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Replica method for three-dimensional snow imaging

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The microstructure is a crucial factor determining many properties of snow such as mechanical strength, thermal conductivity, or optical properties. There are basically three techniques used to measure the full three-dimensional microstructure of snow samples: serial sectioning, direct X-ray computer tomography (micro-CT), or micro-CT of chloronaphthalene cast snow. Samples that have to be transported or stored must be conserved by casting the snow with a solidifying substance, e.g. chloronaphthalene or diethyl phthalate (DEP). Chloronaphthalene, while having a good X-ray contrast, is quite toxic. Image processing of serial sections of DEP cast snow is often very difficult, due to the formation of DEP crystals. Micro-CT was so far not applicable to DEP cast snow samples because there is hardly any absorption contrast between ice and DEP. We developed a new replica method that allows to investigate the microstructure of DEP cast samples by micro-CT. The sampling and casting process can be done as usual. Before the micro-CT measurement, the ice needs to be removed from the cast samples. The vapour pressure of DEP is about a million times smaller than that of ice. Sublimating the ice under vacuum accelerates the process drastically to a few days. This process leaves behind the DEP, which forms an exact negative image of the snow. The porous structure can now be measured in the micro-CT. A numerical inversion of the segmented micro-CT images yields a digital replica of the original snow structure. The accuracy of replication was tested by comparing the digital replica to the original snow structure. The structural parameters of the two structures were compared to each other. The replication of the snow microstructure was very good with relative errors below 4%. The presented replica method is comparably straightforward and, for the snow types tested, the microstructure is accurately reproduced.