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A two-way nested forecasting system to resolve microplastic pathways in Land-to-Ocean-Aquatic-Continuum (LOAC)

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DMI – official focal point of civil oceanography in Danish Realm

Proposed by H.C. Ørsted in 1856, founded in 1872, founder Ludwig Colding, first Director Niels H.C. Hoffmeyer, Deputy Director Poul la Cour

DMI provides data and knowledge based weather, climate and ocean service for public and private users in Denmark, Faroe Island and Greenland.




Challenges and solutions on seamless LOAC modelling

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- Complex transport and transformation of pollutants in land-to-ocean aquatic continuum (LOAC), often not resolved in forecast & climate models; instead, a ”river pipeline” method is used
- Challenges in coastal models:
  - Insufficent resolution
  - Long time tunning when setting up a forecast system; changing of LBC
  - LOAC transport: river plumes:
  - Bentic-pelagic interaction in LOAC:
    - Heat transport: shallow water temperature
    - biofouling, resuspension, sedimentation
- Solutions
  - Unstructured grid
  - Nesting: stand-alone, 1Way or 2Way nesting
  - LOAC resolving

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DMI ocean-ice forecast model HBM with dynamic two-way nesting for Baltic-Limfjord-North Sea

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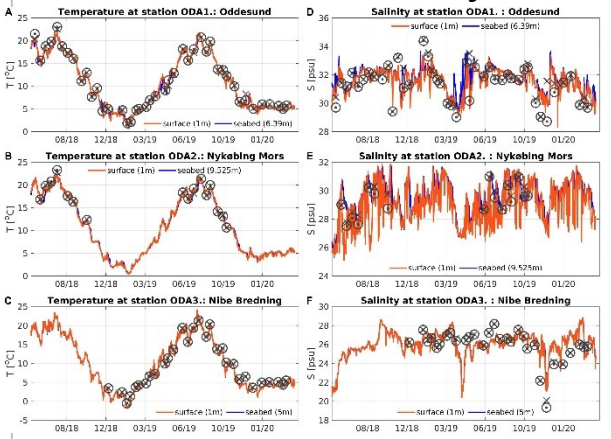
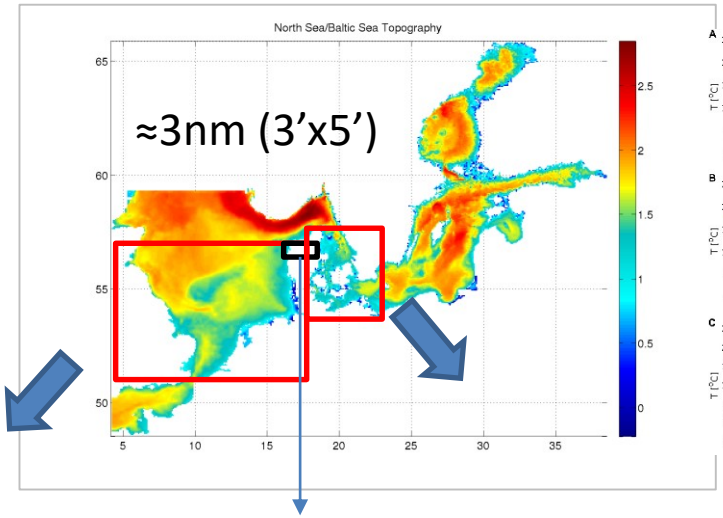
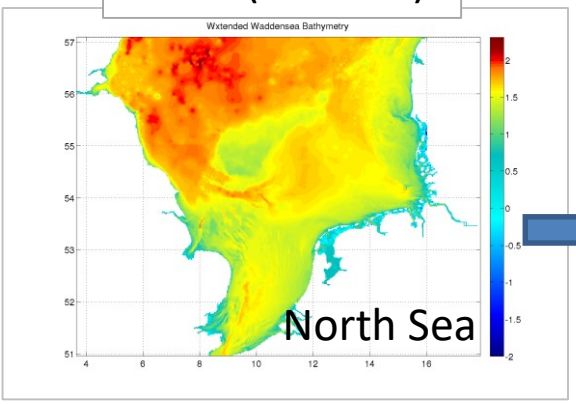
T/S validation in Limfjord

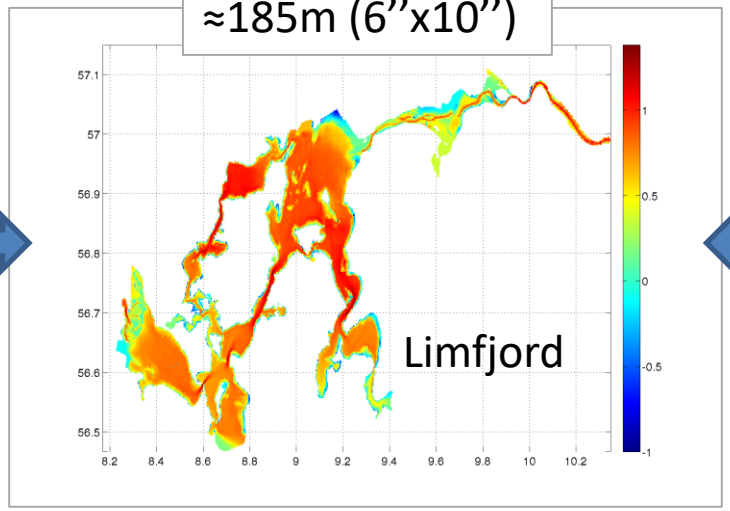




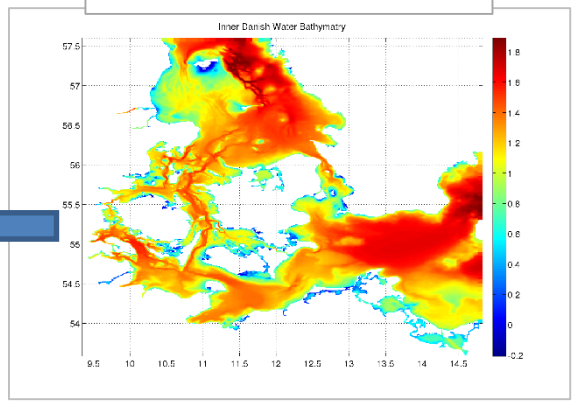
≈1nm (1'x1.66')



≈185m (6''x10'')



≈0.5nm (30''x50'')



Transition waters

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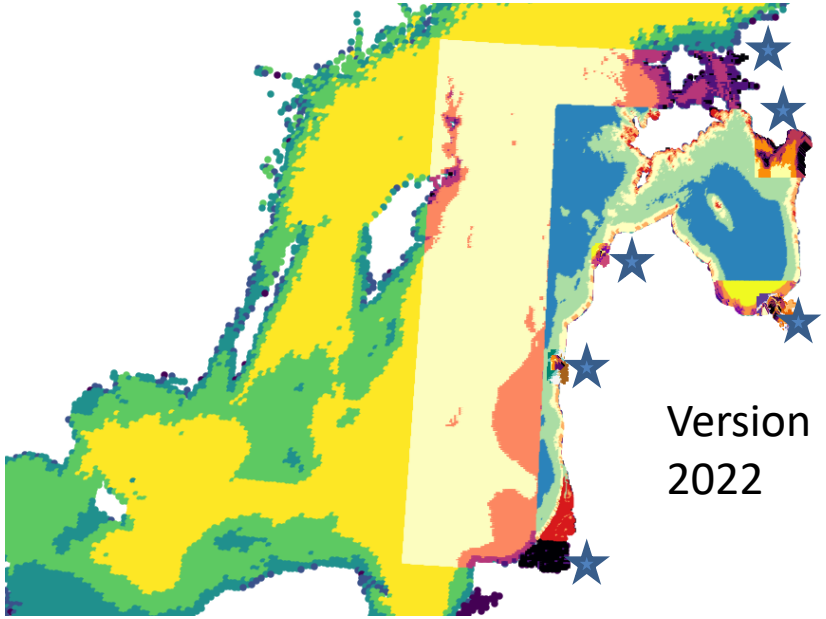
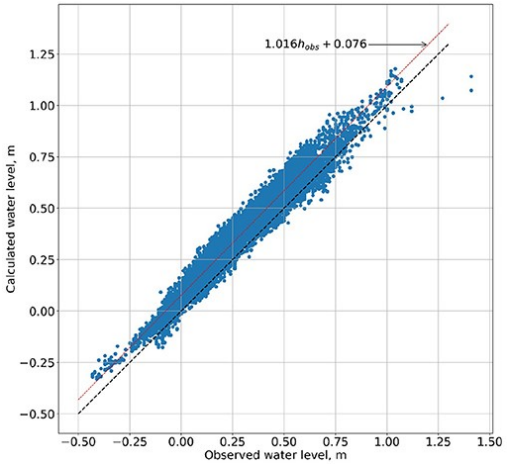
A multi-domain forecasting system HBM for Latvian port management by University of Latvia

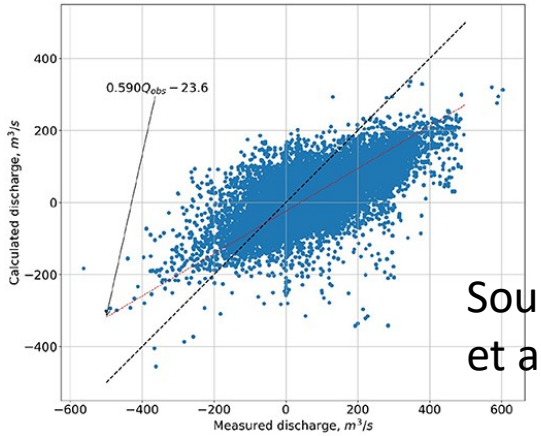
- HBM is set up to make operational forecasts for multiple ports (in Eastern Baltic Sea coast.
- Port domains are represented in different colors, with **30m** resolution for the port region.



Version 2022

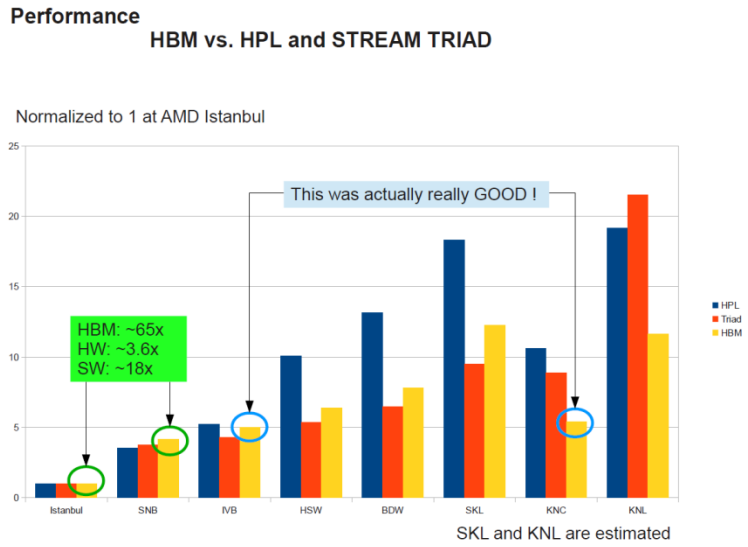


Sea level validation at station “Liepaja” port located in the trade channel.



Source: Frishfelds et al. 2021

HBM HPC performance and shallow water temperature forecasting

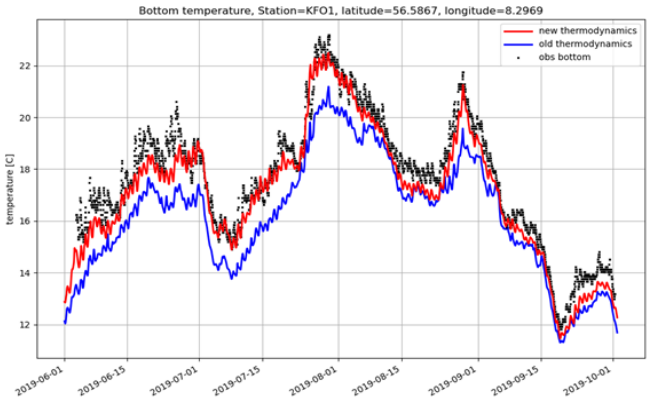


Source: Berg and Poulsen (2016)

$$I = Q_{SW}[R_{SW}\exp(-h/\zeta_1) + (1 - R_{SW})\exp(-h/\zeta_2)]$$

$$\tilde{\zeta}_i = \zeta_i \cdot max(0.2, h/H_{max})$$

$$H_{max} = 5 \text{ m}$$



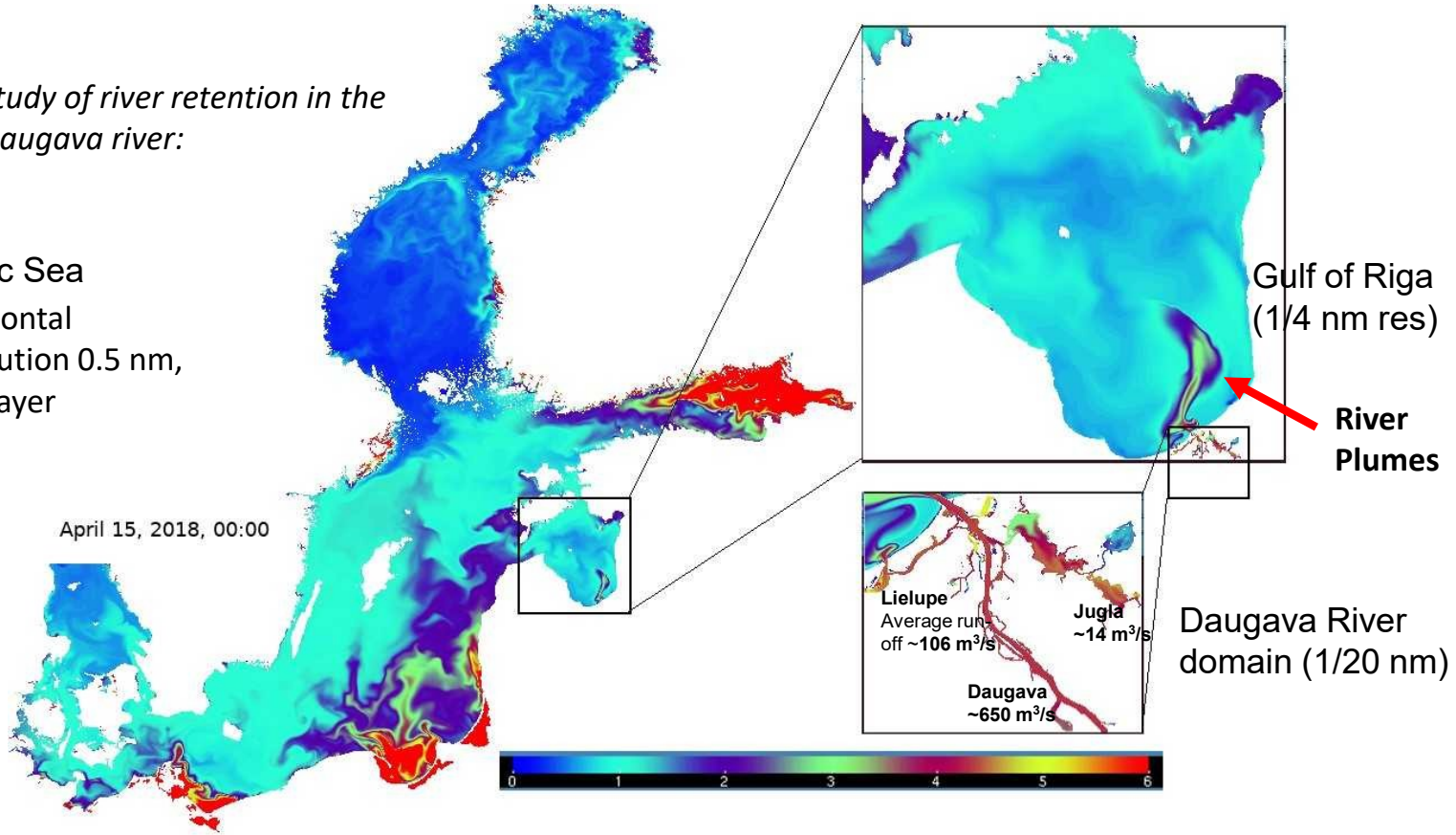
Improvement of temperature in water shallower than 5m. Source: Murawski et al. 2021

Microplastic modelling using a LOAC resolving model

Study of river retention in the Daugava river:

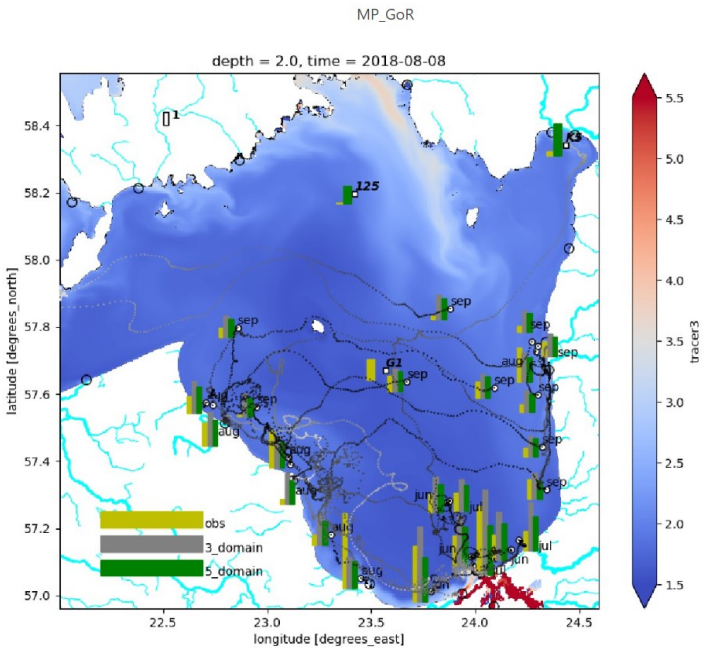
Baltic Sea

Horizontal resolution 0.5 nm, 122 layer



Microplastic observations vs simulations

- Yellow bars are observed values, grey bars - 3 domain setup and green bars - 5 domain setup.
- Dotted lines represent most probable backtracking trajectory to river source. Empty circles at the coast represent location of river outlets in HBM derived from E-hype.
- Background picture is surface MP 300 µm concentration [*0.01 mg/m3] at 2018.08.08.
- Instantaneous model-observation intercomparison give a correlation coefficient of ~0.65



Source: Frishfelds et al., 2022

Concluding remarks

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- A LOAC resolving model HBM has been developed and applied for operational forecasting in Baltic-North Sea
- Shallow water heat transport, riverine-coastal water interaction, biofouling and sedimentation are resolved
- Modelling of shallow water temperature, river plumes, pollutant transformation and transport are improved
- Dynamic two-way nesting is an efficient approach for setting up new LOAC forecast for aquaculture, port management, pollutant protection services
- National LOAC forecasting system in the Baltic-North Sea region can be easily configured as a 2Way nesting subdomain in the Baltic-North Sea, less affected by change of lateral boundary conditions.

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THANKS FOR YOUR ATTENTION!

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