Influence of surface water stratification on phytoplankton blooms in the Arctic: a case study at Fram Strait

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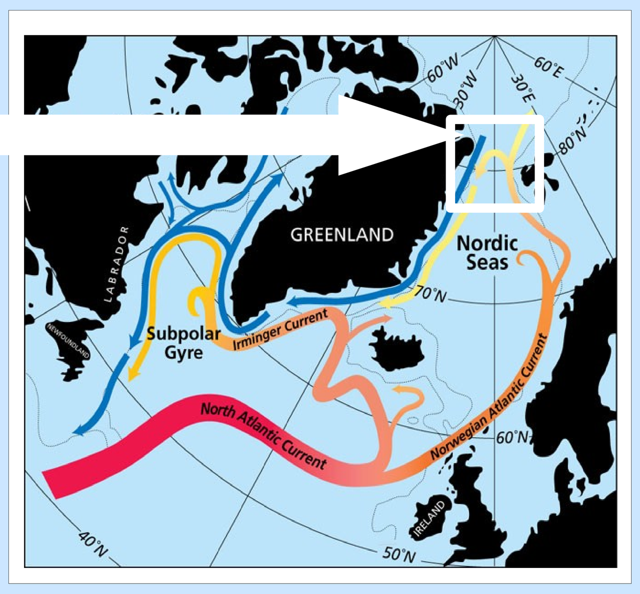
Question of interest

Are more stratified waters associated with stronger and earlier phytoplankton blooms in the Fram Strait?

Region: Fram Strait

- Area of major transport of Atlantic water into the Arctic ocean
- Warm and saline West Spitsbergen Current (extension of Norwegian Atlantic Current) in the eastern part
- Cold and low salinity East Greenland current in the western part (which is ice-covered most time of the year)

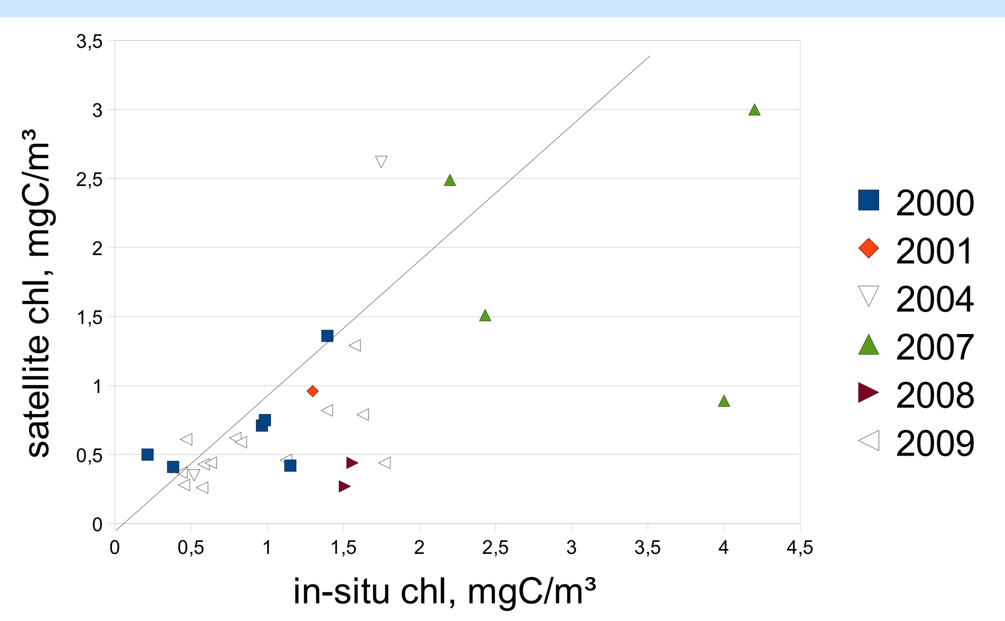


Data used

Name	Time period	Temporal resolution	Spatial resolution
GlobColour (merged MERIS-MODIS-SeaWiFS) CHL	1998-2009	daily, monthly	4.6 km
In-situ CHL (Turner Fluorometer)	2000-2009	-	point measurement
High-resolution NAOSIM output	1998-2009	monthly	9 km
PHAROS group (University of Bremen) SIC (retrieved from AMSR-E)	1998-2009	daily	6.25 km

MERIS - MEdium Resolution Imaging Spectrometer,
MODIS - Moderate Resolution Imaging Spectroradiometer,
SeaWiFS - Sea-viewing Wide Field-of-view Sensor,
CHL – CHLorophyll-a, NAOSIM – North Atlantic/Arctic Ocean Sea Ice Model,
SIC – Sea Ice Concentration, PHAROS - PHysical Analysis of RemOte Sensing images
AMSR-E - Advanced Microwave Scanning Radiometer - Earth Observing System

Validation of satellite data (chlorophyll-a)



N = 28
R^2=0.45
RMS=0.73
SLOPE=0.5
OFFSET=0.22

Figure 1. Comparison of GlobColour CHL daily data [1] to the in-situ CHL data measured with Turner fluorometer [2]. April-September 2000-2009.

No simple relationship between phytoplankton bloom and sea ice

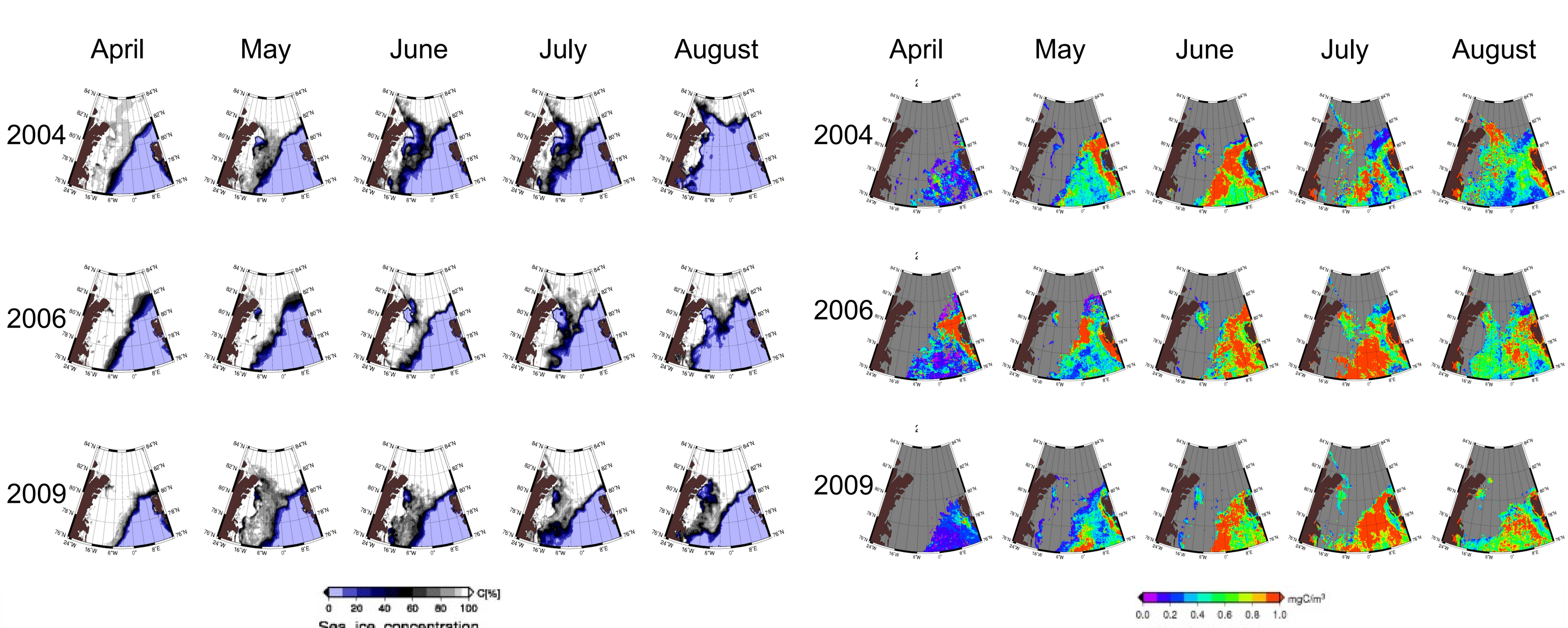


Figure 2. Left: monthly satellite-retrieved sea ice concentration [3]
Right: monthly satellite-retrieved chlorophyll-a [1]

Results of cross-correlation analysis

Time period: April-August 1998-2009
Location: 10 sites with 20km radius in the ice-free part of Fram Strait

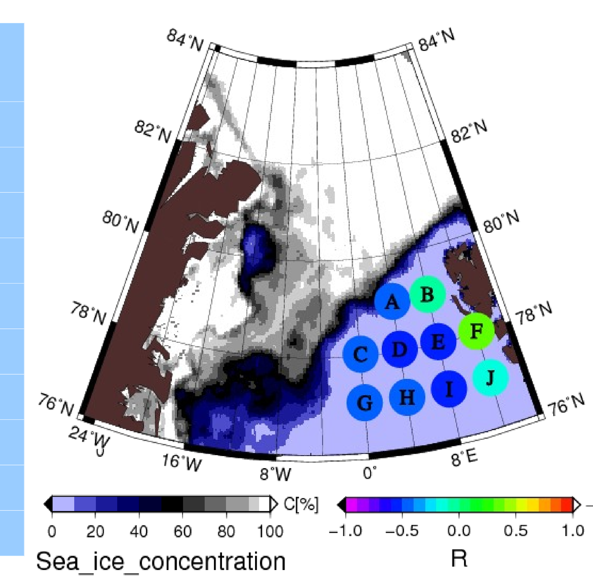
Parameters modeled [4,5] for cross-correlation analysis with chlorophyll-a:
1. Sea Surface Salinity 2. Sea Surface Temperature
3. Sea Ice Concentration 4. Sea Ice Thickness
5. Change in salinity due to melting ice 6. Mixed Layer Depth

Strongest correlation - between CHL and Mixed Layer Depth (MLD)

Mixed Layer Depth: two definitions

Criterion:
density difference 0.125kg/m³ from the surface

Point	R
A	-0.5
B	-0.1
C	-0.5
D	-0.6
E	-0.6
F	0.3
G	-0.5
H	-0.5
I	-0.6
J	-0.2



Criterion:
maximum density gradient

Point	R
A	-0.6
B	0
C	-0.5
D	-0.5
E	-0.5
F	0.3
G	-0.4
H	-0.3
I	-0.4
J	-0.1

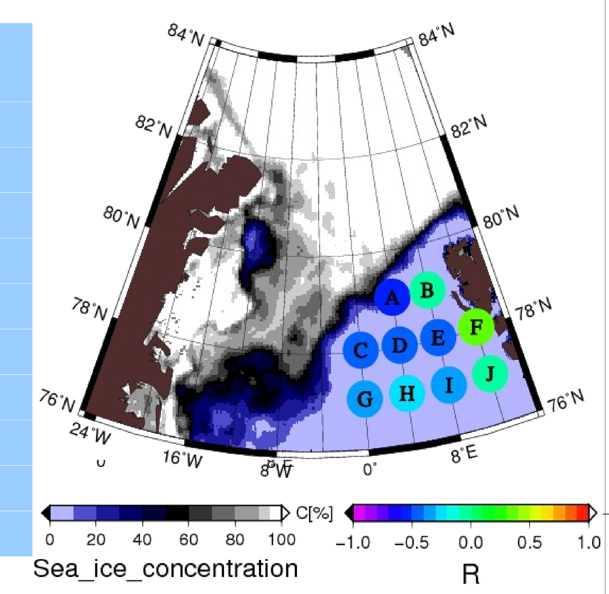


Figure 3. Table and circles show correlation coefficients between CHL and Mixed Layer Depth for 10 sites. Base map is PHAROS Sea Ice Concentration for July 2009 [3]

Conclusions

- We found no simple relationship between the phytoplankton bloom and the sea ice concentration.
- Results of correlating CHL time series with that of 6 physical parameters show the parameter mostly correlated with CHL is the Mixed Layer Depth. The use of two different MLD definitions did not significantly change the results.
- Mixed Layer Depth is negatively correlated with the chlorophyll-a in the open ocean part of region, i.e. shallow MLD corresponds to higher phytoplankton concentrations. We suggest the reason for this lies in the more stratified waters triggering the bloom start.
- In the coastal part we observed hardly any correlation, which can be explained either by different mechanisms guiding phytoplankton growth on the coast or by poor data quality in the coastal area

Outlook

- Perform crosswavelet or EOF analysis to study periodicities of CHL and MLD
- Use in-situ data to adopt global primary production model by Antoine et Morel (1996) to the Greenland Sea conditions [9]. Retrieve primary production values.

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