

# PINE

PORTABLE  
ICE  
NUCLEATION  
EXPERIMENT



**PINE:** A new instrument that revolutionizes the field of atmospheric ice nucleation, allowing researchers to investigate aerosol-cloud processes and to perform fully-automated long-term measurements of ice nucleating particles at temperatures down to  $-65^{\circ}\text{C}$ .

## Overview

Ice nucleating particles (INP) are the source for primary ice formation in clouds, hence their concentration can impact the formation of precipitation and the radiative properties of clouds in the climate system. PINE enables the accurate and long-term measurement of INP concentrations, thus providing researchers with a unique insight into INP concentrations and sources. PINE is the first commercial version of a fully automated online INP counter that requires minimal user input. It is suitable for INP monitoring since it measures continuously and can be operated and maintained by non-experts. PINE is able to measure atmospheric INP concentrations over a wide range of concentrations and temperatures at high time resolution and at conditions relevant for mixed-phase clouds and cirrus clouds. PINE can be upgraded for providing additional information on the aerosol concentration.

## Applications

- Aerosol-cloud research
- Observation and monitoring of ice nucleating particles
- Laboratory investigations on aerosol ice-nucleating properties



In cooperation with



UNIVERSITY OF LEEDS

**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

PINE is operated in a cycled way with series of runs, each composed of three modes (Figure 1): (1) During the flush mode, aerosol is sampled into the cloud chamber of 10 l volume. (2) The sampled aerosol particles are activated to supercooled cloud droplets and ice crystals during the expansion mode. (3) In the refill mode, the chamber is refilled to ambient pressure conditions, and the cloud chamber is ready for the next run.

During the expansion mode, the ice crystals are measured with an optical particle counter (fidas-PINE, Palas GmbH, Karlsruhe, Germany), specifically developed for PINE. The INP number concentration is calculated from the number of ice crystals and the air volume passed through the particle counter.

Measurements can either be conducted over longer time periods at constant temperature (Figure 2), to measure the INP concentration at high time resolution, or with scanning the temperature to measure the temperature dependence of INP concentrations. For the example shown in figure 3, the temperature was varied between -17° and -31°C within a time period of about 2 hours.

For more information see [Möhler et al., Atmos. Meas. Tech., 14, 1143–1166, 2021.](#)

For more information about ongoing measurement activities see [https://www.imk-aaf.kit.edu/pine\\_inp\\_monitoring.php](https://www.imk-aaf.kit.edu/pine_inp_monitoring.php).

### Features

- Cloud expansion chamber with wall temperature control between +20°C and -60°C.
- Ice nucleation and INP measurements between -10°C and -65°C.
- Refrigeration system based on thermal conduction (no fluids).
- Integrated control system.
- Fully automated operation.
- Plug and play instrument (connect only power).
- Minimized connected load and power consumption.
- Compact rack design.

### Included items

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

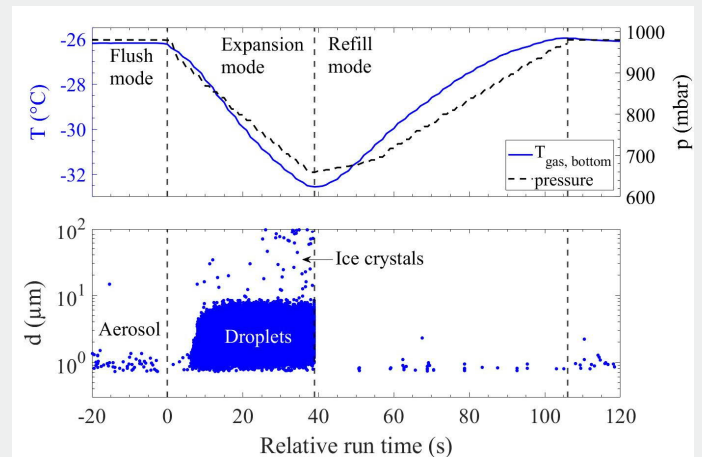


Figure 1

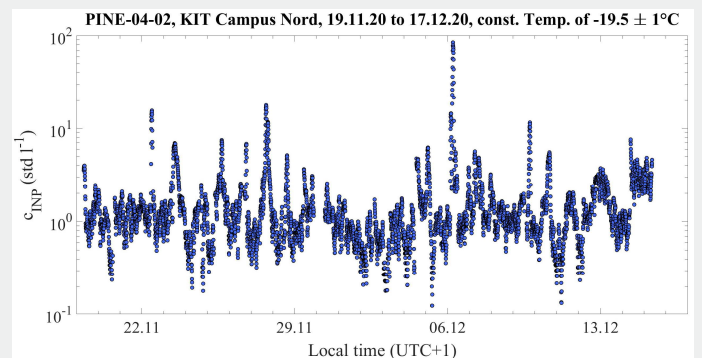


Figure 2

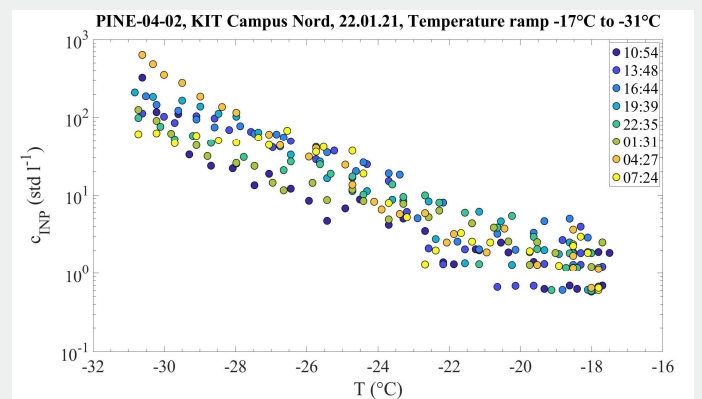


Figure 3

### Add on

The PINE instrument is validated for INP concentration measurements at the KIT cloud facility AIDA before delivery. The validation is documented as part of the operation manual.

For the operation of PINE, a free as-is software is available from KIT. The software allows for temperature profiles and dedicated measurement cycles for long-term measurements.

### Technologies

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**Detailed specifications:**

INP concentration range ..... 0.002 to 1000 L<sup>-1</sup>  
 Sampling temperature..... < 35°C  
 Measurement temperature..... -10 to -65°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..... < 0.5 / 1 kW, 110-240 VAC  
 Altitude (higher on request) ..... < 2000 m