# SeParation of Ice Nuclei via Density Layers (SPINDL): A new method for characterizing ice nuclei using density gradient centrifugation

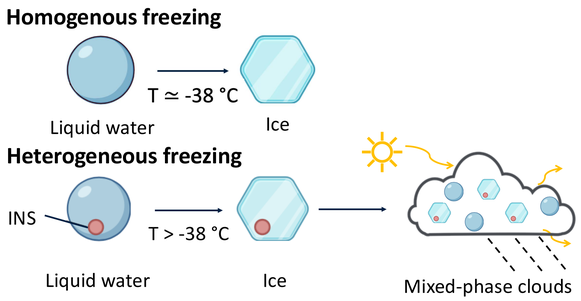
Gurcharan K. Uppal[a], Soleil E. Worthy[a], Lanxiadi Chen[b,c], Cally Yeung[a], Olenna McConville[a], Allan K. Bertram[a]

[a]Department of Chemistry, University of British Columbia; [b]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences; [c]College of Earth and Planetary Sciences, Chinese Academy of Sciences
Contact: guppal@chem.ubc.ca

## INTRODUCTION

**Ice Nucleating Substances (INSs)**

- In the atmosphere, homogenous freezing of water occurs at temperature ≃ -38 °C
- INSs can initiate ice formation at temperatures > -38 °C
- INSs affect cloud radiative properties, cloud lifetime and the hydrological cycle[1,2]




Need for better understanding of organic and inorganic INS concentrations in the atmosphere to test and improve predictions of INSs in the atmosphere.

- Absolute and relative concentrations of organic and inorganic INSs in the atmosphere are not fully known
- Current climate models often do not consider organic INSs[2,3]
  - → Leads to uncertainties when modeling INS global contributions and climate impacts
- Current methods for determining the relative and absolute concentrations of INSs suffer from poor statistics, accessibility, selectivity and false positives[4]
  - → Can lead to over or underestimating INS concentrations and limited sample throughput

## ACKNOWLEDGEMENTS & REFERENCES

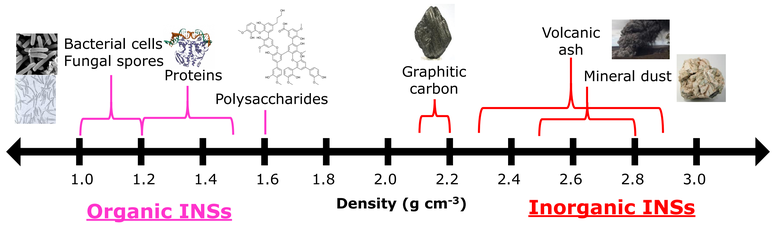
Dr. Allan Bertram
Jessie Chen
Dr. Steven Lindow
Dr. Elena Polishchuk
Dr. Teresa Seifried
Bertram Group

References:
1. Burrows, S. M. *et al. Reviews of Geophysics* (2022)
2. Kanji, Z. A. *et al. Meterol. Monogr.* (2017)
3. Coluzza, I. *et al. Atmosphere* (2017)
4. Worthy, S. E. *et al. ACS Earth Space Chem.* (2024)
5. Vali, G. *J. Atmos. Sci.* (1971)

Introduction graphic made using BioRender

I would like to acknowledge that this work took place at UBC's Vancouver Point Grey campus which is situated on the traditional, ancestral, unceded territory of the Musqueam people.

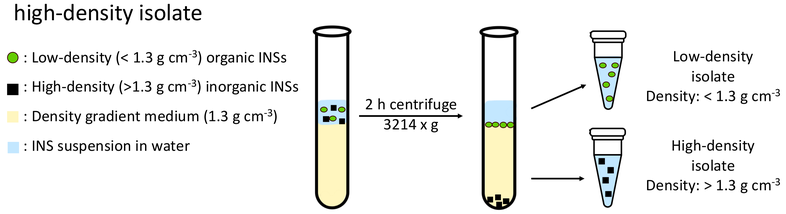
## OBJECTIVE



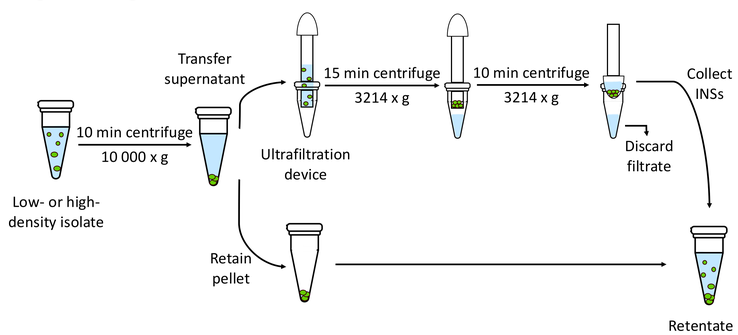

Develop a method to quantify a wide range of organic and inorganic INS concentrations using density gradient centrifugation.

## SPINDL METHOD

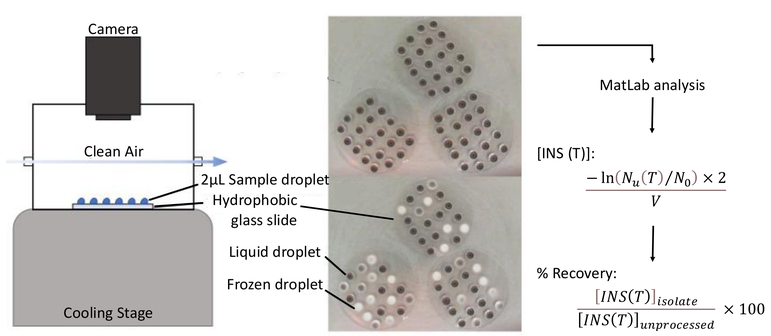
STEP 1: Density gradient centrifugation to separate INSs into low-density and high-density isolate




STEP 2: Washing procedure to remove excess density medium and collect INSs using centrifugation and ultrafiltration

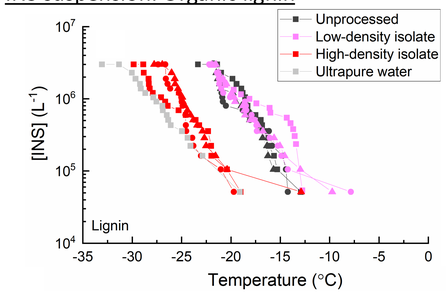



Step 3: Droplet freezing technique[4,5] to quantify INSs




## RESULTS

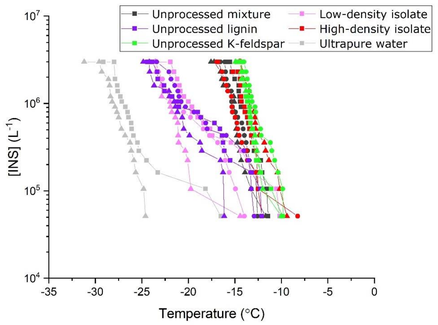
INS suspension: Organic lignin




Goal: Assess SPINDL method on isolated INS suspensions. For example, water-soluble organic lignin

Results: Unprocessed control similar to low-density
INS median (25th-75th) recovery in low-density 115% (98-150%).

INS mixture: Organic lignin and inorganic K-feldspar

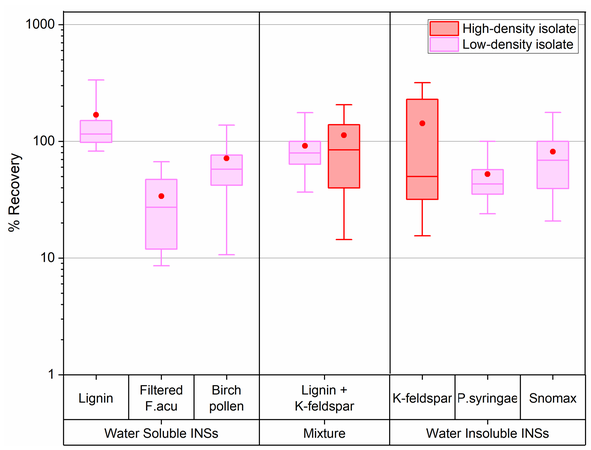



Goal: Assess SPINDL method on an INS mixture.

Results: Unprocessed lignin similar to low-density.
Unprocessed K-feldspar similar to high-density.

INS median (25th-75th) recoveries in low-density 79% (64-100%) and in high-density 84% (40-139%).

Summary of results for all INSs tested:




Goal: SPINDL method on a range of samples. Are the INSs recovered in the expected isolate?

Results: Recovered water soluble INSs from 34-169% and water insoluble INSs from 52-142%

Recoveries in low-density and high-density show SPINDL can separate and quantify inorganic, organic, water soluble, water insoluble and INS mixtures.

## OUTLOOK

This work demonstrates the broad applicability of SPINDL for characterizing a wide range of organic and inorganic atmospheric INSs.

**Future work:**

1. Further test this method on internally mixed samples to assess separation ability
2. Apply method to determine organic and inorganic INS concentrations in an atmospheric sample and use those results to improve predictions of INSs in climate models.