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Comparative Study of Three Data Assimilation Methods for Ice Sheet Model Initialisation

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The current global warming has direct consequences on ice-sheet mass loss contributing to sea level rise. This loss is generally driven by an acceleration of some coastal outlet glaciers and reproducing these mechanisms is one of the major issues in ice-sheet and ice flow modelling. The construction of an initial state, as close as possible to current observations, is required as a prerequisite before producing any reliable projection of the evolution of ice-sheets. For this step, inverse methods are often used to infer badly known or unknown parameters. For instance, the adjoint inverse method has been implemented and applied with success by different authors in different ice flow models in order to infer the basal drag [Schafer et al., 2012; Gillet-chauletet al., 2012; Morlighem et al., 2010].

Others data fields, such as ice surface and bedrock topography, are easily measurable with more or less uncertainty but only locally along tracks and interpolated on finer model grid. All these approximations lead to errors on the data elevation model and give rise to an ill-posed problem inducing non-physical anomalies in flux divergence [Seroussi et al, 2011].

A solution to dissipate these divergences of flux is to conduct a surface relaxation step at the expense of the accuracy of the modelled surface [Gillet-Chaulet et al., 2012]. Other solutions, based on the inversion of ice thickness and basal drag were proposed [Perego et al., 2014; Pralong & Gudmundsson, 2011].

In this study, we create a twin experiment to compare three different assimilation algorithms based on inverse methods and nudging to constrain the bedrock friction and the bedrock elevation: (i) cyclic inversion of friction parameter and bedrock topography using adjoint method, (ii) cycles coupling inversion of friction parameter using adjoint method and nudging of bedrock topography, (iii) one step inversion of both parameters with adjoint method. The three methods show a clear improvement in parameters knowledge leading to a significant reduction of flux divergence of the model before forecasting.