AMBER Annual meeting 2011

Transport of fresh and resuspended particulate organic material in the Baltic Sea - a model study

Research Cluster C: Spatial river basin – coast – sea interaction

Presentation:
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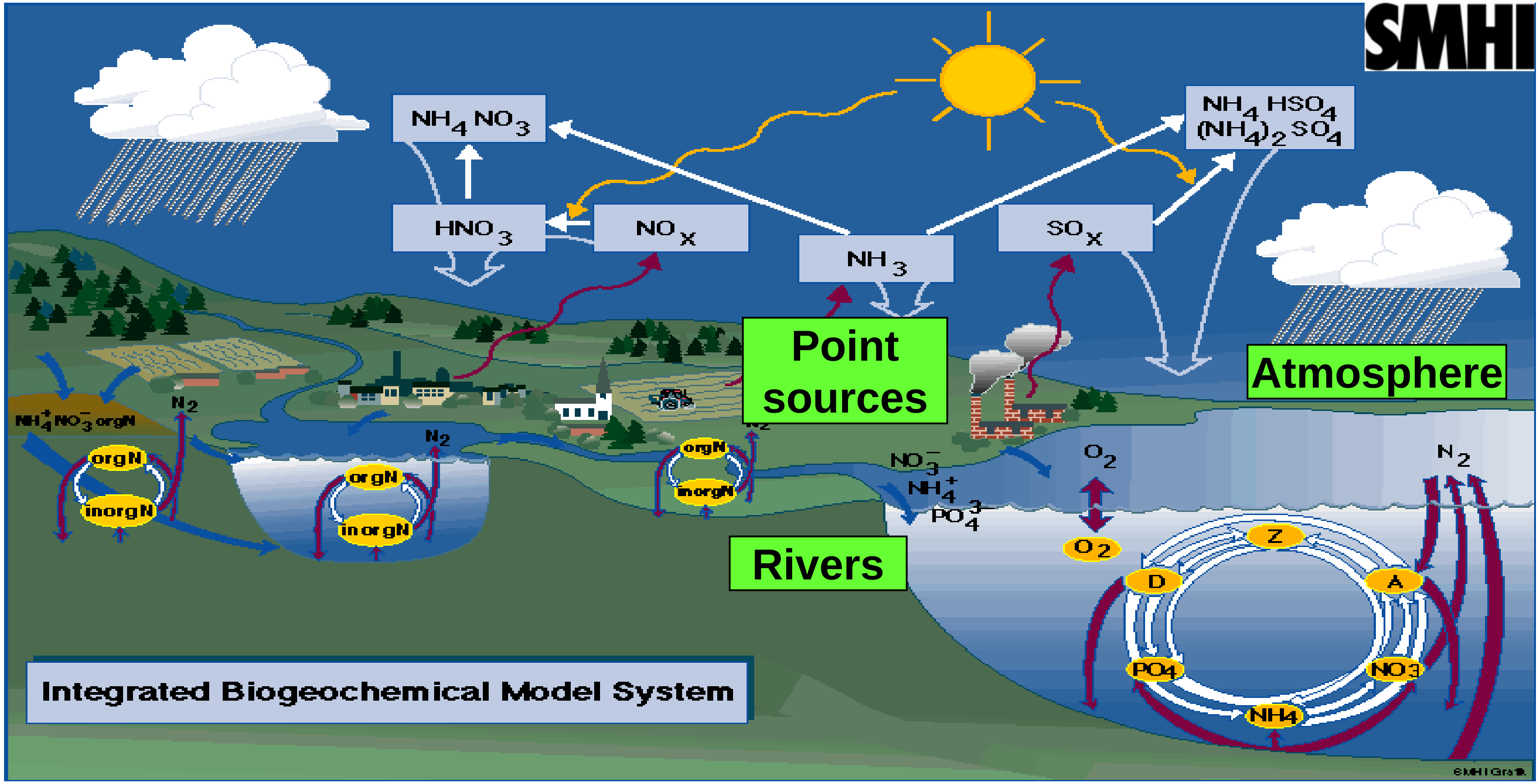
SMHI

Biogeochemical Model System

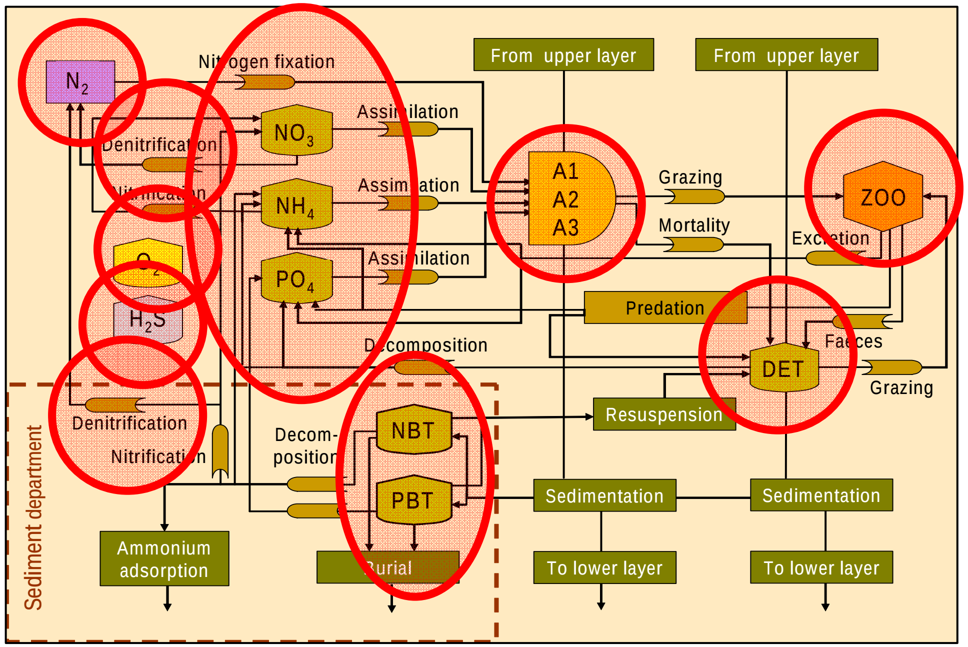


RCO – SCOBI

High resolution (2nm) 3-D model for biogeochemical climate- and process studies in the Baltic Sea.

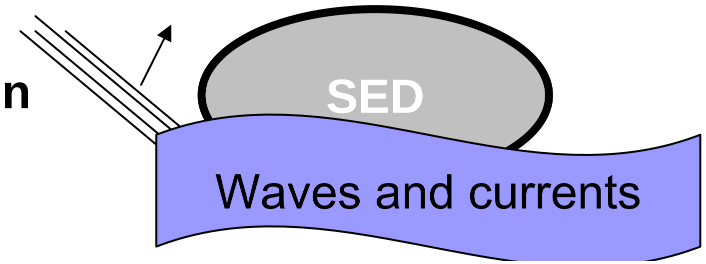
The model handle dynamics of nitrogen, oxygen and phosphorus for example including:

- **inorganic nutrients**
- **nitrogen fixation**
- **particulate organic matter**
- **sediment**
- **oxygen**
- **hydrogen sulphide**
- **denitrification**
- **resuspension**



Resuspension

of sediments



RCO – SCOBI 2nm

Almroth-Rosell, E., et al., Transport of fresh and resuspended particulate organic material in the Baltic Sea — a model study, J. Mar. Syst. (2011), doi:10.1016/j.jmarsys.2011.02.005

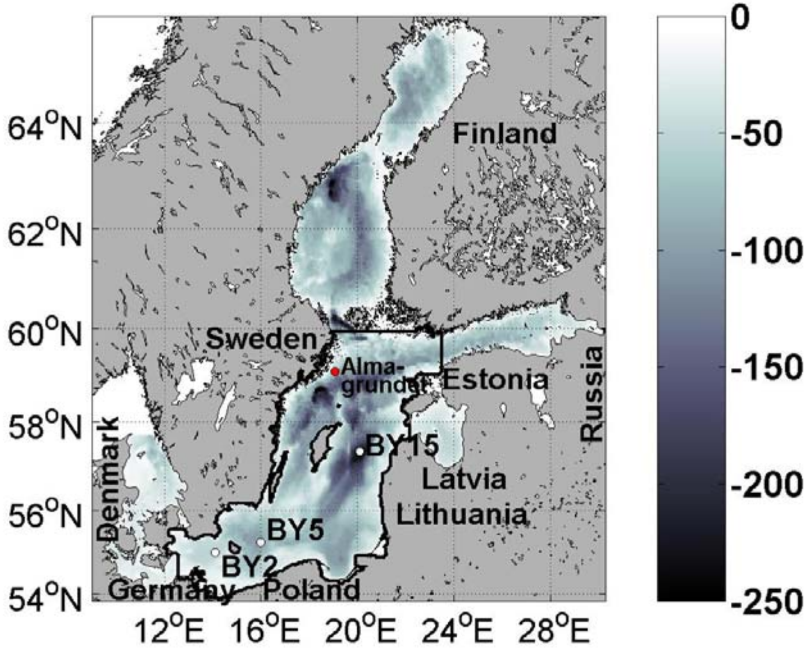
The aim of the study was to investigate:

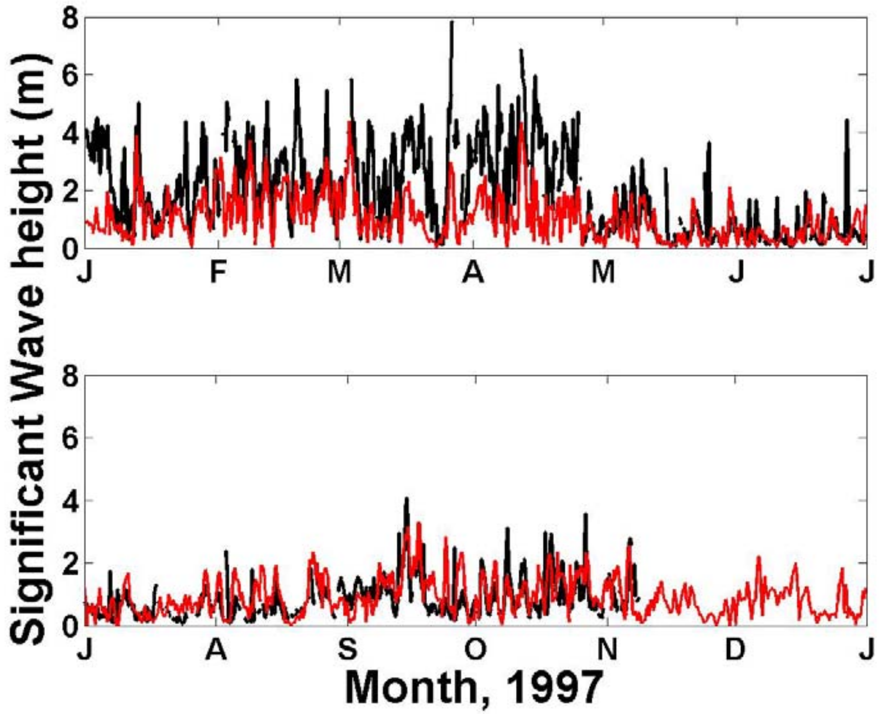
1) **the importance of resuspension for the transport and redistribution of particulate organic matter;**

2) **the distribution of resuspended organic material in the water column and sediments; and**

3) **a method to classify the modelled bottom types.**

Simplified wave model

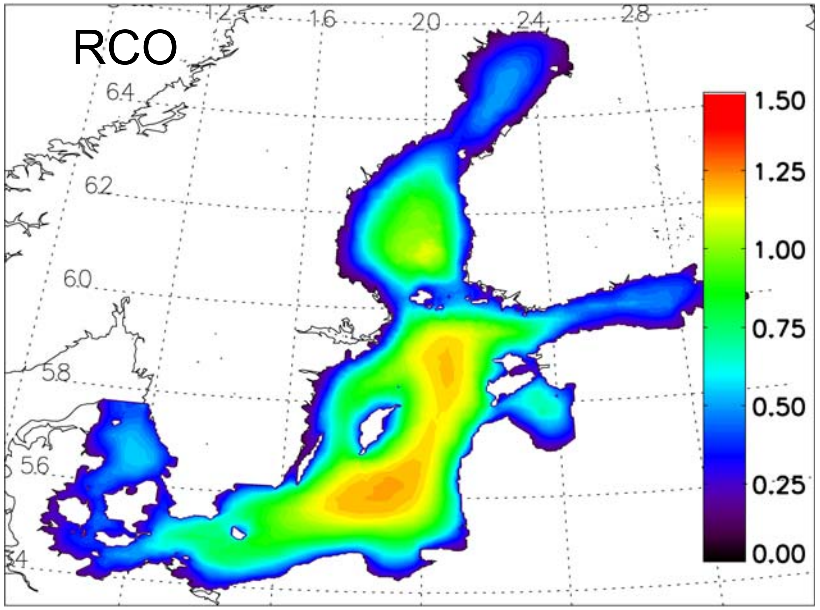


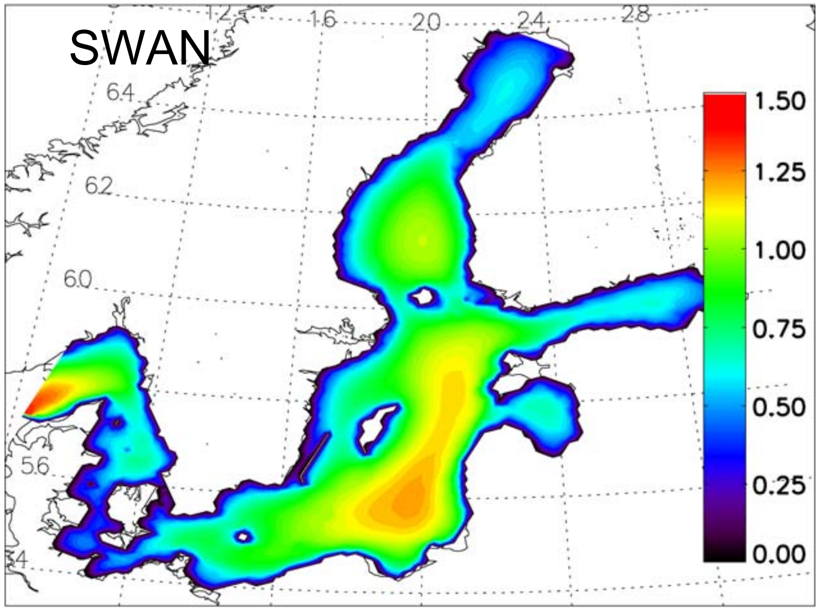


Validation to observations:

Significant wave height (in meters) at Almagrundet light house during 1997 (black line) and simulated (red line). Upper and lower panels show months January-June and July-December, respectively.

Simplified wave model





Validation to a functional wave model:
Mean significant wave height in the Baltic Sea (in meters) for 1997 in RCO to the left and SWAN to the right.

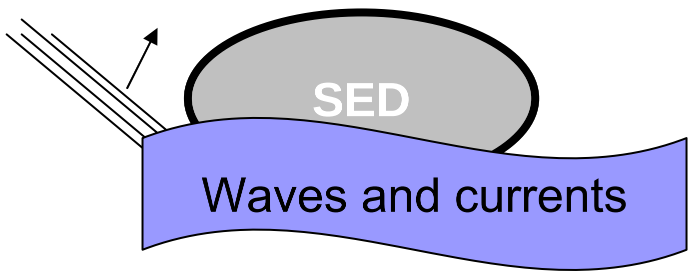
Re-suspension of sediment

S= The upward or downward fluxes of nutrients in the sediments

$$S = \begin{cases} S_o\left(\dfrac{\tau}{\tau_c} - 1\right) & if \;\; \tau > \tau_c \\ W_s\left(1 - \dfrac{\tau}{\tau_c}\right) & if \;\; \tau < \tau_c \end{cases}$$

- When the critical shear stress on the sea floor is exceeded sediment particles are lifted up into the overlying water and resuspension is induced.

S_o = Maximum upward flux of sediments
Ws = Maximum Sinking velocity.
τ_c = Model dependent critical shear stress.



Re-suspension of sediment

Calibration of the critical shear stress:

- Vertical variation of horizontally averaged sediment nitrogen and phosphorus concentrations.
- Oxygen and nutrient concentrations from standard monitoring stations (Fig.1).

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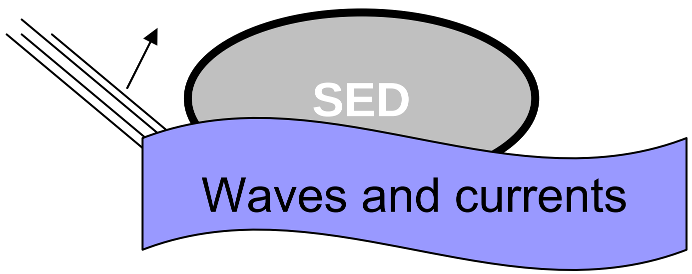
The critical shear stress that resulted in best biogeochemical model properties was τ_c=0.15 N m^{-2}.



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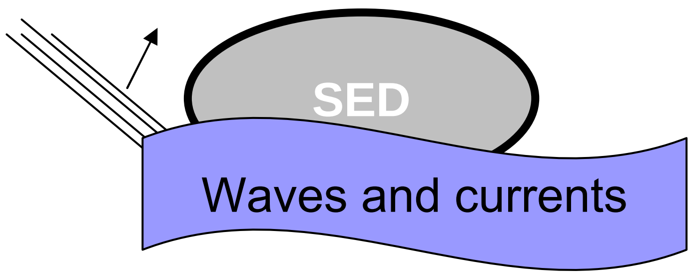
- Definition of “Resuspended matter” = The matter has at least once been re-suspended from the sediment.

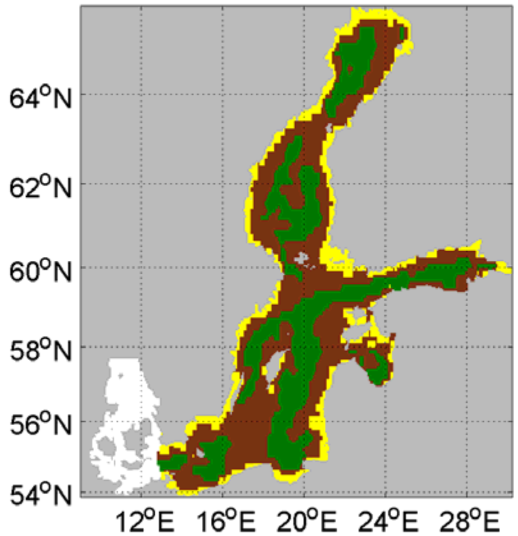


Bottom type classification from observations

Digitized version (Jönsson et al., 2005) of the bottom type map in Carman and Cederwall (2001). The resolution of the digitized map was here increased and transformed to match the RCO grid.

- Accumulation (A), transport (T) and erosion (E) bottoms in the adjusted digitized map covers about 33%, 50% and 17% of the wet grid points, respectively.

- A-bottoms are defined as bottoms where the sediment consists of fine material (<medium silt) that is continuously deposited. T- and E-bottoms are bottoms where fine material is deposited either discontinuously or not at all.



green = accumulation
brown = transport
Yellow = erosion

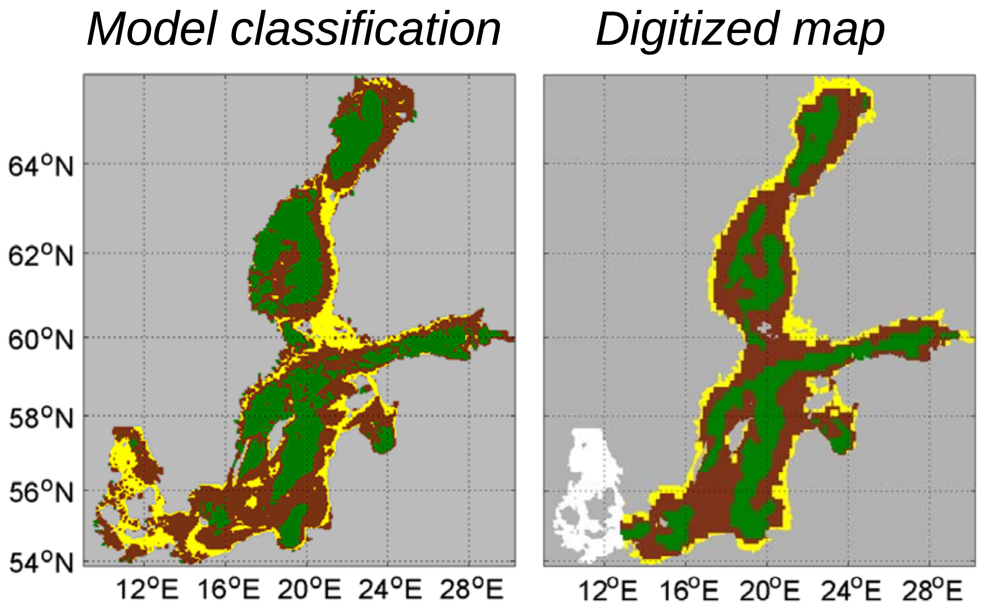
Bottom type classification in model

- Model classification is based on the total number of time steps with resuspension (N) in each grid point (i,j) during 1961-2007.
- Normalization to the total number of wet grid points gives a probability density function $f(N)$.
- The natural logarithm of $f(N)$ has a normal distribution $g(N)$.
- The total area covered by different modelled bottom types are defined in accordance with observations as:

1. Accumulation bottom :
g(N) < 33rd percentile

2. Transport bottom:
33rd percentile ≤ g(N) ≤ 83rd percentile

3. Erosion bottom:
g(N) > 83rd percentile



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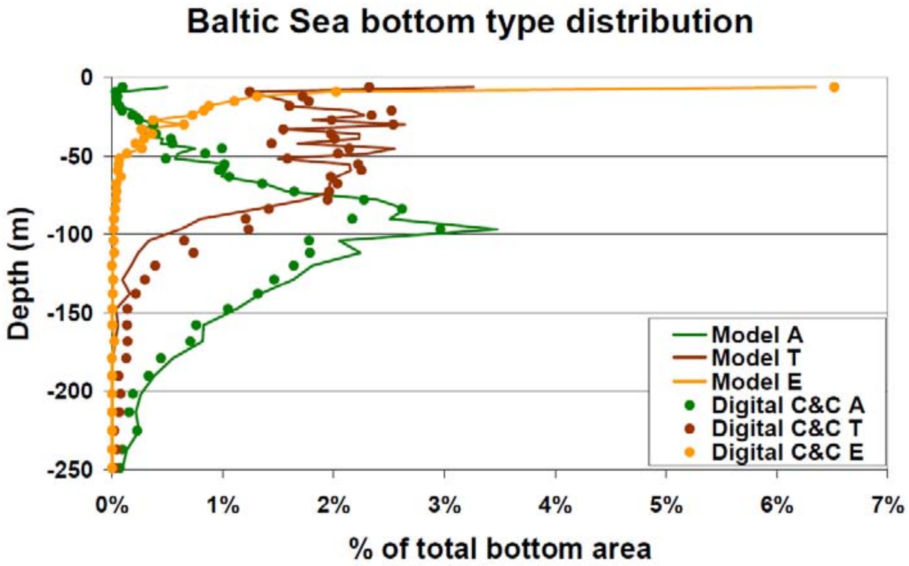
Bottom type classification in model

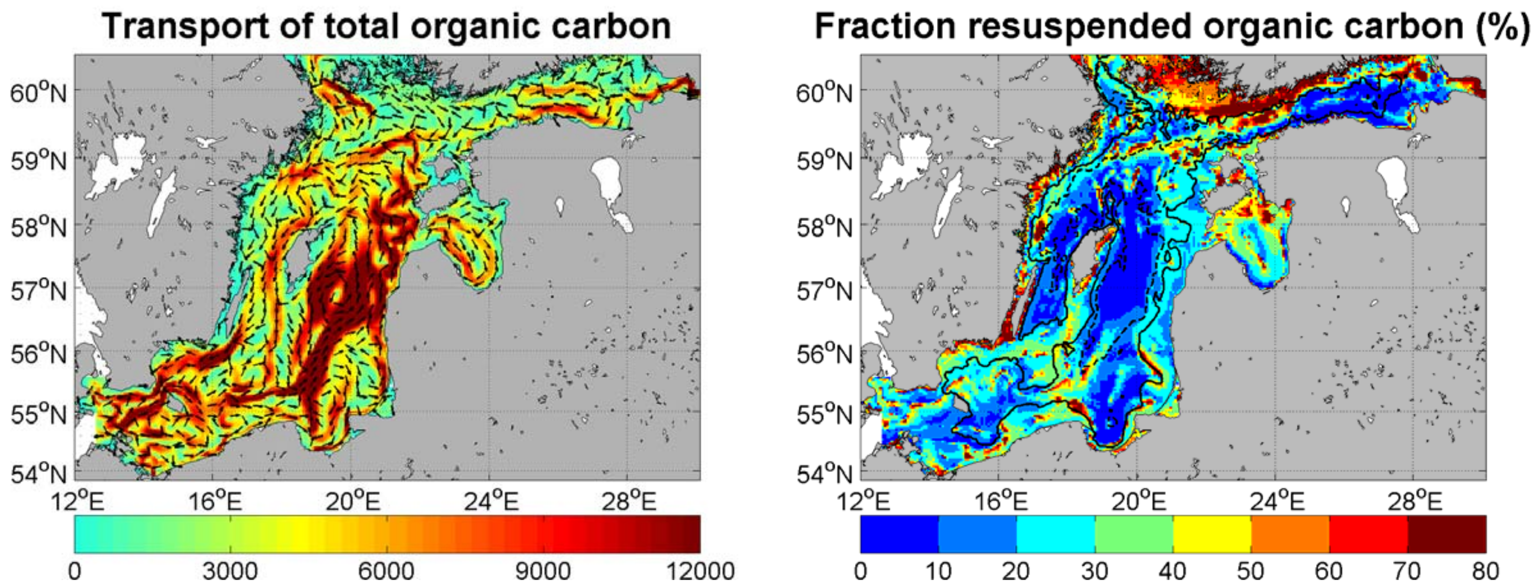
Validation of vertical distribution of the area covered by different bottom types.



- The area is normalized to the total bottom area and the results are presented as percent.
- Model results are shown by green, brown and yellow lines.
- Results from the digitized map are shown by dots in corresponding colours.

green = accumulation
brown = transport
Yellow = erosion

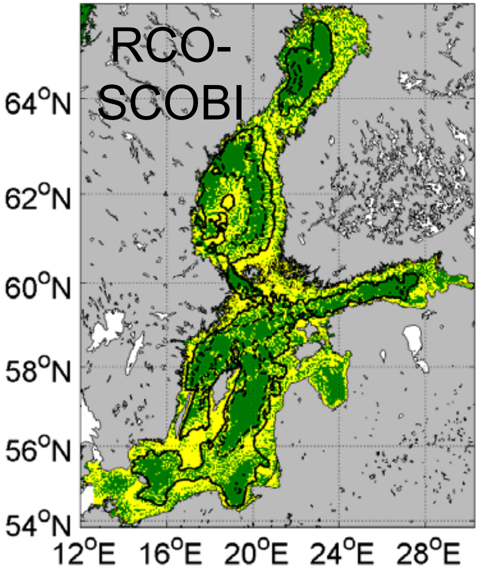
Modelled mean transports

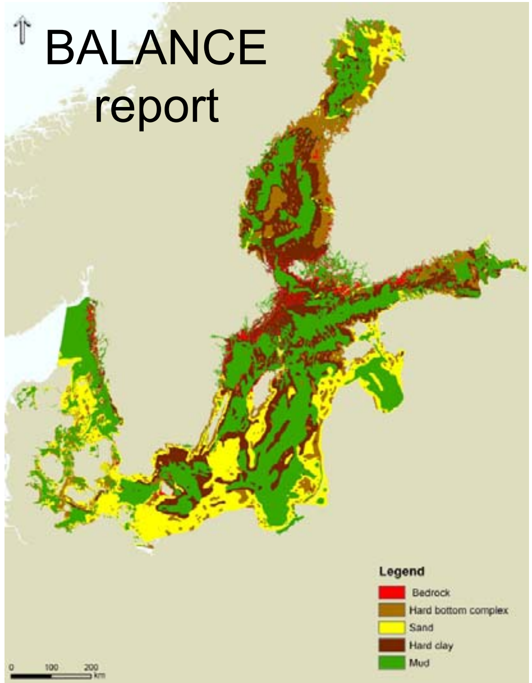


Vertically integrated average (1970-2007) horizontal transport of total organic carbon (ton C km^{-1} yr^{-1}) to the left (*a*) and the fraction of resuspended organic carbon (%) to the right (*b*).

The direction of the transport is indicated by the arrows and the magnitude is shown by the background colour scale. In the right panel (b) the 50 m and 100 m isolines are shown by the black solid and dotted lines, respectively.

Accumulation of organic matter

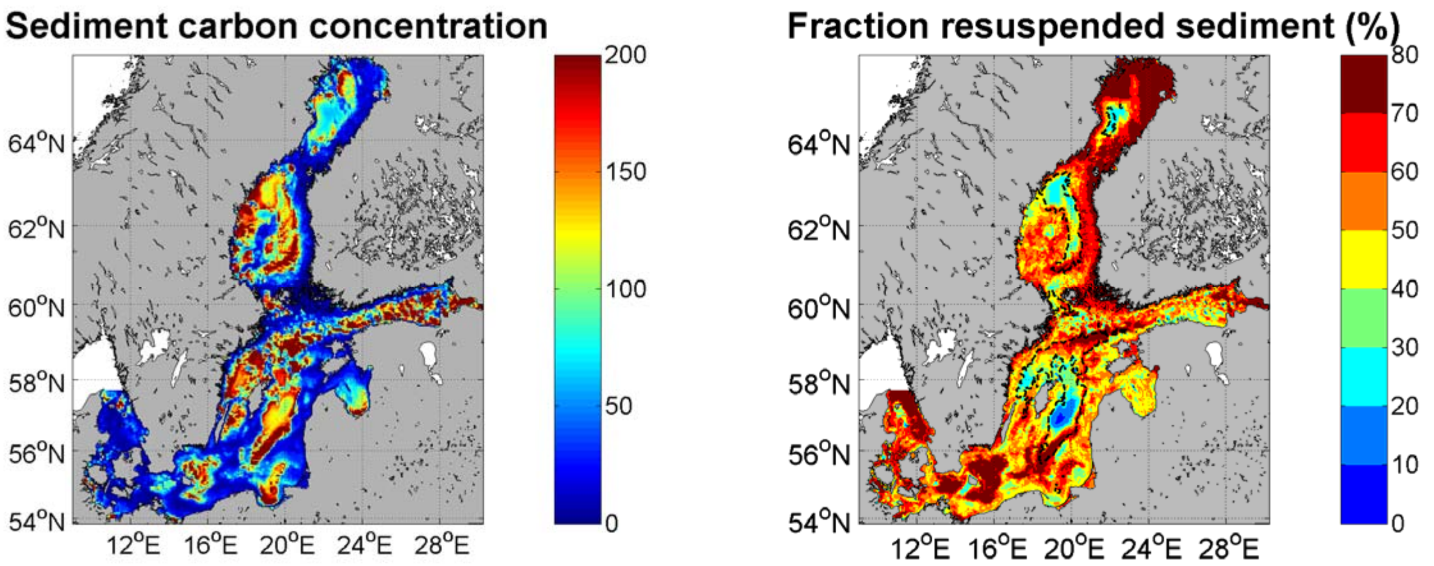




Vertically integrated average (1970-2007) accumulation of organic carbon to the left (*a*). Average import (sink) of organic carbon occurs in green areas, while organic carbon is on average exported (source) from yellow areas.

The 50 m and 100 m isolines are shown by the black solid and dotted lines, respectively. The detailed sediment map from the BALANCE Interim Report from Al-Hamdani and Reker (2007) is shown to the right (*b*). The different sediment classes are shown by the legend. The figure was kindly supplied with permission from Dr. Al-Hamdani.

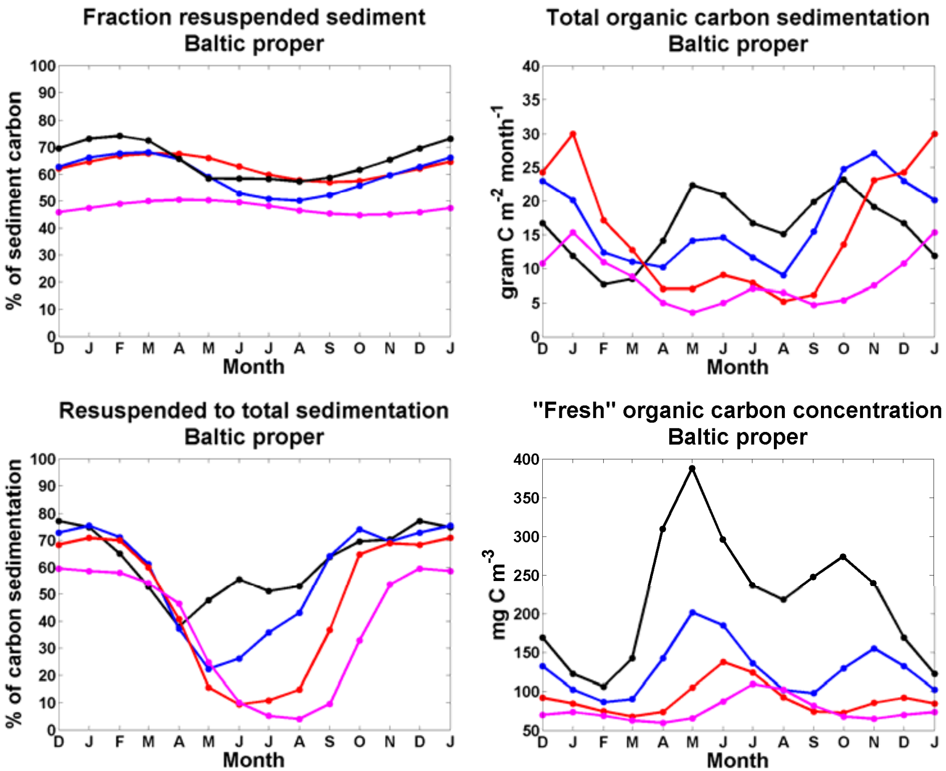
Modelled sediments



The modelled average (1970-2007) benthic organic carbon concentrations (g C m^{-2}) in the Baltic Sea is shown to the left and the fraction of resuspended carbon (%) is shown to the right.

The 100 m isoline of the model is shown by the black dotted line in the left panel.

Seasonal changes

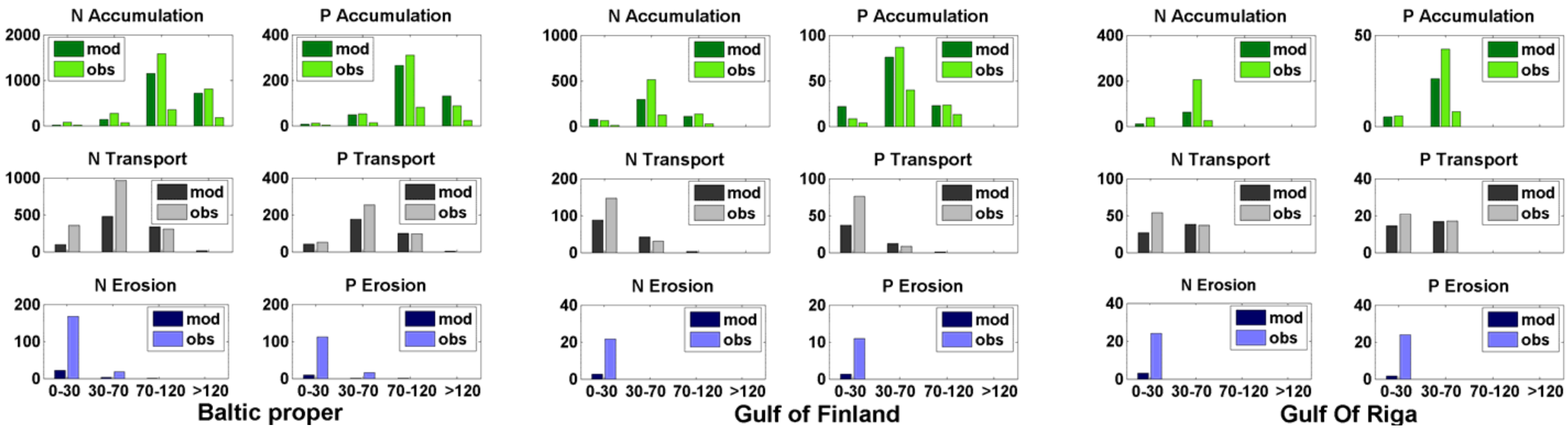


The averages for different depth levels are shown by the black (0-30 m), blue (30-68 m), red (68-120 m) and magenta (120 m- depth) dotted lines, respectively.

The monthly means (1970-2007) of:

- Upper left: the fraction of resuspended organic carbon to total organic carbon in the sediments.
- Upper right: The total sedimentation of organic carbon (g C m^{-2} $month^{-1}$)
- Lower left: The fraction of resuspended matter in the sedimentation
- Lower right: The concentration of fresh organic carbon in the water (mg C m^{-3}).
- Definition of "Fresh"= The organic matter has not touched the sediment.

Sediment nutrient content



Modelled nitrogen and phosphorus content (kton) at the different bottom types and different depth intervals compared to estimations based on observations.

Model results (model) are compared to estimations (obs) based on observations from Carman and Cederwall (2001). At accumulation bottoms the lower and higher observed values correspond to the top 1 cm and 5 cm of the sediment, respectively.

Conclusions and future outlook

• The model successfully managed to capture the horizontal, as well as the vertical, distribution of the different bottom types: accumulation, transport and erosion bottoms and nutrient element contents in the sediments.

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• Although the relative transport of resuspended organic carbon at deeper accumulation bottoms in general is low (<10% of total), the central parts of the sub-basins act on average as sinks that import organic matter while the more shallow areas and the coastal regions acts as sources of organic carbon in the water column.

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• The model seemed to underestimate the nutrient content at the erosion bottoms. Future model investigations might therefore include more information about the structure of the sediment as well as damped wave height in shallow waters. There is at present a lack of sediment nutrient data to be able to do a more extensive validation of the model performance. Compiling of data available from different field campaigns is ongoing and will be used in future model development and validation exercises. More information about how large fractions of the observed sediment nutrients actually incorporated in the biogeochemical cycling is needed.

Thank you

With acknowledgement to:

Al-Hamdani, Z. and Reker, J., 2007. Towards marine landscapes in the Baltic Sea.

BALANCE interim report, No: 10, 117 pp., available at: http://balance-eu.org/.