Title	SeaRISE : Modelling the present-day state and future evolution of the Greenland ce Sheet with the models SICOPOLIS and IcIES
Author(s)	Greve, Ralf; Saito, Fuyuki; Abe-Ouchi, Ayako
Citation	Invited talk presented at 2010 Fall Meeting, AGU, San Francisco, Calif., USA, 13-17 Dec. 2010
Issue Date	2010-12-15
Doc URL	http://hdl.handle.net/2115/45524
Type	conference presentation
File Information	Greve_etal_2010_AGU.pdf

SeaRISE: Modelling the present-day state and future evolution of the Greenland Ice Sheet with the models SICOPOLIS and IcIES

Ralf Greve[1], Fuyuki Saito[2], Ayako Abe-Ouchi[3,2]

1 Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan
2 Research Institute for Global Change, JAMSTEC, Yokohama, Japan
3 Atmosphere and Ocean Research Institute, University of Tokyo, Japan

SeaRISE

= **Sea**-level **R**esponse to **I**ce **S**heet **E**volution

- Multi-ice-sheet model community effort (> 10 models).
- Objective:
  To predict the likely range of contributions of the Greenland and Antarctic Ice Sheets to sea level rise over the next 100’s of years under global warming conditions.
- Possible ice-dynamic acceleration or destabilisation mechanisms will be investigated.

Japanese contribution to SeaRISE

Model SICOPOLIS

= **SI**mulation **CO**de for **POL**ythermal **I**ce **S**heets

(Greve for GrIS, Sato for AIS → yesterday's poster C21C-0548)

Model IcIES

= **Ic**e sheet model for **I**ntegrated **E**arth system **S**tudies

(Saito, Abe-Ouchi)

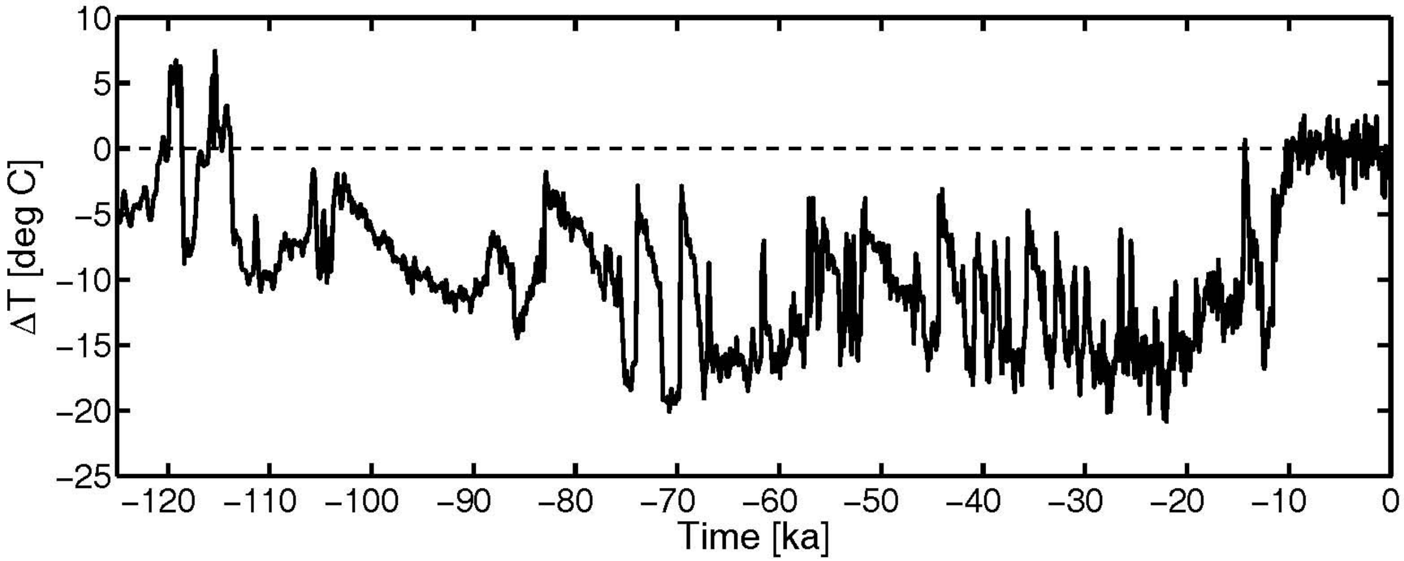
Model Elmer/Ice

→ Yesterday's poster C21C-0552 by Seddik et al.

Paleoclimatic spin-up

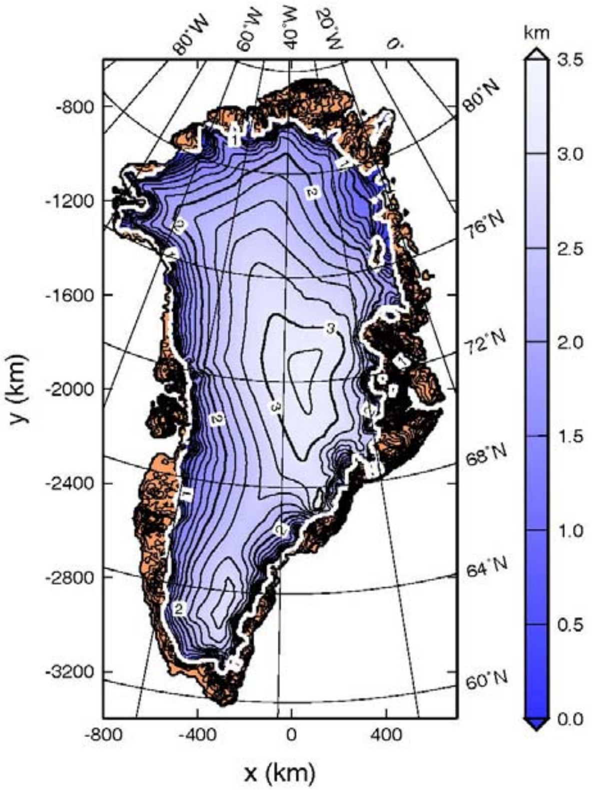
- Grid spacing: Δx = 10 km (SICOPOLIS, IcIES).
- Model time: t = –125 ka ... 0 ka (one glacial cycle).

- Climate forcing based on surface temperature anomaly (from GRIP δ^{18}O record):

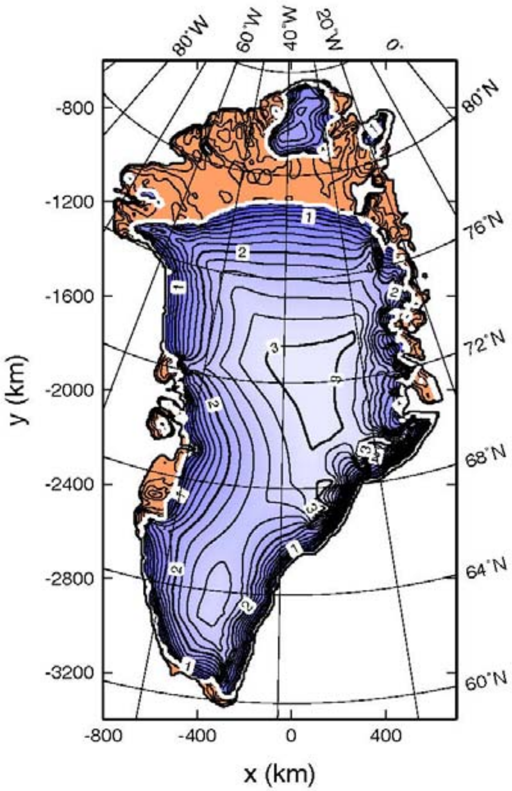


Spin-ups presented @ IGS Sapporo

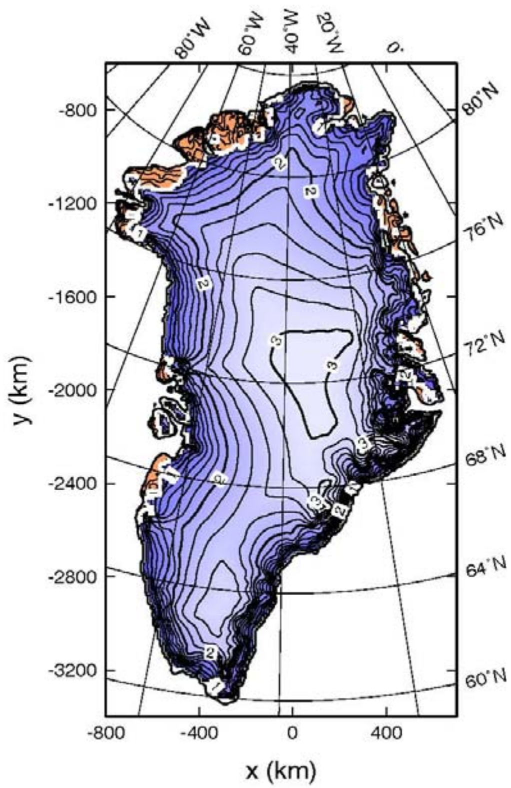
Observed
present-day ice sheet
(Bamber et al. 2001)



SICOPOLIS "off the shelf"
(PDD by
Tarasov and Peltier 2002)

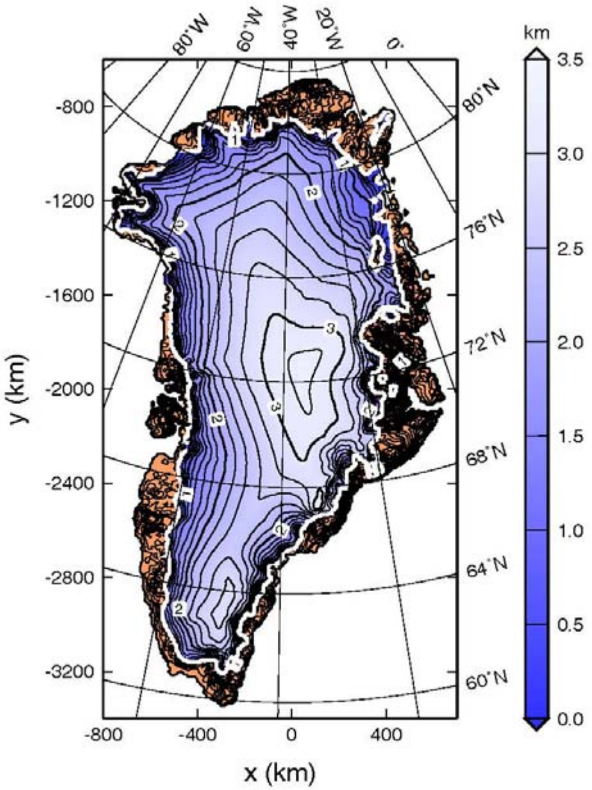


IcIES
"off the shelf"
(PDD by Reeh 1991)

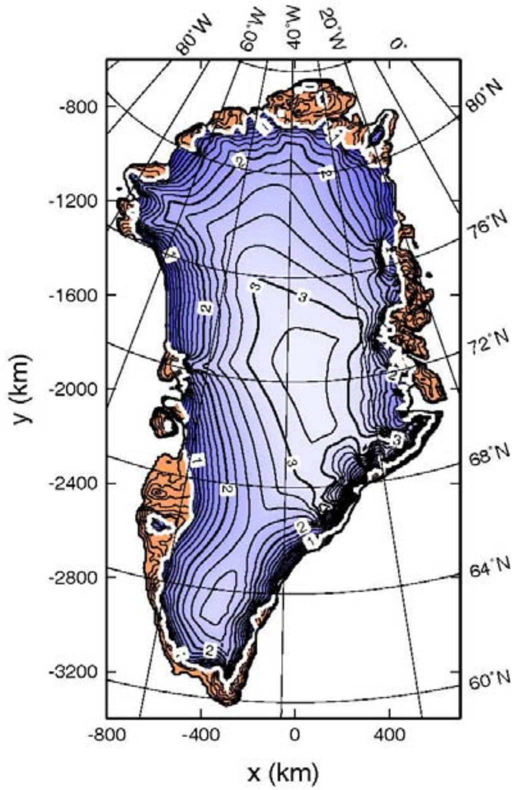


Spin-ups presented @ IGS Sapporo

Observed
present-day ice sheet
(Bamber et al. 2001)

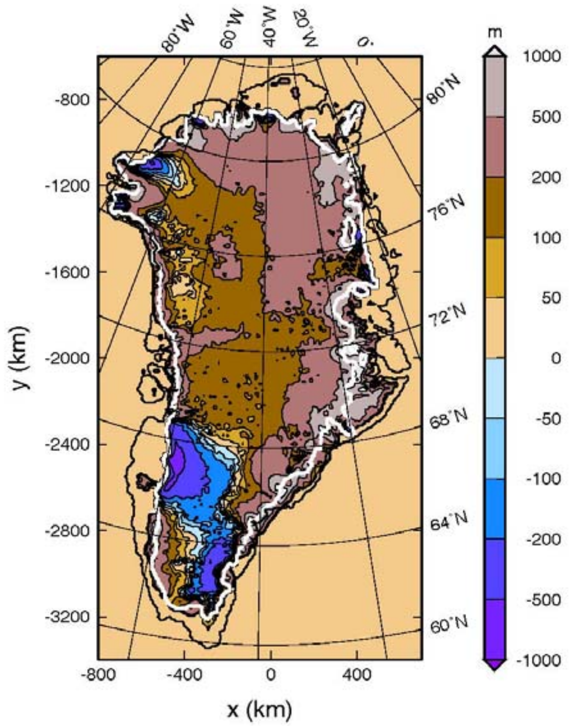


SICOPOLIS with PDD tuning
(latitude-dependent PDD factors)



V_{sim} = 8.26 m SLE
vs.
V_{obs} = 7.2 m SLE

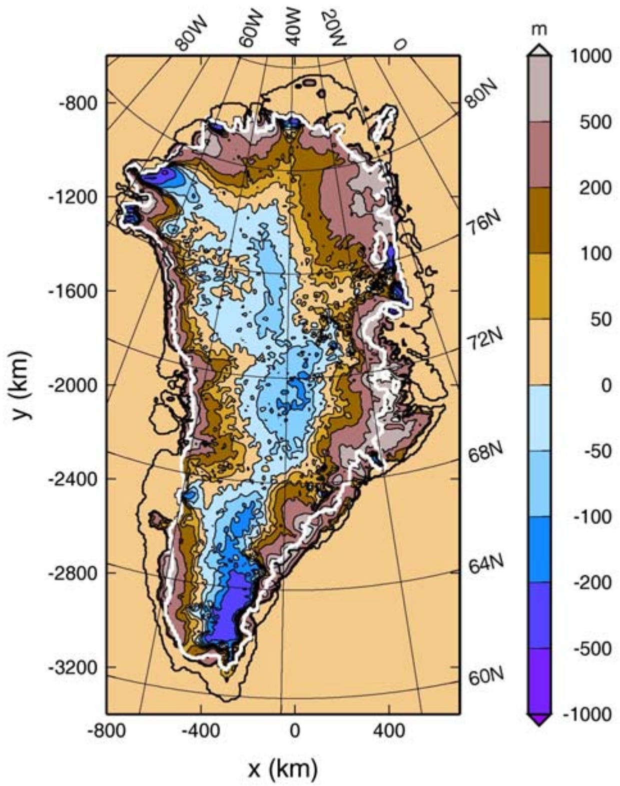
Thickness misfit (sim. – obs.)



Changed enhancement factor improves the fit

SICOPOLIS, E = 3 (like IcIES) instead of $E_{interglac}$ = 1 / E_{glac} = 3.

Thickness misfit (sim. – obs.)

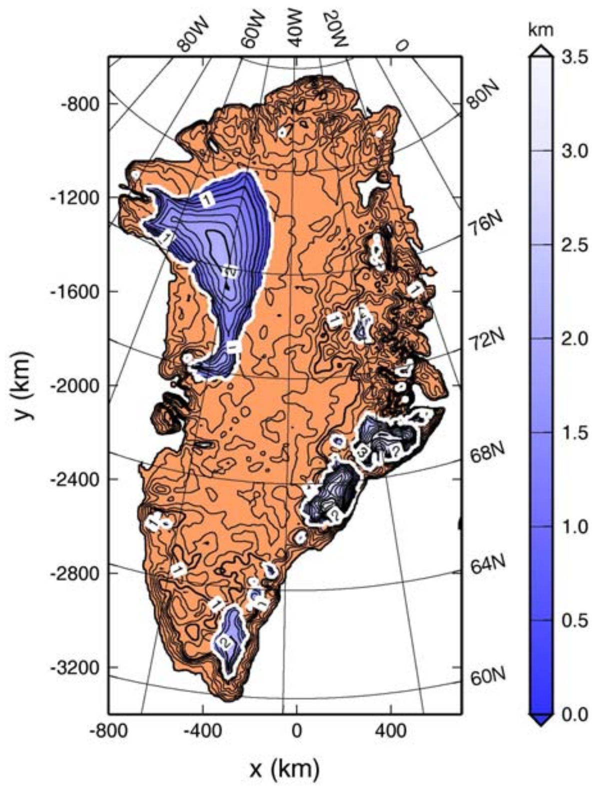


V_{sim} = 7.89 m SLE
vs.
V_{obs} = 7.2 m SLE

So far, so good, but…

Brute-force PDD tuning kills too much ice in the Eemian

114 ka BP,
V_{sim} = 0.68 m SLE



GRIP, GISP2, Dye 3 and NGRIP ice-free

→ apparently not realistic!

Alternative strategy: Spin-up with fixed topography

Initial relaxation over 100 years (with evolving topography), then topography kept fixed.

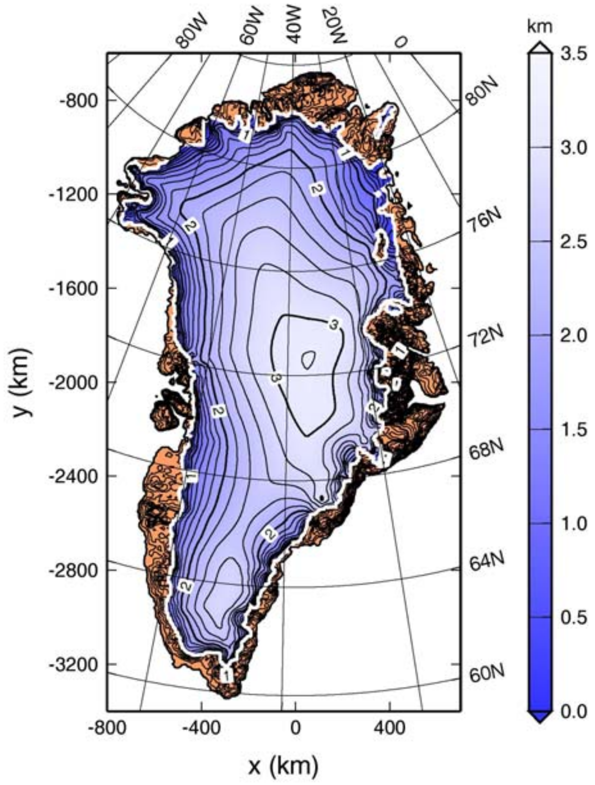
Some changes in order to account for the recommendations by Cuffey and Paterson, "The Physics of Glaciers" (4th ed. 2010):

- Rate factor: $A(-10°\text{C}) = 3.5 \times 10^{-25}\ \text{s}^{-1}\ \text{Pa}^{-3}$.
- Enhancement factor: $E_{\text{interglac}} = 2$, $E_{\text{glac}} = 5$.

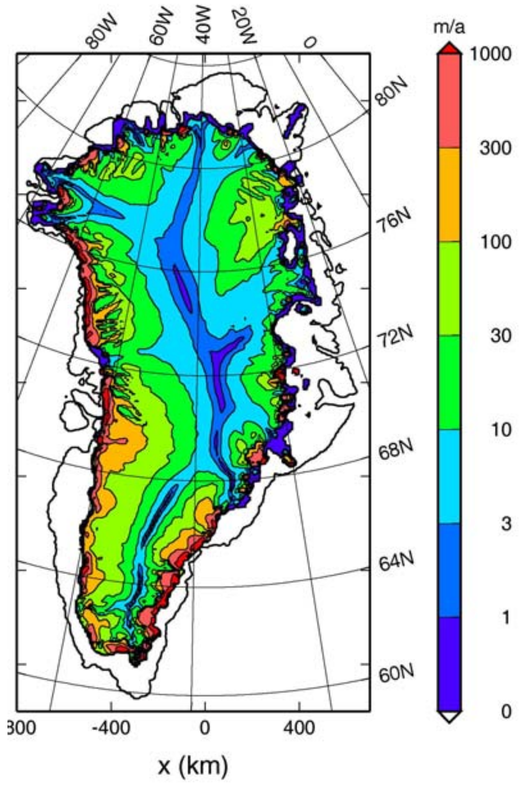
- Creep function: $f(\sigma_e) = \sigma_e^{n-1} + \sigma_0^{n-1}$
  with $n = 3$ and $\sigma_0 = 10$ kPa
  (finite-viscosity flow law; Greve and Blatter 2009).

Alternative strategy:
Spin-up with fixed topography

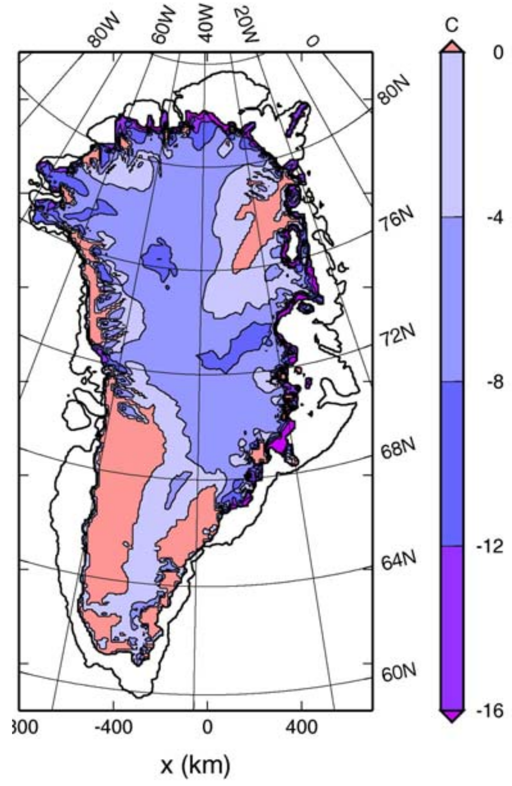
Surface topography



Surface velocity



Basal temperature
(relative to PMP)



Alternative strategy: Spin-up with fixed topography

Basal temperature of ice core locations:

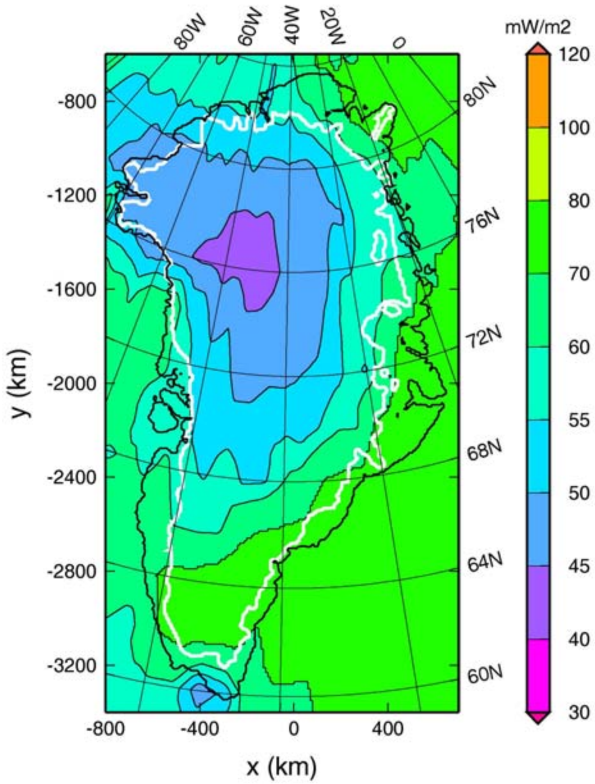
	GRIP	NGRIP	CC	Dye 3
Sim. T_b [°C]	–10.76	–9.91	–9.94	–2.73
Obs. T_b [°C]	–8.56	–2.4*	–13.0	–13.22

*: pressure melting point

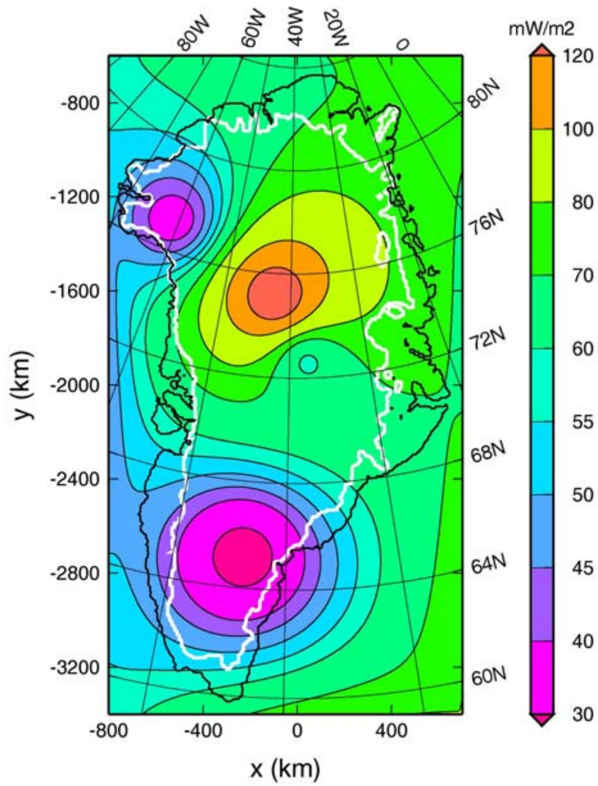
Quite bad → geothermal heat flux?

Geothermal heat flux

SeaRISE
(Shapiro and Ritzwoller 2004)

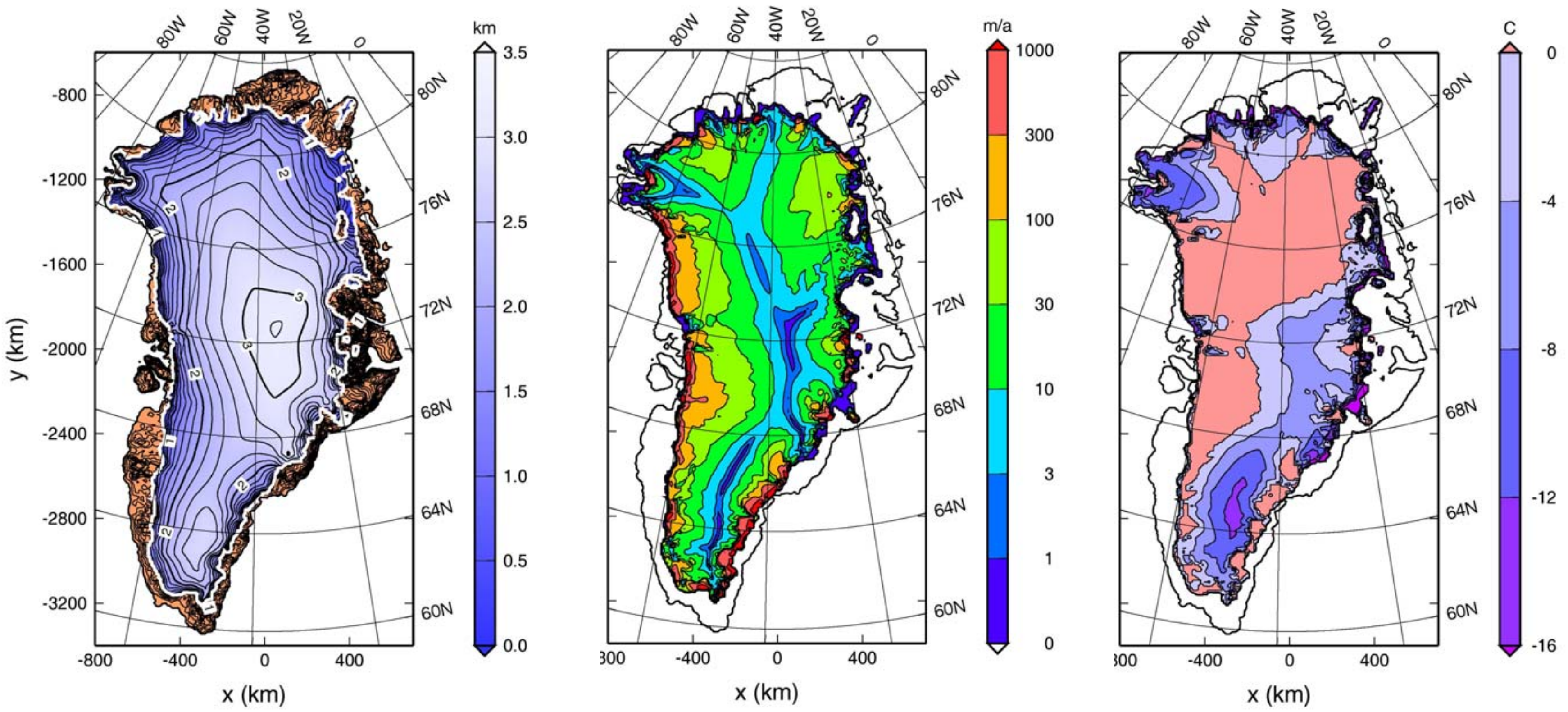


Greve (2005):
Pollack et al. (1993) plus
ice core temperatures



Fixed-topography spin-up with the geothermal heat flux based on Greve (2005)

Surface topography | Surface velocity | Basal temperature (relative to PMP)



Fixed-topography spin-up with the geothermal heat flux based on Greve (2005)

Basal temperature of ice core locations:

	GRIP	NGRIP	CC	Dye 3	
Sim. T_b [°C]	–10.76 –8.47	–9.91 –2.65*	–9.94 –13.01	–2.73 –13.22	(S&R04) (Gr05)
Obs. T_b [°C]	–8.56	–2.4*	–13.0	–13.22	

*: pressure melting point

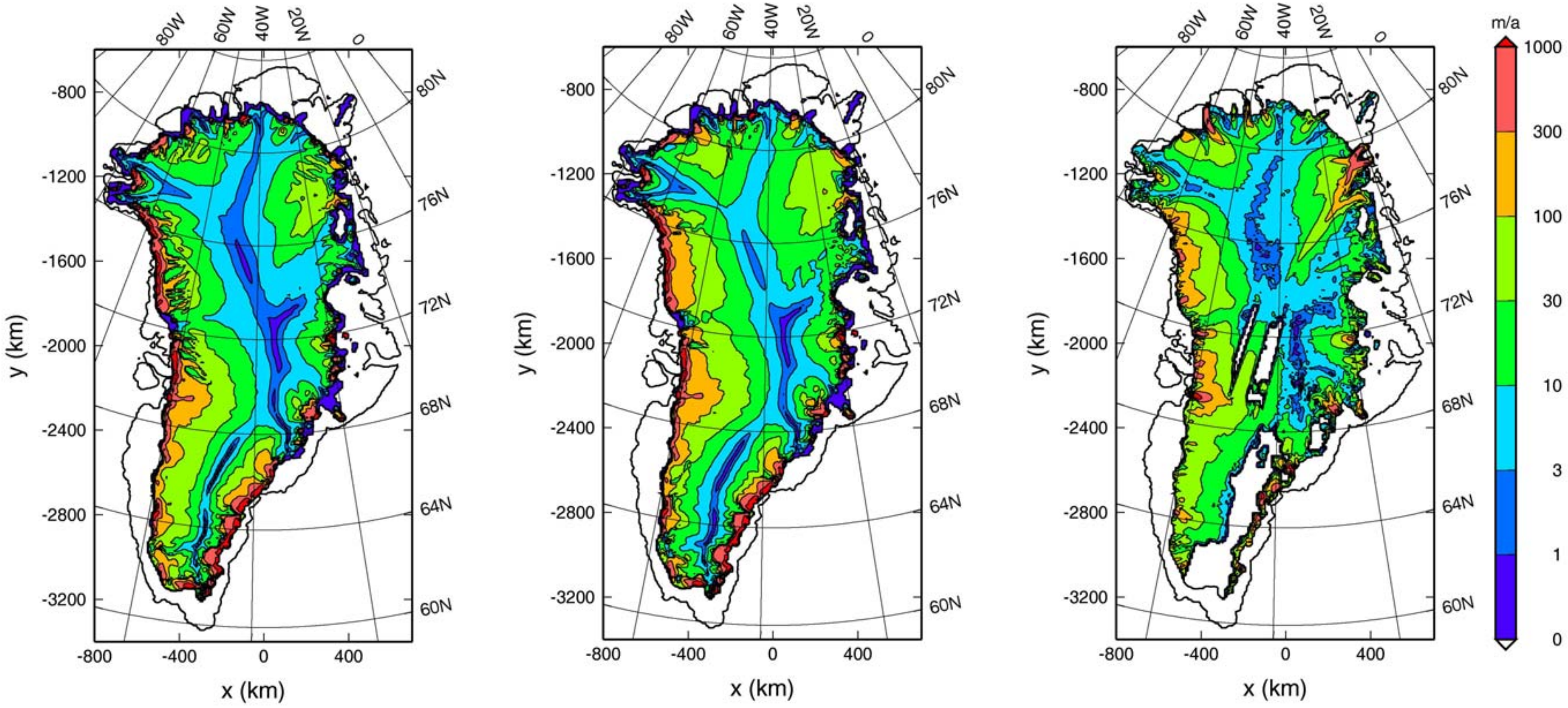
Excellent agreement was achieved!

Comparison of surface velocities

Fixed-topography spin-up, S&R04

Fixed-topography spin-up, Gr05

Obs. (Joughin et al., SeaRISE website)



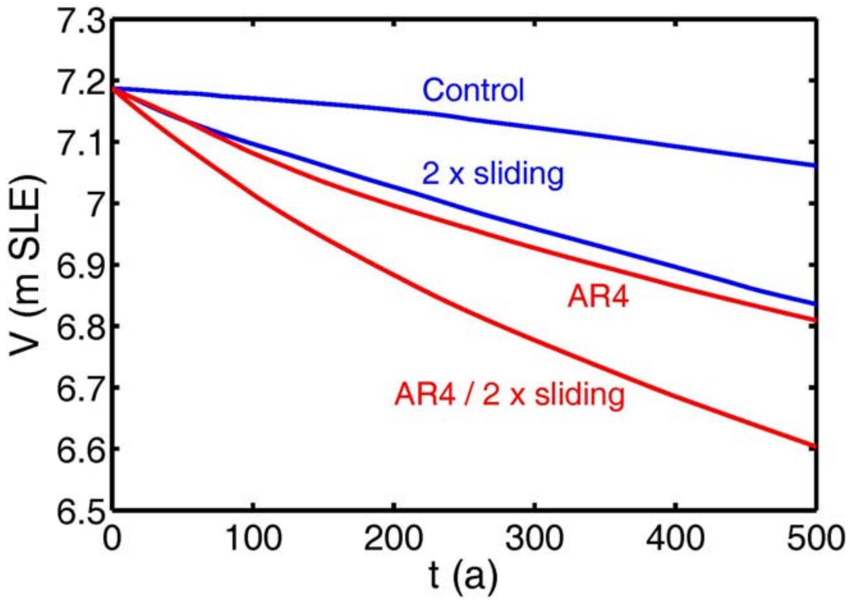
Future climate experiments

- Grid spacing: Δx = 10 km (SICOPOLIS, IcIES).
- Model time: t = 0 a ... 500 a.

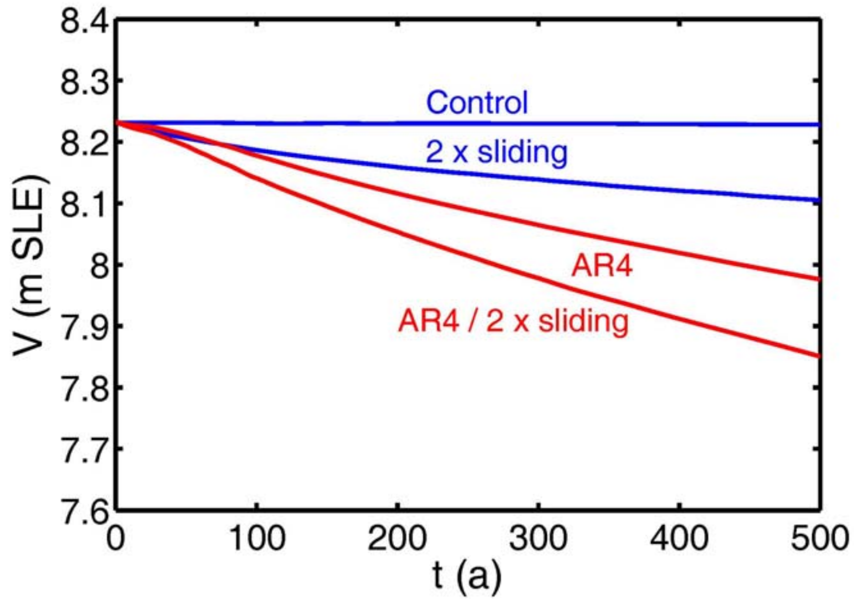
- C1_E0: Constant climate control run.
- C1_E1: Constant climate forcing + doubled basal sliding.
- C2_E0: AR4 climate control run (A1B scenario).
- C2_E1: AR4 climate forcing + doubled basal sliding.

Future climate experiments

SICOPOLIS



IcIES



Sensitivities are very similar for (AR4 – Control) [climatic forcing],

but

significantly different for (2 x sliding – Control) [ice dynamics].

Lessons to learn

- Quite difficult to get a reasonable spin-up without strong constraints.
- Ice-dynamic effects are of concern, but let's not forget about surface mass balance issues.
- Sensitivity between models can vary significantly
  $\rightarrow$ model ensemble reasonable for predictions.

Thanks to…

- Bob Bindschadler, Sophie Nowicki, Jesse Johnson, …
  for getting and keeping SeaRISE up and running;
- Kunio Takahashi for running the SeaRISE experiments with IcIES at JAMSTEC;
- JSPS for providing funding
  (Grant-in-Aid for Scientific Research A, No. 22244058);

- **YOU for listening…**