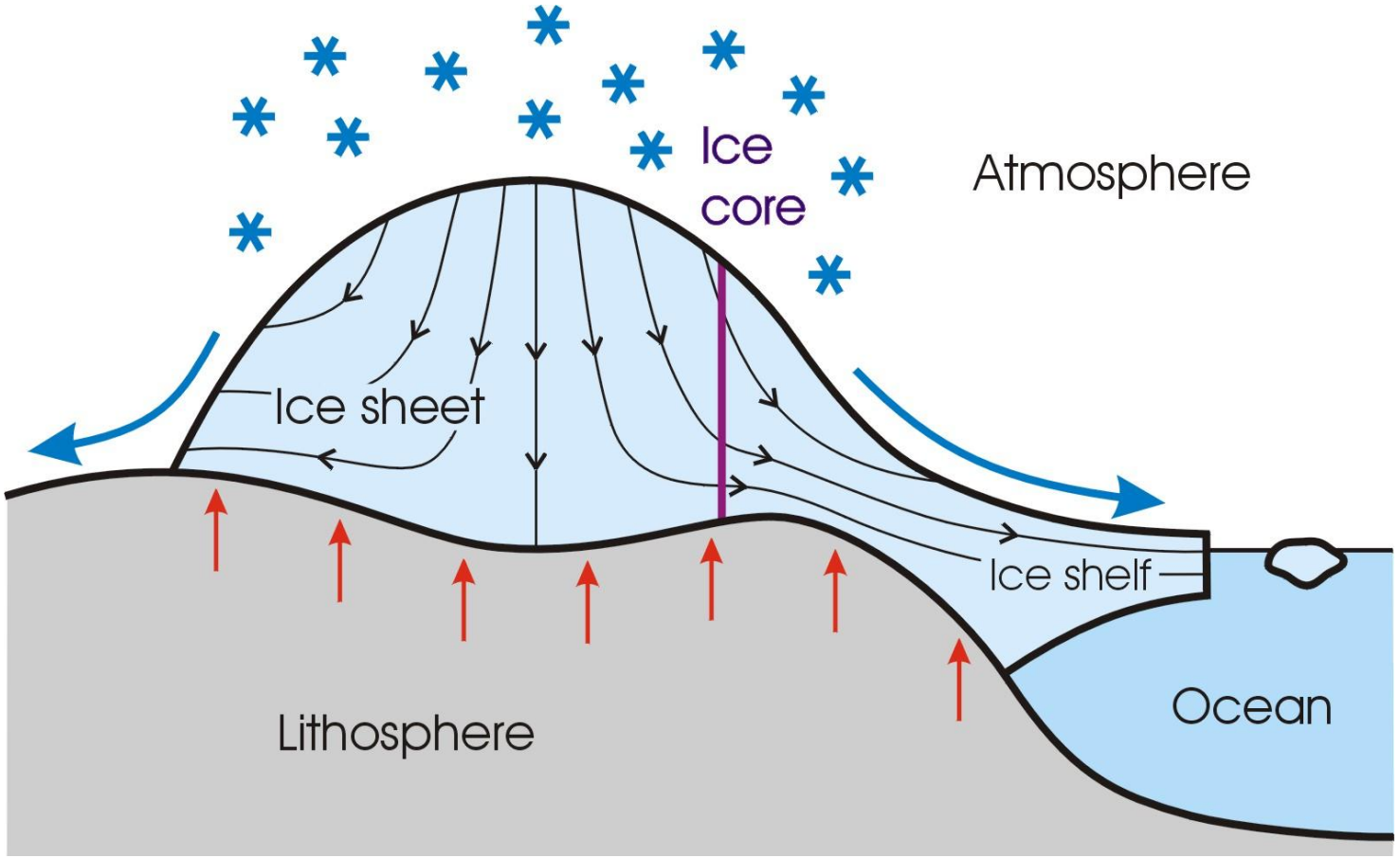
Modelling the response of ice sheets to environmental forcing and projecting future sea level rise

Ralf Greve

Institute of Low Temperature Science, Hokkaido University, Sapporo, Japan

Ice sheets on Earth (schematically)

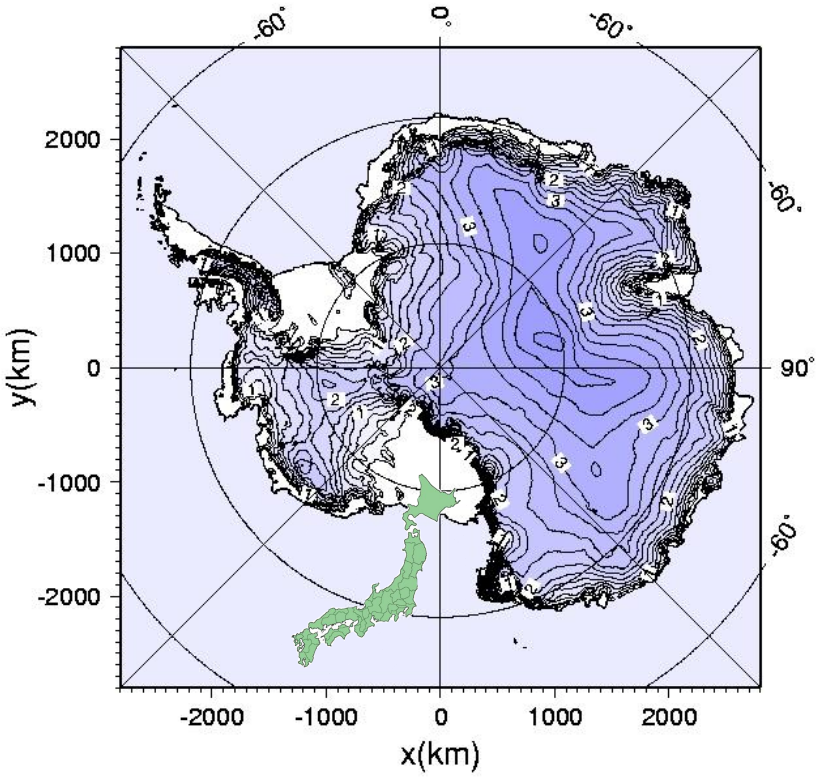


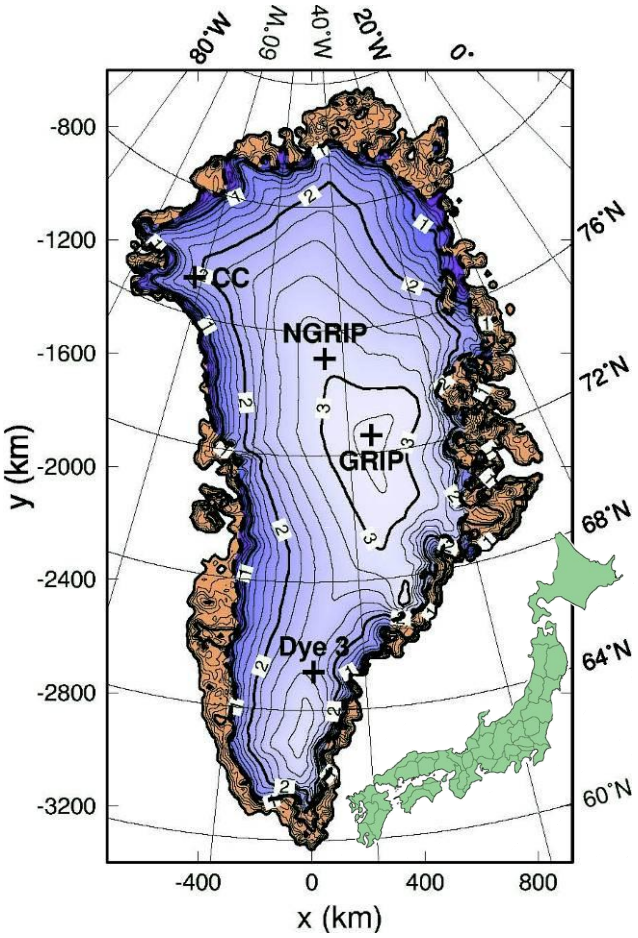
Vertical exaggeration factor ~200-500

Today's ice sheets on Earth

Greenland ice sheet

Antarctic ice sheet
(with ice shelves)





Ice inventory

		Greenland ice sheet	Antarctic ice sheet (+ shelves)
Area (10^6 km^2)		1.7	12.3 (+ 1.5)
Volume (10^6 km^3)		2.9	24.7 (+ 0.7)
Sea level equivalent (m)		7.3	56.6 (+ 0)
Turnover time (vol/accum, years)		~ 5,000	~ 12,000

Source: Lemke et al. (2007) [IPCC AR4 Ch. 4].

SeaRISE

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

- Multi-ice-sheet model community effort.
- 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.
- As at 2012.07.31 (paper submission deadline for IPCC AR5):
  8 models for Greenland
  (AIF, CISM-2, Elmer/Ice, IcIES, ISSM, PISM, SICOPOLIS, UMISM),
  6 models for Antarctica
  (AIF, UMISM w/o shelves, ISSM, PennState3D, Potsdam-PISM, SICOPOLIS w/shelves).

SeaRISE @ ILTS

Model SICOPOLIS

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

(Greenland: Ralf Greve, Antarctica: Tatsuru Sato)

Model Elmer/Ice

= **Elmer Ice Sheet Model**

(Greenland: Hakime Seddik)

SeaRISE future climate experiments

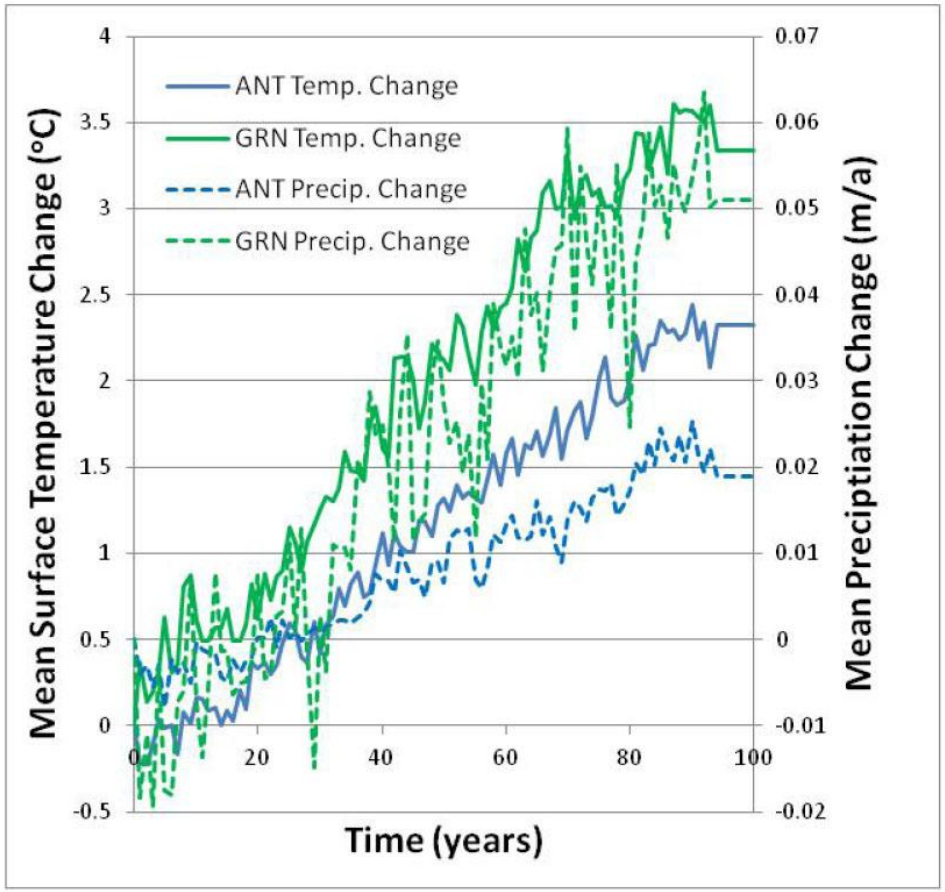
(for Antarctica and Greenland, over 500 years)

Sensitivity experiments

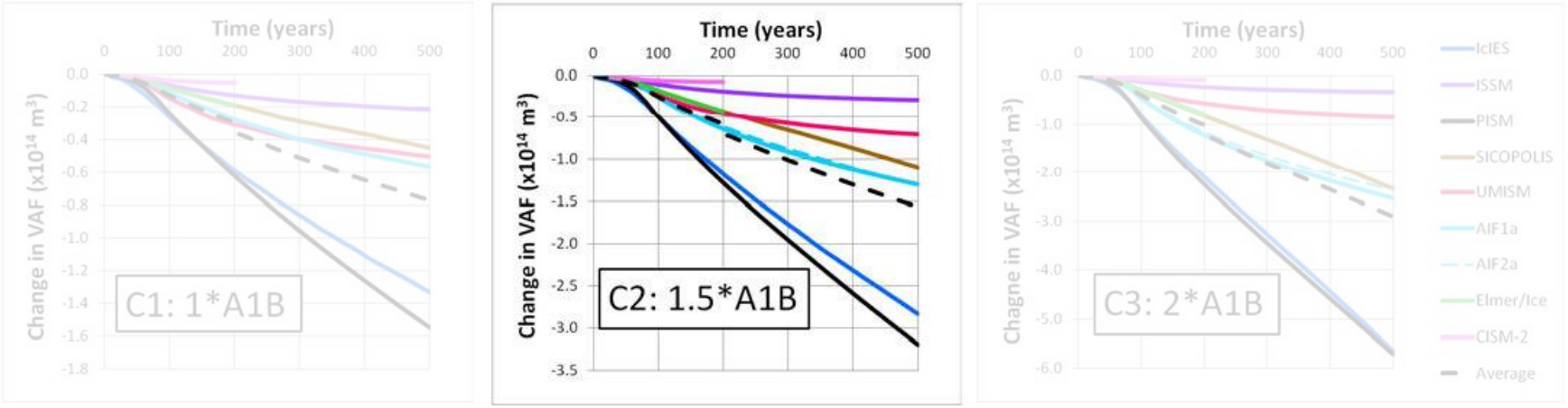
- CTL – constant climate control run.
- C1, 2, 3 – 1 x / 1.5 x / 2 x A1B climate forcing over 100 a, then constant.
- S1, 2, 3 – 2 x / 2.5 x / 3 x basal sliding.
- M1, 2, 3 – ocean-induced sub-ice-shelf and marginal melting of 2 / 20 / 200 m/a.

SeaRISE future climate experiments

1 x A1B climate forcing used for run C1

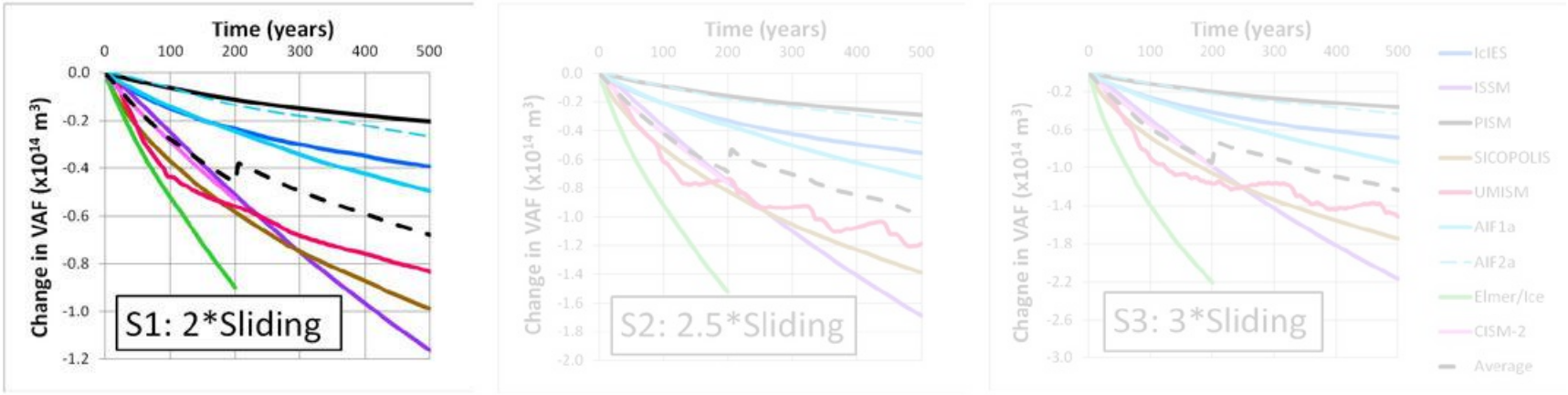


Simulated ice volume changes – Greenland, forcing by climate



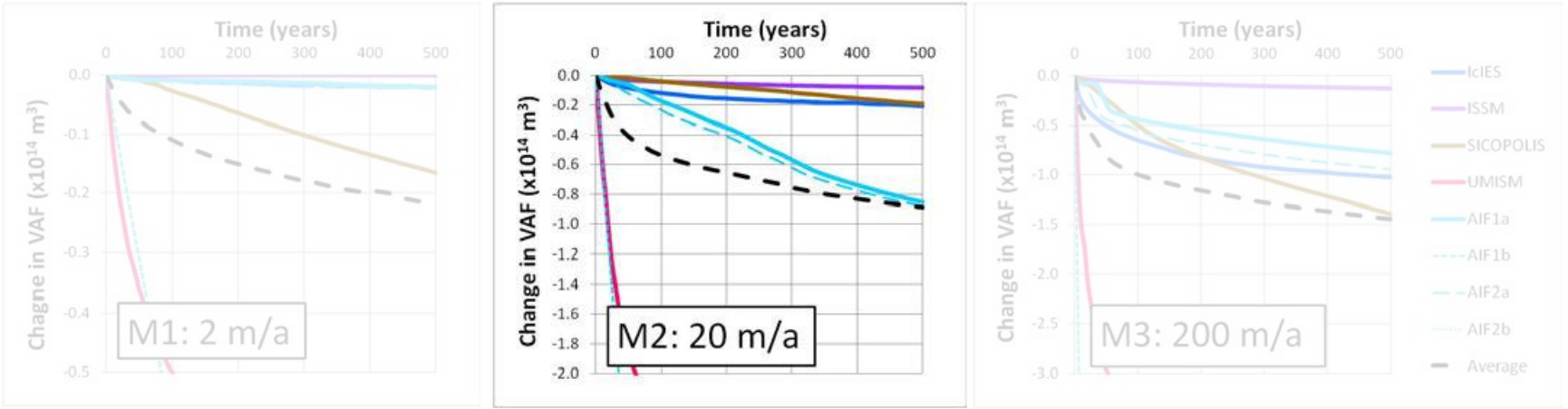
Very sensitive.

Simulated ice volume changes – Greenland, forcing by basal sliding



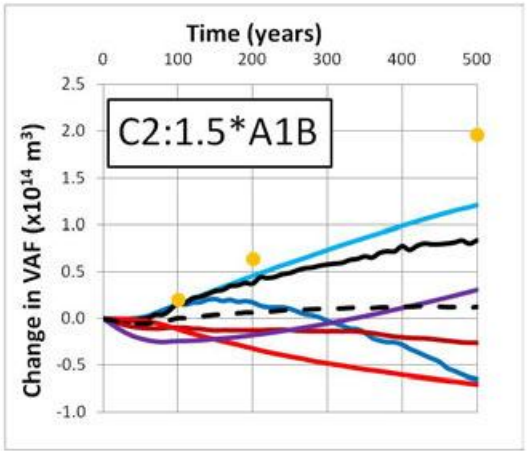
Moderately sensitive.

Simulated ice volume changes – Greenland, forcing by marginal melting



Moderately sensitive.

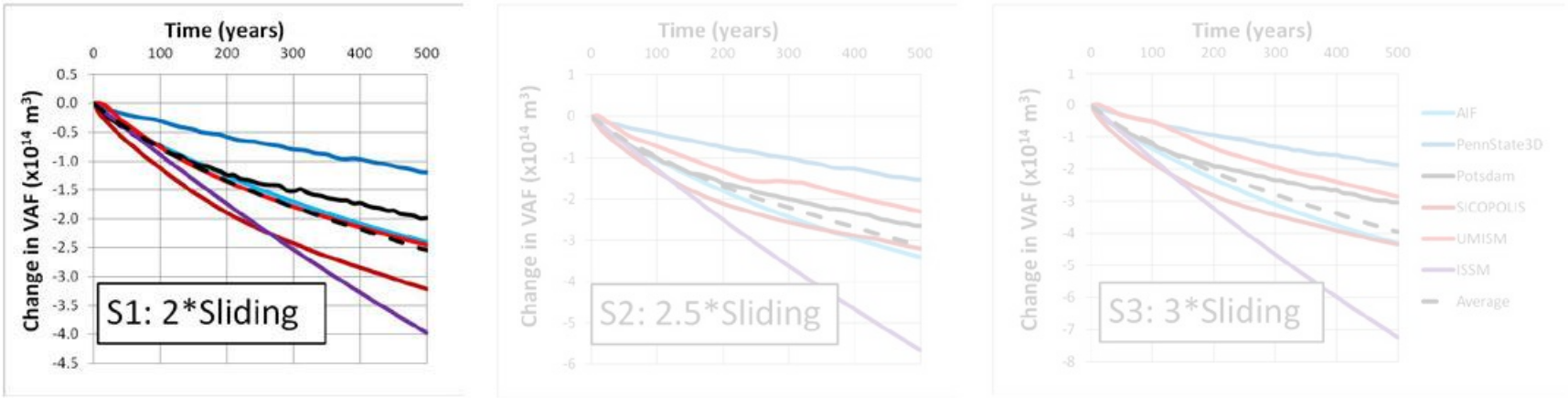
Simulated ice volume changes – Antarctica, forcing by climate



Little sensitive.

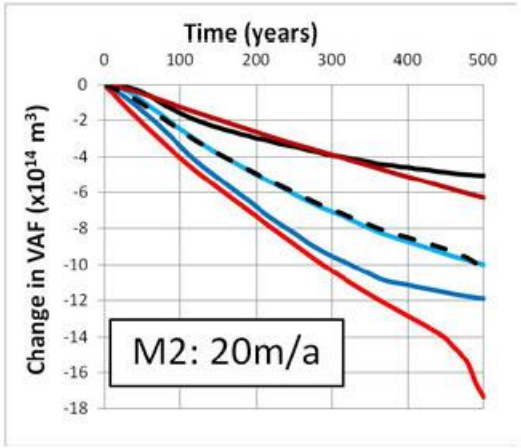
Even the sign is unclear!

Simulated ice volume changes – Antarctica, forcing by basal sliding



Moderately sensitive.

Simulated ice volume changes – Antarctica, forcing by sub-ice-shelf melting

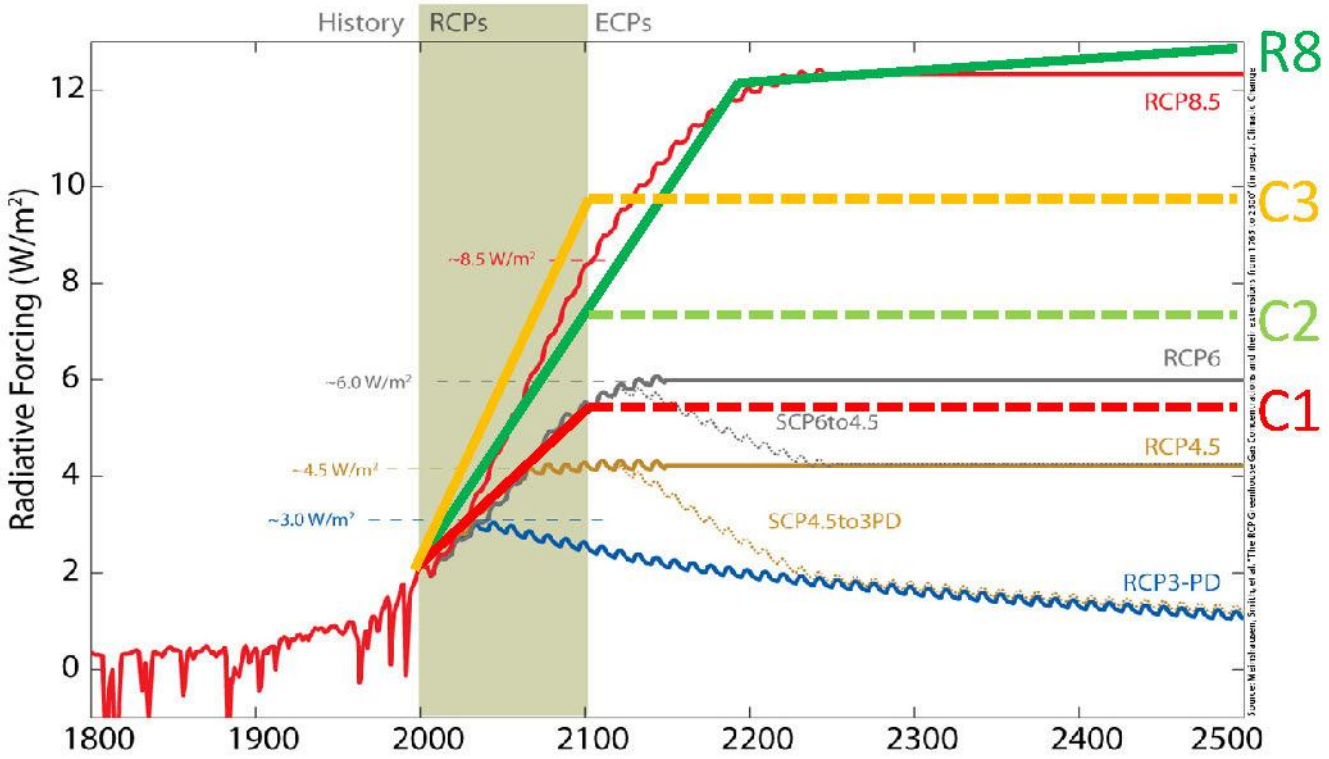


Very sensitive.

SeaRISE future climate experiments

Combination experiment R8

(approximating IPCC's RCP8.5 scenario)



SeaRISE future climate experiments

Set-up of exp. R8 for Greenland

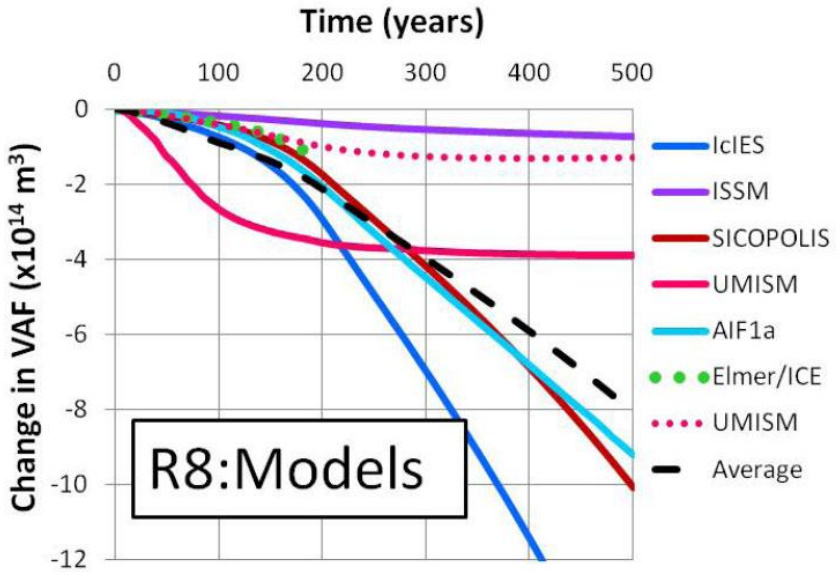
1.5 x A1B climate (continued over 500 a)
+ 1.5 x basal sliding
+ up to 70 m/a ocean-induced marginal melting.

Set-up of exp. R8 for Antarctica

1.5 x A1B climate (continued over 500 a)
+ up to 1.8 x basal sliding (coastal regions only)
+ up to 70 m/a ocean-induced sub-ice-shelf melting
(Amundsen Sea and Amery Ice Shelf only).

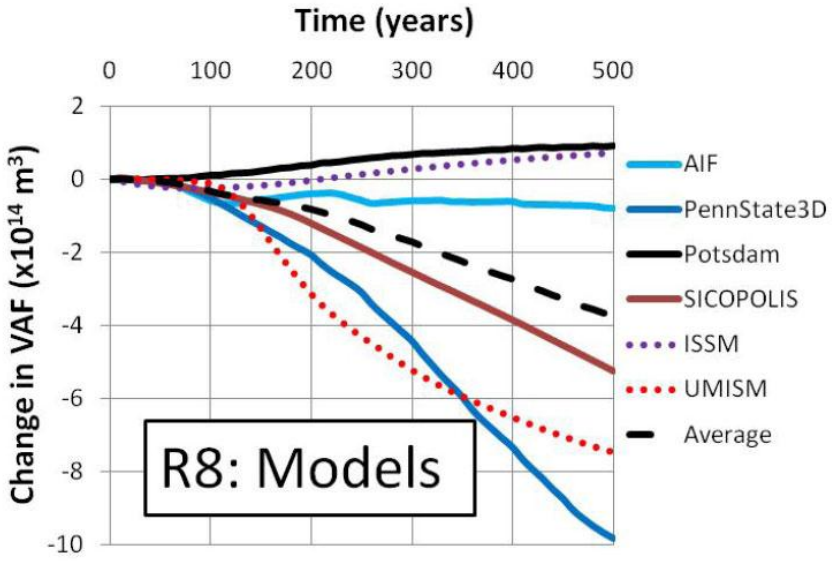
Simulated ice volume changes of exp. R8

Greenland:



Average after 100 a: 0.22 m SLE
200 a: 0.53 m SLE
500 a: 2.02 m SLE

Antarctica:



Average after 100 a: 0.07 m SLE
200 a: 0.21 m SLE
500 a: 0.93 m SLE

Concluding remarks

- Greenland is most sensitive to atmospheric changes in temperature and precipitation.
- Antarctica is most sensitive to sub-ice-shelf melting.
- Large spread of results between the different models.
- Average results for exp. R8 (~RCP8.5 scenario):
  After 500 years Greenland loses ~25% of its VAF,
  Antarctica loses ~1.6% (average results).

Acknowledgements

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(figures on slides 10-17 and 19 taken from Bindschadler and 27 others, *J. Glaciol.*, submitted).

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Thank you !

Ralf Greve