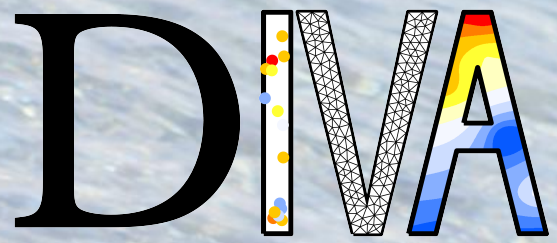
SeaDataNet 2 First Annual Meeting

WP9 – Software – Overview of the new developments



C. Troupin (ctroupin@ulg.ac.be), M. Ouberdous,
A. Barth & J.-M. Beckers

GeoHydrodynamics and Environment Research,
University of Liège, Belgium
http:// modb.oce.ulg.ac.be/

Rhodes, September 20, 2012

Université de Liège

GHER GeoHydrodynamics and Environment Research

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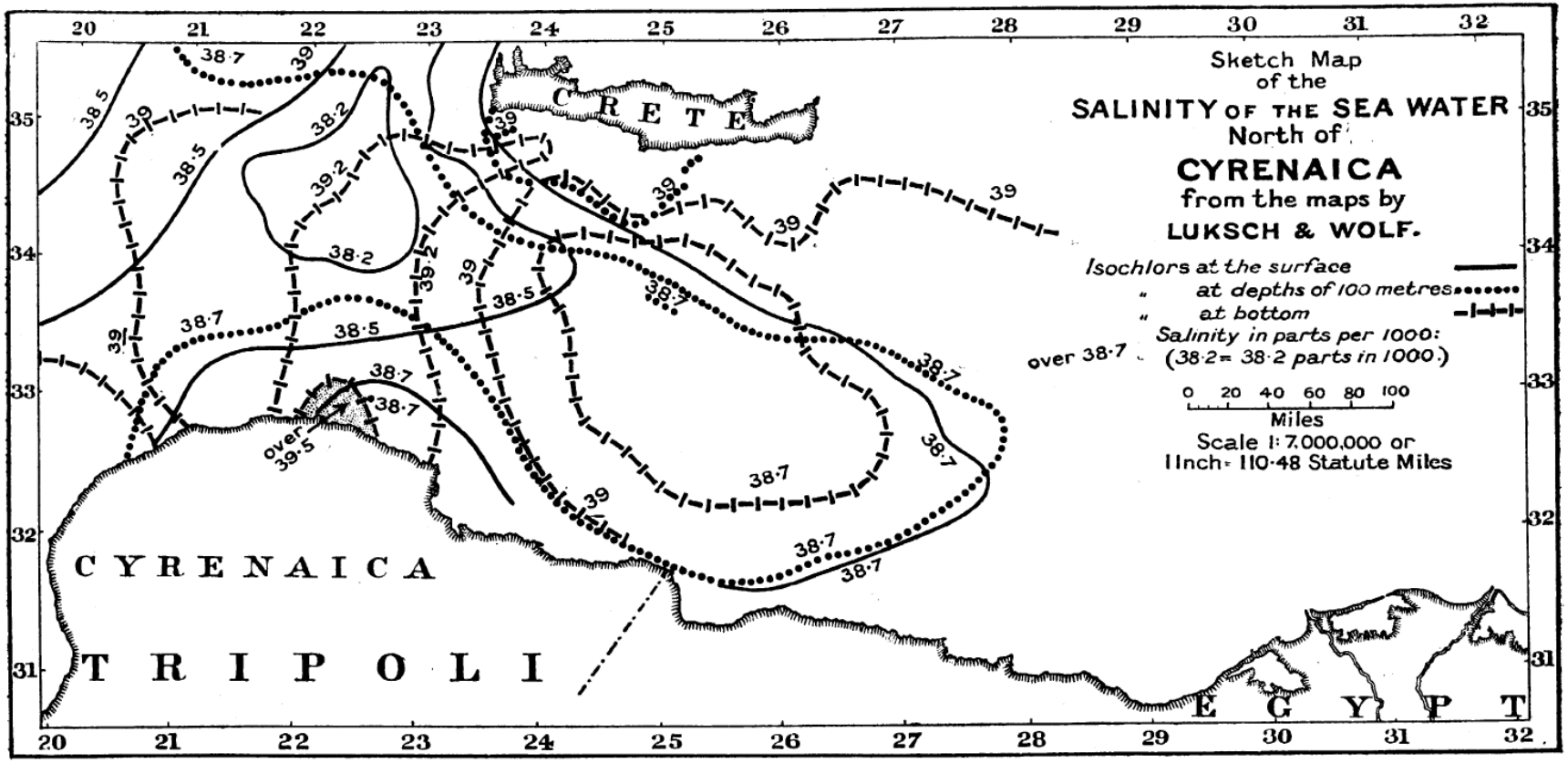
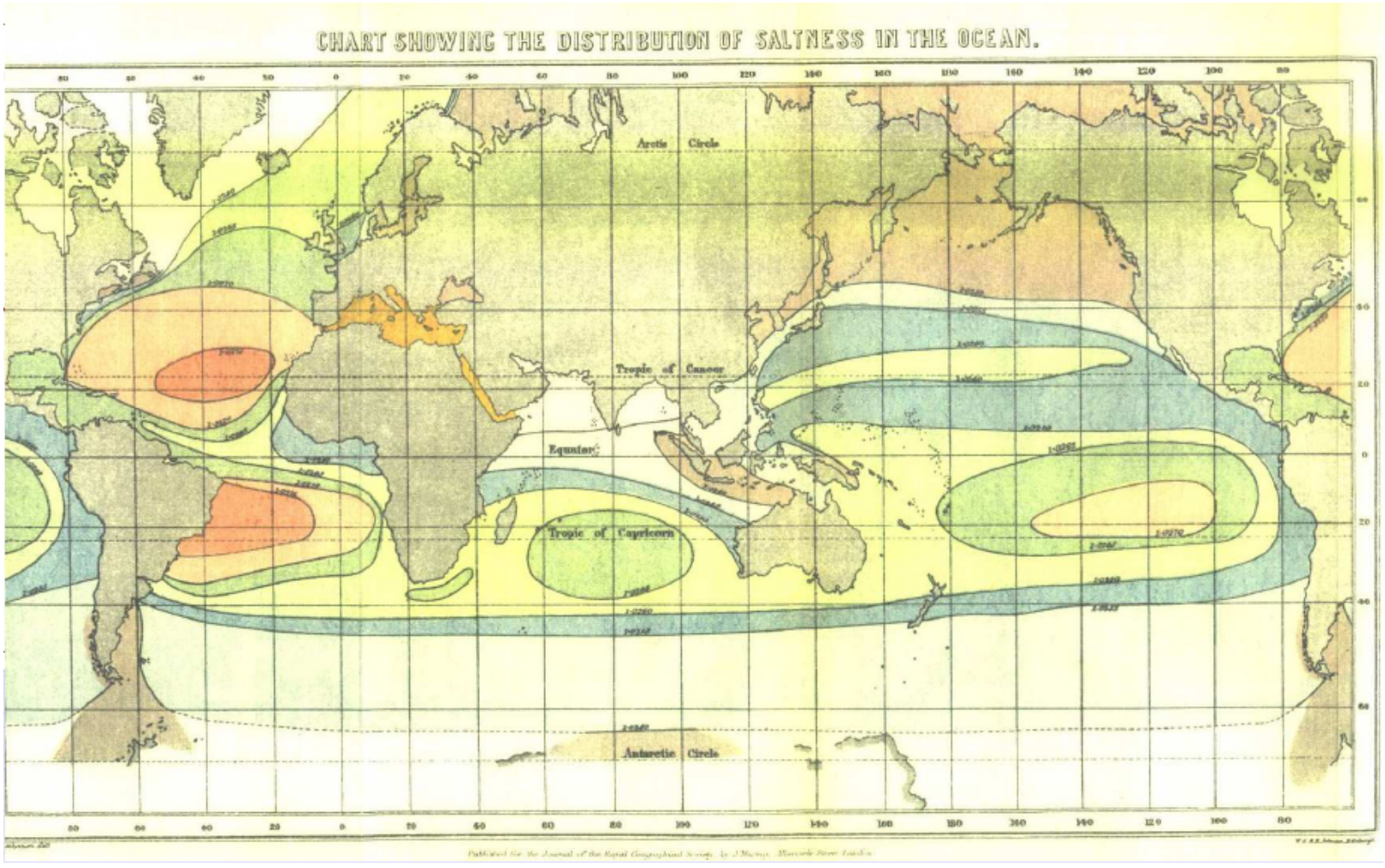
Diva: interpolation (gridding) of in situ data



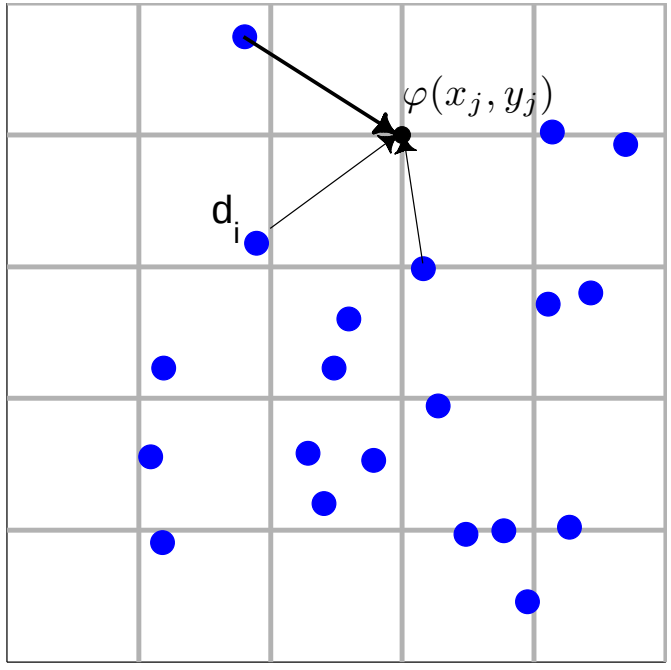
[J.W. Gregory (1916), Cyrenaica, *The Geography Journal*, **47 (5)**, 321-342]

Diva: interpolation (gridding) of in situ data



DIVA = Data-Interpolating Variational Analysis

N_d data points d_i • → gridded field



Formulation: minimize cost function $J[\varphi]$

$$\min J[\varphi] = \sum_{i=1}^{N} \mu_i \left[d_i - \varphi(x_i, y_i)\right]^2 \qquad \text{data–analysis misfit}$$

$$+ \int_D \left(\boldsymbol{\nabla}\boldsymbol{\nabla}\varphi : \boldsymbol{\nabla}\boldsymbol{\nabla}\varphi + \alpha_1 \boldsymbol{\nabla}\varphi \cdot \boldsymbol{\nabla}\varphi + \alpha_0 \varphi^2\right) \mathrm{d}D \qquad \text{field regularity}$$

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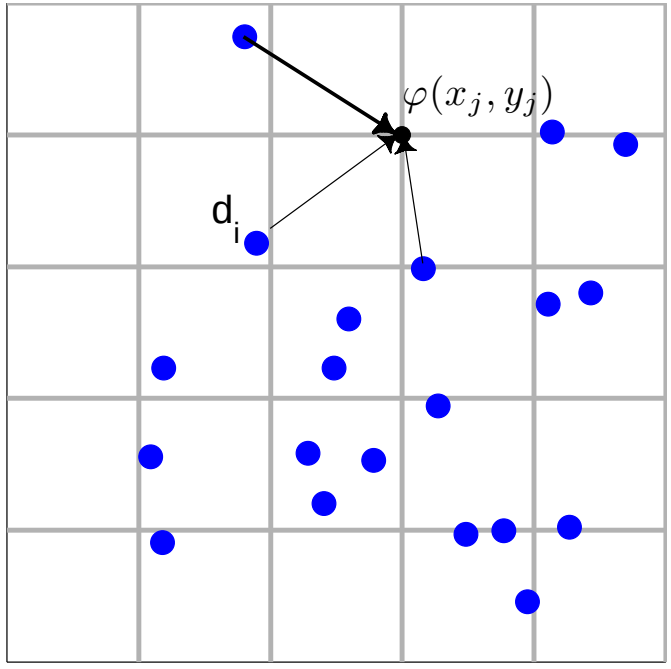

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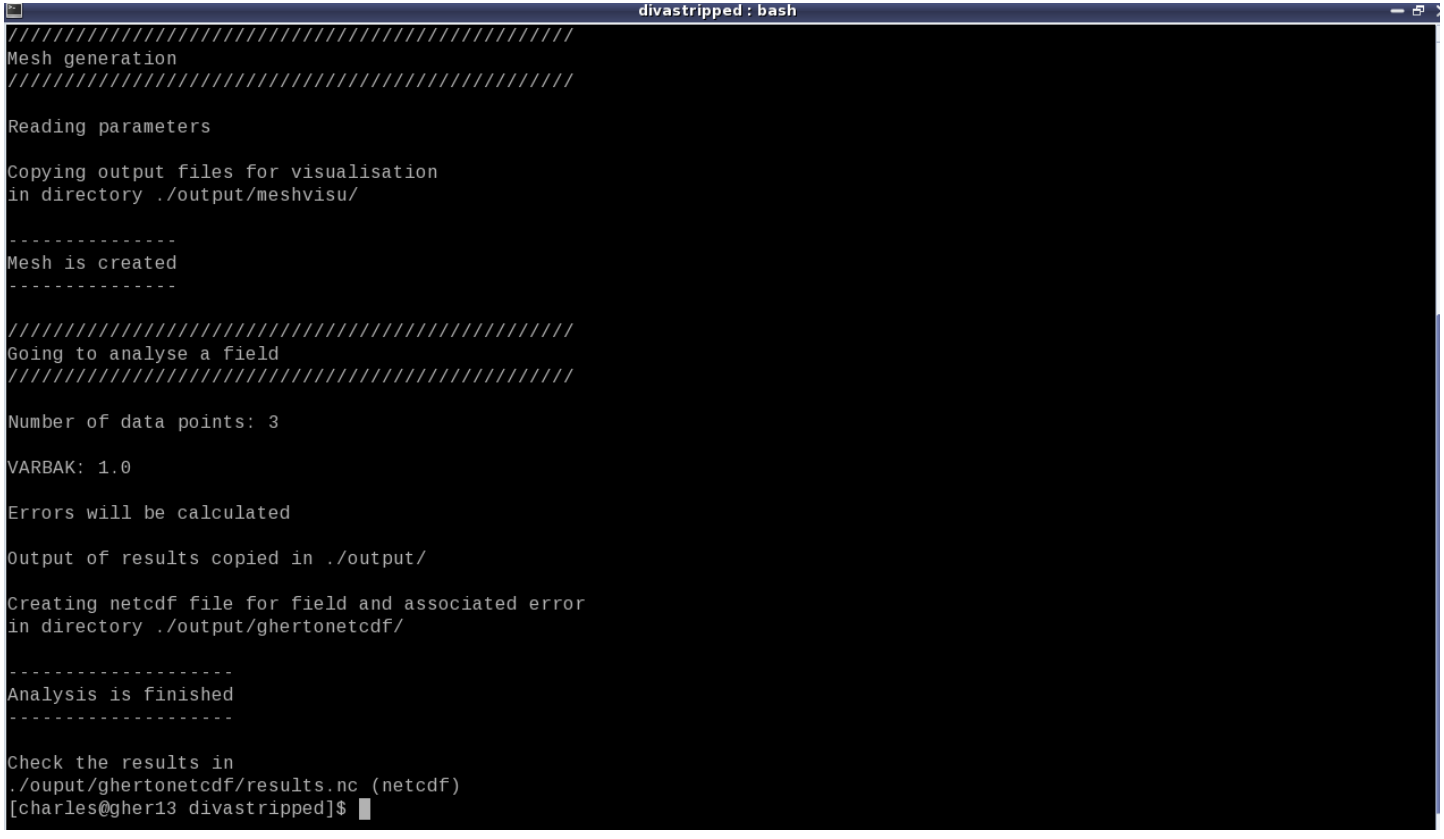
Four ways to use Diva

1. Command line (batch processing)
2. Ocean Data View
3. Diva-on-web
4. Matlab package



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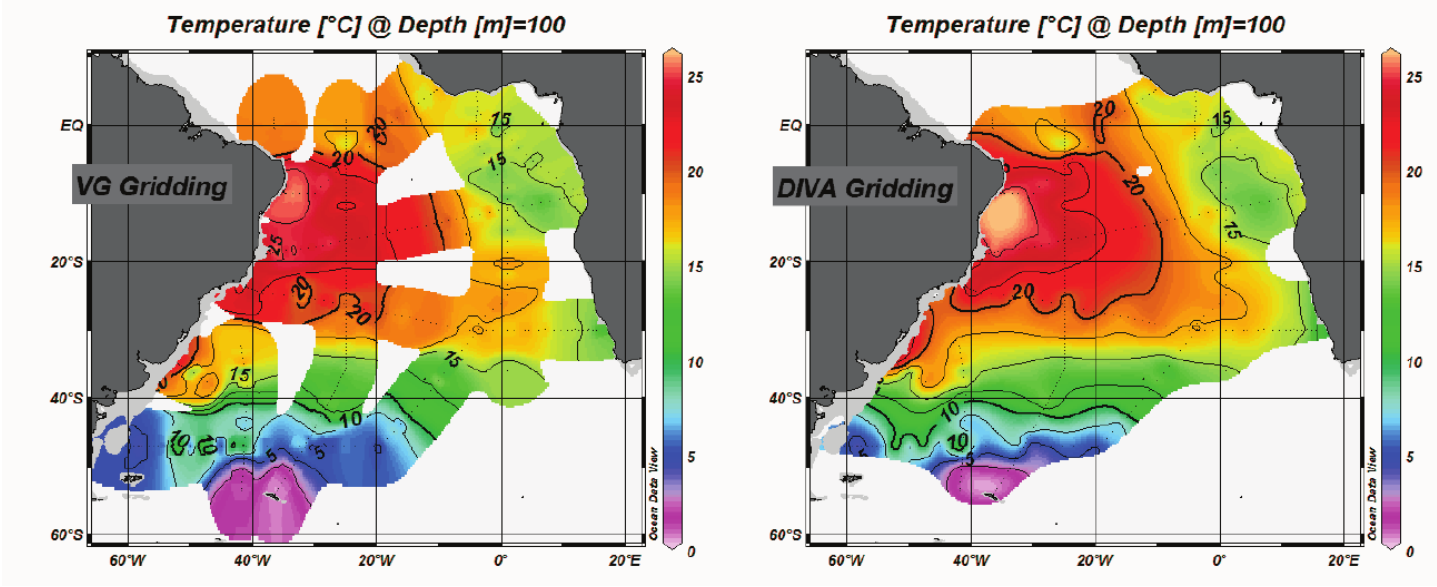

[R. Schlitzer (2009), Ocean Data View User's Guide, Version 4.2]

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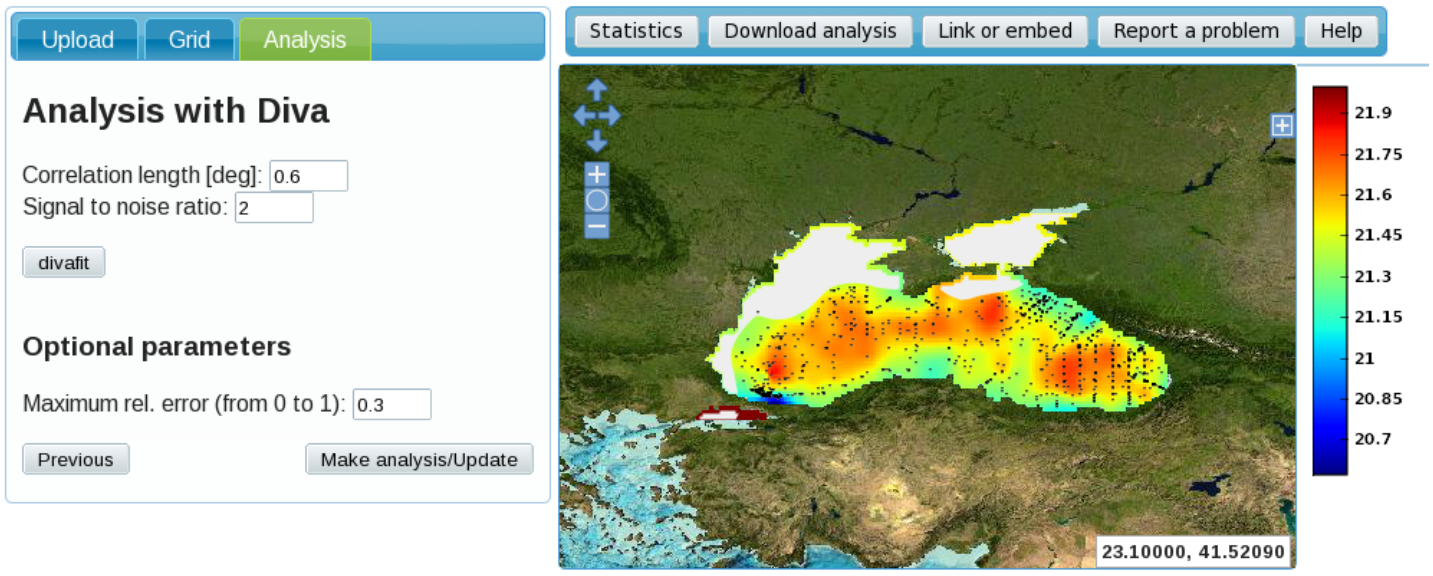
http://gher-diva.phys.ulg.ac.be/web-vis/diva.html



GHER SeaDataNet DIVA

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Four ways to use Diva

1. Command line (batch processing)
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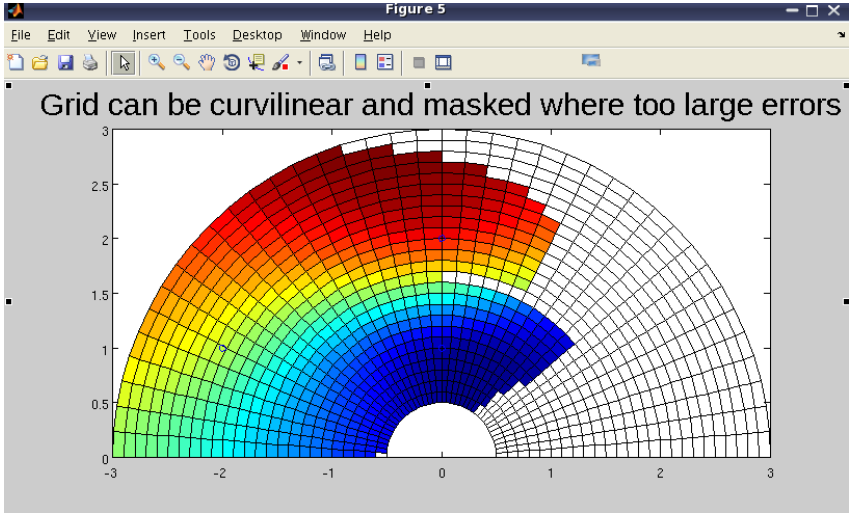
Package available at
http://modb.oce.ulg.ac.be/mediawiki/upload/divaformatlab.zip



Requires executables of Diva (mesh and analysis)

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Planned developments

		Deliverable no.	Date
1	**Updated versions and documentation**	**D9.9**	M 12
2	Multi-dimensional analysis	**D9.10**	M 24
3	Spatially correlated observational errors	**D9.10**	M 24
4	New version of Diva-on-web	**D9.11**	M 24
5	New version of Diva-OceanBrowser	**D9.12**	M 24

- Implementation of source term + decay
- Automatic generation of XML (catalogue)
- Updated documentation

SeaDataNet

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- Implementation of multiple solver algorithms
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SeaDataNet

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- Implemented and tested
- Two-step analysis

SeaDataNet

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Implementation of local source and decay

Standard version:

$$\begin{aligned} \min J[\varphi] &= (\text{difference between data and analysis}) && (1) \\ &+ \underbrace{(\text{shape / regularity of the field})}_{\text{derivatives}} && (2) \end{aligned}$$

Solution: finite-elements

$$\left(\mathbf{K_s} + \mathbf{K_d} \right) \cdot \mathbf{q} = \mathbf{g}$$

- Stiffness matrix related to derivatives
- Stiffness matrix related to data positions
- Connectors (new unknowns)
- Charge vector

SeaDataNet

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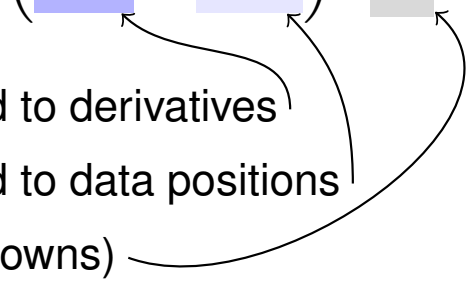

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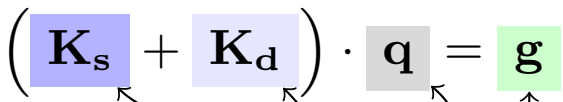

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Implementation of local source and decay

$$\left(K_s + K_d \right) \cdot q = g$$

Advection:

- Add a term taking into account $\mathbf{u} \cdot \boldsymbol{\nabla} \varphi$
- Modify stiffness matrix $\mathbf{K_s}$
- Modify spatial covariance

Source/decay:

- Add corresponding terms $\sum_j Q_j \delta(\mathbf{r} - \mathbf{r}_j) - \gamma \varphi$
- Modify stiffness matrix and charge vector

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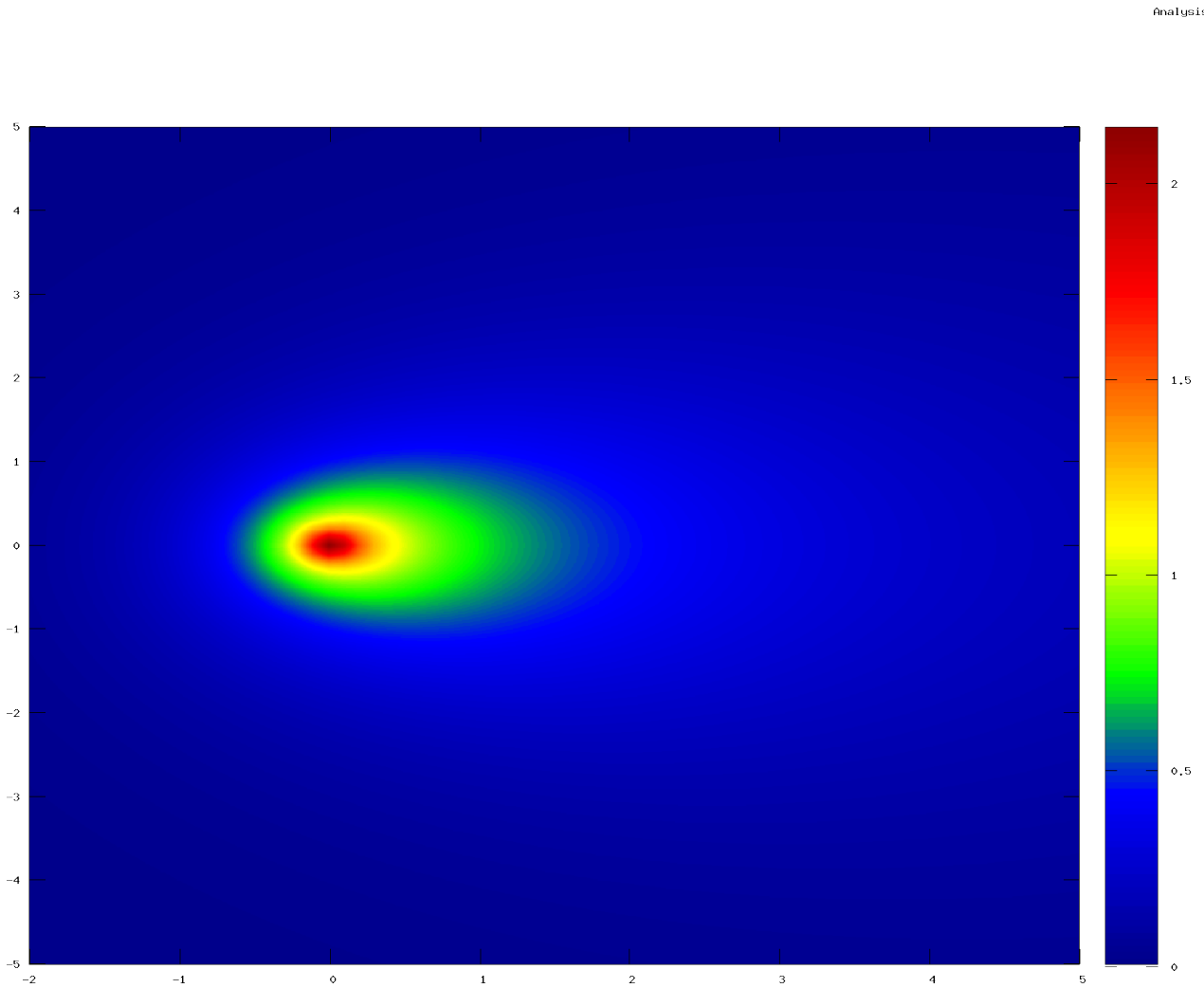
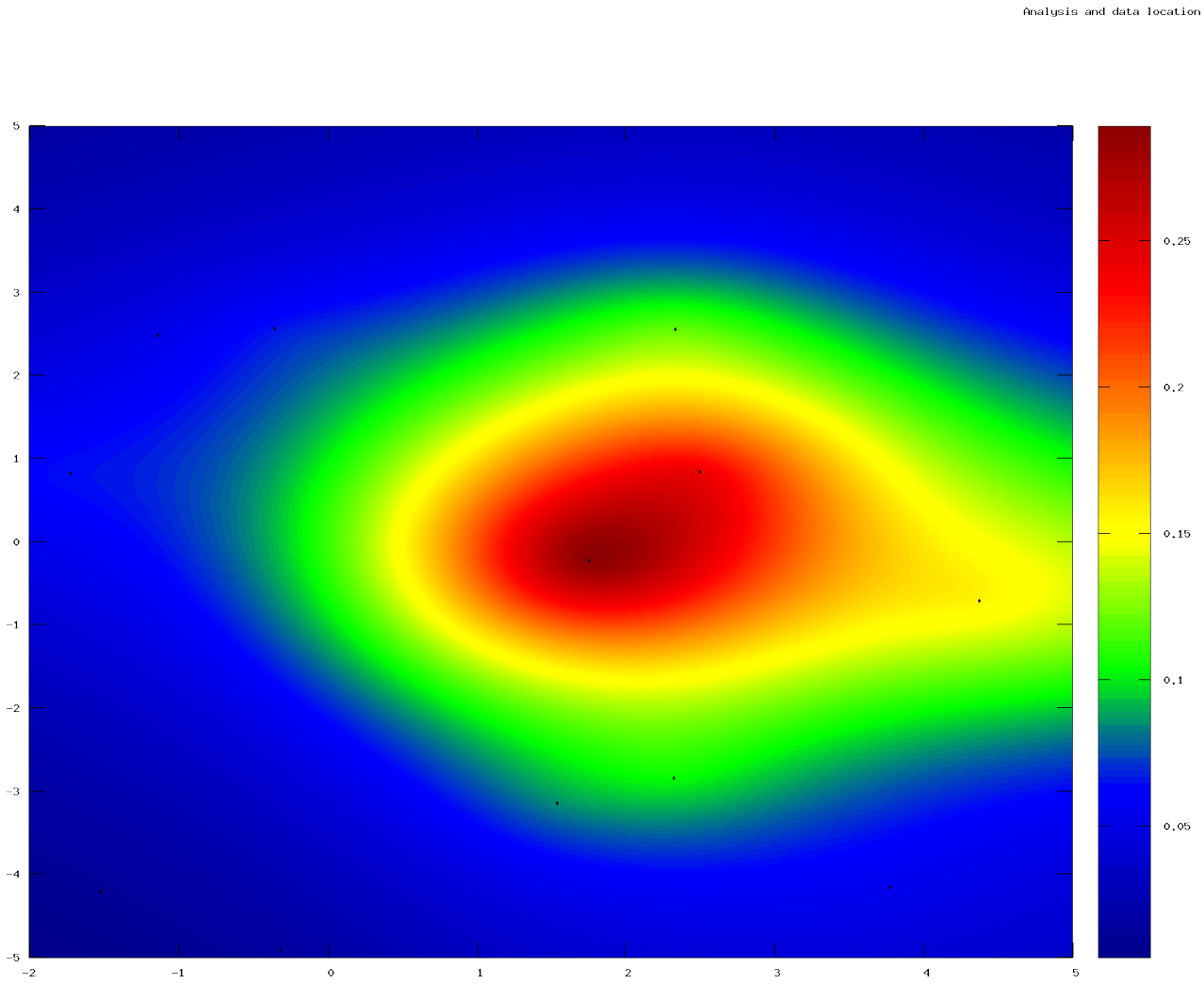
Implementation of local source and decay: example



True field (scale between 0 and 2.1).

Implementation of local source and decay: example



Standard analysis (scale between 0 and 0.3).

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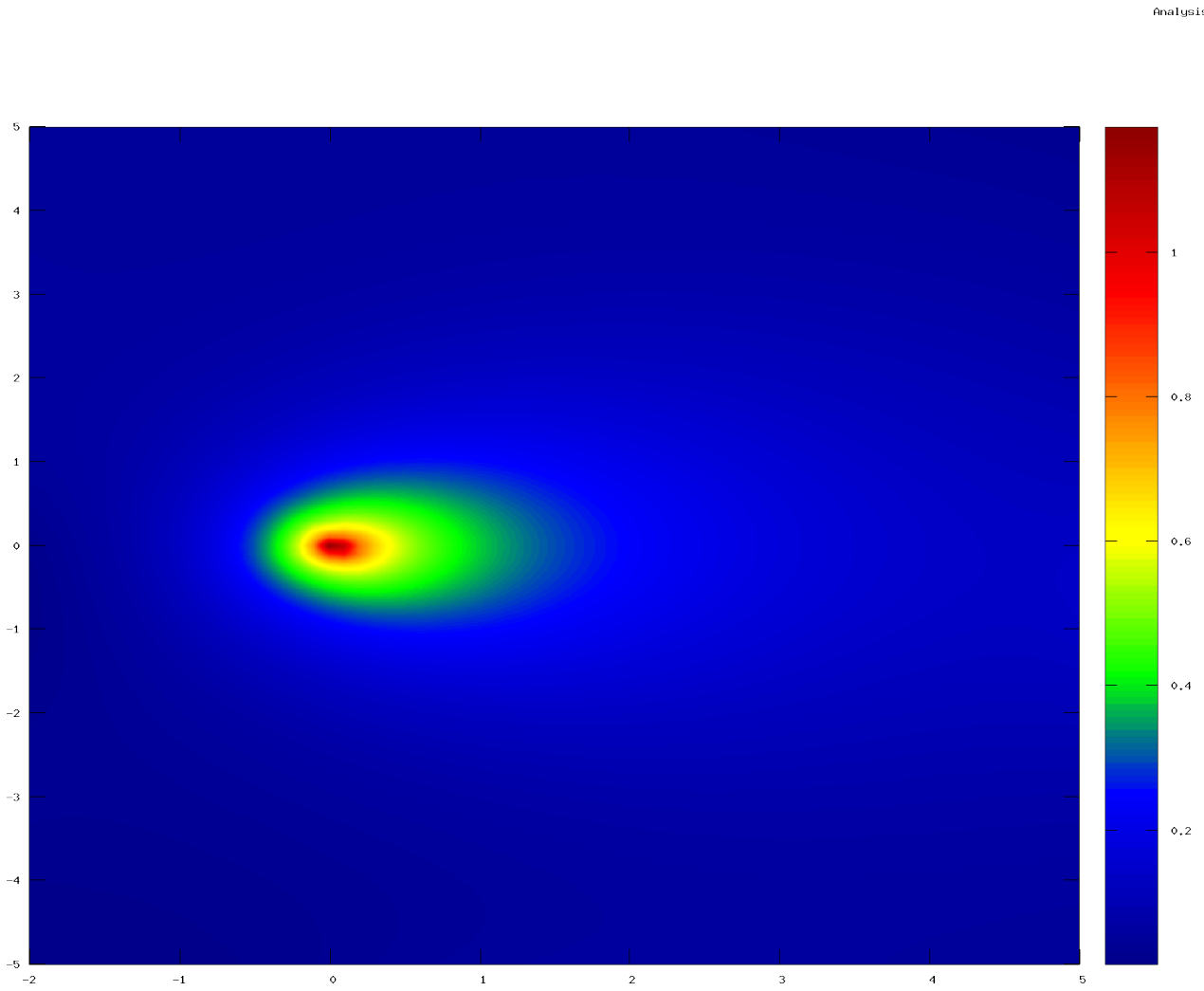
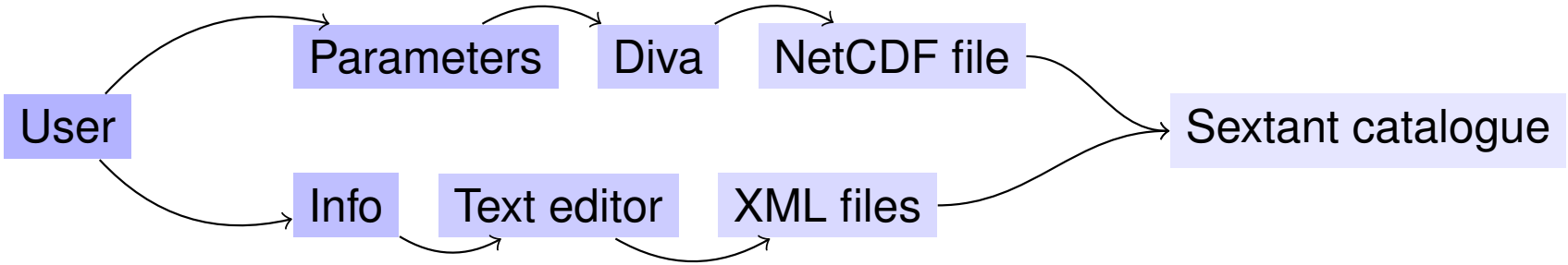
Implementation of local source and decay: example



Analysis with a source and advection(scale between 0 and 1.2).

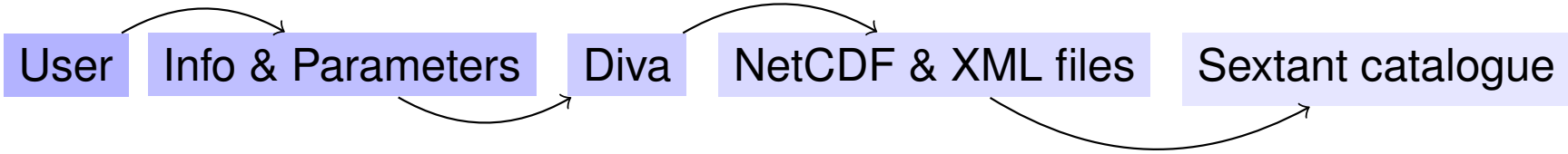
Generation of XML files for catalogues

Before: 2-step procedure



Generation of XML files for catalogues

Now:



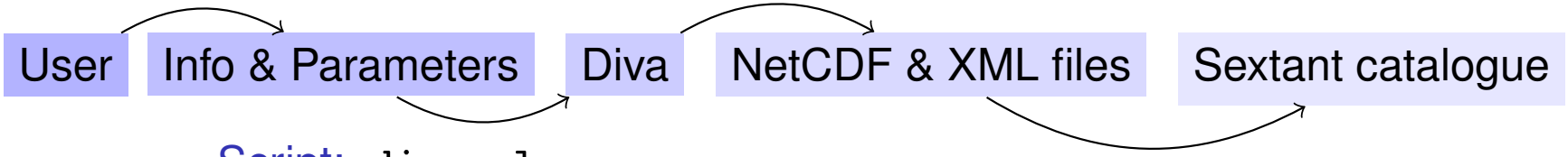
Script: `divaxml`

Input: input files + information provided by the user

Requirement: up-to-date XML template!

Generation of XML files for catalogues

Now:



Script: `divaxml`

Input: input files + information provided by the user

Requirement: up-to-date XML template!

```
##Short name of the dataset:
EMODNET_Nitrates_4DNetCDF
##Parameters in dataset (see liste in ./input/SDN_P021.list):
SDN:P021:68:NTRA = Nitrate concentration parameters in the water column
##Measuring Instruments -SDN L54- (see liste in ./input/SDN_L54.list):
SDN:L054:12:181 = nutrient analysers
##Positioning instruments -SDN L56- (see liste in ./input/SDN_L56.list):
SDN:L056:3:POS02 = Global Navigation Satellite System receivers
##Thumbnail file name
NTRA_image
##Url compliment (to http://gher-diva.phys.ulg.ac.be/data/emodnet-domains/)
Mediterranean Sea
##Geographical area name (see ./input/Geographical_areas.list)
SDN:C16:8:28Bg = Mediterranean Sea
##Time units (month or season)
season
## Usage limitation (all in one ligne)
The data and the data products have been validated by the regional experts.
```

Example file 2.1: Temperature.SDNconv file

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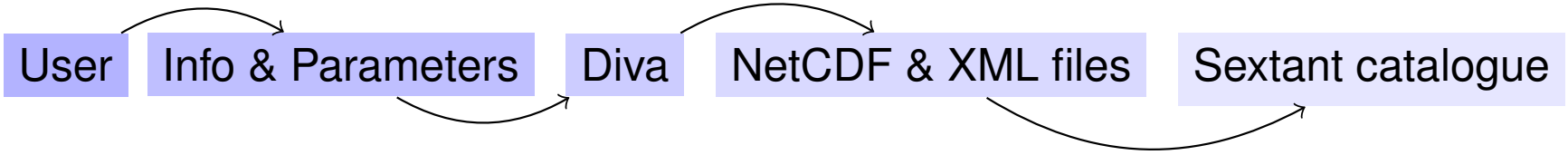
Generation of XML files for catalogues

Now:



Script: `divaxml`

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```
##Organizations name:
SDN:EDMO::xxx = SDN:University of Liege, GeoHydrodynamics and Environment Research
##organisation e-mail adress:
JM.Beckers@ulg.ac.be
##Climatolgy and Metadata author organisation  (Collating Center)
SDN:EDMO::EDMO xxx = SDN:EDMO University of Liege, GeoHydrodynamics and Environment Research
##Climatolgy and Metadata author e-mail adress
M.Ouberdous@ulg.ac.be
```

Example file 2.2: general information file template

Spatially correlated observational errors

Generally: independent observational errors

$\rightarrow$ simplified analysis

$$\left\langle \mathbf{d}\,\mathbf{d}^{\mathsf{T}} \right\rangle = \mathbf{B} + \mathbf{R}$$

$$\text{data-covariance} = \text{Background covariance}$$

$$+ \text{observational error covariance}$$

$\rightarrow$ **R** is diagonal

In development:

correlated observational errors (same cruise, XBT, . . .)

Solution: *Inflation of the diagonal matrix* **R**

Two-step analysis

Spatially correlated observational errors

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Two-step analysis

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Diva-nD

Motivation: multi-dimensional analysis (space + time)
$\rightarrow$ smooth analysis in all dimensions

Solution: n-dimensional cost function

$$J[\varphi] = \text{proximity to observation} + \text{field regularity} + \text{physics} \tag{3}$$

Problem: increased computational cost
need for higher derivatives in the functional

Formulation: primal (grid space) or dual (observation space)

Solvers:

1. Direct: Cholesky factorization
2. Iterative: conjugate gradient method

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Diva-nD: an example

Data: ORCA2 model extracted at positions of ARGO buoys in 2007

$\longrightarrow$ 3D analysis (lon - lat - **time**)

Parameters: [Nelder and Mead (1965)] minimization algorithm

Validation: analysis compared to 2007 monthly model climatology

Conclusion: improvement of the quality of the analysis using time information

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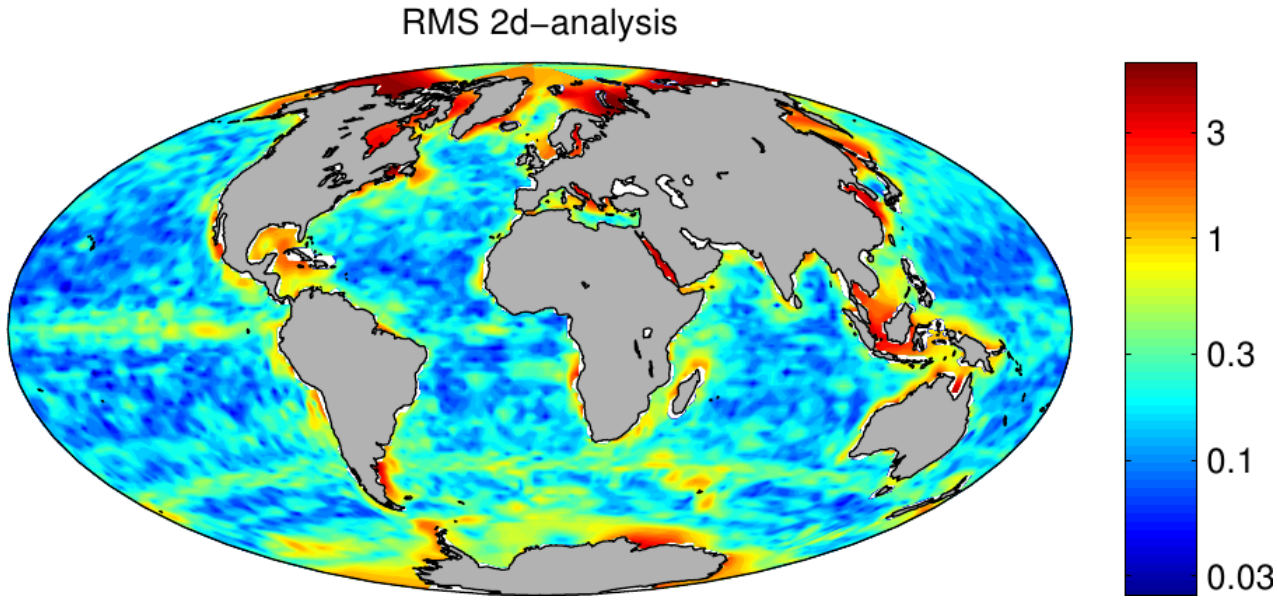

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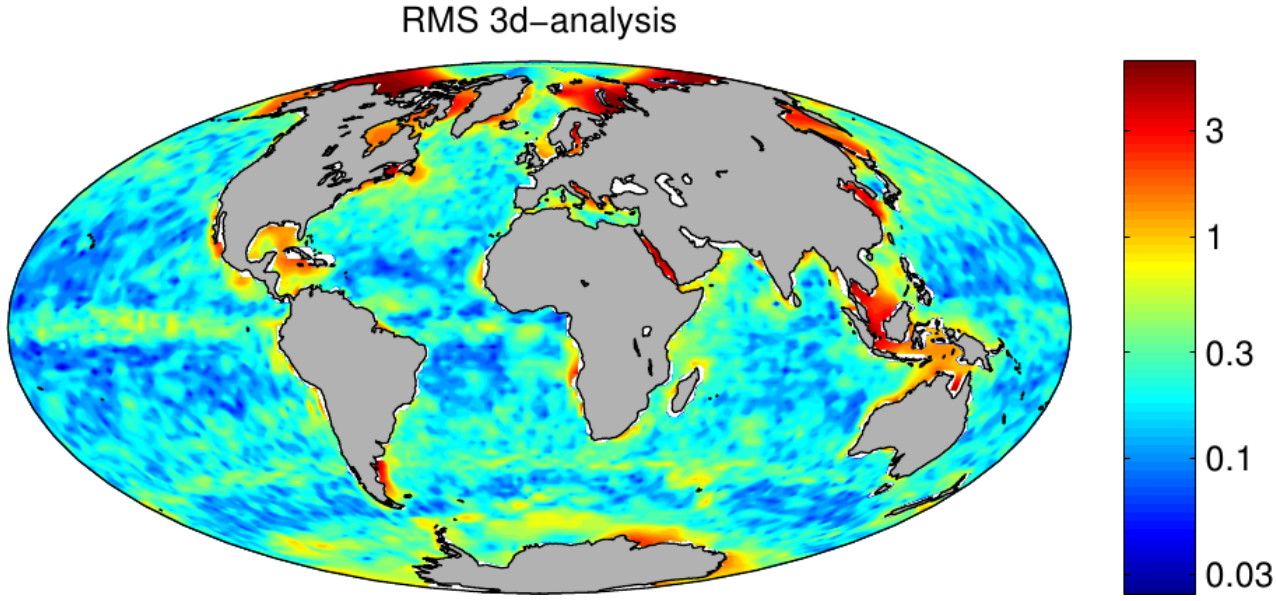

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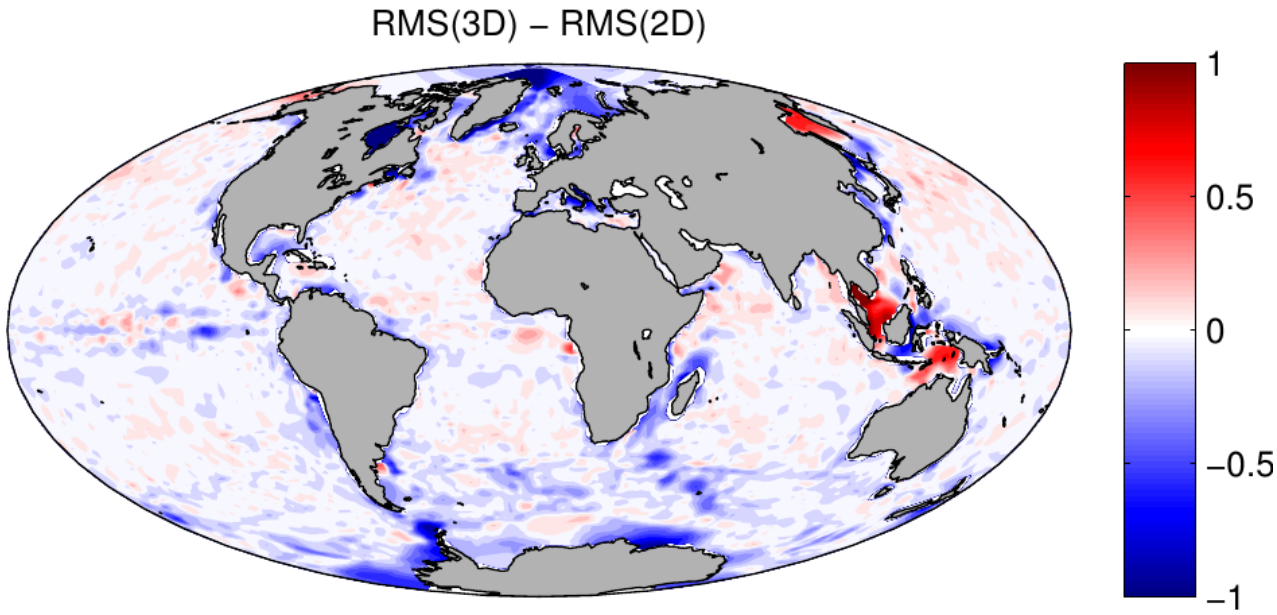

Conclusion: improvement of the quality of the analysis using time information

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Diva-nD: summary of the features

- nD variational analysis, orthogonal curvilinear grid (typical in modelling)
- Consistent error calculation
- Possibly correlated observations (slow)
- Implementation of multiple solver algorithms
- Written Matlab/GNU Octave.

Status: in development
determine Kernel for $n > 2$ (new derivatives)
beta testers?

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OceanBrowser: visualize climatologies and time series

- Improvement of unit tests to include XML validation of the GetCapabilities request (WMS version 1.1.1 and 1.3.0)
- Implementation of "group name" for observation plots (MSFD group names in EMODNet Chemistry)
- Integration with Sextant service

  Needed:
  1. List for mapping NetCDF data products and Sextant ID
  2. Permanent URL for Sextant

- User feedback

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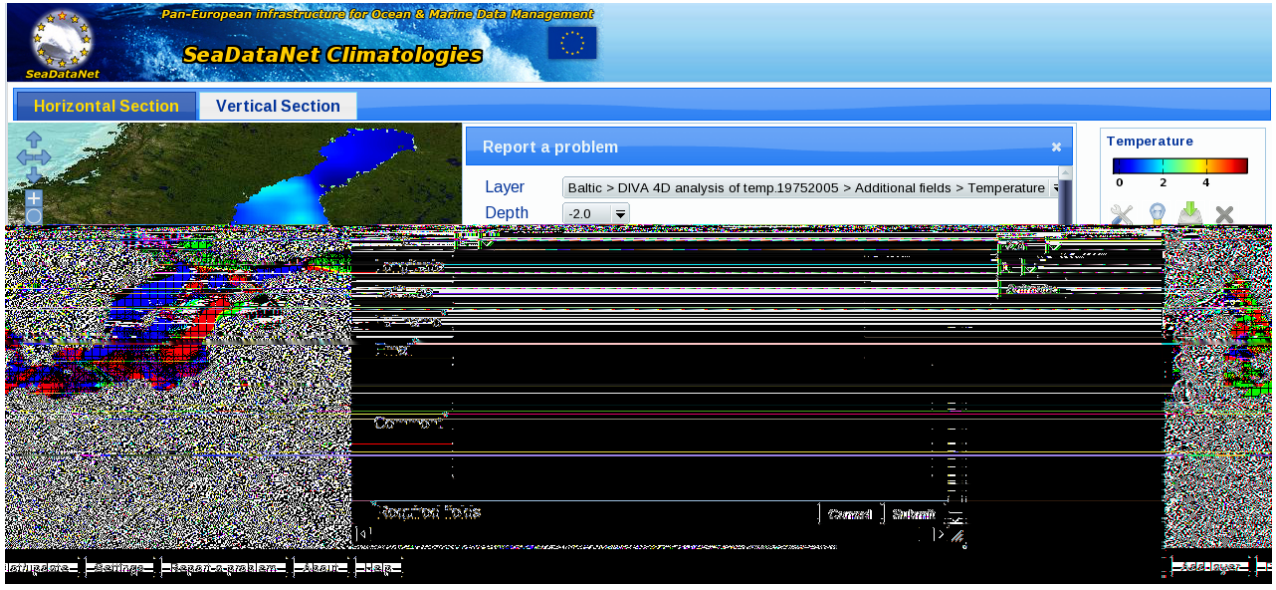

Publications

- Bhaskar et al. (2012) Remote Sensing Letters
  Argo-derived sea surface temperature and microwave sea surface temperature in tropical Indian Ocean
- Yari et al. (2012) Journal of Geophysical Research
  Direct estimate of water, heat, and salt transport through the Strait of Otranto
- Arctic and Antarctic Research Institute and World Data Center for Oceanography (2013)
  Electronic atlas of the Nordic Seas
  (60°N-82°N,45°W-70°E)
- Troupin et al. (2012) Ocean Modelling
  Generation of analysis and consistent error fields using the Data Interpolating Variational Analysis (Diva)
  + posters at conferences (EGU, . . .)

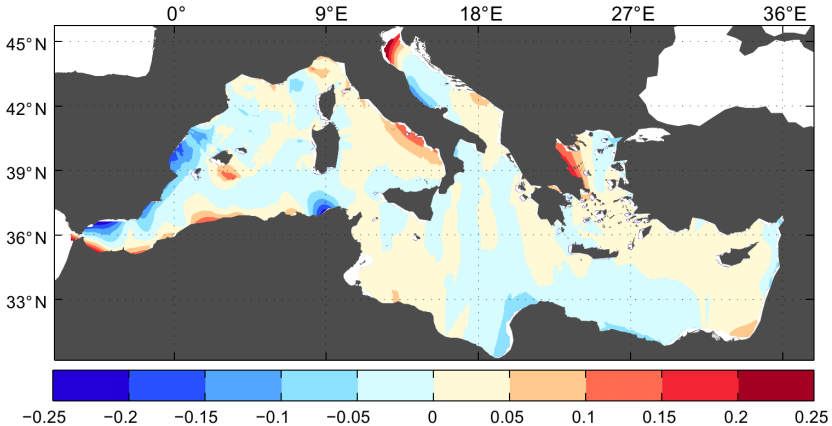

Fig. 7. Difference between OI and DIVA salinity fields obtained with $L = 1.42°$ and $\lambda = 1$.

Training

- SDN2 First training course, 2-6 July 2012, Ostend (Belgium)
  (Claudia and Serge's presentation yesterday)
- Sixth Diva workshop, 8-12 October 2012, Roumaillac (France)
- Master in Oceanography (ULg) – Data acquisition and analysis:
  extraction using SDN2 portal
  $\longrightarrow$ feedback
  $\longrightarrow$ contribution to user panel?

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Diva workshop, 8-12 October 2012, Roumaillac (France)

Program:	user-adapted: Beginner / Intermediate / Expert
Location:	close to Bergerac (France)
Participants:	SeaDataNet + Emodnet
Details:	*http://modb.oce.ulg.ac.be/mediawiki/index.php/Diva_workshop_2012_Roumaillac*

Thanks for your attention