TOWARDS AN IMPROVED 3-D ECOSYSTEM MODEL

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Introduction

Numerical models play an important role in improving understanding of ecosystem structure and function and in predicting ecosystem response to perturbations arising from natural and anthropogenic causes. We are implementing a coupled 3-D hydrodynamic ecosystem model for the southern North Sea based upon hydrodynamics supplied by GETM (General Estuarine Transport Model) and biogeochemical calculations from the Biogeochemical Flux Model (BFM) – a successor to the European Regional Seas Ecosystem Model (ERSEM3). This is the first coupling of GETM to a complex ecosystem model, and it will be used to address questions from estuarine to shelf-seas scales to support UK government needs.

Here we compare results from GETM with observations for an application in the North Sea. We also present a first implementation of a coupled 3-D ecosystem model based upon GETM.

Model design and setup

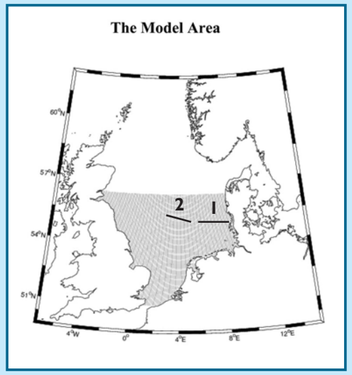

Figure 1: The domain for the model application showing the position of 2 sections (1 and 2) where comparison between observed and modelled temperature has been carried out.

GETM simulates the most important 3-D hydrodynamic and thermodynamic processes in natural waters (Bolding *et al.*, 2002; Burchard *et al.*, 1999). The model can be applied to various systems, scales and specifications. The model includes, for example, flooding and drying of tidal flats, flexible vertical and horizontal coordinate systems, different turbulence models integrated from GOTM (General Ocean Turbulence Model), and is a Public Domain model published under GNU Public Licence (www.bolding-burchard.com).

GETM is designed to run in parallel, taking advantage of affordable and readily available multi-processor computer clusters. Our current hydrodynamic implementation has ~30,000 sea points on 25 sigma levels corresponding to a horizontal resolution of approximately 3.5 km over the model domain (Figure 1). Using 16 computer nodes we achieve run-times of approximately 24 hours for an annual hydrodynamic simulation, 350 times faster than real-time and therefore capable of acceptable run-times when coupled to ecological models.

A comparison of modelled and observed temperature along two sections from the North Sea (Figure 1) in August 2002 (Figure 2), shows excellent reproduction of the thermocline, an absolute requirement for ecosystem models.

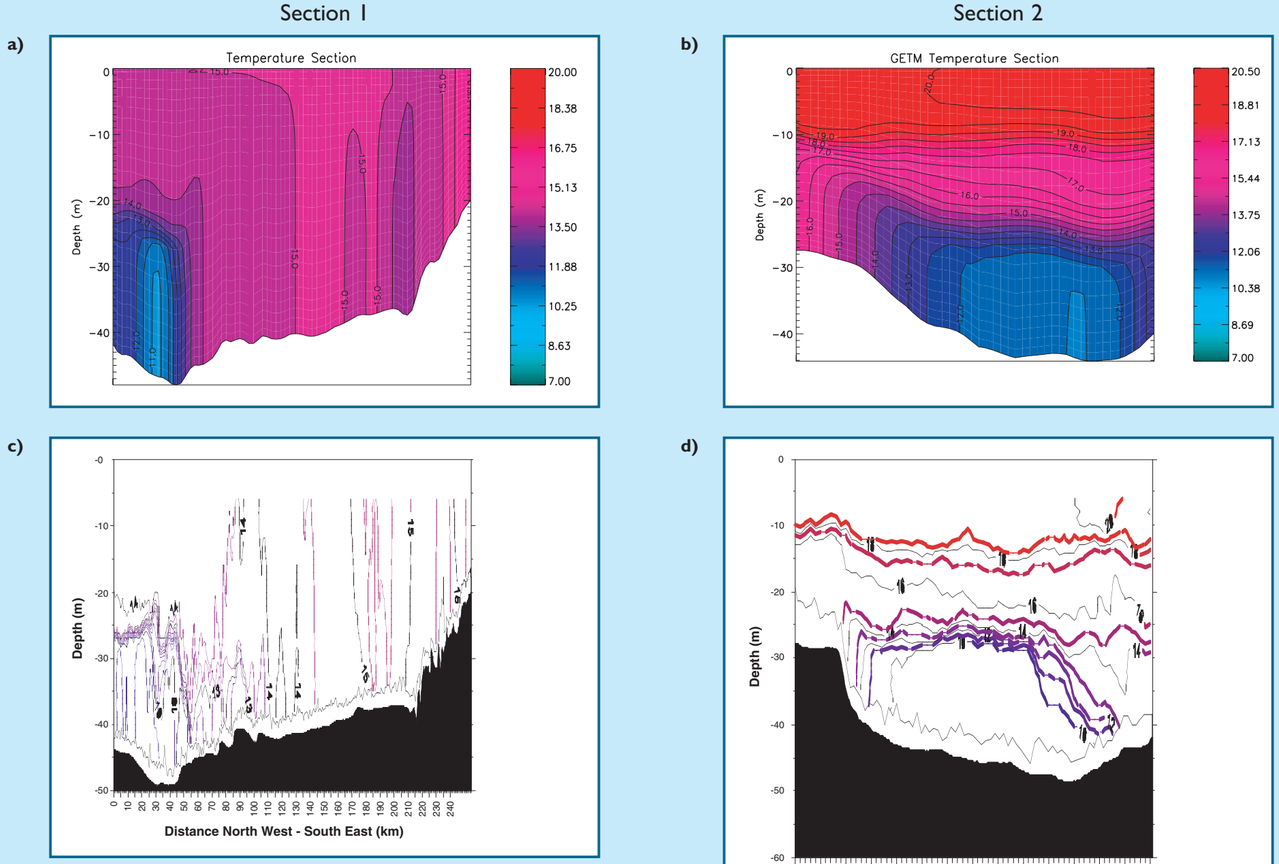

Figure 2(a to d): A comparison between modelled (a and b) and observed (c and d) temperature along sections 1 and 2 (Figure 1). The results show that GETM is capable of simulating the observed tight and diffuse thermoclines, and the bottom fronts. Demonstration of this capability gives confidence in the subsequent application of GETM when coupled to a complex biogeochemical model such as BFM.

Model coupling

Our aim is to couple a suite of ecological models of varying complexity to the GETM hydrodynamic framework. This model system will allow:

- strict comparison of ecological models using the same hydrodynamics,
- use of the most appropriate model for a particular problem,
- use of a suite of ecological models to address the same problem.

GETM has been coupled to a simple biogeochemical NPZD model (Fennel, W. & T. Neumann, 1996). Initial results of near-surface phytoplankton and zooplankton abundance in the North Sea in late April are shown below (Figure 3). Coupling to other ecological models including BFM (http://www.bo.ingv.it/mfstep) is currently underway.

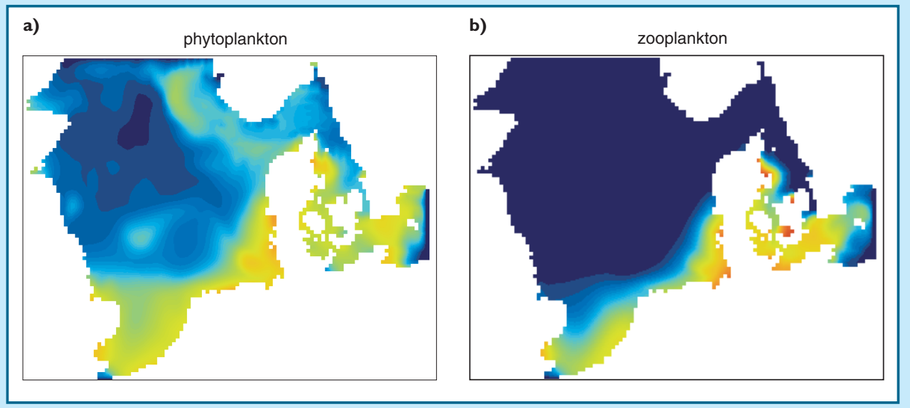

Figure 3 (a and b): Simulated distribution of phytoplankton (a) and mesozooplankton (b) biomass for the North Sea from an application of GETM-NPZD.

Conclusions

1. We have set up and implemented a modern hydrodynamic model (GETM) with short run times and therefore provides a good basis for future applications of coupled ecological models.
2. GETM has been successfully run for the North Sea with initial results showing good agreement between modelled and observed temperature structures.
3. Initial results from application of a simple ecological model (NPZD) coupled to GETM are encouraging.
4. The results give us confidence to proceed with coupling GETM to a range of ecological models.

References

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Burchard, H., Bolding, K. and M. Ruiz Villarreal, 1999. GETM - a general ocean turbulence model. Theory, applications and test cases. Technical Report EUR 18745 EN, European Commission.

Fennel, W. and T. Neumann, 1996. The mesoscale variability of nutrients and plankton as seen in a coupled model, Dt. Hydrog. Z., 48, 49-71.

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