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Modeling polythermal glaciers: regularization with a brine pocket scheme

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Polythermal glaciers exhibit various thermodynamical and hydrological discontinuities. In this work, the cold-temperate transition surface (CTS), which separates cold ice from temperate (wet) ice, is considered in more detail. Ice is defined as temperate if a change in heat content leads to a change in water content alone, and is considered cold if a change in heat content leads to a temperature change alone.

To calculate the temperature distribution in a glacier, the Fourier equation is commonly used. In polythermal glaciers, however, this is can be difficult because the enthalpy function is discontinuous at the pressure melting point. Water in the temperate ice freezes at CTS and latent heat is released into the cold ice, similar to the Stefan problem. The modeling is performed using a commercial finite element software. A variety of methods have been proposed for the numerical solution of the Stefan- and related problems using Finite Element techniques. Here, we use the enthalpy-gradient method to obtain better energy conservation (Pham 1995).

To regularize the enthalpy function, a brine pocket parametrization scheme known from sea ice modeling (Huwald 2005) is applied. In the brine pocket scheme a temperature range exists in which a change in heat content leads to both a change in temperature and brine content. Glacier ice is therefore assumed to be a ternary mixture of ice, water and salt, smearing out the singularity at CTS. The brine pocket parametrization is physically meaningful since glacier ice is never pure ice, impurities (e.g. salt, soot, dust, debris) are always present.

The use of the enthalpy-gradient method in combination with the brine pocket parametrization opens the possibility to predict the reaction of the CTS to changes in the amount of trapped water and changes in the flow field due to a changing cli-

mate.

The proposed method is tested with Storglaciären, a small polythermal valley glacier in northern Sweden. First results already show good agreement of the calculated and the measured postion of the CTS.

References

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