Generation of analysis and consistent error fields using the Data Interpolating Variational Analysis (Diva)

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http://modb.oce.ulg.ac.be/mediawiki/index.php/DIVA

The problem

Spatial interpolation or *gridding* is a very common task in oceanography.

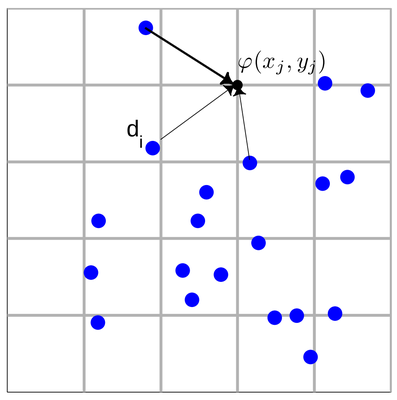

Figure 1: Gridding problem: blue dots are the data points that serve to obtain the field on the regular grid (grey lines).

However, the traditional interpolation methods:

- do not take into account coastline and physical boundaries,
- **and/or** do not provide an error field,
- **and/or** use isotropic correlation function,
- **and/or** are very expensive.

Our solution: Diva

What is Diva?

- ✔ a method to produce gridded field
- ✔ a set of bash scripts and Fortran programs

What is not Diva?

- ✖ a plotting tool
- ✖ a *black-box*
- ✖ a numerical model

How does it work?

We try to find a field that minimises a *cost function* made up of:

1. the distance between analysis and data (*observation constraint*),
2. the regularity of the analysis (*smoothness constraint*),
3. physical laws (*behaviour constraint*).

The domain where the interpolation has to be performed is covered by a *finite-element mesh* that follow the coastline.

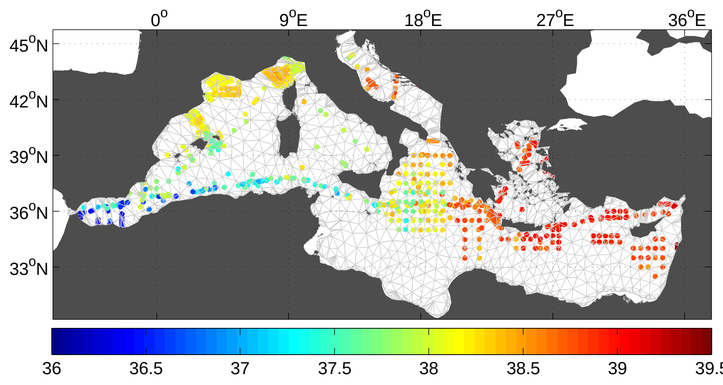

Figure 2: Finite-element mesh and salinity measurements in the Mediterranean Sea at a depth of 30 m in July, for the 1980-1990 period.

Analysis parameters

A given interpolation with Diva is mainly determined by two parameters:

1. The correlation L, which measures the radius of influence of data points.
2. The signal-to-noise ratio λ, which measures the different kinds of noise (representativity, on measurements, ...).

L and λ can be determined objectively using special Diva tools

Analysis

Once the analysis parameters are set, the gridded field is obtained.

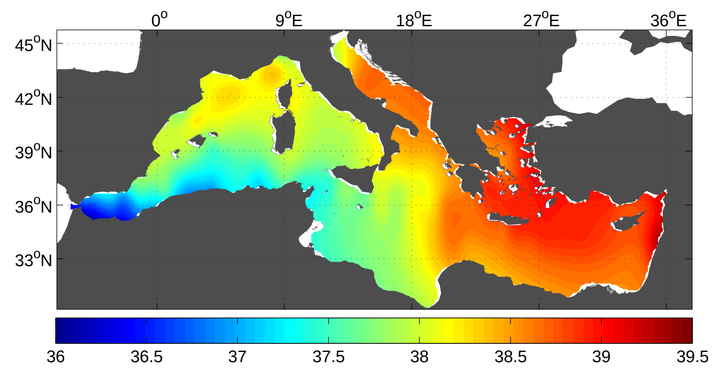

Figure 3: Salinity field obtained with $L = 1.42°$ and $\lambda = 1$.

We observe the characteristic zonal gradient of salinity, with the lowest values in the Alboran Sea.

Comparison with OI

Optimal Interpolation (OI) is frequently used for spatial interpolation.

The main difference between OI and Diva occur near the Italian coasts: the effects of the physical boundary is not taken into account in OI, and an artificial mixing takes place.

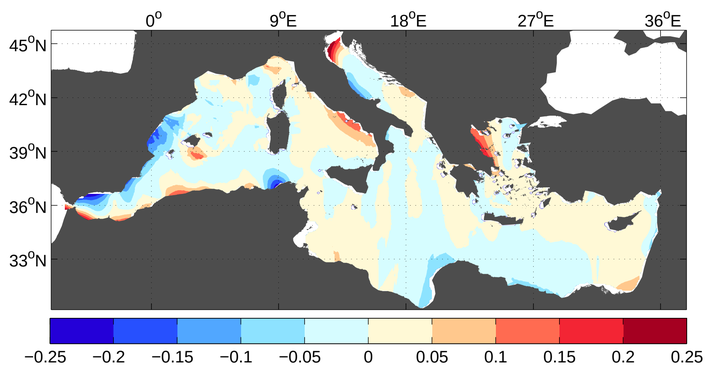

Figure 4: Difference between OI and Diva salinity fields obtained with $L = 1.42°$ and $\lambda = 1$

Error fields

The interest of the error field is to indicate where one cannot *trust* the analysed field.
intuitively, the error is high:

- Where you don't have observations.
- Where you have lot of noise on the observations.

Several methods are implemented to provide an error field:

1. The poor man's estimate,
2. The hybrid method, similar to the error in computed in OI.
3. The real covariance error, obtained by two simultaneous Diva executions.

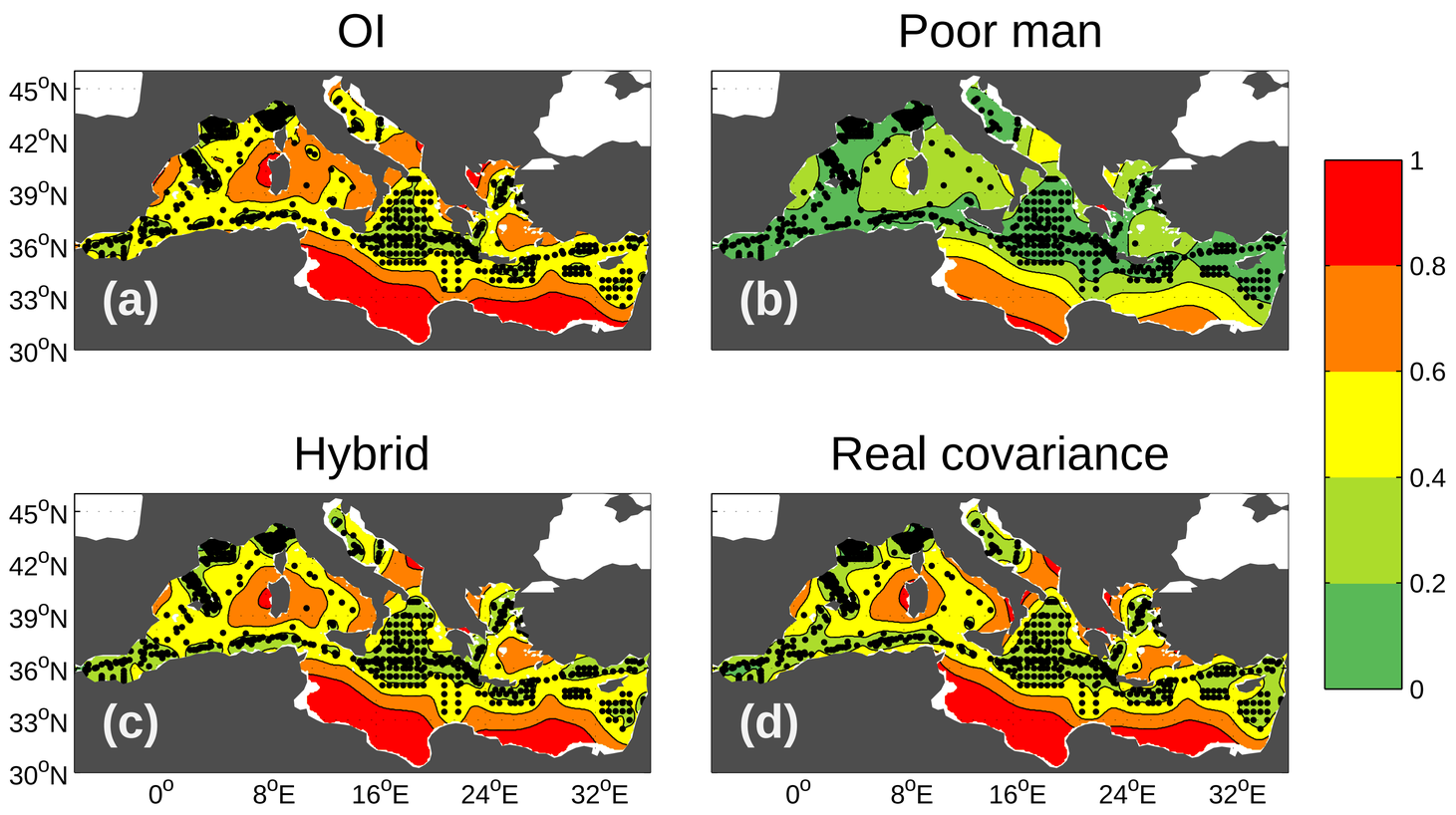

Figure 5: Error fields computed using four different methods: (a) OI, (b) poor man's estimate, (c) hybrid and (d) real covariance methods.

Conclusions

Diva is a method to generate gridded fields from sparse observations by minimising a cost function.

The cost function to minimise considers *observational*, *regularity* and *behaviour* constraints.

The minimisation of the cost function is carried out with a *finite-element solver*. The later reduces the numerical cost and avoid the influence of data points located in disconnected basins.

The error field can be estimated by using the real covariance function, computed with two simultaneous Diva executions.

Acknowledgments

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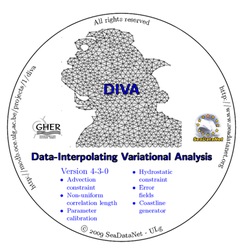
How to get the code

The code is distributed under the terms of the GNU General Public License (GPL). It is available on the Diva homepage or by scanning the QR-code.



This poster is based on:

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