

**Validation aspects in the work of the OSPAR
Intersessional Correspondence Group
on Eutrophication Modelling
(ICG-EMO)**

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on behalf of David Mills (CEFAS)
and the ICG-EMO group*

Contents

- The group and its aims
- The tools
- Validation against usual measurements
- Validation against satellite data
- Cross-validation between models

The group

Organising committee

Dave Mills (Chair) – Cefas, UK

Hermann-Josef Lenhart (Co-Chair) - IfM, Germany

Hanneke Baretta-Bekker (Co-Chair) - RIKZ, Netherlands

Participants

Norway, the Netherlands, Germany, UK, Belgium, France, Portugal

The meetings

1996: Den Haag (RIKZ) ASMO workshop

2005: Hamburg (IfM)

2007: Lowestoft (CEFAS)

2009: Brussels (MUMM)



Reduction scenarios
of nutrient loadings

Transboundary effects of nutrient loadings

The goals

The aim is to compare the results of a number of North Sea ecosystem models :

- 1/ under different reduction scenarios
- 2/ for transboundary biogeochemical fluxes

In order to achieve comparability of model results, the participants are requested to use a minimum spin-up time and a set of common forcing data, with special emphasis on a complete coverage of river nutrient loads.

For the reduction scenarios only, the models are requested to use common boundary conditions, which are derived from a wider domain model.

The tools (physics)

Six 3D eco-hydrodynamical models

Model name	MIRO&CO-3D	ECO-MARS3D	ECOHAM4	Delft3D-GEM	GETM-BFM	POLCOMS-ERSEM
Workshop Term	BE model	FR model	DE model	NL model	UK-Cefas model	UK-POL model
Name hydrodynamic model	COHERENS	MARS-3D	HAMSOM	Delft3D	GETM	POLCOMS
Name biogeochemical model	MIRO	ECO-MARS-3D	ECOHAM4	GEM	BFM	ERSEM
Open source	COHERENS: Yes MIRO: No	No	Yes	No	GETM: Yes BFM: Yes	No
Horizontal Resolution Δh (km)	5' longitude (5.6 km) x 2.5' latitude (4.6 km)	4 x 4 km	20 km	Variable - curvilinear grid (min. 1x1 km, max. 20x20km)	approx. 6 nautical miles	12
Vertical resolution	5 sigma layers	12 sigma levels	24 z-layers	10 sigma layers	25 layers, General Coordinates	32 s-levels
Longitude (degree)	4.0°W – 5.0°E	5.5°W – 5.0°E	15° W – 14° E	4°W -- 10°E	5.15 °W - 18 °E	20 °W -13 °E
Latitude (degree)	48.5°N – 52.5°N	47.85°N - 52.50°N	47,5° N – 64° N	49°N – 57°N	48.5 °N - 60 °N	40 °N - 65 °N
Time step Δt (sec)	900 sec	variable ~400 s	60s	Transport timestep (from D3D-FLOW) 30 min. Ecological processes timestep: 24 hrs	45 sec (stored daily)	15s (barotropic), 300s (baroclinic), 1200s (biochemical)
Oxygen dynamics	No	Yes	Yes	Yes	Yes	Yes
Temperature & Salinity diagnostic or prognostic	Weekly 20 km x 20 km gridded SST (BSH) imposed salinity prognostic	T and S prognostic	T: prognostic; S: diagnostic	T and S prognostic	T and S prognostic	T and S prognostic
SPM dynamics	Seasonal TSM from SeaWiFS climatology (1997-2003) imposed at the surface / bi-monthly	SiAM3D model and satellite forcing (SeaWiFS, monthly averages)	climatology	Weekly varying, based on monthly SeaWiFS composites	local resuspension by waves	IOP assimilation
Inclusion of tides	Yes	Yes	No	Yes	Yes	Yes

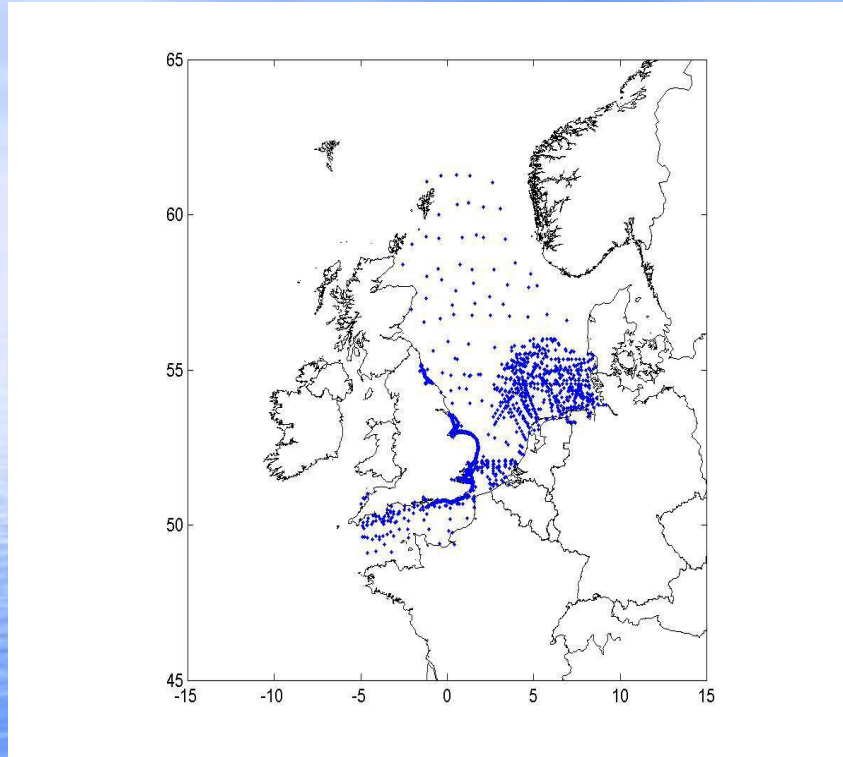
The tools (biology)

Six 3D eco-hydrodynamical models

Model name	MIRO&CO-3D	ECO-MARS3D	ECOHAM4	Def3D-GEM	GETM-BFM	POLCOMS-ERSEM
Workshop Term	BE model	FR model	DE model	NL model	UK-Cefas model	UK-POL model
Pelagic Part						
Pelagic matter cycle	C, N, P, Si	N, P, Si, O	C, N, P, Si, O	C organic part only, N, P, Si complete, O	C, N, P, Si, O	C, N, P, Si, O
No. of pelagic state variables	32	19	24	23	45	51
Pelagic Nutrients (bulk or explicit)	Explicit	Explicit	Explicit	Explicit	Explicit	Explicit
Types of Phytoplankton	Nanoflagellates (3), diatoms (3), <i>Phaeocystis</i> (4)	Diatoms, dinoflagellates, small phytoplankton, <i>Karenia mikimotoi</i> , <i>Phaeocystis globosa</i> (4)	Diatoms and flagellates	12 Functional groups: diatoms (3), microflagellates (3), dinoflagellates (3), <i>Phaeocystis</i> (3)	Diatoms, pico, flagellates, dinoflagellates	Diatoms, pico, flagellates, dinoflagellates
Types of Zooplankton	Micro- and mesozooplankton	Micro- and mesozooplankton	Micro- and mesozooplankton	0	Micro- and mesozooplankton heterotrophic nanoflagellates	Micro- and mesozooplankton heterotrophic nanoflagellates
Types of bacteria	Heterotrophic bacteria	None	Heterotrophic bacteria	None	Heterotrophic bacteria	Heterotrophic bacteria
Pelagic POM	Particulate organic C, N & P of high (1) and low (2) biodegradability, Biogenic Silica	Yes	Slow (C, N, P) and fast sinking detritus (C, N, P, Si, CaCO ₃)	None	Particulate organic C, N & P of high and low biodegradability, Biogenic Silica	Yes
Benthic Part						
Benthic matter cycle	C, N, P, Si	N, P, Si, O	C, N, P, Si, CaCO ₃	C, N, P, Si	C, N, P, Si	C, N, P, Si
No. of benthic state variables	6	10	5	4	53 (in 3 layers)	44
Benthic Nutrients (bulk or explicit)	Diagenetic model (NO ₃ , NH ₄ , PO ₄) First-order kinetics dissolution for biogenic Si	Explicit	Bulk	Explicit	Diagenetic model (NO ₃ , NH ₄ , PO ₄ , SiO ₂)	Explicit

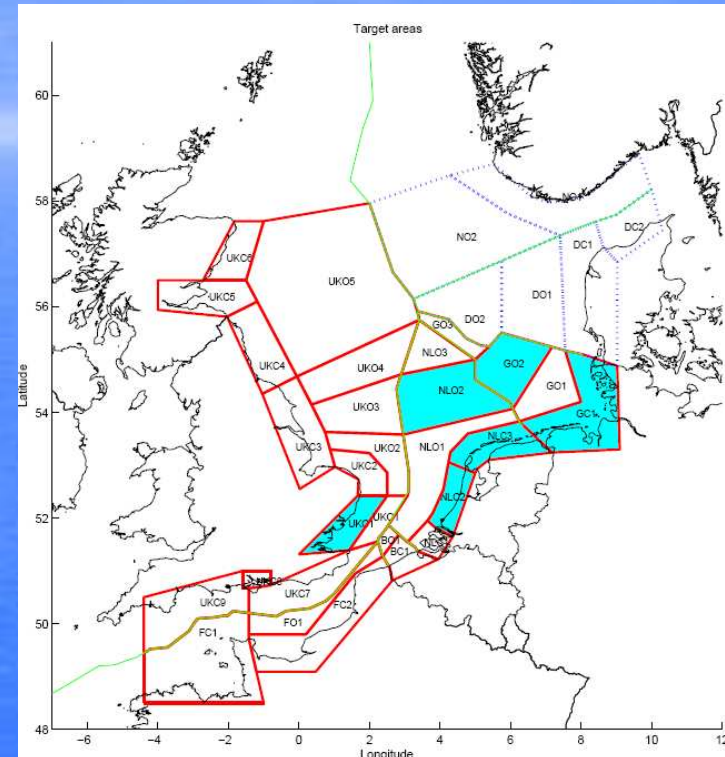
Validation against measurements at sea

The data



Data base :

Spatial distribution of sampling locations from which 2002 data for validation were generated

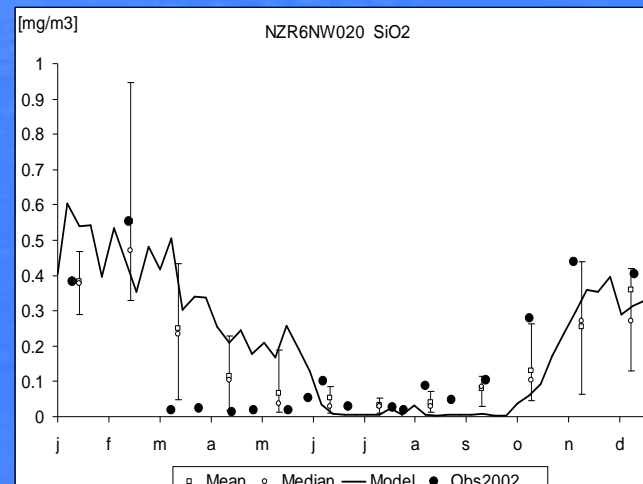
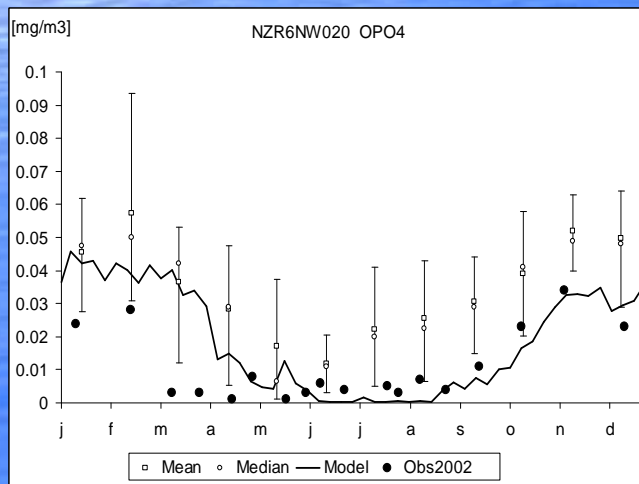
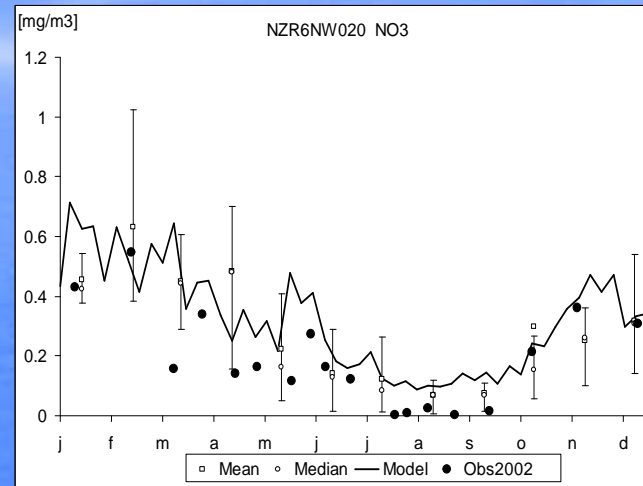
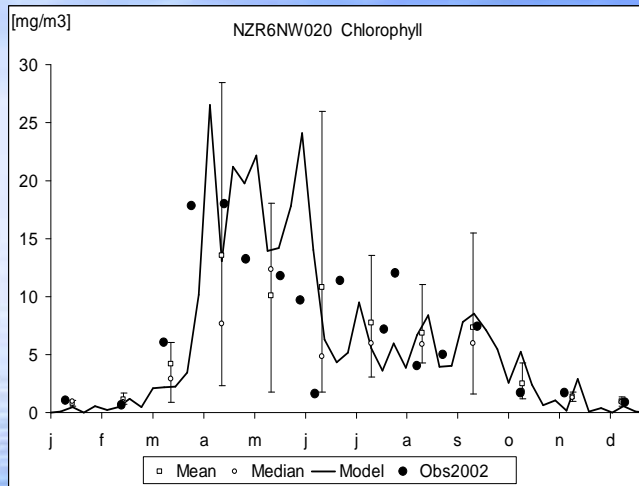


Target areas

For each target area and each variable, monthly means are computed for the surface (data from 0 - 15 m layer), and the bottom (the deeper samples)

Validation against measurements at sea

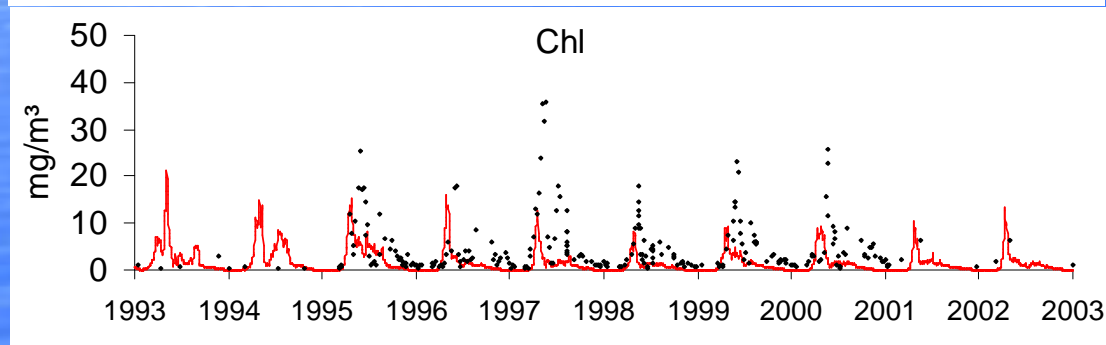
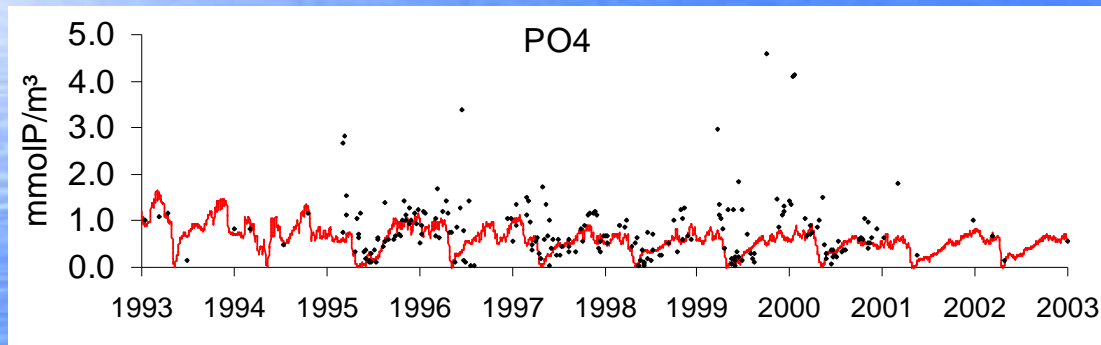
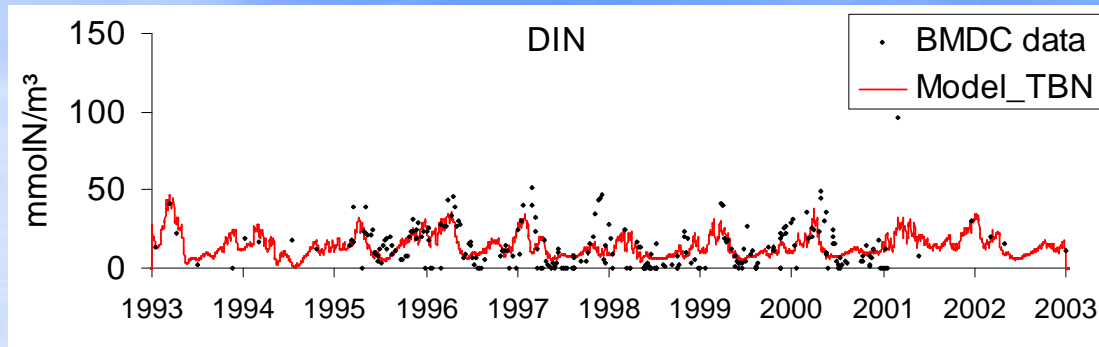
Visual comparison for one year at a station



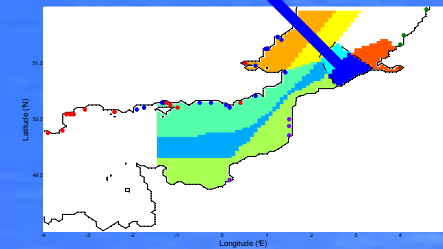
Example of year 2002
for DELTARES model
in Dutch coastal zone

Validation against measurements at sea

Visual comparison for several years at a station

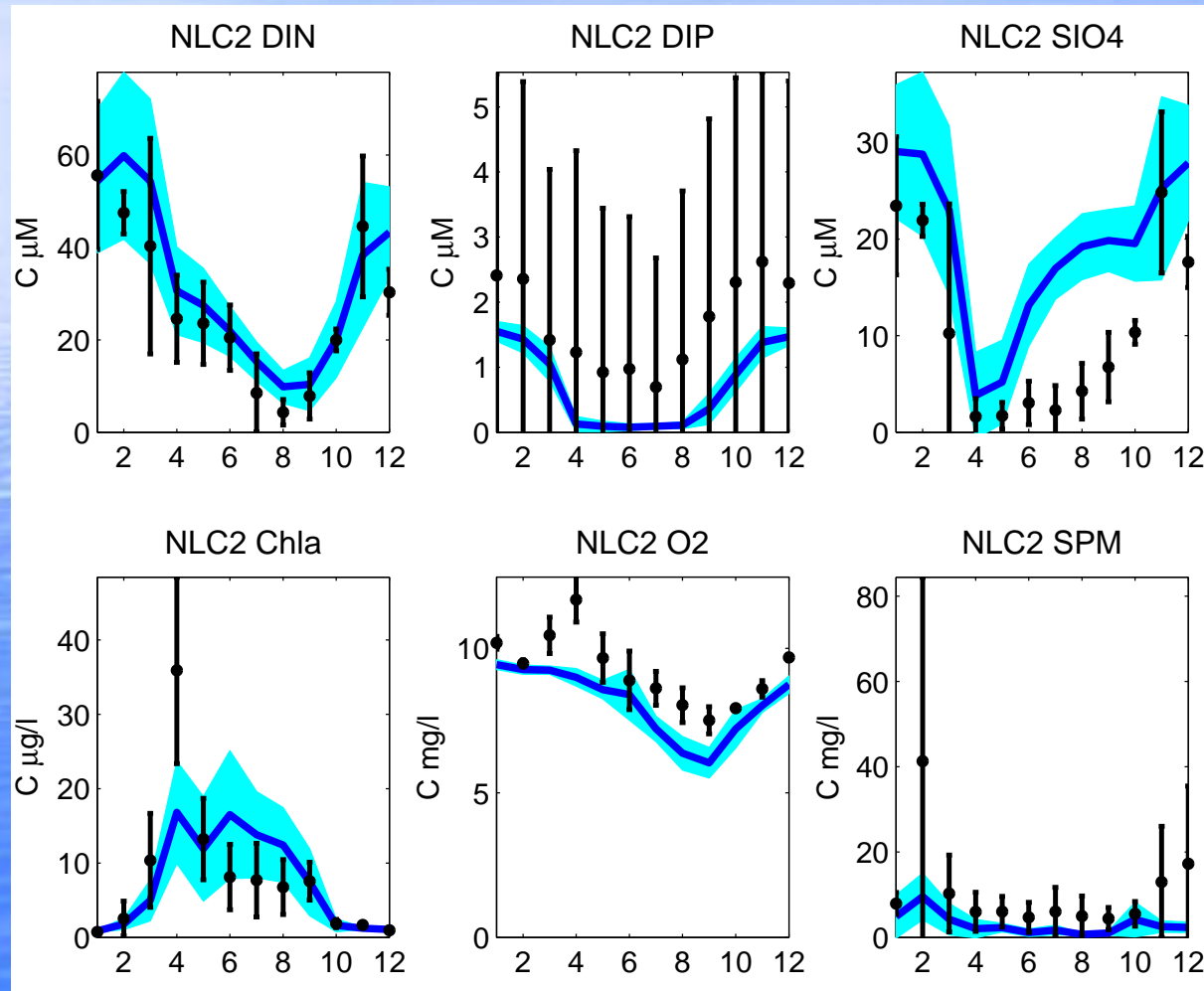


Example of decade 1993-2003
for MUMM model
in Belgian coastal zone

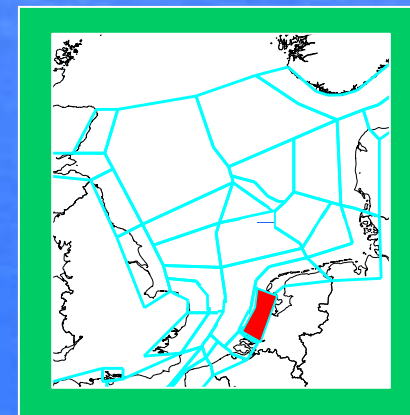


Validation against measurements at sea

Visual comparison in a target area

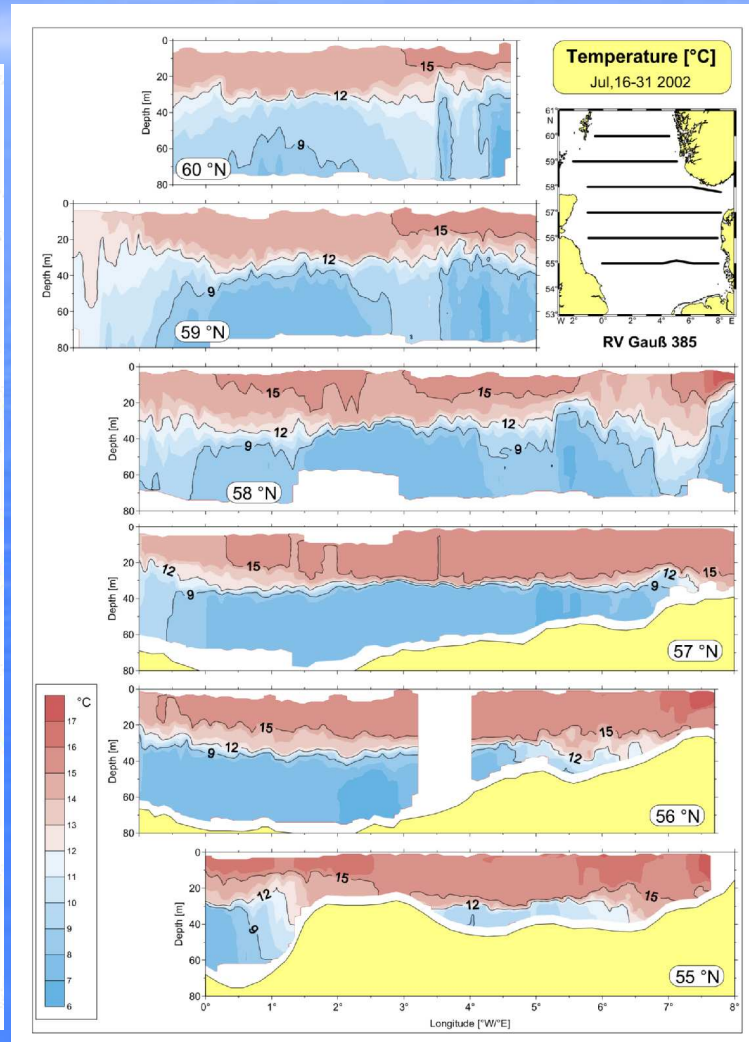
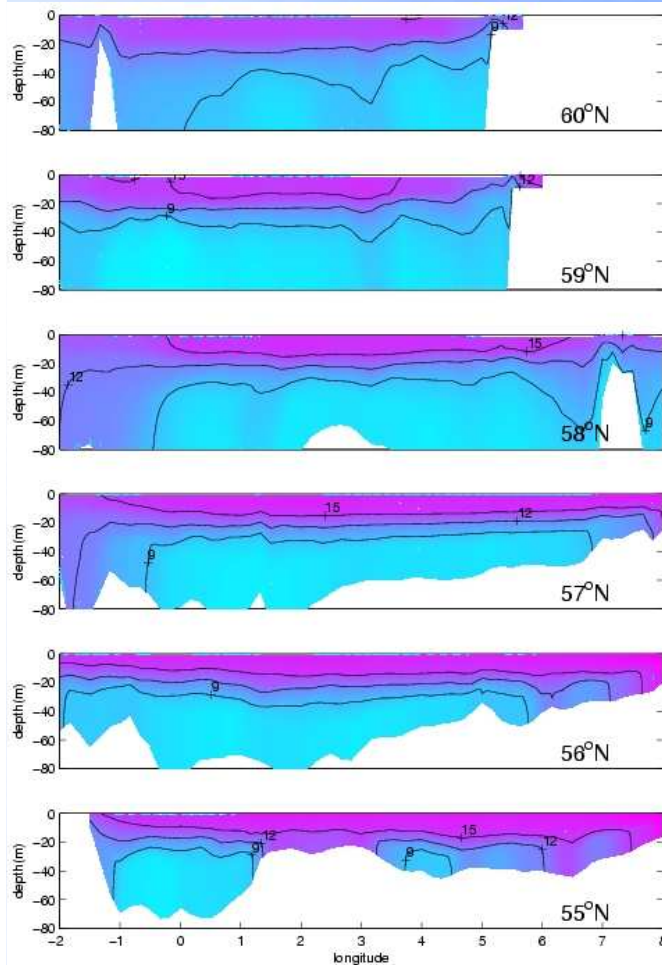


Example of year 2002
for CEFAS model in
Dutch coastal zone



Validation against measurements at sea

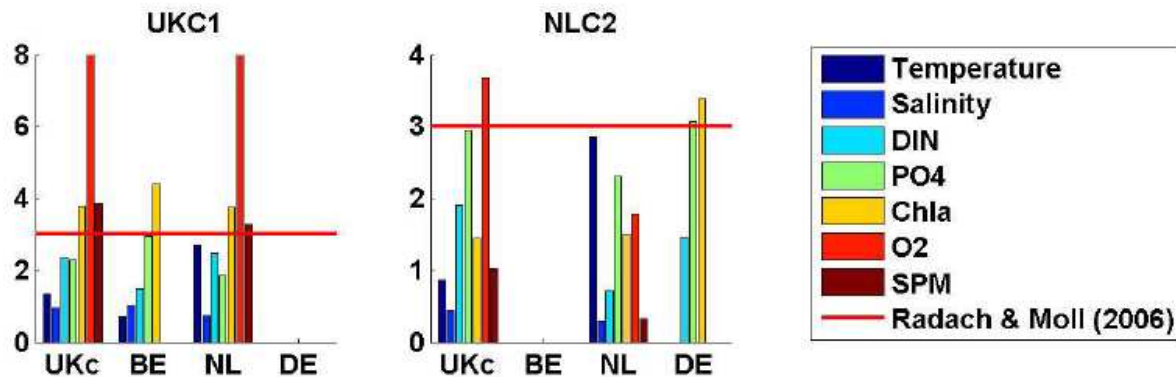
Visual comparison along cross-sections



Example of year 2002
for POL model in
the North Sea

Validation against measurements at sea

Use of a cost function



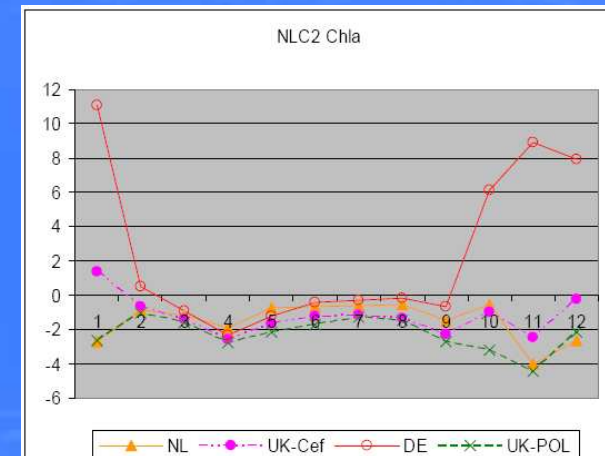
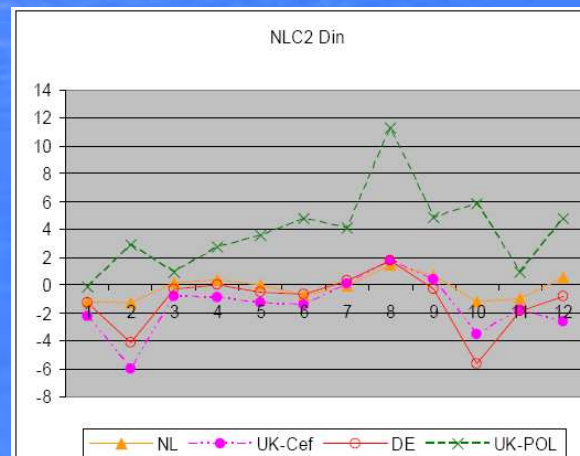
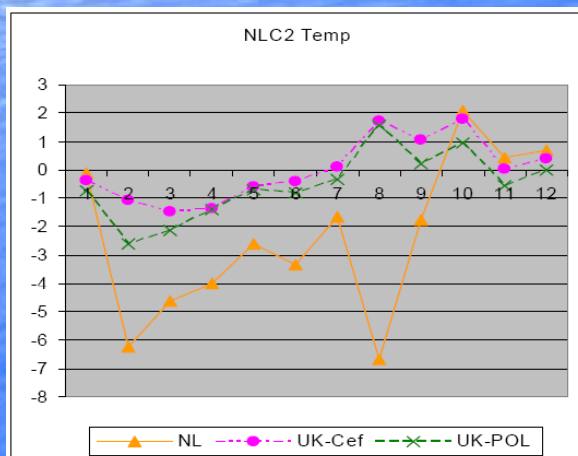
Annual mean

**OSPAR cost function :
normalized mean absolute error**

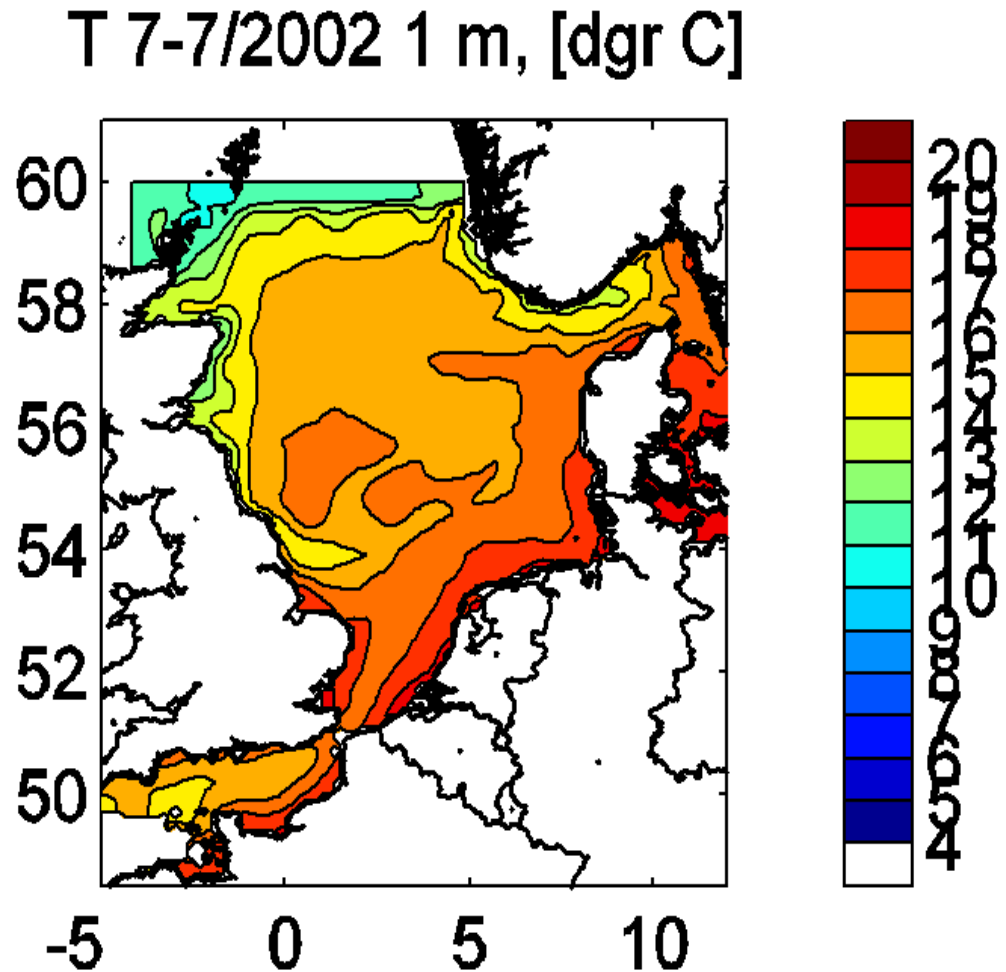
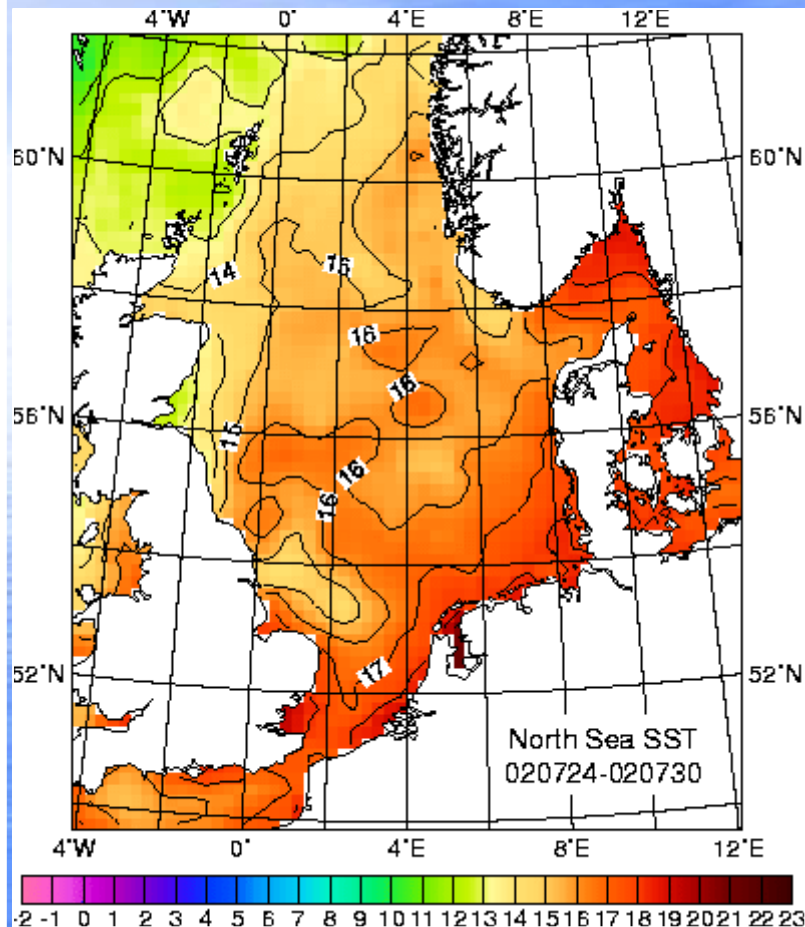
$$\frac{\| \text{Model mean}_{x,t} - \text{Data mean}_{x,t} \|}{\text{Data sd}_{x,t}}$$

Data $\text{sd}_{x,t}$

Monthly means

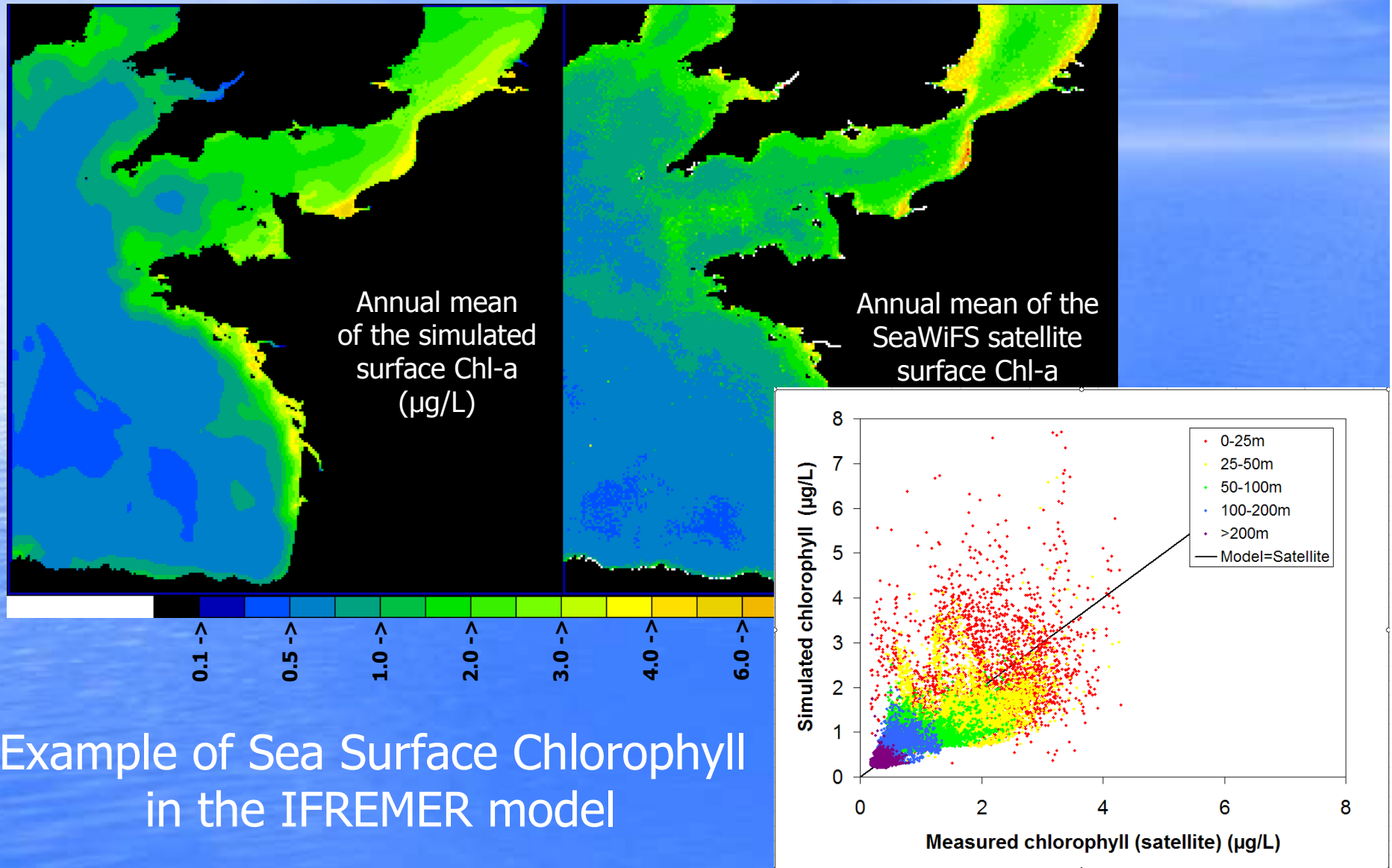


Validation against satellite measurements



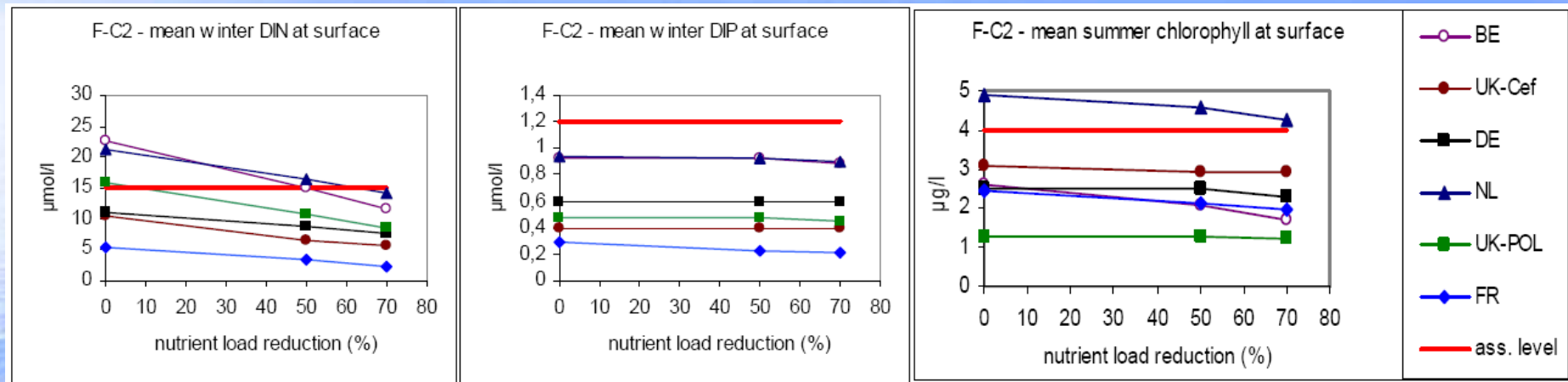
Example of Sea Surface Temperature in the CEFAS model

Validation against satellite measurements



Example of Sea Surface Chlorophyll
in the IFREMER model

Cross-validation between models



Example of impact of nutrient reduction
in the French coastal area of the eastern Channel

CONCLUSIONS

THE VALIDATION PROCEDURE FOR ECOSYSTEM MODELS

- Needs a huge data bank for several variables
- Some state variables have been rarely measured (detrital organic forms, zooplankton)
- Sparse sampling is inadequate for bursting variables
(sudden chlorophyll blooms, sharp bottom oxygen decrease)
- Needs a combined cost function, taking into account the main biogeochemical variables

SOME REMAINING QUESTIONS

- How to compare space/time domains instead of point results?
- What is the impact of open boundary conditions ? von Neumann vs Dirichlet ?
- What is the spin-up duration with sediment layers and benthos variables ?
- How to quickly infer a model modification from a measured discrepancy with data ?