Karlsruhe Institute of Technology

Institute of Meteorology and Climate Research - Atmospheric Aerosol Research (IMK-AAF)

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Ice-nucleating properties of dust from high-latitude regions

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Motivation/Background

- Mineral dust aerosol particles can act as ***ice-nucleating particles (INPs)***[1,2], hence, influencing the microphysical and optical properties of clouds which impacts the climate[3].
- In recent times, there is an increase in natural dust events in the high-latitude regions due to climatic impacts and land use changes[4]. Areas previously covered by glaciers are exposed leading to more dust emissions.

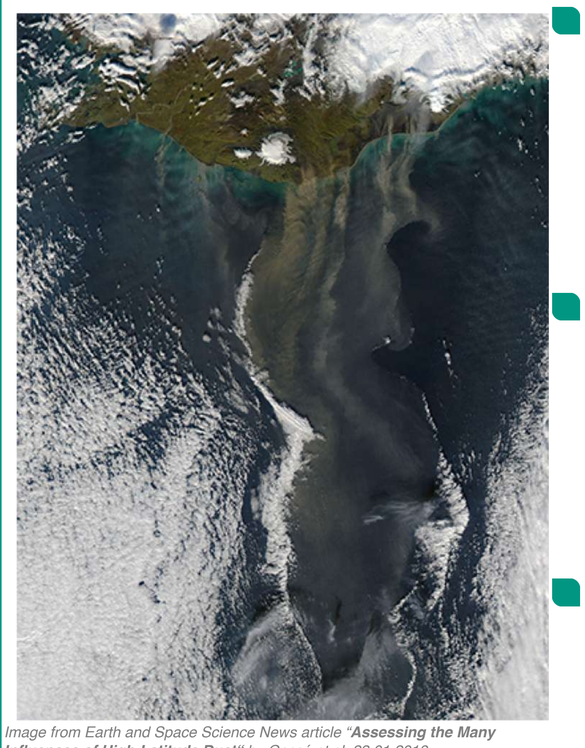
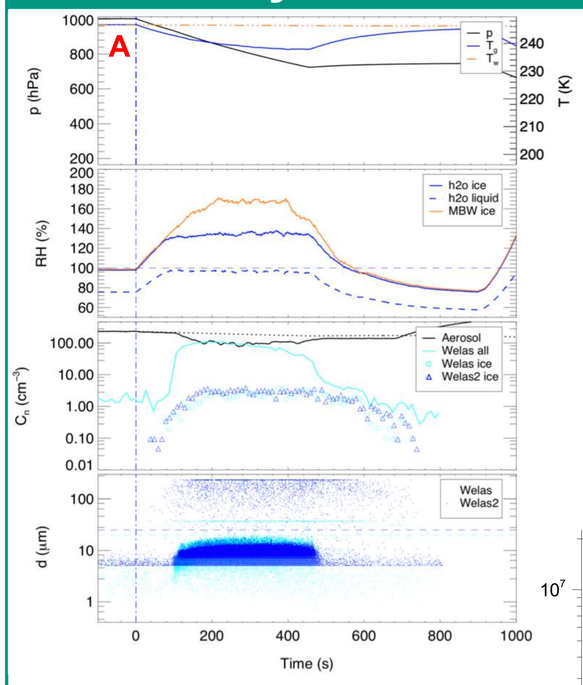


*Image from Earth and Space Science News article "**Assessing the Many Influences of High-Latitude Dust**" by Gassó et al. 23.01.2018*

- A recent estimate shows that over 500,000 km^2 of the high-latitude sources are contributing about 80 – 100 Tg of dust to the Earth system annually[5].
- These emerging dust sources could contribute to the global ice nuclei budget; however, at present, the understanding of IN abilities of dust from high-latitude sources is limited.
- This study investigates the **IN properties** of **high-latitude dust (HLD)** in both **cirrus** and **mixed-phase cloud** conditions.

Preliminary Results

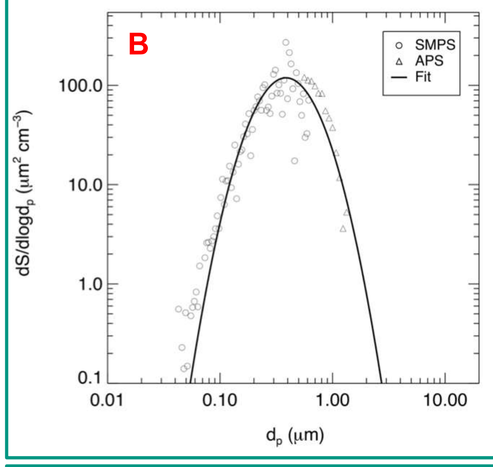


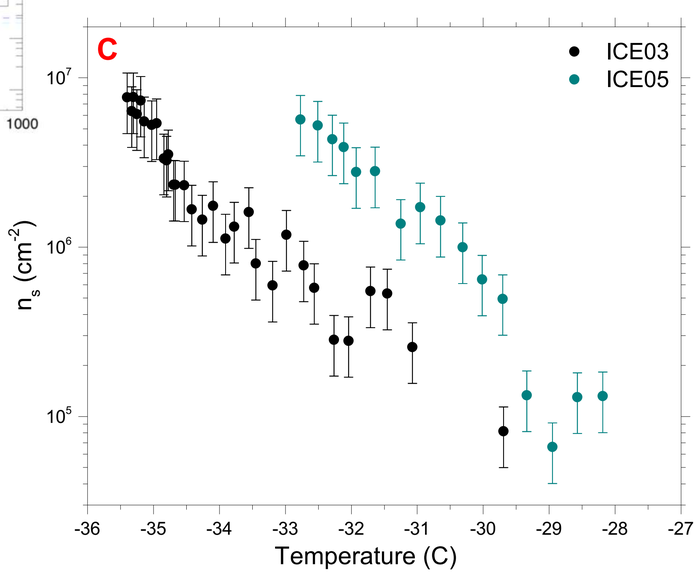
$$n_s(T) = \frac{n_i(T)}{s_{ae}}$$

where

$n_i(T)$ is the ice number concentration at temperature (T). Here, T is in bins.

s_{ae} is the surface area concentration of the aerosol

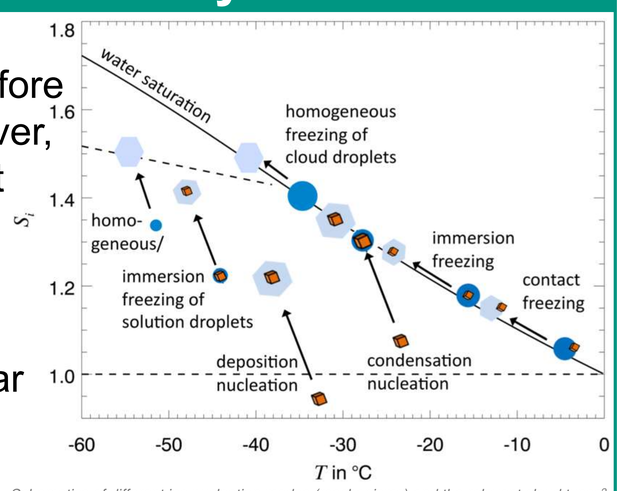




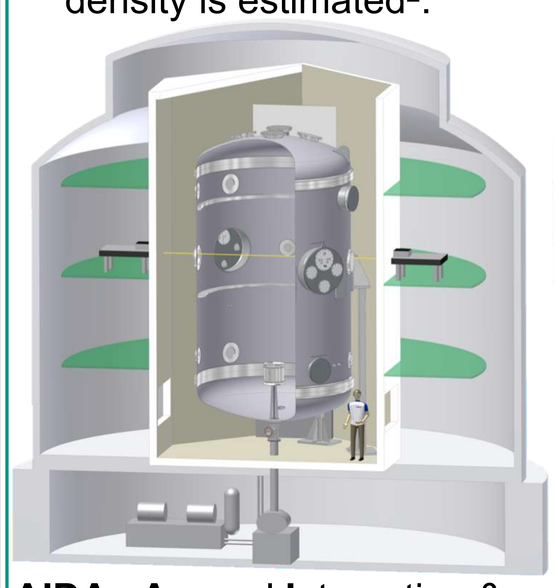
*Temperature, Pressure, Relative humidity, Aerosol & Ice number concentrations and sizes of the ice particles formed (**A**). Size distribution for the aerosol as measured by APS and SMPS (**B**) and the INAS densities of two high-latitude dust samples investigated in this study (**C**).*

Ice Nucleation & Research Facility

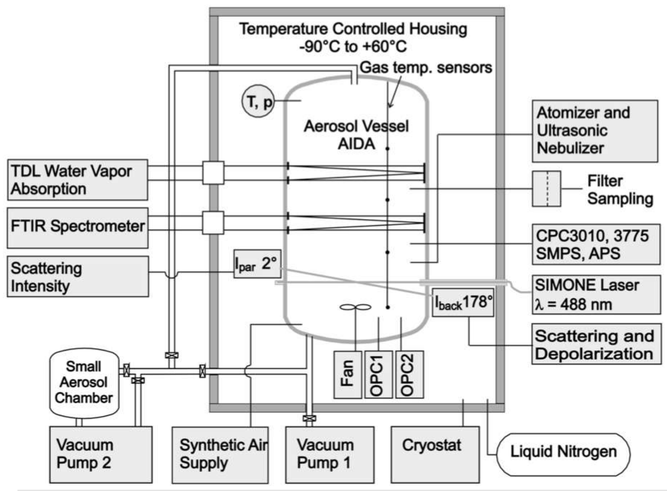
- In clouds, water can be supercooled to about - 37 ^oC before freezing homogeneously. However, INPs can trigger ice formation at much higher temperatures via different pathways[1].
- INPs efficiencies can be quantified using a simple singular model, from which the Ice Nucleation Active Sites (INAS) density is estimated[2].



Schematics of different ice nucleation modes (mechanisms) and the relevant cloud types[2].



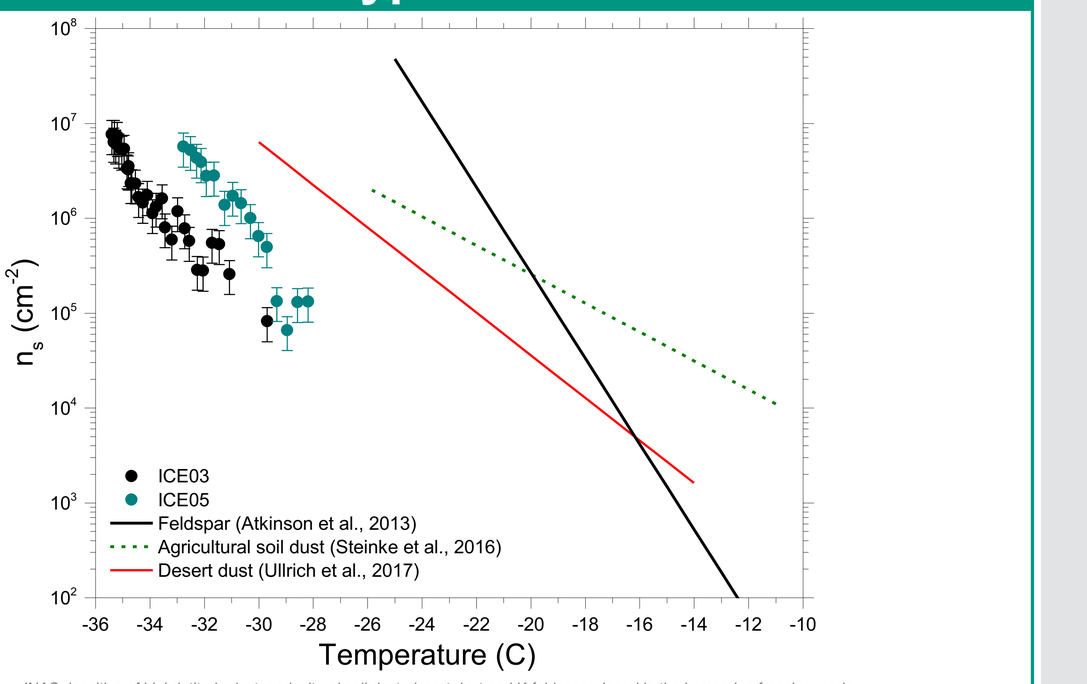
AIDA - **A**erosol **I**nteraction & **D**ynamics in the **A**tmosphere



84 m^3 chamber, ~ 0.1 hPa, Temp err < ± 0.2 K, Bkgd conc. ~ 0.1 cm^{-3}, cooling rate up to 5 K h^{-1}, adiabatic expansion of air parcel & updraft simulations, multi-instrumentation for online sampling and measurements.

AIDA cloud simulation chamber (2D - model) & schematics showing different instrumentation[6,7].

HLD Vs Other Dust Types



INAS densities of high-latitude dust, agricultural soil dust, desert dust and K-feldspar mineral in the immersion freezing mode.

Summary

- High-latitude dust nucleates ice in the immersion freezing mode, which is relevant to the mixed-phase clouds.
- Their ice-nucleating efficiencies are relatively lower than that of agricultural soil and desert dust, however, with similar gradient.
- Understanding the controlling factor in their ice-nucleating behaviours is lacking and requires research attention. Also, modelling efforts should be geared towards estimating their contributions to the global INP budget and indirect climatic effects.

References

[1]***Pruppacher & Klett***, 1997, Kluwer Academic Publishers, Dordrecht. [2]***Hoose & Möhler***, 2012, ACP, doi:10.5194/acp-12-9817-2012. [3]***Boucher*** et al., 2013, www.climatechange2013.org and www.ipcc.ch. [4]Arnalds et al., 2016, AR, https://doi.org/10.1016/j.aeolia.2016.01.004. [5]***Bullard*** et al., 2016, RG, doi:10.1002/2016RG000518. [6]***Möhler*** et al., 2006, ACP, https://doi.org/10.5194/acp-6-3007-2006. [7]***Wagner*** et al., 2013, GRL, doi:10.1002/jgrd.50325.

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