The influence of the atmospheric low-pressure core on the ground-based ice-nucleation particle abundance in the North Slope of Alaska: A preliminary report

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Background & Objectives

Mixed-phase clouds (MPCs), which contain both ice crystals and supercooled liquid droplets, are ubiquitous over the North Slope of Alaska region, and ice-nucleating particles (INPs) in MPCs impact the formation and modulation of MPCs, precipitation, and the solar energy budget. However, the role of MPCs and INPs on Arctic warming is not yet well revealed, which represents a substantial knowledge gap in climate science. As a first step towards filling the gap, in this work, we examine the role of high-latitude pressure core variability on the ground-level INP concentration as a surrogate parameter of ice cloud microphysics.

We in particular discuss how profound atmospheric dynamics and extreme meteorological conditions introduce INP anomaly. Our outcome, besides the sea-ice albedo effect, is a key first step towards a comprehensive understanding of the mechanism and projection of Arctic warming

Motivation

High INP concentrations were measured during low pressure events at the North Slope of Alaska, and we suspect that atmospheric circulation might be modulating the INP concentration in the region.

INP Abundance and Sample Characterizations

To measure the INP abundance, we employed a Portable Ice Nucleation Experiment (PINE) chamber, which simulates virtual adiabatic expansion cooling in a 10 L aluminum vessel, at Barrow Atmospheric Baseline Observatory (71.32° N, 156.61° W)

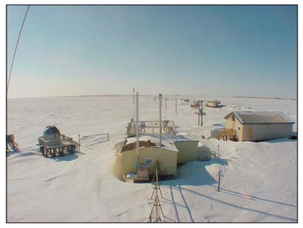

Fig 1: Barrow Atmospheric Baseline Observatory (Barrow, Alaska).

PINE working principle and major advantages

- Enables remote, autonomous, and continuous INP measurement
- Reduces labor intensity of INP monitoring
- Fills the current deficiency in ambient online INP measurement
- **To date, there are no continuous INP measurements with a high temporal resolution (12 min) conducted in the North Slope of Alaska (NSA)**

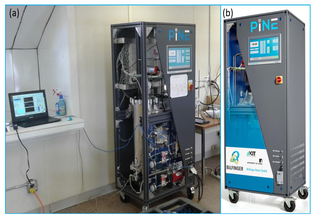

Fig 2: Photograph of PINE located at Barrow Atmospheric Baseline Observatory.

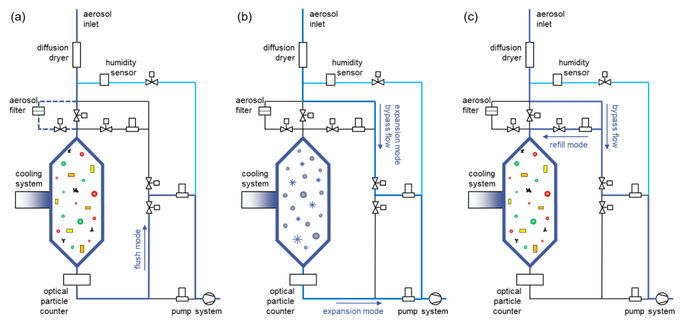

Fig 3: Schematic of PINE (Möhler et al. 2021).

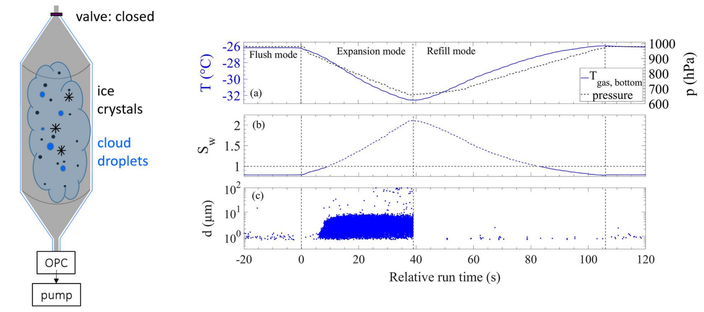

Fig 4: PINE chamber in expansion mode (LEFT) & typical run of PINE (RIGHT)

Assessing how atmospheric dynamics and extreme meteorological conditions introduce INP anomaly

- We assess the role of **the Alaska Blocking Index (ABI)** (Ballinger et al 2022) as a regional (the North Slope of Alaska) indicator by analyzing its variability against the concentration of Ice-Nucleating particles (INP) and other meteorological parameters like temperature, relative humidity, wind speed, and precipitation.
  - → The Alaska Blocking Index (ABI) describes the 500 hPa pressure pattern atop AK.
  - → We particularly assess the atmospheric implications of High &Low ABI in terms of local surface meteorology
  - → We also assess how the ABI correlated to synoptic-scale meteorology
- **We hypothesize** that showing the ABI time series alongside temp, RH, wind, and INP measurements could be an insightful first look in an attempt to draw links between large-scale meteorological forcing, surface weather, and INP.

Preliminary Results

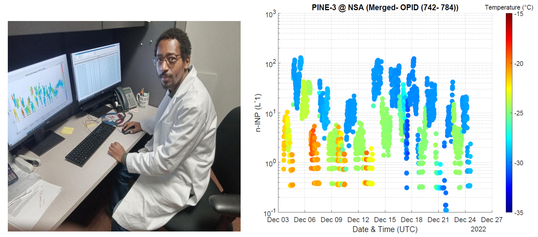

Fig 5: Date processing from PINE (LEFT) & Time resolved INP concentration processed from PINE (RIGHT)

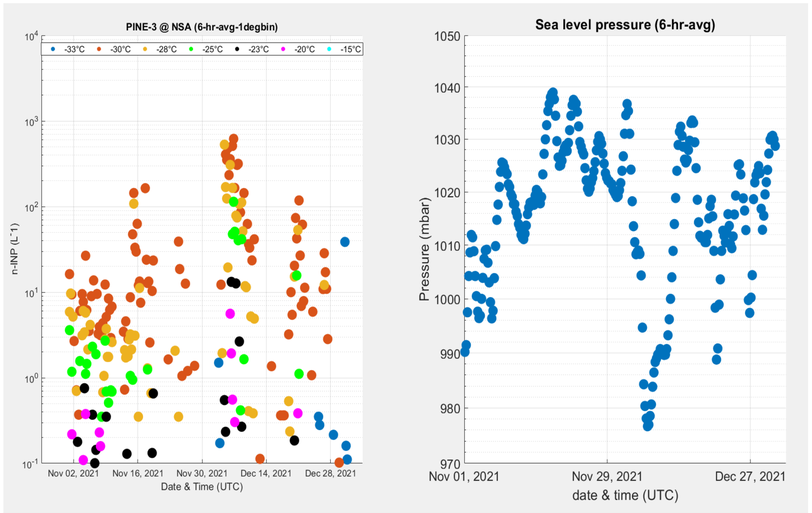

Fig 6: INP concentration time series (Left) along with sea level pressure time series (Right)

Summary

- Already from the preliminary analysis, it seems there is a relationship between INP concentration and the sea level pressure time (and hence ABI).
- However, further work is needed to understand how the ABI related to local surface meteorology and synoptic- scale meteorology.
- Beyond ABI, looking into many other things – e.g., aerosol properties, back trajectory Analysis, meteorological dynamics, anthropogenic impact is needed to get further insights into INP variability in the region.

Acknowledgement

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References

Möhler, Ottmar, Michael Adams, Larissa Lacher, Franziska Vogel, Jens Nadolny, Romy Ullrich, Cristian Boffo, Tatjana Pfeuffer, Achim Hobl, and Maximilian Weiß. "The Portable Ice Nucleation Experiment (Pine): A New Online Instrument for Laboratory Studies and Automated Long-Term Field Observations of Ice-Nucleating Particles." Atmospheric Measurement Techniques 14, no. 2 (2021): 1143-66.

Ballinger, Thomas J, John E Walsh, Vladimir A Alexeev, Peter A Bieniek, and Jordan T McLeod. "The Alaska Blocking Index, Version 2: Analysis and Covariability with Statewide and Large-Scale Climate from 1948 to 2020." International Journal of Climatology 42, no. 16 (2022): 9767-87.