A marine biology contribution to Arctic cloud formation

Marine biogenic aerosol precursors in the Arctic Ocean

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In Short

- Global warming will affect the Arctic region stronger than other parts of the world, a process called Arctic Amplification.
- In remote regions, organic aerosols out of the upper ocean have been shown to act as ice nucleating particles (INP), affecting the clouds and their surface warming effect.
- Arctic INP might originate locally from algal primary production in leads or open water. They consist partly of long sugar chains (PCHO) and their aggregates, transparent exopolymer particles (TEP).
- We use a coupled model setup for sea ice and ocean circulation (FESOM2), and marine biogeochemistry (REcoM2) to study temporal and spatial patterns of TEP production in the Arctic Ocean.
- Our study gives insight into the seasonal and spatial patterns of PCHO and TEP in the Arctic.
- The simulaiton results are in good agreement with observational data. Still, we want to improve the fit of our model because summer TEP concentration is higher in the model compared to observations.

Changes in the Earth's climate system will affect the Arctic region stronger than other parts of the world, resulting in an Arctic Amplification of global warming [1].Arctic clouds tend to have an overall surface warming effect throughout the year except for a short period, but the net cloud radiation effect depends on the presence of liquid or ice phase in clouds [2].Especially in remote regions, organic aerosol particles out of the upper ocean have been shown to act as cloud condensation nuclei or ice nucleating particles (INP), thus, affecting the cloud phase [3].One source of biogenic INP are polysaccharides, (PCHO) which originate from cell lysis or phytoplankton exudation during nutrient stress, and their aggregation products. These are known as transparent exopolymer particles (TEP) [5].

To study the seasonal cycle of TEP production, its regional hotspots, and the impact of Arctic Amplification, we used the Regulated Ecosystem Model (REcoM2) coupled to the Finite VolumE Sea-ice Ocean Model (FESOM2). This model set-up has been optimized to provide a high resolution in the Arctic realm of state-of-the-art ocean circulation, sea ice physics and marine biogeochemistry. The production of TEP depends on the release of organic carbon by phytoplankton during blooming conditions or nutrient stress. Our model results suggest, so far, a clear seasonal cycle of TEP production and remineralization (exemplary seasonal cycle for Eastern Fram Strait in Fig. 1). Computed climatological data of TEP is in good comparison to observation data, but tend to be slightly higher (Fig. 2). A rise of TEP concentration in summer and quick decline in autumn is in accordance with observation data. Still, maxmimum values of TEP in surface waters are high in comparison to observation data.

Our simulation of TEP formation processes resulted in a first description of TEP on large spatial and temporal scales in the Arctic realm, but the maximum TEP concentration are high compared to observations. To test the robustness of our simulations, we will conduct two sensitivity studies on the robustness of TEP remineralization and of the parameter controlling the polysaccharide fraction of organic carbon in our simulations.

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More Information

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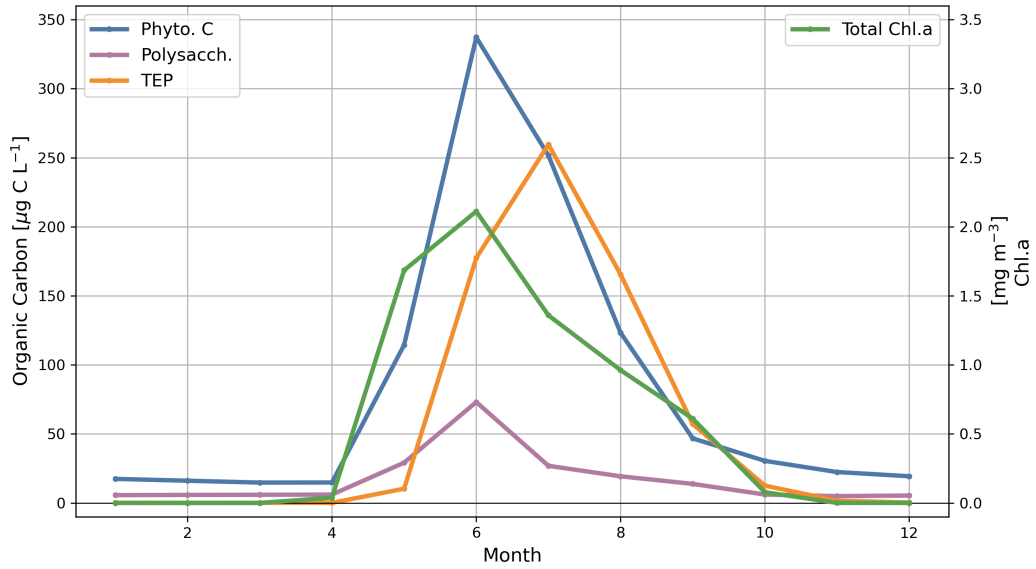

Figure 1: *Seasonal cycle of organic carbon of phytoplankton (PhytoC, blue), polysaccharides (purple), Transparent Exopolymer Particles (TEP, orange), and Total Chlorophyll (Chl.a, green) of the simulated period 2009-2019 as volume-weighted mean of the upper 30 m ocean depth, avareged over Eastern Fram Strait. The phytoplankton bloom is represented by the rise of phytoplankton carbon and Total Chlorophyll. Subsequently, polysaccharides are released by phytoplankton and then quickly aggregated to TEP. After the bloom, phytoplankton carbon and Total Chlorophyll are degraded in autumn. TEP is remineralized over the winter months.*

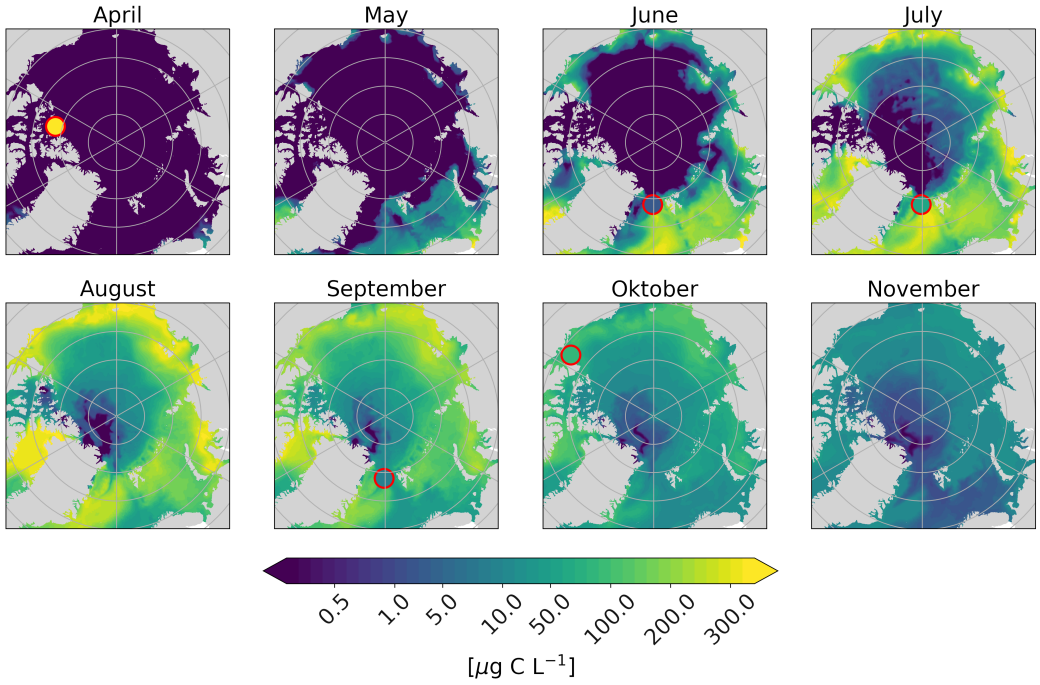

Figure 2: *Climatology of Transparent Exopolymer Particles (TEP) concentration as volume-weighted mean of the upper 30 m ocean depth of the simulated period 2009-2019. Observational data points are highlighted in red and color-coded filled with corresponding TEP concentration. The are generally in good agreement, only a strong under-ice bloom in April is not reproduced in the simulation. Observational data of [6] (April, October), [4] (June), and [5] (July, September).*

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