

BOOS national activities in 2016

part1 - Modelling

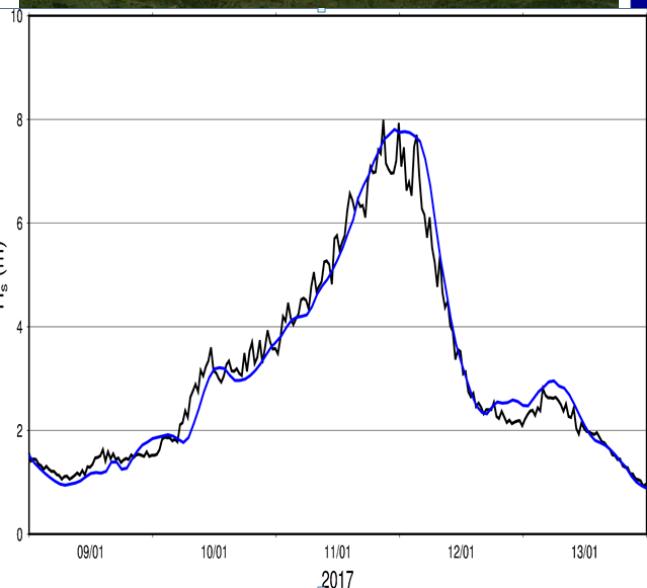
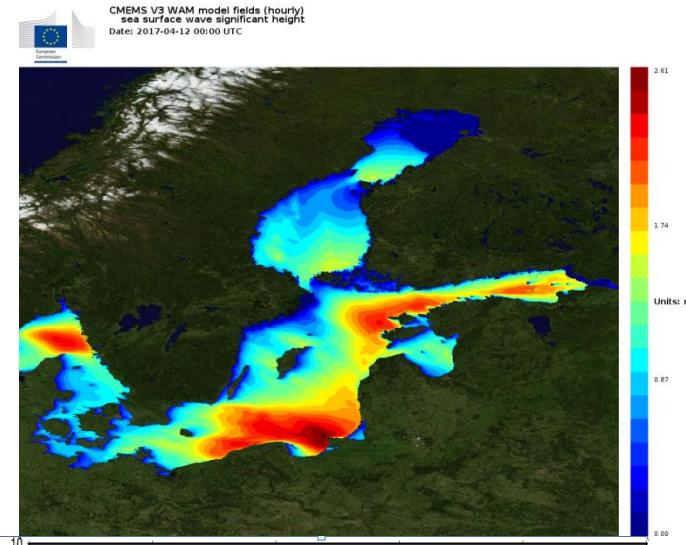
BOOS STG



CMEMS Product Development last year: Waves

Set up:

WAM 4.5.4 + few Baltic modifications
Grid: 1 nmi
2 days forecast 2/day: hourly instantaneous values
Atm: FMI-HARMONIE (2.5 km) / Estonian Weather Service 11 km)
BDY: ECMWF wave spectra
Product: 17 variables.



Pre-Qualification:

2 years: June 2014 – May 2016 at FMI

- **Good forecast: storm event Jan 2017:**
Hs obs: 8.0 m (record: 8.2 m)



BOOS
Baltic Operational
Oceanographic System

CMEMS Upgraded 3D ocean PHY & BIO forecast product: HBM-ERGOM

Sea ice module

Coastal-fast ice (freely drifting ice vs. immovable ice)

Ice dynamics (simple)

Turbulence scheme

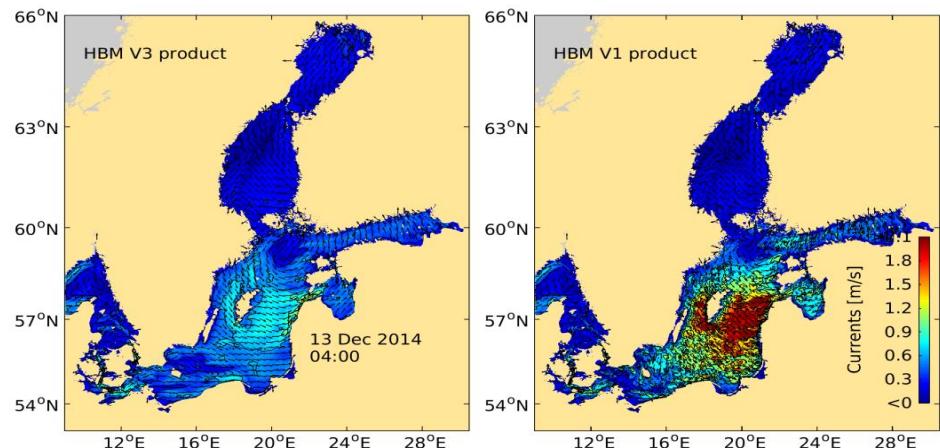
*new set of structure functions
(Canuto part III)*

Atmospheric deposition:

upgraded to include spatial varying data
(oxidised and reduced nitrogen) (EMEP)

N/P ratio:

local quality improved by spatial variable N/P ratio



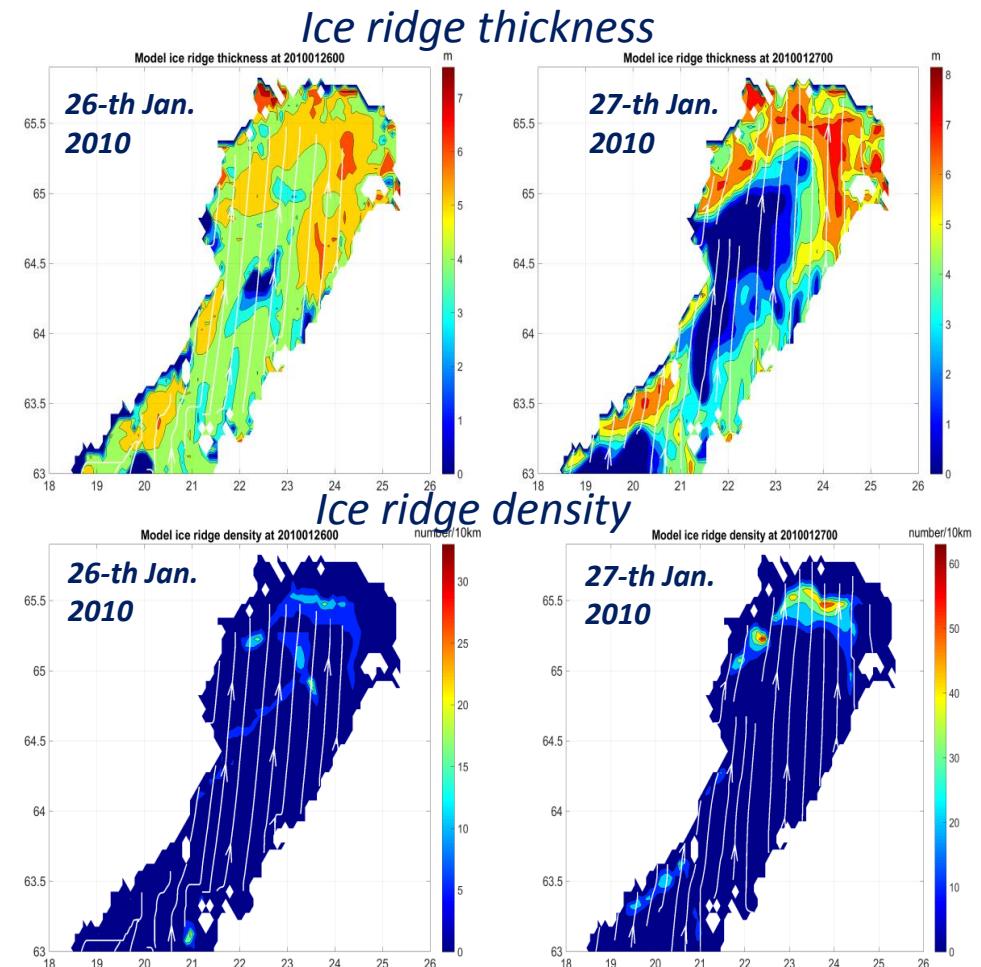
Ice Ridging and Fast Ice Model

Ice ridging in shallow waters might lead to the development of anchor points that support the condition of rigidity.

In the context of plasticity, ice ridging is implemented as additional load compensating stress term.

Ridged fast ice yields to stresses that exceed critical limits. It can also be moved when it loses its bottom contact and gets afloat.

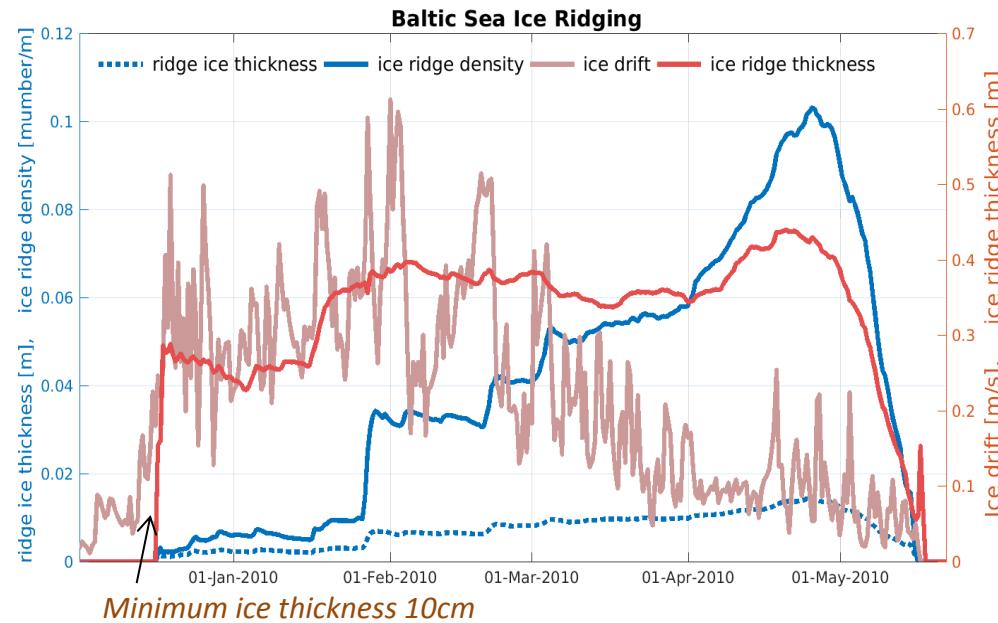
A ice ridging model has been implemented that describes the development of ice ridge thickness and ice ridge density (Mikko Lensu, IRIS project, Lars Axel, HIRLAM)



Ice Ridging and Fast ice

When ice ridging occurs:

- *The number of ice ridges per characteristic length scale (blue) increases, dependent on the convergence of the currents and a characteristic length scale.*
- *The thickness of the ridged ice (blue dots) grows, as a function of the ice volume, i.e. thickness.*
- *The thickness of the ice-ridges (sail-to-kiel) (red) increases, with a rate that depends on the level ice thickness (available ice volumen); and reduces with the number of ice ridges per length scale. → saturation eqn.*



From Ridging to Fast Ice

- *Ridging has been implemented in the plasticity calculus*
- *When the kiel depth equals the total water depth, the ridged ice sticks to the ground and is transformed to fast ice.*

Model comparisson with sattellite data



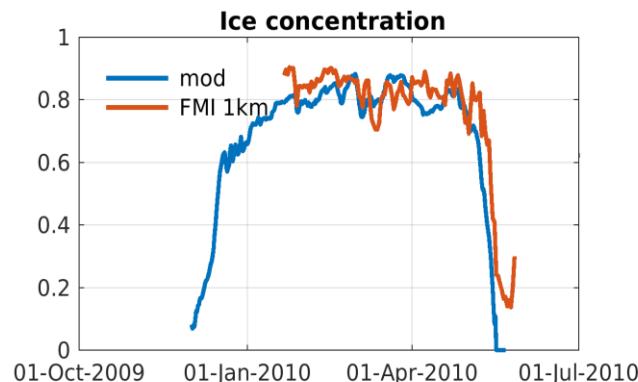
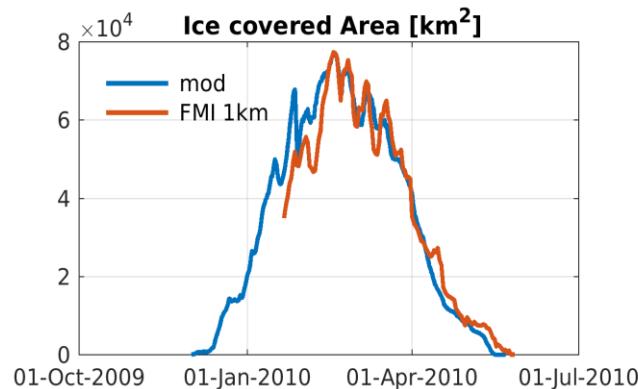
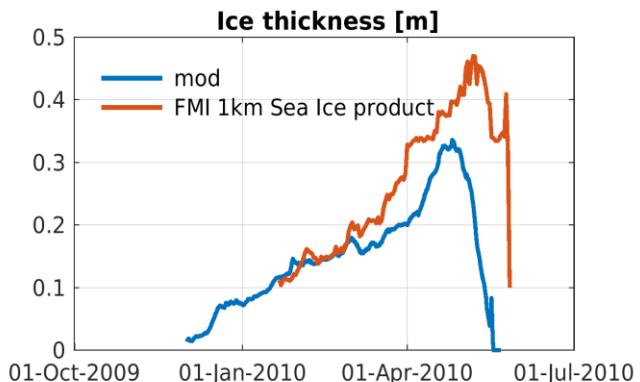
BOOS
Baltic Operational
Oceanographic



The ice model is well able to predict the sea ice covered area, both the maximum extend and the change during the melting phase.

Modelled sea ice thickness is somewhat lower than observed values, even when the thickness of the ridged ice is considered. The analysis on the next page indicates that the observations do not only represent level ice, but also to some extend rafted or ridged ice.

Comparisson at ice covered points



Product Quality Assessment: CMEMS Priority – continuous development

pre-qualification

SICS ANALYSIS AND FORECAST

metadata provided by CMEMS
Credits: E.U. Copernicus Marine Service Information

FIRST VISIT ?

MY CART 0

BACK TO SEARCH

ADD TO CART

VIEW PRODUCT

DOWNLOAD PRODUCT

INFORMATION PDF XML

DOCUMENTATION

SERVICES

NEWS FLASH

PRODUCT IDENTIFIER BALTIC SEA ANALYSIS FORECAST PHYS_003_006

OVERVIEW

Short description:
This Baltic Sea physical model product provides forecasts for the physical conditions in the Baltic Sea. The Baltic forecast is updated twice daily providing a new two days forecast with hourly data for sea level variations, ice concentration and thickness at the surface, and temperature, salinity and horizontal velocities for the 3D field. The product is based on the 3D ocean model code HBM developed within the Baltic ocean community.

Detailed description:
The Baltic Sea physical model product provides information for the physical conditions in the Baltic Sea on a product grid with horizontal resolution of 1 nautical mile and with up to 25 vertical depth levels. The area covers the Baltic Sea including the transition area towards the North Sea (i.e the Danish Belts, the Kattegat and Skagerrak).

The product provides:

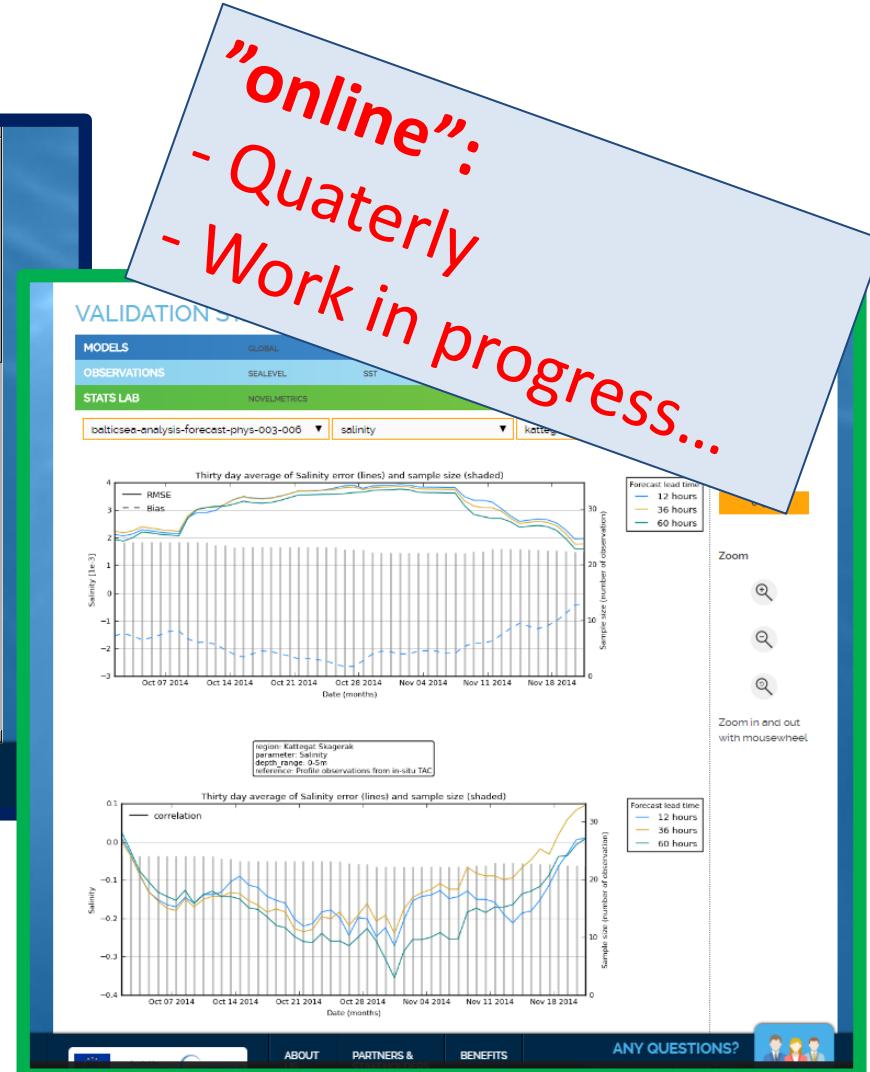
- Hourly instantaneously model data for sea level variations, ice concentration and thickness at the surface, and temperature, salinity and horizontal velocities for the 3D field. The bottom sea temperature from the lowest model grid cell is included as a 2D field; as well as a calculation of the mixed layer depth.
- Daily mean values of the same variables.

Funded by the European Union 

ABOUT US PARTNERS & STAKEHOLDERS BENEFITS

ANY QUESTIONS?
Get help from the Service Desk

"online":
- Quaterly
- Work in progress...



Multi-model-ensemble for BOOS & NOOS

The screenshot shows the BOOS Multi Model Ensemble homepage. At the top, there's a navigation bar with icons for About us, Programmes, Documents, News, and Events. Below that is a main menu with Home, BOOS, Products, Forecasts, Observations, Members, and Newsletter. A breadcrumb trail indicates the current location: BOOS > Multi Model Ensemble. The main content area is titled "Multi Model Ensemble" and is coordinated by BSH. It features logos for Copernicus, DM, foodo, MSI, and SMHI. Below this, there are sections for Currents and Transports, Temperature, and Salinity, each with sub-sections like Surface Currents, PVD of Currents, Total Transports, SSC Difference, Salt Transports, Surface Temperature, Bottom Temperature, SST Difference, SBT Difference, Monthly Validation, Surface Salinity, Bottom Salinity, SSS Difference, SBS Difference, SBS Baltic Inflow, and Monthly Validation.

BOOS: www.boos.org

NOOS: www.noos.cc

MME Community: BSH, DMI, FCOO, FMI, SMHI, **IOPAN**, MSI, UK MetOffice, Met.no, RBINS

Parameter

sea surface temperature (SST)

sea surface salinity (SSS)

sea surface currents (SSC)

sea bottom temperature (SBT)

sea bottom salinity (SBS)

mass transport (TRA)

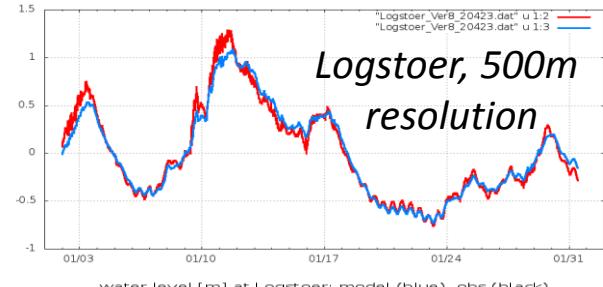
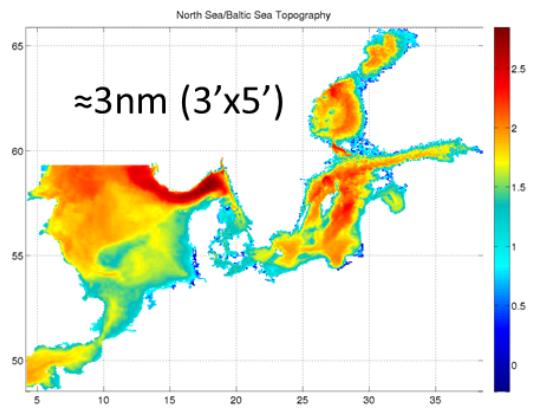
Water level

Download

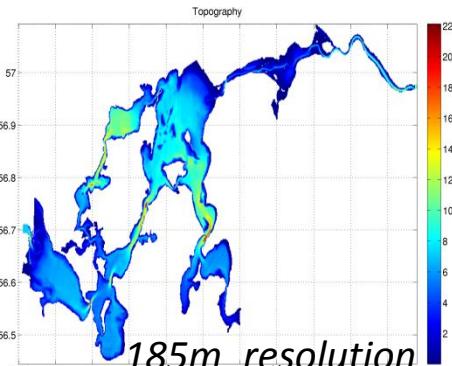
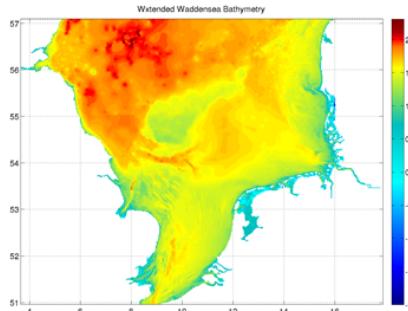
ftp://ftp.bsh.de/outgoing/opmodel/my_ocean/MME

Seamless modelling: coastal-estuary continuum

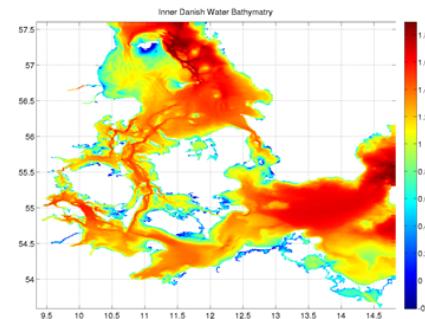
*New DKSS
Storm Surge
Setup*



$\approx 1\text{nm}$ ($1' \times 1.66'$)



$\approx 0.5\text{nm}$ ($30'' \times 50''$)



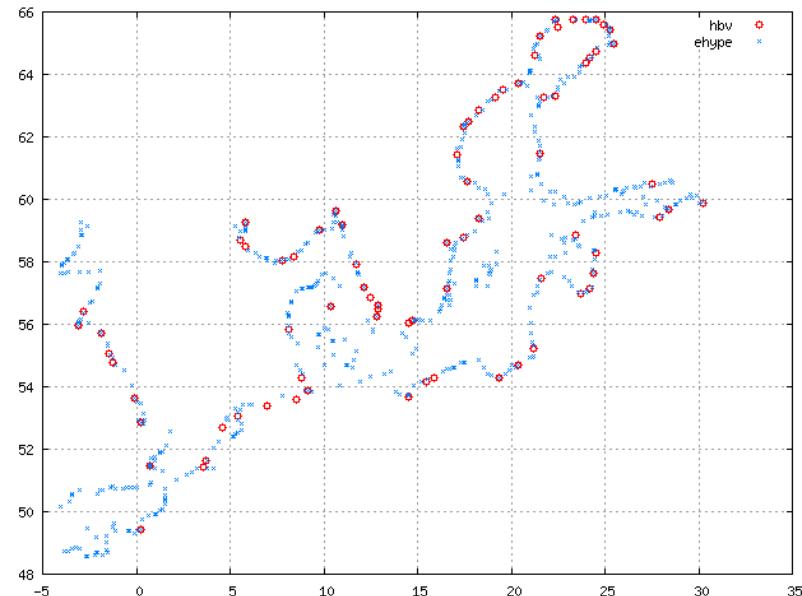
River Data E-hype3



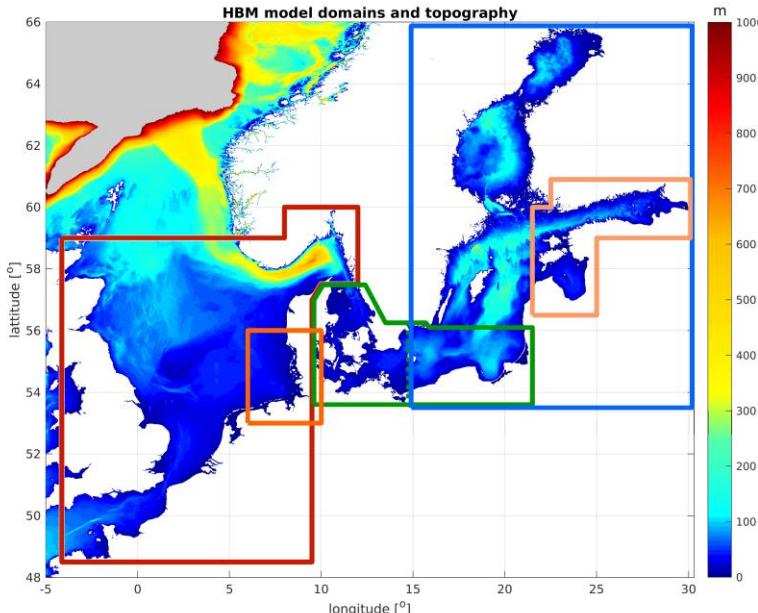
public download page
<http://hypeweb.smhi.se/europehype/time-series/>

- Forecast data is used operationally
- Daily delivery of 10 days: yesterday, today, 8-day forecast
 - run-off [m³/s] sanity checked
 - 30-day accumulated nutrient load [T/30d] Total-N, Total-P
- Annual calendar day climatology generated from 30 years of daily run-off (1980-2010) and 11 years of bioloads (2000-2010)
- 3032 coastal segments / rivers
 - 846 North / Baltic sea river
 - 31 Limfjord river (30 outlets)

*E-Hype3 vs. HBV
~10x more outlet points*

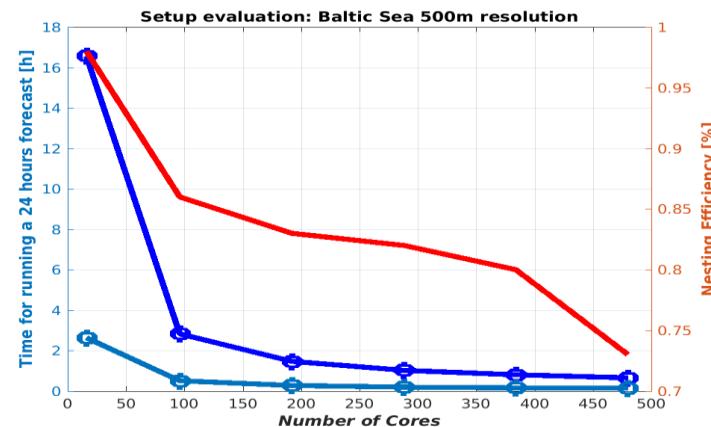


Test of HBM's capabilities to run extensive set-ups



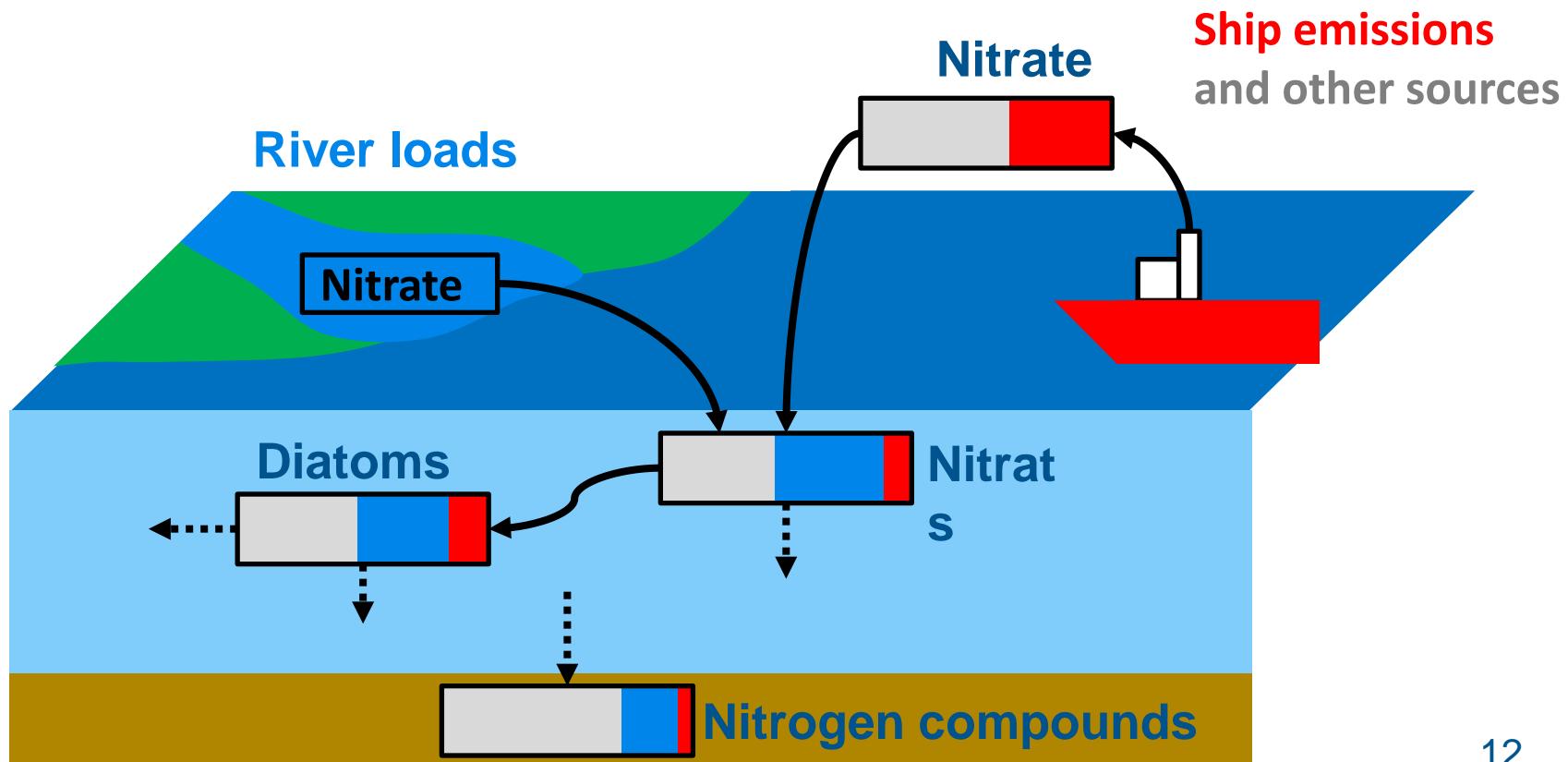
| | Nested | Fine |
|----------------------------------|---------------------------------|----------------------------------|
| Setup | NS, WS, DS, BS^{N^2} , GoF | NS, WS, BS^F^2 |
| Number of 3D points (in million) | 21.8 | 104.2 |
| Expected memory use | 10.81 | 51.7 GB (max. 64 GB per node) |
| Maximum run time ratio N-to-F | 6.43 | |

| Domain | Grid resolution | N3D points (in millions) |
|----------------------------|------------------------|---------------------------------|
| North Sea (NS) | 5km | 0.48 |
| Waddensea (WS) | 2km | 0.1 |
| Danish Straits (DS) | 1km | 6,2 |
| Baltic Sea Fine (BS^F) | 500m | 103.64 |
| Baltic Sea Nest (BS^N) | 2 km | 4.3 |
| Gulf of Finland (GoF) | 500m | 10.72 |



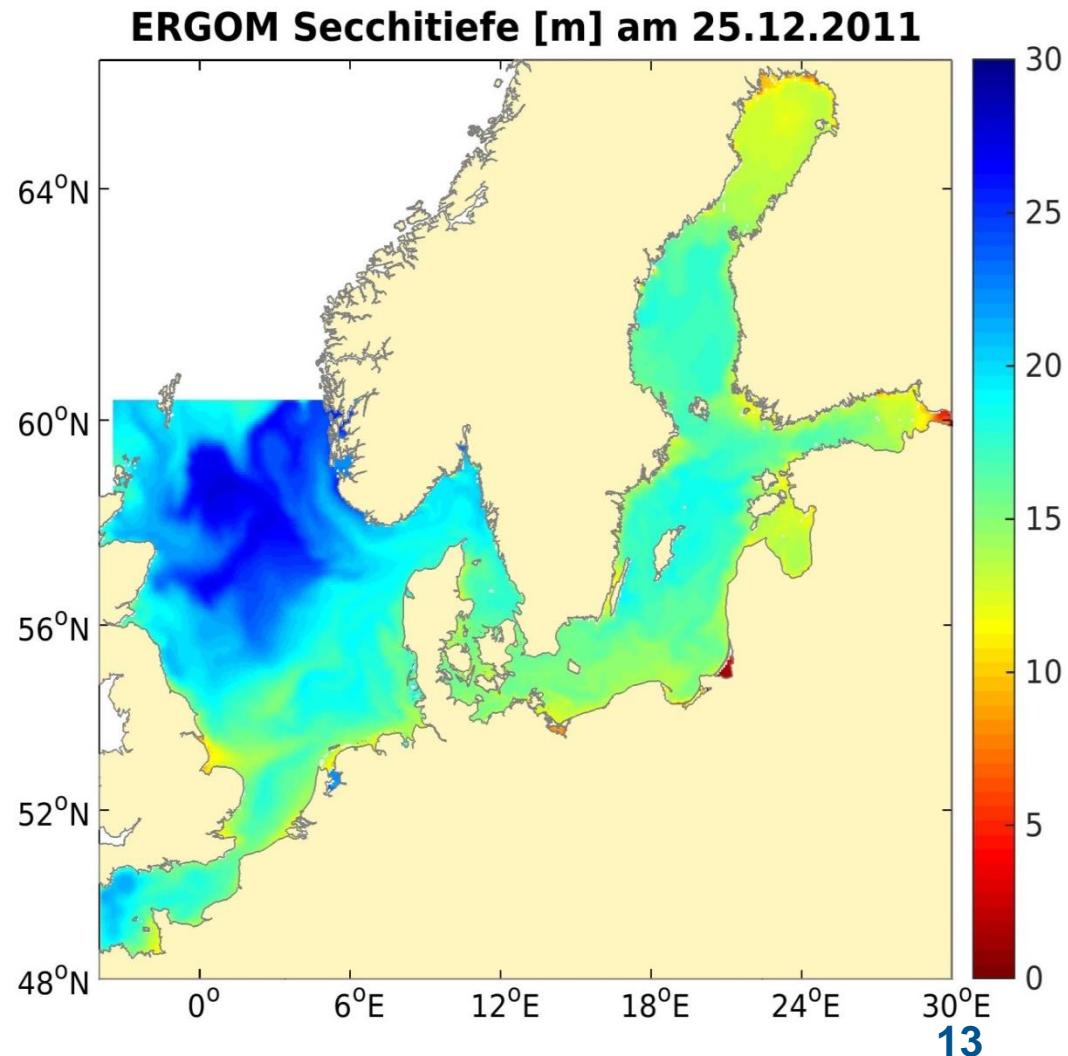
Nutrient tagging

- **Goal:** estimate of contribution of anthropogenic nutrient input to algea blooms and eutrophication
- > Simulations with tagged nitrate input



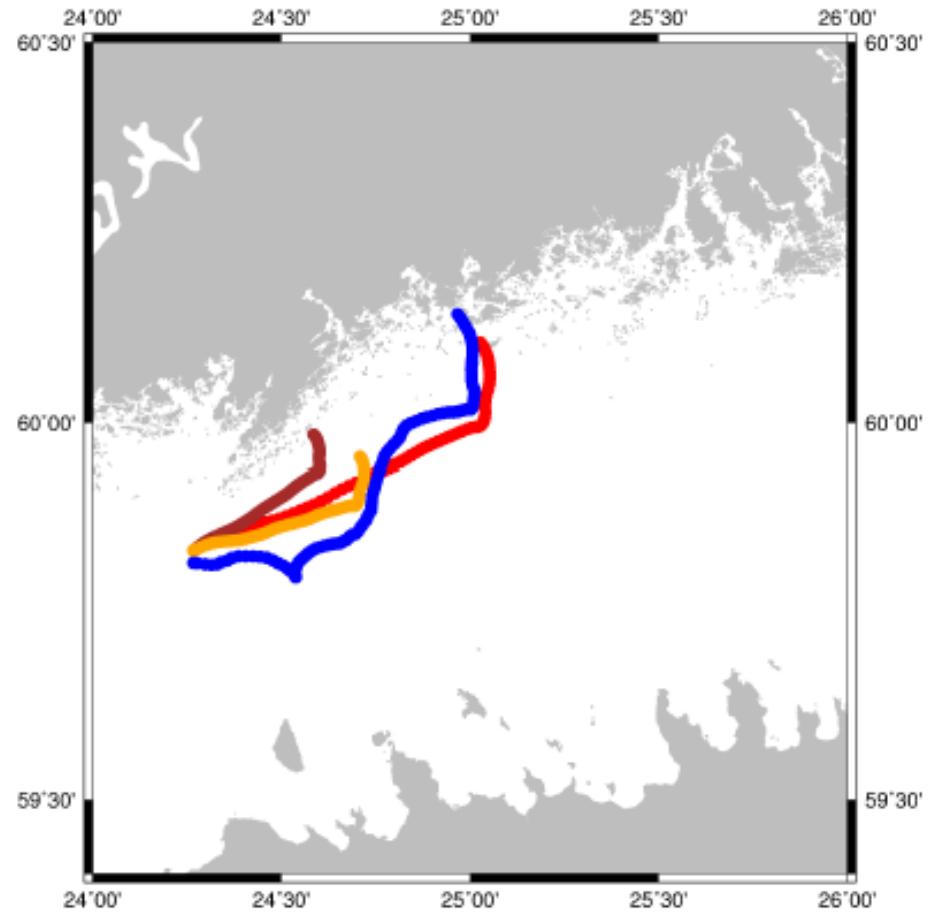
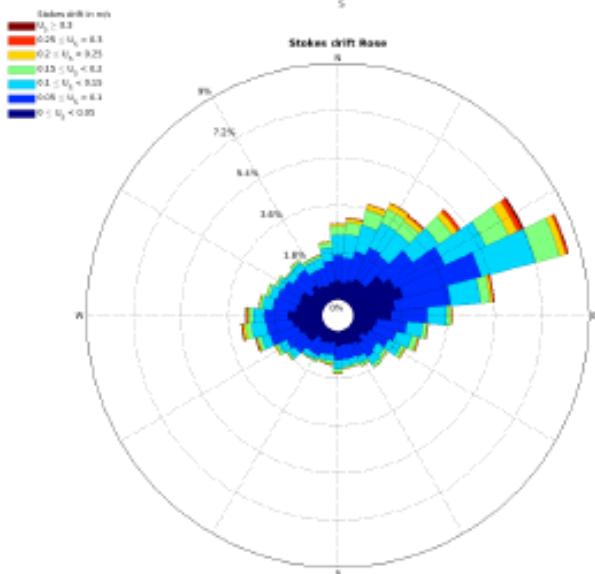
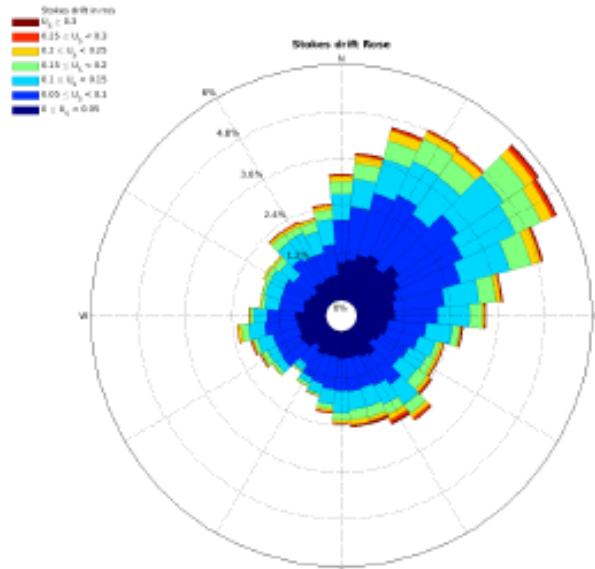
ERGOM development

- Implementation of bio-optical module (Neumann, 2015) > interface to data assimilation
- Calculation of Secchi depth from K_{par} > indicator for water quality





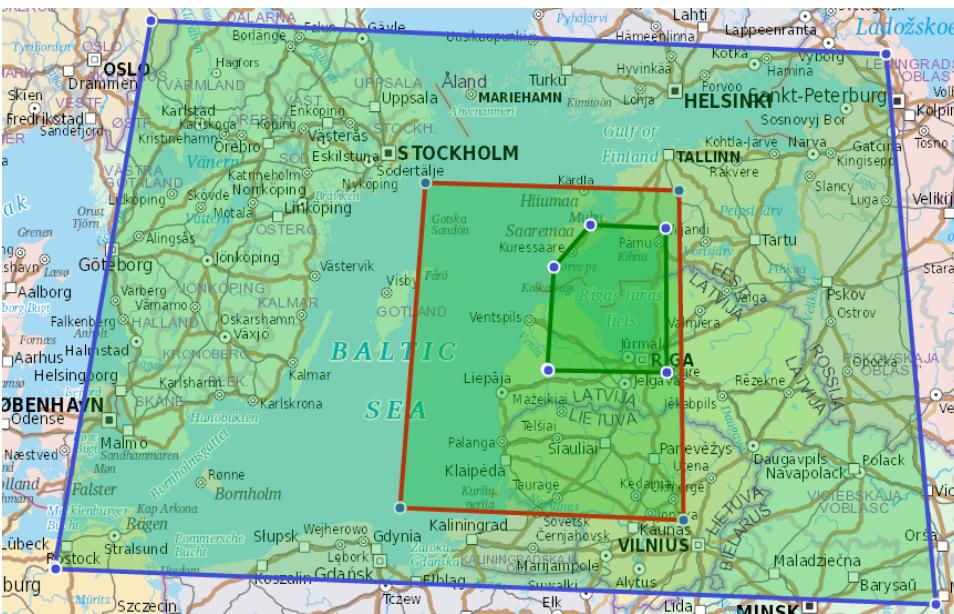
Drift modelling – Stokes drift



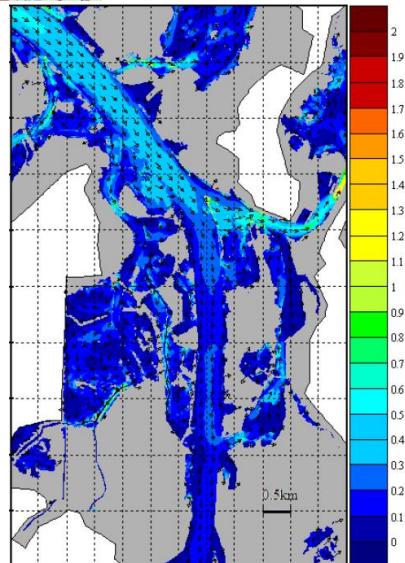
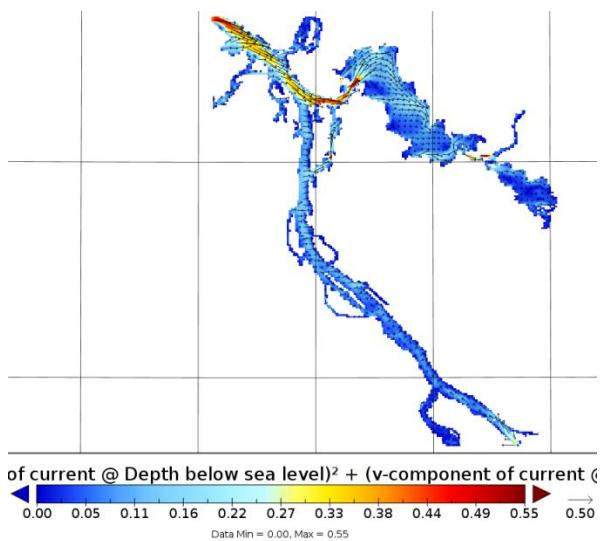
Downscaling forecast for GoR and 12 lakes

Vilnis Frishfelds, Uldis Bethers, Juris Sennikovs

University of Latvia



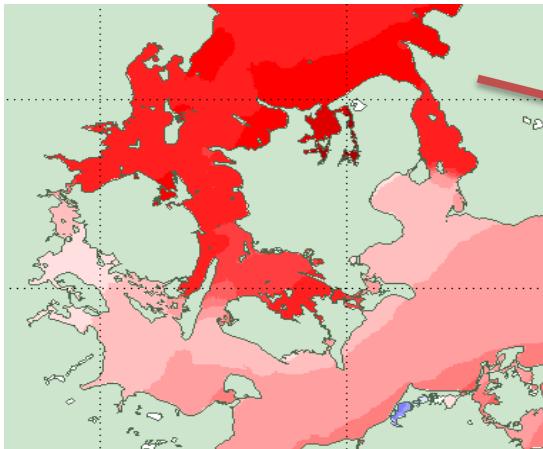
Resolution: blue ~ 2nmi, red ~ 1nmi
Bathimetry: EMODnet
Boundary conditions,
atmospheric forcing, waves: DMI
River run-off: climatological
Ephemeris: NASA
Operational on UL cluster node with
32 cores ~5 days forecast
<http://www.modlab.lv/meteo>



HBM3D (left)
Swevolver 2D (right)

Prognose for oversvømmelse: projekt Varsko

Eksempel: Stormfloden Bodil, 6. december 2013

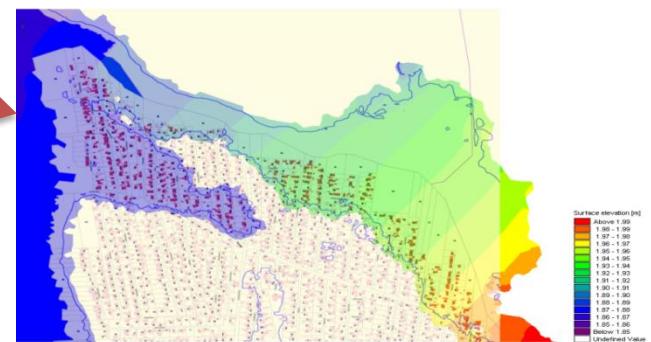


DMI's stormfloodsmodel



DHI's oversvømmelsesmodel

Sammenligning med forsikrings-information om oversvømmede huse

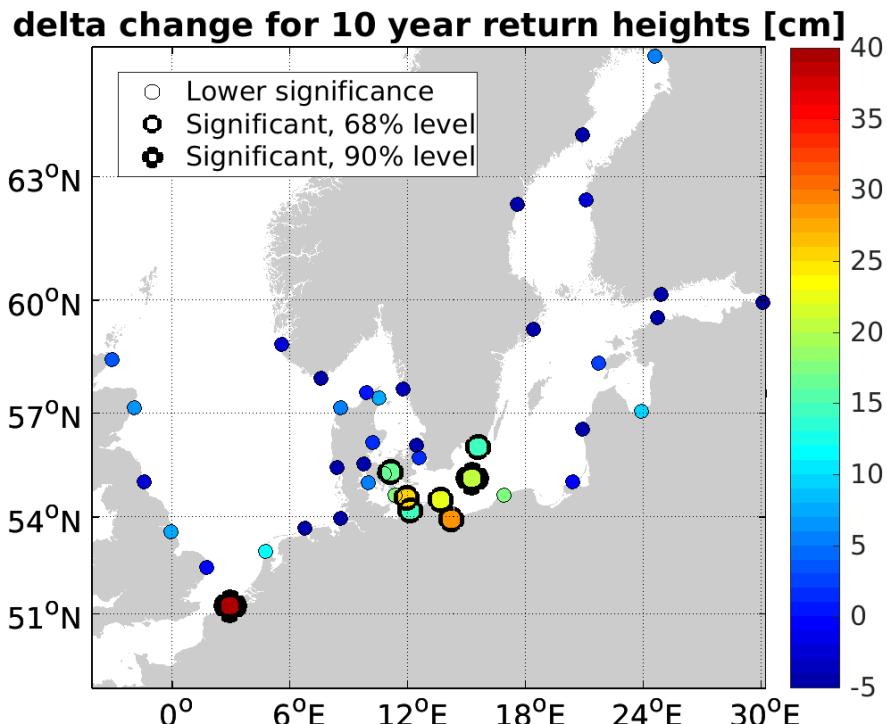


Surge elevation [m]

| |
|------------------|
| Surge above 1.99 |
| 1.97 - 1.99 |
| 1.93 - 1.97 |
| 1.91 - 1.93 |
| 1.89 - 1.91 |
| 1.87 - 1.89 |
| 1.85 - 1.87 |
| 1.83 - 1.85 |
| 1.81 - 1.83 |
| 1.79 - 1.81 |
| 1.77 - 1.79 |
| 1.75 - 1.77 |
| 1.73 - 1.75 |
| 1.71 - 1.73 |
| 1.69 - 1.71 |
| 1.67 - 1.69 |
| 1.65 - 1.67 |
| 1.63 - 1.65 |
| 1.61 - 1.63 |
| 1.59 - 1.61 |
| 1.57 - 1.59 |
| 1.55 - 1.57 |
| 1.53 - 1.55 |
| 1.51 - 1.53 |
| 1.49 - 1.51 |
| 1.47 - 1.49 |
| 1.45 - 1.47 |
| 1.43 - 1.45 |
| 1.41 - 1.43 |
| 1.39 - 1.41 |
| 1.37 - 1.39 |
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| 1.23 - 1.25 |
| 1.21 - 1.23 |
| 1.19 - 1.21 |
| 1.17 - 1.19 |
| 1.15 - 1.17 |
| 1.13 - 1.15 |
| 1.11 - 1.13 |
| 1.09 - 1.11 |
| 1.07 - 1.09 |
| 1.05 - 1.07 |
| 1.03 - 1.05 |
| 1.01 - 1.03 |
| 0.99 - 1.01 |
| 0.97 - 0.99 |
| 0.95 - 0.97 |
| 0.93 - 0.95 |
| 0.91 - 0.93 |
| 0.89 - 0.91 |
| 0.87 - 0.89 |
| 0.85 - 0.87 |
| 0.83 - 0.85 |
| 0.81 - 0.83 |
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| 0.77 - 0.79 |
| 0.75 - 0.77 |
| 0.73 - 0.75 |
| 0.71 - 0.73 |
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| 0.41 - 0.43 |
| 0.39 - 0.41 |
| 0.37 - 0.39 |
| 0.35 - 0.37 |
| 0.33 - 0.35 |
| 0.31 - 0.33 |
| 0.29 - 0.31 |
| 0.27 - 0.29 |
| 0.25 - 0.27 |
| 0.23 - 0.25 |
| 0.21 - 0.23 |
| 0.19 - 0.21 |
| 0.17 - 0.19 |
| 0.15 - 0.17 |
| 0.13 - 0.15 |
| 0.11 - 0.13 |
| 0.09 - 0.11 |
| 0.07 - 0.09 |
| 0.05 - 0.07 |
| 0.03 - 0.05 |
| 0.01 - 0.03 |
| Below 0.00 |

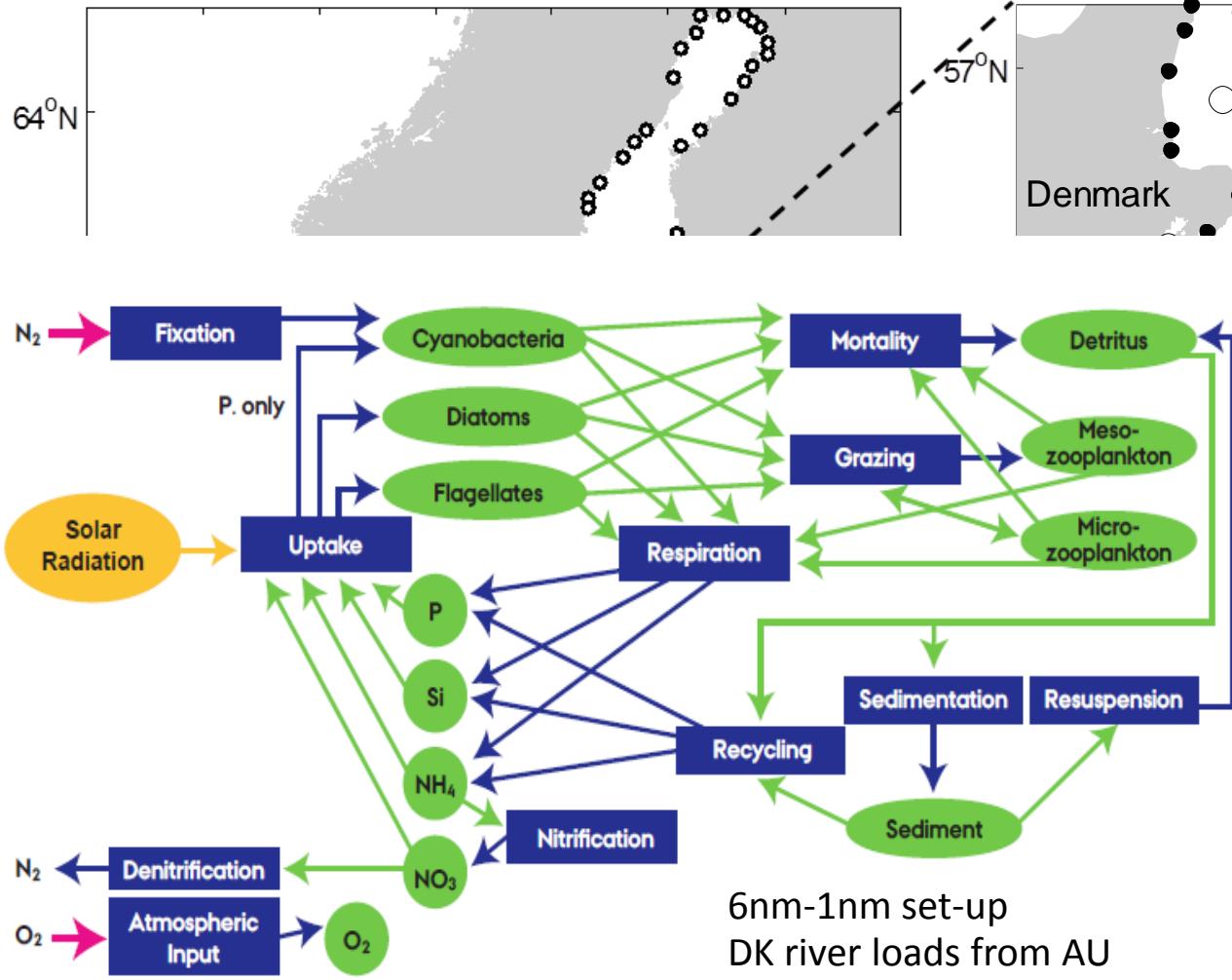
RCP8.5

2046-2065

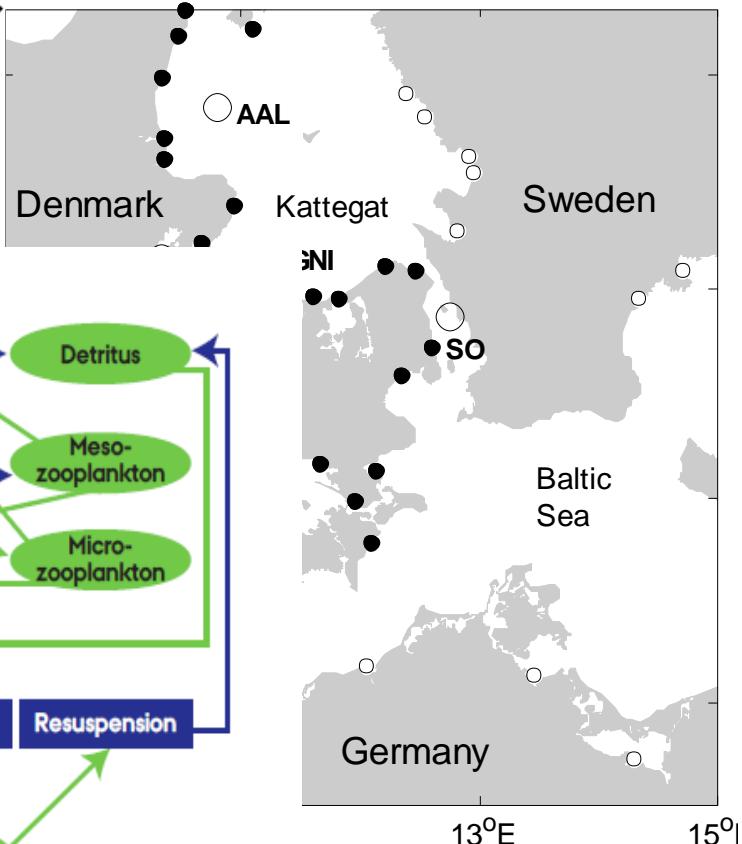


HBM-ERGOM (AU-BIOS)

A) The North Sea - Baltic Sea



B) Transition area



- PP can occur even though there few nutrients:

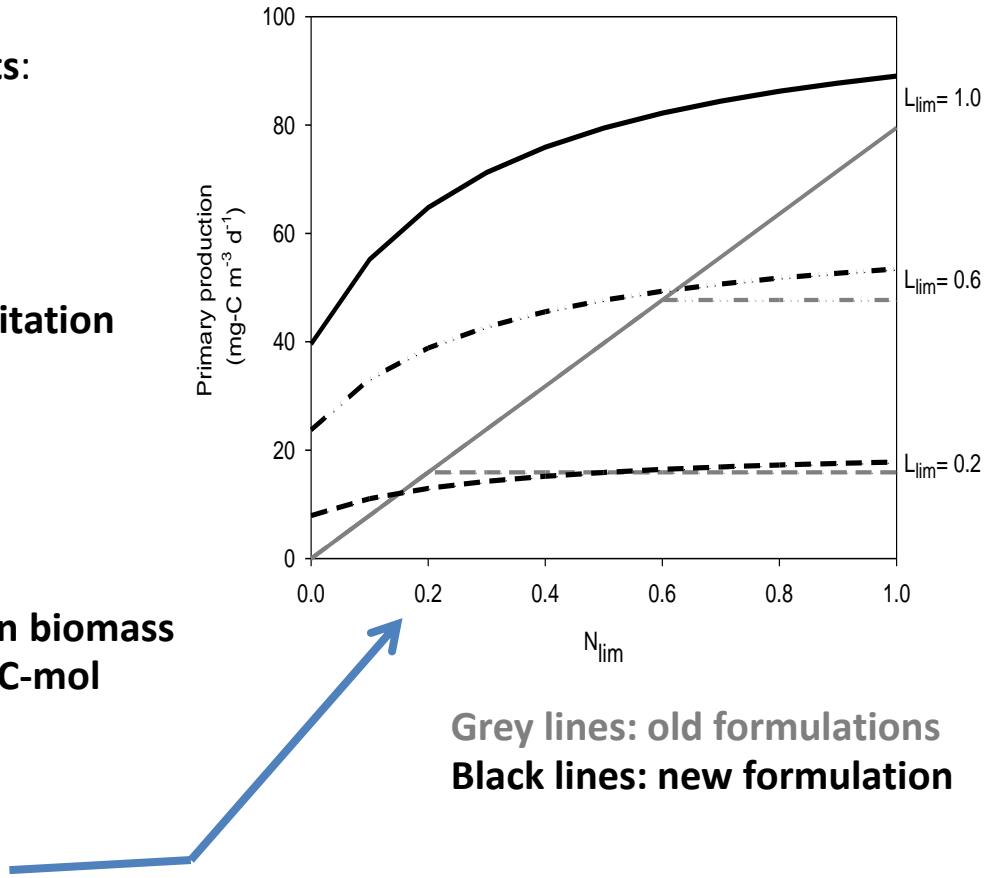
$$\mu C = \max \times T \times L_{\text{lim}} \times (\min (N_{\text{lim}}, P_{\text{lim}}, Si_{\text{lim}}) + \mu_{\text{min}})$$

- C:N-ratio of phytoplankton varies with N-limitation from 0.04-0.15:

$$CN = (0.036 + 0.115 \times N_{\text{lim}})^{-1}$$

- PP can now be estimated from phytoplankton biomass (BN), carbon growth rate (μC), C:N-ratio and C-mol weight (CW):

$$PP_C = BN \times \mu C \times CN \times CW$$

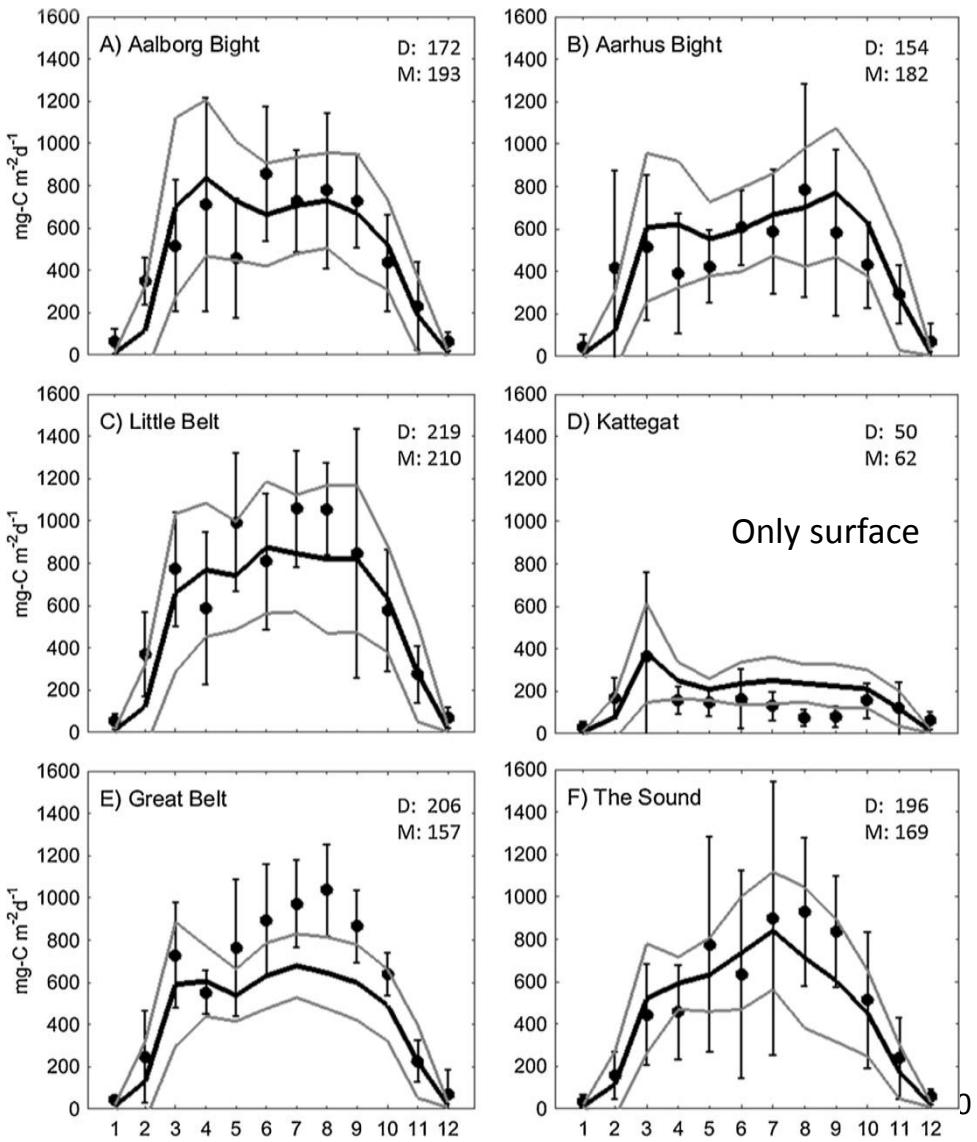
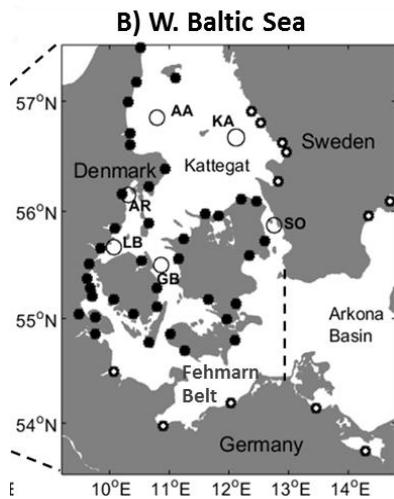


PRIMARY PRODUCTION (PP)

PRIMARY PRODUCTION

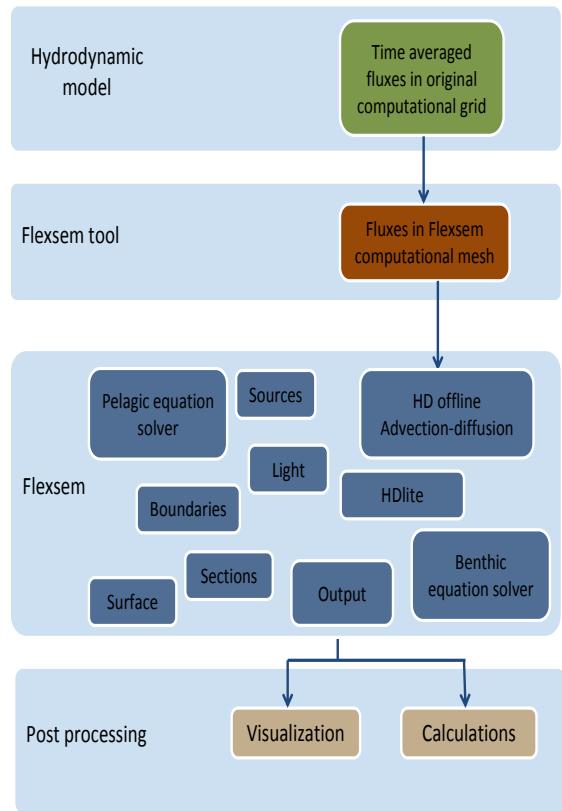
Monthly means 2001-2009

- Data \pm SD (●)
- Model (black line)
- Model mean \pm SD (grey lines)

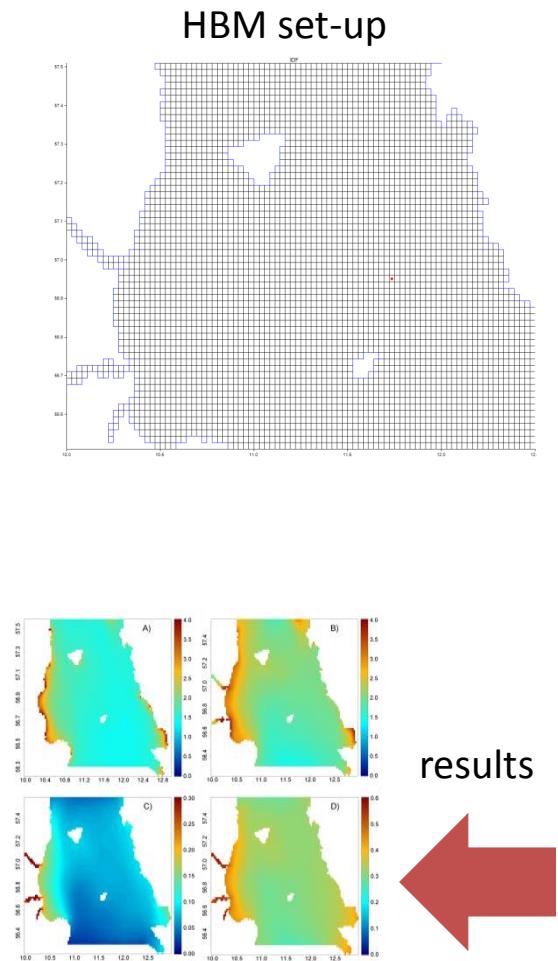


All stations: $R^2 = 0.59$, PMB= 1%, nSD=0.83

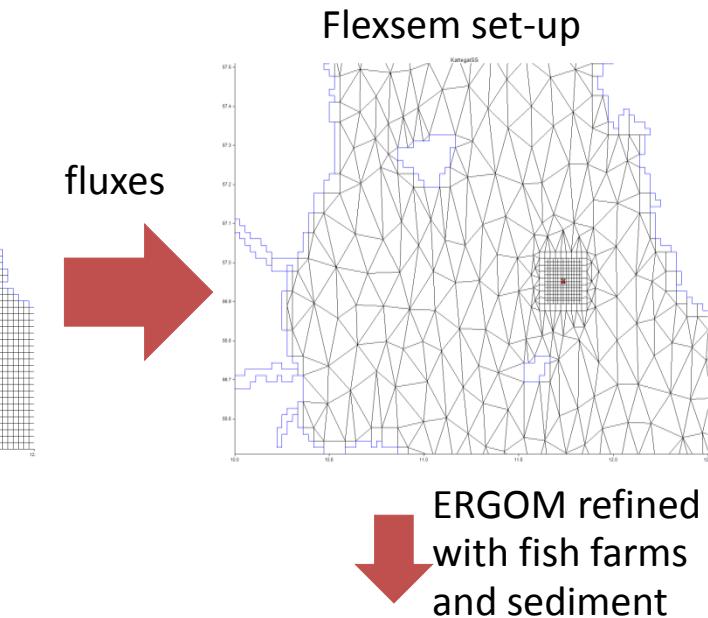
flexsem



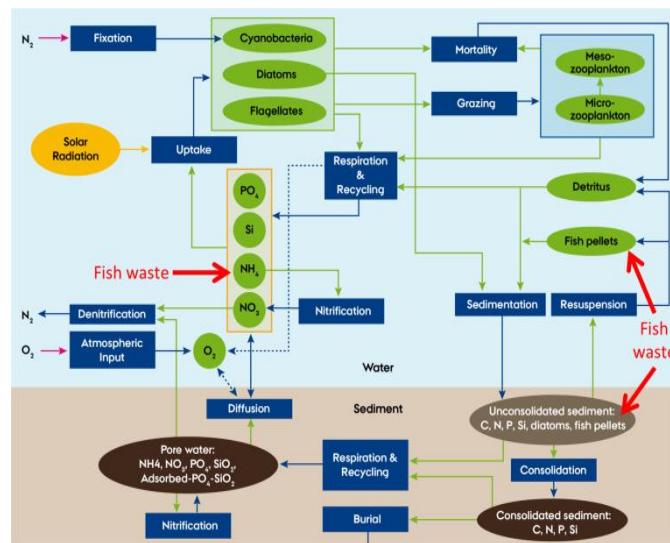
- C++ and text files as input
- Fast, runs on normal pc



HBM set-up



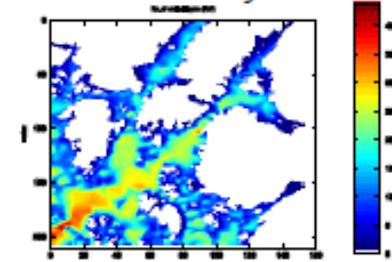
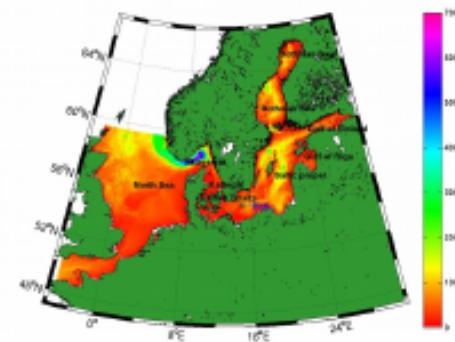
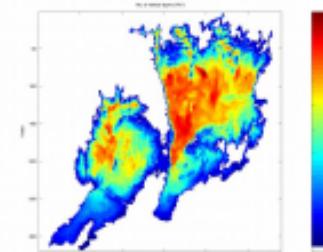
ERGOM refined
with fish farms
and sediment



Offline system that can be used for local set-ups e.g. support the use of Copernicus products

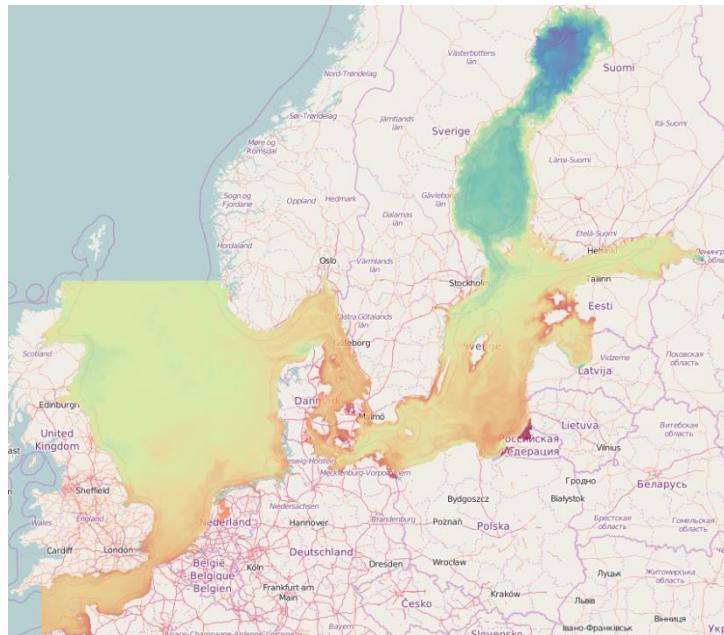
NEMO-Nordic

- Name of the specific version used at SMHI (and other institutes), including...
 - ...namelist settings
 - ...bathymetries
 - ...minor code changes
- Ocean dynamics:
 - NEMO-3.6; "3.6_stable" from Paris trunk (r5628)
 - Included patch from UK Met. Office to be able to run four times a day
- Ice dynamics:
 - LIM-3.6
 - Five ice categories used
 - Fast ice parameterization added
 - Temporary fix for ice thickness (awaiting new advection scheme)
- Setups: See Adam's presentation ...



NEMO-Nordic

- **NEMO-Nordic 60 hour forecast, operational since 2016-05-10**
 - 1 Nautical mile resolution
 - 56 depth levels
 - Forced by:
 - Arome 2.5 km and ECMWF 9km
 - E-Hype
 - Runs four times a day, 00z, 06z, 12z and 18z
 - Output:
 - Netcdf
 - Grib
 - Surface and 3D-files
- **Available on ftp until end of June. We will then transfer to SMHI open data/web service**



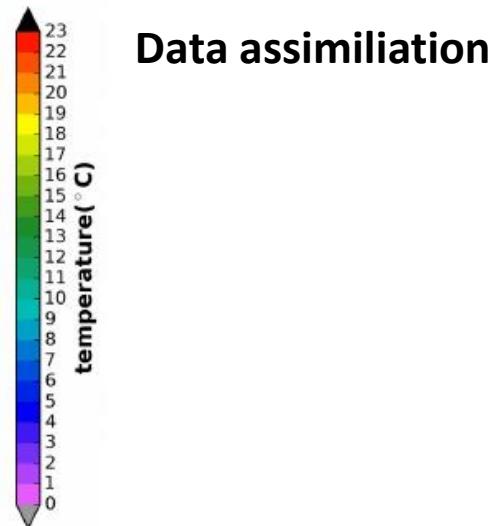
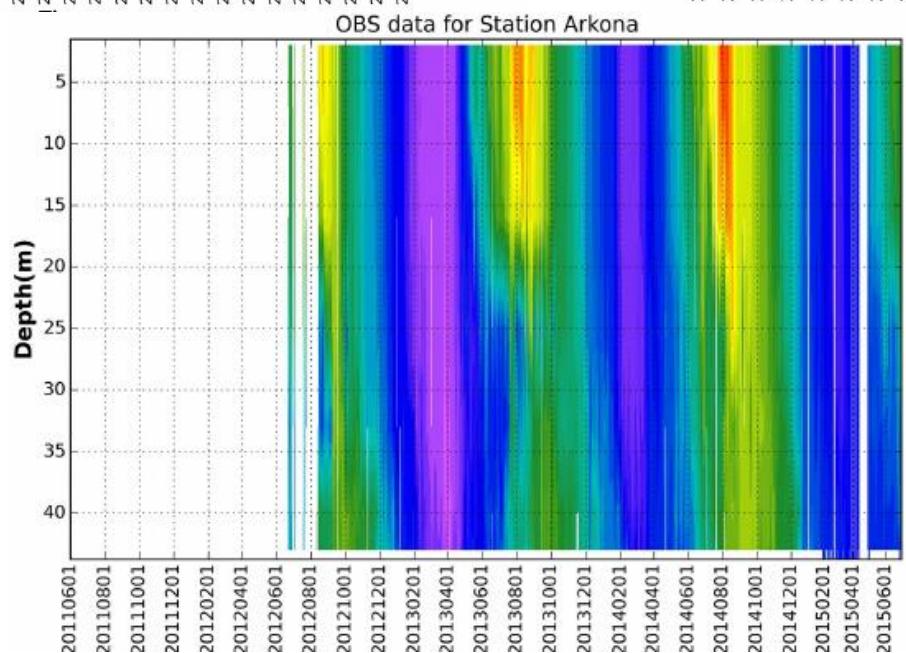
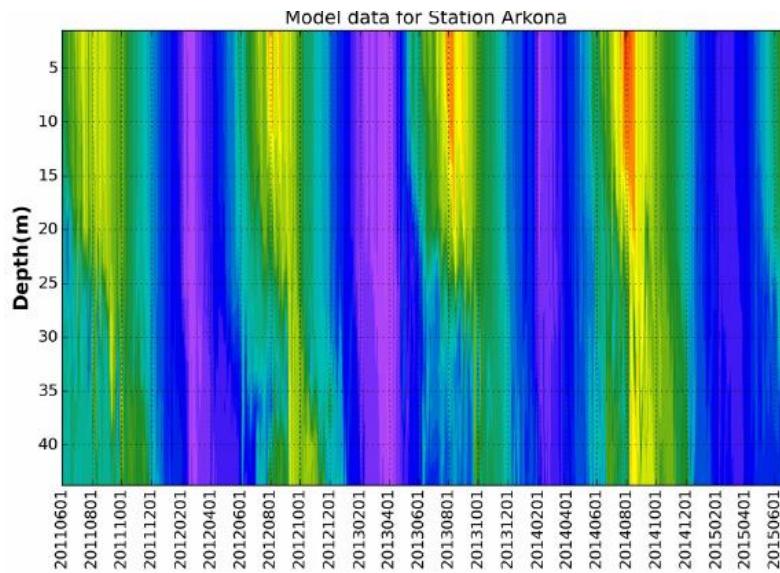
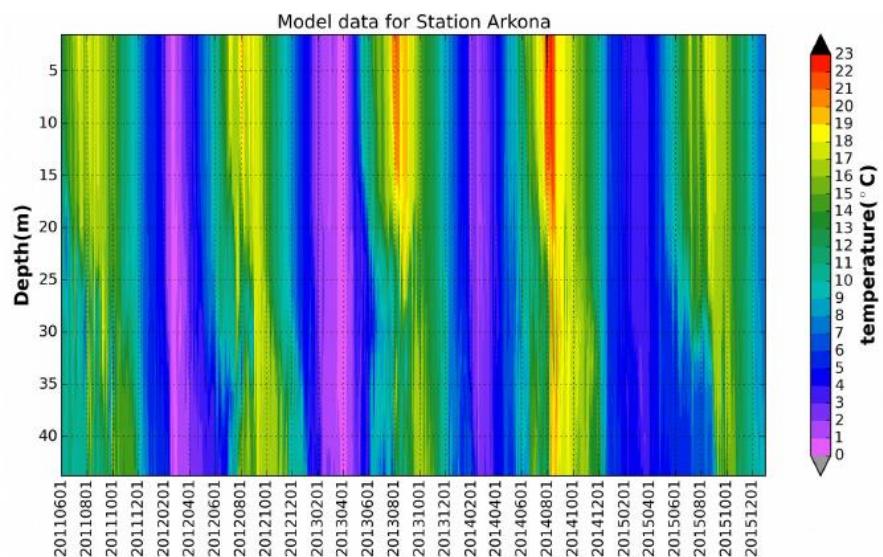
NEMO-Nordic-SCOBI

- Biogeochemistry model developed at SMHI
 - Coupled to NEMO-Nordic ("NEMO-SCOBI")
 - Coupled to NEMO via TOP module
 - Reference version under evaluation now
 - Operational October 2017!
- Data assimilation adapted for NEMO-Nordic (physics)
 - 3D EnVar
 - LSEIK filter (based on PDAF)
- Data assimilation adapted for SCOBI (biogeochemistry)
 - May 2017: 3D EnVar (needs more development)
 - Summer 2017: LSEIK

NEMO-Nordic



BOOS
Baltic Operational
Oceanographic System



What happens next

- **NEMO-Nordic**
 - Data assimilation of ice (runs in test)
 - Improve grid
 - S and T at the open boundaries
 - Wind wave coupling
 - Ensemble forecast using MEPS 2018? (pre-study)
- NEMO-Nordic-SCOBI (biogeochemical) is tested in semi-operational mode.
Operational version in October 2017
- **SWAN:**
 - Tests with Krill-forcing
 - Possibilities for longer forecasts



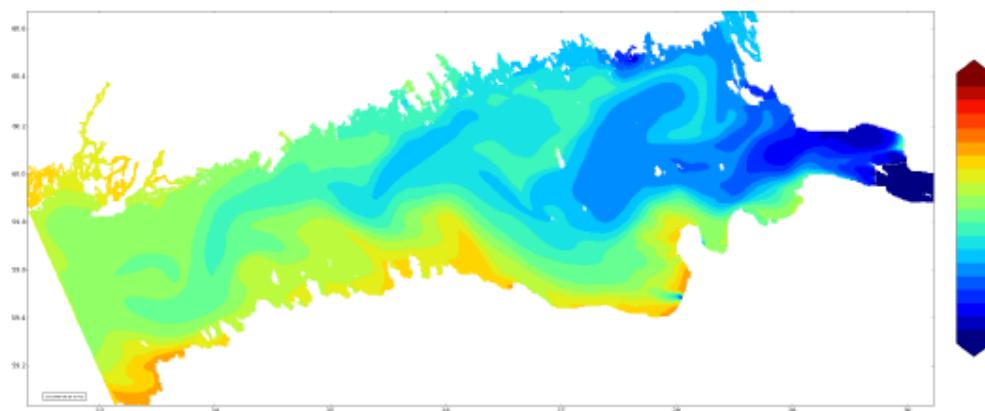
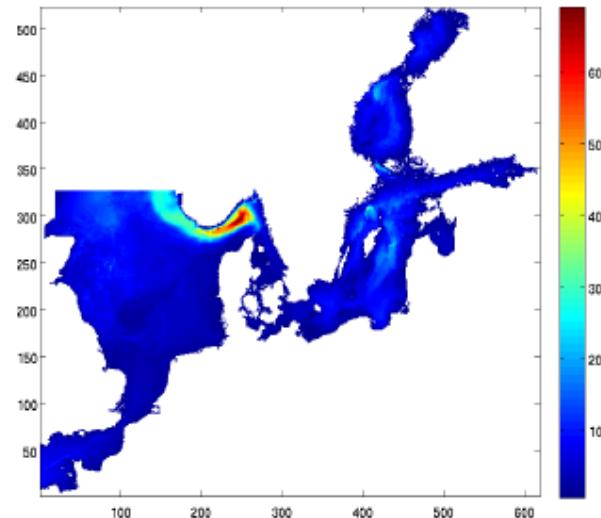
Future of oceanographic modelling at FMI using NEMO

Global version of NEMO is used in climate simulations.

For the Baltic Sea, three setups are used:

- 2 nmi setup for the North Sea - Baltic Sea (NEMO-Nordic, co-operation with SMHI)
- 1nmi setup for the Gulf of Bothnia (SmartSea project)
- 0.25 nmi setup for the Gulf of Finland (EXOSYSTEM project).

FMI also has a NEMO setup for the Kara Sea, which is currently being run in pre-operational mode. (KAMON project).

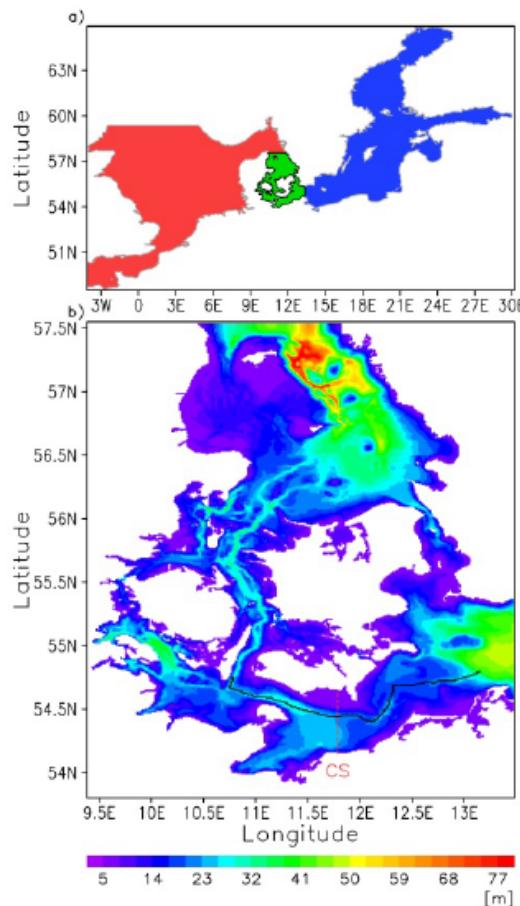


Nested NEMO Experiments Setups Summary

Three nested configuration runs and one reference model simulation run
(2010-01-01 to 2010-12-31)

| <u>North Sea</u> <u>Vert. Grid</u> | <u>Baltic Sea</u> <u>Vert. Grid</u> | <u>Danish Straits</u> <u>Resolution</u> | <u>Nesting</u> |
|---------------------------------------|--|--|----------------|
| S-level | S-level | Coarse (2nm) | N/A |
| S-level | Z-level | Coarse (2nm) | N to B |
| S-level | Z-level | Fine (0.5nm) | N to D to B |

Nesting consists of linear interpolated hourly forcing in the Danish Strait area via Flow-Relaxation-Scheme (FRS) for temperature and salinity and via Flather-Condition-Scheme (FCS) at the outer boundary of the nest for sea surface elevation and barotropic velocities



Unstructured model of the North Sea and Baltic Sea

SCHISM

(Semi-implicit Cross-scale Hydroscience Integrated System Model)

- Horizontal triangular mesh consists of ~400k nodes
- Shaved sigma layers with max. 59 layers in the Norwegian trench
- Forcing at the open boundaries by CMEMS reanalysis (AMM7-Nemo) with horizontal, vertical tides; salinity, temperature
- Climatological river run-off based on SMHI ehype product
- Meteorological forcing from DWD (Ecosmo-EU model)
- Model integration starts 1 March 2014, covers the MBI of December 2014

Data Assimilation cooperation

PDAF - a software environment for ensemble assimilation

<http://pdaf.awi.de/trac/wiki>

- **Partners & Role**

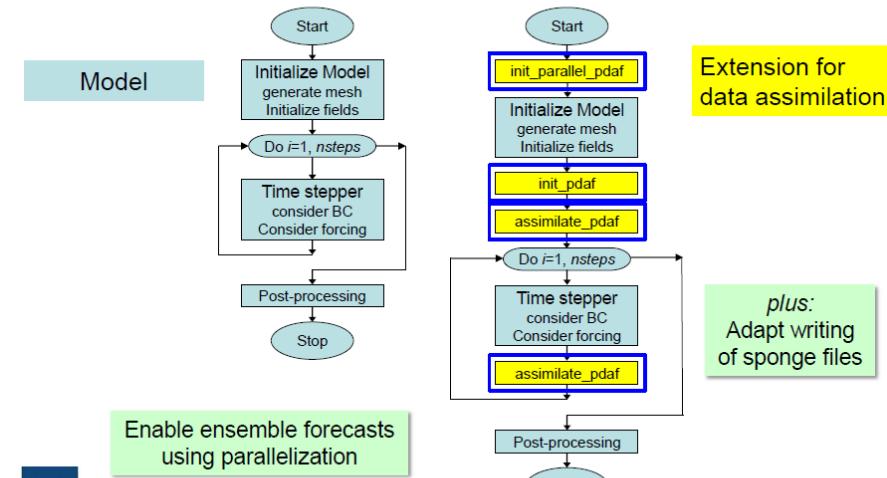
- DMI: HBM-PAF offline system
- BSH: HBM-PDAF online system
- SMHI: NEMO-PDAF offline system
- AWI: Developer, host repository

- **Supporting groups:**

- HBM CDG (Thorger), Cal/Val (Simon)

Extending a Model for Data Assimilation

PDAF
Parallel
Data
Assimilation
Framework



Enable ensemble forecasts
using parallelization



Lars Nerger et al. – HBM-PDAF Assimilation System



SST assimilation improves subsurface in Baltic Sea

T/S errors for October / November 2012

