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.
- Measurements suggest that Arctic clouds tend to have an overall surface warming effect.
- In remote regions, organic aerosols out of the upper ocean have been shown to act as ice nucleating particles (INP), affecting the cloud radiation properties.
- Arctic INP might originate locally from algal primary production in leads or open water. They consist partly of long sugar chains 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 will contribute to an enhanced understanding of Arctic cloud formation and its impact on Arctic Amplification.

The IPCC expects the polar regions to be profoundly different in a future world [1]. 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 [2].Measurements suggest that Arctic clouds also tend to have an overall surface warming effect throughout the year except for a short period in summer [3].The net cloud radiation effect depends on the presence of liquid or ice phase in clouds [4].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 [5,6].One source of biogenic INP are polysaccharides, which originate from cell lysis or phytoplankton exudation during nutrient stress, and their aggregation products. These are known as transparent exopolymer particles (TEP) [7].

The impacts of Global Warming have been observed, for example, as an increase in Arctic primary production within the last 15 to 20 years [8], and as a phytoplankton species composition shift at least for the Fram Strait [9].Furthermore, it could result in an increase of phytoplankton carbon exudation, accumulation of exopolymer substances, and ultimately, in an increased production of marine organic aerosols in the Arctic [7].

To our knowledge, TEP have not yet been integrated into ocean models on a larger scale. To study the seasonal cycle of TEP production, its regional hotspots, and the impact of Arctic Amplification, we will use the Regulated Ecosystem Model (REcoM2) coupled to the Finite VolumE Sea-ice Ocean Model (FESOM2) and Icepack, the single-column component of the sea-ice model CICE. 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.

Until now, testing the coupling of FESOM2-REcoM2 on a simpler set-up (lower resolution, different sea ice model) was successful for TEP (Fig. 1). The model shows spatial variability linked mainly to primary production. The Fram Strait is defined as the region of special interest for evaluation because of higher availability of observation data. The seasonal cycle in Fram Strait could be captured well with an increase of TEP concentration in summer and a steep decline towards autumn. The ocean surface concentrations are highest with a strong decline over the upper 100-200 m.

Generally, the TEP measurements show large variability among different years, observation sites, and measurement methods themselves. We plan to evaluate our model results with observations of different expeditions and remote sensing in close cooperation with colleagues at AWI, GEOMAR and TROPOS. Our own findings will be considered to further study cloud formation processes in the Arctic in atmospheric models within the DFG Transregional Collaborative Research Centre TR 172 ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes and Feedback Mechanisms (AC)^3.

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More Information

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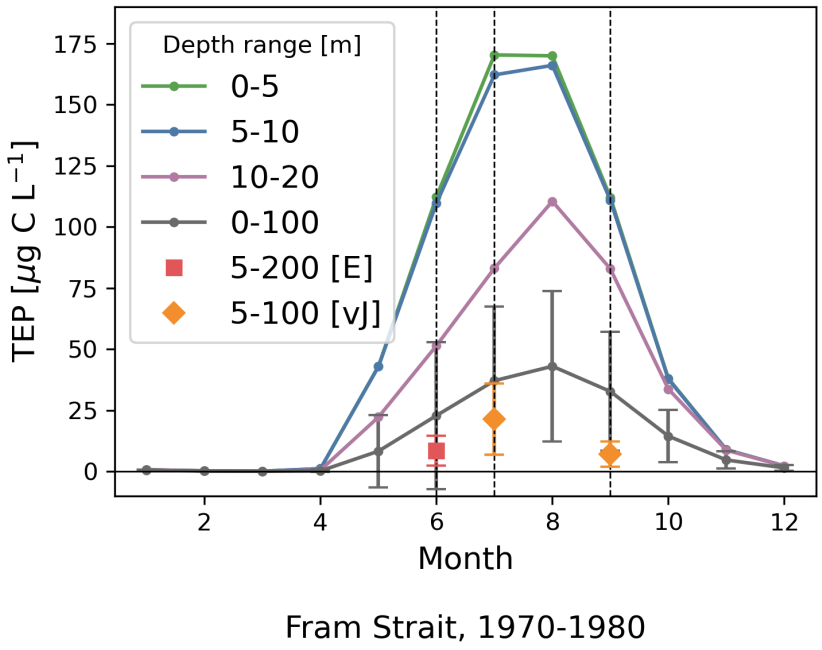

Figure 1: *Seasonal cycle of transparent exopolymer particles (TEP) concentration in Fram Strait as mean over the exemplary period 1970-1980 for surface layers (green, blue, purple) and the volume-weighted mean over 0-100 m depth (gray). Model results are compared to observations of Engel et al. [7] [E] and von Jackowski et al. [10] [vJ] obtained in Fram Strait. Note that cited observations refer to different depth ranges for mean concentration.*

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