ECOTIM – Ecological Tidal Model

A Tidal Flat Model basing on ERSEM

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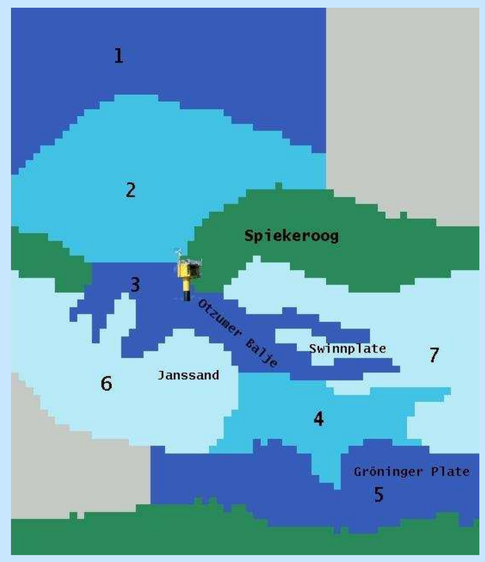
Main Features

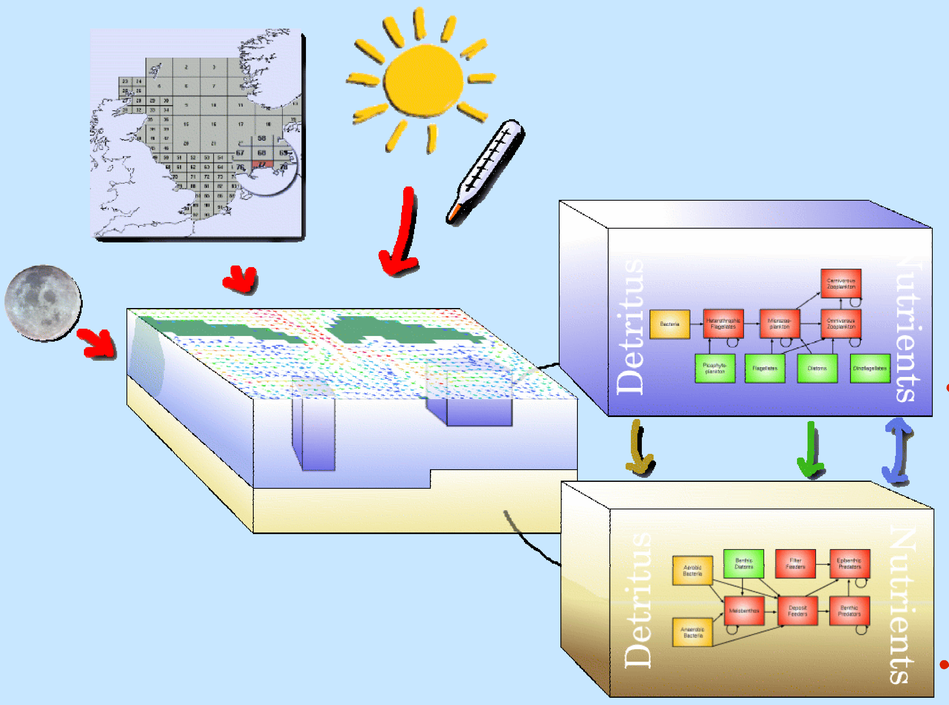
- Differentiation Equation model for the back barrier tidal flat of Spiekeroog
- Simulation of the pelagic system in 100 water bodies
- Simulation of the benthic system in 6 tidal areas
- Resolving key processes down to about 1 hour
- Euler-Lagrange coupling for benthic and pelagic system
- Simulating mass flows of carbon nitrogen, phosphate and silicate
- Benthic and pelagic models are "nearly" ERSEM[1,2]

State variables

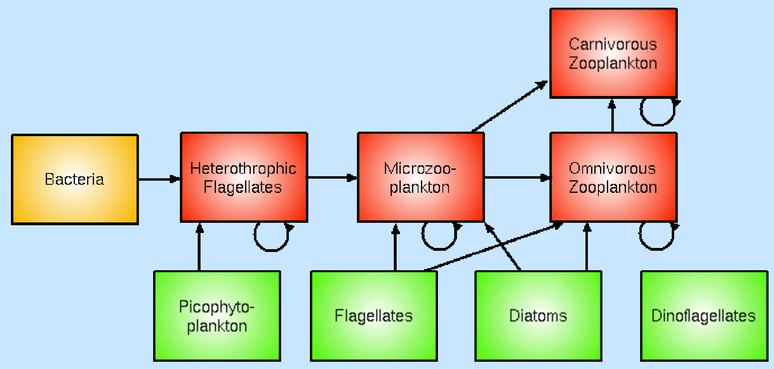
- phosphate, ammonium, nitrate, silicate
- detritus: DOM, POM, ROM
- functional groups of the foodwebs
- oxygen, carbon dioxide, nitrogen gas
- internal nutrient pool concentrations of algae
- optimal light for algae
- penetration depth of oxygen, nitrate and detritus



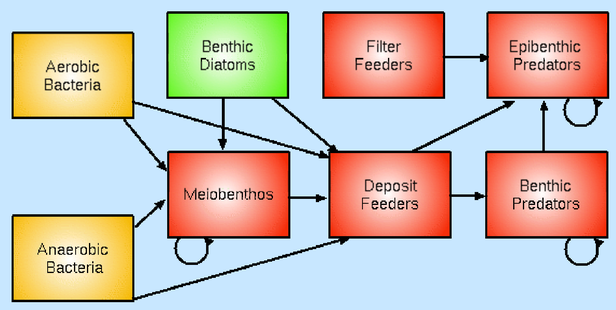
The model area: green regions are land or island, grey regions are not treated by the model, blue numbered areas: model areas where benthic model is active. Remark: The area is rotated and stretched compared to usual projections.



The model concept: Water bodies move along a surface velocity field. In every water body the pelagic model is calculated. In the sediment regions the benthic system is simulated. The coupling between pelagic and benthic systems is determined by the area of a water body as function of the actual water sea level. The northern model boundary values as well as physical forcing values are given by the COCOA[6] implementation of the North Sea.



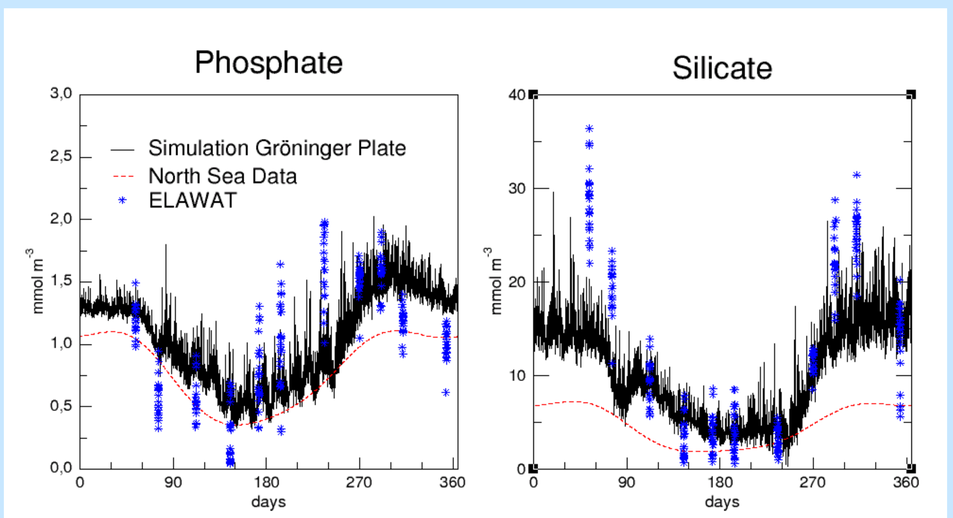
Pelagic Foodweb: The pelagic system contains four functional groups for zoobenthos, four types of algae and bacteria. The arrows show the biomass flow due to grazing.



Benthic Foodweb: The benthic system contains five functional groups for zoobenthos, aerobic and anaerobic bacteria. and benthic diatoms. The arrows show the biomass flow due to grazing.

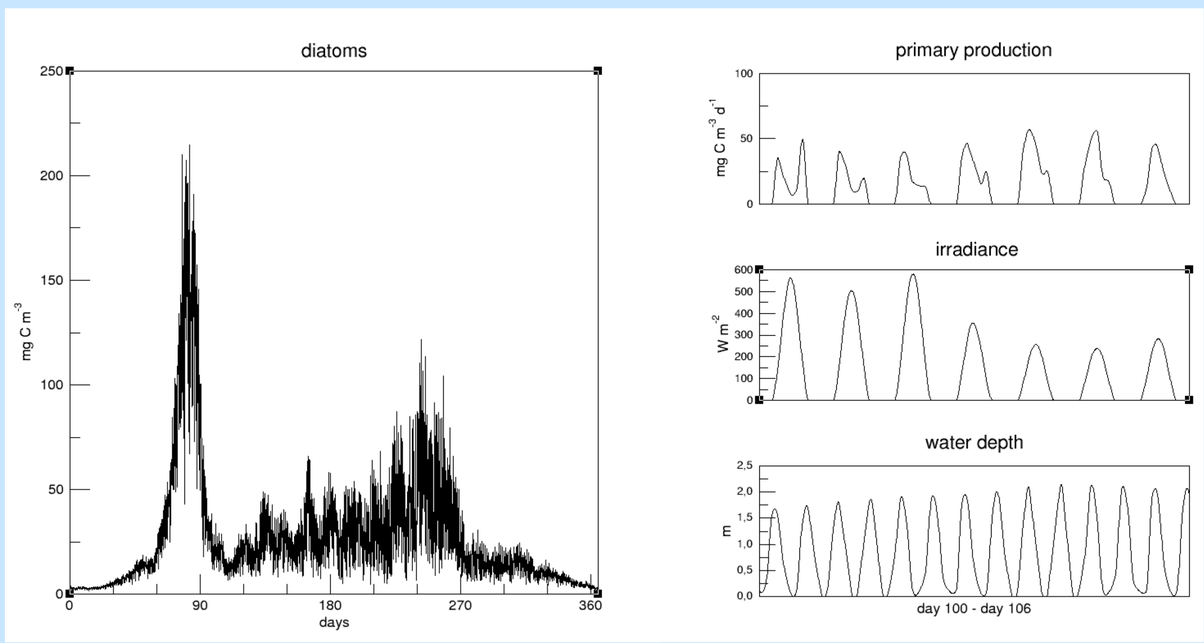
Some tentative results

Nutrient Dynamics



Modelled pelagic phosphate and silicate concentration at the Gröninger Plate (black) compared to measurements from the ELAWAT project (stars)[3]. The concentrations are averaged over all water bodies over the benthic area 5. The red line denotes the boundary conditions of the North Sea (from ECOMOD data base). The high variance in the concentrations during the tidal cycle is reproduced by the model. It can be seen that there is a gradient from the North Sea to the coast. This gradient depends basically on the shallowness of the water near the coast[4,5]. The impact of sedimentation into the benthic system, remineralization and diffusive exchange between water and pore water increases with decreasing water depth. The resulting net inflow of nutrients into the back barrier system is compensated by an outflow of organic material. The steepness of the gradient depends on the amount of an additional inflow of organic material into the system.

Phytoplankton Growth



Left: Modelled diatom concentration at the Gröninger Plate. The concentrations are averaged over all water bodies over the benthic area 5. The model results reconstruct the annual signal very well. The oscillations are a consequence of the tidal signal and the light signal. Right: The primary production depends on the available light as superposition of the actual irradiance and the extinction due to water depth. The local minima in the primary production curve results from the light inhibition due to too high values of available light.

Literature

1.Baretta-Bekker, J.~G., (Ed.), 1995. European Regional Seas Ecosystem Model-I, volume 33 (3/4). Netherlands Journal of Sea Research.
2.Baretta-Bekker, J.-G., Baretta, J.-W., (Eds.), 1997. Special issue: European Regional Seas Ecosystem Model II, volume 38 (3-4). Journal of Sea Research.
3.Dittmann, S. (Ed.), 1999. The Wadden Sea Ecosystem - Stability Properties and Mechanisms. Springer, Berlin, 307p.
4.Ebenhöh, W., Kohlmeier, C., Baretta, J.-W., 2003. Modelling horizontal nutrient gradients in the Wadden Sea. submitted to Journal of Sea Research.
5.Ebenhöh, W., Kohlmeier, C., Baretta, J.-W., Flöser, G. 2003. Shallowness may be a major factor generating nutrient gradients in the Wadden Sea. submitted to Ecological Modelling.
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