Project information

Keywords
benthic-pelagic Arctic Ocean acidification
Project title
Benthic-pelagic coupling of Arctic Ocean acidification
Year
2015
Project leader
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Flagship
Ocean Acidification
Funding Source

Framsenter Flagship

Summary of Results

During 2015 we updated the Bottom RedOx Model (BROM) and applied it to case study runs in the selected region in the Arctic.

The work was performed at a new Windows Server (OCEANMOD.NIVA.NO) with Intel Fortran and Microsoft Visual Studio Fortran. This allowed us to elaborate software necessary to work within the Framework for Aquatic Biogeochemical Models (FABM).

The BROM code was re-written to allow us to completely use the benefits of FABM. The biogeochemical modules of BROM were placed and uploaded to the FABM library.

The transport BROM code was re-written using Fortran-2003 possibilities. Procedures were written to enable input and output of data in NETCDF format. This allowed, in particular, the direct use of output data from ROMS or GETM for hydrophysical forcing. CMAKE was used to compile the projects for use under Windows or Unix, which should simplify the planning of future work with 3D models FVCOM and ROMS.

A basic page describing how to get started with BROM-transport and FABM was uploaded to the internet (https://sourceforge.net/p/fabm/wiki/BROM_FABM/).

In 2015 we focused on construction of a first version of a model framework to allow simulation of the pelagic benthic interactions in the Arctic environment.

Scientific results

The goal of this work is to study how seasonal changes in the bottom biogeochemistry are coupled with the pelagic ones in the Arctic.

We used the a 1-dimensional C-N-P-Si-O-S-Mn-Fe benthic-pelagic coupled model BROM[1] (Fig. 1). This model is now modularized within FABM such that the various modules (i.e. BROM-bio, BROM-carb, BROM-redox) can be independently combined with existing and planned modules (e.g. ERSEM or Ice Algae). The BROM domain includes the water column, the Bottom Boundary Layer (BBL) and the upper layer of the sediments (Fig. 2). The 1D BROM-transport model allows offline coupling with the outputs of hydrodynamical models. In 2015 the hydrophysical scenario for the water column was taken from the results of ROMS[2]-20 km runs for a grid point in the Kara Sea positioned in the vicinity of the sampling points (Fig. 3). This work was done in collaboration with P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences, and we had a possibility to use the data collected in a cruise of RV “Akademik Mstislav Keldysh” in September 2015. This data was used for parameterization of the lower boundary conditions and for validating the runs.

In the model version used in 2015 we assumed that organic matter is produced only by the water column phytoplankton in the ice-free period. The model can numerically demonstrate that the seasonal changes of the carbonate system parameters in the surface layer (pH, aragonite and calcite saturation states) are accompanied by corresponding changes at the sediment-water interface (SWI), that is connected by the supply of organic matter (Fig.4, 5).

In the next stages of model development we plan to study the role of ice algae and the potential influence of organic matter (as a total alkalinity component) on the carbonate system (i.e. CO2 flux).

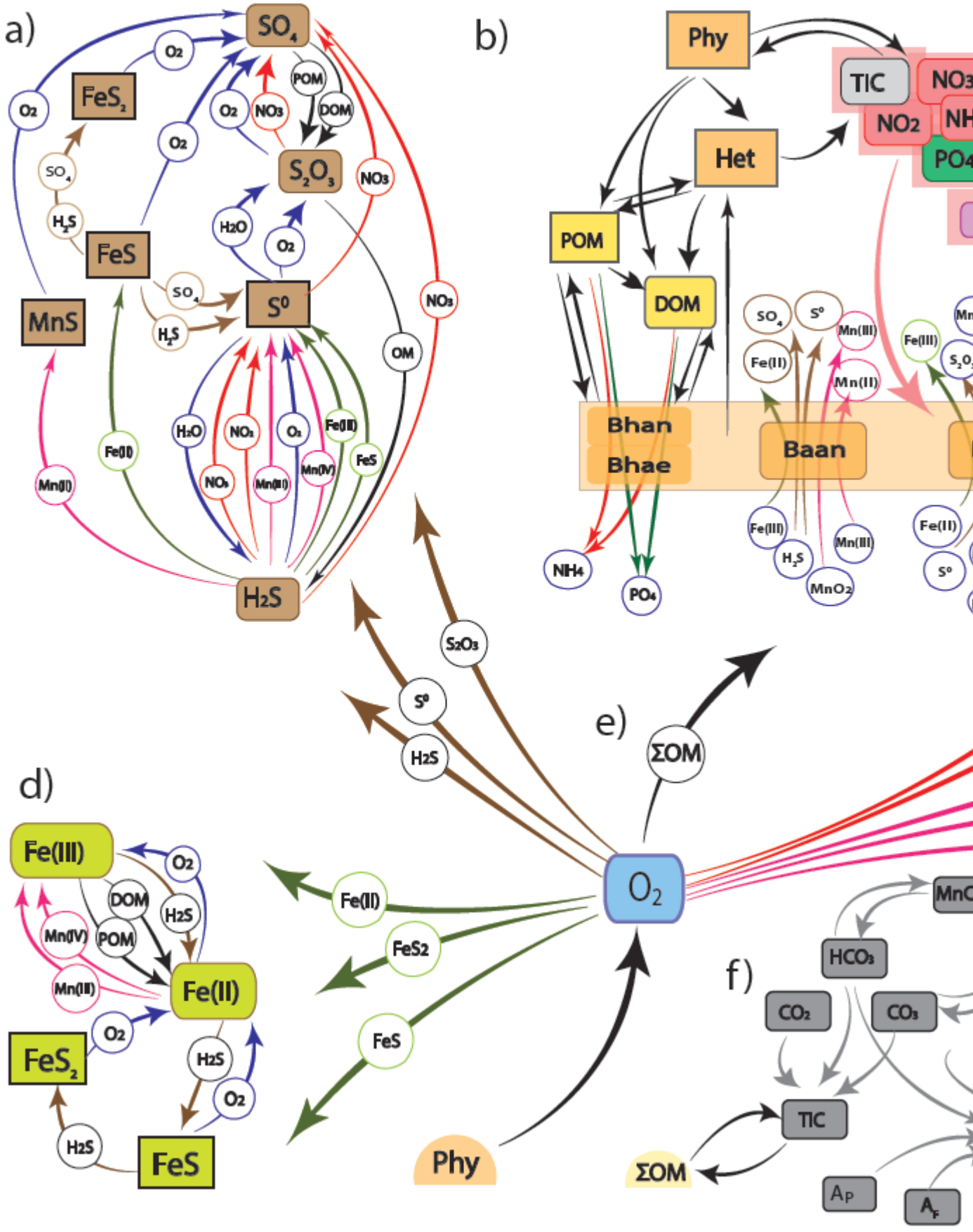


Figure 1. BROM biogeochemical processes.

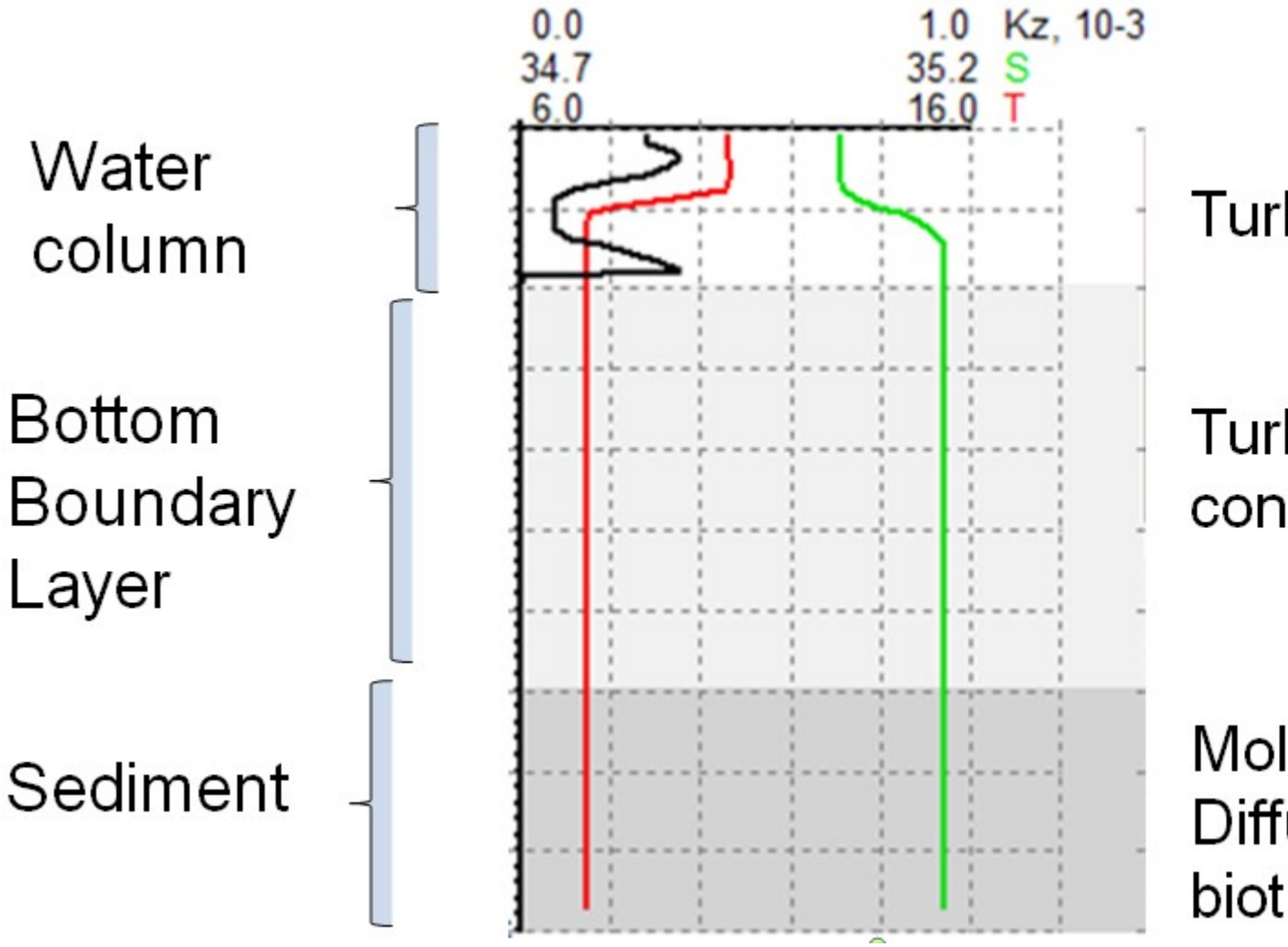
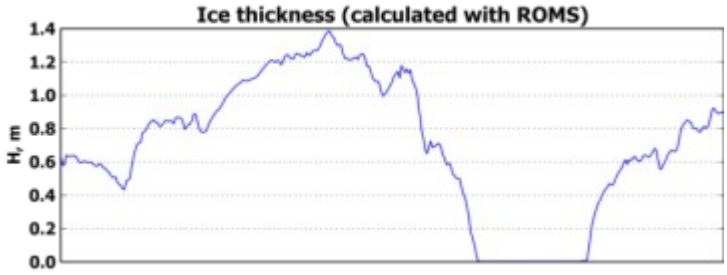


Figure 2. BROM-transport model.

Figure 3. Position of the model application grid point and stations with the observational data.

A



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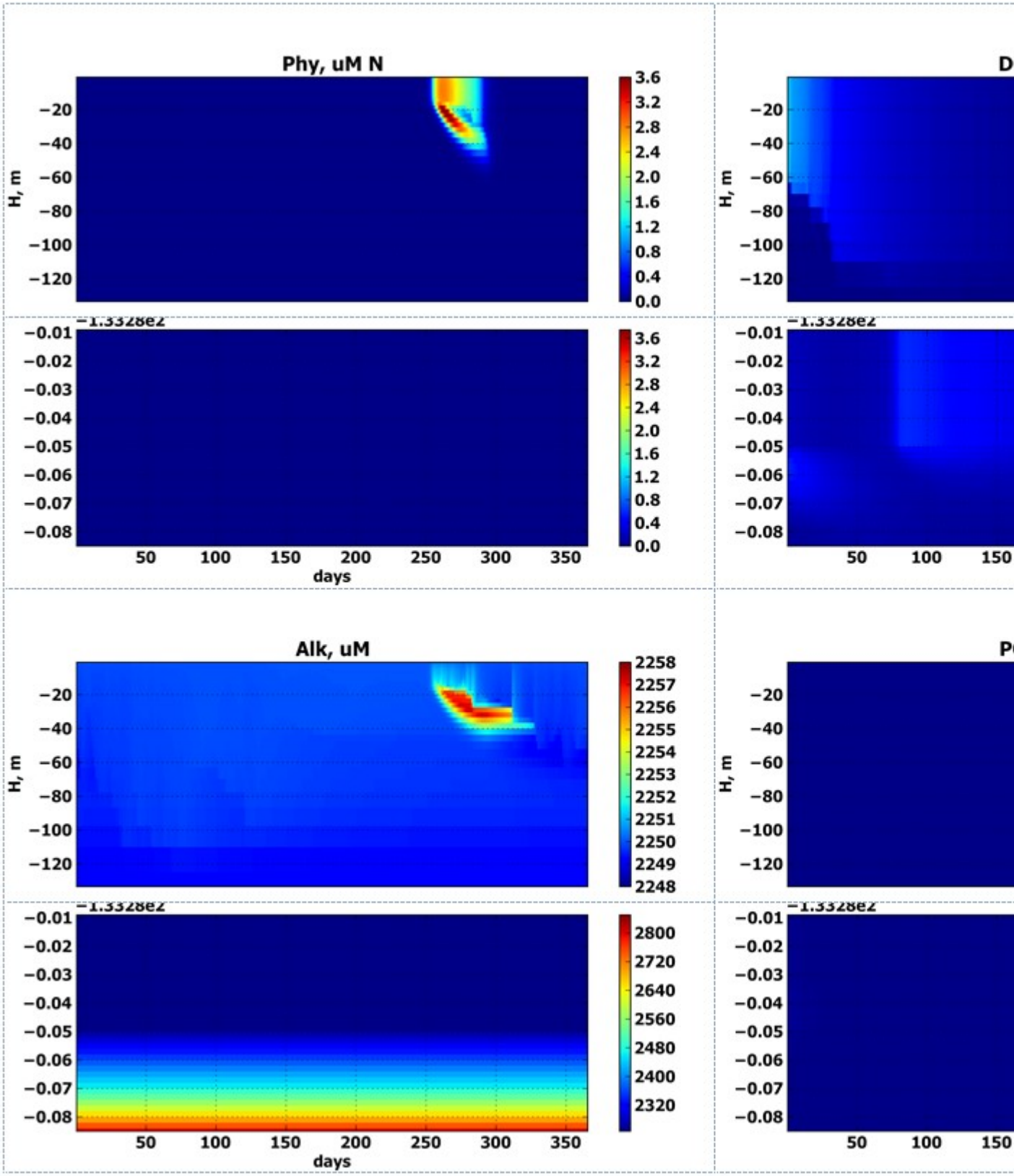
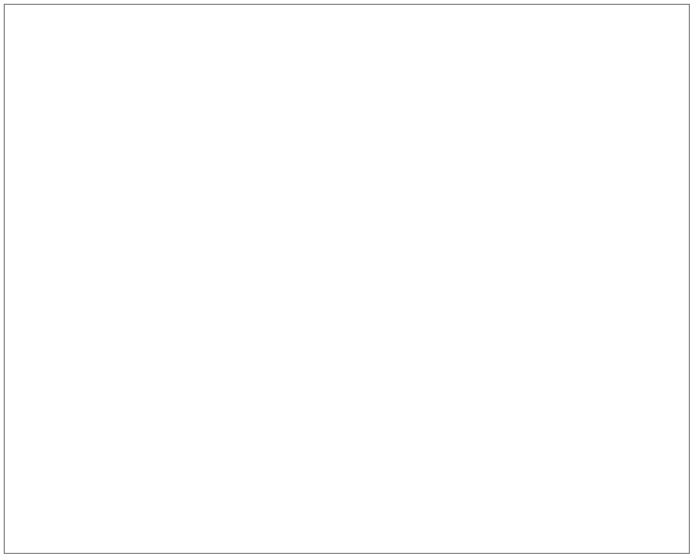


Figure 4. A. Seasonal variability of the ice thickness calculated with ROMS-20 km (top). B. Calculated seasonal variability of the: Phytoplankton biomass, Dissolved Organic Matter, Particulate Organic Matter (mmol N/m3) and Total Alkalinity (uM). Upper plots correspond to the 125 m thick water column, lower plot corespond to the 0.10 m thick sediment-water interface, where the sediment surface is positioned at the depth -0.05 m.

Figure 5. Calculated seasonal variability of phophate, silicate, nitrate (uM), pH (total scale), aragonite and calcite saturation states. Upper plots correspond to the 125 m thick water column, lower plot corespond to the 0.10 m thick sediment-water interface, where the sediment surface is positioned at the depth -0.05 m.

A



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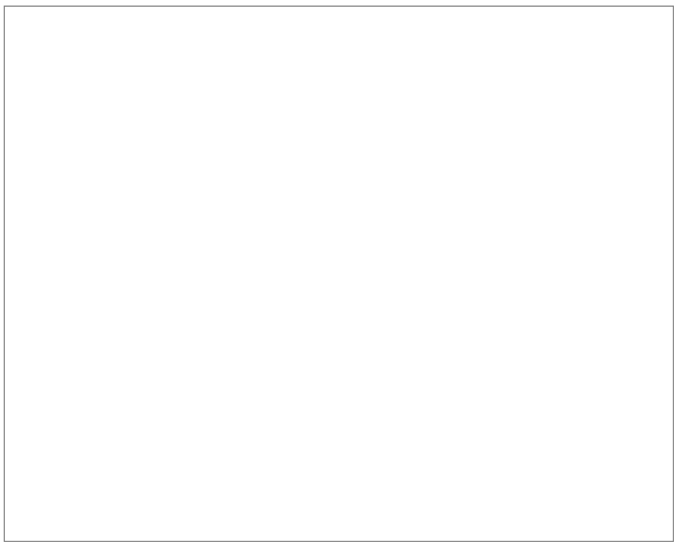

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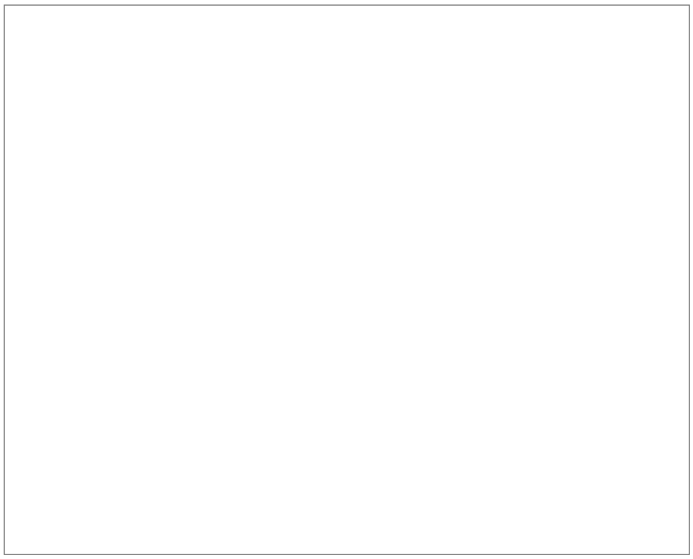

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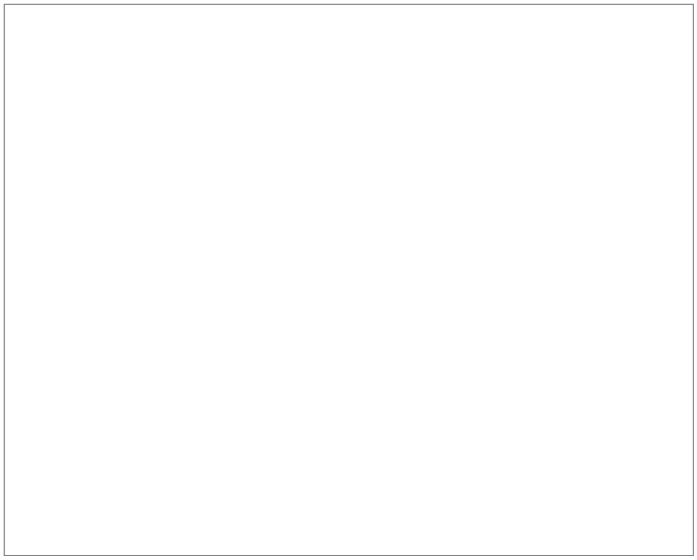

Figure 6. Vertical distributions at the SWI; h=-0.05 m corresponds to the sediment surface.

References

[1] Yakushev E., Protsenko E., Bruggeman J., Bellerby R., Pakhomova S., Couture R.-M., Yakubov S. 2015. Bottom RedOx Model (BROM, v.1.0): a coupled benthic-pelagic model for simulation of seasonal anoxia and its impact. Geoscientific Model Development Discussions (accepted with minor revisions).

[2]Shchepetkin, A. F., and J. C. McWilliams (2005), The Regional Ocean Modeling System: A split-explicit, free-surface, topography following coordinates ocean model, Ocean Modelling, 9, 347-404.

For the Management

Funds have been used in accordance with proposal. Project is currently on-track.

Published Results/Planned Publications

BROM model description paper has been submitted to Geoscientific Model Development and is currently in review.

Communicated Results

Poster was presented at FRAM Science Days conference.

Interdisciplinary Cooperation

This project has involved close collaboration between modellers and observationalists, and between biogeochemical modelling and physical ocean modelling.

Budget in accordance to results

Of the 196 kNOK from Framsenter Flagship, 190 kNOK was used on hourly costs and 6 kNOK was used to cover travel expenses to the FRAM Science Days conference.

Could results from the project be subject for any commercial utilization

No

Conclusions

The BROM model has progressed to the point of connecting seasonal pelagic production events to benthic acidification through the remineralization of organic matter. The project is on track and meeting the objectives laid out in the proposal.