Spatial Distribution, Sources and Cloud Processing of Arctic Aerosol Particles

B04

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1. Summary

The abundance and sources of Arctic aerosol particles at cloud level are still not sufficiently understood and quantified. However, they play important role in Arctic amplification, by influencing the formation, the phase state, and properties of Arctic clouds, and thereby are also important for the radiative balance.

Research questions

Q1 Do the concentrations and properties of Arctic aerosol particles, especially CCN (Cloud Condensation Nuclei), INP (Ice Nucleation Particle), and BC (Black Carbon), inside and outside the ABL (Arctic Boundary Layer) show a long-term trend?

Q2 Does a connection exist between heat and/or energy fluxes and aerosol particle fluxes inside and outside the ABL?

Q3 Can the sea-to-air enrichment of INP (+tracers) explain ambient INP concentrations?

Contribution to SQ3, CCA2 & CCA4

2. Achievements phase II

A new parameterization concerning Arctic INP concentrations

- A new parameterization concerning Arctic INP concentrations as function of season and temperature has been developed for use in atmospheric models.
- Further indications towards the marine origin of INP in the European Arctic have been found.

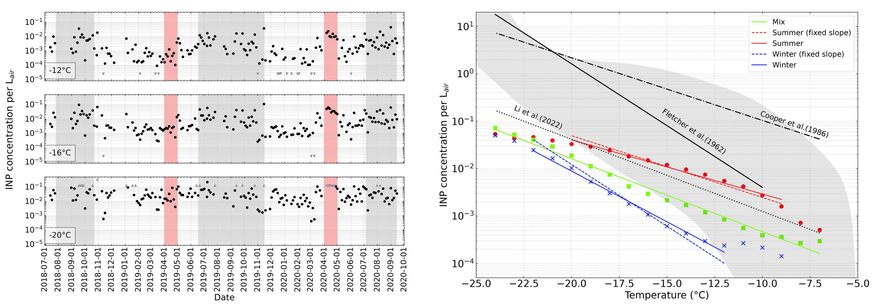


Fig. 1: Time series of N_{INP} at T = -12, -16 and -20 °C as measured at Villum Research Station (VRS) (left) and new parameterization for time and season dependent Arctic INP concentrations (right)

Marine polysaccharides in the Arctic environment can be confirmed as INP

- An optimized analytical method for the analysis of free and combined polysaccharides in saline samples was developed.
- Laboratory studies on Arctic microorganisms revealed that marine polysaccharides in the Arctic contain ice-active molecular groups, so that they act as INP.

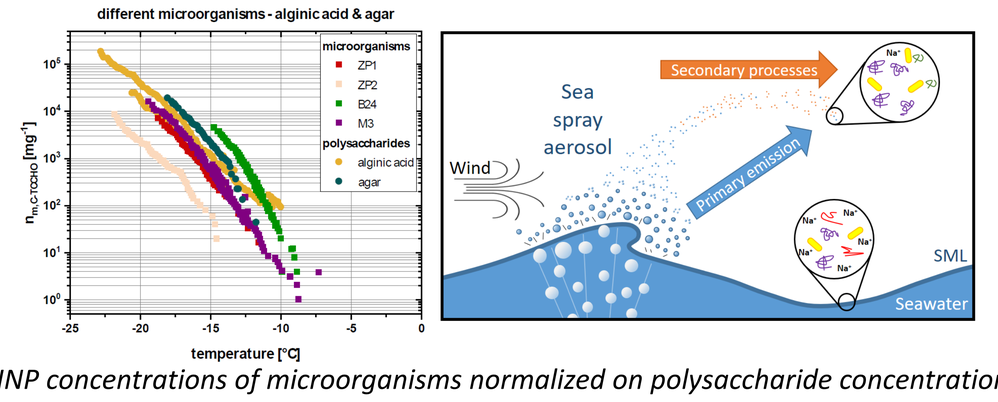


Fig. 2: INP concentrations of microorganisms normalized on polysaccharide concentrations (left); sea spray emissions contribute to the polysaccharide aerosol composition and likely the INPs (right)

Average western (European and Canadian) Arctic BC-properties and BC – cloud interactions

- The BC mass concentration is a factor of four higher across the Arctic in spring, which is a consequence of the increased number of BC particles reaching the Arctic.
- The presence of low-level clouds is associated with a radical change in the concentration and diameter of BC in the ABL compared to the free troposphere.

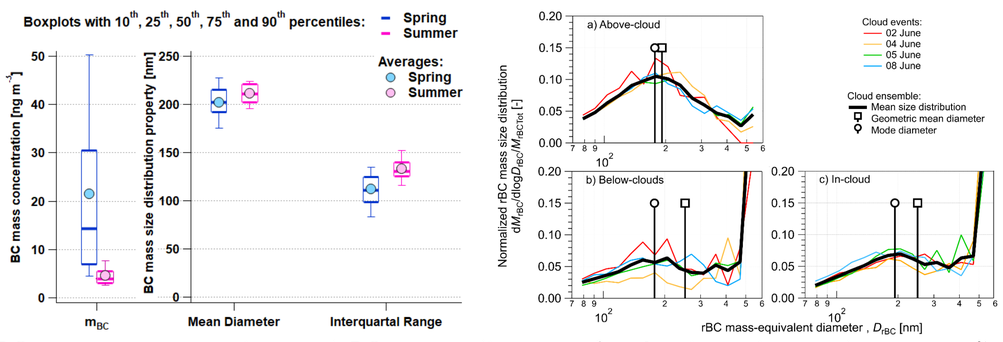


Fig. 3: BC mass concentration and BC mean diameter for Arctic spring and summer (left); rBC normalized size distribution observed in: a) above cloud; b) below clouds; c) in cloud

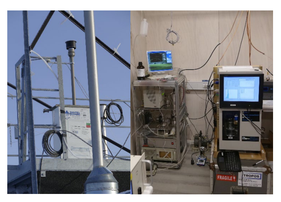
Hypothesis

Turbulent up and downward transport together with ocean-atmosphere transfer and long-range transport play key roles for the distribution and properties of aerosol particles as well as aerosol-cloud interactions in the atmospheric boundary layer over the marginal sea ice zone.

3. Research plan phase III

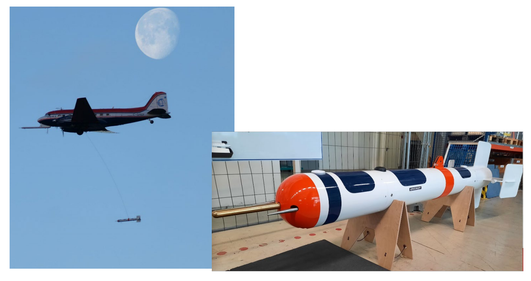
WP1 Airborne and ground-based measurements and characterization of aerosol particles in the Arctic

- Airborne and ground-based measurements and characterization of aerosol particles in the Arctic inside and outside the ABL with with Polar 6 and T-Bird.
- Ground-based measurements (CCN, INP, and BC properties at Villum Research Station – Northeast Greenland).
- Data analysis, characterization, and interpretation (hygroscopicity, freezing spectra, back trajectories, etc.).
- Provide data and parametrization for process representation and model evaluation (D02).



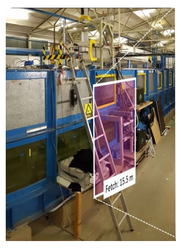
WP2 Airborne measurements of atmospheric turbulence and mixing, as well as characterization of turbulent aerosol particle fluxes

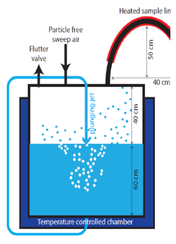
- Airborne measurements of atmospheric turbulence and mixing (A03).
- Data analysis, characterization and interpretation.



WP3 Quantification of INP and INP tracer enrichment in the atmosphere

- Laboratory experiments: Sea-air transfer studies of the INP tracers including their process-related enrichment on different scales.
- Data analysis of polysaccharides, INP, sodium, and comparison with field data (C03).





4. Legacy & Major expected results

Project Legacy

- With the developed T-Bird, we gained a unique measurement tool for answering questions on the mixing of aerosols particles inside and outside the ABL.
- The data provide the basis for an elucidation of distinct marine polysaccharide & INP
- The knowledge and data will be extremely useful for evaluating and driving atmospheric models and predicting how Arctic amplification will evolve.

Major expected results within phase III

- Improved understanding of aerosol particle mixing in the ABL including transfer processes from the ocean and between the free troposphere and the ABL.
- Elucidation of the aerosol-cloud-interactions and resulting radiative effects
- Implementation of data in atmospheric models for better understanding, how Arctic amplification will evolve in the future.

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