How is the surface phytoplankton community composition changing in the Arctic Fram Strait in the last two decades?

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Background

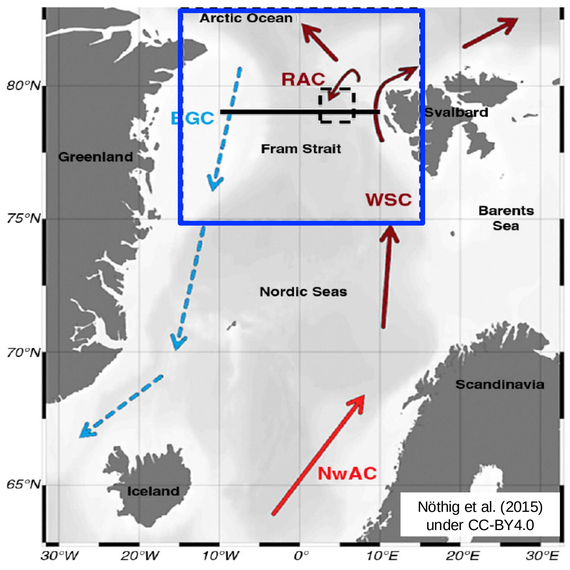
- Phytoplankton community composition varies in ocean biomes and phytoplankton functional types (PFTs) drive differently the marine ecosystem;
- Phytoplankton in the Arctic Ocean are highly influenced by sea ice conditions and brine release; their dynamics are influenced by the extent of stratification as this determines the timing of nutrient and light dependent biological production;
- **Fram Strait – Gateway to the Arctic:** where warmer nutrient-rich Atlantic water meets the cold fresher Arctic water, with complex ecosystem subject to severe climate-induced environmental changes;
- Consistent long-term monitoring of PFTs within the framework of Copernicus Marine Service enables the study for inter-annual variation and trend analysis of the PFTs in the Fram Strait.

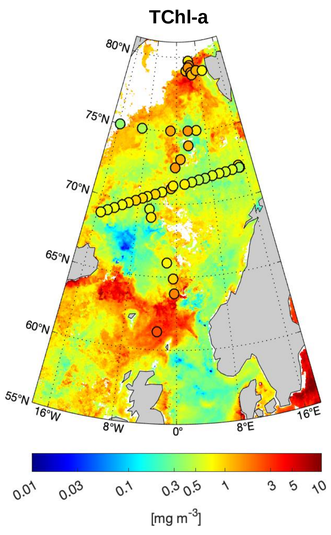
Objectives

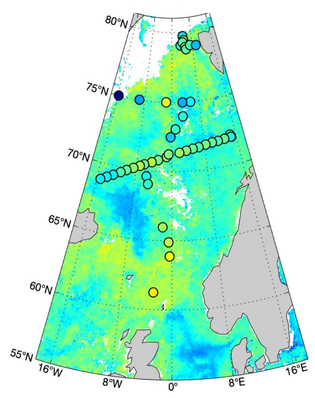
- Evaluation of satellite PFT products in the Fram Strait with in situ time series data;
- Analysis on the time series of PFTs from 2002 to 2023;
- Investigation of relations between PFTs and biogeochemical/physical parameters.

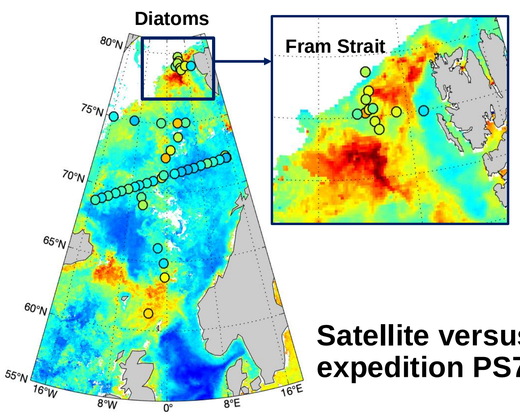
PFT observations in the Fram Strait

- **Region of interest: 16°W – 12°E, 75°N – 81°N**
- **Period: 2002 to 2023**









Satellite versus in situ PFT data during expedition PS74: 20090622-0731 (an example)

Method and Data

Products from Copernicus Marine Service: https://marine.copernicus.eu/

- **Updated satellite PFT products within the framework of Copernicus Marine Service Evolution project 'GLOPHYTS'**
  - A global approach (EOF-PFT) for PFT chlorophyll a (chl-a) retrieval using ocean color reflectance data and SST (Xi et al. 2020; 2021; 2023a)
  - Daily PFT products with 4-km resolution (L3 and L4)
- **Biogeochemical and physical products**
  - Global Ocean Physics Reanalysis: https://doi.org/10.48670/moi-00021

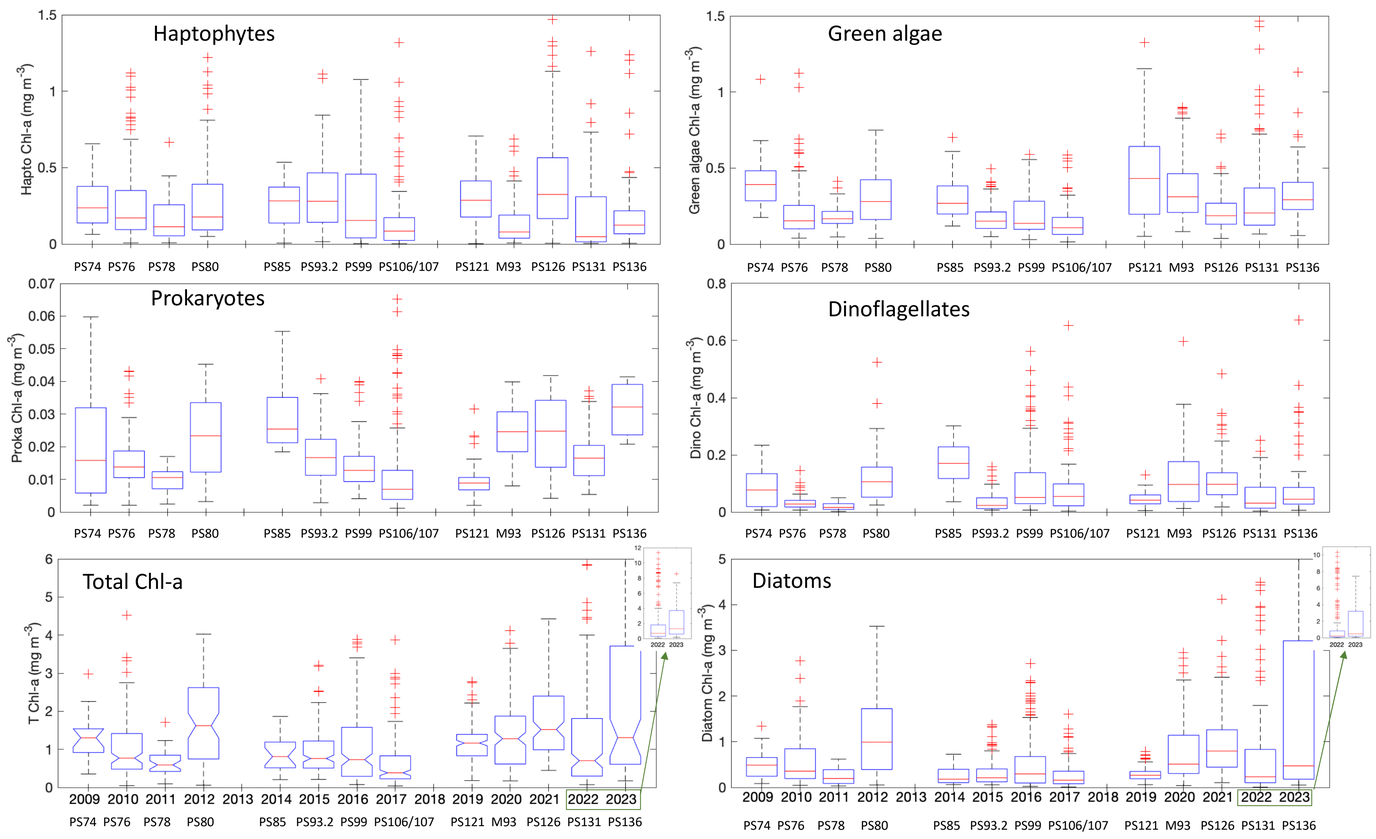
  SST. SSS, Mixed layer depth, salinity, sea ice concentration, sea ice thickness.
  - Global Ocean Biogeochemistry Hindcast: https://doi.org/10.48670/moi-00019

  Nutrients (Silicate, NO3, PO4), pH, spCO2, iron content, oxygen, CO2, NPPV

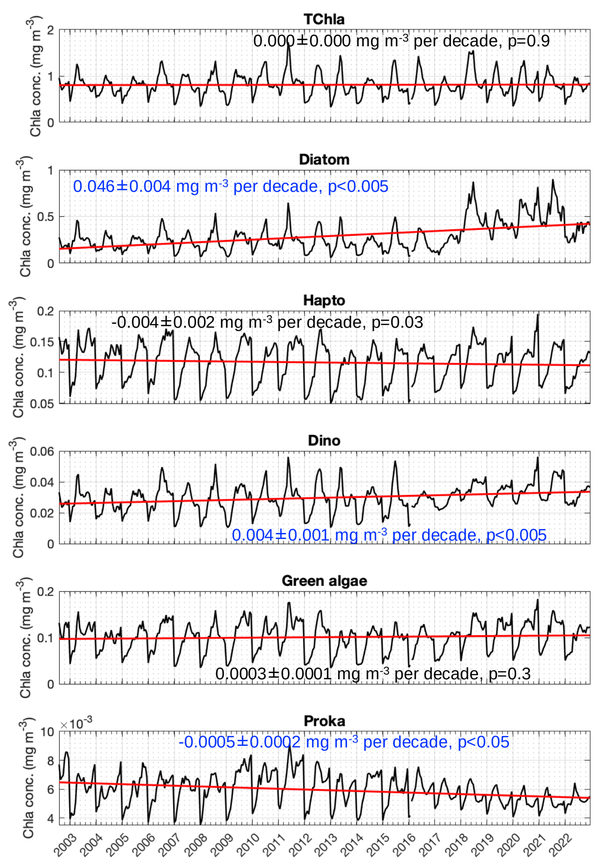
In situ HPLC pigment based PFT data

- **Pigment data** collected from the LTER 'HAUSGARTEN' expeditions in the Fram Strait: PS74, PS76, PS78, PS80, PS85, PS93.2, PS99, PS106/107, PS121, MSM93, PS126, PS131, PS136 (AWI, 2017), available from Xi et al. (2023b) except for the last four expeditions
- Diagnostic pigment analysis (DPA) for in situ PFT Chl-a conc. (Xi et al. 2023a,b)

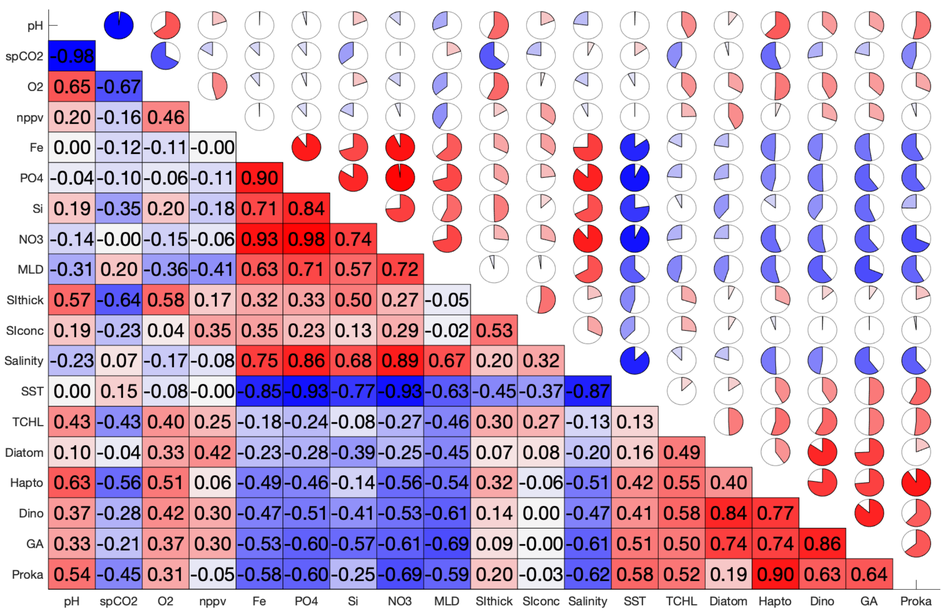
In situ TChl-a and PFT Chl-a time series from 2009 to 2023



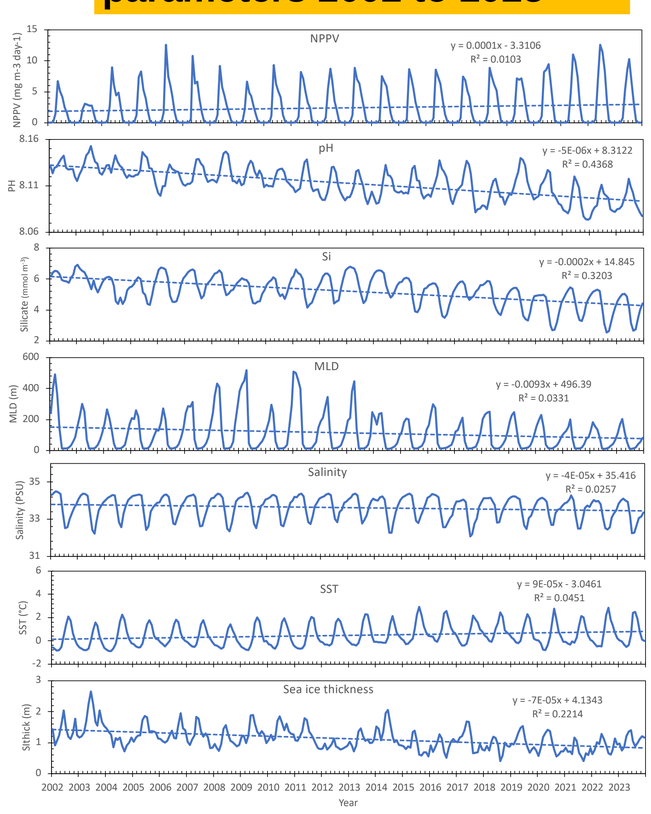
PFT time series from space (Apr. – Sept.)



Correlation matrix between PFTs and BGC/physical variables



Trends of BGC and physical parameters 2002 to 2023



Conclusions

- Satellite PFT time series match well with the in situ data, showing the prominent increase of diatoms since 2019;
- SST, pH, and O_2 drive positively most of the PFTs, while nutrients, iron conc., CO_2, and MLD show mostly significant negative correlation with PFTs. Sea ice thickness shows low positive correlations but no correlation is found with sea ice concentration. Further analysis will be carried out for comprehensive interpretations.

Acknowledgements

- Copernicus Marine Service Evolution projects GLOPHYTS and ML-PHYTAO
- Project 4D-Phyto funded by AWI-INSPIRES and HGF-MarData
- Helmholtz Impulse Fond VHG #300 (HGF Young Investigators Group PhytoOptics)
- DFG (German Research Foundation) (AC)3 (Project C03 *268020496*);
- FRontiers in Arctic marine Monitoring (FRAM)
- ESA S5P+Innovation Theme 7 Ocean Colour (S5POC) project
- PEBCAO team (AWI and GEOMAR)
- NASA, ESA and EUMETSAT for the SeaWiFS, MODIS, VIIRS, MERIS, and OLCI data
- Copernicus Marine Service
- Captain, crew, chief scientist and scientists on expeditions, particularly the AWI led Polarstern expeditions (PS74, PS76, PS78, PS80, PS85, PS93.2, PS99, PS106, PS107, PS121, AWI_PS126_02, AWI_PS131_05, AWI_PS136_04)
- Data repositories: PANGAEA, SEABASS, BODC, AODN

References

- Alfred-Wegener-Institut, 2017, doi: 10.17815/jlsrf-3-163
- Nöthig et al. 2015, Polar Research, doi: 10.3402/polar.v34.23349
- Xi. et al. 2020, RSE, doi:10.1016/j.rse.2020.111704
- Xi et al., 2021, JGR-Oceans, doi: 10.1029/2020JC017127
- Xi et al. 2023a, SP, Copernicus Ocean State Report 7th edition, doi: 10.5194/sp-1-osr7-5-2023
- Xi et al. 2023b, PANGAEA, doi: 10.1594/PANGAEA.954738

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