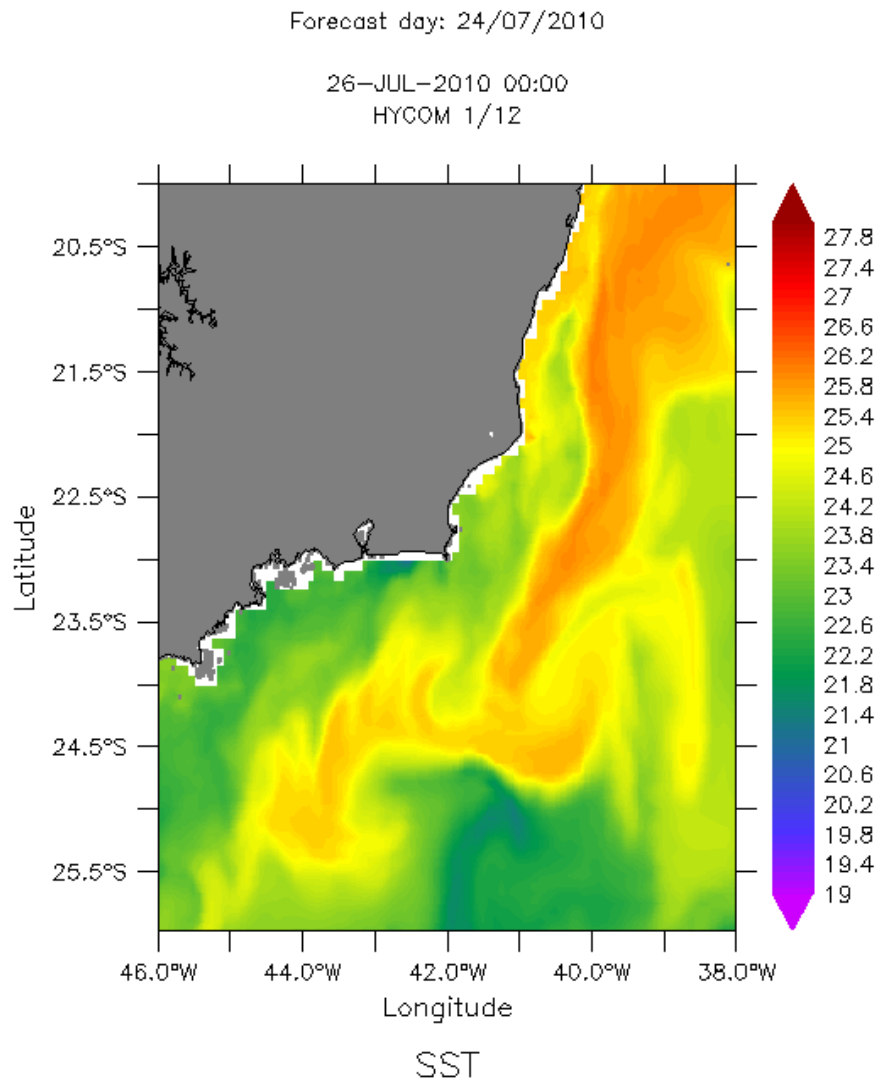
Model results assessment

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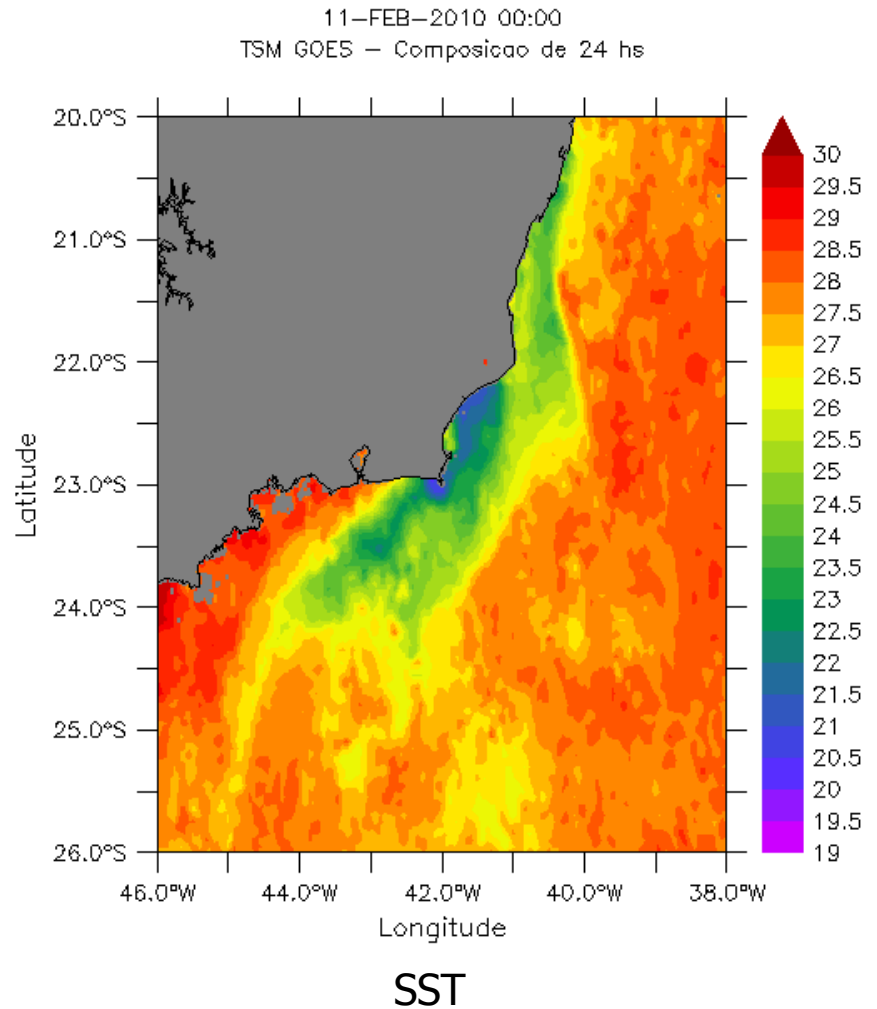
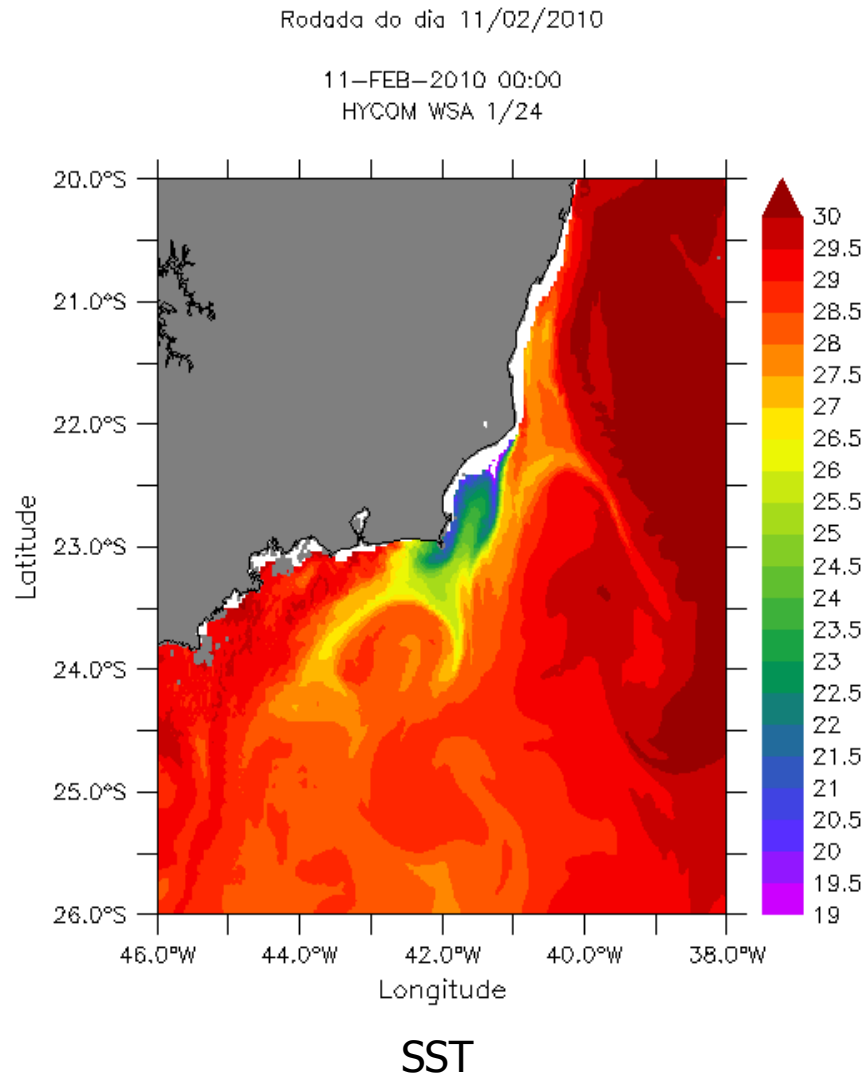
Model results assessment

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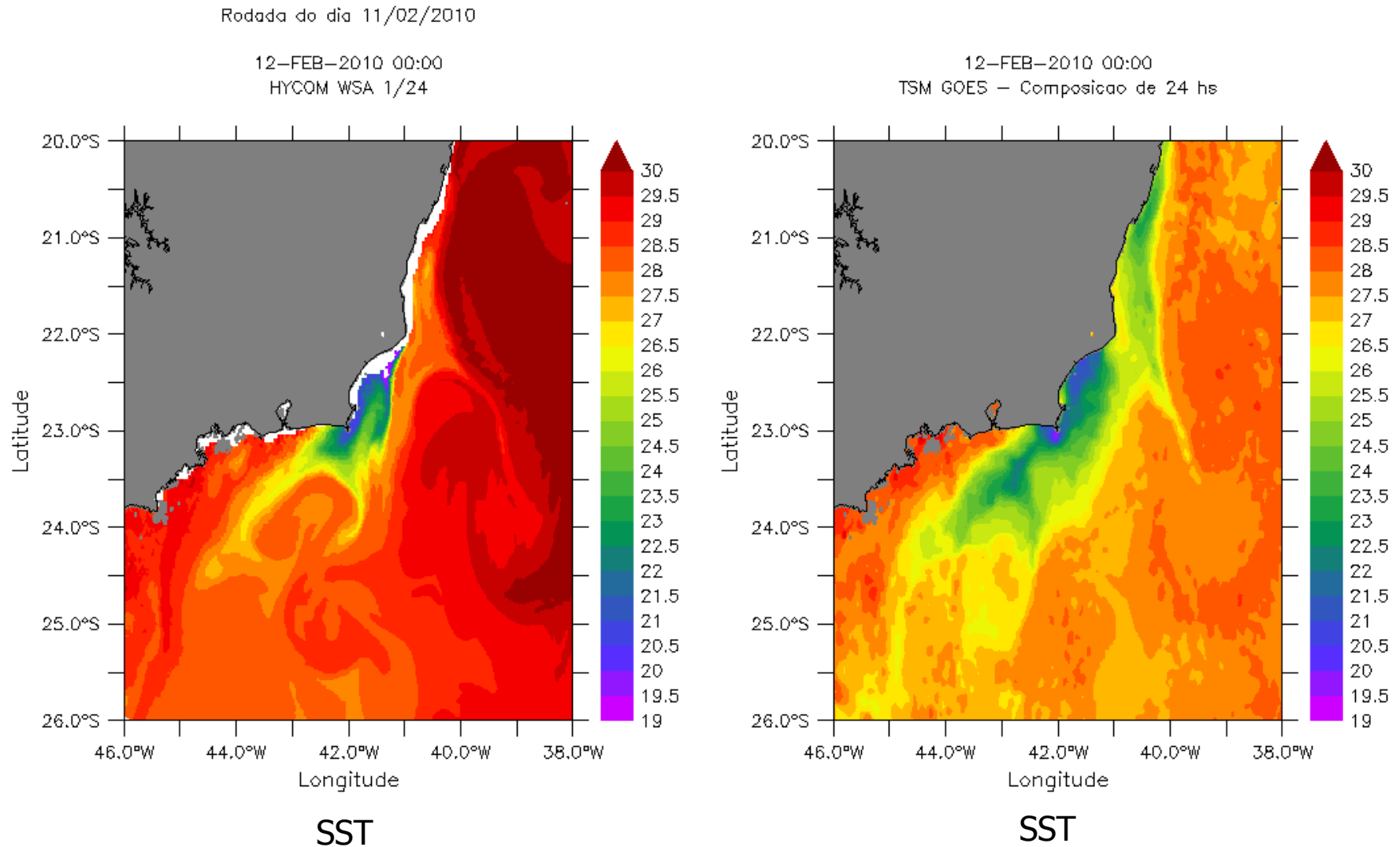
Model results assessment

Model results X remote sensing SST - SE region Model



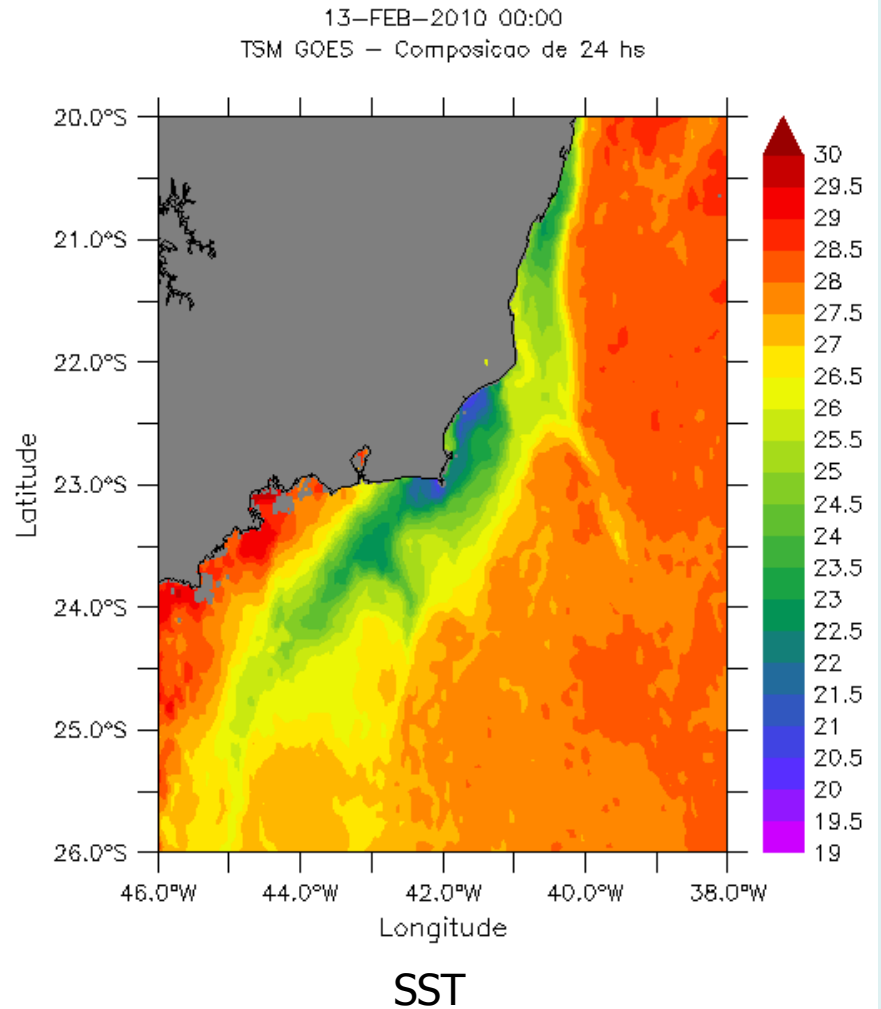
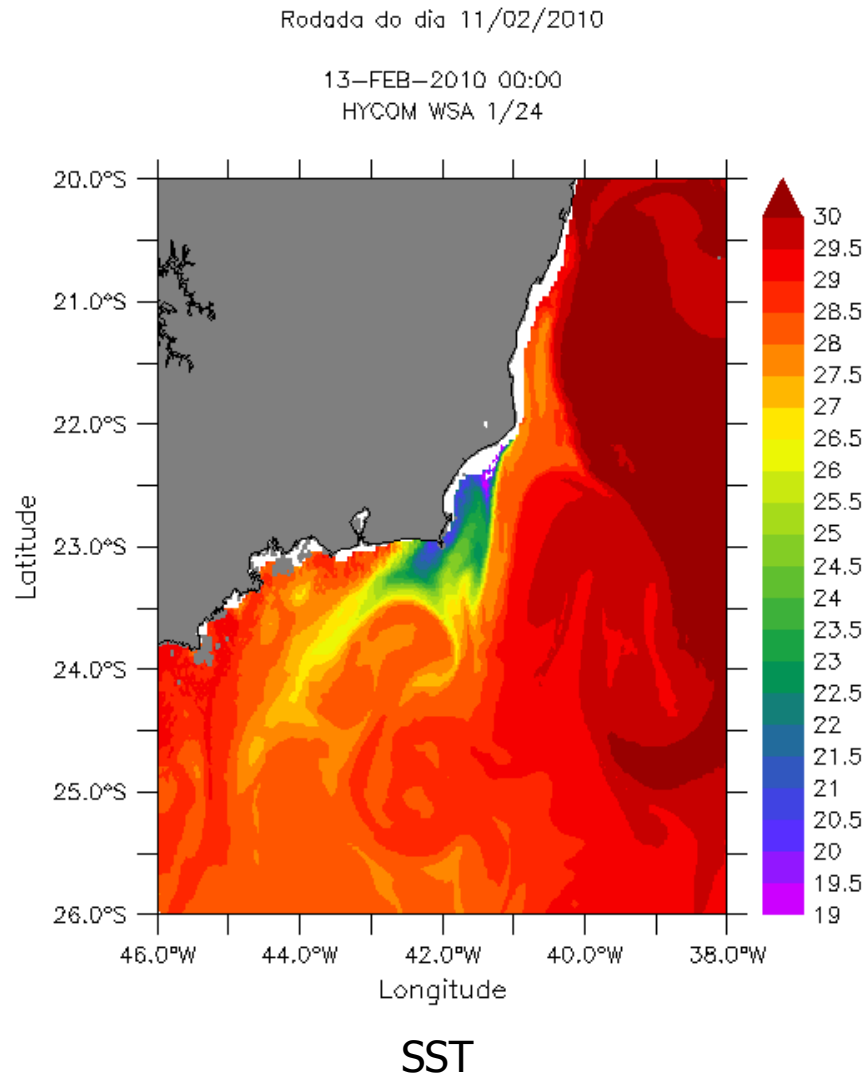
Model results assessment

Model results X remote sensing SST - SE region Model



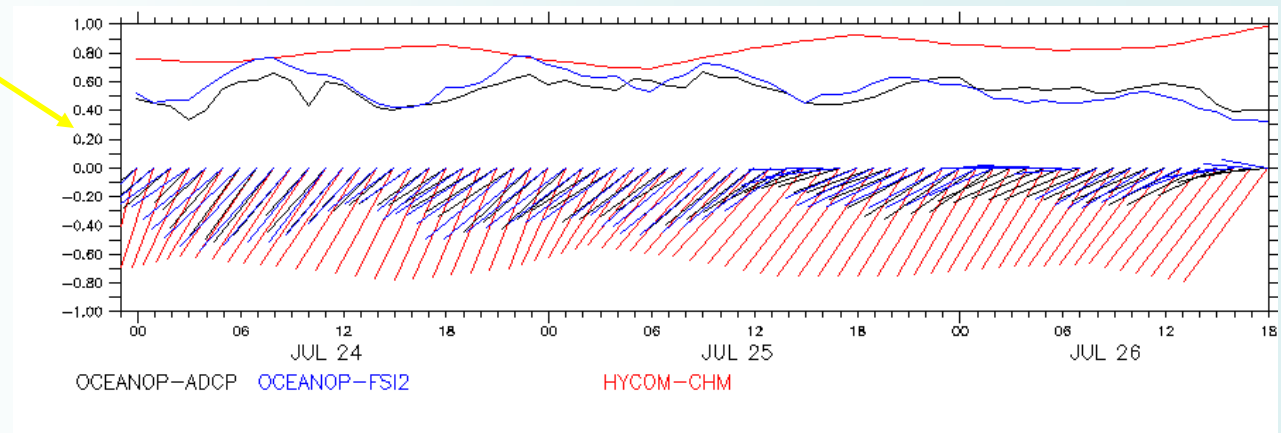
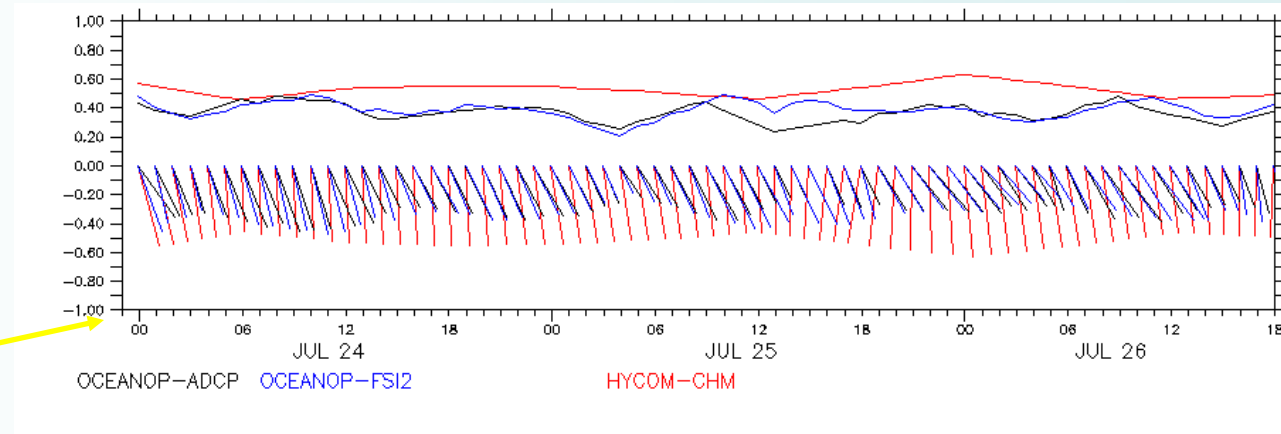
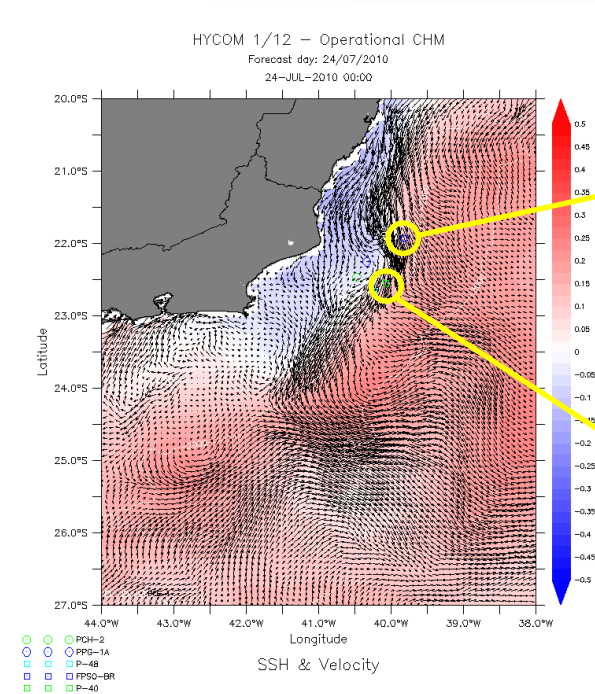
Model results assessment

Model results X remote sensing SST - SE region Model



Model results assessment

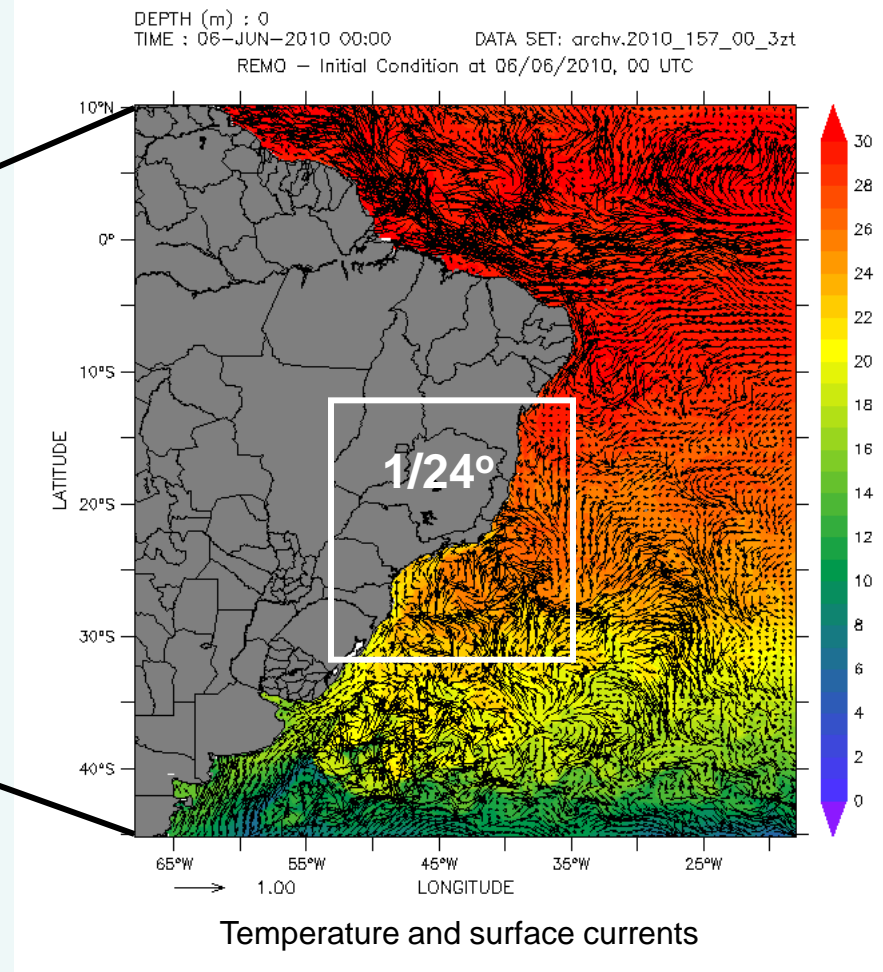
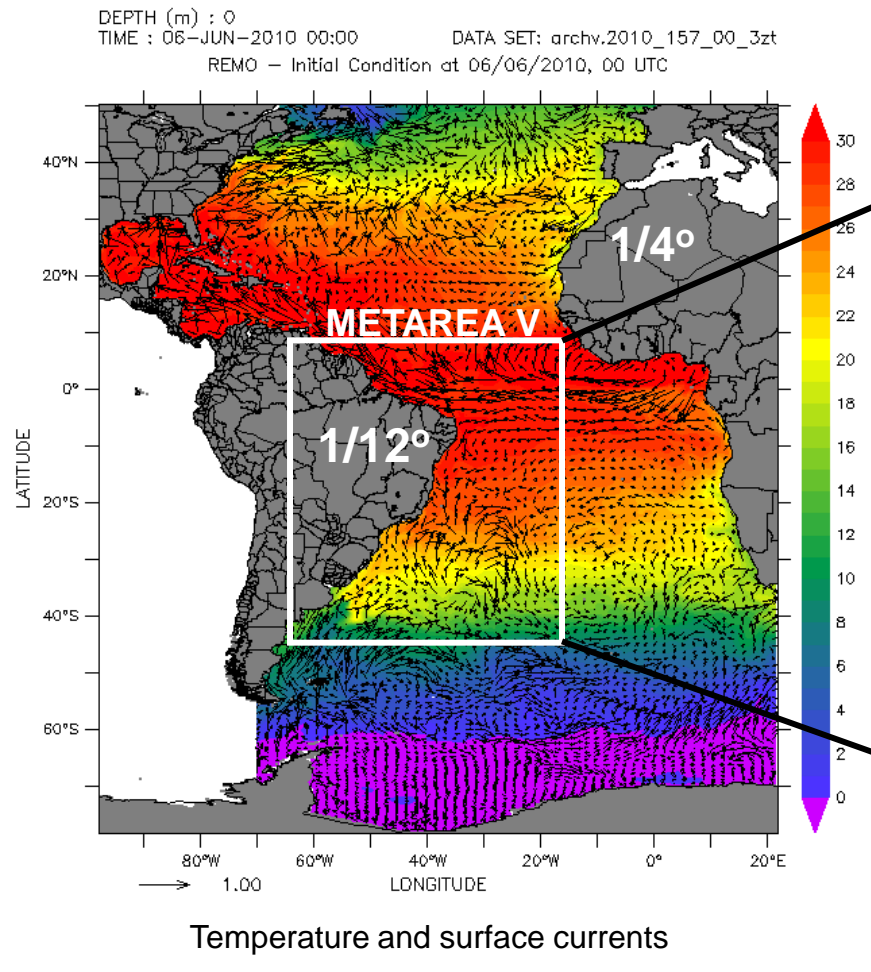
Model results X current data



OUTLINE

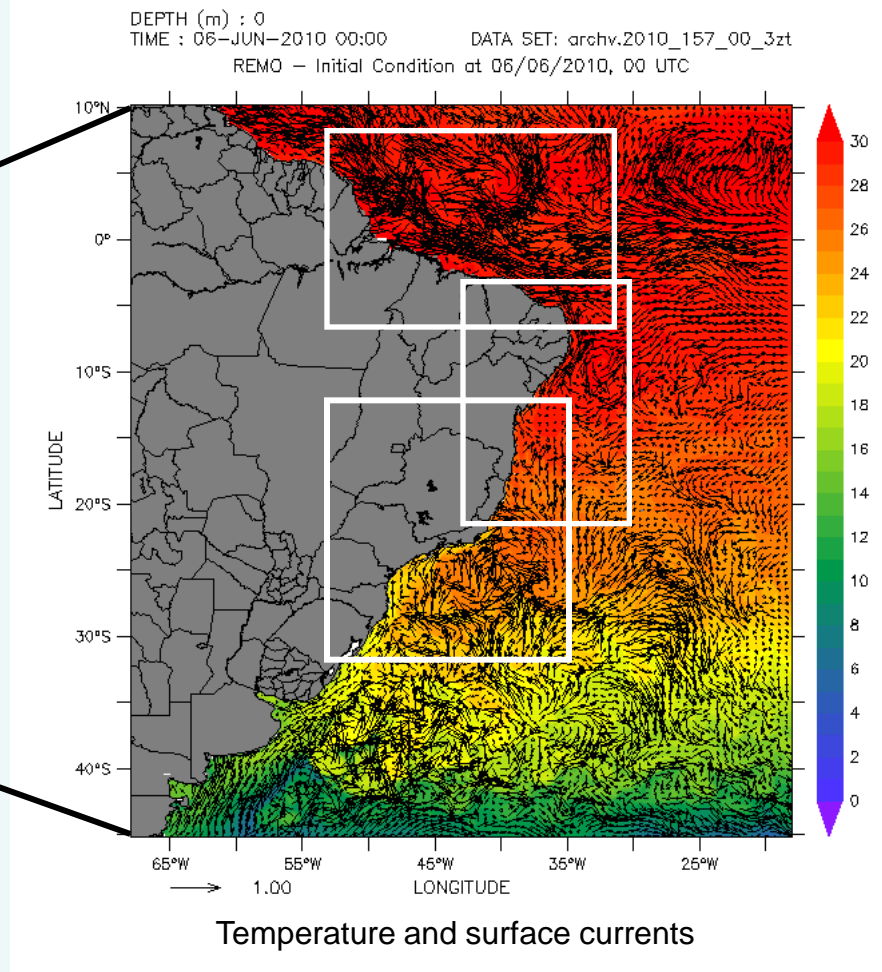
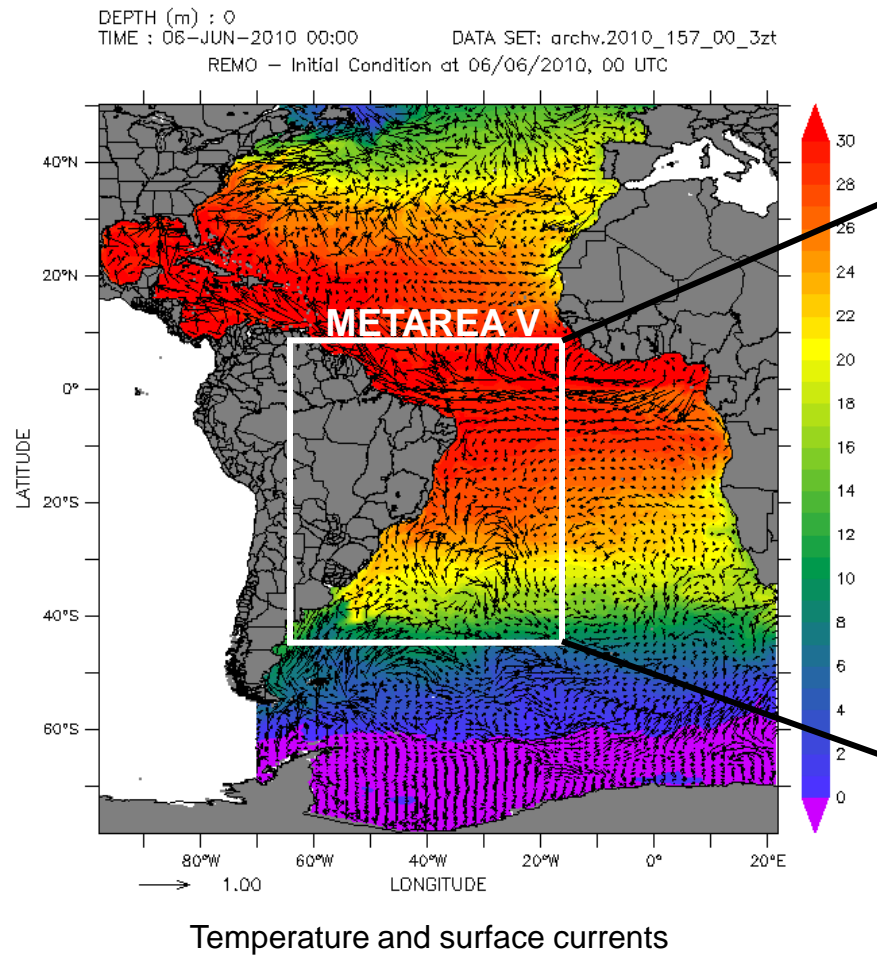
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Concluding Remarks



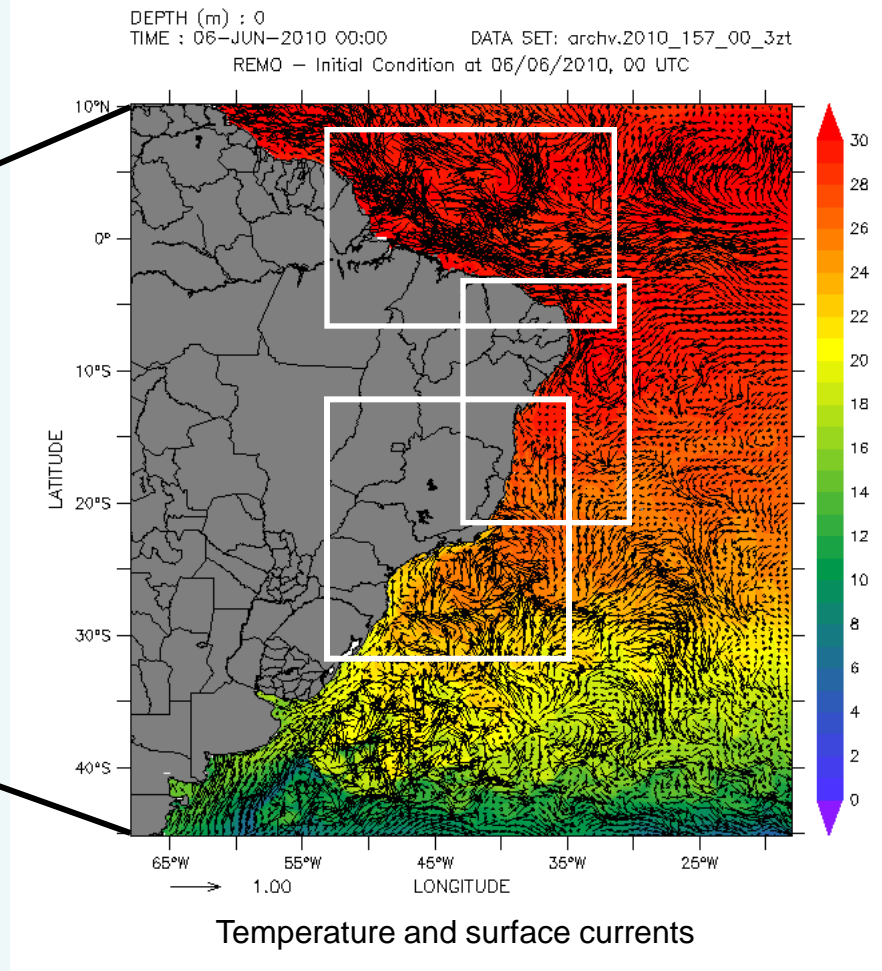
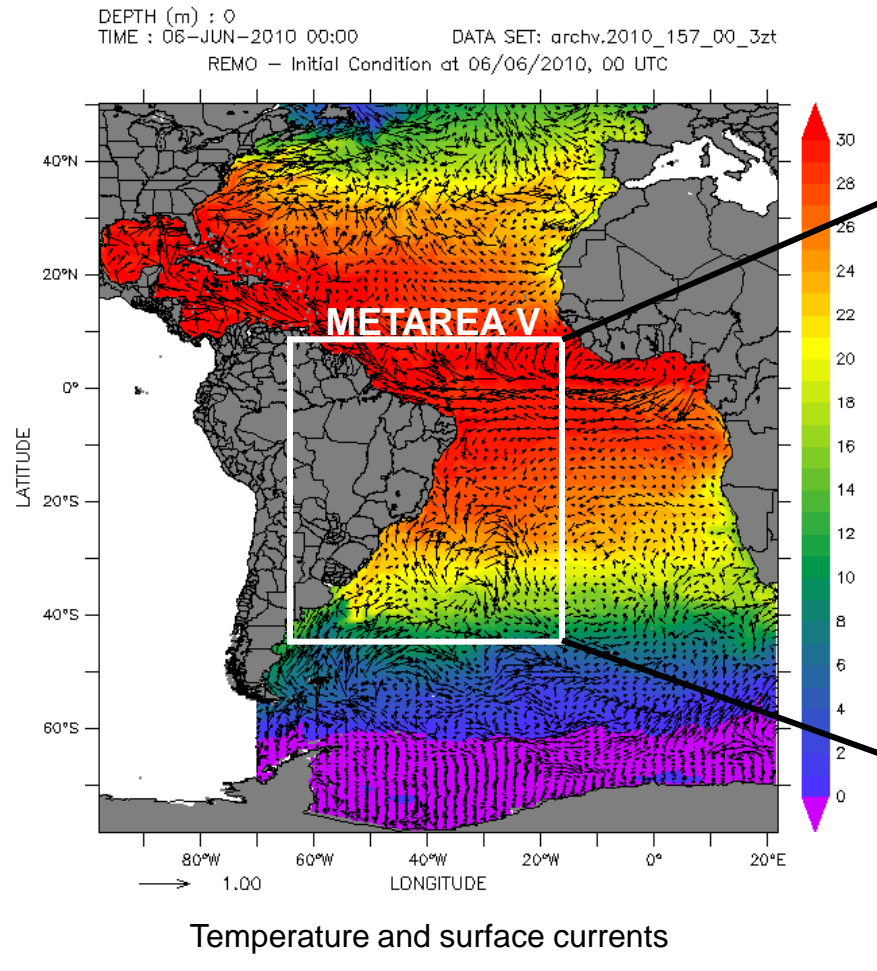
- **Operational ocean forecast system running at Brazilian Navy Hydrographic Center (CHM) with Cooper & Haines scheme**

Following work



- Modeling with ROMS in progress
- New regional modeling at the NE and N areas

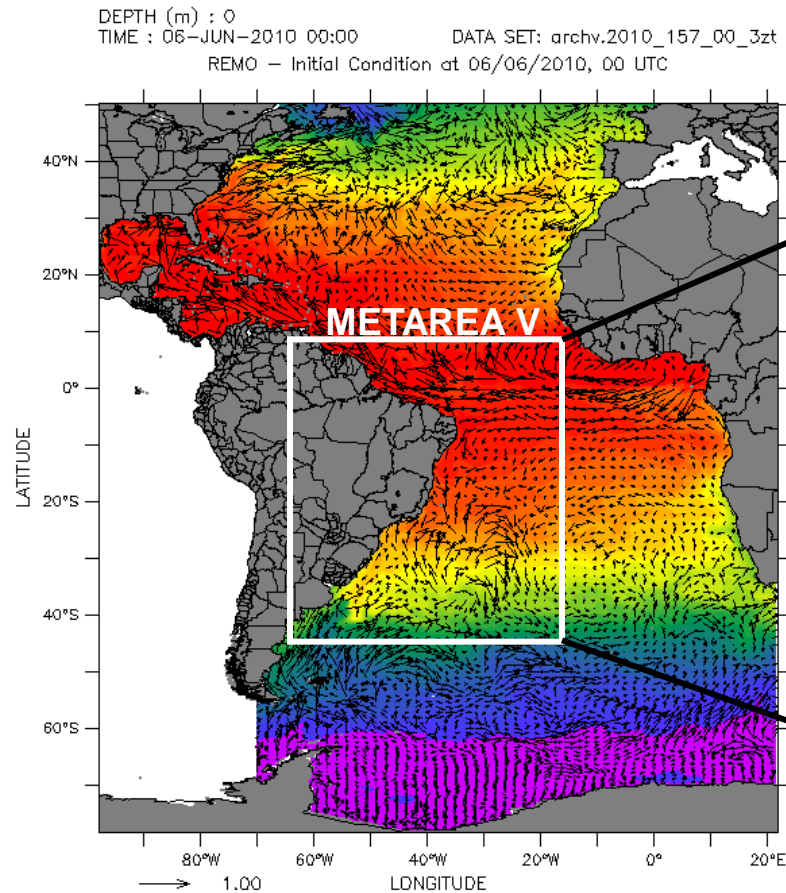
Following work



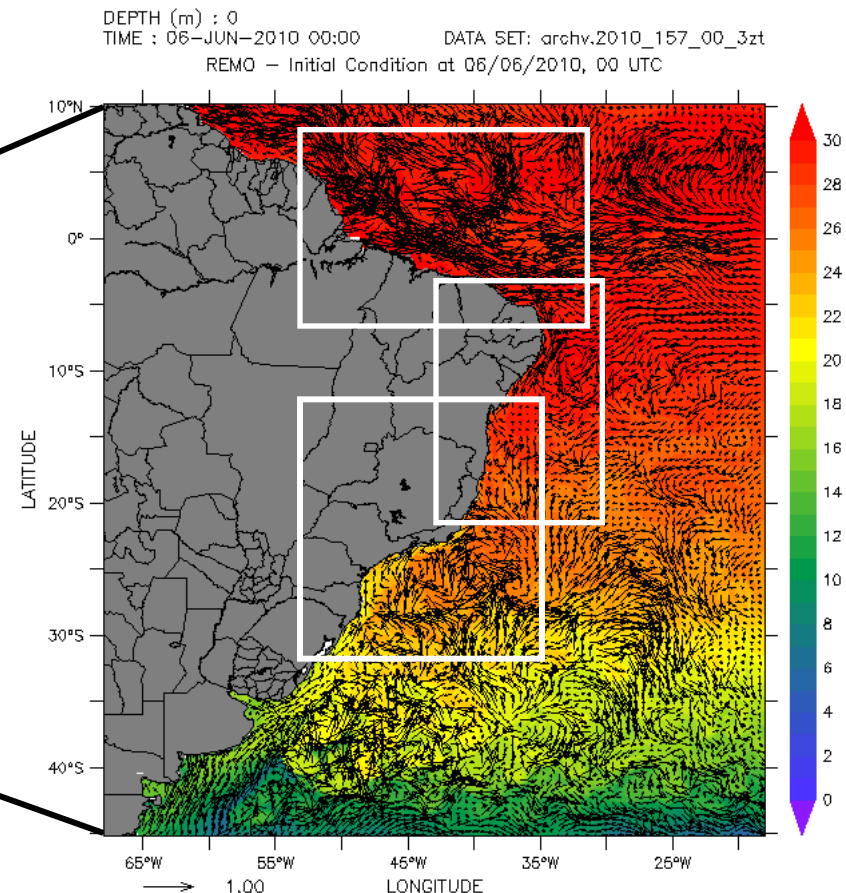
Data Assimilation

- Ensemble Kalman Filters (EnKF)
- Local Transformed Ensemble Kalman Filter (LETKF)
- Optimal Interpolation (OI)
- 4D-VAR

Following work



Temperature and surface currents

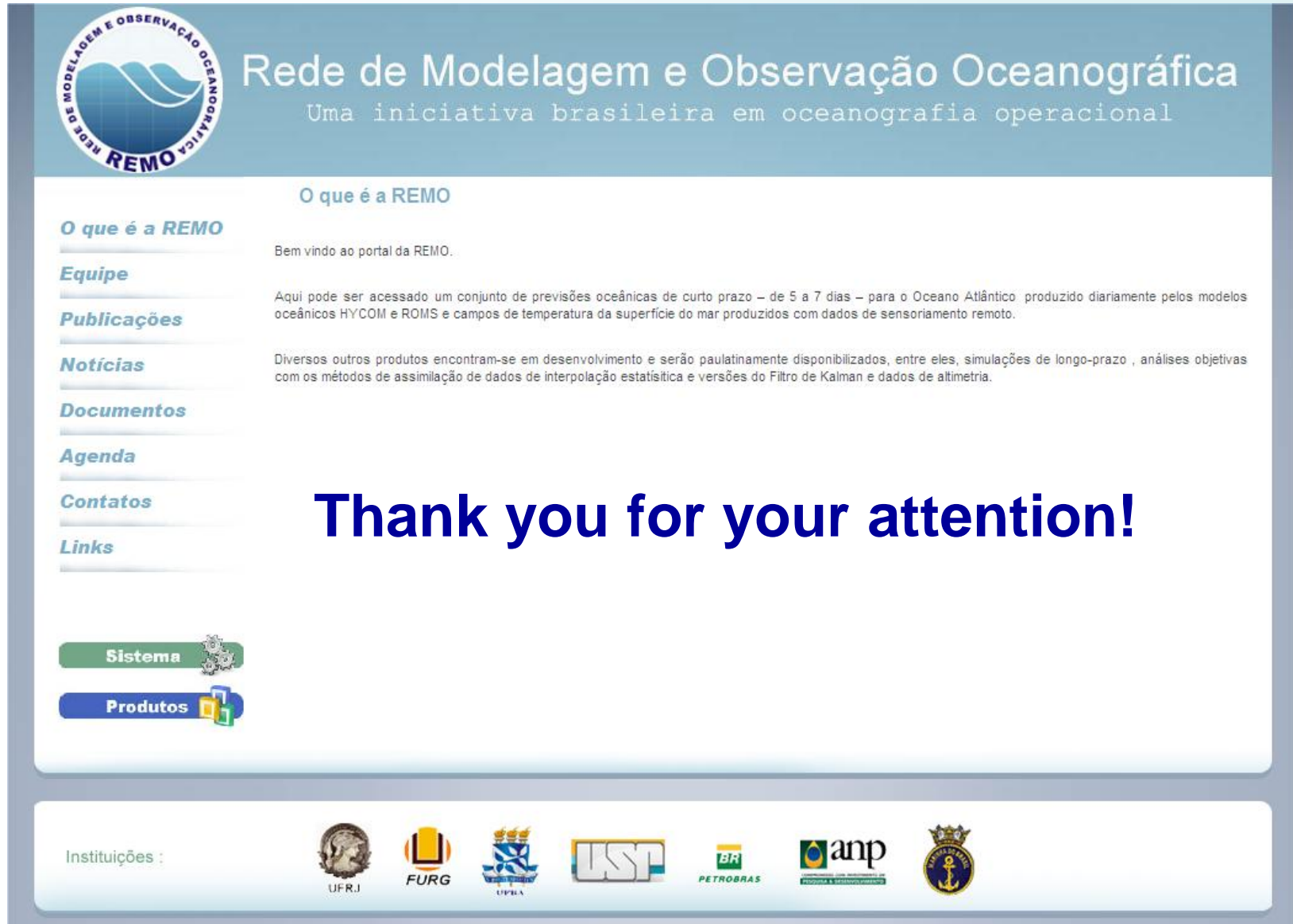


Temperature and surface currents

- Deeper research on the model results
- Better understanding of the model skills

Concluding Remarks and Following Work

- REMO homepage: www.rederemo.org



The screenshot shows the homepage of the Rede de Modelagem e Observação Oceanográfica (REMO). The header features the REMO logo, which is a circular emblem with a blue wave and the text 'REDE DE MODELAGEM E OBSERVAÇÃO OCEANOGRÁFICA' and 'REMO'. To the right of the logo, the text 'Rede de Modelagem e Observação Oceanográfica' is displayed in a large, white font, followed by the subtitle 'Uma iniciativa brasileira em oceanografia operacional' in a smaller, white font.

Below the header, the main content area is divided into two columns. The left column contains a vertical menu with the following items: 'O que é a REMO', 'Equipe', 'Publicações', 'Notícias', 'Documentos', 'Agenda', 'Contatos', and 'Links'. The right column contains the text 'O que é a REMO' followed by a welcome message: 'Bem vindo ao portal da REMO.' Below this, there are two paragraphs of text. The first paragraph states: 'Aqui pode ser acessado um conjunto de previsões oceânicas de curto prazo – de 5 a 7 dias – para o Oceano Atlântico produzido diariamente pelos modelos oceânicos HYCOM e ROMS e campos de temperatura da superfície do mar produzidos com dados de sensoriamento remoto.' The second paragraph states: 'Diversos outros produtos encontram-se em desenvolvimento e serão paulatinamente disponibilizados, entre eles, simulações de longo-prazo, análises objetivas com os métodos de assimilação de dados de interpolação estatística e versões do Filtro de Kalman e dados de altimetria.'

At the bottom of the main content area, there are two buttons: 'Sistema' with a gear icon and 'Produtos' with a folder icon. Below these buttons, there is a large, bold, blue text overlay that reads 'Thank you for your attention!'.

The footer of the page features the text 'Instituições :' followed by a row of logos for the following institutions: UFRJ, FURG, UFPA, USP, PETROBRAS, ANP, and the Brazilian Navy (Marinha do Brasil).