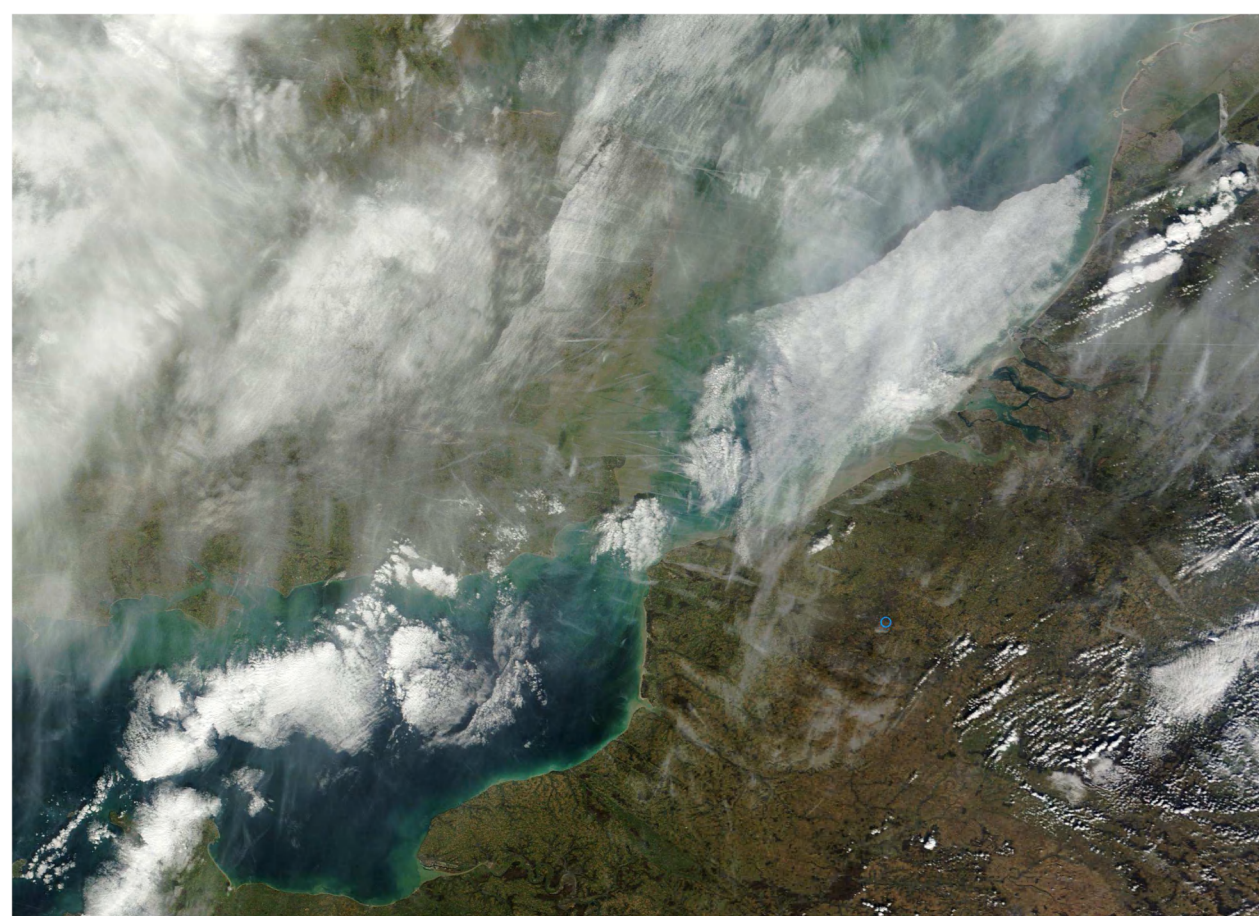


1. Summary



Most of the satellite images are affected by ☁, leaving gaps in the maps. We present an objective method for filling incomplete satellite images and called DINEOF.

2. Method

DINEOF = Data + Interpolating + Empirical Orthogonal Functions [Beckers and Rixen, 2003, Alvera-Azcárate et al., 2005, 2007]

It is an iterative method based on a decomposition into *principal modes* of variations.

The missing pixels are reconstructed using a truncated *Singular Value Decomposition*. If $\mathbf{X}$ is a matrix containing a time series of images:

$$\mathbf{X} = \mathbf{U}\mathbf{S}\mathbf{V}^T \quad (1)$$

with

$\mathbf{U}$, the spatial EOFs,

$\mathbf{V}$, the temporal EOFs and

$\mathbf{S}$, the singular values.

The temporal covariance matrix is filtered in order to enhance the coherence between successive images

[Alvera-Azcárate et al., 2009].

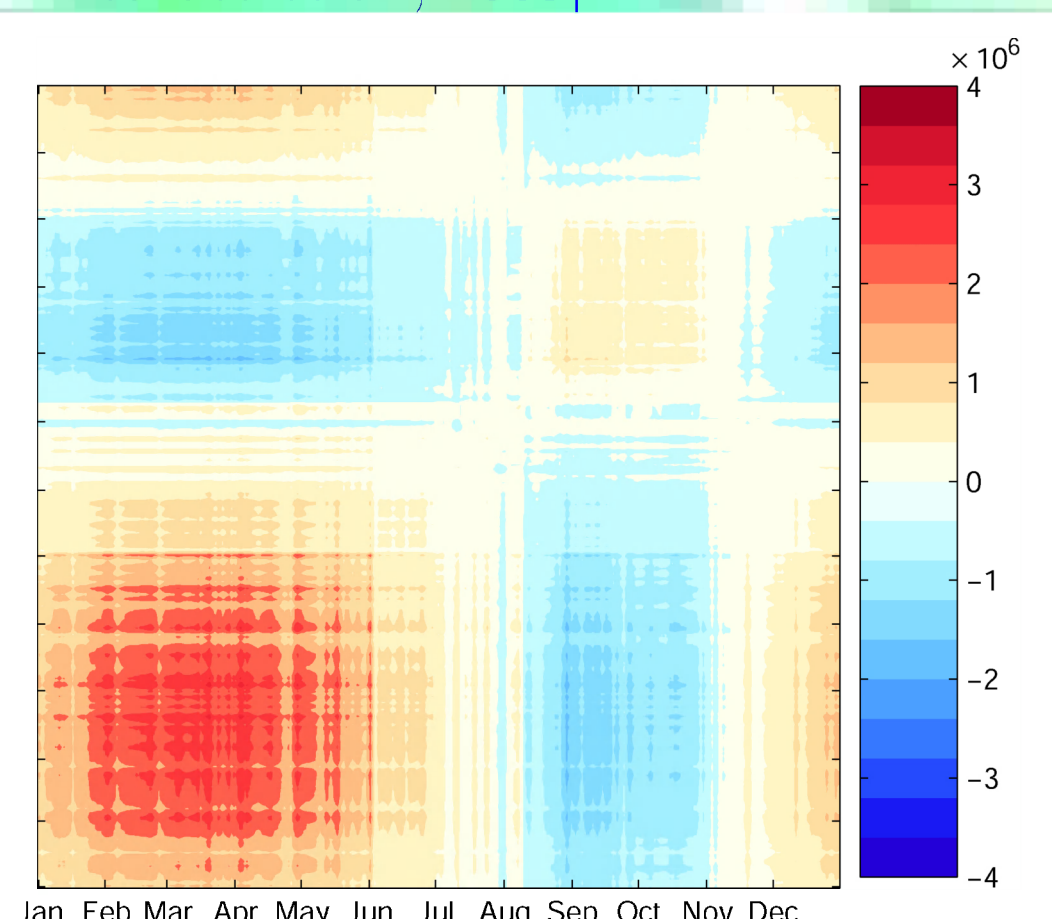


FIGURE 1: Time covariance matrix for the SST in the Canary Island area in 2010.

The optimal number of retained modes is determined by *cross-validation*.

The code can be obtained at <http://modb.oce.ulg.ac.be/mediawiki/index.php/DINEOF>

3. Data

Any kind of satellite measurements can be exploited:

- sea-surface temperature (SST),
- total suspended matter (TSM),
- chlorophyll concentration,
- wind, ...

The method works on a *time series* of images.

The variables can be used separately (*monovariate*) or simultaneously (*multivariate*).

The outputs are:

1. The reconstructed fields.
2. The temporal and spatial modes.

4. Results

1st example: SST in the Canary Islands region

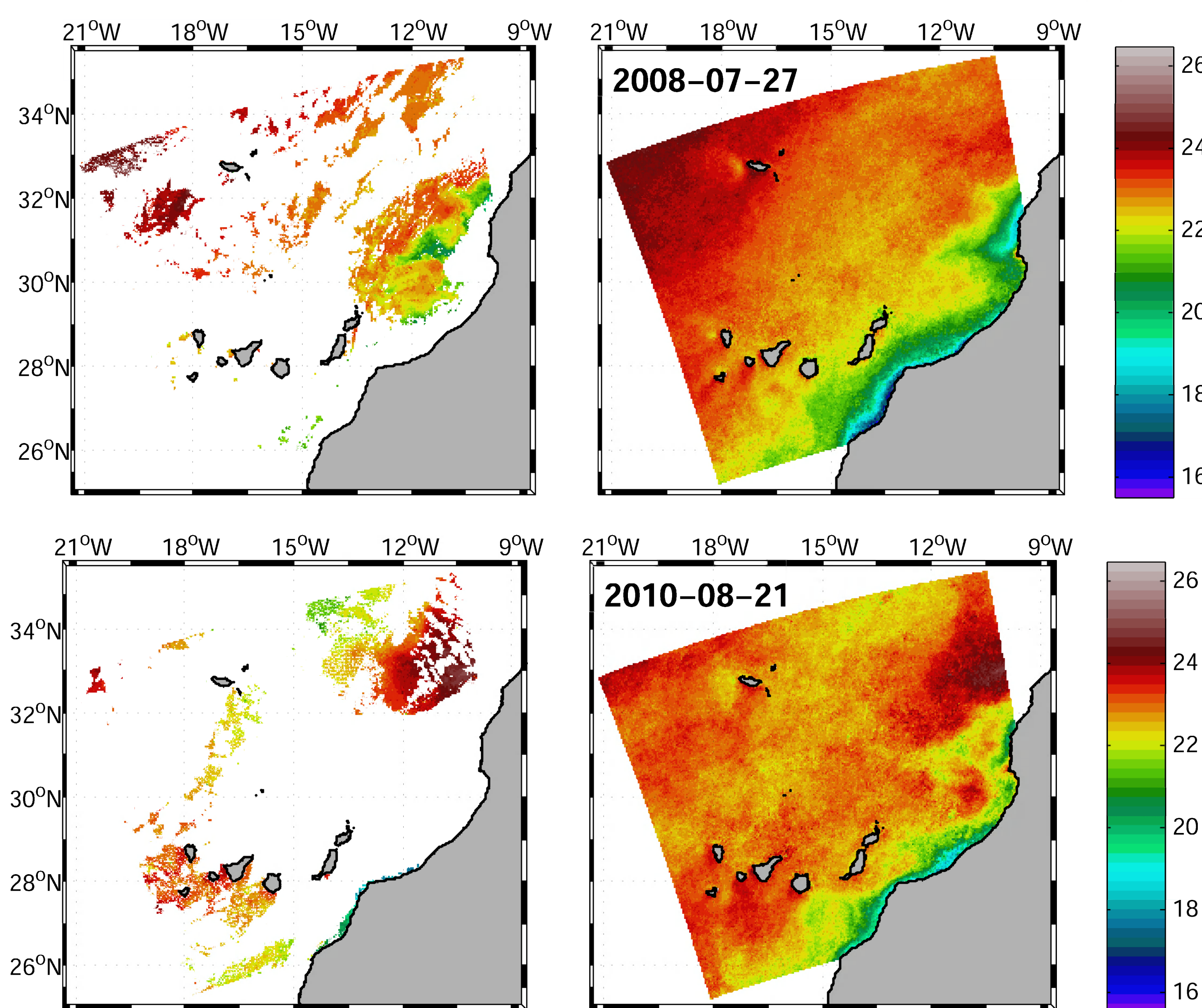


FIGURE 2: Reconstructions of SST for July 27, 2008 and September 1, 2010.

2nd example: TSM in the North Sea

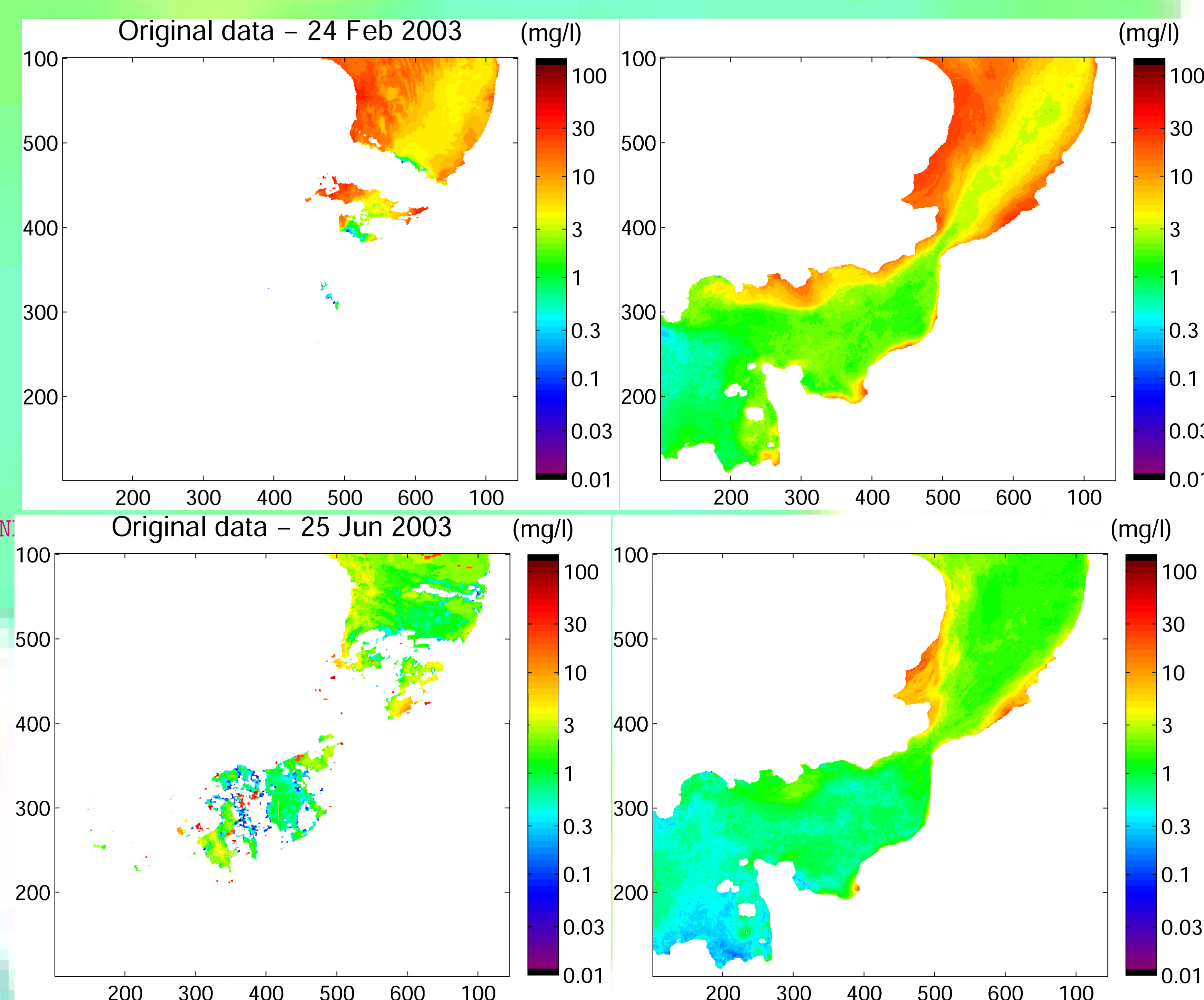


FIGURE 3: Reconstructions of TSM for February 24 and for June 25, 2003.

4.1 Spatial modes

Corresponding to the SST in Figure 2.

1st mode: meridional temperature gradient.

2nd mode: separation between coastal and open-ocean waters.

3rd mode: 1% of the total variance, structure similar to 1st mode.

4th mode: island wakes ...

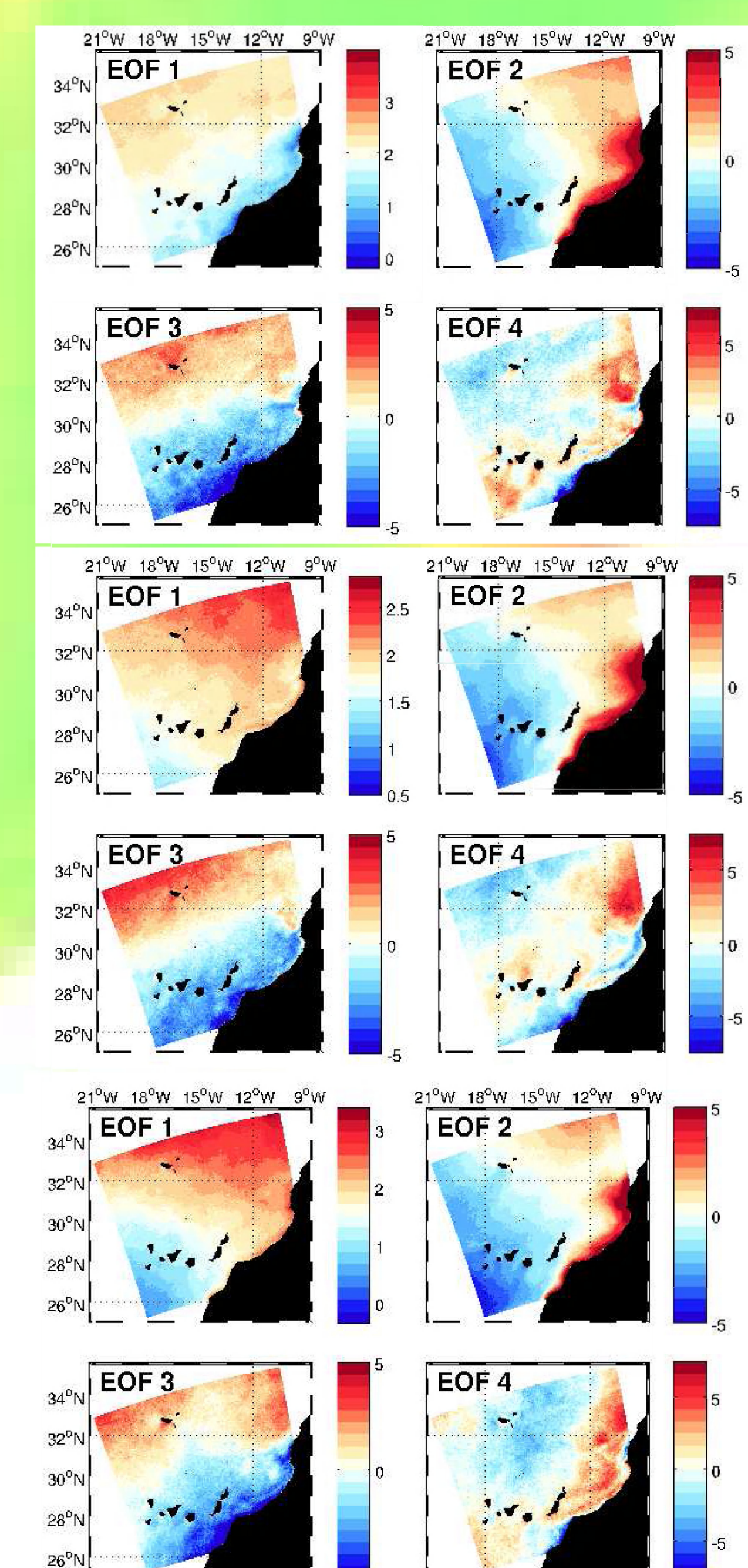


FIGURE 4: First four spatial modes for 2008, 2009 and 2010.

4.2 Temporal modes

1st mode: seasonal cycle of temperature.

2nd mode: related to wind curl.

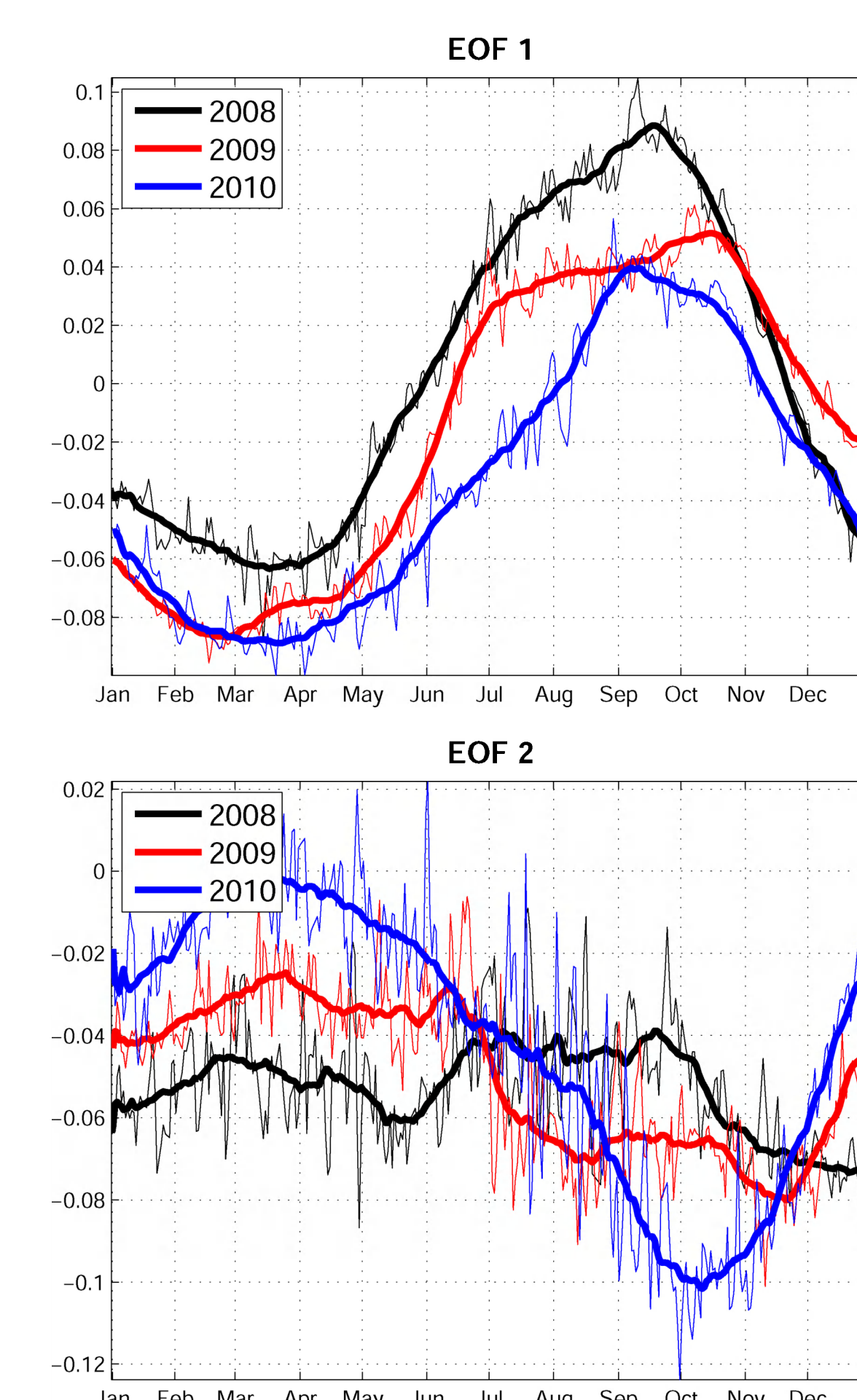


FIGURE 5: First two temporal EOFs. Thick curves indicate the 30-day running averages.

Summary

DINEOF is an *EOF-based* method designed to fill in missing data from geophysical fields. It has been successfully applied to various data sets.



Main references

- Alvera-Azcárate, A.; Barth, A.; Rixen, M. & Beckers, J.-M. (2005), Reconstruction of incomplete oceanographic data sets using Empirical Orthogonal Functions. Application to the Adriatic Sea, *Ocean Model.*, **9**, 325-346, doi:10.1016/j.ocemod.2004.08.001.
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- Sirjacobs, D.; Alvera-Azcárate, A.; Barth, A.; Lacroix, G.; Park, Y.; Nechad, B.; Ruddick, K. & Beckers, J.-M. (2011), Cloud filling of ocean colour and sea surface temperature remote sensing products over the Southern North Sea by the Data Interpolating Empirical Orthogonal Functions methodology, *J. Sea Res.*, **65**, 114-130, doi:10.1016/j.seares.2010.08.002.