BOOS
Baltic Operational
Oceanographic System

BOOS national activities in 2016

part1 - Modelling

BOOS STG

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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)

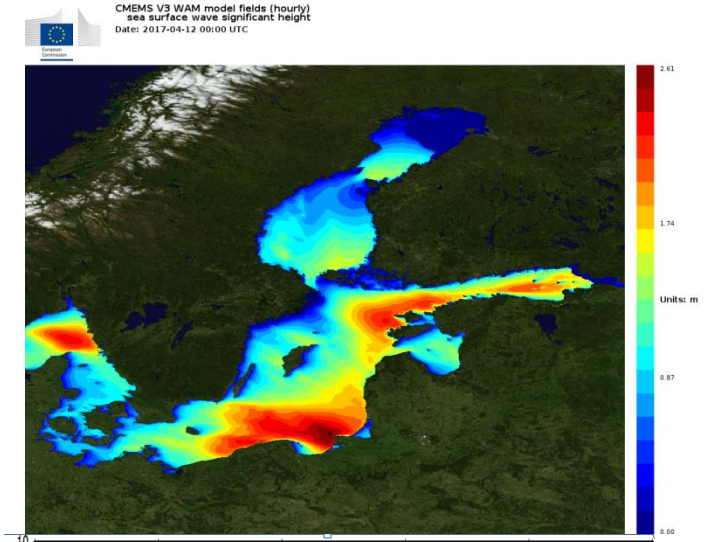
BDY: ECMWF wave spectra

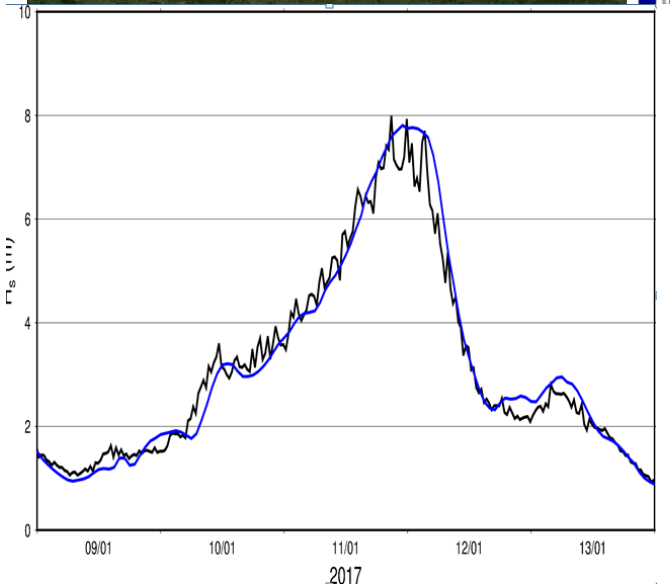
Product: 17 variables.

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)





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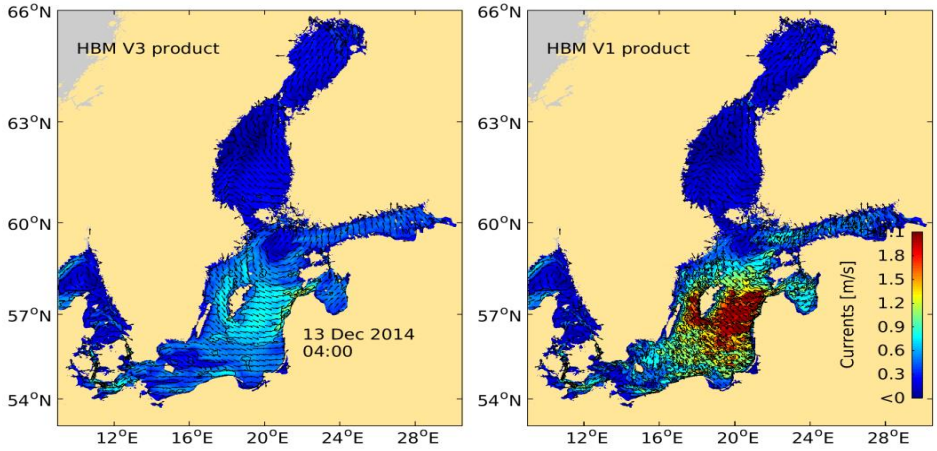
CMEMS Upgraded 3D ocean PHY & BIO forecast product: HBM-ERGOM

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

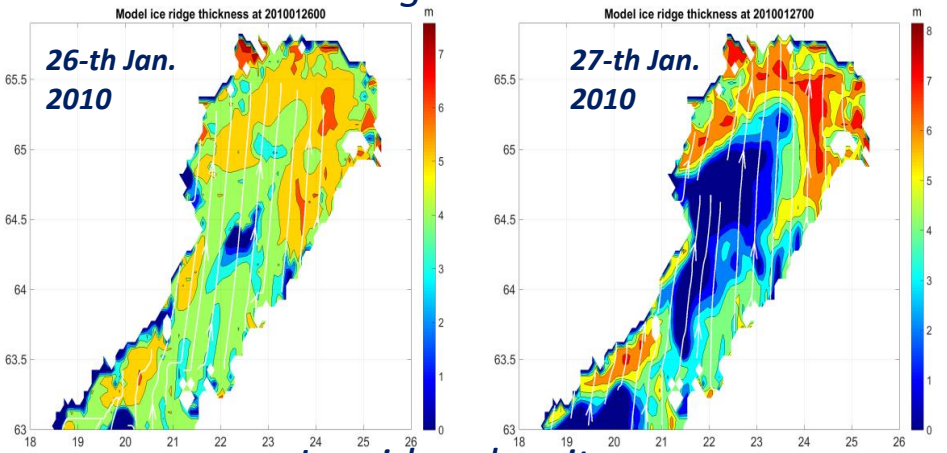
Ice ridging in shallow waters might lead to the development of anchor points that support the condition of rigidity.

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

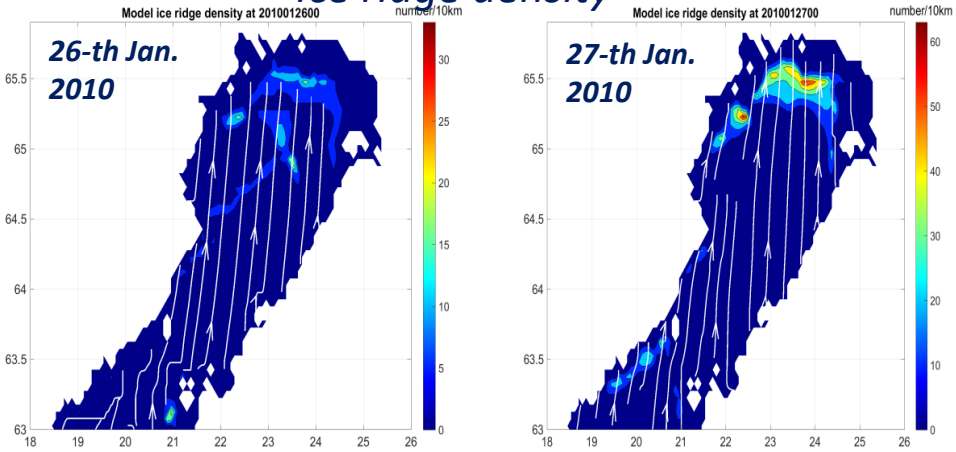
Ridged fast ice yields to stresses that exceed critical limits. It can also be moved when it loses its bottom contact and gets afloat.

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 ridge thickness



Ice ridge density



Jens Murawski, Eckhard Kleine,
BOOS, Copenhagen, 23-rd May

Ice Ridging and Fast ice

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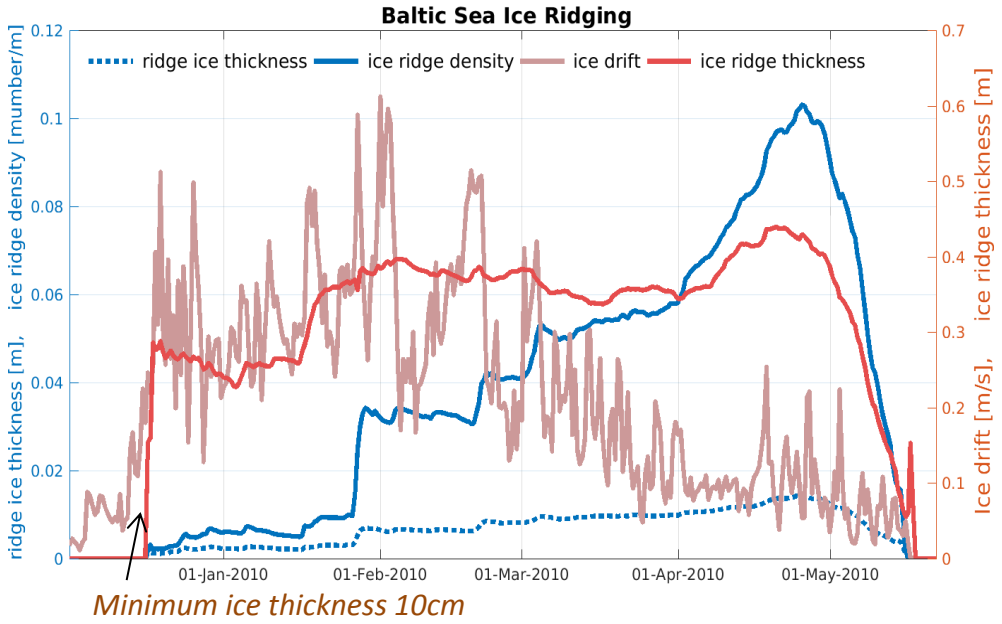
When ice ridging occurs:

- *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

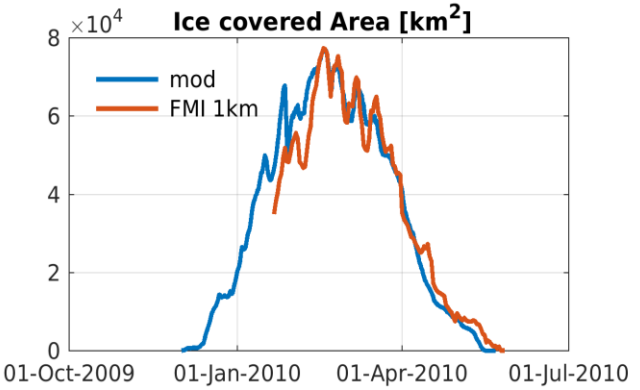
- *Ridging has been implemented in the plasticity calculus*
- *When the kiel depth equals the total water depth, the ridged ice stucks to the ground and is transformed to fast ice.*

Jens Murawski, Eckhard Kleine,
BOOS, Copenhagen, 23-rd May

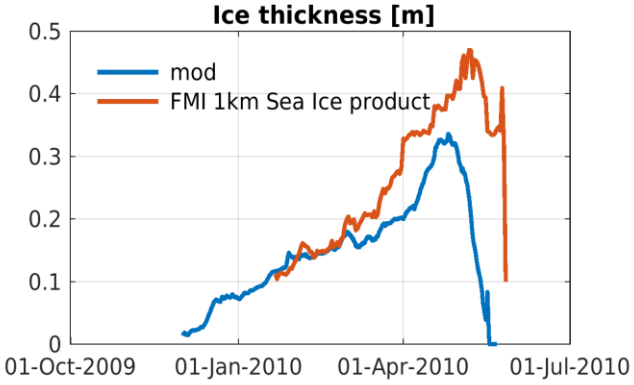
Model comparisson with sattellite data

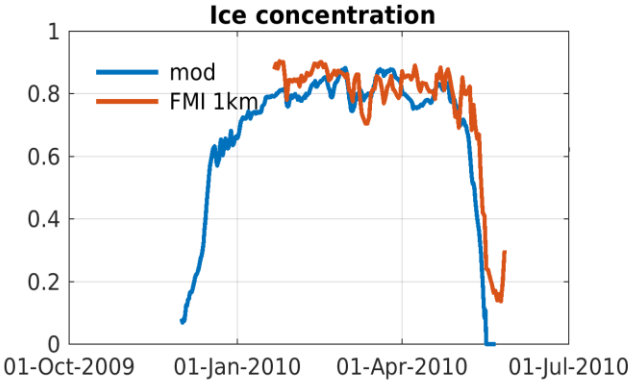
The ice model is well able to predict the sea ice covered area, both the maximum extend and the change during the melting phase.

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





Jens Murawski, Eckhard Kleine, BOOS, Copenhagen, 23-rd May

Product Quality Assesment:

CMEMS Priority – continous development

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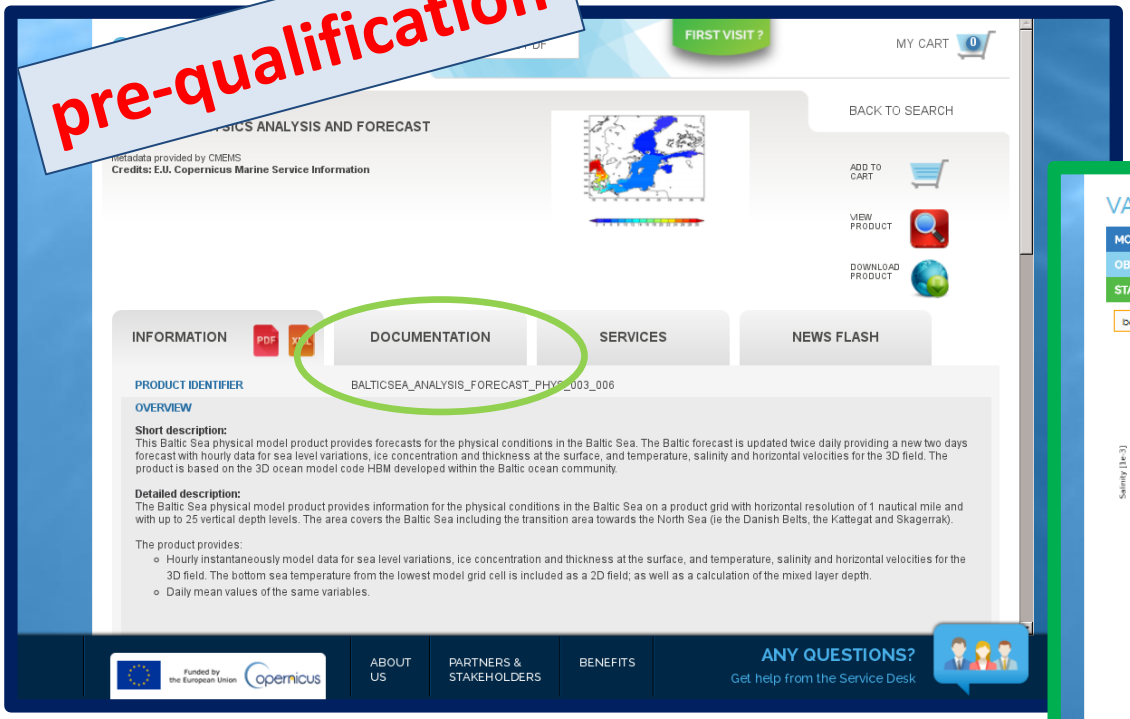
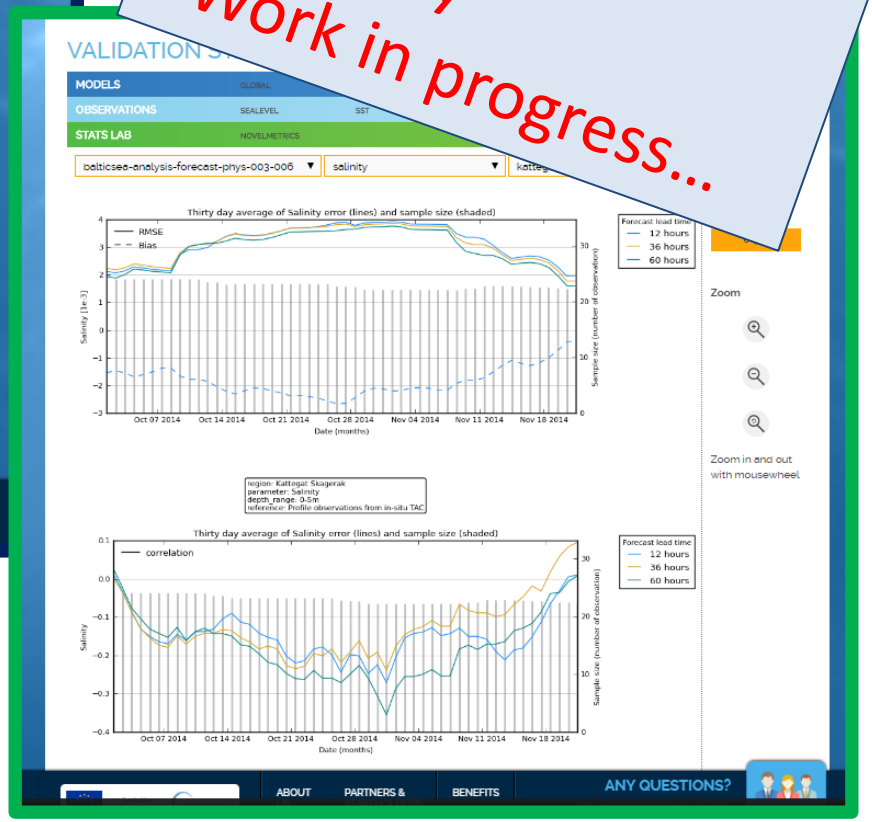
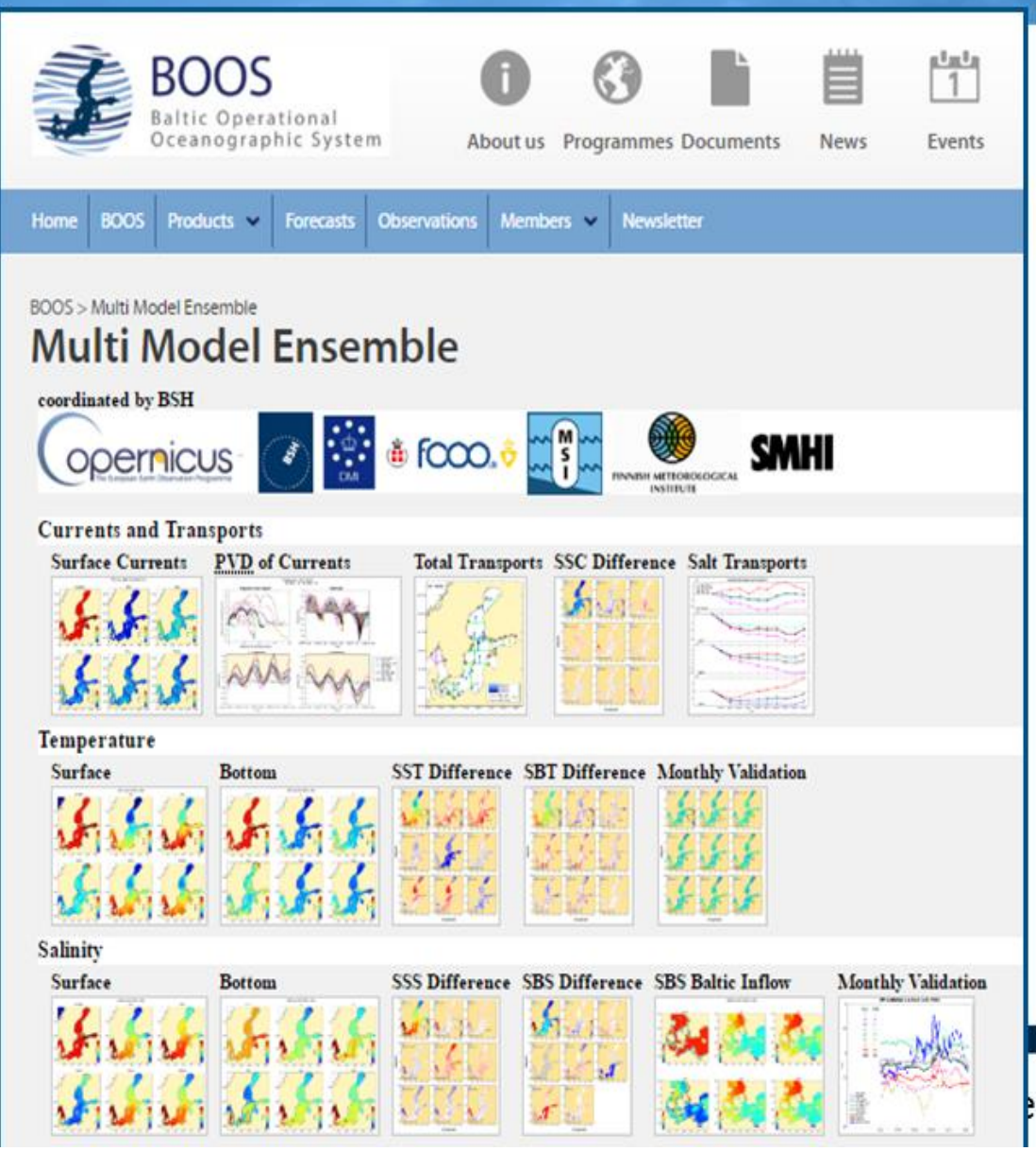
pre-qualification

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





Multi-model-ensemble for BOOS & NOOS



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

DMI
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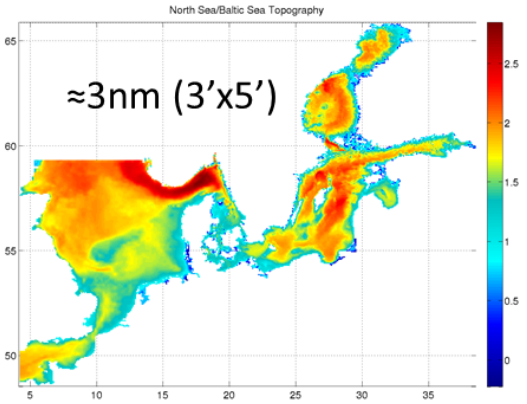
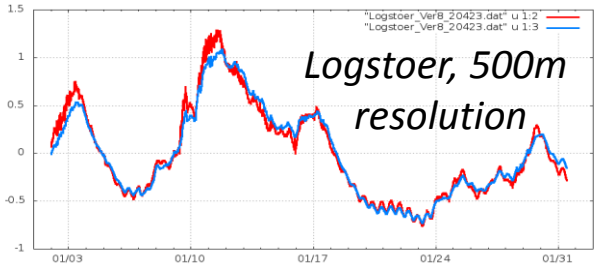
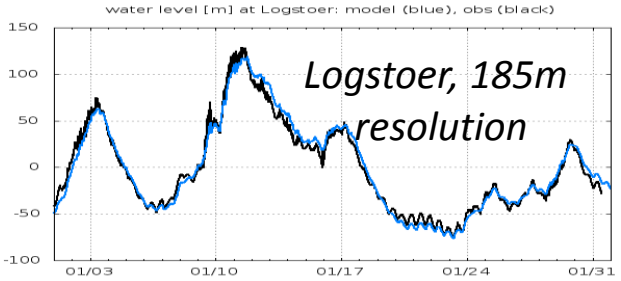
Seamless modelling: coastal-estuary continuum

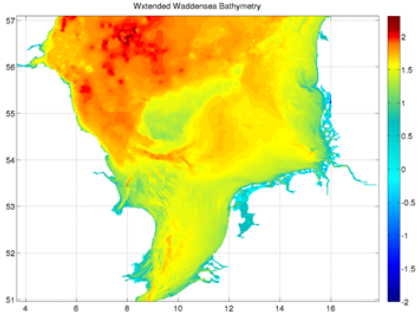
New DKSS Storm Surge Setup

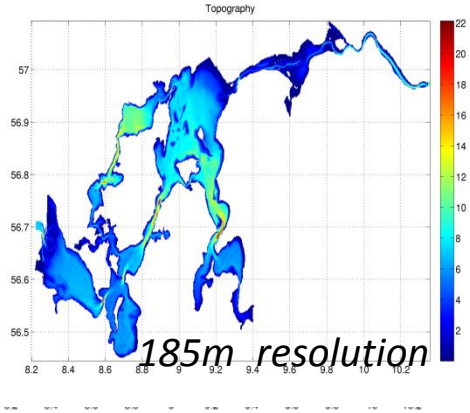




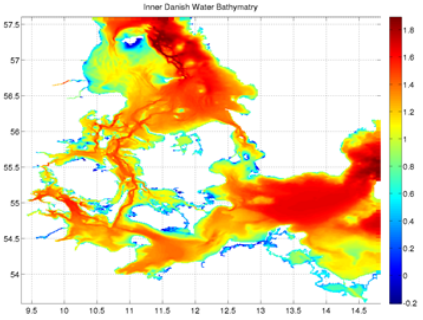


≈1nm (1'x1.66')





≈0.5nm (30''x50'')



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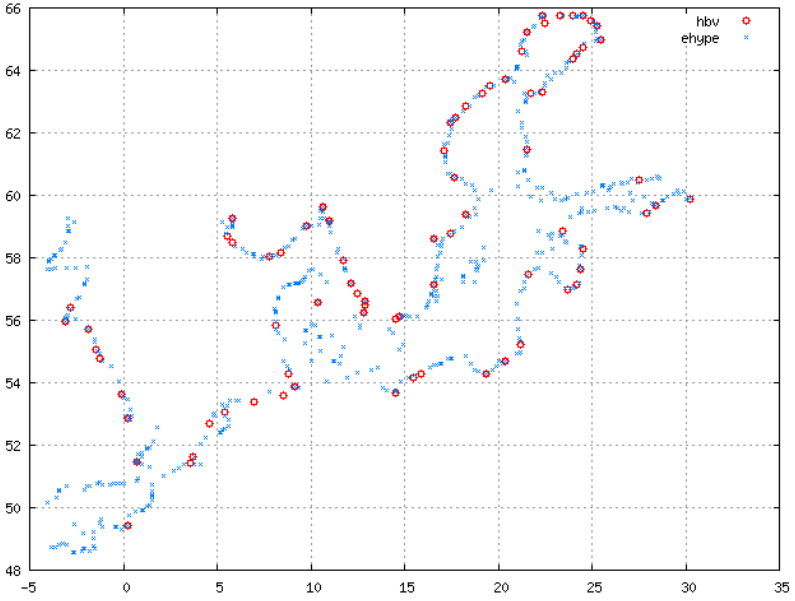
River Data
E-hype3

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 calender 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



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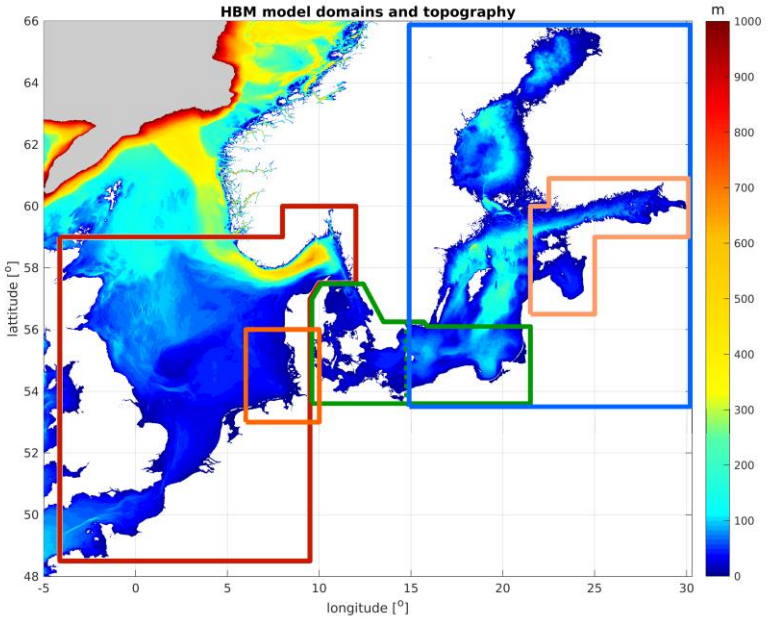
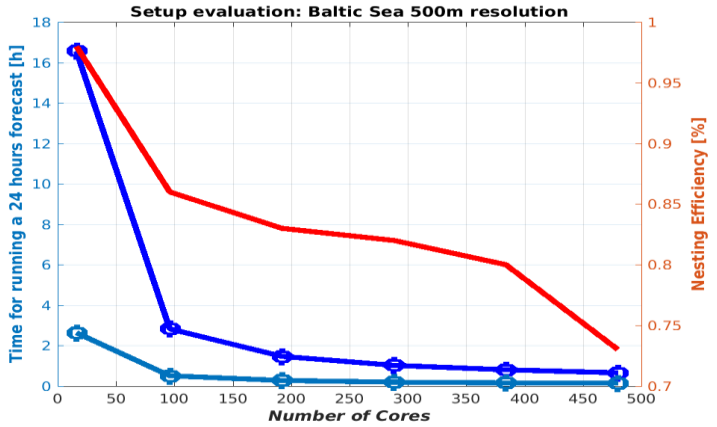
Test of HBM's capabilities to run extensive set-ups



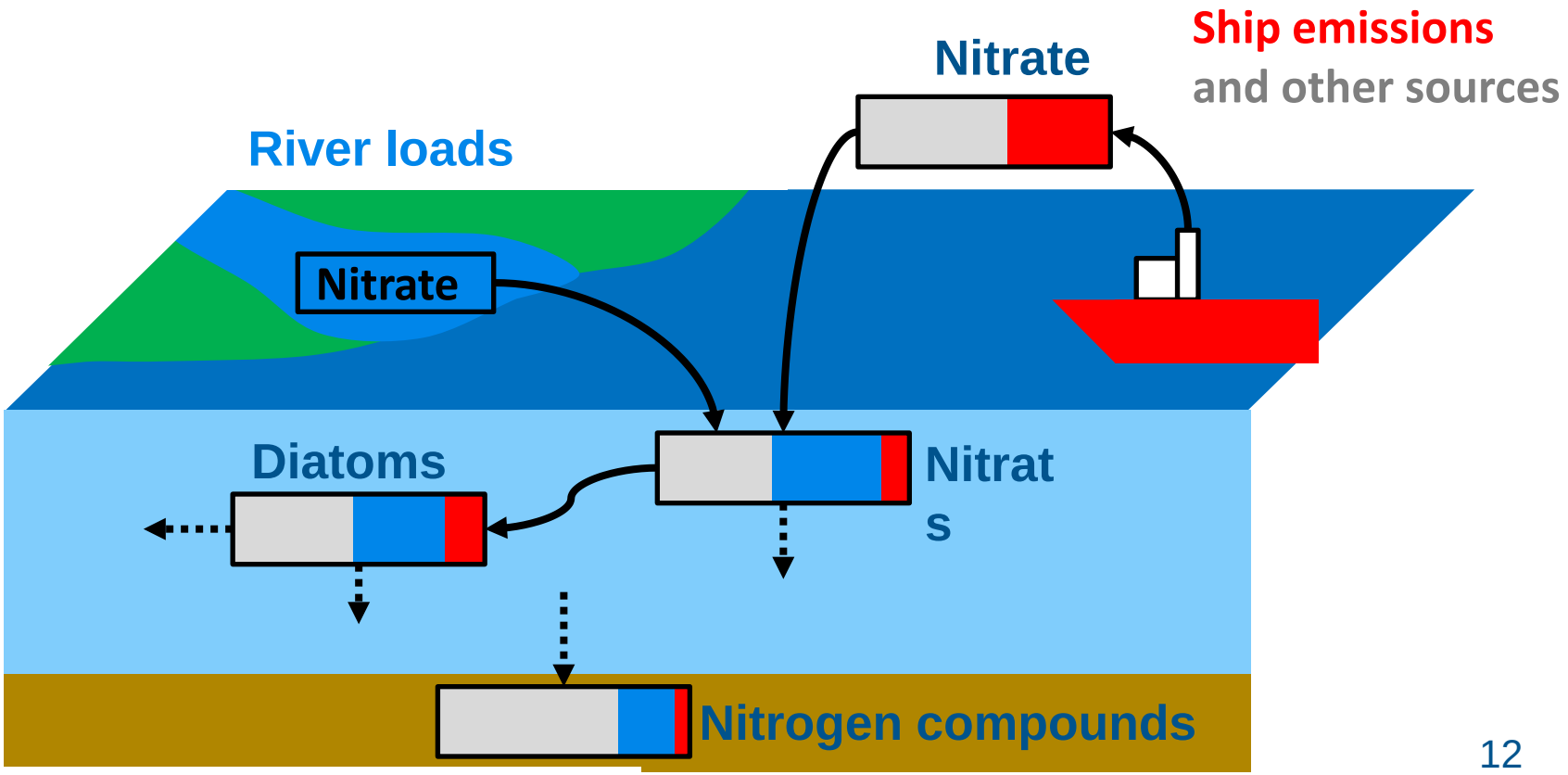
	Nested	**Fine**
Setup	*NS, WS, DS, BS^{N2}, GoF*	*NS, WS, BS^{F2}*
Number of 3D points (in million)	21.8	104.2
Expected memory use	10.81	51.7 GB (max. 64 GB per node)
Maximum run time ratio N-to-F	6.43	

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



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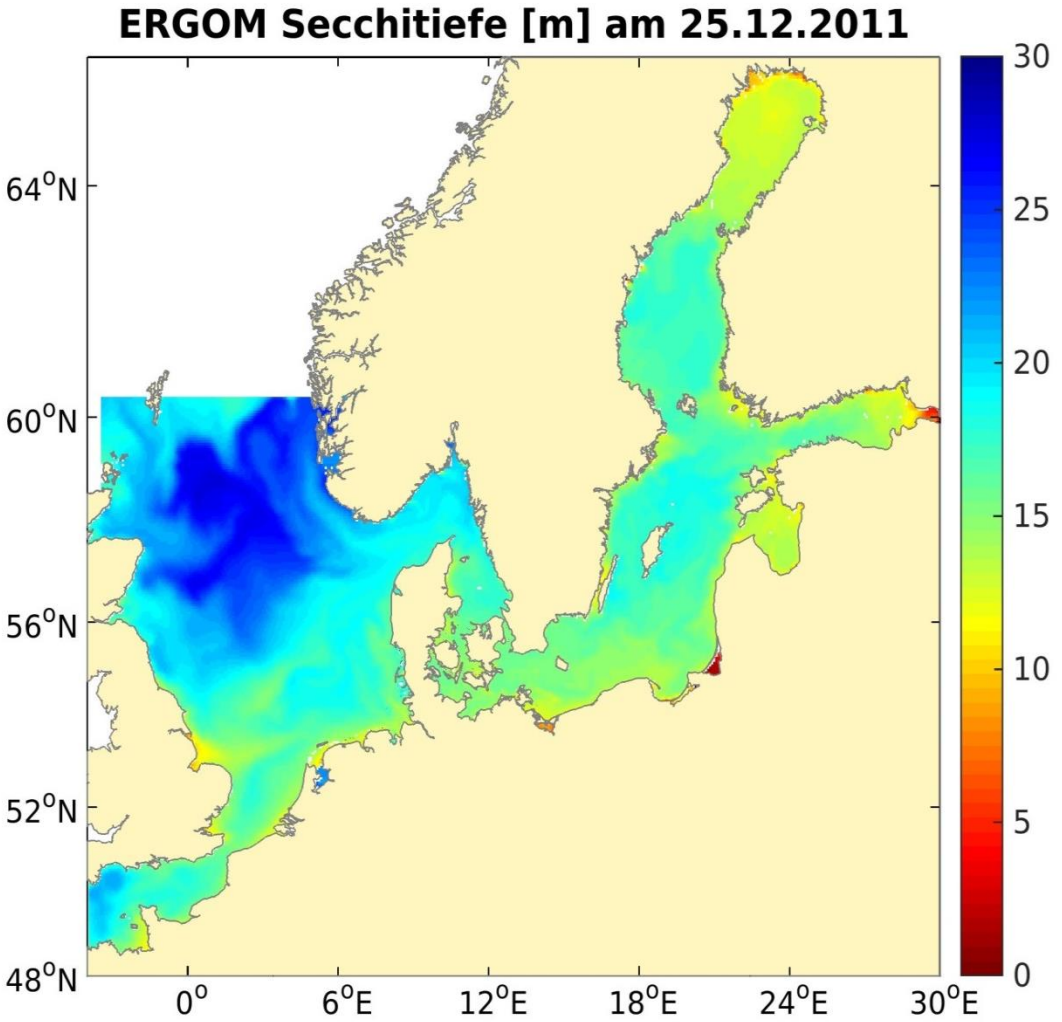
ERGOM development

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



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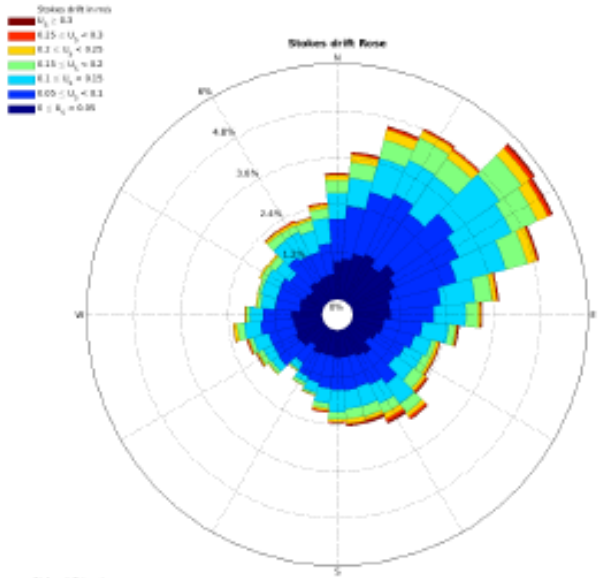
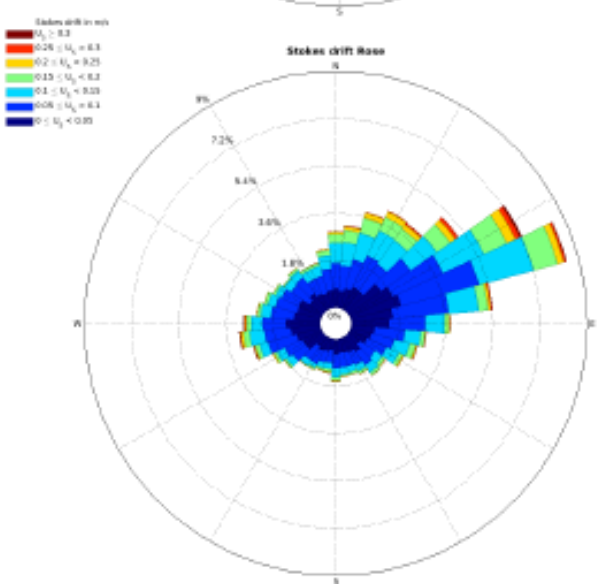
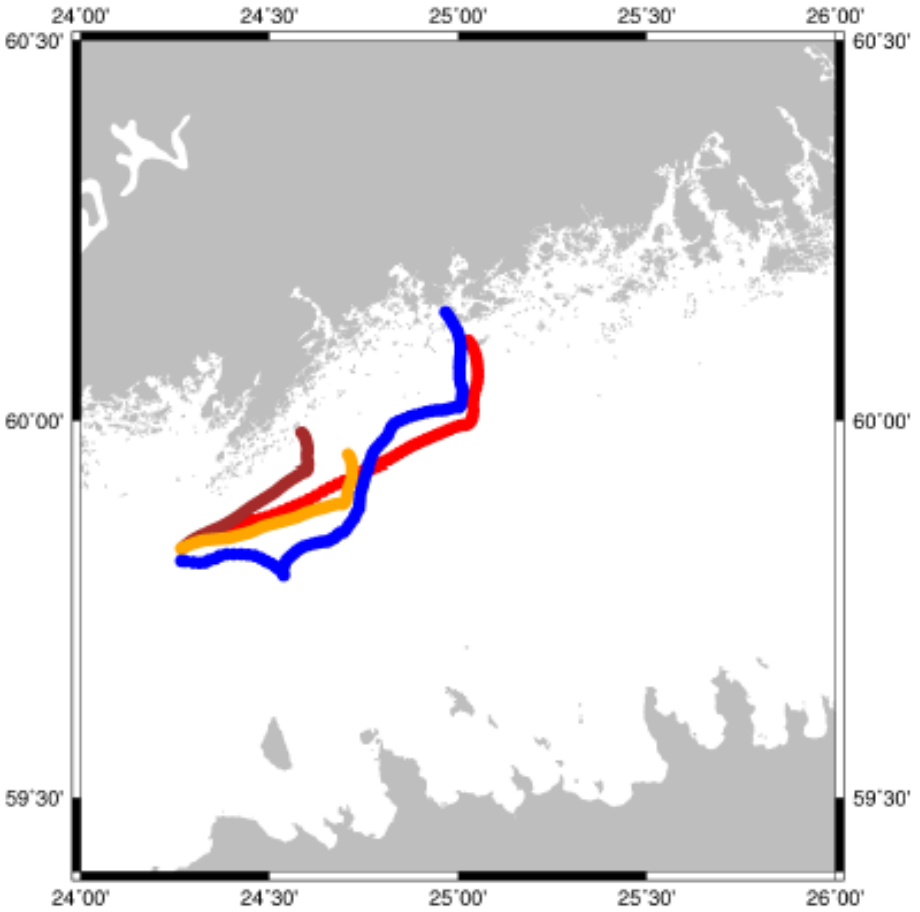
ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Drift modelling – Stokes drift

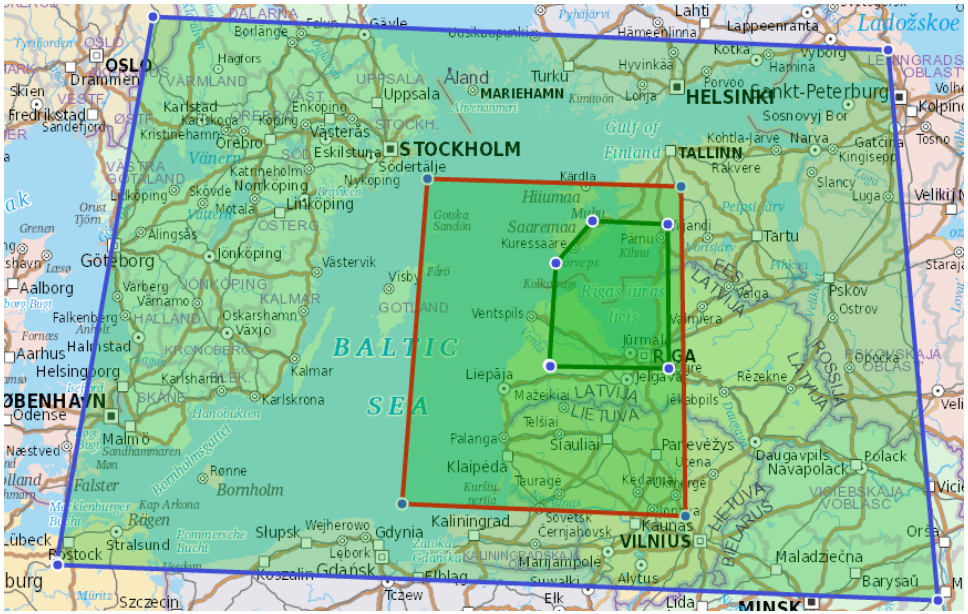




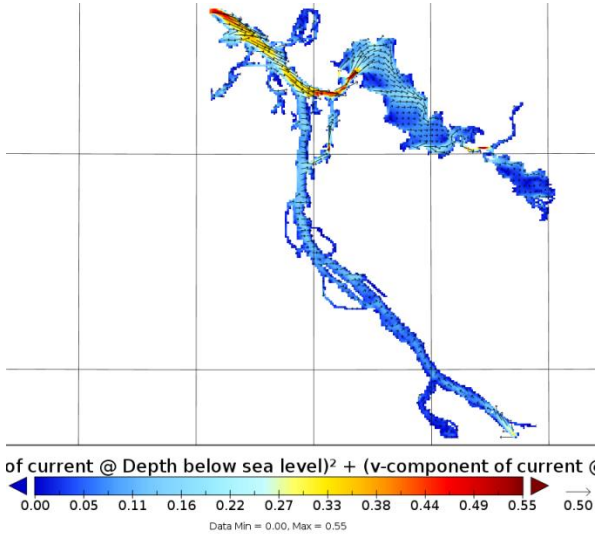


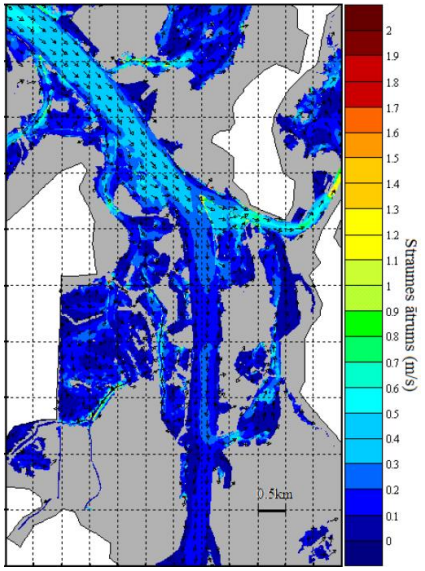
Downscaling forecast for GoR and 12 lakes

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

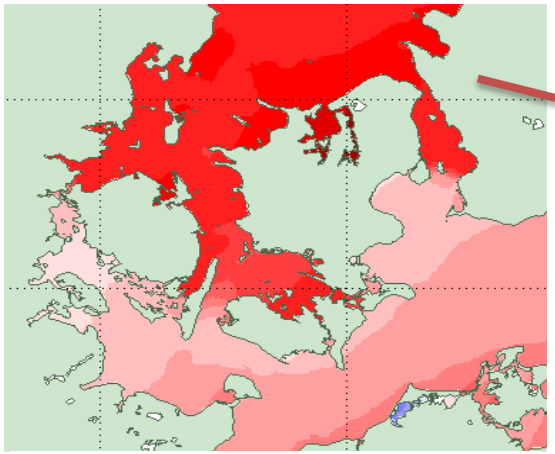




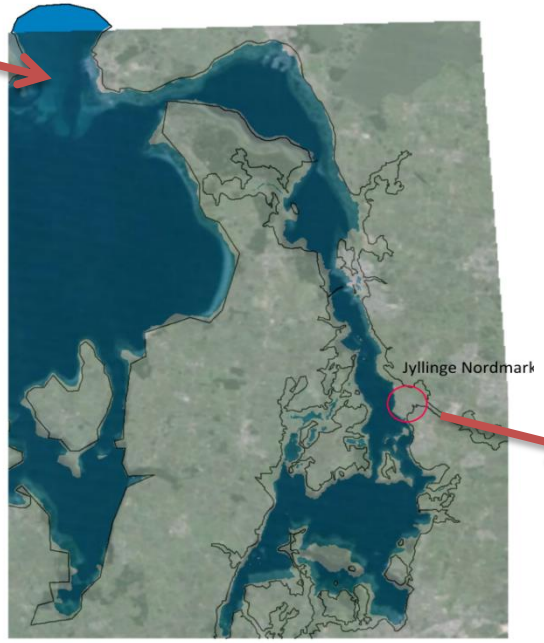
HBM3D (left)
Swevolver 2D (right)

Prognose for oversvømmelse: projekt Varsko

Eksempel: Stormfloden Bodil, 6. december 2013

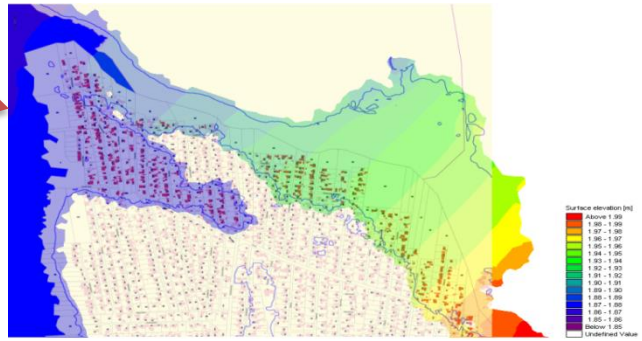


DMI's stormflodsmodel



DHI's oversvømmelsesmodel

Sammenligning med forsikrings-information om oversvømmede huse



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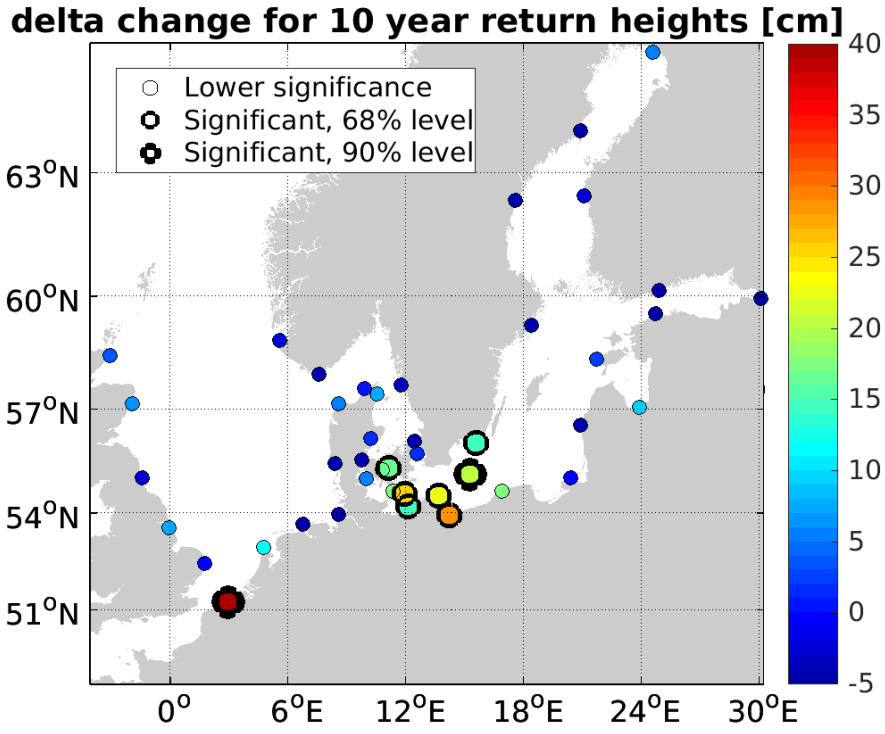
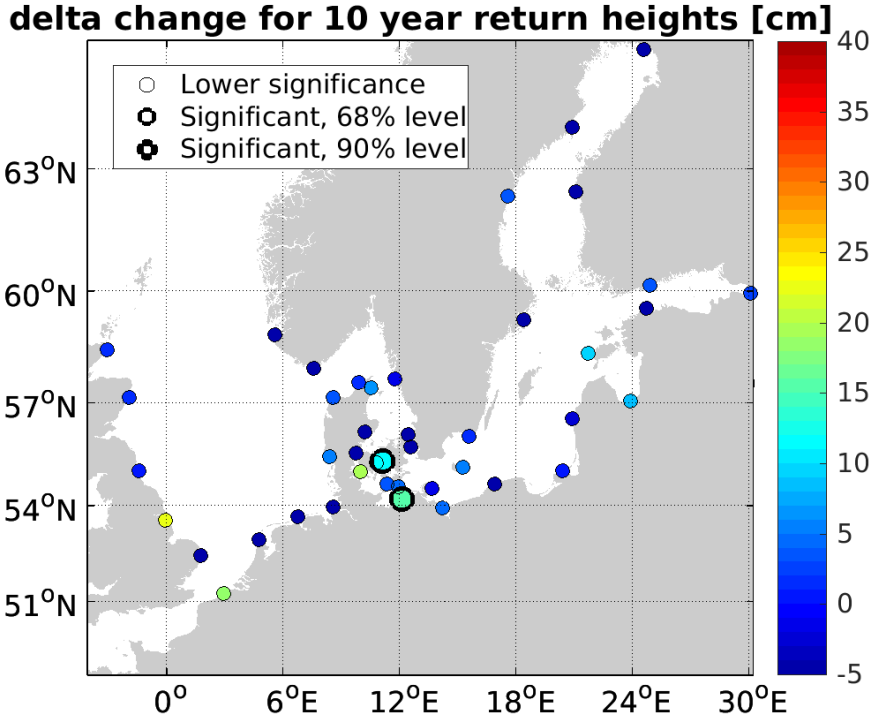
RCP8.5

2046-2065



2081-2100



HBM-ERGOM (AU-BIOS)

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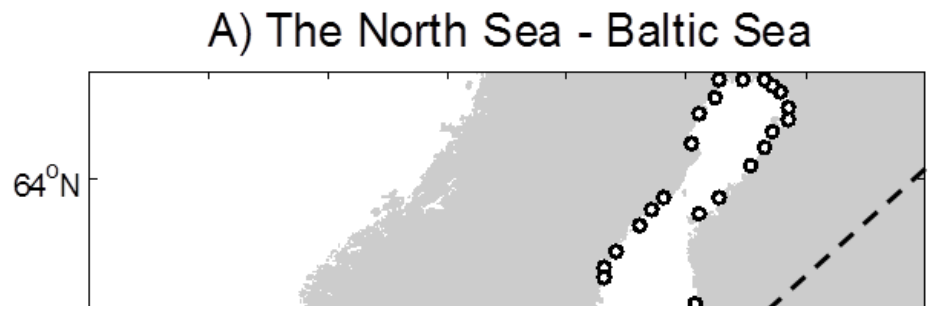

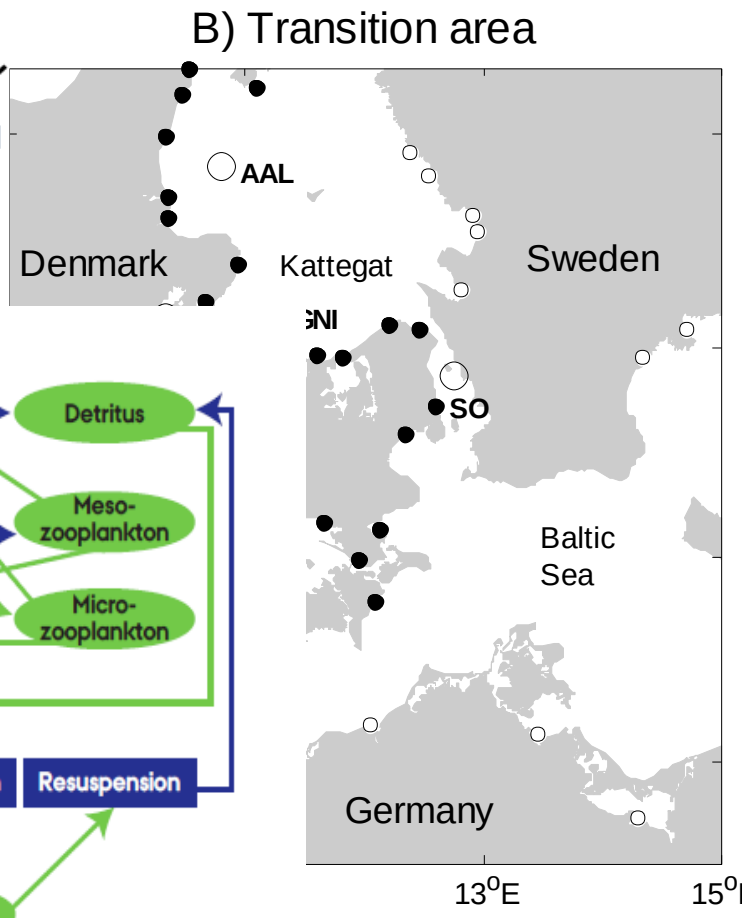

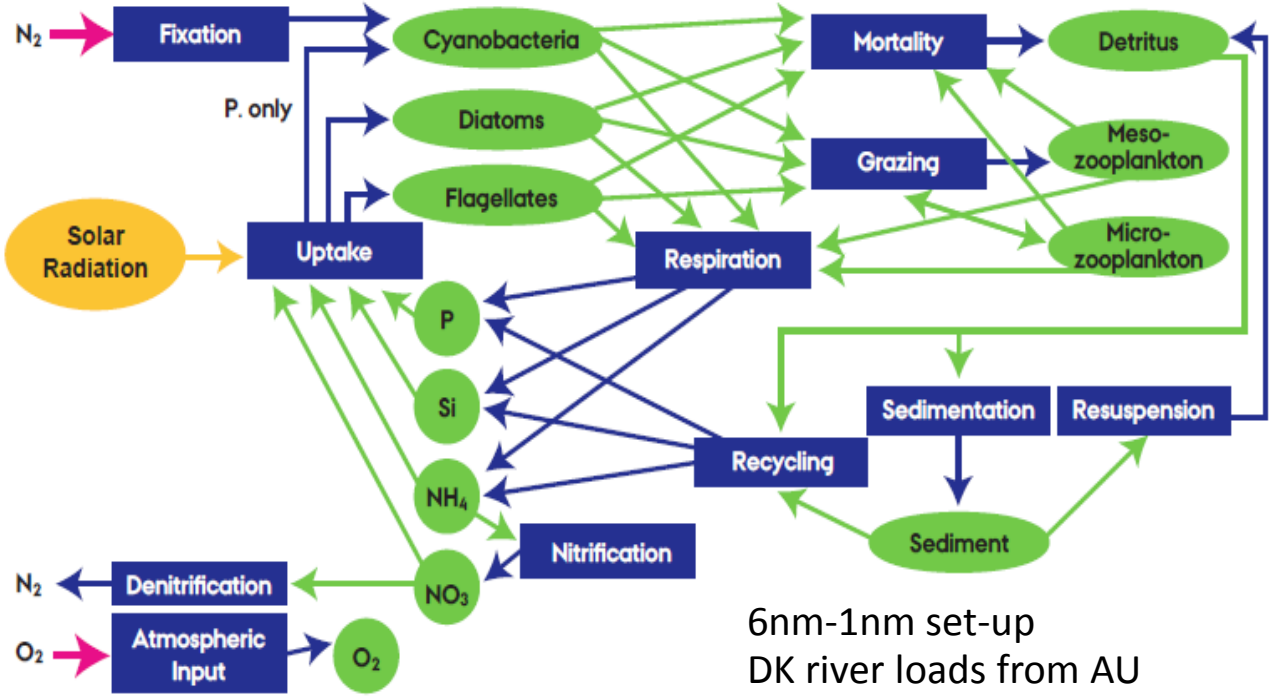

6nm-1nm set-up
DK river loads from AU
Waiting for E-hype data from DMI

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- **PP can occur even though there few nutrients**:

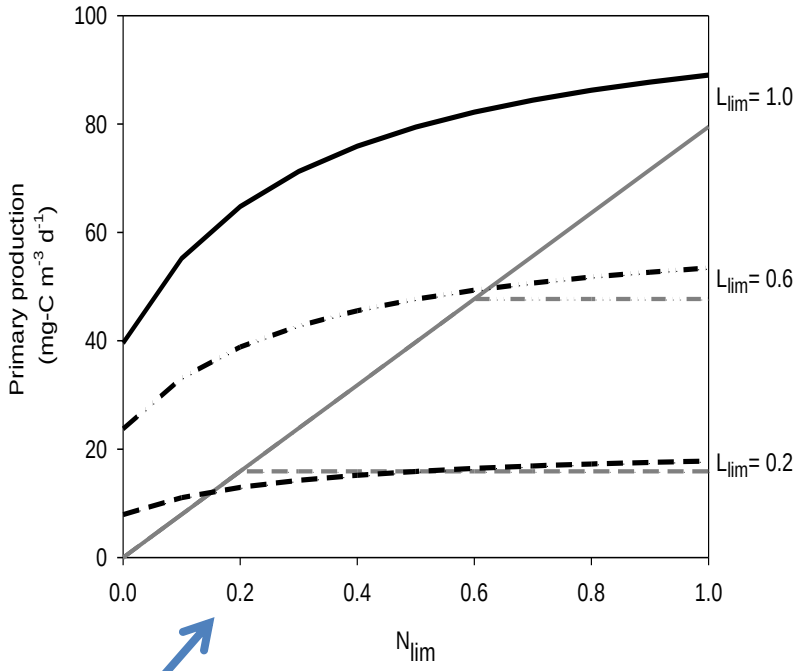
$$\mu C = max \times T \times L_{lim} \times (min\ (N_{lim}, P_{lim}, Si_{lim}) + \mu_{min})$$

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

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

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

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



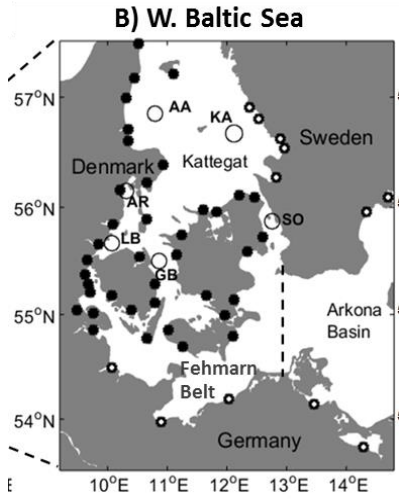
Grey lines: old formulations
Black lines: new formulation

PRIMARY PRODUCTION (PP)

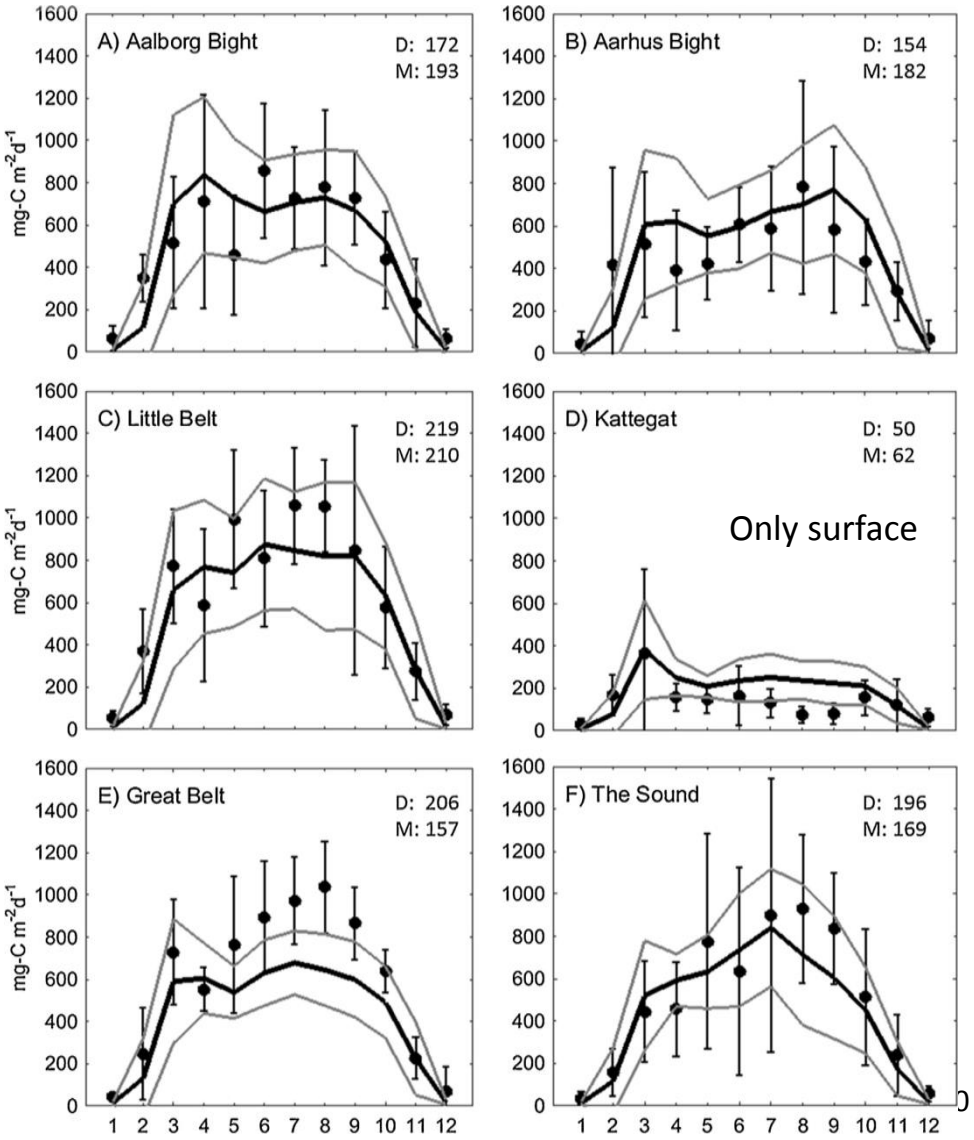
PRIMARY PRODUCTION

Monthly means 2001-2009

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



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



flexsem

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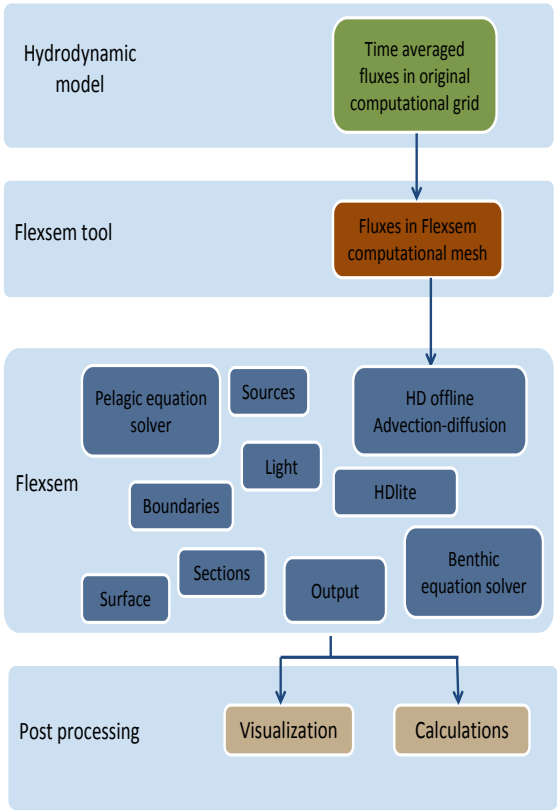
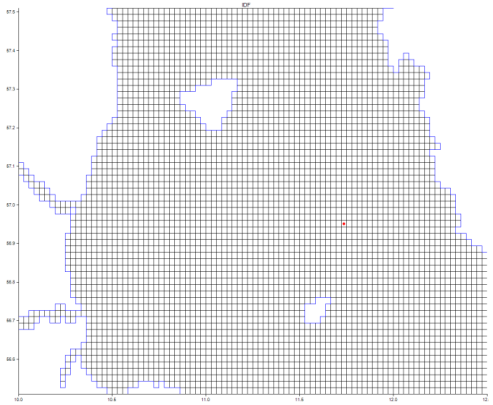
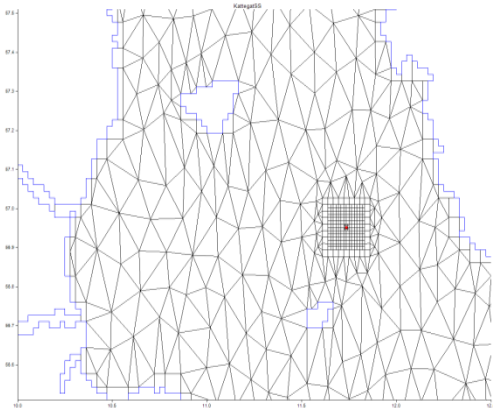


HBM set-up

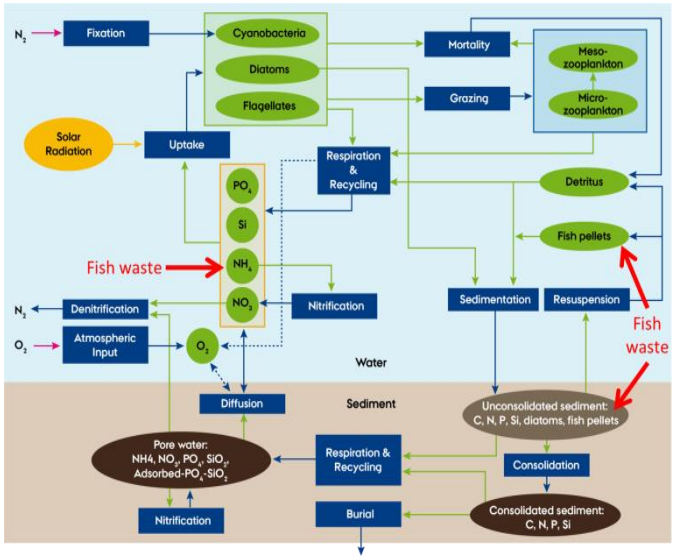


fluxes

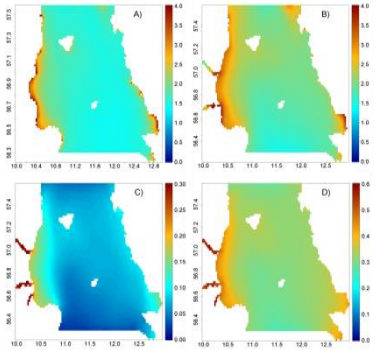
Flexsem set-up



ERGOM refined with fish farms and sediment



results

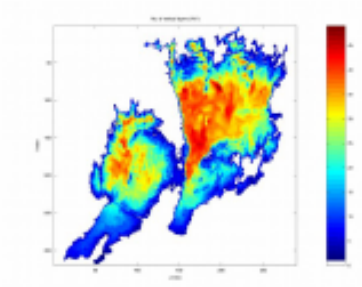


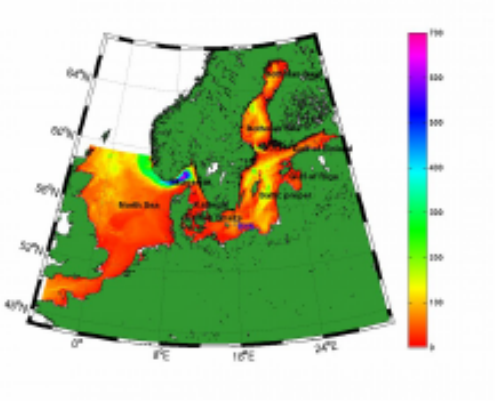
- C++ and text files as input
- Fast, runs on normal pc

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

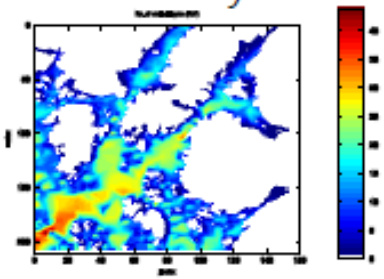
NEMO-Nordic

- Name of the specific version used at SMHI (and other institutes), including...
  - ...namelist settings
  - ...bathymetries
  - ...minor code changes





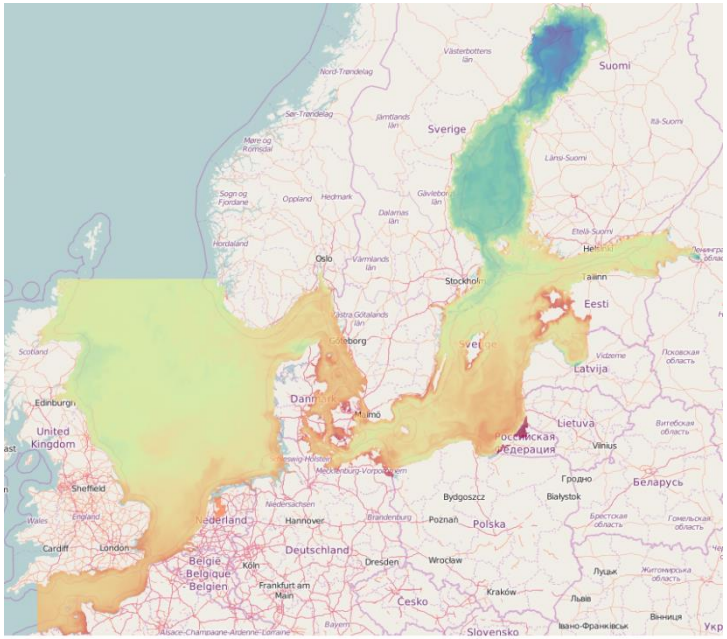
- Ocean dynamics:
  - NEMO-3.6; "3.6_stable" from Paris trunk (r5628)
  - Included patch from UK Met. Office to be able to run four times a day
- Ice dynamics:
  - LIM-3.6
  - Five ice categories used
  - Fast ice parameterization added
  - Temporary fix for ice thickness (awaiting new advection scheme)



- 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**



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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

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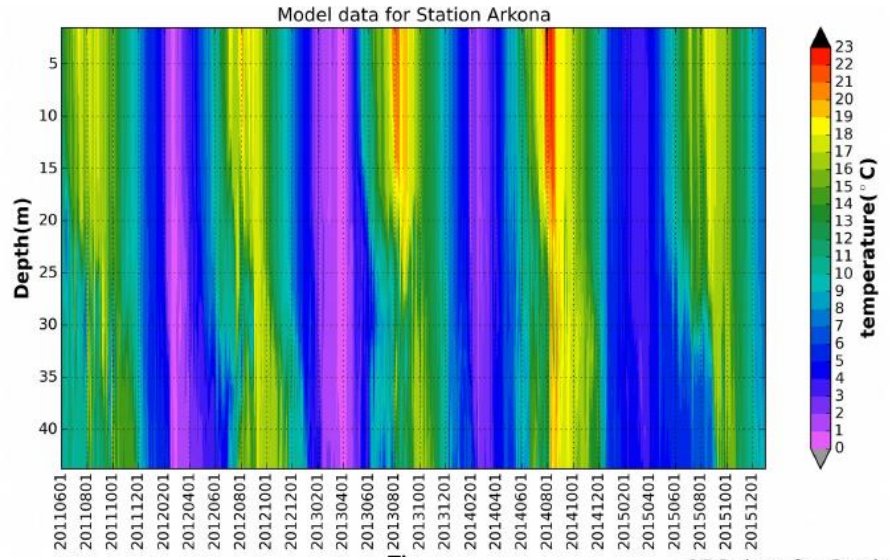
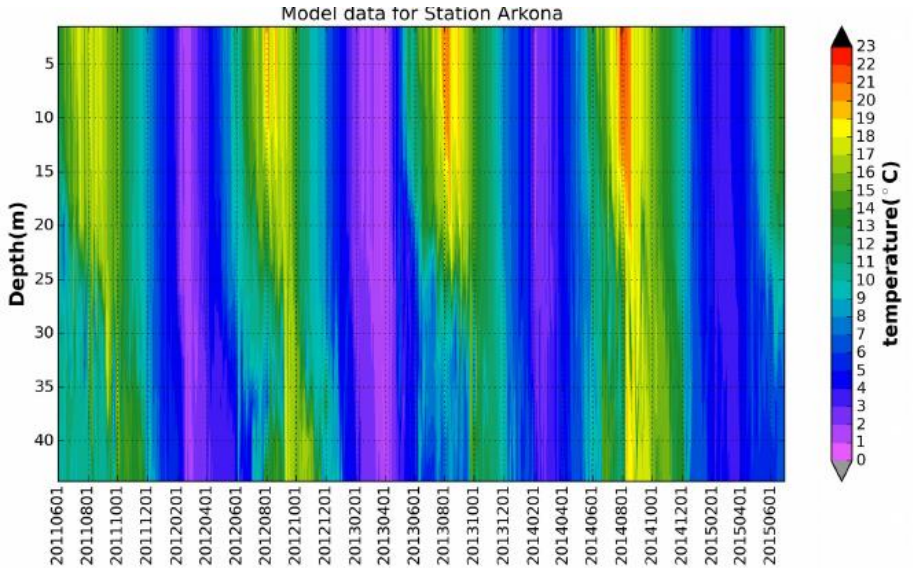
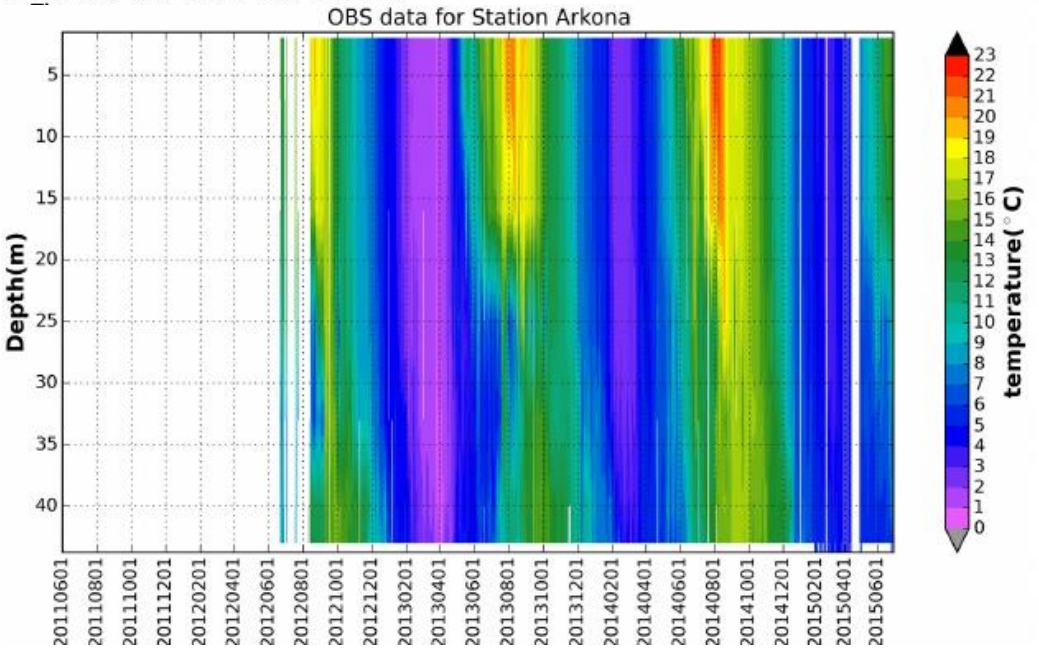






Data assimiliation

What happens next

- **NEMO-Nordic**
  - Data assimiliation 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

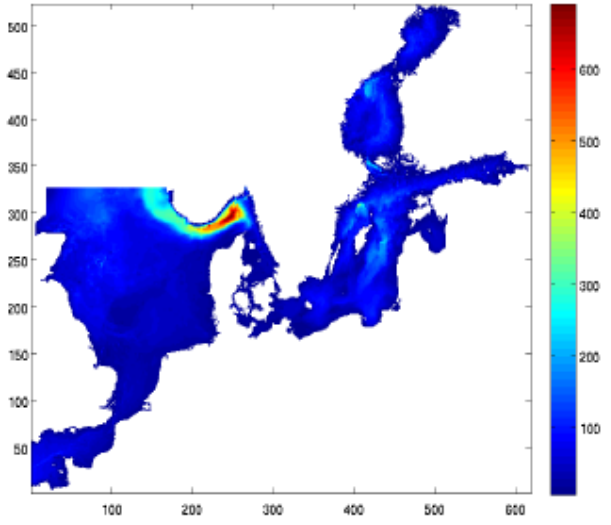
Future of oceanographic modelling at FMI using NEMO

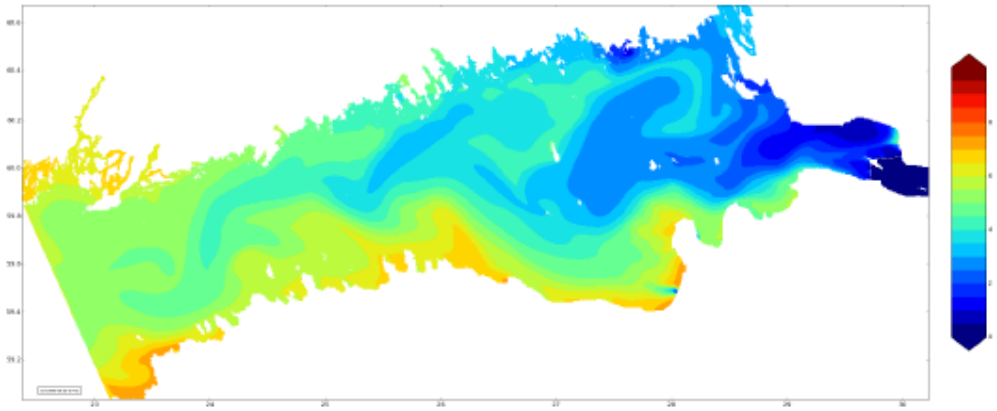
Global version of NEMO is used in climate simulations.

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).





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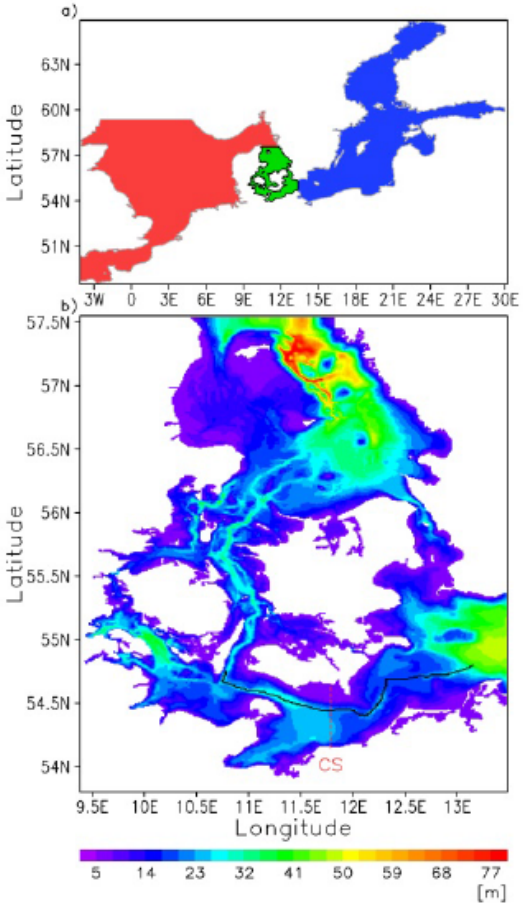
Nested NEMO Experiments Setups Summary

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

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

North Sea Vert. Grid	Baltic Sea Vert. Grid	Danish Straits Resolution	Nesting
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 barotrop velocities



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Unstructured model of the North Sea and Baltic Sea

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

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

DMI
Vejr, klima og hav

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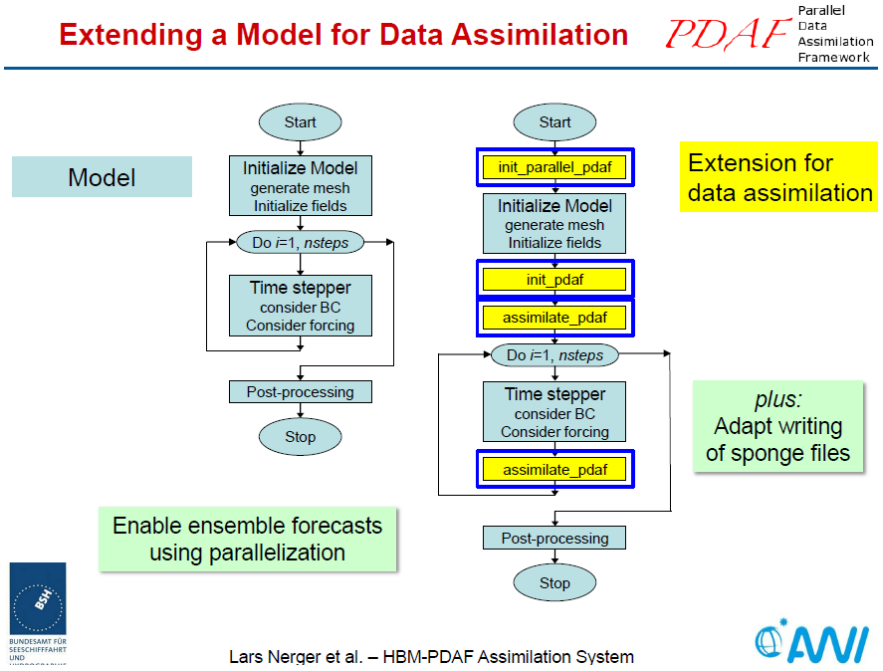
Data Assimilation cooperation

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)



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SST assimilation improves subsurface in Baltic Sea

T/S errors for October / November 2012