ENIGME - Interannual Evolution of the Dynamics in the Bay of Biscay and the English Channel

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Objectives

In a context of global change, ocean regions as the Bay of Biscay and the English Channel represent key domains to estimate the local impact on the coasts of these evolutions. Indeed, the coastal (considering in this project regions above the continental shelf) and regional (including the continental slope and the abyssal plain) environments are sensitive to these long-term evolutions driven by the open ocean, the atmosphere and the rivers. These evolutions can have impacts on the whole ecosystem. To understand and, by extension, forecast evolutions of these ecosystems, we need to go further in the description and the analysis of the past interannual variability over decadal to pluri-decadal periods.

The ENIGME project is organised following three main axes:

- the interannual evolutions (haline and thermal budgets, currents),
- the occurrence of intermittent events and the mesoscale dynamics,
- the sea level in regional models.

To illustrate the first outcomes from the ENIGME project, started the 1rst March 2014, we introduce preliminary results from the study of the interannual variability based on 53-years long simulations. The numerical simulation framework and specific task on observations are also described.

Simulation framework

To explore the interannual variability, different numerical simulations (Tab. 1) will be performed and/or analysed in the frame of the project. The diversity of models and configurations considered (coastal, regional of global) aims to contribute to the understanding of the mechanisms driving the evolution of the considered processes.

	Configuration / model	Simulation	Domain	Spatial resoluton	Contact
≤10 years	**IBIRYS** / NEMO	With assimilation	IBI	1/12° (~9 km) - z	M. Benkiran, G. Reffray
	MANGA-PREVIMER / MARS3D	Without assimilation, OBC : PSY2V4, AF : ARPEGE HR, AROME	English Channel – Bay of Biscay	2.5 km - sigma	L. Pineau-Guillou, F. Dumas
	MANGA-SN / MARS3D	Spectral nudging with IBI12, OBC : IBI12	English Channel – Bay of Biscay	2.5 km - sigma	F. Dumas
	MANGA-36 / MARS3D	Over grid ORCA IBI36, OBC :IBI12	English Channel – Bay of Biscay	1/36° (~3 km) - sigma	S. Theetten
	BACH / MARS3D	OBC: DRAKKAR 1/12°, AF : ERA40+ERAINTERIM	English Channel – Bay of Biscay	4 km, 2.5 km - sigma	F. Vandermeirsch
	HIBACH / MARS3D	OBC : BACH runs 4Km and 2,5Km, AF : ERA40+ERAINTERIM	Bay of Biscay	~1 km - sigma	F. Vandermeirsch
	AZTI / ROMS	Without assimilation, OBC : ECCO (NASA) / TPXO.7, WOA5/TPXO.5; AF: Meteo Galicia products, NCEP-reanalysis	Bay of Biscay	4 km, 6-6.5 km - sigma	L. Ferrer / M. Chifflet
	POC / S25	Targeted simultations for 2-3 given years	Bay of Biscay	~1 km - sigma	N. Ayoub / P. Marsaleix
53 years	**BACH** / MARS3D	OBC : DRAKKAR 1/4°, AF : ERA40+ERAINTERIM	English Channel – Bay of Biscay	4 km, 2.5 km	F. Vandermeirsch
Global reanalysis	**GLORYS** / NEMO	With assimilation	Global	1/4°	Mercator-Ocean
	DRAKKAR / NEMO	Without assimilation	Global	1/4°, 1/12°	A.-M. Tréguier / C. Talandier

Table 1: Numerical simulation to be performed and/or analysed in the frame of the project (OBC: Open Boundary Conditions; AF: Atmospheric Forcings; z: z-level vertical coordinates; sigma: sigma vertical coordinates).

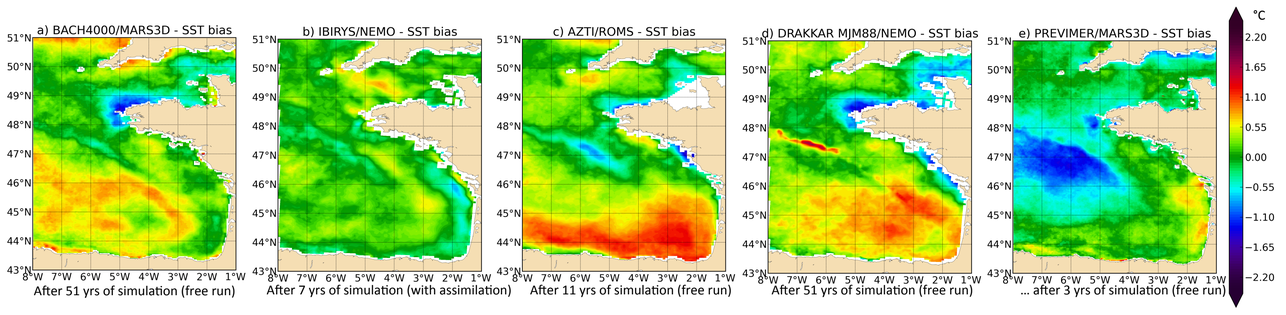

Figure 1: Mean bias (<Observed> - <Modelled>) in Sea Surface Temperature (SST) for the year **2009**. Observations are remotely sensed SEVIRI SST products (Le Borgne *et al.*, 2011). Different numerical simulations are considered: (a) BACH4000/MARS3D, (b) IBIRYS/NEMO, (c) AZTI/ROMS, (d) DRAKKAR MJM88/NEMO, and (e) PREVIMER/MARS3D.

In Fig. 1, an example of the comparisons performed in the project is presented. These maps exhibit a general agreement (with errors lower than 2°C) between simulations and observations even after long-term (around 50 years) simulations (Fig. 1a, Fig. 1d). The global simulation (Fig. 1d) highlights expected errors due to the lack of tide dynamics and the reduced number of river runoffs over the continental shelf. The effect of the assimilation in the reanalysis from Mercator-Ocean (IBIRYS – Fig. 1b) clearly appears in the small biases in SST. Coastal configurations based on sigma vertical coordinates (BACH4000/MARS3D Fig. 1a, ROMS/AZTI Fig. 1c, PREVIMER/MARS3D Fig. 1e) show larger biases close to Brittany (due to the representation of tidal fronts – improved in recent BACH4000 simulations including tides) and in the Southern part of the Bay of Biscay (Fig. 1c). This last point is under investigation as it also appears in more recent BACH4000 experiments.

Observations – new products dedicated to the Bay of Biscay / English Channel region

CORA-IBI – an *in situ* database in the Ireland-Biscay-Iberia region

A dataset has been aggregated over the Ireland-Biscay-Iberia (IBI) region (20°N – 60°N / 35°W – 12°W) for the period 1958-2012 (Szekely, 2014, pers. communication). This dataset is an extraction from CORA4.0 (Cabanes *et al.*, 2013) global dataset combined with the BOBYCLIM dataset (Vandermeirsch *et al.*, 2010).

The Fig. 2 displays the number of vertical profiles during the whole period with the opening of the international databases (SeaDataNet, since 1990), the advent of the ARGO profilers in 2000's. We can also notice the impact of measurements of opportunity with the RECOPESCA project since 2007.

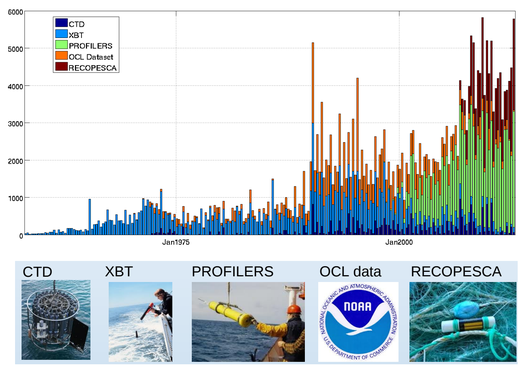

Figure 2: Number of vertical profiles by sources in the CORA-IBI database.

A new Sea Surface Temperature product

Two high resolution (4 Km) Level-4 (without missing data) Sea surface Temperature (SST) datasets are being prepared for the verification of model SST fields. To create those, the Pathfinder v5.2 (Casey *et al.*, 2010) and SEVIRI (Le Borgne *et al.*, 2011) SST datasets are processed with the missing data filling Data Interpolating EOFs (DINEOF) methodology (Beckers and Rixen, 2003; Alvera-Azcárate *et al.*, 2005; Alvera-Azcárate *et al.*, 2009). In the case of the Pathfinder v5.2 dataset only best quality (flag 7) data is used, the reconstructed product covers the 1981-2011 period with twice daily frequency (day and night images) and the details of the methodology can be found in Esnaola *et al.* (2012) and Esnaola *et al.* (2013). In the case of the SEVIRI dataset the methodology is being adapted for hourly data covering the 2004-2014 period, and considering the data with the three highest quality levels (Fig. 3).

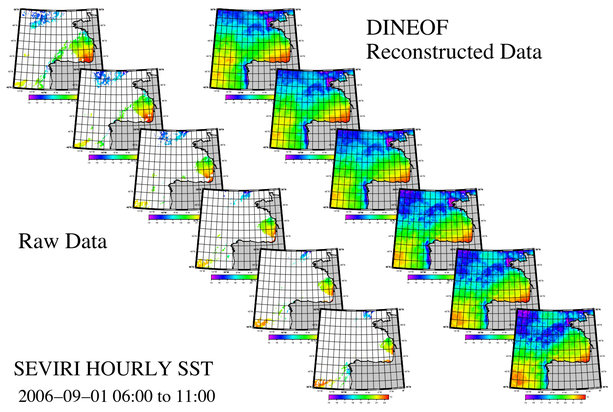

Figure 3: Example of a series of hourly SEVIRI Sea Surface Temperature images processed with the DINEOF technique for the first of September of 2006. Raw and reconstructed versions of the images starting at 06:00 (back) and ending at 11:00 (front) are shown.

Preliminary outcomes from the project – BACH400 experiment

As a first step in the analysis of the interannual variability in the Bay of Biscay and the English Channel, numerical simulations have been performed using the Primitive Equation Ocean Model, MARS3D (Duhaut *et al.*, 2008; Lazure and Dumas, 2008) in the BACH4000 configuration (Tab. 1 - without tide dynamics). The modelled spatial resolution is 4Km for 40 sigma vertical levels.
The simulation in the Bay of Biscay/English Channel extends from 1rst January 1958 to the 31rst December 2010 with daily outputs (Theetten *et al.*, pers. communication, 2014).

Temperature and Salinity over 53 years

Figure 4: Yearly averaged temperature (a, c) and salinity (b, d) over a sub-region (11W-1W / 43N-50N) at 5m depth (a, b), and 400m depth (c, d) for the regional model (BACH4000), the global simulation (GRD100) and the regional interannual climatology (BOBYCLIM) for the temperature only.

The first overview of the interannual variability reproduced by our regional simulation gives promising results. Indeed, in temperature, at 5m depth (Fig. 4a) and 200m depth (not shown), we observe a good agreement between the climatology (Michel *et al.*, 2009a; Vandermeirsch *et al.*, 2010) and our simulation. Furthermore, the regional simulation is closer to the observations than the global results, suggesting a contribution of the regional dynamics resolved with higher spatial resolution. At the opposite, at 400m depth (Fig. 4b), simulated temperature values are less coherent with observations due to a regional simulation too diffusive (solving of this issue in progress).
For the salinity (Fig. 4b, d), we observe a divergence of the solutions between the regional and the global simulations from 1979. This divergence can be due to the switch in atmospheric forcings (ERA40 to ERAINTERIM) and is under investigation.

Water masses in the Bay of Biscay

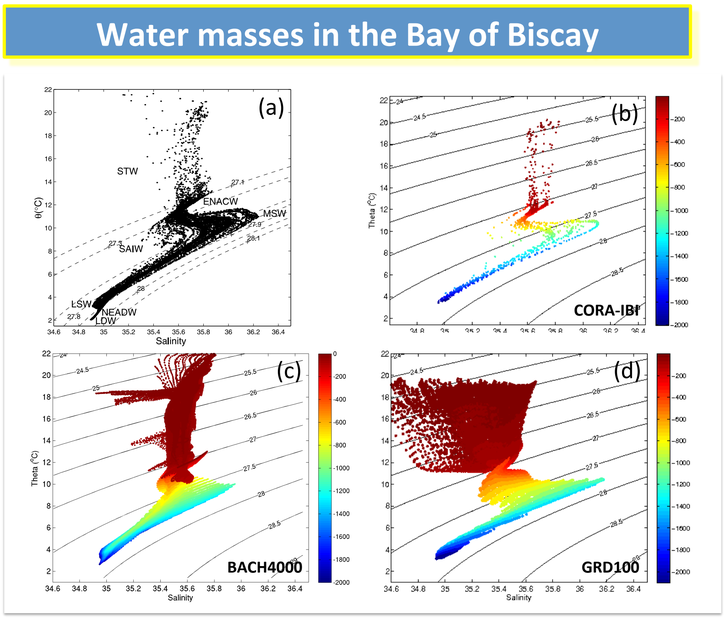

Figure 5: T/S diagrams (a) from Fraile-Nuez *et al.* (2008) during VACLAN cruises in August 2005, (b) from the CORA-IBI database, (c) from the regional simulation (BACH4000), and (d) from the global simulation (GRD100) during August 2005.

The main **water masses** in this region (Fig. 5a) are represented in both global (Fig. 5d) and regional simulations (Fig. 5c) in agreement with vertical profiles, from ARGO floats, in CORA-IBI dataset (Fig. 5b). At this stage, the comparison is qualitative and more quantitative scores are under production but we can already notice that the MSW (Mediterranean Sea Water) is eroded in the regional simulation (Fig. 5c) with salinities lower than 36 for waters between 8°C and 10°C. This result confirms the improvements needed (*e.g.* open boundary conditions, position of vertical levels) in the resolution of deeper structures in the regional simulation.

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Acknowledgements: *The work is part of the ENIGME project supported by the CNRS/INSU and Mercator-Océan through the group LEFE/GMMC. This work was granted access to the HPC resources of CINES under the allocation 2014-017096 made by GENCI. We thank the PREVIMER and DRAKKAR projects for providing simulations necessary for this project. We thank S. Petton for fruitful discussions to perform simulations. We would like to thank the Coriolis Research & Development group (including T. Szekely, G. Reverdin, and S. Pouliquen) for the aggregation of the CORA-IBI database. The data from the EUMETSAT Satellite Application Facility on Ocean & Sea Ice used in this study are accessible through the SAF's homepage http://www.osi-saf.org.*