A synergy study between SST, Chl-a and altimeters to improve surface geostrophic currents
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Objectives

1. Study surface dynamics at mesoscale:
   - relationships with active/passive tracers
   - temperature (SST) and color (Chl-a)

2. Improve surface dynamics:
   - using remote sensing data
   - high resolution SST and Chl-a

SST (RSS) & Currents (Aviso)
Chl−a (MODIS) & Currents (Aviso)
Remote sensing data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Provider</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>SST</td>
<td>RSS</td>
<td><a href="http://www.ssmi.com">http://www.ssmi.com</a></td>
</tr>
<tr>
<td>Chl-a</td>
<td>MODIS</td>
<td><a href="http://modis.gsfc.nasa.gov">http://modis.gsfc.nasa.gov</a></td>
</tr>
<tr>
<td>SSH</td>
<td>Aviso</td>
<td><a href="http://www.aviso.oceanobs.com">http://www.aviso.oceanobs.com</a></td>
</tr>
</tbody>
</table>

- Daily $1/4^\circ$ interpolations
- Year 2004
- Brazil-Malvinas Confluence Zone
Methodology

Introduction

- Local relationships between:
  - (a) SST and SSH
  - (b) Chl-a and SSH

- Dynamical modes between (SST, Chl-a, SSH), how to:
  - separate them?
  - characterize them?
  - track them?
Surface Quasi-Geostrophic (Isern-Fontanet et al. 2006):

**Fourier domain:**
\[ \widehat{SSH} = -\gamma |\kappa|^{-\alpha} \widehat{SST} \iff \widehat{SSH} = \mathcal{H}_k \widehat{SST} \]

**Real domain:**
\[ SSH = H_k * SST \]
with \( H_k \) a spatial convolution operator

\[ \Rightarrow \text{Different } H_1, \ldots, H_K? \]
\[ \Rightarrow \text{How to estimate them?} \]
Methodology
Statistical variables

- **X** → SST and Chl-a patches (9 × 9 pixels)
- **Y** → SSH, U and V (center of the patch)
- **Z** → Hidden dynamical mode (center of the patch)
- Learning dataset → random spatio-temporal sampling

Synergy between SST, ChlA and altimetry
5th of August 2014
Latent class regression (DeSarbo and Cron 1988):

\[ p(Y|X, Z = k) \propto \mathcal{N}(Y; XH_k, \Sigma_k) \]

with \( \mathcal{N}_k \) a multivariate Gaussian pdf:

- evaluated in \( Y \)
- mean \( XH_k \) and covariance \( \Sigma_k \)
Results

Dynamical modes

Estimated dynamical mode (Z)

Four dynamical modes:
- **Z=1** → cyclonic eddy
- **Z=3** → anticyclonic eddy
- **Z=2** and **Z=4** → weaker modes
Results
Current estimation

Fuzzy regression:

\[ \hat{Y}^{(\text{new})} = \sum_{k=1}^{K} \hat{\pi}_k X^{(\text{new})} \hat{H}_k \]

with \( \hat{\pi}_k \rightarrow \) probability for \( Z = k \) and \( \hat{H}_k \rightarrow \) transfer function

Latent class regression
**Fuzzy regression:**

\[
\hat{Y}(HR) = \sum_{k=1}^{K} \pi_k \hat{X}(HR) \hat{H}_k
\]

with \(X^{(HR)} \rightarrow\) high resolution SST and Chl-a (0.05°)
Conclusions

- Learn dynamical modes:
  - low resolution (LR) remote sensing data
  - statistical model
  - learn transfer functions between SST, Chl-a and SSH
Conclusions

- Improve surface currents:
  - high resolution (HR) remote sensing data
  - apply transfer functions
  - high spatio-temporal resolution currents

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SST

Chl-a

MODES

Currents

HR

HR

HR
Perspectives

- Validate estimated currents in south Atlantic
- Apply to other regions (Gulf Stream, Agulhas, Kuroshio)
- Use SMOS salinity data

