A12: Arctic Ice algae distribution as function of large scale sea ice variables

Giulia Castellani[1], Martin Losch[1], Benjamin A. Lange[1,2], Hauke Flores[1,2]

[1]Alfred Wegener Institute (AWI) Helmholtz-Zentrum für Polar- und Meeresforschung (Germany); [2]University of Hamburg (Germany);

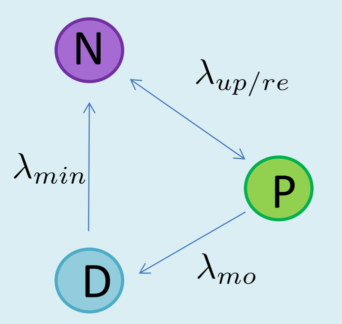
Corresponding author:
Dr. Giulia Castellani
Giulia.castellani@awi.de

INTRODUCTION

Our current understanding of Arctic sea ice algae is based on observations with limited spatial and temporal coverage. In this work we aim to model the spatial distribution of ice algae on the basin scale. Here we present a new parameterization for the sea-ice algae content developed with the aim to model the algae content and variability based on large scale sea-ice characteristics. The parameterization is applied to a large scale coupled sea-ice—ocean model to simulate the algae evolution during the year 2012 and compared to observations. Particular attention is give to the sea-ice physical constraints on algae growth and decay. The novelty of this work is the distinction between level ice and ridges to study the behavior of algae associated to these two different environments.

MODEL DESCRIPTION

We use the MITgcm in a coupled sea-ice-ocean configuration with a spatial resolution of 1/4°. We use a biogeochemical model with one ice algae class , one nutrient (Nitrate) and one detritus. The algae are a tracer in sea ice and occupy the bottom 5 cm. In total 5 runs have been performed to test different initial conditions.

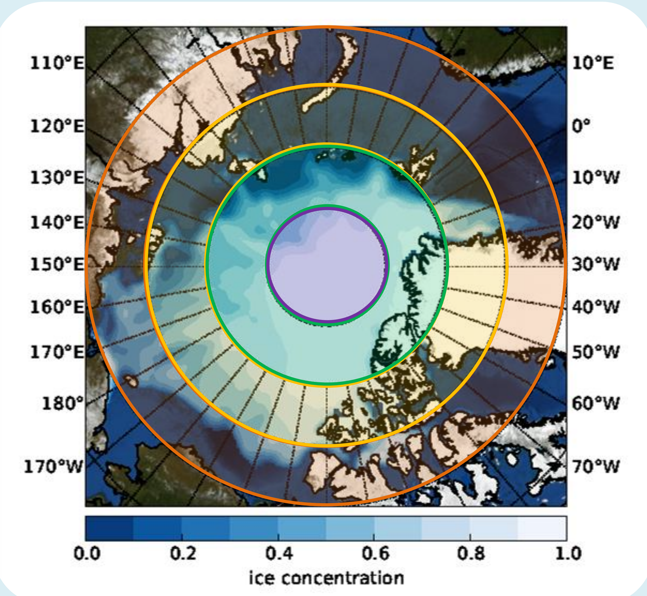


$$\frac{dN}{dt} = -(\mu - \lambda_{up/re})P + \lambda_{min} D$$

$$\frac{dP}{dt} = (\mu - \lambda_{up/re})P - \lambda_{mo} P + \frac{Melt}{\delta z} P$$

$$\frac{dD}{dt} = \lambda_{mo} P - \lambda_{min} D$$

$$\mu = \mu(PAR, N) \qquad \lambda_{up/re}, \lambda_{min}, \lambda_{mo} = \text{const.}$$

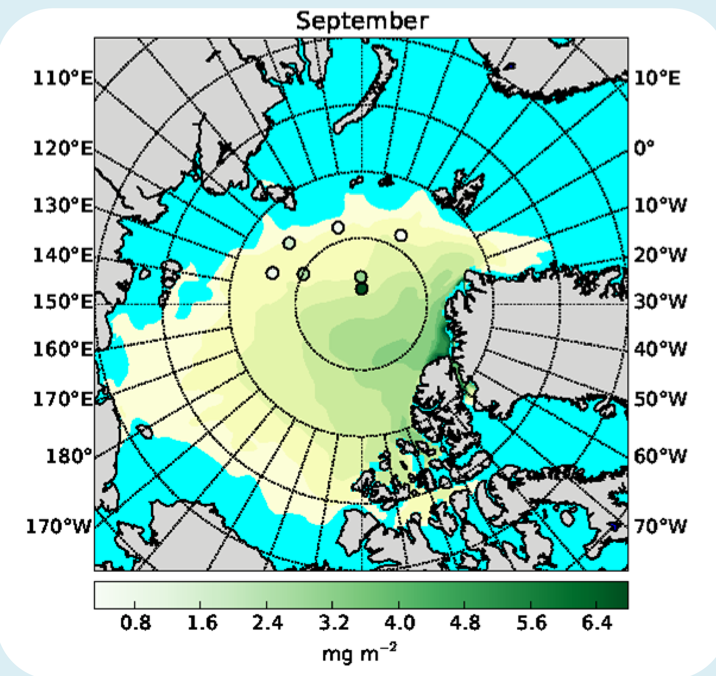


Masks:
- 70 < lat < 75
- 75 < lat < 80
- 80 < lat < 85
- 85 < lat

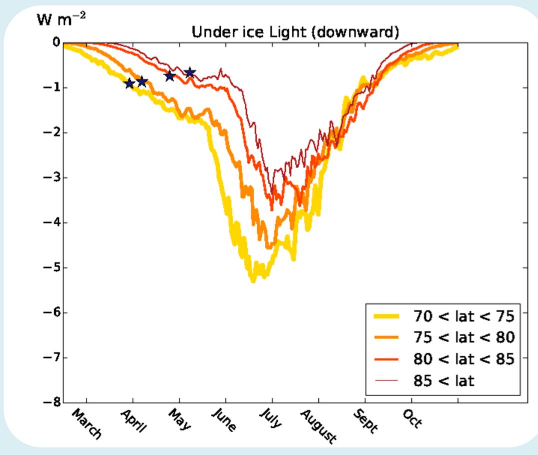
Left: Map showing the sea ice concentration in September 2012. The coloured rings represent the masks applied to analyze different regions.

RESULTS

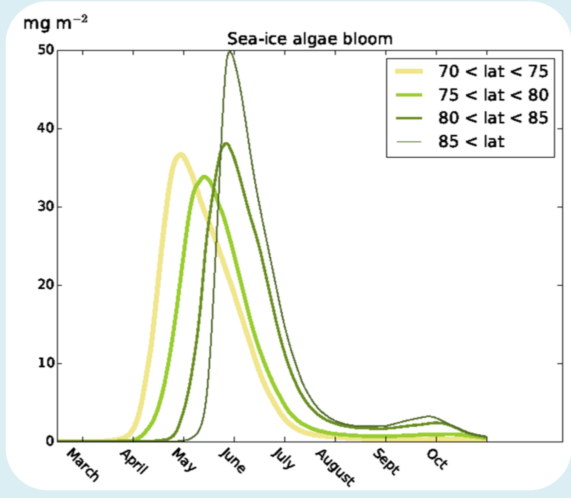
A reference run has been chosen as the one that matches best observations

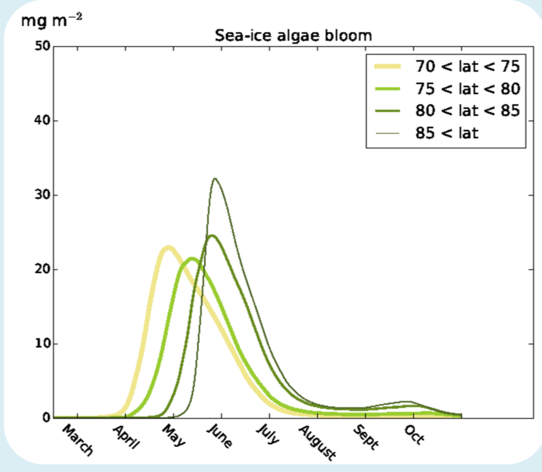


Left: Sea ice algae concentration in September 2012 compared to algae content retrieved from under-ice hyperspectral data collected in August and September 2012 [Lange et al., *In Preparation*].

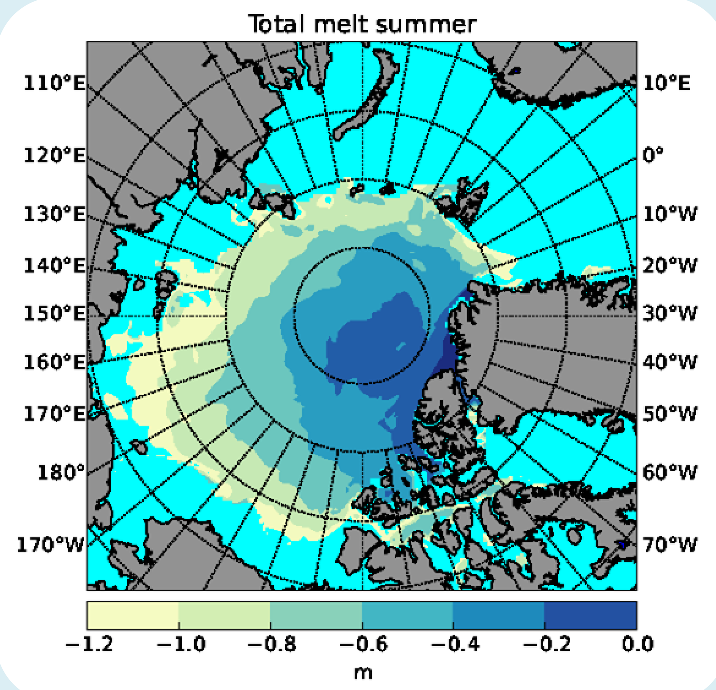


Left: Under ice radiation (positive upward). The stars correspond to the start of the alae bloom.

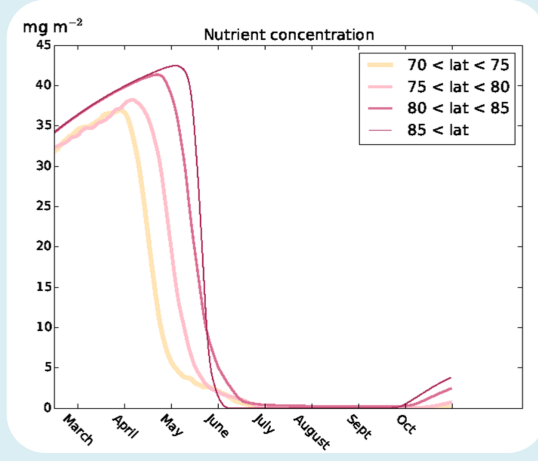




Left: sea-ice algae bloom for the reference run. Up: sea-ice algae bloom for a simulation with different initial condition.



Left: Total summer melt (April-July) 2012.

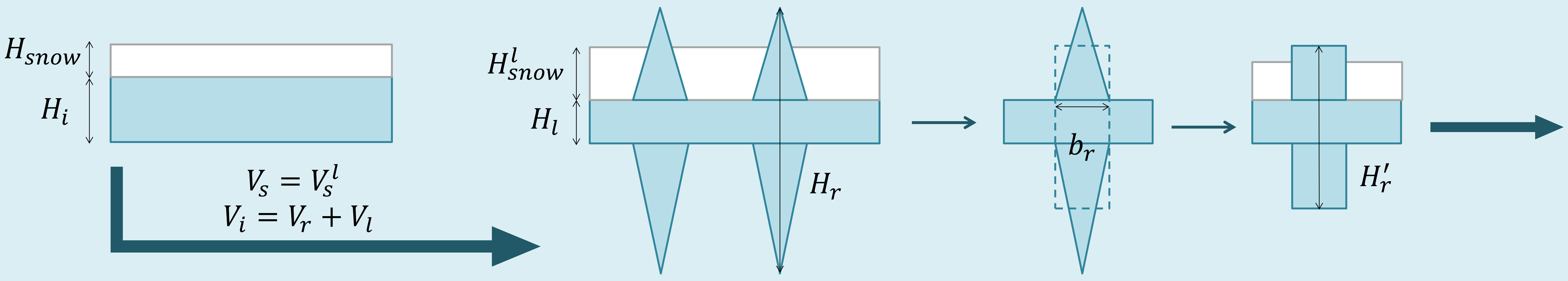


Right: Nutrient evolution for the run chosen as reference run.

The algae bloom is triggered by light availability and then limited by nutrients. The spatial pattern after the bloom season is mainly a consequence of sea ice melting.

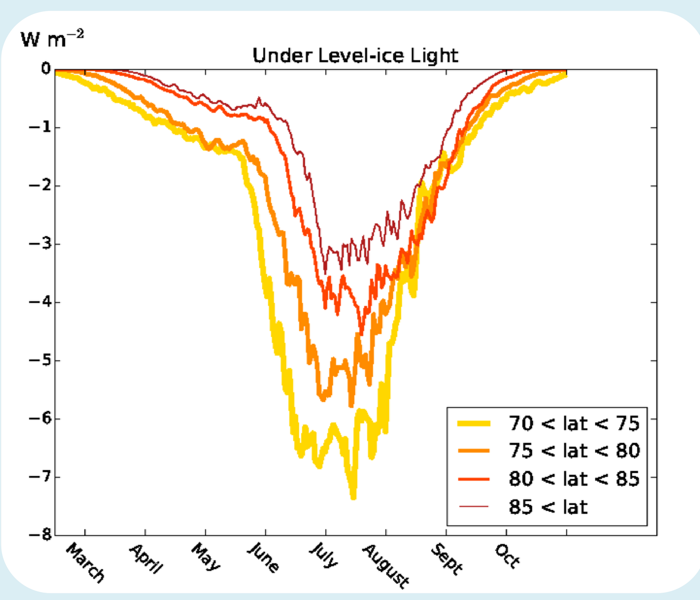
RIDGES AND LEVEL ICE

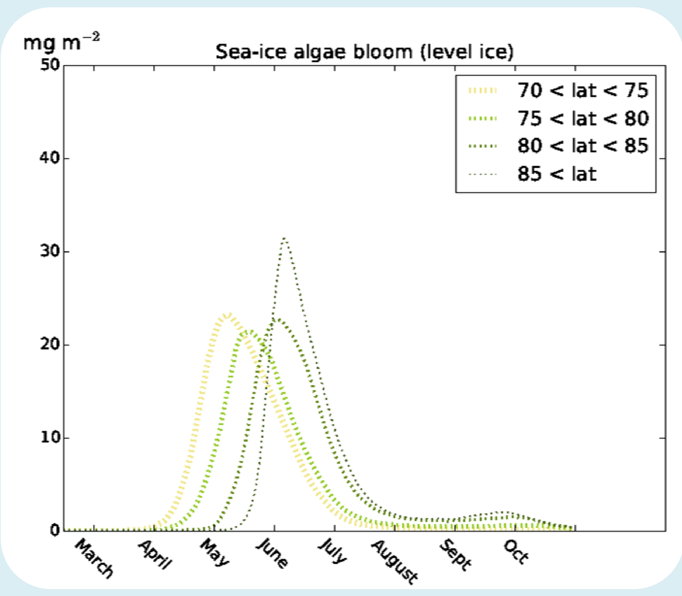
Using the information on the number of ridges per grid cell S_d [Castellani et al., *In preparation*], the ice has been divided into ridged ice and level ice with the constraint of ice and snow volume conservation. The snow is assumed to lie only on level ice. Algae concentrations have been computed separately for the two different environments.

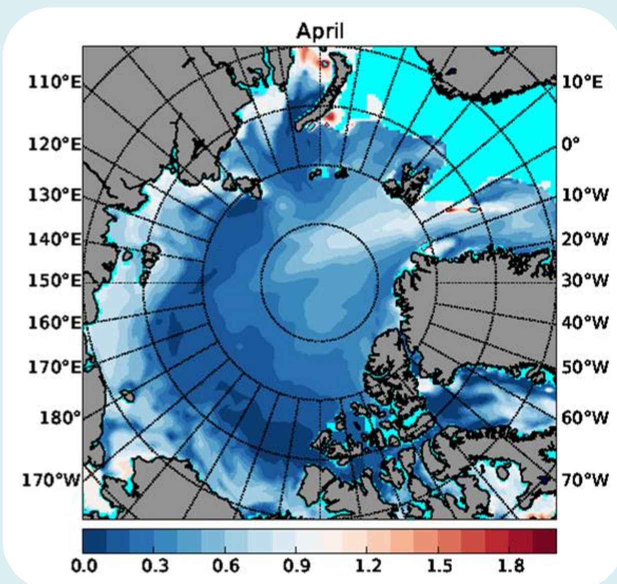


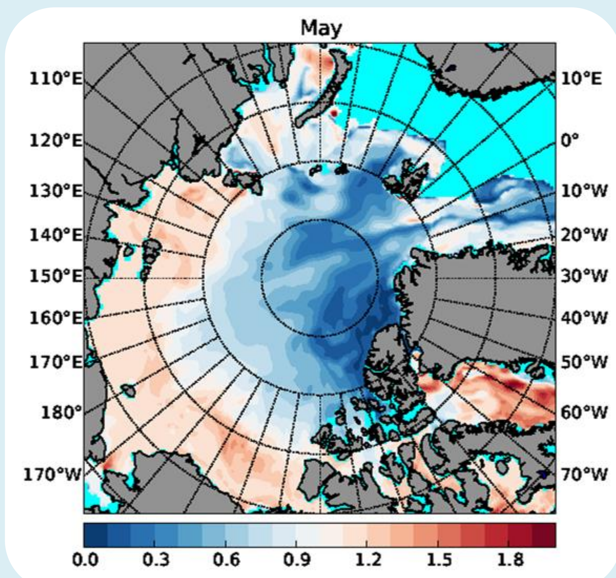
$$H_{snow}^l = \frac{H_{snow}}{1 - S_d b_r} \qquad b_r = 0.92\,\text{m}$$

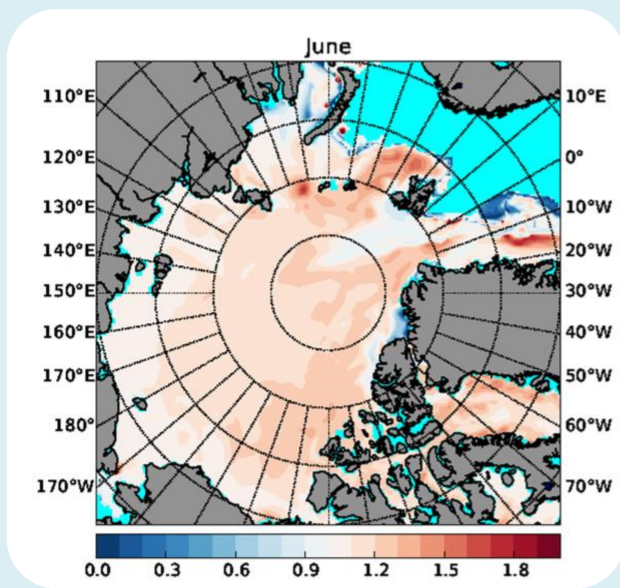
$$H_l = \frac{H_i - H_r' b_r S_d}{1 - S_d b_r} \qquad H_r' = 6.5\,\text{m}$$





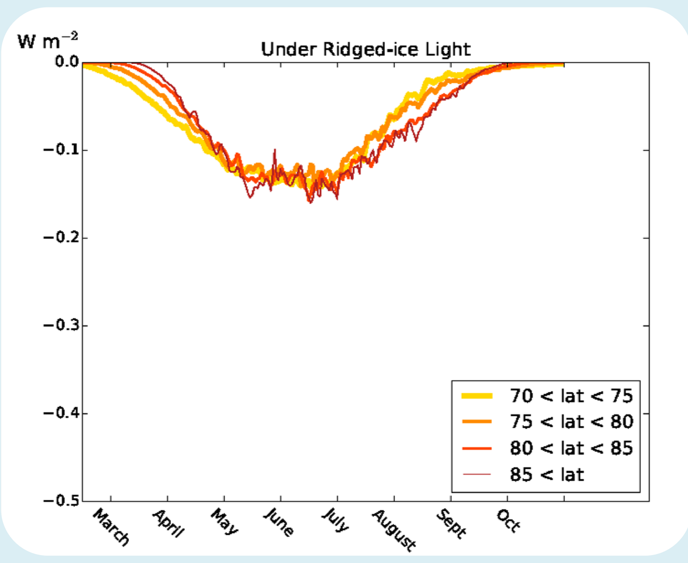


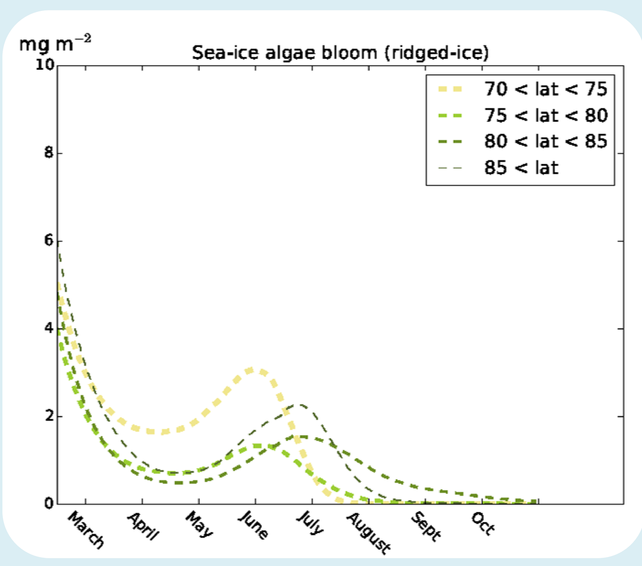


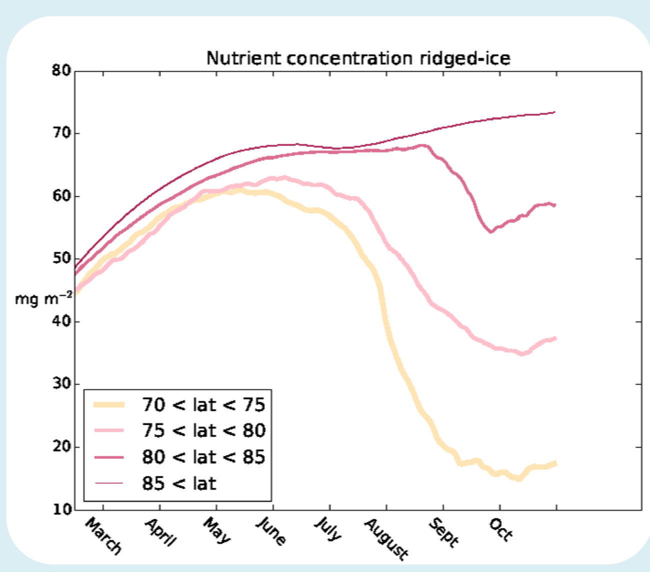


From left to right: light under level ice. Sea-ice algae bloom in level ice. Ratio for April, May and June, between total level-ice algae and total algae computed with no differentiation between ice classes.

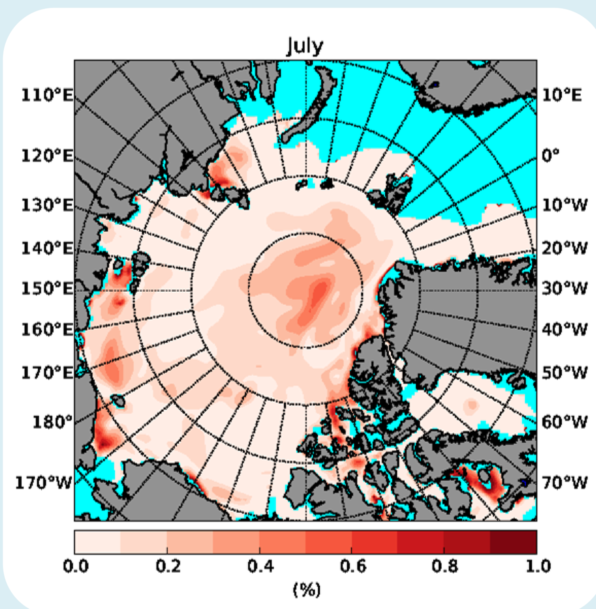
The level ice is thinner and thus more light is available for algae growth. Neverteless the presence of more snow delays the algae bloom of few weeks.







Algae can grow under ridges, but the bloom is very small and delayed in time. After a small bloom the algae are light limited. The ratio between ridges associated algae and algae computed with no differentiation of environments shows that ridges-algae contribute to maximum 1% to the total amount per grid cell.



From left to right: Light under ridged ice. Bloom of algae associated to ridged ice. Nutrient evolution in ridged ice. Percent of ridges-associated algae with respect to algae concentration calculated with no distinction between ice classes.

CONCLUSIONS

1) The simulated spatial distribution of sea ice algae has the same pattern shown by observations
2) The algal bloom depends on the conditions during the preceding months, to stress the need for more observations in critical seasons such as winter and early spring
3) Ridges-associate algae do not contribute substantially to the total amount of sea-ice algae. Nevertheless it is shown that ridges can host communities of algae and such algae have a bloom later in the season
4) The distinction of sea ice in ridged-ice and level-ice shows that the cosideration of different sea ice classes is helpful when the aim is to represent the time evolution of sea ice algae and in particular the spring bloom