Supplement of The Cryosphere, 11, 247–265, 2017
http://www.the-cryosphere.net/11/247/2017/
doi:10.5194/tc-11-247-2017-supplement

The Cryosphere
Open Access

Supplement of

Comparison of hybrid schemes for the combination of shallow approximations in numerical simulations of the Antarctic Ice Sheet

J. Bernales et al.

Correspondence to: Jorge Bernales (bernales@gfz-potsdam.de)

S1. Ice sheet model resolution

This document describes a model resolution sensitivity study carried out prior to the experiments presented in the main text.

As part of this study we have tested model horizontal grid resolutions of 40, 20, and 10 km, which encompass a range of model resolutions often used for continental-scale numerical simulations of the Antarctic Ice Sheet (e.g., de Boer et al., 2015; Pollard and DeConto, 2012; Pollard et al., 2015). This sensitivity analysis is motivated by a large number of simulations required for the comparison study of the four hybrid schemes, and the fact that forward ice sheet modelling at a resolution of 10 km is computationally expensive. As a result, we have decided to test a 10-km resolution only for one hybrid scheme (namely HS-3), merely as a proof-of-concept, and to confirm the low sensitivity of the model results to changes in the grid size discussed by Pollard and DeConto (2012) and Pollard et al. (2015).

The experimental set-up closely follows that of the main experiments (Section 4), except for a shorter time span for each relaxation/free-evolution stage (50,000 model-years per stage here vs. 100,000 model-years per stage in the main experiments) to allow for the use of a model resolution of 10 km, over a total time span of 200,000 model-years for each model resolution tested.

As shown in Fig. S1 (top row), the ice sheet thickness distribution resulting from the use of different model resolutions is very similar at the end of the simulations, with only minor differences which are mostly confined to the areas near the ice sheet margins.

The calibrated basal sliding coefficients (Fig. S1, middle row) exhibit a relatively higher sensitivity to a change in model resolution, with discrepancies mainly caused by larger gradients in the lower model resolution runs. This is particularly visible in the simulation that uses a model resolution of 40 km, where a single calibrated value of the basal sliding coefficient is used for a larger ice sheet area. This effect is less pronounced in the 20-km resolution simulation. However, overall the estimated basal sliding coefficients are robust over the ice sheet-covered area.

Modeled ice surface velocities (Fig. S1, bottom row) showcase a good ability of the model to reproduce observations (Section 5.2), even at the lowest model resolution of 40 km tested here. However, it is readily visible that changes in the grid size do affect the resulting ice velocities close to the ice sheet margins, where small outlet glaciers are often poorly resolved in simulations using a 40-km resolution. On the contrary, the modeled ice velocities in the 20-km resolution run closely follow the flow patterns produced by the 10-km simulation with only small-scale, isolated discrepancies.

Based on a high degree of similarity between our results of the simulations using model resolutions of 10 and 20 km, we have decided to use the latter for the comparison of the four hybrid schemes presented in the main text.

References

de Boer, B., Dolan, A.M., Bernales, J., Gasson, E., Golledge, N.R., Sutter, J., Huybrechts, P., Lohmann, G., Rogozhina, I., Abe-Ouchi, A. and Saito, F., 2015. Simulating the Antarctic ice sheet in the late-Pliocene warm period: PLISMIP-ANT, an ice-sheet model intercomparison project. The Cryosphere, 9, pp.881–903.

Pollard, D. and DeConto, R.M., 2012. A simple inverse method for the distribution of basal sliding coefficients under ice sheets, applied to Antarctica. The Cryosphere, 6(5), pp.953–971.

Pollard, D., DeConto, R.M., and Alley, R.B., 2015. Potential Antarctic Ice Sheet retreat driven by hydrofracturing and ice cliff failure. Earth and Planetary Science Letters, 412, pp.112–121.

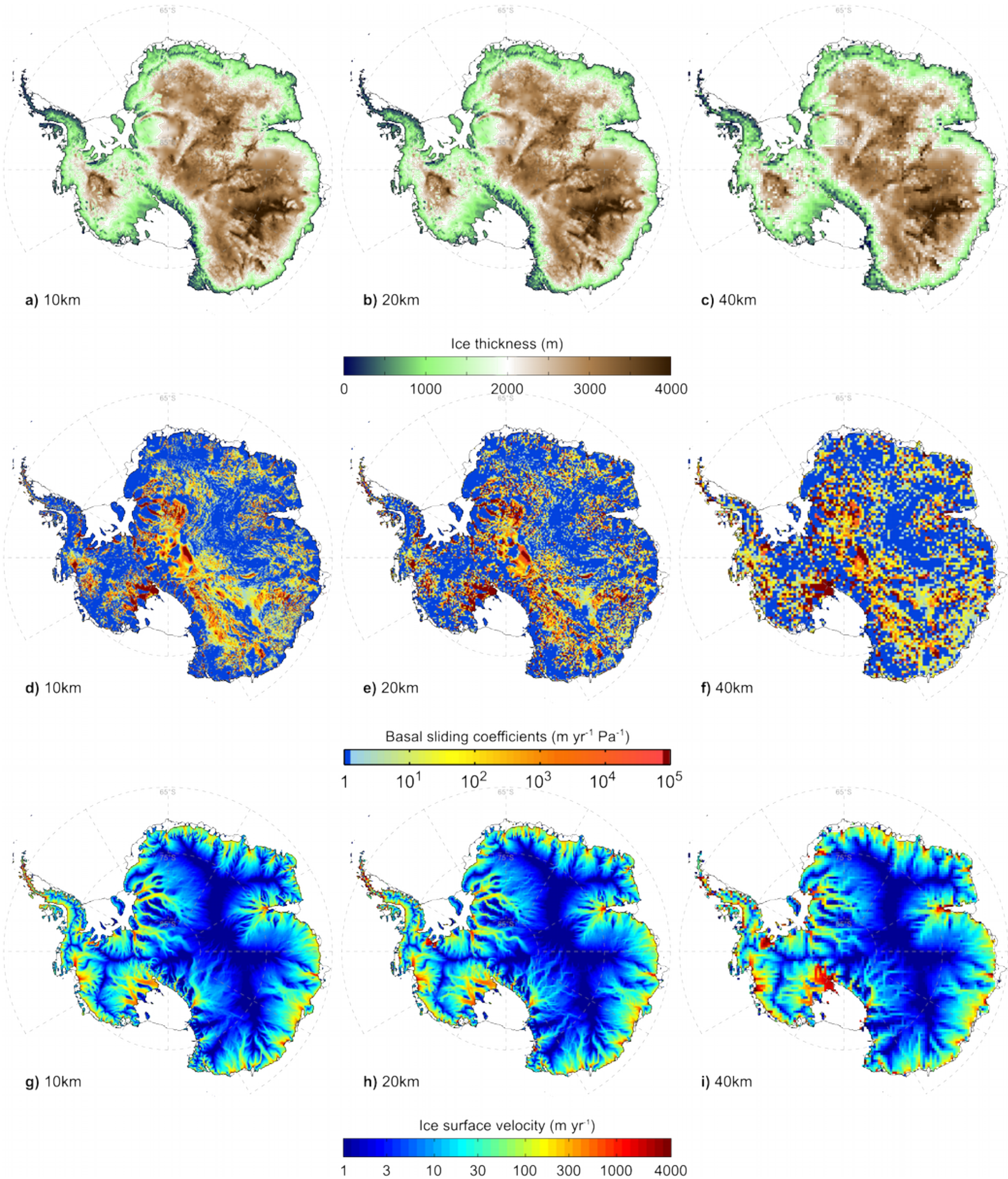

Figure S1. Modeled ice sheet thickness (in m, top row), calibrated basal sliding coefficients (in m/yr/Pa, middle row), and modeled surface ice velocities (in m/yr, bottom row) at the end of 200,000-years-long steady-state simulations using model resolutions of 10 km (left column), 20 km (middle column), and 40 km (right column). See main text for further details.