# Separation and sampling of ice nucleation chamber generated ice particles by means of the counterflow virtual impactor technique for the characterization of ambient ice nuclei.

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## Overview and Objectives of Research Project 2 within INUIT

- In 2011, the German research foundation (DFG) research group called Ice Nuclei Research Unit (INUIT) was established.
- INUIT has the objective to achieve a better understanding concerning heterogeneous ice formation.
- The field part of INUIT aims for a better microphysical and chemical characterization of atmospheric aerosol particles that have the potential to act as ice nuclei (IN).
- For this purpose a counterflow virtual impactor system (IN-PCVI, Kulkarni et al., 2011) was developed and characterized.
- The IN-PCVI enables the separation and collection of ice particles generated in the Fast Ice Nucleus Chamber (FINCH; Bundke et al., 2008).
- After evaporation of ice behind the IN-PCVI, dry particles which had acted as IN in FINCH are obtained for analysis, with respect to:
  - ➢ Number concentration
  - ➢ Size
  - ➢ Chemical composition

## Experimental Setup and Methods

- The IN-PCVI was used for an inertial separation of ice particles produced with FINCH from smaller drops and interstitial particles.
- This is realized by a counterflow inside the IN-PCVI that matches the FINCH output flow (Fig. 1).
- IN-PCVI flows (Fig. 1 middle) determine the aerodynamic cut-off diameter.
- A larger add/output flow leads to larger cut of diameter (Dp50) in opposite to a larger input flow which leads to smaller Dp50

→Large ice particles (>Dp50) are sampled, small drops/interstitial particles (<Dp50) are segregated into the pump flow

- The collected ice particles are transferred into the IN-PCVI sample flow where they are completely evaporated in a particle-free and dry carrier air.
- In this way, the aerosol particles that had been detected as IN FINCH can be extracted and analysed further.
- In the present study, the IN-PCVI was operated with different flow settings (Fig. 2) than known from literature (Kulkarni et al., 2011)
- Therefore, a further characterisation of its cut-off-behaviour was required.

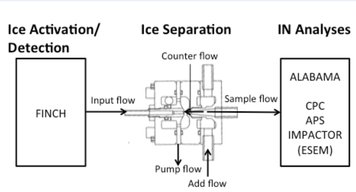


**Fig. 1: Overview of the measurement setup deployed during the JFJ-INUIT/CLACE 2013 campaign.**

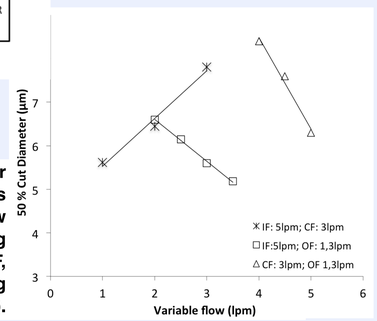


**Fig. 2: Dp50 ranges for different flow setups (changing output flow (OF, crosses), changing counterflow (CF, squares) and changing input flow (IF, triangles).**

## INUIT/CLACE 2013 campaign at JFJ

**Fig. 3: Sphinx research station at the top of the Jungfraujoch is located in the Berner Alps in central Switzerland.**

- Ice crystal activation and detection (FINCH), ice particle selection (IN-PCVI) and aerosol instrumentation (Fig. 1) were deployed at the JFJ-Research-Station during the joint measurement campaign JFJ-INUIT/CLACE 2013.
- The Sphinx (Fig. 3) at the JFJ is the highest ground based research site in Europe (3580 m a.s.l.).
  - ➢ Sampling of ice crystals and supercooled droplets out of mixed phase clouds during winter time
- Main goal of the joint campaign was the microphysical, chemical and biological characterization of IN and ice particle residuals (IPR) under following aspects:
  - ➢ Distinction between more anthropogenic (wind from north) or "natural" (wind from south) IN/IPR (exposed position of the JFJ research station Sphinx leads to this possibility)
  - ➢ Determination of the influence of size and chemical composition of the sampled aerosol particles on their ice nucleating ability
  - ➢ Examination of the role of atmospheric aging and the presence of biogenic material acting as IN/IPR

## Results of RP2 during INUIT/CLACE 2013

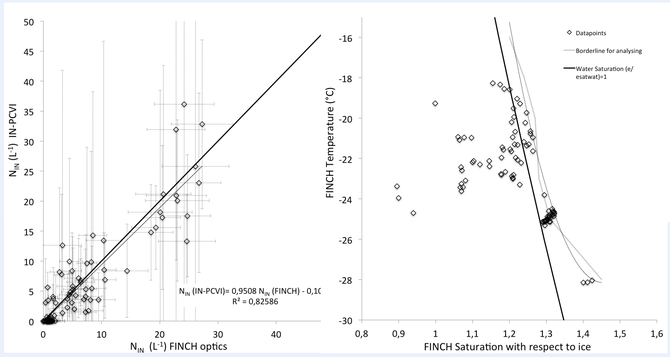


**Fig. 4: On the left the 10 min avg. number concentration of IN is plotted over the number of ice crystals for the whole campaign. In the right figure the FINCH thermodynamic conditions during the measurements of number concentration is plotted in a scatter plot.**

- Depending on the operation and thus freezing conditions inside FINCH (temperature and supersaturation), IN number concentrations between 1 and 50 per litre (Fig. 4 left) were detected by FINCH and a CPC mounted downstream of the IN-PCVI for stable and discrete conditions inside FINCH (1 % deviation of saturation in 300 s and saturation with respect to water roughly 1 (fat line Fig. 4 right)).
- The aerodynamic diameter of IN measured via APS has a slightly decrease for larger diameter (in comparison to ambient aerosol) → larger particles have a larger IN activity
- The offline electron microscopy revealed that on average 80% of the IN consist of dust and metal oxides. 20 % are carbonaceous material, of which less than 5 % are soot (Fig. 6 left).
- The ALABAMA spectra of an IN showed organic material from biomass burning (Fig. 6 right).

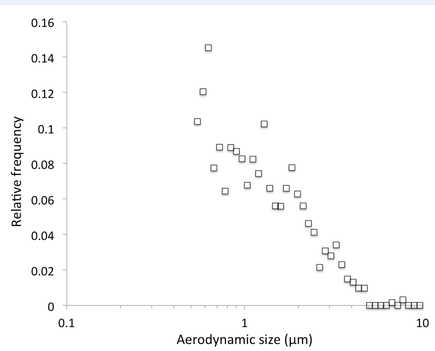


**Fig. 5: Relative frequency of occurrence of different aerodynamic IN diameters averaged over the whole campaign measured by APS.**

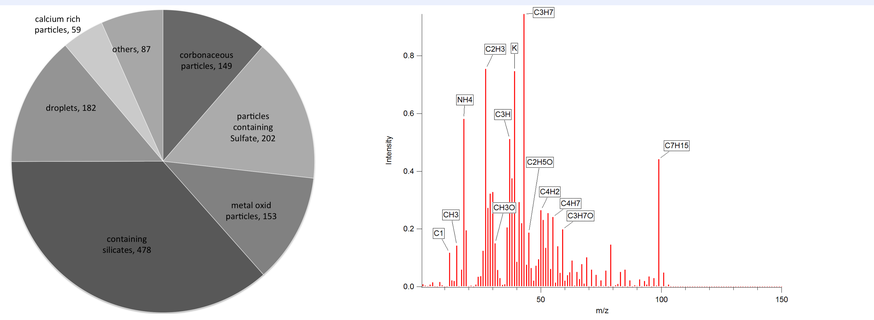


**Fig. 6: In the left the chemical composition of the amount of FINCH-IN, analysed offline via electron microscopy, is shown. IN were sampled with impactor technique. The right figure shows an example the chemical composition of a FINCH-IN measured online with the ALABAMA (single particle spectrometer) instrument. It shows particles from biomass burning (oxidized organic composition, K and NH4).**

## Summary and Acknowledgments

- In this project the principal functionality of the combination of an ice nucleus counter with aerosol instrumentation via pumped counter flow impactor technique is shown (especially for field conditions)
- Good interplay of FINCH and IN-PCVI was shown for certain FINCH conditions (maximum of saturation with respect to water roughly 1)
- First results of the JFJ-INUIT/CLACE 2013 campaign of the combination FINCH – IN-PCVI are shown.
  - ➢ Number concentration of IN is in a range of 0 - 50 per litre (further investigation like trajectories and FINCH conditions)
  - ➢ IN number concentration decreases slightly with size in comparison to ambient aerosol
    - 10 % of IN samples with the APS are in a size range of 1 $\mu$m, 2 % in a range of 4$\mu$m
    - Particles larger than 5 $\mu$m were not observed
  - ➢ Biological particle acting as IN were found
  - ➢ Dust plays the biggest role as ice acting material

**Acknowledgements:** This Project is funded by the DFG research group INUIT (FOR 1525, grant STR 453/7-1).

## References

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