The ice-nucleating efficacy of glacial dust from the Copper River, Alaska

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Introduction

- Clouds containing ice play a crucial role in Earth’s energy balance and water cycle
- Ice-nucleating particles (INPs) can trigger the formation of ice in clouds and influence radiative properties, cloud lifetime and precipitation
- Many global aerosol models do not take high latitude sources of INPs into account
- High latitude dust sources have been identified but their importance for INPs is still not well quantified
- The south coast of Alaska has been identified as a significant dust source with the potential to be important for ice-nucleating particles
Focus of this study

Copper River Delta, Alaska:
- Located at ~60°N in the Valdez-Cordova region
- Identified as one of the largest dust sources on the south coast of Alaska with regular dust storms in late Summer/Autumn
- The Copper River drains an area of >62,000 km² and is fed by numerous glaciers
- Glacial dust is transport and deposited on the river delta, which has area of > 2,800 km², where it dries and can be lofted during high wind events

Objectives:
- Collect samples of glacial dust from the Copper River Delta, Alaska
- Quantify the ice-nucleating efficacy of the samples
- Determine the composition of samples in order to investigate what controls the ice-nucleation
Methods: sample collection

- **Field campaign to the Copper River Delta in October 2019**
- **Surface sampling:**
  - Dust collected from the surface at areas with visible dust emissions
  - Sieved to 45 μm in the field
- **Airborne sampling:**
  - Size resolved aerosol samples collected on to filters using SKC Sioutas cascade impactor
  - 4 size ranges (0.25 - 0.50 μm, 0.50 - 1.0 μm, 1.0 - 2.5 μm, > 2.5 μm) plus after filter for < 0.25 μm,
  - 9 l/min flow rate
  - 7 impactor runs (3-6 hours long) during dust events
- **Other measurements:**
  - Particle size distribution with N2 optical particle counter (limited data due to instrument failure 😞)
  - Wind speed
Methods: laboratory analysis

University of Leeds Microlitre Nucleation by Immersed Particle Instrument (µL-NIPI) used to determine ice nucleating activity of samples

Filter sample preparation:
- Aerosol washed off each filter into 3 ml milli-Q ultrapure water

Surface sample preparation:
- 1 wt% suspensions prepared of 45 µm sieved sample in milli-Q ultrapure water
- Suspensions filtered using 10 µm nylon mesh filter

Additional analyses:
- Samples heated to 95°C to investigate potential biogenic contribution to ice-nucleating efficacy
- X-Ray diffraction for mineralogy
- Laser diffraction for particle size distribution of surface samples

Filter samples: Ice nucleating particle concentration per litre of air ([INP])
Surface samples: Active site density per unit surface area ($n_s$)

(Wheel et al, AMT, 2015)
Preliminary results

Results from 1 impactor run

- Higher activity/INP concentrations for particle sizes > 1 µm
- Different INP spectra/slope for stages A and B vs C and D indicating different INPs
- Slope of stages C and D consistent with potassium feldspar parametrisations (Compared to K-feldspar parametrisation from Harrison et al, ACP, 2019)
Preliminary results

Results from heat test on stage A

- Stage A deactivated by heating, fraction frozen and [INP] after heating more similar to stages C and D
- This suggests a biogenic component that is active at higher temperatures
- Results after heating are once again consistent with the slope of potassium feldspar parametrisations
Preliminary results

Surface samples also show some deactivation after heating, further suggesting a biogenic component.

XRD analysis of bulk surface samples show around 9% Microcline (K-feldspar) known to be one of the most important minerals for ice nucleation.
Preliminary conclusions and next steps

Preliminary conclusions:
- Initial results suggest INP concentrations relevant for mixed phase clouds
- The ice-nucleating efficacy of glacial dust from the Copper River appears to be controlled by potassium feldspar however there could be a biogenic component at > 1 µm sizes

Next steps:
- Remaining filter samples to be analysed (6 x impactor runs), including further heat tests
- Surface area measurement to calculate $n_s$
- Modelling of dust transport using FLEXPART particle dispersion model
Glacial dust could be an important source of ice-nucleating particles in the high latitudes

Samples were collected from the Copper River Delta, Alaska during a field campaign in October 2019

- Surface samples and airborne samples using a multi-stage cascade impactor
- Laboratory analysis to determine the ice-nucleating efficacy and composition of the samples is in progress
- Initial results show heat tested samples deactivate suggesting a possible biogenic component to the samples however this is only observed at > 1 µm sizes
- At < 1 µm particle sizes the nucleation appears to be consistent with potassium feldspar, this is in agreement with XRD analysis which shows around 9% Microcline

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