School of Earth and Environment

INSTITUTE FOR CLIMATE & ATMOSPHERIC SCIENCE

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

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# Introduction

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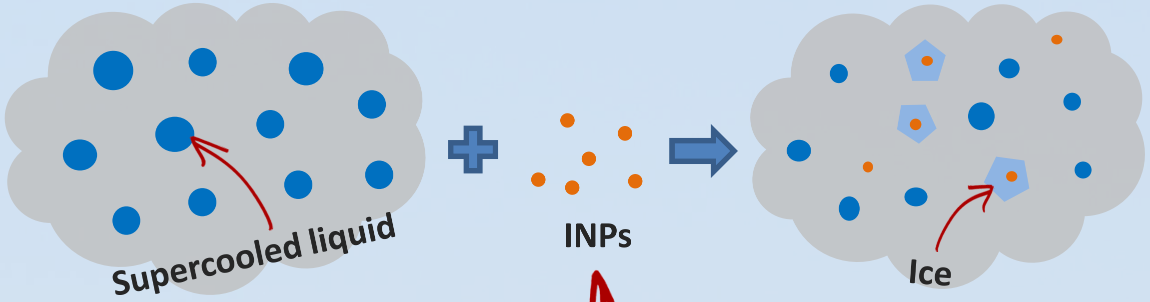
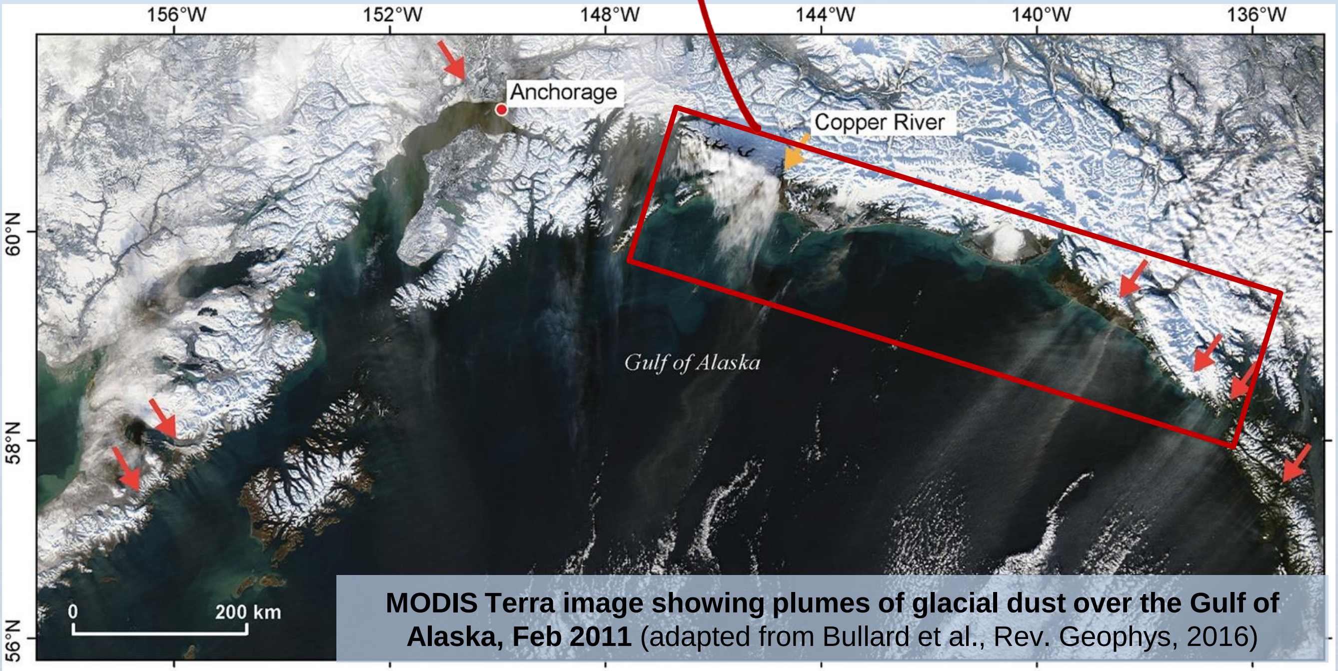
- Clouds containing ice play a crucial role in Earth's energy balance and water cycle
- Ice-nucleating particles (INPs) can trigger the formation of ice in clouds and influence radiative properties, cloud lifetime and precipitation
- Many global aerosol models do not take high latitude sources of INPs 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




**MODIS Terra image showing plumes of glacial dust over the Gulf of Alaska, Feb 2011** (adapted from Bullard et al., Rev. Geophys, 2016)

# Focus of this study

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## Copper River Delta, Alaska:

- Located at ~60ºN 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 km$^2$ and is fed by numerous glaciers
- Glacial dust is transport and deposited on the river delta, which has area of > 2,800 km$^2$, where it dries and can be lofted during high wind events


**Copper River Delta** (Photo: Jon Williams, flikr.com)

## 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

**Dust event at the Copper River, Nov 2017** (Image: NASA, Landsat 8)

# 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

Region where surface samples were collected

Impactor sampling set up in-situ

# Methods: laboratory analysis

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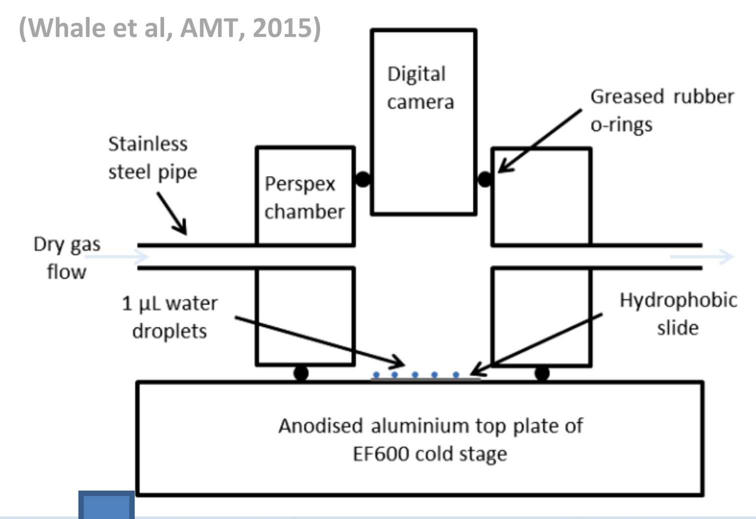
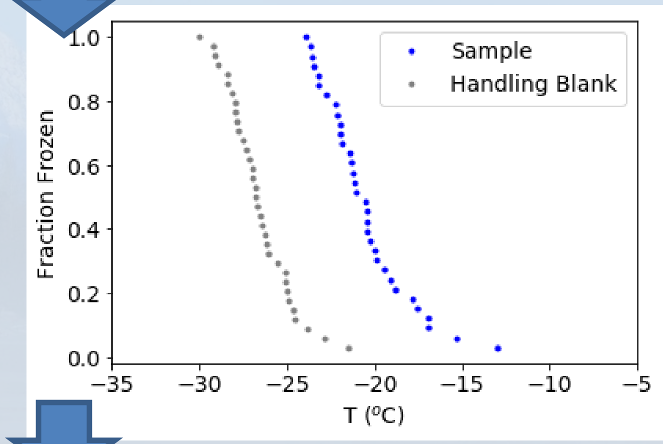
- University of Leeds **Microlitre Nucleation by Immersed Particle Instrument (μL-NIPI)** used to determine ice nucleating activity of samples
- **Filter sample preparation:**
  - Aerosol washed off each filter in to 3 ml milli-Q ultrapure water
- **Surface sample preparation:**
  - 1 wt% suspensions 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 ($n_s$)

# Preliminary results

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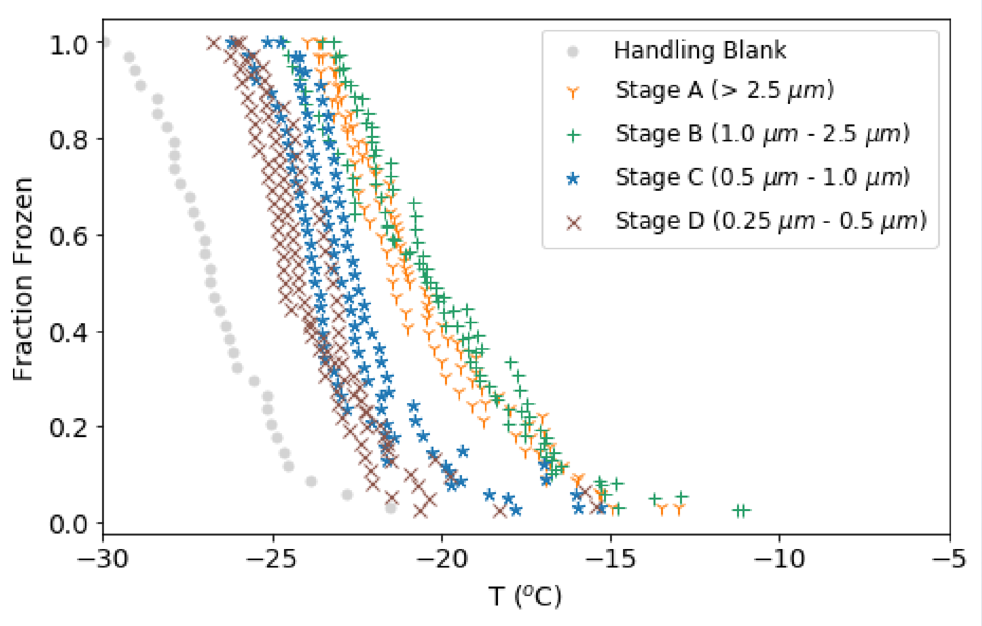
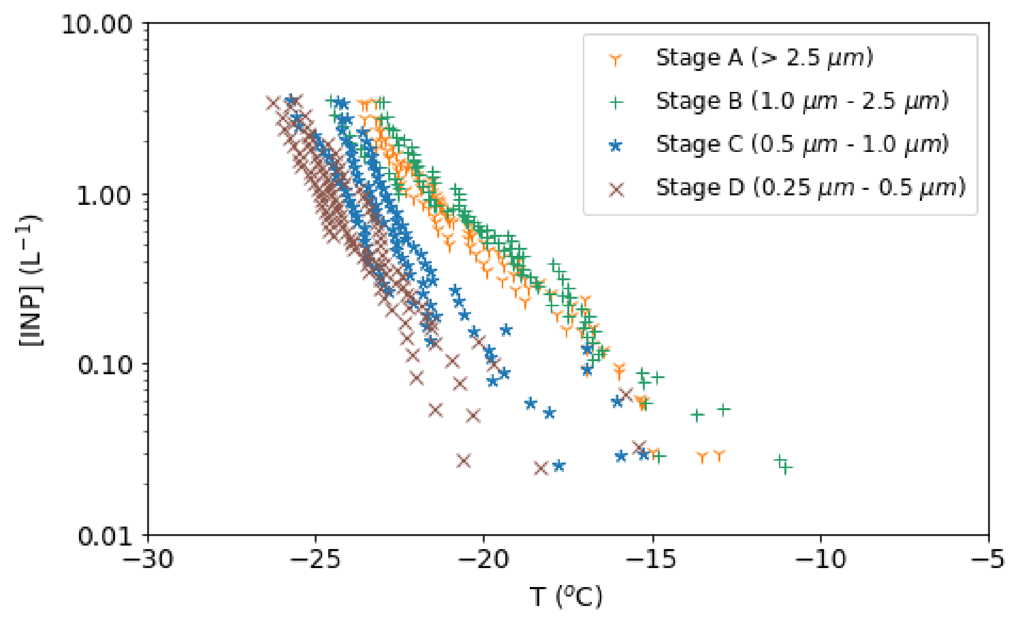
## Results from 1 impactor run




- 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

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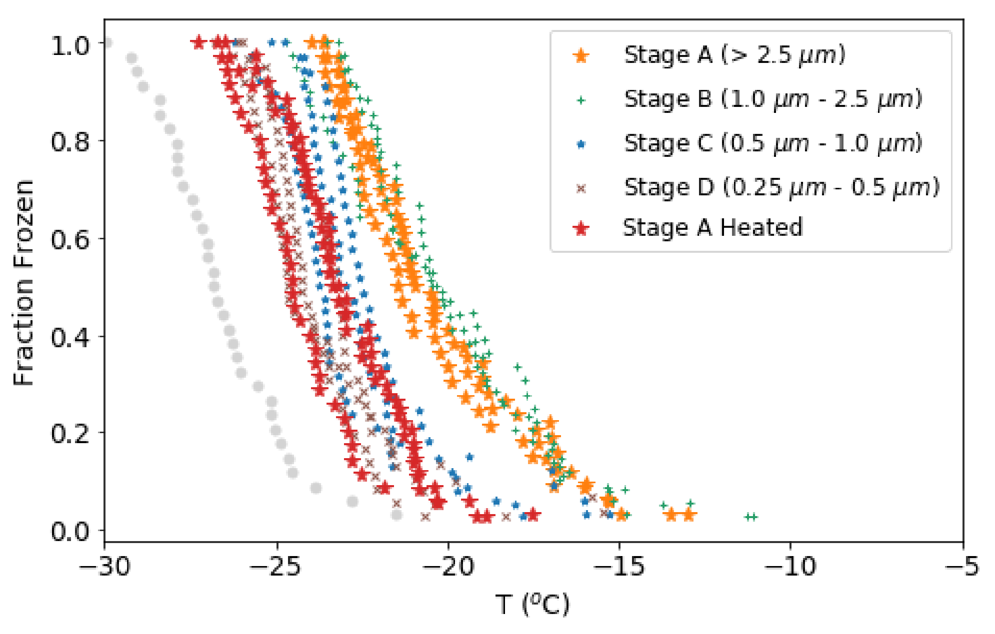
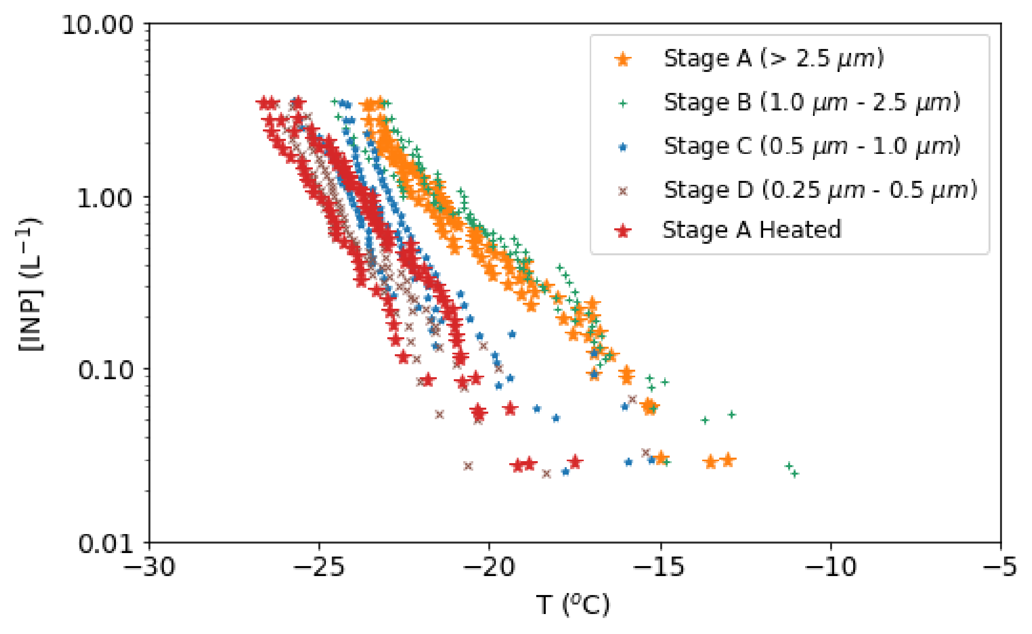
## Results from heat test on stage A




- 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

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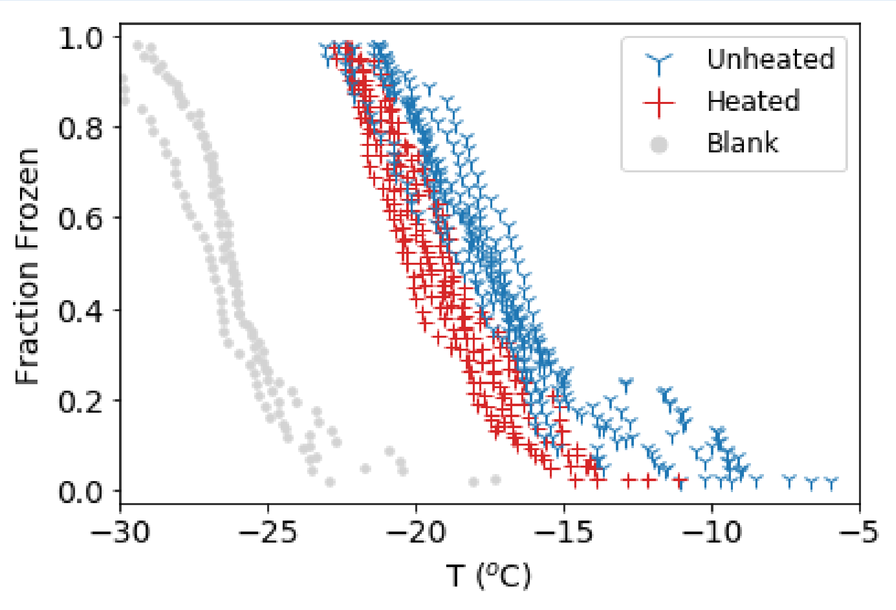
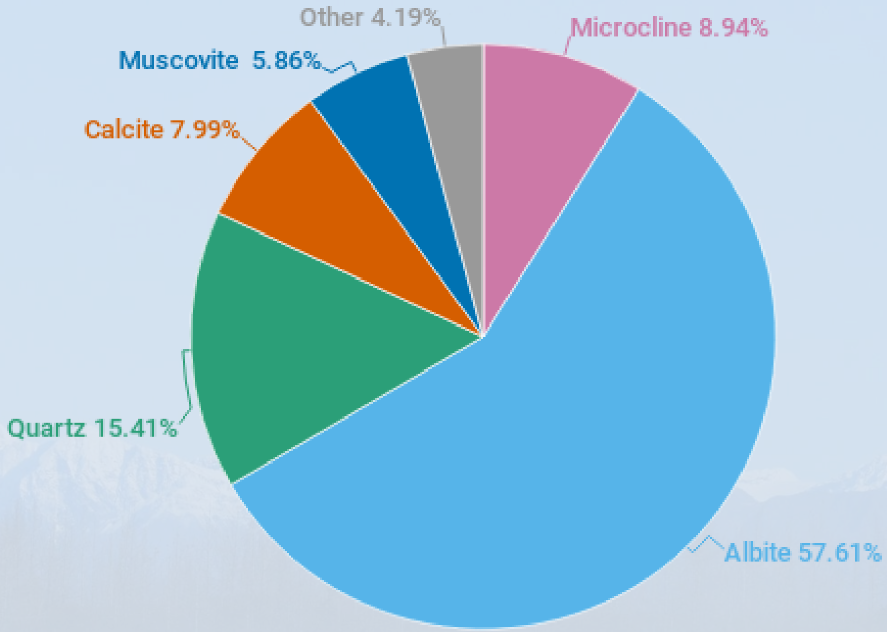
## Results from surface samples




## Results from XRD




- 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

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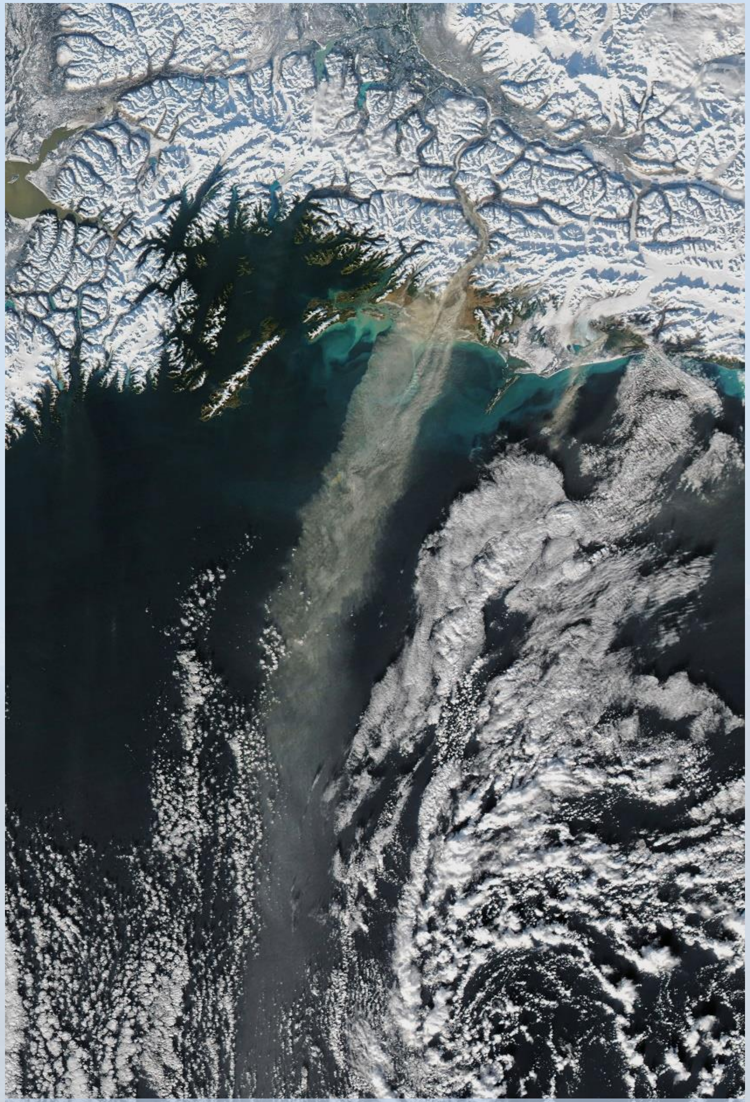
**Preliminary conclusions:**

- 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



**Dust event at the Copper River Delta, Nov 2011**
(Image: NASA, MODIS Terra)

# Summary

- 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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