From the ocean to the atmosphere – the transfer of marine sugars as potential players in cloud processes

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Scientific background

The transfer of organic matter from the ocean to the atmosphere is a possible key process for the formation of aerosol particles that may impact cloud processes (e.g. droplet activation and freezing) and cloud properties (e.g. Russell et al., 2010).
There are strong indications that oceanic produced marine sugars, among them *transparent exopolymer particles* (TEP), are present in the diverse marine compartments in the Arctic. Recent findings suggest that low-level cloud formation above the Arctic Ocean may be linked to such organic polymers produced by marine microorganisms (e.g. Orellana et al., 2011; Galgani et al. 2016). However, detailed chemical investigations of the organic matter in Arctic particles, its possible sources from the sea-surface microlayer (SML) and/or bulk water, and its linkage to ice nucleating particles (INP) and cloud condensation nuclei (CCN) number concentrations are extremely sparse.
During MOSAiC we aim at a comprehensive investigation of the different Arctic compartments with a focus on marine sugars and mainly TEP and their INP and CCN potential. Within MOSAiC we will strongly benefit from the opportunity to monitor a year round cycle of these potential key compounds for Arctic clouds.

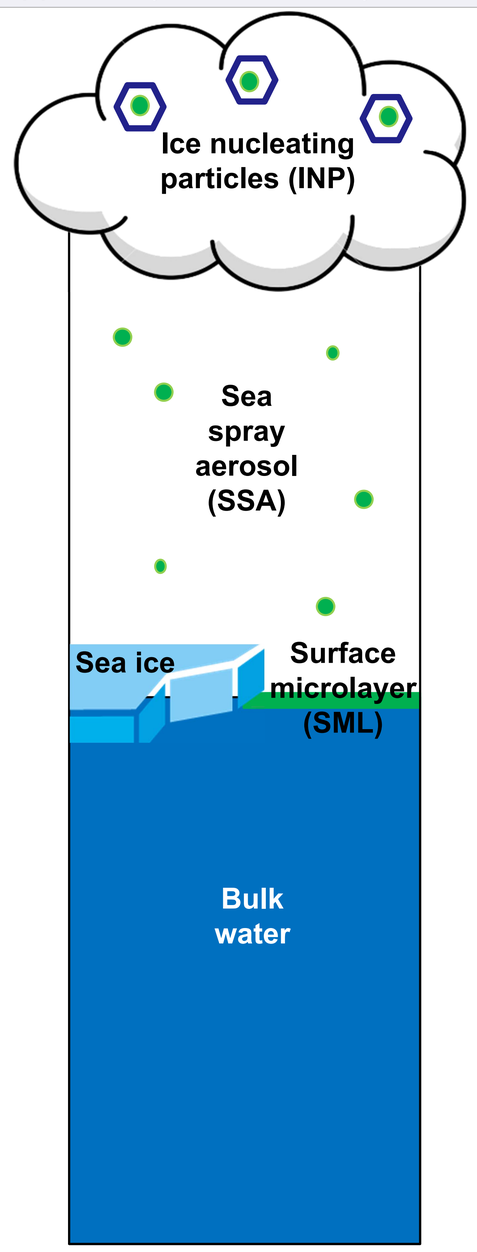
Science questions

The possibility of measurements of a full annual cycle will provide information about the formation and the transfer of marine sugars from the ocean to the atmosphere as well as their INP potential. Specifically we plan to elucidate:

- What is the annual variability of marine sugars regarding all marine compartments: bulk water, SML, sea ice, aerosol particles, cloud particle residues and cloud water?
- What is the link of marine sugars to biological activity (phytoplankton, heterotrophic bacteria) in the ocean over the year?
- What are the sources of the marine sugars / INP in the different seasons (local vs. other sources)? Are there TEP in aerosol particles / cloud particle residues / cloud water when the ocean is covered with sea ice?
- Are the marine sugars enriched in sea ice in the winter season?
- At which time of the year are marine sugars present/formed/released from the ocean / sea ice / melt ponds? How efficiently are they transferred into aerosol particles ?
- What is the annual variation of the linkage of marine sugars abundance (i) at the ocean surface, (ii) in aerosol particles and (iii) INP and CCN activity?

Linkage to biological/microbial formation of marine sugars

1. Connectivity to bacterial and primary production, particles, and microbial diversity (*Cooperation with Allison Fong, AWI*)
2. Synergistic pigment concentration to determine major phytoplankton groups (*Cooperation with Astrid Bracher, AWI*)



Sampling procedures (in cooperation with MOSAiC partners)

1. Sampling of aerosol particles:

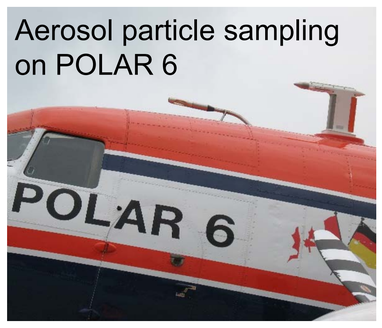
-> Cooperation with Atmosphere team (OCEANET)
- Sampling of aerosol particles on filters with a sampling unit consisting of a filter holder equipped with a polycarbonate filter and a pump (located on the ship/ice camp) **(Leg 1-6)**
- Whenever possible: Sampling aerosol particles on filters (and possibly cloud water) in the vertical profile with the TROPOS tethered balloon

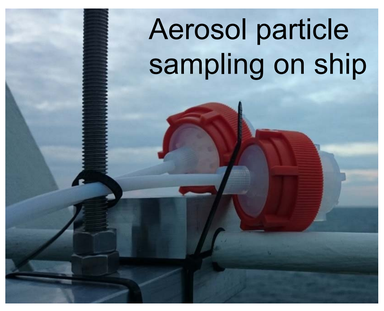
-> *Cooperation with POLAR 6*
- Whenever possible: Sampling aerosol particles and cloud particle residues (CVI inlet) on filters and real time measurements via mass spectrometry onboard the Polar 6 airplane

2. Sampling of seawater, SML, snow and ice:

-> Cooperation with Ecosystem and Sea Ice team
- Probing the oceanic bulk water (using CTD/RO or manual water sampling), probing ice cores, and sampling snow (upper layer) (***Leg 1-6***)

-> Cooperation with Ecosystem and Biogeochemistry team
- In melting season (***Leg 4-6***): sampling the SML with the glass plate technique as soon as melting starts from (i) melt ponds on the ice, (ii) ice edges, (iii) open water with the Zodiac.





References:

- Orellana, M. V., Matrai, P. A., Leck, C., Rauschenberg, C. D., Lee, A. M., and Coz, E., PNAS, 108, 13612-13617, 10.1073/pnas.1102457108, 2011.
- Galgani, L., Piontek, J., and Engel, A., Scientific Reports, 6, 10, 10.1038/srep29465, 2016.
- Russell, L. M., Hawkins, L. N., Frossard, A. A., Quinn, P. K., and Bates, T. S., PNAS, 107, 6652-6657, 10.1073/pnas.0908905107, 2010.

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