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How to model enhanced firn densification due to strain softening

Falk Oraschewski[1,2] and Aslak Grinsted[1]
[1]Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
[2]Department of Geoscience, University of Tübingen, Tübingen, Germany

Most classical firn densification models merely consider temperature and accumulation rate as variable input parameters. However, in locations with high horizontal strain rates, such as the shear margins of ice streams, a reduced firn thickness can be observed. This is explained by an enhancement of power-law creep due to the effect of strain softening, which is not yet captured by existing firn models. We present a model extension that corrects the densification rate, predicted by any classical, climate-forced firn model, for the effect of strain softening caused by horizontal strain rates. With the presented model firn densities measured along a cross-section of the North-East Greenland ice stream (NEGIS) are reproduced with good agreement, validating the accuracy of the developed model. The results further indicate the general importance of considering strain rates in firn densification modeling and pave the way for the development of a firn model that inherently uses temperature, accumulation rate and horizontal strain rates as forcing parameters.