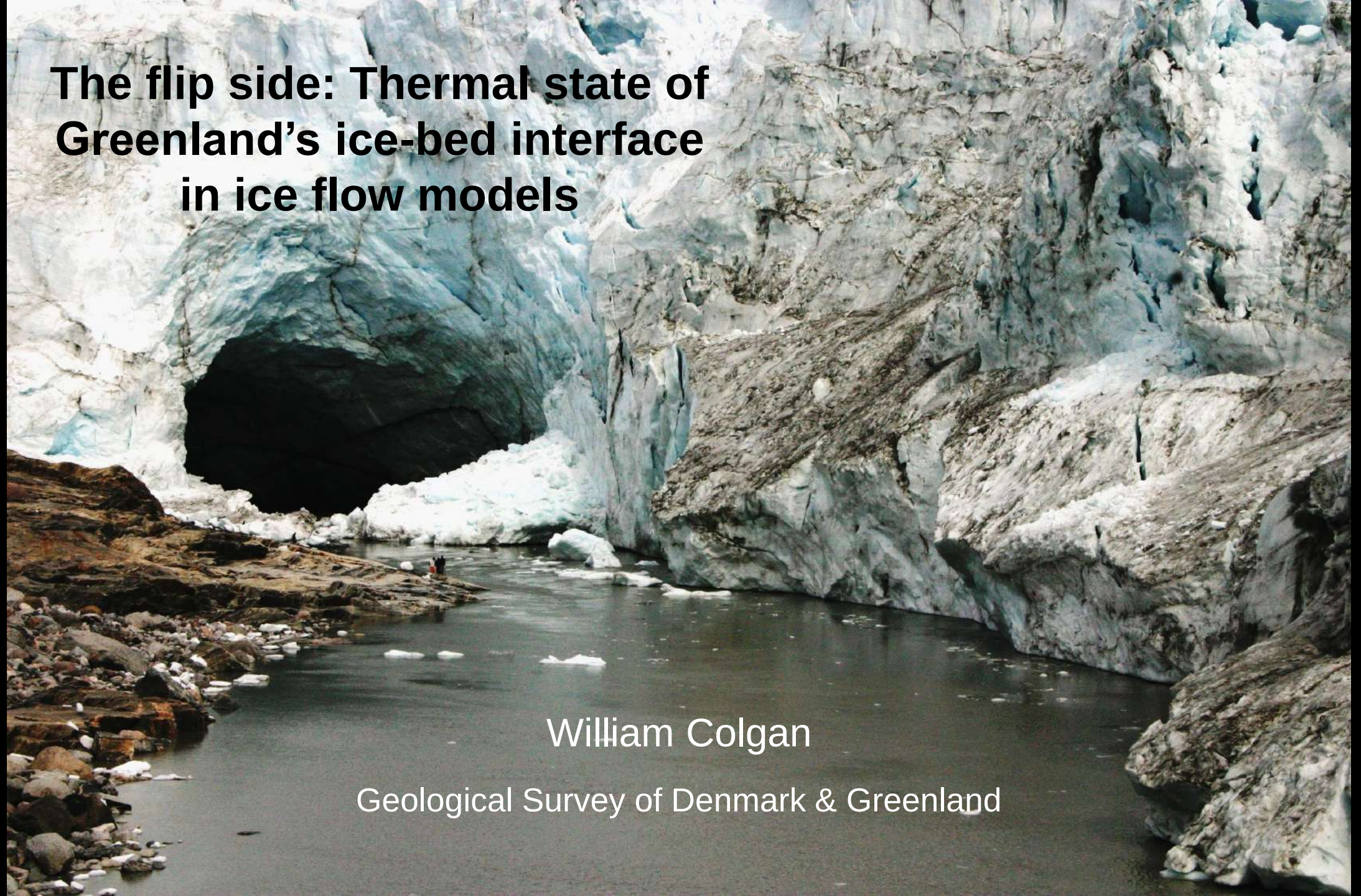


The flip side: Thermal state of Greenland's ice-bed interface in ice flow models

William Colgan

Geological Survey of Denmark & Greenland

How have we improved the Greenland heat flow map?

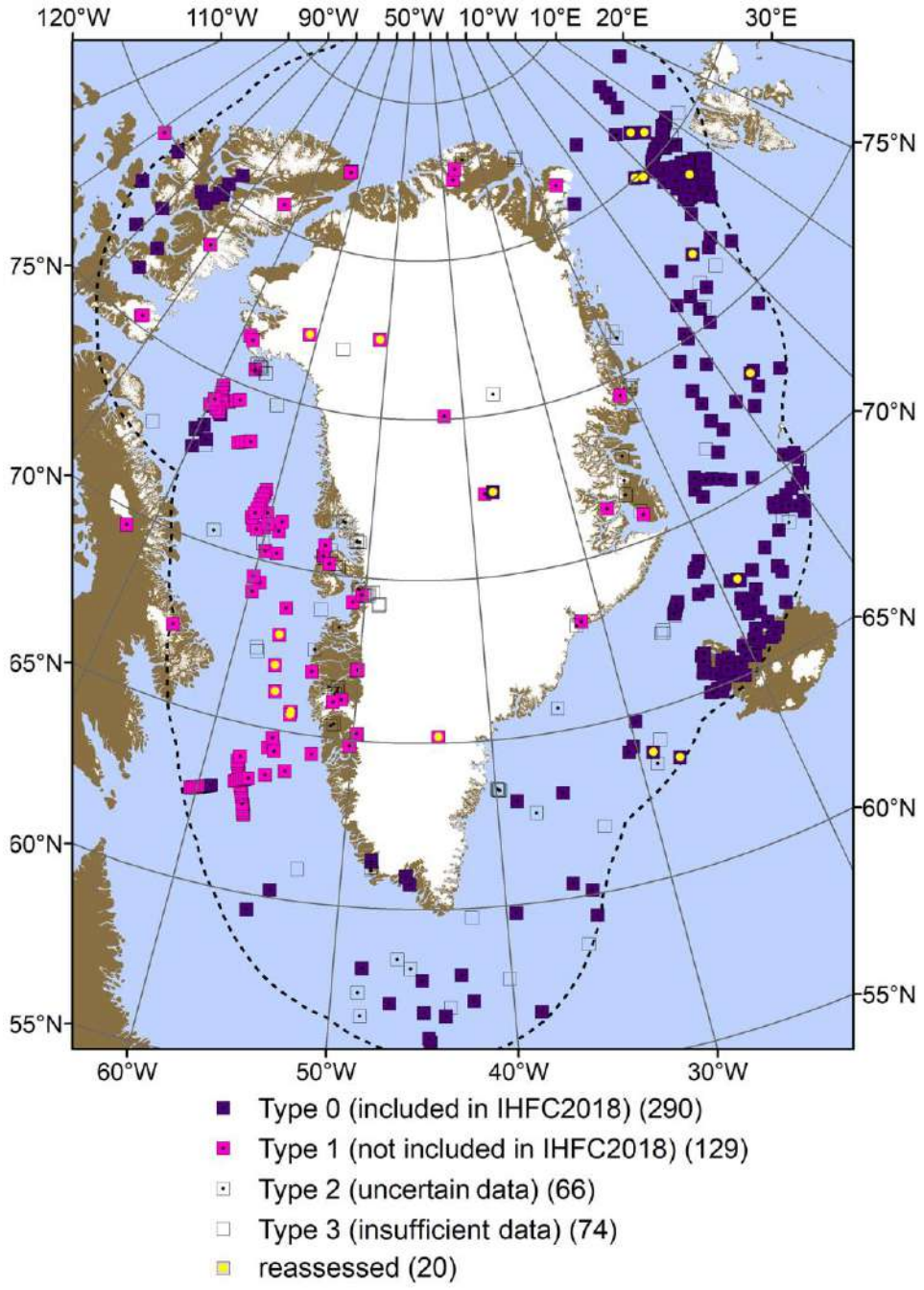
Earth Syst. Sci. Data, 14, 2209–2238, 2022
https://doi.org/10.5194/essd-14-2209-2022

Open Access Earth System Science Data

Greenland Geothermal Heat Flow Database and Map (Version 1)

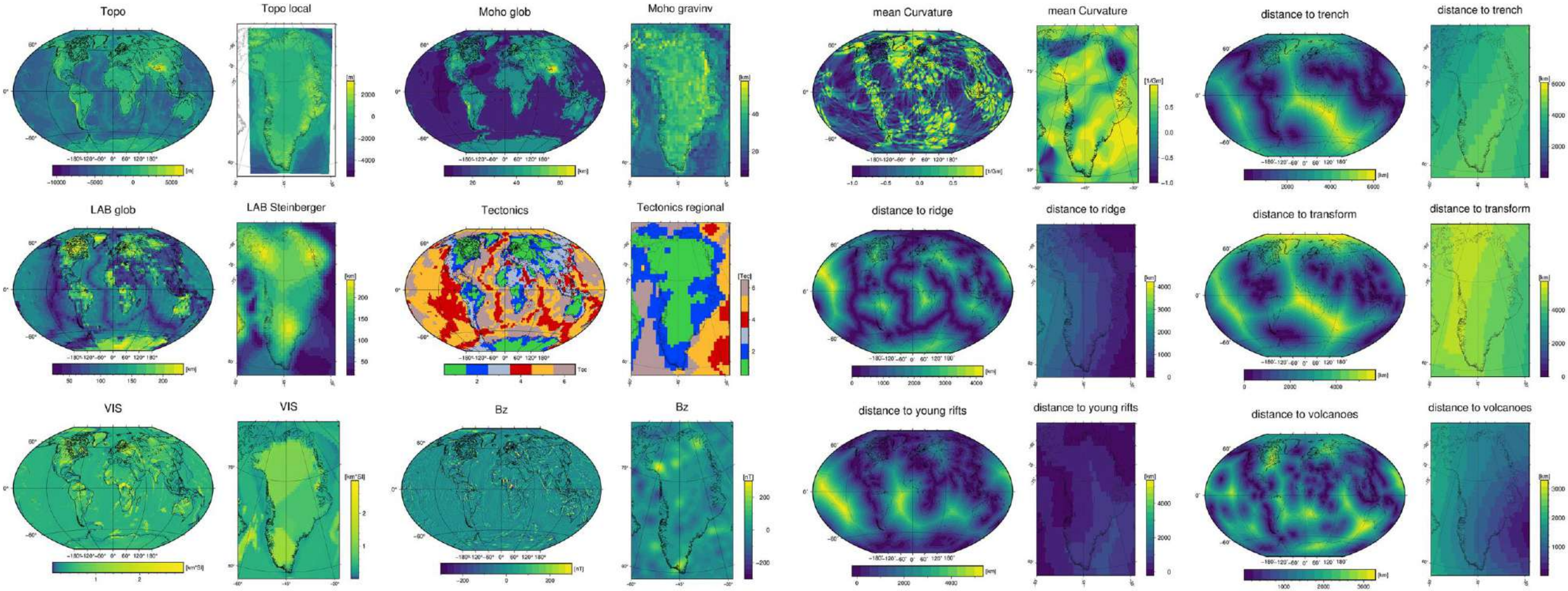
William Colgan[1], Agnes Wansing[2], Kenneth Mankoff[1], Mareen Lösing[2], John Hopper[1], Keith Louden[3], Jörg Ebbing[2], Flemming G. Christiansen[1], Thomas Ingeman-Nielsen[4], Lillemor Claesson Liljedahl[5], Joseph A. MacGregor[6], Árni Hjartarson[7], Stefan Bernstein[1], Nanna B. Karlsson[1], Sven Fuchs[8], Juha Hartikainen[9], Johan Liakka[9], Robert S. Fausto[1], Dorthe Dahl-Jensen[10], Anders Bjørk[11], Jens-Ove Naslund[9], Finn Mørk[1], Yasmina Martos[12], Niels Balling[13], Thomas Funck[1], Kristian K. Kjeldsen[1], Dorthe Petersen[14], Ulrik Gregersen[1], Gregers Dam[1], Tove Nielsen[1], Shfaqat A. Khan[15], and Anja Løkkegaard[1]

How have we improved the Greenland heat flow map?



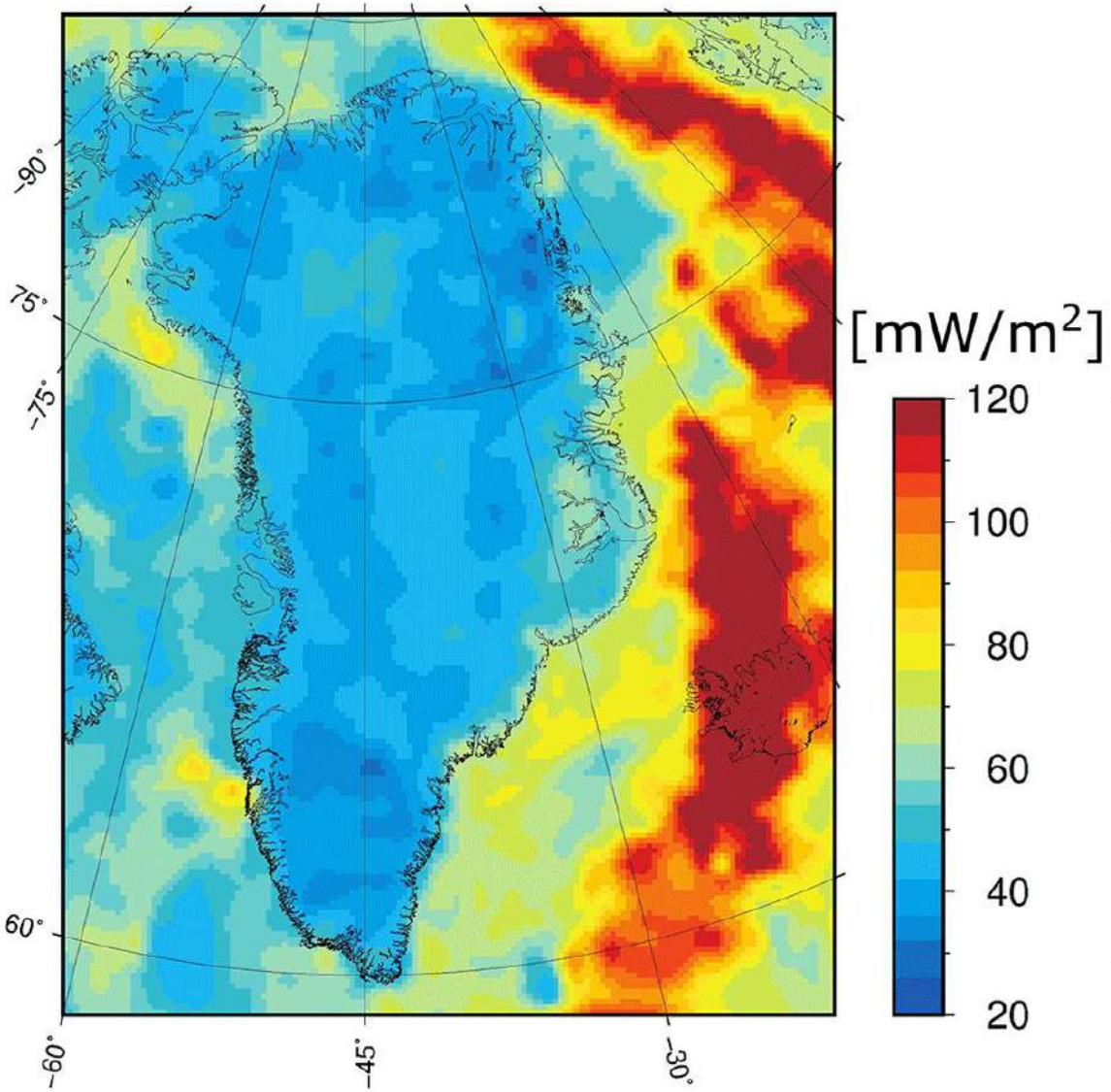
290 existing IHFC
129 new
- **88 submarine**
- **24 subglacial**
- **17 subaerial**

How did we convert point observations into a map?



12 geophysical datasets to predict heat flow through machine learning

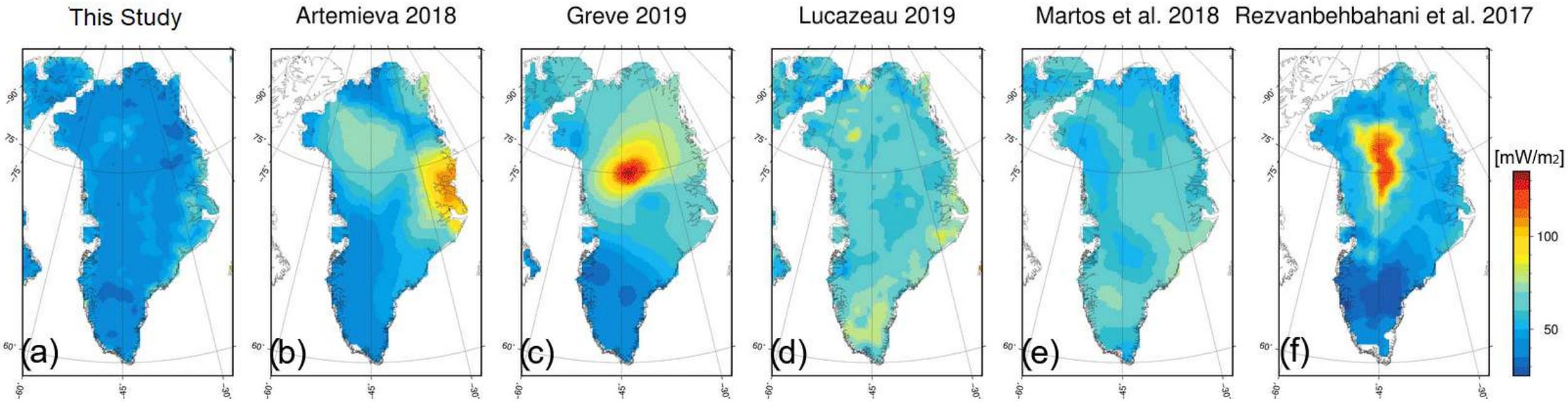
What does our new model of Greenland heat flow look like?



"Cold Greenland" model (seamless)

Model	Min [mW m^{-2}]	Mean [mW m^{-2}]	Max [mW m^{-2}]
This study (without NGRIP)	28	44	76
This study (with NGRIP)	29	48	102
Rezvanbehbahani et al. (2017)	20	54	124
Artemieva (2019)	40	58	108
Martos et al. (2018)	50	60	75
Greve (2019)	32	62	130
Lucazeau (2019)	46	64	83

Which geothermal heat flow map to use for ISMIP7?



Several choices for the ice-sheet basal boundary condition!

Which geothermal heat flow map to use for ISMIP7?

Model	Number of Greenland heat flow measurements			Number of geophysical datasets	Interpolation method
	Onshore		Offshore		
	Subglacial	Subaerial			
This study	25	77	317	12	Machine learning
Rezvanbehbahani et al. (2017)	5	4	0	20	Machine learning
Artemieva (2019)	1	60	229	8	Thermal isostasy model
Martos et al. (2018)	6	2	0	5	Forward model
Greve (2019)	5	3	0	3	Paleoclimate and ice flow model
Lucazeau (2019)	4	62	248	14	Geostatistical model

Different approaches, geophysical data, and training data

How do the current generation of heat flow maps influence simulations?

The Cryosphere, 18, 387–402, 2024
https://doi.org/10.5194/tc-18-387-2024

The Cryosphere
Open Access
EGU

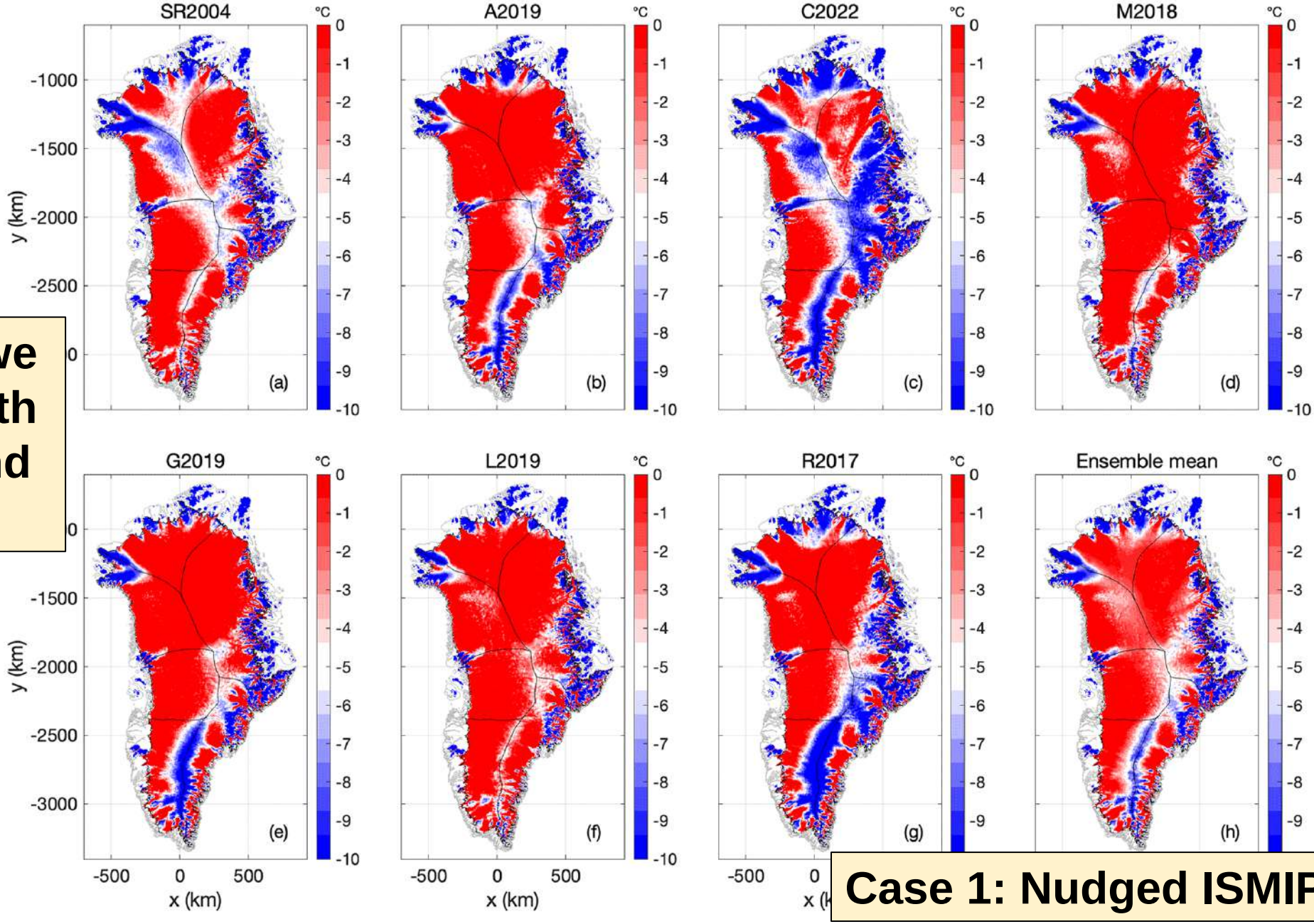
Evaluating different geothermal heat-flow maps as basal boundary conditions during spin-up of the Greenland ice sheet

Tong Zhang[1], William Colgan[2], Agnes Wansing[3], Anja Løkkegaard[2], Gunter Leguy[4], William H. Lipscomb[4], and Cunde Xiao[1]

[1]State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, Beijing, China
[2]Geological Survey of Denmark and Greenland, Copenhagen, Denmark
[3]Institute of Geosciences, Kiel University, Kiel, Germany
[4]Climate and Global Dynamics Laboratory, NSF National Center for Atmospheric Research, Boulder, CO, USA

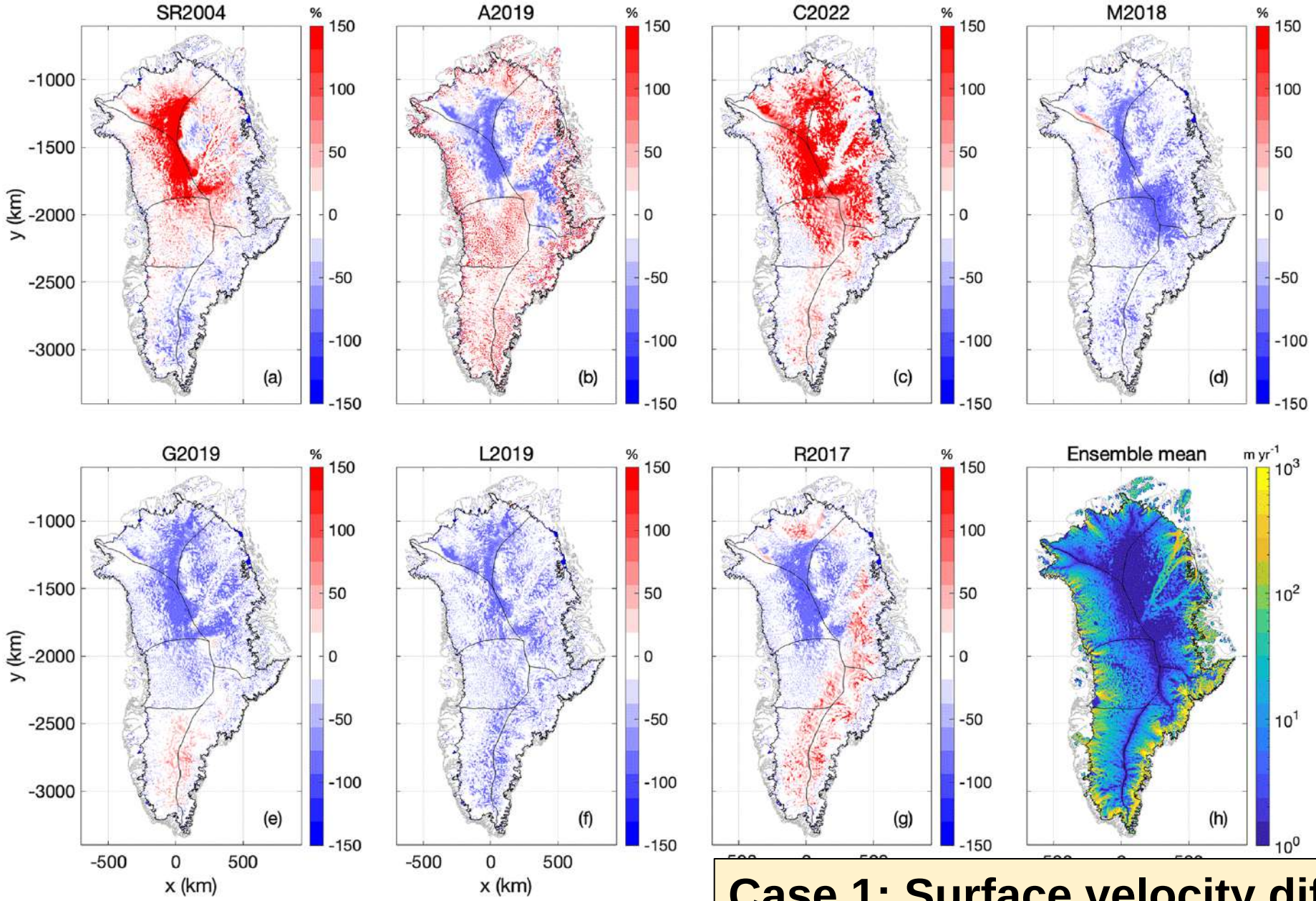
How do the current generation of heat flow maps influence simulations?

How do we keep North Greenland frozen?



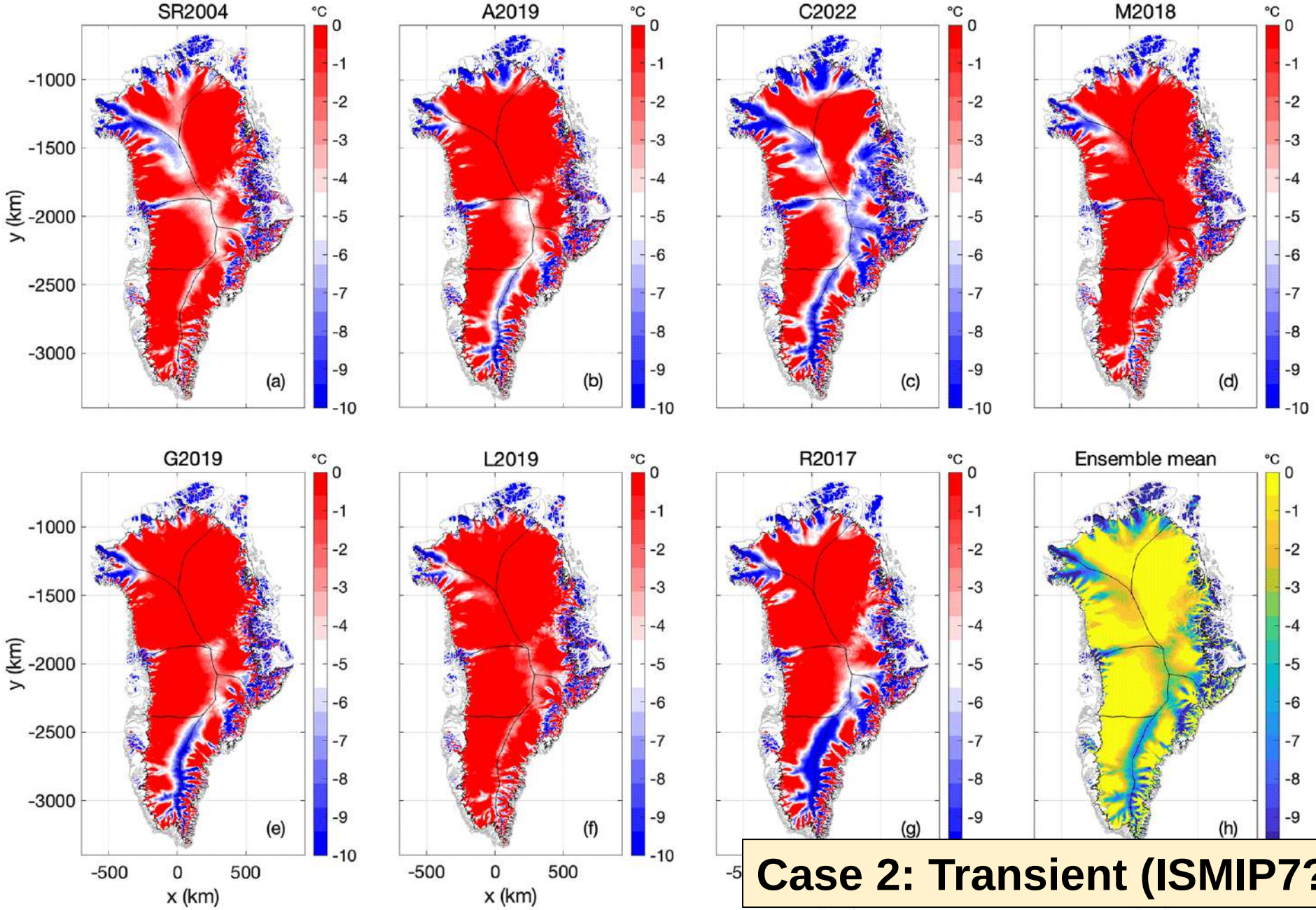
Case 1: Nudged ISMIP6 spin-up

How do the current generation of heat flow maps influence simulations?



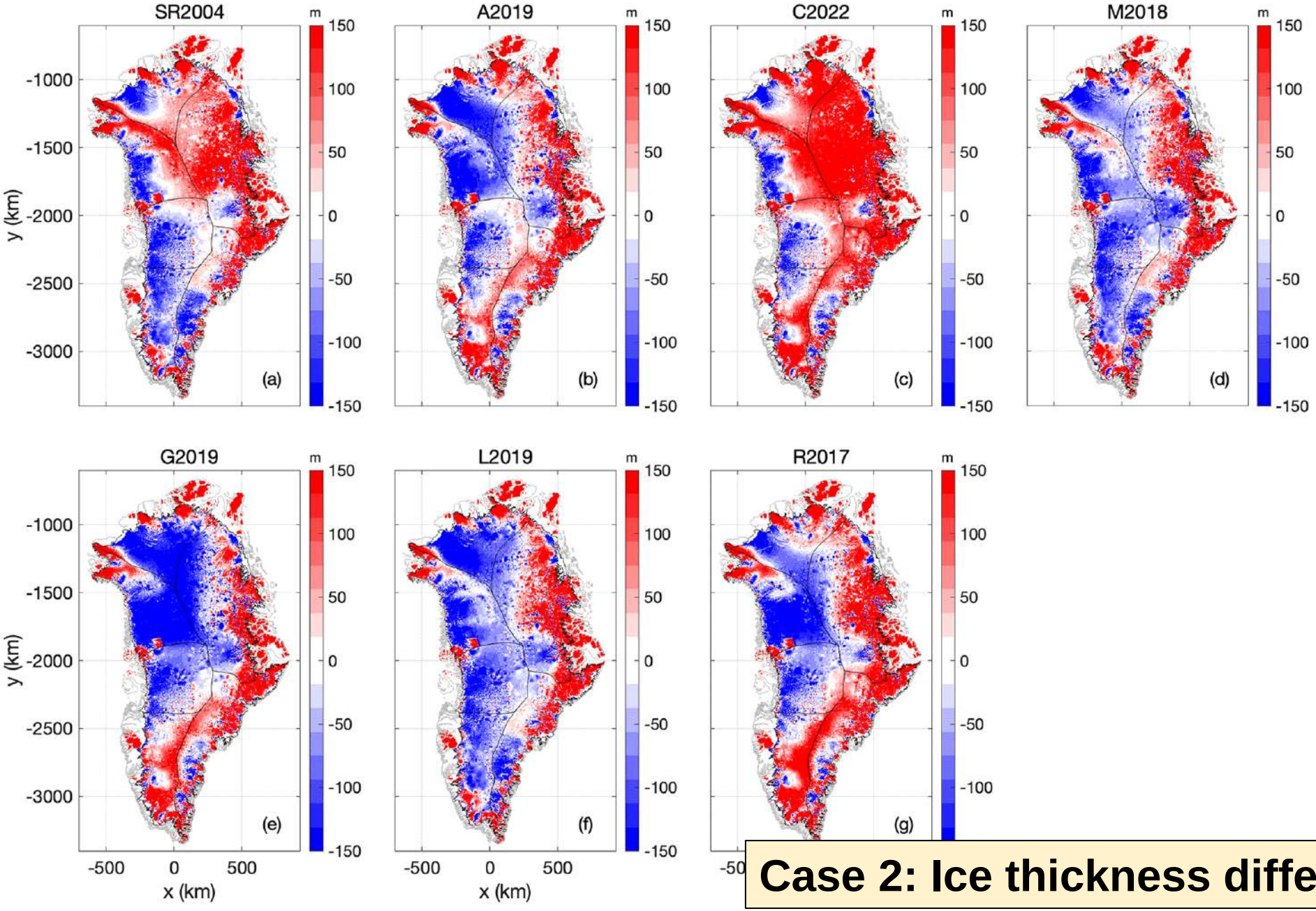
Case 1: Surface velocity differences

How do the current generation of heat flow maps influence simulations?



Case 2: Transient (ISMIP7?) spin-up

How do the current generation of heat flow maps influence simulations?



Case 2: Ice thickness differences

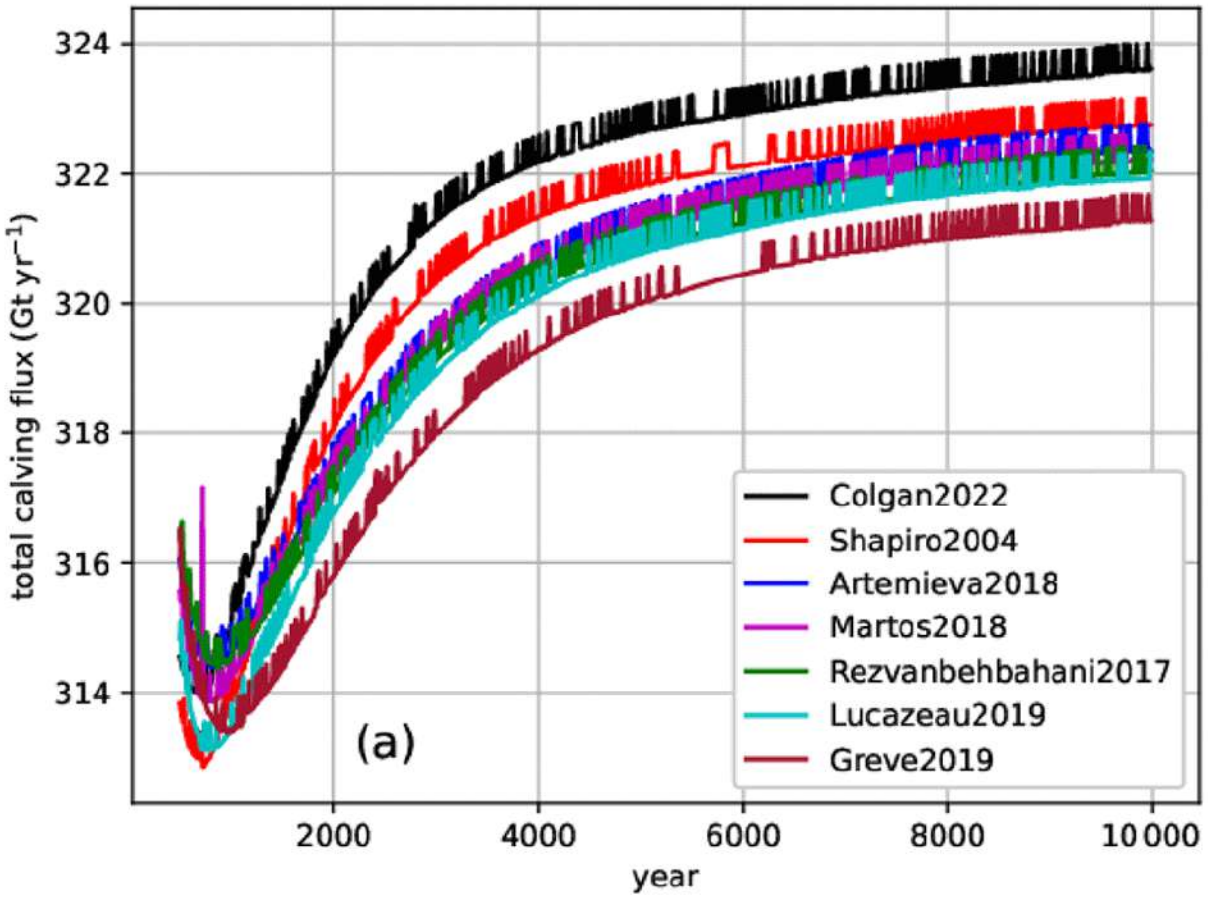
What is the heat flow influence on ice-sheet sensitivity?

Name	Reference	Case 1	Case 2
C2022	Colgan et al. (2022)	21.8 %	33.5 %
R2017	Rezvanbehbahani et al. (2017)	43.0 %	48.0 %
SR2004	Shapiro and Ritzwoller (2004)	35.5 %	44.3 %
A2019	Artemieva (2019)	50.2 %	52.8 %
M2018	Martos et al. (2018)	54.4 %	60.0 %
G2019	Greve (2019)	53.6 %	57.4 %
L2019	Lucazeau (2019)	52.5 %	59.7 %

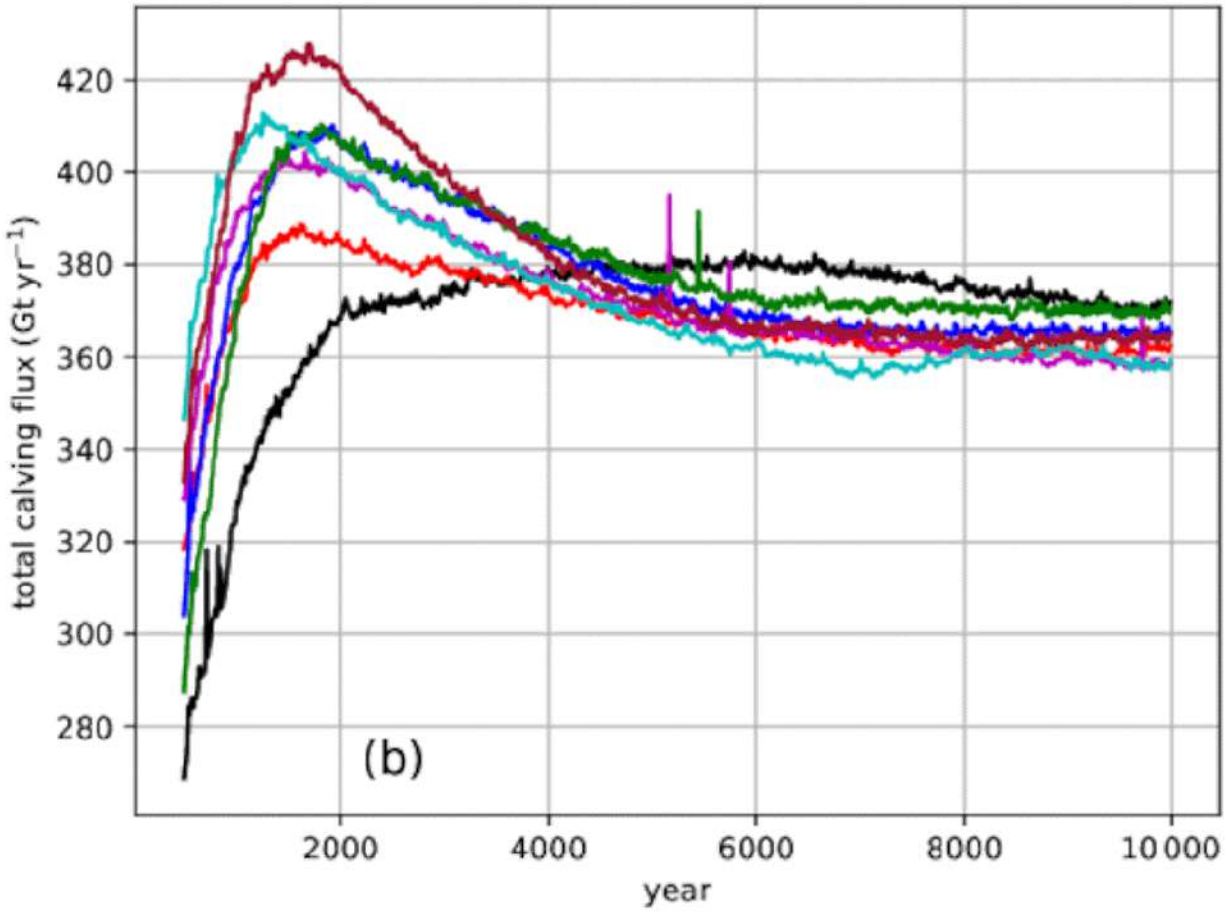
Temperate fraction of ice-bed interface

What is the heat flow influence on ice-sheet sensitivity?

Case 1 (nudged)



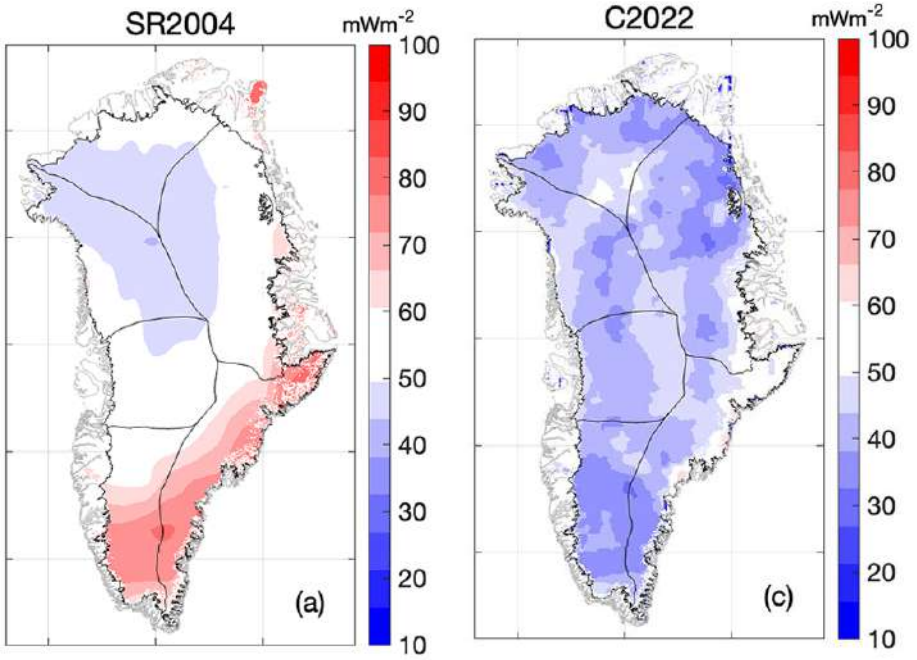
Case 2 (transient)

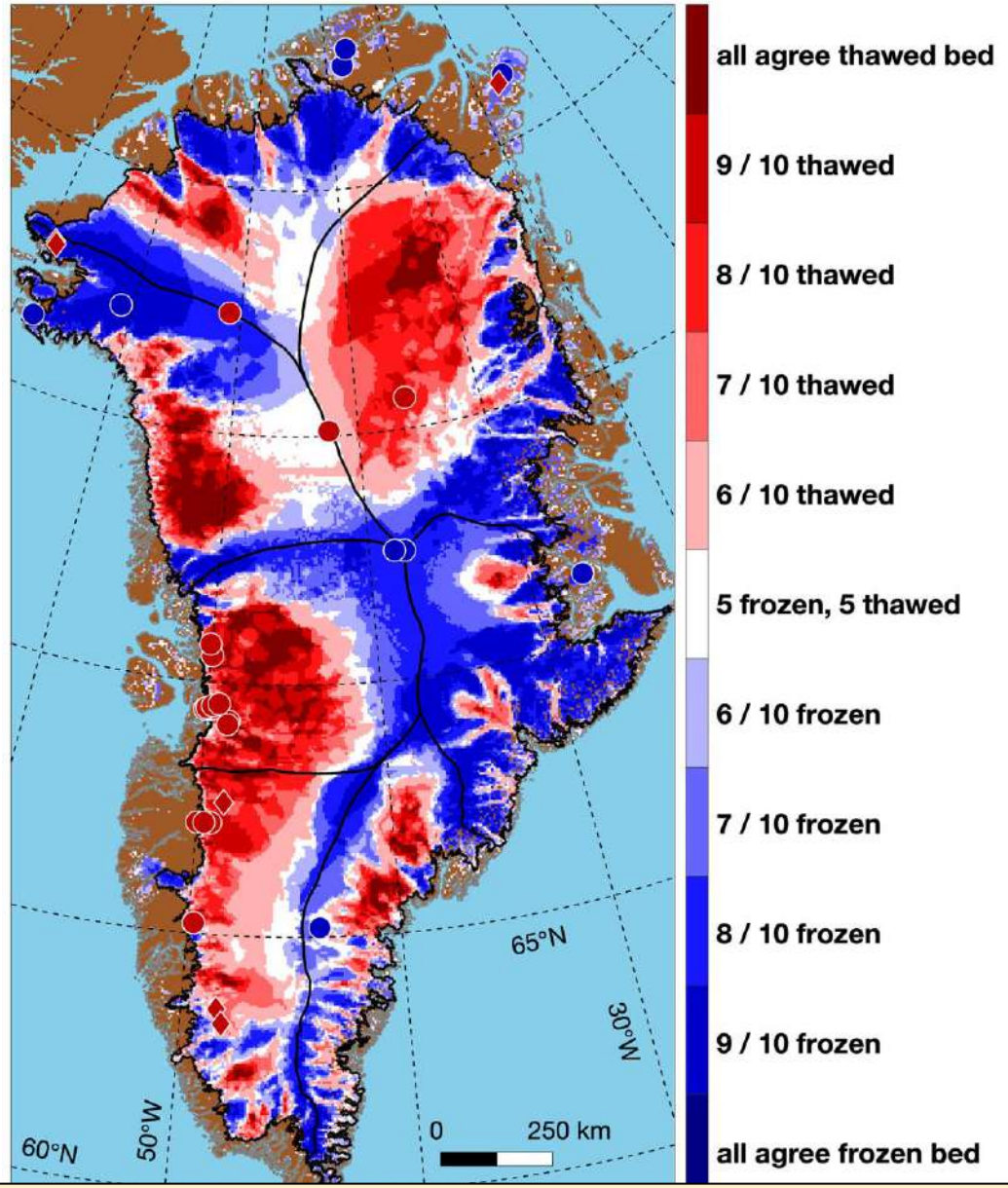


Differences in iceberg calving

How did geothermal heat flow map influence ISMIP6?

"Of the 21 Greenland model submissions to ISMIP6, 12 prescribed geothermal heat flow from a 20-year-old global heat flow product that had limited evaluation data and a known warm bias in South Greenland."





MacGregor et al., 2022, *The Cryosphere*

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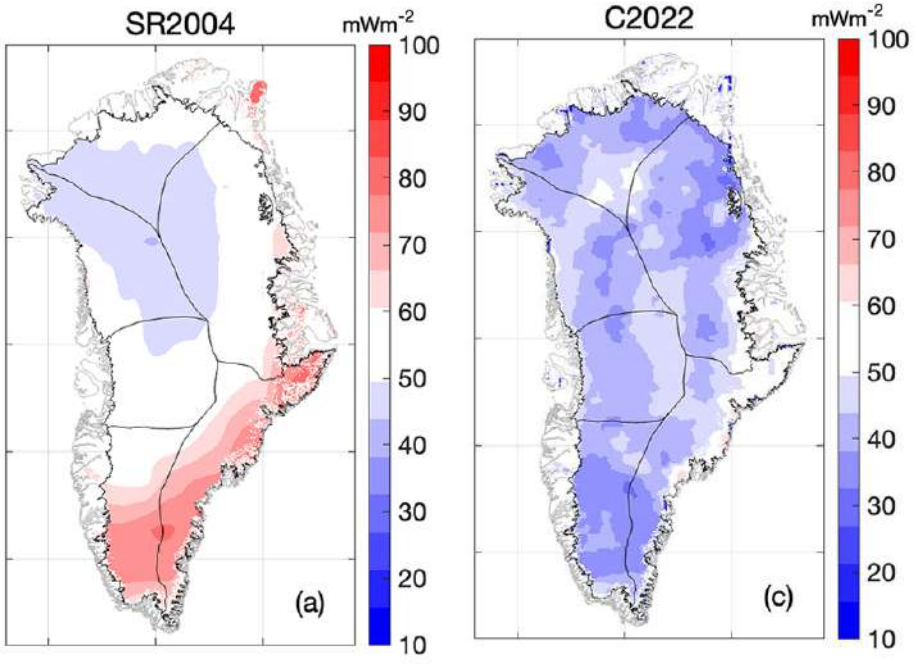
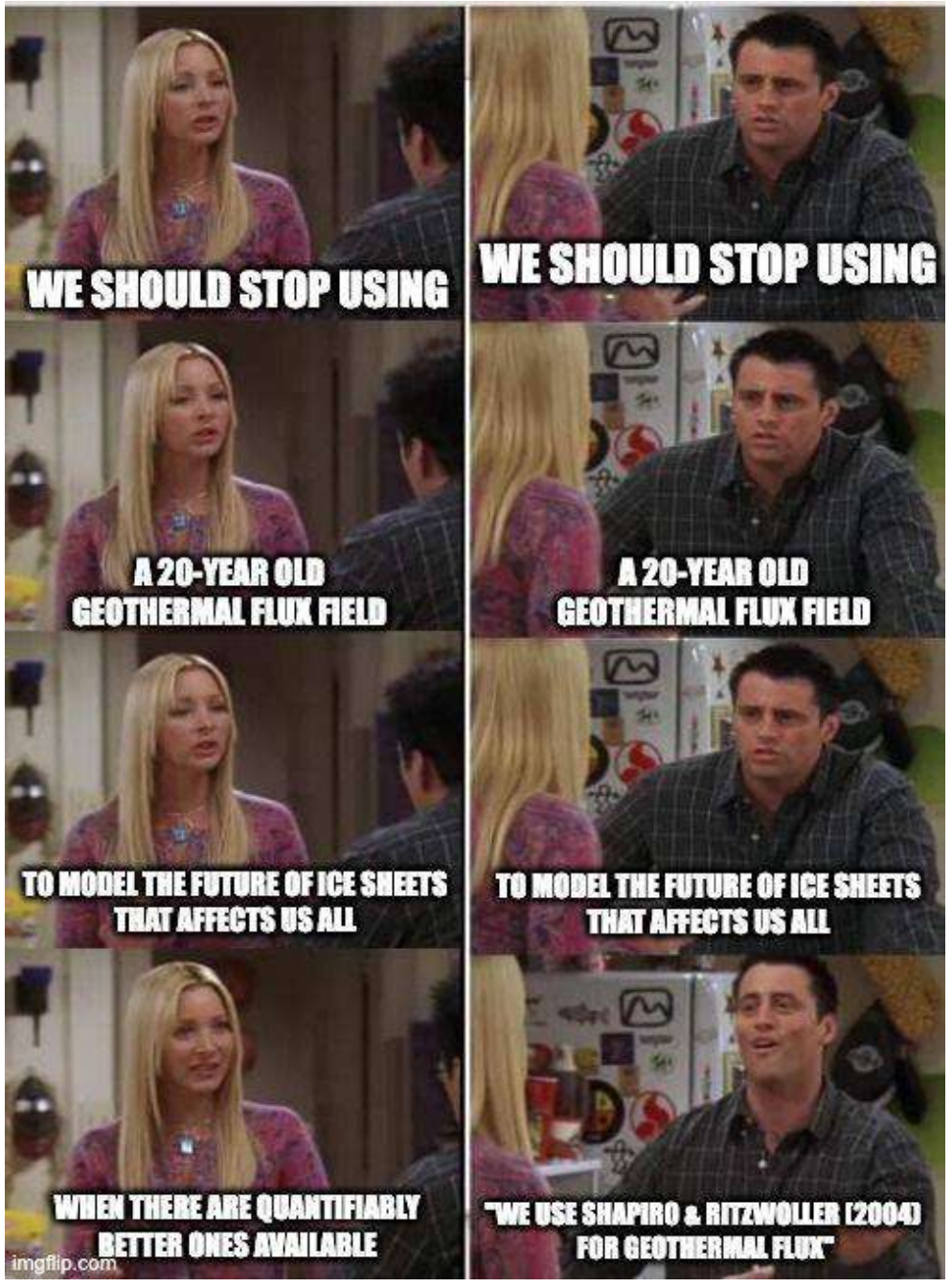
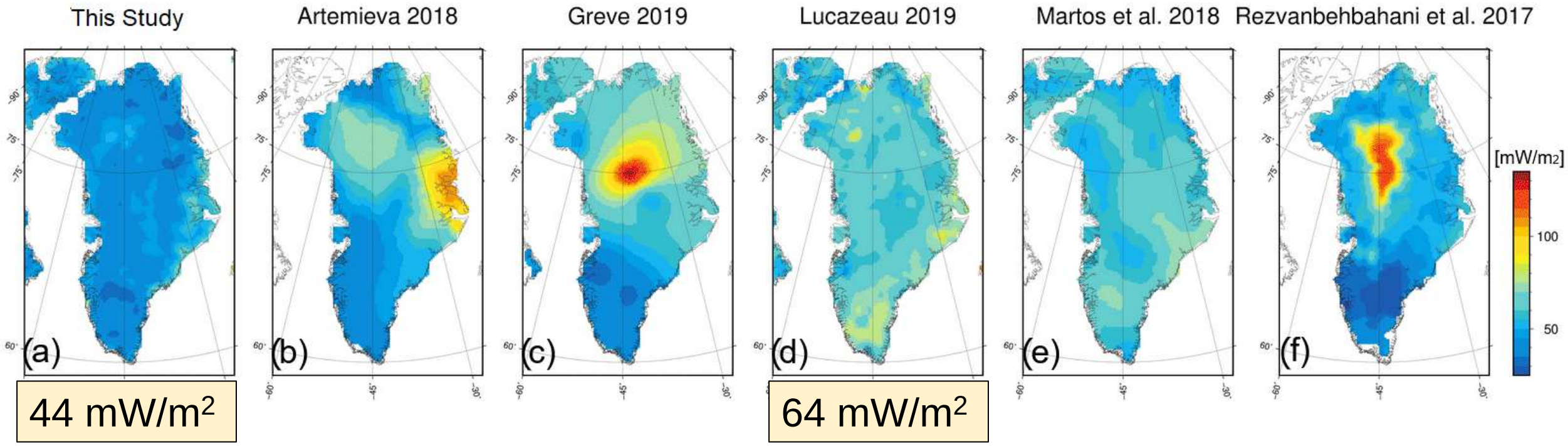




Looking ahead to ISMIP7

"We suggest that ISMIP7 should only employ newer and better validated geothermal heat-flow maps, namely those exhibiting high agreement against comprehensive observation datasets.

Similar to climatic forcing, ISMIP7 should explore the influence of geothermal heat flow forcing on simulated thermal state and ice flow."



Antarctica too!

The Cryosphere, 18, 1139–1155, 2024
https://doi.org/10.5194/tc-18-1139-2024

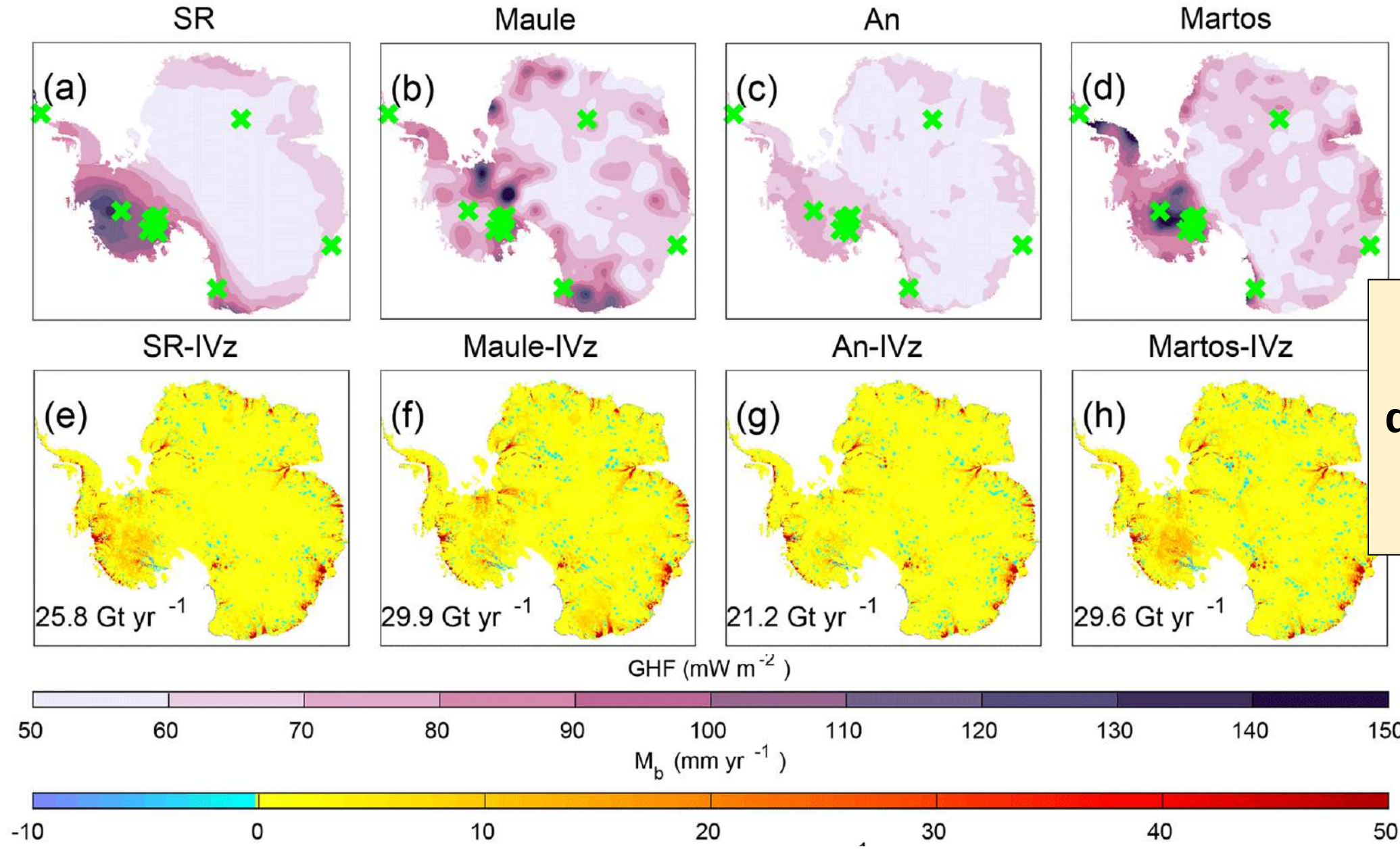
The Cryosphere Open Access EGU

Impact of boundary conditions on the modeled thermal regime of the Antarctic ice sheet

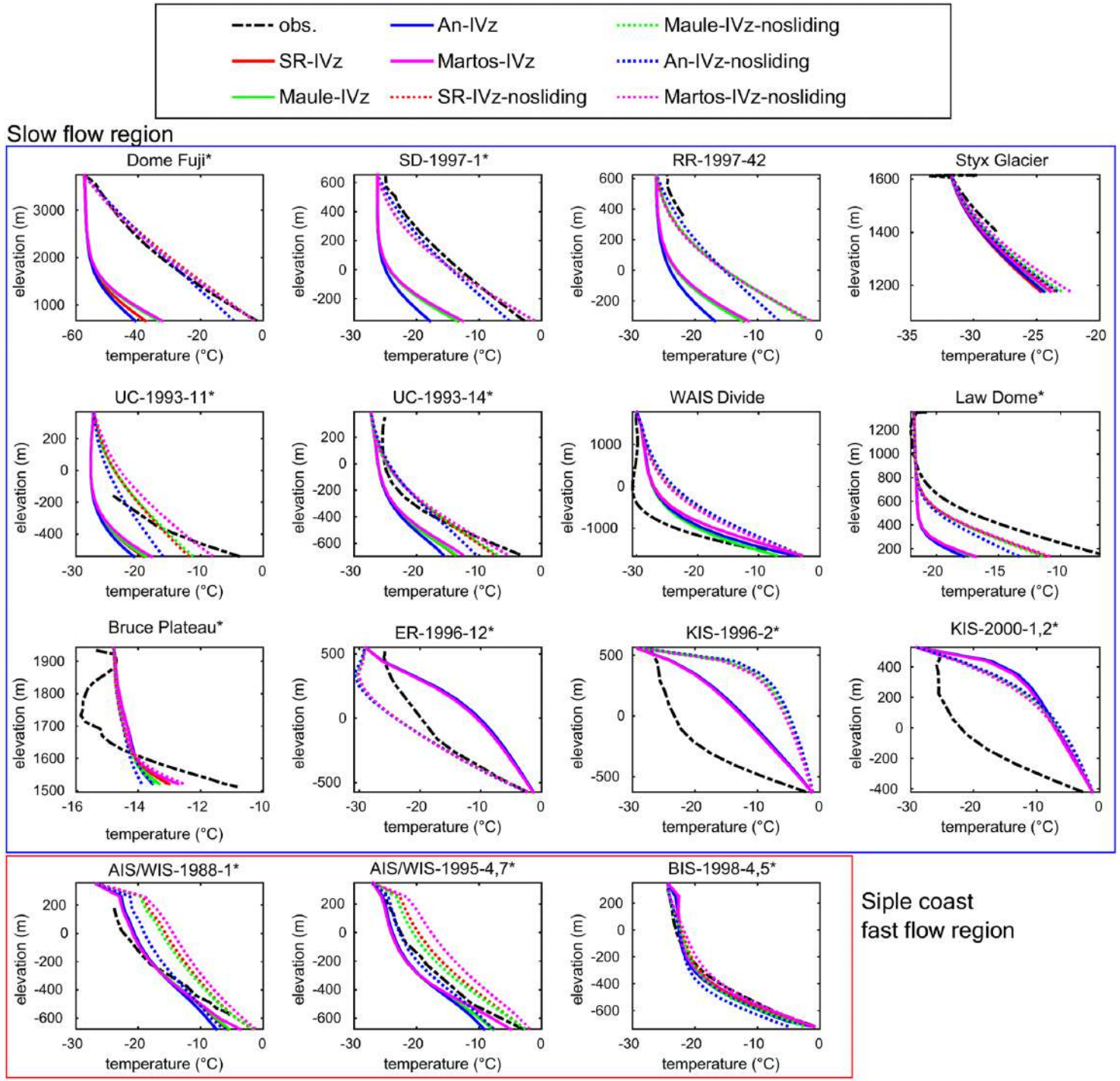
In-Woo Park[1,2], Emilia Kyung Jin[2], Mathieu Morlighem[3], and Kang-Kun Lee[1]

[1]School of Earth and Environmental Sciences, Seoul National University, Seoul, South Korea
[2]Korea Polar Research Institute, Incheon, South Korea
[3]Department of Earth Sciences, Dartmouth College, Hanover, NH, USA

Which geothermal heat flow map to use for ISMIP7?



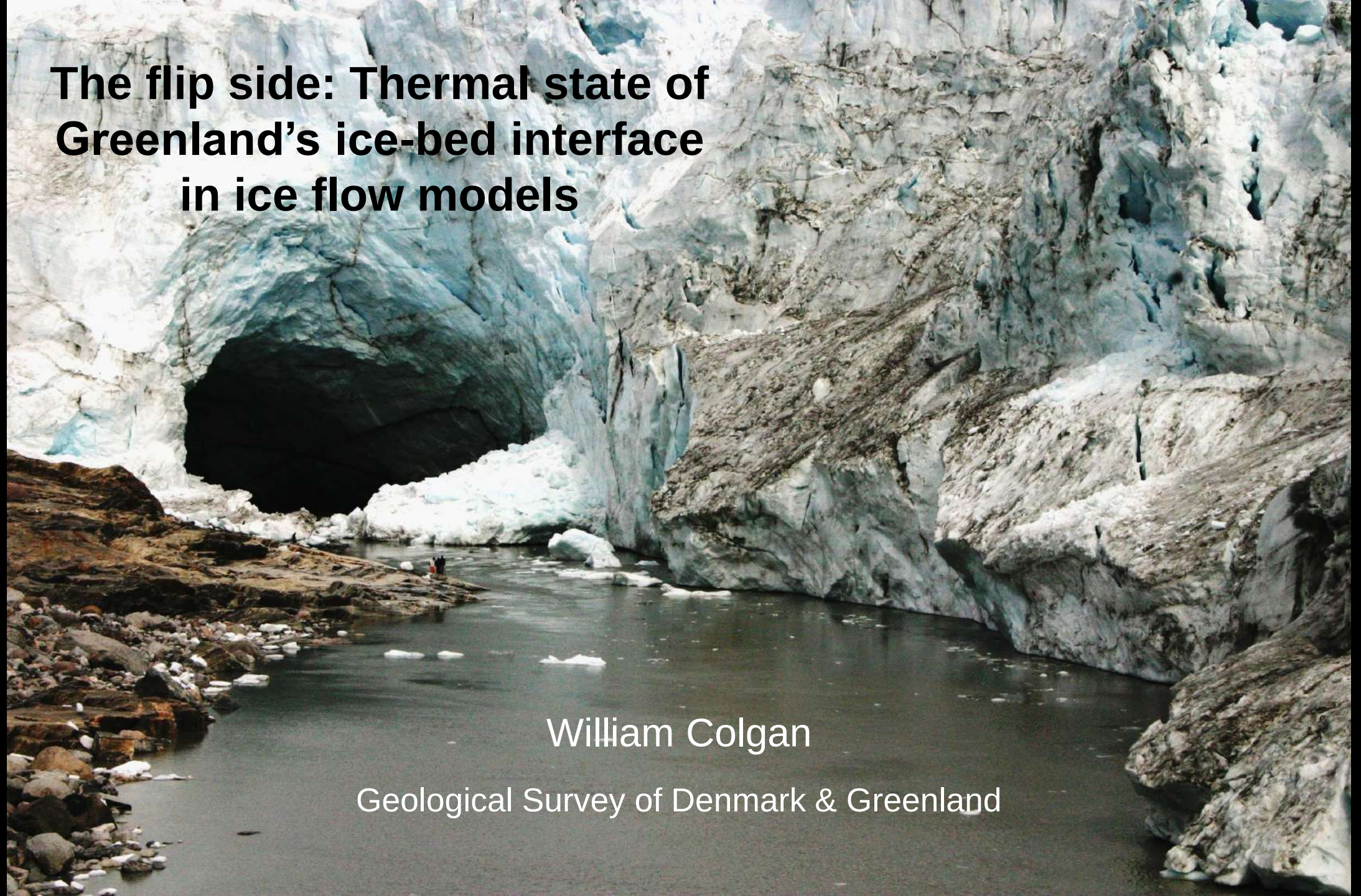
Absolute magnitude of differences can be larger than Greenland.



"We find that the impact of using different GHF fields has only a modest influence on the ice temperature field and the total grounded ice basal melting volume."

An2015 is too cold.

Temperature profiles more dependent on parameterization of vertical advection (accumulation and basal melt rates).



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