An ensemble-based forecasting system for the North and Baltic Seas using the BSH circulation model and PDAF

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Outline

- Assimilation system with BSHcmod and PDAF
- Assimilation of satellite SST and in situ data
- Assimilation software

Related projects:

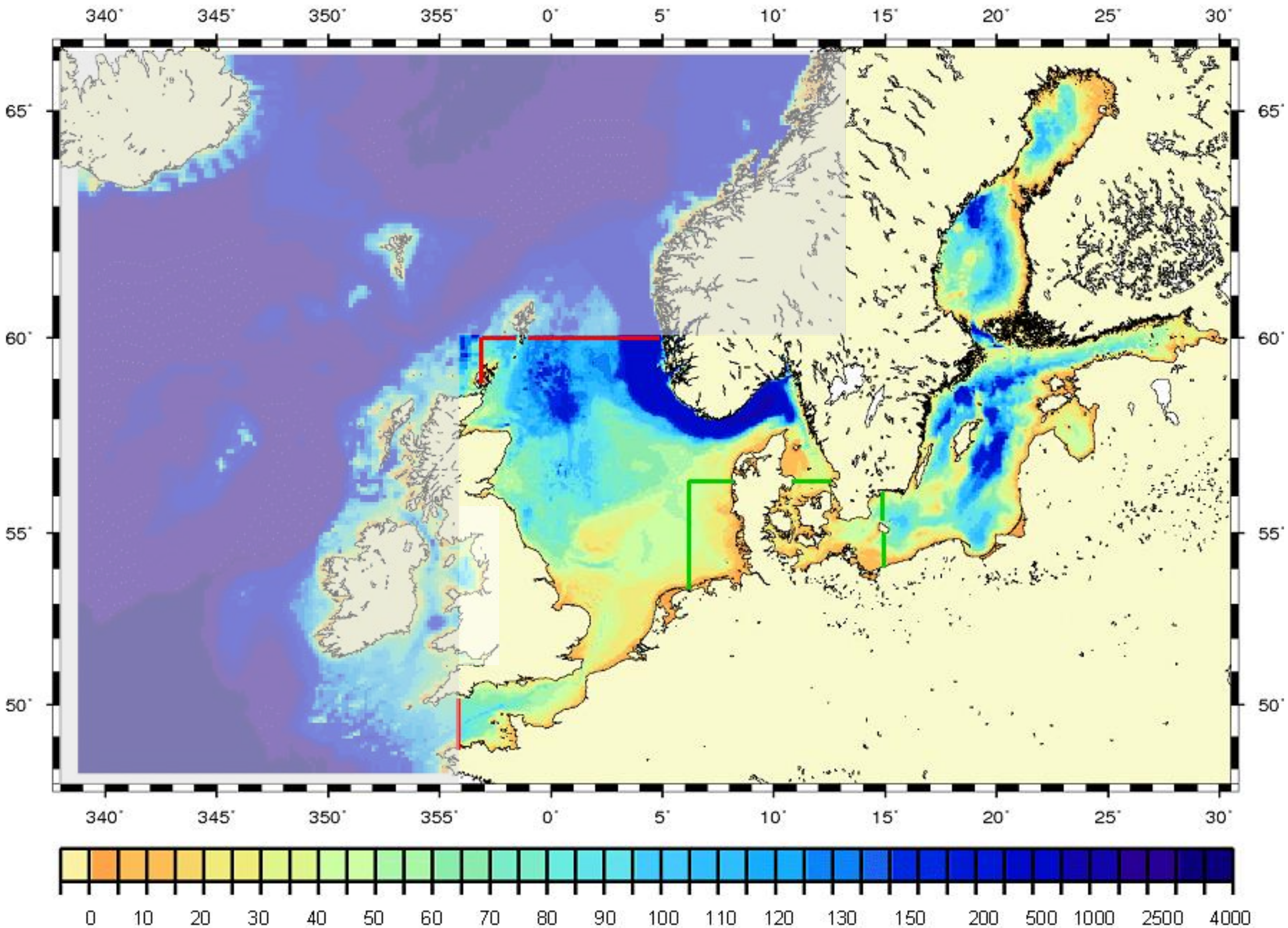
DeMarine

Development of the assimilation system (German GMES project)

SANGOMA

Unification of assimilation tools and new algorithms (EU FP7)

Operational BSH Model (BSHcmod), Version 4



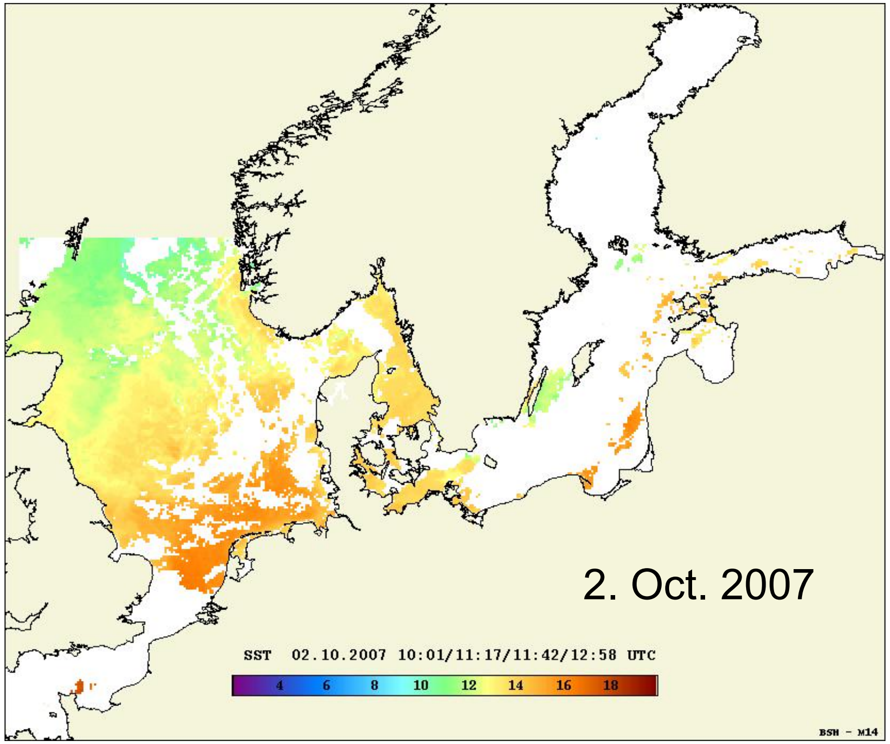
BSSC 2007, F. Janssen, S. Dick, E. Kleine

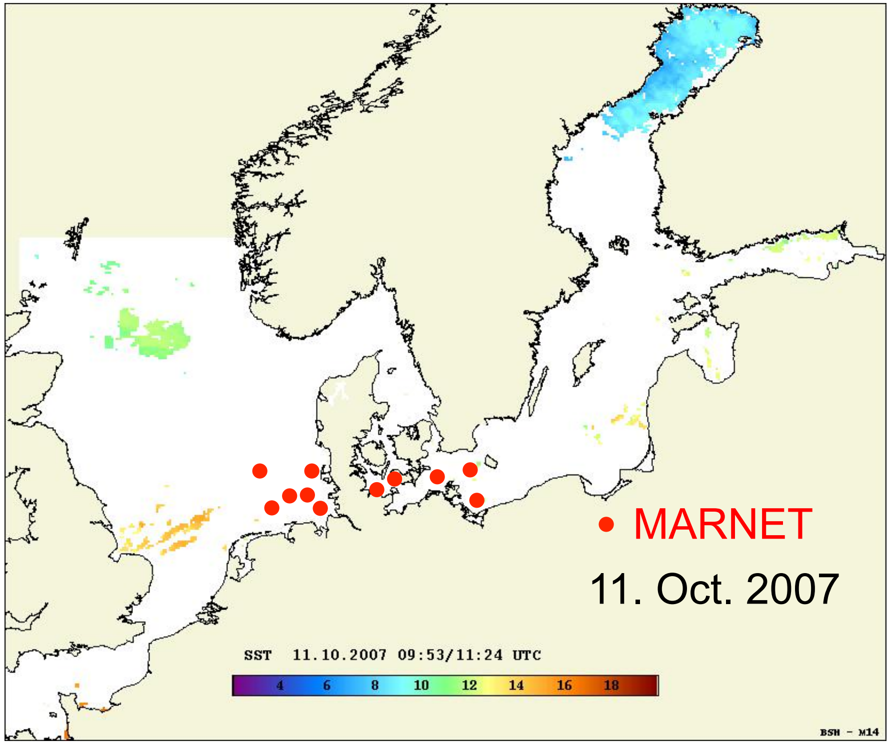
Grid nesting:

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

Data assimilation: 5 km grid

Assimilated Data - Satellite





- Surface temperature (from NOAA satellites)
- 12-hour composites
- Strong variation of data coverage (clouds)

Assimilation Methodology

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

  uncorrelated, 0.8°C (gave best results)
- Localization:
  - Weight on data errors
  - Exponential, e-folding at 100 km (tuned)

- Implementation:
  - Single program with PDAF (more later)

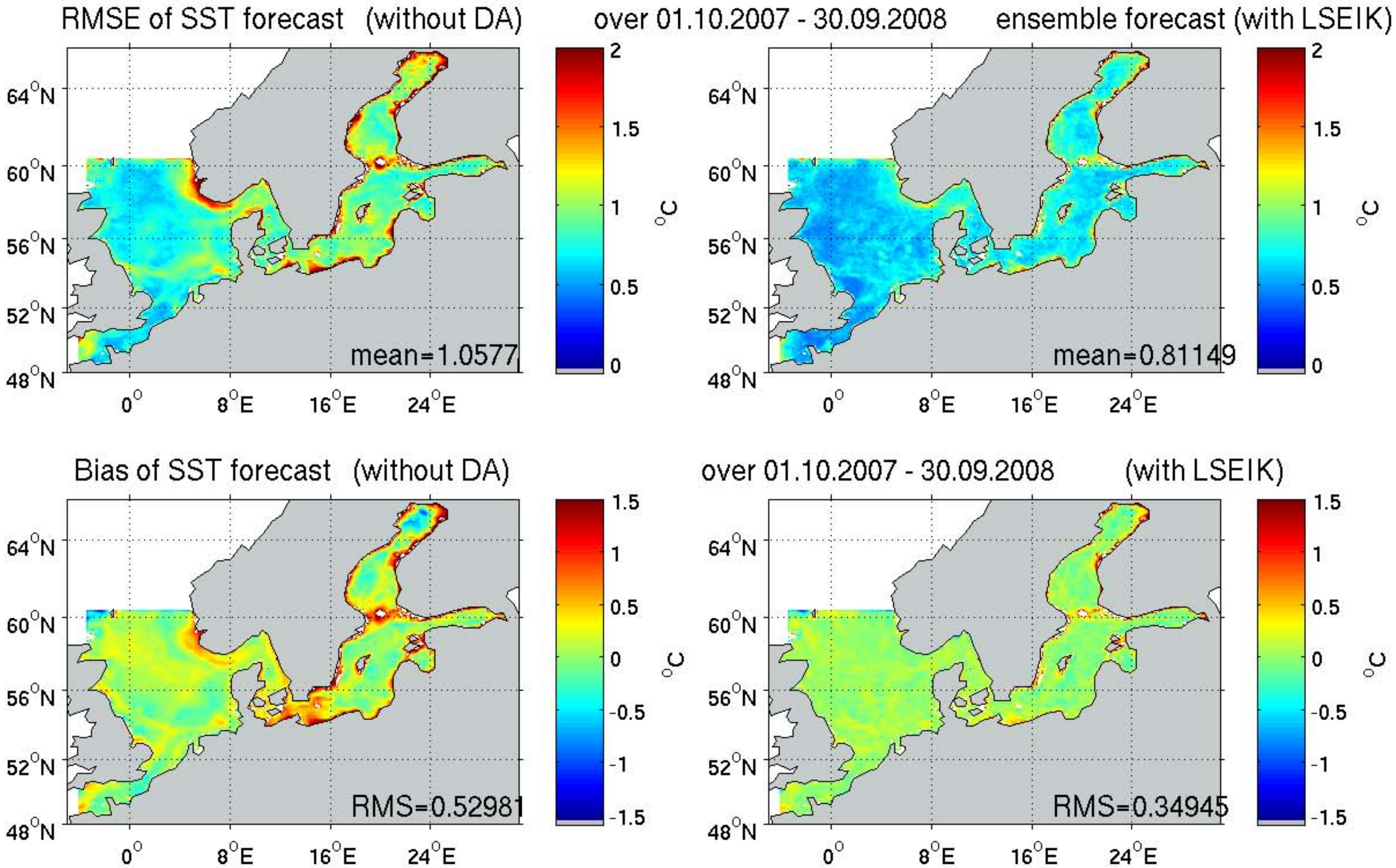
Deviation from NOAA Satellite Data

No assimilation

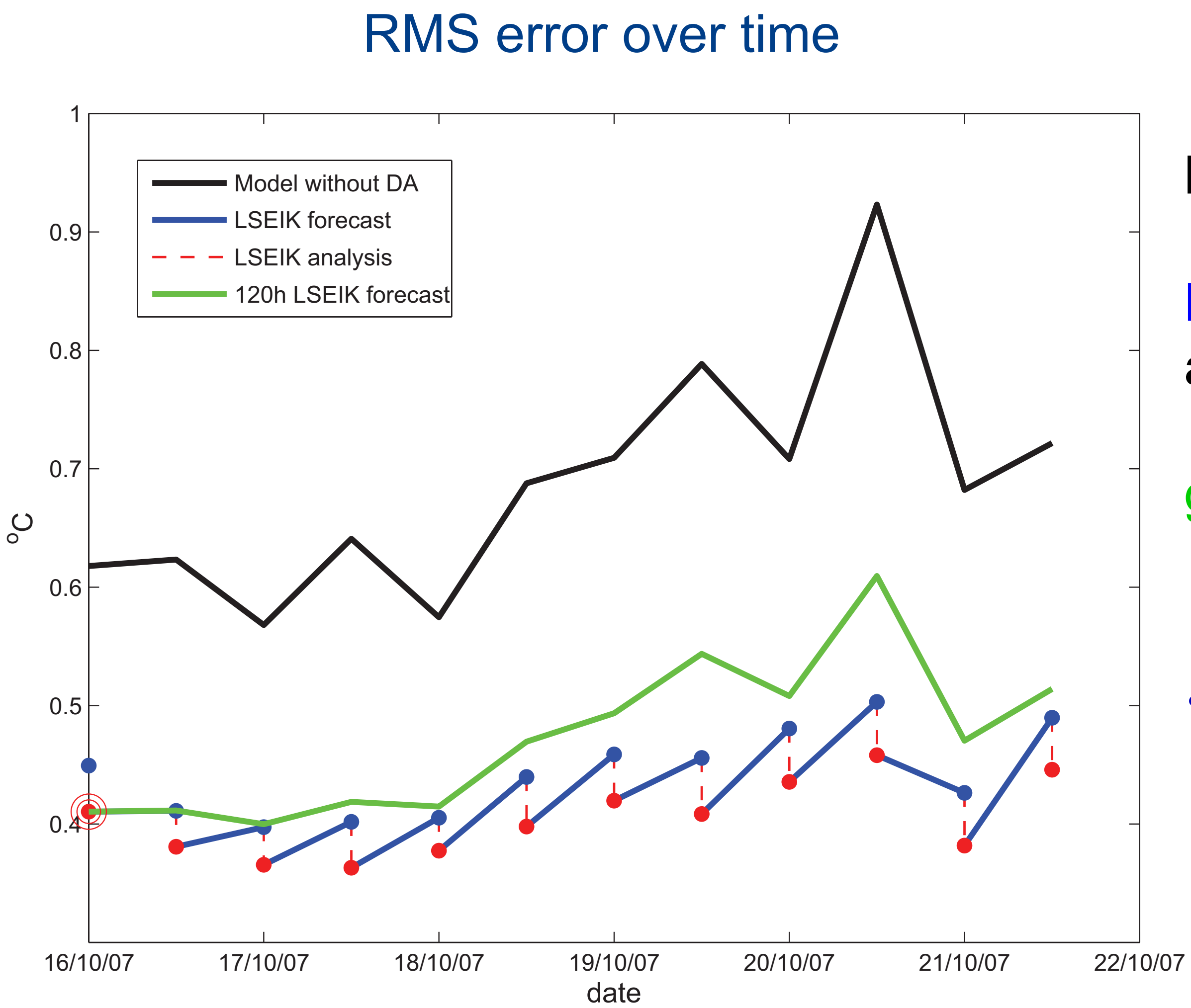
Assimilation

RMS

bias



Improvement of long forecasts



black: free model run

Blue/red: 12h assimilation/ analysis cycles

green: 5 day forecast

➜ Very stable 5-day forecasts

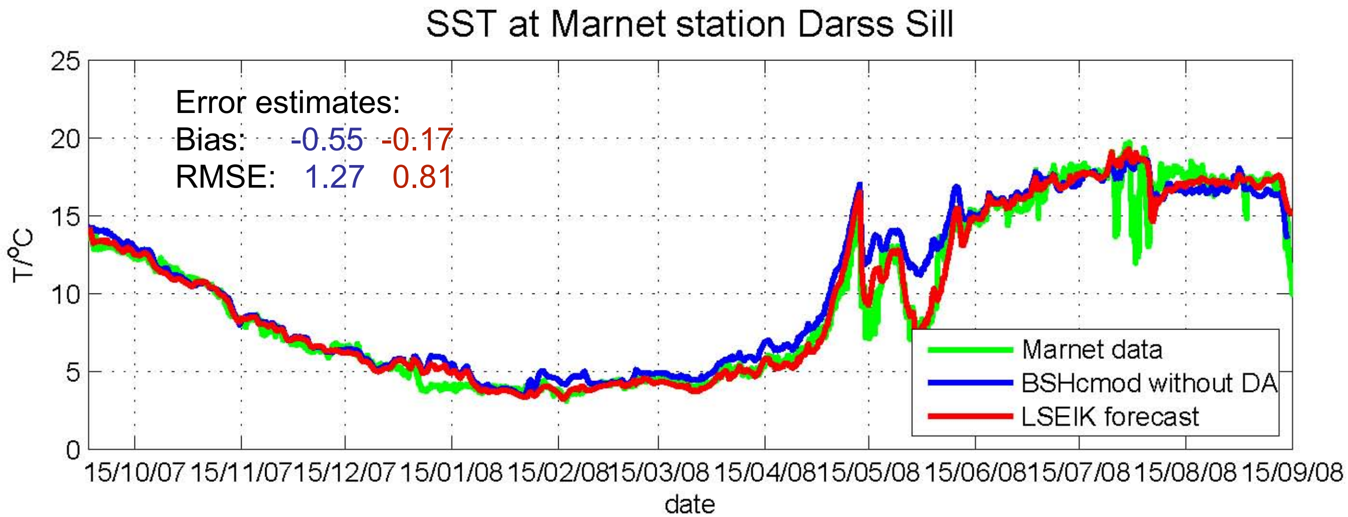
Validation with independent data (only SST assim.)

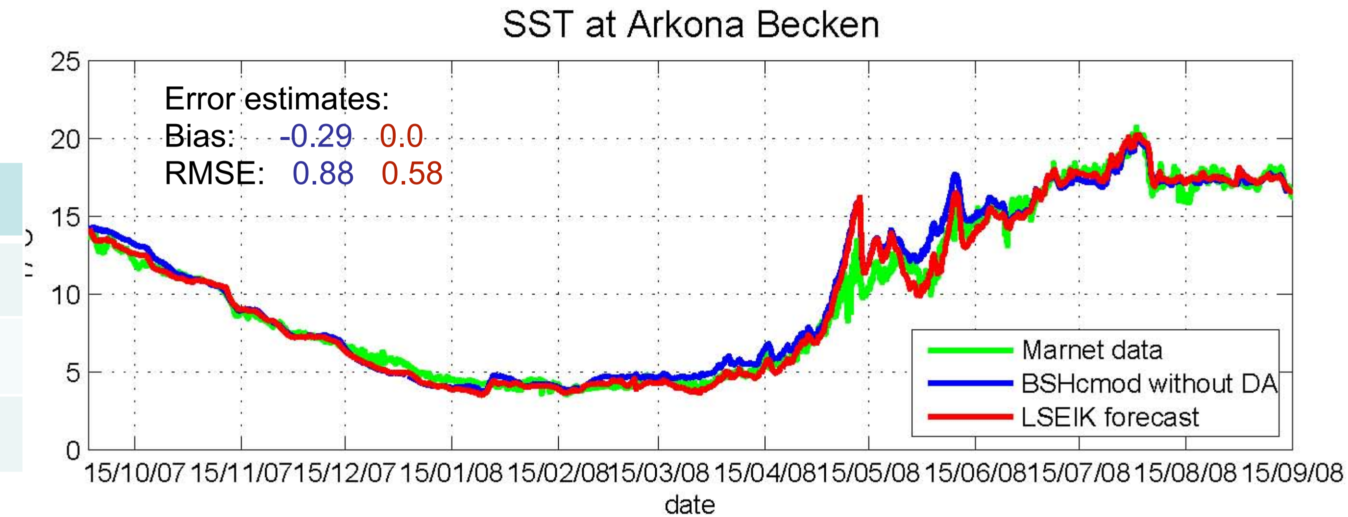
MARNET station data

- Reduction of
  - Bias
  - RMS error

1 year mean over 6 stations:

	RMSe	bias
free	0.87	0.3
data	0.59	0.11
assim.	0.55	0.08





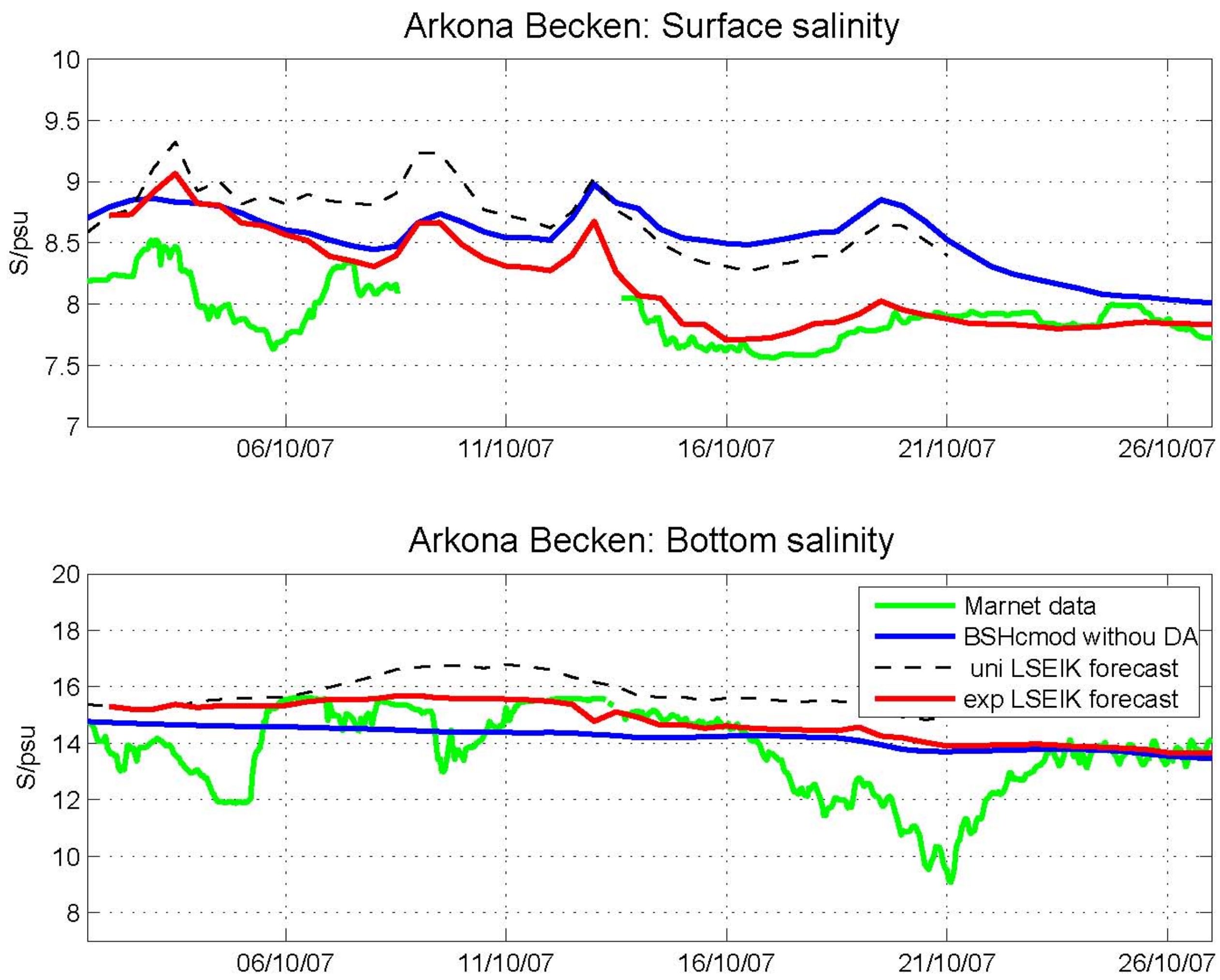
Red: Assimilation 12h forecasts

Independent salinity data

No salinity data assimilated

Success depends on localization method

Difficulties at the bottom (model resolution only 5 km)



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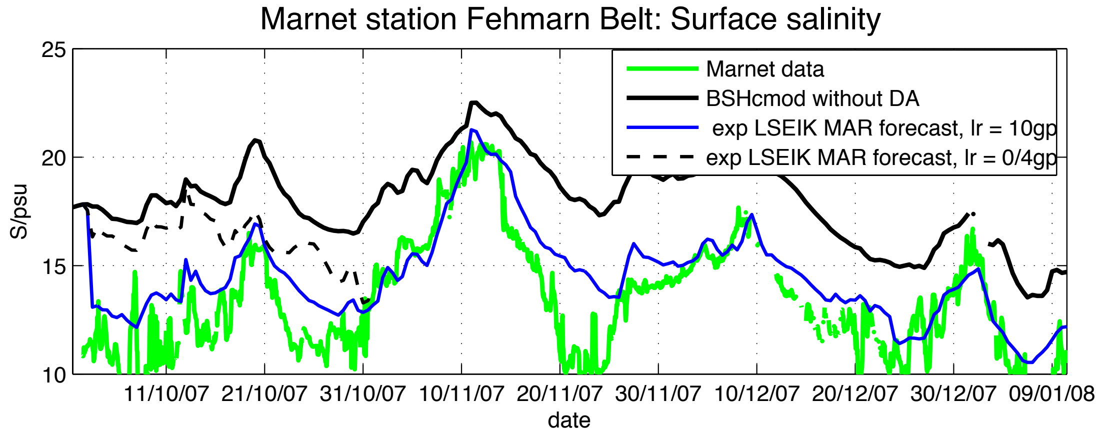
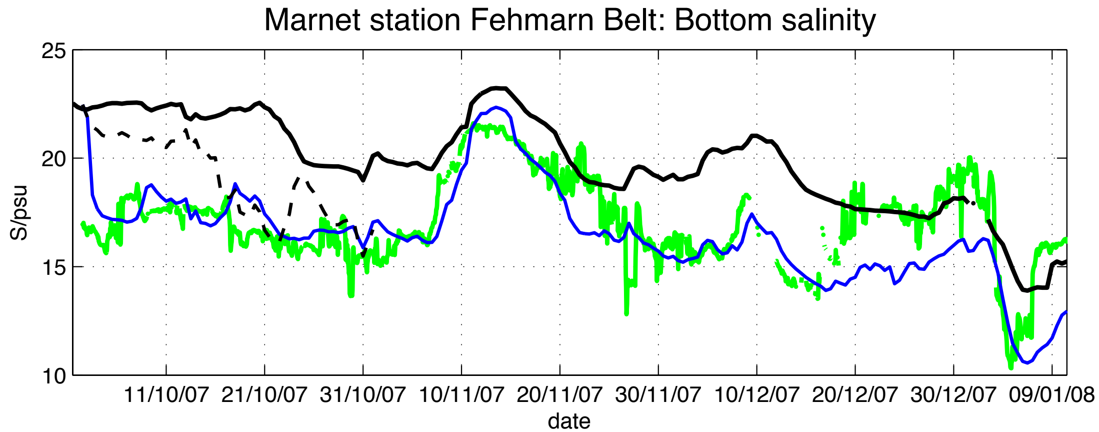
Assimilation of MARNET data





- Salinity: Significant improvement at surface and bottom
- Success depends on localization parameters

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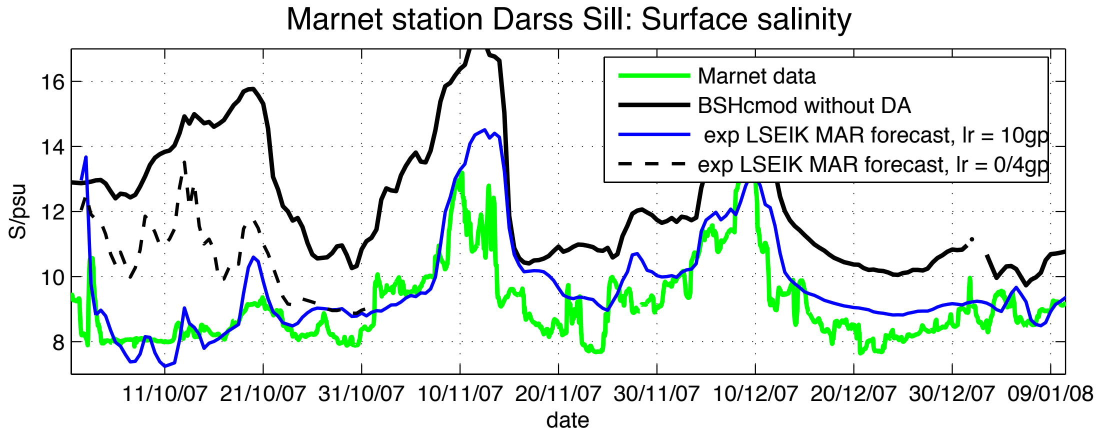
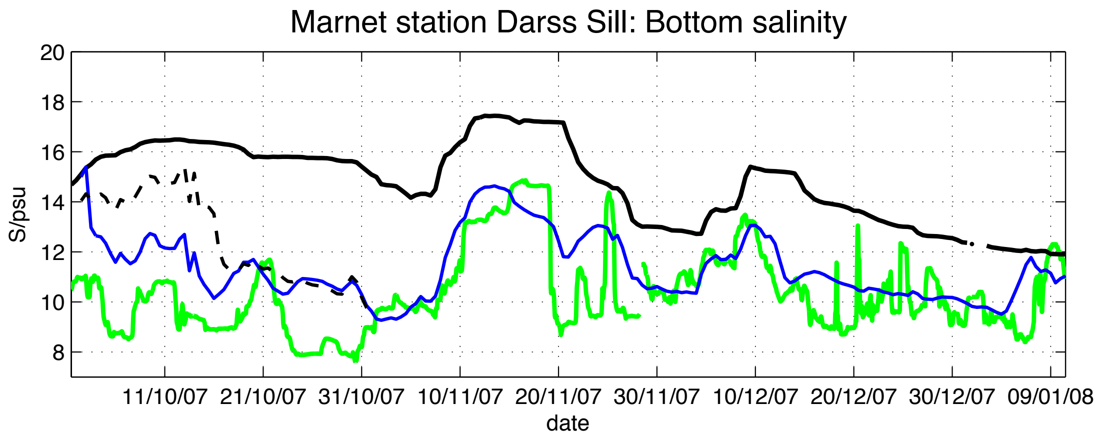
Assimilation of MARNET data





For details see Poster by Losa et al. (Board 26)

Also CTD and Scanfish data

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PDAF: A tool for data assimilation

PDAF Parallel Data Assimilation Framework

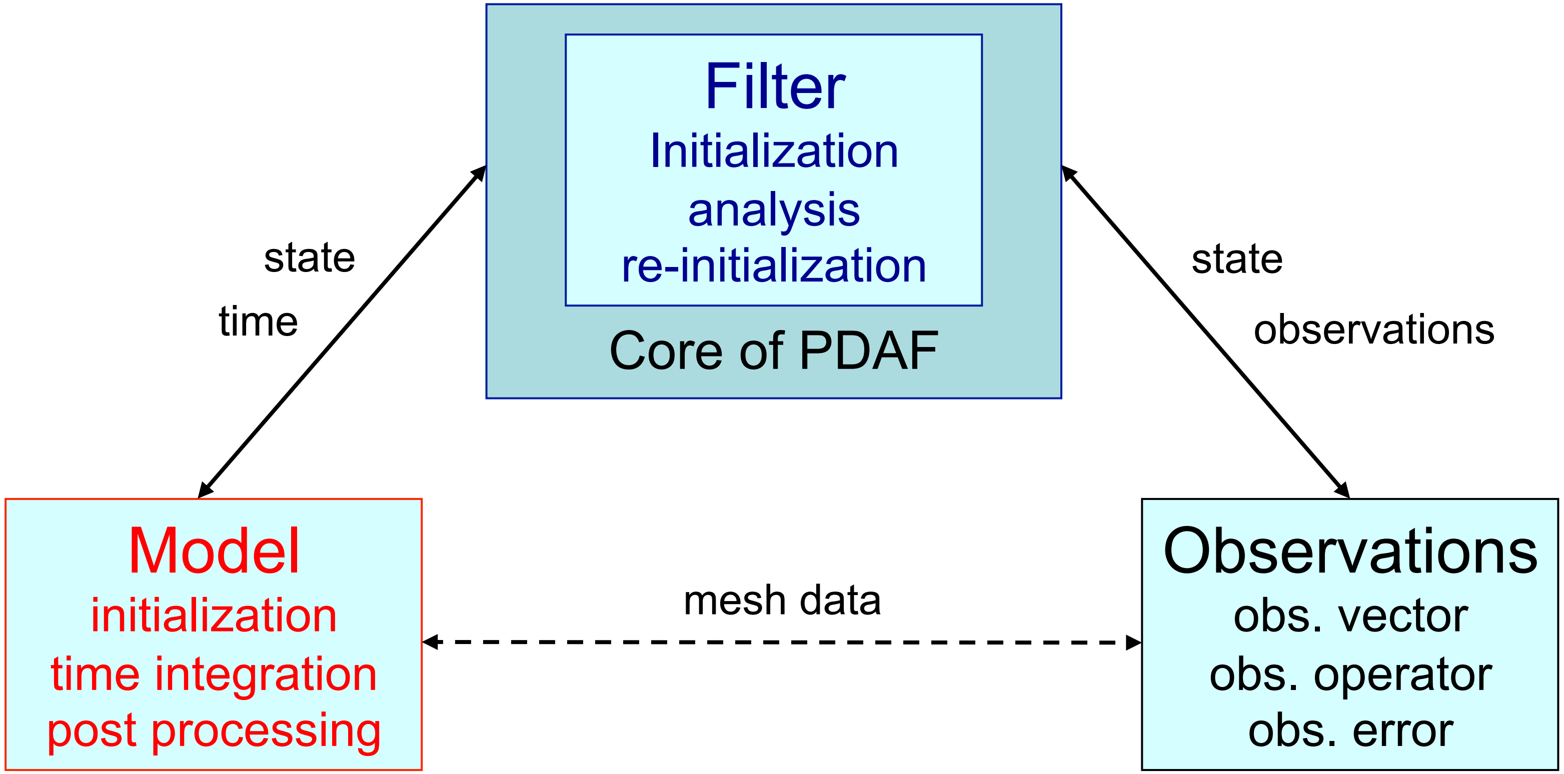
PDAF - Parallel Data Assimilation Framework

- a software to provide assimilation methods
- an environment for ensemble assimilation
- for testing algorithms and real applications
- useable with virtually any numerical model
- also:
  - apply identical methods to different models
  - test influence of different observations
- makes good use of supercomputers
  (Fortran and MPI; tested on up to 4800 processors)

More information and source code available at

http://pdaf.awi.de

Logical separation of assimilation system



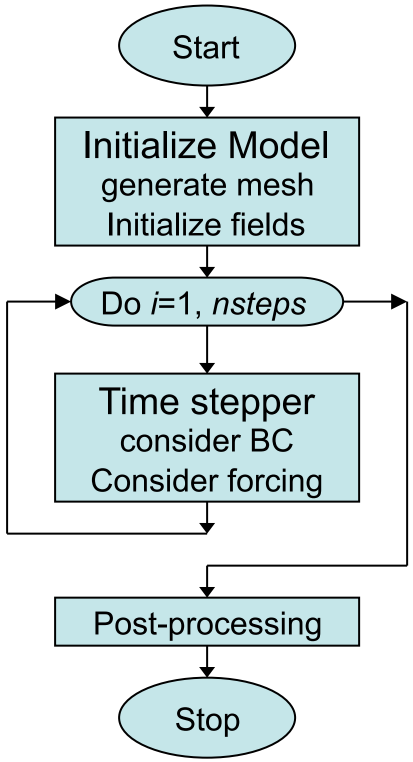
For online implementation:

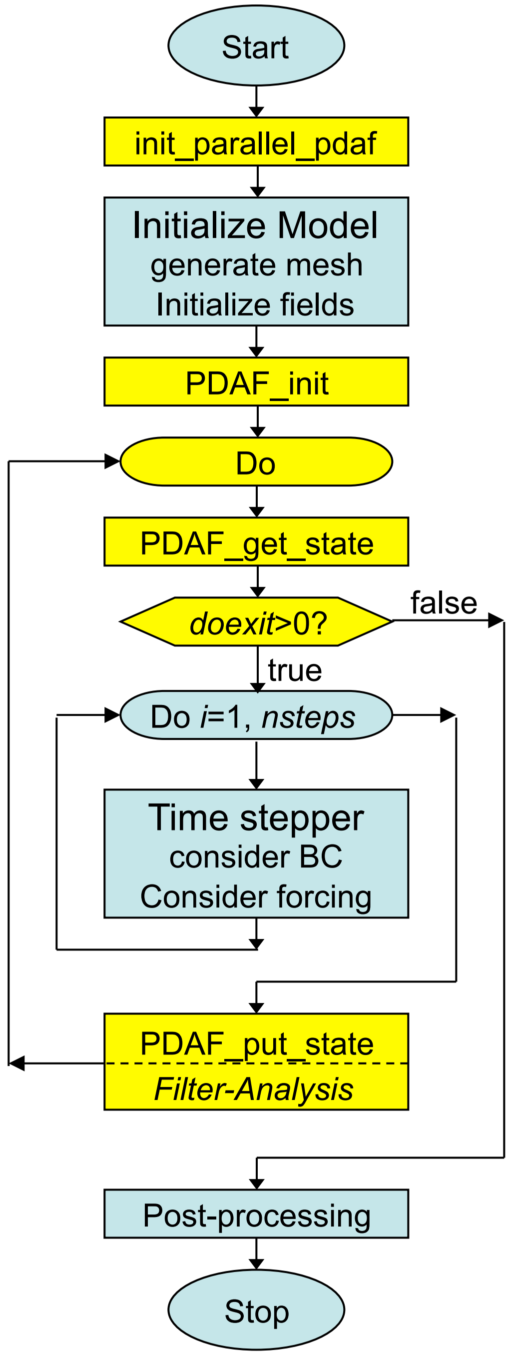
⟷ Explicit interface

⟵ - - - ⟶ Indirect exchange (Fortran: module/common)

Nerger, L., Hiller, W. (2012). Software for Ensemble-based DA Systems – Implementation and Scalability. Computers and Geosciences. In press. doi:10.1016/j.cageo.2012.03.026

Model





Extension for data assimilation

External Do-loop can be avoided – lower flexibility!

Building an assimilation system with PDAF

Don't adapt the model to the assimilation system

➜ Attach DA functionality to model

Very small changes to model code:

- Model time stepper not required to be subroutine
- Low abstraction level for optimal performance
- Elementary user-supplied routines
  (interfacing with model, observation handling)
- Model-sided configuration of assimilation system

➜ Run assimilation system like model with additional parameters

SANGOMA: Development of assimilation tools

- Tools are addition to assimilation frameworks (PDAF, OpenDA, OAK, SESAM, …)
- Past PDAF development focused on core part (framework & filter algorithms)
- In SANGOMA:
  - New filters for nonlinear assimilation
  - Addition of tools (collaborative development)

Diagnostics	Perturbations	Transformations	Utilities
Assess assimilation performance	Ensemble generation	e.g. for Gaussianity	e.g. for particular observations

More information
http://www.data-assimilation.net

and next talk by Jean-Marie Beckers

Ongoing and future work

- Switch to HBM (HIROMB-BOOS model)
- Switch to ESTKF filter (Nerger et al., MWR, 2012)
- Include coastal mesh (900m resolution)
- Include Ecosystem model ERGOM
- Assimilation of ecosystem data

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

Posters:
Losa et al. – board 26 – on in situ data assimilation
S. Siiriä et al. – board 27 – Baltic Sea operational data assimilation
Ehlert et al. – board 47 – Marine GMES Products for German Users

DeMarine

Summary

- Assimilation system of BSHcmod and PDAF for operational use
- Successful assimilation of satellite SST & in situ data
- Flexible assimilation framework PDAF
- New tools and assimilation methods expected in SANGOMA

Thank you!

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