# A 500 year Record and present Day Observations of Ice Nucleating Particles in the high Arctic

Hartmann Markus[1], Brügger Sandra[2], Gong Xianda[1], Herrmann Hartmut[1], van Pinxteren Manuela[1], Schmale Julia[3], Schwikowski Margit[4], Vogel Alexander[4]*, Welti André[1], Wex Heike[1], Zeppenfeld Sebastian[1], and Stratmann Frank[1]

[1] Leibniz-Institute for Tropospheric Research, Leipzig, Germany

[2] Institute of Plant Sciences, University of Bern, Bern, Switzerland

[3] Laboratory of Atmospheric Chemistry, Paul Scherrer Institute, Villigen, Switzerland

[4] Laboratory of Environmental Chemistry, Paul Scherrer Institute, Villigen, Switzerland

* now at Institute for Atmospheric and Environmental Sciences, Goethe University, Frankfurt, Germany

The Arctic is more sensitive to climate change than any other region on Earth, and changes are proceeding at an unprecedented pace and intensity. The role of clouds and their properties in these changes is still unclear and an area of intense research. In this context, aerosol-cloud interactions in general, and cloud condensation nuclei (CCN) and ice nucleating particles (INP) in particular – both potentially affecting cloud radiative properties and live-time -, are of specific interest. As, in view of a changing climate, their abundance and properties need to be put into historic context, we here compare present-day observations of ice nucleating particle concentrations ($N_{INP}(T)$) onboard the RV Polarstern (PASCAL cruise from May to July 2017 in the area around Svalbard up to 83.7°N) to ice core-derived concentrations for the past 500 years. Measurements of INP in the Arctic are scarce, and a historical record is a novelty by itself.

During PASCAL, the $N_{INP}(T)$ were measured online with the Spectrometer for Ice Nuclei (SPIN; DMT), and determined from filter samples by application of freezing array techniques similar to the ones introduced in Conen et al. (2012) and in Budke & Koop (2015). By combining these methods, the whole temperature regime relevant for mixed phase clouds is covered. The ice cores originate from Summit (Greenland) and Lomonosovfonna (Svalbard), and cover a time range from 1457 to 1989 AD and 1480 to 1949 AD, respectively. The ice core samples were analyzed by the freezing array techniques only.

The contribution of local sources to present-day INP is assessed by comparing the INP populations (a) from different sources such as the sea surface micro layer (SML), deeper sea water and fog, (b) the correlation to meteorological parameters, and (c) the use of back trajectory modelling. The sensitivity of the historical INP concentrations to other ice core-derived parameters is investigated to identify potential INP sources.

The measured present-day $N_{INP}(T)$ at the onset of the Arctic melt season are in general low (median of $1.62*10^{-2}$ per Liter at -20°C). Occasional high concentrations seem to be associated with local sources, e.g. dust/biological material from Svalbard. Increased $N_{INP}(T)$ in SML, seawater and fog are correlate with increased algae and polysaccharide concentrations.

The historical record of $N_{INP}(T)$ derived from ice core samples, which cover several years, shows no overall trend over the centuries and the concentrations vary mostly within the boundaries reported by Petters & Wright (2015). On the other hand the analysis of ice core samples with sub-year resolution exhibits a strong short-term temporal variability of $N_{INP}(T)$, which suggests that Arctic INP

follow a seasonal cycle. Volcanic eruptions and black carbon (BC) concentrations seem not to influence INP concentrations at the measured temperatures.

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**Literature**

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