

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

COSPAR 2014  
Moscow, Russia

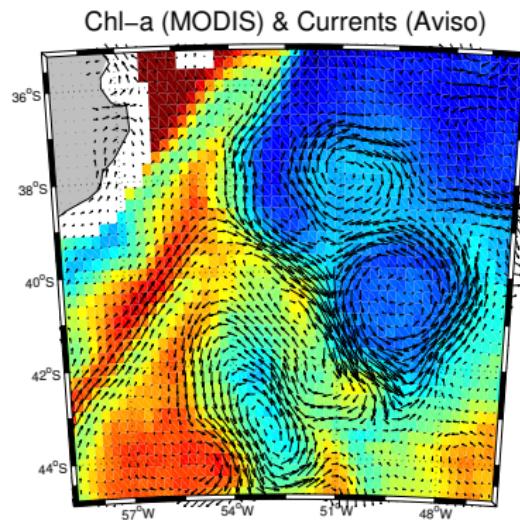
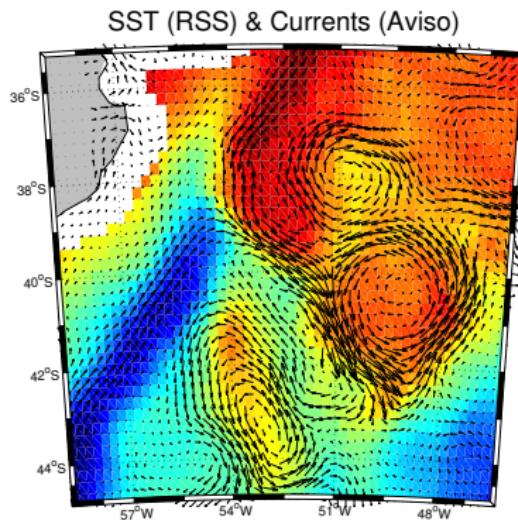
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5<sup>th</sup> of August 2014

# Objectives

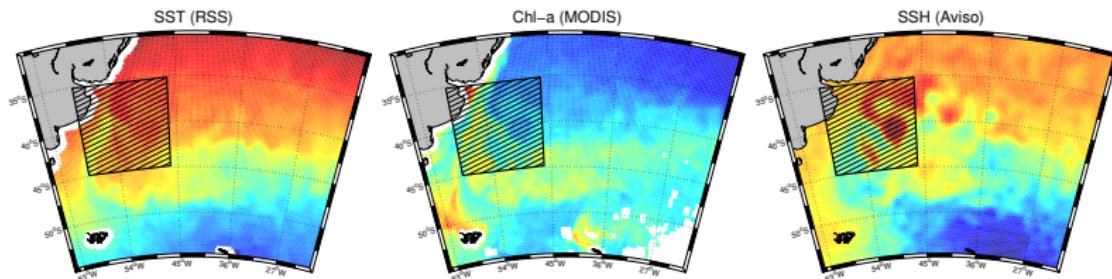
- ① Study surface dynamics at mesoscale:
  - relationships with active/pассив tracers
  - temperature (SST) and color (Chl-a)
- ② Improve surface dynamics:
  - using remote sensing data
  - high resolution SST and Chl-a



# Remote sensing data

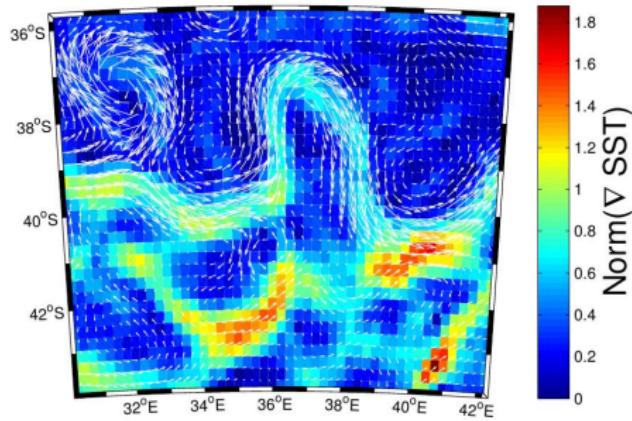
Parameter	Provider	Website
SST	RSS	<a href="http://www.ssmi.com">http://www.ssmi.com</a>
Chl-a	MODIS	<a href="http://modis.gsfc.nasa.gov">http://modis.gsfc.nasa.gov</a>
SSH	Aviso	<a href="http://www.aviso.oceanobs.com">http://www.aviso.oceanobs.com</a>

- Daily 1/4° interpolations
- Year 2004
- Brazil-Malvinas Confluence Zone

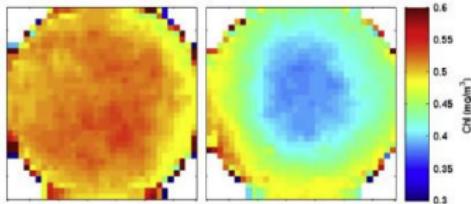


# Methodology

## Introduction



(a) Tandeo et al. 2014



(b) Saraceno and Provost 2012

- 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?

# Methodology

## Theory

Surface Quasi-Geostrophic (Isern-Fontanet et al. 2006):

Fourier domain:

$$\widehat{\text{SSH}} = -\gamma |\kappa|^{-\alpha} \widehat{\text{SST}} \quad \Leftrightarrow \quad \widehat{\text{SSH}} = \mathcal{H}_k \widehat{\text{SST}}$$

Real domain:

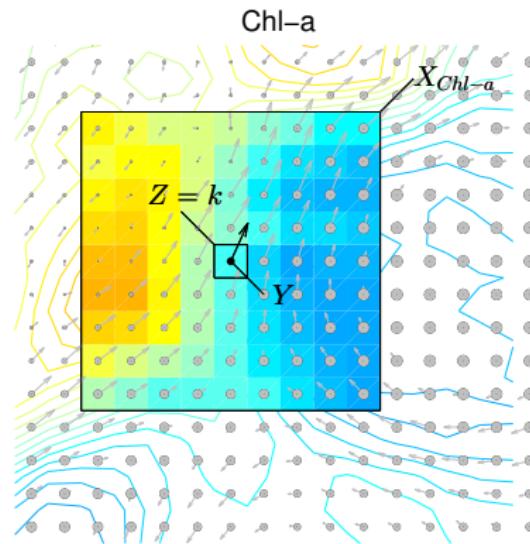
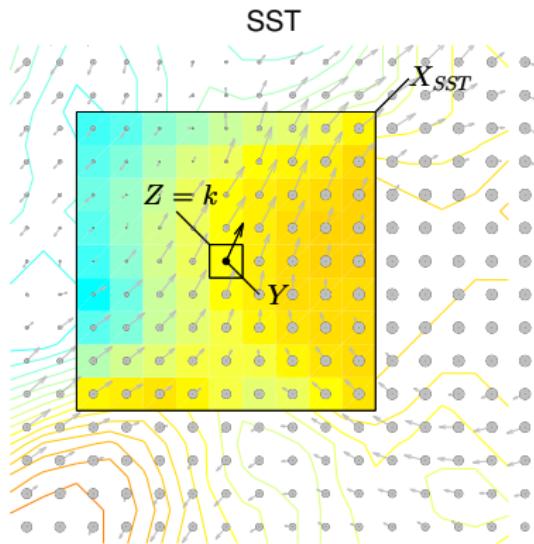
$$\text{SSH} = \mathbf{H}_k * \text{SST}$$

with  $\mathbf{H}_k$  a spatial convolution operator

- ⇒ Different  $\mathbf{H}_1, \dots, \mathbf{H}_K$ ?
- ⇒ How to estimate them?

# Methodology

## Statistical variables



- $\mathbf{X} \rightarrow$  SST and Chl-a patches ( $9 \times 9$  pixels)
- $\mathbf{Y} \rightarrow$  SSH, U and V (center of the patch)
- $\mathbf{Z} \rightarrow$  Hidden dynamical mode (center of the patch)
- Learning dataset  $\rightarrow$  random spatio-temporal sampling

# Methodology

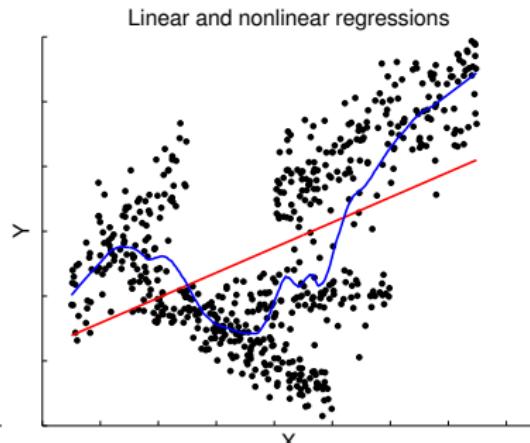
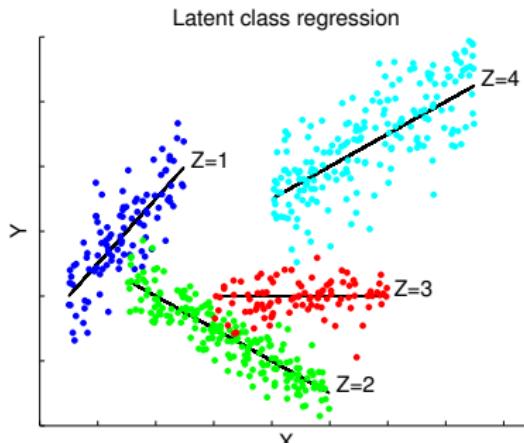
## Statistical model

Latent class regression (DeSarbo and Cron 1988):

$$p(\mathbf{Y}|\mathbf{X}, Z = k) \propto \mathcal{N}(\mathbf{Y}; \mathbf{X}\mathbf{H}_k, \boldsymbol{\Sigma}_k)$$

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

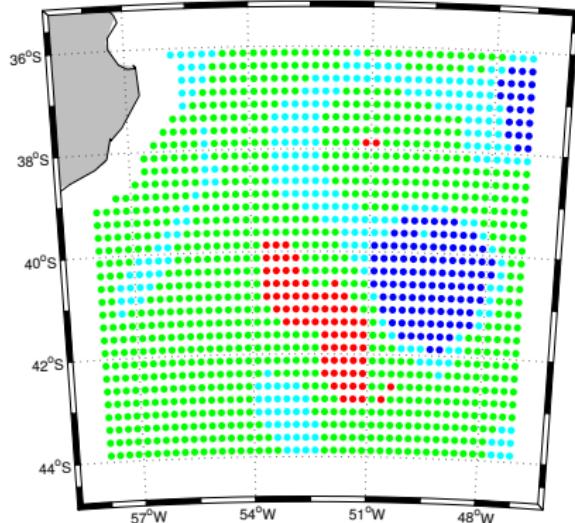
- evaluated in  $\mathbf{Y}$
- mean  $\mathbf{X}\mathbf{H}_k$  and covariance  $\boldsymbol{\Sigma}_k$



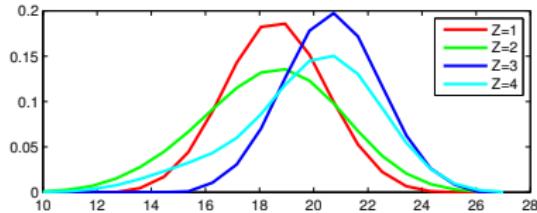
# Results

## Dynamical modes

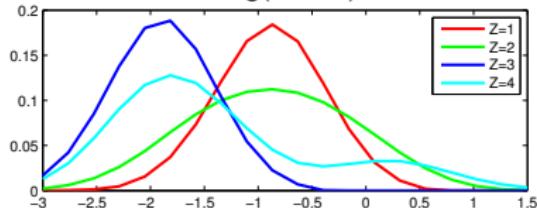
Estimated dynamical mode (Z)



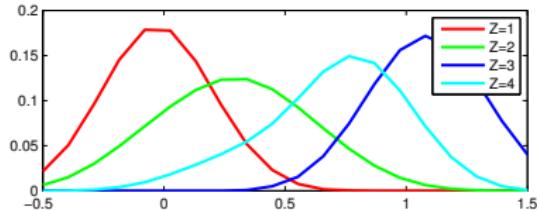
SST



Log(Chl-a)



SSH



Four dynamical modes:

- $Z=1 \rightarrow$  cyclonic eddy
- $Z=3 \rightarrow$  anticyclonic eddy
- $Z=2$  and  $Z=4 \rightarrow$  weaker modes

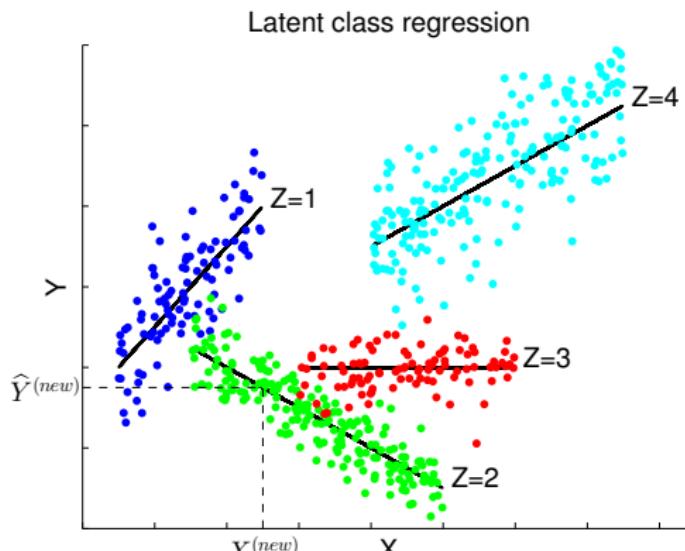
# Results

## Current estimation

### Fuzzy regression:

$$\hat{\mathbf{Y}}^{(new)} = \sum_{k=1}^K \hat{\pi}_k \mathbf{X}^{(new)} \hat{\mathbf{H}}_k$$

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



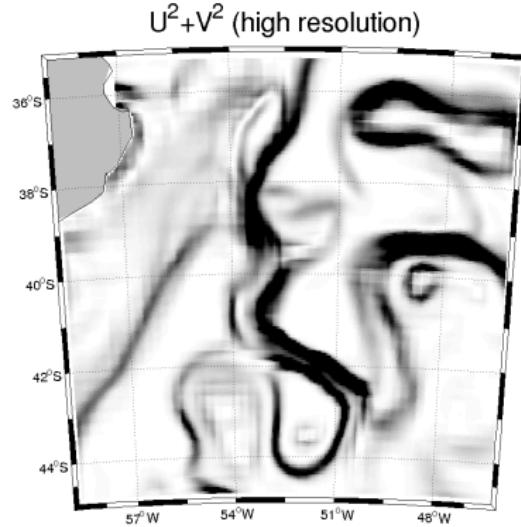
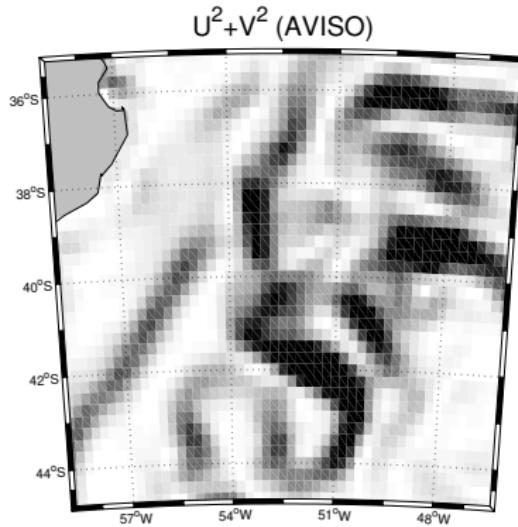
# Results

## Current estimation

Fuzzy regression:

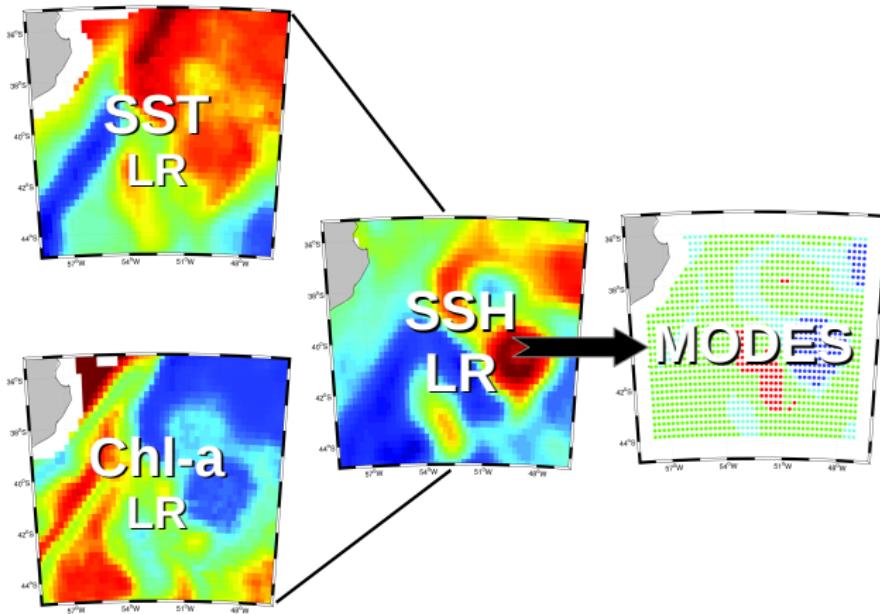
$$\hat{\mathbf{Y}}^{(HR)} = \sum_{k=1}^K \hat{\pi}_k \mathbf{X}^{(HR)} \hat{\mathbf{H}}_k$$

with  $\mathbf{X}^{(HR)}$   $\rightarrow$  high resolution SST and Chl-a ( $0.05^\circ$ )



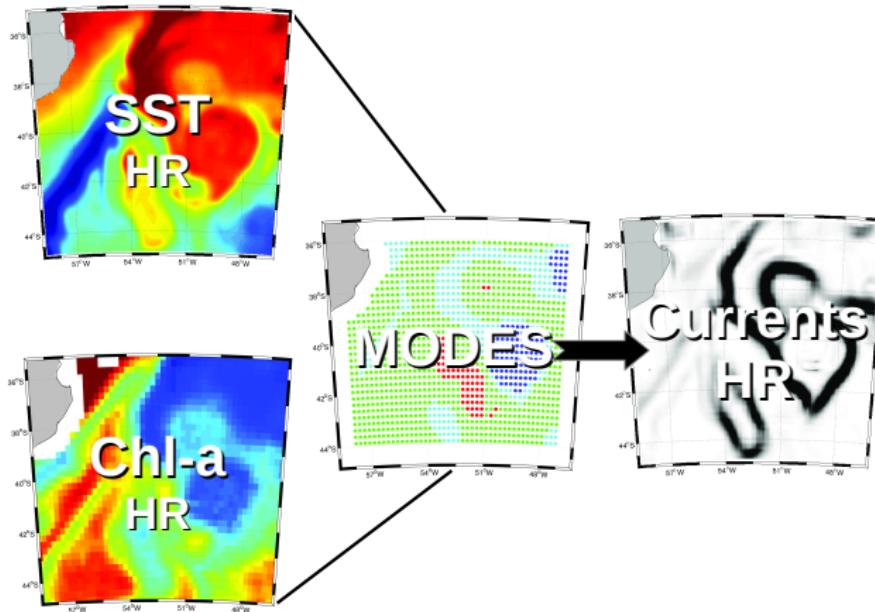
# Conclusions

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



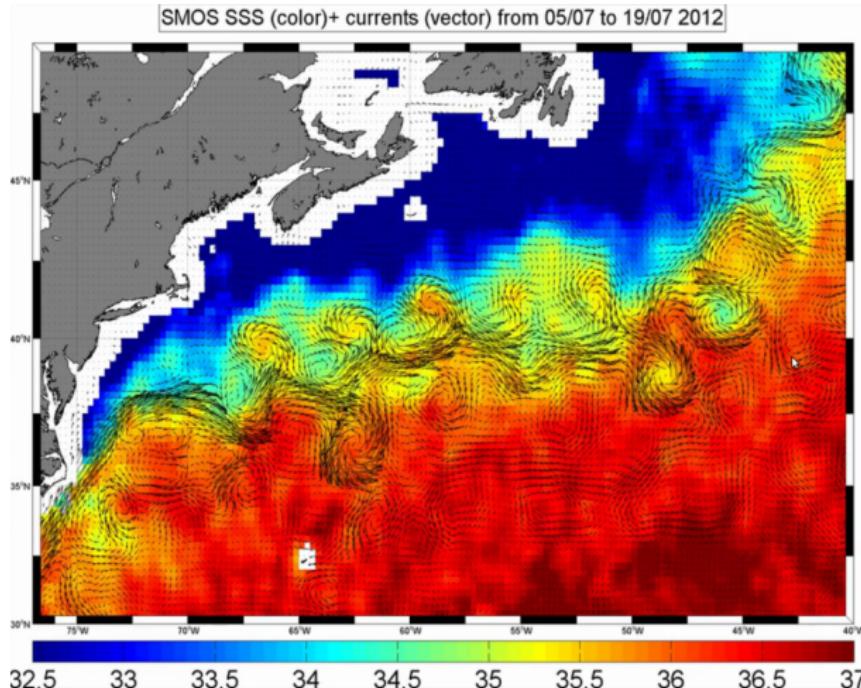
# Conclusions

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



# Perspectives

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



## References

- DeSarbo and Cron 1988. A maximum likelihood methodology for clusterwise linear regression. *Journal of Classification*, **5**, 249-282
- Isern-Fontanet et al. 2006. Potential use of microwave sea surface temperatures for the estimation of ocean currents. *Geophysical Research Letters*, **33**, L24608
- Saraceno and Provost 2012. On eddy polarity distribution in the Southwestern Atlantic. *Deep Sea Research I*, **69**, 62-69
- Tandeo et al. 2014. Segmentation of mesoscale ocean surface dynamics using satellite SST and SSH observations. *Geoscience and Remote Sensing, IEEE Transactions on*, **52**, 4227-4235