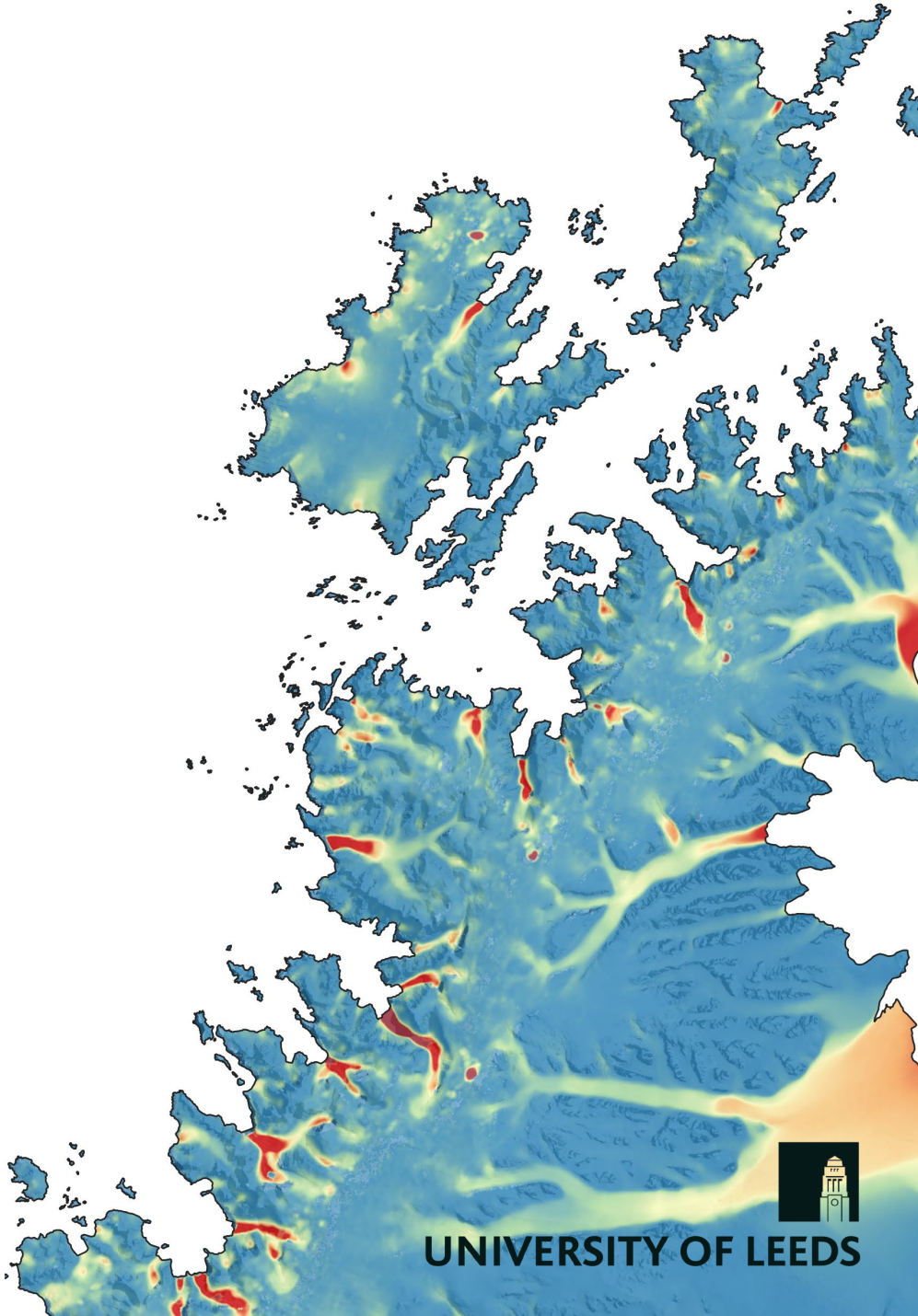
Causes and consequences of the rapid dynamic activation of a marine-terminating glacier on the west Antarctic Peninsula

Benjamin J. Wallis
Institute for Climate and Atmospheric Science,
University of Leeds,
UK

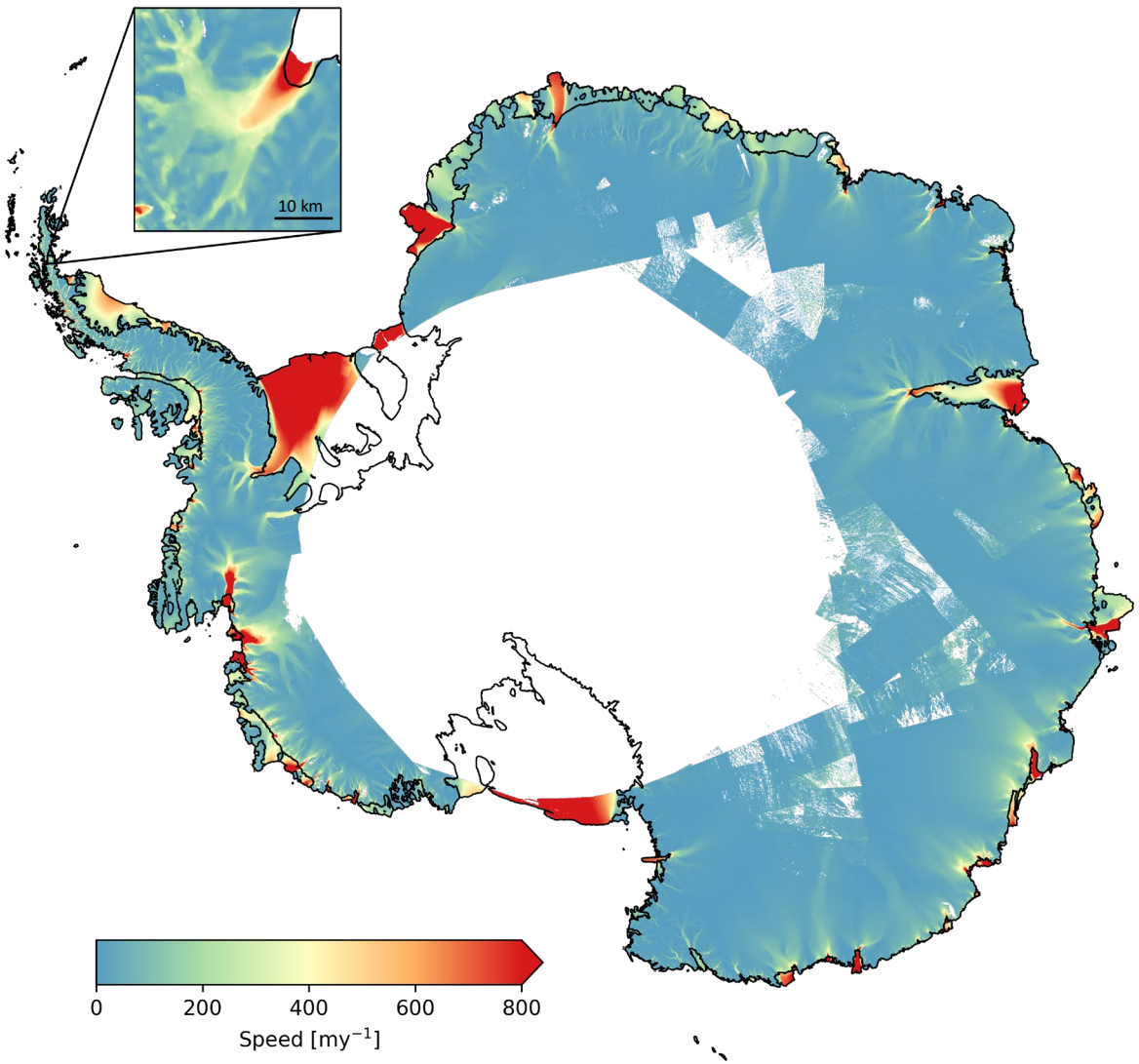
Results from: Ocean warming drives rapid dynamic activation of marine terminat glacier on the west Antarctic Peninsula (2023)
Benjamin J. Wallis, Anna E. Hogg, Michael P. Meredith, Romilly Close, Dominic Hardy, Malcolm McMillan, Jan Wuite, Thomas Nagler & Carlos Moffat.

14/10/2024



Studying Ice Dynamics in Antarctica

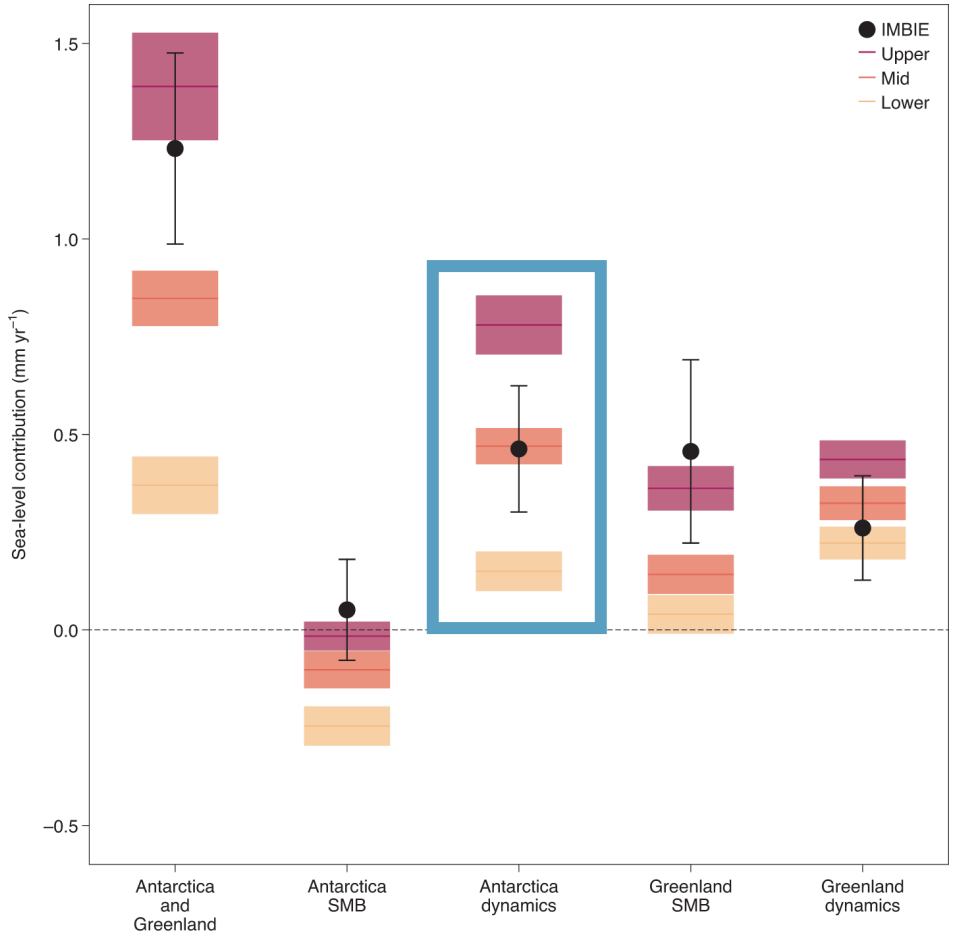
- The Satellite Ice Dynamics Group at Leeds measures ice sheet flow and dynamics using remote sensing.
- We routinely processes ice velocity data for the whole of Antarctica from Sentinel-1 SAR.
- We use this as our core dataset to investigate ice sheet change.
- **But we also make use of lots of other datasets – including altimetry!**



UNIVERSITY OF LEEDS

Why monitor Antarctic Ice Sheet dynamics?

- Ice sheet mass loss is a major contributor to global sea-level rise.
- Ice dynamics constitute 90% of Antarctica's sea-level rise contribution[1].
- Knowledge of ice dynamics is crucial to developing our understanding of ice-sheet processes.
- Satellite data is the only way to achieve monitoring on the scale our challenges demand.



(Reproduced from Slater et al. 2020)

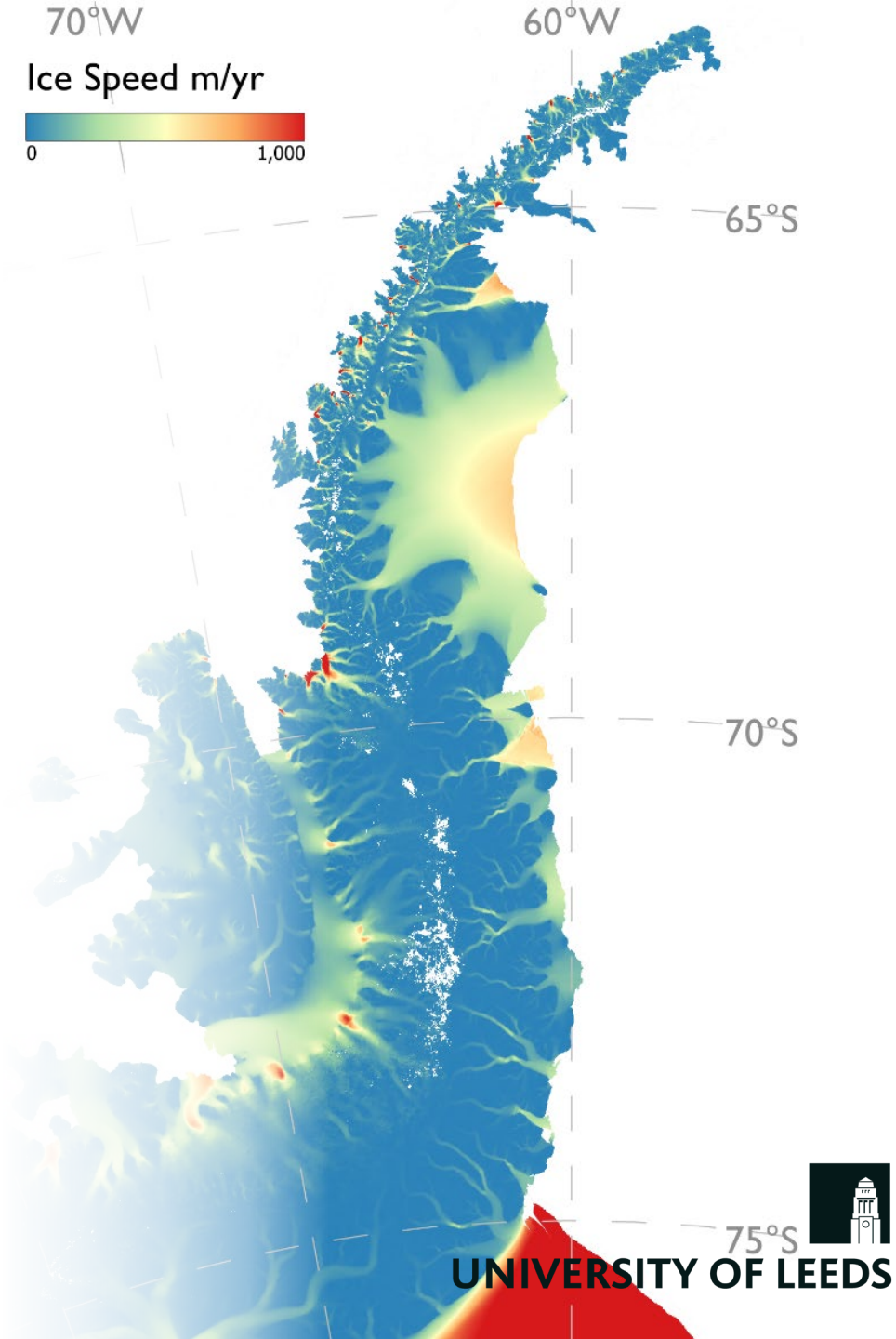
[1]Slater et al. 2020

How does altimetry fit into our work?

- Measuring ice speed with SAR is only one piece of the equation.
- We need altimetry data to support our ice dynamics measurements.
- Examples include:
  - Thickness changes for ice discharge calculations.
  - Grounding line migrations.
  - Observations of dynamic thinning.

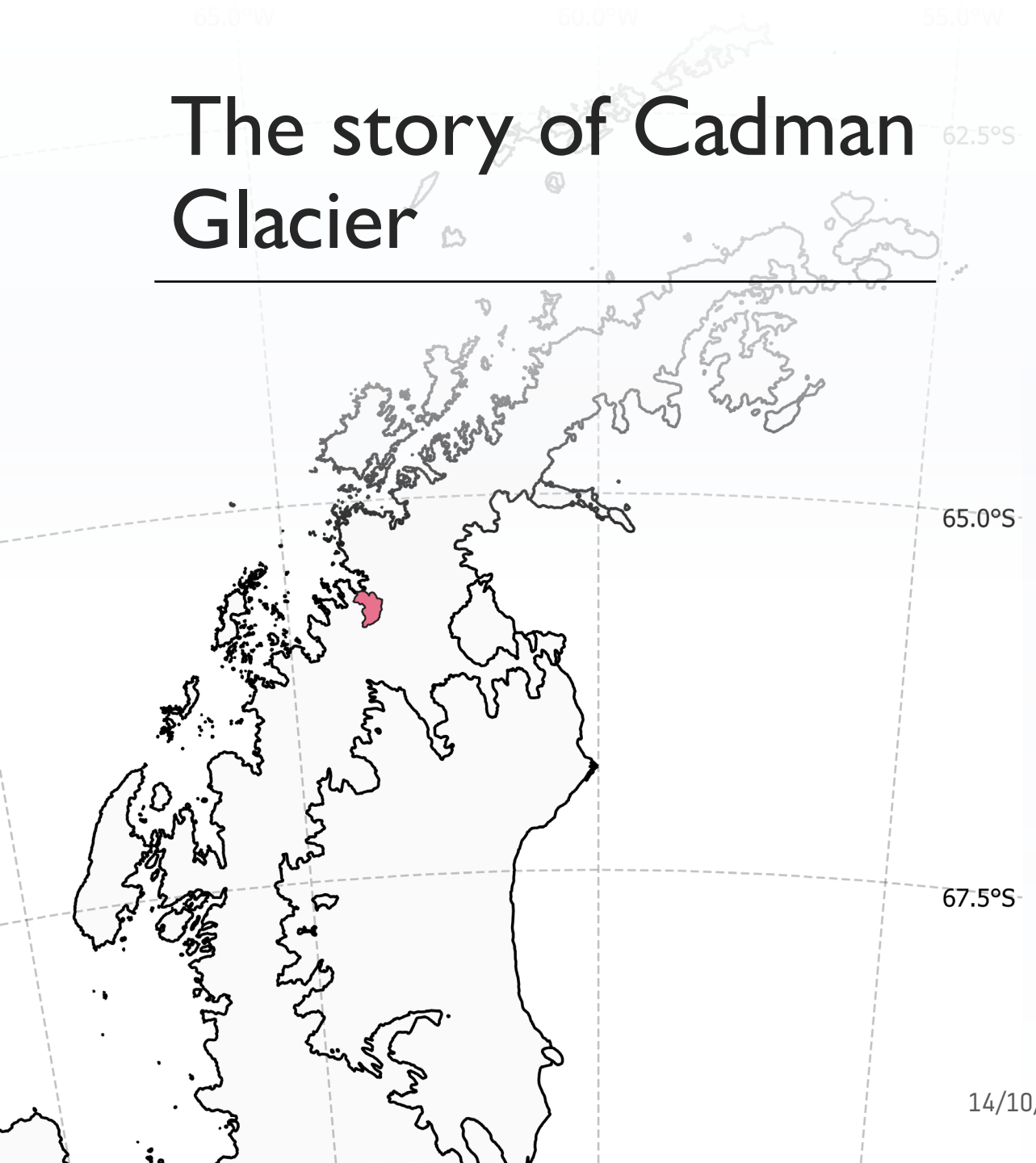
My work – The Antarctic Peninsula

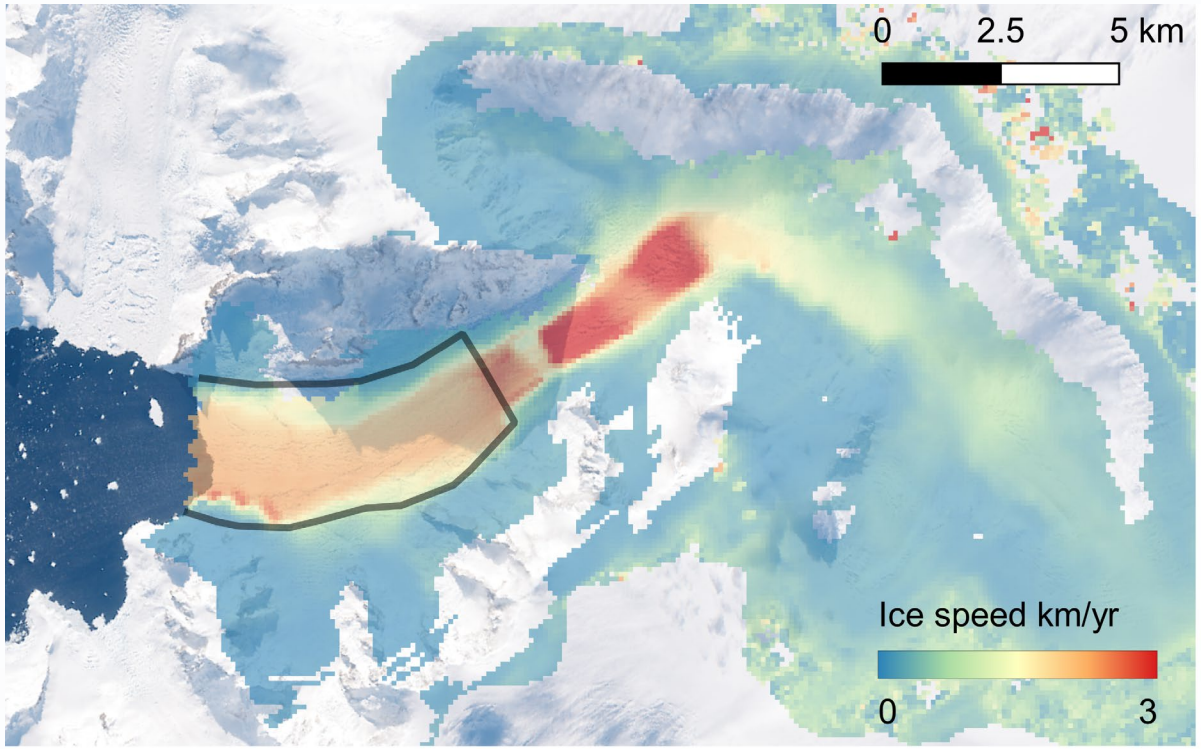
- From 1992 to 2020 the Antarctic Peninsula accounted for **14%** of Antarctica's ice mass loss[1].
- In the remote sensing era: major ice shelf collapses[2,3], ice flow acceleration[4,5] and glacier retreat[6].
- The AP is a unique venue to study ice dynamics in Antarctica.
- Observations from the AP have been influential to how we think about Antarctica's future.



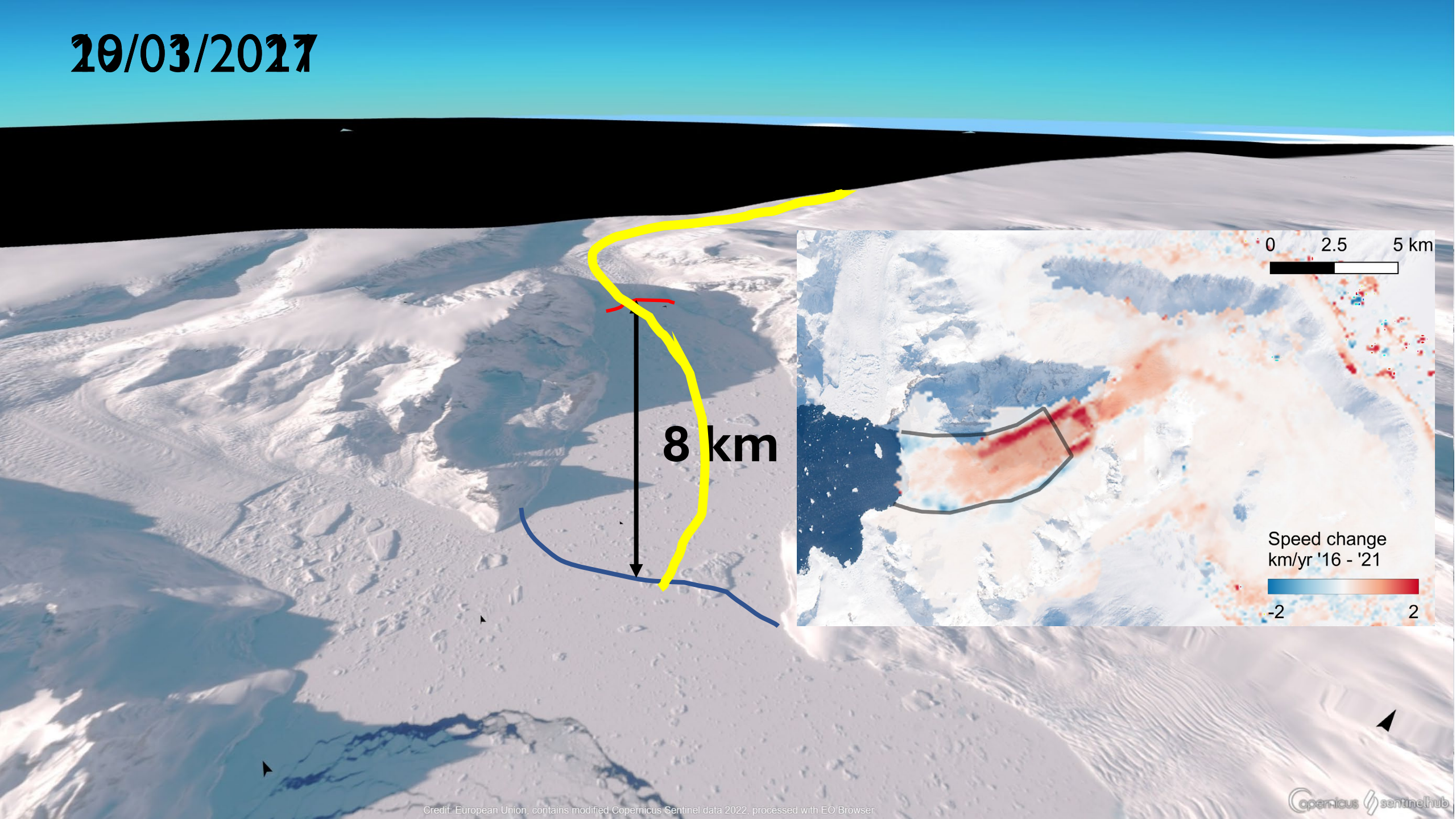
[1]Otosaka et al., 2023, [2]Rott et al., 1996, [3]Rack & Rott, 2004, [4]Rignot et al., 2004, [5]Wuite et al. 2015, [6]Cook et al. 2016

The story of Cadman Glacier



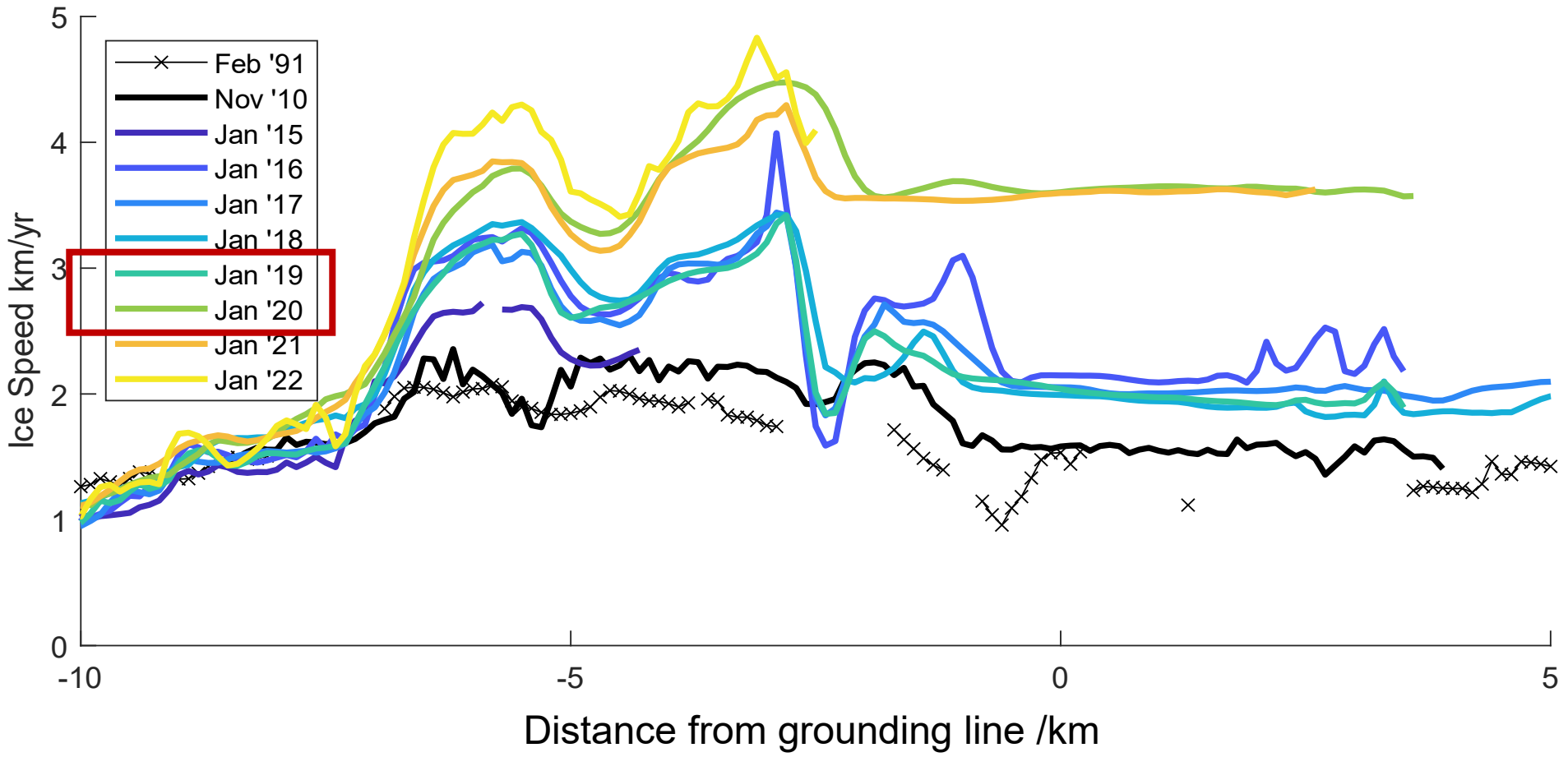


UNIVERSITY OF LEEDS


19/03/2017
8 km
0
2.5
5 km
Speed change
km/yr '16 - '21
-2
2
Credit: European Union, contains modified Copernicus Sentinel data 2022, processed with EO Browser

Cadman glacier – acceleration and retreat

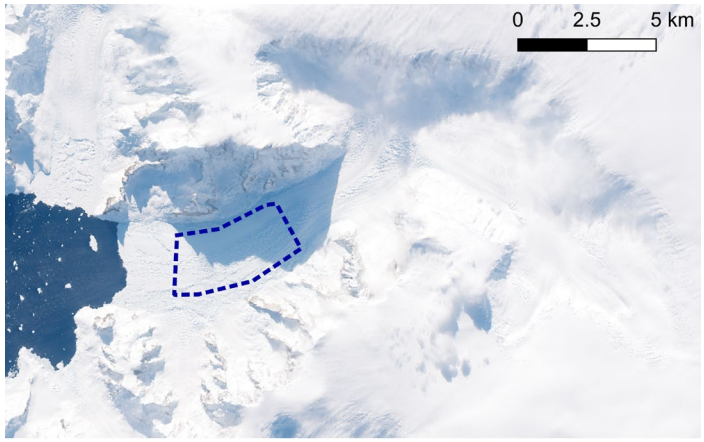
2019 acceleration

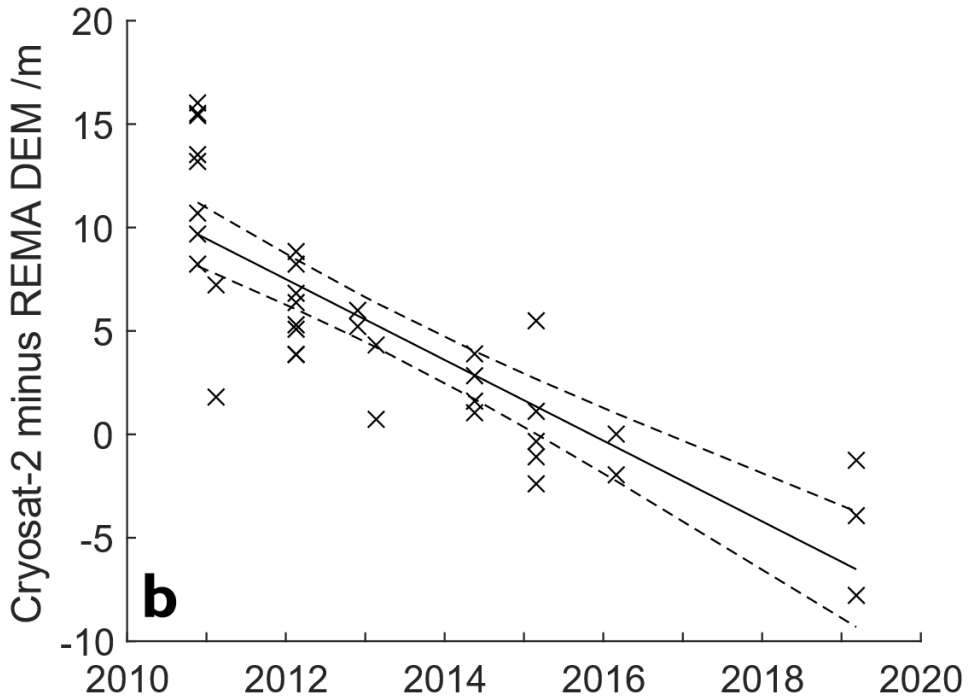


UNIVERSITY OF LEEDS

Thinning of Cadman Glacier's ice tongue

- Data from altimetry show that Cadman's ice tongue was thinning rapidly from 2010 onwards.
- From CryoSat-2 we measure a surface elevation change of -1.95 ± 0.53 m/yr.
- From REMA DEM tiles[1], we measure consistent rate of -1.61 ± 0.46 m/yr.
- These results reflect previous studies of surface elevation change[2] and iceberg melting[3].

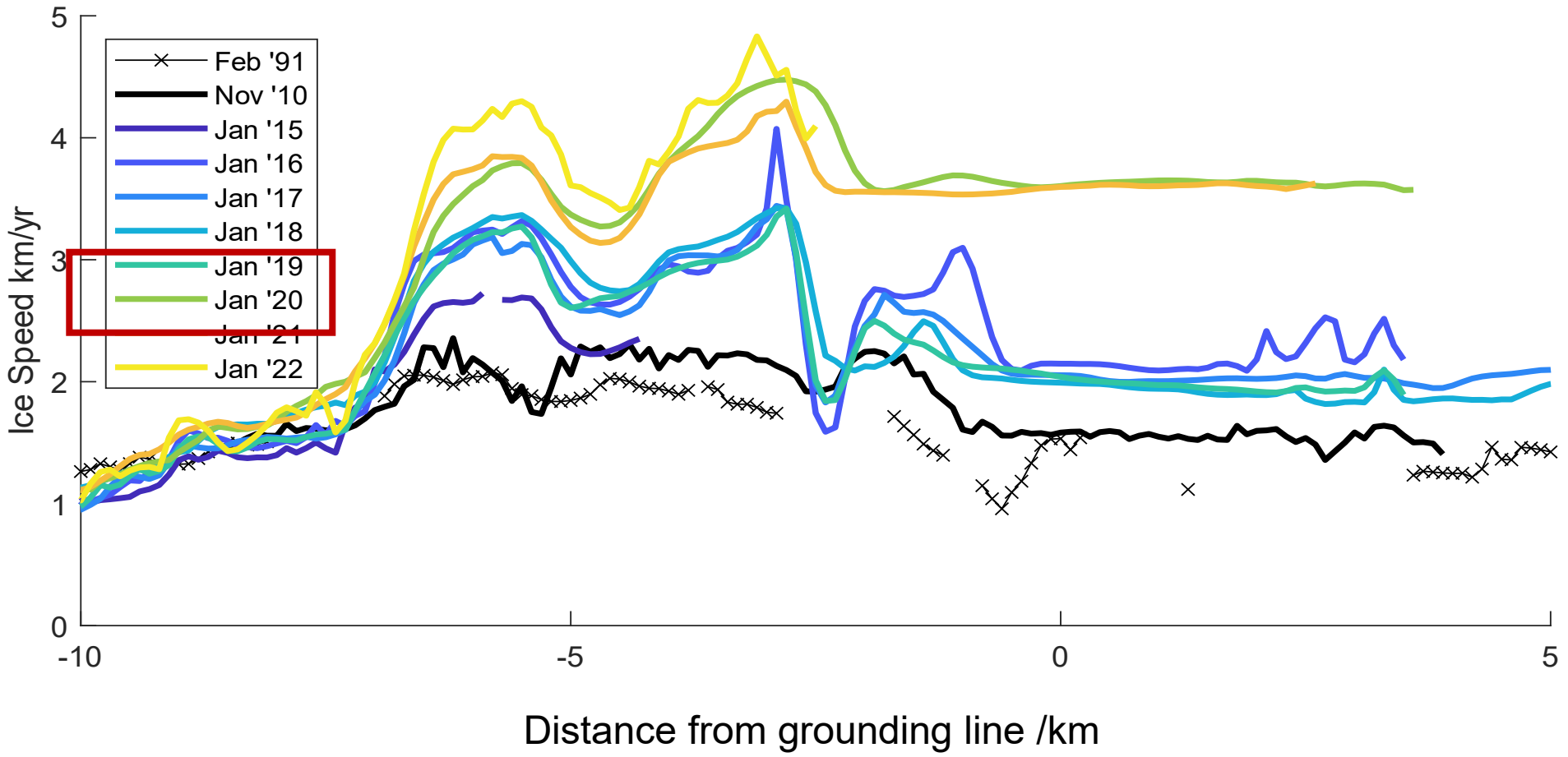




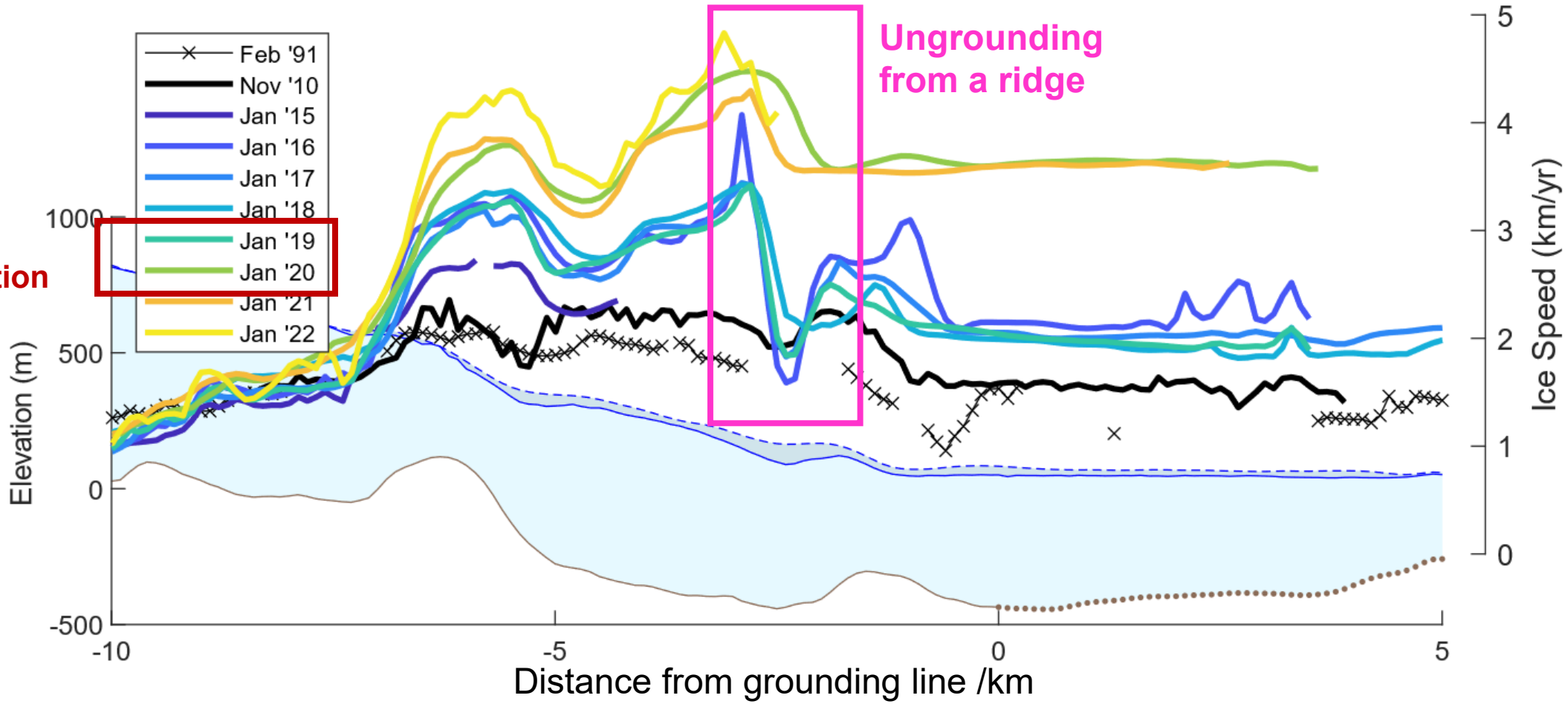
[1]Howat et al. 2022, [2]Scambos et al. 2014, [3]Dryak et al. 2020.

Cadman glacier – acceleration and retreat

2019 acceleration



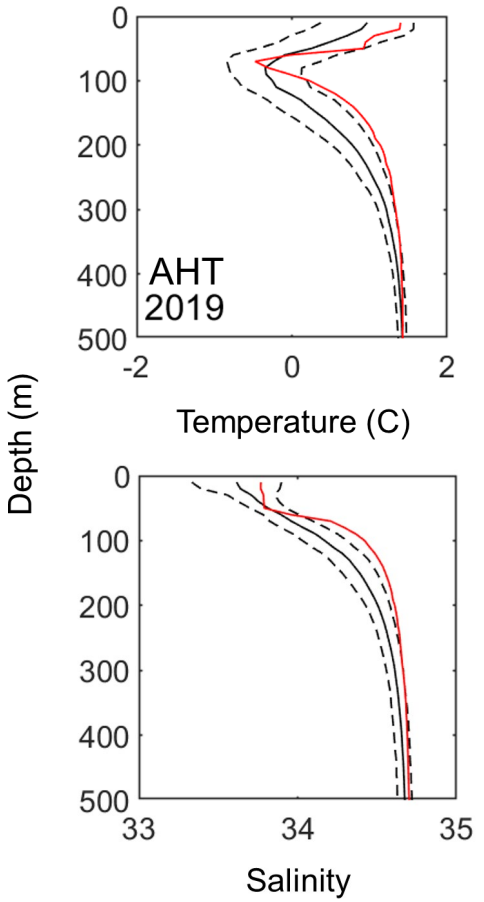
Ungrounding from a bedrock ridge

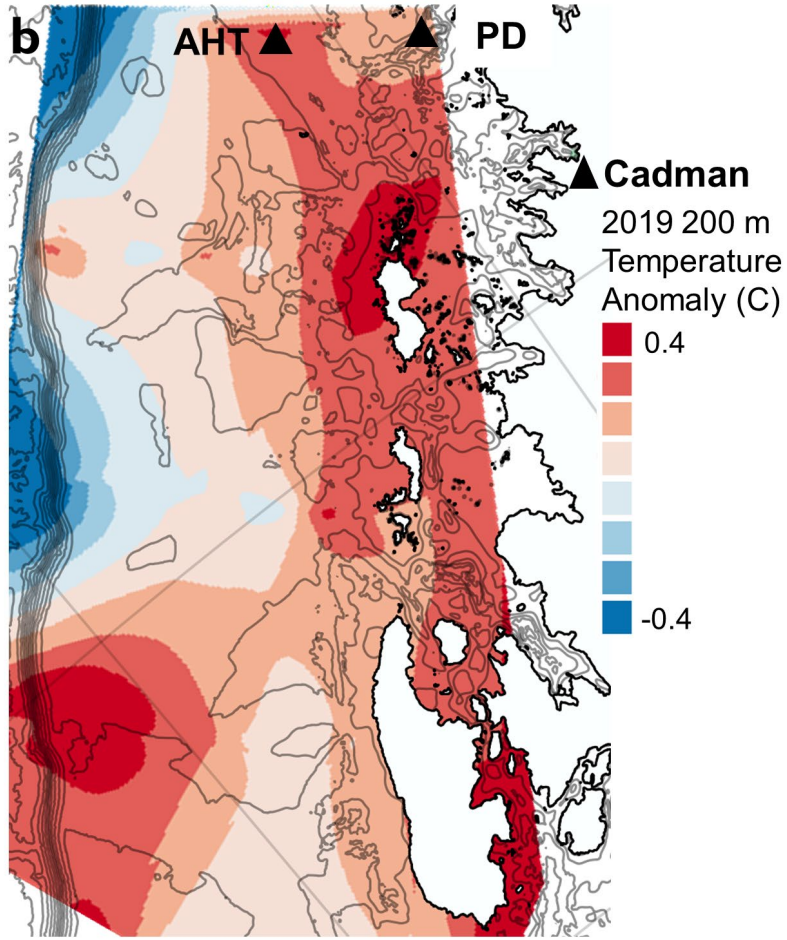


UNIVERSITY OF LEEDS

Ocean forcing drove Cadman's acceleration

- Cadman's acceleration coincided with a period of warm temperature anomalies on the west AP shelf.
- But neighboring Funk and Lever Glaciers did not respond to this forcing.
- High-resolution bathymetry shows that they are protected by shallow sills, but Cadman isn't.

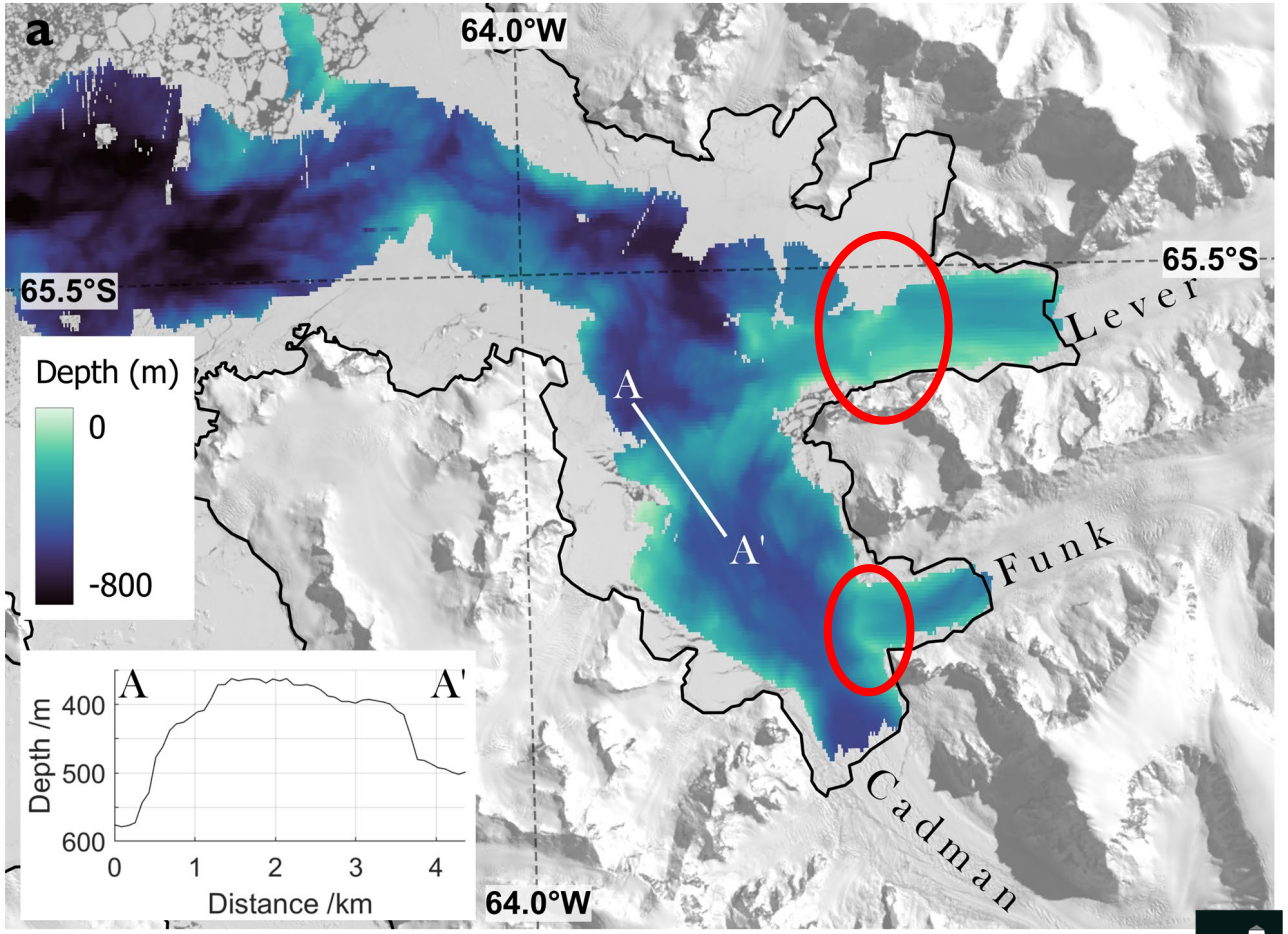




UNIVERSITY OF LEEDS

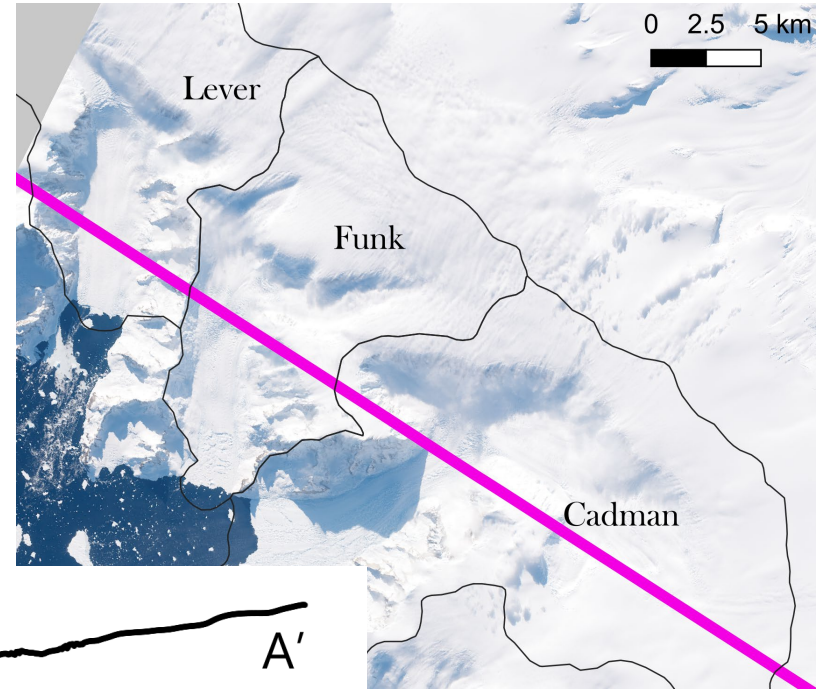
Ocean forcing drove Cadman's acceleration

- Cadman's acceleration coincided with a period of warm temperature anomalies on the west AP shelf.
- But neighboring Funk and Lever Glaciers did not respond to this forcing.
- High-resolution bathymetry shows that they are protected by shallow sills, but Cadman isn't.

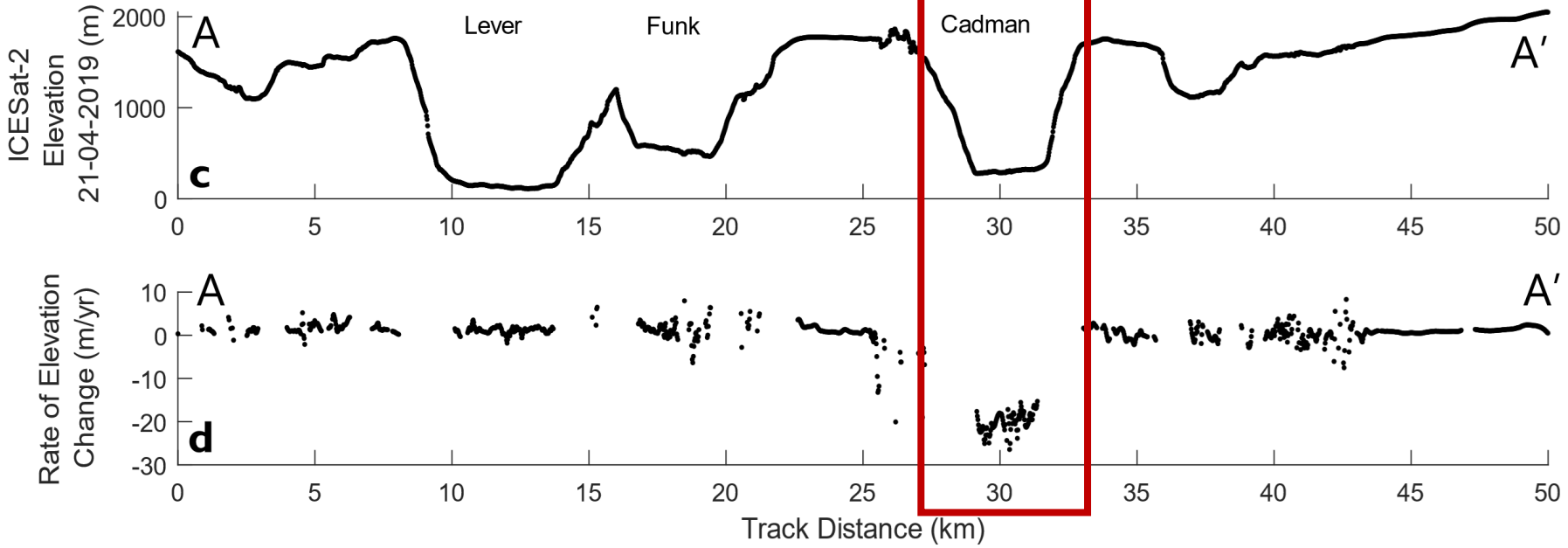


UNIVERSITY OF LEEDS

Consequences - dynamic thinning

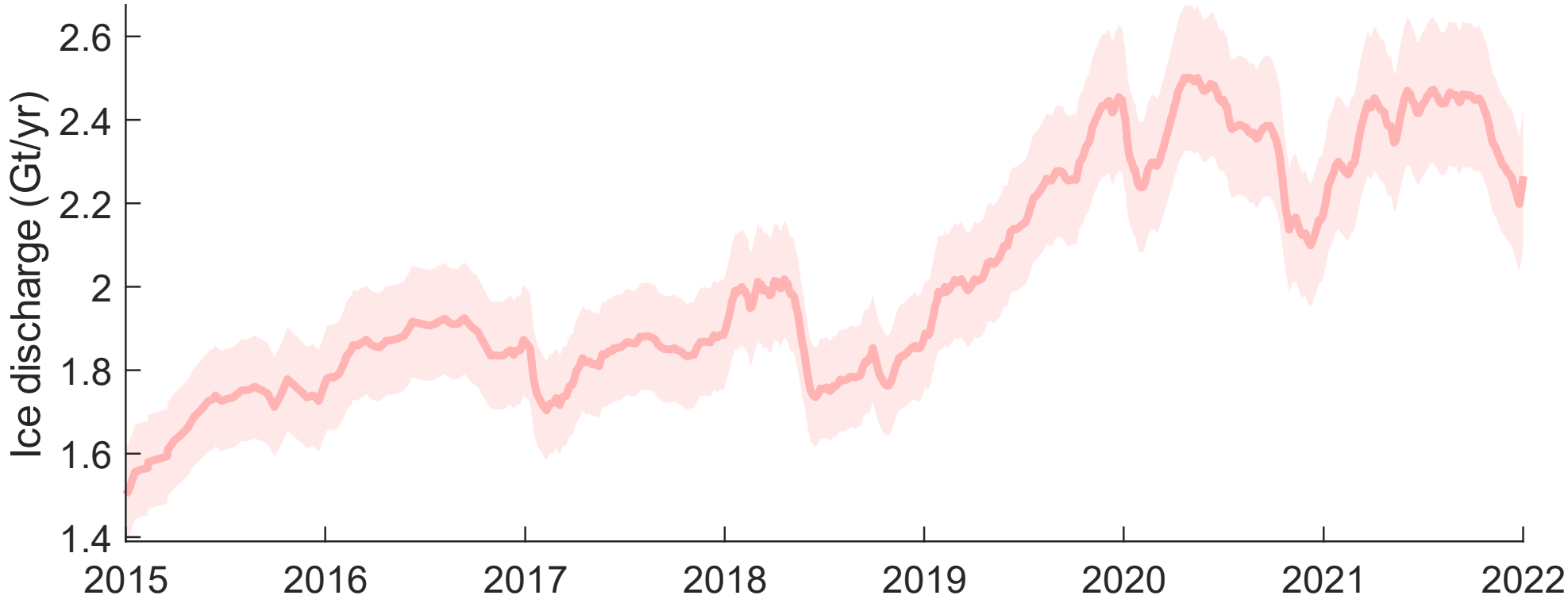


-20.1 ± 2.6 m/yr

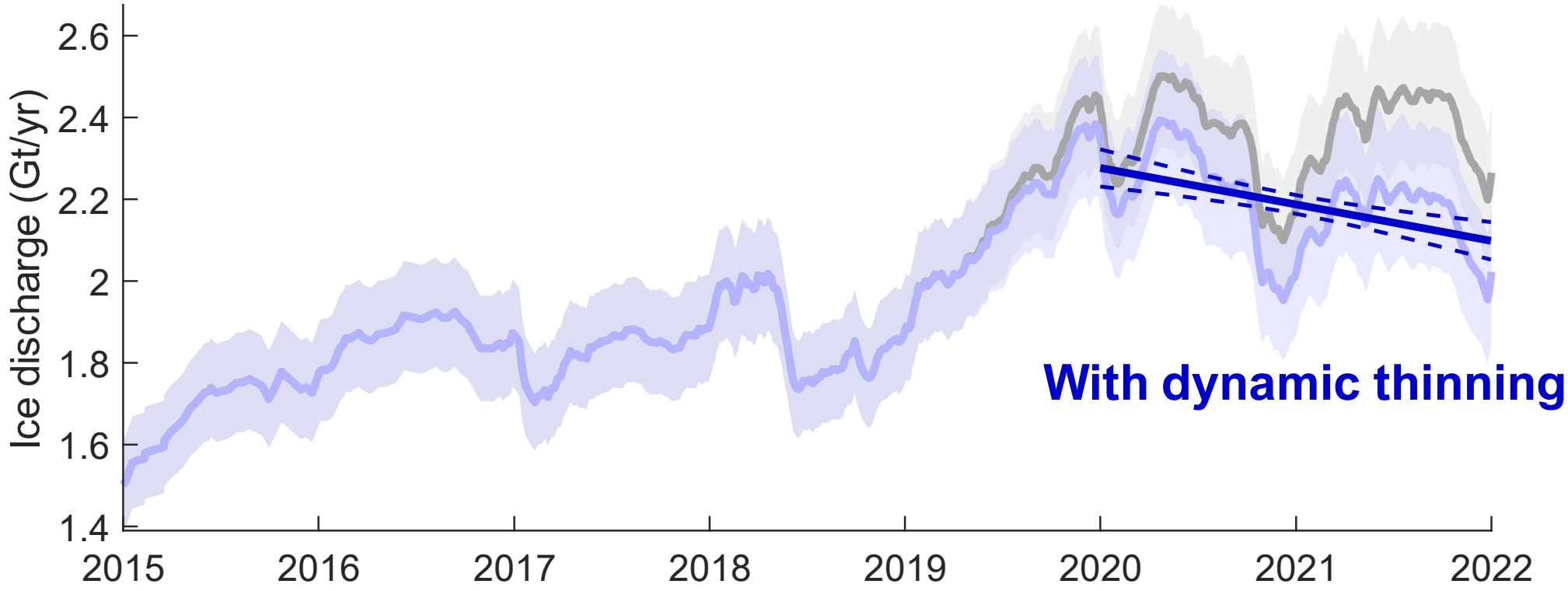


UNIVERSITY OF LEEDS

Consequences – increased ice discharge

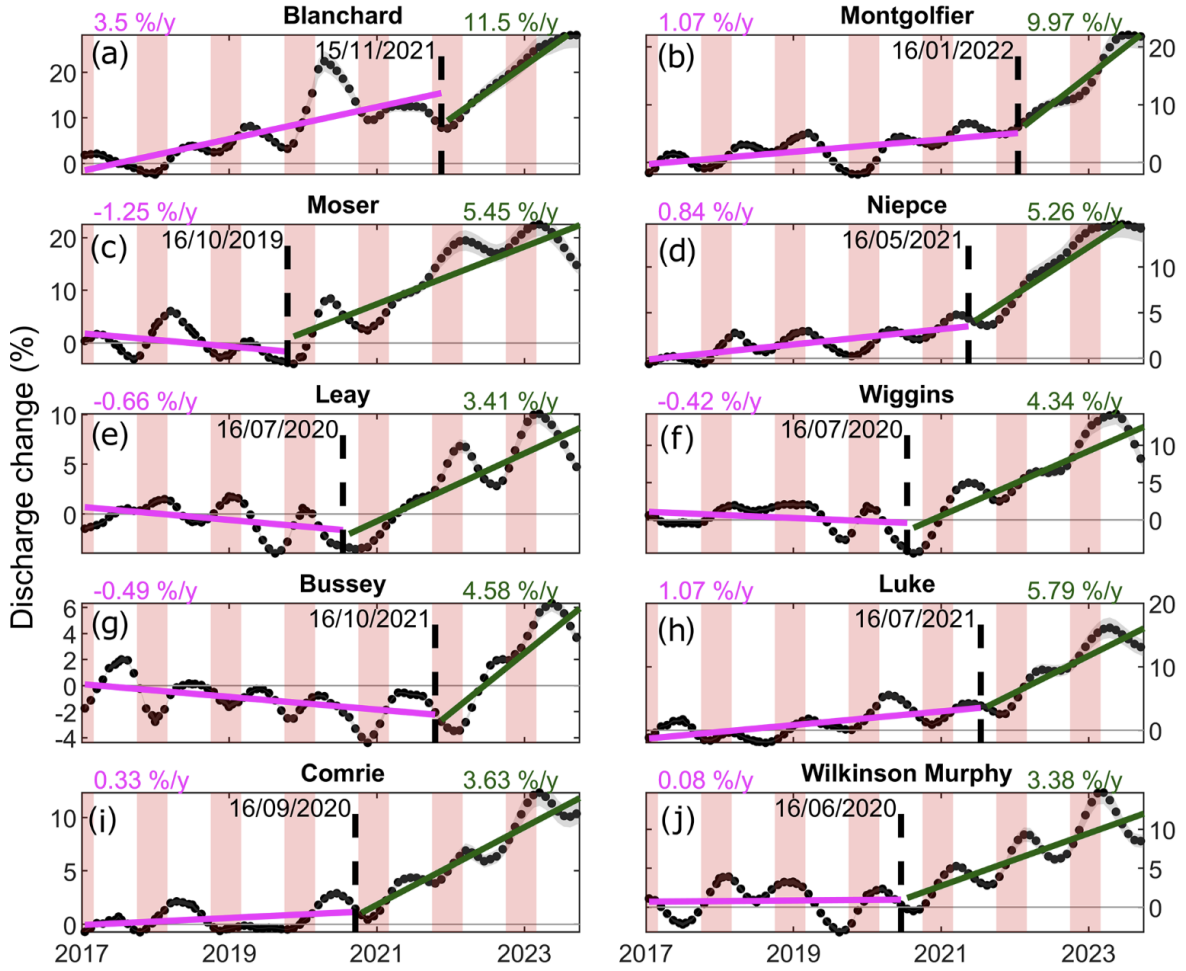


Consequences – increased ice discharge



Increased Antarctic Peninsula ice discharge

- Cadman Glacier was the most striking example of a wider trend of increased ice-discharge around the west AP[1].
- This trend began after Cadman's acceleration for most glaciers – around 2020/21.
- Ice discharge from the west AP has increased 7.4 % since 2017.



[1]Davison et al. 2024.

Summary and Conclusions

- We observed a doubling in speed and 8km retreat of Cadman Glacier on the west Antarctic Peninsula.
- CryoSat-2 altimetry and oceanographic measurements show this was due to warm water melting the glacier's tongue.
- ICESat-2 showed that this caused a dynamic thinning of over 20 m/yr.
- This is part of a wider trend: ice discharge from the west AP has increased 7.4 % since 2017.