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à Rimouski

The impact of oceanic and climatic forcing on the inter-annual variability of pelagic phytoplankton in NOW polynya

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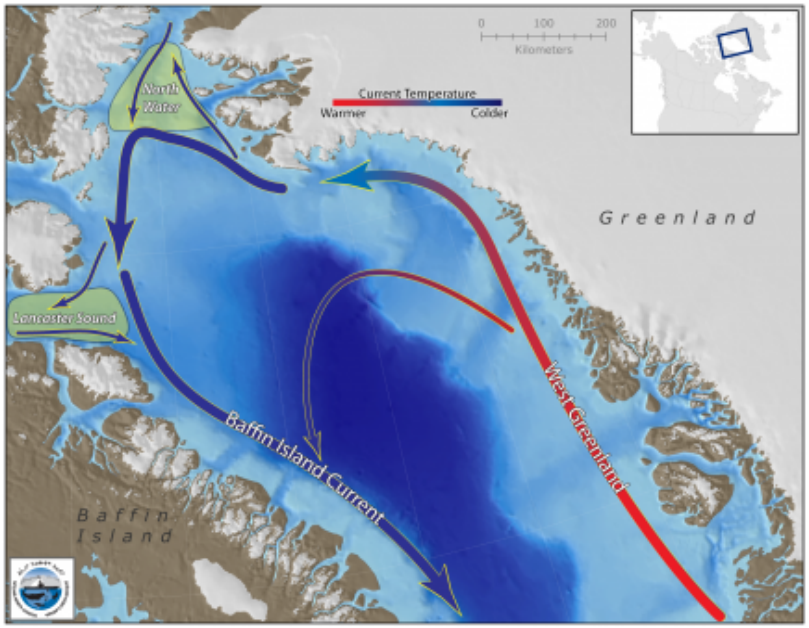
Québec OCÉAN
Le groupe interinstitutionnel de recherches océanographiques du Québec

BORÉAS
GROUPE DE RECHERCHE SUR LES ENVIRONNEMENTS NORDIQUES

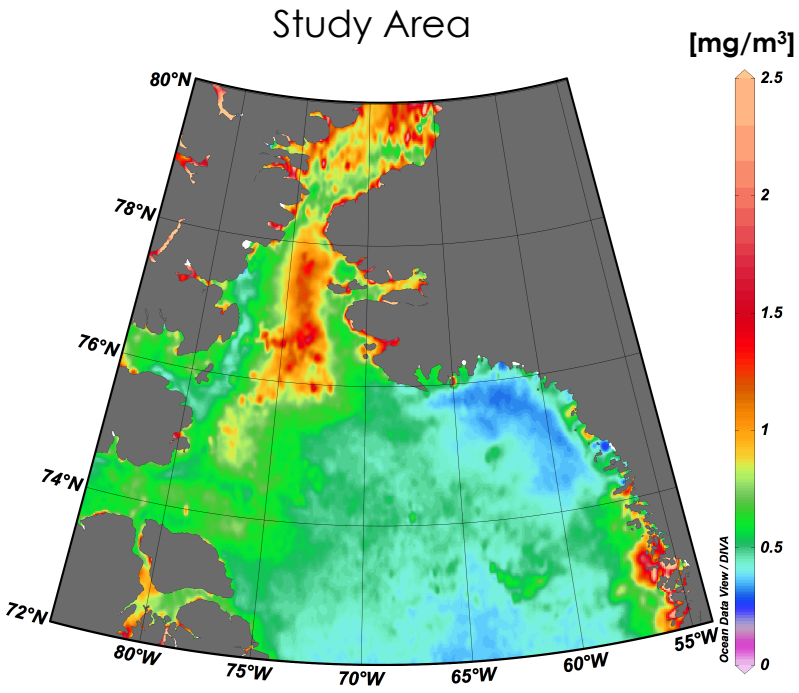
OUTLINE

- Study Area
- Goals
- Phytoplankton and sea-ice phenology
- Satellite data used to quantify the inter-annual variability of phytoplankton phenology
- Bloom timing metrics and the model to quantify the seasonality
- Preliminary results
- Main conclusions
- Next to do…

Study Area



Map of the Baffin Island and West Greenland currents



Chlorophyll-a concentration climatology (MODIS 2002 – 2012)

The North Water (NOW) is one of the largest polynyas in the Northern Hemisphere, occupying Smith Sound and the northern part of Baffin Bay, between Greenland and Ellesmere Island.

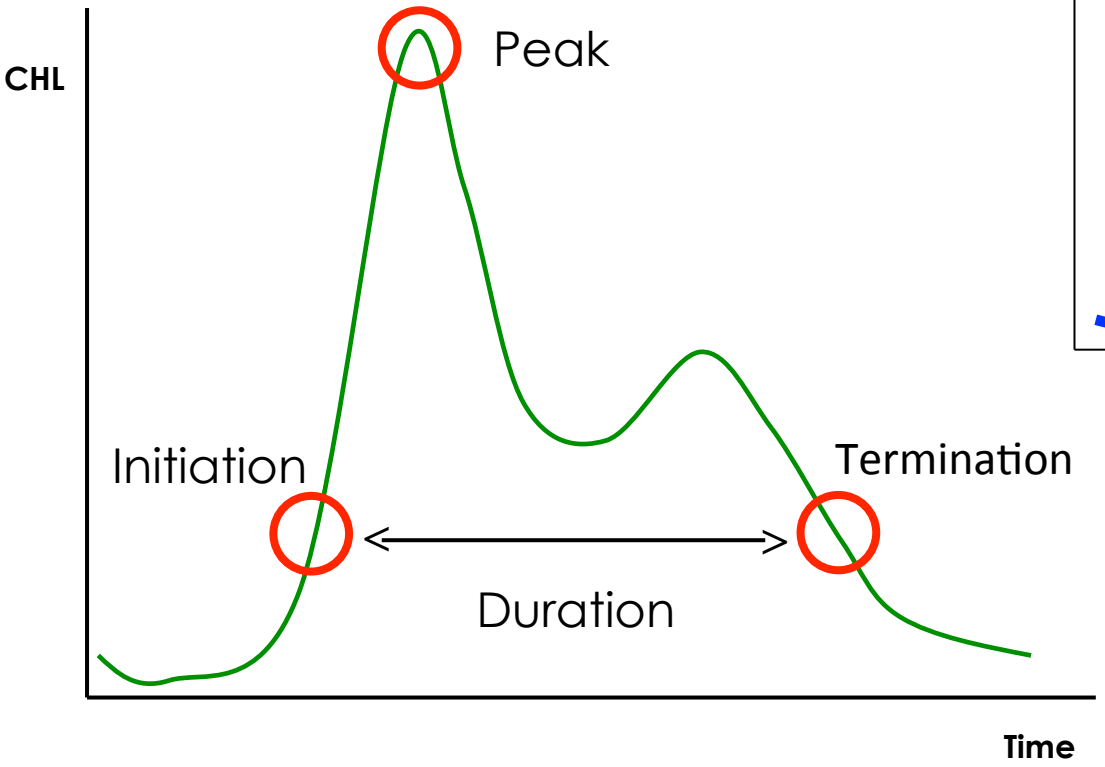
GOALS

Investigate the inter-annual variability of phytoplankton phenology in NOW (North Baffin Bay), using satellite ocean color data.

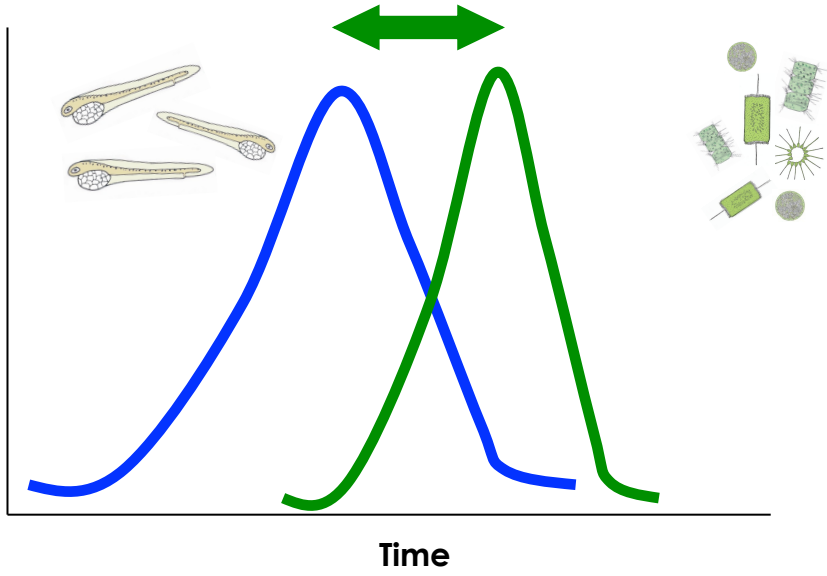
Describe:

1. regional differences in phytoplankton phenology
2. phenological responses to climatic/oceanic forcing

Phytoplankton phenology



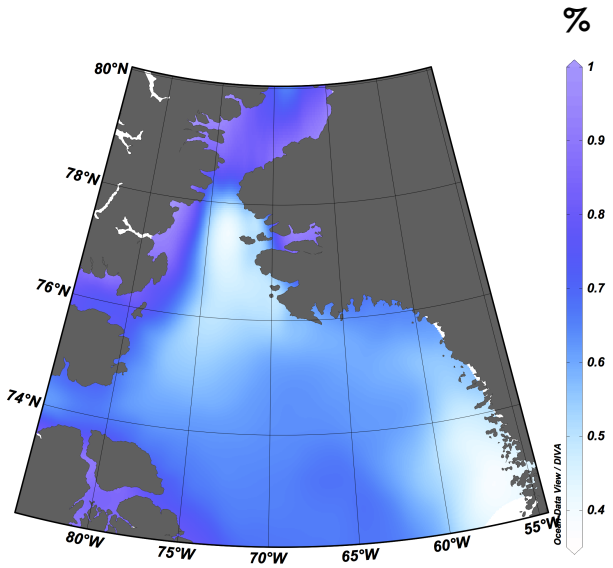
Match-mismatch hypothesis (Cushing, 1990)



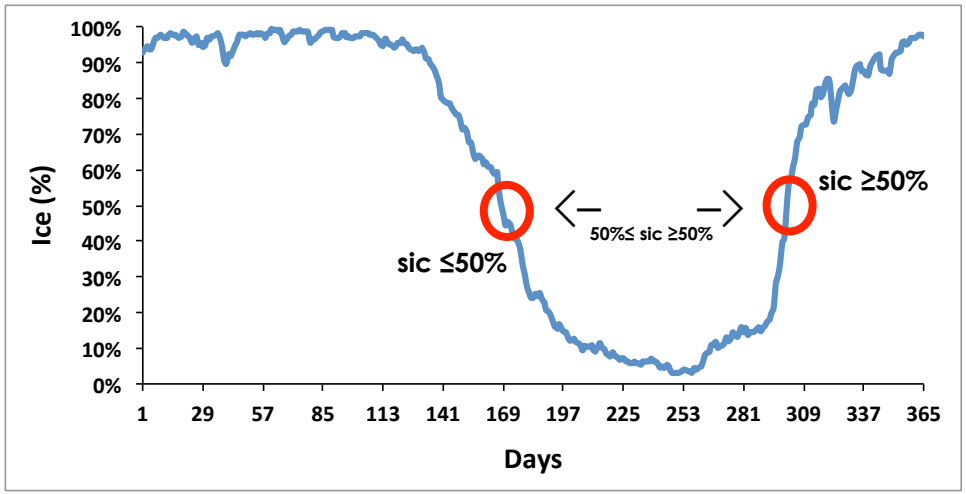
Key feature of the time series is seasonal signal: bloom is the dominant event in seasonal cycle. Inter-annual fluctuations in phase are important for marine ecosystem (Platt, et al. 2007).

Sea-ice phenology

The day-of-year when the ice concentration at each pixel drops below 50% is used as a proxy for ice-retreat timing



Mean annual (2007) ice concentration



Percent ice concentration as a function of day (year 2007)

$T_{\text{ice-retreat}} \leq 50\%$

$T_{\text{ice freeze-up}} \geq 50\%$

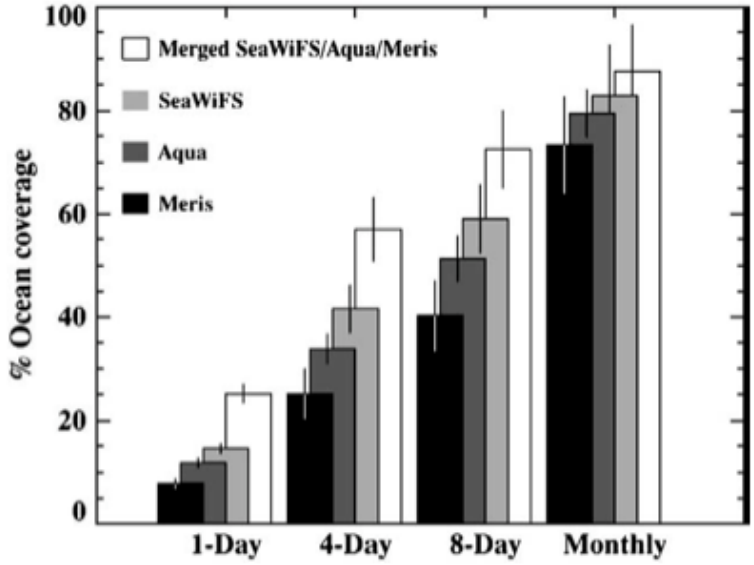
data source: National Snow and Ice Data Center (NSIDC)

Satellite data used to quantify the inter-annual variability of phytoplankton phenology

GlobColour time series of Chl-a merged from three satellite data sources:

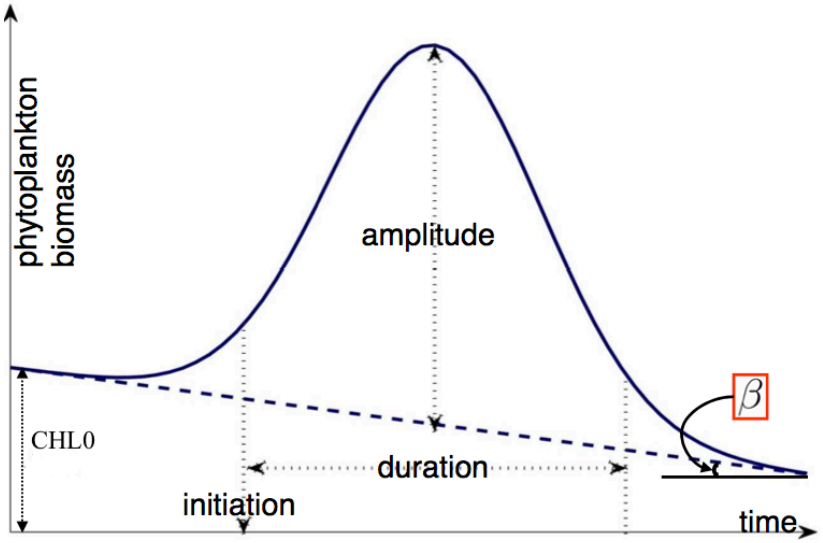
- SeaWiFS
- MERIS
- MODIS-Aqua

- Time period: from 1998 to 2012
- Spatial resolution: 25 km
- 8-Days composite



Coverage for daily and multiple-day composite imagery for SeaWiFS, AQUA and MERIS and when the three sensors are merged for the 2002–2009 period (from Maritorena et al., 2010).

Bloom timing metrics and the model (M_{ulti}-$G_{aussian}$-F_{itting}-M_{ethod}) to quantify the seasonality



Background biomass: CHL_0

Linear term: β

Amplitude: CHL_H

Initiation: $t_p - 1.79\sigma$

Duration: 3.59σ

Timing of bloom peak: t_p

- Simple-peak Gaussian (1)

$$\mathrm{CHL(t)} = CHL_0 + CHL_H * \exp\left[-\frac{(t-t_p)^2}{2\sigma^2}\right]$$ **(Sasaoka et al., 2011)**

- Simple-peak Gaussian with linear term (2)

$$\mathrm{CHL(t)} = CHL_0 + \beta t + CHL_H * \exp\left[-\frac{(t-t_p)^2}{2\sigma^2}\right]$$ **(Zhai et al., 2011)**

- Double-peak Gaussian (3)

$$\mathrm{CHL(t)} = CHL_0 + CHL_{H1} * \exp\left[-\frac{(t-t_{p1})^2}{2\sigma_1^2}\right] + CHL_{H2} * \exp\left[-\frac{(t-t_{p2})^2}{2\sigma_2^2}\right]$$

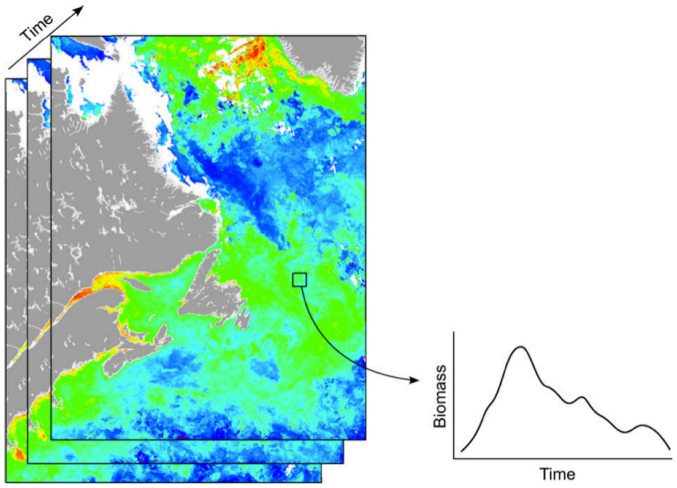
- Double-peak Gaussian with linear term (4)

$$\mathrm{CHL(t)} = CHL_0 + \beta t + CHL_{H1} * \exp\left[-\frac{(t-t_{p1})^2}{2\sigma_1^2}\right] + CHL_{H2} * \exp\left[-\frac{(t-t_{p2})^2}{2\sigma_2^2}\right]$$

(Zhai et al., 2012)

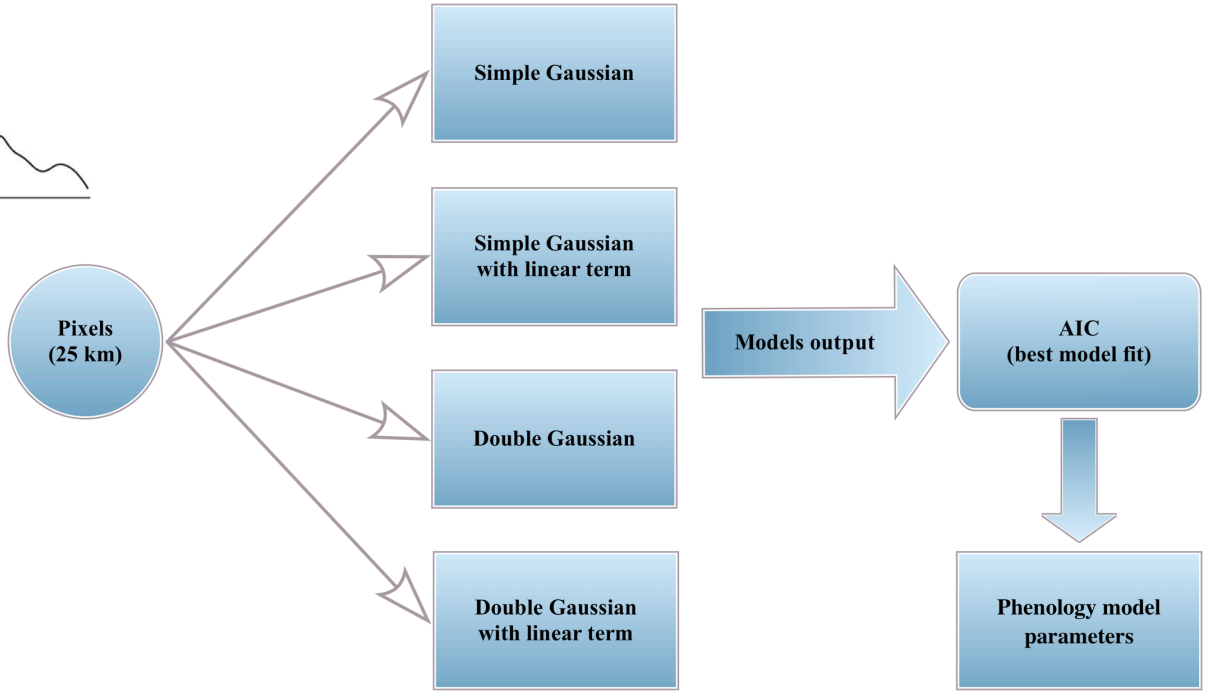
Any or all of these indices may vary between years (at any or all of the pixels in the study area)

Bloom timing metrics and the model (M_{ulti}-$G_{aussian}$-F_{itting}-M_{ethod}) to quantify the seasonality



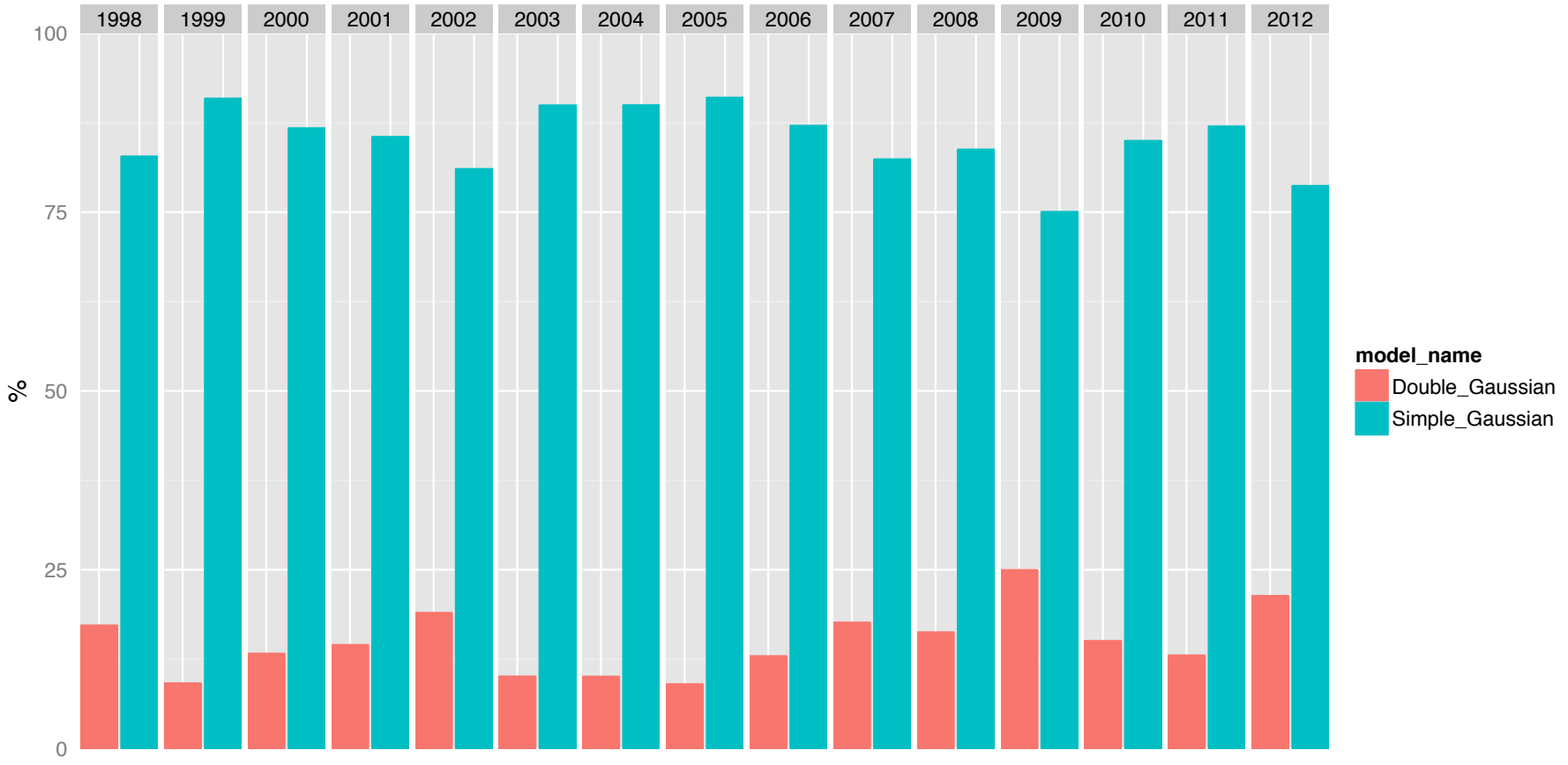
(From Platt and Sathyendranath, 2008)

Flowchart summarizing the processes to model the bloom



The Akaike information criterion (**AIC**) is used to provide a means for model selection

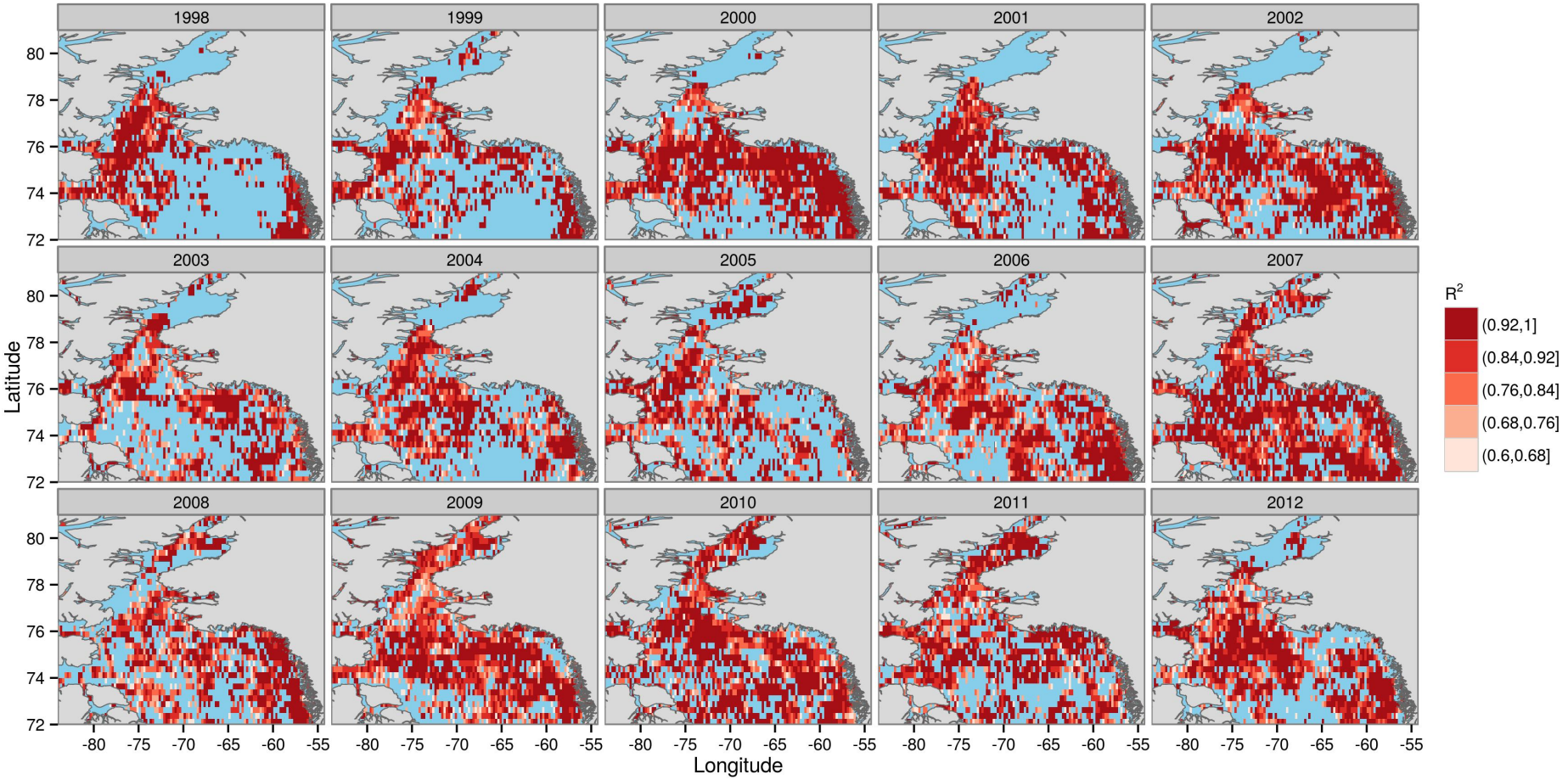
Results



Percentage of pixel fitted by models through the years

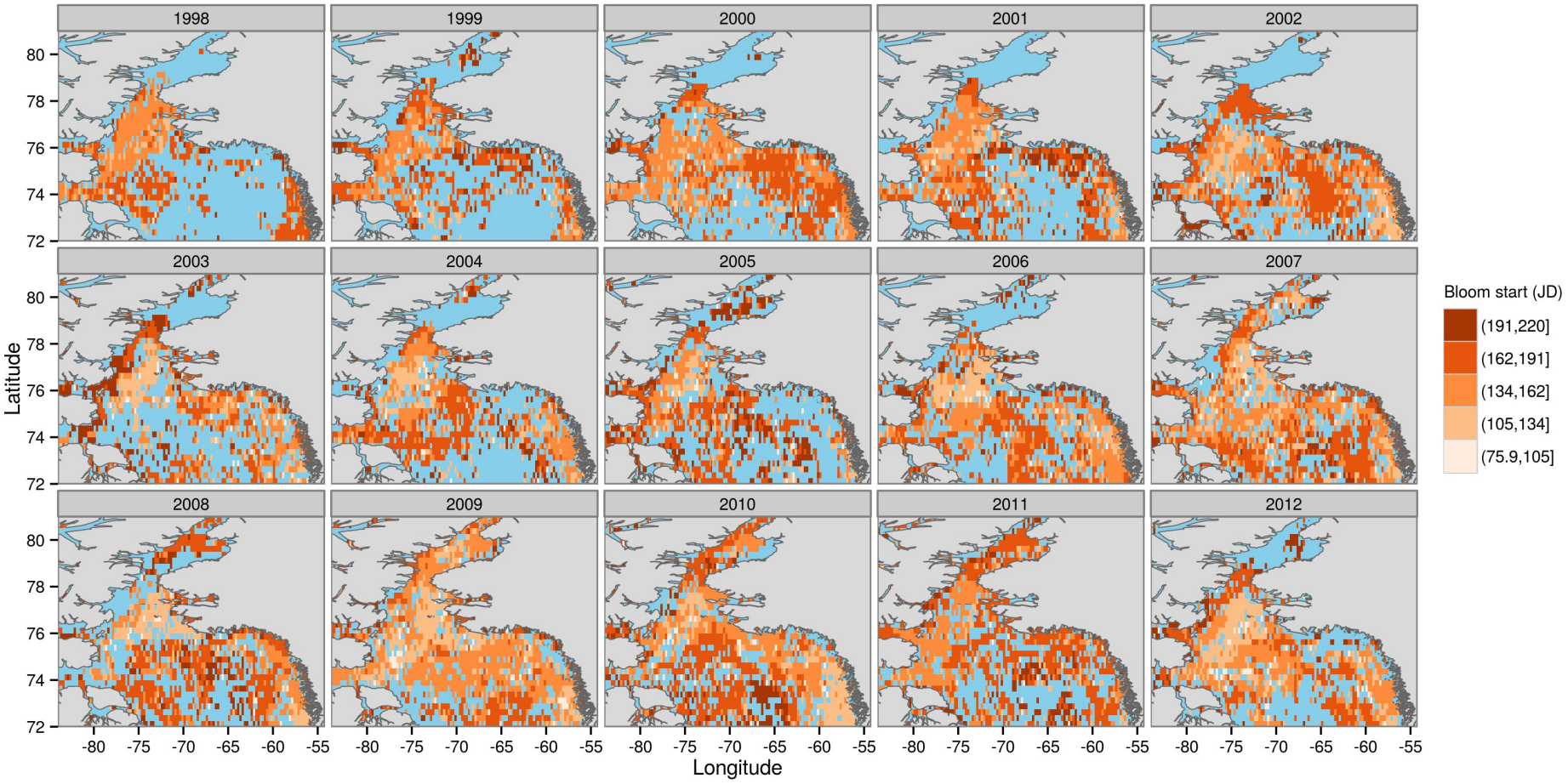
Results

Quality of fits ($R^2 \geq 0.6$)



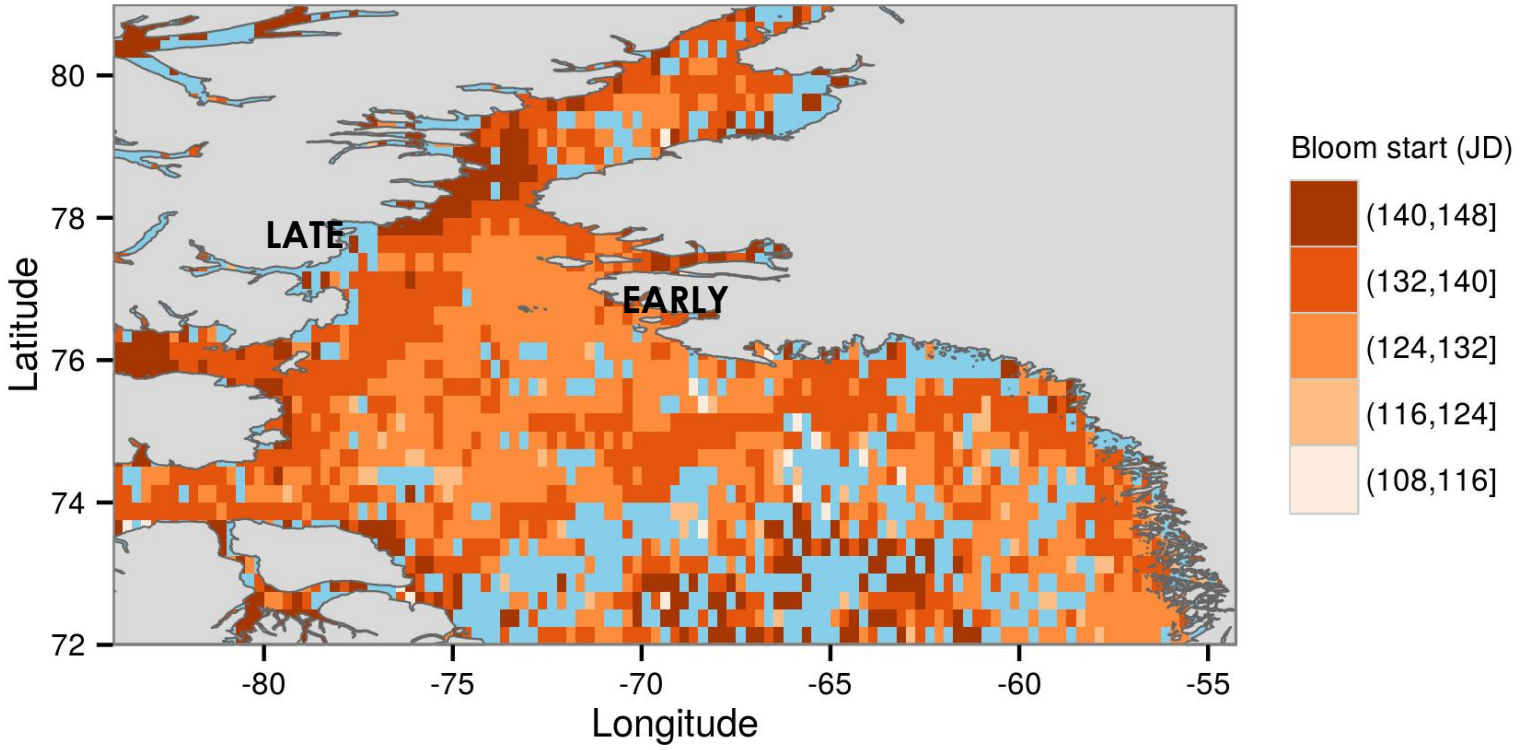
Results

Initiation of the bloom



(when Chl-a reaches 20% of the amplitude of the bloom)

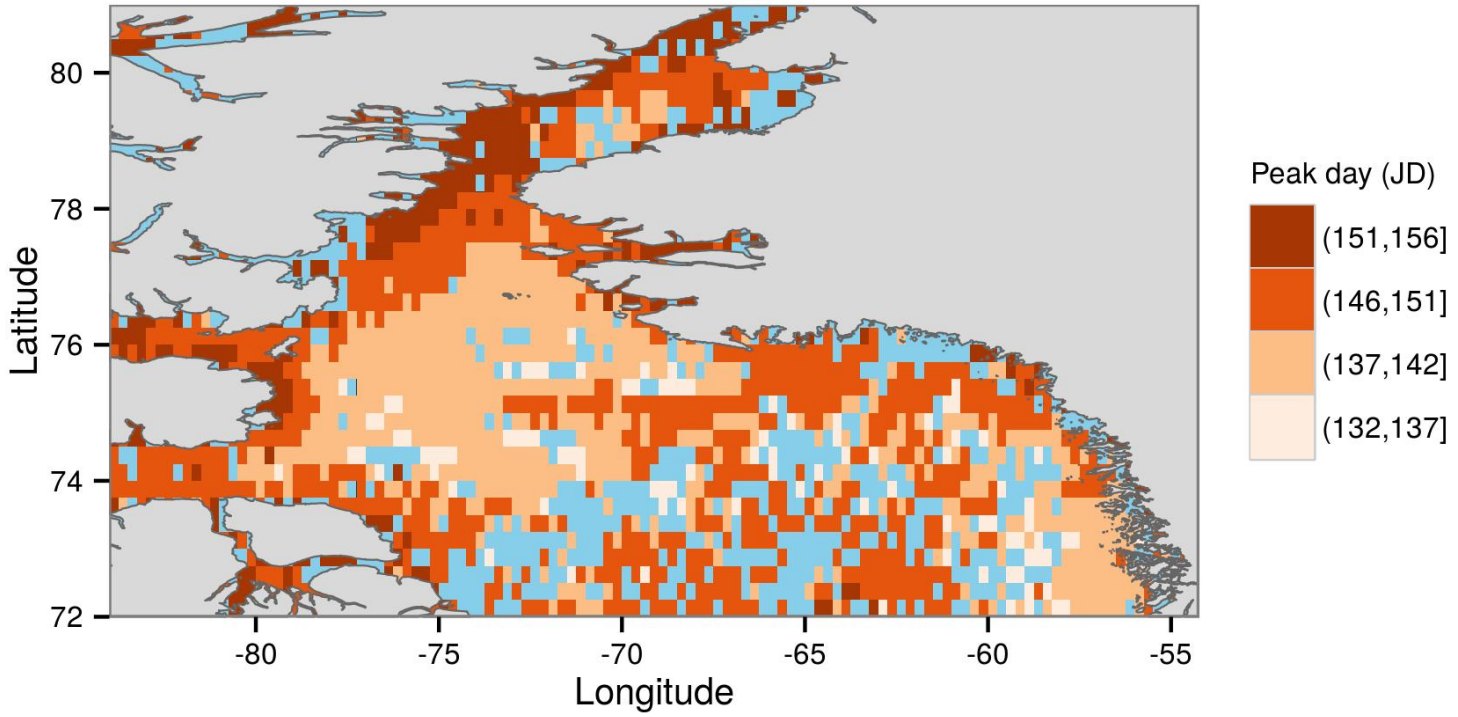
Initiation of the bloom



Climatology

Time period: 1998 - 2012

Bloom peak timing



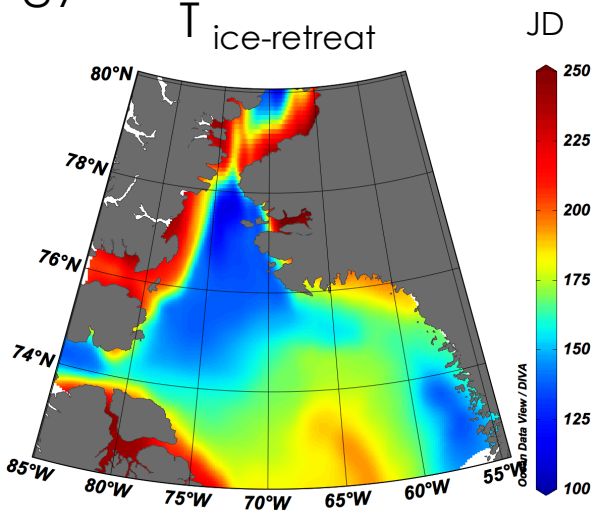
Climatology

Time period: 1998 - 2012

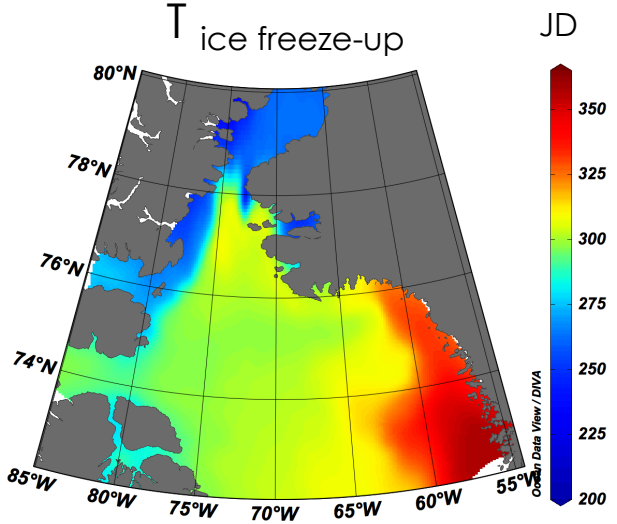
Results

Sea-ice phenology (year 2007)

(1)



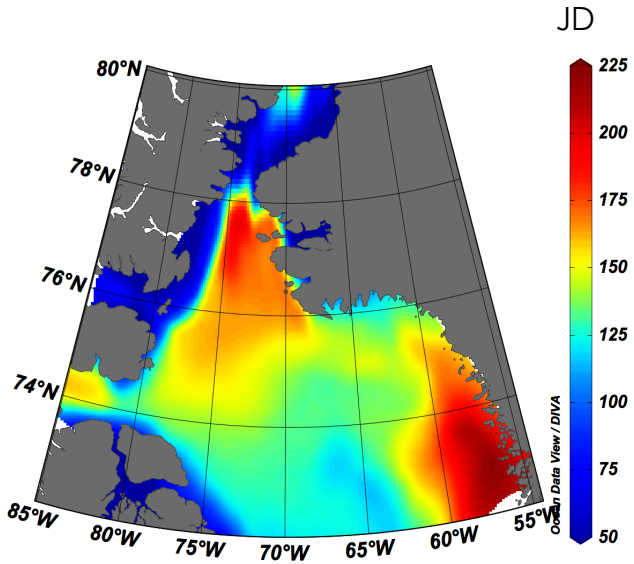
(2)



Correlations	Initiation of the bloom	Bloom peak timing
T ice-retreat	0.22*	0.34*

* $p < 0.001$

(3)



Intermediate period 50% ≤ ice ≥ 50%

Main Conclusions

- The timing of the bloom shifts between years, showing a strong inter-annual variability.
- The earliest bloom occurs around Carey Island in the east part of the polynya where thinner sea-ice, favorable irradiance and shallow mixed-layer are common features.
- The latest bloom occurs in the north (Kane Basin) and in west side of the polynya where the presence of partial ice cover may prevent light to penetrate the water column until July.
- The start time of ice retreat shows (at least for the year 2007) weak correlation with the initiation of the bloom and with the bloom peak timing.
- Overall, these preliminary results suggest the dominant role of a succession of oceanic and climatic forcing in controlling the timing and magnitude of blooms in the NOW.

Next to do…

- Evaluate the most robust method to describe phenology metrics of phytoplankton blooms for the study area.

- Determining (using multiple satellite data) the influence of different environmental conditions (such as sea-ice, air temperature, wind speed and sea-surface temperature) on the inter-annual variability of phytoplankton biomass.

Thank You!