Project information

Keywords
Modeling, Benthic-Pelagic, Arctic Ocean acidification
Project title
ECOAN WP3-OA11: Benthic-pelagic coupling of Arctic Ocean acidification
Year
2016
Project leader
Evgeniy Yakushev
Geographical localization of the research project in decimal degrees (max 5 per project, ex. 70,662°N and 23,707°E)
72,000N 20,000E; 80,000N 90,000E
Participants

Phil Wallhead (NIVA), Elizaveta Protsenko (NIVA)

Flagship
Ocean Acidification
Funding Source

Framsenter Flagship

Summary of Results

During 2016 there was continued work on the Bottom RedOx Model (BROM) and its application for the studies in the Arctic.

BROM aims to represent key biogeochemical processes in the water and sediments and to simulate changes occurring in the bottom boundary layer (Figure 1). BROM consists of a transport module (BROM-transport) and several biogeochemical modules that are fully compatible with the Framework for the Aquatic Biogeochemical Models (Figure 2), allowing independent coupling to hydrophysical models in 1D, 2D or 3D. We demonstrated that BROM is capable of simulating the seasonality in production and mineralization of organic matter as well as the mixing that leads to variations in redox conditions. BROM can be used for analyzing and interpreting data on sediment-water exchange, and for simulating the consequences of forcings such as climate change, external nutrient loading, ocean acidification, carbon storage leakage, and point-source metal pollution.

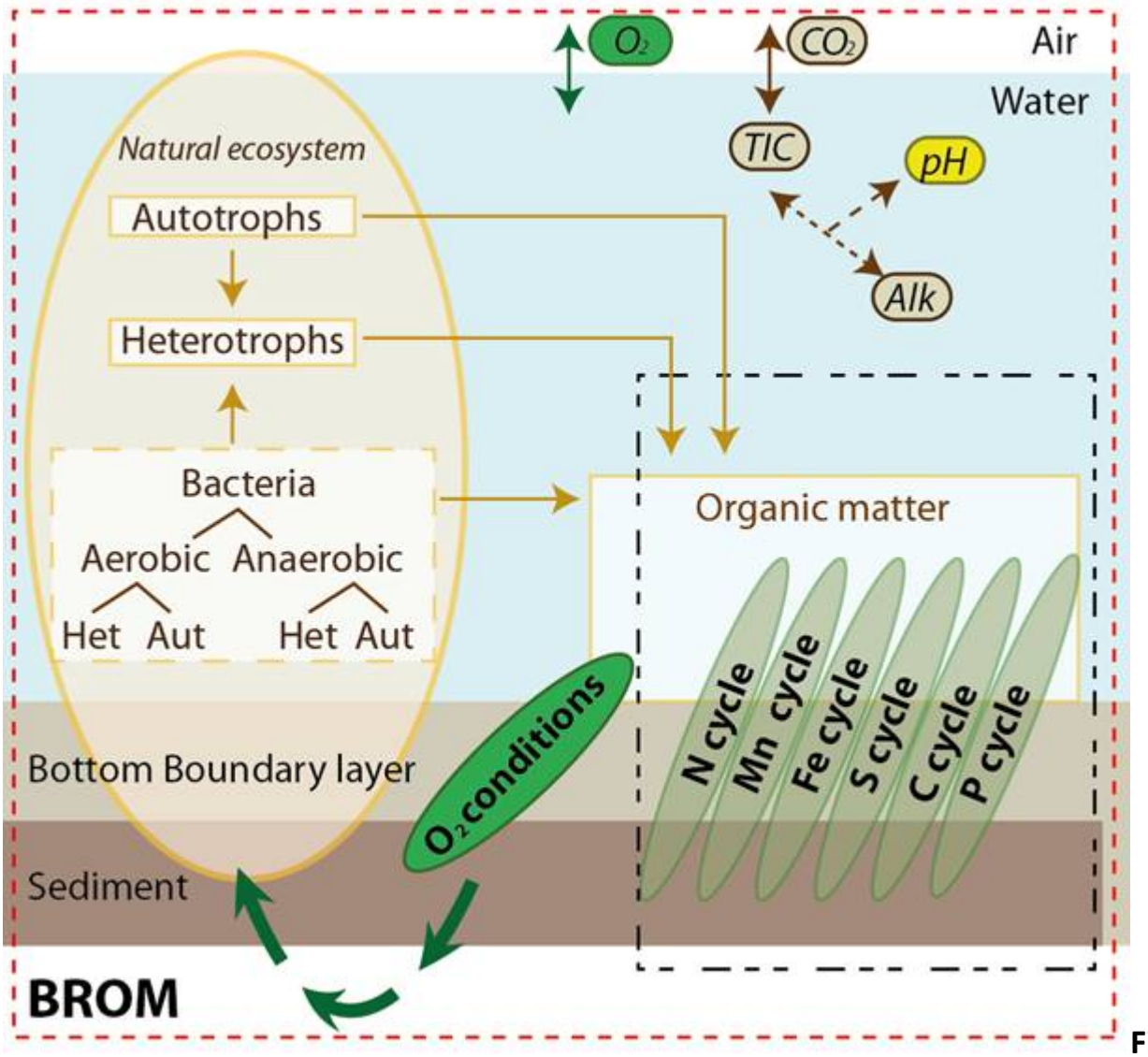

Figure 1. Flow-chart of the processes represented in the Benthic RedOx Model (BROM) and the model' domain.

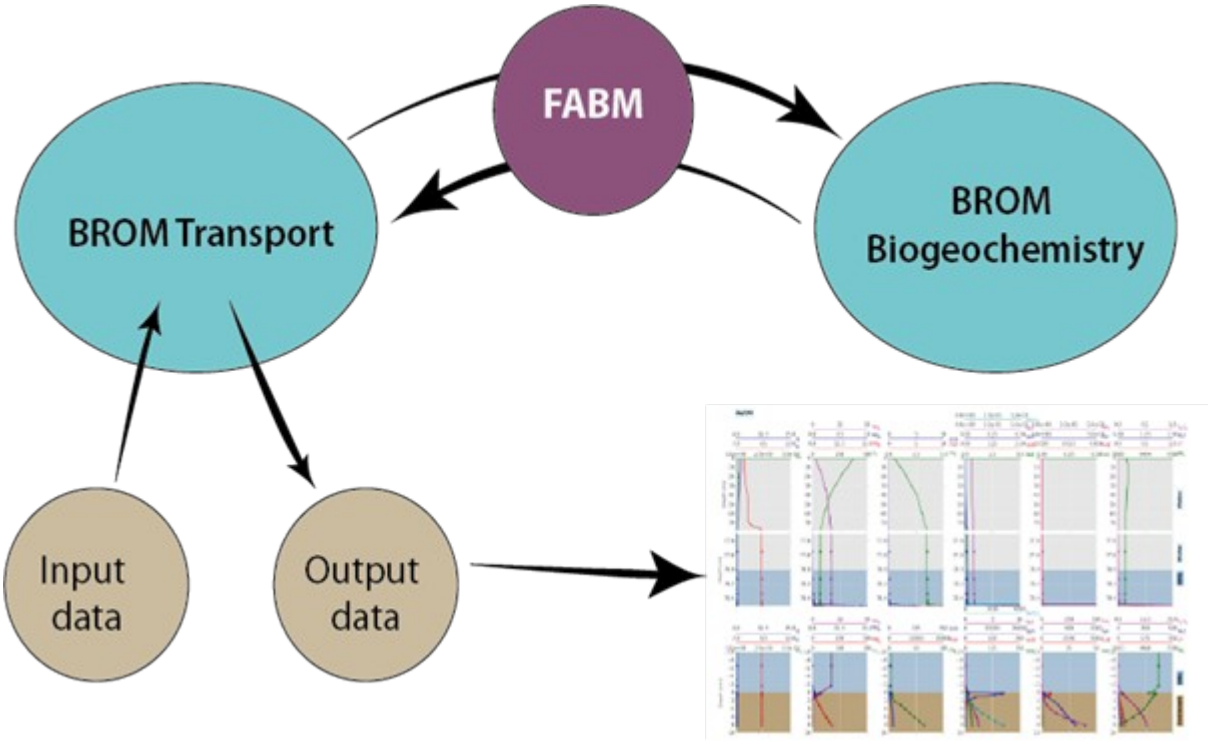

Figure 2. Scheme of interaction between BROM-transport and BROM-biogeochemistry.

The model as presented consists of two components, BROM-transport and BROM-biogeochemistry. The first is a set of biogeochemical modules (brom/redox, brom/bio, brom/carb, brom/eqconst), available as part of the official FABM distribution (http://fabm.net); BROM-specific files are located in subdirectory src/models/niva/brom). The second is a hydrophysical driver (BROM-transport) that provides the 1D vertical context and resolves transport; this is available separately from https://github.com/e-yakushev/brom-git.git. When combined, the 1D BROM model as presented is obtained.

Both FABM and BROM-transport are coded in object-oriented Fortran 2003, have a build system based on CMake (https://cmake.org), and use YAML files (http://yaml.org) for run-time configuration. The code is platform independent and only requires a Fortran 2003-capable compiler, e.g., gfortran 4.7 or higher, or the Intel Fortran compiler version 12.1 or higher. BROM-transport includes facilities for producing results as NetCDF files, which can be read by a variety of software on different platforms.

Specifically, during 2016 there was made the following:

- The code of the brom-transport software was modified. Now it can be used for parameterization of the transport as vertical 1D and vertical 2D model. The latter is very important to predict the small horizontal scale (first 10s of meters) changes in the bottom environment. The code is available at https://github.com/BottomRedoxModel/brom-git.git and https://github.com/BottomRedoxModel/fabm-brom.git.
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- There was parameterized horizontal relaxation of the model results to the baseline variability of parameters, that can be estimated from a 3D model or a database (i.e. WOD).
- The carbonate system calculations module was completely re-written, there was implemented a proposed by (Munhoven; 2014) Newton-Rapson approach for solving of the equation for pH. It allowed to significantly decrease the computer time needed for this operation.
- It was added a possibility to read the output files from hydrodynamical models FVCOM and TELEMAC for the BROM-transport forcin.,
- There was created the Python 2.7 script, preparing field data for using as boundary conditions or for field data relaxation.

Currently the script produces monthly averaged data along the needed profile. Data is interpolated for standard levels and standard distances from the beginning point, in script we use linear interpolation.

Obtained values are written into text files. There are 2d arrays, x axis is distances, y axis is depths. Each file is for 1 month and 1 variable.

The main algorithm of preparation data is:

1. To download data from region of interest from World Ocean Database https://www.nodc.noaa.gov/OC5/WOD/datageo.html
2. Create the Ocean Data View collection, choose more precise region of interest, and produce netCDF file with these data.
3. Run the script using Python
4. Read the produced text file in BROM

Later in BROM as relaxation data may be used as single columns with data or the whole profile. The script is available at: https://github.com/BottomRedoxModel/wod_fielddata

- It was added a 0D ice model to the BROM model domain, that allowed to simulate fluxes of matter during formation and melting of ice (the ice fate was read from the ROMS output)
- There was started work on the ice-algae model, that should be completed in 2017.

Summarizing, the work in 2016 was devoted mainly to the code improvements, and its application is planned to the year 2017.

Master and PhD-students involved in the project

Elizaveta Protsenko (PhD student)

For the Management

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

Published Results/Planned Publications

E.V.Yakushev, E.A.Protsenko, J.Bruggeman, P.Wallhead, S.V.Pakhomova, S.Yakubov, R.G.J.Bellerby, R.-M. Couture. 2016. Bottom RedOx Model (BROM, v.1.1): a coupled benthic-pelagic model for simulation of water and sediment biogeochemistry. Geoscientific Model Development (accepted with minor revisions).

Yakushev E. 2016. Modeling benthic-pelagic interaction for the Arctic Ocean acidification studies. Goldschmidt Conference Abstracts. 2016. p. 3511. (http://goldschmidt.info/2016/uploads/abstracts/finalPDFs/3511.pdf

Communicated Results

Scientific results were reported at the Goldschmidt Conference 2016, Yokohama, Japan , June 26-July 1, 2016: Modeling benthic-pelagic interaction for the Arctic Ocean acidification studies by Evgeniy Yakushev, Shamil Yakubov, Elizaveta Protsenko, Philip Wallhead (an oral presentation).

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

Funds were used on hourly costs

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.