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The HBM-PDAF assimilation system for operational forecasts in the North and Baltic Seas

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DeMarine

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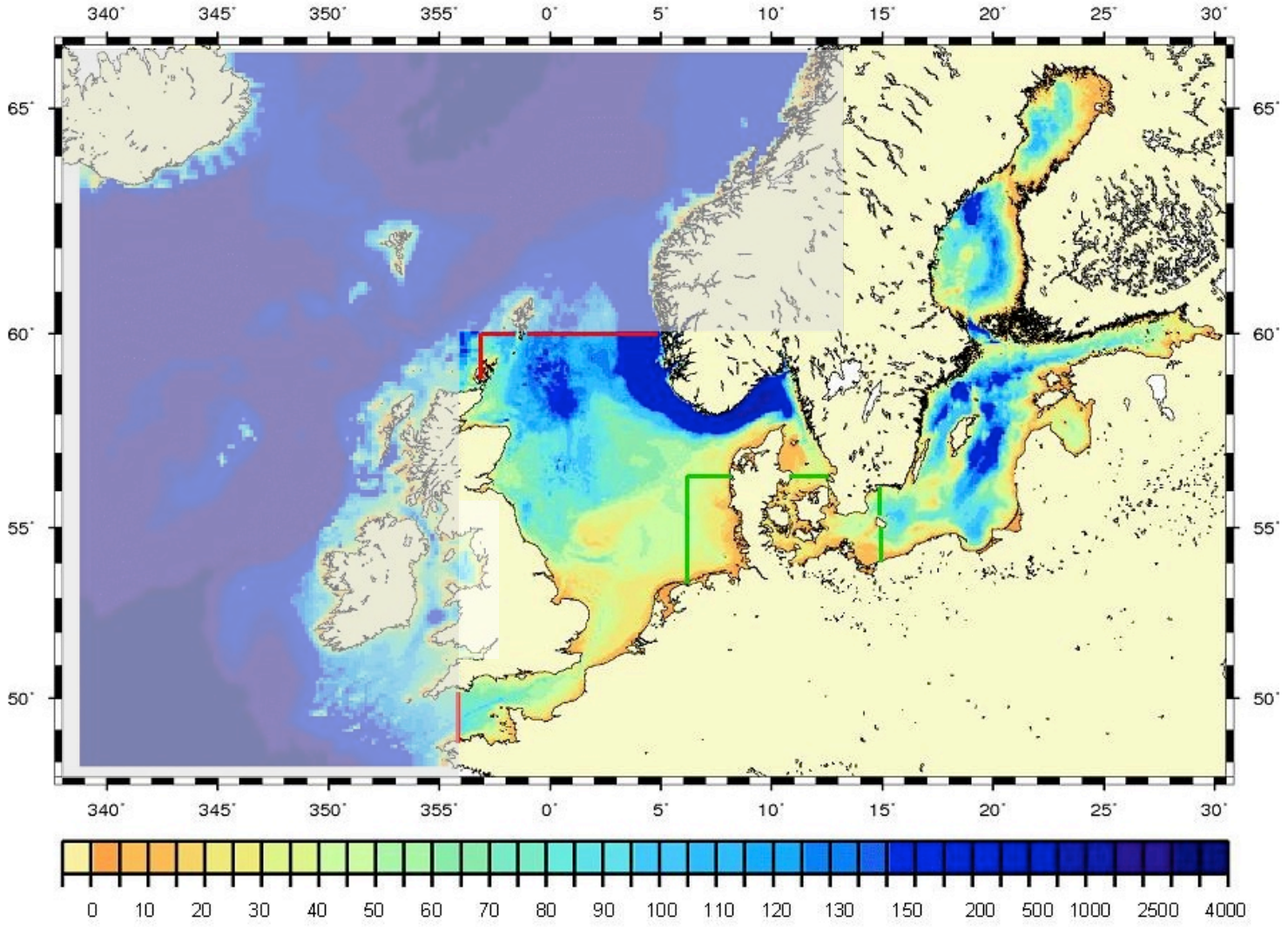
Starting point: Operational BSH Model (BSHcmod), V4

Grid nesting:

- 10 km grid
- 5 km grid
- 900 m grid



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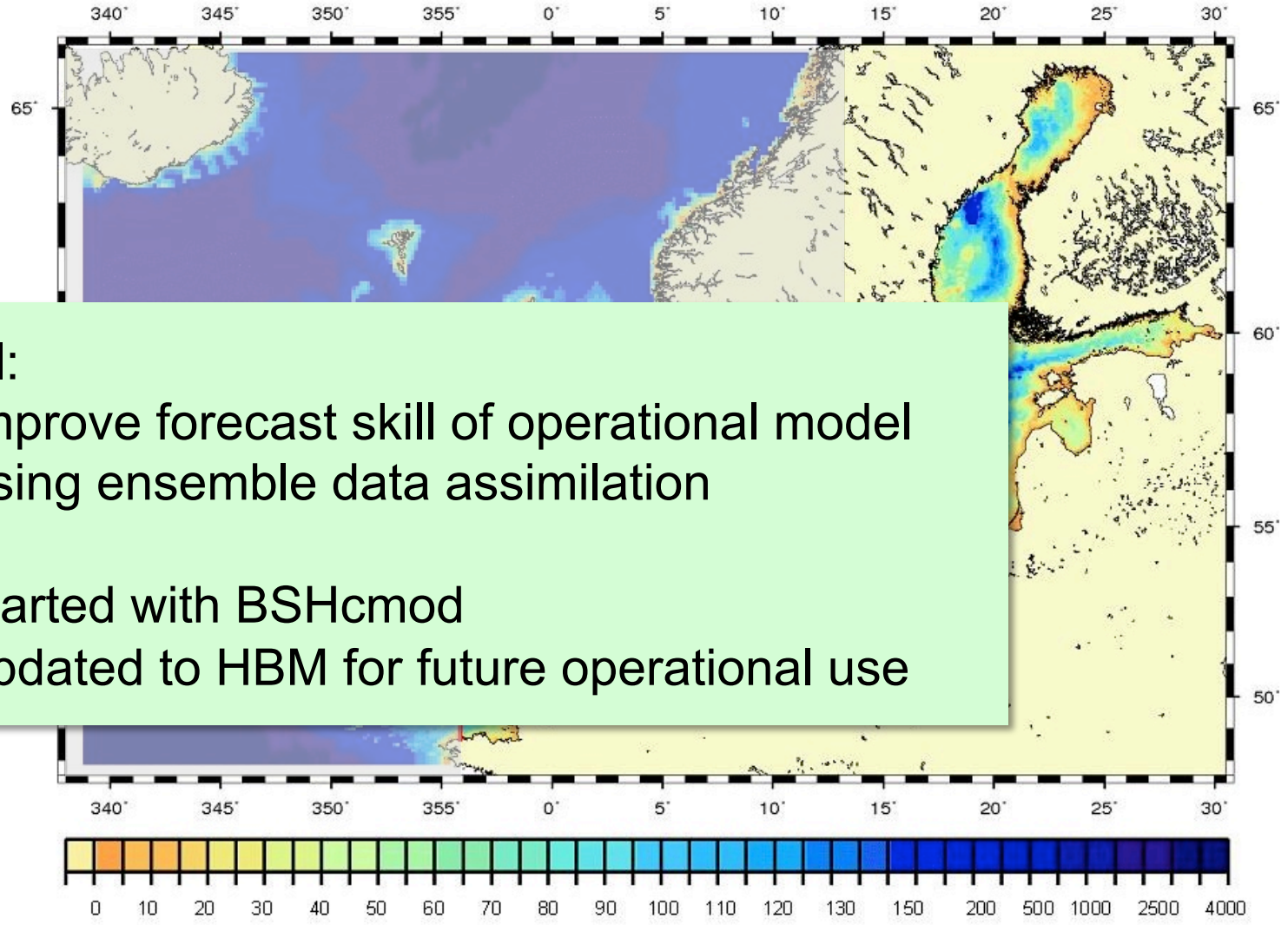

Goal:

- improve forecast skill of operational model using ensemble data assimilation

- started with BSHcmod
- updated to HBM for future operational use

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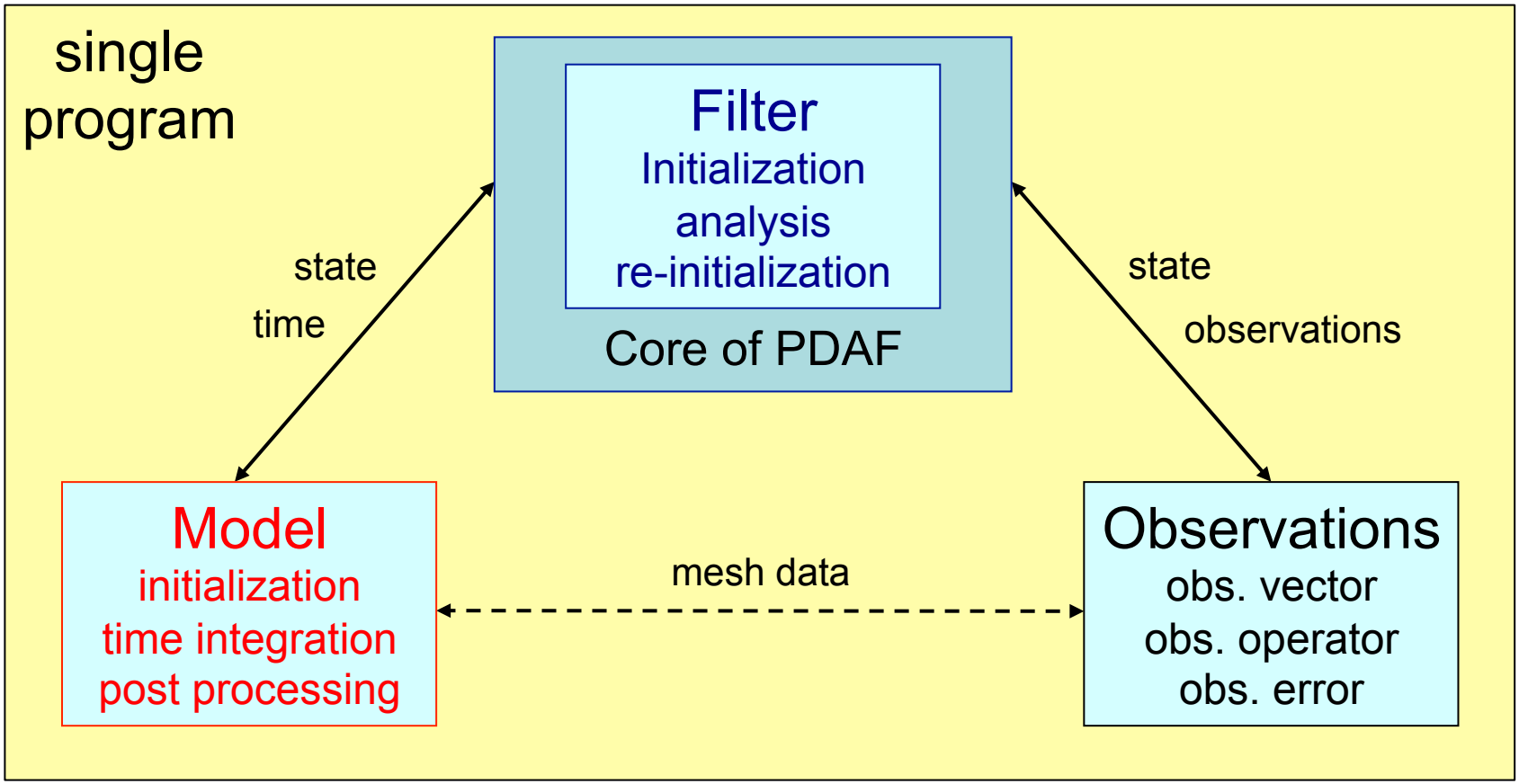
Logical separation of assimilation system

PDAF Parallel Data Assimilation Framework



Explicit interface

Indirect exchange (module/common)

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Nerger, L., Hiller, W. Software for Ensemble-based DA Systems – Implementation and Scalability. Computers and Geosciences. 55 (2013) 110-118

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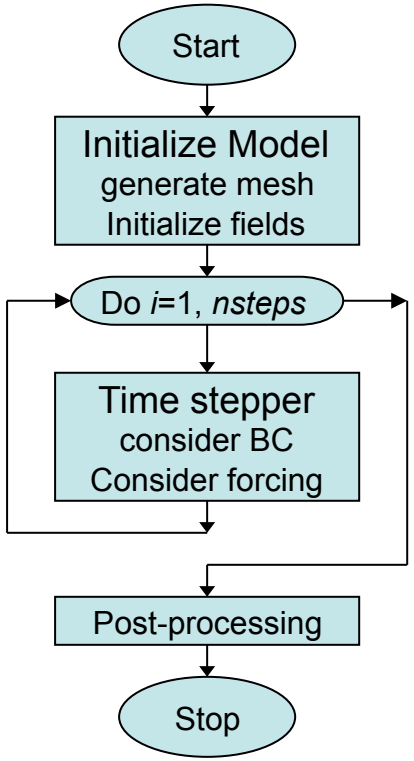
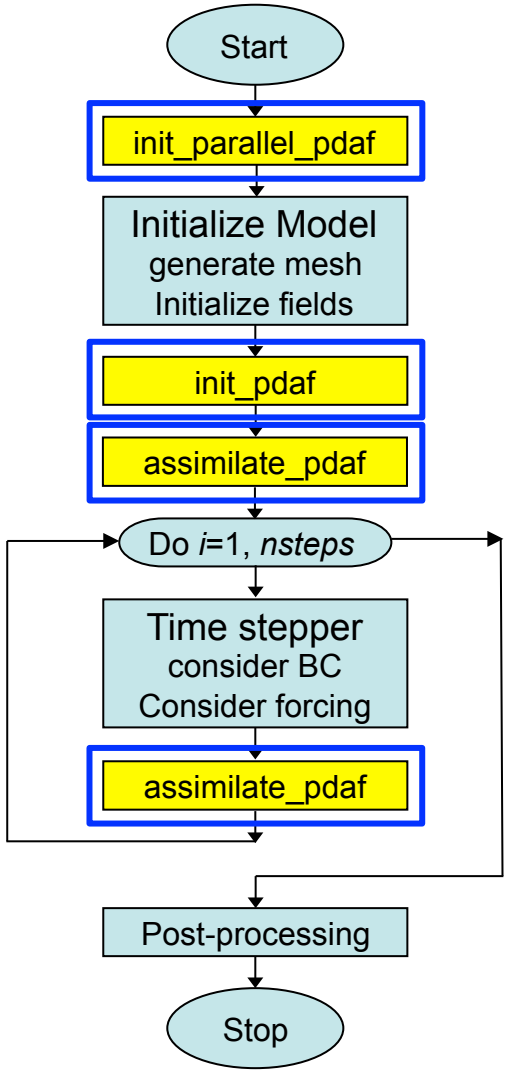
Extending a Model for Data Assimilation

PDAF Parallel Data Assimilation Framework

Model



Enable ensemble forecast using parallelization



Extension for data assimilation

plus:
Adapt writing of sponge files

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User-supplied routines (call-back)

PDAF Parallel Data Assimilation Framework

- Model and observation specific operations
- Elementary subroutines implemented like model routines
- Called by PDAF routines through a defined interface

Link to model

- initialize model fields from state vector
- initialize state vector from model fields

Observation handling

- application of observation operator **H** to some vector
- initialization of vector of observations
- multiplication with observation error covariance matrix

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PDAF: A tool for data assimilation

PDAF Parallel Data Assimilation Framework

PDAF - Parallel Data Assimilation Framework

- provide support for ensemble forecasts
- provide fully-implemented filter algorithms
- easily useable with (probably) any numerical model (coupled also to NEMO, MITgcm, FESOM, ADCIRC)
- makes good use of supercomputers
- separate development of model and assimilation algorithms

Open source:
Code and documentation available at

http://pdaf.awi.de

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L. Nerger, W. Hiller, Computers & Geosciences 55 (2013) 110-118

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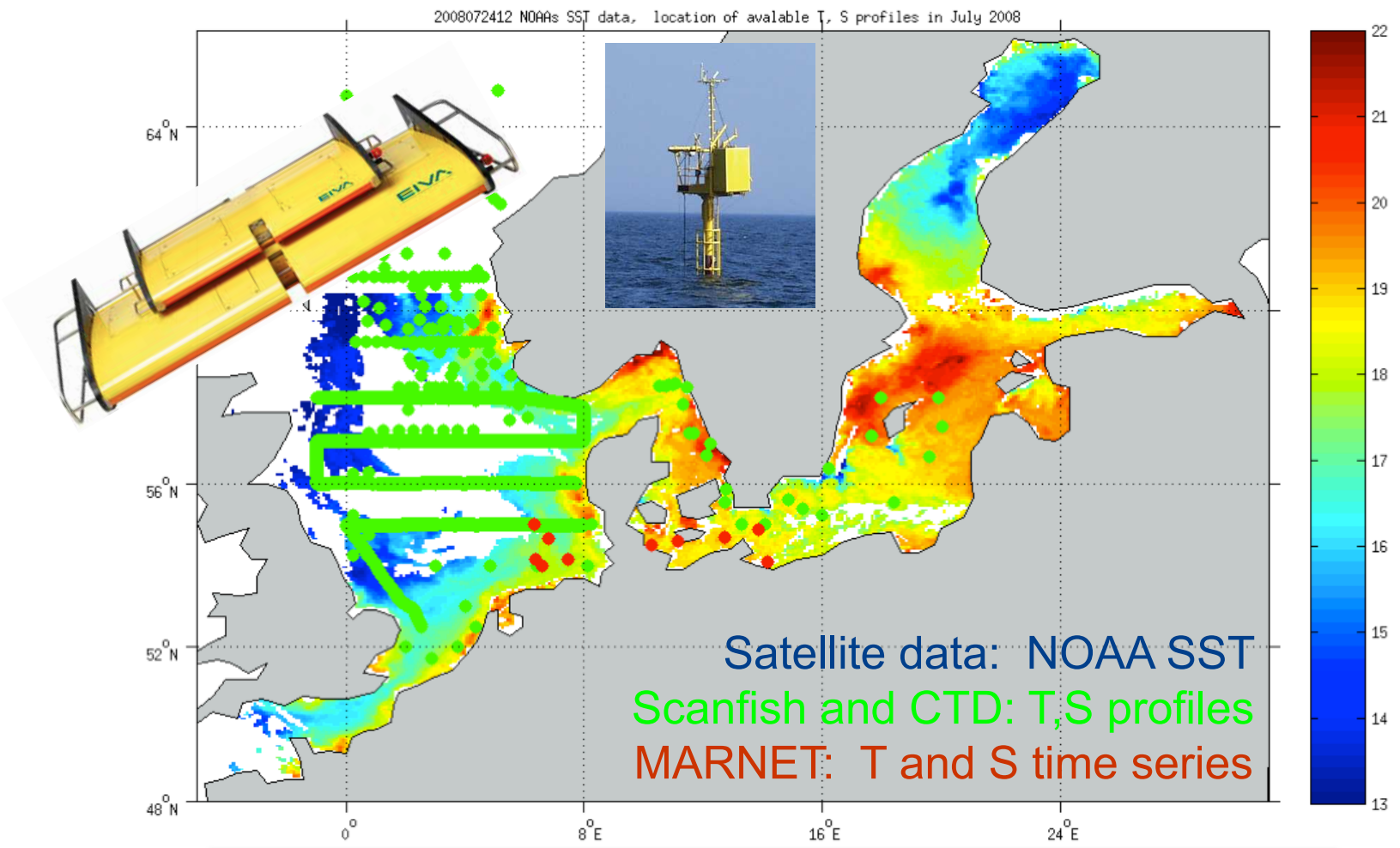
Assimilated Data – Satellite, MARNET and profiles



- Surface temperature: 12-hour composites
- Strong variation of data coverage (clouds)

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Assimilation Methodology

- 12-hour forecast/analysis cycles
- Ensemble size 8 (sufficient for good results)
- Assumed data errors:

  SST: 0.8°C (gave best results)

  MARNET: 0.5°C, 0.5 psu

  Scanfish: 0.8°C, 0.5 psu
- Ensemble Kalman filter (local SEIK)
- Localization:
  - Influence radius 100 km (tuned)
  - Weight on data errors

    (Exponential, e-folding at 100 km)

- Showing mainly results from BSHcmod

  (very similar to HBM)

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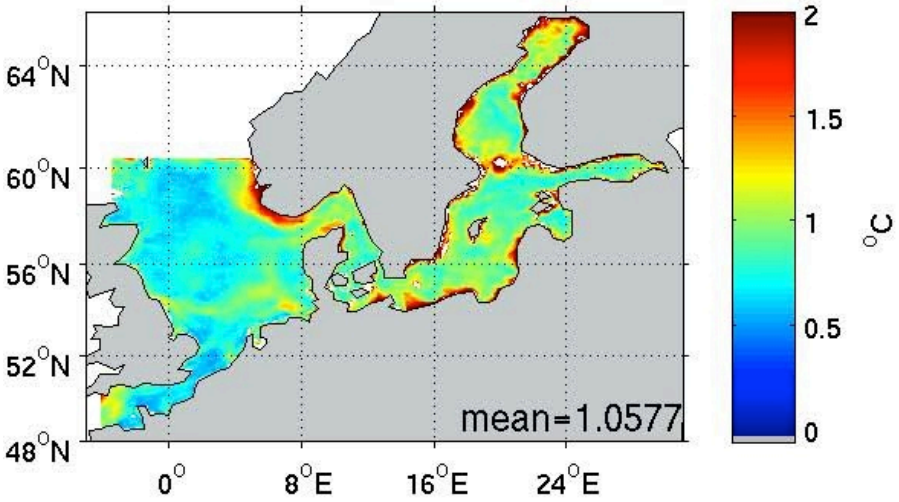
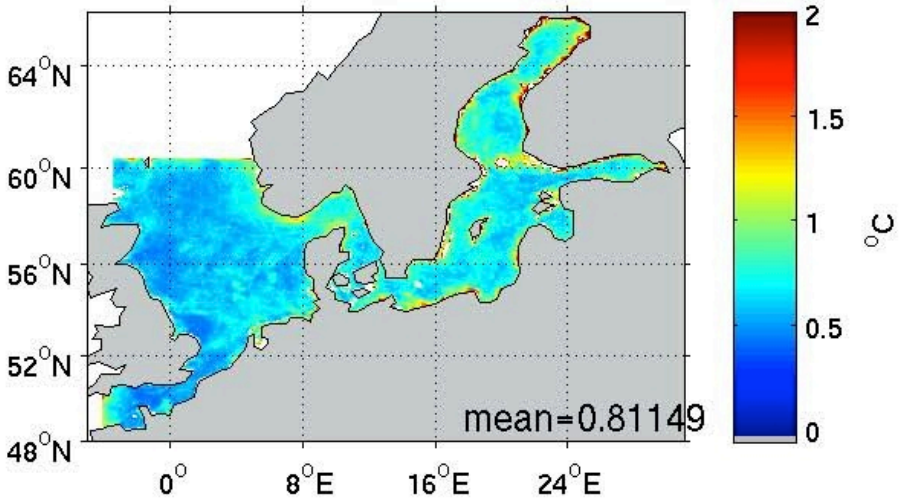
Deviation from NOAA Satellite Data

- RMS errors for SST in 12-hour forecasts
- Average over 1 year (10/2007 – 9/2008)

No assimilation



SST assimilation



- 23% overall reduction
- Mean error also reduced

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Forecast improvements

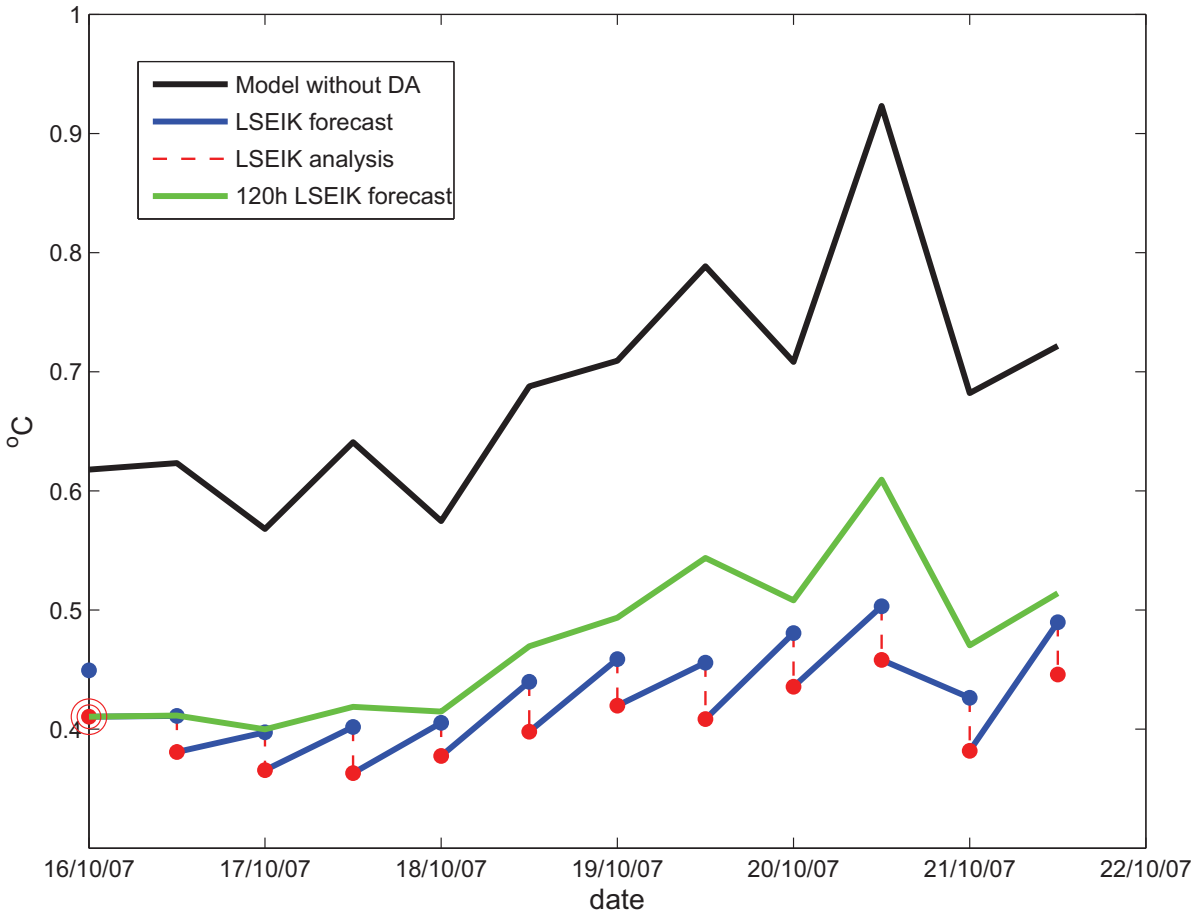
black: free model run

blue/*red*: 12h assimilation/ analysis cycles

green: 5 day forecast from 16/10

➜ Very stable 5-day forecasts

RMS error for SST over time



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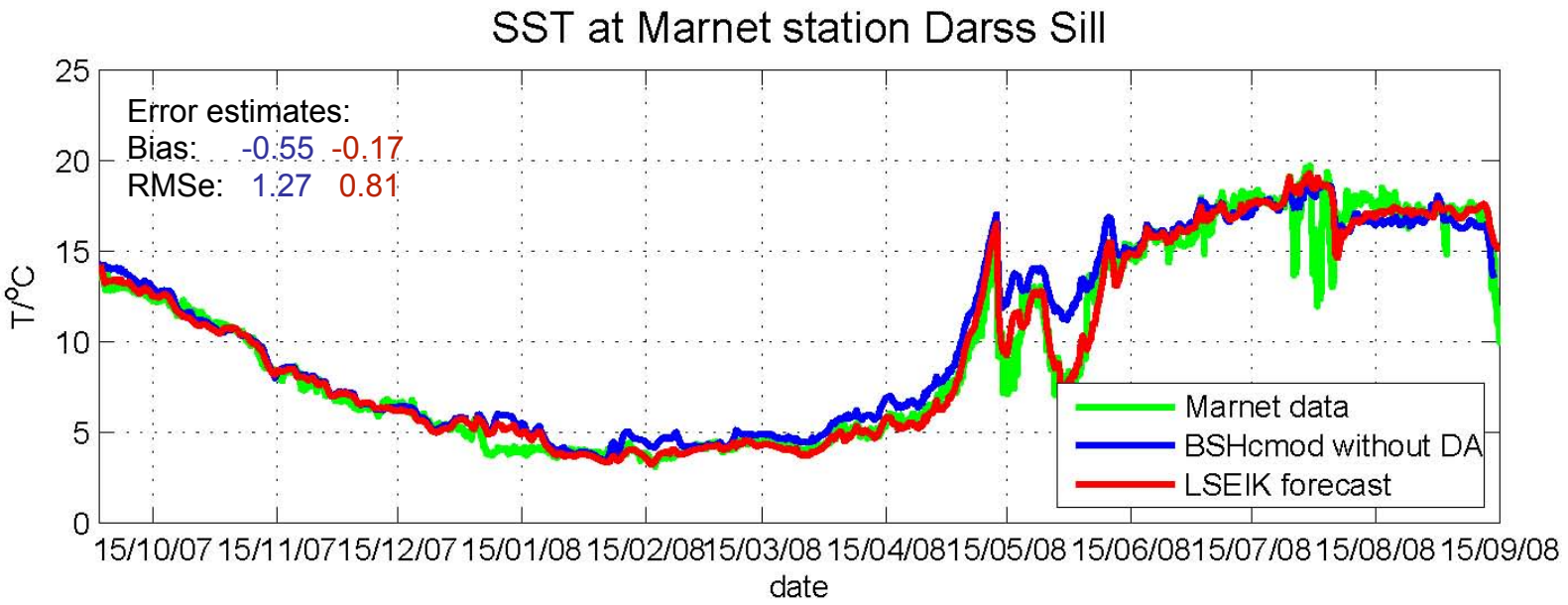
Validation with independent data (only SST assim.)



MARNET station data

- Reduction of
  - Bias
  - RMS error

1 year mean over 6 stations:

	RMSe	bias
free	0.87	0.3
satellite data	0.59	0.11
assimilation	0.55	0.08

Red: Assimilation 12h forecasts

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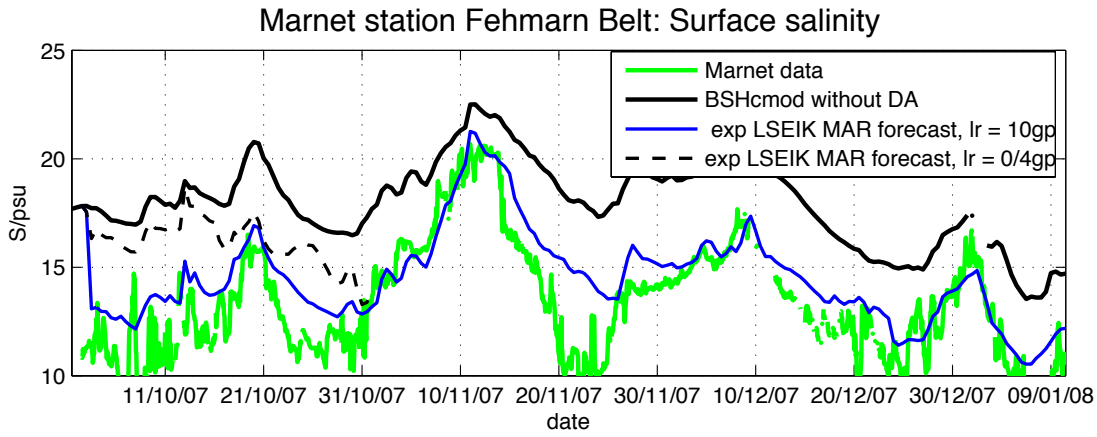
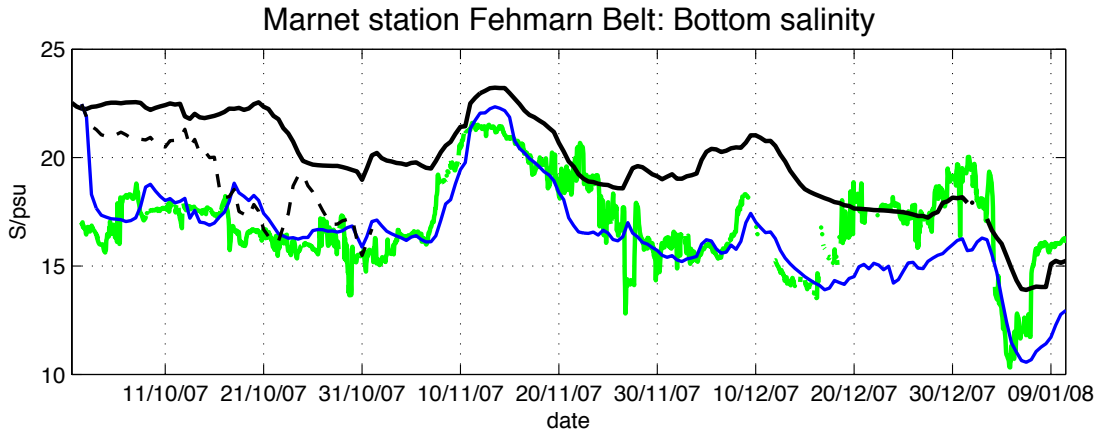
Assimilation of MARNET data

- Salinity: Significant improvement at surface and bottom
- Localization parameters influence assimilation performance





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Summary

- HBM-PDAF system provides improved forecasts
- Very small increase of run time
- Assimilation framework PDAF to implement assimilation systems (http://pdaf.awi.de)

Ongoing work

- Include coastal mesh for assim. (900m resolution)
- Include ecosystem model ERGOM (@BSH)
- Assimilation of clorophyll data
- Switch to ESTKF filter (Nerger et al., MWR, 2012)

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References

Nerger, L., Hiller, W. (2013) Software for Ensemble-based Data Assimilation Systems – Implementation and Scalability. *Computers and Geosciences*. 55, 110-118

Losa, S.N. et al. (2012). Assimilating NOAA SST data into the BSH operational circulation model for the North and Baltic Seas: Inference about the data. *Journal of Marine Systems*, 105-108, pp. 152-162

Losa, S. N. et al. (2014). Assimilating NOAA SST data into the BSH operational circulation model for the North and Baltic Seas: Part 2. Sensitivity of the forecast's skill to the prior model error statistics. *Journal of Marine Systems*, 129, 259-270

PDAF Parallel Data Assimilation Framework

http://pdaf.awi.de

DeMarine

www.demarine.de

SANGOMA

www.data-assimilation.net

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