New Instrument INKA for Ice Nucleation and Growth Experiments

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Motivation

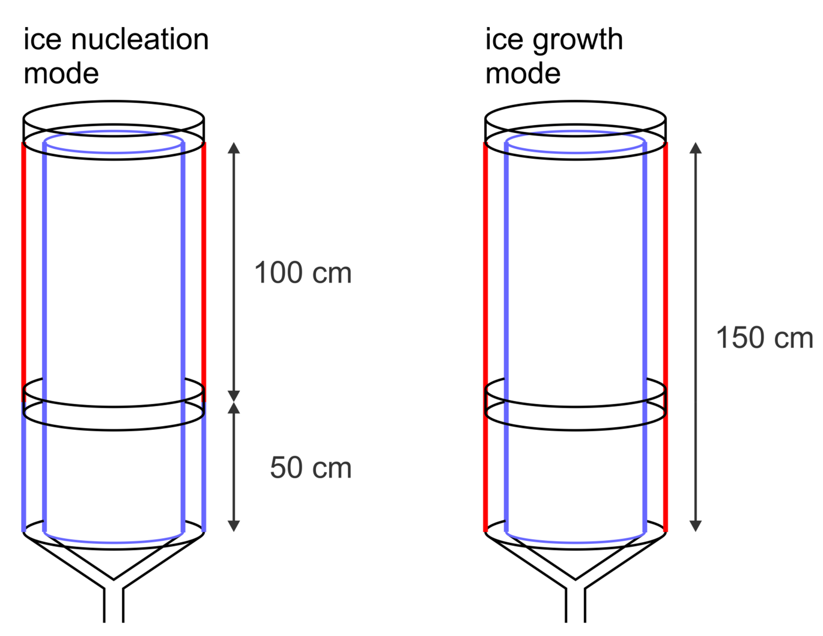
Microphysical processes in clouds (e.g., formation and growth of ice crystals)
→ cloud structure and life time
→ weather and climate

Further laboratory studies + formulation and parameterization of these processes
→ quantitative information on the ice activity of various atmospheric aerosol species

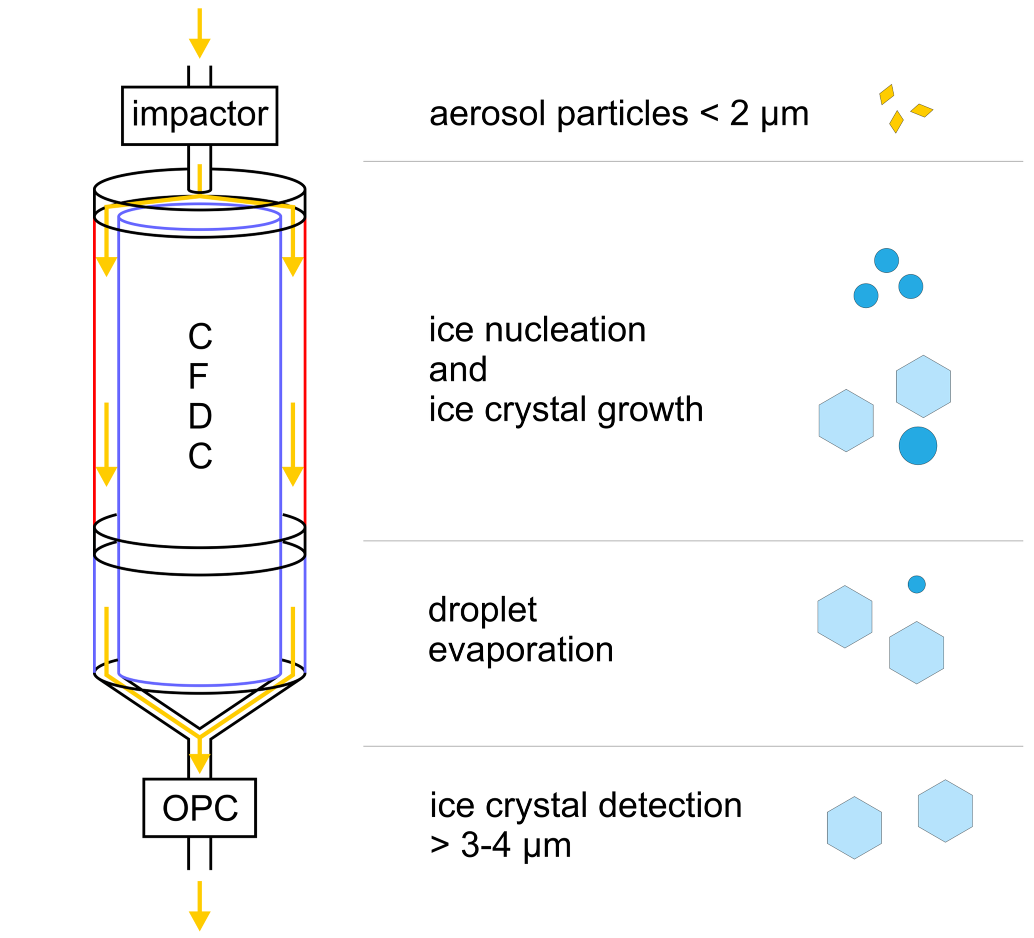
INKA

Ice **N**ucleation Instrument of the **KA**rlsruhe Institute of Technology

- Collaboration with Colorado State University (CSU)
- Continuous flow diffusion chamber (CFDC)
  - Cylindrical design (Rogers, 1988)
  - Laboratory version → cooling with cryostats
  - -40 °C < T < -10 °C
  - $S_{ice} > 1$, $S_{liq} < 1.1$
  - 12.5 lpm total flow, 1.25 lpm sample flow
  - 15-22 s residence time, depending on operation mode
- Ice nucleation and growth experiments at defined temperatures and saturation ratios
- Investigation of different freezing modes possible (deposition nucleation and condensation freezing)
- Two different operation modes
  - Ice nucleation mode: With evaporation section
  - Ice growth mode: Total length operated as one ice nucleation and ice crystal growth section



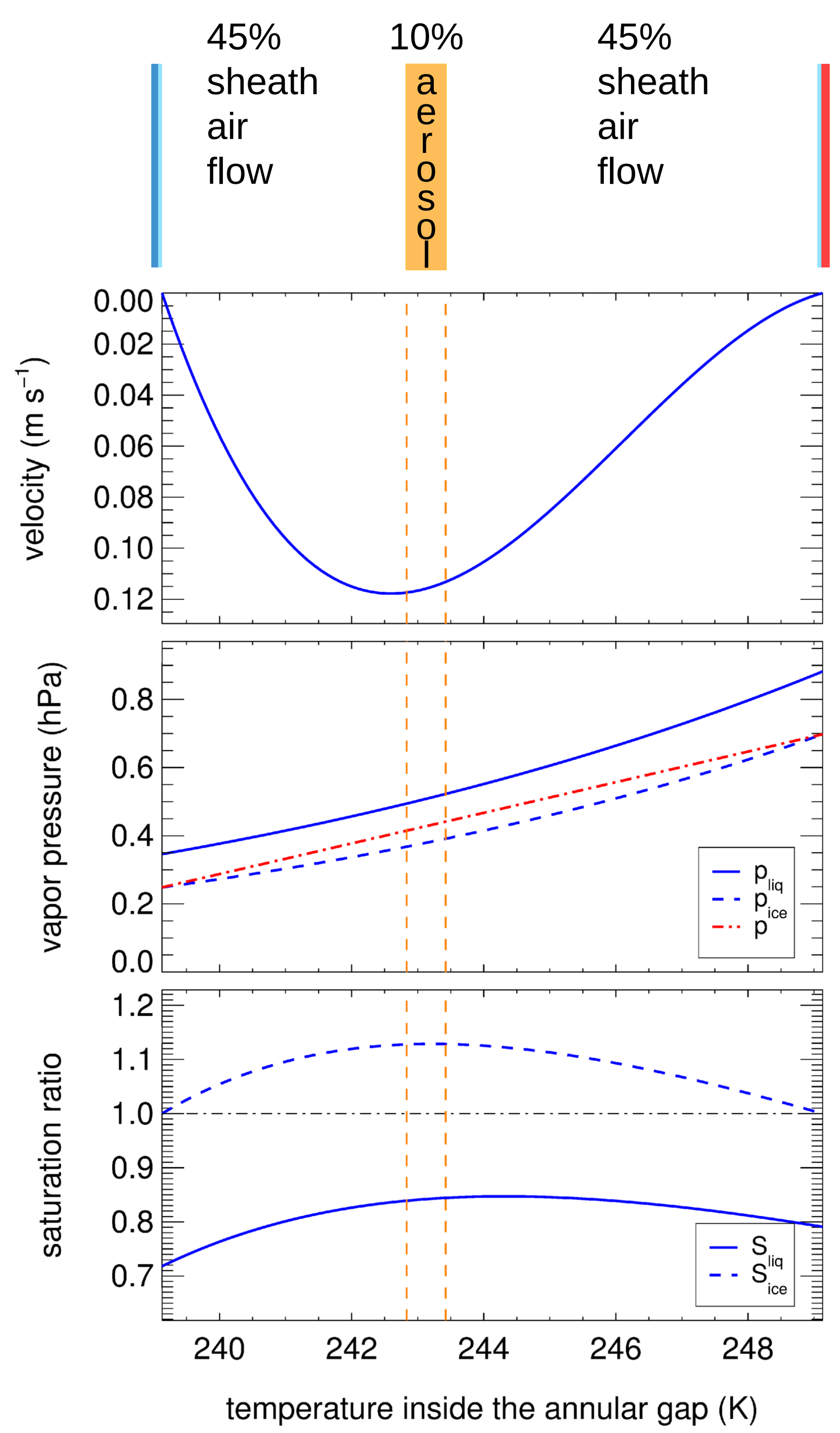
Working Principle



both walls ice-coated and at defined but different temperatures
→ saturation profile

both walls ice-coated and at same temperature
→ ice saturated, water subsaturated

Ice Nucleation and Ice Crystal Growth Section



cold (inner wall, left margin of the x-axis) and warm wall (outer wall, right margin of the x-axis) of the annular gap between the two concentric cylinders, both coated with a thin ice layer

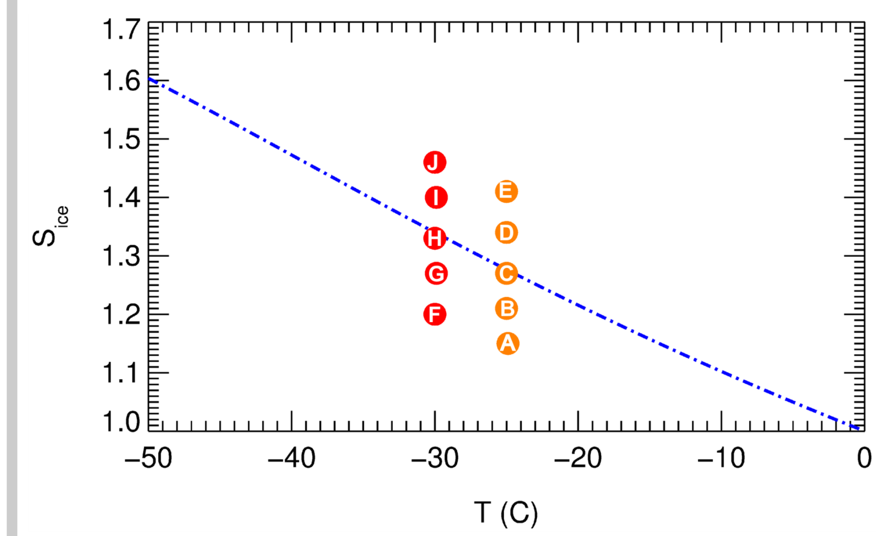
buoyant circulation
→ aerosol particle flow shifted towards cold wall

p: steady state water vapor pressure due to diffusion of water vapor between the two ice-coated walls (Stetzer et al., 2008)
$p_{liq,ice}$: T-dependent saturation vapor pressure with respect to liquid water and with respect to ice, respectively (Murphy and Koop, 2005)

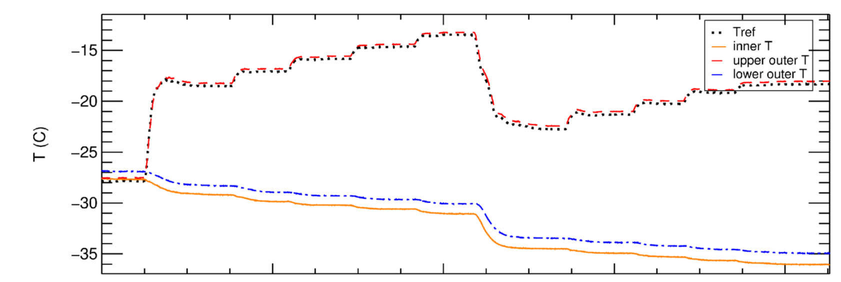
$S_{liq,ice}$: saturation ratio with respect to liquid water and ice, respectively

linear T gradient
→ x-axis ≙ distance from the cold wall

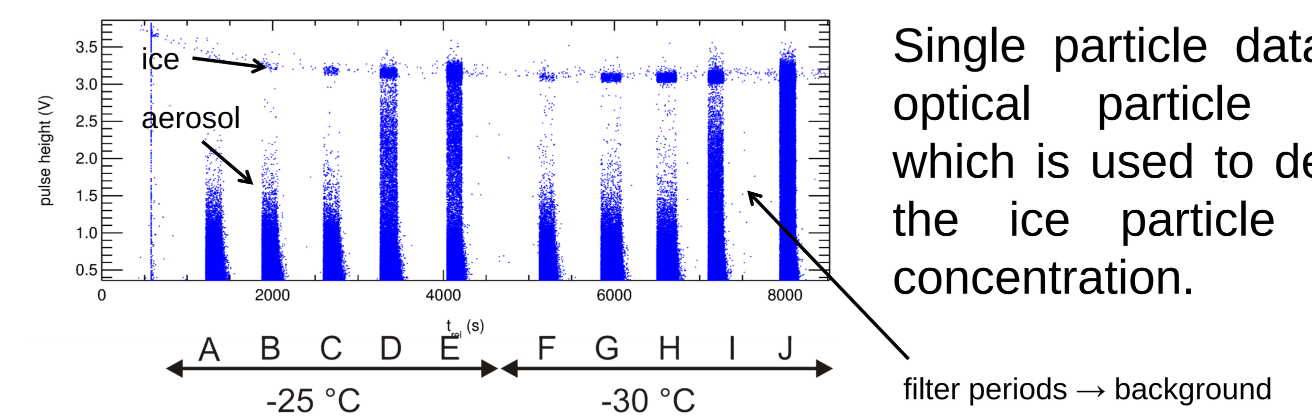
First Measurements



Calculated aerosol particle conditions during the stepwise scanning of an ice nucleation experiment with Saharan Desert Dust.



Wall temperatures together with the temperature of a reference sensor, which is located at the upper outer wall.



Single particle data of the optical particle counter, which is used to determine the ice particle number concentration.

Summary and Outlook

- Construction of a new CFDC chamber to investigate heterogeneous ice nucleation
- First measurements show that the instrument is in good working order
- Mobile version to investigate atmospheric ice nucleating particles (INPs) is planned

Acknowledgement

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References

Murphy and Koop (2005) *Quart. J. R. Met. Soc.* **131**, 1539-1565.
Rogers (1988) *Atmos. Res.* **22**, 149-181.
Stetzer et al. (2008) *Aerosol Sci. Tech*. **42**, 64-74.