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Some effects of anisotropy on ice-flows

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It is now well known, from mechanical tests in the laboratory and from texture measurements on deep ice-cores, that polycrystalline polar ice acquires a strong viscoplastic anisotropy, depending on the strain-rate history it has undergone. This macroscopic anisotropy results from the strong viscoplastic anisotropy of the ice single crystal combined with the development, by crystals lattice rotation, of fabrics with very pronounced preferred orientations. This strong macroscopic anisotropy of polar ice can affect the global flow of ice-sheets and then modify the depth-age relation essential for the interpretation of the climatic signals recorded in the ice-cores.

An efficient and easy-to-use method to take into account the strain induced fabric development and the associated anisotropy has been developped and implemented in a thermo-mechanical ice-flow model.

All the equations that govern the ice flow (i.e. the Stokes equations for an incompressible fluid obeying an anisotropic stress-strain-rate relation, the convection dominated evolution equations for fabric development, and the heat equation) are solved by the Finite Element (FE) method, in a coupled way, using the FE package Elmer.

Two and three dimensional tests with different basal conditions (irregular bedrock, melting, sliding ...) have been performed to study the effects of anisotropy on the global flow of ice and the implications in terms of ice-sheet surface geometry and ice-core dating.