Improved representation of ice discharge from the Greenland ice sheet into the surrounding ocean

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Introduction

Here, we introduce a simple parameterization of ice discharge of the Greenland ice sheet (GIS) included in the large scale ice sheet model SICOPOLIS, which is coupled with the regional energy and moisture balance model REMBO. We investigate the dependence of the major characteristics of GIS, as position of ice margins and mass balance partition, on the parameters of the discharge model and the REMBO melt model. The fluxes from the major GIS basins are compared with various observational sources.

Model Outline

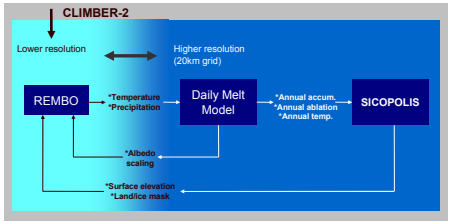

Fig. 1: The climate system model CLIMBER-2 provides “offline” temperature anomalies added to ECMWF ERA-40 boundary data. The regional energy and moisture balance model REMBO is coupled bi-directional with the ice sheet model SICOPOLIS.

Parameterisations

Melt (ITM): $$m = \frac{1}{\rho_w L_m}\left[\tau(1-a_s)S + c + \lambda T\right]$$

Discharge (DISC): $$d = c_f\, c_d(\varphi)\, \frac{H^p}{D^q}$$

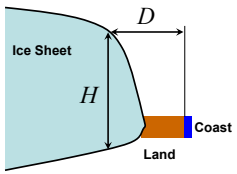

Fig. 2: Sketch illustrating the ice discharge parameterization.

Simulations

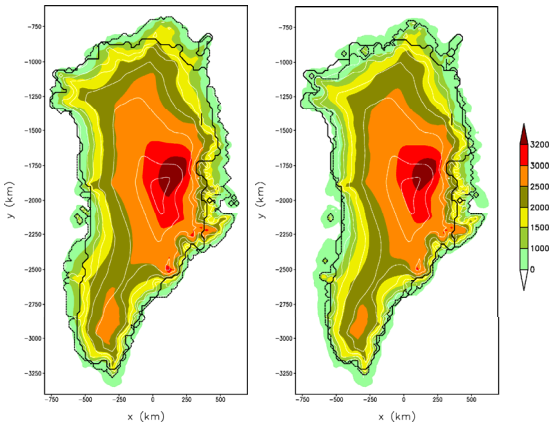

Fig 3: Surface elevation and ice margins. Left: standard run. Right: Simulation with discharge parameterization. Modeled surface elevation is shaded. Observed surface elevation is indicated by the thin white lines. Observed ice margins are shown by the black solid lines and modeled ones by the black dashed lines.

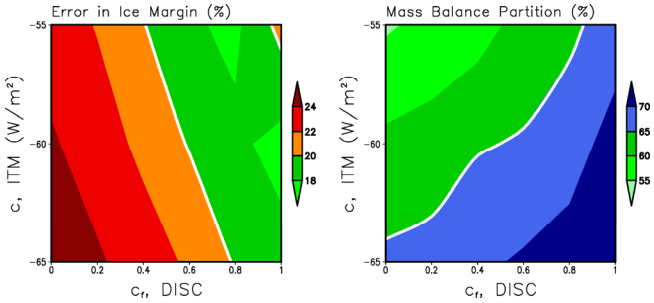

Fig. 4: Error in ice margin (left) and mass balance partition (i.e., the partition between the totals of surface melting and ice discharge; right panel) from various simulation with different melt and discharge parameter values. The green shadings indicate the error, which we chose as tolerable for the ice margins (left), and the acceptable range for the mass balance partition (45%-65%, right panel).

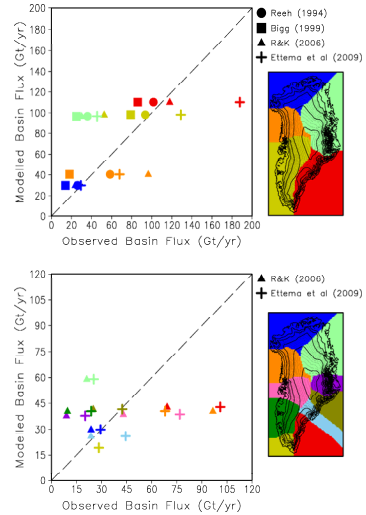

Fig. 6: Simulated basin fluxes compared with different observations. The colors of the marks correspond to different basins. The locations of the basins are indicated by the shading of the right hand side insets. The upper panels uses coarse basins after Reeh. For the lower panel the basin are refined based on Rignot and Kanagaratnam (2006) , but not for all the basins.

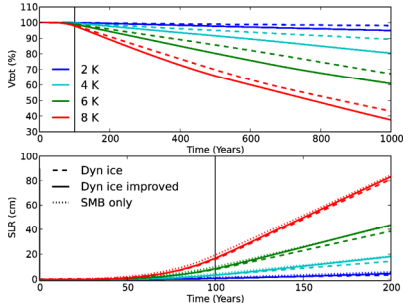

Fig 7: Transient simulations for different future stabilization scenarios. Colors indicate the temperature rise after 100 years. The solid lines are from simulations with the a model version model with discharge parameterization, while the dashed lines are from the standard model. The lower panel is a zoom over the first 200 years, expressed in global sea-level equivalent (cm). The dotted line are from computations with REMBO only, using a standard surface mass balance approach.

Conclusions

We presented simulations with the coupled models REMBO and SICOPOLIS investigating a parameterization of ice discharge. We have demonstrated that this parameterization enables an improvement of both representation of ice margins and surface mass balance partition. Explicit modeling of ice discharge is important for the stability behavior of the Greenland ice as well as for its response to future climate change.