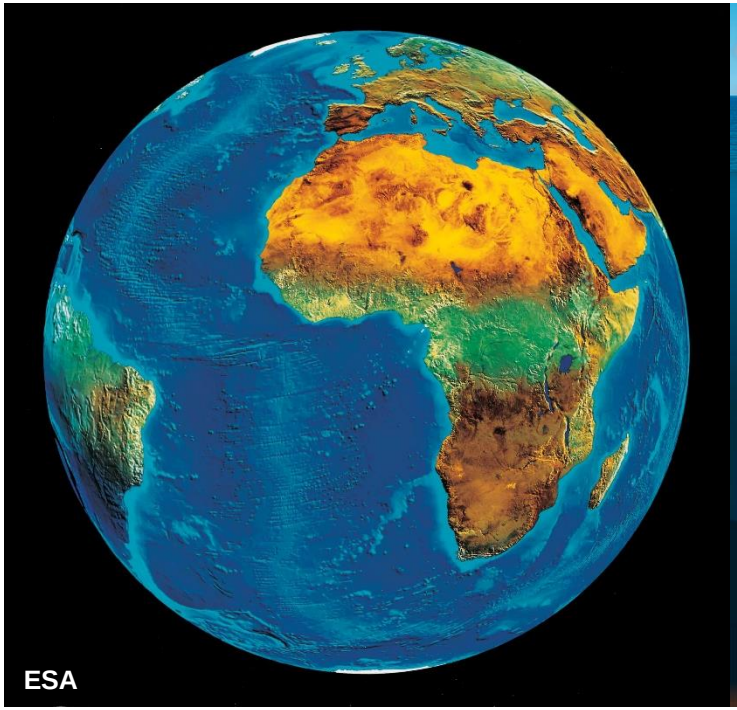
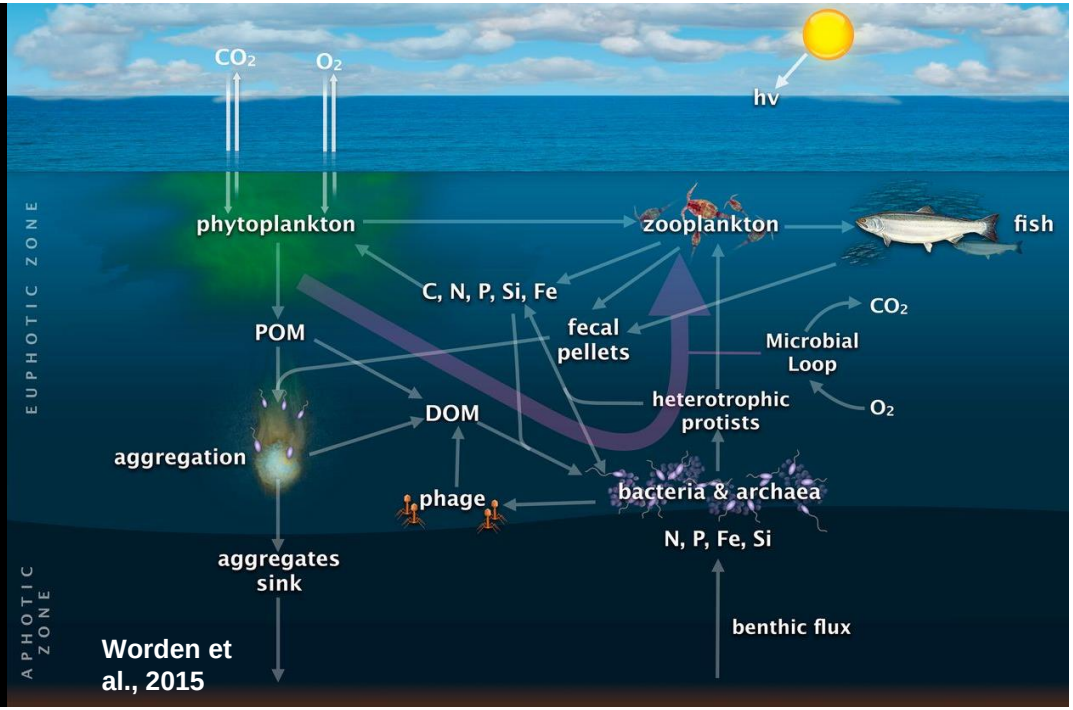
CMEMS Primary production from satellite remote sensing: spatial and temporal evolution and comparison with other products

Marine Bretagnon, Philippe Garnesson, Antoine Mangin

marine.bretagnon@acri-st.fr

Context





Primary production:

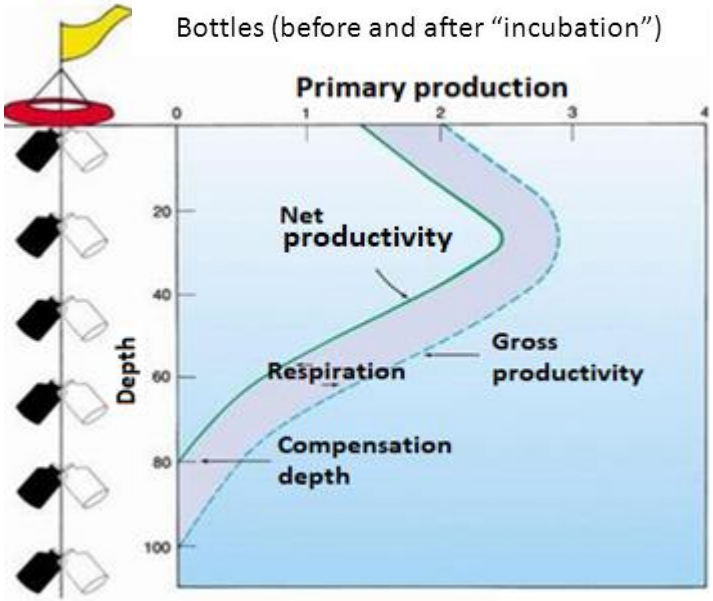
- Taken up about 50% of anthropogenic CO_2 emission
- Constitute the basis of marine food web

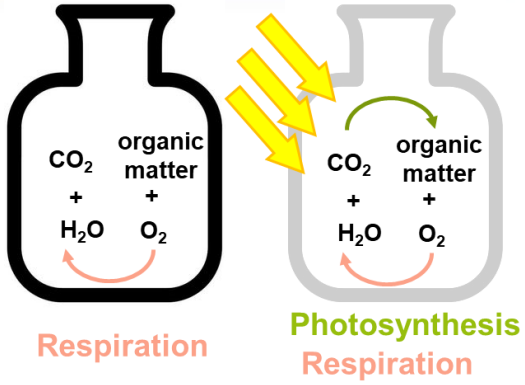
Primary Production Observations

Light and Dark Bottle Method;

Measure dissolved oxygen in the

Bottles (before and after "incubation")





***In situ* measurements**

Different protocols used (^{14}C incubation, oxygen incubation, etc…)

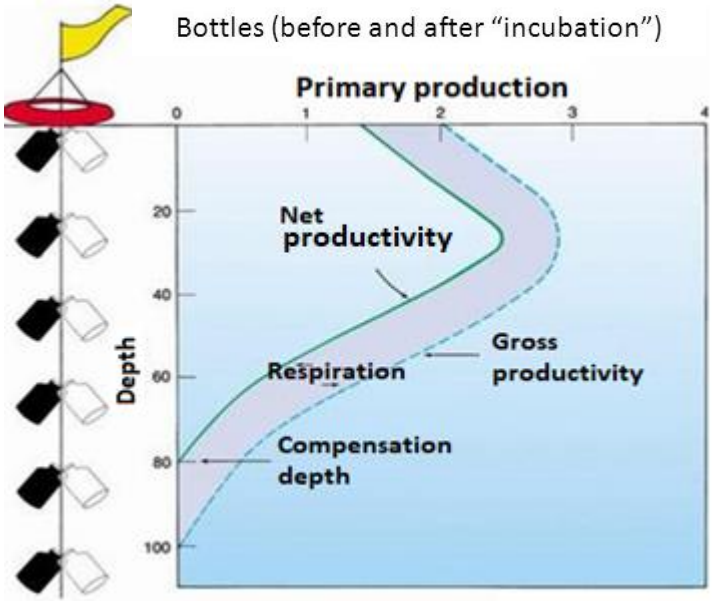
Costing and scattered measurement

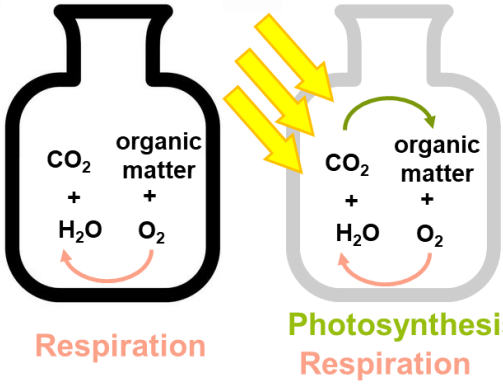
Primary Production Observations

Light and Dark Bottle Method;

Measure dissolved oxygen in the

Bottles (before and after "incubation")

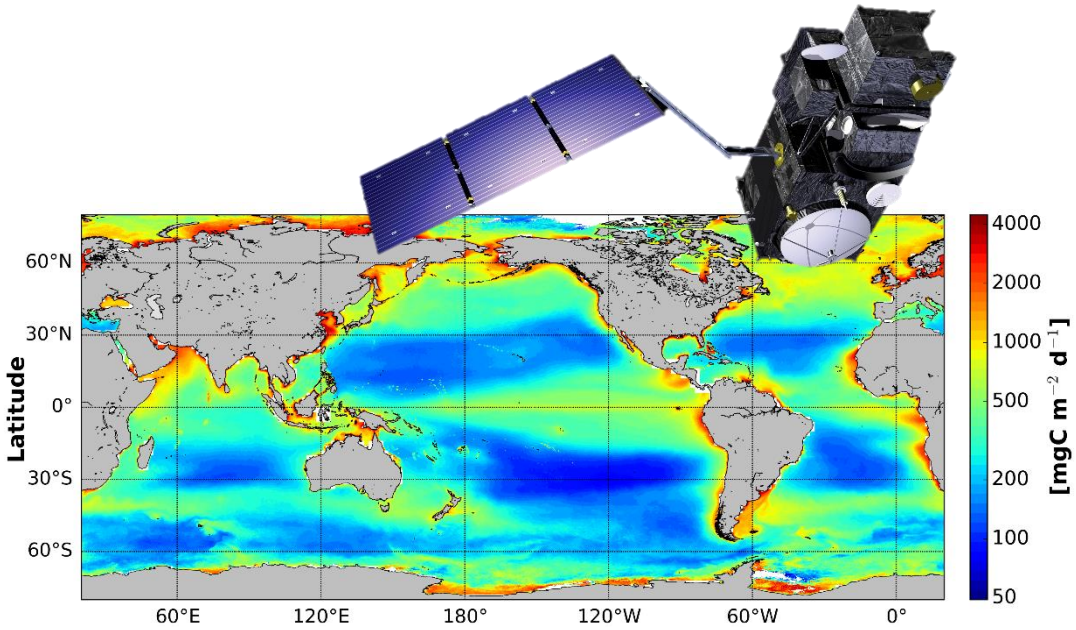




Respiration

Photosynthesis

Respiration



$$P(z,t,\lambda) = 12 * chl(z,t) * a^*(z,t,\lambda) * PAR(z,t,\lambda) * \phi(z,t,\lambda)$$

Energy absorbed by algae

Transformation efficiency of energy into carbon

Satellite observations:

- Palliate the scarcity of in situ measurements
- Offer 21 years of archive

➢ Antoine and Morel 1996 algorithm used

Primary Production Observations

Implemented by Mercator Ocean International as part of the Copernicus Programme

Copernicus Europe's eyes on Earth | Copernicus Marine Service

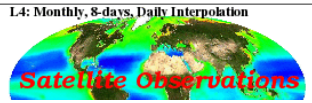
Home | User Corner | Contact Us

Access your ocean information | OCEAN PRODUCTS | OCEAN MONITORING INDICATORS | OCEAN STATE REPORT | 0 | Hello, Sign in

OCEANCOLOUR_GLO_CHL_L4_NRT_OBSERVATIONS_009_033

GLOBAL OCEAN CHLOROPHYLL (COPERNICUS-GLOBCOLOUR) FROM SATELLITE OBSERVATIONS - NEAR REAL TIME

OBSERVATION	L4	GLO
CHL PP		
4 km x 4 km (Surface only)		
From 2016-04-25 to Present		
monthly-mean,daily-mean		

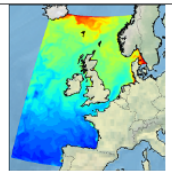


MORE INFO | ADD TO CART | WMS

NORTHWESTSHELF_REANALYSIS_BIO_004_011

ATLANTIC- EUROPEAN NORTH WEST SHELF- OCEAN BIOGEOCHEMISTRY REANALYSIS

MODEL	✖ ✖ ✖ ✖ ● ✖	NWS
CHL PHYC O2 NO3 PO4 SPCO2 PH PP KD		
0.067 degree x 0.111 degree (24 depth levels)		
From 1998-01-01 to 2018-12-30		
daily-mean monthly-mean		

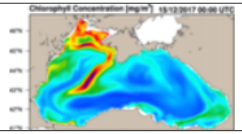


Sub-setting

BLKSEA_REANALYSIS_BIO_007_005

BLACK SEA BIOGEOCHEMISTRY HINDCAST

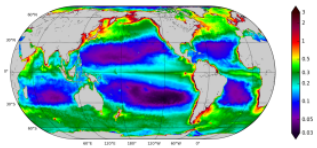
MODEL	✖ ✖ ✖ ✖ ✖ ✖	BS



GLOBAL_ANALYSIS_FORECAST_BIO_001_028

GLOBAL OCEAN BIOGEOCHEMISTRY ANALYSIS AND FORECAST

MODEL	✖ ✖ ✖ ✖ ● ✖	GLO
CHL PHYC O2 NO3 PO4 SI FE SPCO2 PH PP		
0.25 degree x 0.25 degree (50 depth levels)		
From 2018-04-01 to Present		
daily-mean,monthly-mean		

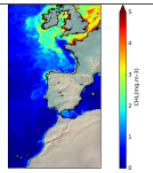


MORE INFO | ADD TO CART | WMS | Sub-setting

IBI_ANALYSIS_FORECAST_BIO_005_004

ATLANTIC-IBERIAN BISCAY IRISH- OCEAN BIOGEOCHEMICAL ANALYSIS AND FORECAST

MODEL	✖ ✖ ✖ ✖ ✖ ✖	IBI
CHL PHYC O2 NO3 PO4 SI FE NH4 SPCO2 PH PP ZEU		
0.028 degree x 0.028 degree (50 depth levels)		
From 2018-04-01 to Present		
daily-mean,monthly-mean		

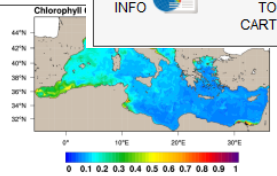


MORE INFO | ADD TO CART | WMS | Sub-setting

MEDSEA_ANALYSIS_FORECAST_BIO_006_014

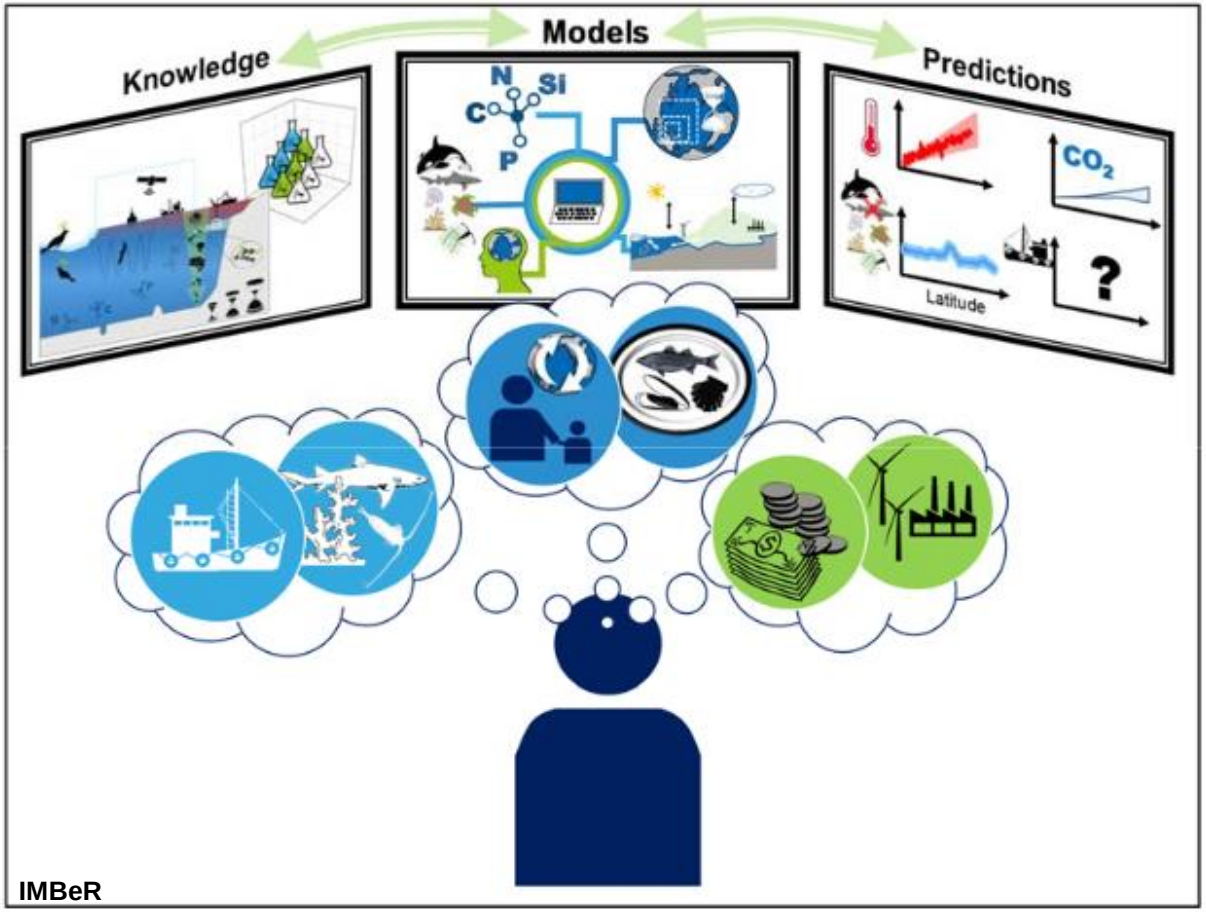
MEDITERRANEAN SEA BIOGEOCHEMISTRY ANALYSIS AND FORECAST

MODEL	✖ ✖ ✖ ✖ ● ●	
CHL PHYC O2 NO3 PO4 SPCO2 PH FGCO2 PP		
0.042 degree x 0.042 degree (125 depth levels)		
From 2020-05-05 to Present		
daily-mean,monthly-mean		

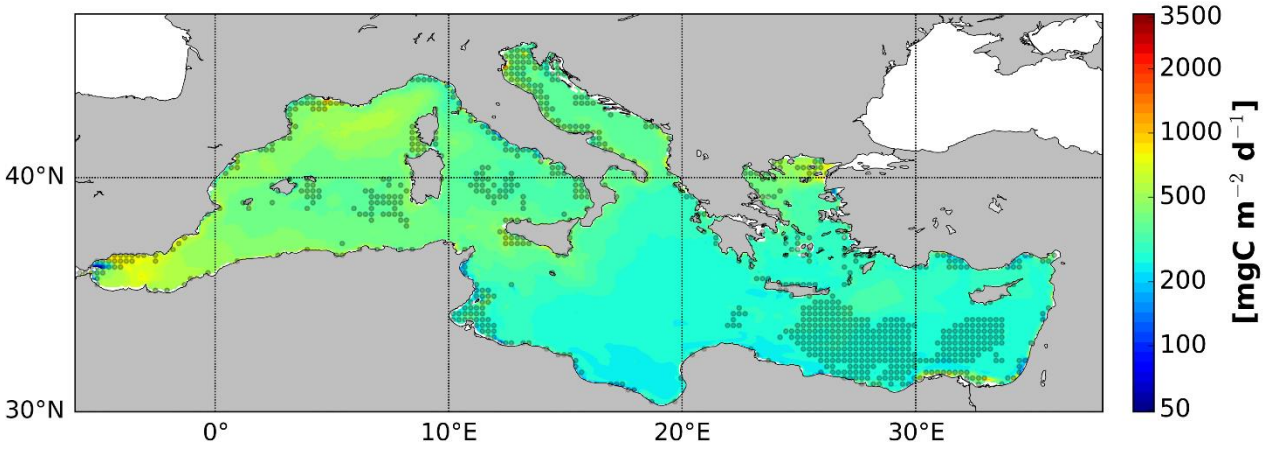


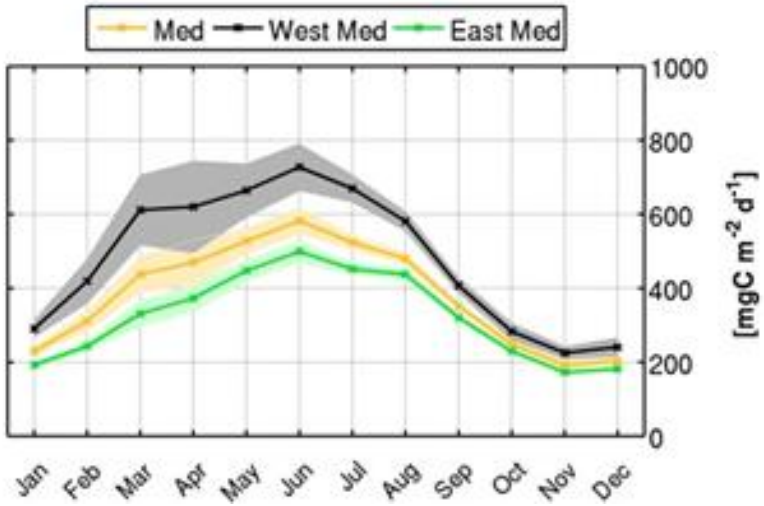
MORE INFO | ADD TO CART | WMS | Sub-setting

Methods complementarity



Mediterranean Sea

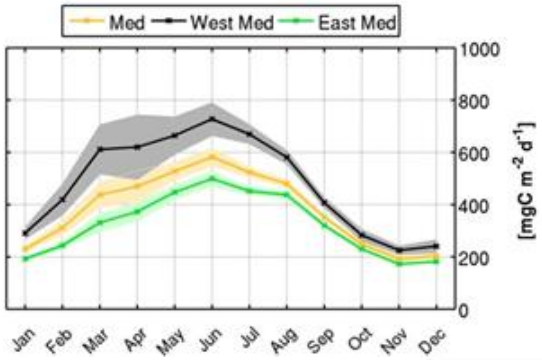


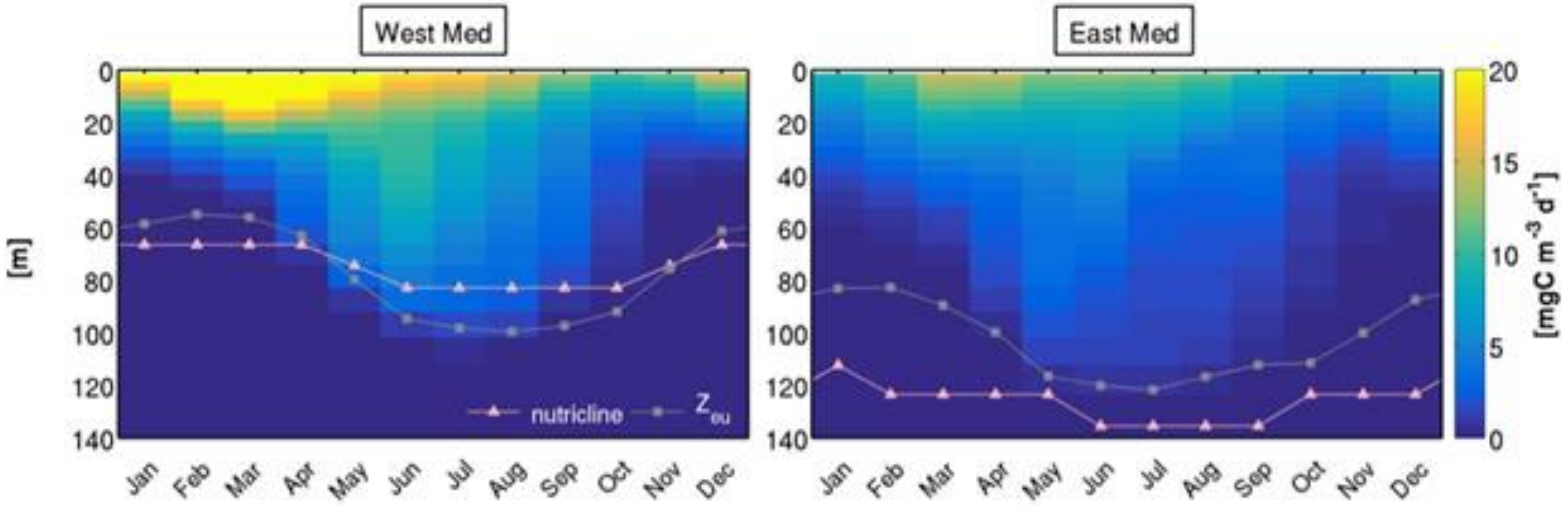


- Most of the discrepancies occurred in oligotrophic waters
- Seasonal cycle roughly equivalent for both estimates

Cossarini et al., 2020 OSR#4

Mediterranean Sea





- The west-to-east decreasing gradient partly explained by nutricline position relatively to the euphotic depth
- Modulation of primary production follows the nutricline vertical displacement

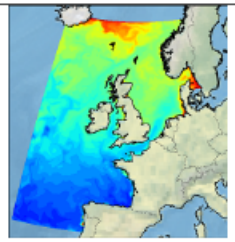
Cossarini et al., 2020 OSR#4

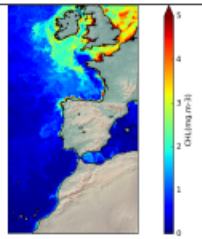
Atlantic Ocean

Model

PISCES + IBI

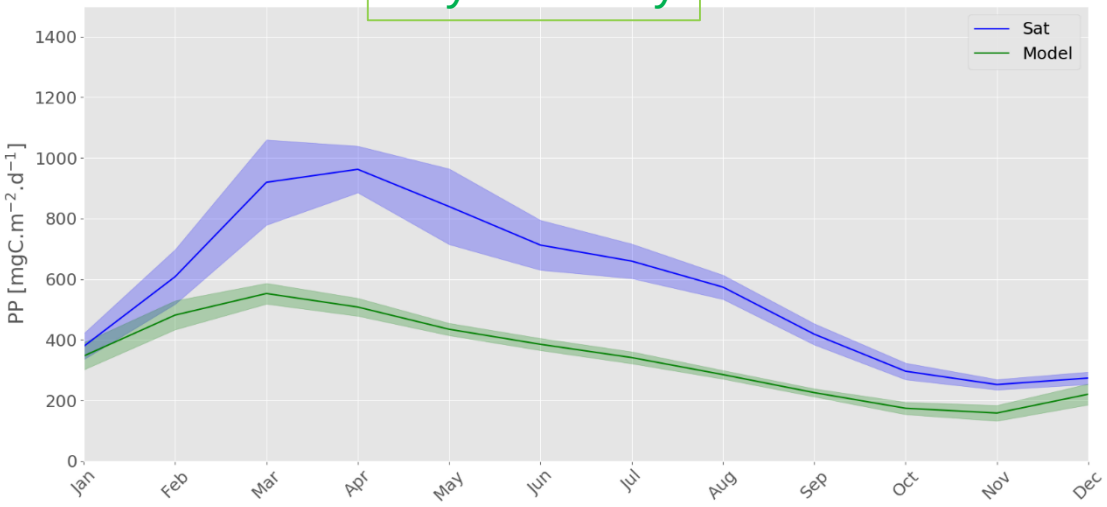
PISCES + ERSEM

NORTHWESTSHELF_REANALYSIS_BIO_004_011		
ATLANTIC- EUROPEAN NORTH WEST SHELF- OCEAN BIOGEOCHEMISTRY REANALYSIS		
MODEL		NWS
CHL PHYC O2 NO3 PO4 SPCO2 PH PP KD ⓘ		
0.067 degree x 0.111 degree (24 depth levels)		
From 1998-01-01 to 2018-12-30		
daily-mean,monthly-mean		
MORE INFO ADD TO CART WMS Sub-setting		

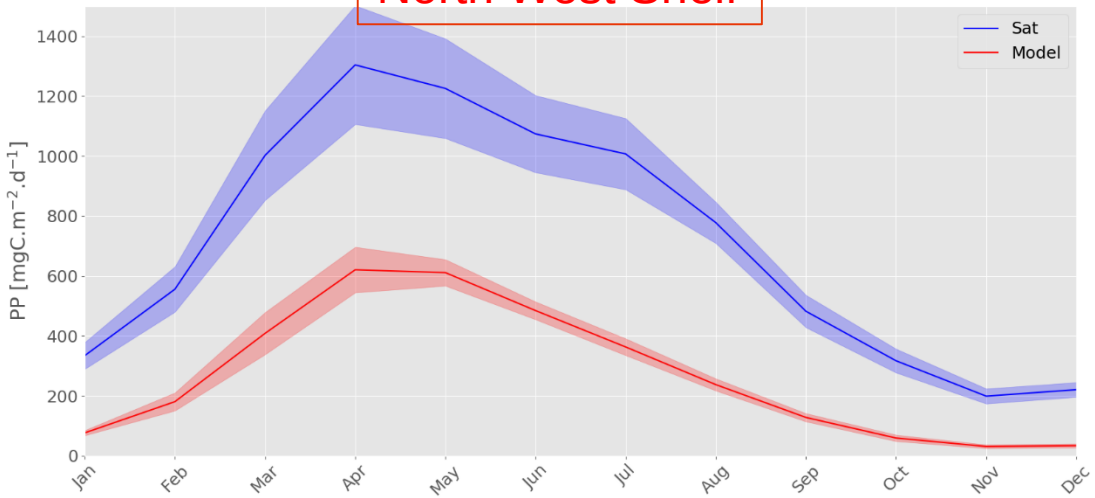
IBI_ANALYSIS_FORECAST_BIO_005_004		
ATLANTIC-IBERIAN BISCAY IRISH- OCEAN BIOGEOCHEMICAL ANALYSIS AND FORECAST		
MODEL		IBI
CHL PHYC O2 NO3 PO4 SI FE NH4 SPCO2 PH PP ZEU ⓘ		
0.028 degree x 0.028 degree (50 depth levels)		
From 2018-04-01 to Present		
daily-mean,monthly-mean		
MORE INFO ADD TO CART WMS Sub-setting		

Atlantic Ocean – Seasonal cycle

Bay of Biscay



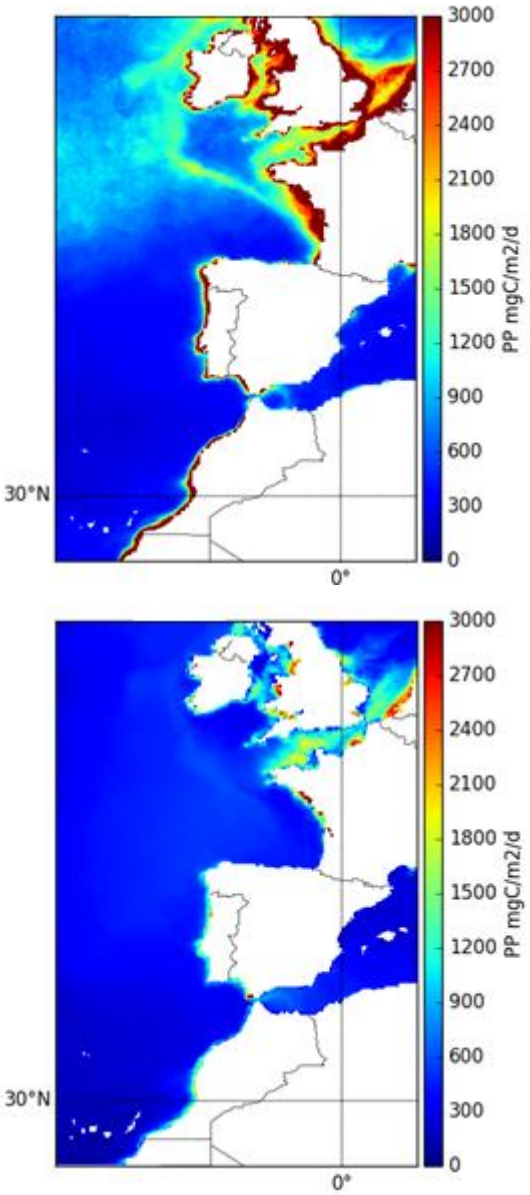
North West Shelf



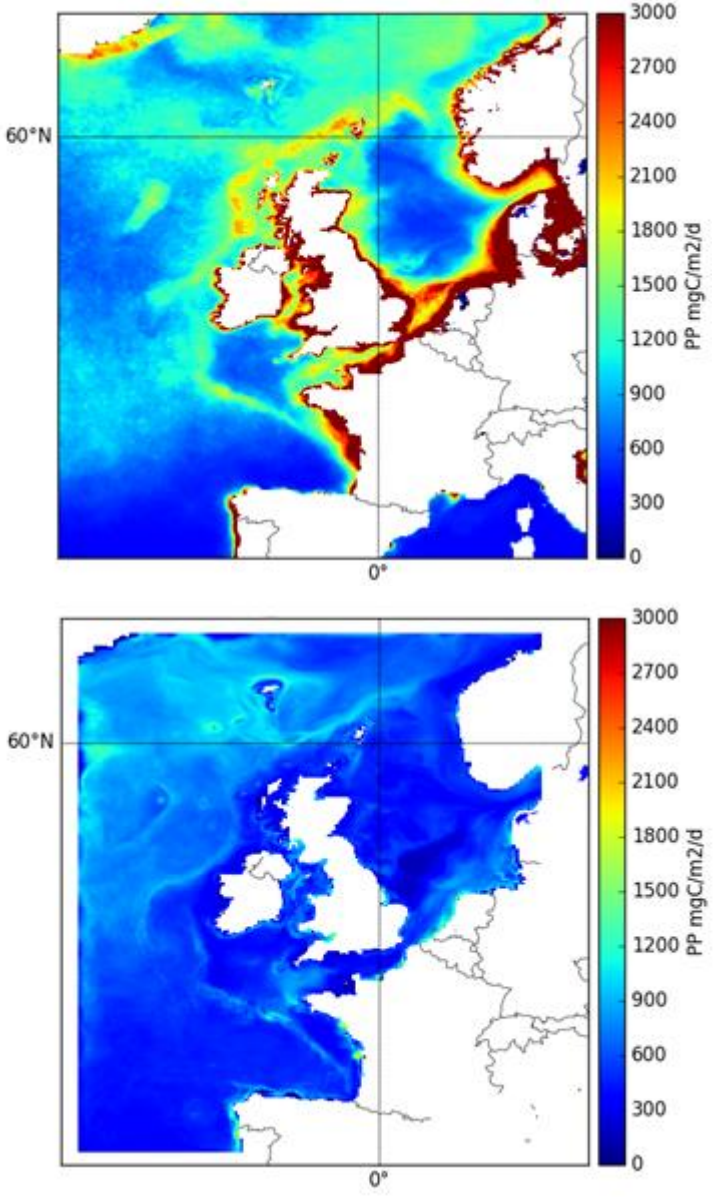
Seasonal cycle in phase but discrepancy of intensity for both model

Atlantic Ocean

Bay of Biscay



North West Shelf

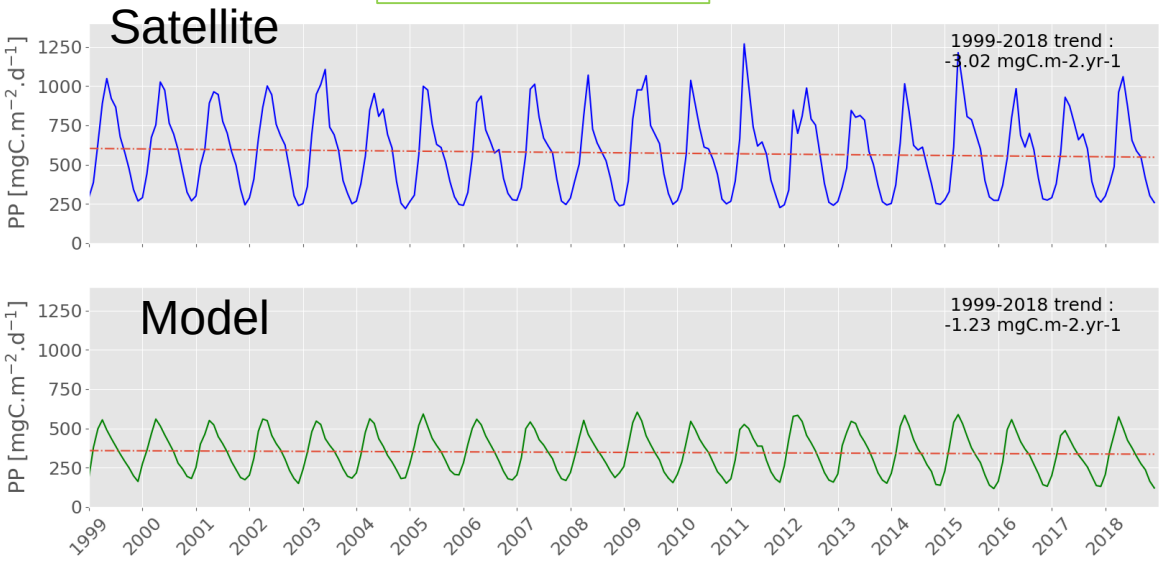


Satellite

Model

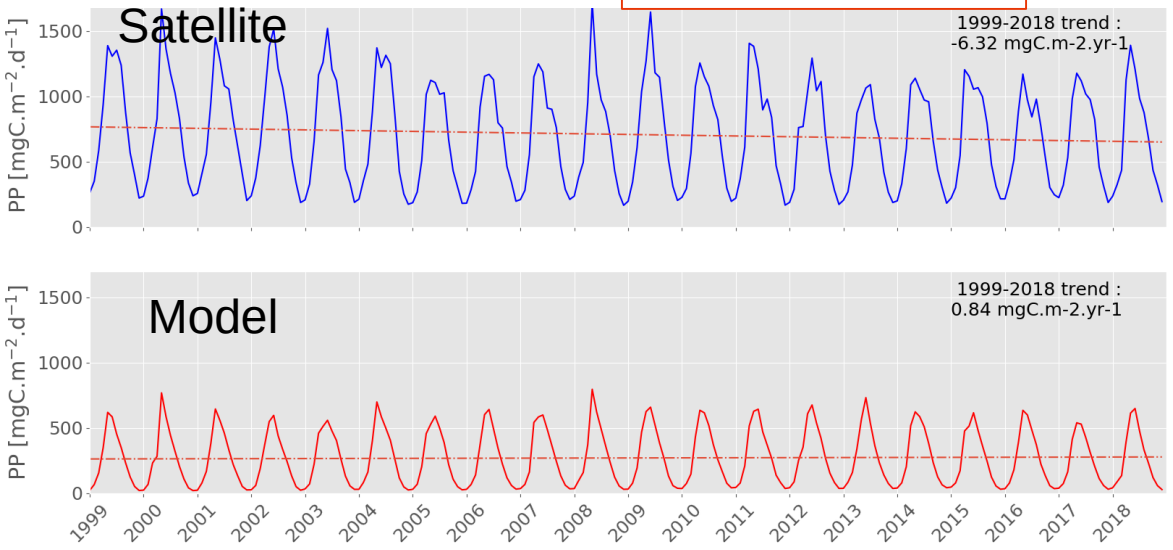
Atlantic Ocean – Primary Production trends

Bay of Biscay



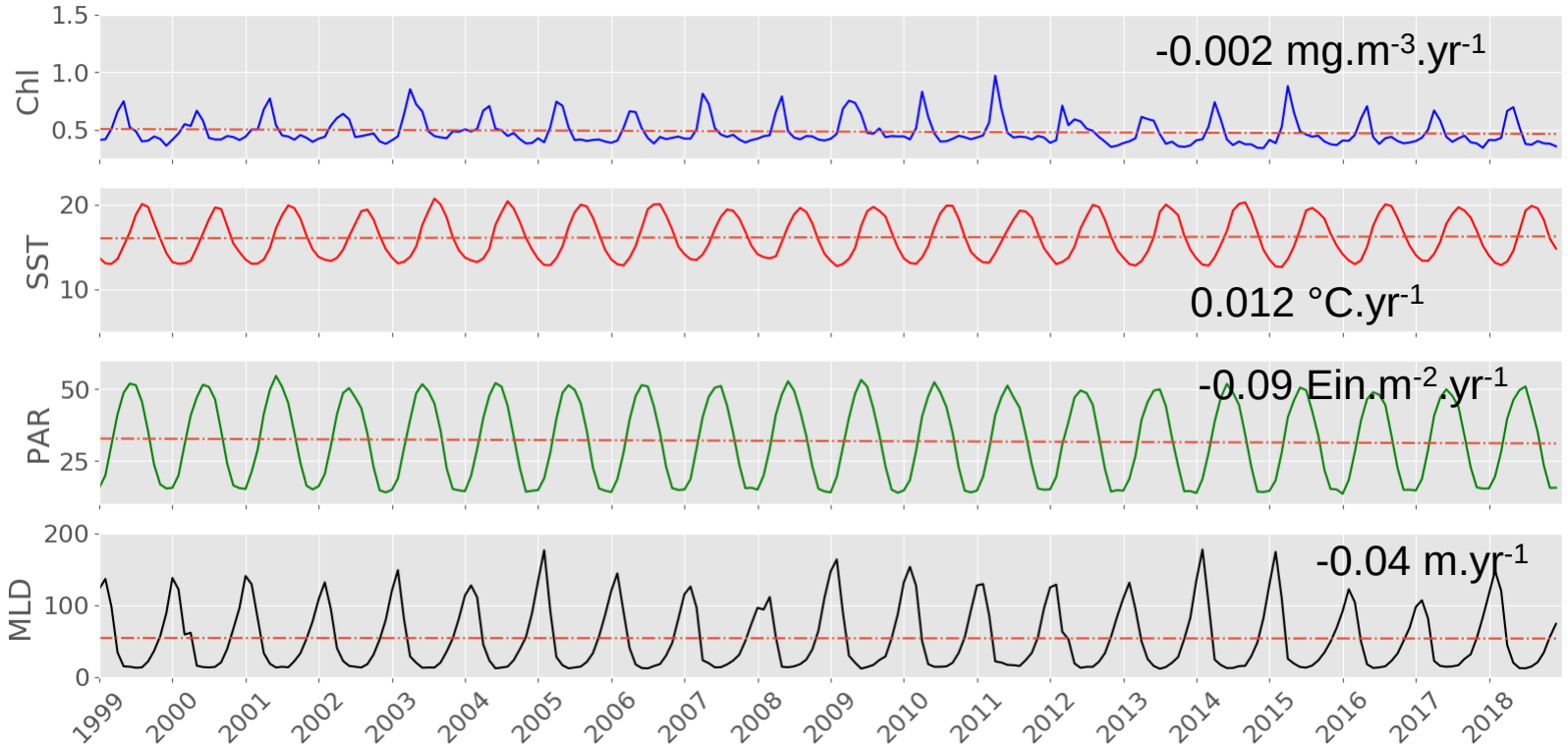
PP decrease comprise between 20.4 and 24.6 mgC.m^{-2} over the archive

North West Shelf



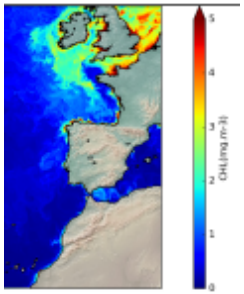
Reverse trend over the archive for satellite and model.

Atlantic Ocean – Trend for the Bay of Biscay

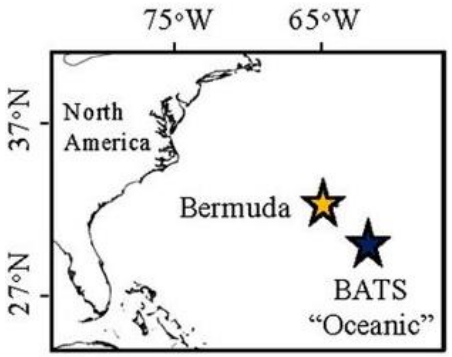


Over the 20 years archive:

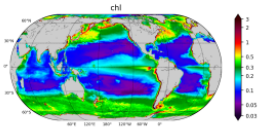
- Biomass ↓
- Temperature ↑
- Light ↓
- Mixed layer depth ↓

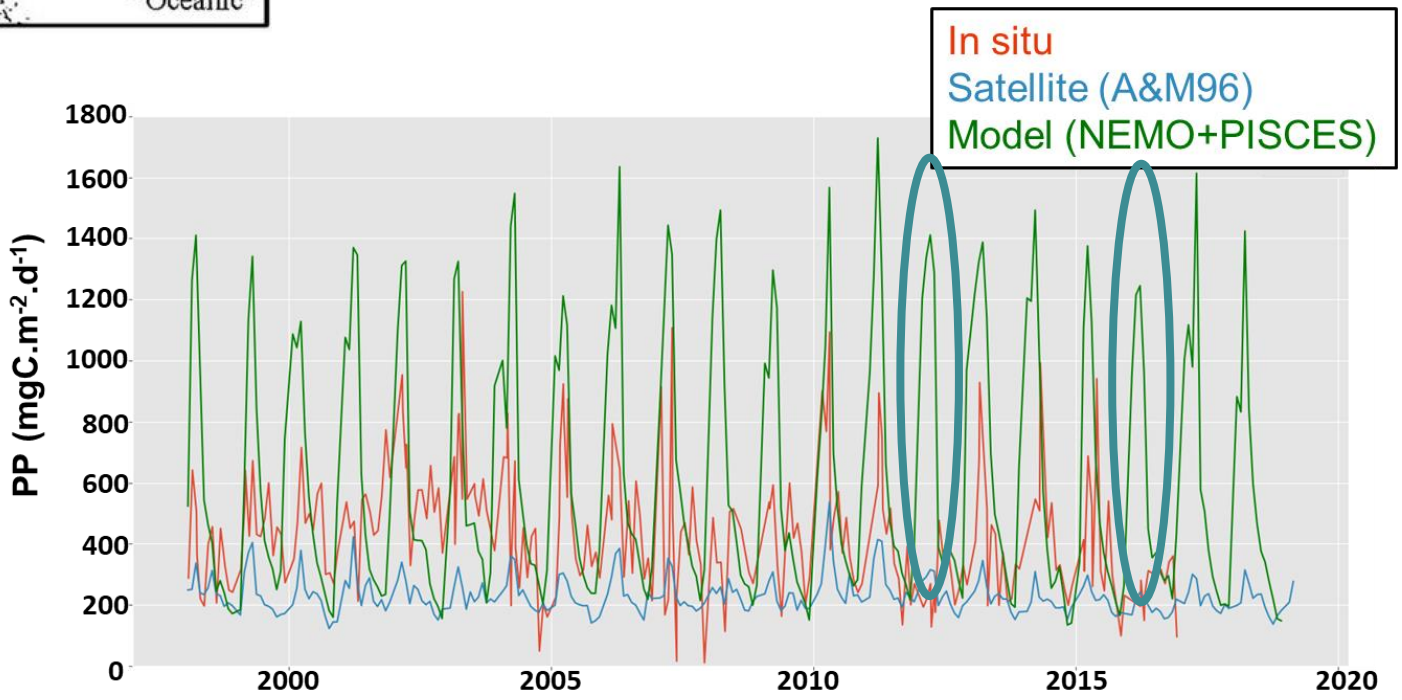


Global Ocean – comparison with in situ



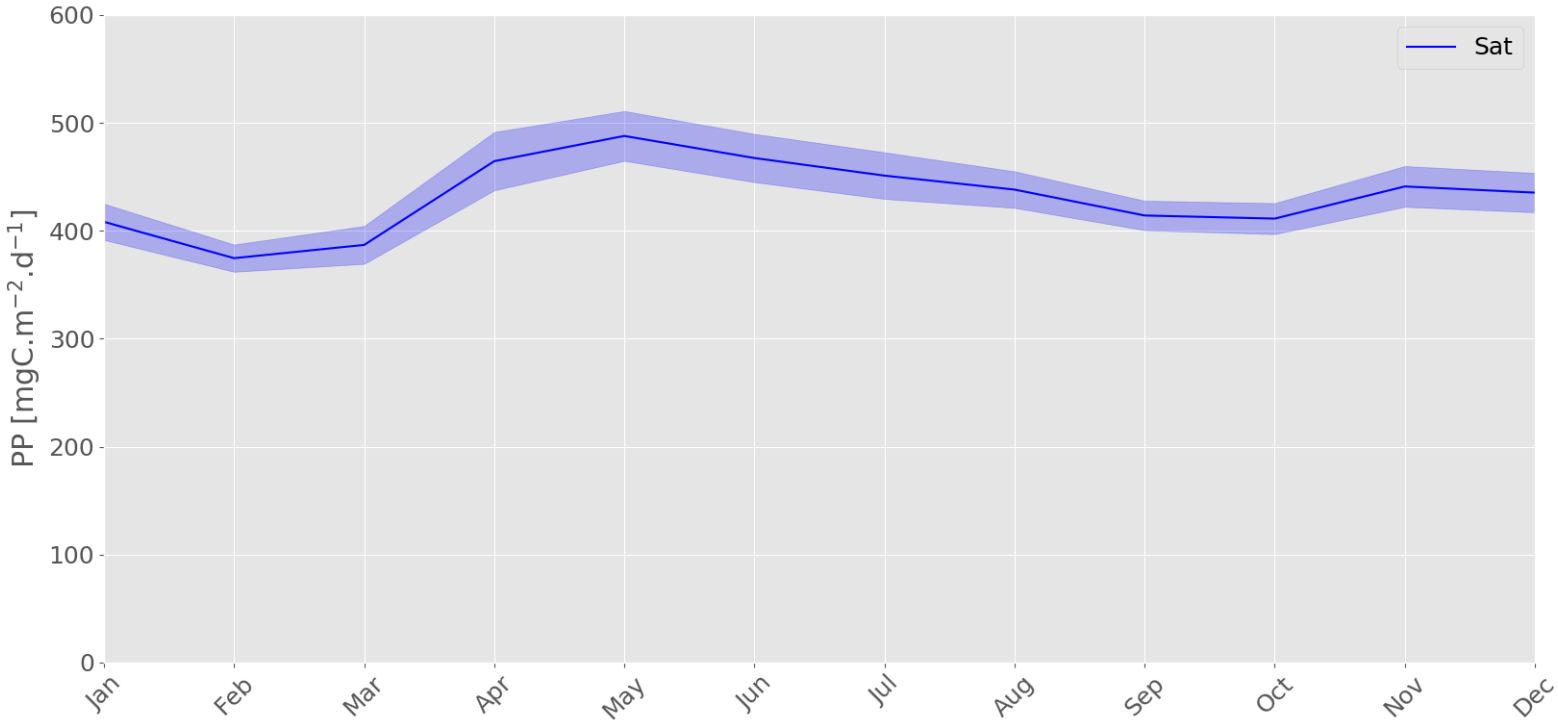
NEMO-PISCES model

GLOBAL_REANALYSIS_BIO_001_029		
GLOBAL OCEAN BIOGEOCHEMISTRY HINDCAST		
MODEL	X X X X X X	GLO
CHL PHYC O2 NO3 PO4 SI FE SPCO2 PH PP		
0.25 degree x 0.25 degree (75 depth levels)		
From 1993-01-01 to 2018-12-25		
daily-mean,monthly-mean		
MORE INFO ADD TO CART WMS Sub-setting		



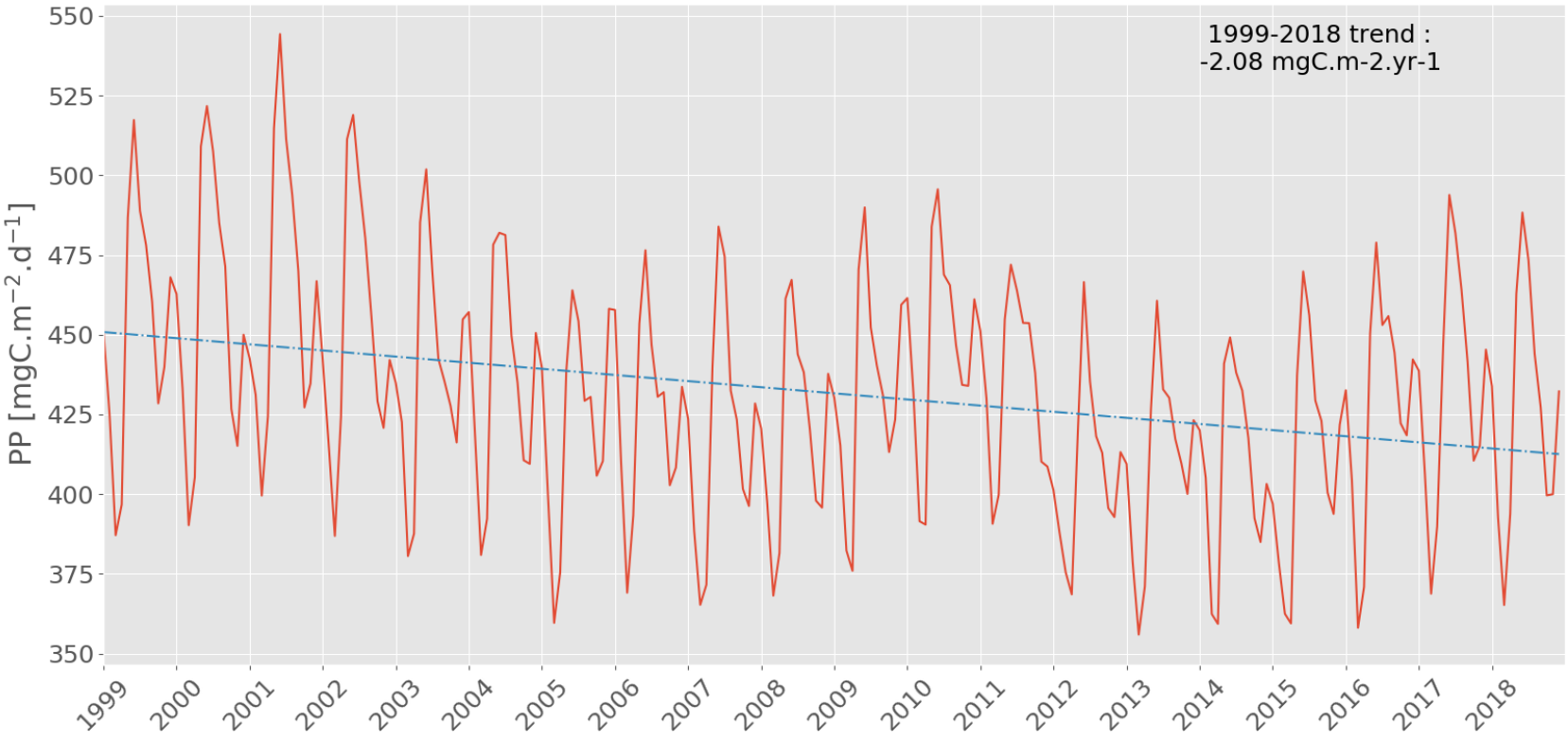
Model: difficulty to get the inter-annual variability ?
Satellite: underestimation of the signal due to monthly smoothing ?

Global ocean – satellite observations



Smooth seasonal cycle due to average over North and South Hemisphere

Global ocean – trend estimate



Satellite estimate: decrease of 41 mgC.m^{-2} over the archive

Global ocean – parameter effect

Very low variation of parameters affecting PP
Potential decrease of PP due to decreasing light

Concluding remarks

- Complementarity of satellite observations and modelling outputs
- Allow to investigate of biogeochemical and physical processes
- Under estimation of modelling outputs for the Atlantic
- Estimate the impact of data assimilation
- Potential decrease of primary production at global scale and for the Northern Atlantic

Thank You !