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3D sequential data assimilation in Elmer/Ice with Stokes

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Providing suitable initial states is a long-standing problem in numerical modelling of glaciers and ice sheets, as well as in other areas of the geosciences, due to the frequent lack of observations. This is particularly acute in glaciology, where important parameters such as the underlying bed may be only very sparsely observed or even completely unobserved. Glaciological models also often require lengthy relaxation periods to dissipate incompatibilities between input datasets gathered over different timeframes, which may lead to the modelled initial state diverging significantly from the real state of the glacier, with consequent effects on the accuracy of the simulation. Sequential data assimilation using an ensemble offers one possibility for resolving both these issues: by running the model over a period for which various observational datasets are available and loading observations into the model at the time they were gathered, the model state can be brought into good agreement with the real glacier state at the end of the observational window. The mean values of the ensemble for unknown parameters, such as the bed, then also represent best guesses for the true parameter values. This assimilated model state can then be used to initialise prognostic runs without introducing model artefacts or a distorted picture of the actual glacier.

In this study, we present a framework for conducting sequential data assimilation and retrieving the bed of a glacier in a 3D setting of the open-source, finite-element glacier flow model, Elmer/Ice, and solving the Stokes equations rather than using the shallow shelf approximation. Assimilation is undertaken using the open-source PDAF library developed at the Alfred Wegener Institute. We demonstrate that the set-up allows us to accurately retrieve the bed of a synthetic glacier and present our plans to extend it to a real-world example.