CO_2 Sensitivity to Chl-a Data assimilation

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OceanFlux GHG is funded by: esa and affiliated to: solas

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- The model GOTM-ERSEM-CO_2
- Data Assimilation setup
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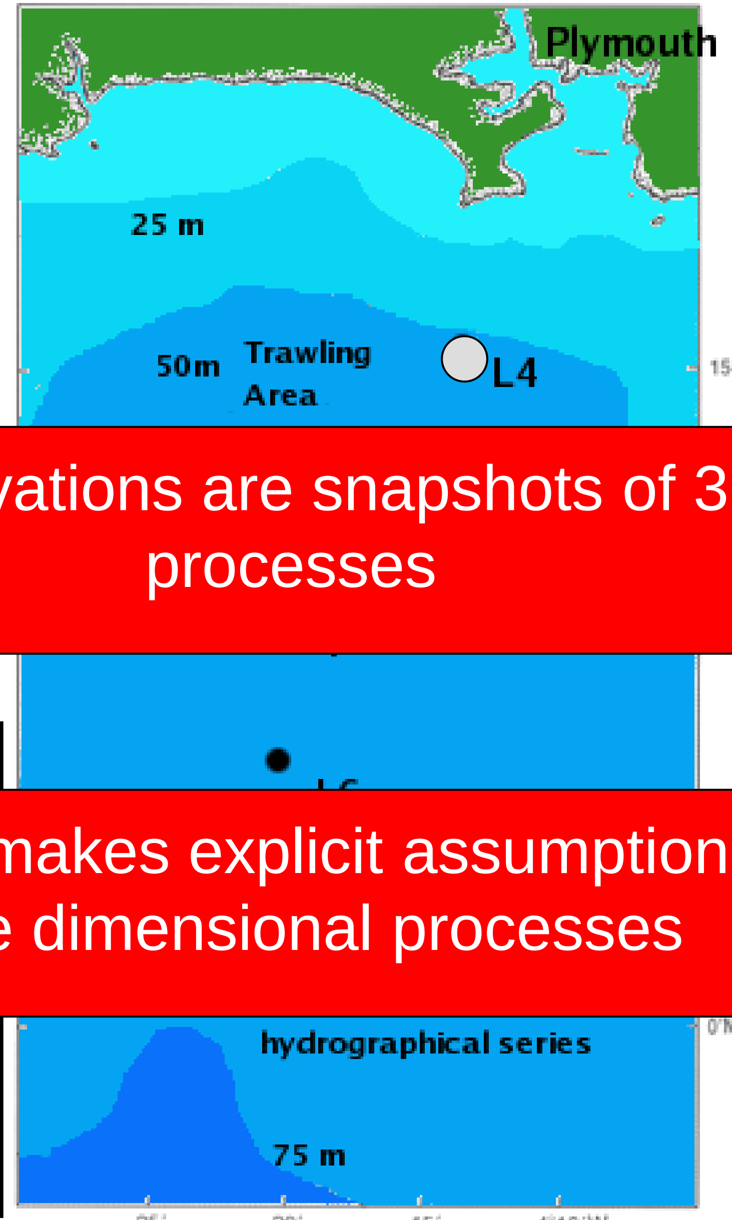
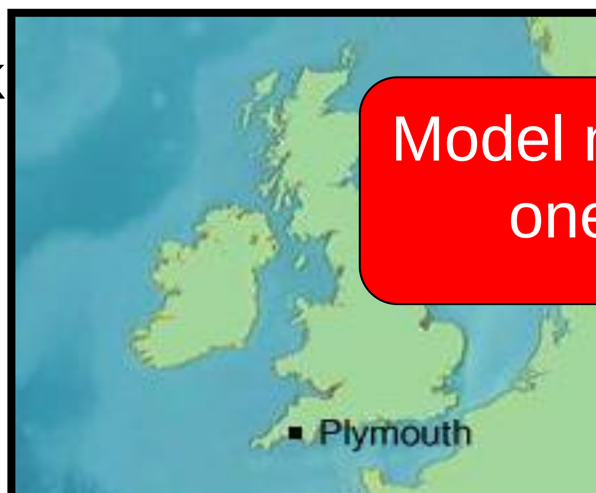
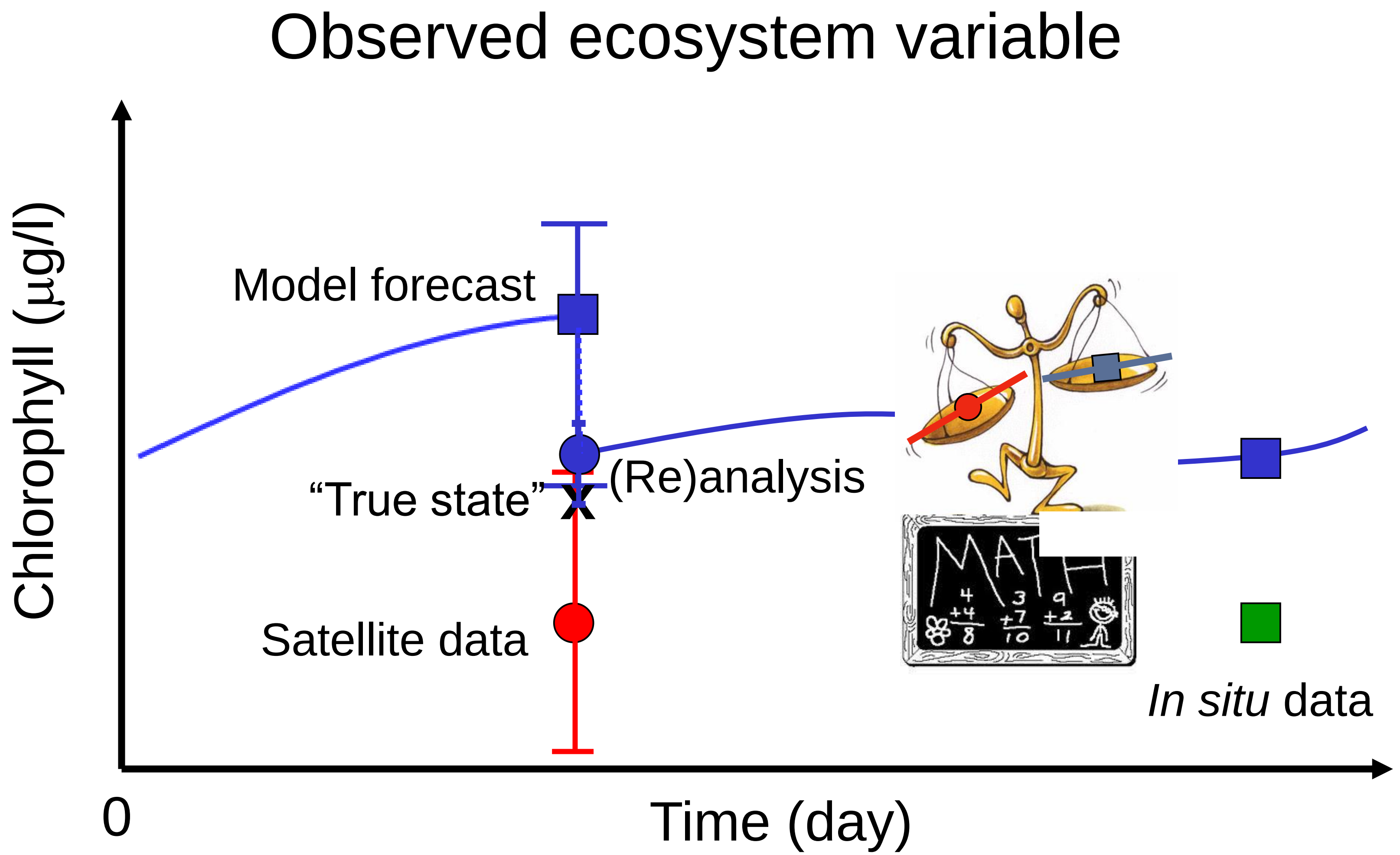


Observations are snapshots of 3D processes

Model makes explicit assumption of one dimensional processes



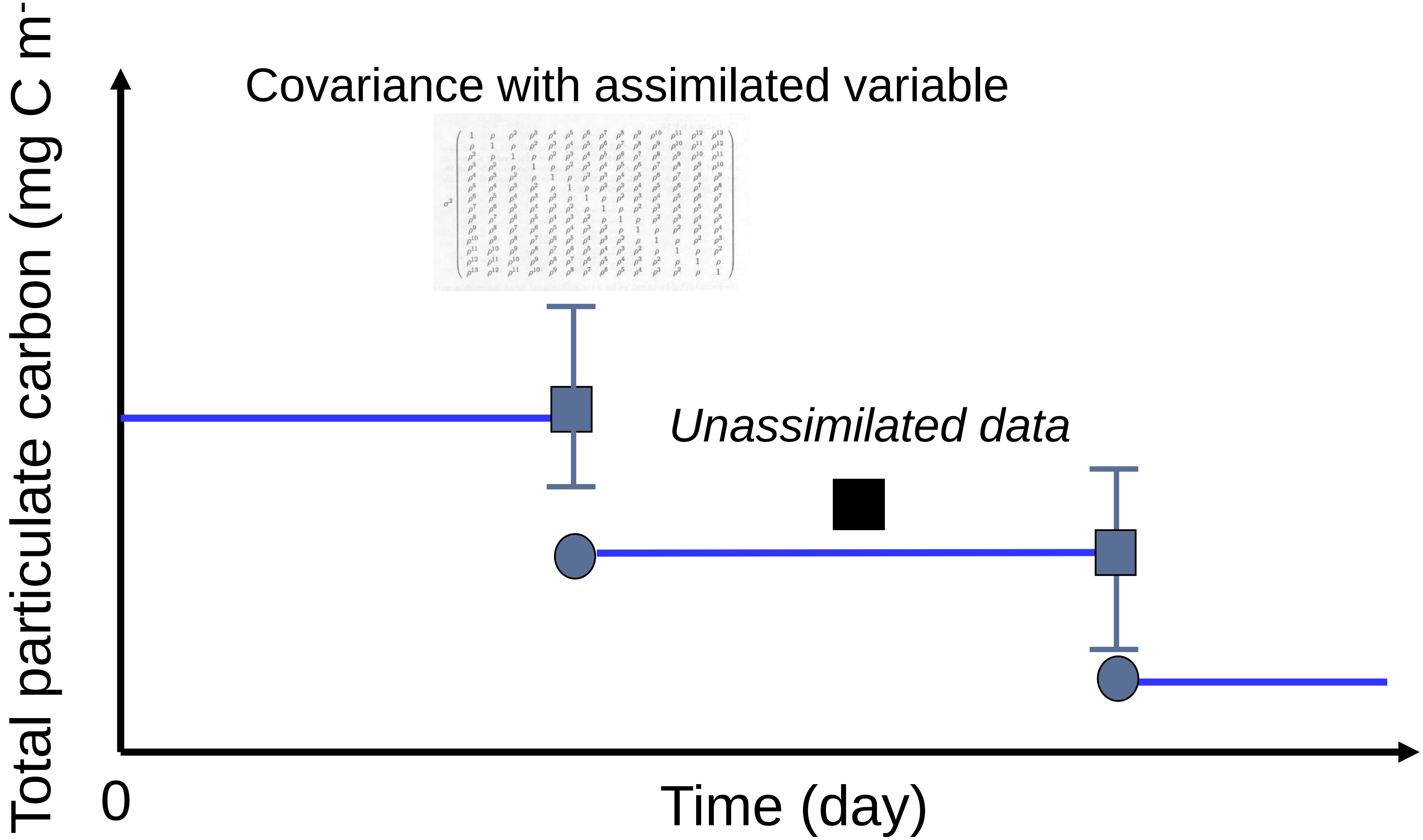
Ensemble Kalman Filter



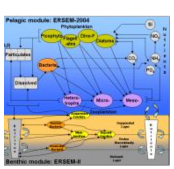
Better simulation

Cont…

Unassimilated variable/parameter

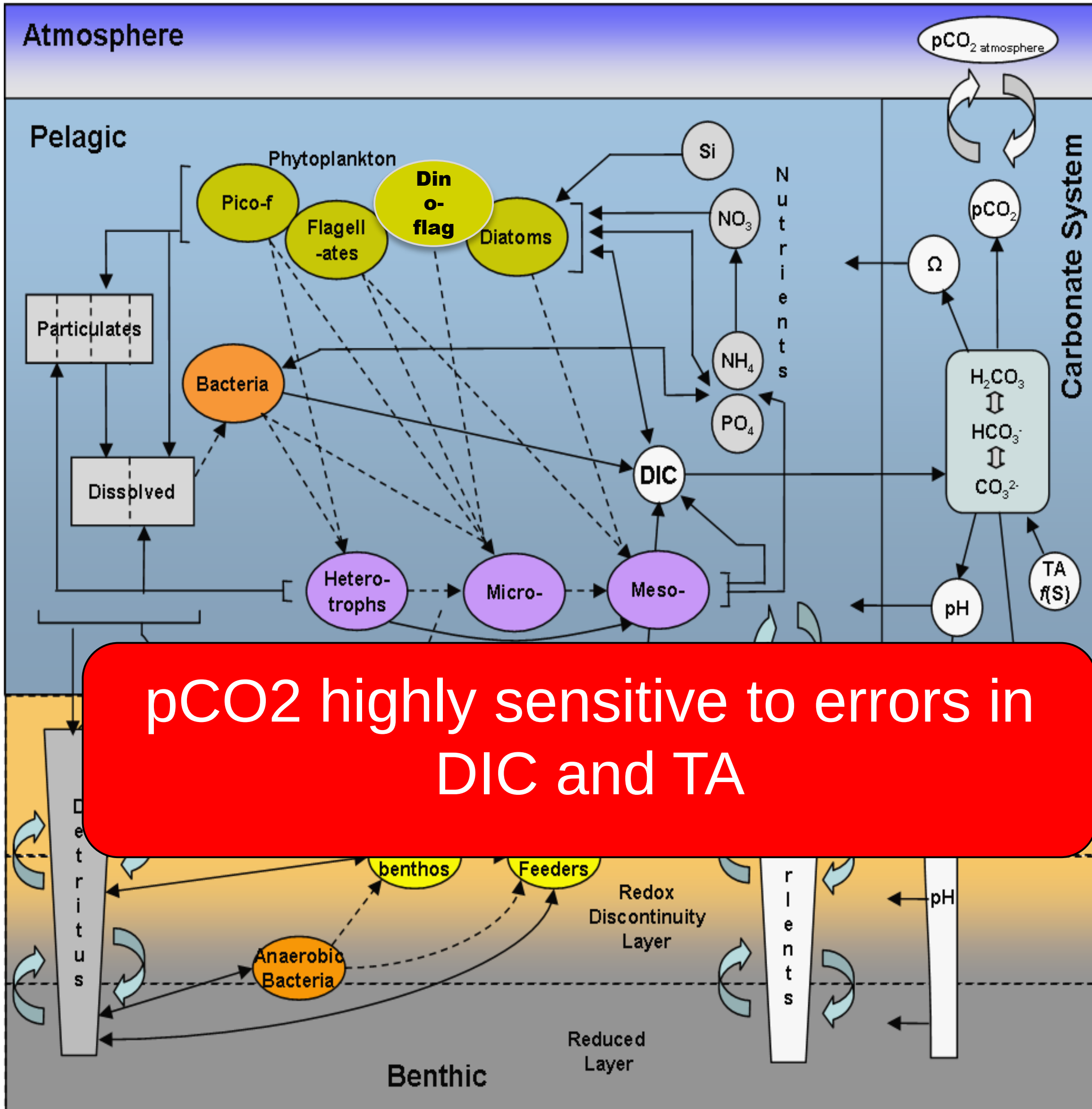


Better understanding



ERSEM model

- LTL biogeochemical model
- PFT model
- Processes based model
- C, N, P, Si dynamics completely decoupled
- Benthic-pelagic coupled model
- Coupled with several hydrodynamic model:
  - 1D (e.g.GOTM)
  - 3D (POLCOMS, NEMO,FVCOM)

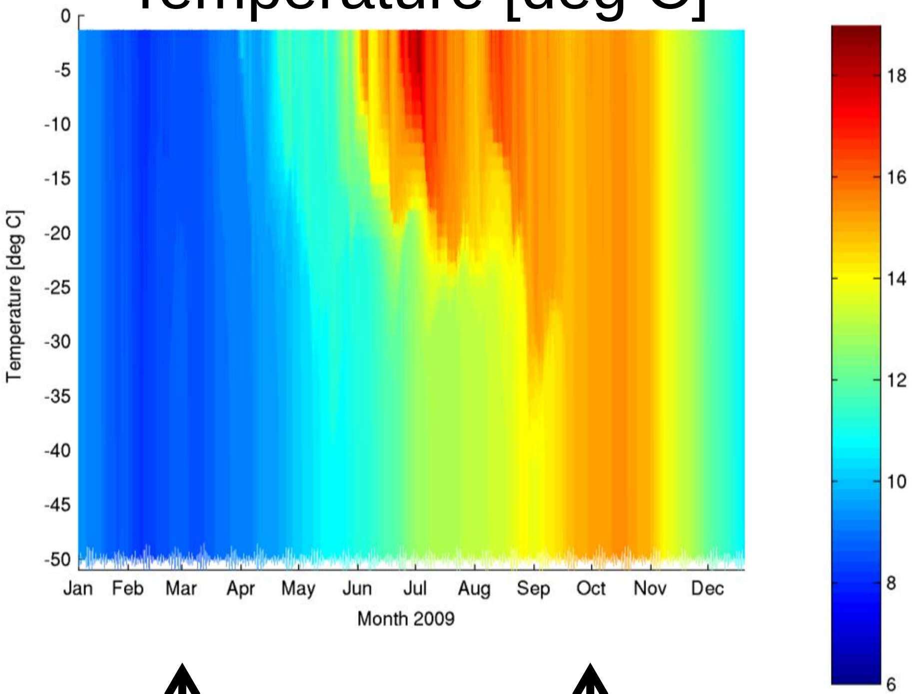


pCO2 highly sensitive to errors in DIC and TA

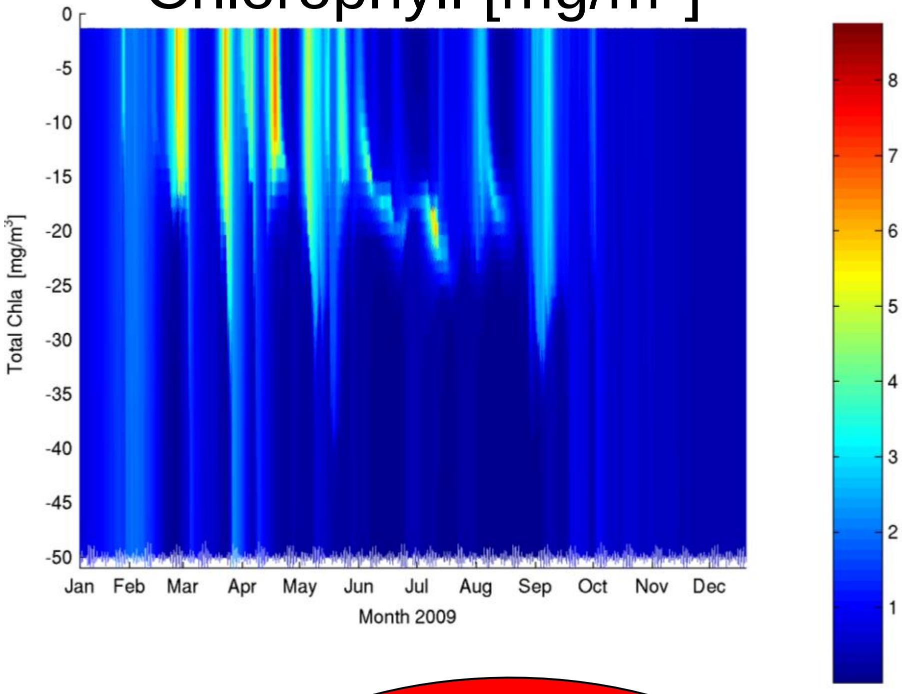
Artioli et al., 2012 JMS

Reference simulation

Temperature [deg C]



Chlorophyll [mg/m^3]



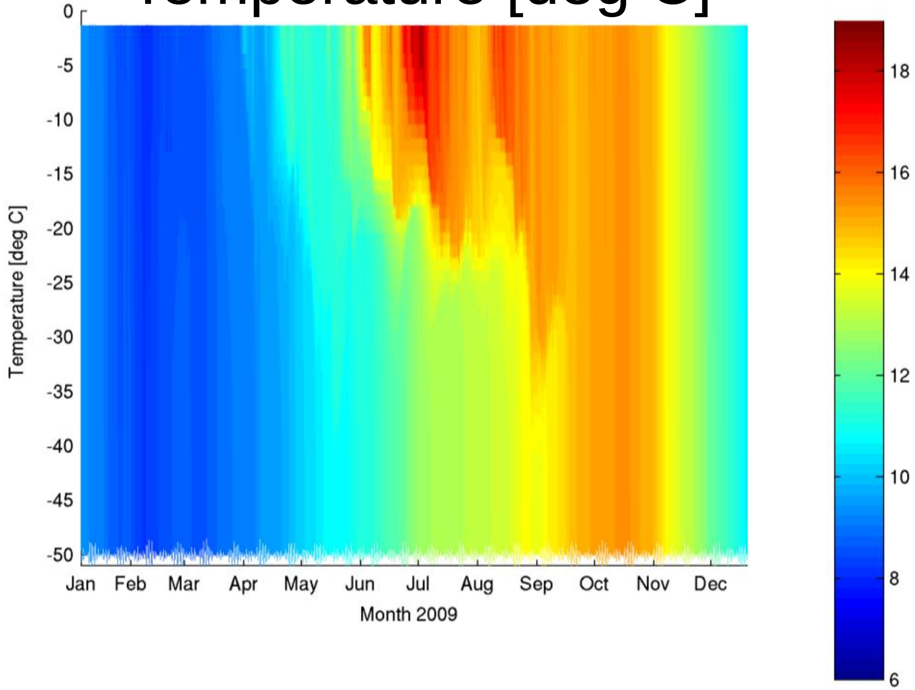
Winter Mixed

Autumn break-down of stratification

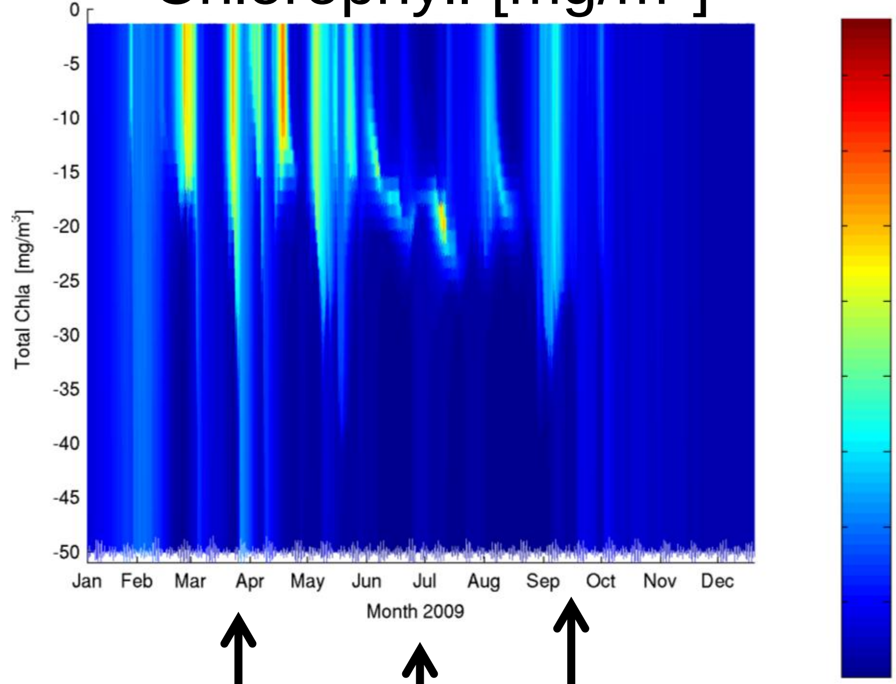
T and S are relaxed to weekly CTD profiles

Reference simulation

Temperature [deg C]



Chlorophyll [mg/m^3]



Spring bloom
Autotrophy

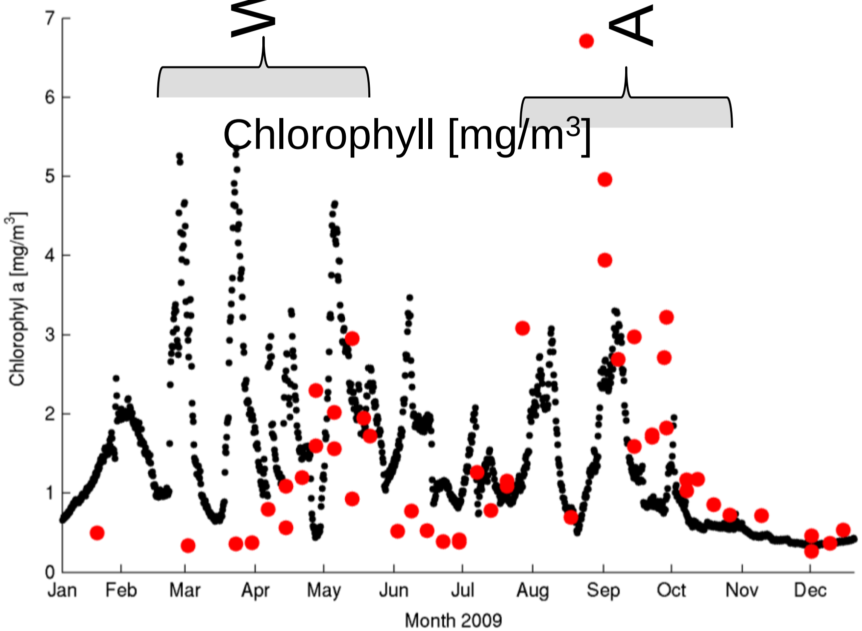
Autumn bloom

Summer deep chla
Heterotrophy

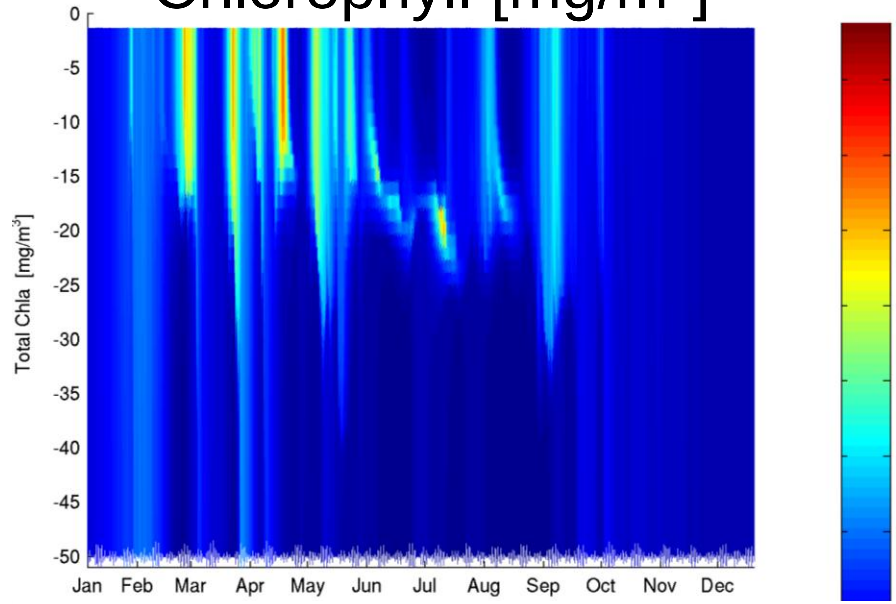
Reference simulation

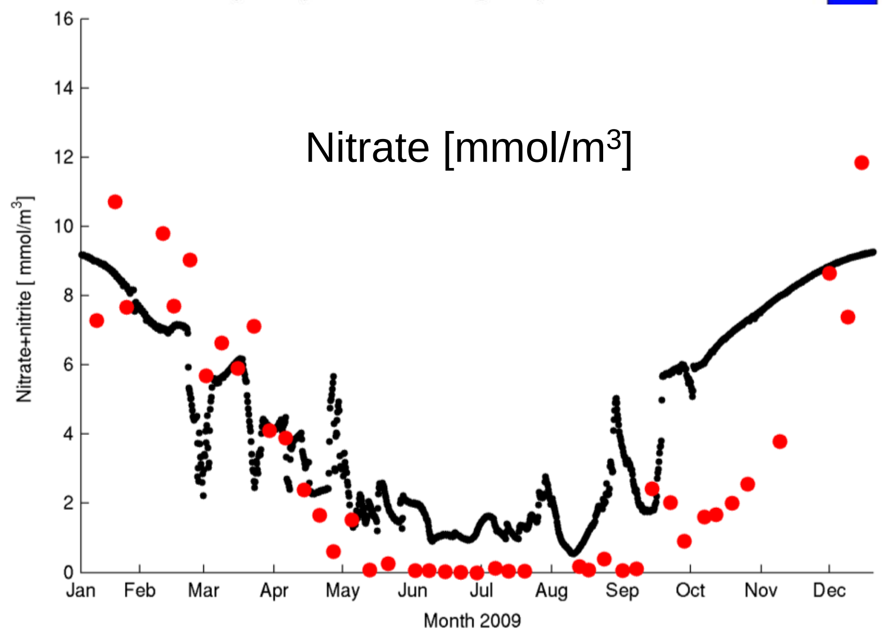
Winter over-estimation

Autumn under-estimation



Chlorophyll [mg/m^3]



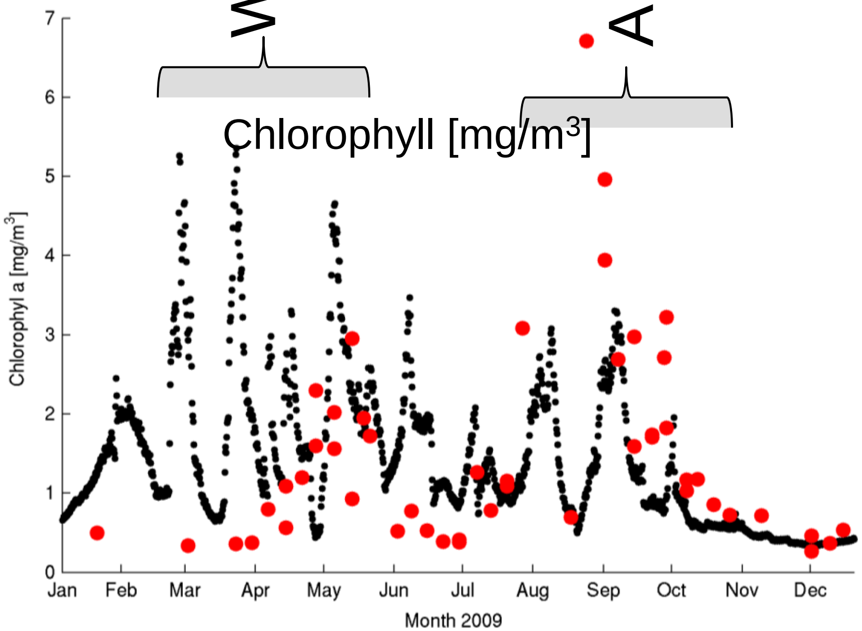


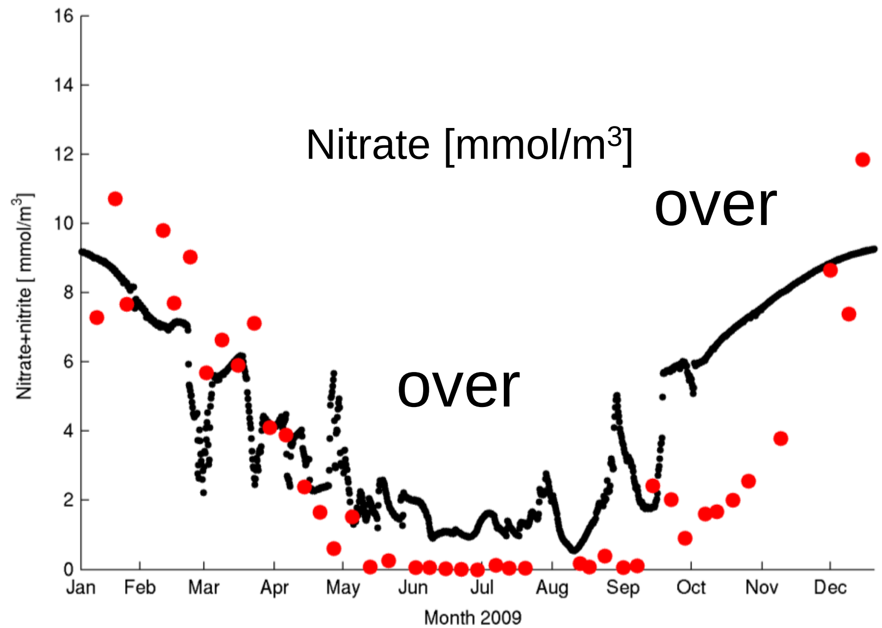
Reference simulation

Winter over-estimation

Autumn under-estimation

Good seasonal cycle but…





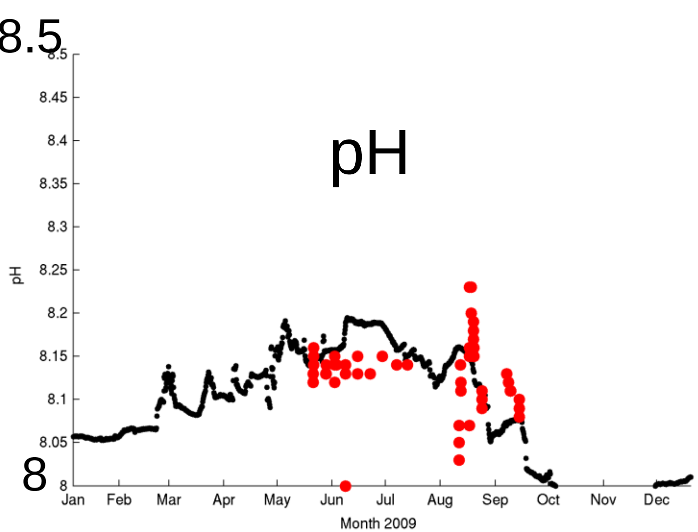
Reference simulation

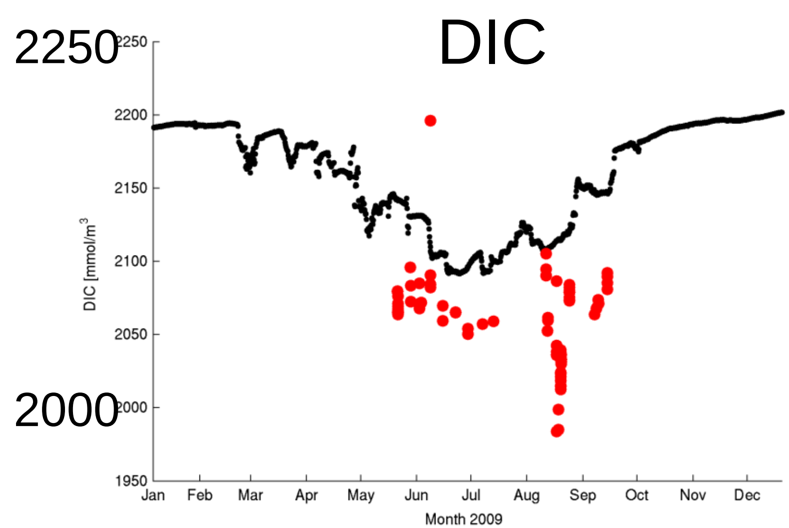
Variable	Correlation
Total Chlorophyll	0.24
Silicates	0.56
Nitrate	0.75
Phosphate	0.84
TotC	0.32
pH	0.22
DIC	0.14
pco2	0.22

Overall good model seasonality

Poor short-time skill

Carbonate variables lack the daily variations present in observations



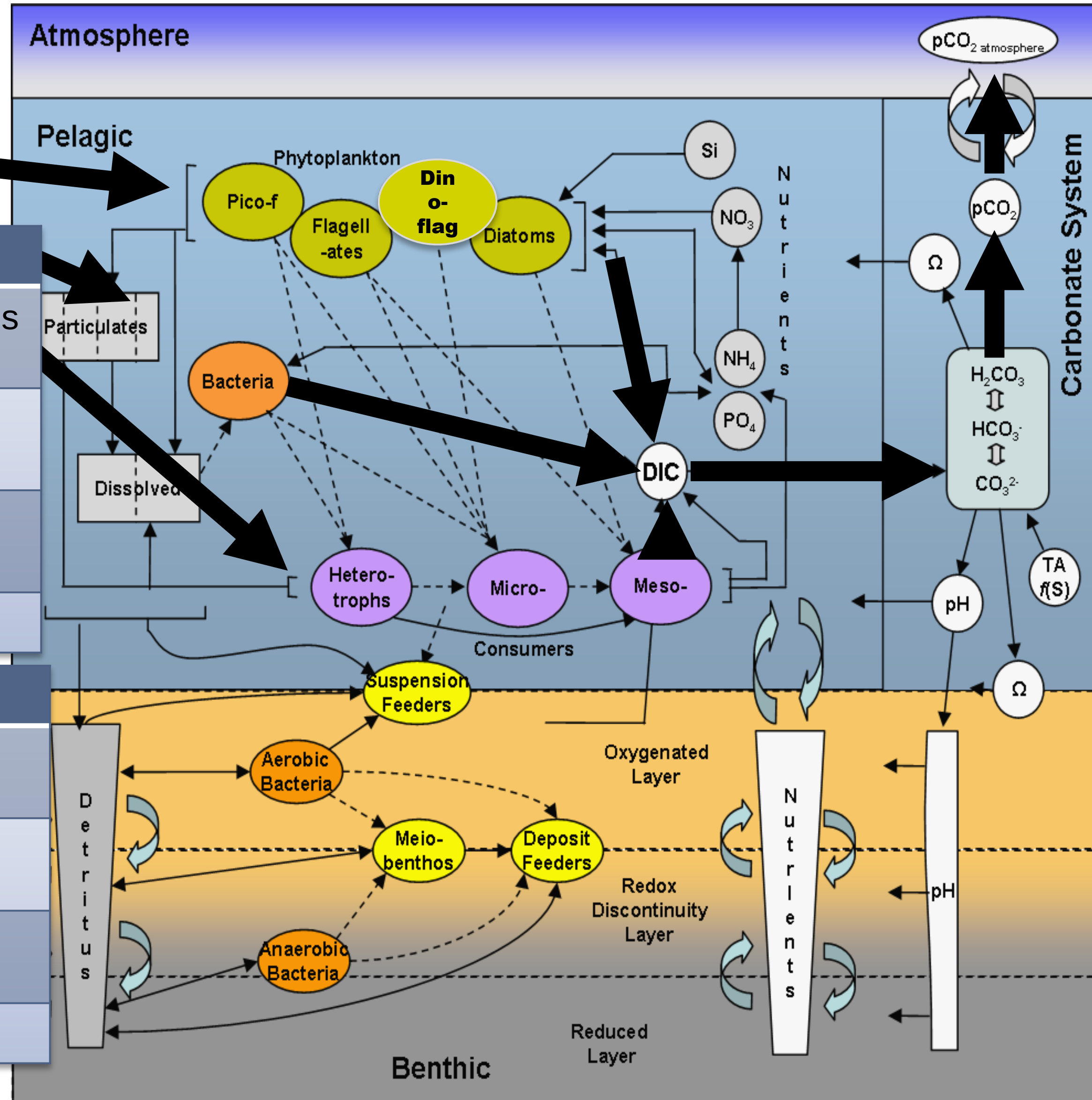


Data assimilation setup

Chlorophyll

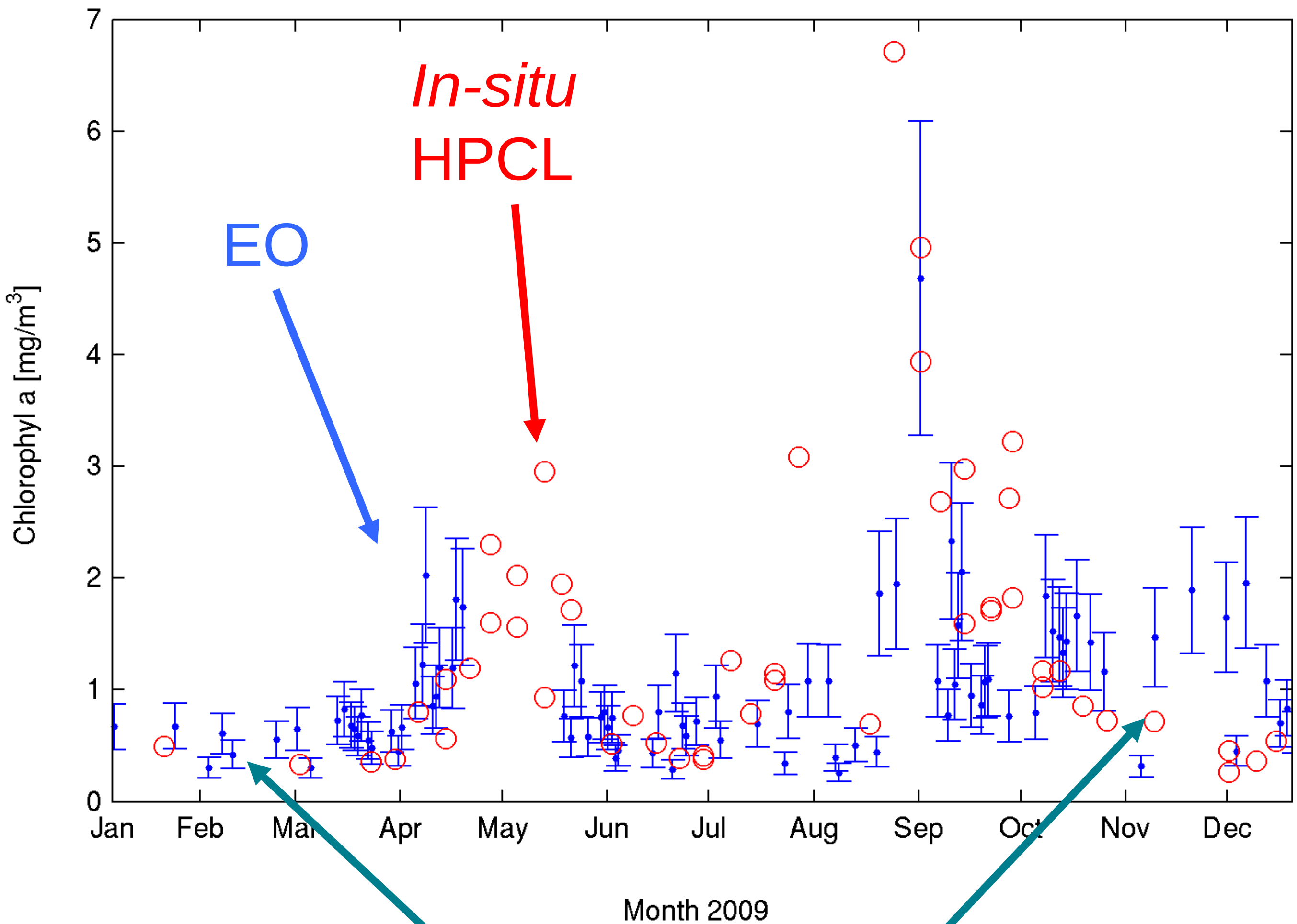
Variable	Effect
T and S vertical structure	Kz and vertical fluxes
Surface Irradiance	Light availability at depth
Background SPM	Light availability at depth
ALL Initial Conditions	Model trajectory

Variable	Value
Nº Ensembles	100
Observations Error	30%
Irradiance Error	25%
SPM Error	25%



Observations

EO chlorophyll with 30% errors

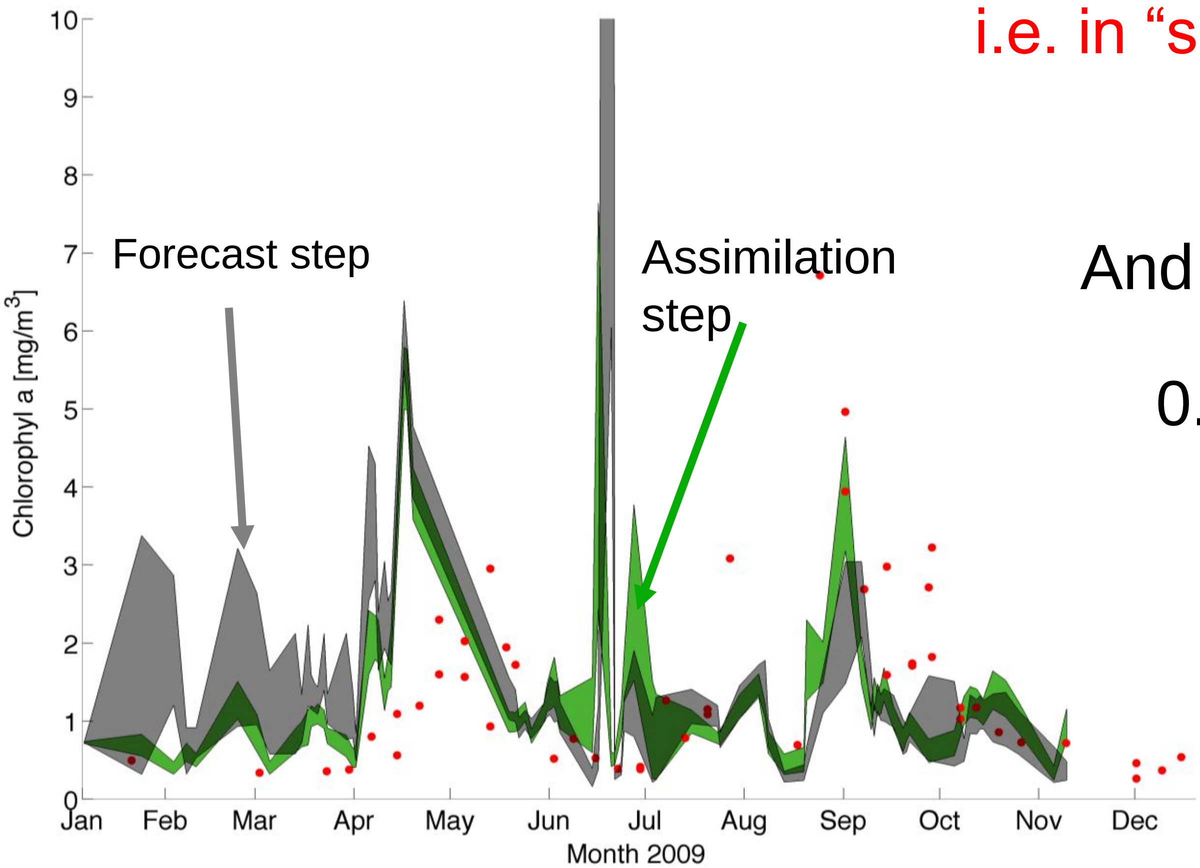


Over-estimation

Chl-a assimilation Experiment

Strong reduction in ensemble spread

i.e. in "simulation error"



And improved correlation

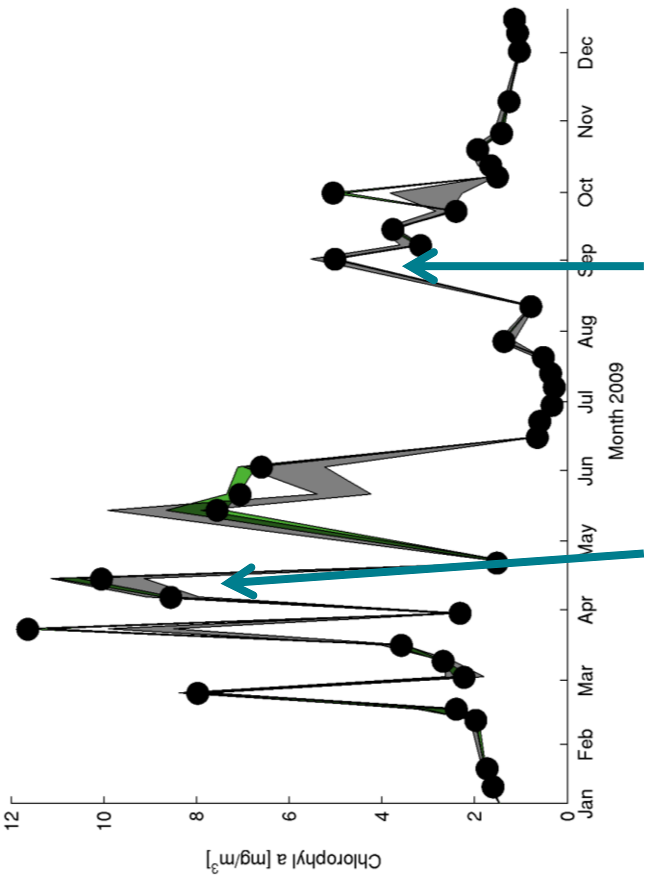
0.24 → 0.33

Reduces winter blooms

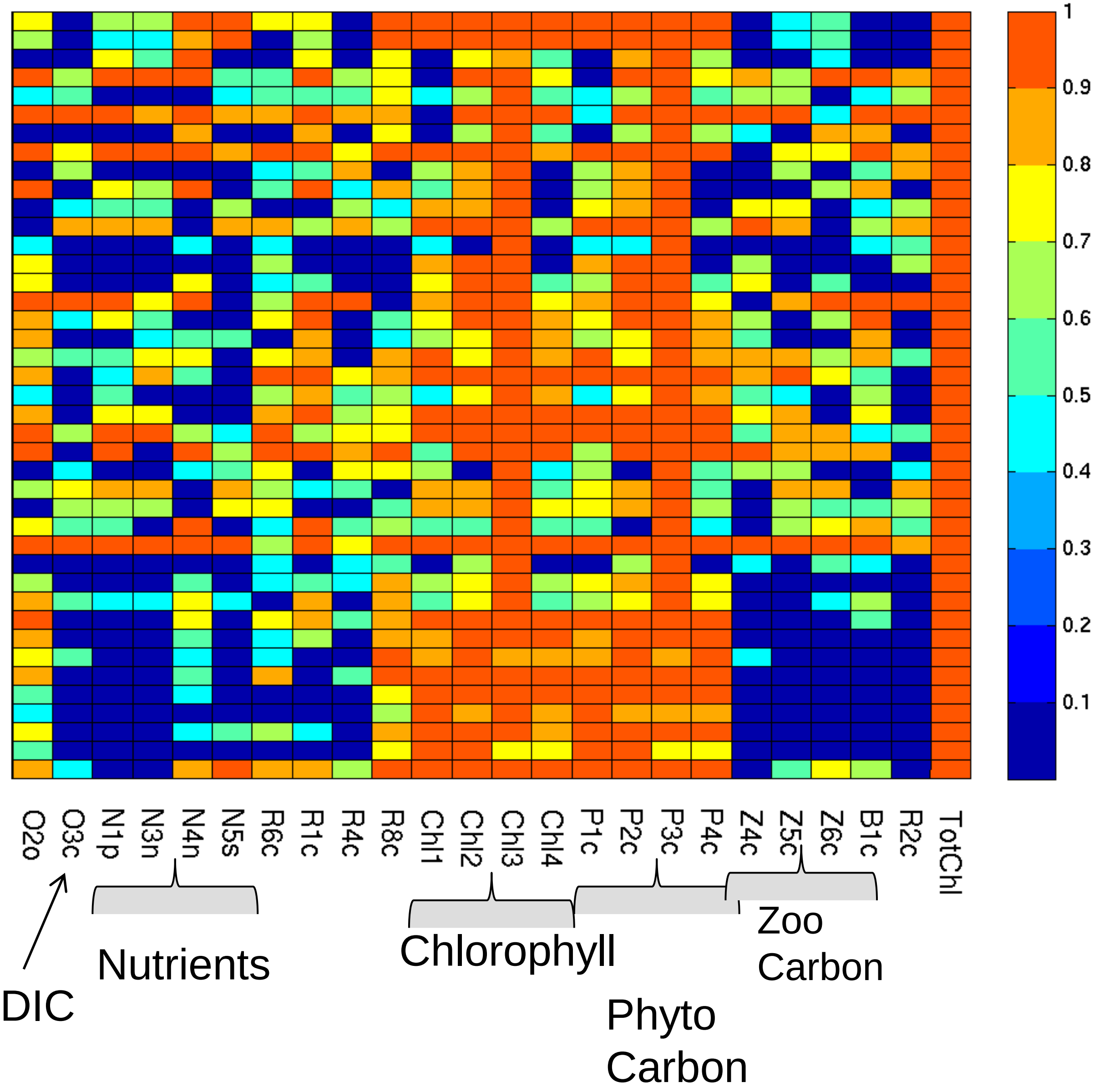
Captures autumn blooms

Non-assimilated variables

Chlorophyll [mg/m³]



Correlations Total chl vs variables [surface]

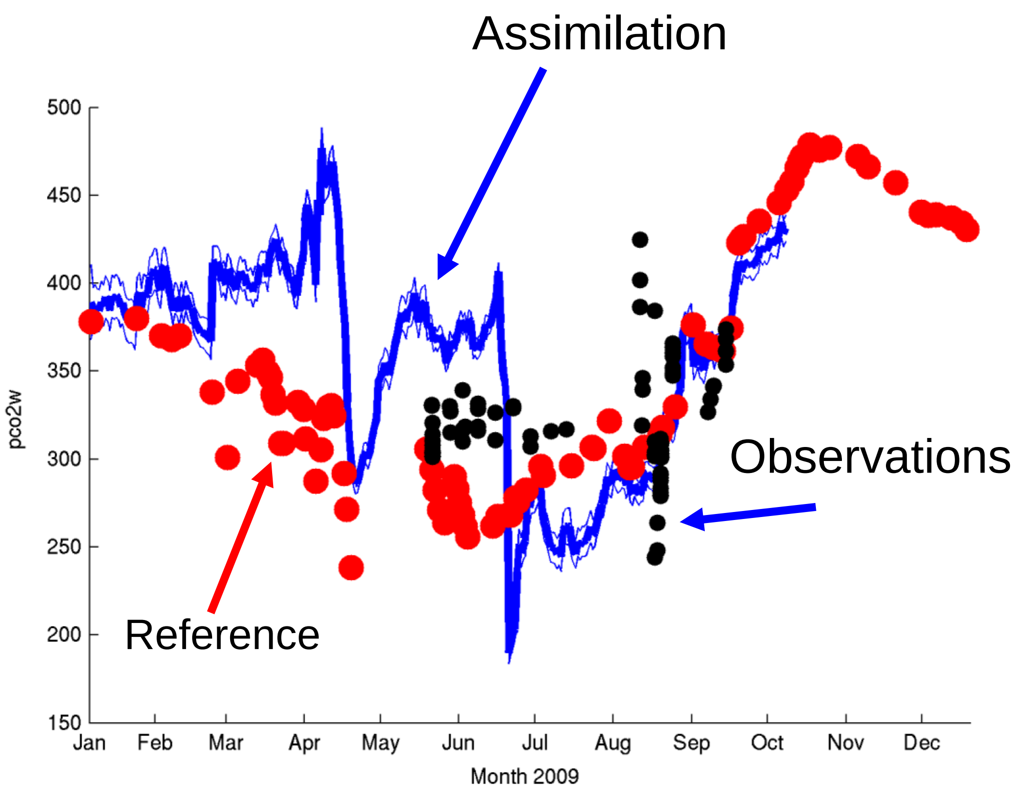


PML | Plymouth Marine Laboratory

Chl-a assimilation Experiment

Effect on pCO_2

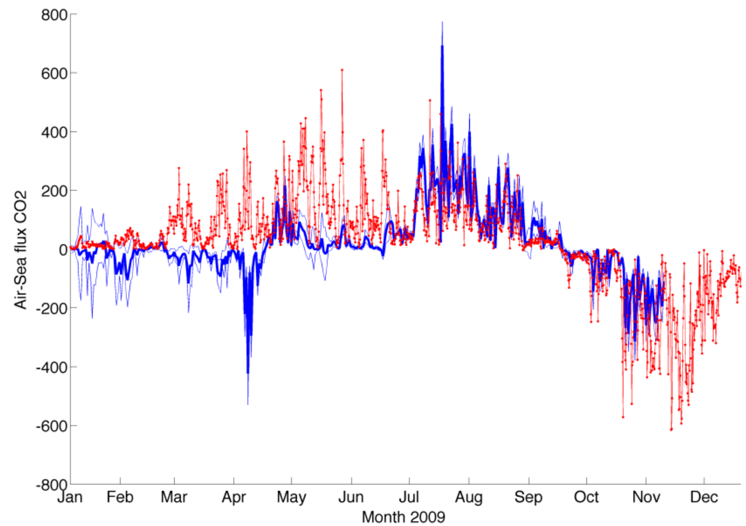
0.22 → 0.30

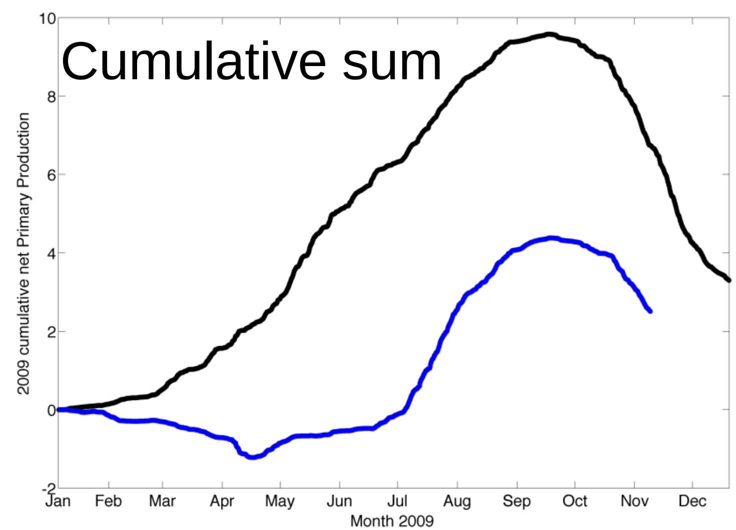


Reduces winter blooms

Captures autumn blooms

Air-Sea flux pCO_2



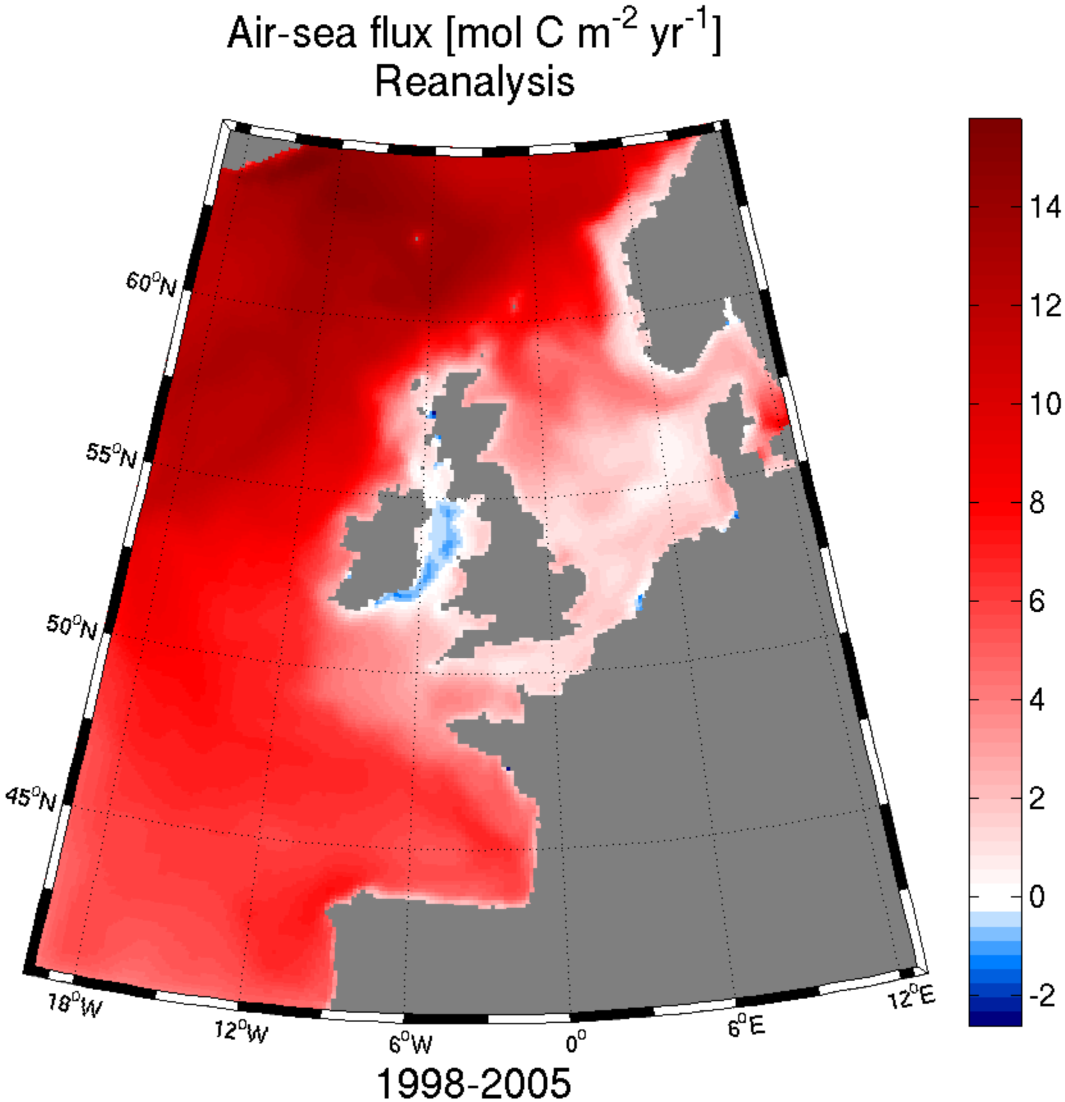


Chl-a assimilation Experiment

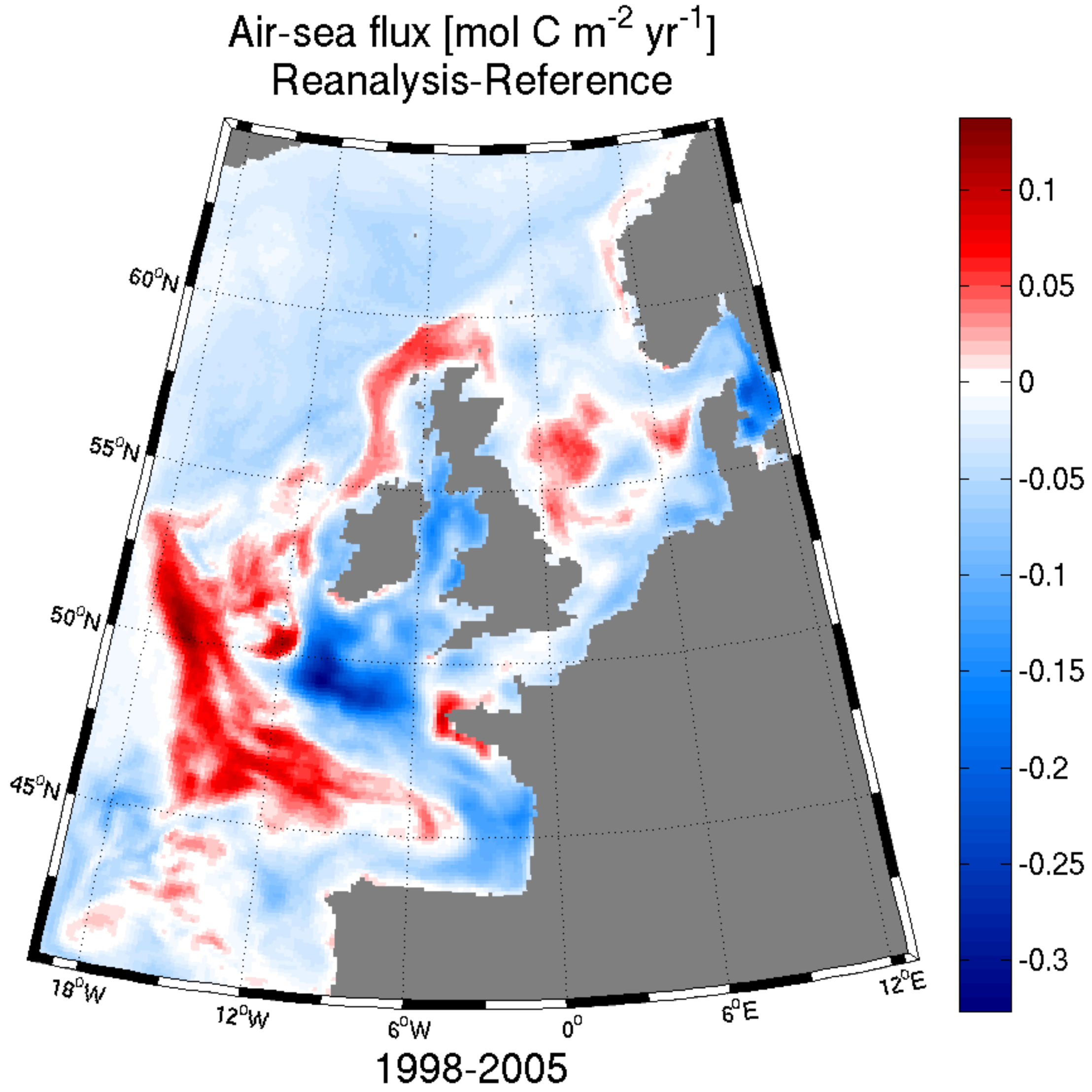
Variable	Correlation	Correlation Assim
Total Chlorophyll	0.24	**0.33**
Silicates	0.56	**0.6**
Nitrate	0.75	0.75
Phosphate	0.84	0.85
pH	0.22	**0.13**
DIC	0.14	**0.44**
pco2	0.22	**0.3**

Chl-a assimilation 3D

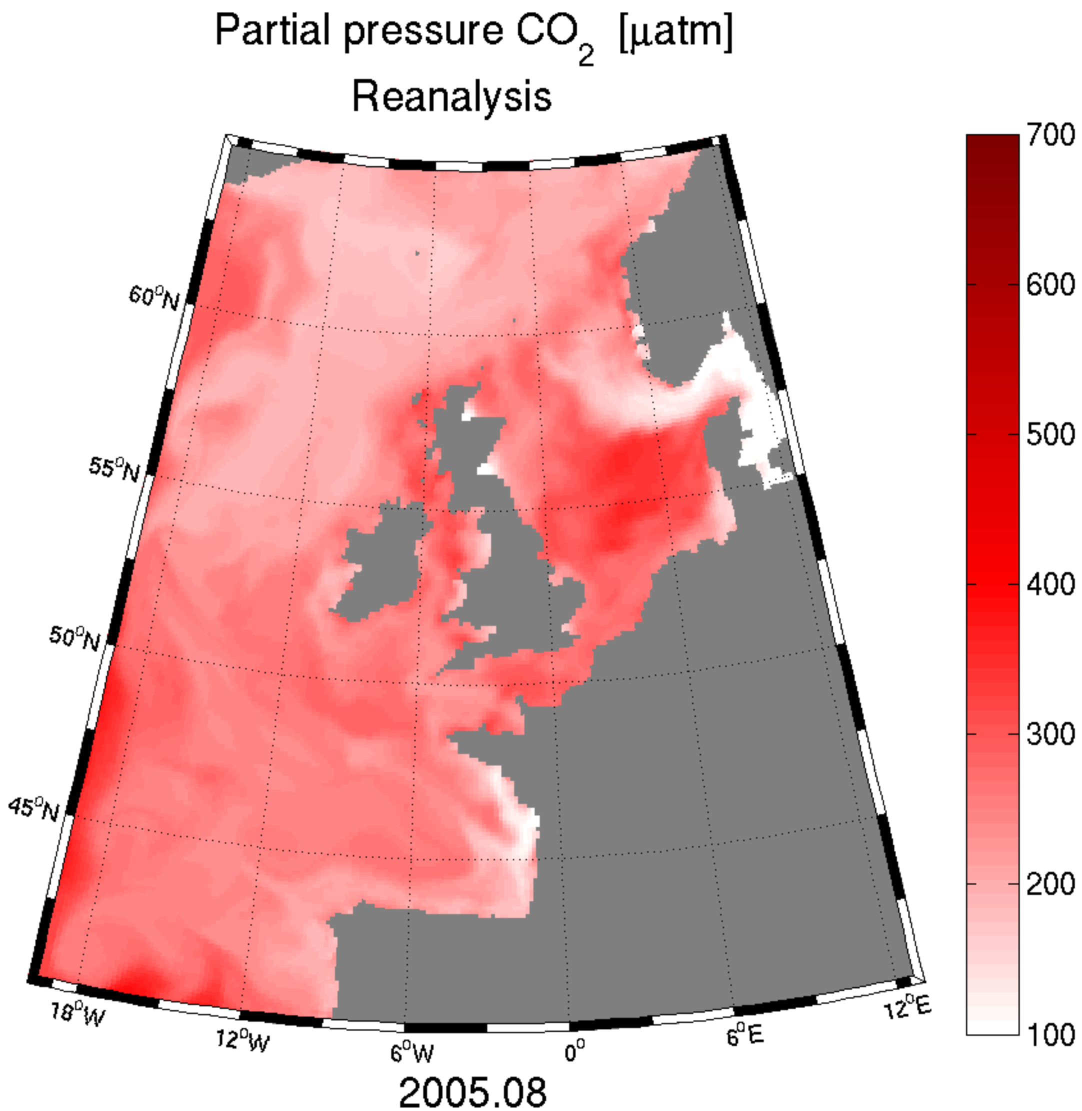
Monthly Chla assimilation



Chl-a assimilation 3D



Chl-a assimilation 3D



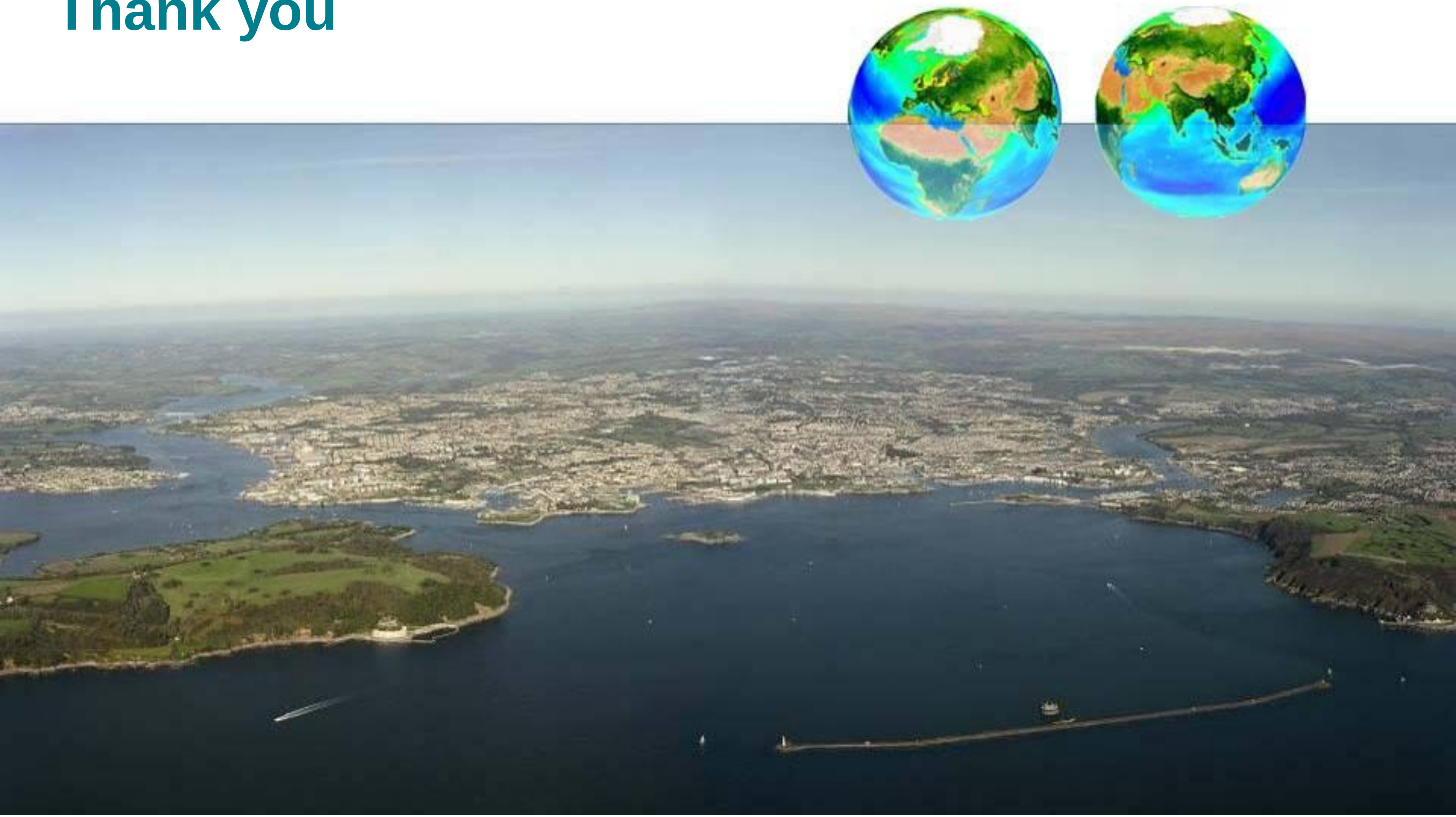
Conclusions

- Chla assimilation can improve simulations system-wide
- Improvements in Total Chla cascade to carbonate system variables
- This results in a significant change in the Air-Sea fluxes, specially at times of high production

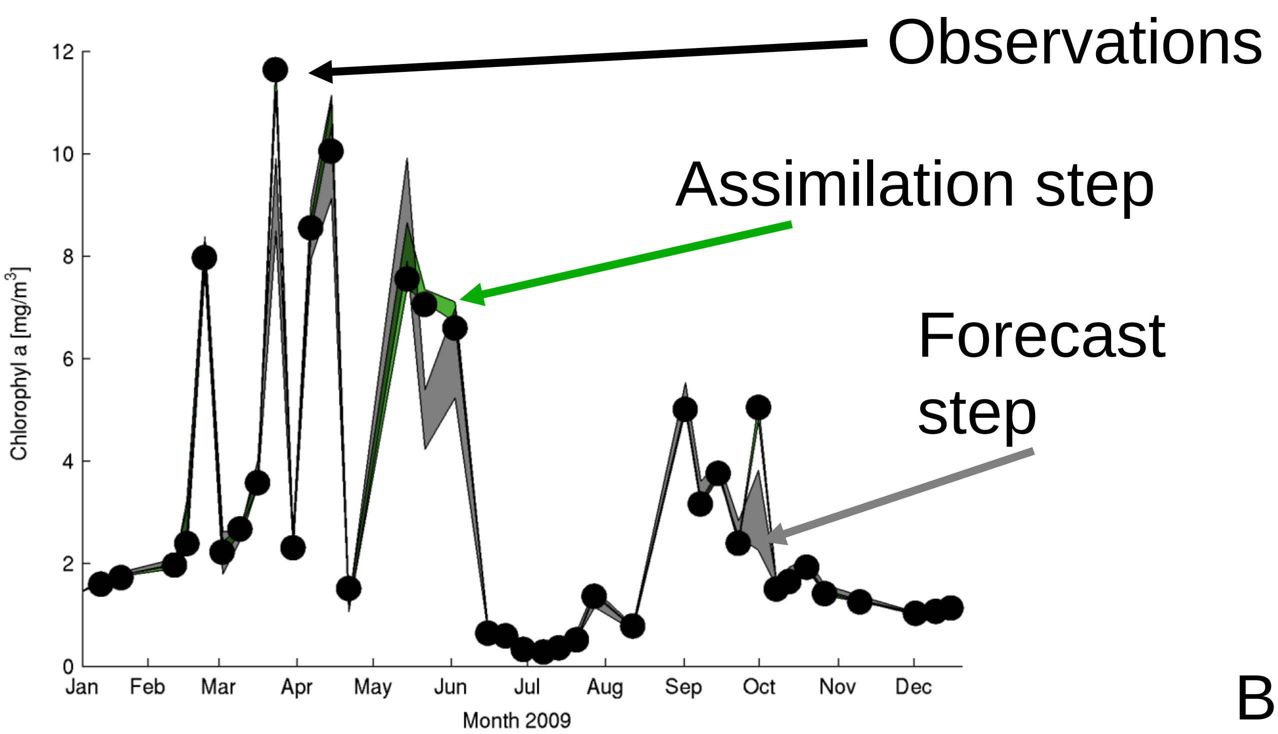
Future Work

- Introduce seasonality in SPM at L4 in model
- Model evaluation against zooplankton data
- Perform more sensitivity analysis to covariance matrix
- Assimilate on different years (2009 to 2010)
- Remove sub-daily observations from correlations.

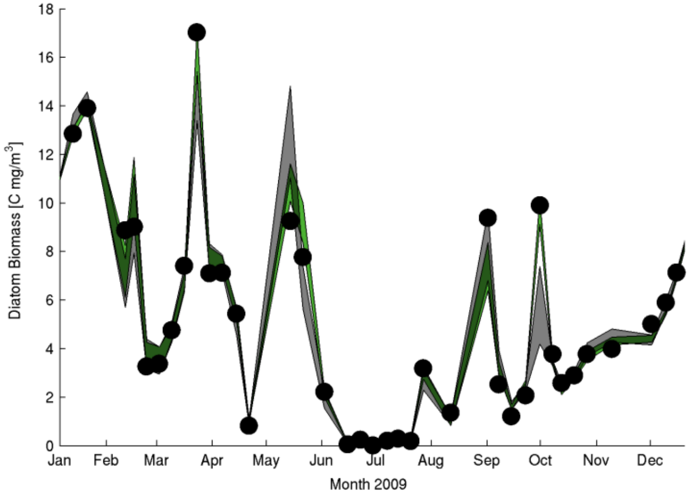
Thank you



Twin Experiment simulation

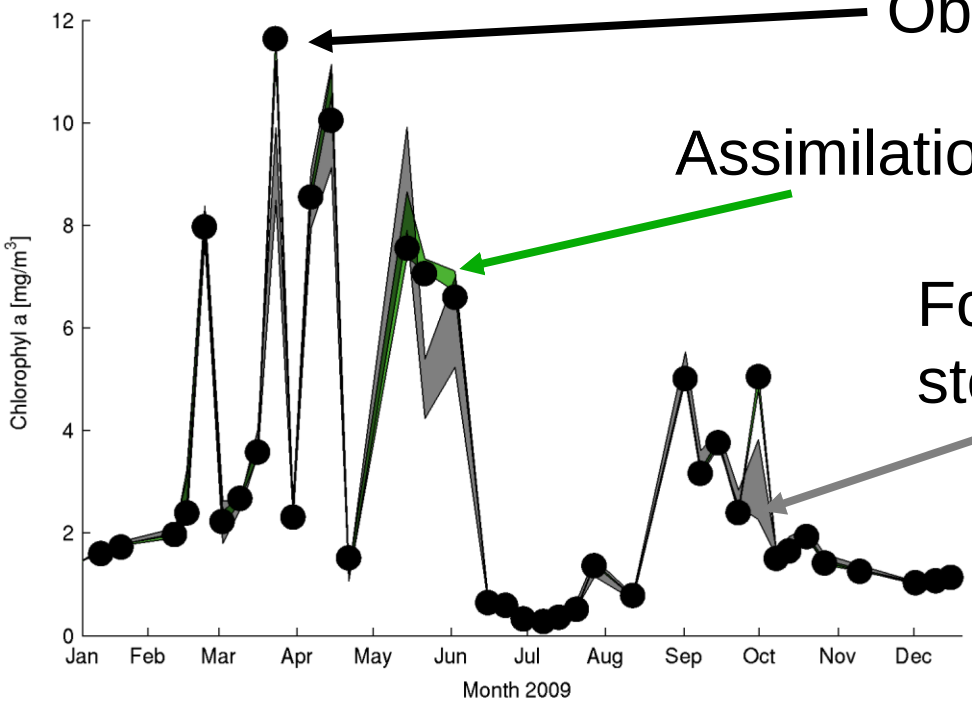


Biomass corrected

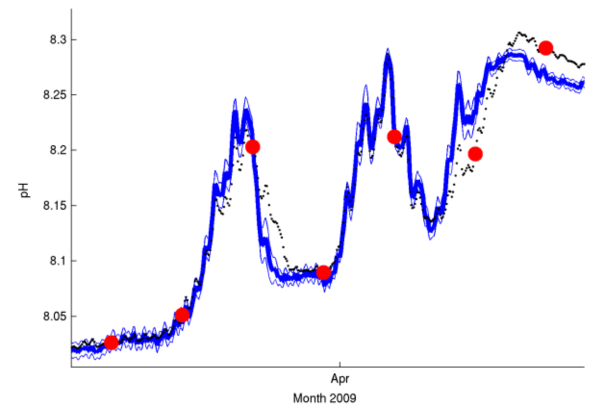


Shaded area represents mean ± one standard deviation

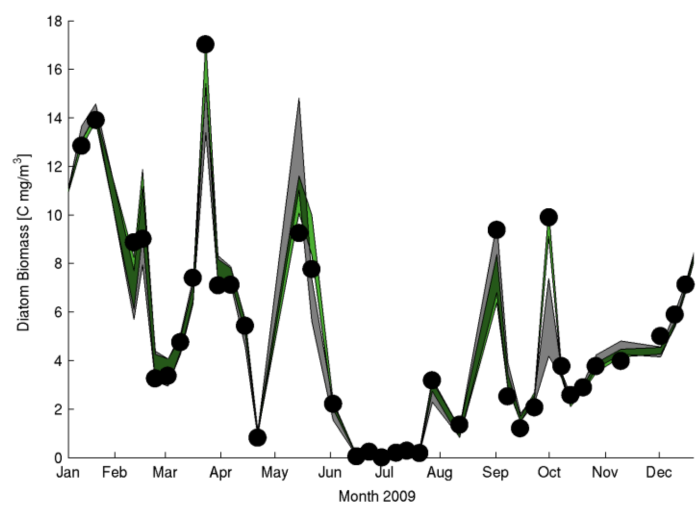
Twin Experiment simulation



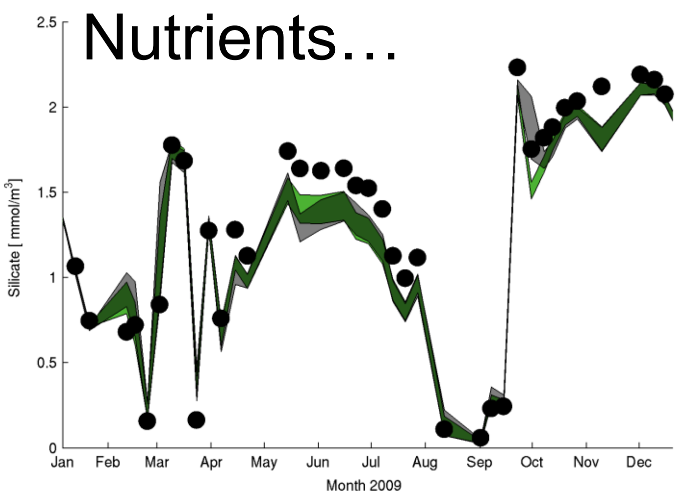
pH

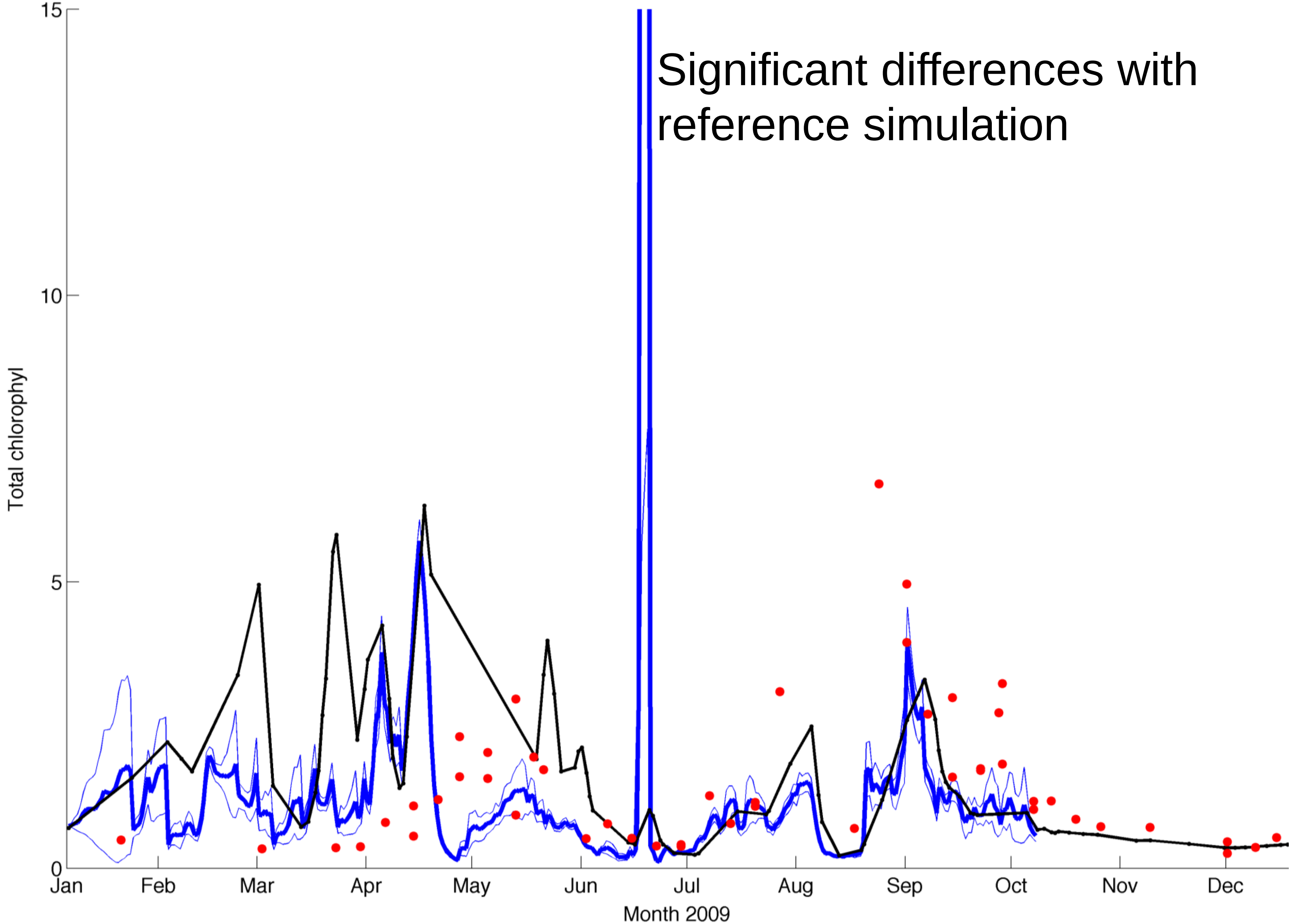


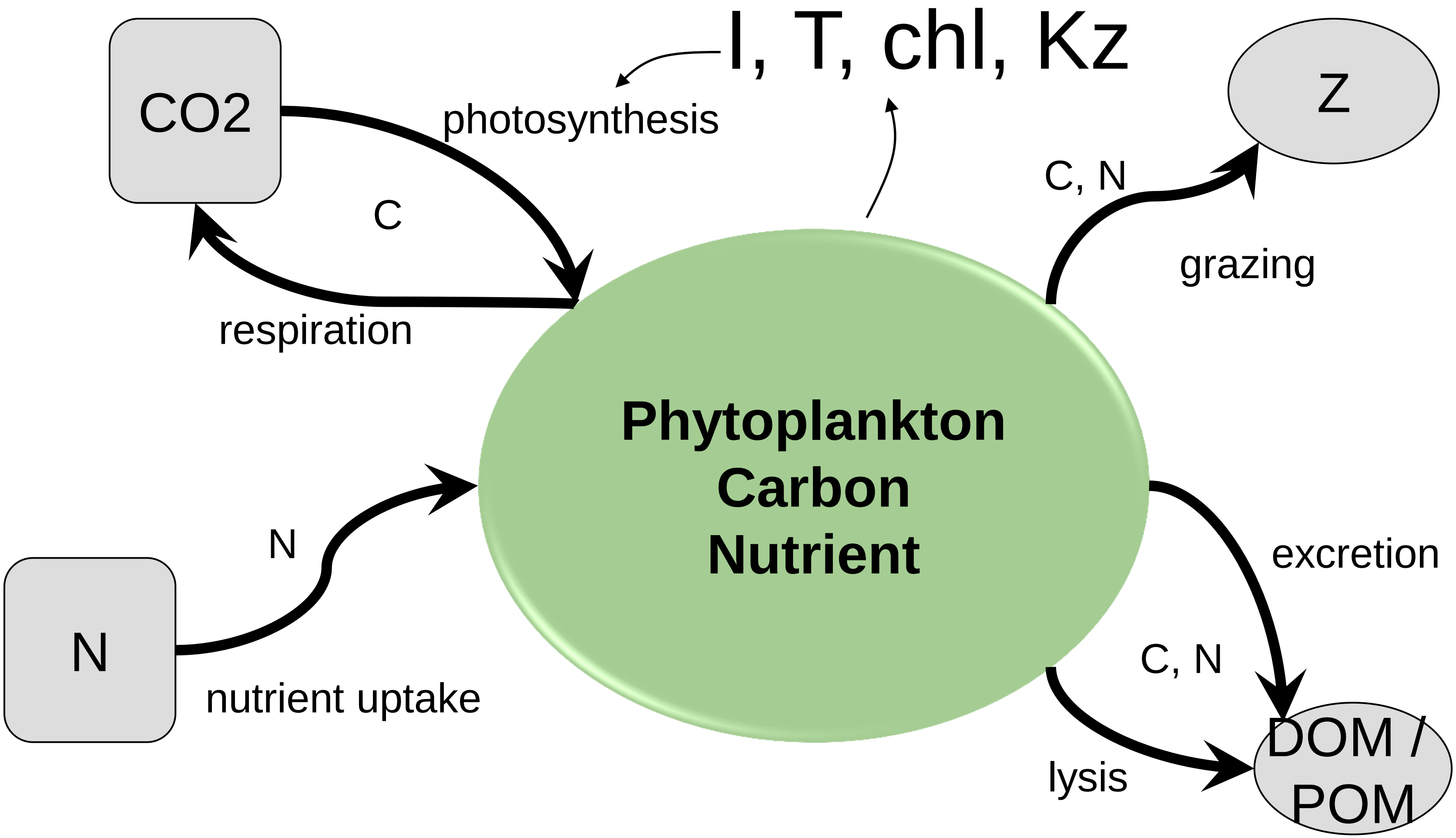
Biomass corrected



Nutrients…



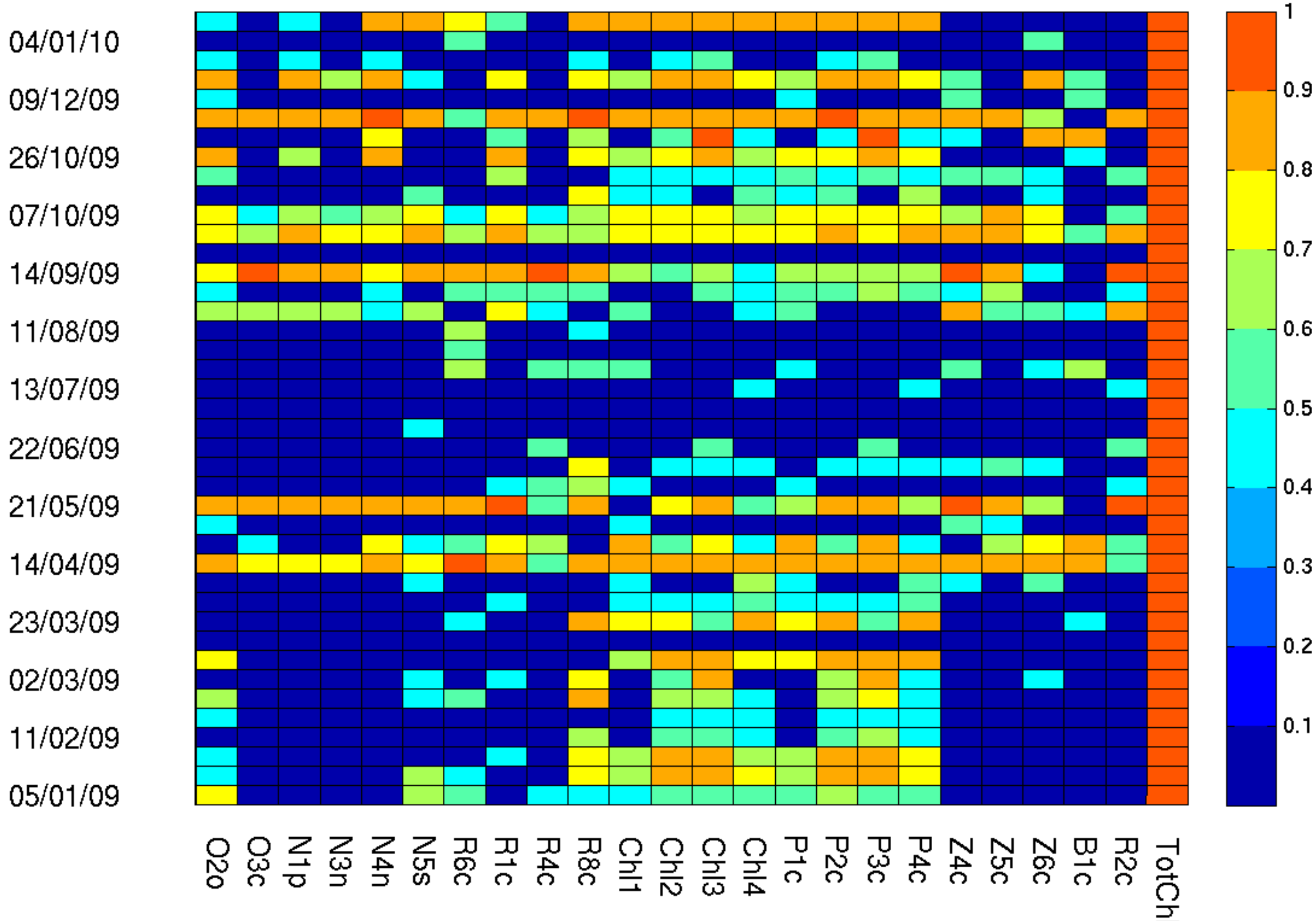

Significant differences with reference simulation
Total chlorophyl
15
10
5
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month 2009

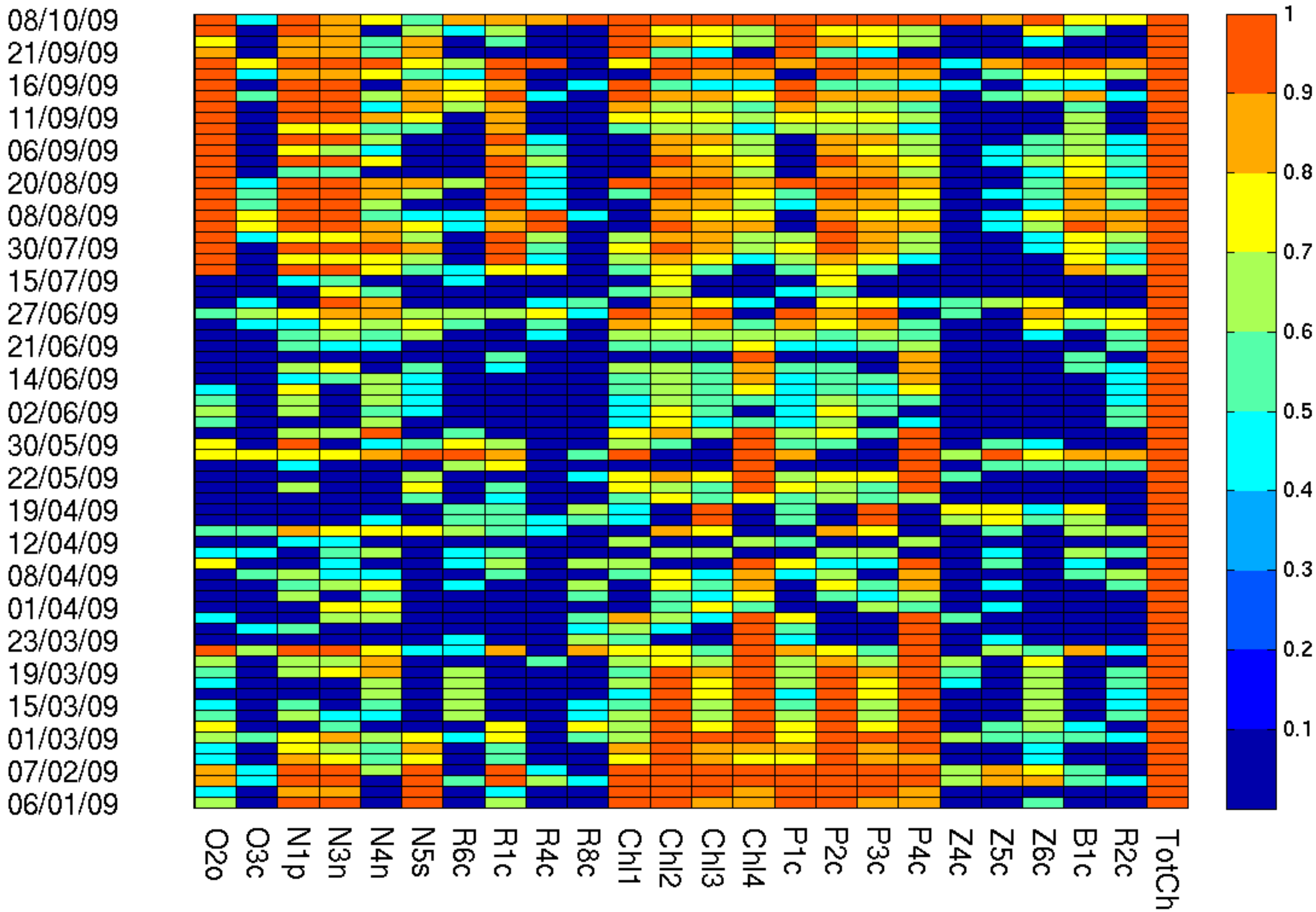


$$\frac{dC}{dt} = \text{photosynthesis} - \text{respiration} - \text{excretion} - \text{lysis} - \text{grazing}$$

$$\frac{dN}{dt} = \text{nutrient uptake} - \text{excretion} - \text{lysis} - \text{grazing}$$

Twin Experiment simulation




08/10/09
21/09/09
16/09/09
11/09/09
06/09/09
20/08/09
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30/07/09
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27/06/09
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14/06/09
02/06/09
30/05/09
22/05/09
19/04/09
12/04/09
08/04/09
01/04/09
23/03/09
19/03/09
15/03/09
01/03/09
07/02/09
06/01/09
O2o
O3c
N1p
N3n
N4n
N5s
R6c
R1c
R4c
R8c
Chl1
Chl2
Chl3
Chl4
P1c
P2c
P3c
P4c
Z4c
Z5c
Z6c
B1c
R2c
TotChl
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

Model setup

- Boundary region between coastal and open-shelf
- Straddles biogeographical provinces;
- Considerable fluctuation of flora and fauna over the past century;
- Easily accessible from PML (within 30 km)