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Listen to the ocean

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

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OBO CMEMS OC-TAC

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Copernicus Marine Environment Monitoring Service (CMEMS)

http://marine.copernicus.eu/

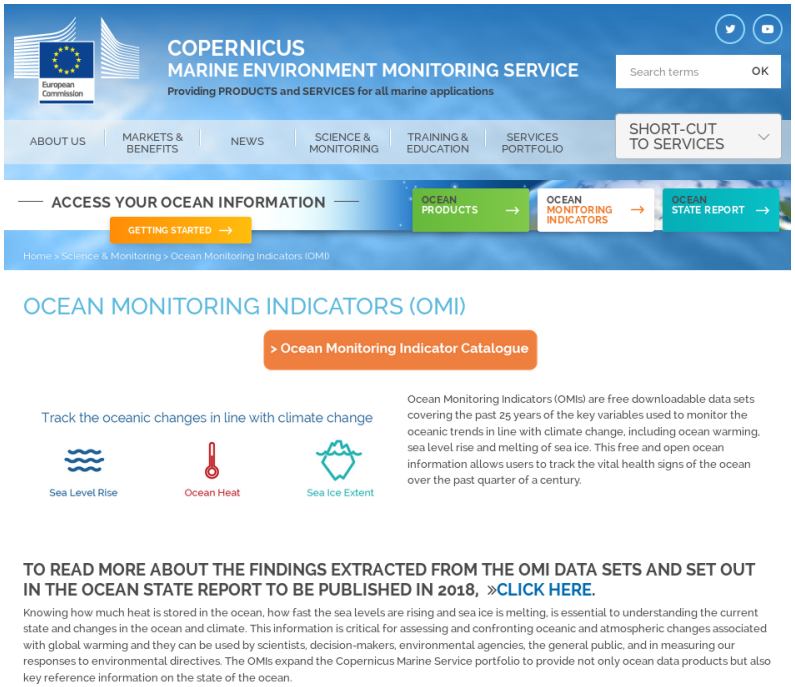
Ocean Product Catalogue:

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



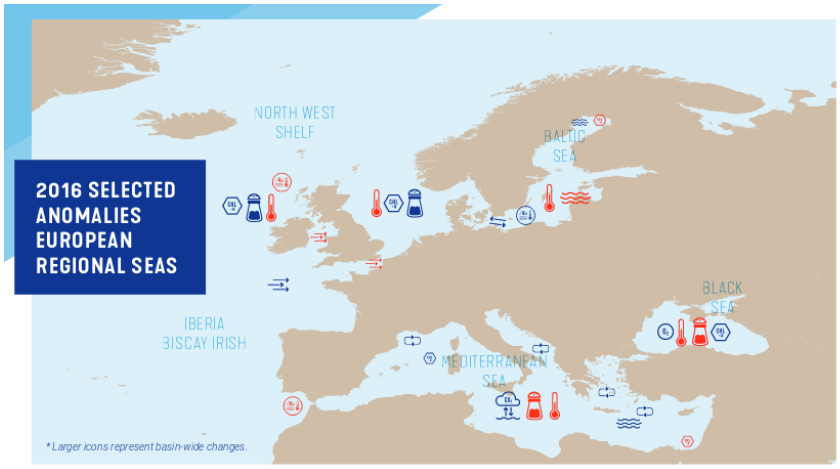
http://marine.copernicus.eu/science-learning/ocean-state-report

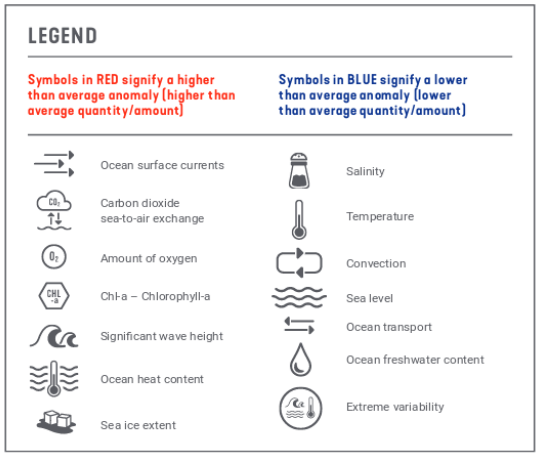
 # Ocean Monitoring Indicators:
key variables to monitor the oceanic trends in line with climate change.

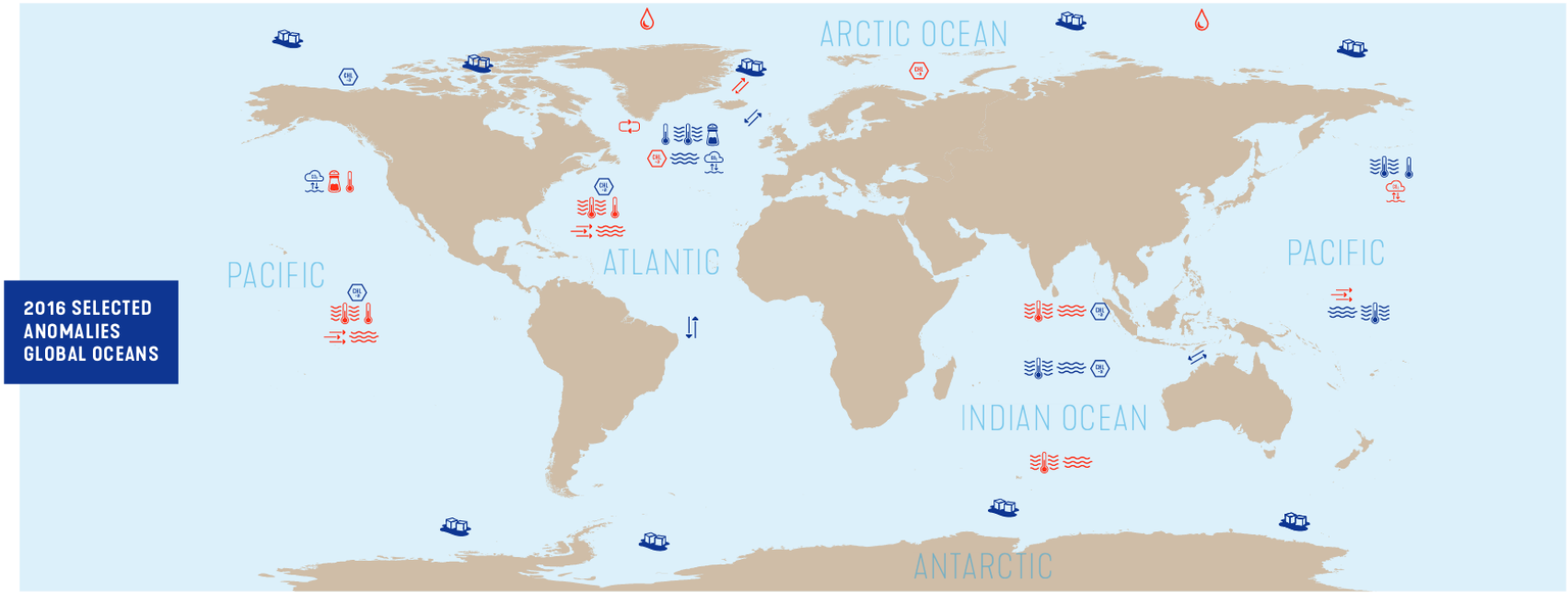
Ocean State Report: annual assessment of the state of the global /regional seas for the ocean scientific community + policy and decision-makers.

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



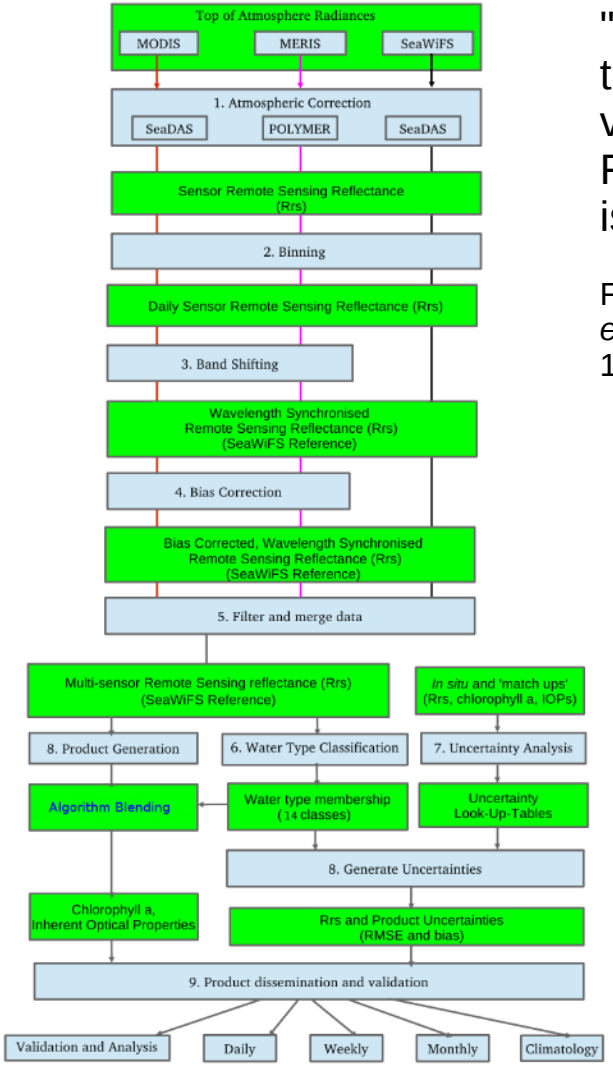




http://marine.copernicus.eu/science-learning/ocean-state-report/ocean-state-report-2nd-issue/

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:10.5285/9c334fbe6d424a708cf3c4cf0c6a53f5.

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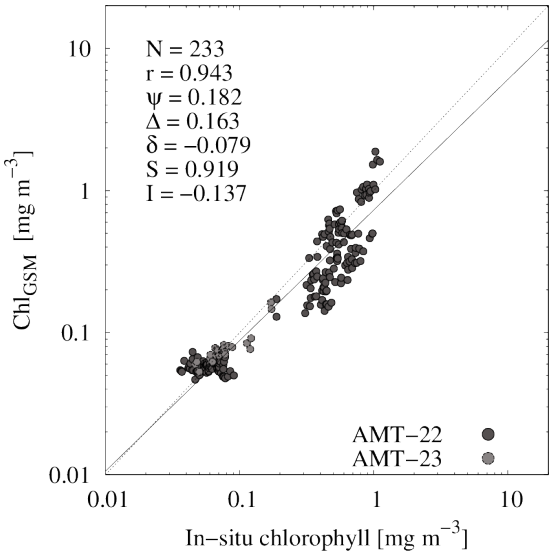
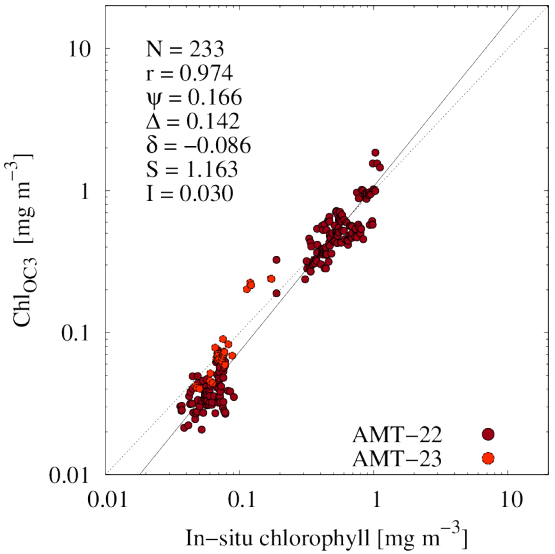
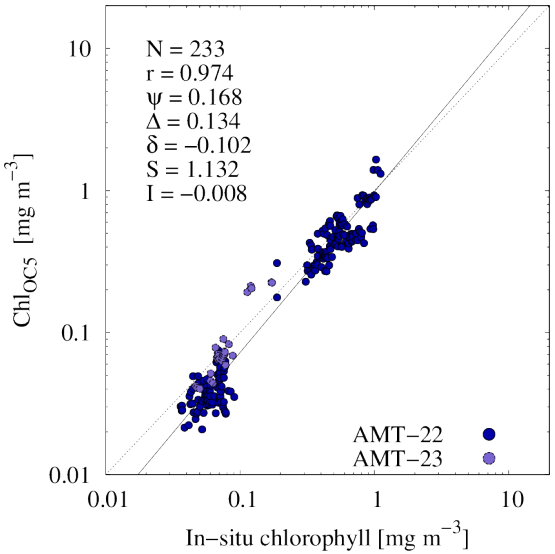
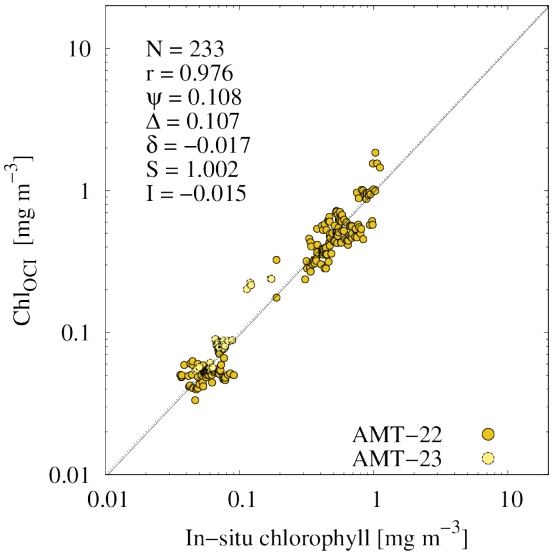
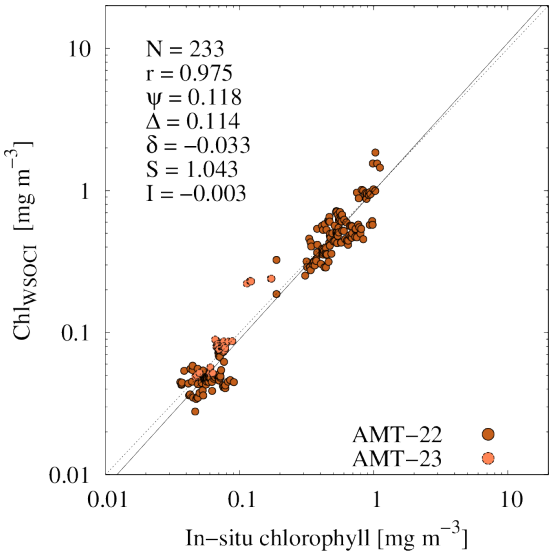
CMEMS Chl-a algorithm for the Atlantic

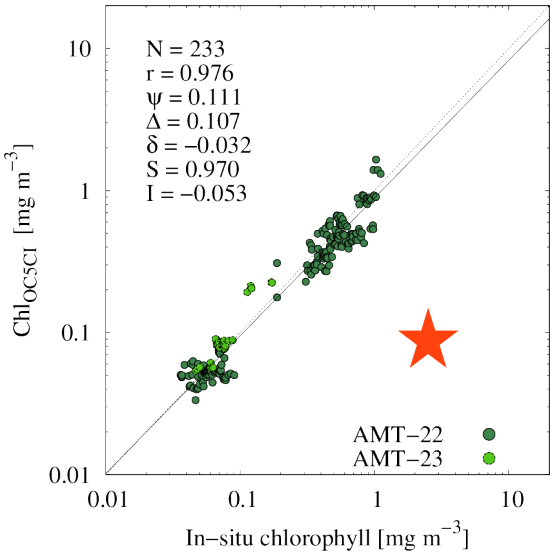






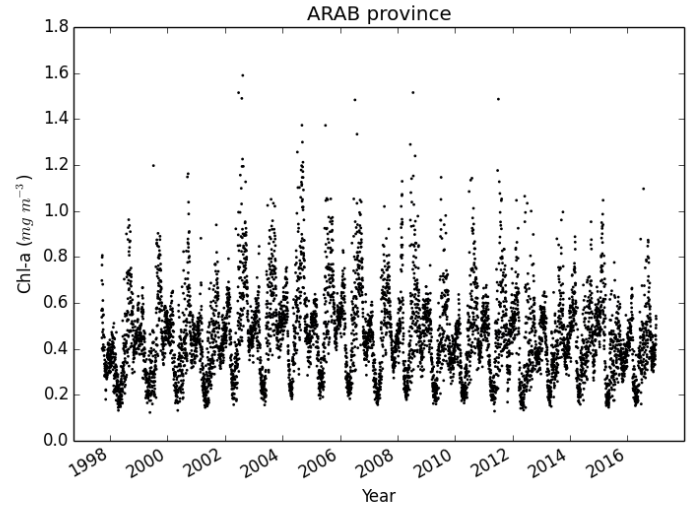


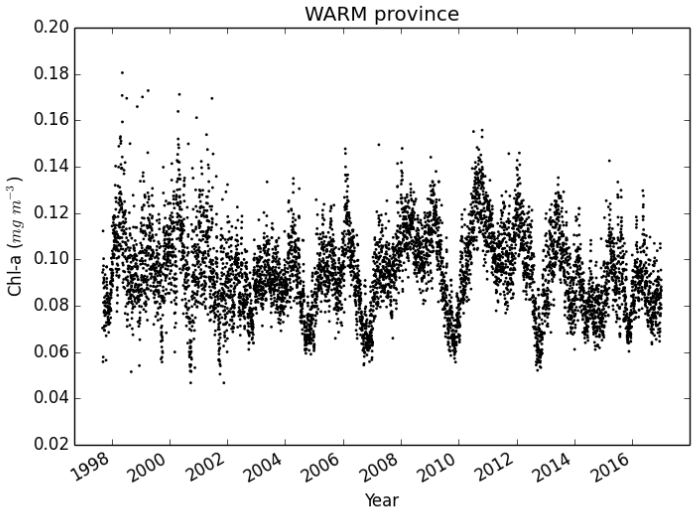


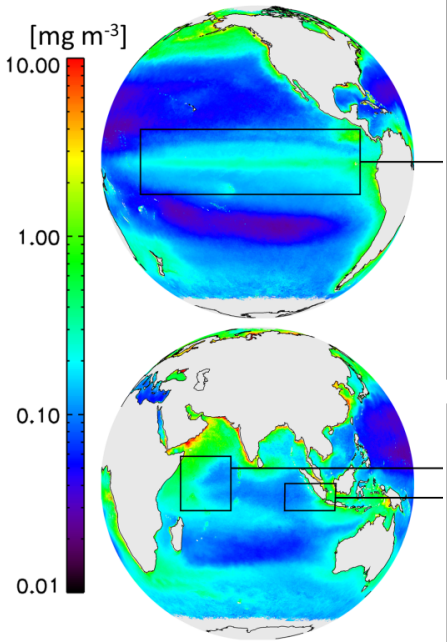


Anomaly and trend detection methods

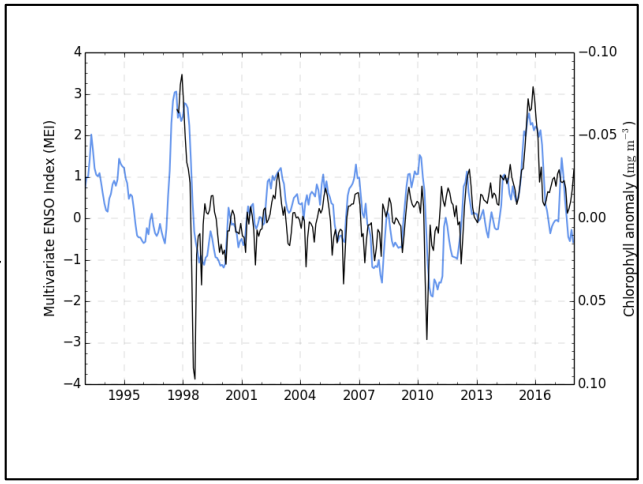
Time series: Daily regional weighted mean values over the region of interest.

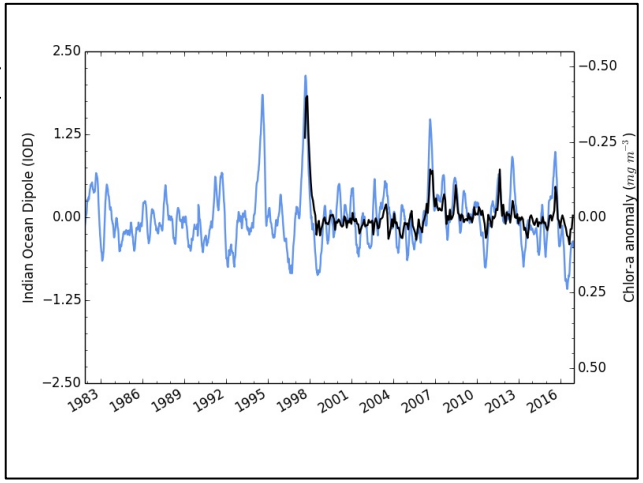






Anomalies: difference between daily, monthly or annual chlorophyll mean and a corresponding reference climatology.





Copernicus Marine Service Ocean State Report, Issue 2

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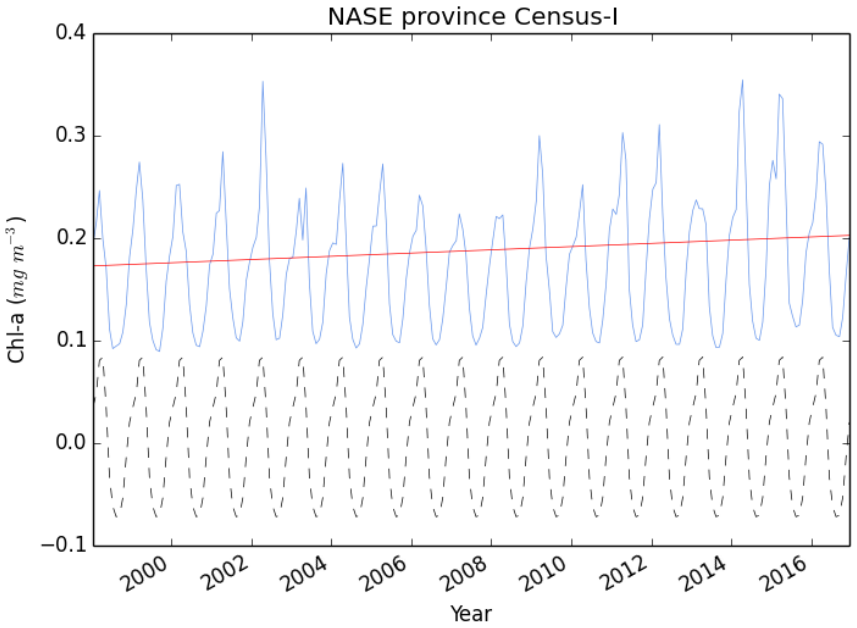
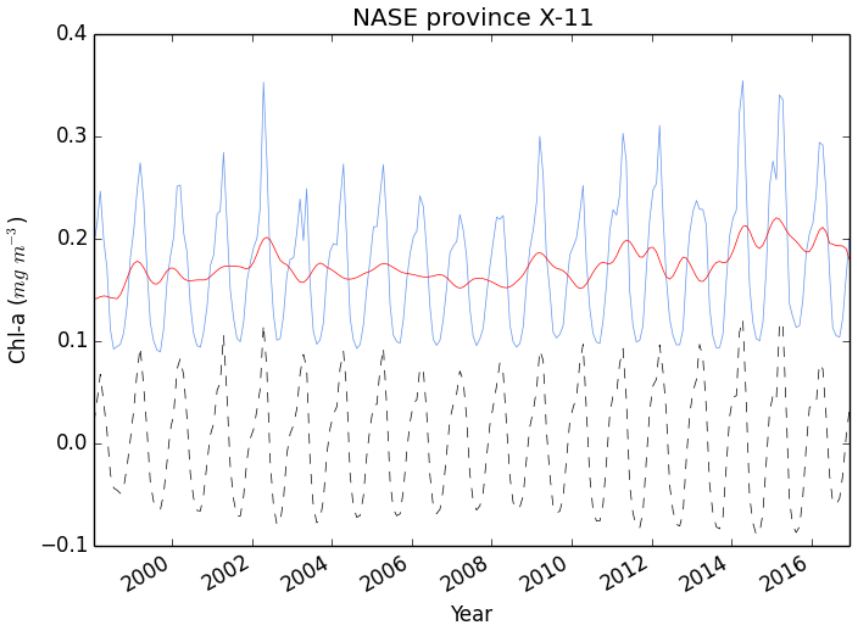
Anomaly and trend detection methods

Trend detection:



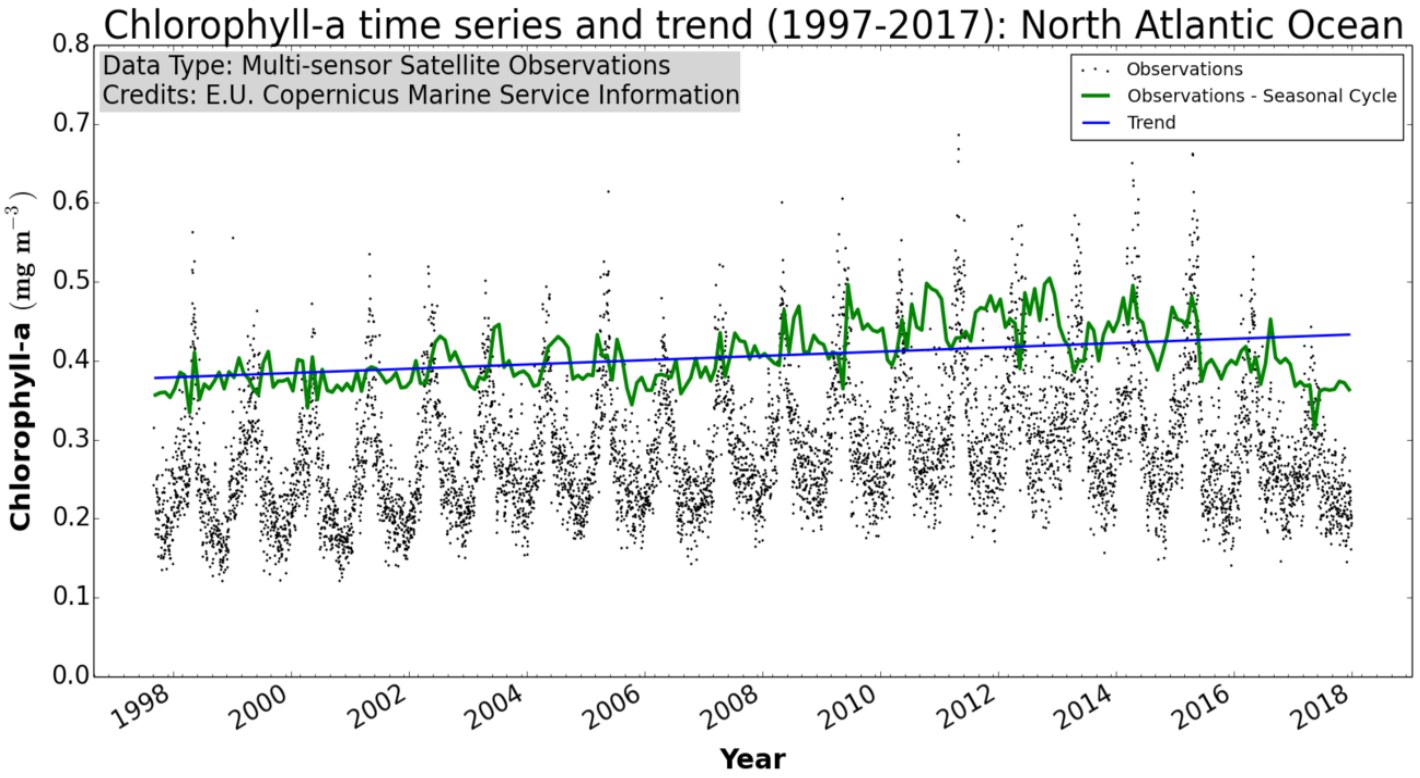


X(t) = S(t) + T(t) + I(t): Census-I or X11?

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.

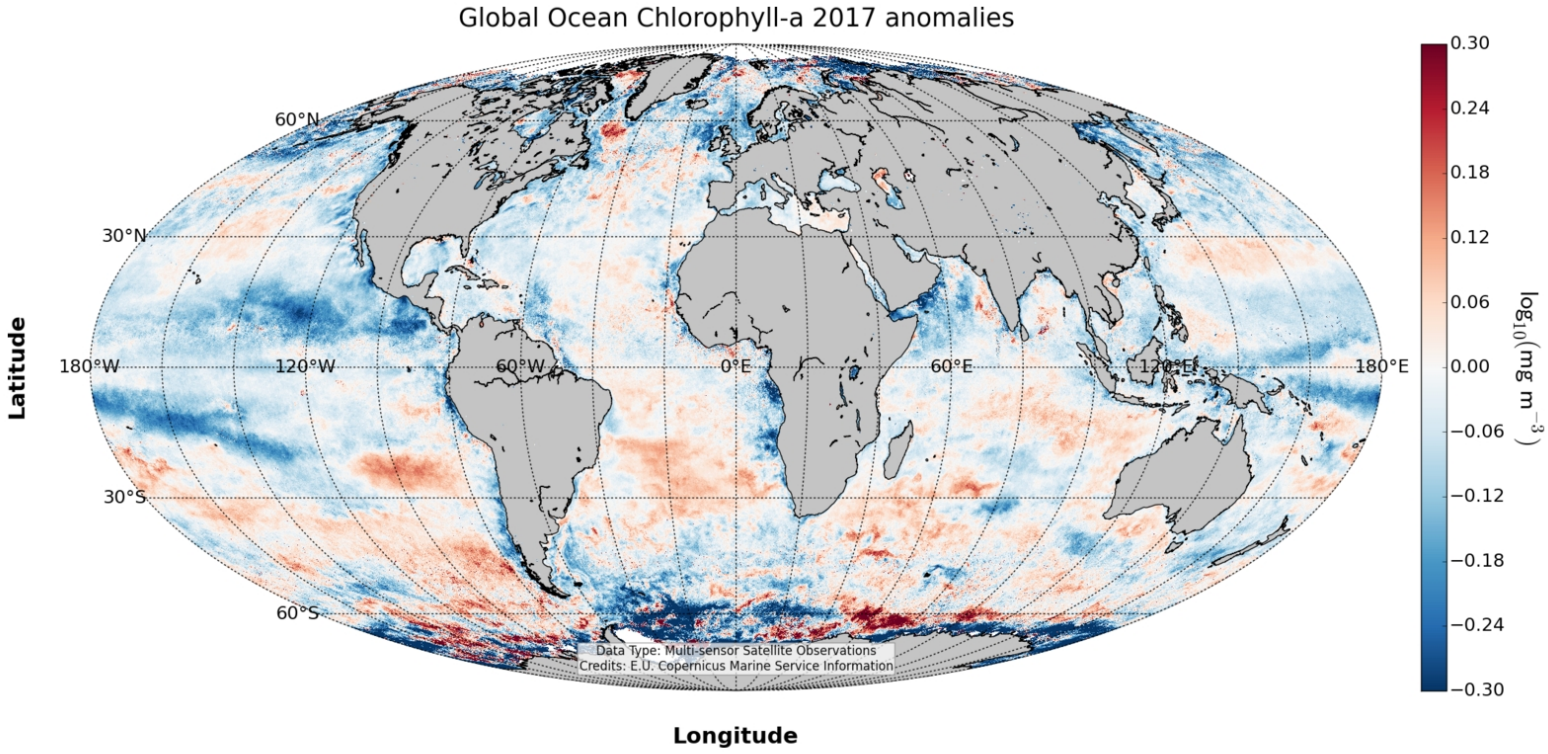
Chlorophyll time series



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}

Chlorophyll anomalies



Copernicus Marine Service

implemented by MERCATOR OCEAN INTERNATIONAL

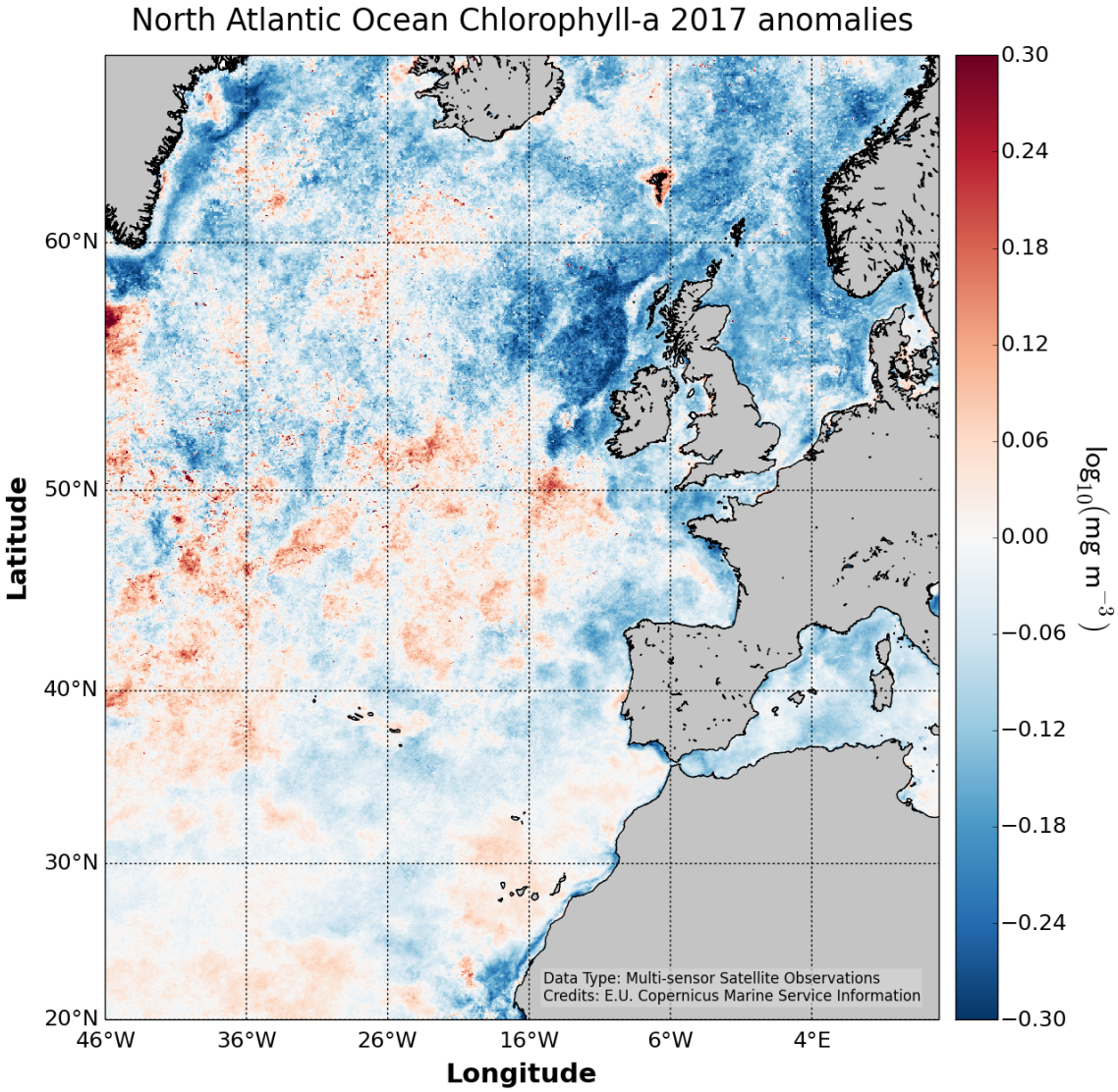
In 2017:

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

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

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

Chlorophyll anomalies



In 2017:

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

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

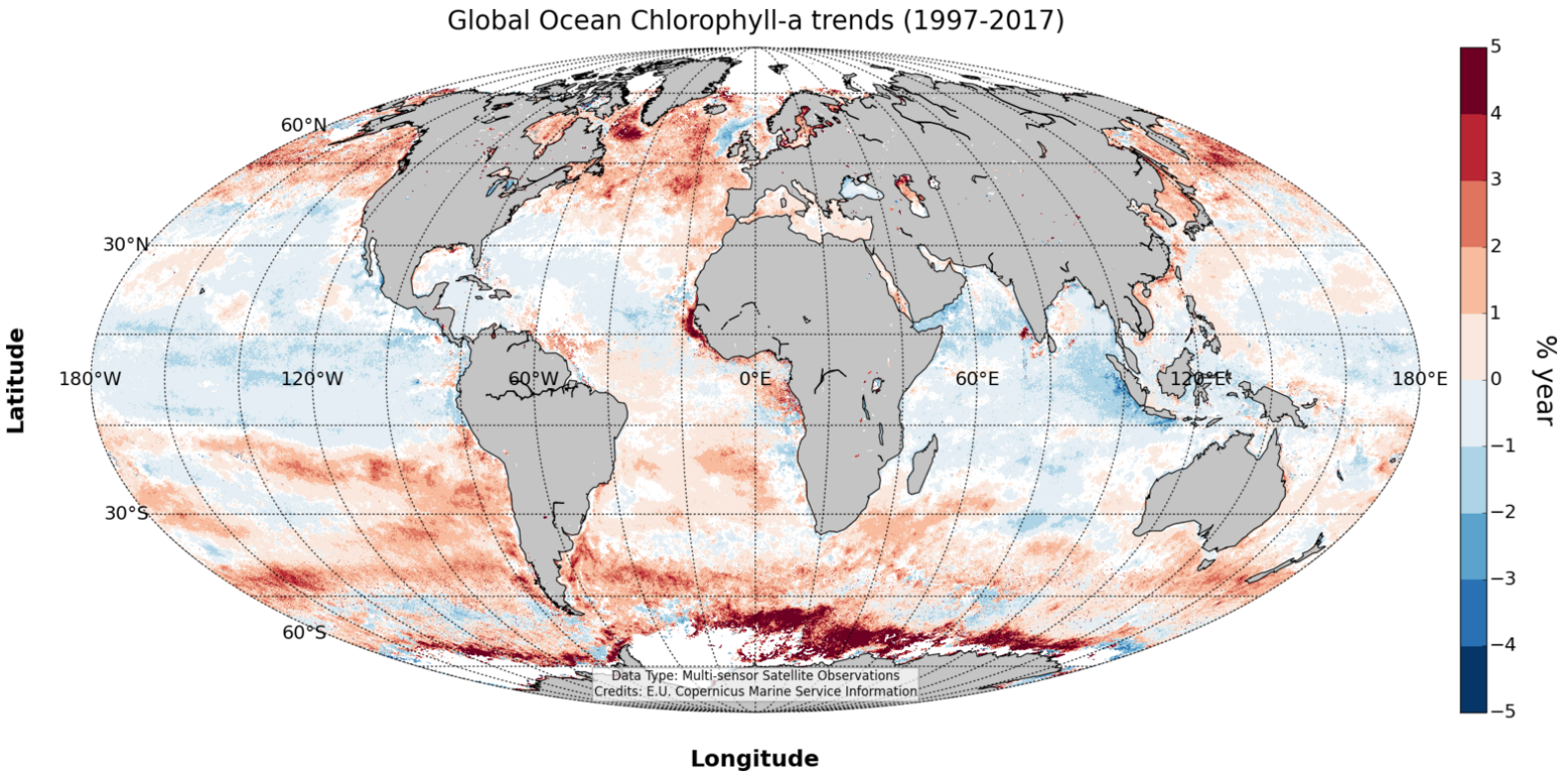
Average regional anomaly:
-0.031 $\log_{10}$(mg m^{-3})

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

Copernicus Marine Service

Copernicus implemented by MERCATOR OCEAN INTERNATIONAL

Chlorophyll trends



Copernicus Marine Service

implemented by MERCATOR OCEAN INTERNATIONAL

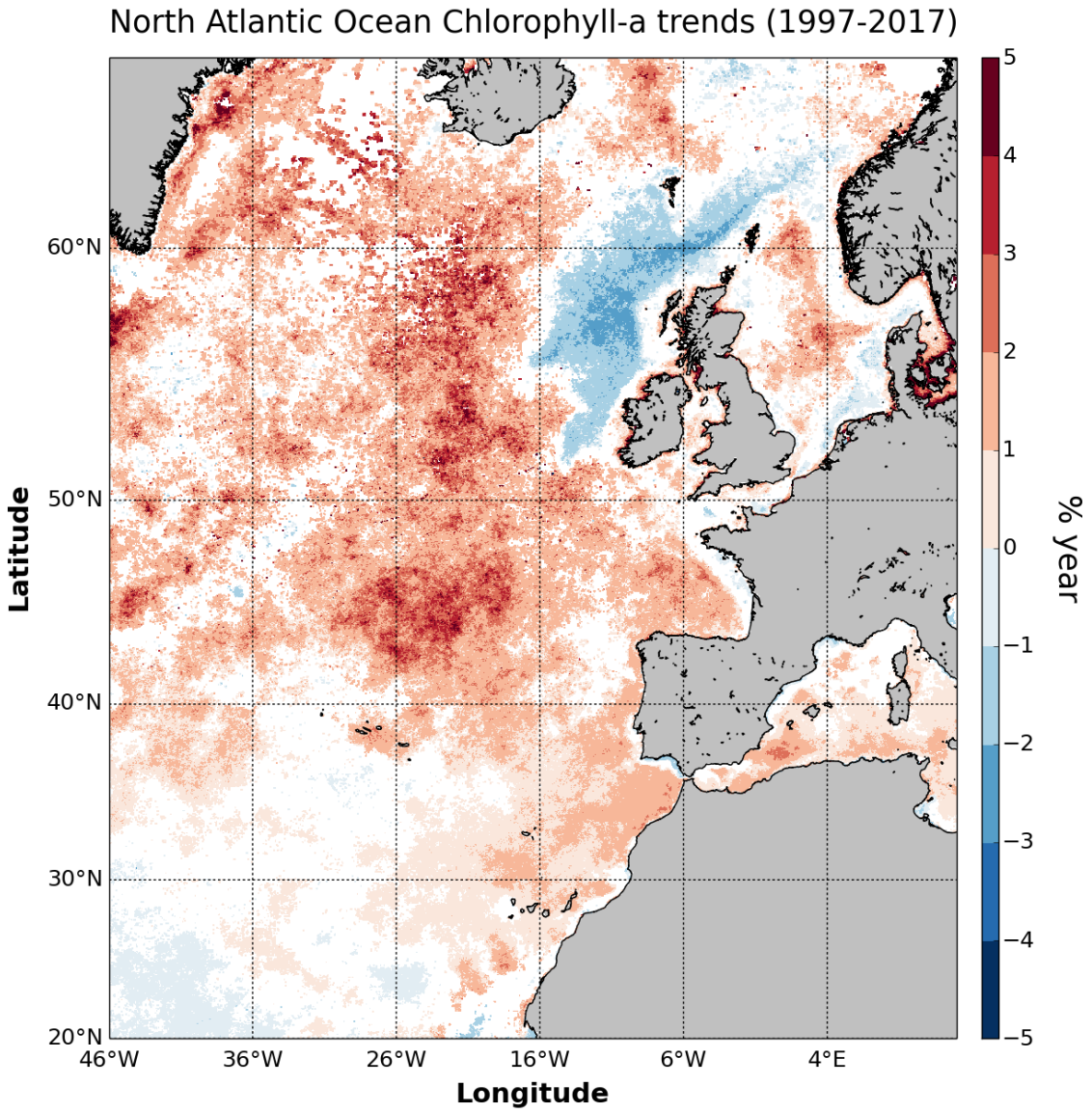
In 2017:

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

Chlorophyll trends



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
|trend| < 5 % per year

Atlantic oligotrophic gyres

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.

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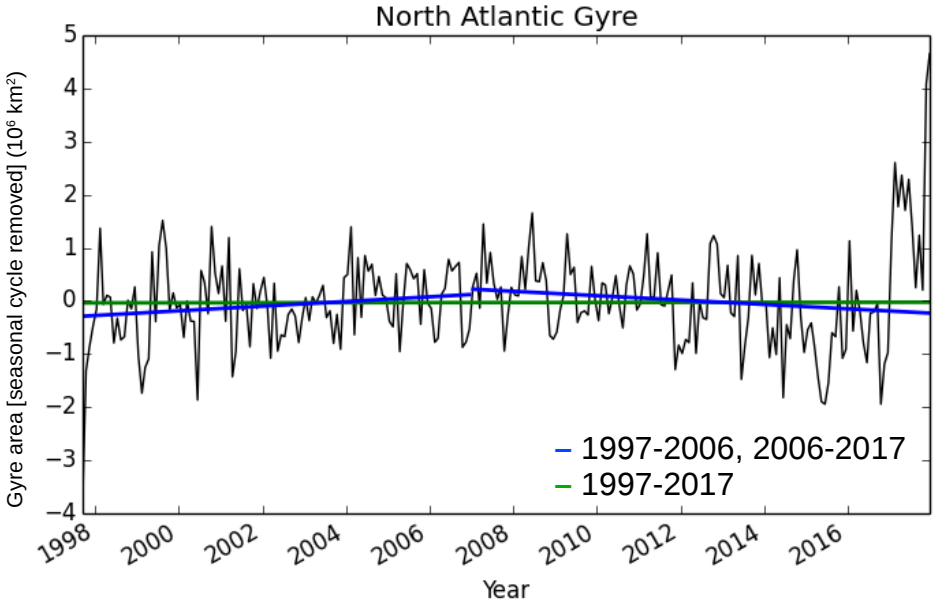
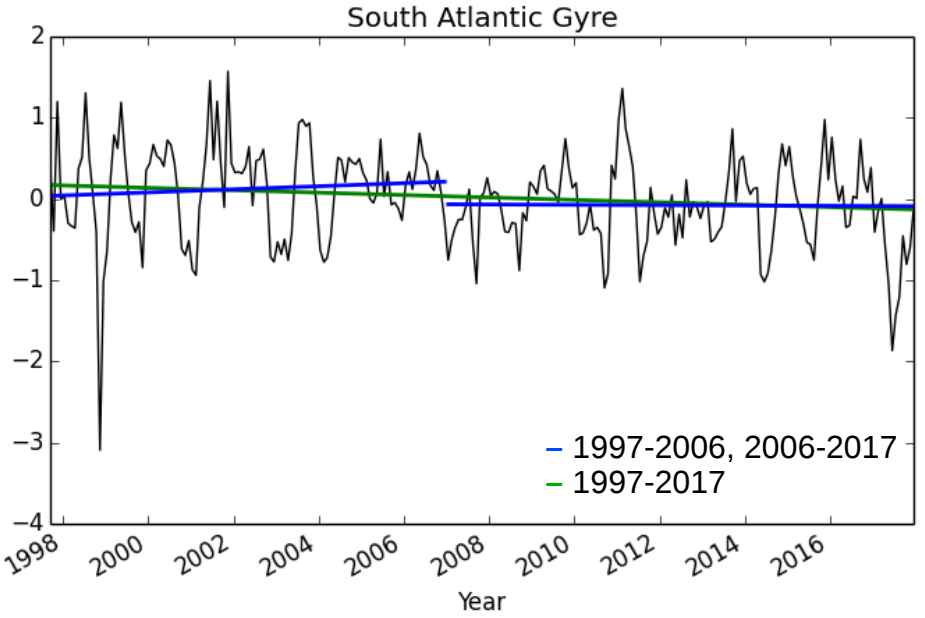




OMI & OSR developments 2019

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**.

Conclusions & Recommendations

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**.

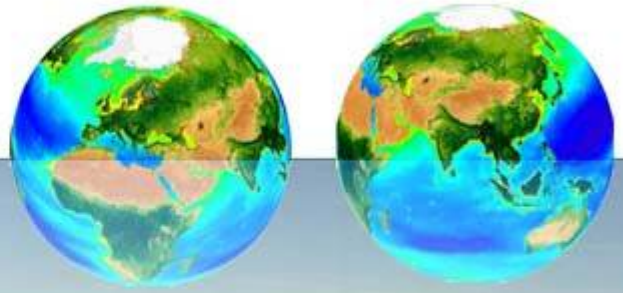
CMEMS Ocean Colour for the Atlantic Ocean needs:

 # 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?