Investigating the role and impact of fine-scale processes on exchange between the open ocean and UK shelf seas

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Is this a CASE studentship? YES

If so, please state intended CASE partner: UK Met Office

Introduction:

The shelf seas around the UK have a large impact on seasonal climate and local weather patterns. Globally, the shelf seas provide a large source of nutrients and act as a net carbon sink. They also provide a source of fresh water (via river outflows), modifying local water mass properties via turbulence and mixing. Quantifying exchange between the shelf seas and deep ocean is therefore important not only for understanding the environment within the shelf seas, but is also critical to the global carbon and water cycles.

Despite their important role, the shelf seas are still not well represented in global climate models. In particular, key processes in cross-shelf exchange can only begin to be resolved at O(1 km) implying that global models currently used to assess carbon and water cycles will be missing key processes. This project will use the next generation ocean forecast model for the European North West Shelf, AMM15 (Atlantic Margin Model, 1.5 km resolution), which is scheduled to become operational in 2018. AMM15 provides an ideal tool to investigate small-scale features (such as eddies, frontal-jets and internal tides), and their impact on exchange. This project will focus on the representation of shelf-break exchange processes in AMM15, and pull through improved representation to coarser resolution models.

Project Summary (max 700 words inc introduction):

The PhD project will be organised around three themes:

1) Resolved processes: What is the role of shelf bathymetry and tides in determining the local cross-shelf exchange?
Shallow coastal oceans are separated from the deep ocean by a steep continental slope. With increased resolution, AMM15 is able to resolve more detail of the shelf break bathymetry, as well as small scale processes, such as internal tides. This impact will be explored via theory, and a suite of AMM15 simulations. The simulations will range from full physics to idealised configurations (with modified tides or simplified bathymetry). The student will be able to utilise existing model output where available, but will also be supported to design and run their own experiments and test hypotheses.

2) Unresolved processes: How is cross-shelf exchange affected by parameterisation choices?

Even at 1.5 km resolution, a number of processes must be parameterised, e.g. bed friction. AMM15 process attribution will be investigated using a vorticity budget framework, comparing against theory and benchmarking against available observations (e.g. shelf edge mooring data from the NERC FASTNEt and Shelf Sea Biogeochemistry campaigns).

3) Broader impacts: Can we quantify the impact of missing processes on carbon budgets and their representation in lower resolution global simulations? The magnitude and variability of shelf-break exchange in AMM15 will be compared with coarser resolution regional and global configurations. Determining mechanisms for exchange in AMM15 will enable uncertainties in future climate projections, due to missing processes, to be quantified, and recommendations to be made for potential improvements in global models.

Understanding the impacts of resolving the cross-shelf exchange is an important Met Office question as we move towards more accurate projections of the global carbon cycle through IPCC scenarios. There is an urgent need to assess whether global ocean configurations, used in UKESM, need to explicitly resolve shelf seas and represent key processes for cross-shelf exchange.

This project will analyse the operational configuration for the UK shelf seas, enabling the student to directly assess its current performance and advise on potential improvements. Results from the project will be pulled-through to configurations that will impact Met Office Operational Ocean Modelling and UK Environmental Prediction (UKEP)

A key goal of this project is to determine the limitations of current global ocean configurations, which do not have sufficient resolution to represent processes at the shelf break; make recommendations for model improvements, and an assessment of model uncertainty (due to lack of resolution and/or processes). This research will link with future development of the UK Earth System Model (UKESM).

References

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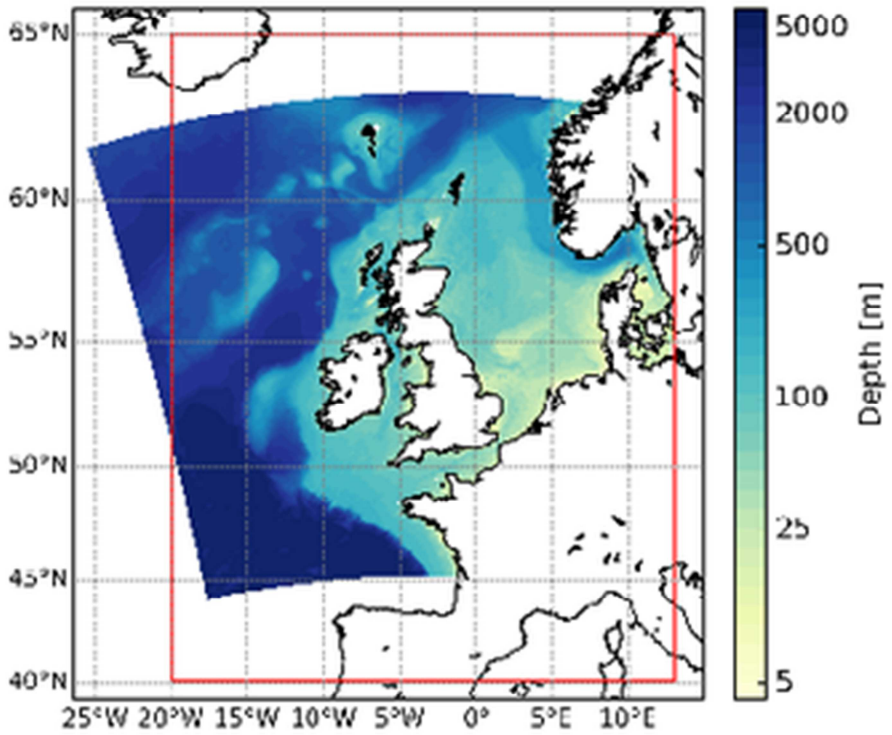

Image 1 *Model domain. Shading shows bathymetry. Red line shows extent of current operational domain.*