Deformation and recrystallisation at the firn-ice transition - Microstructural simulations -

Florian Steinbach\(^1,2\), Ilka Weikusat \(^1,2\), Paul Bons \(^1\), Albert Griera \(^3\), Maria-Gema Llorens \(^1,2\), Daniela Jansen \(^2\)

**Introduction**

- Necessity to understand the dynamic processes that control the flow of ice when investigating the past and future climate
- The mechanical behaviour of ice: Result of properties of individual ice crystals and the distribution of second phases (e.g. air bubbles)
- At firn-ice transition: Air bubbles are sealed off and become a valuable paleo-atmosphere archive
- Elle / VPFFT simulations by Llorens et al. (2016) gave insight in deformation and recrystallisation of pure ice (free of impurities and bubbles)

**Research conclusions**

- Bubbles control strain localisation and induce more heterogeneous microstructures in their vicinity
- This localisation leads to a more localised dynamic recrystallisation as proposed by Faria et al. (2014) using EDML firn data
- Dynamic recrystallisation occurs in firn as observed by Kipfstuhl et al. (2009), it is related to stress bridging and strain localisation between bubbles

**Remaining challenges**

- Possibility to take into account grain size sensitive processes such as grain boundary sliding
- Update the simulations to be suitable for general shear deformation
- Take impurities into account and investigate their effect on recrystallisation and deformation

**Goals achieved: Updated numerical approach**

- Updated multi-process model with Elle / VPFFT: Full-field theory (VPFFT) crystal plasticity code coupled with modelling platform Elle (elle.ws) Successively running different codes in short numerical timesteps effectively enables multi-process modelling of deformation and recrystallisation.

**Goals achieved: Systematic simulations**

**Initial microstructures and setup:**

- Pure shear conditions up to 53% vertical shortening = 1x2 box \(\rightarrow\) 2x1 box
- Initially 20x10 cm box, mean ice grain area \(\approx 6 \text{ mm}^2\) using a grid of 256x256 unodes
- Basal slip set 20x easier than non-basal, air is set 5000x softer (incompressible and isotropic)

**Results:**

- Localisation factors and strain rate maps: Intensified strain localisation with increasing amount of bubbles
- Maps of instantaneous normalised von Mises strain rates
- Comparison with natural microstructures

**Author affiliations:**

(1) Department of Geosciences, Eberhard Karls University of Tübingen, Germany
(2) Alfred-Wegener-Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany
(3) Departament de Geografia, Universitat Autònoma de Barcelona, Spain.

**Publications associated with the project**


Scan for simulation movies