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The GRISLI ice sheet model (version 2): calibration and validation for millenial-scale variability of the Antarctic ice sheet

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Over the last decades, we measured an accelerating rise in sea level. If recent observations have already shown evidences for ice sheet dynamical response to increasing temperatures, we expect Greenland and Antarctica to exert the major control in future sea level changes. Whilst during most of the Holocene (starting about 10 kaBP) ice sheets were probably relatively stable this was not the case for earlier time periods for which we can retrieve rates of sea level change as high as four metres within a century, notably during the so-called melt-water pulse 1A at 13.6 kaBP. The reasons for the ice sheet destabilisation, either North and South, are yet to be defined but hypotheses include surface mass balance feedbacks, ice-ocean interactions such as the marine ice sheet instability or thermo-mechanical basal property changes. All these processes include millennial-scale feedback that could lead to abrupt, decadal to centennial, global climate changes.

In this study, we present an updated ice sheet model with emphasis towards reproducing large and fast ice sheet variability and suitable for studying the importance of millennial-scale feedback. The GRISLI ice sheet model is an hybrid shallow ice – shallow shelf model running over various Cartesian domains for resolutions ranging from 5 to 40 km at a low computational cost. From its original formulation (Ritz et al., 2001), several model improvements have been recently implemented, in particular the analytical grounding line flux computations following Schoof (2007) and Tsai et al. (2015). Here, we present a calibration of the mechanical parameters of the model based on an ensemble of 150 members sampled with a Latin Hypercube method. The ensemble members performance is assessed relative to the deviation from present-day observed Antarctic ice thickness (Bedmap2, Fretwell et al., 2013) and velocity (Rignot et al., 2011). Using the best ensemble members, we discuss the model capability at reproducing the Antarctic ice sheet variability over the last glacial-interglacial cycle, in particular the ice advance over the continental shelf and the fast retreat which marks the end of the last glacial period.