

Uses of DINEOF algorithm for reconstruction and analysis of incomplete satellite databases over the North Sea and the Mediterranean, synthesis from the RECOLOUR project.

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Project RECOLOUR (REconstruction of COLOUR scenes) - SR/00/111

RESEARCH PROGRAMME FOR EARTH OBSERVATION "STEREO II" - BELGIAN SCIENCE POLICY

OUTLINE

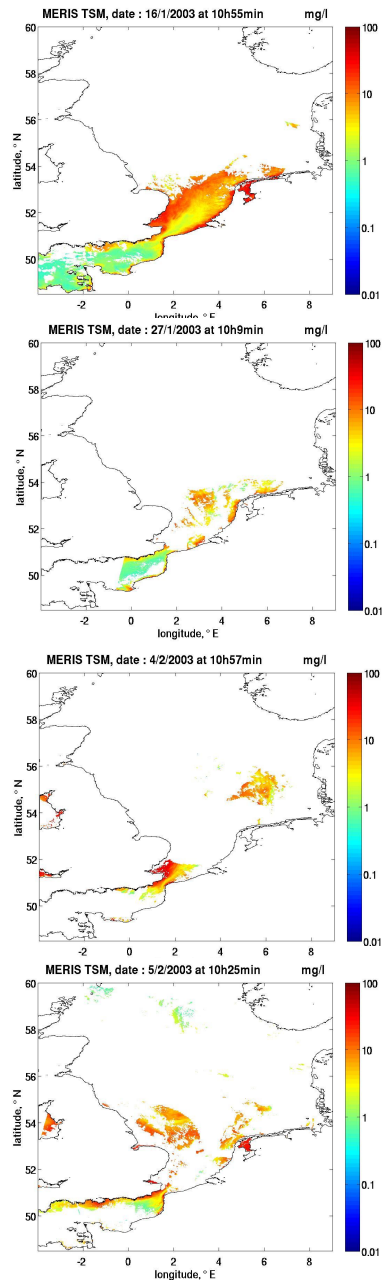
1. ***DINEOF tool: motivation and principle***
2. ***The Southern North Sea and English Channel***
 - ***Bathymetry and dataset used***
 - ***Reconstruction quality check***
 - ***Outliers detection***
 - ***TSM, CHL and SST monthly climatologies and weekly averages***
 - ***Multivariate analysis of satellite TSM and hydrodynamic fields***
3. ***Western Mediterranean SST***

seen by DINEOF / DIVA / GHER

 - ***SST outlier detection***
 - ***DINEOF vs GHER3D weekly mean fields for 1998***
4. ***CONCLUSIONS and PERSPECTIVES***

historical satellite data

1. DINEOF tool: principle



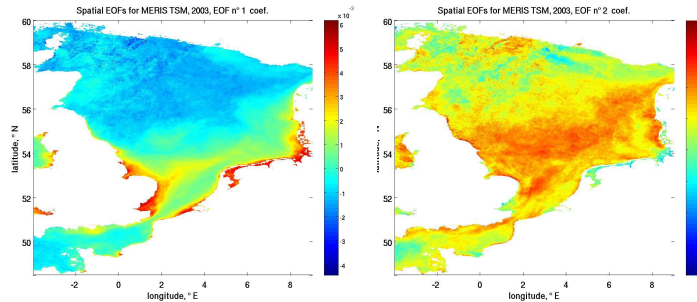
EOF decomposition

field reconstruction

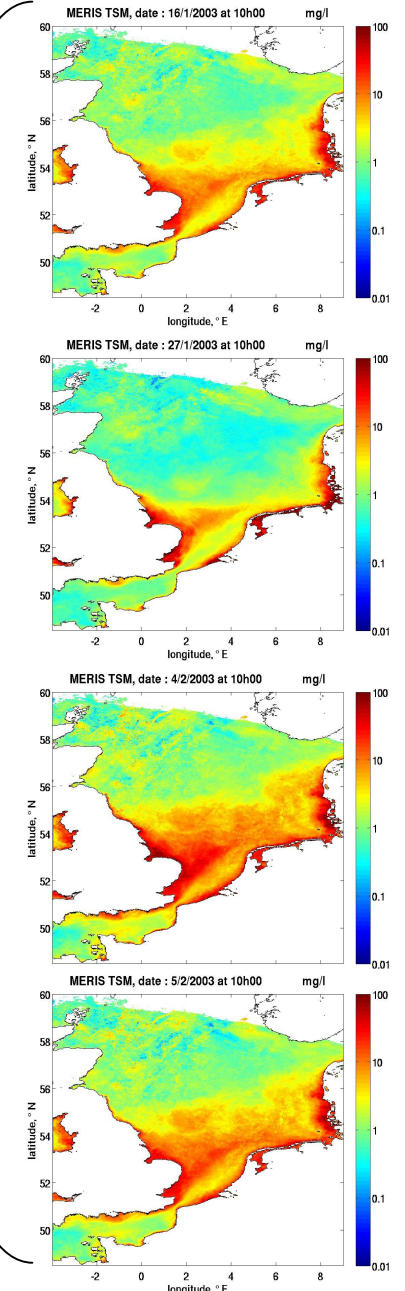
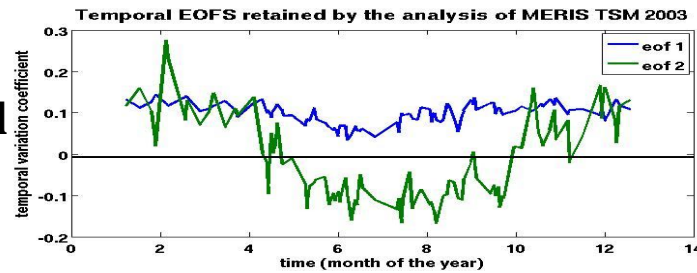


identify dominant spatio-temporal dynamics and correlations

Spatial Modes

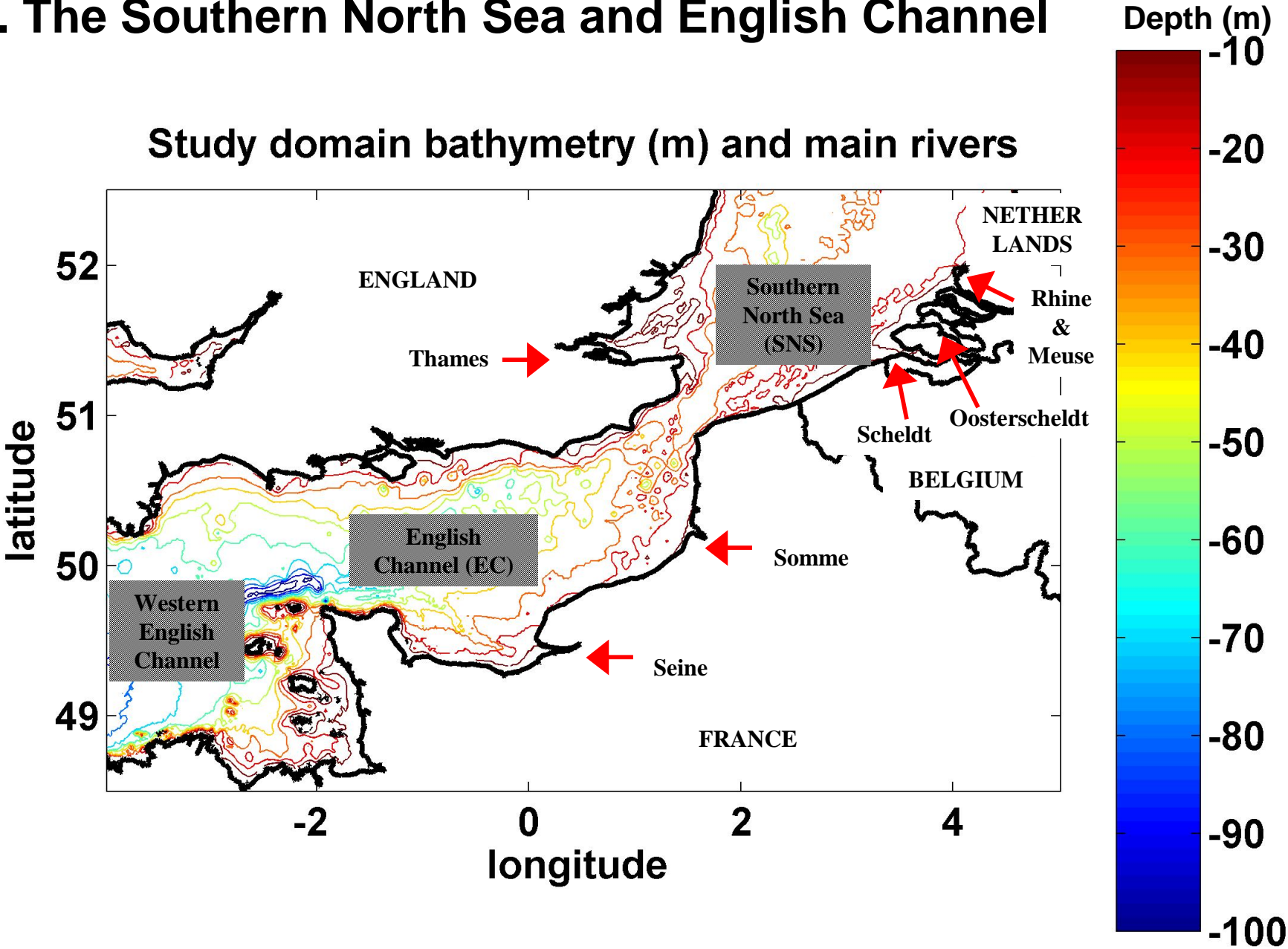


Temporal Modes

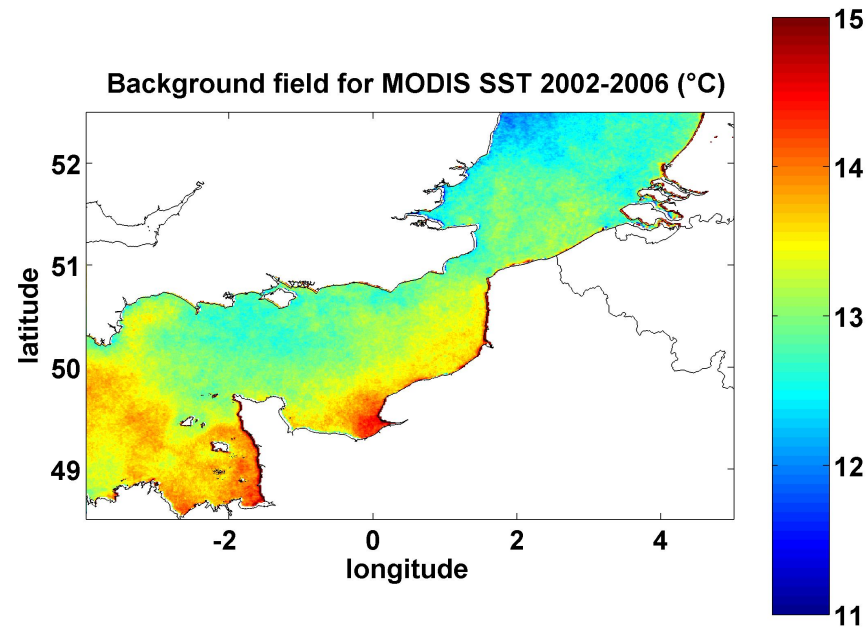
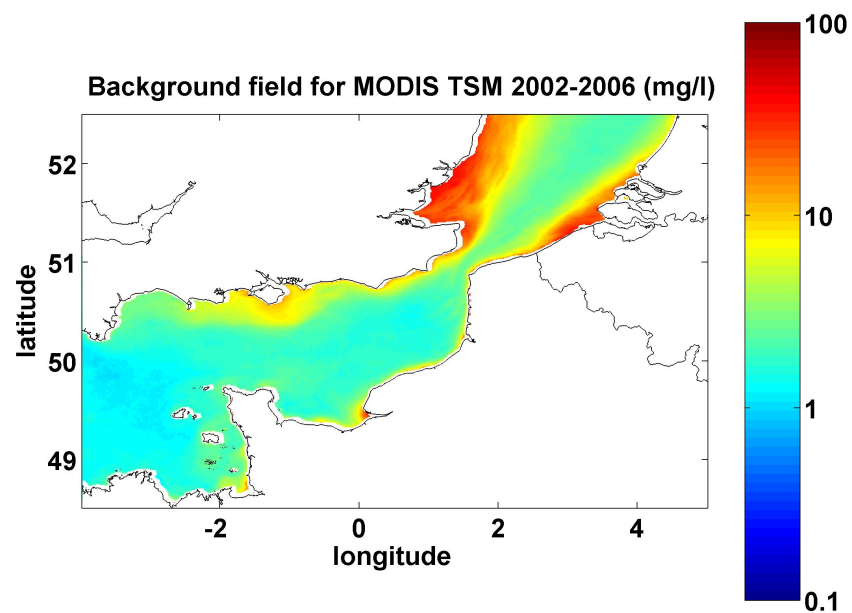
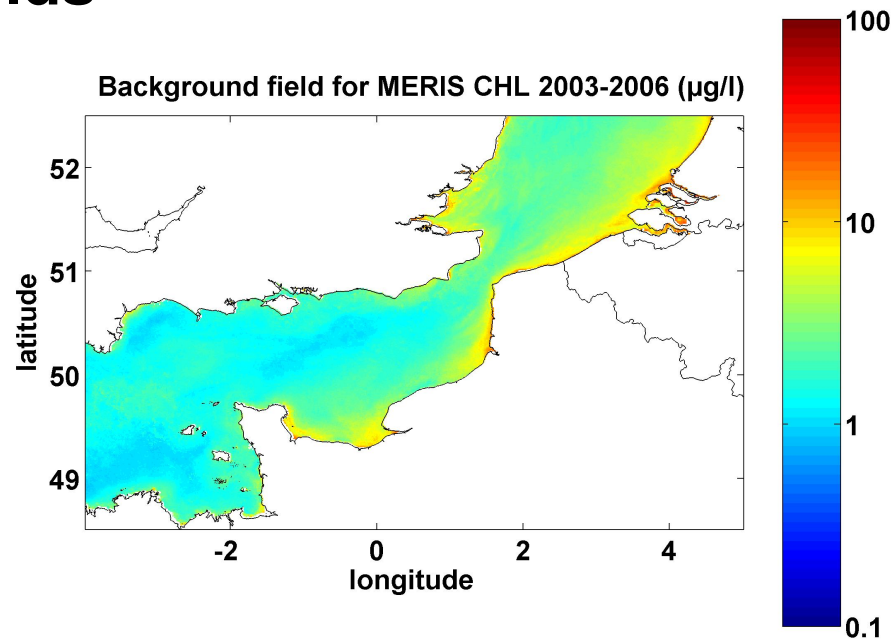
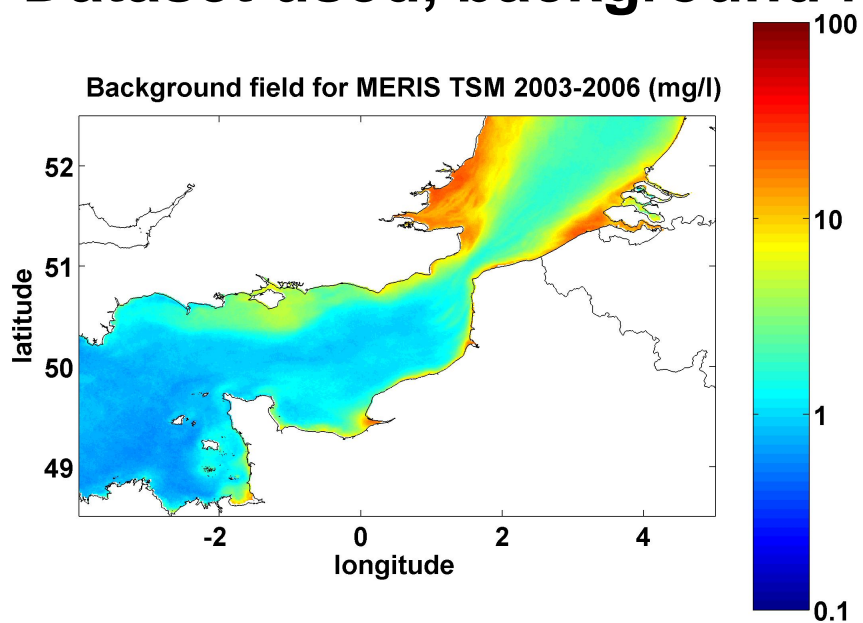


(illustrated for MERIS TSM 2003 data on the North Sea)

2. The Southern North Sea and English Channel

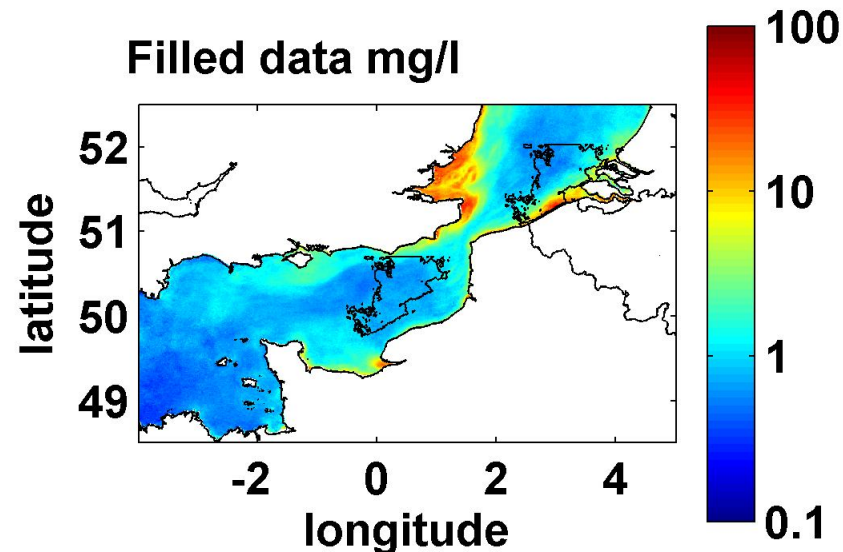
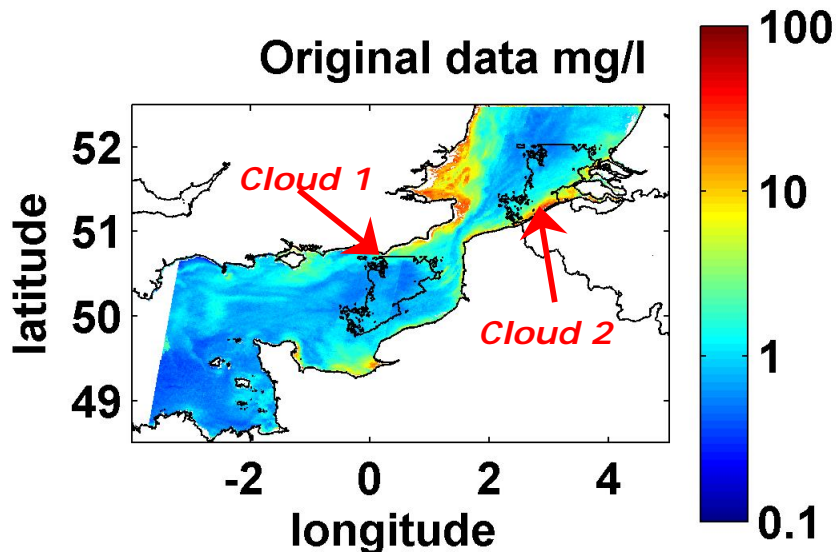


Dataset used, background fields

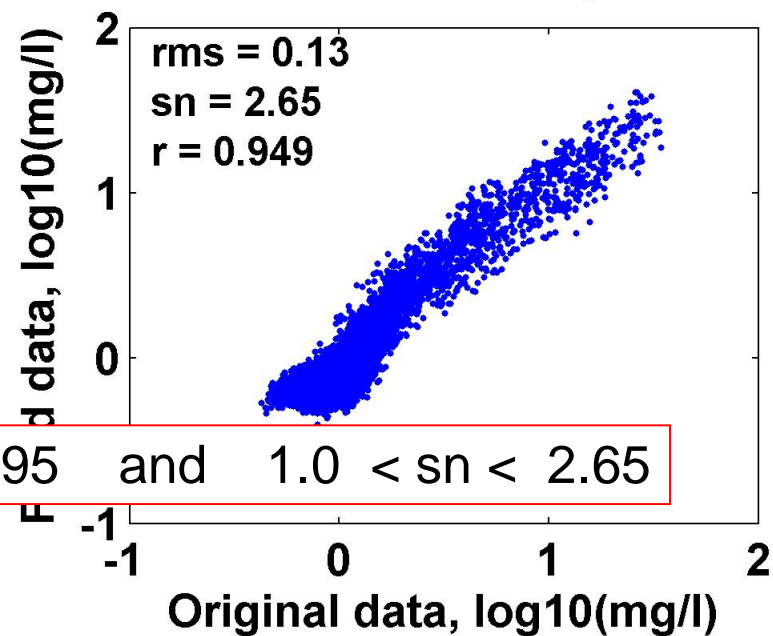
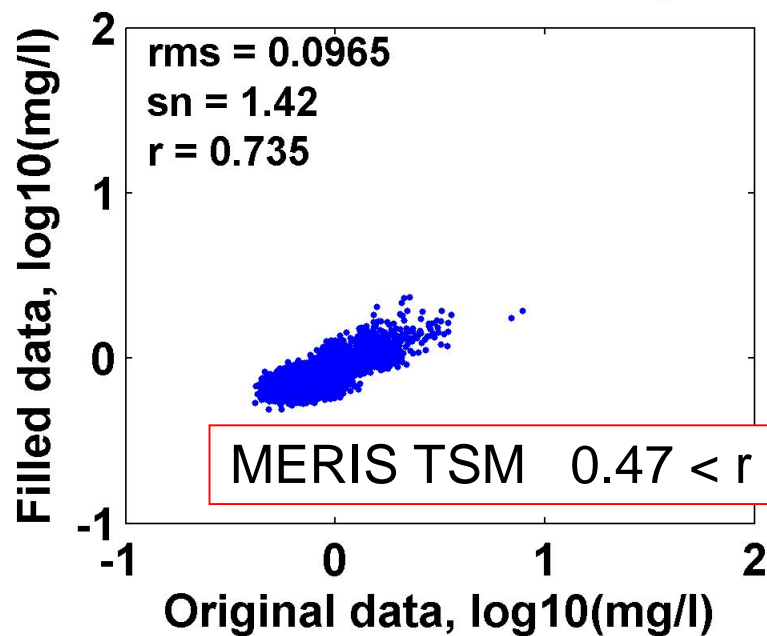


Reconstruction quality check

MERIS TSM 16/07/06



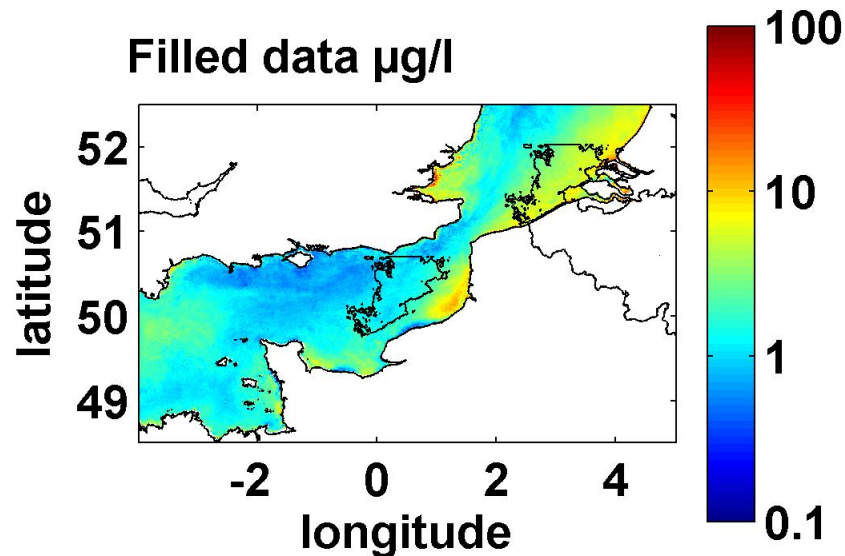
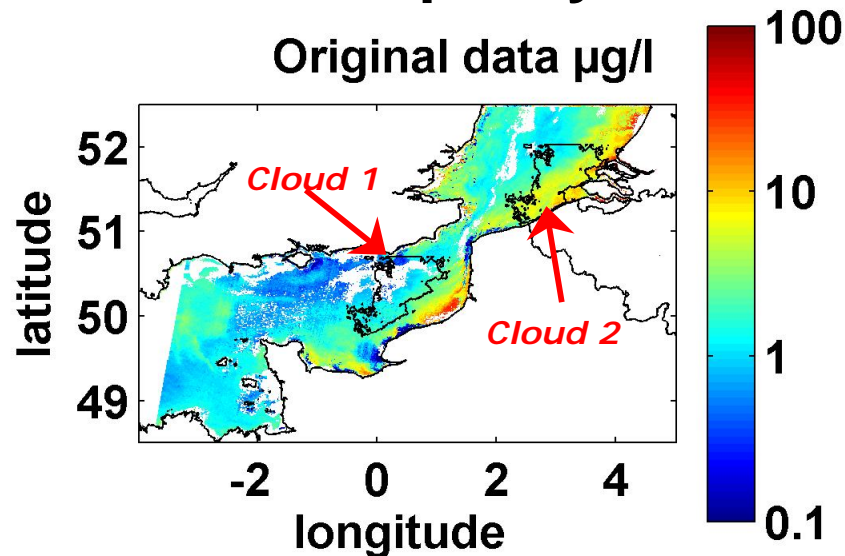
Reconstruction quality under cloud 1 (left) and cloud 2 (right)



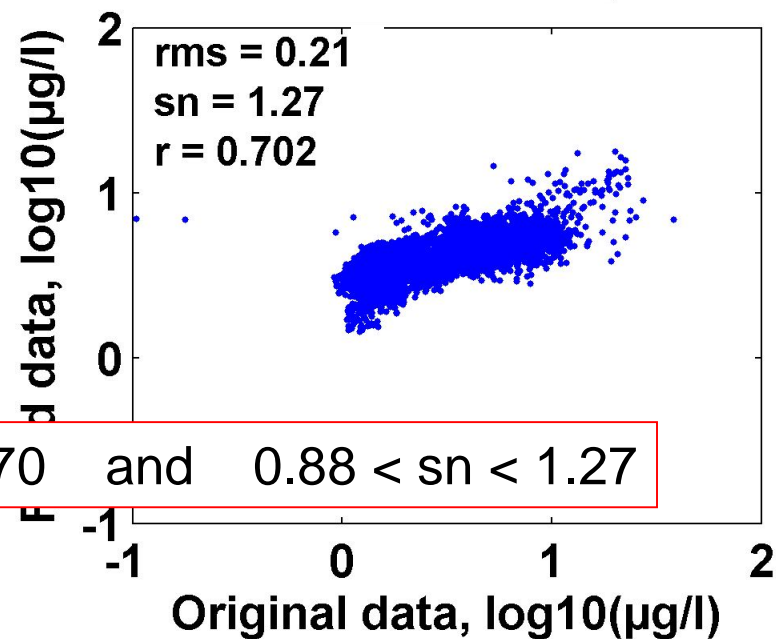
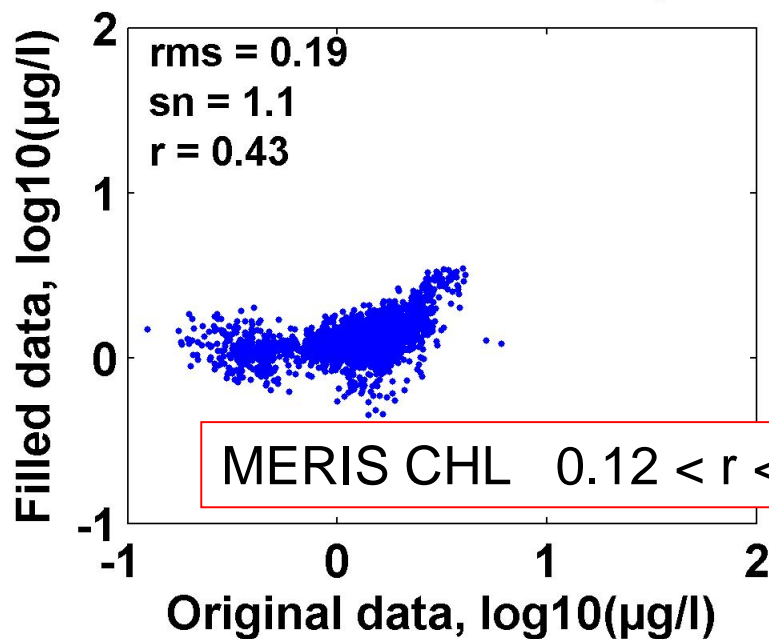
MERIS TSM $0.47 < r < 0.95$ and $1.0 < sn < 2.65$

Reconstruction quality check

MERIS CHL 16/07/06



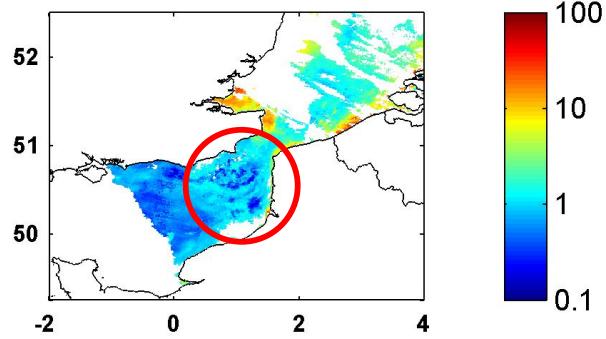
Reconstruction quality under cloud 1 (left) and cloud 2 (right)



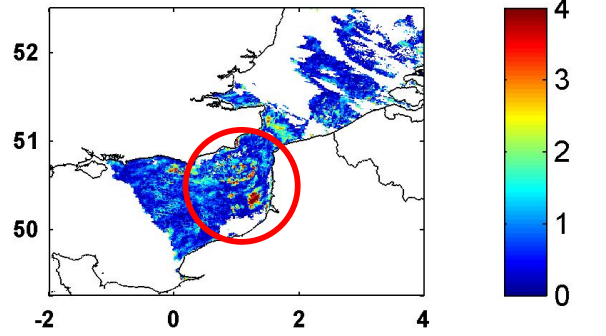
MERIS CHL $0.12 < r < 0.70$ and $0.88 < \text{sn} < 1.27$

Outliers detection

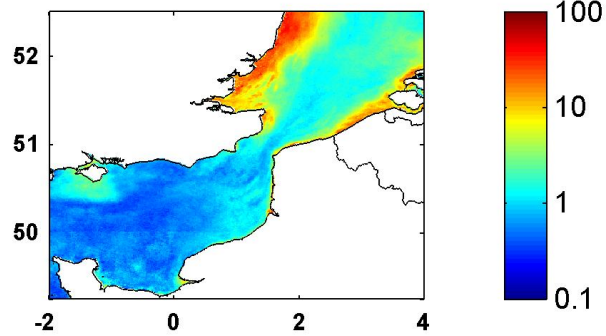
MERIS TSM 13/4/2003 original data mg/l



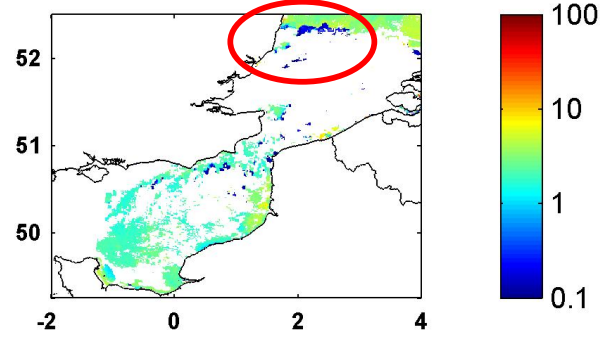
outliers field coef.



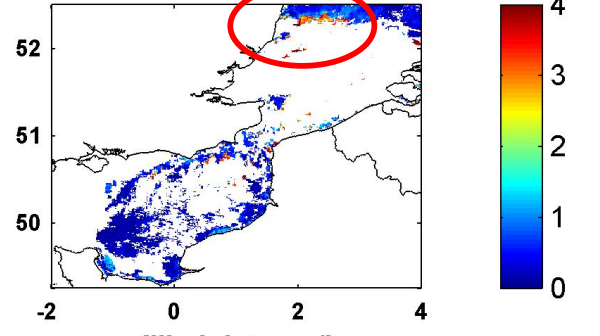
filled data mg/l



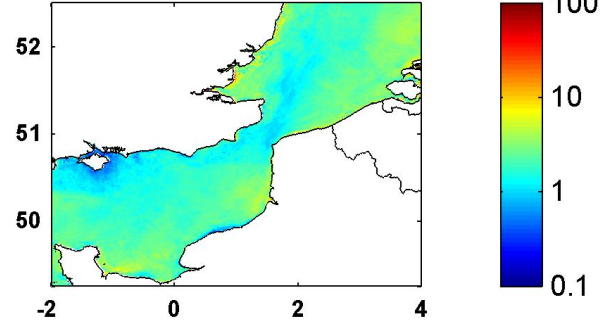
MERIS CHL 18/10/2003 original data $\mu\text{g/l}$



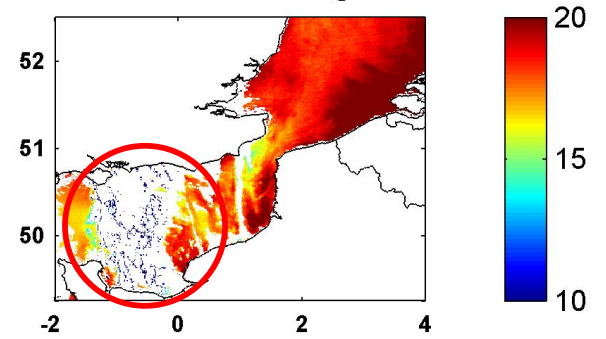
outliers field coef.



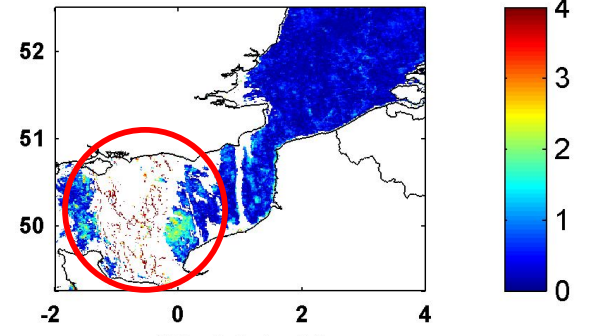
filled data $\mu\text{g/l}$



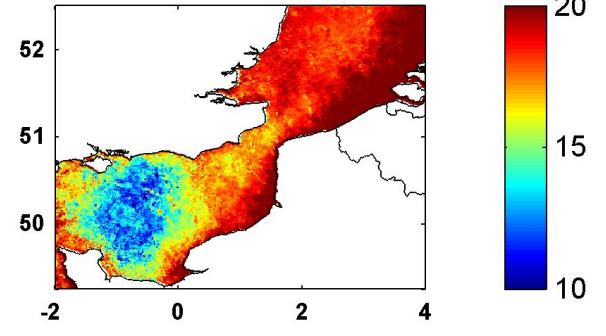
MODIS SST 17/8/2002 original data $^{\circ}\text{C}$



outliers field coef.

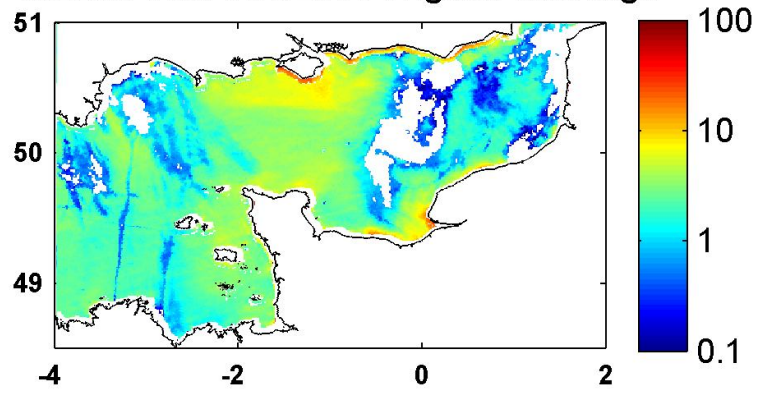


filled data $^{\circ}\text{C}$

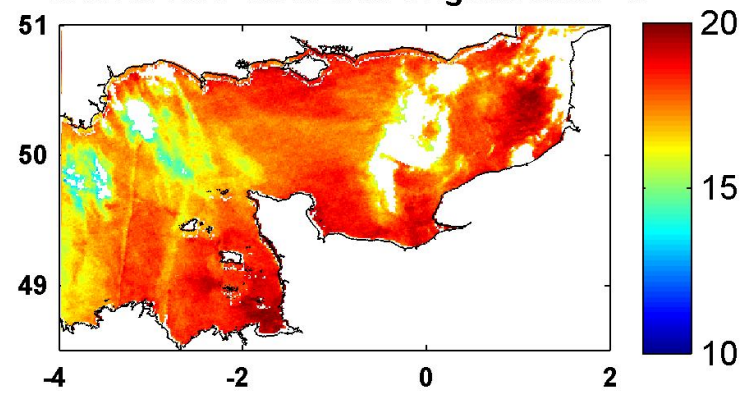


Outliers detection

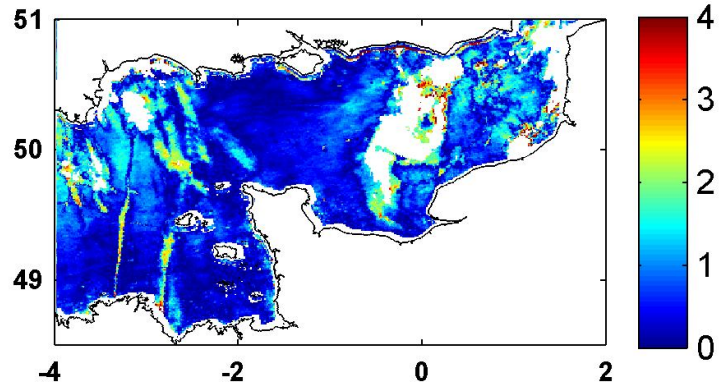
MODIS TSM 16/9/2003 original data mg/l



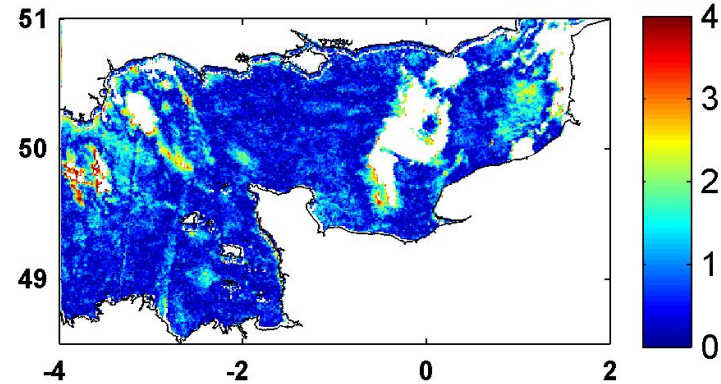
MODIS SST 16/9/2003 original data °C



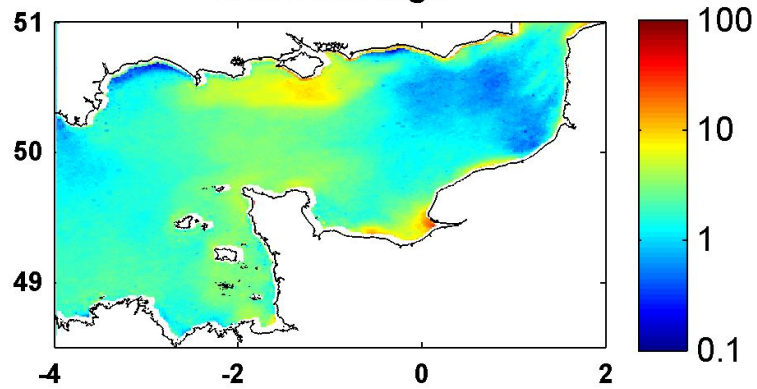
outliers field coef.



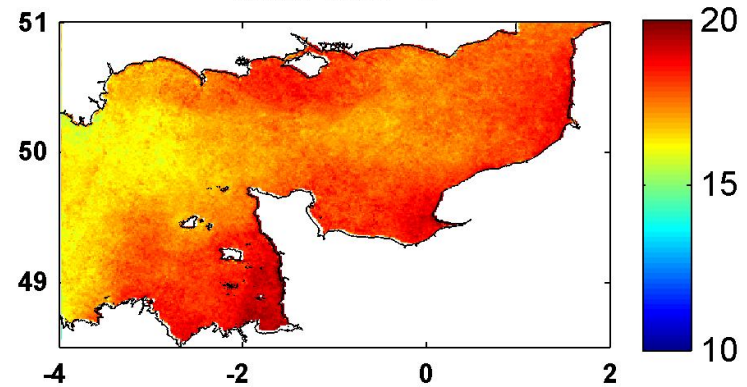
outliers field coef.



filled data mg/l

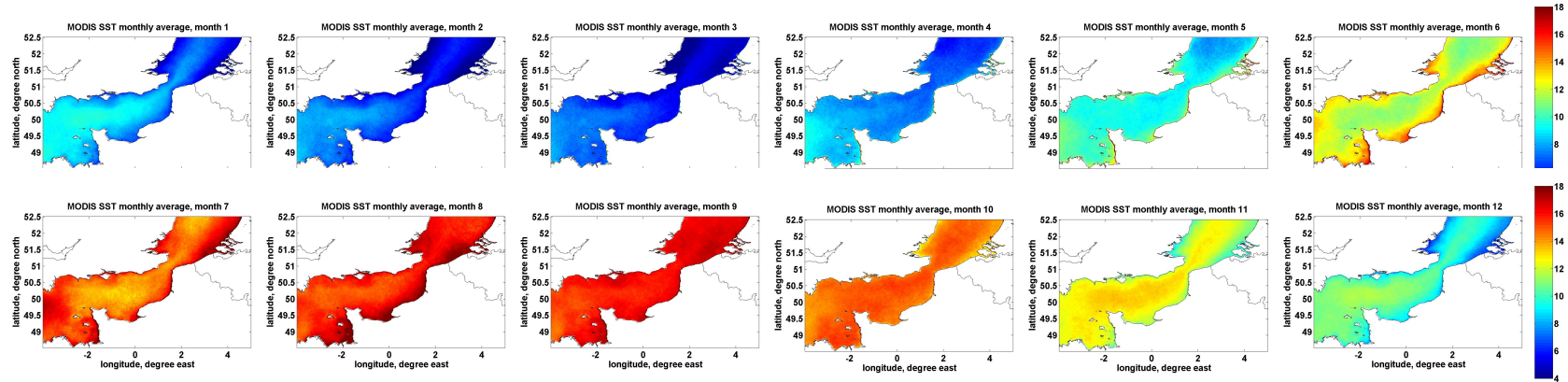


filled data °C

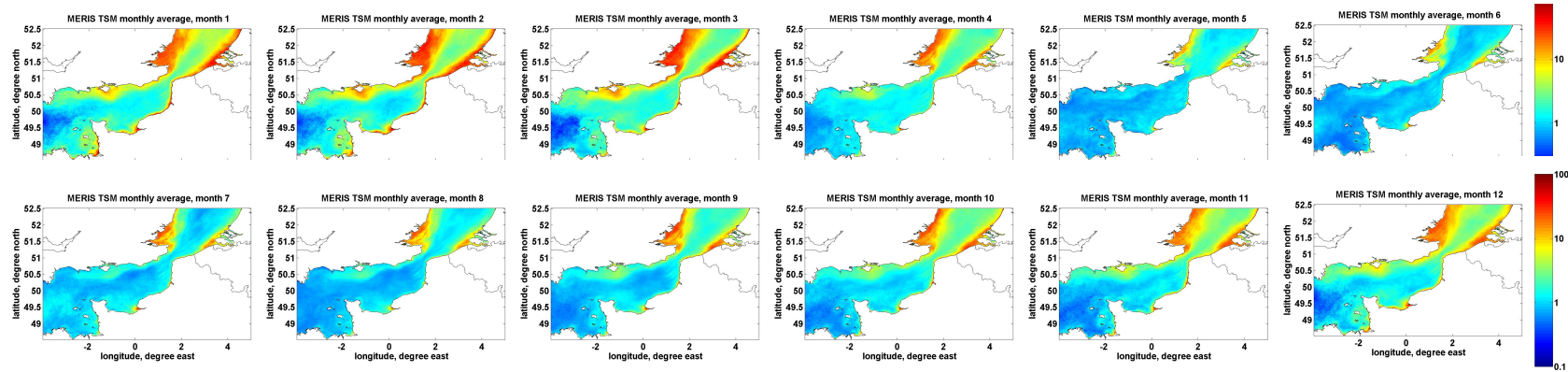


Monthly climatologies of SST, TSM and CHL

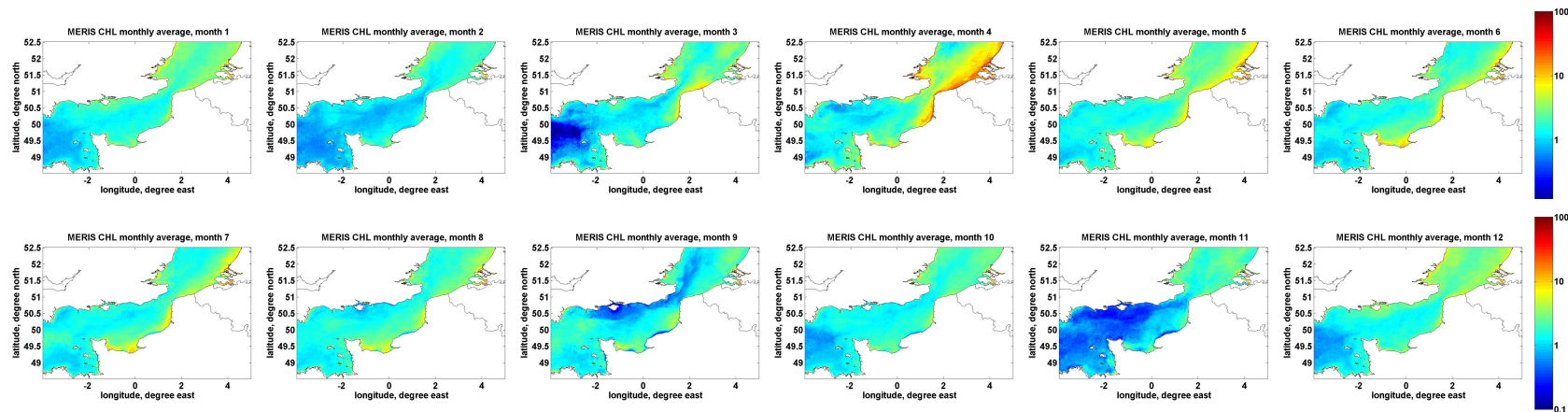
MODIS SST



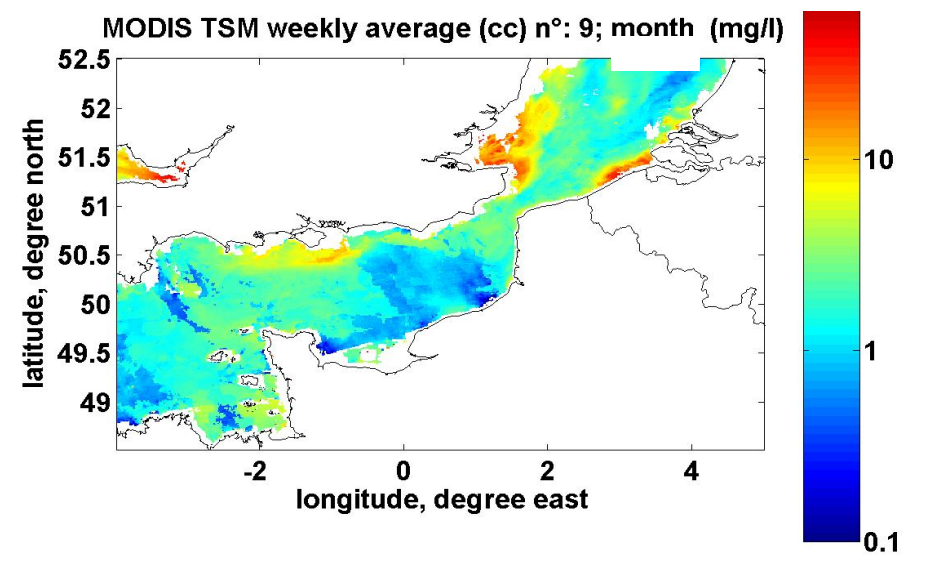
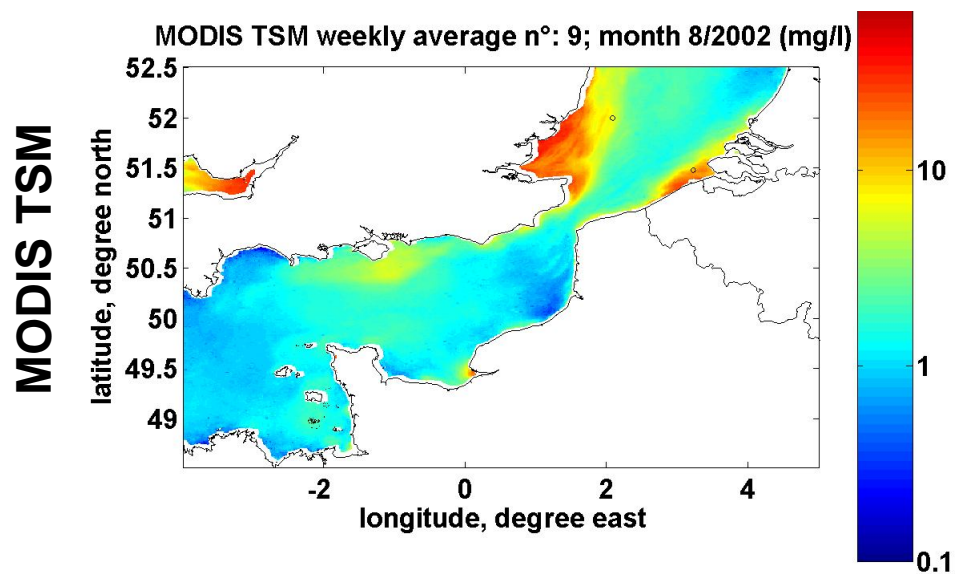
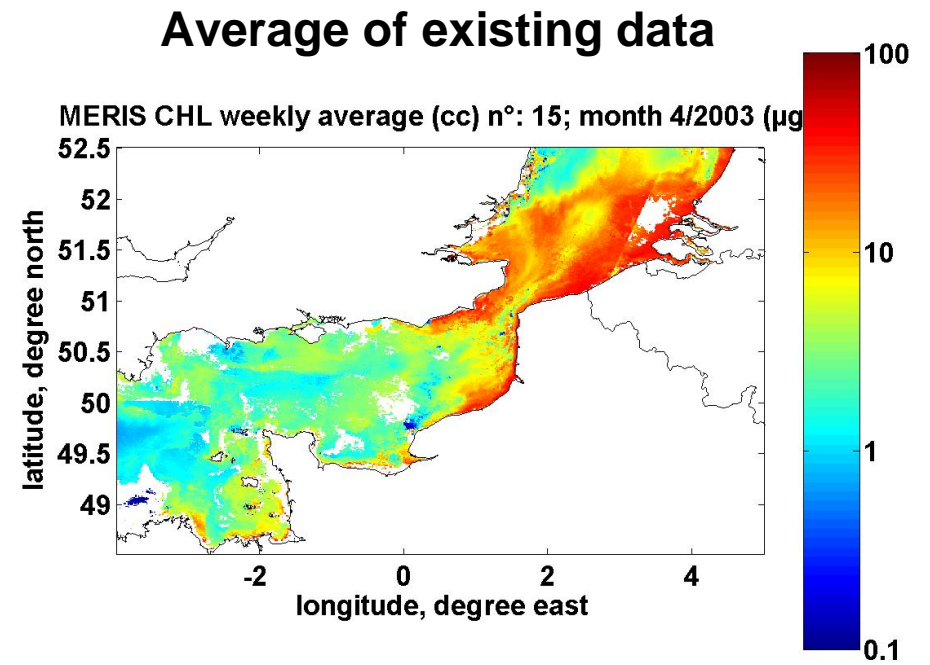
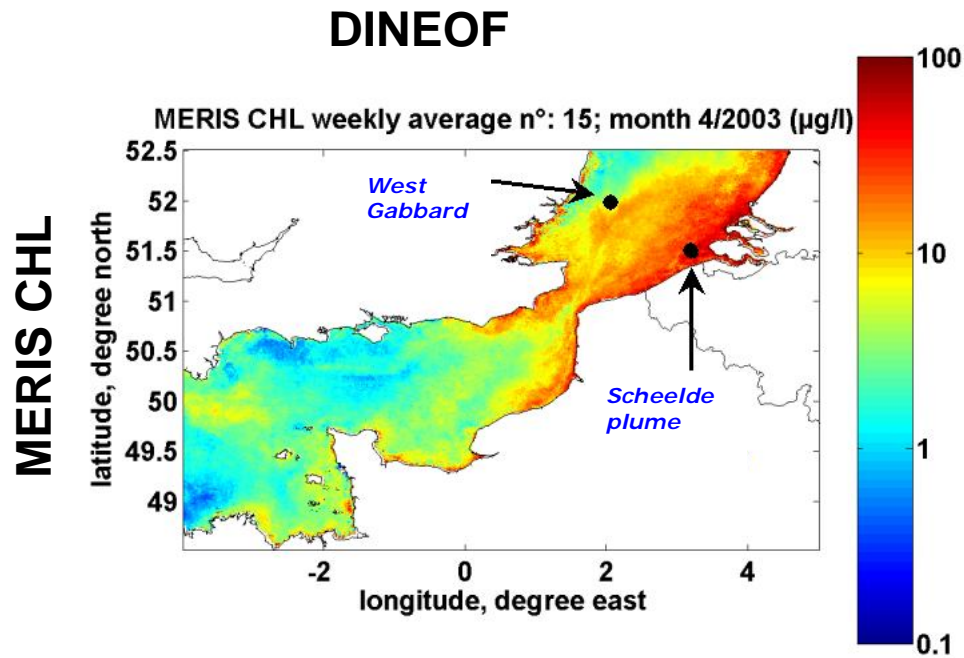
MODIS TSM



MERIS CHL



Weekly averaged fields



Multivariate Analysis of Satellite TSM and Hydrodynamic fields

DINEOF MULTIVARIATE EXPLOITATION

principle: augmented state vectors = hydrodynamic fields + satellite image.

Interests : -> Test for improvements of missing data reconstruction
-> Explore common traits of the dynamics of several parameters.

DATA

REMOTE SENSING DATA

MODIS TSM
year 2005
313 images

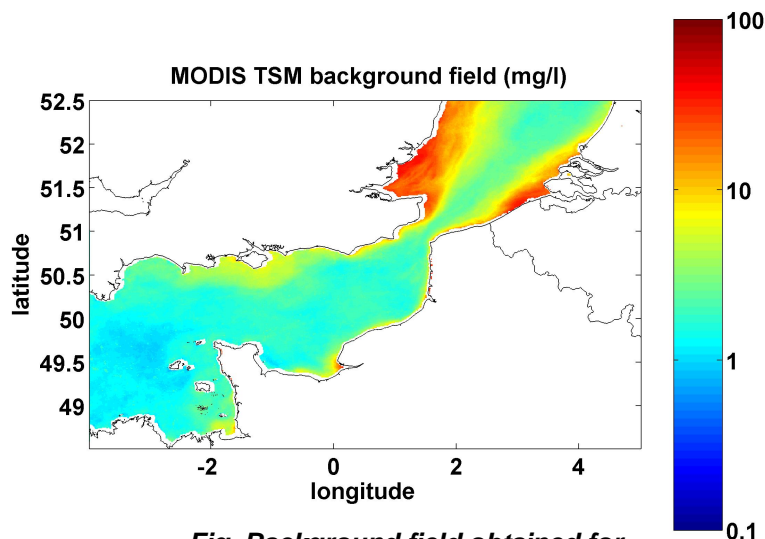


Fig Background field obtained for MODIS TSM data, year 2005.

+

C&SNS HYDRODYNAMIC MODEL DATA

A 3D hydrodynamical model implemented for the English Channel and the Southern North Sea (C&SNS) (Lacroix et al., 2004).

5 km spatial resolution; 15 minutes temporal resolution

Parameters :

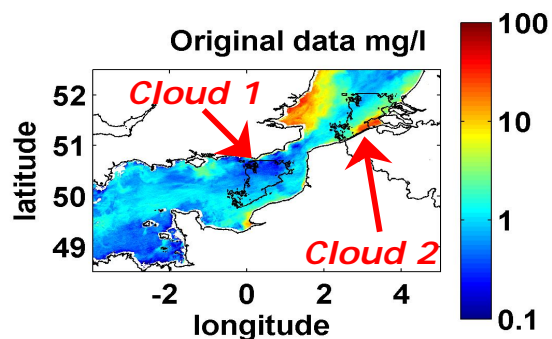
- 1) Wind-U [m/s];
- 2) Wind-V [m/s];
- 3) mean depth U-velocity [m/s];
- 4) mean depth V-velocity [m/s];
- 5) surface elevation [m];
- 6) Bottom stress maximum [m^2/s^2], between 8hpm previous day-9am satellite image day.

Multivariate Analysis of Satellite TSM and Hydrodynamic fields

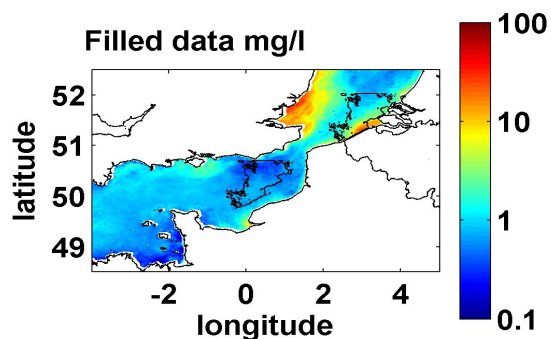
RESULTS

run	parameters	Neof	Sumvarex	Cor. length.
			%	km
a	monovariate	6	97,22	17,12
b	wind U V	14	97,93	15,09
c	as in runs b and g	17	98,87	17,66
d	current U V	12	99,12	15,62
f	Wind and Current UV	17	98,88	15,82
g	surface elevation	6	97,15	19,23
h	shear stress max	6	97,15	19,23
i	as in run g and h	6	97,08	21,67
j	current U V and g	12	99,11	17,19
k	current U V and h	12	99,11	17,19
l	all param.	17	98,87	17,66

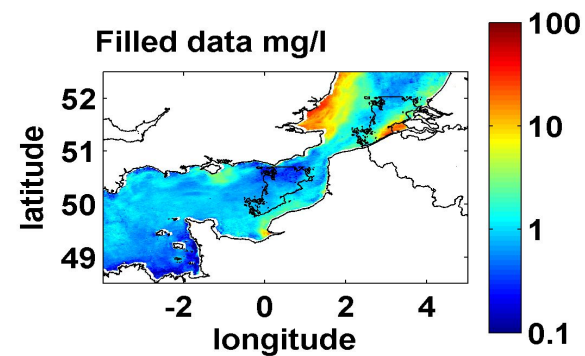
Original Data 29/08/05



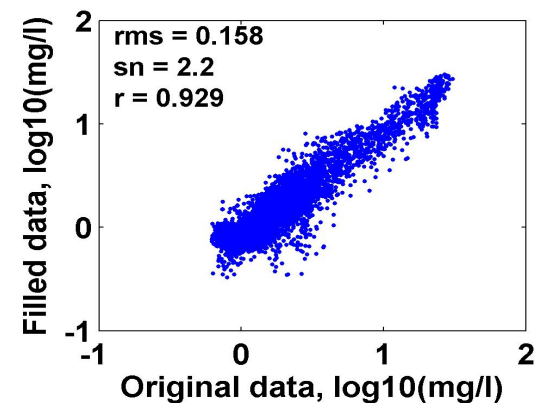
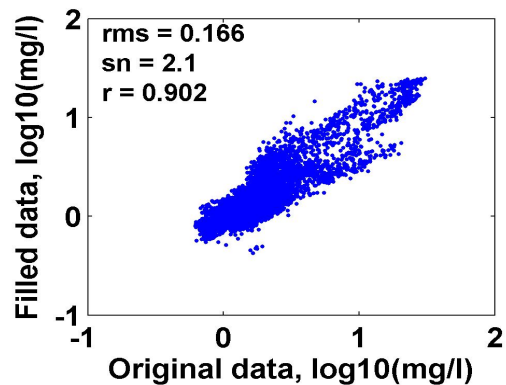
Univariate R.



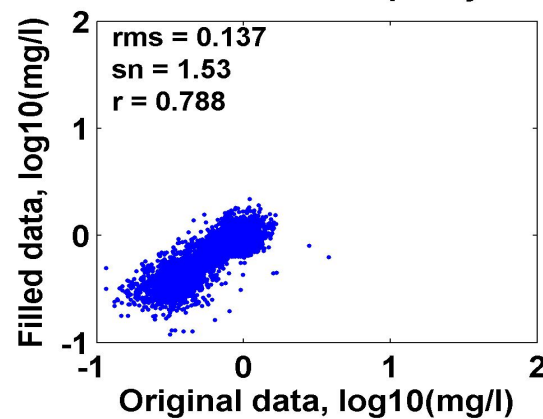
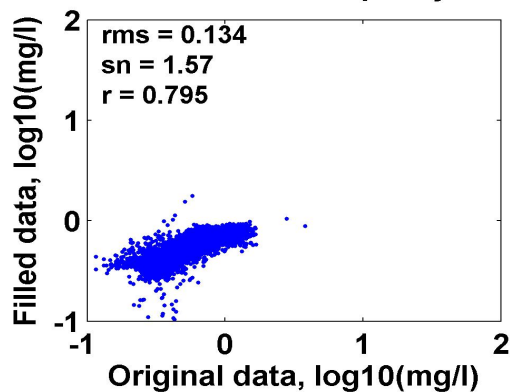
Multivariate R.



Cloud 2



Cloud 1

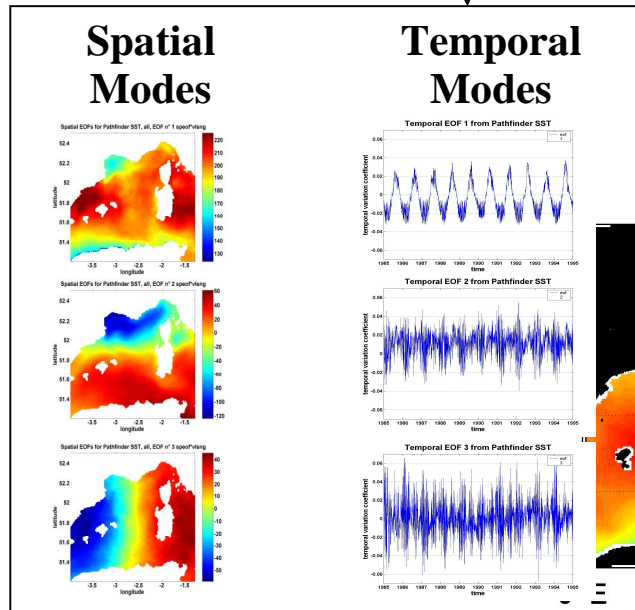


3. Western Mediterranean SST seen by DINEOF / DIVA / GHER

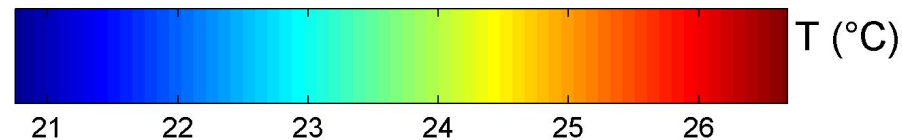
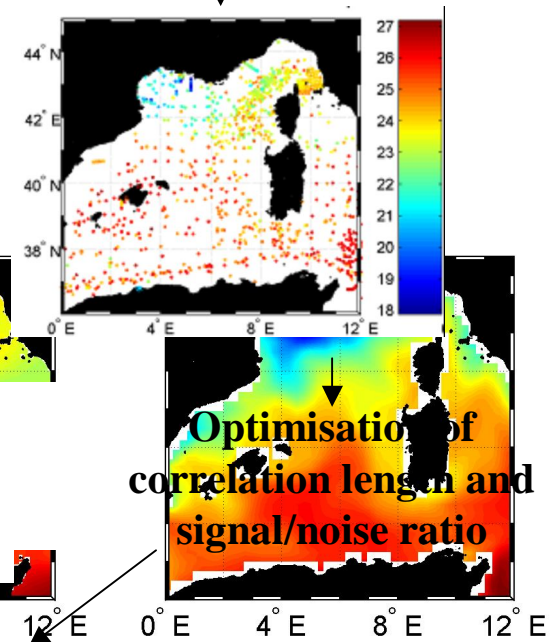
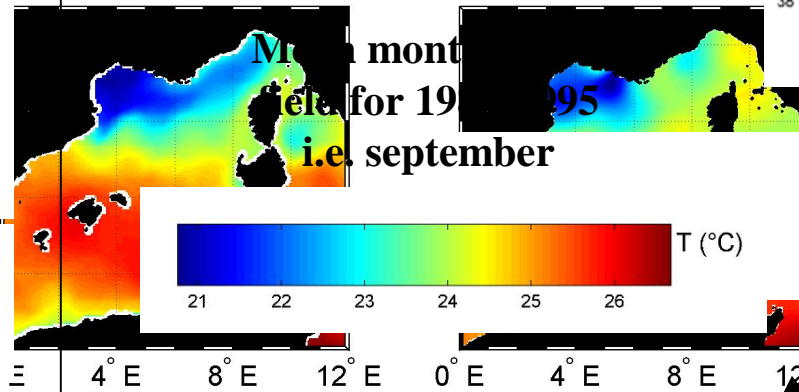
DINEOF: Data Interpolation by Empirical Orthogonal Functions
Satellite databases

DIVA: Data Interpolating Variational Analysis
in-situ scattered data

AVHRR Pathfinder SST ↓ EOF decomposition

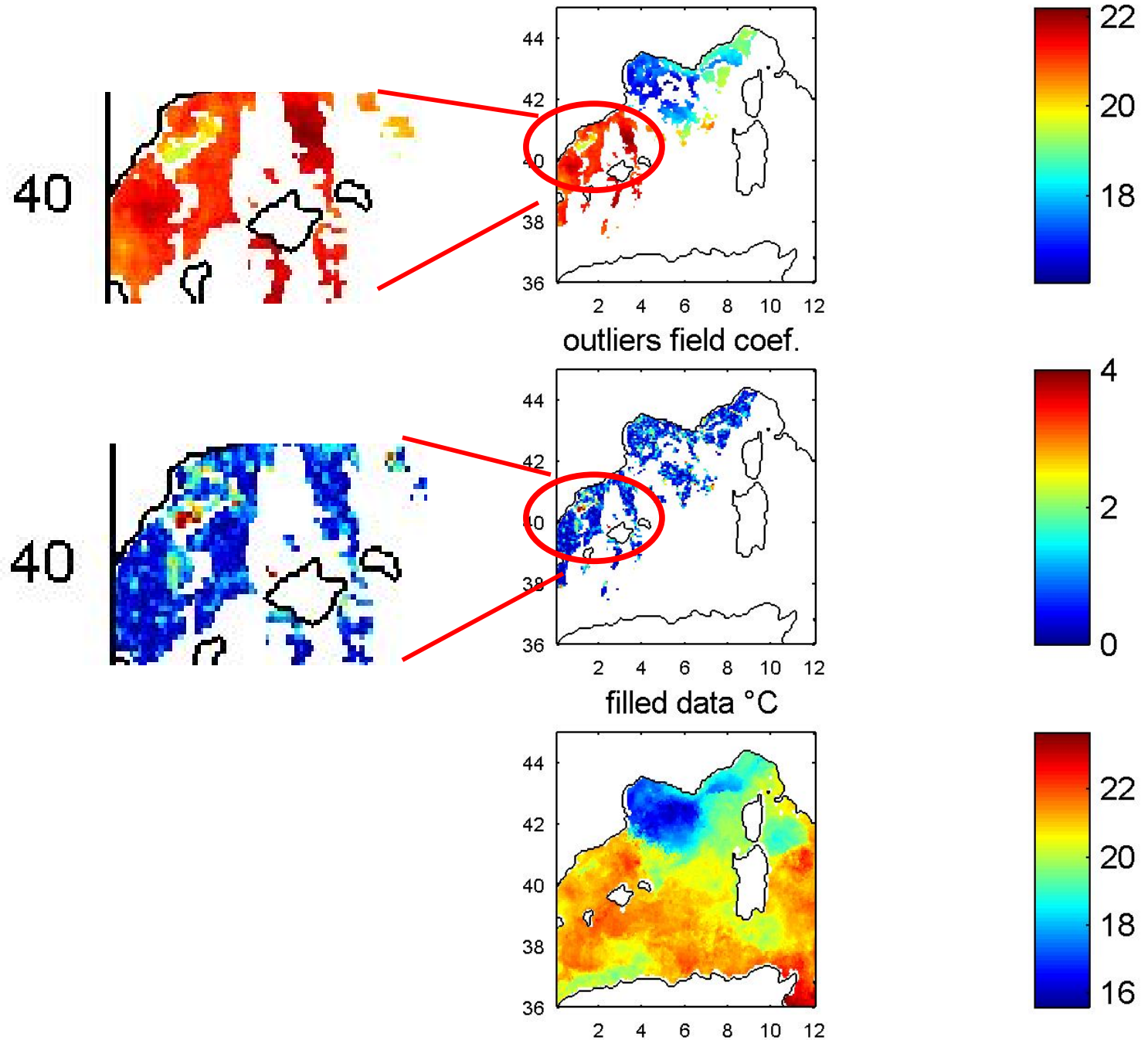


daily field reconstructions & multitemporal averages

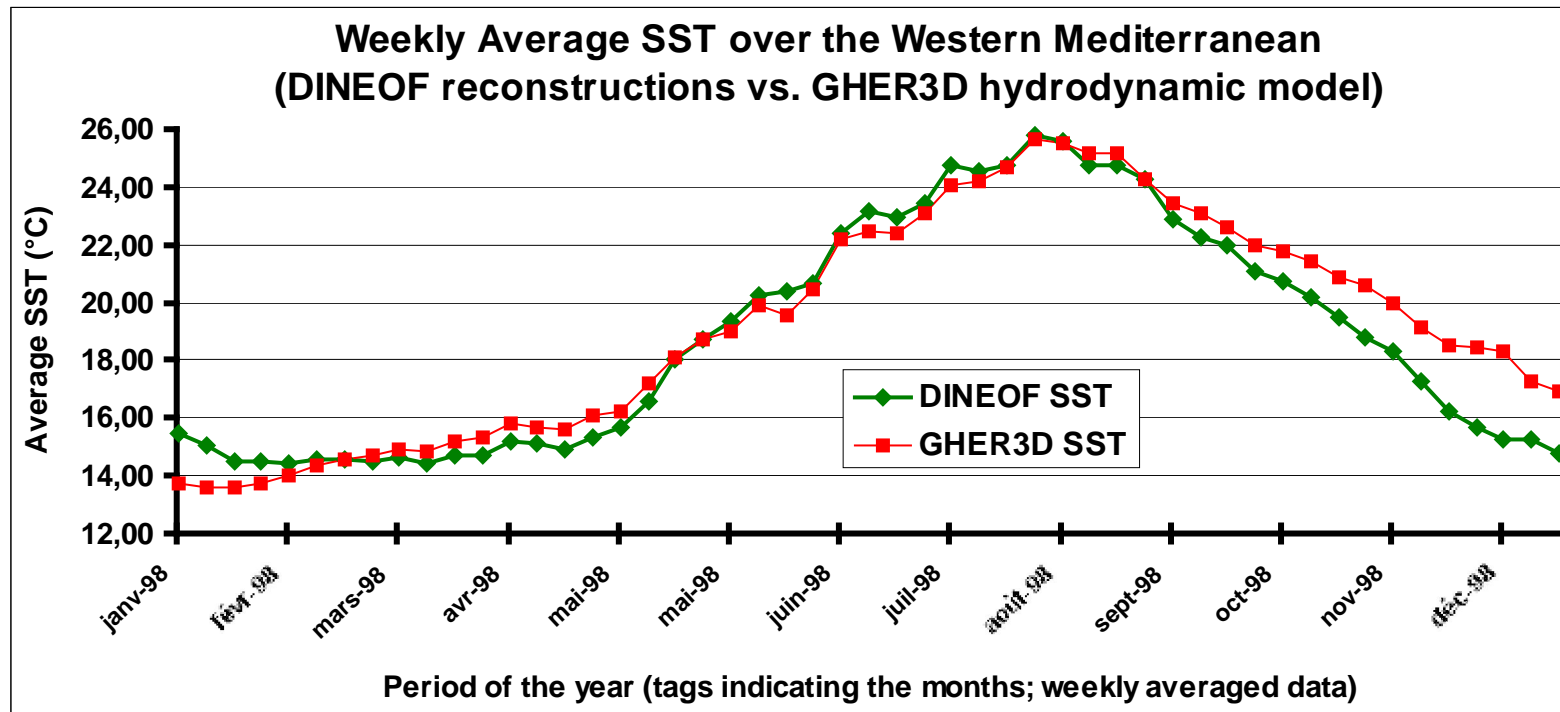


SST outliers detection

Pathfinder SST 20/10/1998 original data °C



DINEOF vs GHER3D Weekly mean fields for 1998

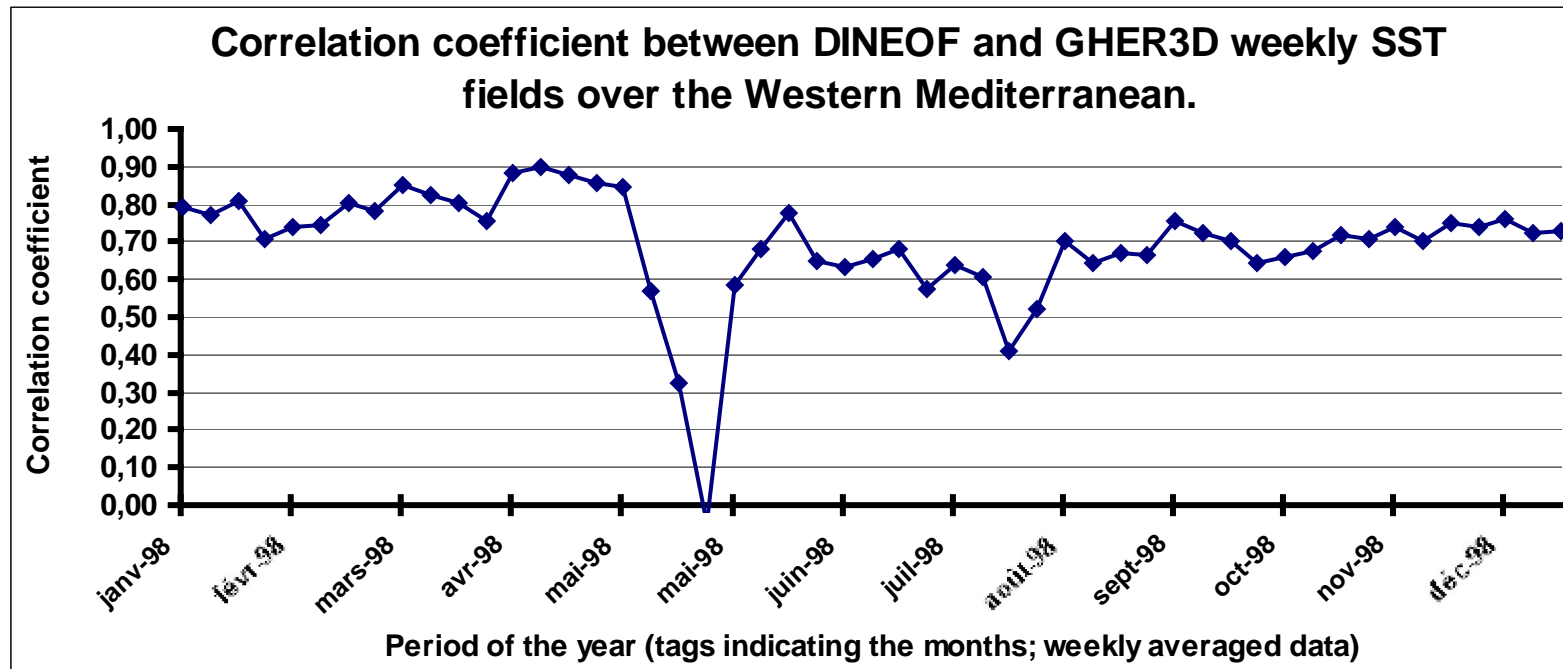


- Good agreement between DINEOF reconstructions and GHER modeled SST products from march to october 1998 (-0,085 °C)

- Larger discrepancies in winter (higher cloud cover introduces bias in DINEOF?; some phenomena underestimated by the GHER model?)

global average DINEOF-GHER SST difference of -0.4 °C probably due to the skin temperature effects of night-time AVHRR images.

DINEOF vs GHER3D Weekly mean fields for 1998



- Generally good correlation between the DINEOF and GHER SST fields (60-90 %), indicating well captured general dynamics, ...
- ...But not for weeks of may and some weeks in july, why? we're searching ...

4. CONCLUSIONS

➤ *Successfull applications of the parameter free DINEOF method to satellite optical data*

4 years of MERIS TSM data → 18 EOFs; varex = 97,2 %

4 years of MERIS CHL data → 8 EOFs; varex = 93,5 %

4,5 years of MODIS TSM data → 14 EOFs; varex = 97,5 %

(4,5 years of MODIS SST data → 13 EOFs; varex = 98,0 %)

→ “less biased” multitemporal averages and climatologies

➤ *Outliers maps succesfull in pointing haze, cloud egdes, contrails, cloud shadows, unusual events, both on optical and SST data, both regions*

→ improve data quality

→ provides efficient insigth into large databases

➤ *Multivariate analysis of TSM with hydrodynamic model data can improve reconstruction.*

→ best improvements with mean depth current components

→ less filtration of smaller structures

➤ *Validation of Hydrodynamical model SST simulations, 20 y trends analysis*

4. PERSPECTIVES

➤ *Occasional spikes in EOFs, inconsistent reconstructions:*

- *Elimination of inconsistent projections based on conditioning number of the problem*

- *Use a second DINEOF reconstruction cycle based on the data cleaned from outliers by a first DINEOF analysis*

- *Filtration of covariance matrix to eliminate high frequency variations of temporal EOFs modes*

➤ *Comparison of DINEOF products with DIVA and various "O.I." methods*

➤ *Excessive spatial filtering?*

Combine DINEOF and DIVA to target reconstruction of smaller scale and higher frequency dynamics, and increase distinction noise - small scale processes

Thanks for attention!

Acknowledgments:

To the GHER and MUMM teams for their teaching and support

RECOLOUR project was funded by the Belgian Science Policy (BELSPO)

MERIS DATA was provided by ESA

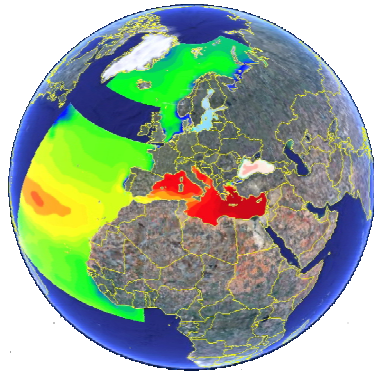
AVHRR Pathfinder SST, <http://podaac.jpl.nasa.gov>

Links :

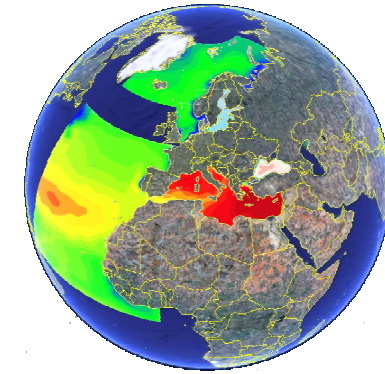
GHER-ULG : <http://modb.oce.ulg.ac.be/projects/2>

MUMM - RBINS : <http://www.mumm.ac.be/BELCOLOUR>

DINEOF: <http://groups.google.com/group/dineof>



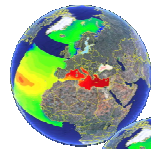
Thanks for attention!



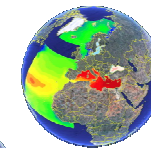
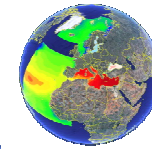
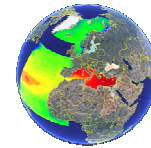
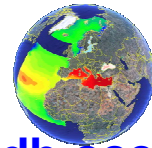
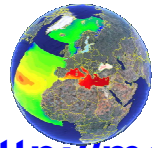
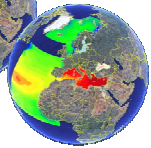
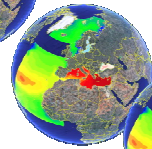
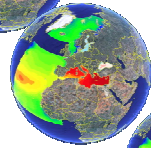
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MUMM - RBINS : <http://www.mumm.ac.be/BELCOLOUR>

DINEOF: <http://groups.google.com/group/dineof>