Modelling the Channel and the Bay of Biscay using the MARS model

Contributions:
Dyneco – Physed / Pelagos / Benthos
EMH
Overview

1. The MANGA Configuration

2. Model validation: *Sea Surface Temperature*

3. Sensitivity studies

4. Numerical Methods: *Advection schemes and diapycnal diffusion*

5. Future developments

6. Model applications for the biology
MANGA configuration

A Bay of Biscay / Channel regional modelling  ...
Physical spin-up - 25/12/2003 to 01/07/2004

Analyzed period - 01/07/2004 to 01/07/2006

Heat fluxes.
From Luyten and Mulder (1992)
to Large and Yeager (2004) and Fairall et al. (2003)

Turbulence.
From Gaspard et al (1990)
to the Generic length scale turbulence closure model (Umlauf and Burchard, 2003)
<table>
<thead>
<tr>
<th><strong>MANGA</strong></th>
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</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
<td>MARS v. 8.18*</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>4km, 2.5km / 30 levels</td>
</tr>
<tr>
<td><strong>Grid</strong></td>
<td>Spherical coordinates, Arakawa C</td>
</tr>
<tr>
<td><strong>Coordinates</strong></td>
<td>Generalized sigma</td>
</tr>
<tr>
<td><strong>Bathymetry</strong></td>
<td>Composite (filtered bathymetry, Δh/h &lt; 0.2)</td>
</tr>
<tr>
<td><strong>Vertical mixing</strong></td>
<td>TKE vertical mixing model (Gaspard, 1990)</td>
</tr>
<tr>
<td><strong>Rivers</strong></td>
<td>72 rivers</td>
</tr>
<tr>
<td><strong>Atmospheric forcings</strong></td>
<td>Meteorological forcing from Arpege (Météo-France)</td>
</tr>
</tbody>
</table>
| **Oceanic forcings** | OGCM : ORCA025 – B83 in hindcast mode  
Tide : Sea level calculated by a barotropic 2D model (Mars2D) of the Western European Shelf forced by tides, atmospheric pressure and surface wind stress. |
| **Bottom friction** | Quadratic bottom friction (Z₀ formulation) |
| **Solar penetration** | Jerlov classification + monthly climatology (Gohin, OSD, 2011) |

*In this MARS version:  
- New numeric temporal scheme \( \Rightarrow \) possibility to take \( v = 0 \): no explicit viscosity  
- Better numerical dispersion (better propagation of physical wave on a wider part of the spectrum)  
- Improvement of the standard ADI scheme on the second order error*
Characteristics of MANGA configuration

- 4 km et 2.5 km horizontal resolution
- Two spatial extensions
• 30 vertical generalized sigma layers

\[ z = \zeta(1 + \sigma) + h_c\sigma + (h - h_c)C(\sigma) \]

\[ C(\sigma) = (1 - b) \frac{\sinh(\theta \sigma)}{\sinh(\theta)} + b \frac{\tanh[\theta(\sigma + 0.5)] - \tanh(0.5\theta)}{2\tanh(0.5\theta)} \]

• b = 0.0; theta = 6.0; hc=9.0
Open boundary conditions

\[ u \big|_{\partial \Omega} = u_{\text{marée}} + u_{\text{NEMO}} \]

- Dynamics (dirichlet)

\[ \zeta \big|_{\partial \Omega} = \zeta_{\text{marée}} + \zeta_{\text{NEMO}} \]

- Tracers

\[
\frac{\partial T}{\partial t} = -k(T - T0) \\
T_{\text{ext}}^{n+1} = T_{\text{ext}}^n \left(1 - \frac{dt}{T_{\text{ref}}} \right) + \frac{dt}{T_{\text{ref}}} T_{\text{clim}}
\]

\[
\frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} = 0 \\
T_{\text{ext}}^{n+1} = T_{\text{ext}}^n \left(1 + u \frac{dt}{dx} \right) - u \frac{dt}{dx} T_{\text{int}}^n
\]
Model validation

From Sea Surface Temperature  ...
Observation coverage

From Ocean and Sea Ice Satellite Application Facility (OSI SAF):

**SEVIRI SST**

- Hourly data, midnight considered
- 0.05° grid
Weak bias (<0.4°C) over 2 years except:
- above the continental slope
- along the western northern boundaries
- close to rivers
Seasonal mean bias

Larger biases in summer

⇒ Weak stratification

⇒ too much vertical mixing
Vertical section: 6°W
Sensitivity studies

A set of parameters to tune …
Using $k-\varepsilon$:

- Improvement along the western boundary and in the Ushant front
- Larger bias over the continental slope

→ Further investigations needed for a final conclusion

In the meantime, other experiments in progress …
(for example, using different bulk formulations … Luyten & Mulder or Fairall)
Numerical methods

Advection schemes and diapycnal diffusion
Description of the experiment (1/2)
Description of the experiment (2/2)
Results: sensitivity to the temporal integration method

Methods efficient to reduce errors from implicit diffusion

Diffusion increases with the CFL value
Results: *sensitivity to the temporal integration method*

Methods efficient to reduce errors from implicit diffusion

Diffusion increases with the CFL value
Future developments ...
Few planed actions …

- Assessment of turbulence closure schemes with 2 equations (k-ε, k-w, k-kl, generic)
- Parametrization of air/sea exchanges
- Open boundary conditions
- Influence of waves on the littoral circulation
- Generalised coordinates
Model applications for the biology
From the biogeochemistry to the fish ecology …
The derived indices from the 1972-2008 Hindcast

Stratification  Fronts  Plumes  Eddies  Primary Prod.

A set of ~20 mesoscale and biological indices to characterise the oceanography in the BoB. and relate to fish ecology
Drift and survival of anchovy larvae from an IBM forced by the hindcast

Seasonal pattern of drift for anchovy larvae from dark (beginning) to light (end of season)

Survival maps of anchovy larvae (from homogeneous spawning (l), from observed spawning (c), at the end of drift)

Use in fisheries oceanography
Hindcast use in fisheries oceanography

- Maps of indices
- Time-series

- River plumes
- Temperature, Currents
- Primary Prod.

Environmental Monitoring Indicators

Dynamic models of fish
(IBM larvae / DEB adults)

Habitat mapping
Development of the BGC model for the openwaters in the South of the BoB

Impact of the offshore circulation on the biological production over the shelf

WATER

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<p>| | |</p>
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<tbody>
<tr>
<td>P ad.</td>
<td>P diss.</td>
</tr>
<tr>
<td>Phosphate</td>
<td>N diss.</td>
</tr>
<tr>
<td>Nitrate</td>
<td>P, Si</td>
</tr>
<tr>
<td>Silicate</td>
<td>N part.</td>
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SEDIMENT

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<td>P, Si</td>
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Equilibrium

```
30%  100%
```

Variable $\times 2$ (OW / C)
Mean – August Chl.a

1- Fast remineralisation of the organic matter into the sediment (importance of the benthic activities and our limitation in the evaluation of the rivers impact).
Mean – August Chl.a

2 – Improvement due to the hydrodynamic model evolution
ECO-MARS 3D in the Channel and the Bay of Biscay

Different configurations
The biogeochemical model
Results – example: *Pseudo-Nitzchia*

**Mean Pseudo-Nitzchia from 2000-2009 (REPHY)**

**Simulated biomass in 2003**