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FFT simulation of dynamic recrystallization in polar ice

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Research on ice flow is a key to understand how climate changes affect polar ice. Numerical modelling provides a better insight into the mechanics of ice from the microstructure to the ice sheet scale. The mechanics of polar ice are very sensitive to temperature changes mainly due to active recrystallization processes, as the material is very close to its melting point. We present numerical simulations that predict the microstructural evolution of ice polycrystals during deformation and dynamic recrystallization at large strain, using a full-field approach.

The crystal plasticity code (Lebensohn, 2001) is used to calculate the response of a polycrystalline aggregate that deforms by dislocation glide, applying a Fast Fourier Transform (FFT). The coupling between FFT and the ELLE microstructural evolution platform allows us to include recrystallization in the aggregate, which is simulated by means of two main processes: (1) recovery and subgrain rotation, which locally reduces the crystal misorientation, and (2) grain boundary migration, which is driven by grain boundary curvature and intra-grain strain energies.

This contribution presents a comparison of numerical simulations under pure and simple shear conditions up to high strain at different strain rates. The results show a strong effect of the recrystallization on the final microstructure. Dynamic recrystallization masks the strain rate and finite strain heterogeneity resulting from the strong slip anisotropy of ice. However, this strong effect does not significantly modify the single-maximum pattern of c-axes that are distributed at a low angle to the shortening direction in both pure and simple shear. In both cases, recrystallization produces larger and more equidimensional grains, with smooth boundaries.

References:

R. A. Lebensohn. N-site modelling of a 3D viscoplastic polycrystal using Fast Fourier Transform. 2001. Acta Materialia 49, pp 2723-2737.