

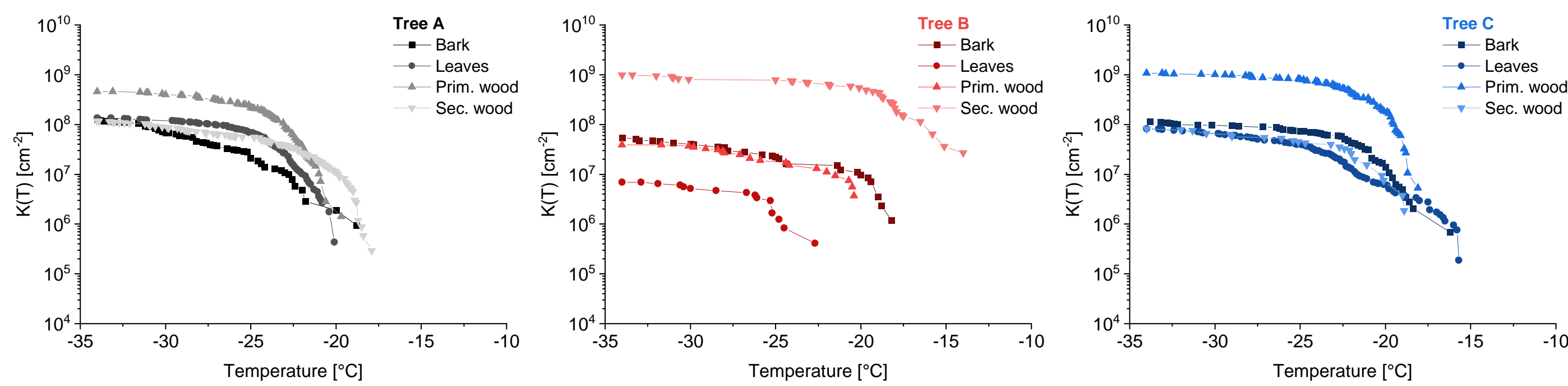
# Birch and Pine Forests are Massive Reservoirs of Biological Ice-Nucleating Macromolecules (INMs)

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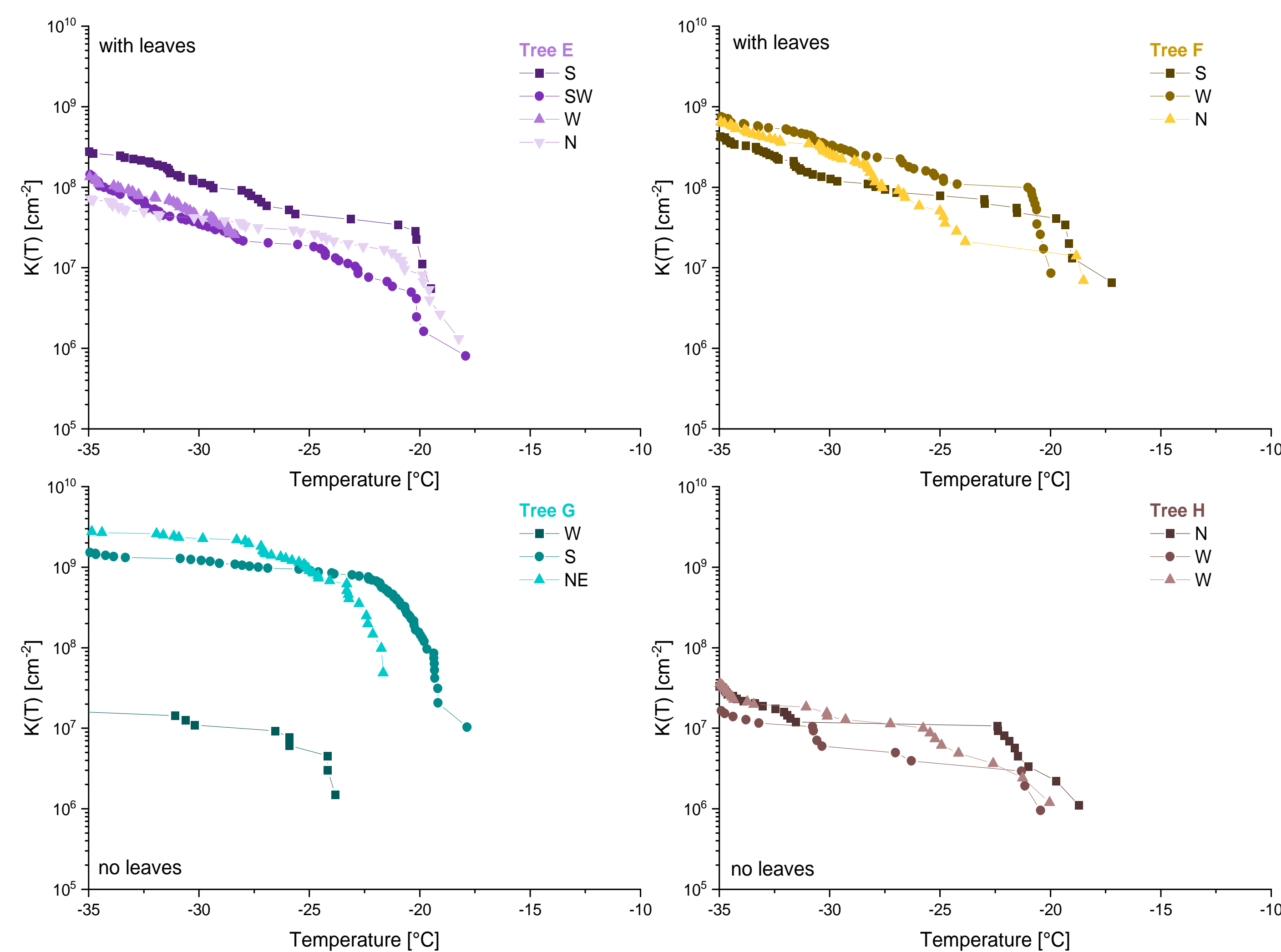
## Silver birch (*Betula pendula*)

9 *Betula pendula* trees located in Tyrol, Austria [3]  
 4 tissue types: leaves, primary & secondary wood, and bark



Concentration of water-soluble surface extractable INMs (per cm<sup>2</sup> of extracted surface). Selection of 3 from the 9 sampled birch trees. Nearly all samples (34/36) released INMs with  $K(-34^\circ\text{C})$  values in the order of magnitude between  $10^5$  and  $10^9$  cm<sup>-2</sup>

Rainwater samples beneath *Betula pendula* trees [3]: investigation of potential release mechanism

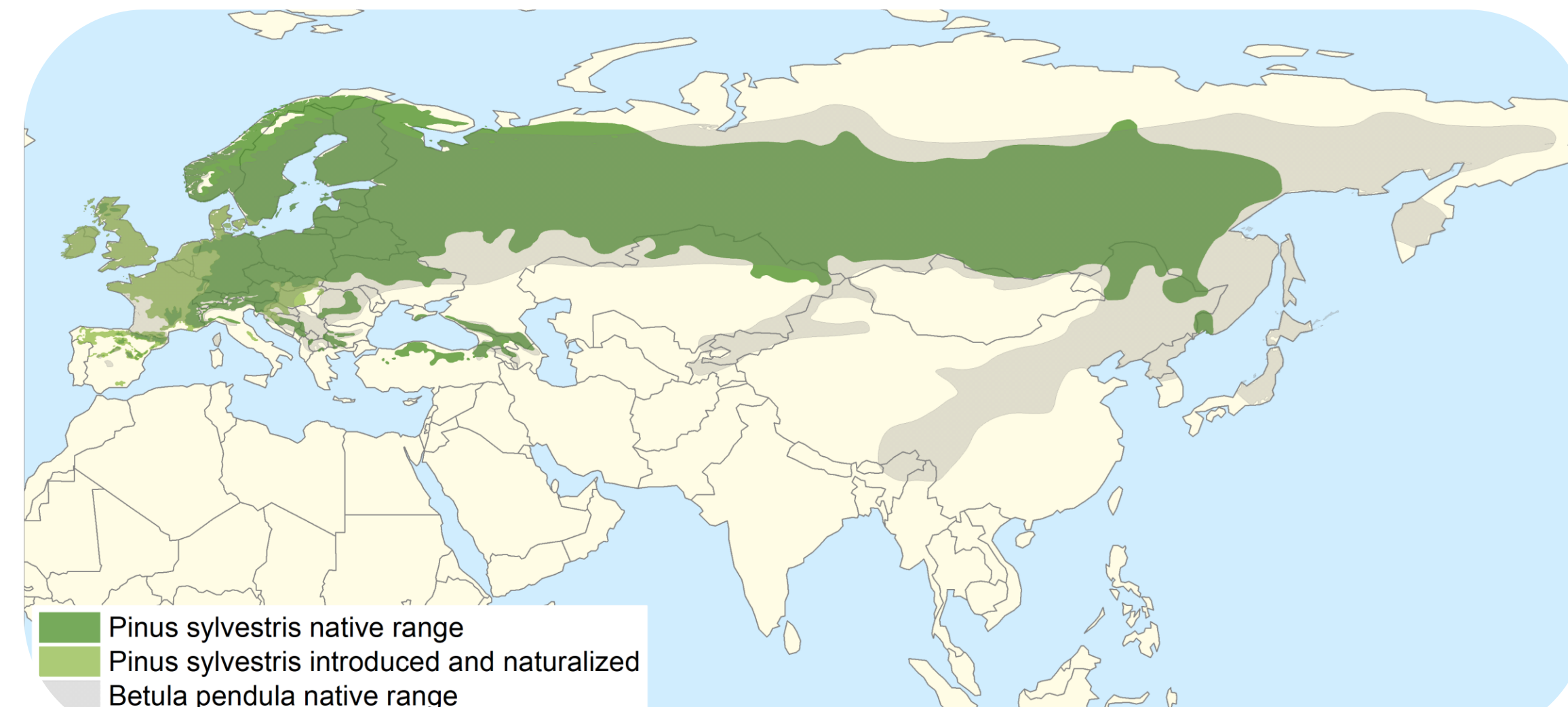


Rain splashed off INMs from the surface of all studied Silver birches at concentrations and freezing temperatures similar to surface extracts samples.

## Motivation

- Ice-nucleating macromolecules (INMs) influence climate by allowing cloud droplets to freeze, impacting cloud lifetime, precipitation, and albedo.
- Initially discovered in various pollen including Silver birch (*Betula pendula*) and Scots pine (*Pinus sylvestris*) [1], INMs were later found throughout birch tissue [2].
- If trees release INMs into the atmosphere, forests are significant INM emitters, greatly affecting climate.

## Distribution map of *Betula pendula* and *Pinus sylvestris*



$10^{13}$  to  $10^{15}$  surface extractable INMs per m<sup>2</sup> birch stands [3]

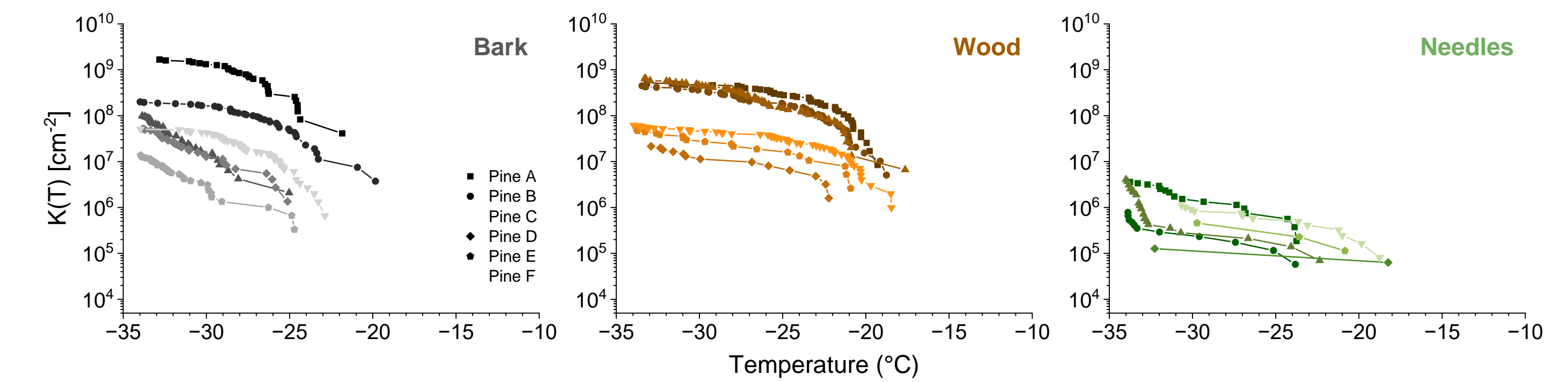
$10^9$  to  $10^{12}$  surface extractable INMs per m<sup>2</sup> pine stands [4]

## Key results

- Nearly all analysed tree tissues contained surface extractable INMs.
- Rain can easily wash INMs off tree surfaces, suggesting that they can be easily released into the atmosphere.
- Betula pendula* and *Pinus sylvestris* are massive reservoirs of INMs.

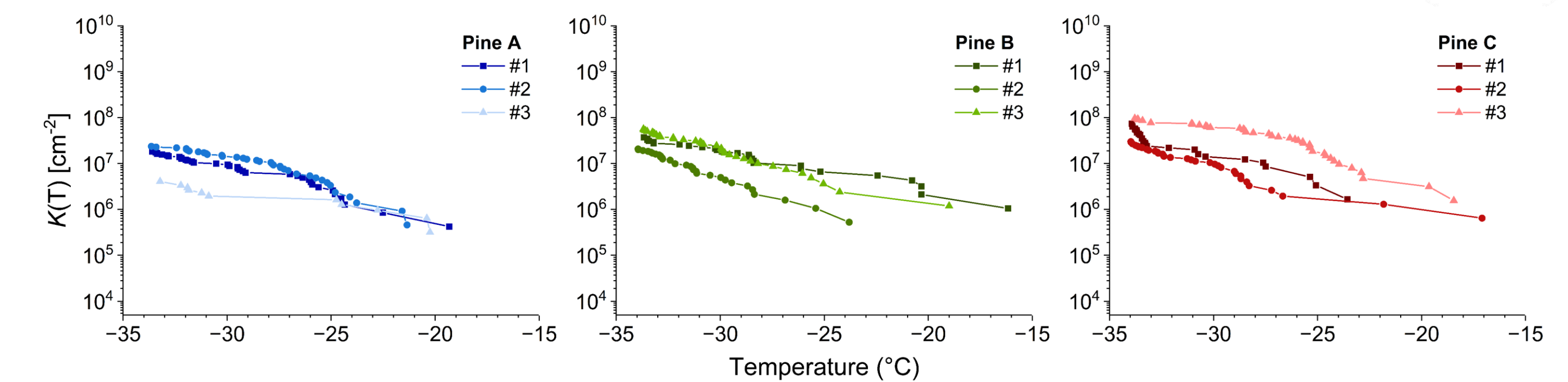
## Scots Pine (*Pinus sylvestris*)

6 *Pinus sylvestris* trees from Vienna, Austria [4]  
 3 tissue types: bark, branch wood, and needles



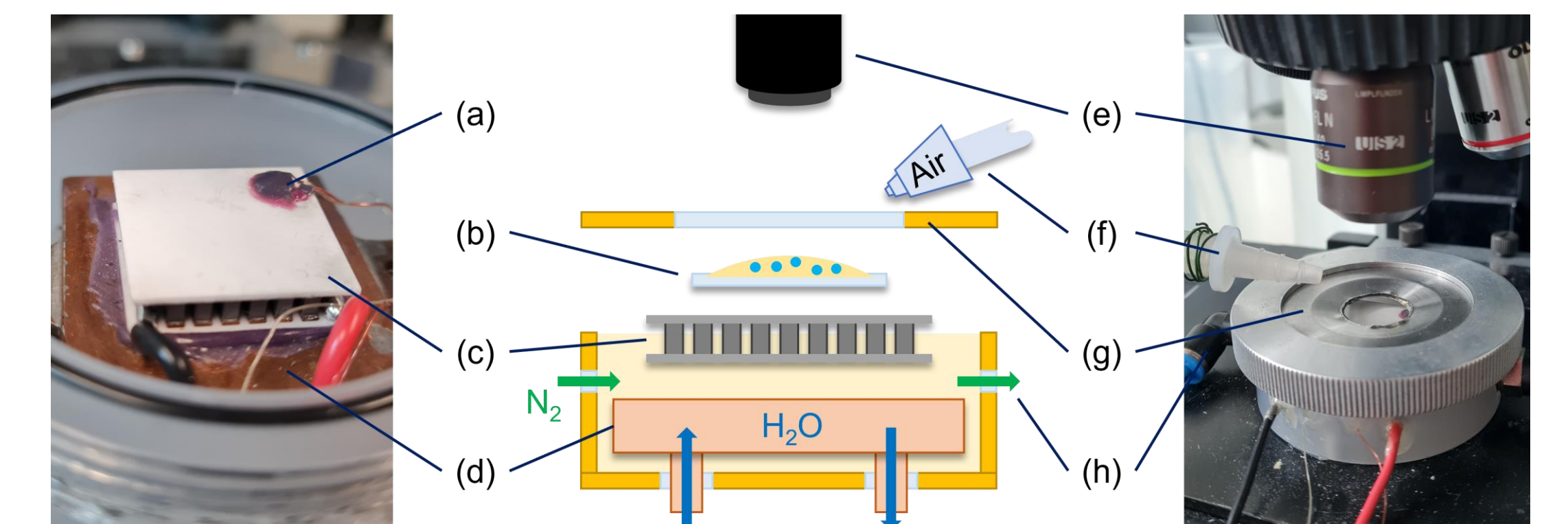
Water-soluble surface extractable INMs from *Pinus sylvestris*. All analysed samples (18/18) released INMs with  $K(-34^\circ\text{C})$  values in the order of magnitude between  $10^5$  and  $10^{10}$  cm<sup>-2</sup>

Rainwater samples beneath *Pinus sylvestris* trees [4]: investigation of potential release mechanism



Rain splashed off INMs from the surface of all studied Scots pines at concentrations and freezing temperatures similar to surface extract samples.

## Vienna Optical Droplet Crystallization Analyzer



(a) a thermo-couple, (b) a glass slide with the oil-sample emulsion, (c) a Peltier element, (d) a copper block flushed with iced water, (e) a camera connected to a microscope, (f) an air nozzle to avoid condensation on the lid (g), (h) a nitrogen line to flush the cell  
 $K(T)$ ... cumulative number of INMs at Temperature  $T$  in either cm<sup>-2</sup> extracted surface or rain collector area

## References

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- Felgitsch, L. *et al.* Birch leaves and branches as a source of ice-nucleating macromolecules. *Atmospheric Chem. Phys.* **18**, (2018).
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- Seifried, T. M. & Reyzek F. *et al.* Scots Pines (*Pinus Sylvestris*) as Sources of Biological Ice-Nucleating Macromolecules (INMs). *Atmosphere* **14** (2), (2023).

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