

PML

Plymouth Marine
Laboratory

Listen to the ocean

Deriving Ocean Monitoring Indicators over the Atlantic Ocean from the CMEMS Ocean Colour time series

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Copernicus Marine Environment Monitoring Service (CMEMS)

<http://marine.copernicus.eu/>

The screenshot shows the CMEMS website interface. At the top, there is a header with the Copernicus logo and the text 'COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE'. Below this is a navigation menu with options like 'ABOUT US', 'MARKETS & BENEFITS', 'NEWS', 'SCIENCE & MONITORING', 'TRAINING & EDUCATION', and 'SERVICES PORTFOLIO'. A search bar is located in the top right corner. The main content area is divided into sections for 'YOUR SEARCH' and 'OCEAN STATE REPORT'. The 'YOUR SEARCH' section includes filters for 'REGIONAL DOMAIN', 'PARAMETERS', 'TEMPORAL COVERAGE', and 'PRODUCT WITH DEPTH LEVEL'. The 'OCEAN STATE REPORT' section displays a list of products, each with a title, description, and a thumbnail image. The products shown are related to North Atlantic Surface Chlorophyll Concentration (CHL) from satellite observations, with details such as observation level (L4, L3), resolution (1 km x 1 km, 1.0 km x 1.0 km), and time range (From 2016-04-25 to Present, From 1997-09-04 to 2017-12-19).

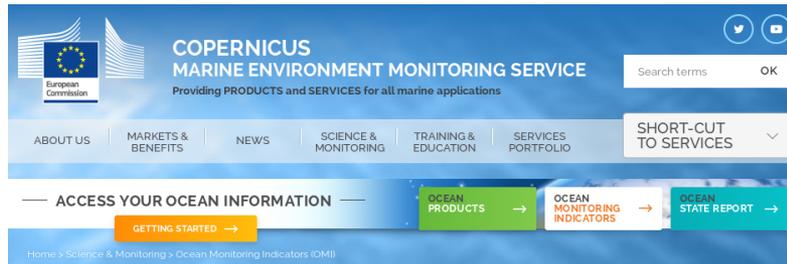
Ocean Product Catalogue:

7 geographical areas : Global Ocean, Arctic Ocean, Baltic Sea, Atlantic European NWS and SWS Oceans, Mediterranean Sea, Black Sea.

Parameters: Temperature, Salinity, Currents, Sea Ice, Sea Level, Wind, Ocean Optics, Ocean Chemistry, Ocean Biology, Ocean Chlorophyll.

Time Coverage: Forecast, Near-Real time, Long time series, time invariant products (observations/modelling).

<http://marine.copernicus.eu/science-learning/ocean-monitoring-indicators>



OCEAN MONITORING INDICATORS (OMI)

> Ocean Monitoring Indicator Catalogue

Track the oceanic changes in line with climate change



Sea Level Rise



Ocean Heat



Sea Ice Extent

Ocean Monitoring Indicators (OMIs) are free downloadable data sets covering the past 25 years of the key variables used to monitor the oceanic trends in line with climate change, including ocean warming, sea level rise and melting of sea ice. This free and open ocean information allows users to track the vital health signs of the ocean over the past quarter of a century.

TO READ MORE ABOUT THE FINDINGS EXTRACTED FROM THE OMI DATA SETS AND SET OUT IN THE OCEAN STATE REPORT TO BE PUBLISHED IN 2018, »[CLICK HERE](#).

Knowing how much heat is stored in the ocean, how fast the sea levels are rising and sea ice is melting, is essential to understanding the current state and changes in the ocean and climate. This information is critical for assessing and confronting oceanic and atmospheric changes associated with global warming and they can be used by scientists, decision-makers, environmental agencies, the general public, and in measuring our responses to environmental directives. The OMIs expand the Copernicus Marine Service portfolio to provide not only ocean data products but also key reference information on the state of the ocean.

Ocean Monitoring Indicators:

key variables to monitor the oceanic trends in line with climate change.

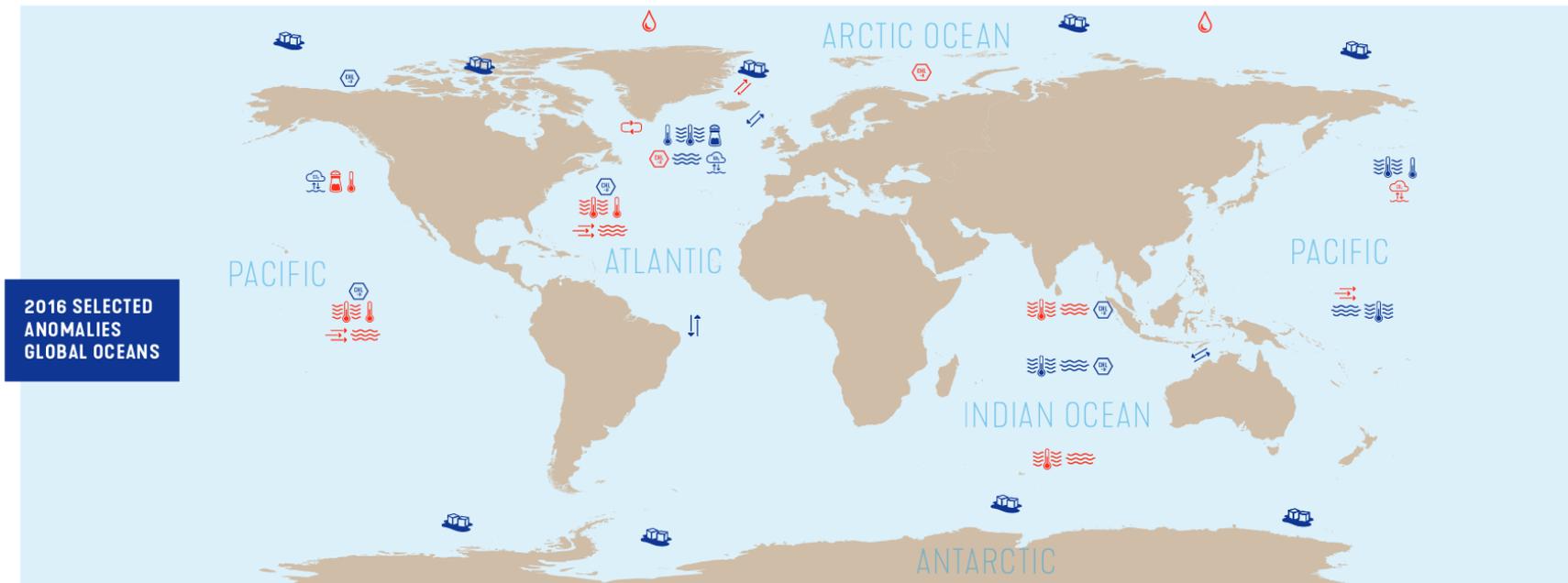
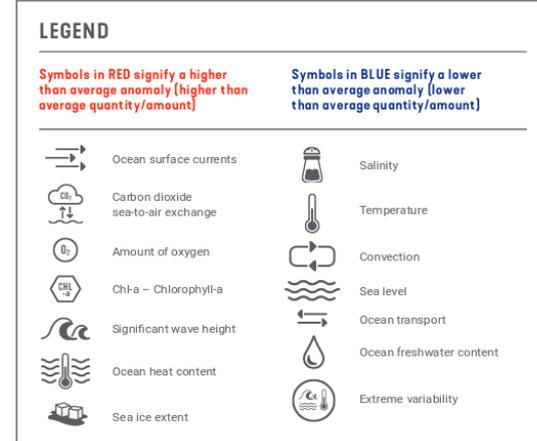
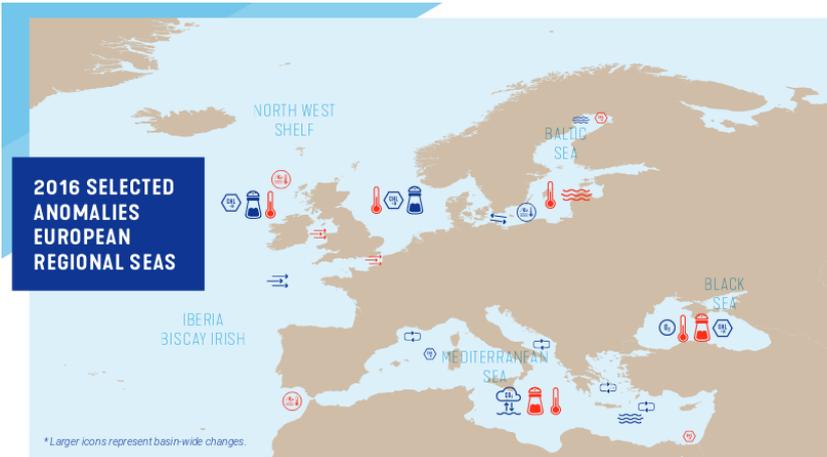
Ocean State Report: annual assessment of the state of the global /regional seas for the ocean scientific community + policy and decision-makers.

<http://marine.copernicus.eu/science-learning/ocean-state-report>



K. von Schuckmann (Editor) et al., 2016. *Copernicus Marine Service Ocean State Report*, Journal of Operational Oceanography, 9:sup2, S235-S320, DOI: 10.1080/1755876X.2016.1273446

K. von Schuckmann (Editor) et al., 2018. *Copernicus Marine Service Ocean State Report*, Journal of Operational Oceanography, 11:sup1, S1-S142, DOI: 10.1080/1755876X.2018.1489208



Ocean Colour Climate Change Initiative (ESA OC CCI) → C3S, CCI+

<http://www.esa-oceancolour-cci.org>

"Inter-mission differences can introduce artefacts affecting trend evaluations, and the impact of the bias between the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and Moderate Resolution Imaging Spectroradiometer (MODIS) chl-a products is shown to be significant in a substantial part of the ocean."

F. Mélin (2016) *Impact of inter-mission differences and drifts on chlorophyll-a trend estimates*, International Journal of Remote Sensing, 37:10, 2233-2251, DOI: 10.1080/01431161.2016.1168949

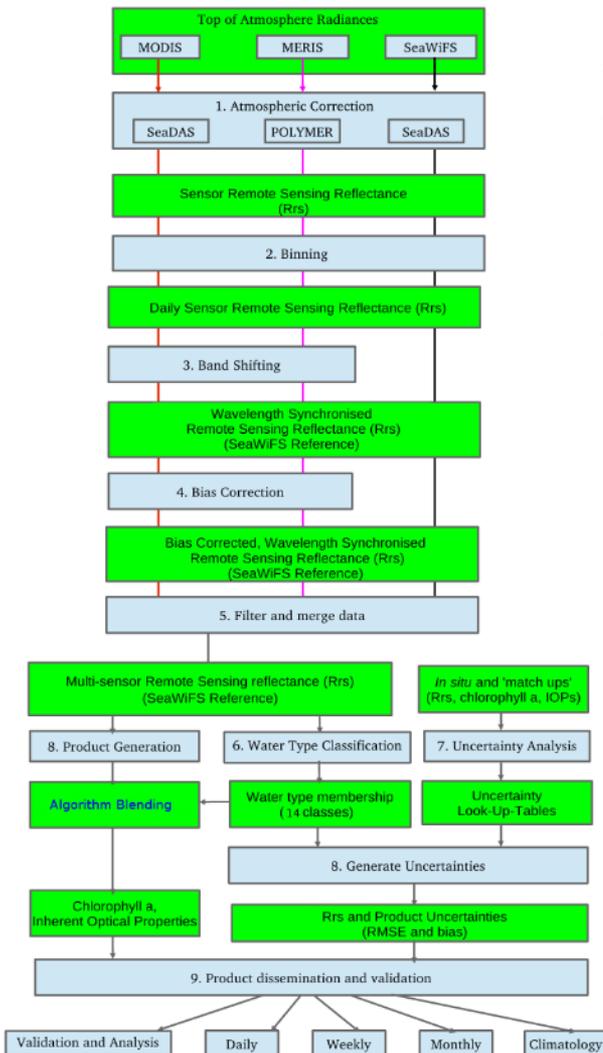
Best atmospheric correction for each sensor determined on round-robin comparison

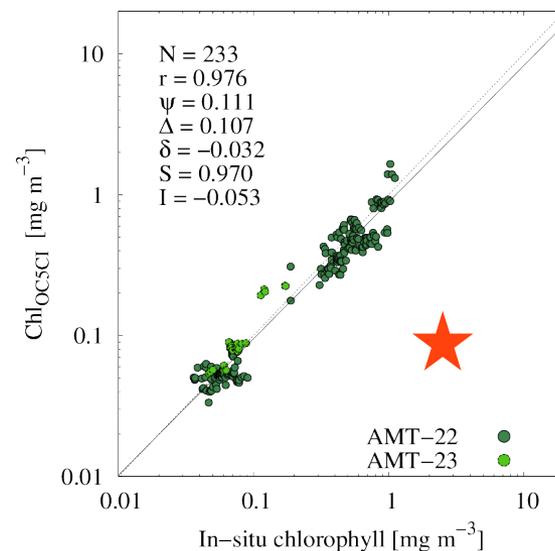
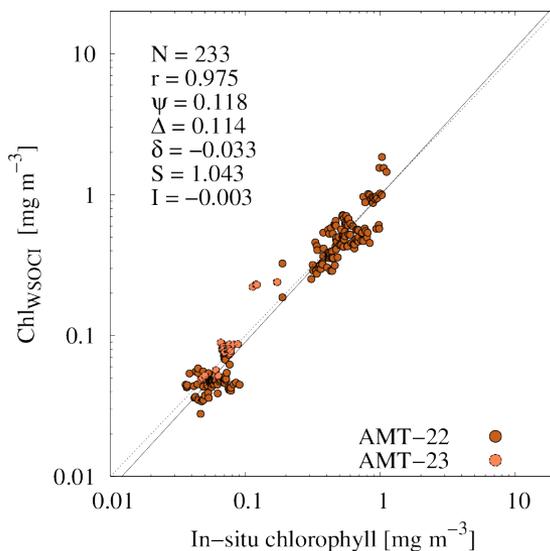
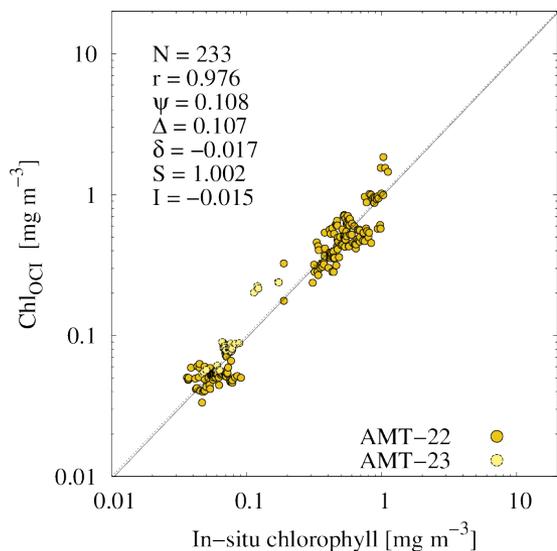
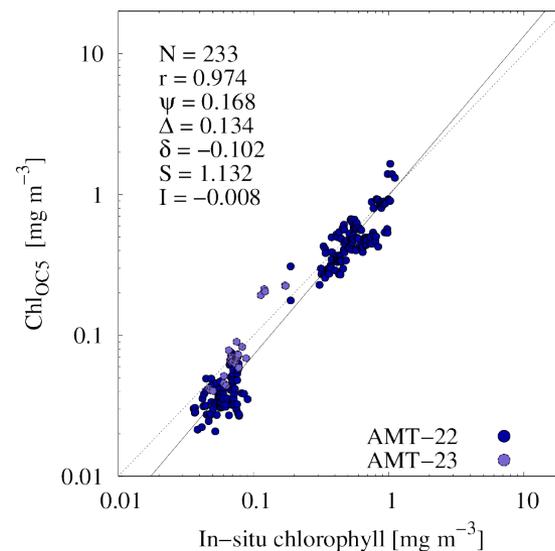
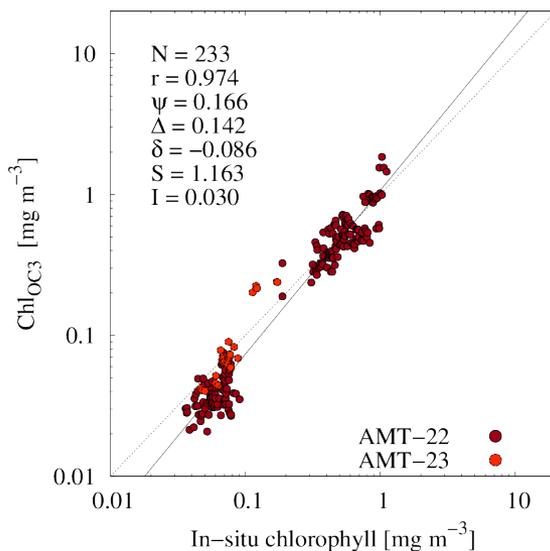
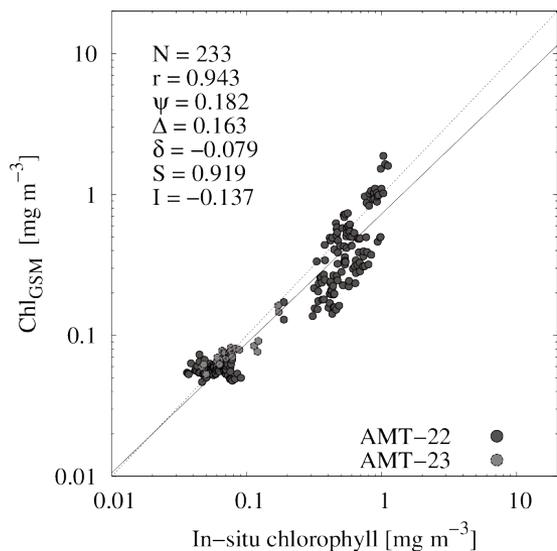
Band Shifting to SeaWiFS set of reference bands

Inter-sensor Bias correction

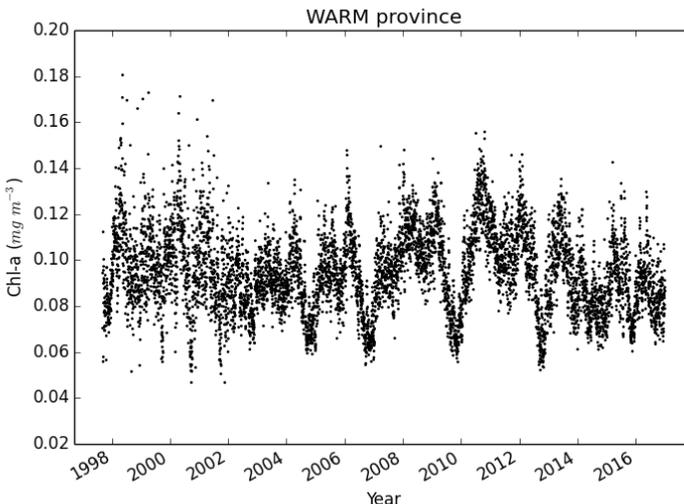
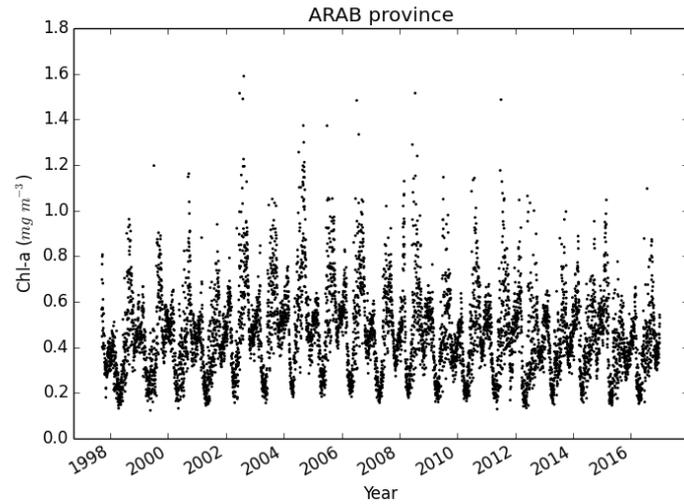
Algorithm blending based on fuzzy optical water classification + best-performing algorithm per class

S. Sathyendranath, et al. (2018). *ESA Ocean Colour Climate Change Initiative (Ocean Colour_cci): Version 3.1*. Technical Report Centre for Environmental Data Analysis. doi:10.5285/9c334f3c424a708cf3c4cf0c6a53f5.

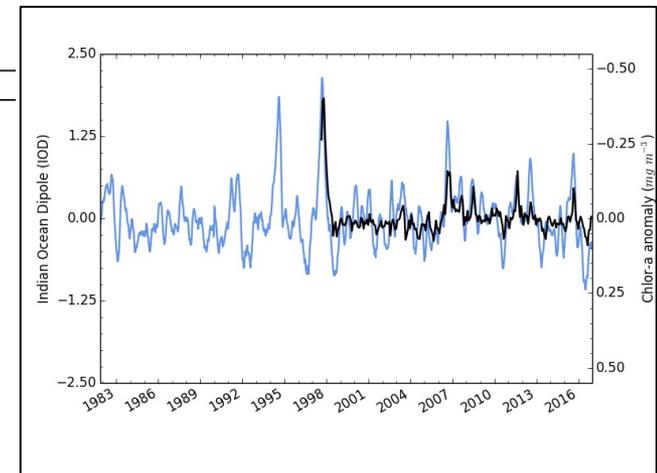
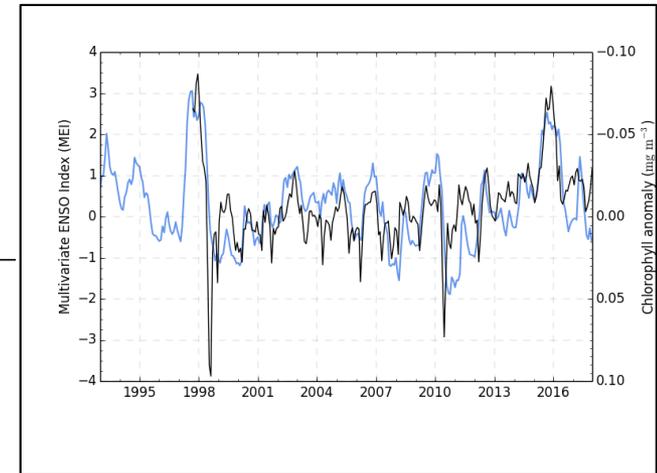
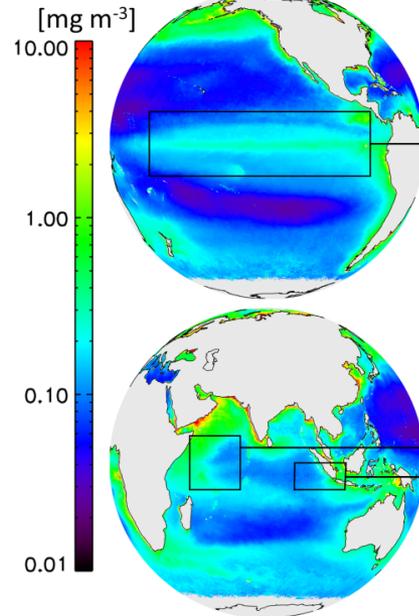




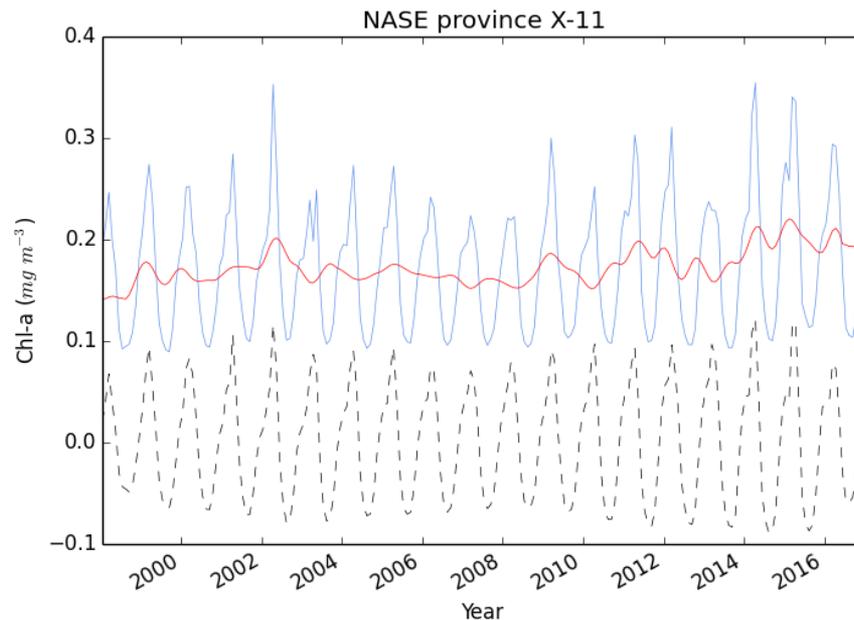
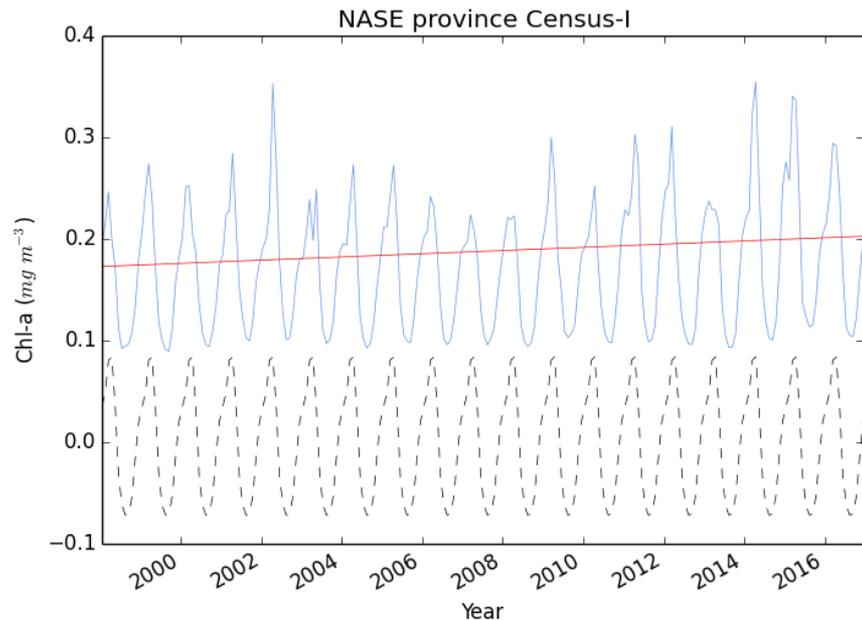
Time series: Daily regional weighted mean values over the region of interest.



Anomalies: difference between daily, monthly or annual chlorophyll mean and a corresponding reference climatology.



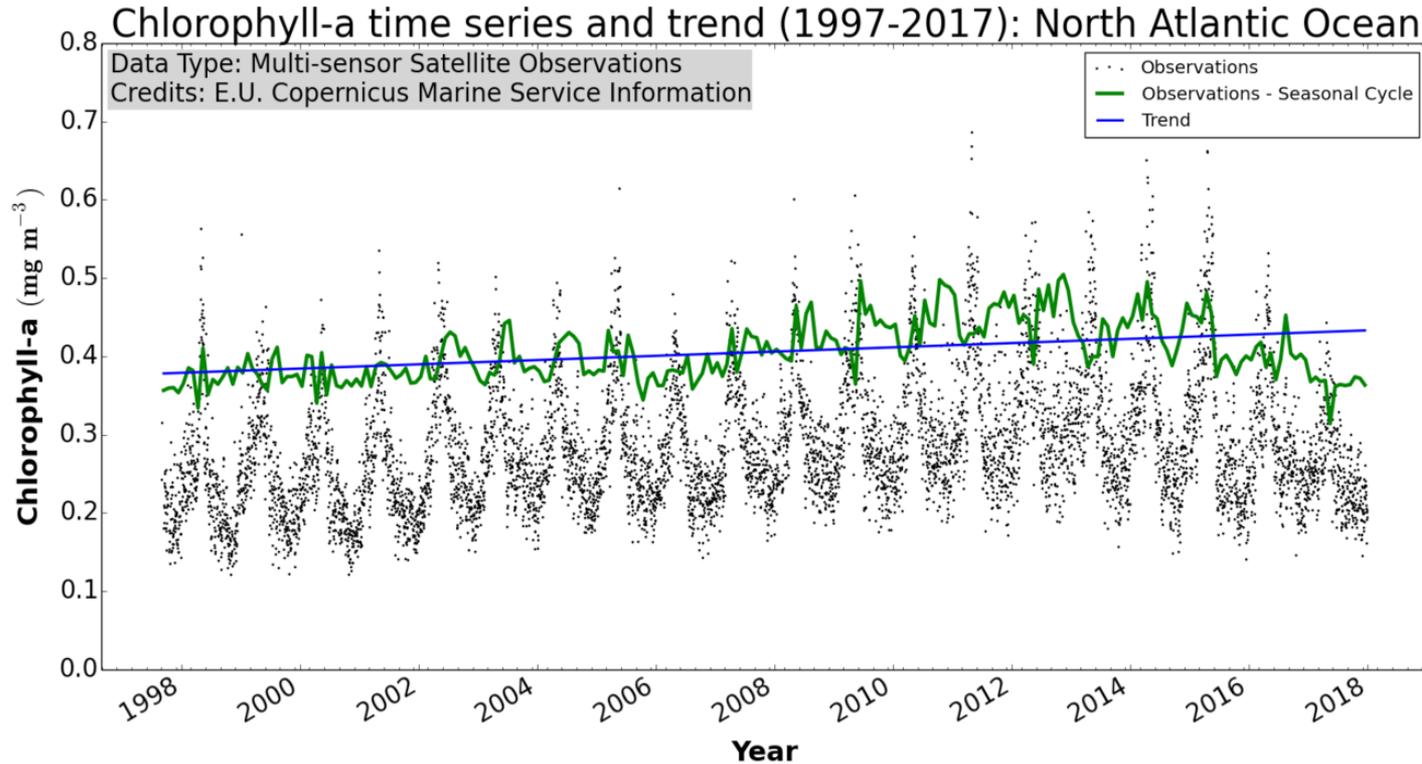
Trend detection:



$$X(t) = S(t) + T(t) + I(t): \text{Census-I or X11?}$$

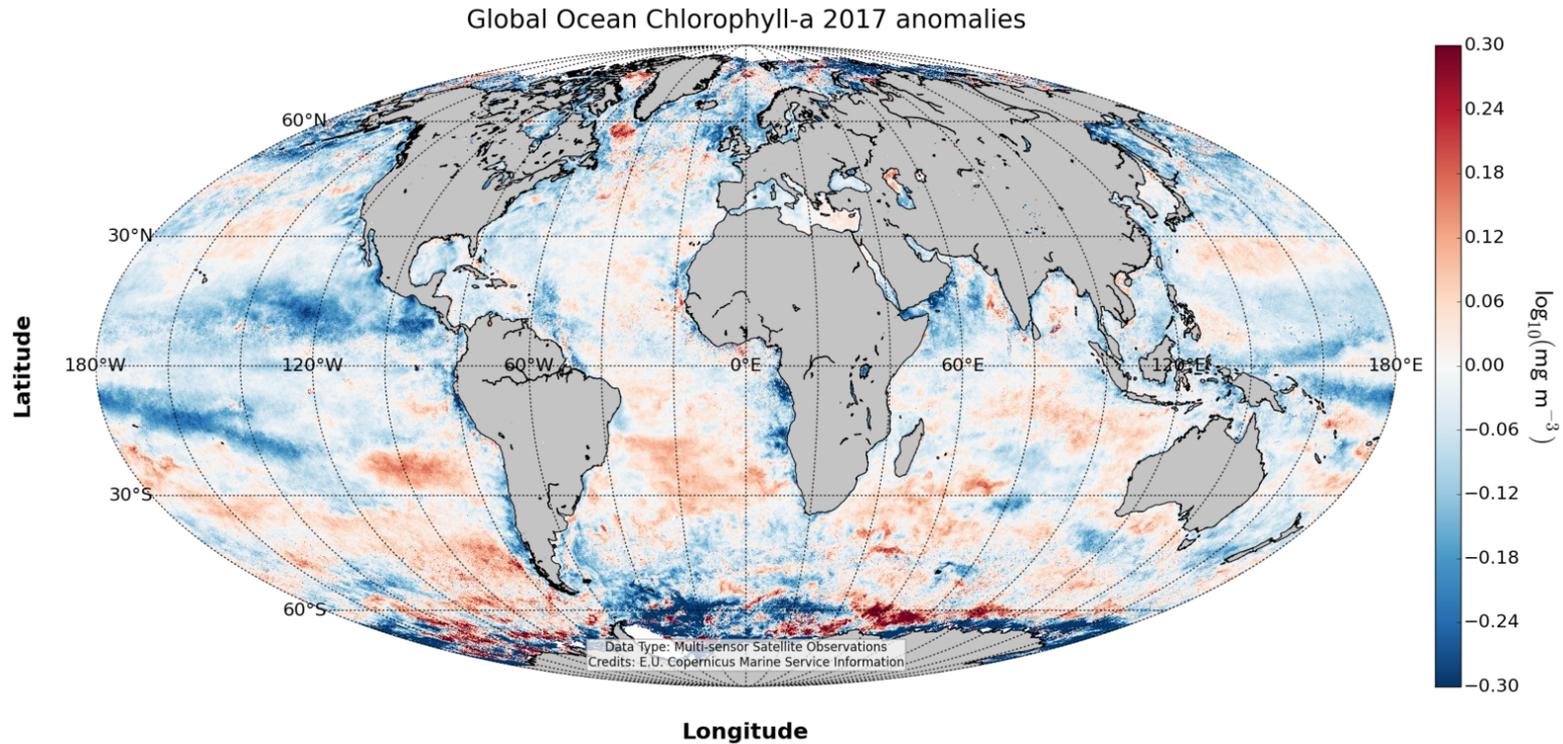
Vantrepotte, V., and Mélin, F. 2009. Temporal variability of 10-year global SeaWiFS time-series of phytoplankton chlorophyll a concentration. *ICES Journal of Marine Science*, 66: 1547–1556

F. Mélin, et al., 2017. Assessing the fitness-for-purpose of satellite multi-mission ocean color climate data records: A protocol applied to OC-CCI chlorophyll-a data, *Remote Sensing of Environment*, 203: 139-151.



In 2017:

- Annual average: 0.38 mg m^{-3}
- 20-year average: 0.29 mg m^{-3}
- Local minimum DS: April 2017
- Spring bloom max.: 0.42 mg m^{-3}
- 20-year Spring bloom average max.: 0.55 mg m^{-3}



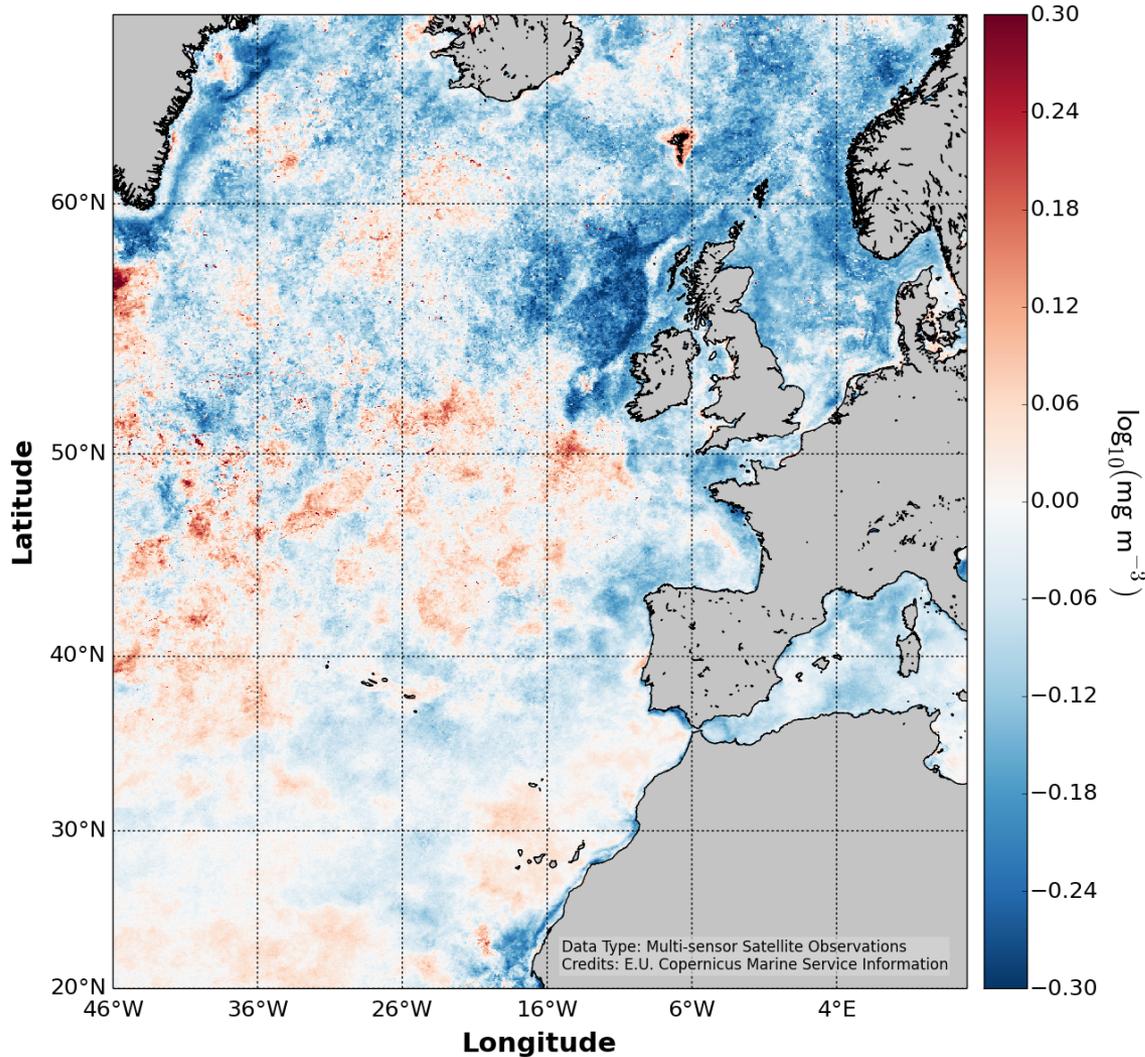
In 2017:

Max. and min global anomaly: $2.50 \log_{10}(\text{mg m}^{-3})$, $-3.23 \log_{10}(\text{mg m}^{-3})$

Average global anomaly: $-0.033 \log_{10}(\text{mg m}^{-3})$

Globally 95.85 % valid pixels verify $|\text{anomaly}| < 0.30 \log_{10}(\text{mg m}^{-3})$

North Atlantic Ocean Chlorophyll-a 2017 anomalies



In 2017:

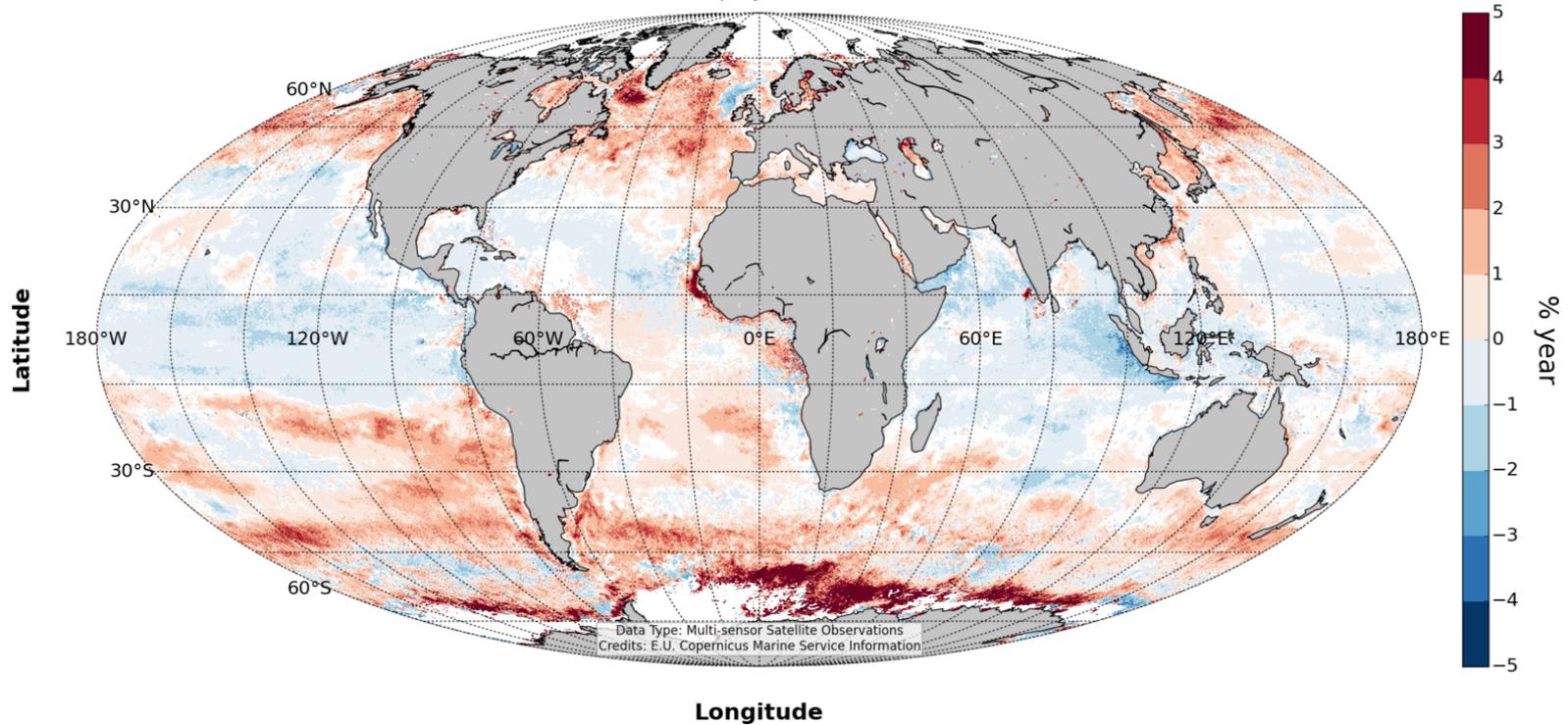
Max. regional anomaly:
 $1.7 \log_{10}(\text{mg m}^{-3})$

Min. regional anomaly:
 $-2.7 \log_{10}(\text{mg m}^{-3})$

Average regional anomaly:
 $-0.031 \log_{10}(\text{mg m}^{-3})$

Absolute anomaly:
99.76 % valid pixels
 $|\text{anomaly}| < 0.30 \log_{10}(\text{mg m}^{-3})$

Global Ocean Chlorophyll-a trends (1997-2017)



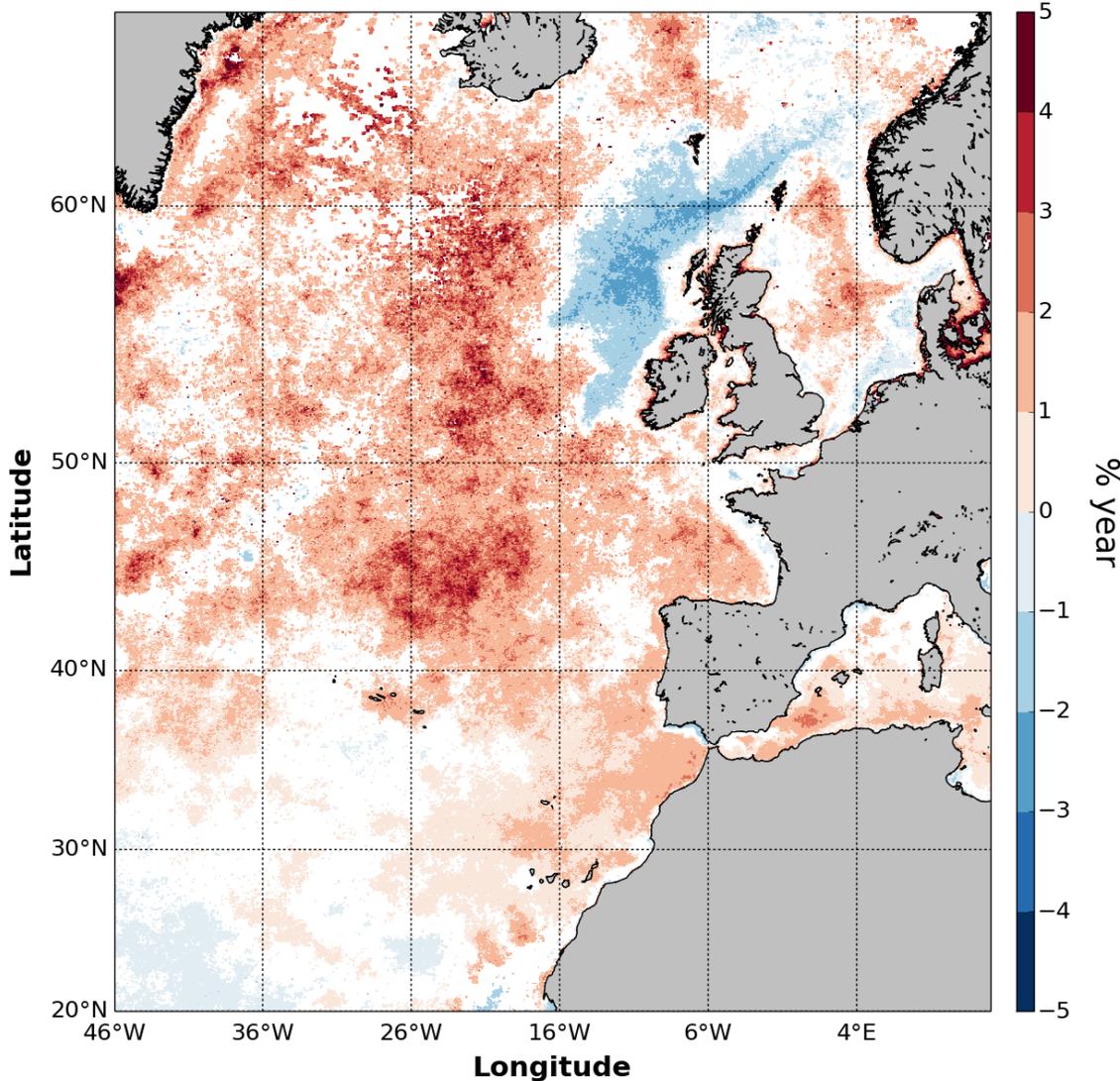
In 2017:

Max. and min global trend: 10.3 % per year , -6.1 % per year

Average global trend: 0.62 % per year

Global absolute trend values: 97.16 % valid pixels |trend| < 5 % per year

North Atlantic Ocean Chlorophyll-a trends (1997-2017)



In 2017:

Maximum regional trend:
2.3 % per year

Minimum regional
trend :-1.3 % per year

Average regional trend:
1.1 % per year

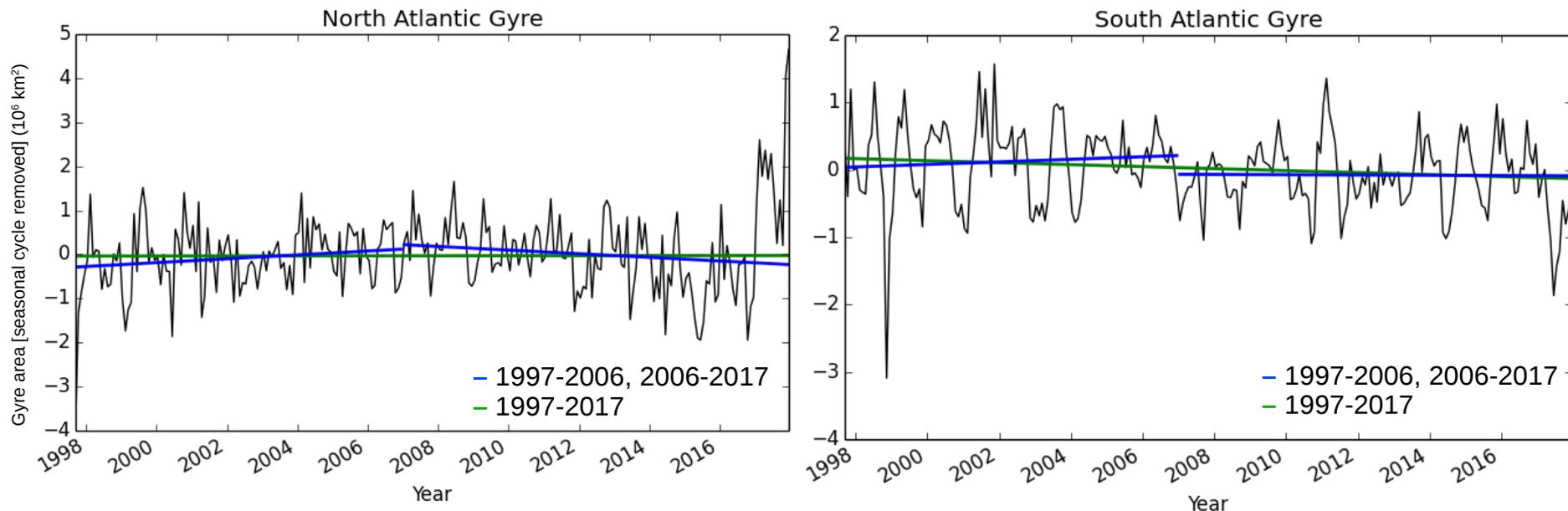
Absolute trend values :
99.71 % valid pixels
 $|\text{trend}| < 5 \%$ per year

Previous work:

- Atlantic and Pacific gyres **0.07 mg m⁻³**, 10 -year SeaWiFS dataset: Polovina, J. J., et al., (2008), *Ocean's least productive waters are expanding*, *Geophys. Res. Lett.*, 35, L03618, doi: 10.1029/2007GL031745.

- Atlantic gyres, **0.15 mg m⁻³**: Aiken, J., et al., (2017), *A synthesis of the environmental response of the North and South Atlantic Sub-Tropical Gyres during two decades of AMT*, *Progress in Oceanography*, 158, 236-254, doi: 10.1016/j.pocean.2016.08.004.

Copernicus Marine Service Ocean State Report, Issue 2



OMIs EIS April 2019:

Regional **time series**, global and regional **anomaly** maps, global **trend** map.

Community dynamics in the North Atlantic:

Phytoplankton functional types (PFTs) → annual map of # **weeks per year** showing **diatom** (micro cells) **domination**.

Phenology:

Detection, timeliness, intensity and **duration** of the phytoplankton **bloom(s)** in the North Atlantic.

Primary Production:

Time series of global PP average 1998-2018, global **PP trend** map, global **PP anomaly** map relative to the 1998-2016 reference.

User cases: S3 EUROHAB

Interreg France (Channel) England. Satellite products for detecting **Eutrophication** and **Harmful Algal Bloom** events in the **French-English Channel**.

CMEMS Ocean Colour for the Atlantic Ocean provides chlorophyll-derived products and indicators to monitor and manage the **marine ecosystem** for:

aquaculture,

fisheries,

water quality,

mapping and monitoring **harmful algal blooms,**

mapping and monitoring ocean's response to **climate change.**

CMEMS Ocean Colour for the Atlantic Ocean needs:

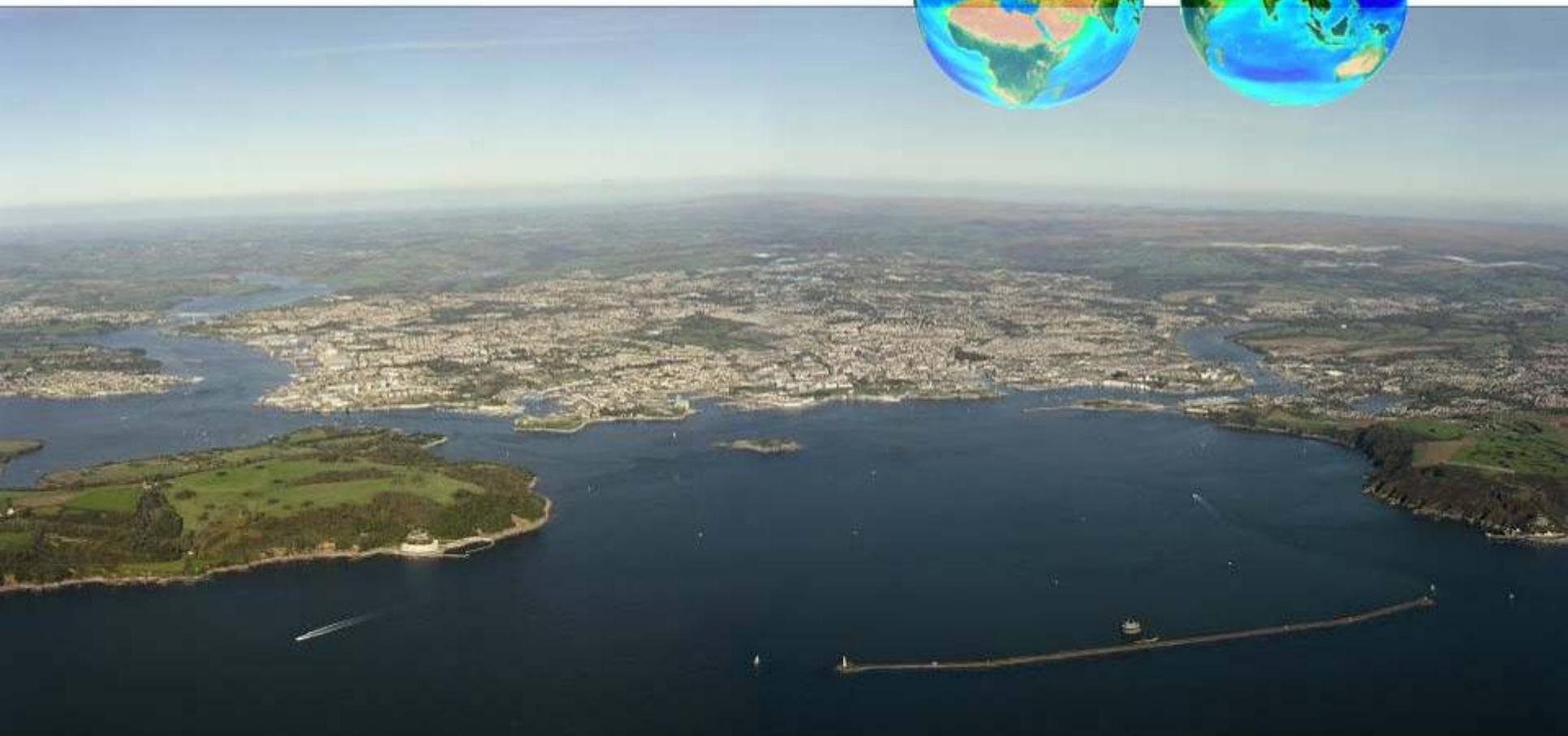
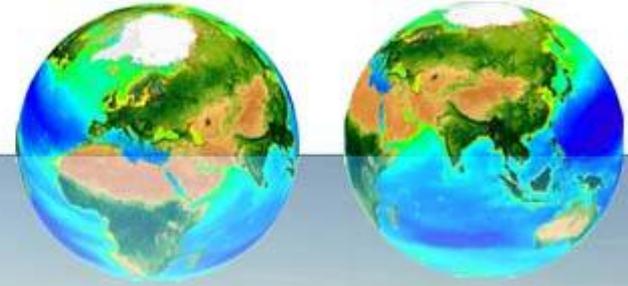
In situ data: AMT4SFRM, AMT4OceanFlux.

Climate satellite datasets: CCI+, C3S.

User input:

OMI user consultation? OSR4 proposal for users cases & 2018 events!

Thank you!



Questions?