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Evolution of ice crystal microstructures during creep experiments

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Knowledge of mechanical properties of ice is of vital importance for the interpretation and dating of ice core records and modeling of ice sheet flow. Interpretation of deformation effects in polar ice samples is complicated by the fact that initial properties of samples and physical parameters are unknown and changing from layer to layer. Furthermore, interaction with other processes occurs and cannot easily be distinguished from substantial deformation effects. For example, inherited attributes of the ice such as inclusions significantly influence grain growth behaviour. Laboratory experimental creep tests help to improve the understanding on flow and deformation behaviour and processes in polycrystalline ice.During flow, various processes on the atomic scale are conducting the deformation and producing or promoting strain. As these processes are acting on the atomic scale, they are difficult to observe directly in deformed polycrystalline ice. However, they leave behind certain structures on the microscopic scale indicating deformation mechanisms. The microstructure mapping method enables detailed observation and recording of many kinds of microstructures such as grain boundaries, sub-grain boundaries and slip lines. Analysis of samples from uni-axial compression creep tests with small grained and bubble-free isotropic ice (stress: 0.2 to 0.6MPa, strain: 0.5 to 8.6%, temperature:-5∞C and -20∞C) reveal a strain dependence of sub-grain boundary density, which reaches a steady value together with the achievement of constant secondary strain rate at ca. 2% strain. Grain shape, measured by the perimeter ratio, the first time applied for ice, also depends on strain, which clearly demonstrates the increasing influence of strain induced grain boundary migration.