




SeaDataCloud

DIVA software and the

 @CharlesTroupin, A. Barth, S. Watelet & J.-M. Beckers
University of Liège, GeoHydrodynamics and Environment Research

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sdn-userdesk@seadatanet.org - www.seadatanet.org

Can you guess the temperature at the "?"



Spatial interpolation: Why is it needed?

Ocean observation is expensive and complex



Credit: www.socib.es



Ocean observation is expensive and complex

"A measurement not made is a measurement lost forever"

"Collect once, use many times"

Can you guess the temperature at the "?"

$$\frac{14.4 + 16.1}{2} = 15.25^{\circ}\text{C} \quad ??$$



Can you guess the temperature at the "?"

$$\frac{14.4 + 16.1}{2} = 15.25^{\circ}\text{C} \quad ??$$



NOT BAD



6 reasons why

spatial interpolation

is not so easy

1 Synopticity error

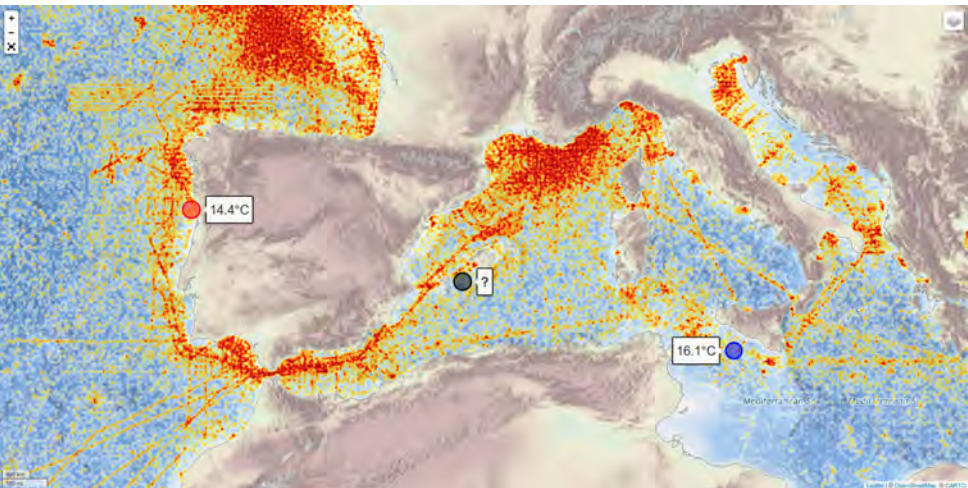
Measurements not collected at the same time

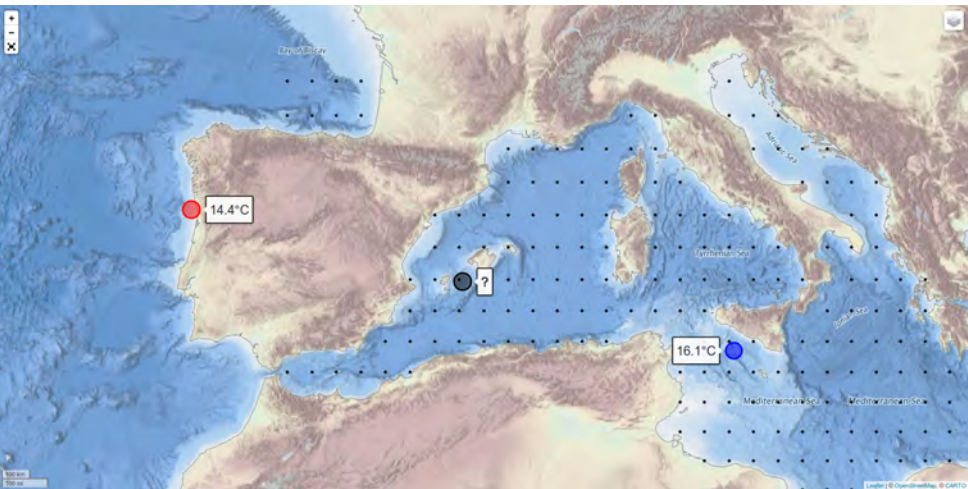


What we measure is not always
what we intend to analyse

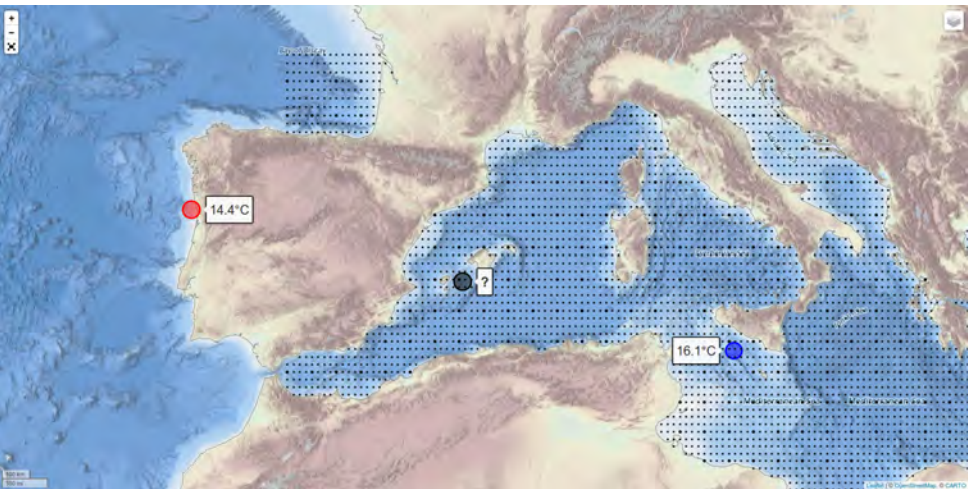
Example: I want the mean annual temperature off Porto
but ships are only at sea when the weather is good

3 A lot of observations, but not everywhere





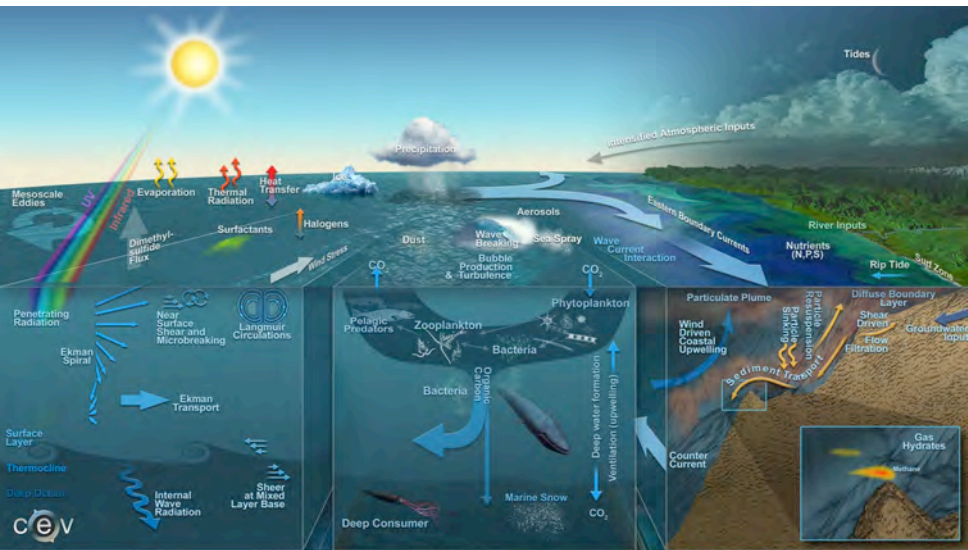
Need to interpolate at many locations



Land acts as a physical barrier



6 A lot of processes taking place...





How do we do it?

Minimisation of a cost function taking into account:

- 1 Closeness to the observations
- 2 Regularity/smoothness of the solution

$$J[\varphi] = \sum_{i=1}^N \mu_i [d_i - \varphi(x_i, y_i)]^2 + \int_D (\nabla \nabla \varphi : \nabla \nabla \varphi + \alpha_1 \nabla \varphi \cdot \nabla \varphi + \alpha_0 \varphi^2) dD,$$

solved by a finite-element technique

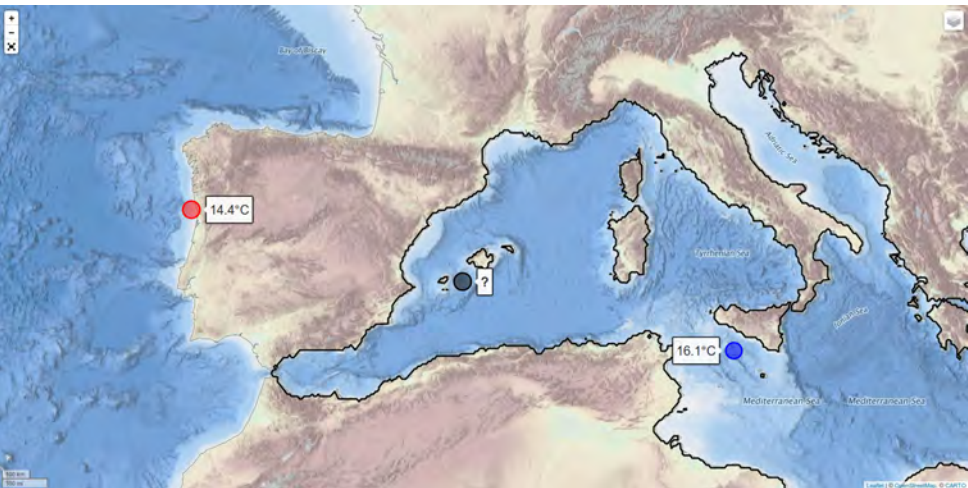
 <https://github.com/gher-ulg/DIVA>

 DOI [10.5281/zenodo.836727](https://doi.org/10.5281/zenodo.836727)



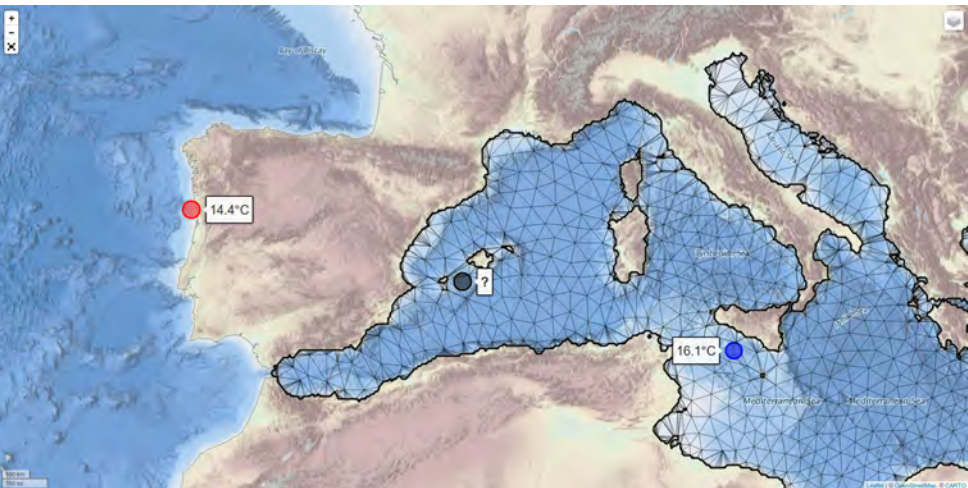
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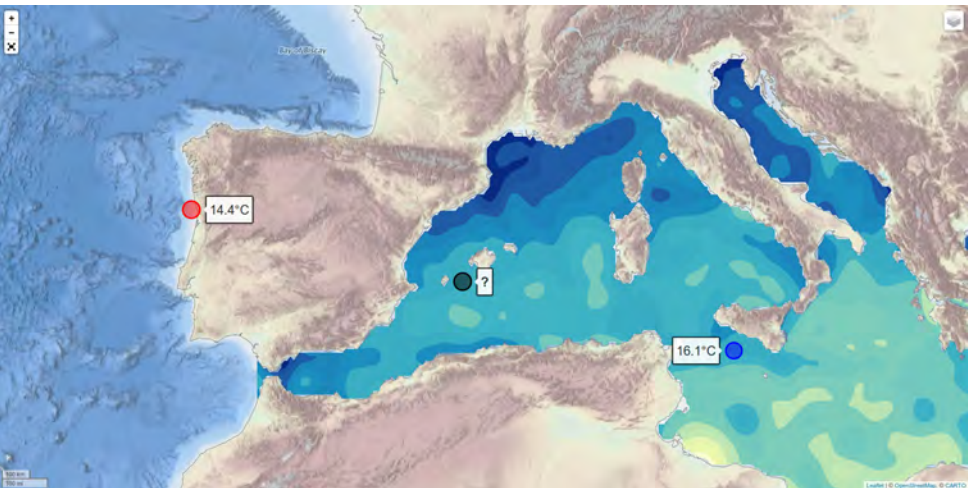
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2013:  GNU Octave or MATLAB

2016:  julia

faster, better, stronger

divand-1.0: n -dimensional variational data analysis for ocean observations

A. Barth^{1,*}, J.-M. Beckers¹, C. Troupin², A. Alvera-Azcárate¹, and L. Vandenbukke^{3,4}

¹GHER, University of Liège, Liège, Belgium

²IMEDEA, Esporles, Illes Balears, Spain

³seamod.ro/Jailoo srl, Sat Valeni, Com. Salatrucu, Jud. Arges, Romania

⁴CIIMAR, University of Porto, Porto, Portugal

* *Invited contribution by A. Barth, recipient of the EGU Arne Richter Award for Outstanding Young Scientists 2010.*

Correspondence to: A. Barth (a.barth@ulg.ac.be)

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 <https://www.geosci-model-dev.net/7/225/2014/gmd-7-225-2014.pdf>

 <https://github.com/gher-ulg/divand.jl>

$$\begin{aligned}
& K^{n,m}(r) \\
&= c^{n,m} \frac{(2\pi)^{-\frac{n}{2}}}{2(1-m)} r^{\frac{2-n}{2}} \int_0^\infty J_{\frac{n-2}{2}}(kr) k^{\frac{n-2}{2}} \frac{d}{dk} \left(\frac{1}{(1+k^2)^{m-1}} \right) dk \\
&= c^{n,m} \frac{(2\pi)^{-\frac{n}{2}}}{2(m-1)} r^{\frac{4-n}{2}} \int_0^\infty J_{\frac{n-4}{2}}(kr) k^{\frac{n-4}{2}} \frac{k}{(1+k^2)^{m-1}} dk \\
&= \frac{1}{4\pi(m-1)} \frac{c^{n,m}}{c^{n-2,m-1}} K^{n-2,m-1}(r)
\end{aligned}$$

n is the dimension

m is the highest derivative

where

$K^{n,m}$ is the Kernel

$J_\nu(r)$ is the Bessel function of first kind or order ν

Problem

- 1 Synopticity error
- 2 Representativeness error
- 3 Many observations
- 4 Interpolate at many locations
- 5 Anisotropy
- 6 Currents

Solution in DIVA

Regularity constrain in cost function

Numerical cost (almost) independent on the number of data points

Finite-element solver

Finite-element solver

Advection included in the cost function

- 1 Documentation, including equations and export to pdf
- 2 Code fragments for different steps of the interpolation
- 3 Figures illustrating the data or intermediate results

```
In [2]: import numpy as np
import matplotlib.pyplot as plt
```

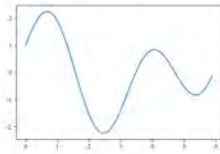
Data

Let's create a simple function.

```
In [6]: x = np.arange(0, 6, .1)
y = np.cos(x) + 1.5 * np.sin(2 * x)
```

Make a simple plot

```
In [7]: plt.plot(x, y)
plt.show()
```



NATURE | TOOLBOX



Interactive notebooks: Sharing the code

The free IPython notebook makes data analysis easier to record, understand and reproduce.

Helen Shen

05 November 2014

[http://www.nature.com/news/
interactive-notebooks-sharing-the-code-1.16261](http://www.nature.com/news/interactive-notebooks-sharing-the-code-1.16261)



Notebooks: workflow description

Provide the jupyter-notebooks
along with the data product (interpolation)

Easy to share: <http://nbviewer.jupyter.org/>,
<http://github.com/>

Make easier the **reproducibility** and peer-review

Why do we need

Virtual

Research

Environments?



Computational resources

Storage and inversion of huge matrices

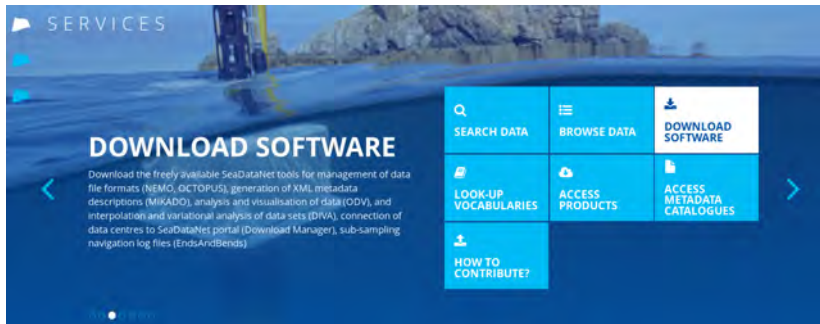
Typical case:

Horizontal grid: 500×500

Vertical levels: 50 depth levels

Time periods: 20

People connect, access the data, and work!



The screenshot shows a web interface for SeaDataCloud services. The background is a blue-tinted image of a ship's deck with a crane. The word "SERVICES" is in the top left. A large "DOWNLOAD SOFTWARE" section is prominent, with a description of tools for data management. A grid of navigation buttons is on the right, including "SEARCH DATA", "BROWSE DATA", "DOWNLOAD SOFTWARE", "LOOK-UP VOCABULARIES", "ACCESS PRODUCTS", "ACCESS METADATA CATALOGUES", and "HOW TO CONTRIBUTE?".

SERVICES

DOWNLOAD SOFTWARE

Download the freely available SeaDataNet tools for management of data file formats (NEMO, OCTOPUS), generation of XML metadata descriptions (MIKADO), analysis and visualisation of data (ODV), and interpolation and variational analysis of data sets (DNA), connection of data centres to SeaDataNet portal (Download Manager), sub-sampling navigation log files (EndsAndBends)

SEARCH DATA	BROWSE DATA	DOWNLOAD SOFTWARE
LOOK-UP VOCABULARIES	ACCESS PRODUCTS	ACCESS METADATA CATALOGUES
HOW TO CONTRIBUTE?		



Installing is sometimes much harder than running the code...




DIVAnd in the VRE with jupyterhub



Management of multiple instances of the single-user Jupyter notebook server

The screenshot shows the JupyterHub interface. At the top left is the 'jupyter' logo. To the right are 'Control Panel' and 'Logout' buttons. Below the logo are tabs for 'Files', 'Running', and 'Clusters'. A message says 'Select items to perform actions on them.' To the right of this message are 'Upload' and 'New' buttons. The main area shows a file browser view for the path '/ Projects / SeaDataCloud / Julia'. It contains a table of files and folders:

	Name	Last Modified
Folder icon	-	seconds ago
Folder icon	data	a month ago
Folder icon	test	4 months ago
Notebook icon	DIVAnd-in-Jupyter-Notebook.ipynb	5 months ago
Notebook icon	DIVAnd_EUDAT_example_pub.ipynb	5 months ago

 <https://github.com/jupyterhub/jupyterhub>
Demo available at <https://hub-test.oceanbrowser.net/>
(deployed at CINECA via Docker)

Authentication

Inputs: CDI data and user data

Results of the interpolation

Outputs: data products, climatologies,
gridded fields

MarineID or





Summary

- ✓ Spatial interpolation is a **frequent** but **not trivial** operation in ocean sciences

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- ✓ **Specific** tools (DIVA, DIVAnd) have been designed for data interpolation

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- ✓ **Specific** tools (DIVA, DIVAnd) have been designed for data interpolation
- ✓ With a VRE, **more** users can access **more** easily SeaDataCloud resources (metadata, data & tools)



Thanks for your attention

Tools	Leaflet DIVA DIVAnd
Map layers	EMODnet Bathymetry Earth At Night 2012
MedSea observations	Temperature and salinity observation collection V1.1

The temperature at the "?"

