EGU2013-12708 Session CR3.1 Location B563

Are the simulated climatic and dynamic mass losses of the Greenland Ice Sheet decoupled during the next 100 years?

Guðfinna Aðalgeirsdóttir (gua@hi.is), Andy Aschwanden

Institute of Earth Sciences, University of Iceland, Reykjavík, Iceland
Geophysical Institute, Arctic Region Supercomputing Center, University of Alaska Fairbanks, USA

Abstract

Model simulations with the state-of-the-art ice sheet model PISM (Parallel Ice Sheet Model), that is forced with a number of climate forcings for the next century are presented. The climate forcings come from the EU FP7 project ice2sea where 3 regional climate models (HIRHAM5, MAR and HadRM3P) were used to dynamically downscale two scenario runs (A1B and E1) from two GCMs (ECHAM5 and HadCM3). These climate models are run with a constant ice sheet topography and therefore climate-elevation change feedback not included in the simulated mass changes. To assess the sensitivity of the projections to the ice sheet model initial state, four initialisaton methods were used. Analyses of these 100 years simulations indicate that the mass changes due to climate forcing are decoupled from the changes due to dynamic response and the initialisation procedure. The simulated mass loss has a relatively large range, 0.5 to 6.5 cm sea level rise equivalent, which is to a large extent due to the range in the projected climate forcing from the regional climate models that were used to downscale the climate fields.

Volume evolution during scenario runs

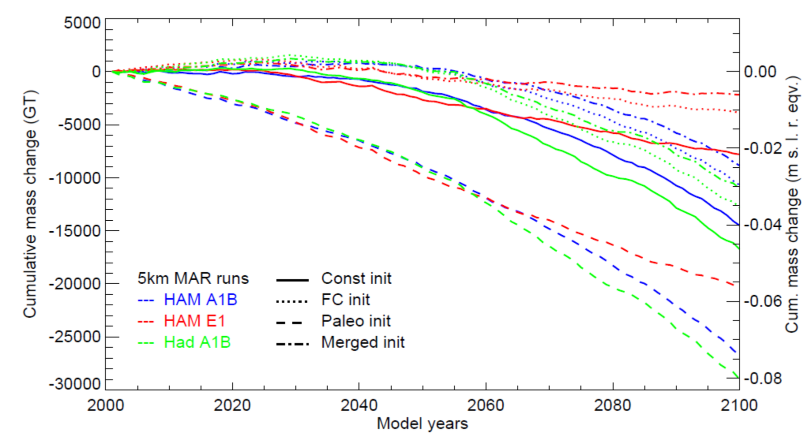

Fig 1. Results from runs starting from the four initialised ice sheets and forcing from one RCM, MAR, that has downscaled two emission scenarios from two GCMs

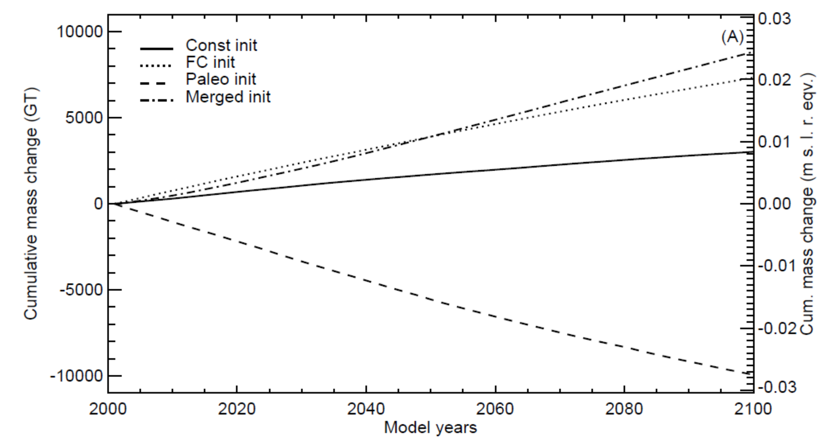

Fig 2. Results from runs starting from the four initialised ice sheets and constant reference forcing. This is the model drift resulting from the initialisation method.

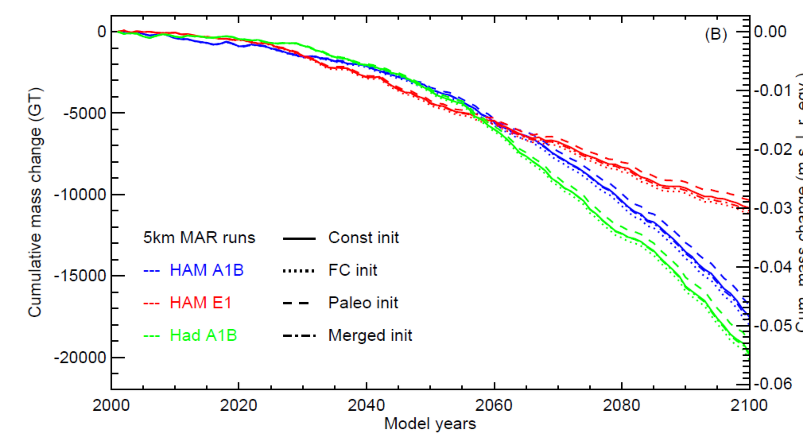

Fig 3. Results from runs starting from the four initialised ice sheets and the model drift (Fig. 2) has been subtracted from direct results (Fig. 1)

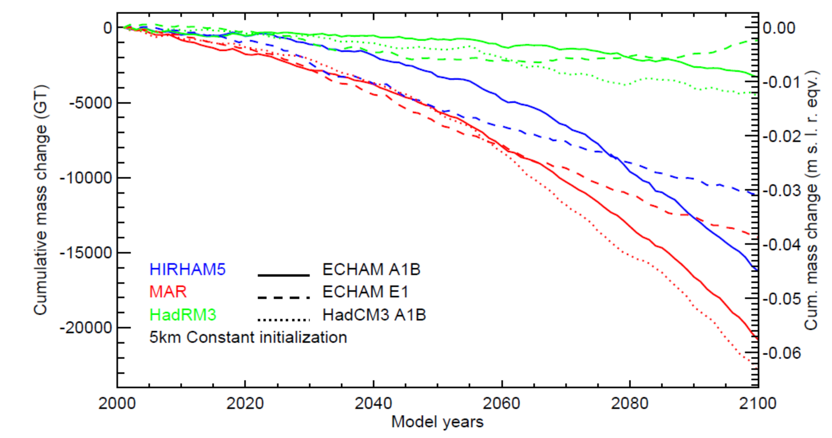

Fig 4. Results from runs starting from Const init ice sheet forced with downscaled results from HIRHAM5, MAR and HadRM3P that have downscaled two emission scenarios from two GCMs (ECHAM and HadCM3) (drift also subtracted)

Elevation changes during 100 years scenario runs: Different initialisation methods

Four initializing methods are used:

Paleo initialisation (Paleo init): model is run through a full glacial cycle from 125 ka BP until present (0 model years) by scaling reference climate with oxygen isotopes record from the GRIP ice core.

Constant initialisation (Const init) starts with the ice sheet from end of Paleo init and forces the model with constant reference SMB for 60 ka to a steady state.

Flux-corrected initialisation (FC init) is same as the Paleo init, except that a mass balance modifier that forces the ice thickness to be the measured one at year 0 is applied during the last 5000 years of the run.

Merged initialization (Merged init) is a combination of the topography of the Const init and the ice temperature (enthalpy), basal conditions and basal uplift rate from the Paleo init ice sheet.

Elevation changes are the results of direct climate mass balance forcing and dynamic changes:

$$\frac{h_{100}-h_0}{\Delta t} = \sum_{t=0}^{100} CMB + \sum_{t=0}^{100} \nabla\cdot\mathbf{q}_{all} = \sum_{t=0}^{100} CMB + \frac{h^C_{100}-h_0}{\Delta t} + \sum_{t=0}^{100} \nabla\cdot\mathbf{q}_{dyn}$$

Const init | Merged init | FC init | Paleo init

Row labels: $\frac{h_{100}-h_0}{\Delta t}$; $\sum_{t=0}^{100} \nabla\cdot\mathbf{q}_{all}$; $\frac{h^C_{100}-h_0}{\Delta t}$; $\sum_{t=0}^{100} \nabla\cdot\mathbf{q}_{dyn}$

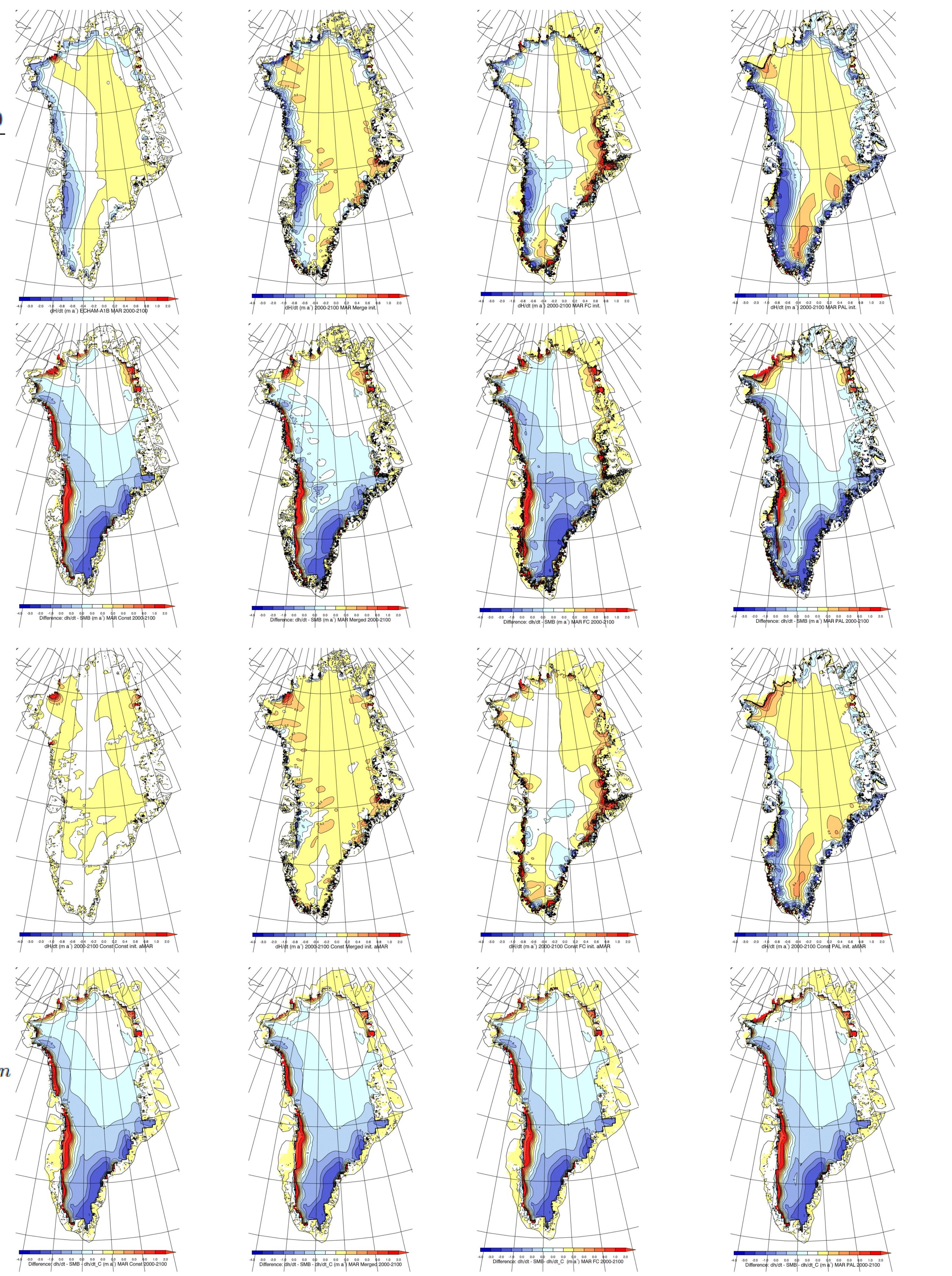

Fig. 5 Resulting elevation changes, top row the difference in elevation after 100 year scenario runs (Fig. 1), second row the total dynamic component, the third row shows the dynamic part resulting from constant forcing with reference climate (drift of model, Fig. 2) and the bottom row shows the dynamic elevation changes after the ΣCMB and the drift have been subtracted from the top row. The columns show the results from the different initialisation methods. Comparison of the bottom row figures shows that after subtracting the drift in the model due to initialisation the dynamic elevation changes are very similar for all the initial states.

Elevation changes during 100 years scenario runs: Different climate forcing

MAR | HIRHAM5 | HadRM3P

Row labels: $\frac{h_{100}-h_0}{\Delta t}$; $\sum_{t=0}^{100} CMB$; $\sum_{t=0}^{100} \nabla\cdot\mathbf{q}_{all}$; $\sum_{t=0}^{100} \nabla\cdot\mathbf{q}_{dyn}$

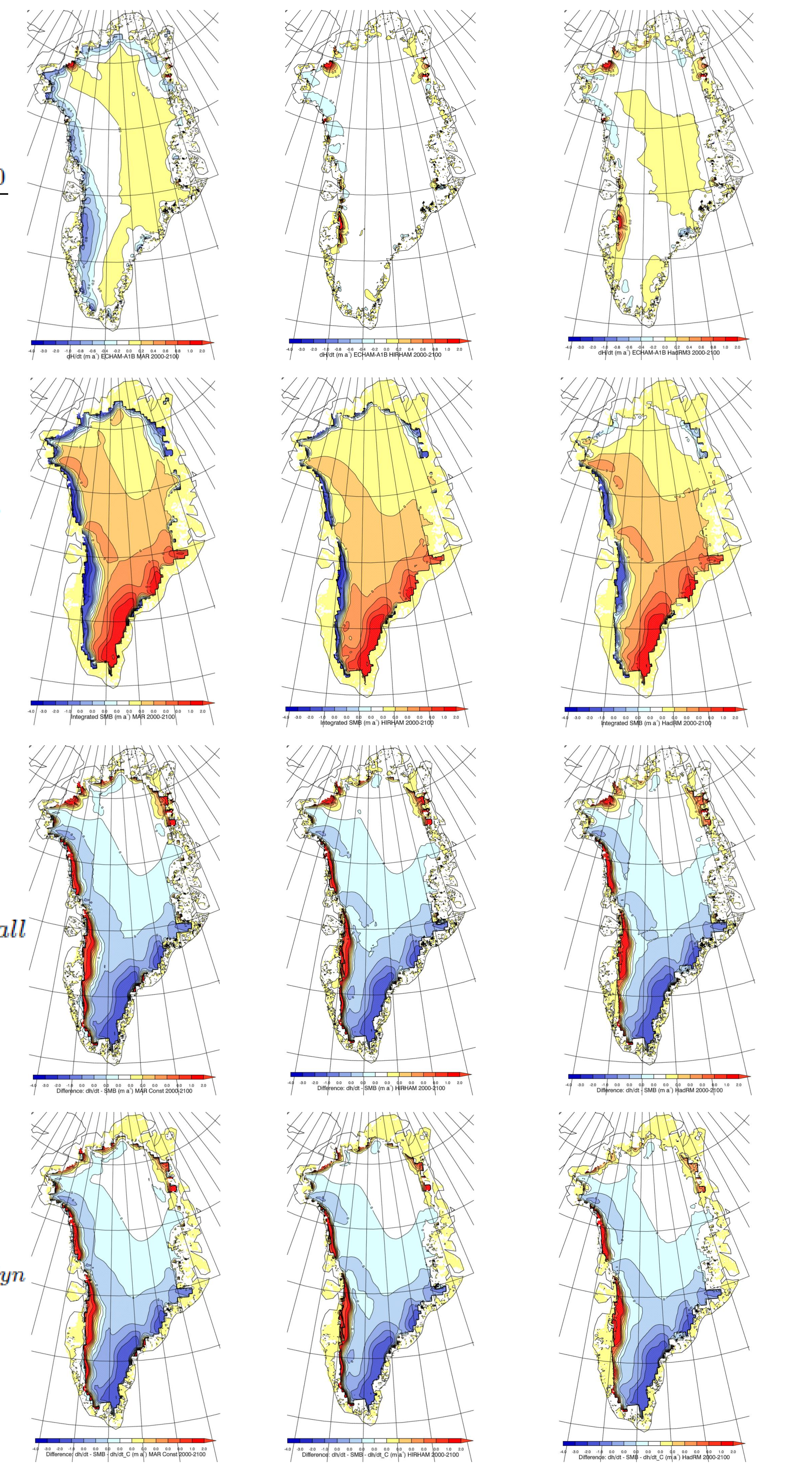

Fig. 6 Resulting elevation changes during scenario runs top row: the difference in elevation after 100 year scenario runs, second row shows the total mass balance, third row the total dynamic component and the bottom row shows the dynamic elevation changes after the ΣCMB and the drift have been subtracted from the top row.
The columns show the results from the different RCM forcing fields, MAR, HIRHAM5 and HadRM3P.

Conclusion

The simulated mass loss during the 100 year scenario runs is in the range 0.5 to 6.5 cm sea level rise equivalent, the difference is due to the difference in climatic forcing and scenario (Fig. 4). The difference in the dynamic response after the climatic mass balance and the drift due to initialisation method has been subtracted from the simulated elevation changes (bottom row in Figs. 5 and 6) is only 2-3 mm sea level rise equivalent. It is concluded that the climatic mass balance is decoupled from the dynamic response for short time scales. This model setup does not include climate-elevation change feedback.

www.ice2sea.eu

Estimating the future contribution of continental ice to sea-level rise.
A programme of research funded by the European Union Framework 7 Programme. 2009 – 2013