SMOS sea surface salinity in the North Atlantic Ocean: signal of Douro and Gironde river plumes.

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In this poster:

- Use of DINEOF (Data Interpolating Empirical Orthogonal Functions) to reconstruct missing data in SMOS SSS, detect outliers and reduce noise. Validation with TSG data

- Physical signals of Douro and Gironde rivers are detected in the SSS dataset

1. Introduction

SMOS salinity data have been measured since 2010 and provides an unprecedented source of information about the spatial and temporal variability of the oceans' surface salinity.

There are however several problems and shortcomings to be addressed, namely the presence of outliers, noise and missing data. In addition there exist biases and differences between the ascending and descending swaths.

This poster presents our work to reduce these problems, using DINEOF.

2. Materials and Methods

Data used

• Level 2 Ocean Salinity User Data Product (UDP) version 5.50, provided by ESA
• Roughness model #1
• Ascending/descending passes treated separately

Zone: North-East Atlantic Ocean and Mediterranean Sea
Period: January – December 2013

Preprocessing steps

- Quality flags:
• poor geophysical retrieval (Fg ctrl poor geophysical)
• flag for poor retrieval Fg ctrl poor retrieval
• flag for roughness model used (Dg quality SSS1)
- Range check (minimum/maximum salinity)
- Outlier detection (using DINEOF, see below)

Outlier detection

A first DINEOF analysis is performed on the initial data
Three tests are applied to classify pixels as suspect:
- Departure from the DINEOF truncated EOF basis
- Departure from a local median
- Proximity to clouds and land

A weighted sum of these 3 tests allows to determine which pixels will be finally classified as outliers

For this particular configuration:
- Weights: EOF test (1/3), local median (1/3), proximity to missing data/land (1/3)
- Threshold level to classify a pixel as outlier: 1

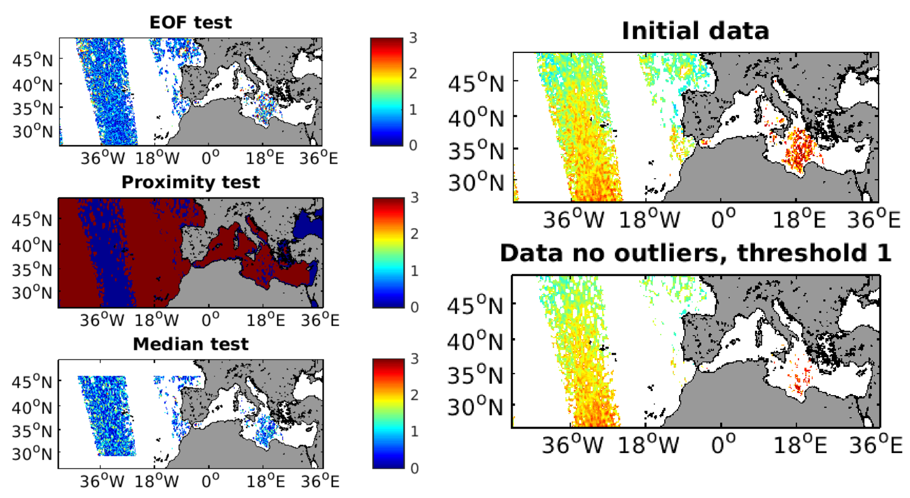

Figure 1: Outliers test example for 7 February 2013

3. DINEOF: Data Interpolating EOFs

• Technique to **fill in missing data** in geophysical data sets
• **Truncated EOF** basis to calculate missing data (iterative method)
• Optimal number of EOFs?: reconstruction error by **cross-validation**
• Uses EOF basis to infer missing data: **non-parametric** in its basic form
• No need of a priori information (correlation length, covariance function...)
• Spatio-temporal coherence exploited to calculate missing values
• EOFs extract main patterns of variability

Example of DINEOF reconstruction

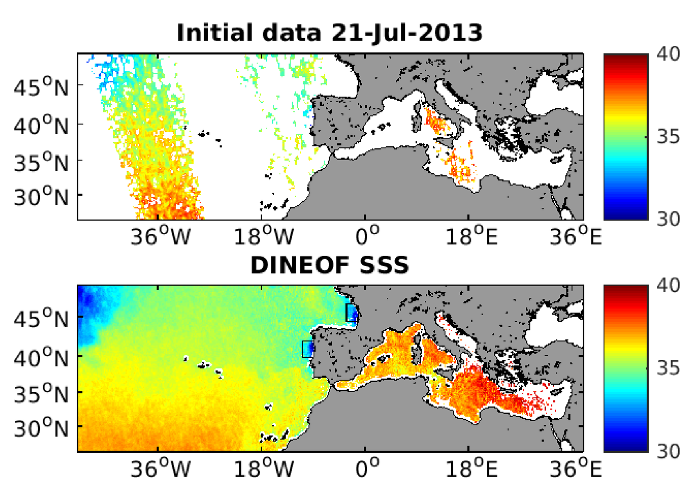

Figure 2: example of reconstruction of SSS using DINEOF

In figure 2 we can observe:

- the meandering Gulf Stream
- An east-west gradient in the Mediterranean Sea
- Fresh signals at the Douro and Gironde river plumes

Acknowledgements
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In situ salinity data were obtained from the Coriolis database (http://www.coriolis.eu.org) and World Ocean Database (http://www.nodc.noaa.gov/)

4. Validation with TSG data

The DINEOF reconstruction does not remove bias, therefore the bias between in situ data and the DINEOF SSS estimation can be high, especially near land masses.

All available TSG data are used for validation, results summarised in Table 1 (daily average values for TSG)

Table 1: validation results: centered RMS, bias, correlation and number of data

	CRMS	bias	r	#data
TSG Initial SMOS	0.55	-0.39	0.79	29
TSG DINEOF initial points	0.37	-0.38	0.87	29
TSG DINEOF	0.55	-0.57	0.86	184

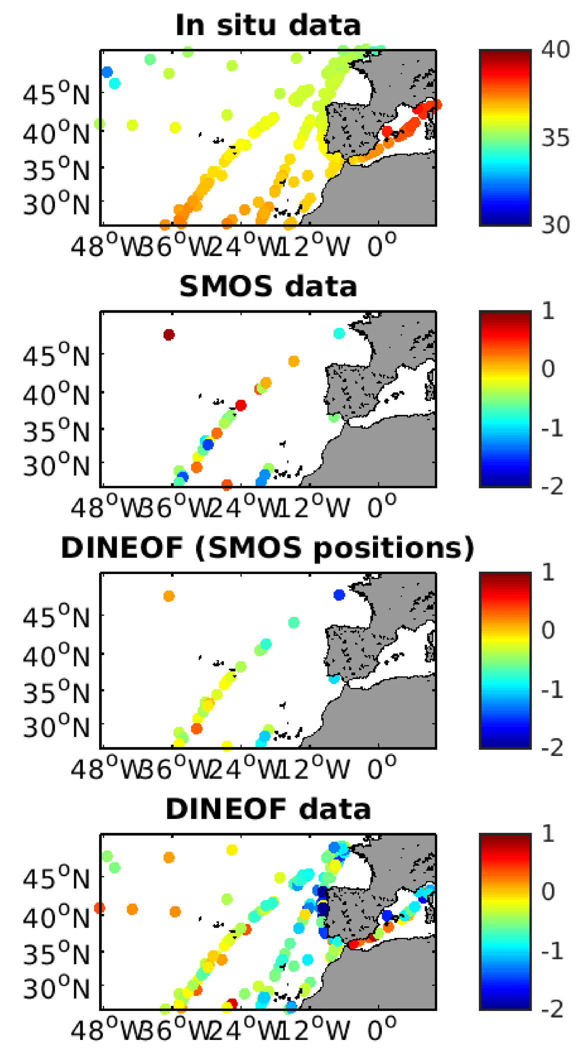

Figure 3: First panel: TSG data, averaged daily. Second panel: original SMOS SSS data anomalies with respect to the TSG data. Third panel: DINEOF reconstruction of SSS data (anomalies with respect to the TSG data) at the initially present SMOS positions. Fourth panel: DINEOF reconstruction of SSS data anomalies with respect to the TSG data at all positions.

Fresh biases can be seen along the French, Spanish and Portuguese coasts.

At the highest spatial and temporal resolution, the original and DINEOF SSS data (daily data at 0.15°×0.15°) are interpolated to the TSG positions (measured every ~5min).

In figure 3, two transects are shown:

Transect a (gets close to continent): centered RMS = **0.22**; bias = -0.35
Transect b (open ocean transect) : centered RMS = **0.2**; bias = -0.3

These results show the capability of DINEOF to retain the high resolution of the initial dataset.

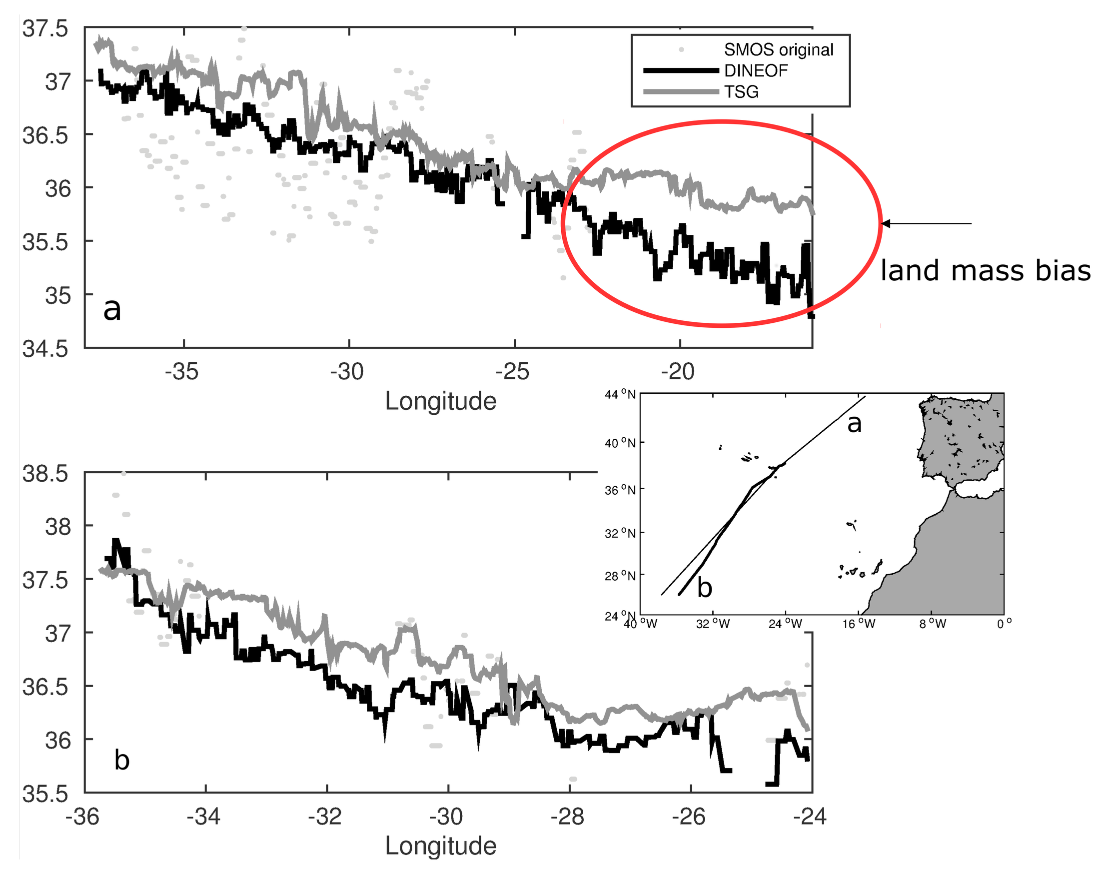

Figure 4: Two TSG transects at their original temporal resolution (~5 minutes) in the North Atlantic Ocean and their SMOS and DINEOF interpolated to the TSG positions.

5. Rivers in the DINEOF SSS dataset

• The signal of the Douro and Gironde rivers can be observed in the DINEOF SSS reconstruction results.
• It is difficult to assess quantitatively the accuracy of the SMOS data at these river plumes
• The qualitative description of these signals can be helpful to analyse the extent of the plumes and their seasonal variability.

Gironde river: Following Jalón-Rojas et al.(Hydrology and Earth System Sciences 19, 28052819, 2015), a flood event occurred in the Gironde estuary in June 2013, which explains the low salinity values observed in the DINEOF reconstruction (figure 3)

Douro river: visible in SSS and chlorophyll-a concentration data (figure 4). The zone of the lowest SSS near the mouth of the river is associated with a higher chlorophyll-a concentration, and that the plume has a spatial signature that reaches a longitude of ~11ºW.

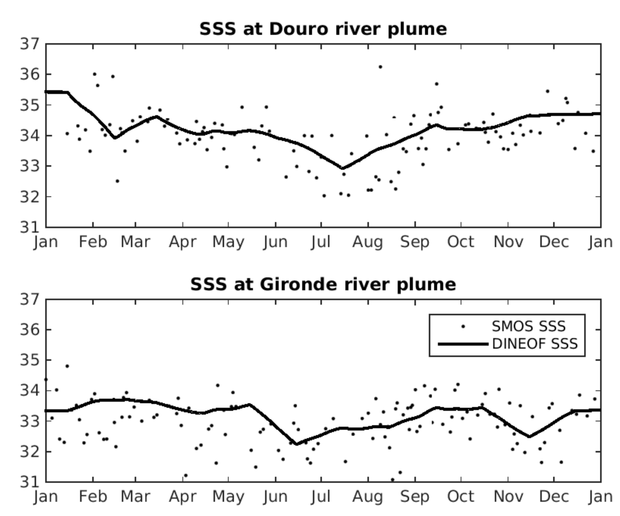

Figure 3: Time series of SSS at the Douro (top panel) and the Gironde (bottom panel) river plumes. The boxes delimiting these two zones are shown in figure 2.

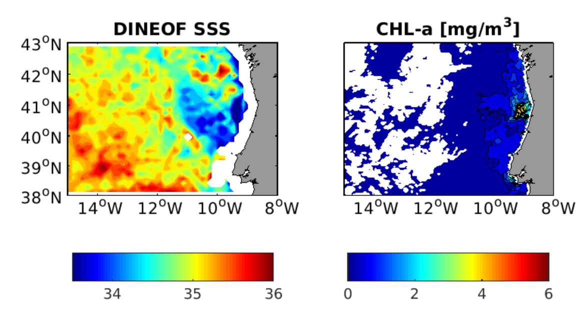

Figure 4: Example of the signal of the Douro river plume in SSS (left panel) and chlorophyll-a concentration (right panel) averaged over the period 26 February to 5 March 2013

6. Conclusions

A procedure to obtain SMOS SSS data at a daily time step and with a spatial resolution of 0.15° ×0.15° using DINEOF has been presented.

DINEOF allows to retrieve complete daily fields of SSS with reduced noise and error.

The centered RMS error between the DINEOF SSS (at the highest spatial and temporal resolution) and TSG data in open waters is 0.2.

For the whole domain of study (including the Mediterranean Sea) the centered RMS increases to 0.55.

Bias are not corrected by DINEOF

The presence of the river plumes in the SMOS data is evidenced by a localised salinity minimum that is superimposed to constant biases present along the coast and that are due to the presence of land masses.

Future work includes multivariate analyses of SSS with variables like temperature and precipitation

The assessment of the spatial and temporal variability of the river plumes observed in this work, and their correlation with river discharge and turbidity will be also the focus of future studies.

7. DINEOF references:

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DINEOF and SMOS:
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More information: **http://www.gher.ulg.ac.be/WP/**
http://modb.oce.ulg.ac.be/DINEOF