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Calorimetric determination of the unfrozen water content in glacier ice

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Glacier ice at the melting temperature may contain up to 6% of unfrozen water, as was inferred with indirect methods such as ice-penetrating radar. This inter-grain water influences ice deformation, the thermal structure of ice sheets, and subglacial hydrology.

We determined by the content of free water in-situ in ice caves and at the base of several temperate glaciers. The calorimeter consists of an active cooling system in a central borehole and a set of thermistors which are placed in several distances from the center. We thus measure the velocity of the freezing front as well as the cooling rates. With help of a 3D finite element heat flow model synthetic freezing curves are obtained for various initial water contents. Matching these synthetic curves to the measurements yields in-situ water contents between 0 and about 3% in basal ice. These values confirm the indirectly derived free water contents within the ice matrix of Alpine glaciers.

Significance statement

We present unique in-situ measurements of free water within the ice matrix of Alpine glaciers.

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