Climatology and circulation of the Azores-Canary region by Data-Interpolation Variational Analysis

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1 Abstract

The Azores-Canary region, located off NW Africa, is characterized by a strong mesoscale variability induced by the presence of the Canary archipelago in the passage of the Canary Current, the outflow of Mediterranean water and upwelling filaments generated near the capes (Ghir, Jubi, Blanco) of the NW Africa coast.
The available climatologies (World Ocean Atlas 2001; World Ocean Atlas 2005; HydroBase) do not permit a satisfying representation of those mesoscale phenomena, since their resolution is sensitively larger than the typical length scale of the processes (Rossby deformation radius).
Although numerous cruises were carried out in the region (CANIGO, RODA, etc.), few work were focused on the compilation of the data available in the region.
With these arguments in mind, we used the software DIVA (Data-Interpolation Variational Analysis) based on the Variational Inverse Method (Brasseur et al., 1996) on the data collected from major data sets in order to reproduce monthly, seasonal and annual climatologies of temperature and salinity at various depths.

2 Data

Data were initially gathered from various databases in the region $0-60°$N $\times$ $0-50°$ W. Duplicate removal, outlier detection and time sorting (monthly and seasonal) and vertical interpolation (*Weighted Parabolas* method, Reiniger and Ross, 1968) were performed on the whole dataset.

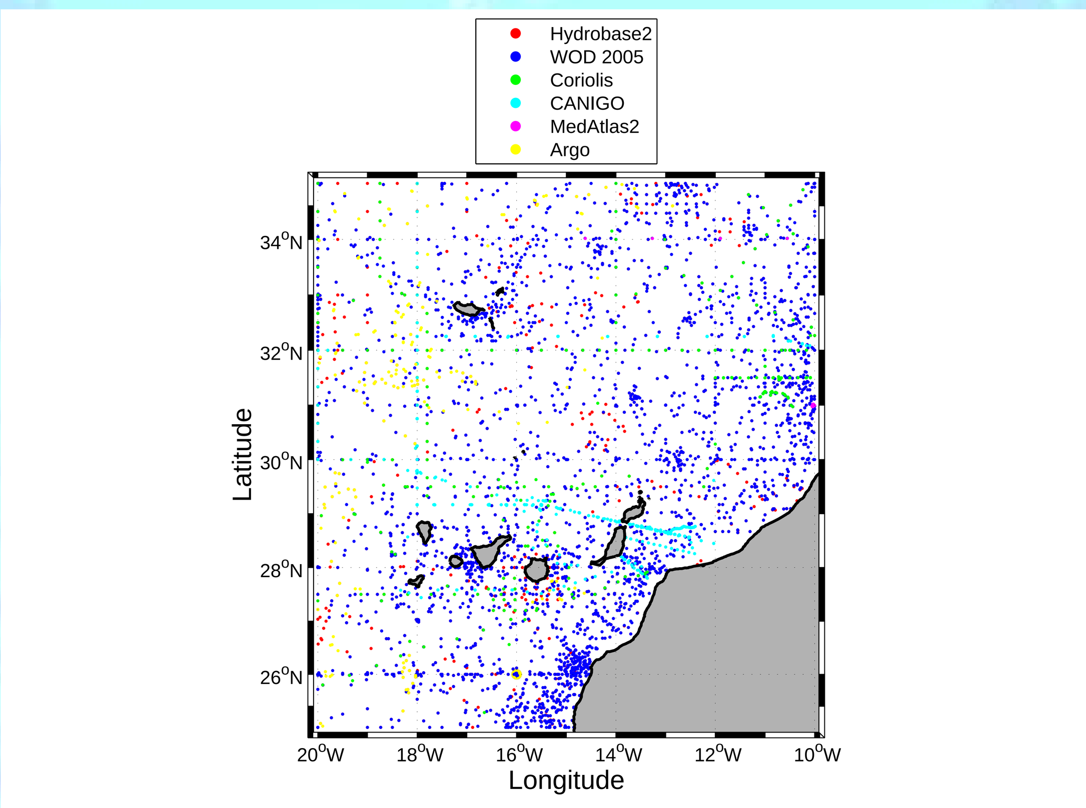

FIGURE 1: *Localization and source of the profiles used in the analysis.*

3 Method

Diva is designed to perform *data-gridding*, with the assets of taking into account the intrinsic nature of oceanographic data, *i.e.* the uncertainty on the *in situ* measurements and the anisotropy due to advection and irregular coastlines and topography.
Resolution of relies on a highly optimized finite-element technique, which permits computational efficiency independent on the data number and the consideration of real boundaries (coastlines and bottom).

3.1 Variational inverse method

The field φ reconstructed by Diva using N_d data d_j located at (x_j, y_j) is the solution of the variational principle

$$J[\varphi] = \sum_{j=1}^{Nd} \mu_j \left[d_j - \varphi(x_j, y_j)\right]^2 + \|\varphi\|^2 \qquad (1)$$

with

$$\|\varphi\| = \int_D (\alpha_2 \nabla\nabla\varphi : \nabla\nabla\varphi + \alpha_1 \nabla\varphi \cdot \nabla\varphi + \alpha_0\varphi^2)\, dD \qquad (2)$$

where α_i and μ are determined from the data themselves, through their *correlation length* L and *signal-to-noise ration* λ.

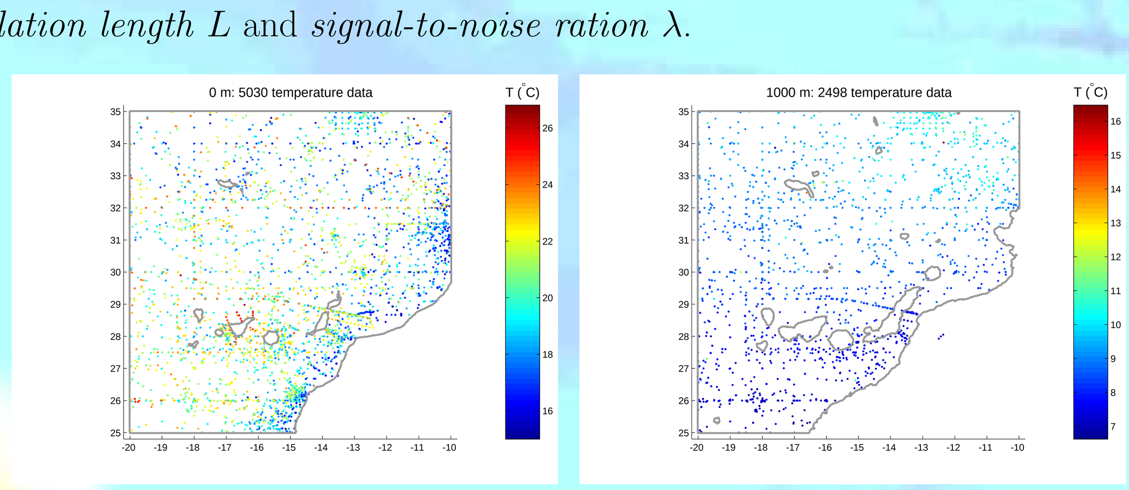

FIGURE 2: *Scatter plots of temperature at surface (a) and at 1000 m depth (b).*

3.2 Finite-element mesh

The triangular-element mesh (Fig. 3) allows a very high resolution of the coastlines, while usual methods (Optimal Interpolation, Gandin, 1965; Bretherton et al., 1976) deal with horizontal resolutions from 1 to 0.25°. For this reason, Diva is a more appropriate method When studying coastal processes such as upwelling.
Moreover, the mesh is adapted to the corresponding contour, which depends on the depth where the analysis is performed (Fig. 3(b)). This limitation of the domain of computation is particularly important when islands are present.

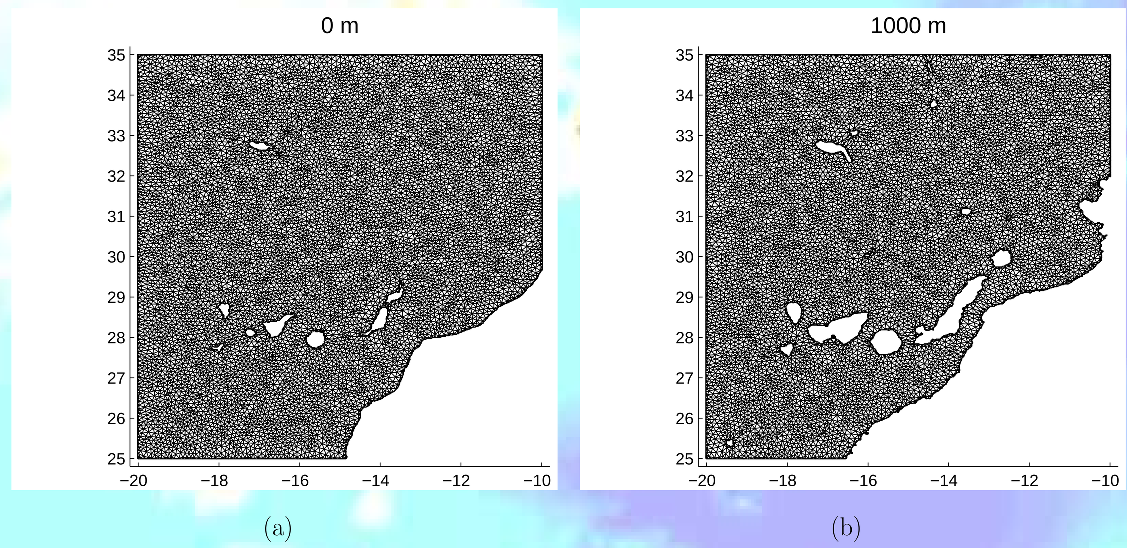

FIGURE 3: *Finite-element mesh at surface (a) and at 1000 m depth (b). The characteristic length of each element is about 10 km.*

4 Results

We present some results of gridded fields reconstructed with the help of Diva software using a data gathered from several databases. The fields are obtained with the following parameters:

- $L = 1°$,
- $\lambda = 0.1$,
- $\Delta x = \Delta y = 0.05°$.

These values were chosen so that we obtain smooth fields that we will compare to other climatologies.
Fig. 4 shows the surface temperature fields for the months of January, April, July and October. In both cases the upwelling is clearly observable, with the lowest temperatures between Cape Jubi and Cape Bojador in January, and off Cape Ghir in July.

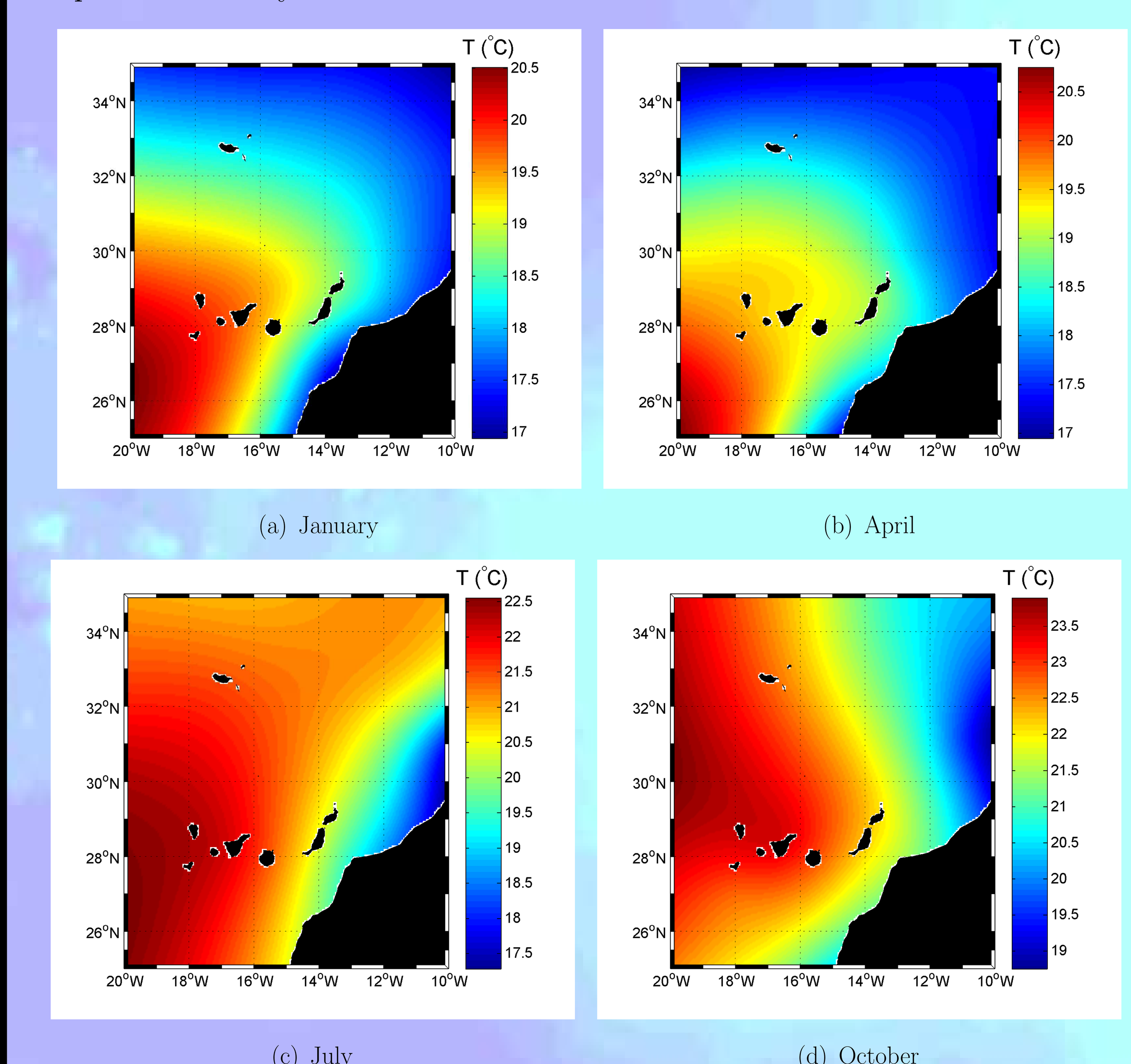

FIGURE 4: *Monthly surface temperature fields for different times of the year.*

Temperature fields at 1000 m (Fig. 5) for January and July illustrates the capability of the method to consider land mask depending on the depth and to analyses the fields only in the ocean part of the domain. It is important to point out that two zones which are physically separated by land will have a smaller influence one on each other.

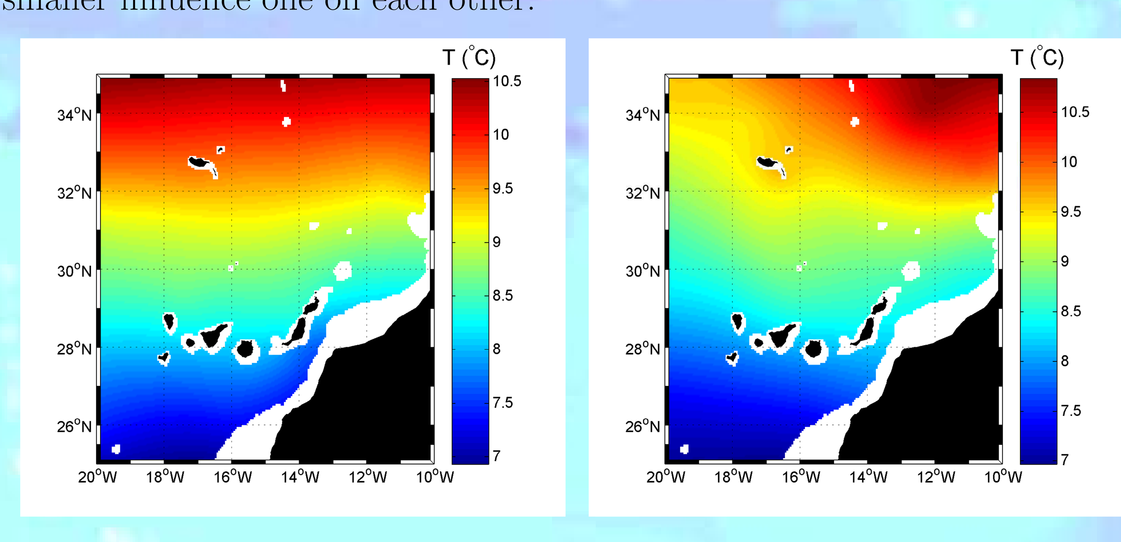

FIGURE 5: *Temperature at 1000 m in January (a) and July (b). Black shaded areas represent the surface coastlines, while the white zone 1000 m is the 1000 m land mask.*

5 Discussion

Comparison with surface temperature maps (Fig. 6) extracted from the World Ocean Atlas 2001 (WOA01, [Boyer et al. (2005)]) underlines the assets of Diva mentioned in Sec. 3. In this case, the island effects are not taken into account during the analysis process and their representation is limited by squares.
Considering that climatologies are frequently use to initialize hydrodynamic models, we believe that having high-resolution gridded field can improve the results of such models.

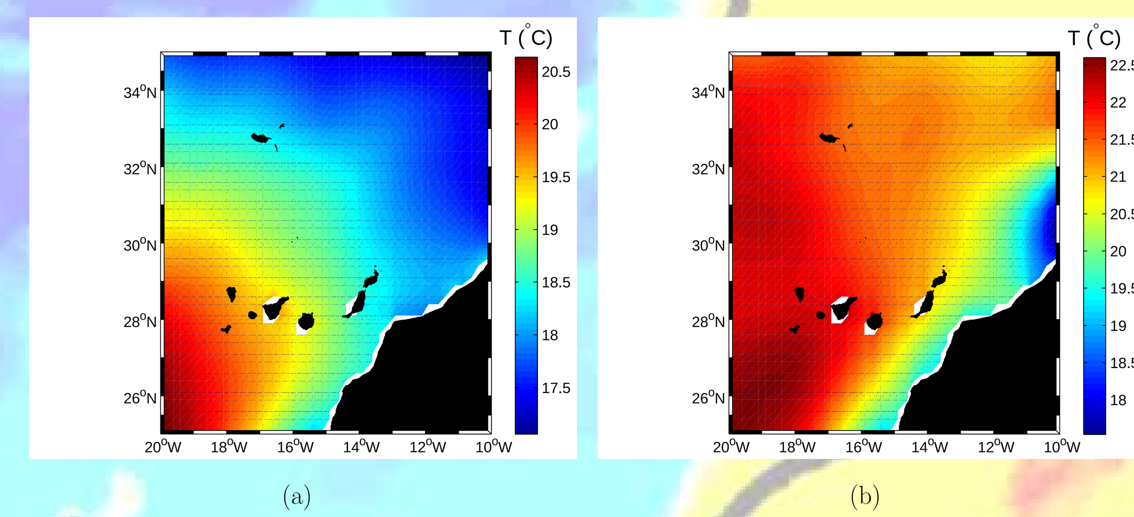

FIGURE 6: *WOA01 surface temperature in January (a) and July (b).*

6 Conclusion

We considered a large dataset covering the Canary Island region to illustrate the efficiency of Diva software for producing realistic gridded fields.
The method provide results comparable to WOA01 climatology, but with much better representation of the coastlines and the islands. Furthermore the size of the data set is not an obstacle here, since the computation time is nearly independent on the number of data.
Further work will be dedicated to the creation of gridded field corresponding to model grid (*e.g.* ROMS) in order to provide the model with new initial conditions.
We also expect to use the full software capacity by adding advection constraint to the analysis so that we can produce even more realistic fields.

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http://modb.oce.ulg.ac.be/projects/1/diva

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