The relationship between surface tension and atmospheric ice-nucleating activity of agricultural soil

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INTRODUCTION

- Ice-nucleating particles (INPs) initiate ice formation in supercooled clouds below around -38°C[1].
- INPs control cloud radiative properties and lifetimes

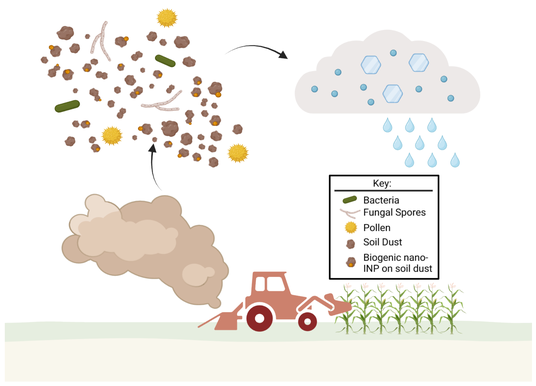

Figure 1. *Association of nano-INP with soil dust aerosol.*

- Agricultural dust contributes 25% of global dust emissions[2].
- These soils dusts are rich in organic matter, which is thought to significantly enhance their ice-nucleating abilities[3].
- Many organic components have surface-active properties which may enhance the ice-nucleating ability of soil dusts.
- The aim of this research is to investigate the relationship between surface active properties of organic components in soil and their ice-nucleating activity.

CONCLUSIONS

- Fertile soils have very high ice-nucleation activities which vary significantly between samples.
- Despite lignin having an IN activity which trends with surface tension, this trend is not observed in more complex soil mixtures.

RESULTS

Bottom-up Approach

- Higher average freezing temperature of lignin solutions were associated with lower surface tension measurements (Figure 4).
- Suggests that ice active macromolecules can have surface active properties.

Top-down Approach

- A wide range of ice-nucleating activities was observed in soil samples from different locations (Figure 5)
- A greater variation in freezing temperatures than has been previously observed from similar soils[3].
- Heat tests revealed that both heat-liable and heat-stable INPs are present in these samples (Figure 6).

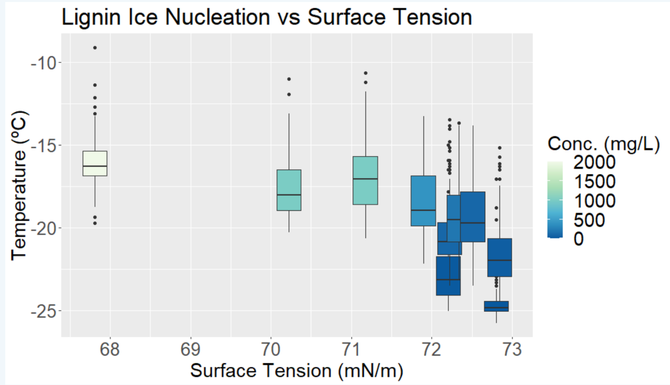

Figure 4. *Freezing temperatures vs. surface tension for lignin solutions.*

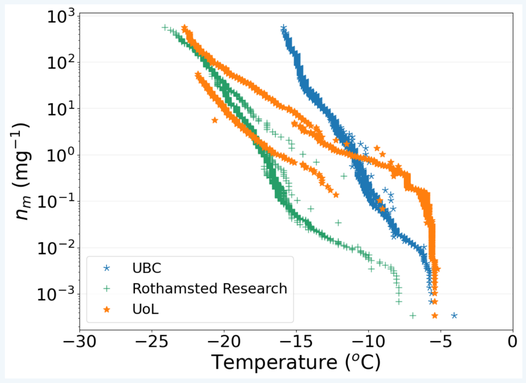

Figure 5. *Ice nucleation activity of three extracted soil samples and their dilutions, normalised by the mass of soil used for extraction.*

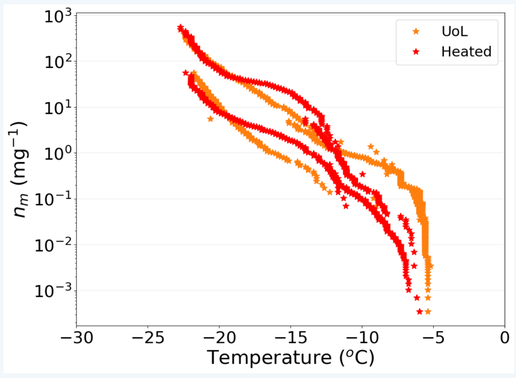

Figure 6. *Ice nucleation activity of extracted soil sample 1 from the University of Leeds Farm , the heat tested sample and their dilutions, normalised by the mass of soil used for extraction.*

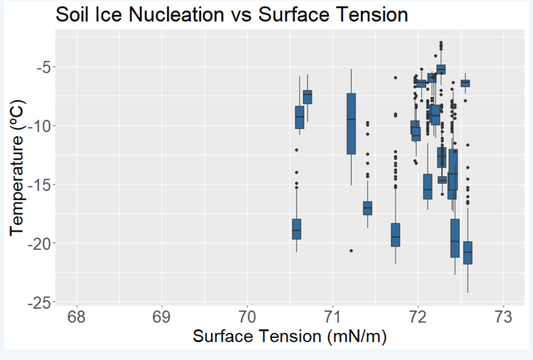

Figure 7. *Freezing temperature vs. surface tension for extracted soil solutions and dilutions.*

- No correlation between the freezing activity and the measured surface tensions of the extracted soil solutions was observed (Figure 7).
- Organic soils are complex mixtures and the results here suggest that biological components such as bacterial and fungal proteins dominate ice nucleation in these soils.

METHODS

Sampling and soil extraction:

- Lignin is a common biopolymer which has been shown to be ice-nucleation active[4], was used as a reference material.
- Soil samples were collected from three different agricultural locations in the UK and Canada.
- Soil suspensions prepared and centrifuged to remove larger particles.
- Supernatant extracted and filtered through a 0.22 µm filter. The subsequent solution was used for further analysis.

Sample Analysis:

- Surface tension measurements taken using the pendent droplet method using the DataPhysics OCA 15EC tensiometer (Figure 2).
- Ice nucleation freezing assays by immersion freezing using the Freezing Ice Nuclei Counter (FINC)[5].

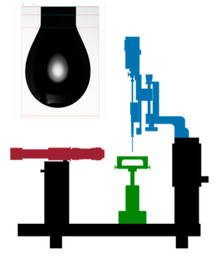

Figure 2. *DataPhysics OCA 15EC Tensiometer.*

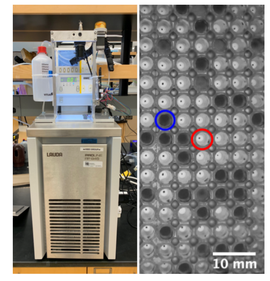

Figure 3. *FINC setup and example of freezing.*

Acknowledgements:
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References:
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2. Ginoux et al., Reviews of Geophysics, 2012.
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