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Computational analysis of dynamic recrystallization of ice aggregates during viscoplastic deformation

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Ice is a common mineral at the Earth's surface. How much ice is stored in the Greenland and Antarctic ice sheets depends on its mechanical properties. Therefore properties of ice directly impact on human society through its role in controlling sea level. The bulk behaviour of large ice masses is the result of the behaviour of the ensemble of individual ice grains. This is strongly influenced by the viscoplastic anisotropy of these grains and their lattice orientation. Numerical modelling provides a better insight into the mechanics of ice from the micro to the ice sheet scale. We present numerical simulations that predict the microstructural evolution of an aggregate of pure ice grains at different strain rates. We simulate co-axial deformation and dynamic recrystallization up to large strain using a full-field approach.

The crystal plasticity code (Lebensohn et al., 2009) is used to calculate the response of a polycrystalline aggregate that deforms by purely dislocation glide, applying a Fast Fourier Transform (FFT). This code is coupled with the ELLE microstructural modelling platform to include intracrystalline recovery, as well as grain boundary migration driven by the reduction of surface and strain energies.

The results show a strong effect of recrystallization on the final microstructure, producing larger and more equiaxed grains, with smooth boundaries. This effect does not significantly modify the single-maximum pattern of c-axes that are distributed at a low angle to the shortening direction. However, in experiments with significant recrystallization the a-axes rotate towards the elongation axis at the same time as the c-axes rotate towards the compression axis. If slip systems on prismatic and/or pyramidal planes are active, it is thought that a-axes gradually concentrate with depth (Miyamoto, 2005). The bulk activity of the slip systems is different depending on the relative activity of deformation versus recrystallization: the non-basal slip systems are more active at high strain in experiments with dynamic recrystallization compared to those experiments with low recrystallization activity.

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