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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BRASIL
UN workshop

UN-SPIDER in Riyadh – Saudi Arabia:

*Oil spill detection system* via remotely sensed data

Our concerning 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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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
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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.

PETROBRAS - Research Center

Brazilian Navy – CHM/IEAPM

Federal University of Rio de Janeiro - UFRJ

University of São Paulo - USP

Federal University of Rio Grande - FURG

Federal University of Bahia - UFBA

UN-SPIDER Bonn Workshop, Bonn 12-14 Oct, 2010
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
**Observations (Remote Sensing and Metocean Measurements)**

- Satellite Sensors (SST and Altimetry)
- Termohaline Structure (OI of TS fields)
- Buoys and Radars (Wave, Wind, Current)
- Measurements with moorings

**Model Development**

- Basin Scale Modeling (HYCOM)
- Regional Modeling Initialization and Assimilation schemes
- Regional Modeling Boundary conditions and Thermodynamics

**Regional Modeling**

- N/NE – Processes study (HYCOM/ROMS)
- S/SE – Processes study (HYCOM/ROMS/POM)
- E – Processes study (HYCOM/ROMS)

**Modeling Operation**

- Meteorological Model (Operational)
- Ocean Models (Operational)
- Wave Models (Operational)

**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

**Observations**

- Satellite Sensors
- Termohaline Structure
- Buoys and Radars
- Measurements with moorings
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Remote Sensing Product - Ocean Model Input

- SST (IR+MW)
- SSHA (JASON 1 and JASON 2)

OCEAN MODEL

Live Access Server (LAS)

www.rederemo.org
Remote Sensing Product - Ocean Model Input

SST (IR+MW)

SSHA (JASON 1 and JASON 2)

OCEAN MODEL

Live Access Server (LAS)

www.rederemo.org
Barnes Sub-optimal interpolation technique:

FIRST GUESS ANALYSIS

SECOND GUESS ANALYSIS

INTERPOLATED SST

Weight Function

\[ w_m^{(0)} = \exp\left(-\frac{r^2}{k} - \frac{\tau^2}{\nu}\right) \]

\[ w_m^{(1)} = \exp\left(-\frac{r^2}{ak} - \frac{\tau^2}{\alpha\nu}\right) \]
SST - Validation

Buoys locations

Location: 15°N 38°W

Date

SST (°C)

23.50
23.70
23.90
24.10
24.30
24.50
24.70
24.90
25.10
25.30
25.50
25.70
25.90
26.10
26.30
26.50
26.70
26.90

Jan/06
Feb/06
Mar/06
Apr/06
May/06
June/06
July/06
August/06
September/06
October/06
November/06
December/06
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.

<table>
<thead>
<tr>
<th>Buoy Location</th>
<th>RMSE</th>
<th>MAE</th>
<th>MBE</th>
<th>CORRELATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15°N – 38°W</td>
<td>0.37</td>
<td>0.35</td>
<td>0.28</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>(**)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12°N – 38°W</td>
<td>0.50</td>
<td>0.49</td>
<td>0.39</td>
<td>-0.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8°N – 38°W</td>
<td>0.33</td>
<td>0.31</td>
<td>0.27</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4°N – 38°W</td>
<td>0.28</td>
<td>0.26</td>
<td>0.22</td>
<td>0.05</td>
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<tr>
<td></td>
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<td></td>
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</tr>
<tr>
<td>0°N – 23°W</td>
<td>0.31</td>
<td>0.28</td>
<td>0.26</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8°S – 30°W</td>
<td>0.25</td>
<td>0.22</td>
<td>0.21</td>
<td>0.18</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14°S – 32°W</td>
<td>0.35</td>
<td>0.32</td>
<td>0.29</td>
<td>-0.19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19°S – 34°W</td>
<td>0.31</td>
<td>0.29</td>
<td>0.25</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

(*) without restriction of wind speed (≥ 5 m/s)  (***) with restriction of wind speed (≥ 5 m/s)
Remote Sensing Product - Ocean Model Input

- **SST (AVHRR+TRMM)**
- **SSHA (JASON 1 and JASON 2)**

OCEAN MODEL

Live Access Server (LAS)

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

**The system:**

1. **Atmospheric and geophysical corrections and SSHA estimation**
2. **Redundant data elimination**
   - **Spurious data elimination**
   - **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° grid)**

**Smoothed along-track SSHA database**

**Model assimilation**

**Local tidal correction**

**Cross calibration**
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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 $\sigma_\theta$
- 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° and 21 vertical layers $\sigma_\theta$
- **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)
Model: HYCOM
Resolution: 1/24° and 21 vertical layers $\sigma_\theta$
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)

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

Forecast day: 24/07/2010

24–JUL–2010 00:00
HYCOM 1/12

24–JUL–2010 00:00
SST GOES – 24 hs composition
Model results assessment

Model results X remote sensing SST - METAREA V Model

Forecast day: 24/07/2010

25-JUL-2010 00:00
HYCOM 1/12

SST
Model results assessment

Model results X remote sensing SST - METAREA V Model

Forecast day: 24/07/2010

26-JUL-2010 00:00
HYCOM 1/12

26-JUL-2010 00:00
SST GOES - 24 hs composition
Model results assessment

Model results X remote sensing SST - SE region Model

Redada do dia 11/02/2010

11-FEB-2010 00:00
HYCOM WSA 1/24

11-FEB-2010 00:00
TSM GOES - Composição de 24 hs

SST
Model results assessment

Model results X remote sensing SST - SE region Model

Rodada do dia 11/02/2010

12-FEB-2010 00:00
HYCOM WSA 1/24

TSM GOES - Composicco de 24 hs

SST

SST
Model results assessment

Model results X remote sensing SST - SE region Model
Model results assessment

Model results X current data
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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

- Deeper research on the model results
- Better understanding of the model skills
Concluding Remarks and Following Work

- REMO homepage: www.rederemo.org

Thank you for your attention!