#OSM24

How does the oceanic heat supply to ice shelves respond to year-to-year changes in the Amundsen icescape?

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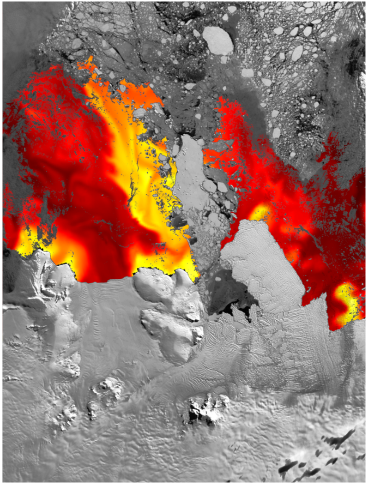


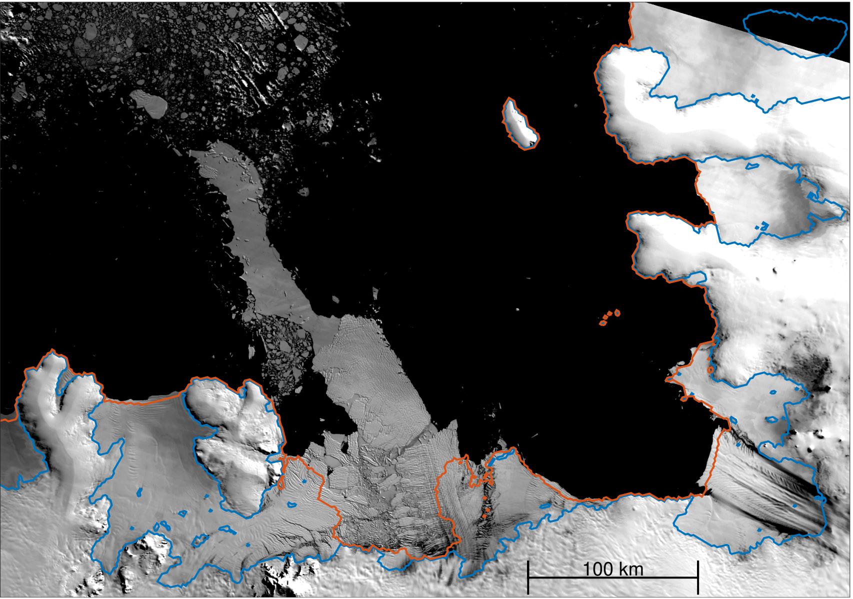
20-CRYO2020-0034

Introduction

Icescape: icebergs + ice shelves + fast-ice (we exclude sea ice).

Icescapes change from year-to-year, but this evolution is not represented in models used for sea level rise projections.
Is this a major oversight (or not)?

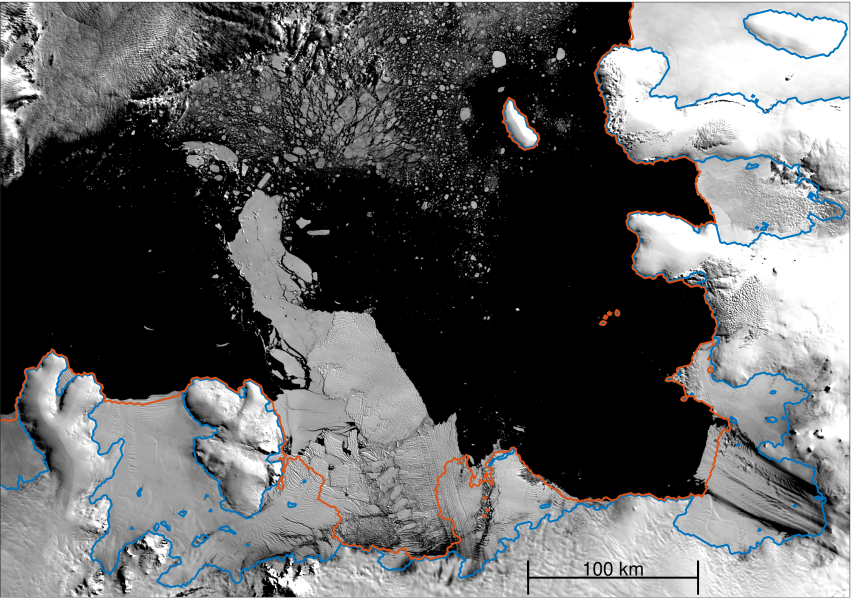
Next slides: Yearly images from eastern Amundsen Sea (2010–2019).



2010 (summer)

BedMachine's
ice shelf front
grounding line

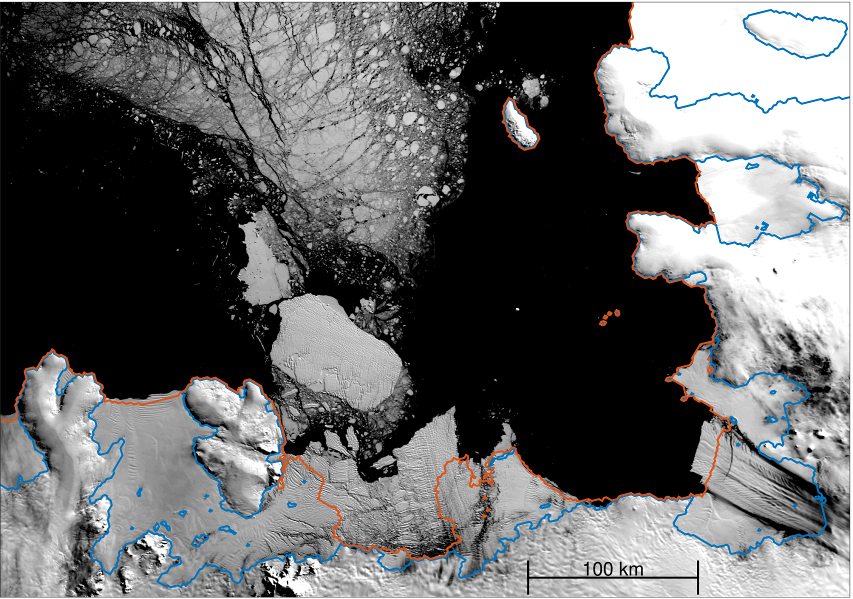
Scambos, Wallin & Bohlander



2011 (summer)

BedMachine's
ice shelf front
grounding line

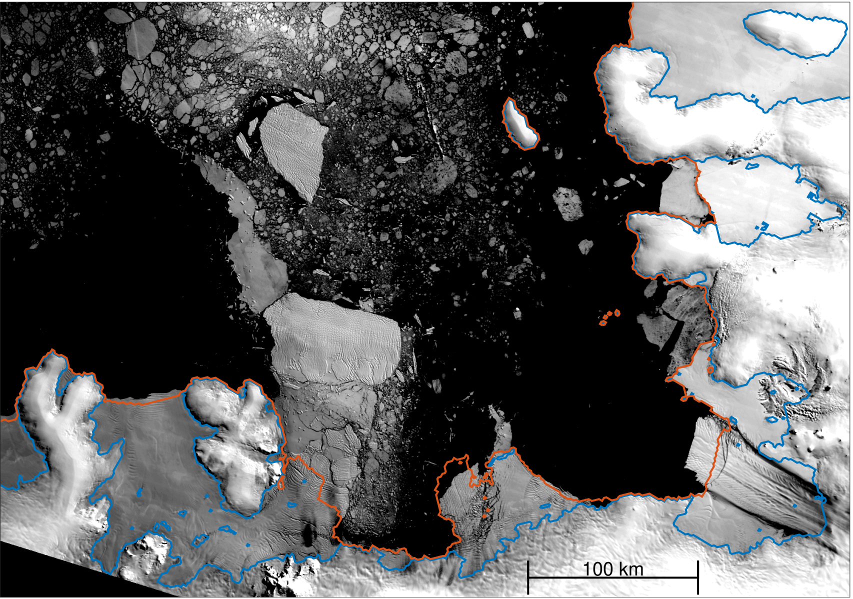
Scambos, Wallin & Bohlander



2012 (summer)

BedMachine's
ice shelf front
grounding line

Scambos, Wallin & Bohlander



2013 (summer)

BedMachine's
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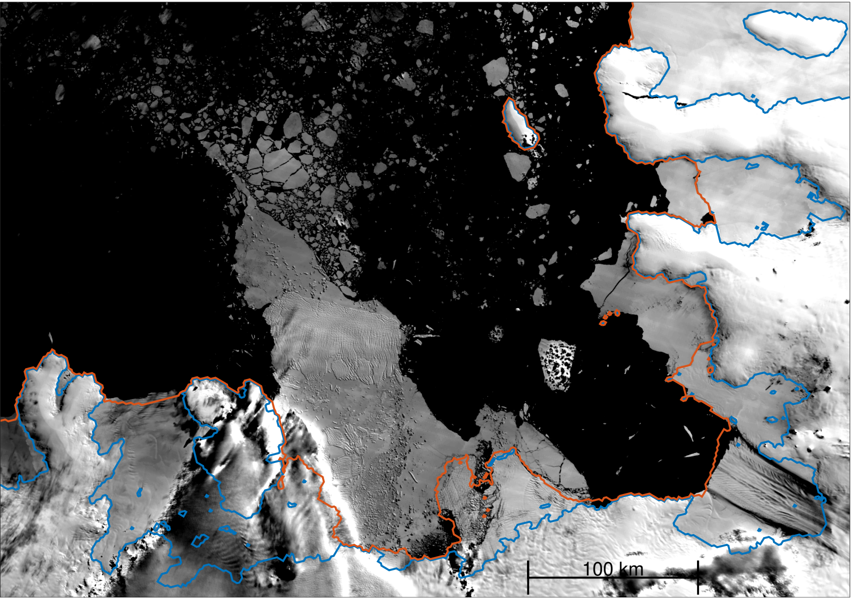
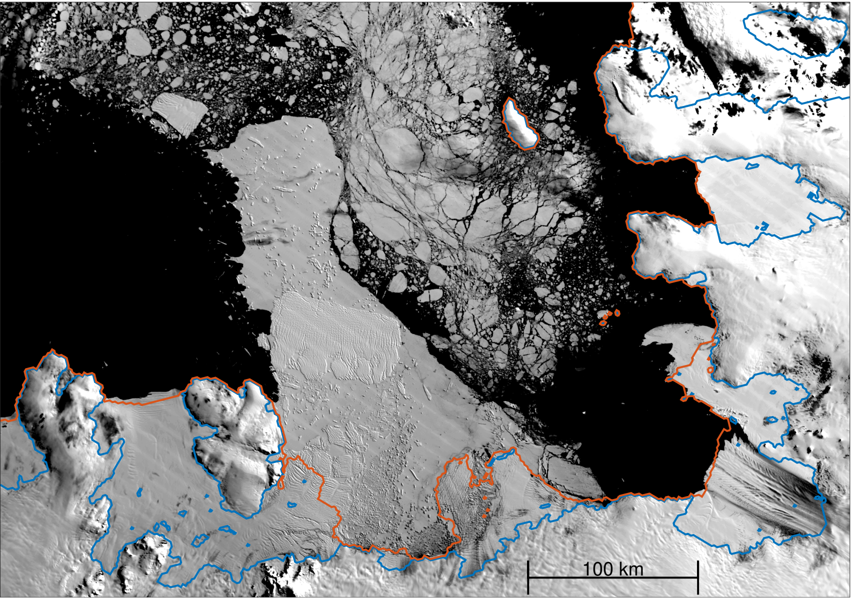
Scambos, Wallin & Bohlander



2014 (summer)

BedMachine's
ice shelf front
grounding line

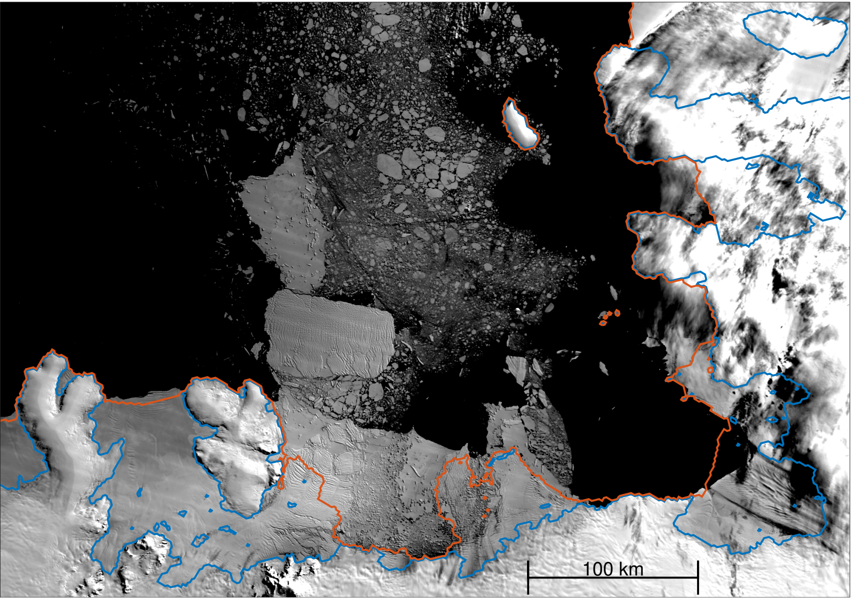
Scambos, Wallin & Bohlander



2015 (summer)

BedMachine's
ice shelf front
grounding line

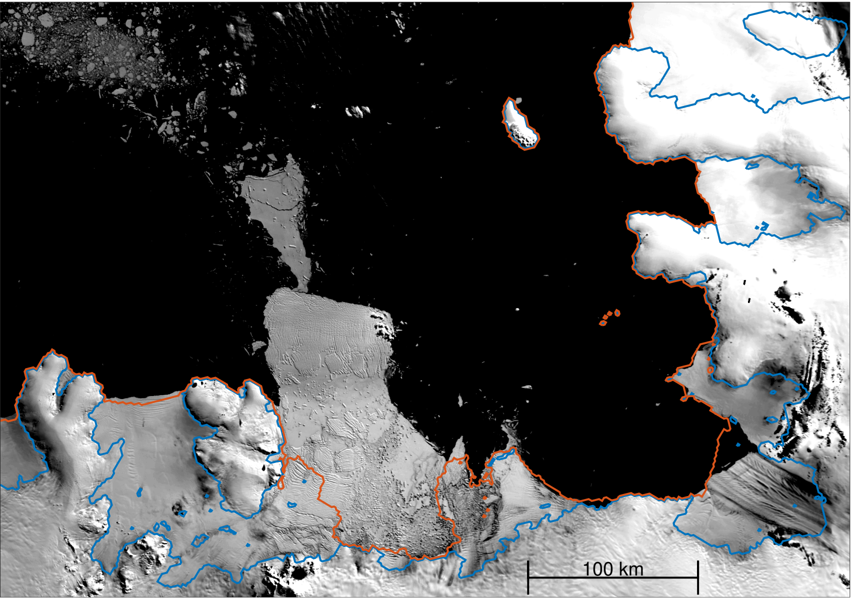
Scambos, Wallin & Bohlander



2016 (summer)

BedMachine's
ice shelf front
grounding line

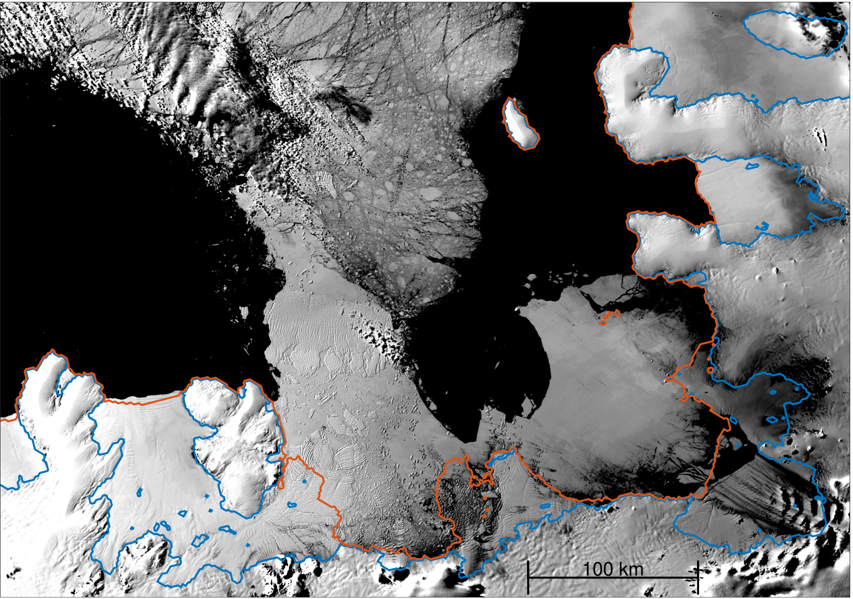
Scambos, Wallin & Bohlander



2017 (summer)

BedMachine's
ice shelf front
grounding line

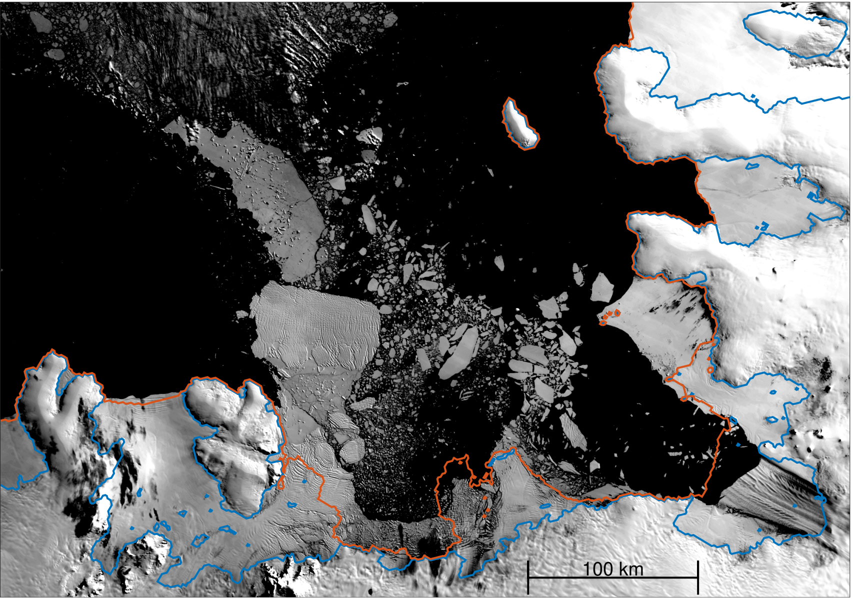
Scambos, Wallin & Bohlander



2018 (summer)

BedMachine's
ice shelf front
grounding line

Scambos, Wallin & Bohlander



2019 (summer)

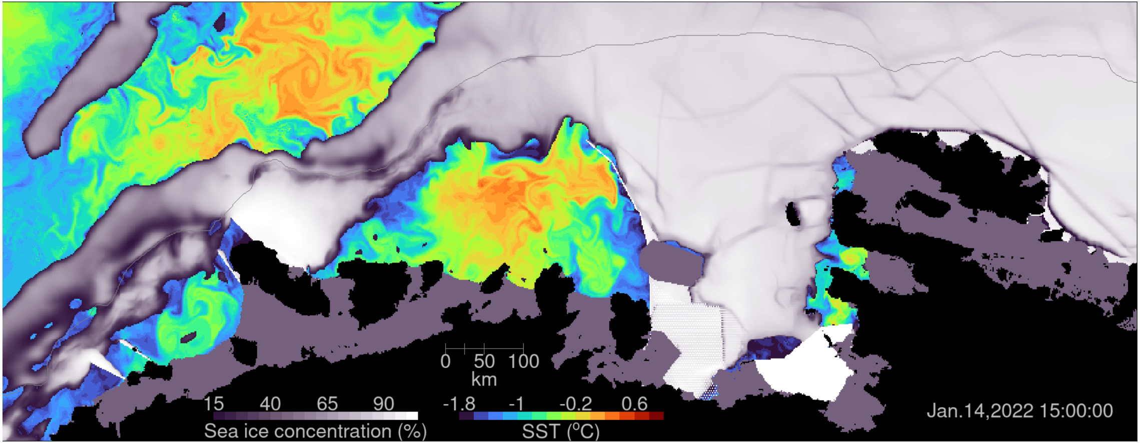
BedMachine's
ice shelf front
grounding line

Scambos, Wallin & Bohlander

Changes in icescape are **rapid** and they impact a **large** fraction of the embayment.

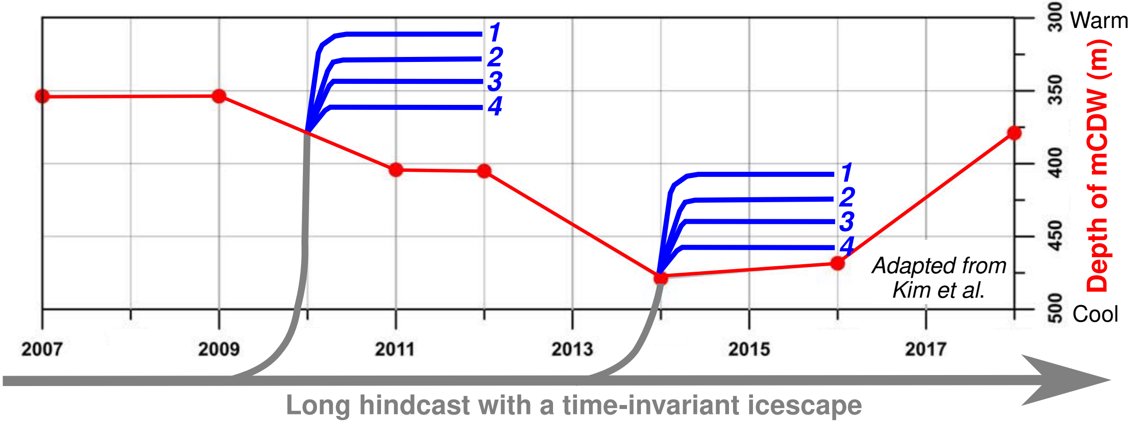
Hypothesis:
Certain icescape configuration will severely limit the supply of oceanic heat to ice shelves, leading to lower ice shelf basal melt rates.

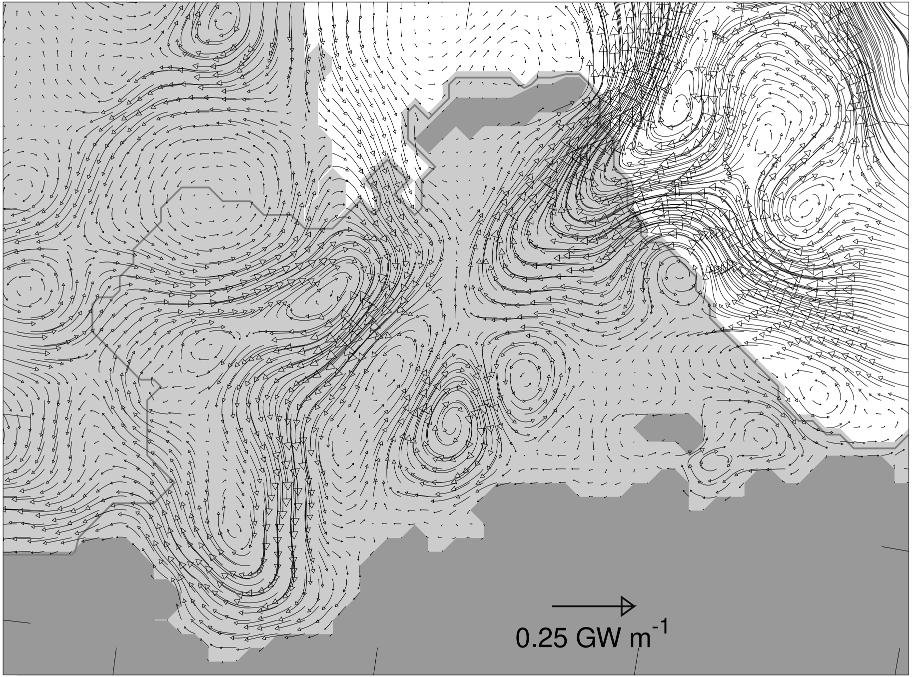
Methods: semi-idealized numerical experiments



A 3D ocean – sea ice – ice shelf coupled model, resolution of 1.5 km.

Methods: semi-idealized numerical experiments



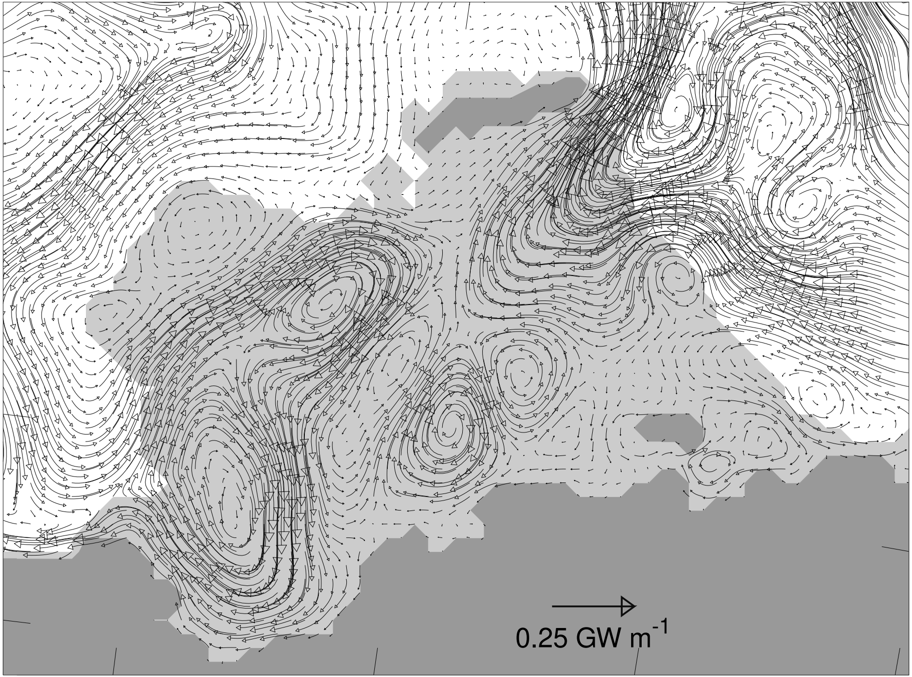


Thwaites, with TGT at its maximum extent

← Mean horizontal oceanic heat flux relative to −1.85°C

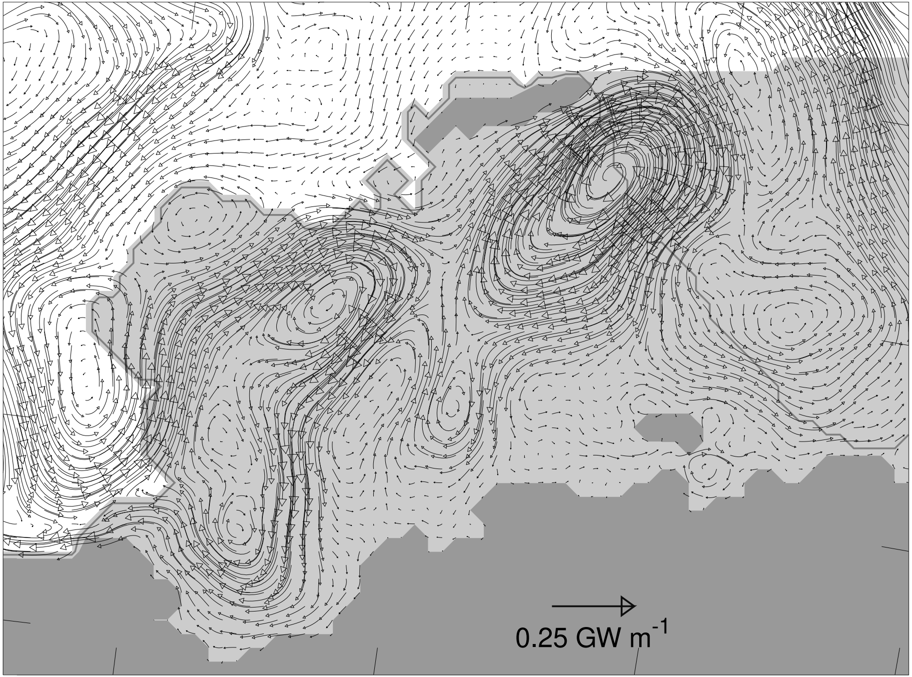
- Not a pipeline with simple in/out pattern*,
- 3 major entry points for oceanic heat,
- Multiple entry points provides redundancy for the heat supply.

*See also Nakayama *et al.* 2019, Wåhlin *et al.* 2021.



After TGT collapse:

- Reorganization of heat fluxes following collapse,
- Contribution from western half jumps from 24% to 40%.



After TGT collapse,
+ fast-ice cover

- Another reorganization of the heat flux on the eastern side, just from the presence of fast-ice.

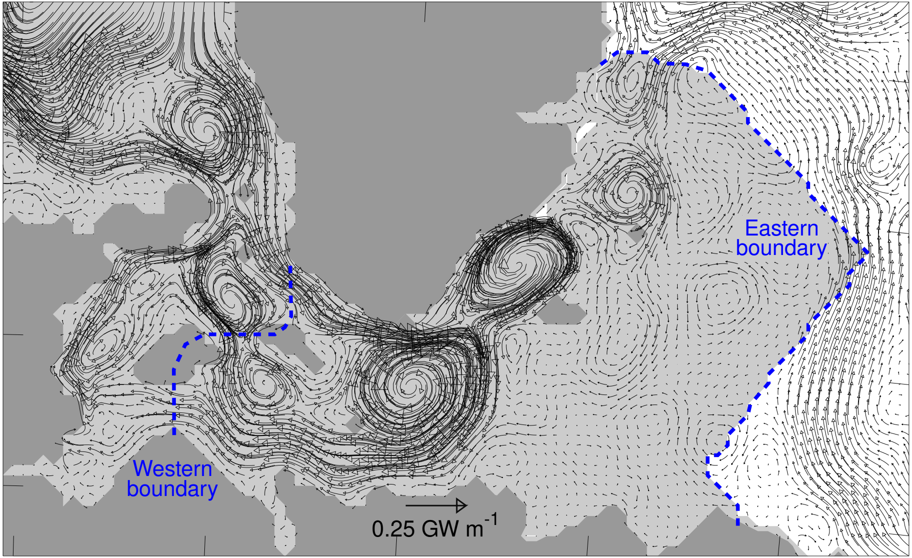
Do these reorganizations of the heat flux impact ice shelf basal melt rates?

Icescape configurations	I	II	III	IV
Basal melt Thwaites (Gt yr^{-1})	89.6	96.3	96.1	91.6
Net heat flux Thwaites (TW)	0.93	1.01	1.02	0.97

Answer: Variations are only 2–6%.

Interpretation:
Regional thickness of mCDW layer determines the overall heat forcing; icescape changes only influence the pathway.

Is this result specific to Thwaites?
What about Crosson Ice Shelf?



Crosson after TGT collapse:

- 2 entry points, west and east.
- Net heat flux across boundaries: 0.05 TW (west) versus 0.40 TW (east).

TGT at its maximum extent (not shown):

- 0.40 TW (west) versus −0.03 TW (east).

Relative importance of the two boundaries flipped after TGT collapse.

Do these reorganizations of the heat flux impact Crosson's basal melt rates?

Icescape configurations	I	II	III	IV
Basal melt Crosson (Gt yr^{-1})	34.1	42.2	42.0	38.3
Net heat flux Crosson (TW)	0.37	0.45	0.45	0.42

Answer: Variations are only 3–15%.

Again, icescape changes influence the pathway but not the overall thermal forcing.

Discussion

1. Thwaites and Crosson appear to have multiple viable sources of oceanic heat (redundancy), not inconsistent with data (*e.g.* Wåhlin *et al.* 2021).

2. We see a re-routing of the flux following icescape changes, but no substantial reduction in ice shelf basal melt rates.

3. Melt rates instead reflect the regionally-averaged mCDW thickness; *e.g.* De Rydt *et al.* 2014.

4. Relying on icescape changes to stop the heat from reaching Thwaites (*e.g.* Wolovick *et al.* 2023) would be playing a whack-a-mole game.

5. Future changes in coastal icescape are unlikely to mitigate the current high melting rates.

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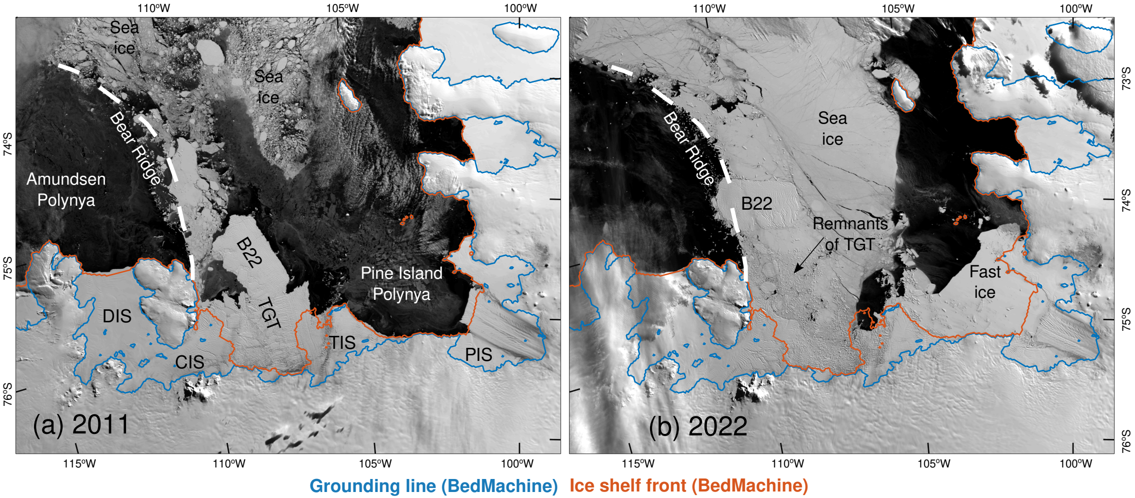
Appendix



1. TGT at its maximum extent
2. TGT collapsed
3. No iceberg B22, no BRIC
4. No fast-ice next to PIG