Using ROMS to Model the Iroise Sea Region, on the West Coast of Brittany.

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Objectives

The dynamics of temperate coastal ecosystems results from multiple strains operating at high or medium frequency, superimposed to pluri-annual fluctuations of anthropogenic or climatic origin.

At the tip of Western Europe, the "Bay of Brest - Iroise Sea" coastal system is a privileged site to study these phenomena since it is affected by both :

o the natural long term fluctuations connected with the North Atlantic Oscillation . This oscillation affects not only the atmosphere (temperature, rainfall, sunny period) but also the ocean (temperature, salinity).

o the anthropogenic disturbances resulting from urbanization and modification of agricultural practices (ex : nitrate fluxes were doubled over the past 20 years in the two main rivers feeding the Bay of Brest).

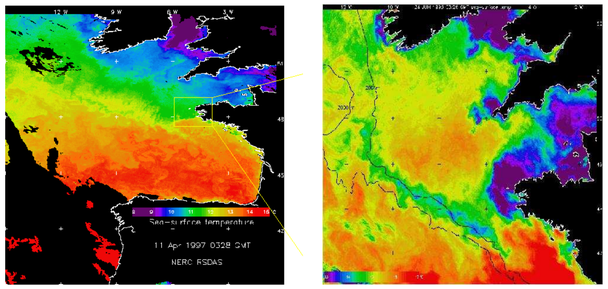
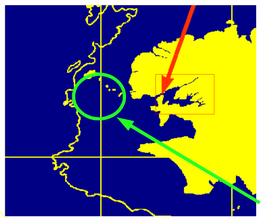


Figure 1
Sea Surface Temperature from satellite data.
The left panel shows a well developed tidal front in the Iroise Sea



The Iroise Sea is a very strong tidal area. In summer (period of stratification), an intense tidal front appears. The frontal region is an area of intense biological production and activity.

The Model: ROMS_AGRIF

This UCLA-IRD version of the code (ROMS_AGRIF) makes use of the AGRIF grid refinement procedure developed at the LMC-IMAG and is accompanied by a powerful toolbox for ROMS pre- and post-processing: ROMS_TOOLS.

The horizontal resolution of this configuration is 1.5 km, with 20 vertical levels. An embedded domain provides a zoom of the Bay of Brest at 300 m resolution.

We forced the tides using the TPXO6 database. The bottom topography is taken from the SHOM database.

Our first goal was to reproduce the frontal pattern in this region where tides are very strong.

Formation of the Tidal Fronts

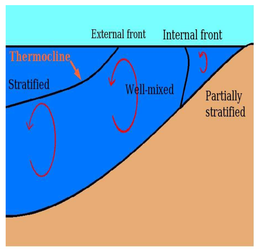


Figure 2
Diagram of tidal front mixing in summer .

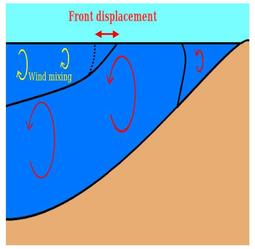


Figure 3
Impact of the winds on front displacement

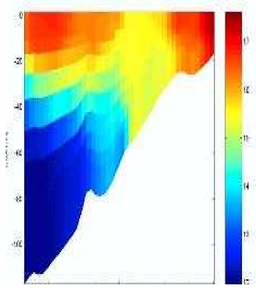


Figure 4
Vertical section of temperature along the front in Iroise Sea.

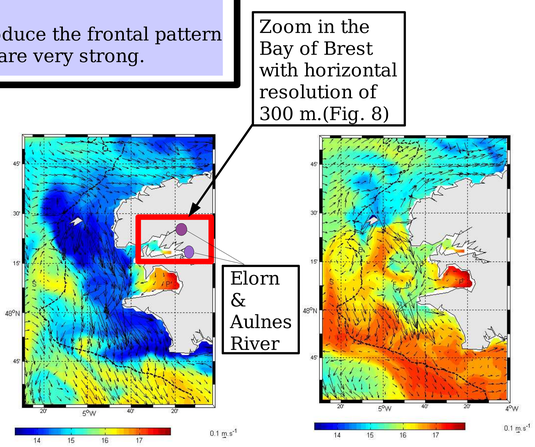


Figure 5
SST map from simulation in stratification period, (left) simulation with wind. (right) simulation without wind.

Methods:
Parameter study:
- Bottom friction parameterization
- Bottom topography
- Horizontal resolution

Study of the forcing:
- Small scales and synoptic winds (H. Muller and P.Marchesiello)
- Small scale and synoptic variability of heat forcing (solar radiation). To be done.

Results:
• The tidal circulation and frontal pattern is reproduced qualitatively well in comparison with buoys and satellite observations.
• The wind has an important role in limiting the stratification process (Fig 2-3). We expect an even stronger impact from the synoptic modulation of solar radiation.

Lagrangian Transports

To better understand the residual lagrangian circulation in the frontal region, we perform lagrangian experiments. For that we use both ROMS online floats and the offline model called ARIANE (Blanke et al,1997).

ARIANE is an offline code dedicated to the computation of 3D streamlines in a given velocity field and subsequent water mass analysis

Results:
2 pathways for water masses in Iroise Sea:
- **A fast way: northward and along the coast.**
- **A slower way: northward, to the west of Ushant Islands**
- **Water masses from the Bay of Brest follows the fast way along the coast. (figure 7, on right)**

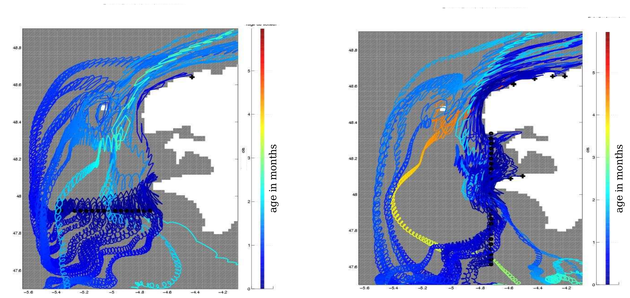
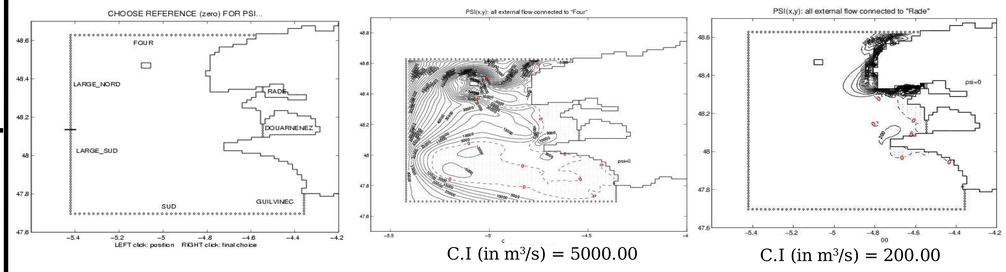


Figure 6
Online Roms floats trajectories in a 6 months run (April - September) with a hourly sampling which allowed us to get the tidal signal.

Examples of Ariane quantitative approach



C.I (in m^3/s) = 5000.00 C.I (in m^3/s) = 200.00

Figure 7
3 D streamlines from Ariane diagnostics. On the left: definition of control sections. At the center: streamlines of particules flowing through the northern section from all sections. On the right: streamlines from the Bay of Brest to the northern section.

Residence times and Biological cycles in the Bay of Brest – A Nesting Approach

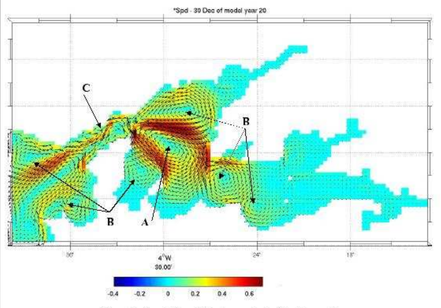


Figure 8
Residual circulation in the Bay of Brest (in $m.s^{-1}$). Horizontal resolution: 300 m

The Bay of Brest is a 180 km^2 – spread basin, connected to the ocean by a 1.8 km-wide narrow passage (Goulet de Brest). Despite the high increase of nutrients through river inputs over the last 20 year, the ecosystem of the bay has shown very few toxic blooms or green tides, which indicates a resistance to eutrophication. The present study intends to give some key elements to understand how the ecosystem works and more precisely to explain this resistance using ecosytem modelling.

Studies:
- Rivers implementation in the code (nitrate flux) to be used in the biological model.
- a residence time map of this Bay using online floats.

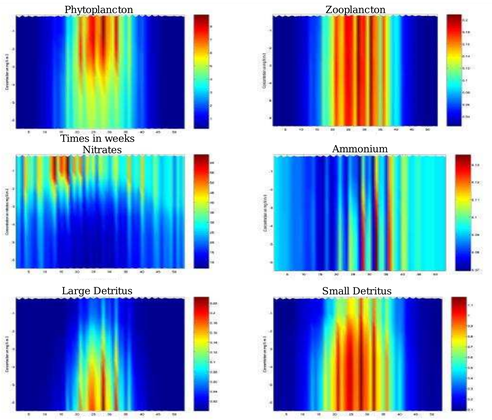


Figure 9
Annual evolution of concentrations in differents compartments of biological model. The impact of the spring-neap tide cycle is evident on the biological fields.

Results:
We obtain a residence time in the Bay of 26 days wich invalidates the hypothesis the tidal flushing is strong enough to rid the bay of nitrate excess. This study leads to give more emphasis on the biological hypothesis: a strong influence of the benthic community and silicate cyle on the ecosystem of the Bay.

References:

V.Mariette, V, B Le Cann, 1985: Simulation of the formation of Ushant therma fronts.
J. Geophys. Res. 999, 937-960, Chauvaud, L., Jean, F., Ragueneau, O., Thouzeau, G. 2000. Long-term variations of the Bay of Brest ecosystem: benthic-pelagic coupling revited. Marine ecology Progress series 200, 35-48