

# PINE

PORTABLE  
ICE  
NUCLEATION  
EXPERIMENT



**PINE:** the instrument that revolutionizes the field of atmospheric ice nucleating particle concentration measurement allowing researchers to perform unattended, fully automated campaigns and long-term monitoring down to  $-60^{\circ}\text{C}$ .

## Overview

Ice nucleating particles (INP) are the source for primary ice formation in clouds, hence their concentration has a critical impact on the temporal and spatial distribution of precipitation as well as a major impact on climate. PINE enables the accurate measurement of the INP concentration, thus providing researchers and meteorologists with a unique and valuable insight into INP properties. PINE is the first automated online INP counter and requires minimal user input. This makes it suitable for INP monitoring since it measures continuously and can be operated and maintained by non-experts. It is thereby able to detect atmospheric INP concentrations over a wide range of concentrations and temperatures at high time resolution and at conditions relevant for many cloud types. In addition, PINE provides information on the overall aerosol concentration.

## Applications

- Cloud physics research
- Observation and monitoring of ice nucleating particles
- Systematic laboratory investigation of the ice nucleation activity of different aerosol species



## BILFINGER NOELL GMBH

PINE is the result of a collaboration between Bilfinger Noell GmbH, the Karlsruhe Institute of Technology and University of Leeds.



**BILFINGER**

**PINE:** the first instrument to automatically measure long-term series of INP concentrations at high sensitivity, time resolution and in a wide range of temperatures.

### How it works

The core element of PINE is an air tight vessel, several liters in volume, which can be cooled to a specified temperature. Air is drawn into the chamber through a valve at the top, and pulled through by a pump below. For a cloud formation experiment, the pressure within the chamber is reduced, causing the gas temperature to drop by expansion cooling. The chamber walls are temperature controlled, allowing to start cloud expansion runs at any pre-selected temperature between 0°C and -60°C

The frost point of the air sampled into the chamber is controlled to be low enough for preventing frost formation at the cold chamber walls, but high enough for allowing cloud droplet activation and ice formation during the expansion runs. Varying the temperature and humidity determines which nucleation mode will occur within the chamber, and therefore which cloud types the measurements are relevant for.

When the chamber is operated in the immersion mode (relevant for mixed-phase clouds), a large number of supercooled water droplets are formed during the expansion run. Only a minor fraction of those droplets containing an INP freezes, and ice crystals are formed and grow to larger size.

To access cirrus cloud conditions, the chamber is operated at ice super saturation, but below water saturation. This leads to deposition ice nucleation as the temperature within the chamber decreases and the ice supersaturation increases. The resulting ice particles rapidly grow into the detection range of the optical particle counter (OPC).

The OPC (fidas-100, Palas GmbH, Germany) detects large aerosol particles, cloud droplets, and ice crystals and differentiates by optical size between the different particle types.

### Features

- Expansion chamber with operating temperatures between 0°C and -60°C.
- Refrigeration system based on thermal conduction (no fluids).
- Integrated control system.
- Fully automated operations.
- Plug and play instrument (connect only power).
- Compact rack design.

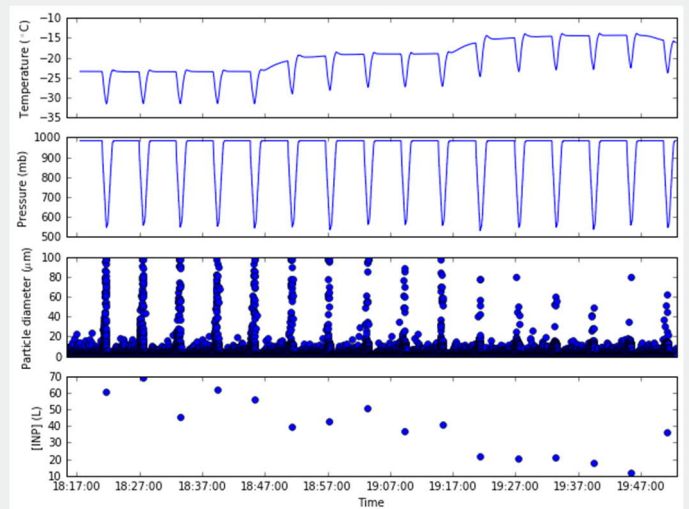
### Included items

- » PINE instrument
- » Operator manual
- » Email and phone technical support

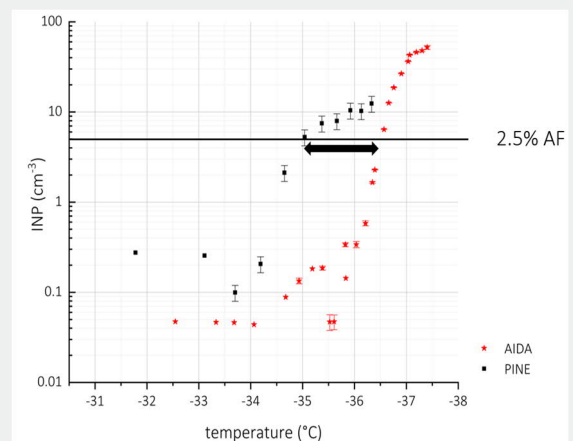
#### Detailed specifications:

INP concentration range ..... 0.1 to 1000 L<sup>-1</sup>  
 Sampling temperature ..... < 35 °C  
 Wall temperature ..... 0 to -60 °C  
 OPC particle detection range ... 0.2 to 200 μm

Dimensions ..... 0.80 m x 0.60 m x 1.83 m  
 Weight ..... < 200 kg  
 Avg. load / Peak load ..... < 1.5 / 2 kW, 110-240 VAC  
 Altitude (higher on request) ..... < 2000 m



Preliminary results of the prototype PINE chamber during the HyICE test campaign at the Hyttiälä (Finland) field station in 2018.



Validation experiment: the temperature for homogeneous freezing of sulfuric acid particles agrees within 1.5°C to AIDA measurements

### Add on

The PINE instrument will be validated for temperature and INP concentration measurements at the KIT cloud facility before delivery. The validation will be documented and is part of the operation manual.

For the operation of PINE, a free as-is software is available from KIT. The software allows setting temperature ramps as well as defining measuring cycles.

### Technologies

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### In cooperation with

