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The Microstructure of Ice and effective Diffusion of VOCs in snow: A laboratory study

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Emission from the snow-pack in polar regions can have a significant impact on the chemistry and thus trace gas budget of the overlaying air. The transport of trace gases through the snow-pack into the air of the boundary layer depends on several factors, such as advection and diffusion in the interstitial air, adsorption to the snow surface, and diffusion into the bulk ice. Here we describe new results from laboratory experiments that focused on the role of grain boundaries on the transport of volatile organics through a snow-pack.

Two different types of snow pack where used for the experiment:
1.) Water was frozen in the gas phase at moderate temperatures leading to artificial snow where each snow grain is a single ice grain.
2.) Water is rapidly frozen from the liquid at harsh liquid nitrogen conditions. This produces artificial snow where 60% - 70% of the snow grains are formed from several ice grains.
For both snow samples the grain-boundary density was determined using a recently developed stereology method. This method also allowed to quantify other parameters that determine the transport, or the effective diffusion, such as the total surface area, porosity and tortuosity of the samples.

The observed effective diffusion of three different volatile organics through both types of snow sample are discussed and compared to the grain boundary density. Two different types of volatile organics were investigated:
1.) Methanol, for which adsorption played a negligible role under our experimental conditions and which was mainly transported by gas-phase diffusion processes.
2.) Acetone and acetic acid, the transport of which was governed by gas-phase diffusion and adsorption to the snow surface.

These results will deepen our understanding of the interplay of microstructure and chemical processes in snow and enhance the modeling capabilities of atmosphere-snow exchange.