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Calculating bedrock level from ice surface elevation using the shallow ice approximation

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In glaciated regions where detailed radar studies or seismic surveys have not been made, ice thickness and location of the bedrock often remain poorly constrained. We explore the possibility of reliably determining bedrock level below a steady-state glacier from ice surface and mass balance data, assuming that the shallow ice approximation (SIA) holds.

In SIA, ice flow is highly non-linear with respect to ice thickness. We transform the relationship into linear form by change of variables and use the Jacobi iterative method to reach a steady-state solution for ice thickness and bedrock level.

We analyse the criteria that fields of ice surface elevation and mass balance have to meet in order to yield a convergent solution. Keeping in mind that the accuracy of SIA depends on the geometry of the ice body and its velocity field, we test the applicability of this technique for establishing the bedrock level in a variety of glacial environments.