CO_2 issues: capacity and resilience of marine carbon reservoirs

Process studies of the stability and vulnerability of carbon storages in the North Sea with a special focus on the Wadden Sea

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In Short

- investigation of the capacity and stability of marine carbon reservoirs
- quantification of dissolved organic sulfur (DOS) sources within the North Sea
- coupled hydrodynamic-biogeochemical modelling

With respect to global warming and climate change, the reduction of greenhouse gas emissions, above all carbon dioxide (CO_2) emissions, is extremely important. The oceans have a big capacity to balance the carbon dioxide of the atmosphere to maintain a habitable climate by taking up atmospheric CO_2 to some extend. Within the global carbon cycle, carbon is stored in different 'pools' of different sizes. In order to mitigate climate change in a responsible way, a detailed knowledge and understanding of the natural occurring carbon pools together with the interacting fluxes and processes is essential.

As part of the global ocean, coastal seas and shelf seas are critical regions e.g. because of their high primary production and their potential of storing carbon in various pools like sea floor sediments, mangroves, salt marshes and seagrasses [1]. To asses the climate-change-mitigation potential of natural carbon pools, quantification of these pools and their changes with respect to specific environmental changes is essential. As an example, very recently, Legge et al. (2020) [2] made a carbon budget for the northwest European continental shelf seas (NWES) using available estimates for coastal, pelagic and benthic carbon stocks and flows. One major aim of this project is to extend this research and to break it down to carbon pools within the North Sea and especially the Wadden Sea by using a coupled physical-biogeochemical ocean circulation model. We use the triangle-based unstructured-grid approach to simulated the two-way interaction between the North Sea and the Wadden Sea (see Fig. 2).

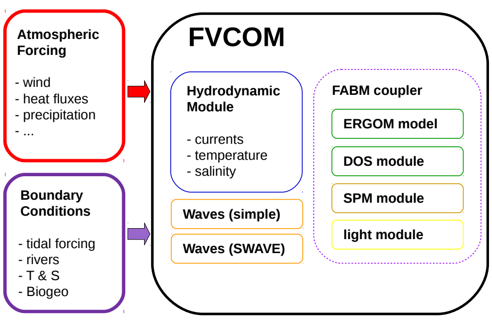

***Figure 1:** Structure of the numerical modelling system. Using the model coupler FABM [6] different modules have been coupled to the hydrodynamic part of the FVCOM modelling system.*

Furthermore, if organic carbon is converted to long-living refractory fractions, the likelihood of degassing back into the atmosphere as CO_2 decreases. One process, by which carbon bound in labile sedimentary organic matter is converted to refractory pools, is 'sulfurizing' of organic matter by sulfide produced via microbial sulfate reduction in euxinic sediments [3,4]. The resulting covalent C-S bonds are thought to be resistant to microbial degradation as a result of stable S-S cross-linking and replace otherwise more labile functional groups. As such, sulfurization reactions (building also dissolved organic sulfur, DOS) have been recognized as an important pathway for sedimentary organic matter preservation and implicated in the carbon cycles of the ancient ocean [4]. Thus DOS in the ocean turns over on a millennium time scale. Within the Wadden Sea this process could take place in anoxic sediment layers, from which the dissolved organic sulfur (DOS) fractions can be released into the water column above. Within the second major aim of the project, using some kind of data-guided inverse-modelling we want to quantify DOS inputs into the water column from the Wadden-Sea region, from estuarine regions (e.g. river mouths) or the sea-floor sediments of the North Sea.

As a third research topic, in order to simulate particle resuspension by surface gravity waves, a simple fetch-based parameterization has been implemented to provide a correct light field within the water column for primary production. However, this simple fetch-based approach might have some weaknesses although it is very fast. The situation is similar to Earth System Models of Intermediate Complexity (EMICs), which are designed for long-term simulations over millennia but at the cost of only using simplified parameterizations or coarse grid resolution. In order to access the model uncertainties of this

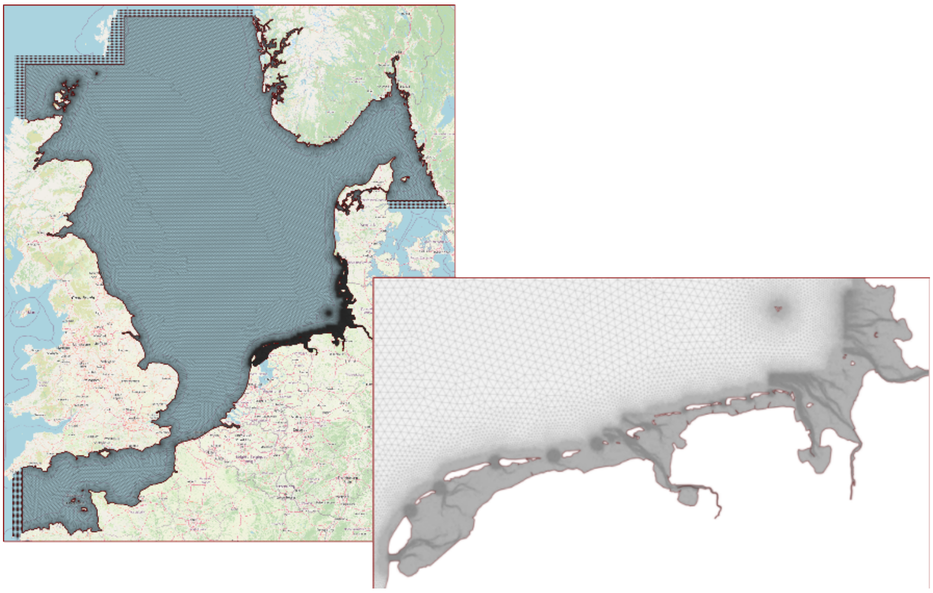

Figure 2: Illustration of the unstructured model grid. The lower right panel shows the high resolution of the grid within the Wadden Sea region. Overall, the model grid has a spatial resolution of 250 - 4000 m.

simple wave model, we want to compare it against more sophisticated surface gravity wave models.

In order to reach these three major research tasks, the unstructured-grid based modelling system FV-COM [5] is coupled with different submodules via the model coupler FABM [6] as illustrated in Fig. 1.

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More Information

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Project Partners

Leibniz Institute for Baltic Sea Research Warnemünde (IOW); Institute of Oceanography, University of Hamburg; Institute of Carbon Cycles, Helmholtz-Zentrum hereon GmbH, Geesthacht

Funding

Bundesministerium für Bildung und Forschung, Projekt FKZ 03F0875C