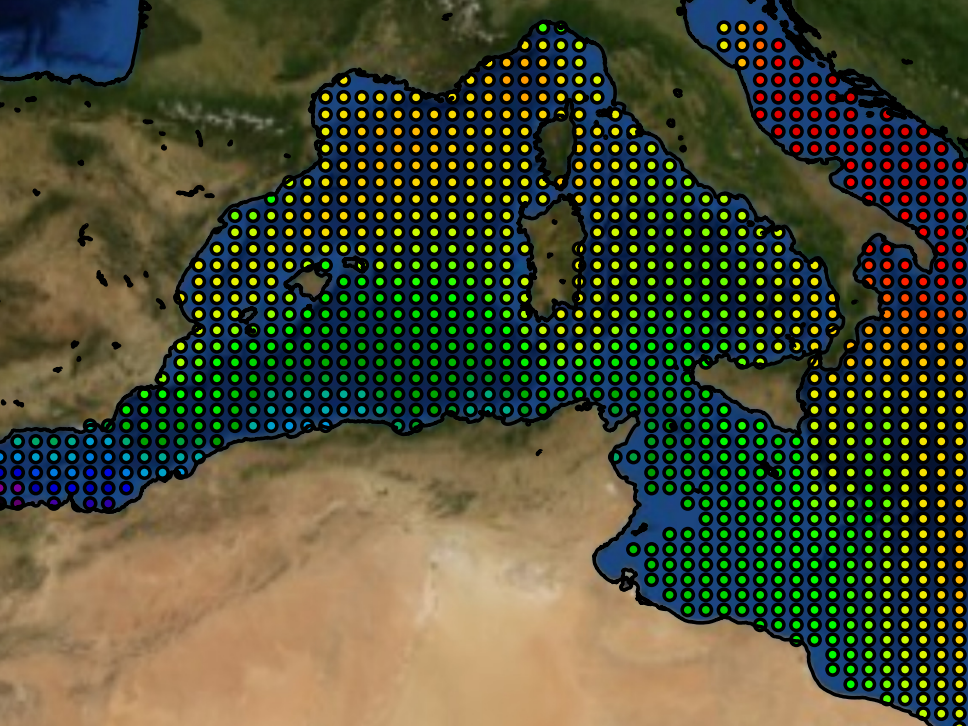


Variational data analysis for generating ocean climatologies (Diva) and web-based distribution of data products (OceanBrowser)

Alexander Barth, **Charles Troupin**,
Aida Alvera-Azcárate & Jean-Marie Beckers

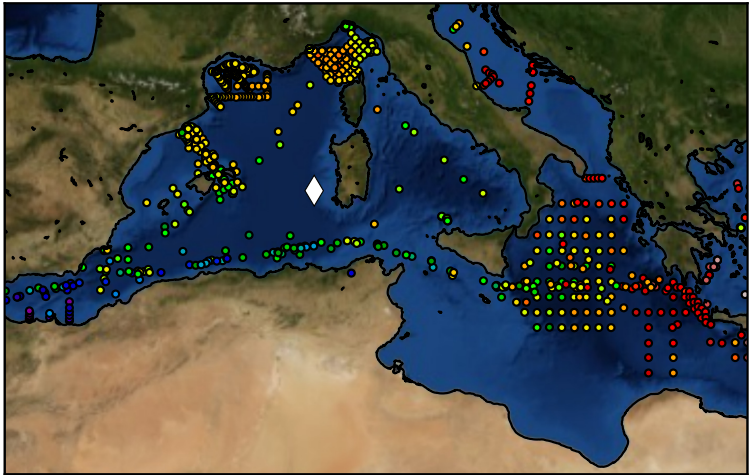
Acknowledgement: SeaDataNet,
EMODnet Chemistry, EMODnet Biology







Objectives of data analysis



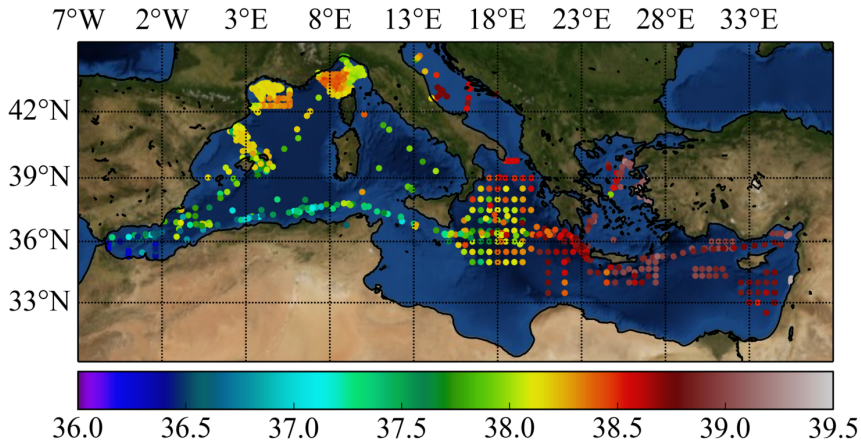
- 1 Temperature at the \diamond ?
- 2 Mean field?
- 3 Uncertainty of your estimate for 1 and 2?

Variational analysis

What is the "*best looking*" field close to the observations?

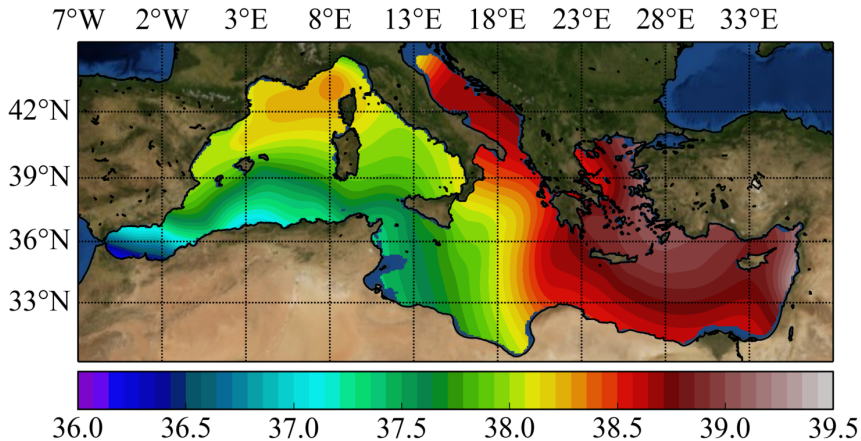
How can we quantify "*good-looking*"?

Good-looking?



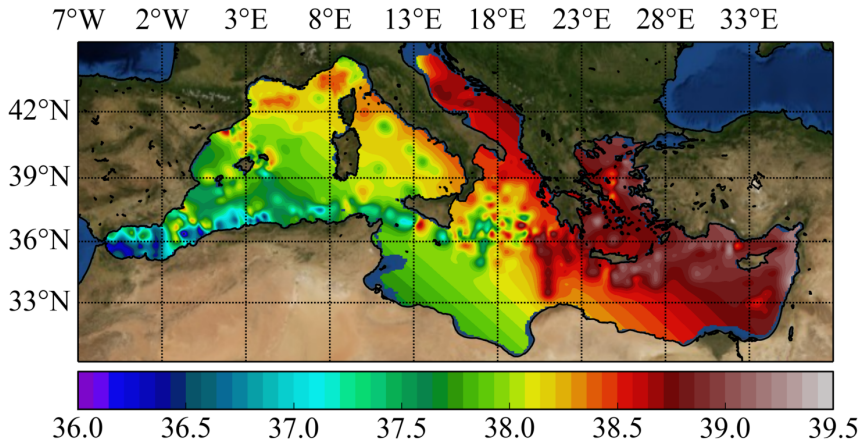
Salinity in the Mediterranean Sea

Good-looking?



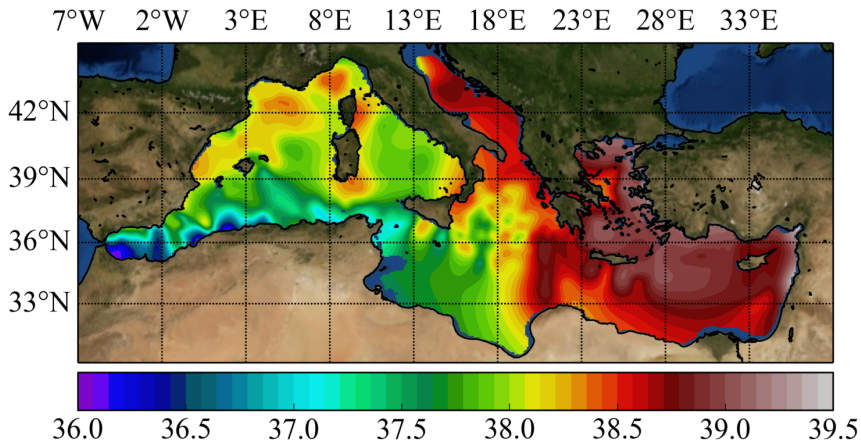
Too smooth!

Good-looking?



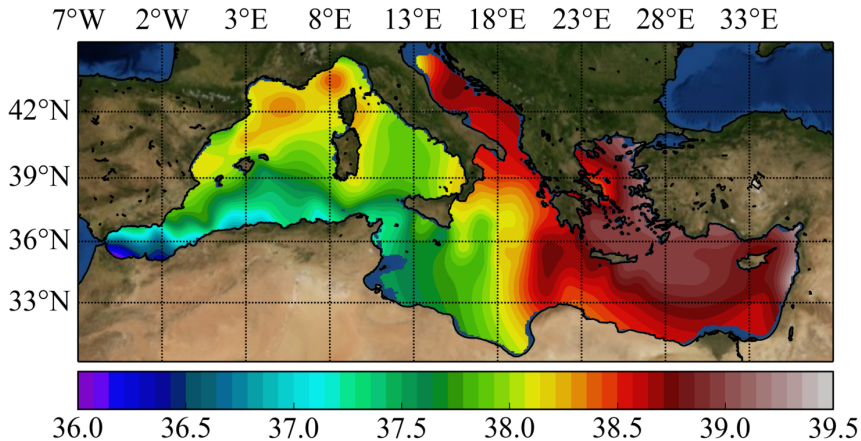
Too noisy!

Good-looking?



Slightly better...

Good-looking?



OK, looks nice!

Good-looking analysed field?

Close to observations but...

not too close

cruises should not be visible

Smooth variations but...

not too smooth

more than a uniform gradient should be visible

Good-looking analysed field?

Analysis parameters:

1. correlation length scale
2. signal-to-noise ratio

determined from data themselves

Diva Cocktail Recipe

Ingredients:

- 1 1/2 oz vodka
- 1/2 oz passion-fruit juice
- 1/2 oz lime juice
- 1 tbsp cherry juice
- fill with soda



Diva Cocktail Recipe

Ingredients:

- Smoothness
- Observation constraint
- Behaviour constraint



Diva Cocktail Recipe

Proportions:

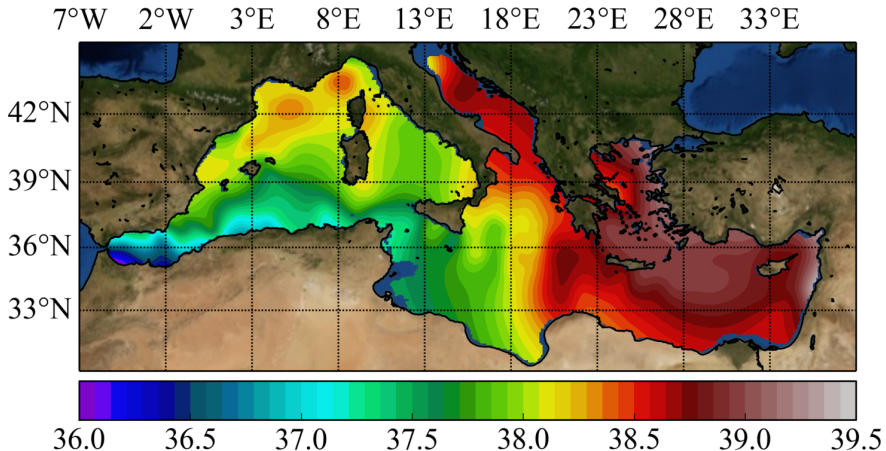
- correlation length scale
- signal-to-noise ratio



Diva 2D: longitude/latitude

Procedure repeated

- for various depth levels
- for different periods



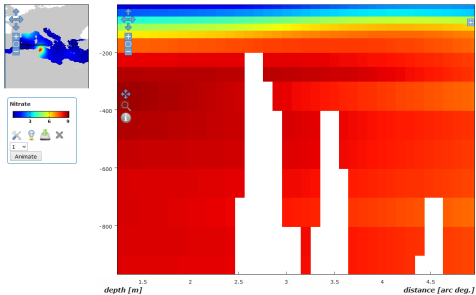
Diva in 3D

- Result layers *stacked* together



Diva in 3D

- Result layers *stacked* together
- Problems may occur between two levels...



Diva in 3D

- Result layers *stacked* together
- Problems may occur between two levels...
- ...so stabilisation is required



Extension to higher dimensions

Classic Diva: smoothness constraint only in 2D

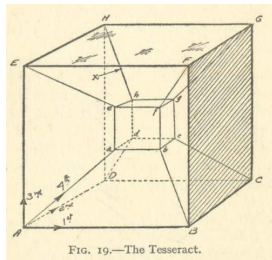
DIVAnd: arbitrary high dimensional space (time, depth, ...)

Extension to higher dimensions

Classic Diva: smoothness constraint only in 2D

DIVAnd: arbitrary high dimensional space (time, depth, ...)

1928: [*Theosophy and the Fourth Dimension*, Alexander Horne]

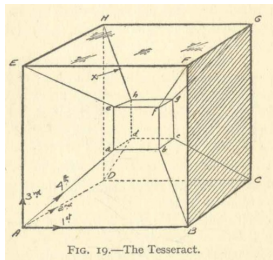


Extension to higher dimensions

Classic Diva: smoothness constraint only in 2D

DIVAnd: arbitrary high dimensional space (time, depth, ...)

1928: [*Theosophy and the Fourth Dimension*, Alexander Horne]



2013: [*Theory of Diva in the Fourth Dimension (and more)*, Alexander Barth]

$$K^{n,m}(\vec{x}) = \frac{2}{\Gamma(\nu)} \left(\frac{|\mathbf{L}^{-1}\vec{x}|}{2} \right)^\nu K_\nu(|\mathbf{L}^{-1}\vec{x}|) + \text{many more!}$$

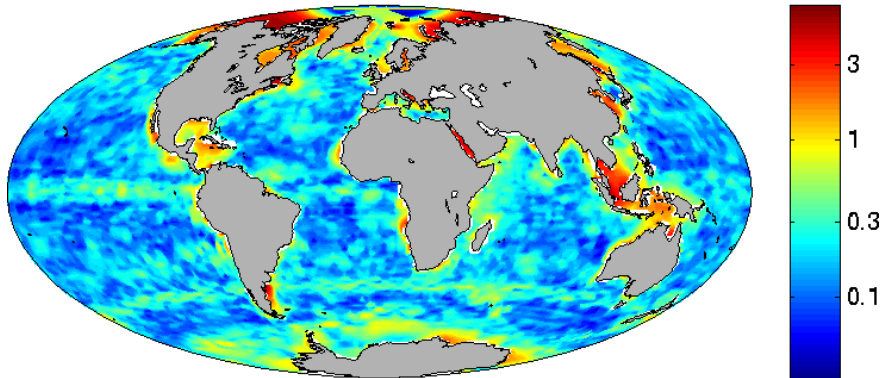
Application

- Pseudo-**observations**: temperature from a global ocean model (NEMO-LIM2).
- Horizontal **resolution**: $\approx 2^\circ$
- **Positions**: ARGO observations from 2007
- Analysis **quality**: comparison between
 - analysed field
 - original model data
- Observations: **daily** model results
Analysis: **monthly** means
- Surface fields only

Application

Analysis parameters: optimized by minimizing RMS to model climatology

RMS 3D-analysis

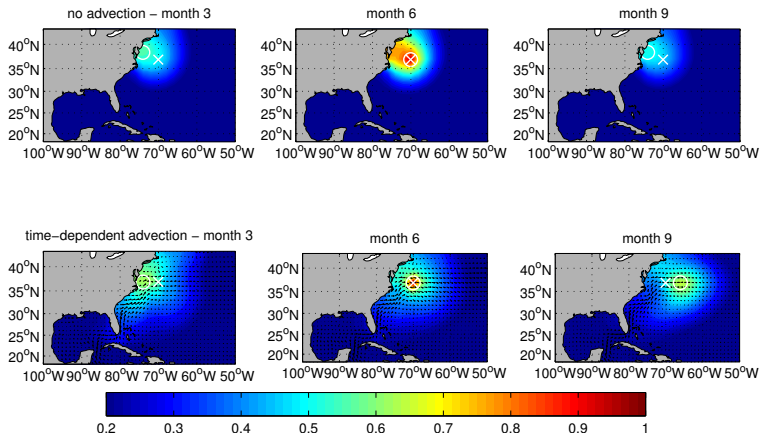


Advection constraint

Forces gradients of interpolated fields to align with currents

In 3D: distinction between upstream and downstream

3D case: background error covariance without (upper row) and with advection constraint (lower row) for a data point located at the cross and at month 6



Comparison

Experiments:

- with/without time dimension
- with/without advection

Skill-score (in %): relative reduction of mean square error

dimension of analysis	advection constraint	skill-score
2D	no	0

Comparison

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Skill-score (in %): relative reduction of mean square error

dimension of analysis	advection constraint	skill-score
2D	no	0
2D	yes	29

Comparison

Experiments:

- with/without time dimension
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Skill-score (in %): relative reduction of mean square error

dimension of analysis	advection constraint	skill-score
2D	no	0
2D	yes	29
3D	no	27

Comparison

Experiments:

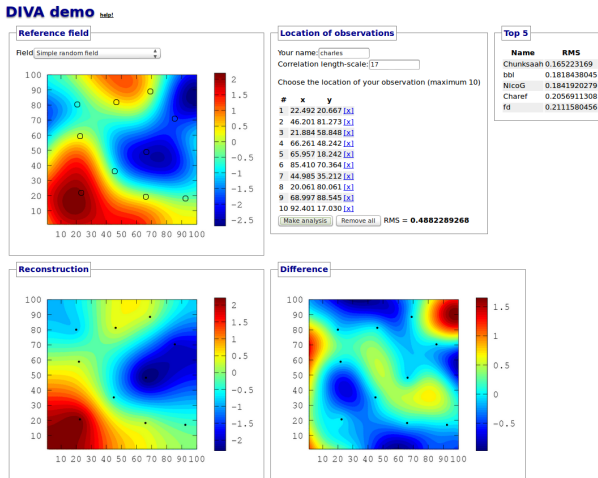
- with/without time dimension
- with/without advection

Skill-score (in %): relative reduction of mean square error

dimension of analysis	advection constraint	skill-score
2D	no	0
2D	yes	29
3D	no	27
3D	yes	44

Want to use Diva?

Playing...

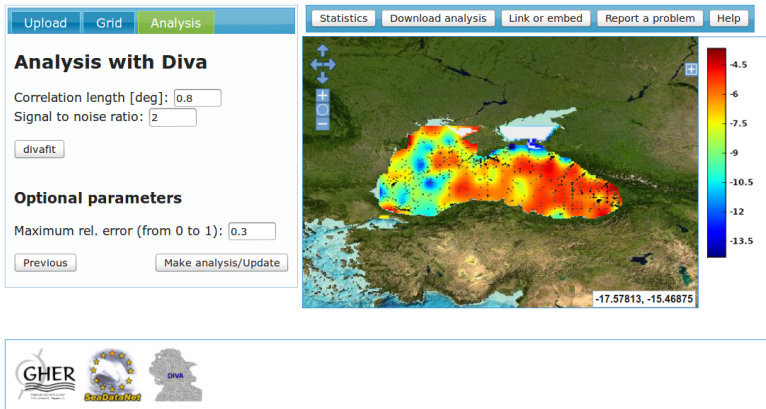


Contact: Alexander Barth, a.barth at uig.ac.be, 2012.

http://data-assimilation.net/Tools/divand_demo/html/

Want to use Diva?

With your own data...



The screenshot displays the Diva web interface. On the left, the 'Analysis' tab is active, showing 'Analysis with Diva' with input fields for 'Correlation length [deg]: 0.8' and 'Signal to noise ratio: 2'. Below these are buttons for 'divafit', 'Optional parameters', and 'Maximum rel. error (from 0 to 1): 0.3'. At the bottom of this panel are 'Previous' and 'Make analysis/Update' buttons. On the right, a navigation bar includes 'Statistics', 'Download analysis', 'Link or embed', 'Report a problem', and 'Help'. The main area features a spatial map of the North Sea region with a color-coded data overlay. A vertical color scale on the right ranges from -13.5 (blue) to -4.5 (red). The map includes a zoom control on the left and a coordinate box at the bottom right showing '-17.57813, -15.46875'. At the bottom of the interface, logos for GHER, SeaDataNet, and Diva are displayed.

<http://gher-diva.phys.ulg.ac.be/web-vis/diva.html> or ODV

OceanBrowser

Web-based viewer of climatologies (in NetCDF)

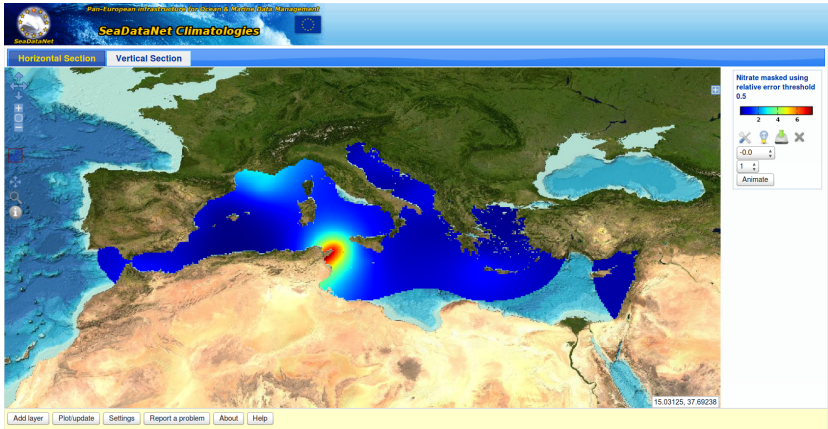
The screenshot displays the OceanBrowser web interface. At the top, there is a header with the SeaDataNet logo and the text "Pan-European infrastructure for Ocean & Marine Data Management" and "SeaDataNet Climatologies". Below the header, there are two tabs: "Horizontal Section" (selected) and "Vertical Section". The main area shows a satellite-style map of the Atlantic Ocean with a blue color scale representing ocean depth or temperature. A vertical toolbar on the left side of the map contains various navigation and tool icons. An "Add layer" dialog box is open in the foreground, featuring a search input field, an "Add Server" button, and a list of layers under the heading "SeaDataNet Map Server [-]". The layers list includes:

- Arctic
- Atlantic
- Baltic
 - DIVA 4D analysis of AMON.19752005
 - DIVA 4D analysis of H2SX.19752005
 - DIVA 4D analysis of NTOI.19752005
 - Chlorophyll-a Climatological Monthly Mean - Baltic Sea
 - DIVA 4D analysis of SLCA.19752005
 - DIVA 4D analysis of sal.19752005
 - DIVA 4D analysis of temp.19752005
 - DIVA 4D analysis of CPHL.19752005
 - DIVA 4D analysis of SLCA.19752005
 - DIVA 4D analysis of TPHS.19752005
- Black Sea

At the bottom of the dialog box are "Cancel" and "Add layer" buttons. The bottom of the main interface features a navigation bar with buttons for "Add layer", "Plot/Update", "Settings", "Report a problem", "About", and "Help". A small text string "-19.02344, 96.28906" is visible in the bottom right corner of the map area.

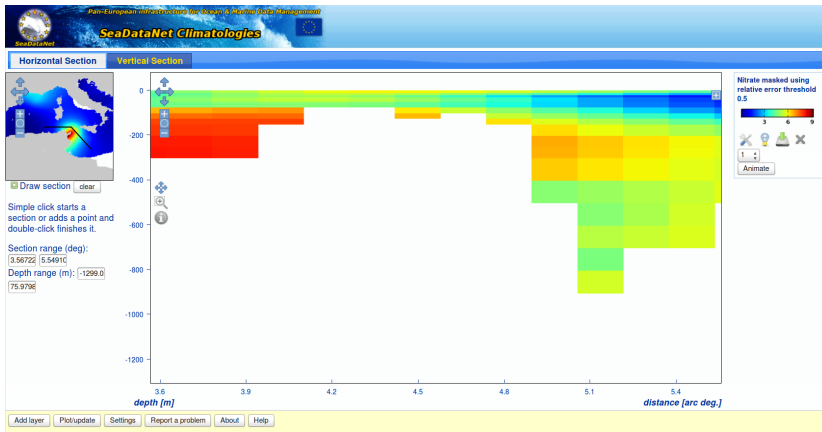
OceanBrowser

Based on OGC standards: WMS, WFS



OceanBrowser

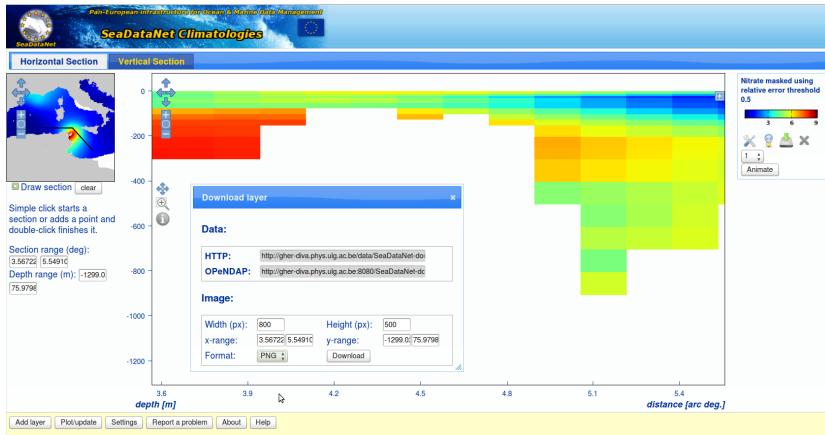
Horizontal section at predefined depth
and arbitrary vertical sections



OceanBrowser

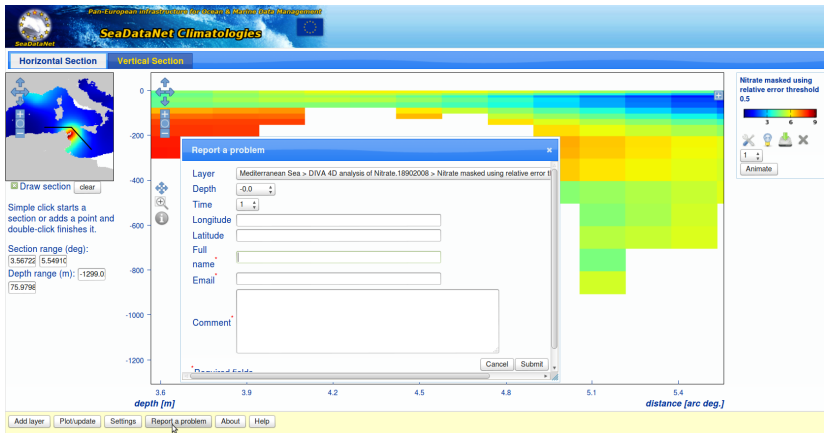
Output formats:

- Images: PNG, SVG, EPS, KML
- Animations: MP4 and WebM



OceanBrowser

Direct user feed-back ☒



Conclusions

- 1 Implementation of **Diva** in more than 2 dimensions (on a curvilinear grid).

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Conclusions

- 1 Implementation of **Diva** in more than 2 dimensions (on a curvilinear grid).
- 2 The benefit of the advection constraint demonstrated in 2 and 3 dimensions.
- 3 Various ways (with various degrees of complexity) are offered to use or try this method.
- 4 A web interface has been developed to visualize the output of **Diva** aiming to simplify the dissemination of data products.

Thanks for your attention

- http://data-assimilation.net/Tools/divand_demo/html/
- <http://gher-diva.phys.ulg.ac.be/web-vis/diva.html>
- <http://modb.oce.ulg.ac.be/mediawiki/index.php/DIVA>

