High-resolution modelling of ocean-shelf exchange: assessment of a $1/60°$ NEMO configuration of the Atlantic margin (AMM60)

National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

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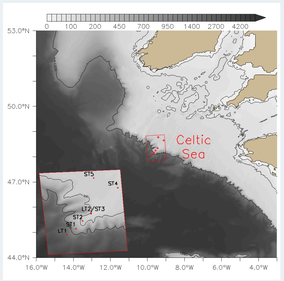
The **FASTNET** project



The FASTNEt project (Fluxes Across Sloping Topography of the North East Atlantic) aims to elucidate the key processes controlling seasonal, inter-annual and regional variations in ocean-shelf exchange, through a combined strategy of observations and modelling.

In this context, a new $1/60°$ degree resolution ($\approx$1.8km) NEMO configuration has been developed. AMM60 extends on the same domain as the UK Met Office operational Atlantic Margin Model ($\approx$7km), enveloping the whole North West European Atlantic margin.

We evaluate here the capability of this high-resolution configuration to reproduce realistically high frequency processes at the shelf break and on the shelf, focusing principally on the Celtic Sea and the Malin Shelf.

Location of the 2 main study areas of FASTNEt. Crosses show the stations locations.
Up: D376 (June 2012, Celtic Sea). Down: JC88 (July 2013, Malin Shelf).

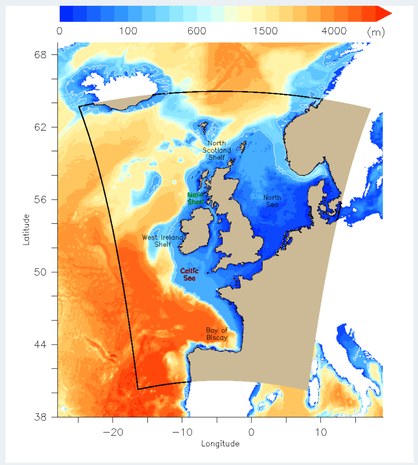
AMM60 (Atlantic Margin Model at $1/60°$)

Domain:
- North-West European Atlantic shelf ($\approx$ same domain as AMM7)
- Regular grid ≈ 1.8 km (1 nm)
- bathymetry from GEBCO

Parameterisation:
- NEMO 3.6
- 2000 processors
- 51 σ-levels
- time-step = 1 minute
- GLS turbulent closure scheme
- TVD advection scheme

Forcings:
- Surface forcings: ERA-interim (CORE bulk formulation)
- Tidal forcing: TPXO7.2
- BDY forcings: NNATL (NEMO, $1/12°$)

Period of simulation:
- 2010 - 2014



Bathymetry of the domain (metres) and key locations.
Isobath 200-m is shown in white

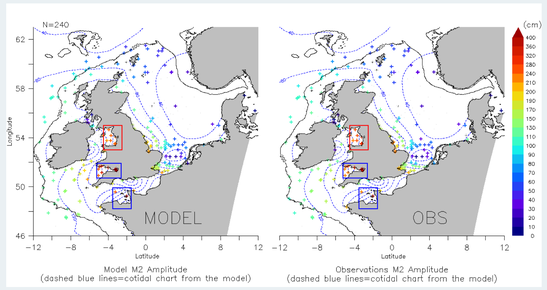
Validation of the configuration

1) Validation of the tidal amplitude

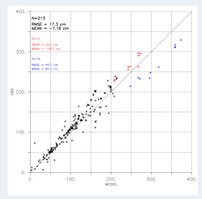
240 tide gauge measurements of the M2 constituent around the UK.

The amplitude of the M2 simulated constituent is in good agreement with tide gauges:
→ small amplitudes in the Irish Sea and the North Sea
→ high amplitudes in the Channel, the Severn and Liverpool Bay
There is a slight overestimation of the amplitude in regions of strong tide (Severn, Channel, in red), but a slight underestimation in Liverpool Bay (in blue).

AMM60 reproduces correctly the amplitude of the M2 constituent, despite a slight overestimation in regions of strong tides. It is well fit for shelf studies.



Left: Simulated amplitude of the M2 constituent (dashed line). Crosses show the amplitude simulated at tide gauge locations.
Right: Simulated amplitude of the M2 constituent (dashed line). Crosses show the amplitude measured at tide gauge locations.

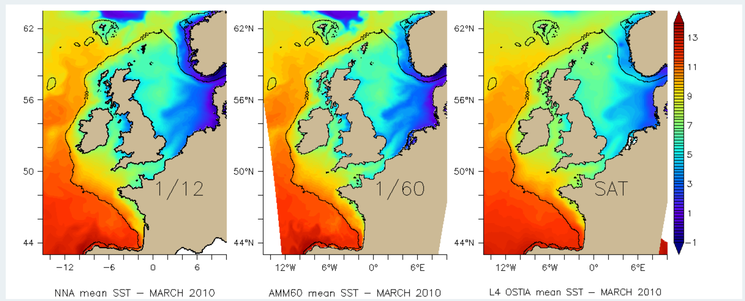


Model versus observations map. The blue stars refer to the Channel and Severn area. The red stars refer to the Liverpool Bay area (areas shown on the figure on the left).

2) Assessment of the SST fields

- The SST is correctly reproduced by AMM60, in agreement with satellite data:
  → Warm front at the shelf break
  → Intrusion of cold waters from the north of the domain and the Baltic Sea
- NNATL and AMM60 have similar patterns:
  → NNA forces AMM60 at the lateral boundaries.
  → Surface forcings are from the same source (ERA interim).

The model reproduces correctly the surface water masses. The forcings have a strong impact on the intruding water masses (cold water intrusion in the North of the domain). No bias is introduced by the increase in resolution.

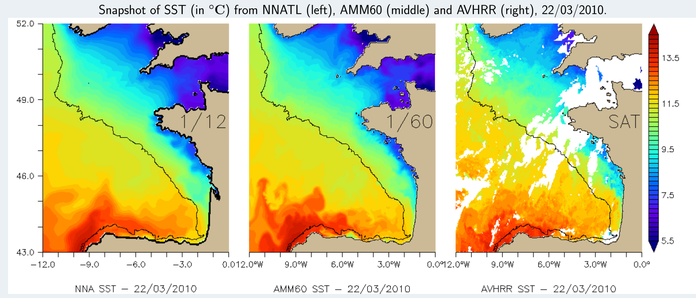


Mean SST (in °C) from NNATL (left), AMM60 (middle) and OSTIA (left), 03/2010.

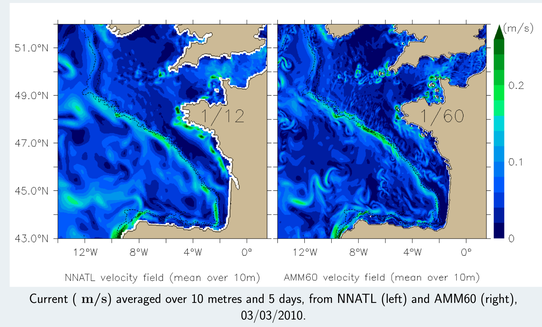
High-resolution processes

1) Mesoscale processes

Snapshot of SST (in °C) from NNATL (left), AMM60 (middle) and AVHRR (right), 22/03/2010.



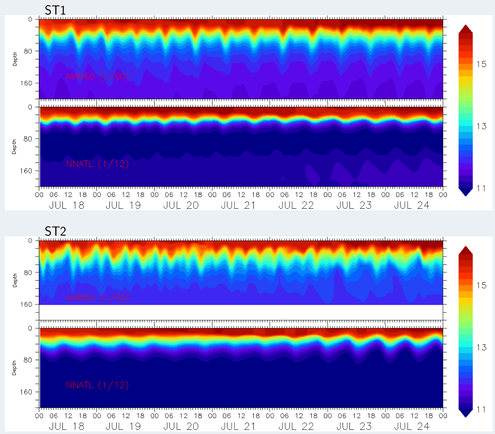
We observe the same general patterns in the $1/60°$ as in the $1/12°$ configuration, but with numerous eddies and filaments in AMM60: offshore, along the slope, and on the shelf.



Current (m/s) averaged over 10 metres and 5 days, from NNATL (left) and AMM60 (right), 03/03/2010.

The presence of mesoscale structures on the shelf break and around banks will lead to more mixing and ocean-shelf exchange.

2) Internal tides (IT)



Time series of Temperature at stations ST1 (up) and ST2 (down), in the Celtic Sea, in summer 2010. On each figure AMM60 is shown on the upper panel, and NNATL on the lower panel.

Time series of temperature show the propagation of IT on the Celtic Sea, in both $1/12°$ and $1/60°$ configurations.

→ There are more high-frequency processes in AMM60 compared against NNA.
→ Deepening of the thermocline in AMM60, dut to the propagation of IT.

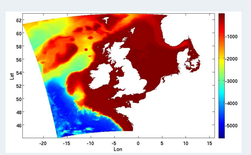
The high-resolution simulation reproduces more IT, which is likely to increase the vertical and cross-shelf mixing.

Conclusions on the assessment of AMM60

- Good reproduction of the tides, despite an underestimated amplitude in regions of strong tides
  → How to improve it? Bathymetry, wetting/drying, surface forcing, ...
  → At the moment AMM60 is mostly designed for non-coastal shelf studies, where the tide has the right amplitude
- The SST is in good agreement with satellite data
  → There is a cold bias in the North of the domain, but the same bias is found in NNATL
  → Using a higher-resolution atmospheric forcing could improve the shelf/coastal processes
- Upcoming work
  → T/S: comparison against in-situ measurements (EN4, gliders, FASTNEt data)
  → Dynamical validation: ADCP, altimetry, ...?

Future work on high-frequency processes and other projects

- About the observation of IT and mesoscale structures:
  → We will have new insight on the shelf/sea exchanges.
  → It allows combined data-model studies.
- Simulations on 2012-2014
  → Variability of ocean-shelf processes
  → FASTNEt cruises (gliders, stations)
  → Model intercomparison (MITgcm)



AMM60 is the precursor to UKO, a 1.5km configuration aimed at a fully coupled (air, land, sea) system. AMM60 or UKO will be evaluated as a possible successor to the NWS operational system. Development of UK0 started in MYOCEAN-II and will continue in MYOCEAN-FO

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