Short-scale variations in high-resolution crystal-preferred orientation data in an alpine ice core - do we need a new statistical approach?

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Abstract

We analysed crystal-preferred orientation of c-axis and microstructure data from the Alpine ice core KCC at an unprecedented resolution and coverage of any Alpine ice core. We find that an anisotropic single-maximum fabric develops as early as 25 m depth in firn under vertical compression and strengthens under simple shear conditions towards the bedrock at 72 m depth. The analysis of continuously measured intervals with subsequent thin section samples from several depths of the ice core reveals a high spatial variability in the crystal orientation and crystal size on the 10 cm-scale as well as within a few centimeters. We quantify the variability and investigate the possible causes and links to other microstructural properties. Our findings support the hypothesis that the observed variability is a consequence of strain localisation on small spatial scales with influence on fabric and microstructure. From a methodological perspective, the results of this study lead us to challenge whether single thin sections from ice cores provide representative parameters for their depth to be used to infer the fabric development in a glacier on the large scale. Previously proposed uncertainty estimates for fabric and grain size parameters do not capture the observed variability. This might therefore demand a new scale-sensitive statistical approach.