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Towards to operational forecasting the North and Baltic Seas ecosystem dynamics

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F. Janssen and C. Brockmann

MyOcean Science Days, 22-24 September 2014

BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

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Outline

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- Introduction of the operational system for forecasting the hydrology of the North and Baltic Seas
- Coupling with biogeochemistry
- Data Assimilative module based on the Parallel Data Assimilation Framework, PDAF
- Example of a DA implementation
- Highlights of further DA development in order to improve forecasting the ecosystem dynamics

Operational BSH model

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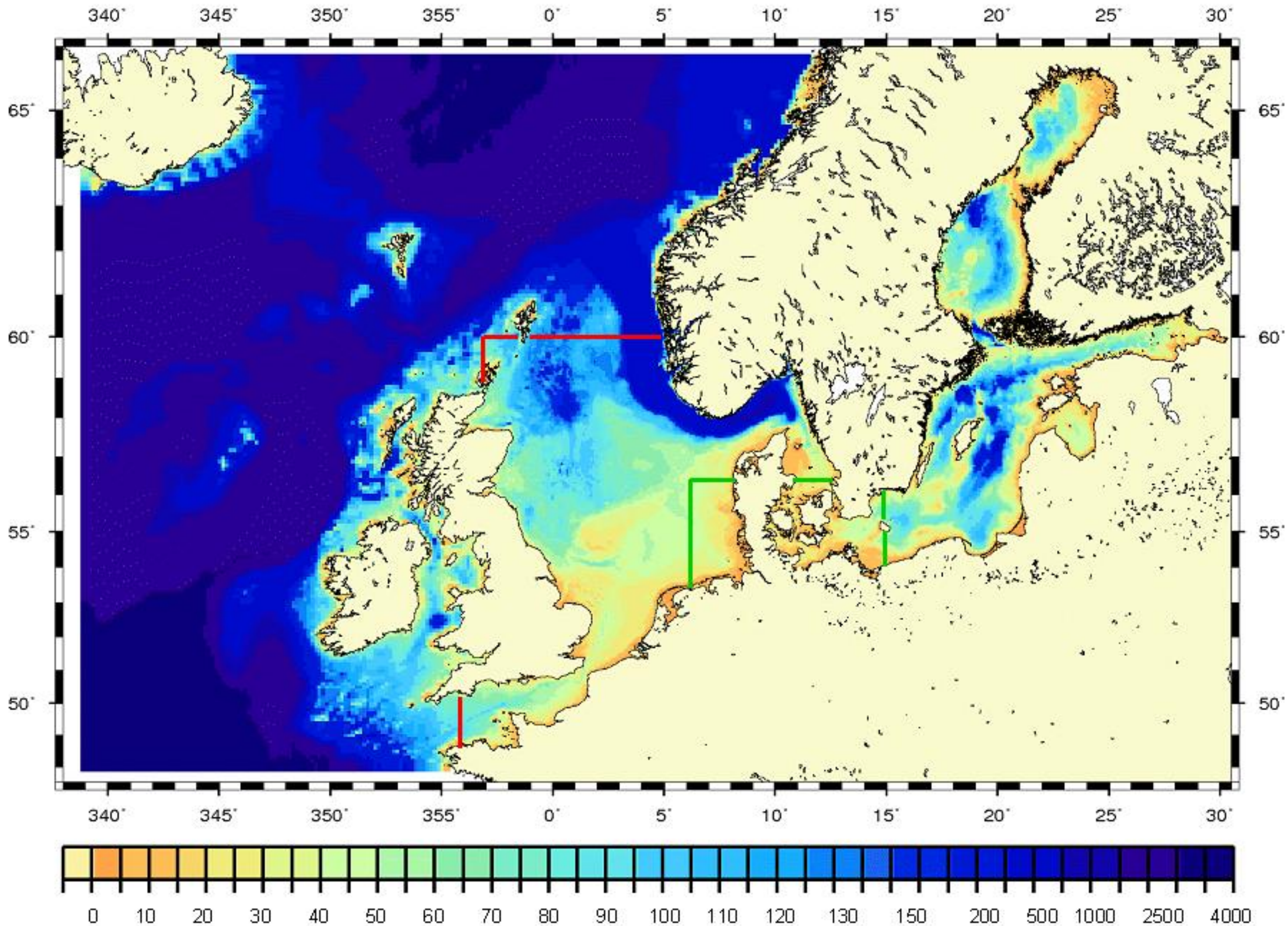

BSSC 2007, F. Janssen, S. Dick, E. Kleine

Grid nesting :

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

BSHcmod version 4 → HBM&ERGOM

ERGOM ecosystem model

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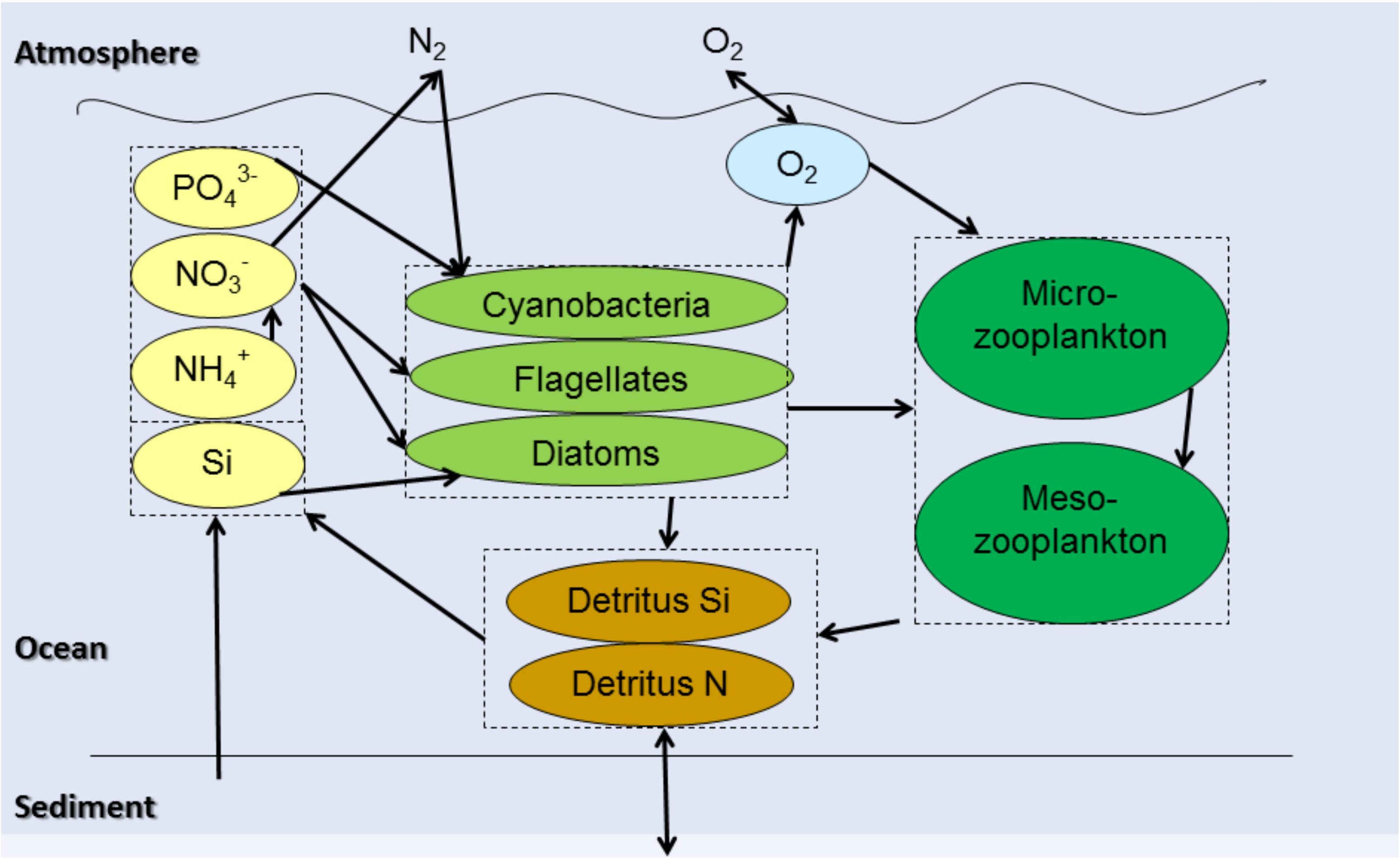


Modified after Maar et al. 2011

PDAF: A tool for data assimilation

PDAF - Parallel Data Assimilation Framework

- an environment for ensemble assimilation
- provide support for ensemble forecasts
- provide fully-implemented filter algorithms
- for testing algorithms and for real applications
- easily useable with virtually any numerical model
- makes good use of supercomputers

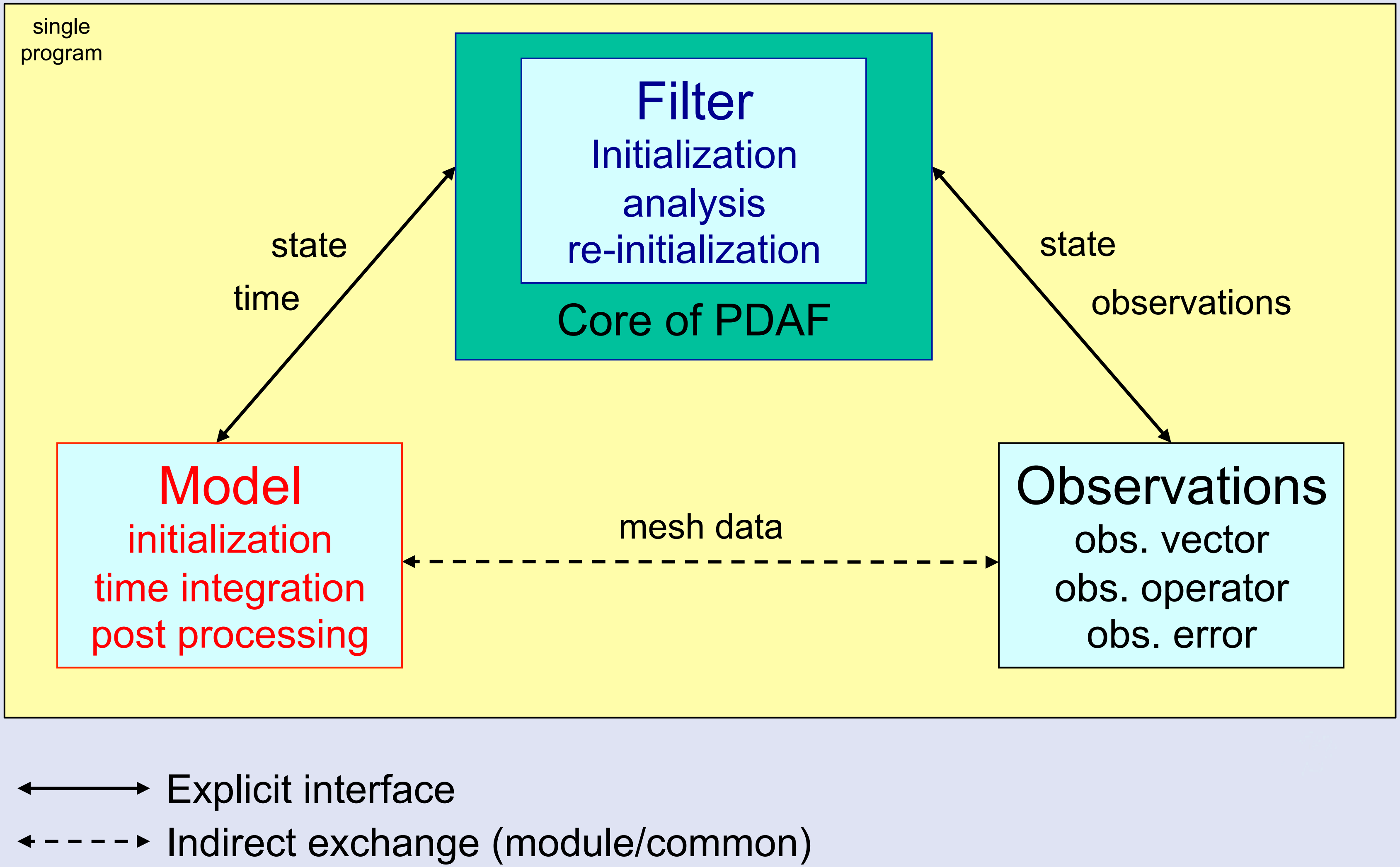
Open source:
Code and documentation available at

http://pdaf.awi.de

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

Logical separation of assimilation system

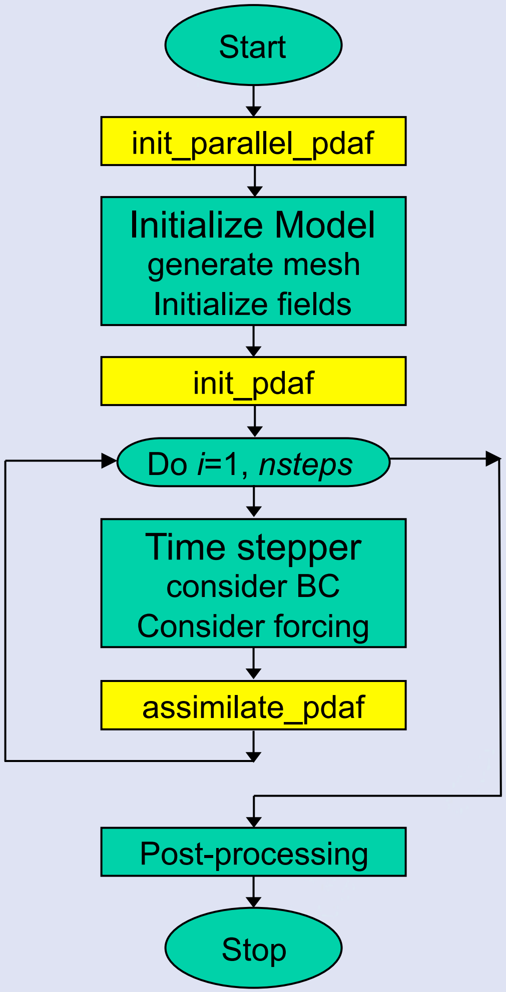
PDAF Parallel Data Assimilation Framework



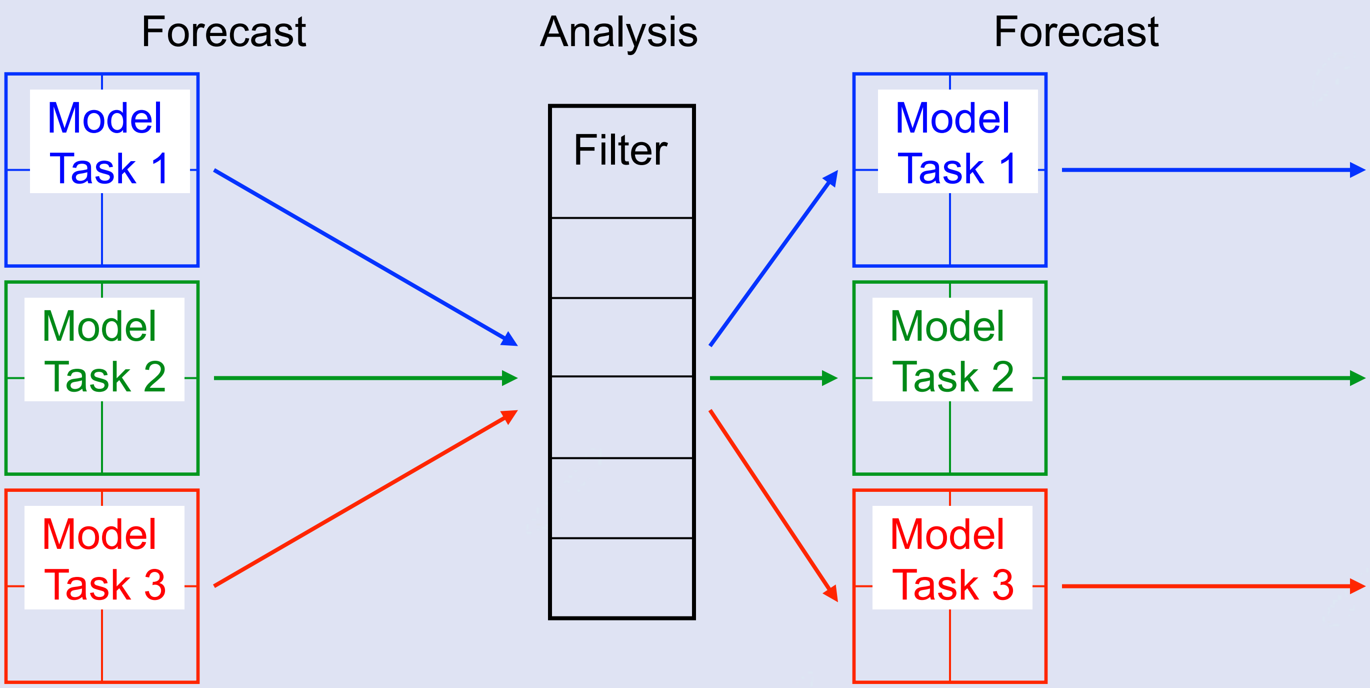
Nerger, L., Hiller, W. (2013). Software for Ensemble-based DA Systems – Implementation and Scalability. Computers and Geosciences. 55: 110-118

Features of the assimilation program

- minimal changes to model code when combining model with filter algorithm
- model not required to be a subroutine
- no change to model numerics!
- model-sided control of assimilation program (user-supplied routines in model context)
- observation handling in model-context
- filter method encapsulated in subroutine
- complete parallelism in model, filter, and ensemble integrations
- Used this implementation approach also for NEMO (poster by Nerger et al., no. *III.11*), FESOM, ADCIRC



2-level Parallelism



1. Multiple concurrent model tasks
2. Each model task can be parallelized

➢ Analysis step is also parallelized

Assessing real-time SST forecast, March 2011

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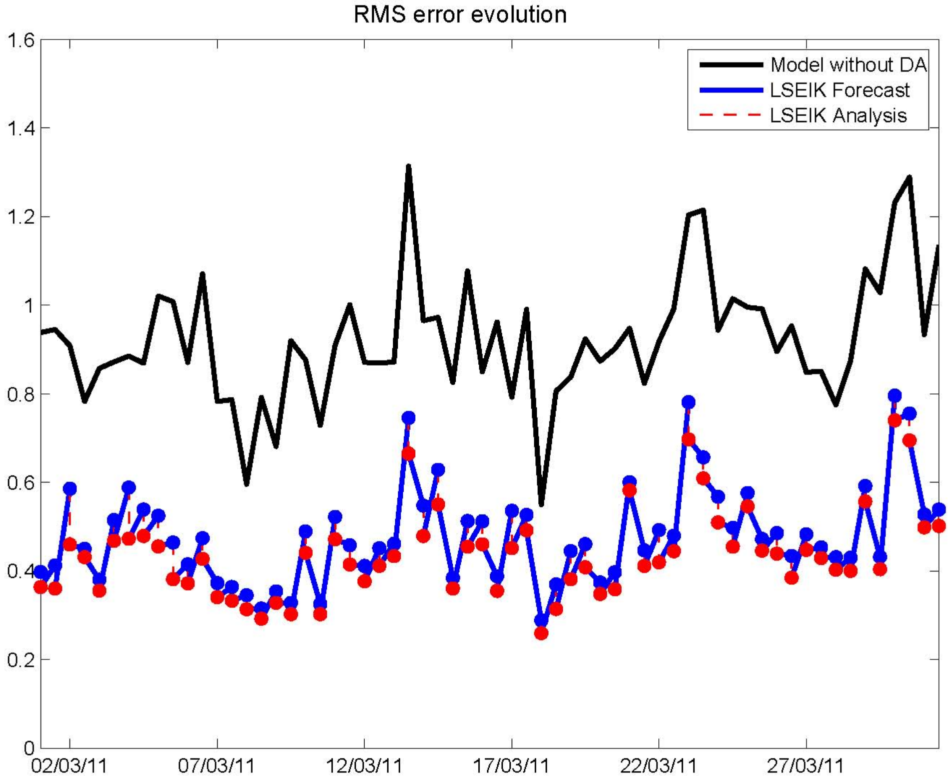
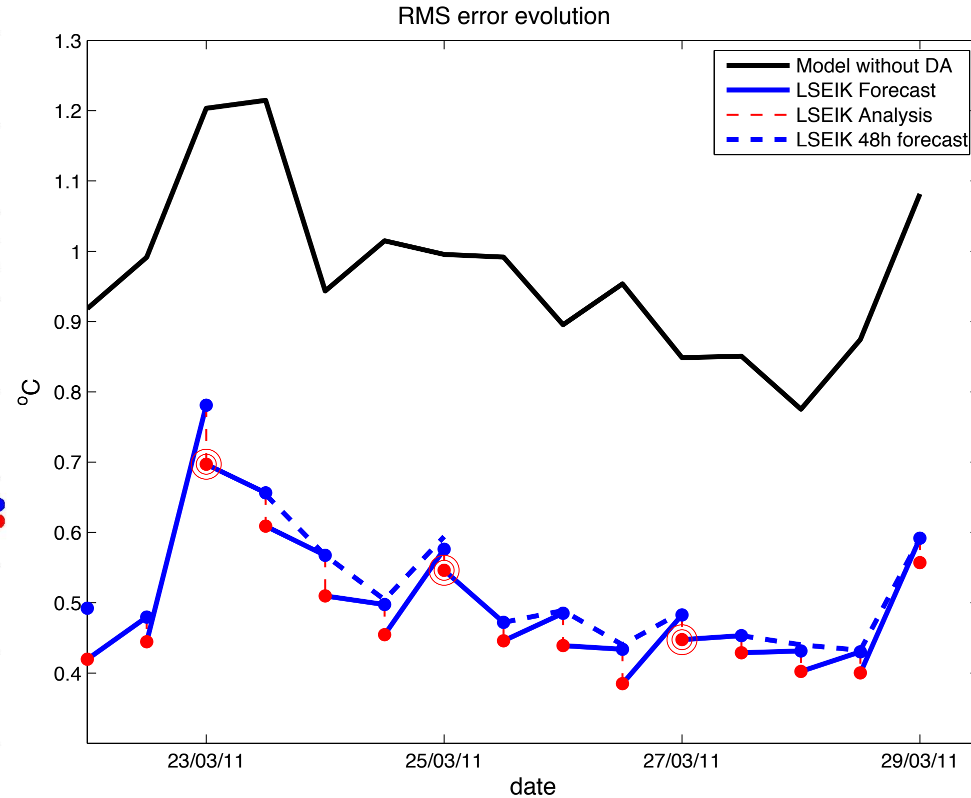
Ensemble based Singular Evolutive Interpolated Kalman filtering (SEIK, Pham, 1998)





37% of the error reduction

Good quality of 48 hours forecast

Losa et al., 2012, Losa et al. 2014

CTD, MARNET and Scanfish Data Assimilation

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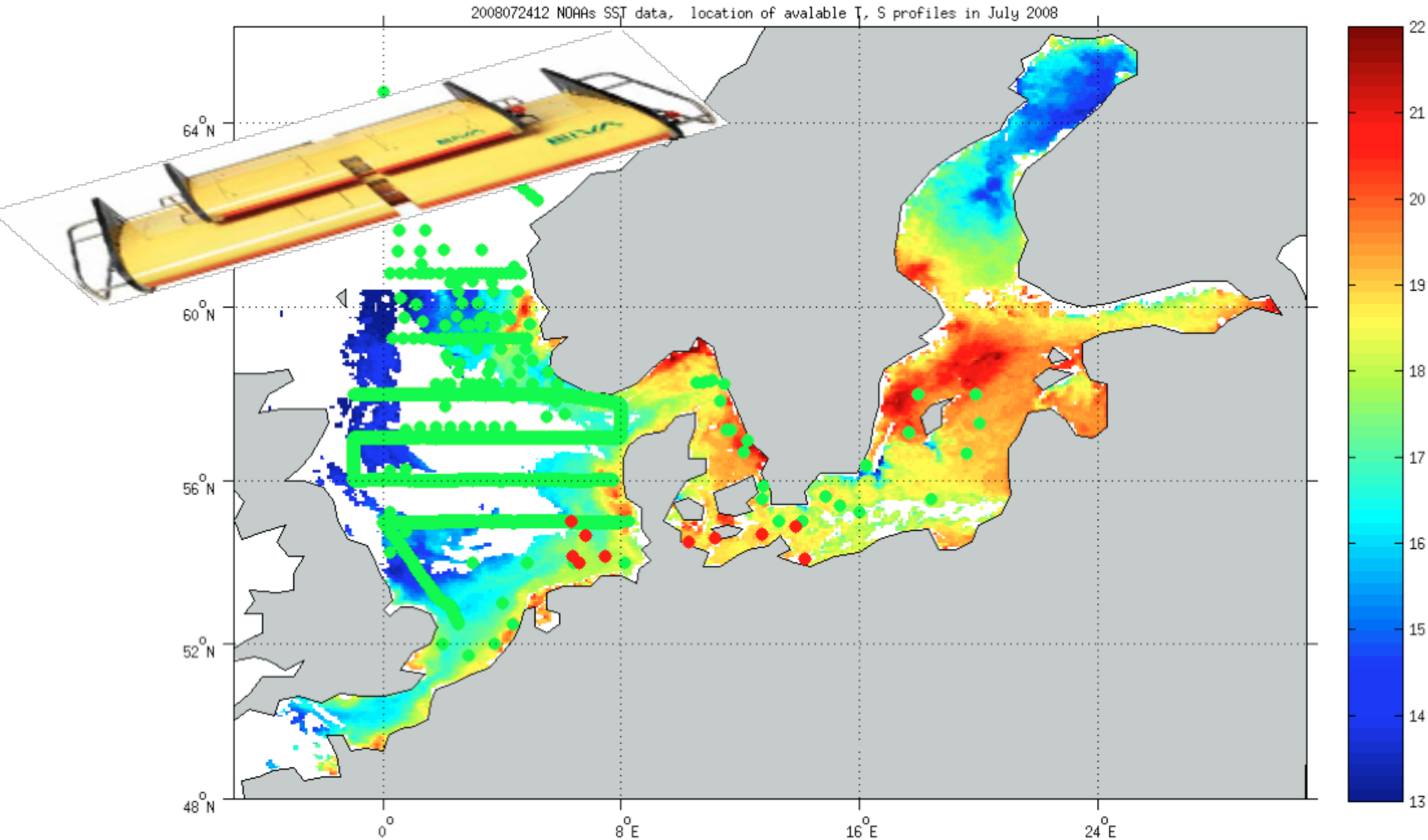

Localisation radius based on the E_{brcl}/E_{brtr}

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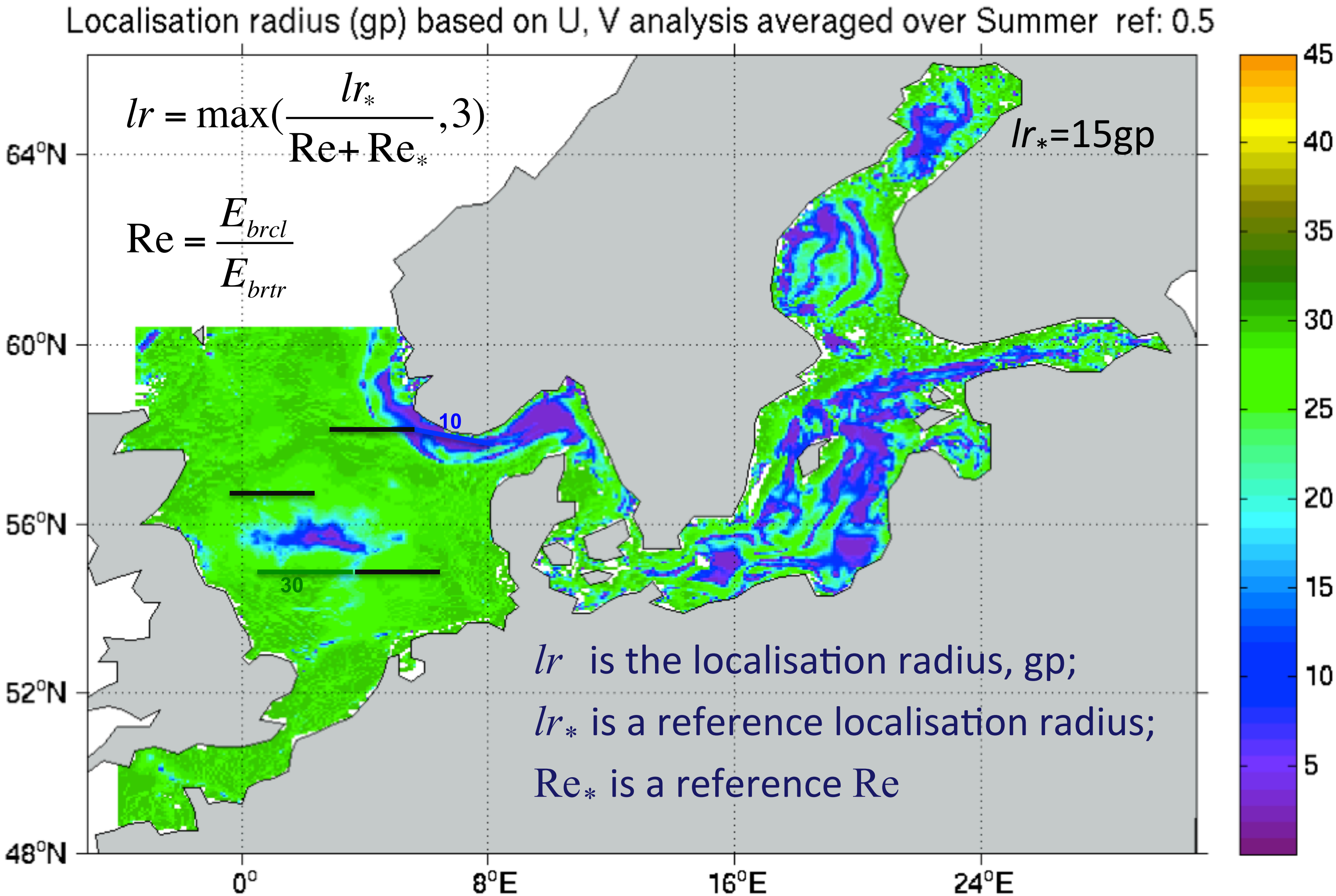

$$lr = \max\left(\frac{lr_*}{Re + Re_*}, 3\right)$$

$$Re = \frac{E_{brcl}}{E_{brtr}}$$

lr is the localisation radius, gp;

lr_* is a reference localisation radius;

Re_* is a reference Re

Forecast validation with Scanfish data

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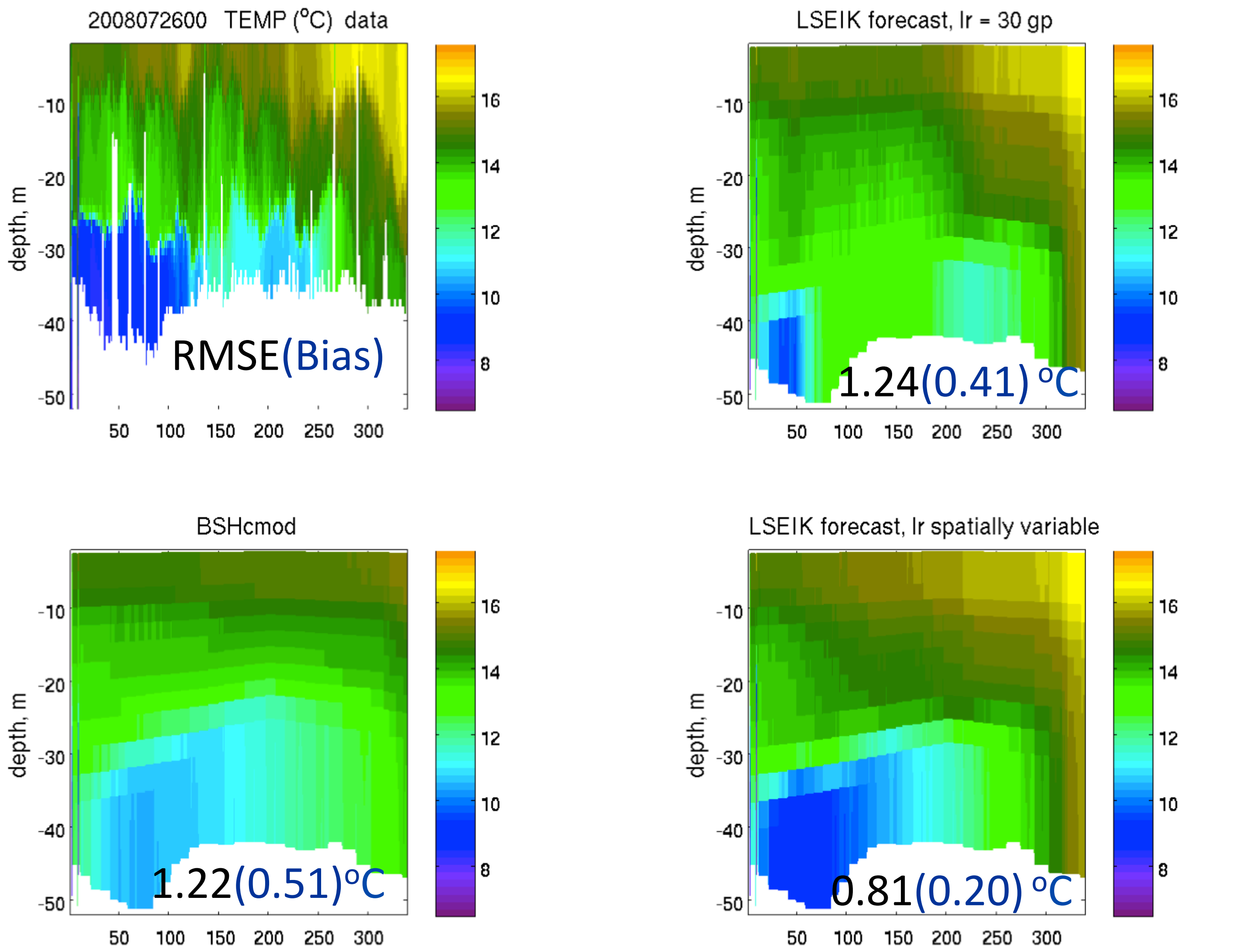
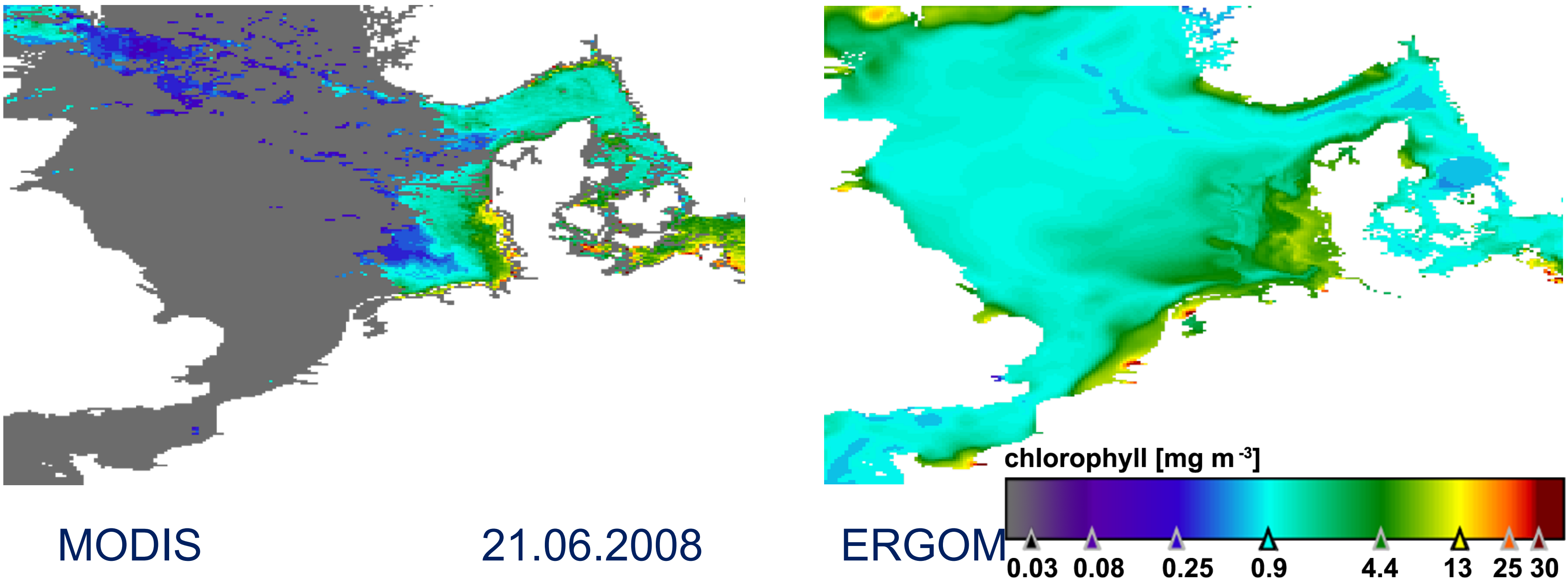


Satellite vs model Chlorophyll a



- Chlorophyll is not a prognostic model variable
- Converting from phytoplankton biomass (assumed constant or variable stoichiometry)
- A need of evaluation both model and satellite derived information with independent observations

ERGOM validation

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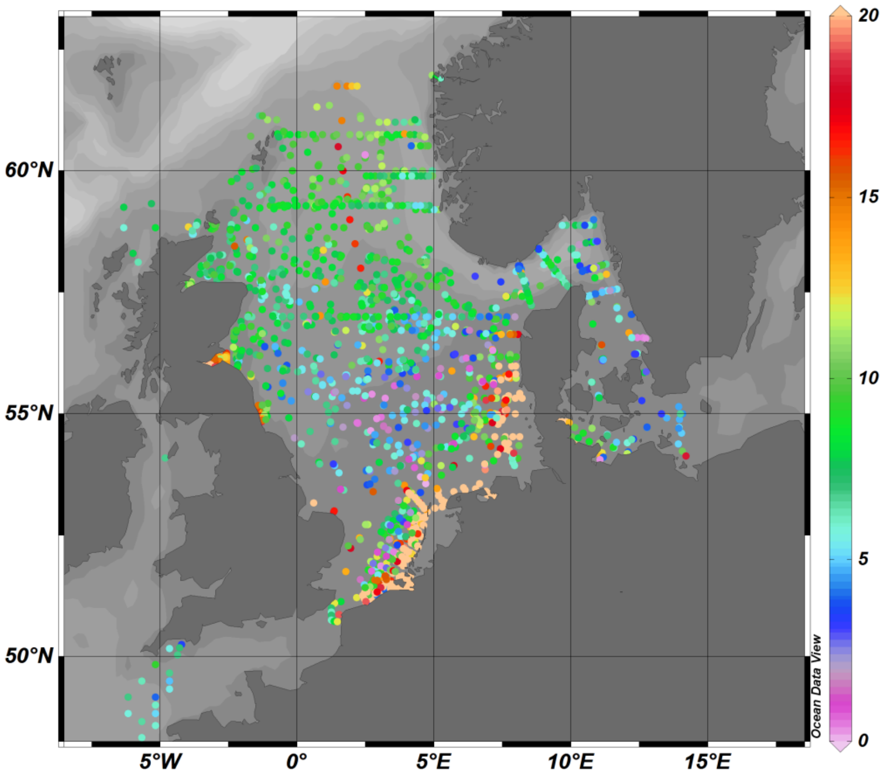
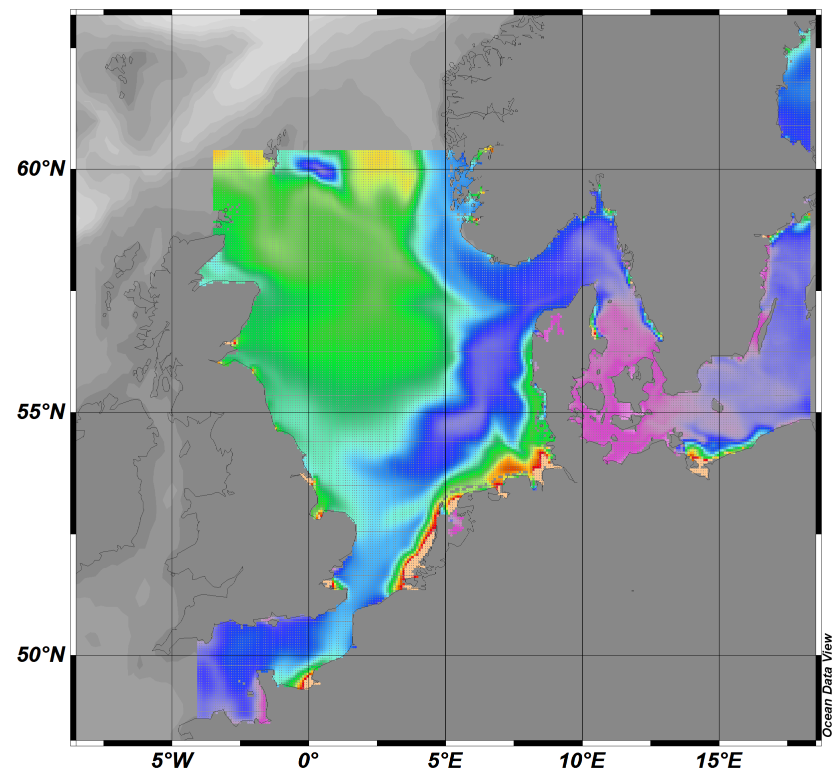
Nitrate, mmol N/m³ in February

NOWESP Data (thanks to J. Pätsch, IFM UHH)



Modell



Parameter Sensitivity Study

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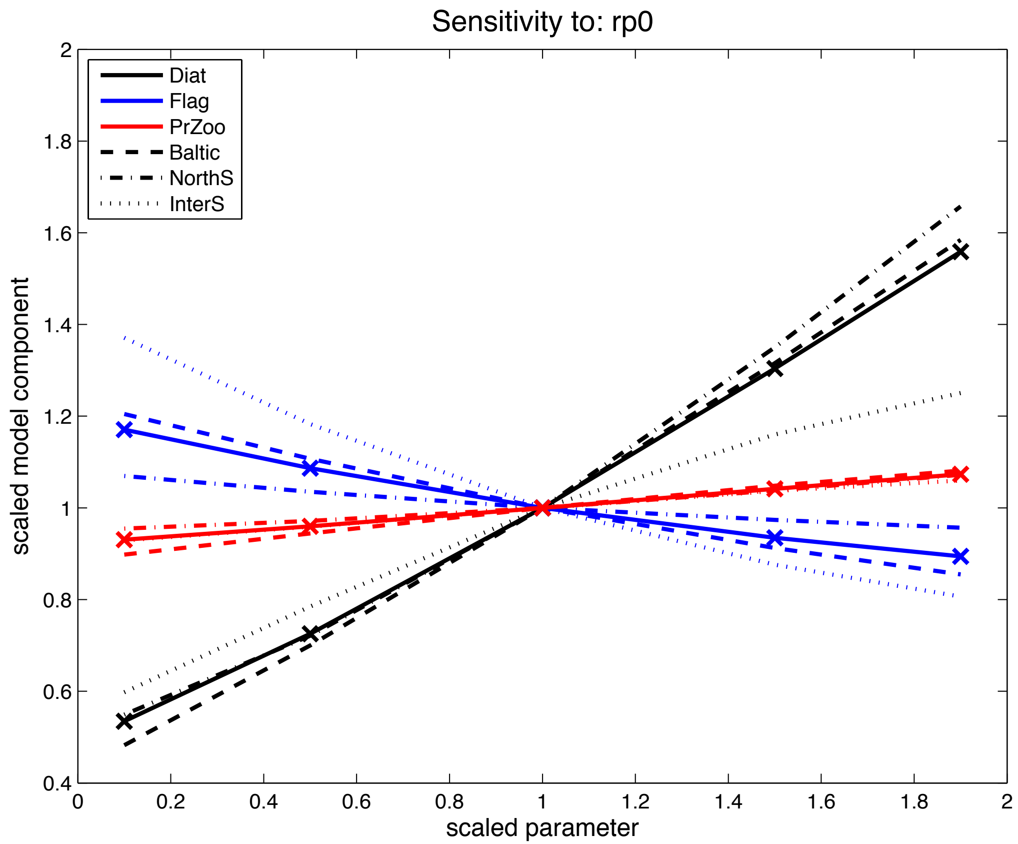
Assessment of model sensitivity to variation of 20 parameters of the ecosystem model

Example: rp0 (maximum uptake rate at T_0 for diatoms)



Parameter Sensitivity Study

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After examination of 20 parameters:

The most crucial for the ecosystem dynamics are

1. Diatom and Flagellates half-saturation constants
2. Diatom and Flagellates maximum uptake rate at T_0
3. Microzooplankton grazing constant
4. Loss rate of primary production to detritus

These parameters will be optimised in the following work package

To design biogeochemical data assimilation

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(as an extension of the developed data assimilative forecasting system validated with satellite SST and in situ T&S observations)

We consider

- Identification of crucial ecosystem parameters;
- Evaluation of the assumed stoichiometry and satellite data product with independent observations;

- Testing the SEIK filtering with a scaling of biogeochemical variables;
- Spatially variable localization radius (optional);
- Estimation of probability density function of model parameters with SIR filtering implemented within PDAF.

Further algorithmic developments

PDAF Parallel Data Assimilation Framework

- EU project SANGOMA
(Stochastic Assimilation for the next generation ocean model applications)

- Develop
  - common software tools
  (e.g. for ensemble generation, performance scores,…)
  - Ocean assimilation benchmarks
  - Assimilation methods for highly nonlinear systems

See Poster on SANGOMA tools by Nerger et al. (No. *III.10*)

SANGOMA

SEVENTH FRAMEWORK PROGRAMME

www.data-assimilation.net

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