20-year satellite observations of phytoplankton functional types (PFTs) in the Atlantic Ocean

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Background

Phytoplankton composition structure varies in ocean biomes. Different phytoplankton groups drive differently the marine ecosystem and biogeochemical processes. Therefore, variations in phytoplankton composition influence the entire ocean environment, specifically the ocean energy transfer, the deep ocean carbon export, water quality etc. As one of the algorithms deriving phytoplankton composition from space borne data, the EOF-PFT algorithm was developed using multi-spectral satellite data collocated to an extensive global in-situ PFT data set based on HPLC pigments and sea surface temperature data (Xi et al. 2020, 2021). By using multi-sensor merged products and Sentinel-3 OLCI data, the algorithm provides global chlorophyll *a* (Chla) data with per-pixel uncertainty for diatoms, haptophytes, dinoflagellates, chlorophytes and prokaryotic phytoplankton spanning the period from 2002 until today, with products available on the EU Copernicus Marine Service (CMEMS).

Objectives of the present study

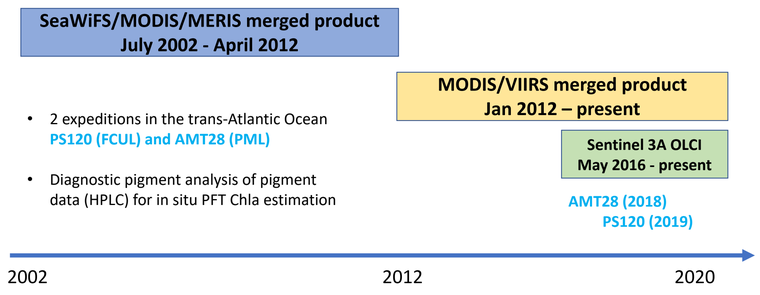
1) evaluate CMEMS PFT products and improve their continuity along the products derived from different satellite sensors;
2) 20-year satellite PFT products for time series analysis of climatology, trends, anomaly and phenology of multiple PFTs in the whole Atlantic and its different biogeochemical provinces (Longhurst et al. 2006).

Data sets

Satellite PFT products

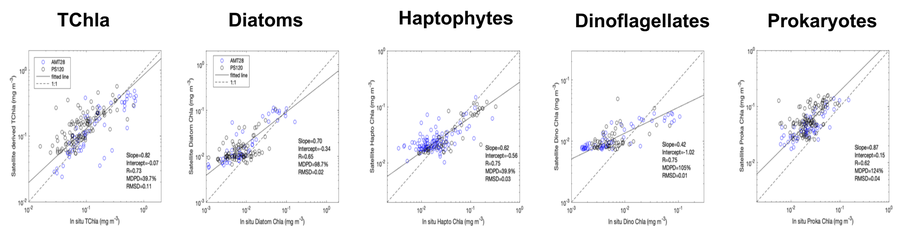
- A global approach (EOF-PFT) for PFT chlorophyll retrieval using ocean colour reflectance data and SST (Xi et al. 2020; 2021)
  - A set of empirical orthogonal function based algorithms
  - Capability of retrieving Chla of 6 groups – diatoms, haptophytes, prokaryotes and others
- **Monthly PFT products with 25-km resolution available** in **CMEMS** at https://marine.copernicus.eu/

Timeline of satellite PFTs and in situ data

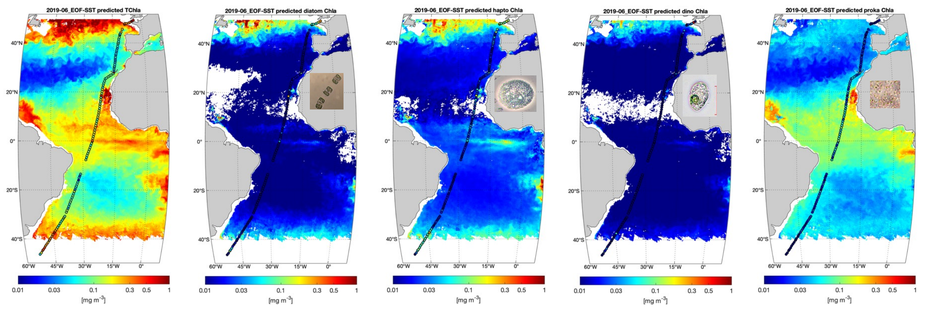


Satellite PFT Validation

Comparison between satellite and in situ PFTs from two transatlantic expeditions

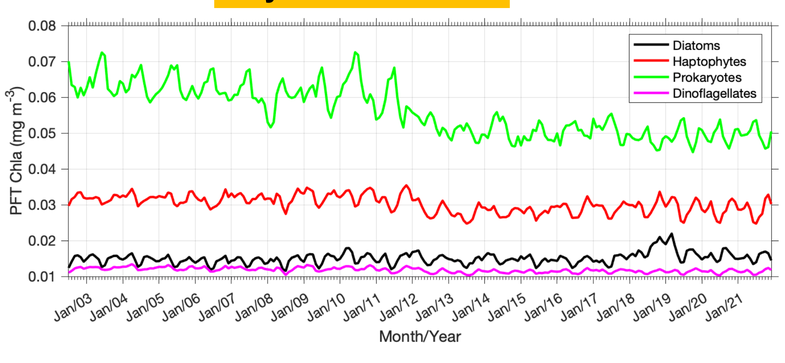


Satellite PFT maps with in-situ data points (PS120: June 2019)

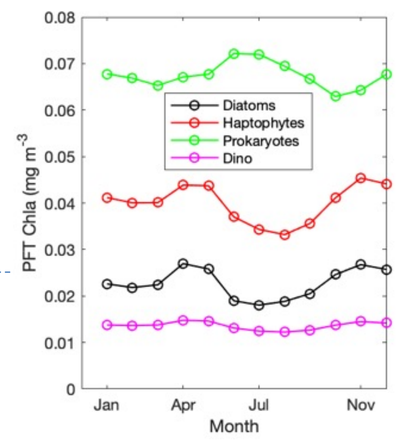


20-year PFT observations

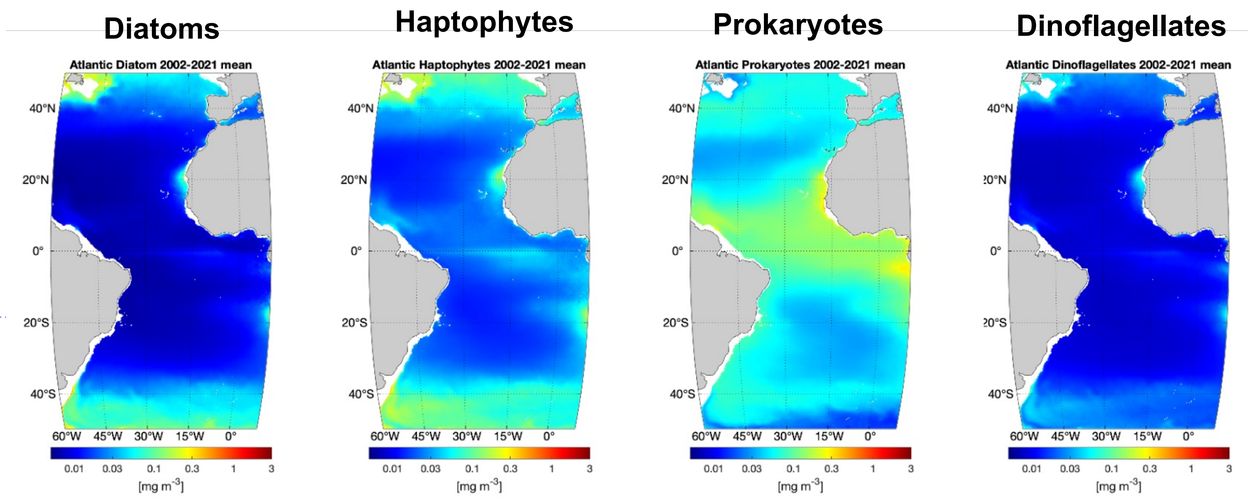
20-year time series



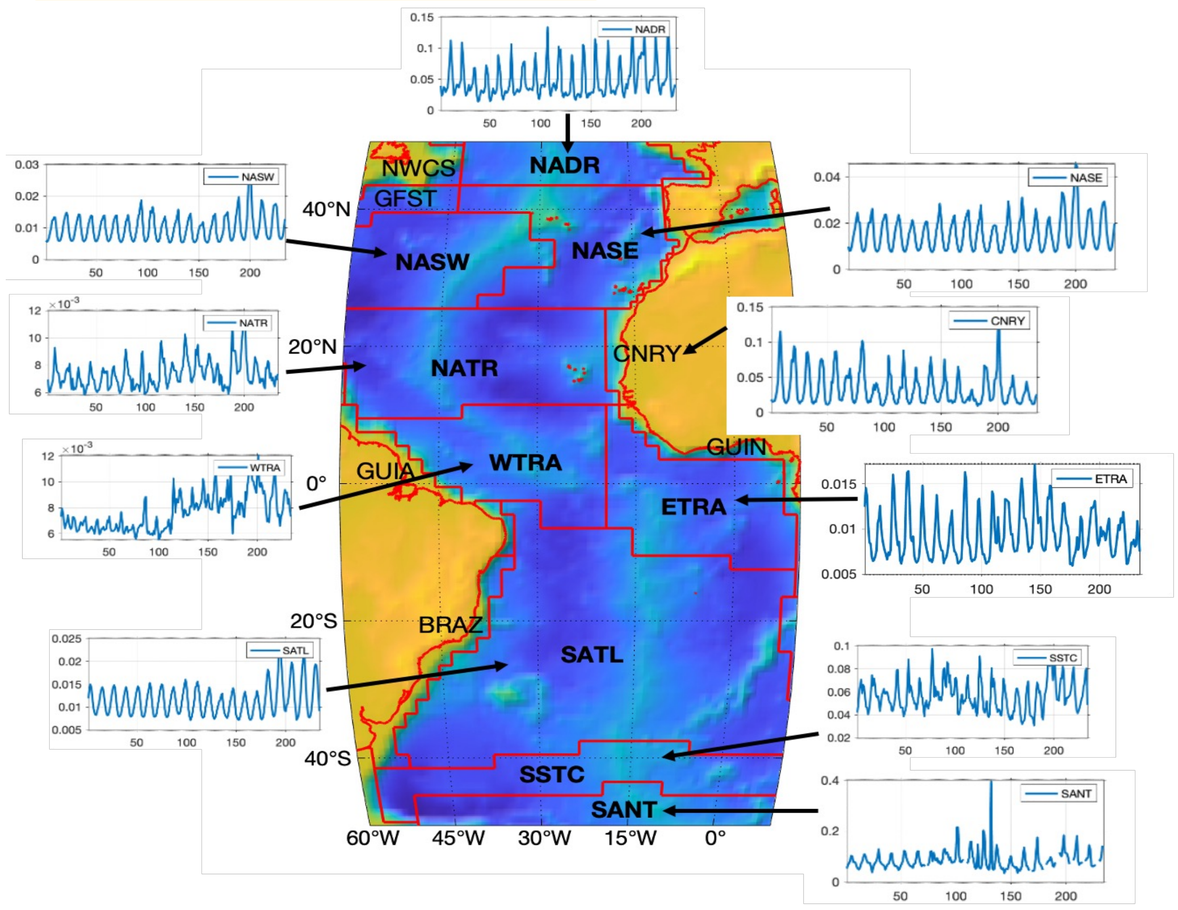
PFT annual cycle in the whole Atlantic region



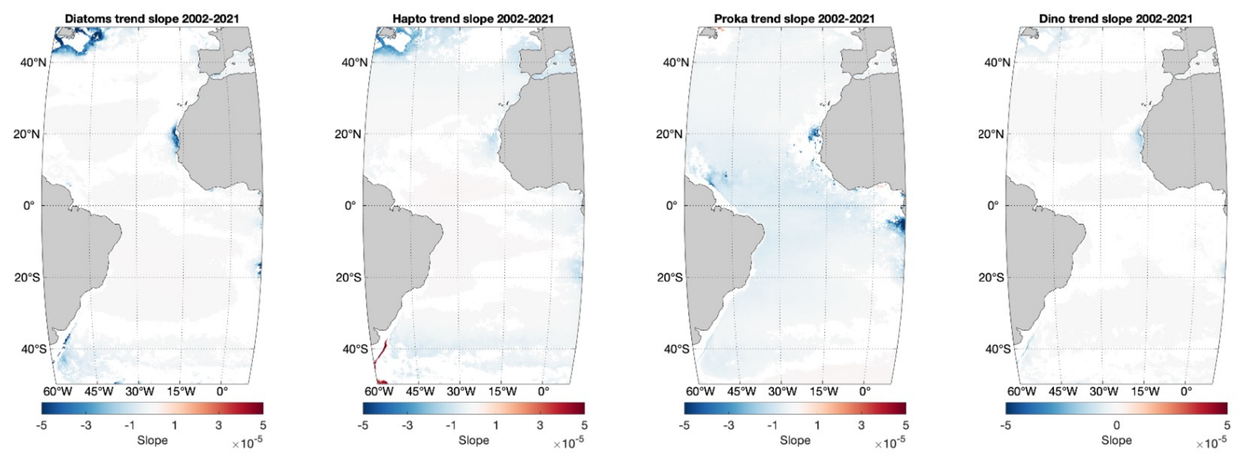
20-year climatology



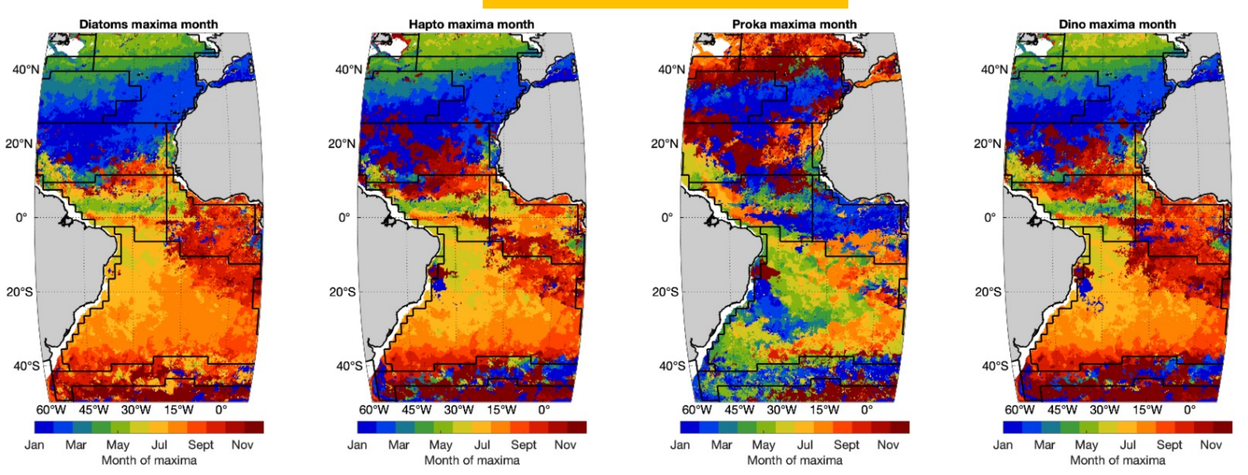
20-year diatoms in different provinces



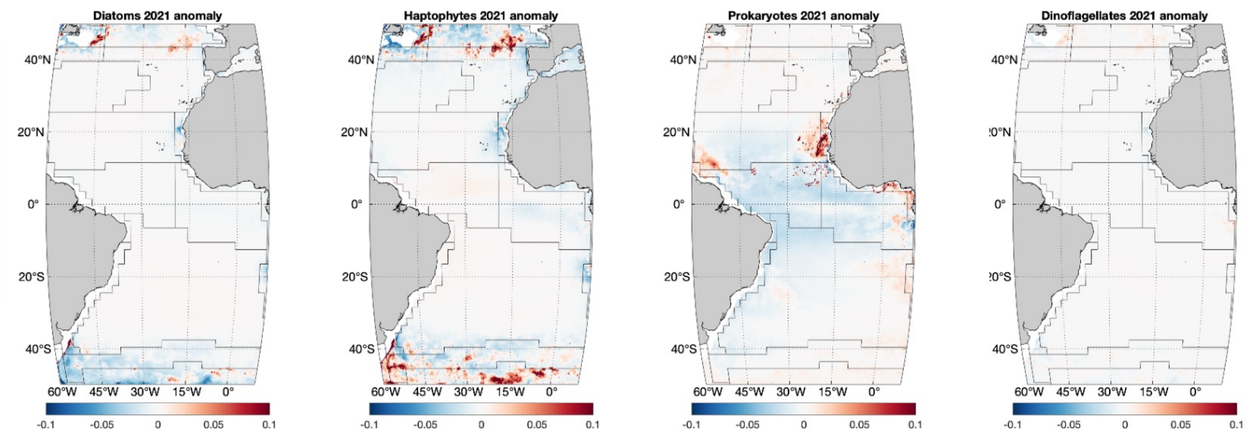
PFT per-pixel trends



PFT Chla maxima month



PFT anomaly 2021



Conclusions

- Satellite PFT products provide robust spatial distributions which are comparable to in situ data with overestimation at low Chla (< 0.01 mg m^{-3}) for diatoms, haptophytes and dinoflagellates. Prokaryotes were in general overestimated but show good correlation to in situ.
- PFT time series over the whole Atlantic region show mostly no clear trend over the last 20 years – except a small decline (-0.001 mg m^{-3} per year) in prokaryotes and an increase in diatoms during 2018-2019 which is mainly observed in the northwest Atlantic provinces (NASW,NATR, WTRA) and SATL. More in situ data are necessary to prove the trends detected.
- The phenology of diatoms, haptophytes and dinoflagellates are very similar: in the higher latitudes bloom maxima are reached in spring (April in the northern and October in the southern hemisphere), in the oligotrophic regions in winter time, and in the tropical regions during May to September. Prokaryotes show opposite annual cycles to these three PFTs.
- The PFT anomaly of 2021 compared to the 20-year mean reveals mostly a slight decrease in diatoms and a strong increase in haptophytes in most areas of the high latitudes, but no significant change in the mid to low latitudes, while prokaryotes show a clear decrease in the central tropical regions and increase in the western African coast (CNRY and GUIN) and southwest corner of NATR. Dinoflagellates are relatively stable in the whole Atlantic region.

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References

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