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First Long-term Field Measurements of Ice-Nucleating Particles with a Mobile Expansion Chamber

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Clouds containing ice play a key role in the Earth's energy budget and in the supply of fresh water by precipitation. The ice in clouds can either form homogeneously at temperatures below 235 K or heterogeneously. Heterogeneous freezing is triggered by ice-nucleating particles (INPs) originating from different sources and in different concentrations. To assess the contribution of various INPs to the ice formation in clouds, field measurements were performed in the past using mostly continuous flow diffusion chambers (CFDCs) or filter sampling and offline analysis with a cold stage set up. Nevertheless, field INP measurements are still rare and measurement techniques need improvement.

In order to obtain more information on ambient INP characteristics, the new mobile chamber PINE (Portable Ice Nucleation Experiment) was developed, which is the first instrument measuring INPs in a fully automated way with a high sensitivity and time resolution over a long time. PINE as an expansion chamber is able to simulate cloud formation in an air parcel rising in the atmosphere. Measurements can be performed in a temperature range of 273 K to 213 K. The maximum saturation reached inside the chamber during an expansion run can be limited to above or below water saturation, detecting immersion freezing and deposition nucleation, respectively.

Here we present results from the HyICE-2018 campaign in Hyytiälä (Finland), organized by the University of Helsinki. This was the first field campaign where the first prototype version of PINE (PINE-1A) was deployed for long-term INP measurements. PINE-1A was operated from the 13th of March until the 11th of May, 2018 at temperatures between 249 K and 242 K for immersion mode INP measurements.

The resulting time series show that PINE-1A was able to measure the daily variability of the ambient INP concentration with a time resolution of 1 h and thus highlights the strength of this new instrument. A comparison of PINE-1A measurements with INP temperature spectra from the Ice Nucleation Spectrometer of the Karlsruhe Institute of Technology (INSEKT) showed a good agreement between both instruments. A case study for one of the campaign days (25th of March) shows the importance of highly time-resolved PINE measurements, when a sudden change in air mass origin lead to an increase in the INP concentration by two orders of magnitude.