Operational forecasting of the Black sea: merging model simulations and satellite products

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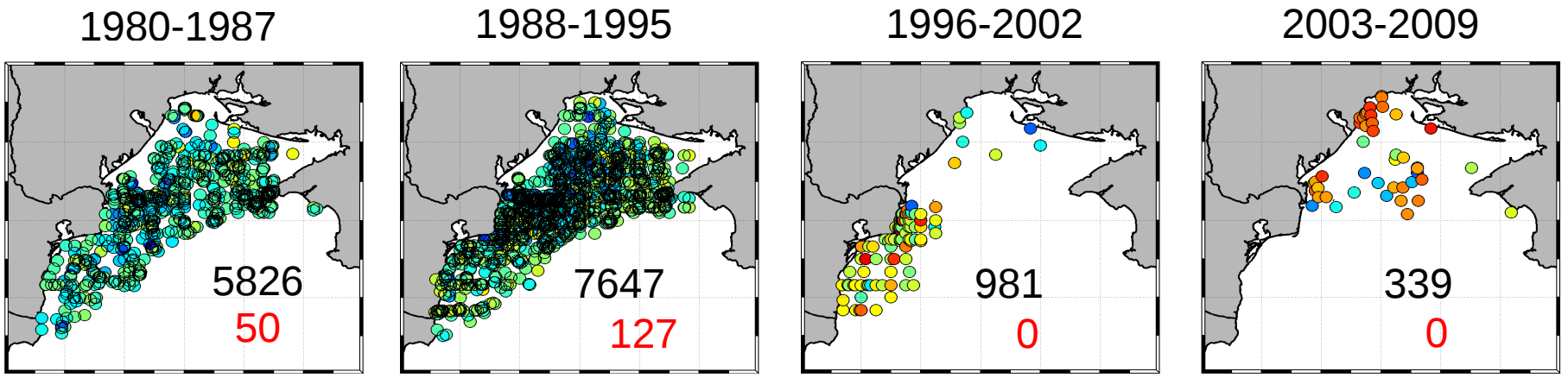
Modelling for
Aquatic SysTems

Outline

- BAMHBI biogeochemical model
- oxygen and hypoxic events
- chlorophyll data and difficulty of model validation
- CMEMS / BS-MFC reanalysis and real-time forecasts

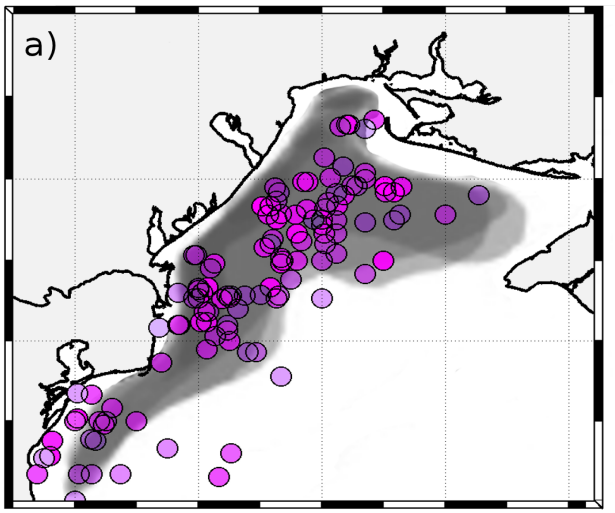
BAMHBI biogeochemical model

- need for a model ?



Oxygen records
(World ocean atlas, Seadatanet, Black Sea Comission data)

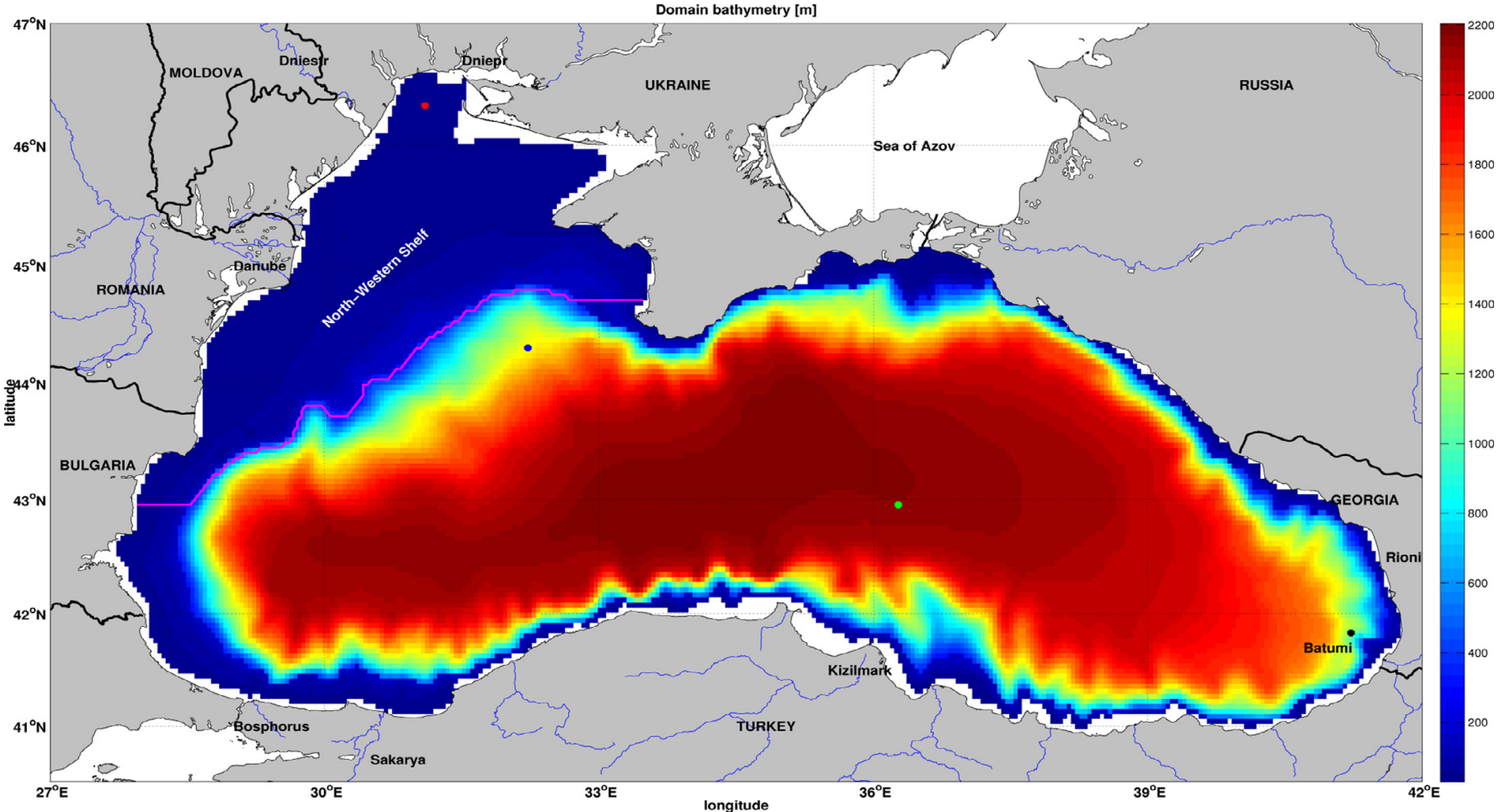
Hypoxic records
(<62 mmol O/m³)



BAMHBI biogeochemical model

GHER hydrodynamic model

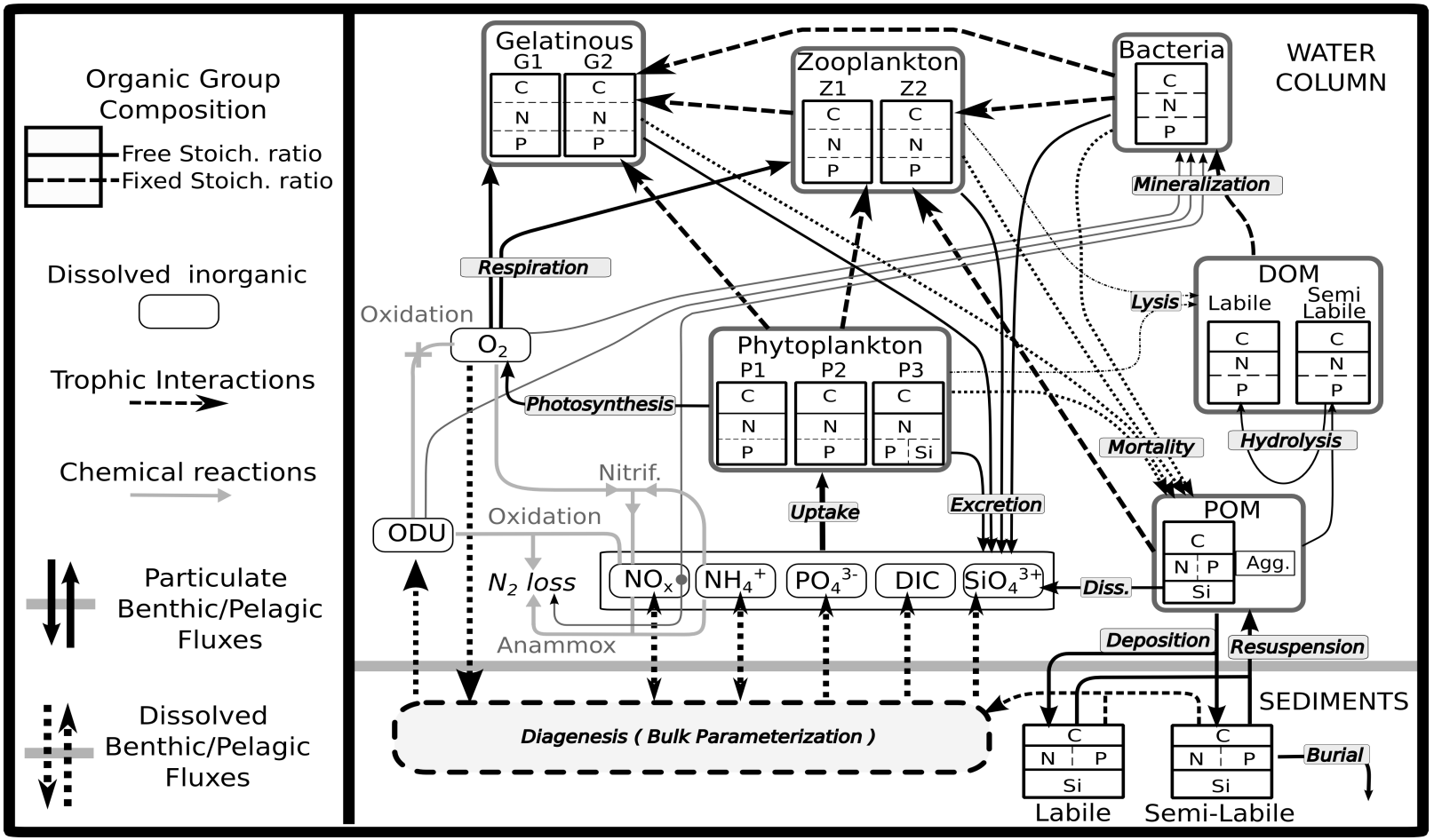
- 15 and 5 km horizontal grid, 31 terrain-following vertical levels
- temperature, salinity, velocity, turbulent kinetic energy
- External forcings : ECMWF atmospheric fields, 6 rivers, Bosphorus budget closure
- no data assimilation



BAMHBI biogeochemical model

- simulates oxygen, nitrogen, phosphorus, silicate and carbon cycles (e.g. Gregoire et al, 2008)
- explicitely represents processes in anoxic and suboxic conditions
- benthic sub-model represents 2D stocks of carbon and nitrogen with 2 degrees of liability (e.g. Capet et al., 2016).
- the hydrodynamic, biogeochemical and benthic models are fully coupled.

  Examples : transport, temperature – solar radiation and light penetration -- bottom temperature, currents, sedimentation of biogeochem variables …



(Capet et al. 2013, Biogeosciences)

BAMHBI biogeochemical model

Validation : can the model represent ?

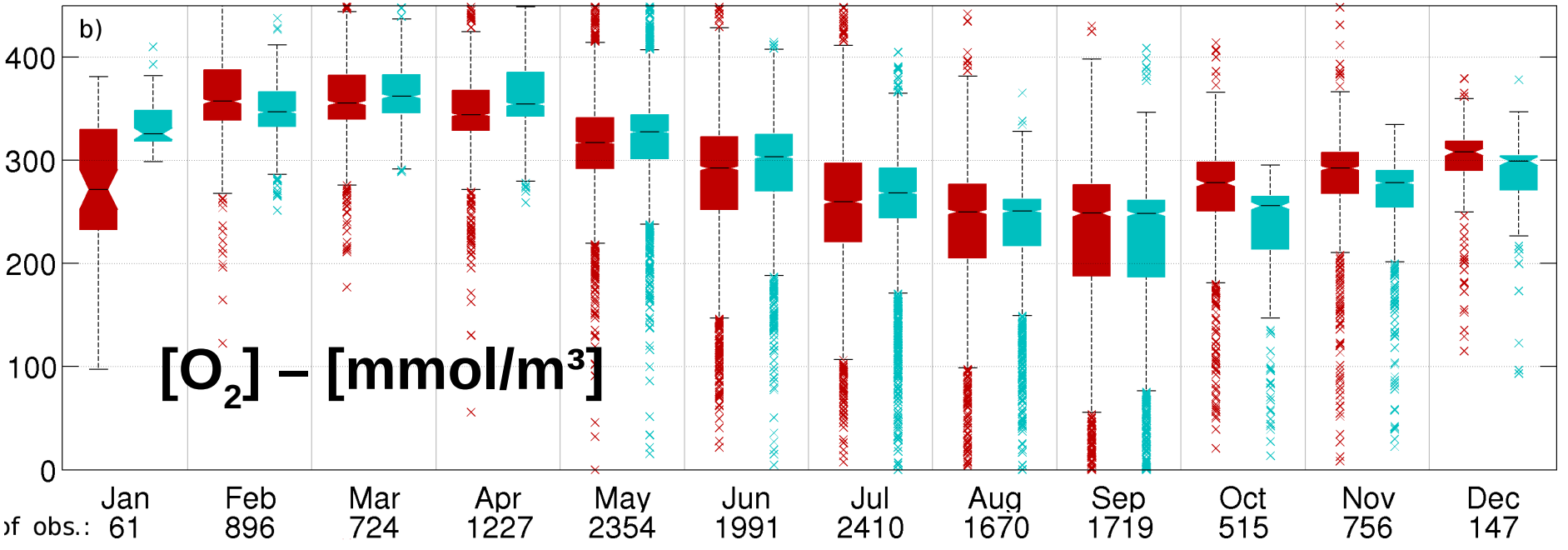
the horizontal distribution
the vertical distribution
the interannual distribution
the seasonal distribution

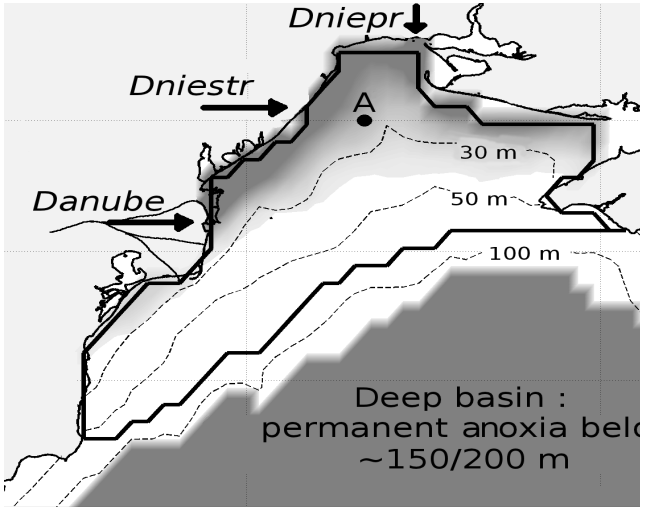
Yes, see e.g. Capet et al (2012) or Vandenbulcke et al (2015)
SST , MLD , CCC , …
Capet et al (2013)
Oxygen

Specific occurences of hypoxia … reflected by in situ observations

Hypoxia

Merged by months → validation of the seasonal cycle

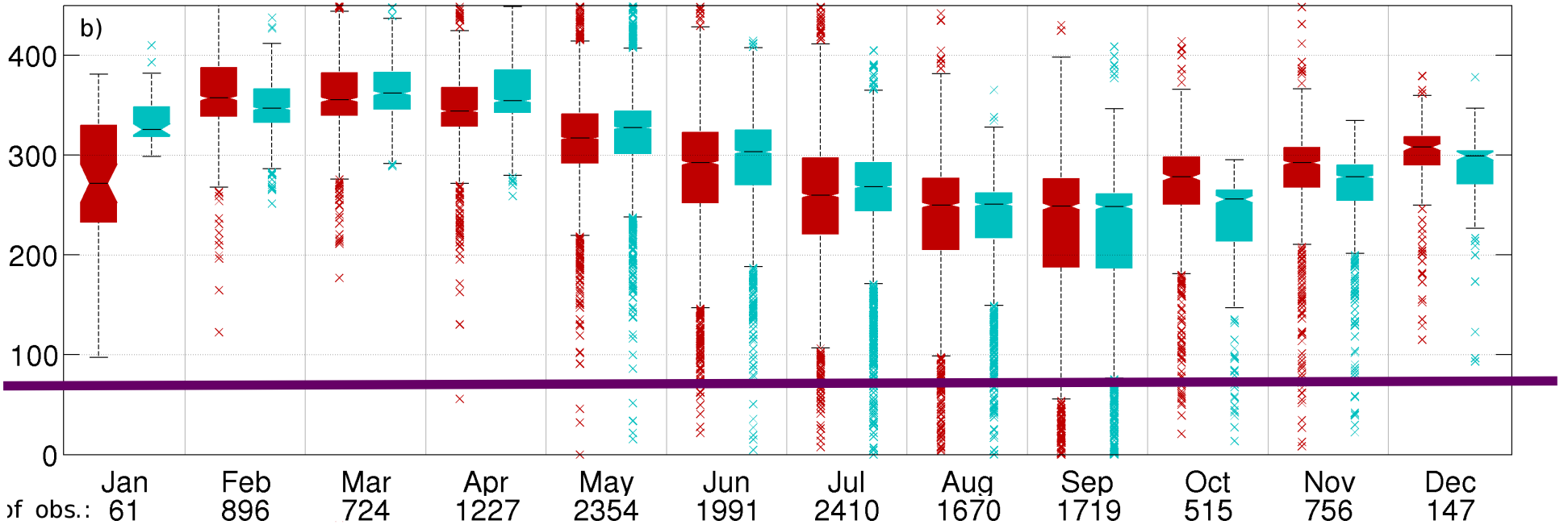


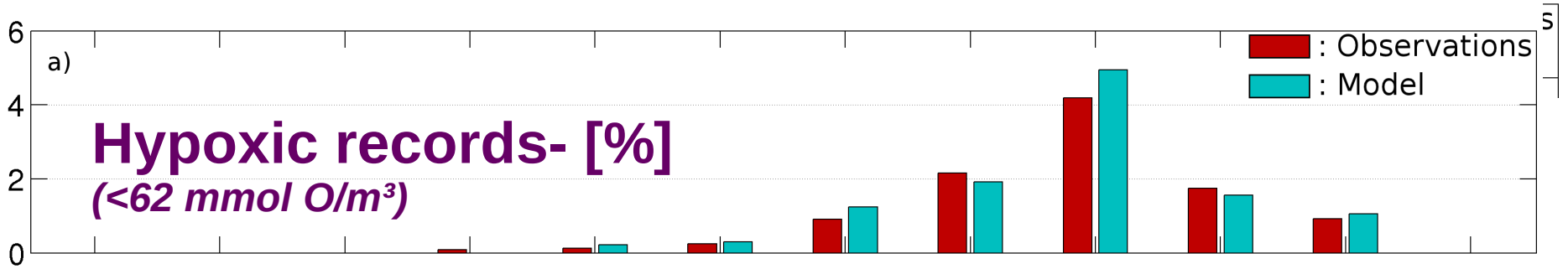


: Observations
: Model

Hypoxia

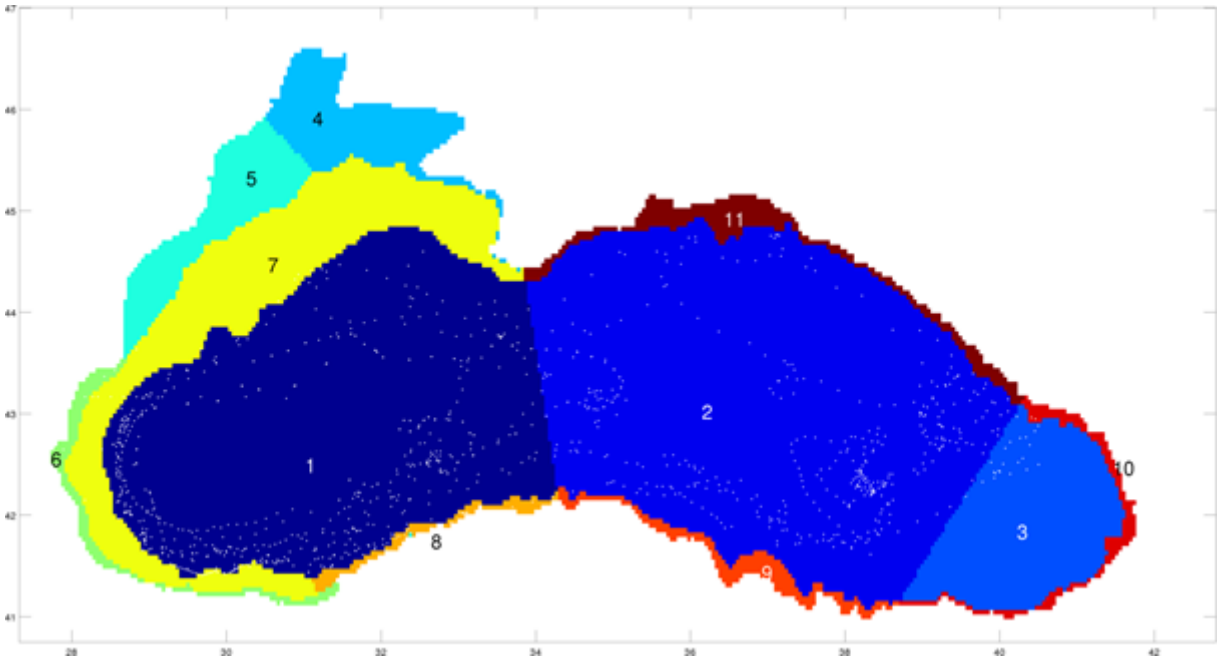
Merged by months → validation of the seasonal cycle





Chlorophyll

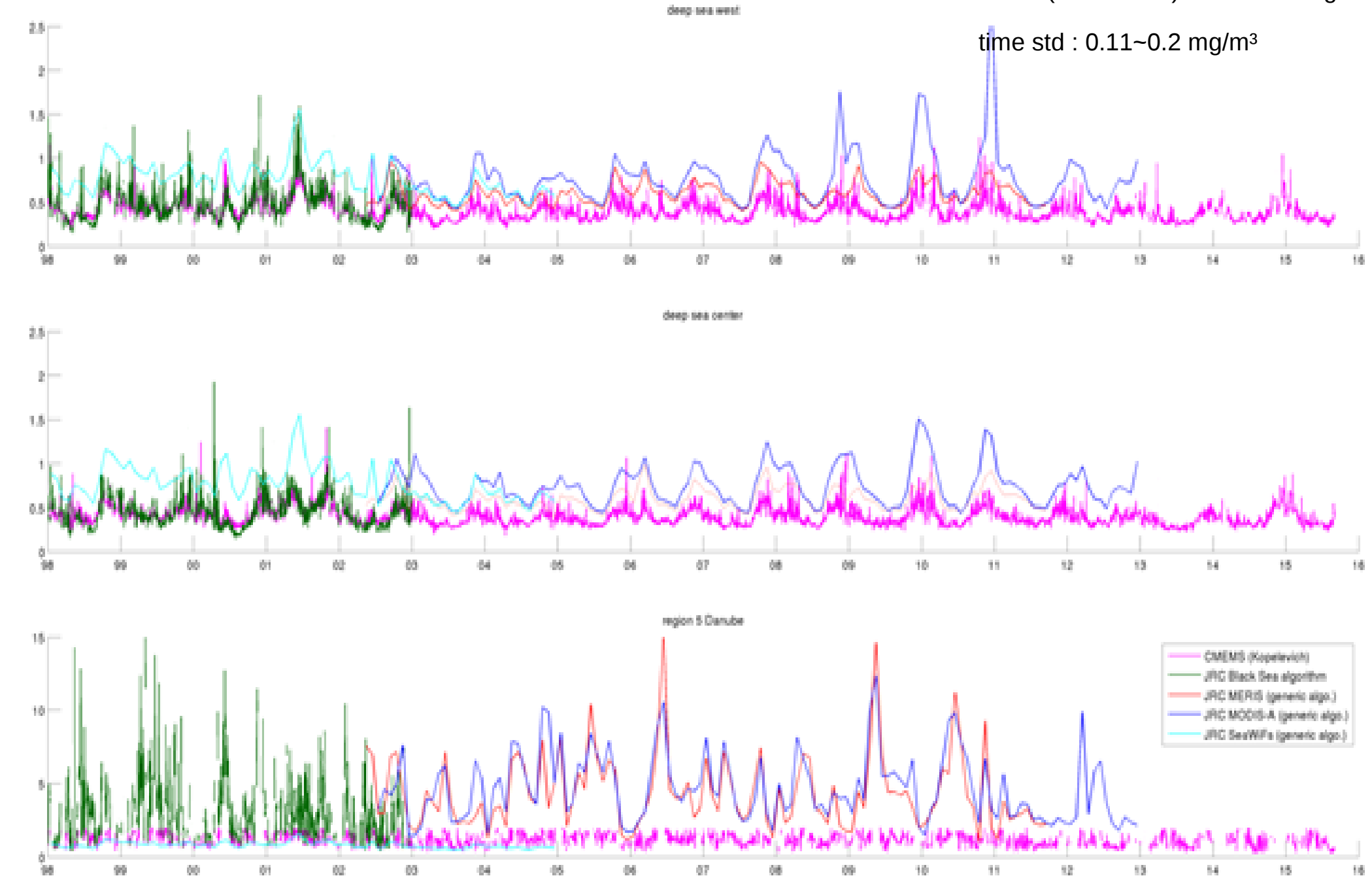
- diagnostic model variable
- recent years : bio-Argo profiles
  - with their own problems specific to the Black Sea regarding Chl-a data, due to : inefficient decomposition of chlorophyll-a pigment in low and anoxic conditions ?
- satellite data : multiple datasets
  - CMEMS (Kopelevich algorithm), JRC (generic algorithm, SeaWiFs, MODIS-A, MERIS), JRC (specific algorithm for the Black Sea)



Chlorophyll

mean (1998-2016) : 0.4~0.78 mg/m³

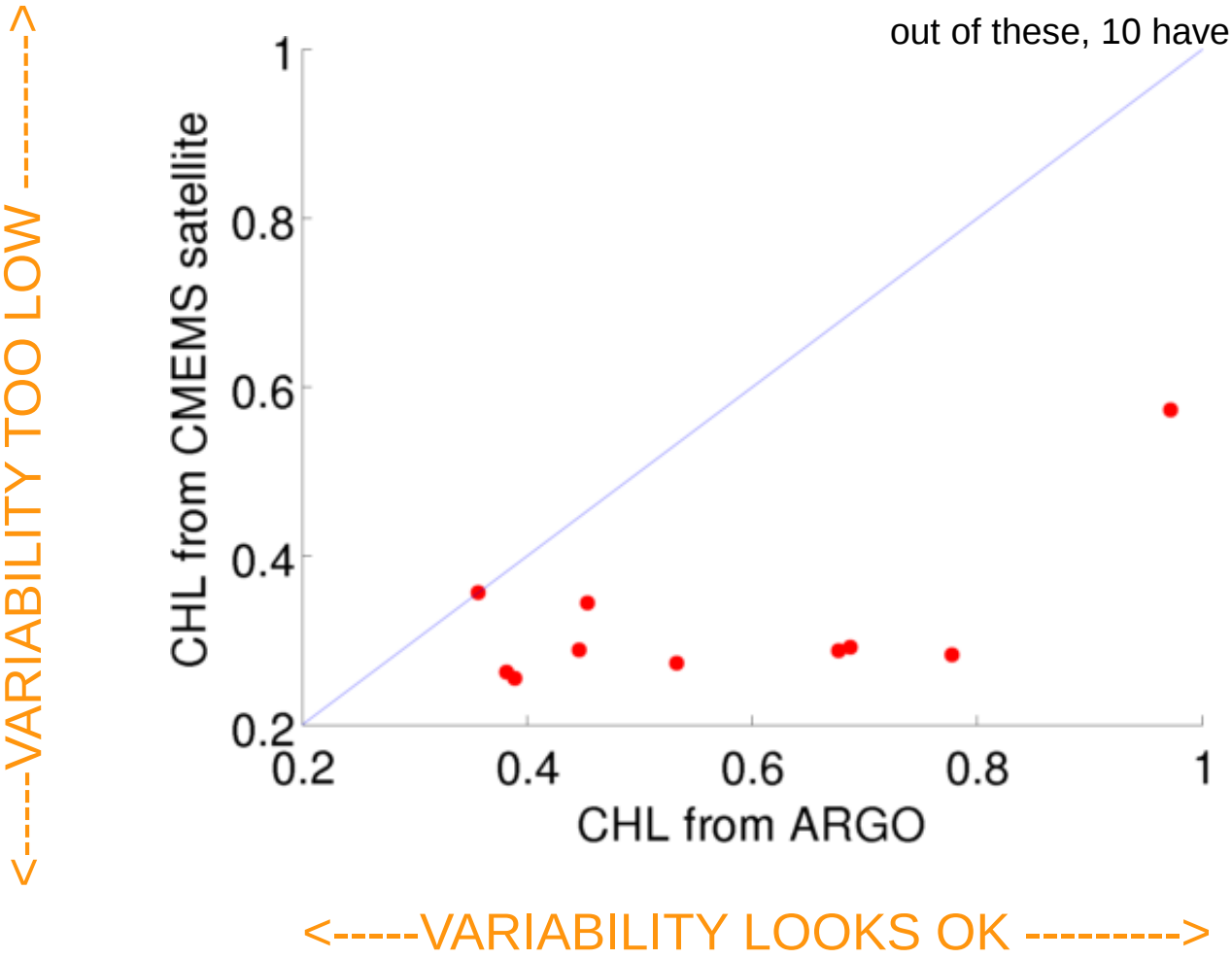
time std : 0.11~0.2 mg/m³



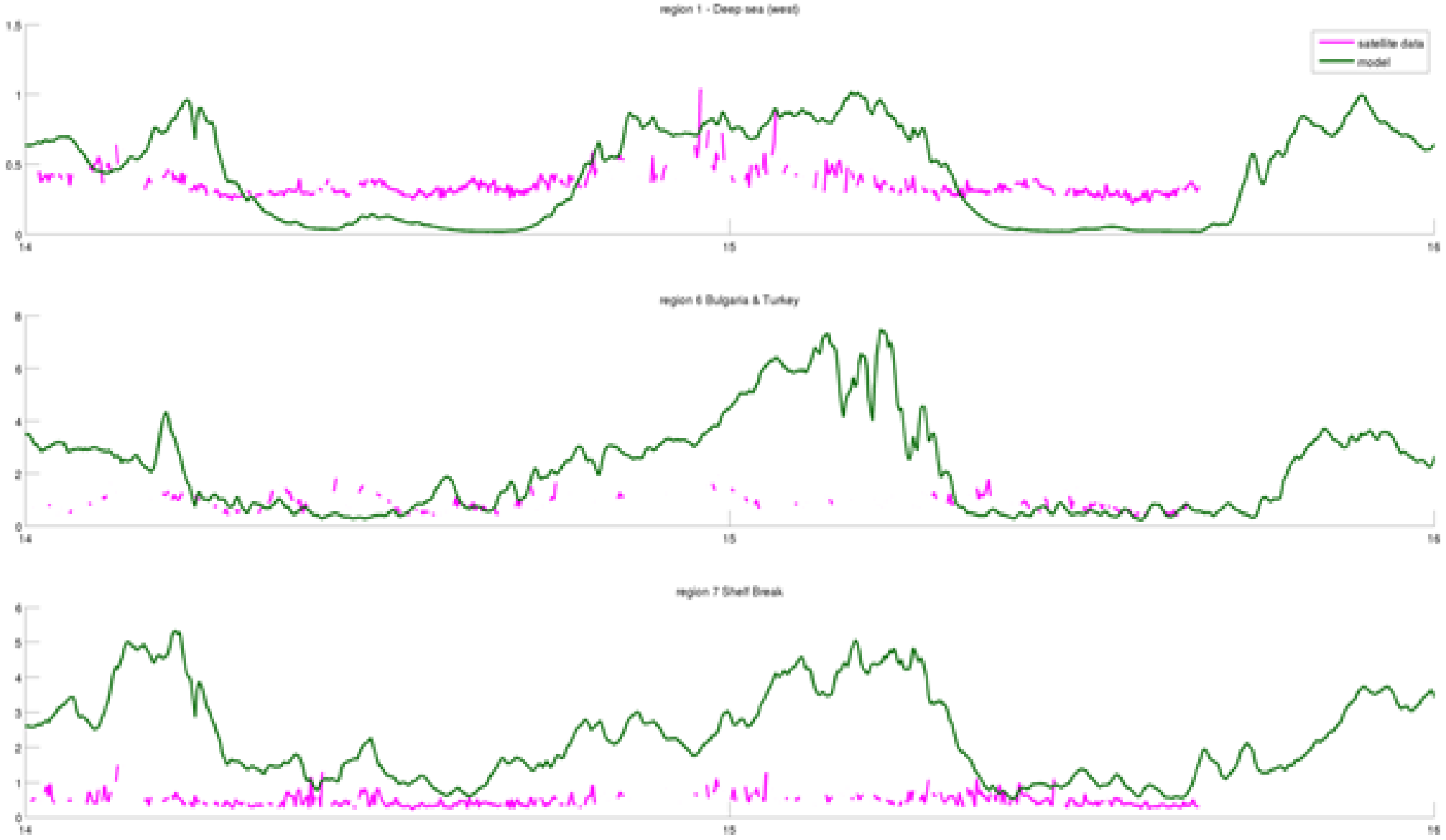
Chlorophyll

2014-2015 : 112 ARGO profiles from Coriolis

out of these, 10 have L3 sat CHL data



Chlorophyll



CMEMS BS-MFC biogeochemical component

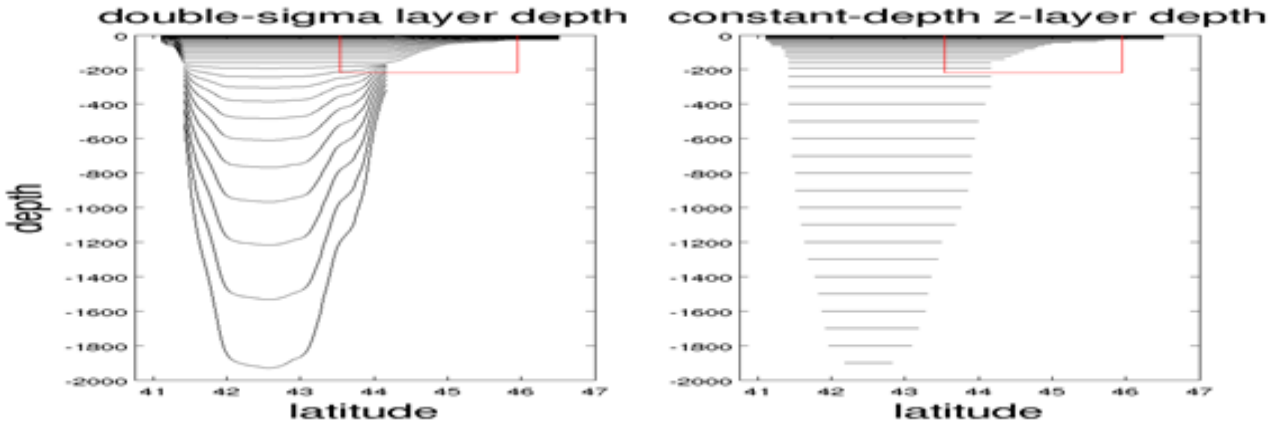
35 years reanalysis, and daily 10-day forecast :

http://marine.copernicus.eu/

http://labos.ulg.ac.be/mast/

CMEMS BS-MFC biogeochemical component

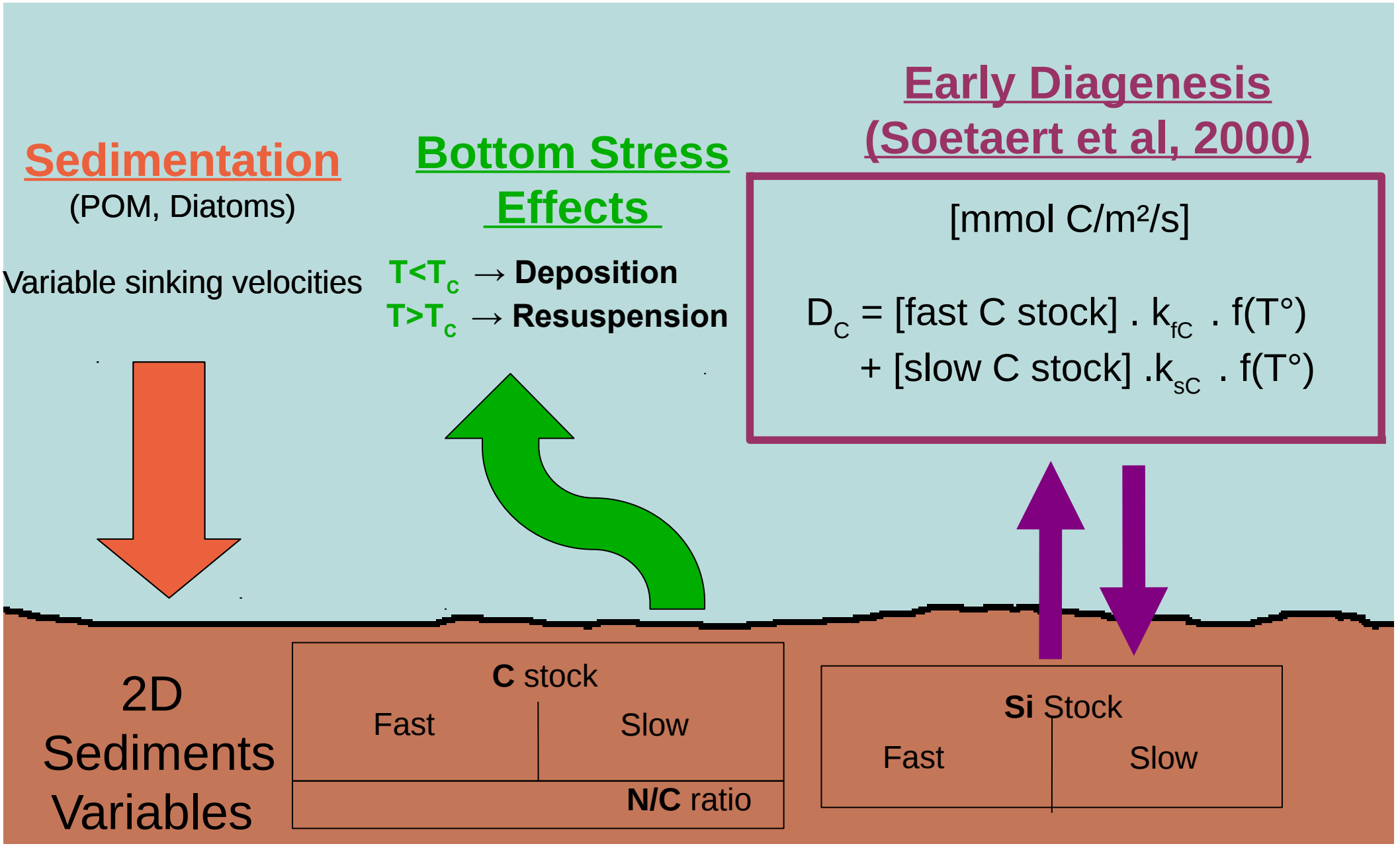
- Daily 10-day forecast interpolated on constant-depth layers:



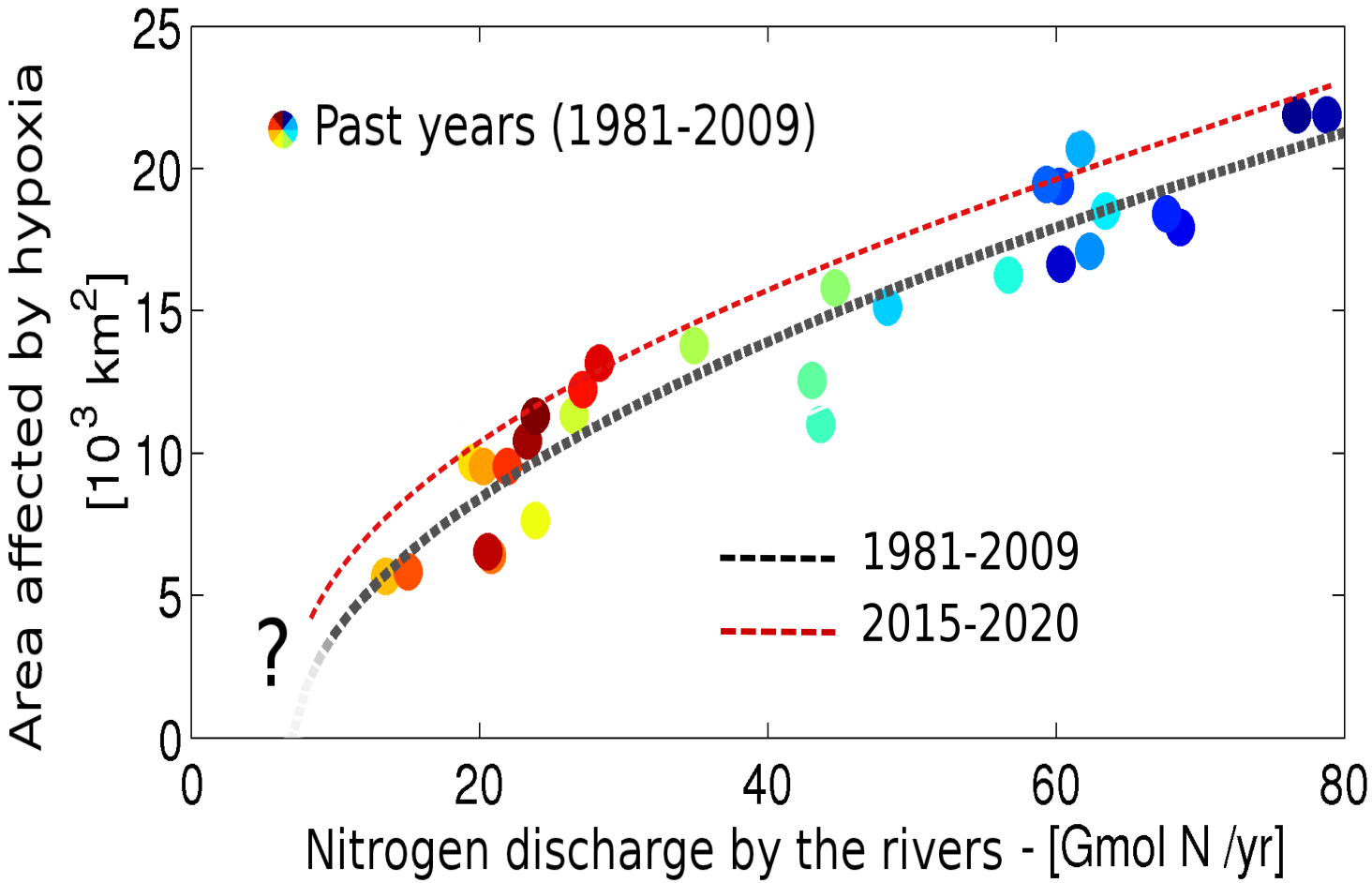
- nutrients (nitrate, phosphate), oxygen, phytoplancton, primary production, chlorophyll
- Current version V2.2: GHER hydrodynamic model, no data assimilation (physics nor biogeochemical)
- Validation available from CMEMS web (QUality Information Document)
- V3 (2017) : NEMO hydrodynamic model, data assimilation

Thank you

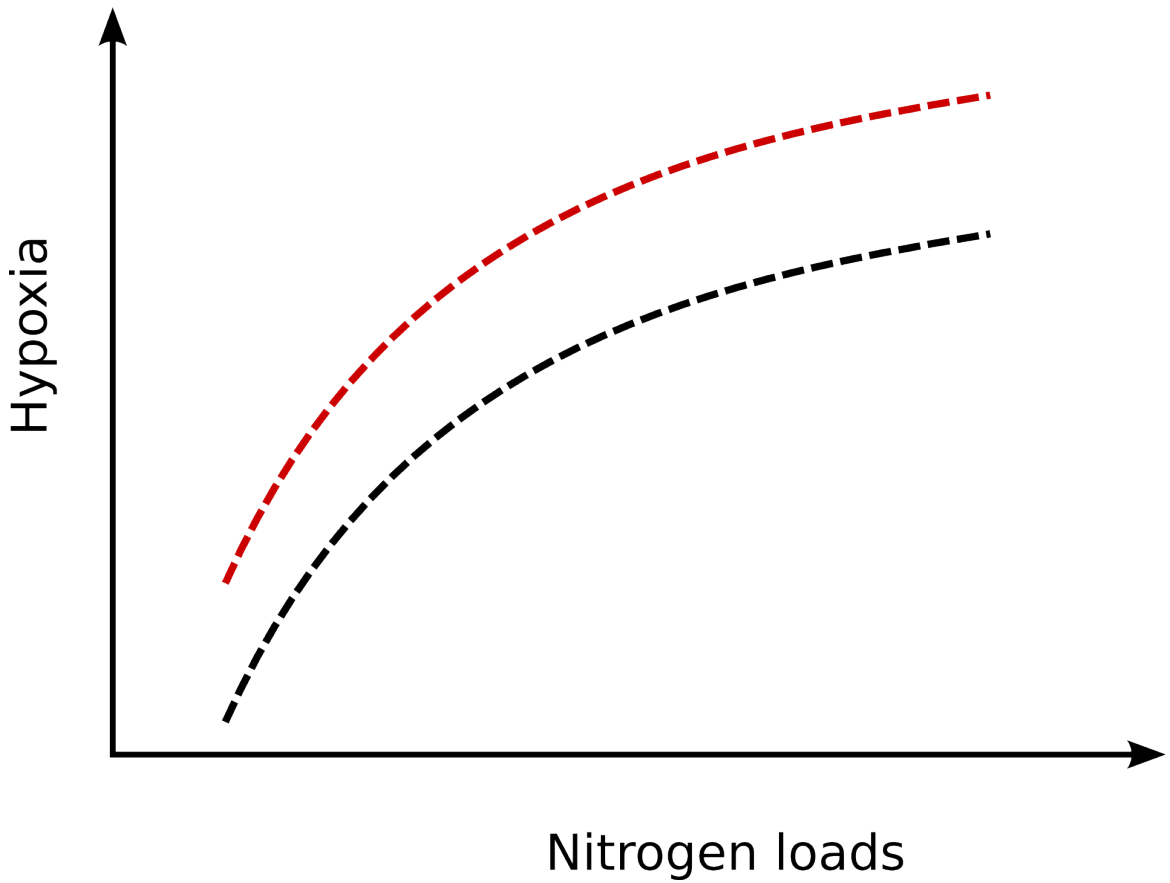
Benthic Model



Hypoxia as a function of N



The cost of warming



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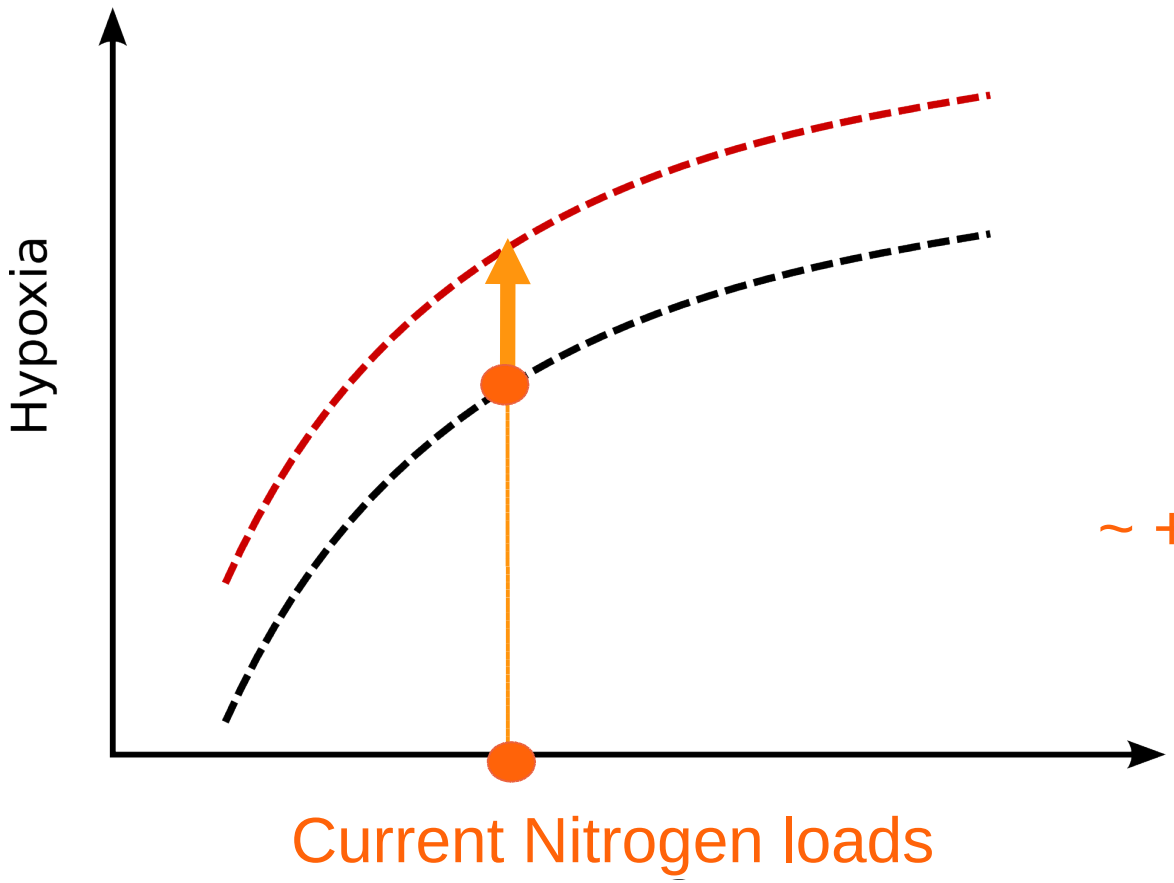
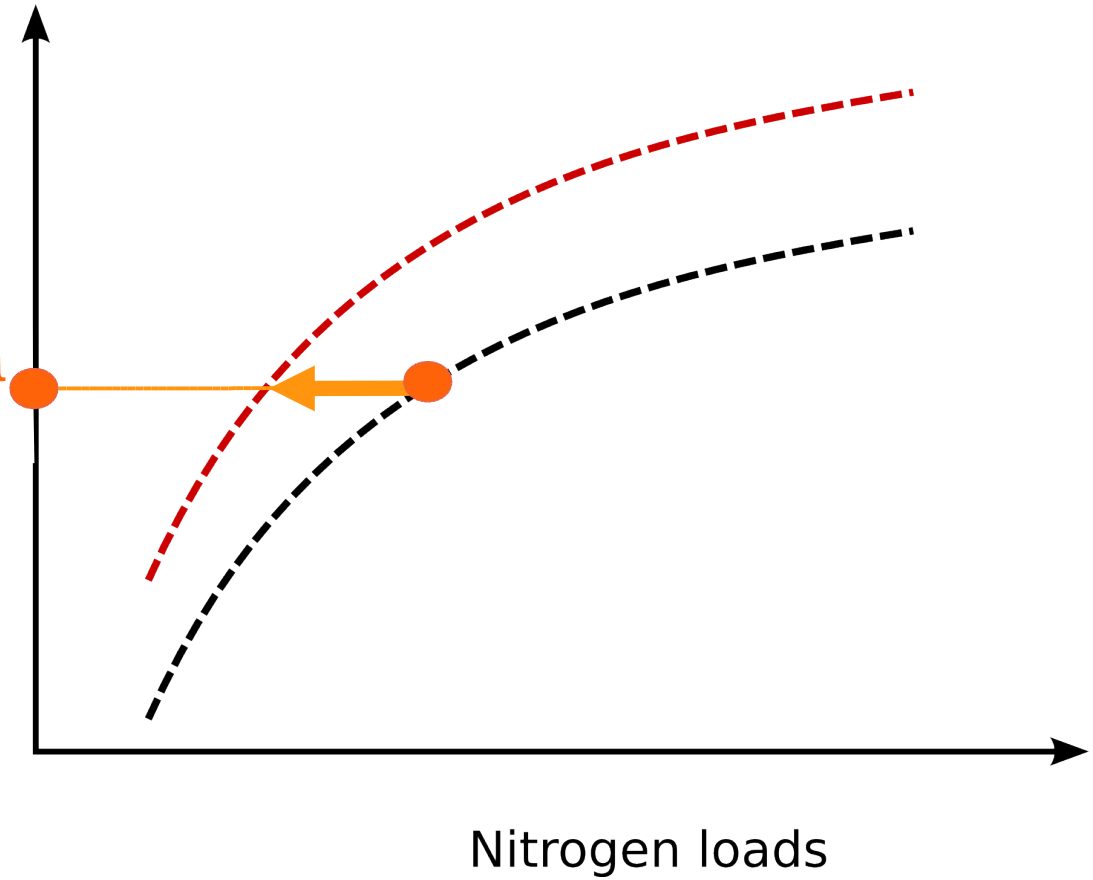


<u>Environmental cost</u>
H increase by 17%

~ +2500 km²
~ +4.5% of the shelf area

The cost of warming



Economical cost
24 % reduction of
nutrient loads