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Impurity controlled firn densification: a new model approach

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Models of firn densification are a necessary requisite for dating air inclusions in polar ice cores. Previous densification models assume a homogenous firn column where densification is mainly dependent on accumulation rate, temperature and surface density. From measured density profiles with a vertical resolution of millimetres it is known that firn is a layered medium with considerable porosity variations at the firn-ice transition (sometimes more than 50 percent in adjacent layers). Very recently it turned out that the density (porosity) variations in deep firn are linked to variations of the Ca++ concentration which points to an impurity effect on densification.

In our contribution we will present the first densification model for layered firn that accounts for the impurity effect. In the model the impurity effect is parameterized by the Ca++ concentration. The impurities are assumed to act like a catalyst: they increase the densification rate by reducing the activation energy. The model is applied to firn from Greenland (B26) and Antarctica (B36, EDML, EDC). The simulations are fitted on measured density profiles to find reasonable model input parameters for the impurity effect in recent firn. The derived parameterization is used to simulate the densification in Glacial periods in Antarctica and Greenland. Applying our model to Glacial conditions on the Antarctic plateau the firn column is reduced as it is suggested by d15N measurements without assuming convective zones of several tens of meters.