Towards to operational forecasting the North and Baltic Seas ecosystem dynamics

S. Losa, L. Nerger, I. Lorkowski, C. Lebreton, F. Janssen and C. Brockmann

MyOcean Science Days, 22-24 September 2014
• 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

Grid nesting:
- 10 km grid
- 5 km grid
- 900 m grid

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

BSHcmod version 4 ➔ HBM&ERGOM
Modified after Maar et al. 2011
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

Logical separation of assimilation system

- Filter
  - Initialization
  - Analysis
  - Re-initialization

Core of PDAF

- Model
  - Initialization
  - Time integration
  - Post processing

- Observations
  - Obs. vector
  - Obs. operator
  - Obs. error

- State
- Time
- Observations
- Mesh data

Explicit interface

Indirect exchange (module/common)

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
1. Multiple concurrent model tasks
2. Each model task can be parallelized
   ➢ Analysis step is also parallelized
Assessing real-time SST forecast, March 2011

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

Localisation radius (gp) based on U, V analysis averaged over Summer ref: 0.5

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

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

$lr_*$ is a reference localisation radius;
$Re_*$ is a reference Re
Forecast validation with Scanfish data
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

Nitrate, mmol N/m³ in February

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

Modell
Parameter Sensitivity Study

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

Example: $r_{p0}$ (maximum uptake rate at $T_0$ for diatoms)
Parameter Sensitivity Study

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

(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

- 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)

www.data-assimilation.net