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Bio-Surfaces of Frost Resistant Plants as Source of Ice-Nucleating Macromolecules

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The ice nucleation activity of pollen from silver birch (*Betula pendula*), pines (e.g. *Pinus sylvestris*) and other trees has been assigned not only to pollen grains but also to subpollen particles (SPP) and extractable macromolecules, i.e. ice-nucleating macromolecules (INMs) (Pummer et al., 2012). The number concentration of pollen in comparison to other ice-nucleating particles suggests a minor impact to atmospheric cloud glaciation (Hoose et al., 2010). When focusing on macromolecules, the importance of INMs from vegetation, however, needs to be re-evaluated in respect to atmospheric ice nucleation. It has been shown that INMs are present in nearly every tissue of birches (Felgitsch et al., 2018) and furthermore, that the macromolecules are extracted from the surface, when they come into contact with water (Seifried et al., 2020). We hypothesize that extractable INMs from tree surfaces are emitted during rainfall by splash induced emissions and field experiments were performed to evaluate the amount of INMs extracted by rain-droplets. Sampled rainwater, which was splashed off from birch surfaces, revealed INMs in high number concentration (10^8 cm^{-2}) and can be attributed to the vegetation surface (Seifried et al., 2020). To further investigate emission sources an aerosol sampling tool (including an impinger and an impactor) has been developed and mounted on two rotary-wing drones (Bieber et al., 2020). Aerosol samples were collected in an alpine environment on ground level and above the canopy of birches and pines. We found that the bioaerosol concentration increased after rainfall and collected INMs show a similar onset freezing temperature as birch surface extracts (around -20°C). Microscopic images revealed a fluorescent organic film on aerosol particles, which might be linked to extractable material from bio-surfaces. We suggest splash induced aerosolization of INMs during rainfall to be an underestimated source for atmospheric cloud glaciation, since INMs can easily be carried on larger aerosol particles, e.g. on SPP or on mineral dust particles.

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