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A simple anisotropic flow law for polar ice based on anisotropic, scalar flow enhancement

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The flow of polycrystalline polar ice is often described by Glen's flow law, in which ice is assumed to be an isotropic, nonlinearly viscous fluid. This goes along with the assumption that the ice crystallites (grains) in the polycrystalline aggregate are essentially randomly oriented. However, observations show that, especially in the deeper parts of an ice sheet or glacier, different patterns of preferred c-axis orientations and anisotropic flow properties develop, which vary according to the flow regime. Adopting some concepts proposed by Budd et al. (J. Glaciol. 59, 374-392, 2013), we will describe a newly developed, simple anisotropic flow law based on an anisotropic, scalar flow enhancement factor. The scalar character is similar to the flow law of the CAFFE model by Placidi et al. (Cont. Mech. Thermodyn. 22, 221-237, 2010). However, while the CAFFE model contains an evolution equation for the anisotropic fabric, here we assume that on a large scale the fabric (microstructure) evolves at a rate to remain compatible with the deformation regime. This makes ice deformability a function of the current deformation regime, eliminating the requirement for a fabric evolution scheme. The parameters of the anisotropic flow law are based on laboratory ice deformation experiments conducted in a range of combined stress configurations incorporating compression and simple shear (Treverrow et al., J. Glaciol. 58, 301-314, 2012). These results show that ice is softer under simple shear than under compression. We have implemented the new flow law in the three-dimensional ice sheet model SICOPOLIS (www.sicopolis.net), and we will discuss some simulation results for a simple geometry (EISMINT; Payne et al., J. Glaciol. 46, 227-238, 2000) and for the Antarctic ice sheet.

キーワード: Anisotropy, Flow law, Polar ice, Antarctic ice sheet, Modelling
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