Seabed curtain interventions for ice sheet conservation: Jakobshavn and Thwaites compared

What role for glacioclimate engineering to mitigate climate change?

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- Climate-related all-time records
- Recent trends in planetary vital signs
- Scientists' warning recommendations
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JOURNAL ARTICLE

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BioScience, biad080, https://doi.org/10.1093/b

Published: 24 October 2023 **Article histor**

For several decades, scientists have consistently warned of a future marked by extreme climatic conditions because of escalating global temperatures caused by ongoing human activities that release harmful greenhouse gasses into the atmosphere. Unfortunately, time is up.

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https://doi.org/10.1038/s41467-023-42198-2

Rapid disintegration and weakening of ice shelves in North Greenland

Received: 11 June 2023

Accepted: 3 October 2023

R. Millan[1] ✉, E. Jager[1], J. Mouginot[1], M. H. Wood[2], S. H. Larsen[3], P. Mathiot[1], N. C. Jourdain[1] & A. Bjørk[4]

nature climate change

Article

https://doi.org/10.1038/s41558-023

Unavoidable future increase in West Antarctic ice-shelf melting over the twenty-first century

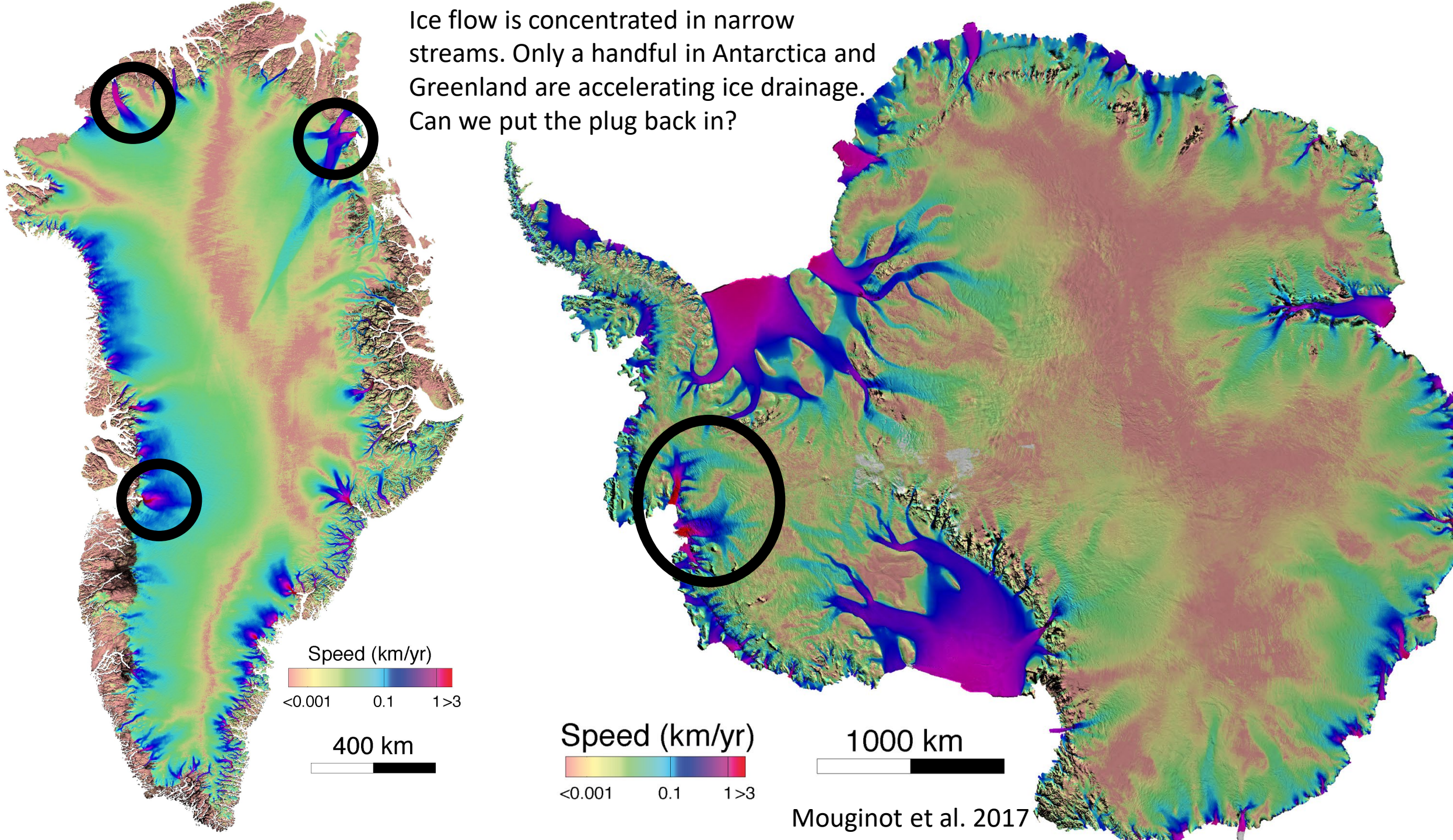
Received: 13 April 2023

Accepted: 23 August 2023

Kaitlin A. Naughten[1] ✉, Paul R. Holland[1] & Jan De Rydt[2]

FABRICE COFFRINI/AFP VIA GETTY IMAGES

Ice flow is concentrated in narrow streams. Only a handful in Antarctica and Greenland are accelerating ice drainage. Can we put the plug back in?

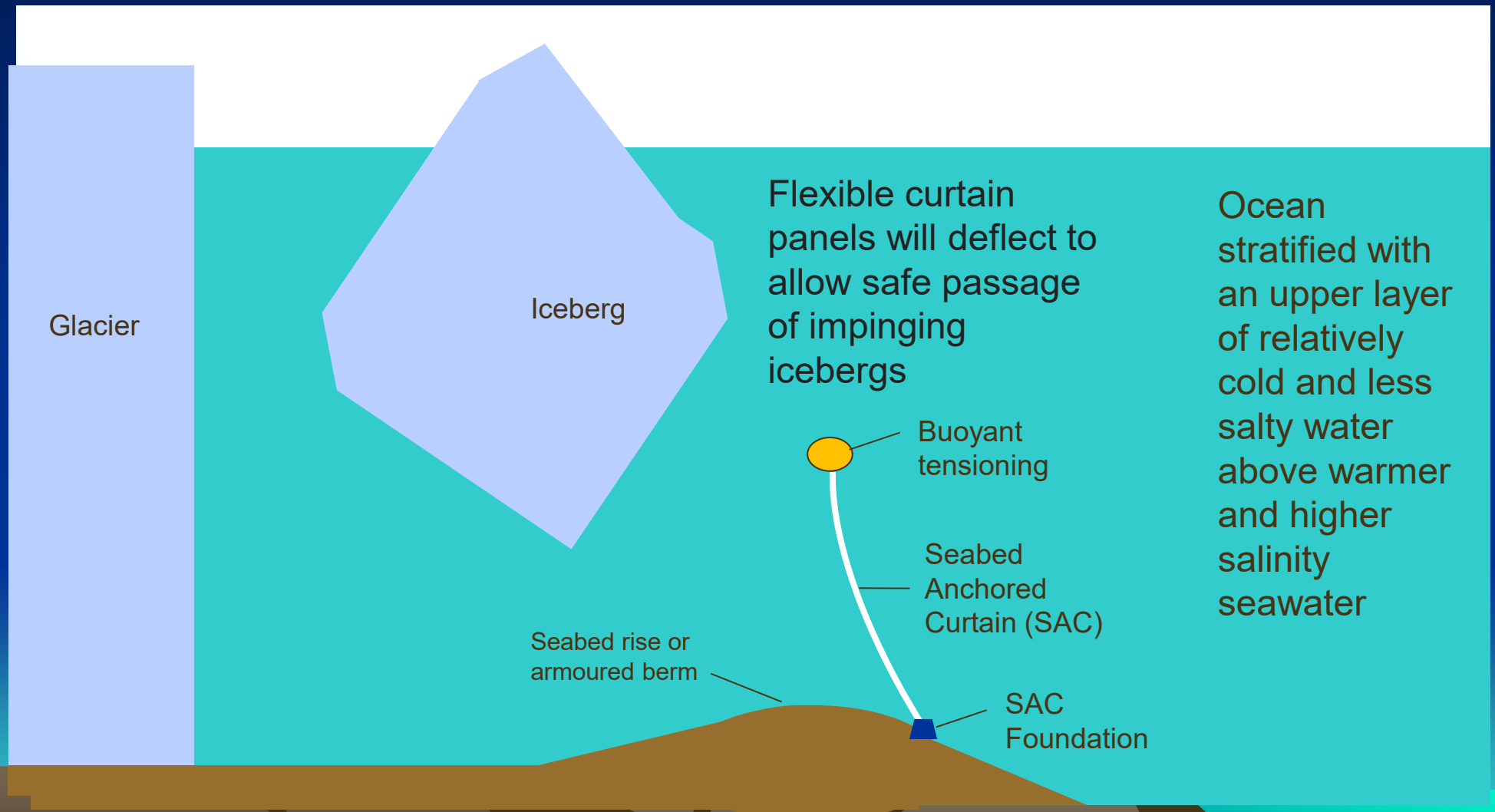


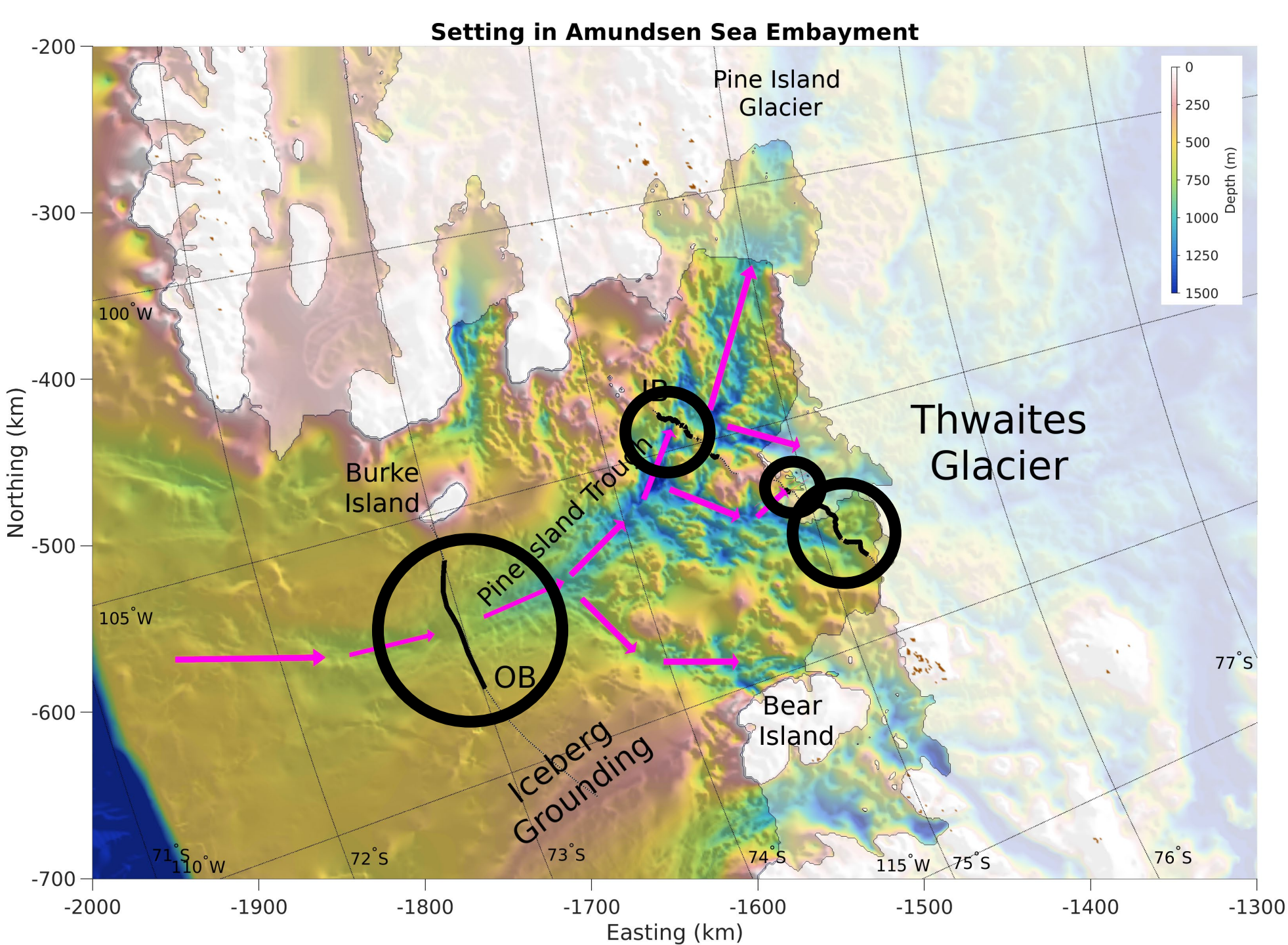
Mouginot et al. 2017

How does this save an ice sheet?

Seabed Anchored Curtain

Narrow outlet glaciers drain most of the ice sheets. Ocean melting is thinning them. Divert the warm deep waters. Conserve the ice sheet, avoid massive coastal protection. Removable. Massive leverage: x 1000



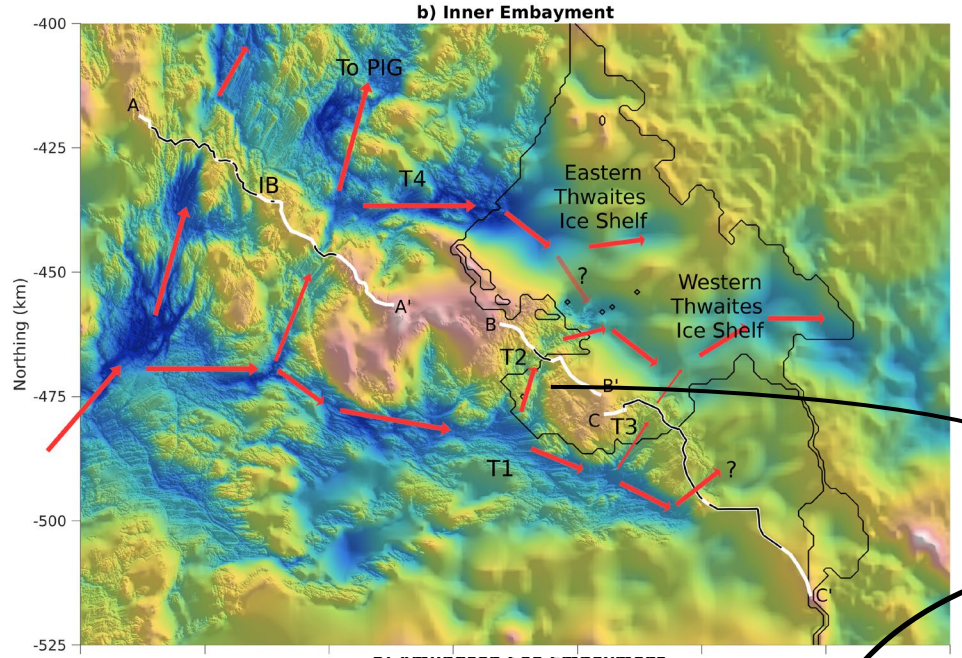


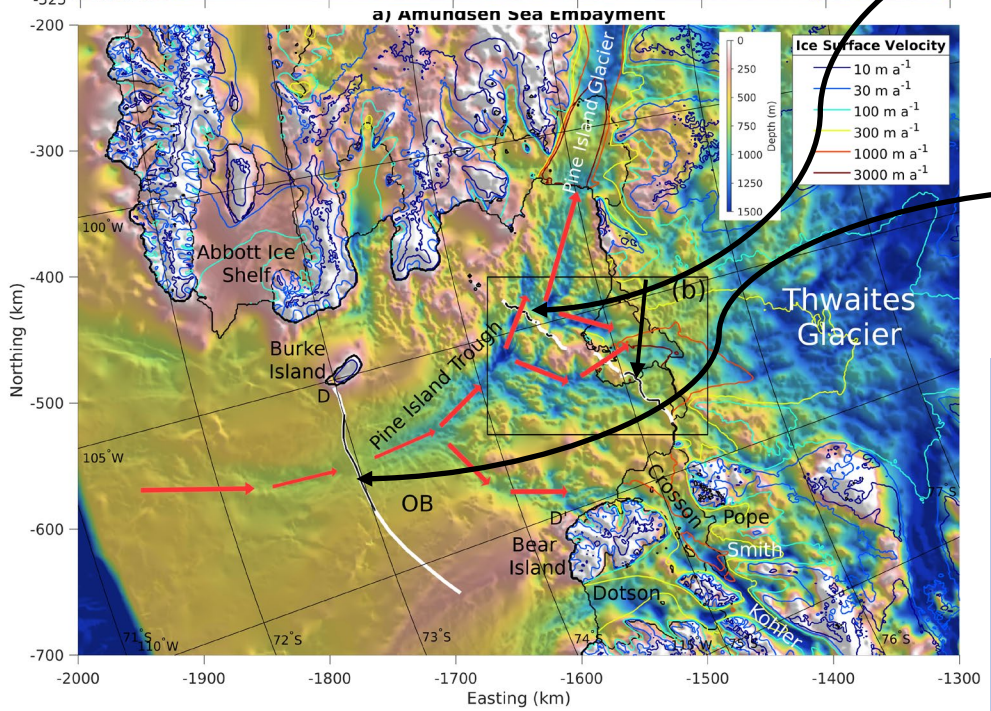
Keefer et al. 2023

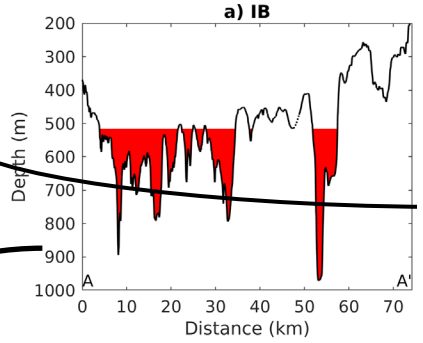
Siting curtains to divert deep warm waters

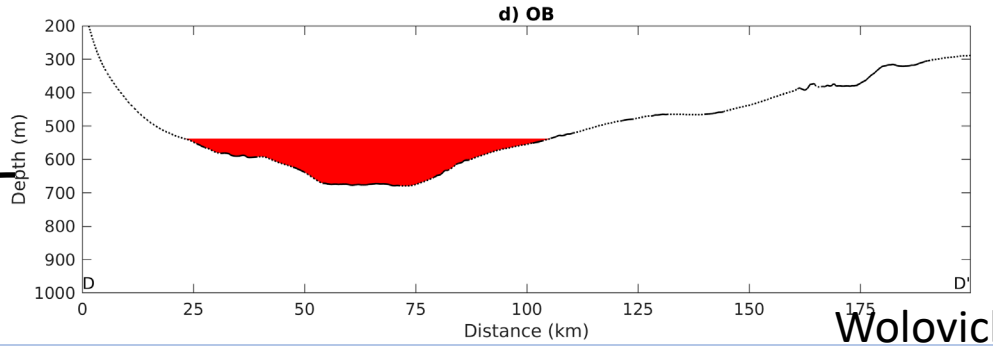
Western Thwaites is being rapidly eroded by warm deep waters flowing in narrow channels

Longer curtain protect more vulnerable glaciers









T2 is only 4.5 km across and is the route of warm water melting the most vulnerable ice shelf on the planet

Wolovick, Keefer, Moore: in Preps

Model of curtain includes static and dynamic loads
Cost function includes foundation depth, curtain length & height, iceberg impacts
Pre-fabricated elements installed using modified oil industry methods

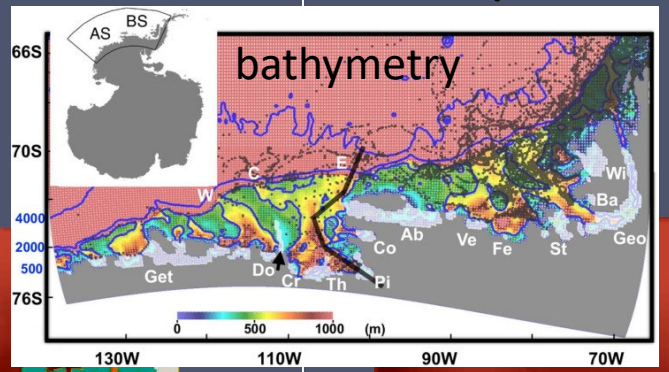
Diverted waters go to melt more stable glaciers

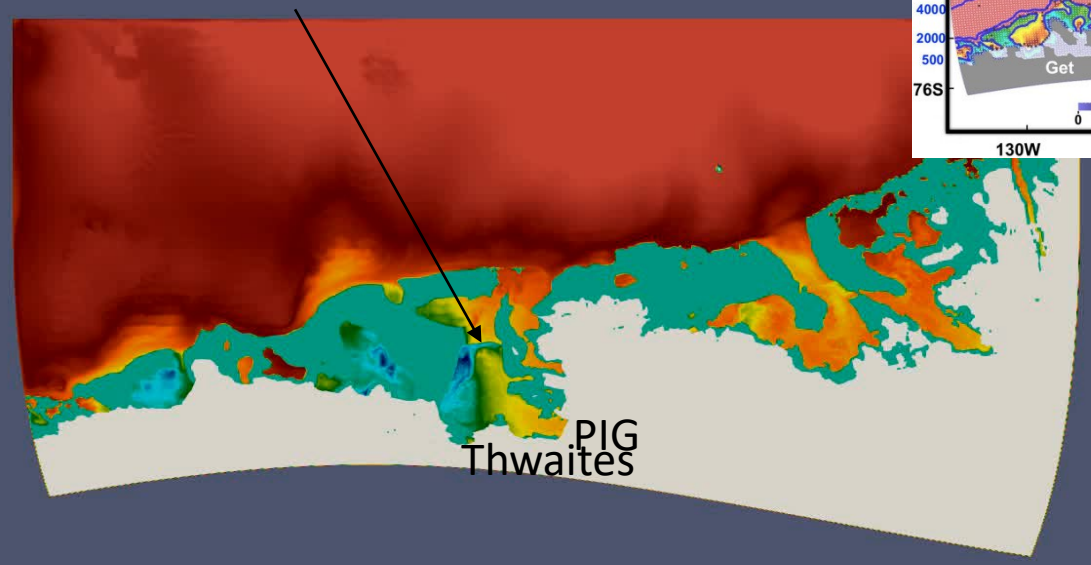
Hogan et al 2020 https://doi.org/10.5194/tc-14-2883-2020

e: 0.000000

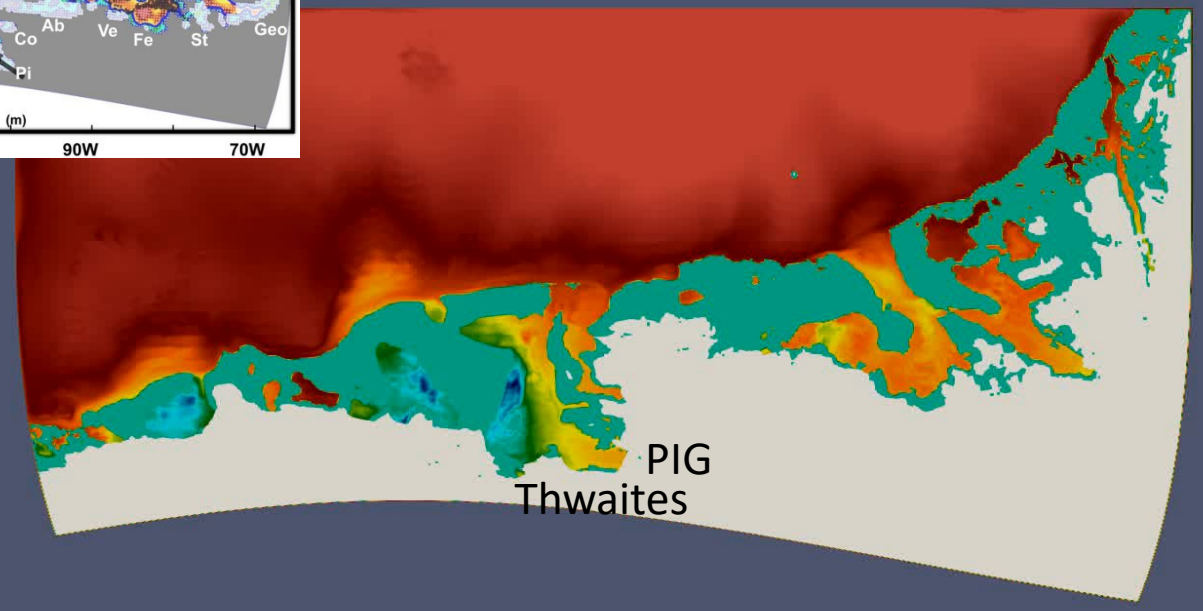
ERA-interim running 1992-2001 - 552 m potential temperature at 10 km resolution Amundsen&Bellingshausen Seas (Yoshihiro Nakayama, Hokkaido U)

Curtain at 400 m depth across OB channel

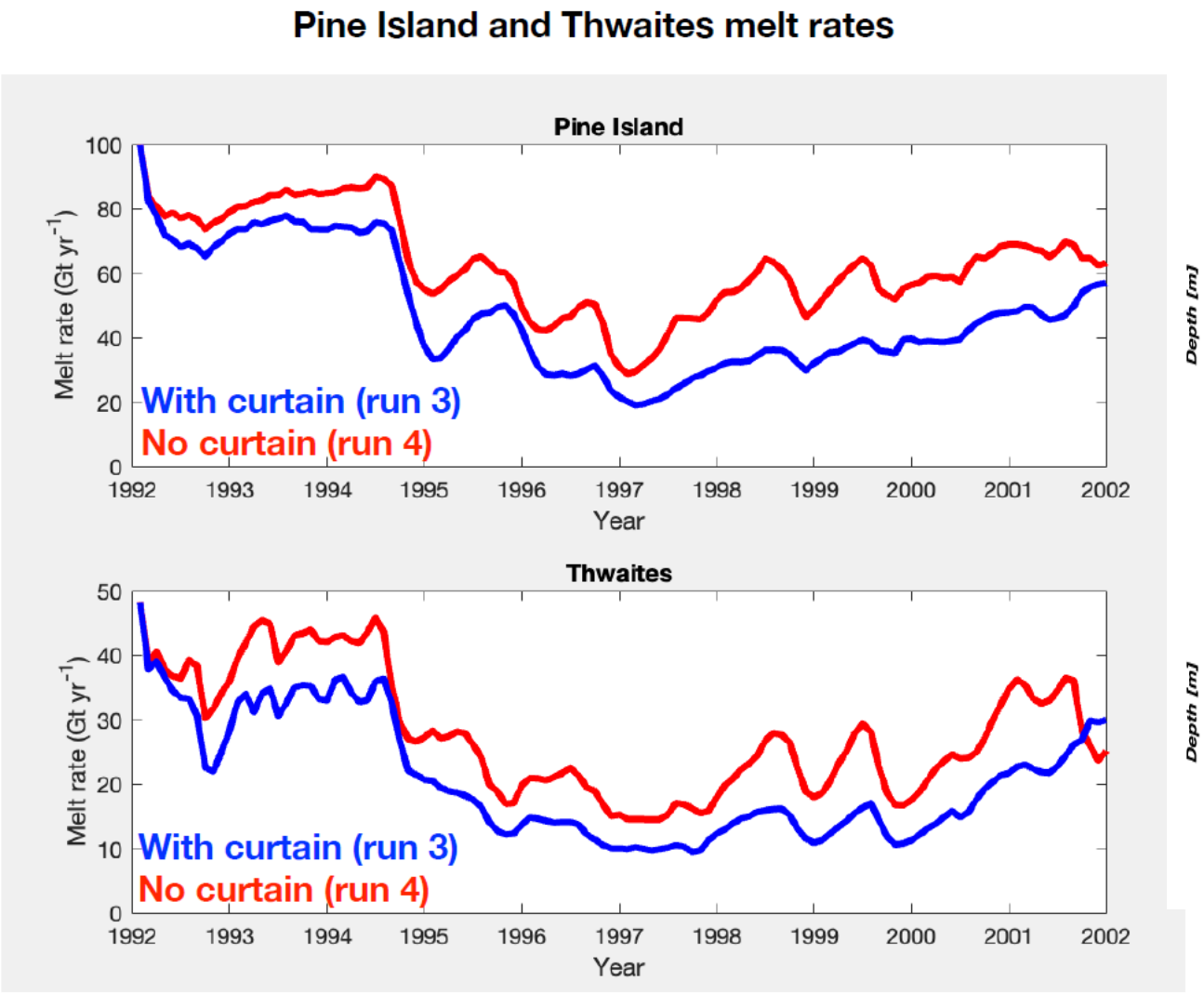


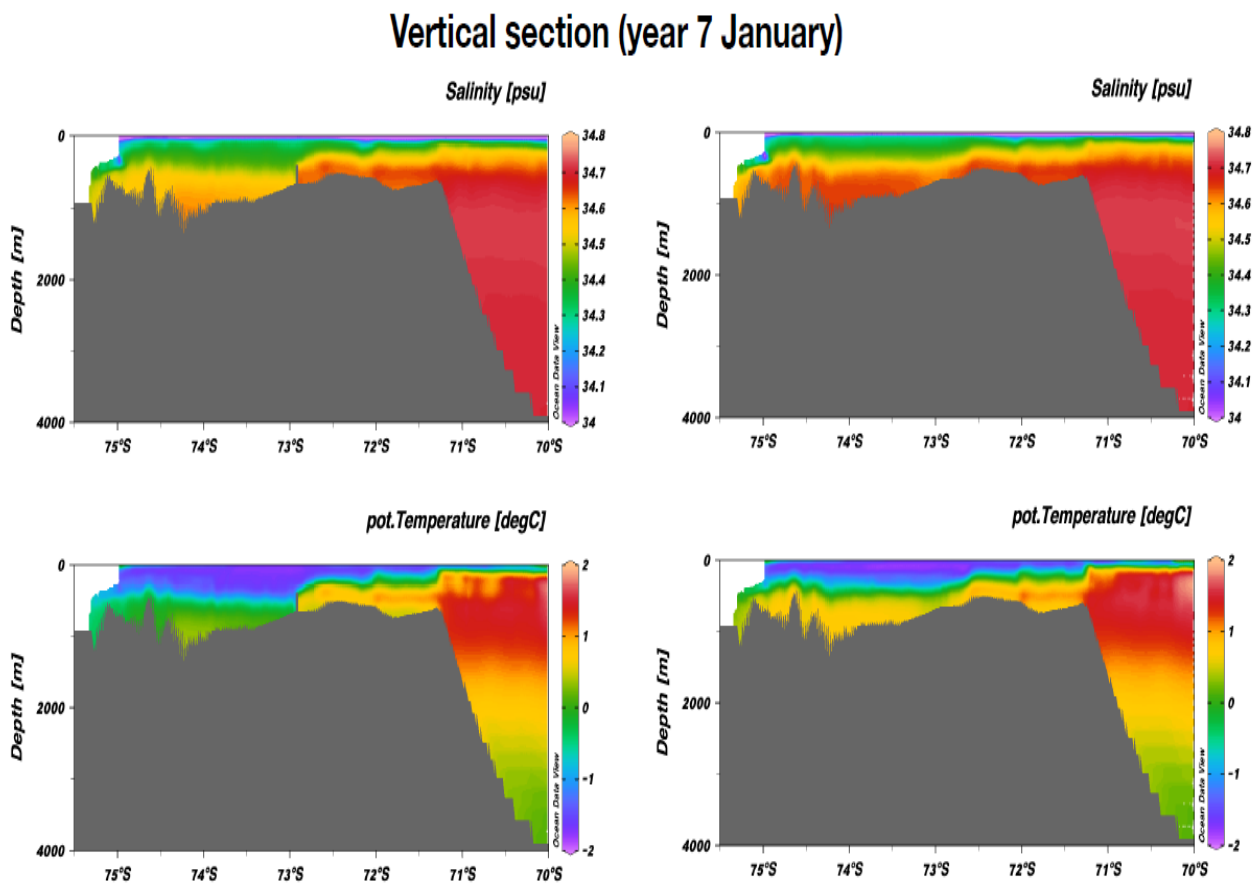


Control run, no curtain



Nakayama model melt rates

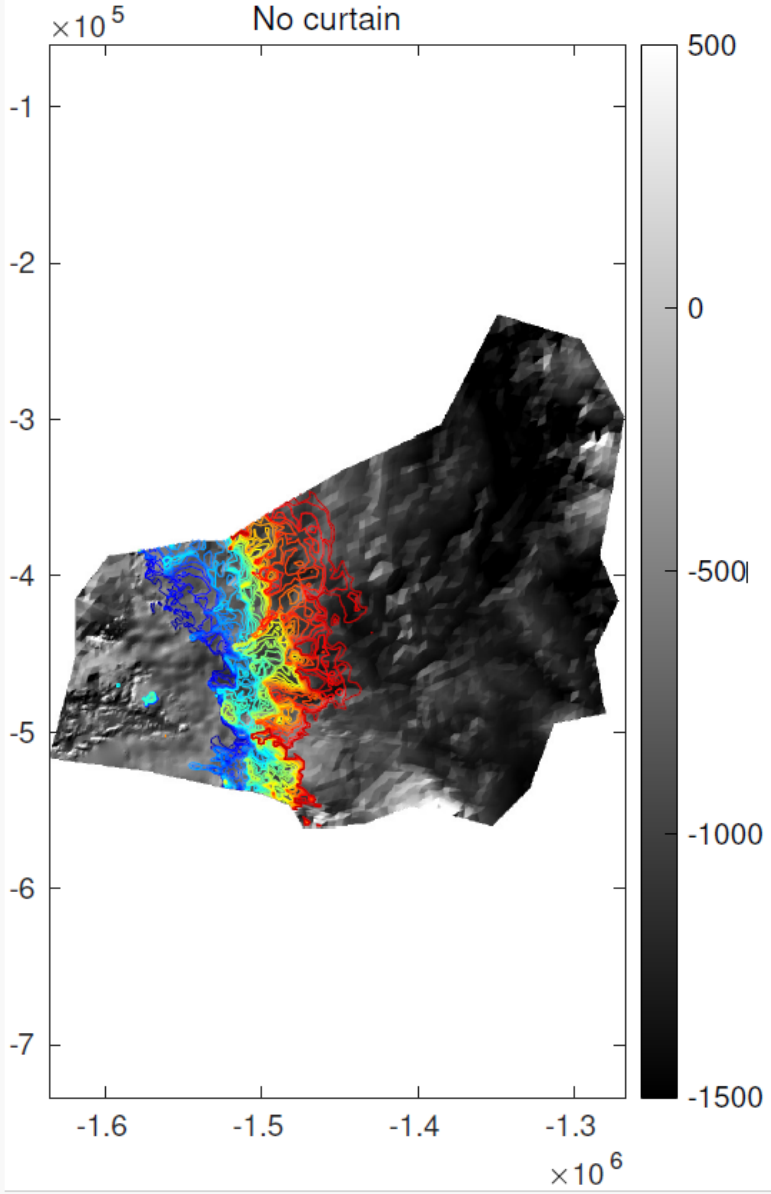


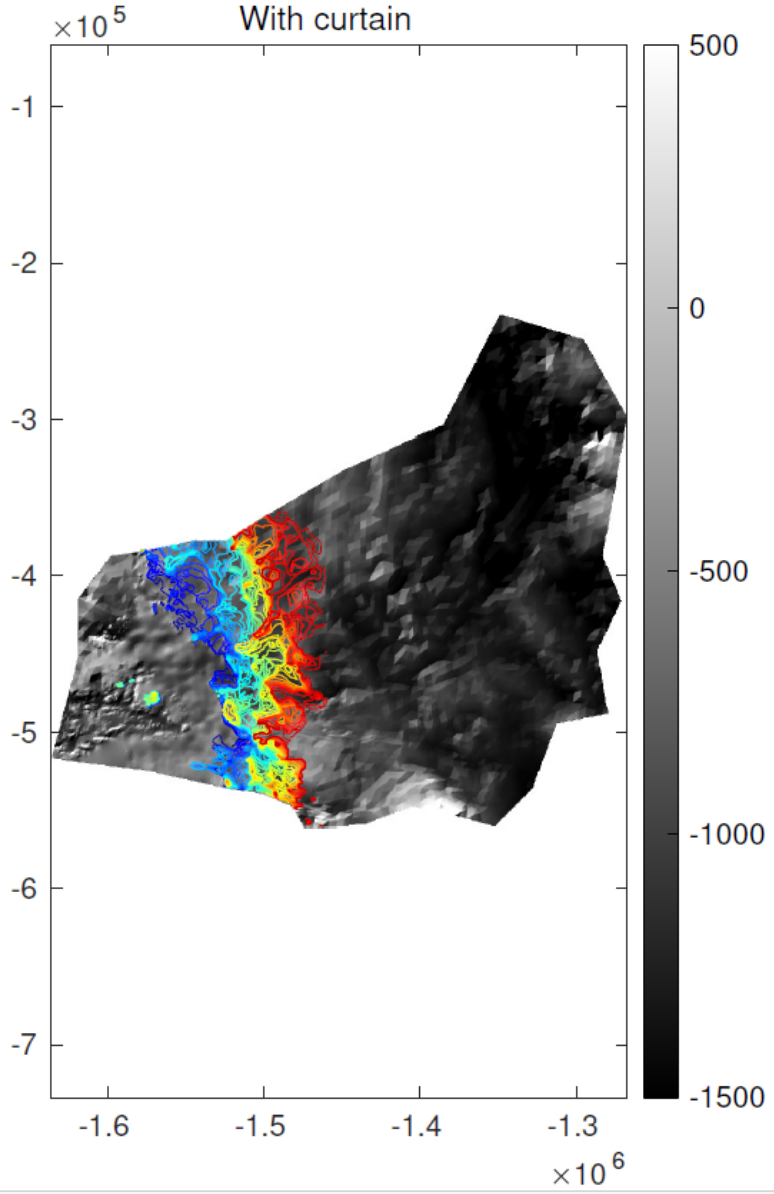


Curtain

No curtain

Big difference due to the curtain. Curtain top depth 400 m average height is 150 m, max 280 m, length 150 km. Sea depth ≈ 650 m





Morlighem ISSM model - simulation #1: **no curtain**, using Nakayama melt simulation is applied a melt of 25 m/yr at a depth of 700 m (linearly decreasing to 0 as we reach the surface)
- simulation #2: **with curtain**, same but with max melt = 20 m/yr below 700 m

300 years under constant SMB from RACMO, so we are only seeing the effect of a 5 m/yr reduction in melt under the ice shelf. Here is the pattern of grounding line retreat (1 line every 10 years)

Step by Step – climb carefully Thwaites is a goal - not the start

Thwaites & PIG

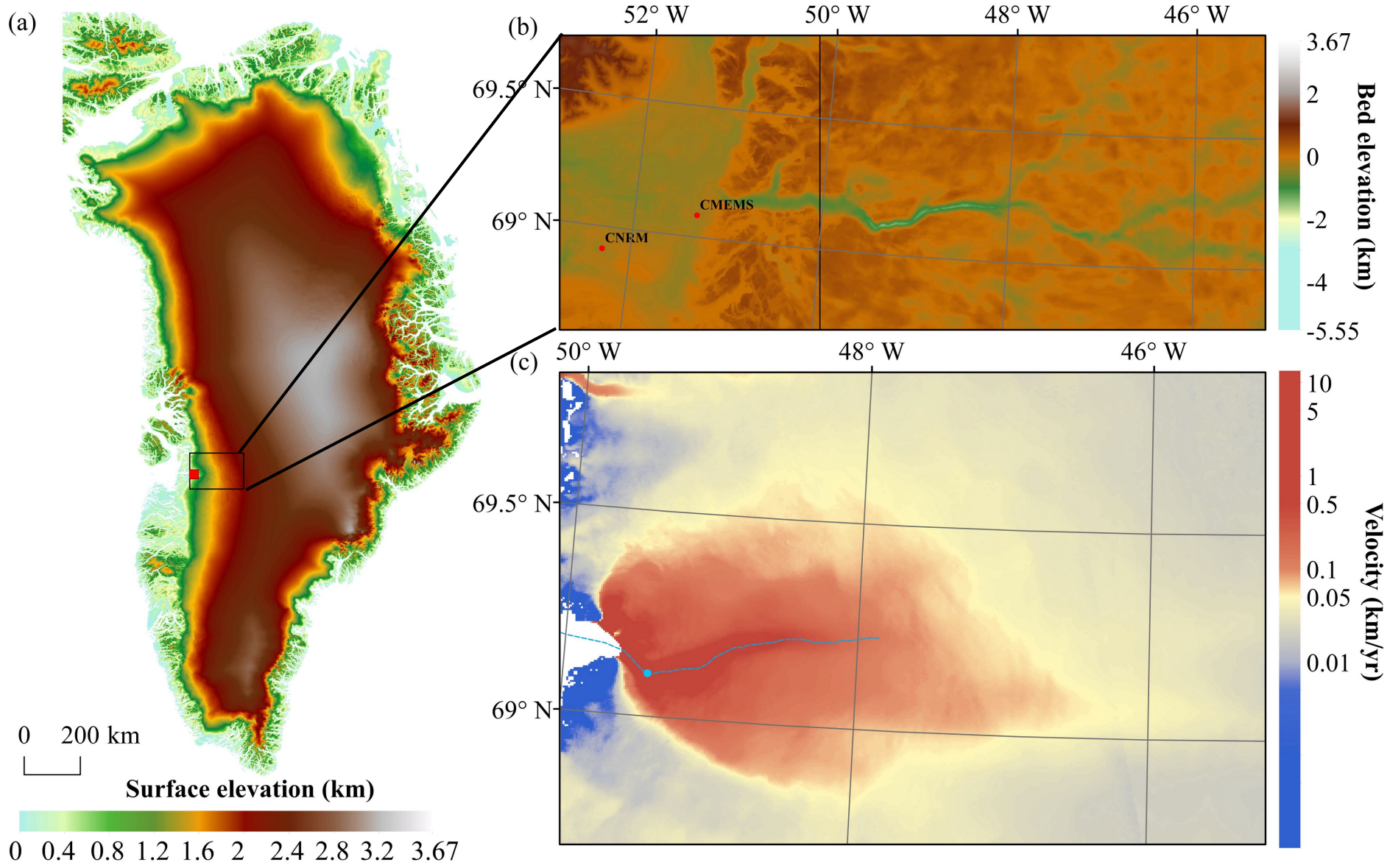
Zachariae / Jakobshavn

Norwegian fjord / Svalbard

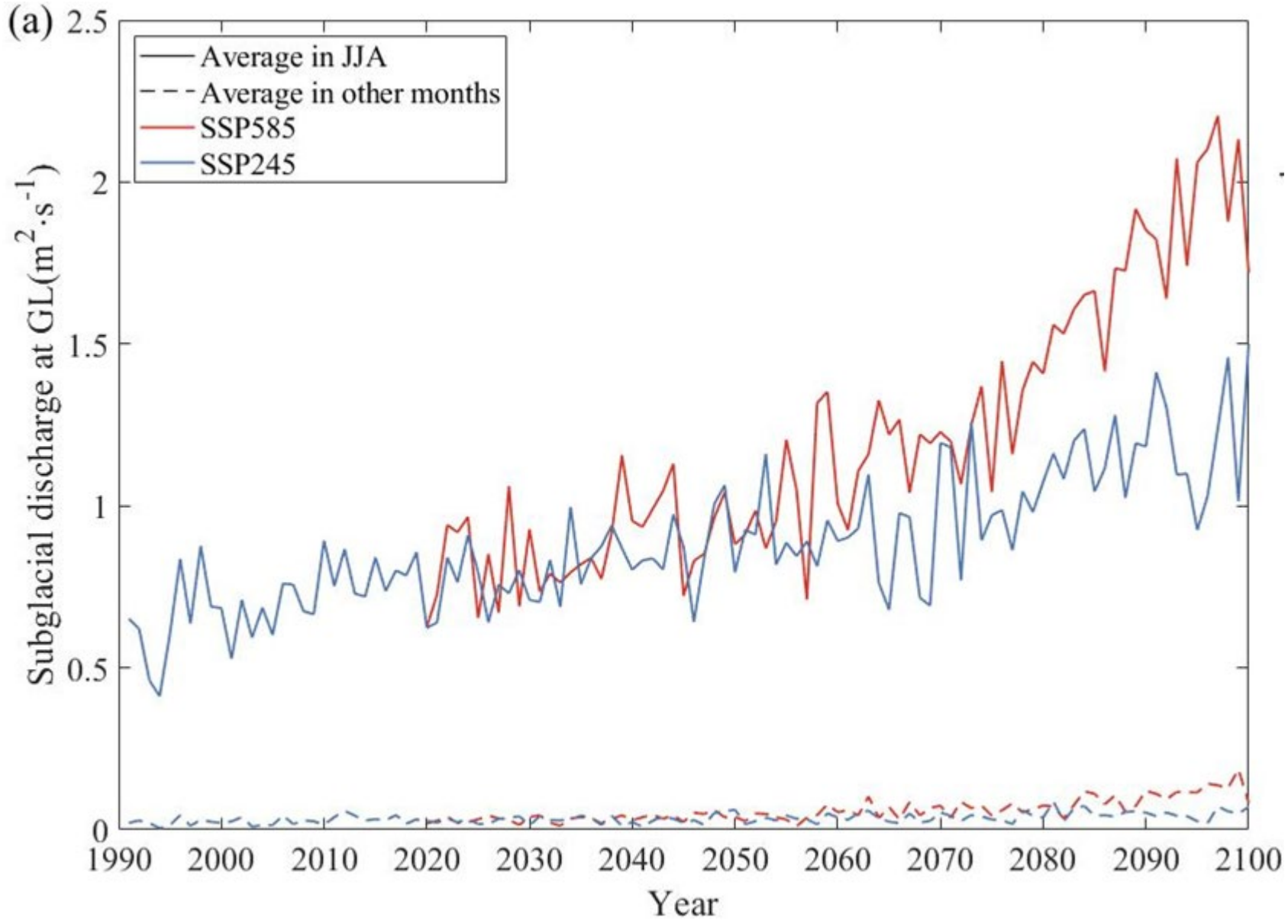
Tank tests and River Cam

Each step is an exit if any red flags

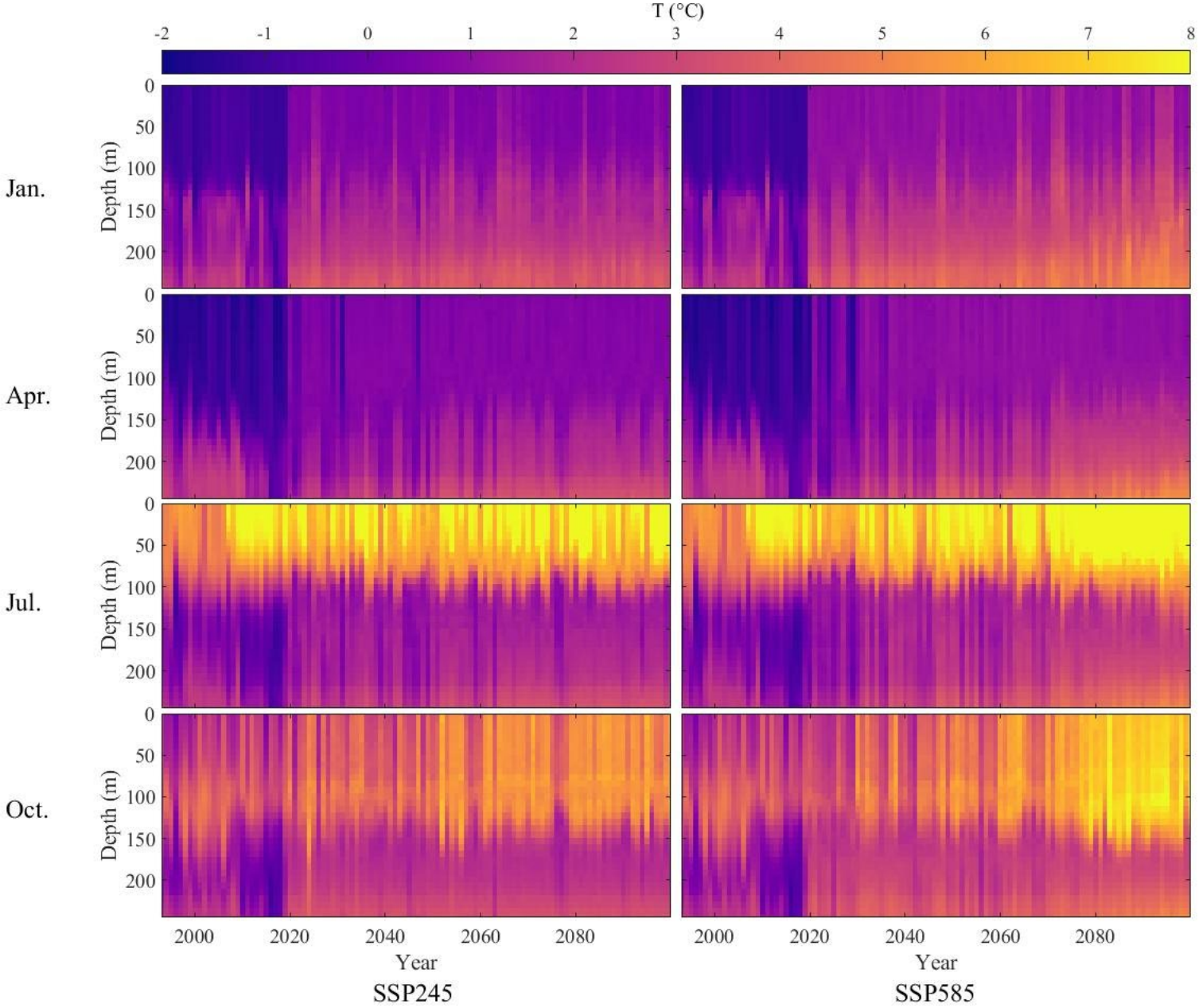
Lessons learned applied to next steps



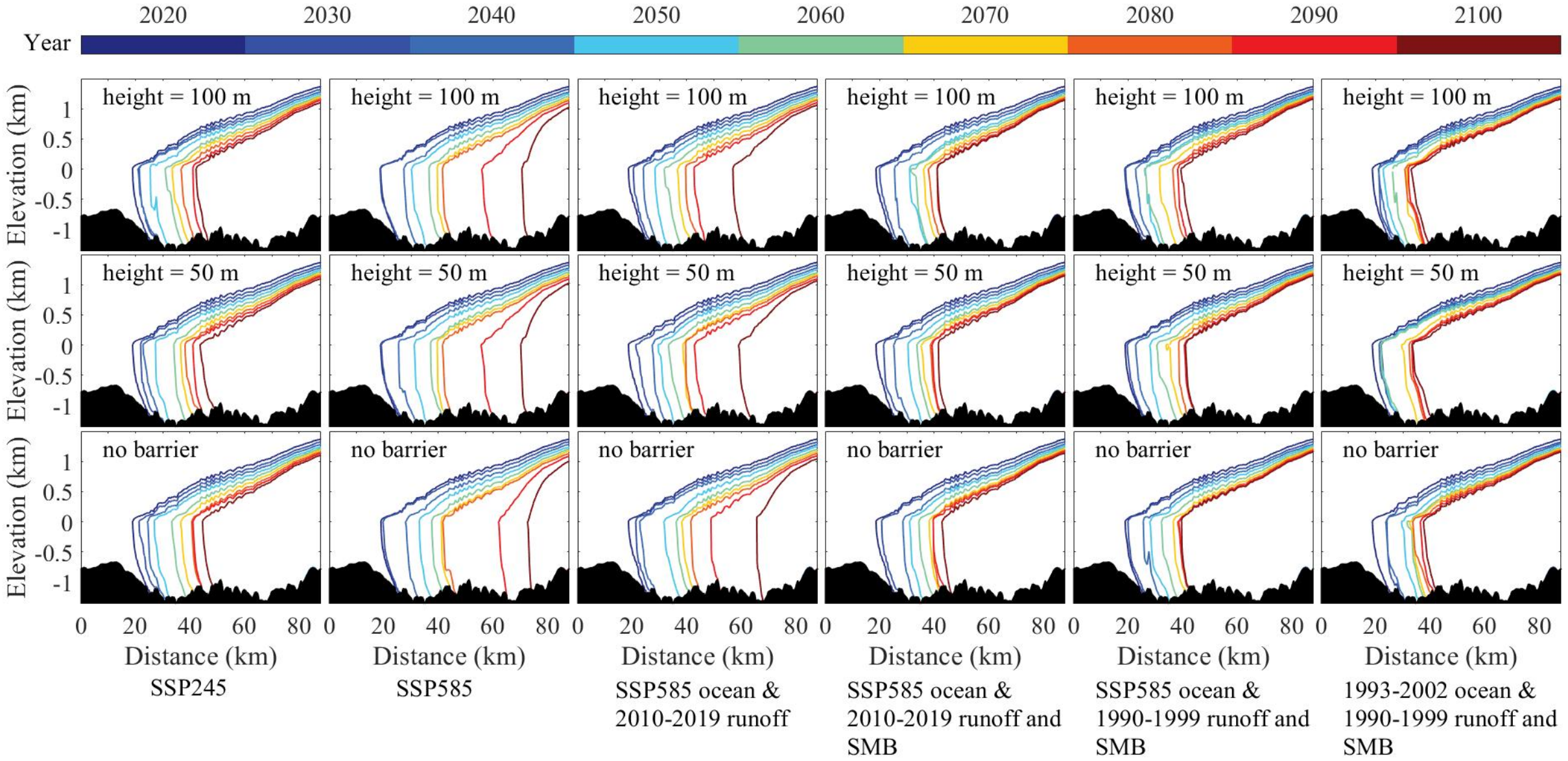
(a) BedMachine V3 (Morlighem, 2017), Red circles in (b) are 250-meter-depth ocean temperature modelled by CMEMS, CNRM-ESM2-1. (c) surface velocity in the year 2009 from MEaSUREs Greenland Ice Sheet Velocity Map (Joughin et al., 2010). Blue circle in (c) is velocity sampling point. Blue dashed line in (c) represents the central flow line, which is used to calculate terminus position, defined as the distance along flow line from the starting point on the left side of flow line to the intersection point of flow line and ice front.



Simulated monthly surface water runoff from the MAR regional surface mass and energy balance model (Alexander and Luthcke, 2016) Integrated surface water flux over the modelled domain divided by GL width through grounding line.



Bias-corrected monthly ocean temperature started from 1993 at the CNRM location from the MAR 3.11.3 driven by CNRM-ESM2-1 for 1993-2100



Modelled ice front profile with barrier height of 100 m (top row) , 50 m (middle row) and no barrier (bottom row) under the labeled ocean and atmospheric forcing.

Research and co-design task in GRISCO (2021-2023):

Is it possible to build a curtain in the Ilulissat Icefjord in a sustainable and locally acceptable way?

- No

But let's not forget the rest of Greenland (ICC and elected officials)

Jakobshavn may be the most unstoppable glacier on the planet – for now