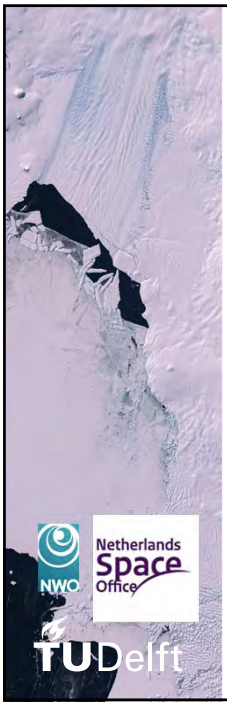

Remote sensing of damage feedbacks and ice shelf instability in Antarctica

Stef Lhermitte

@steflhermitte

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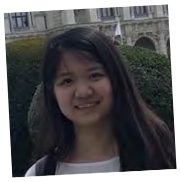
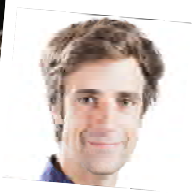
1

EarthMapps.io team





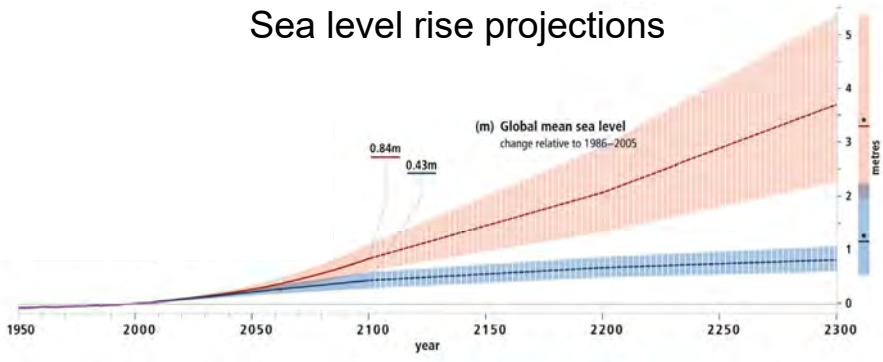
- Thore Kausch, *PhD*
  "SMB variability from remote sensing"
- Weiran Li, *PhD*
  "Firn properties from remote sensing"
- Maaike Izeboud, *PhD*
  "Ice shelf weakening from remote sensing & machine learning"
- Harry Zekollari, *post-doc*
  "CAPSizing ICE caps: tipping points through global modelling"

MARIE CURIE ACTIONS

2

Why?

Sea level rise projections

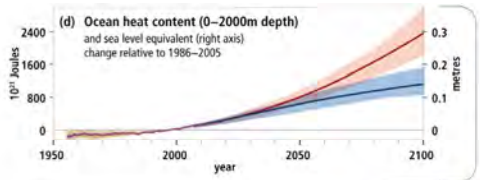


Business as usual

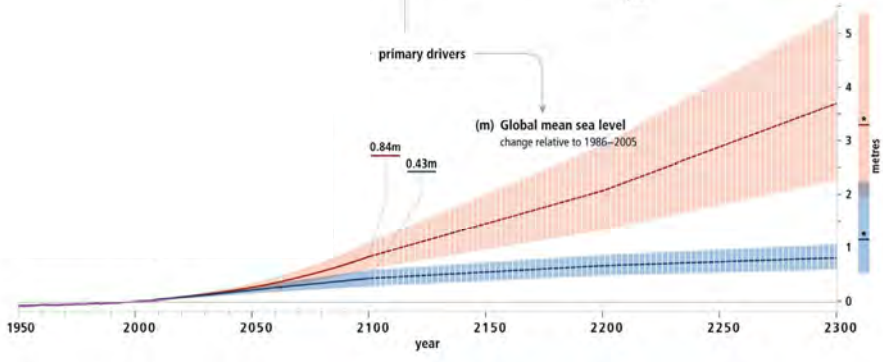
Paris agreement

SROCC, 2019

3



Thermal expansion



Business as usual

Paris agreement

SROCC, 2019

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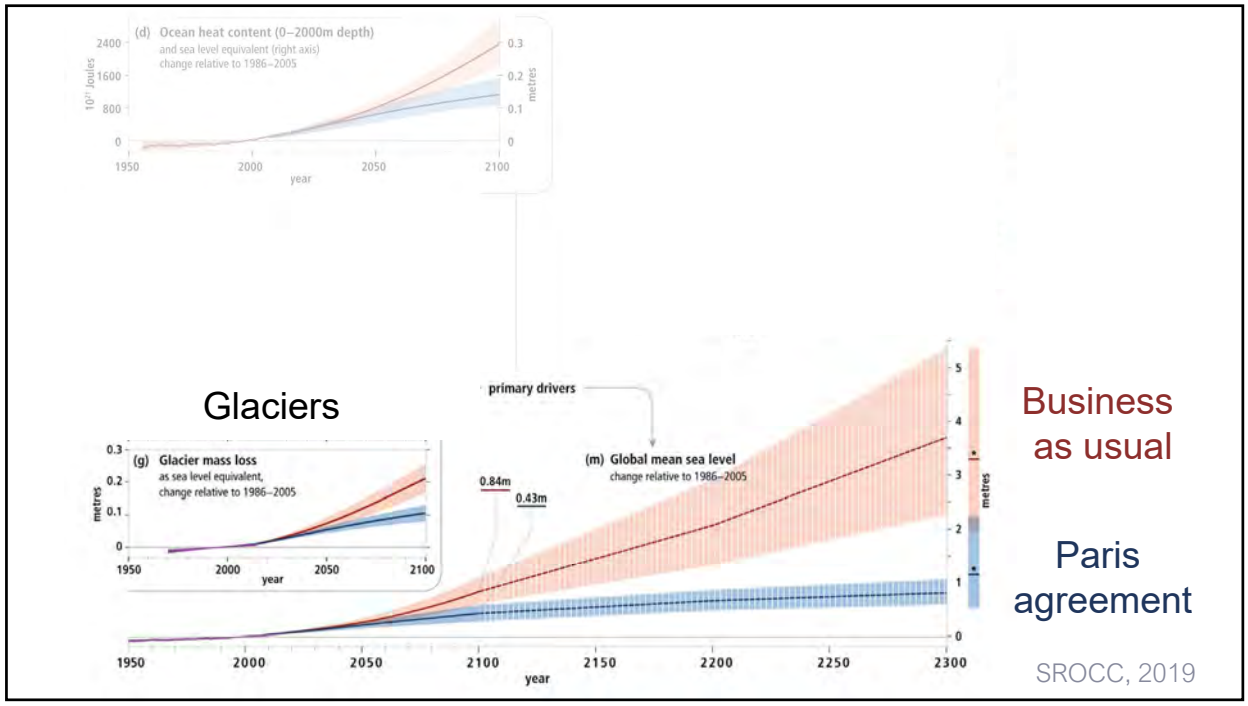
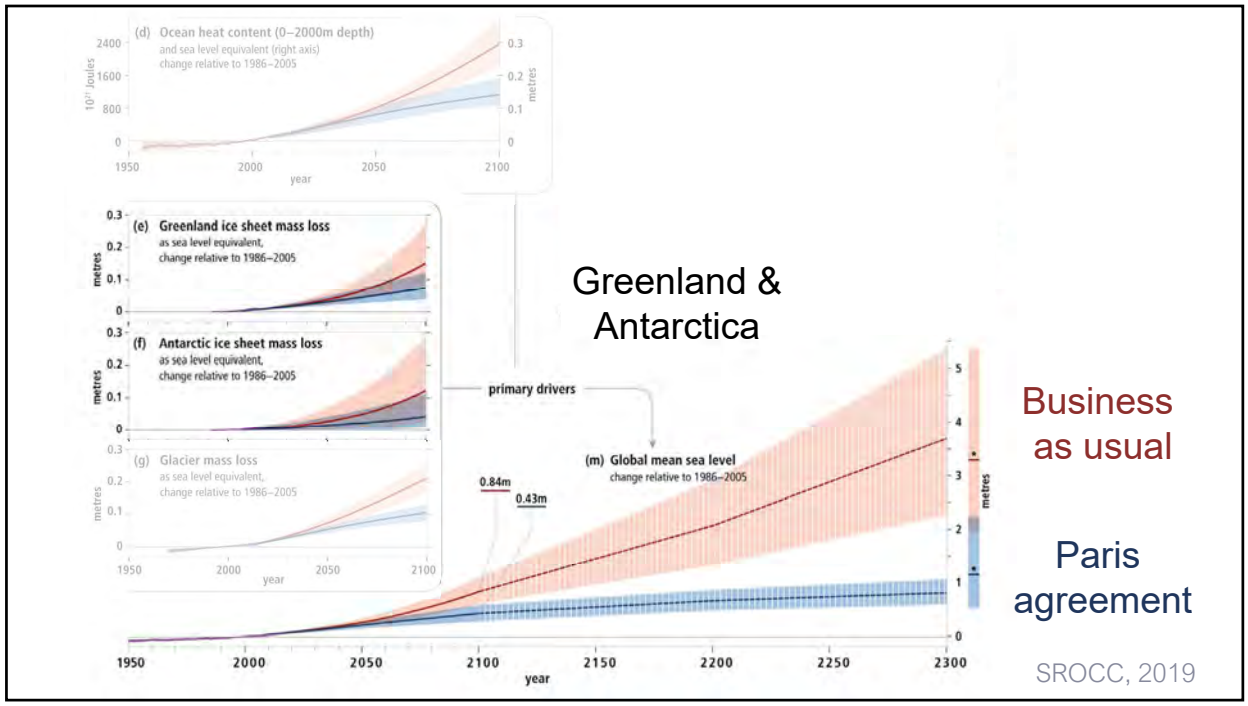
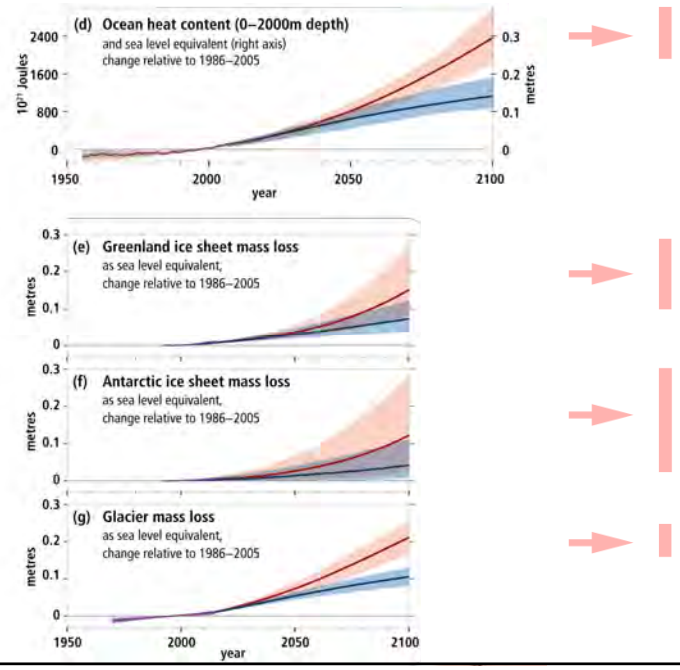

(d) Ocean heat content (0–2000m depth)
and sea level equivalent (right axis)
change relative to 1986–2005
Glaciers
primary drivers
(g) Glacier mass loss
as sea level equivalent,
change relative to 1986–2005
(m) Global mean sea level
change relative to 1986–2005
0.84m
0.43m
year
Business as usual
Paris agreement
SROCC, 2019

5


(d) Ocean heat content (0–2000m depth)
and sea level equivalent (right axis)
change relative to 1986–2005
(e) Greenland ice sheet mass loss
as sea level equivalent,
change relative to 1986–2005
(f) Antarctic ice sheet mass loss
as sea level equivalent,
change relative to 1986–2005
(g) Glacier mass loss
as sea level equivalent,
change relative to 1986–2005
Greenland & Antarctica
primary drivers
(m) Global mean sea level
change relative to 1986–2005
0.84m
0.43m
year
Business as usual
Paris agreement
SROCC, 2019

6



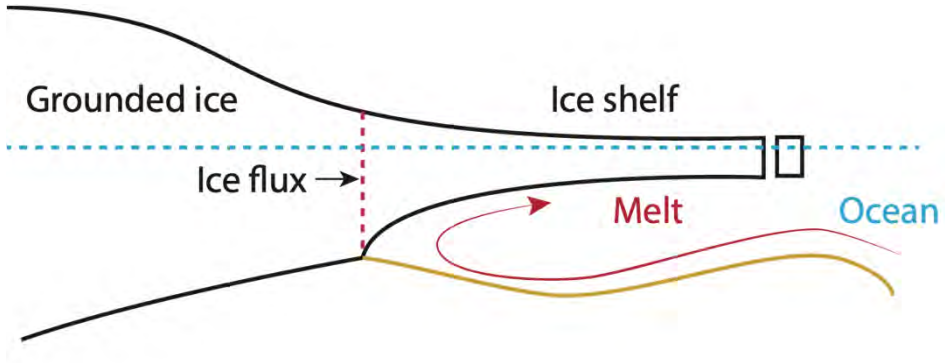
Antarctica is largest uncertainty

SROCC, 2019

7

8

Ice shelves: gatekeepers to Antarctica's ice



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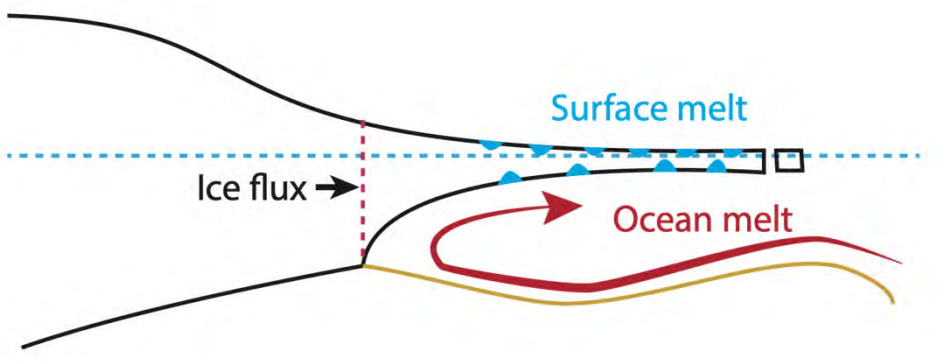
Ice shelves: gatekeepers to Antarctica's ice



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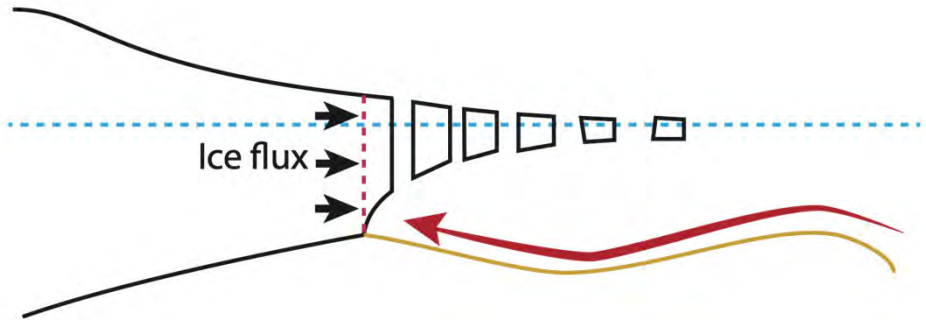
Ice shelves: gatekeepers to Antarctica's ice



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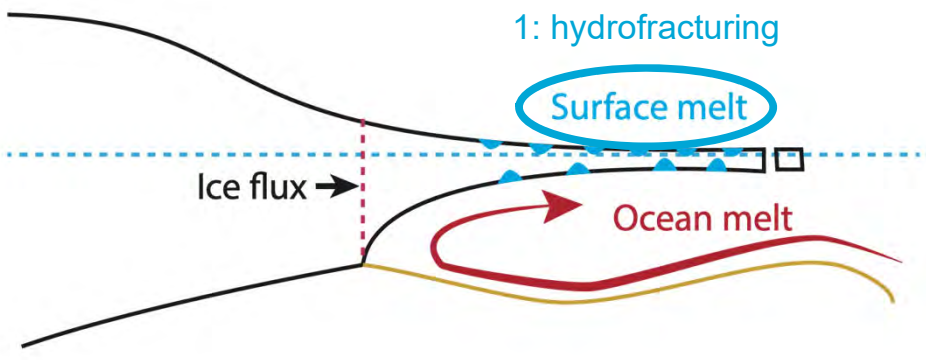
4 processes key for instability



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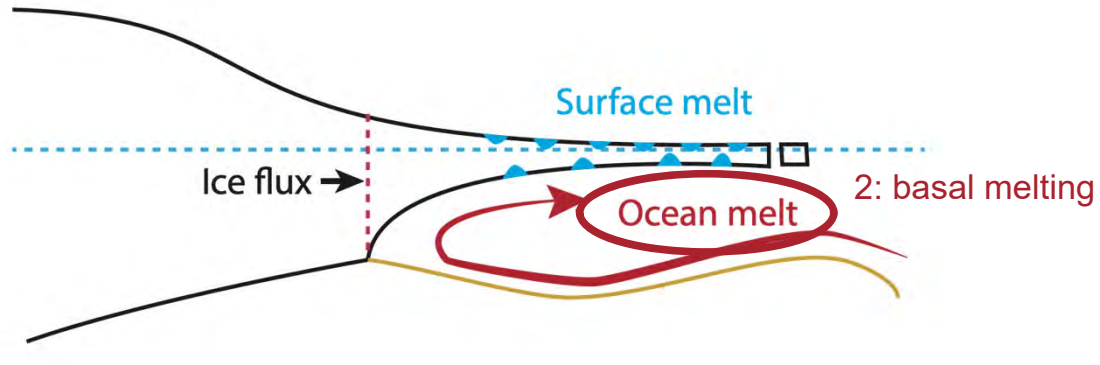
4 processes key for instability



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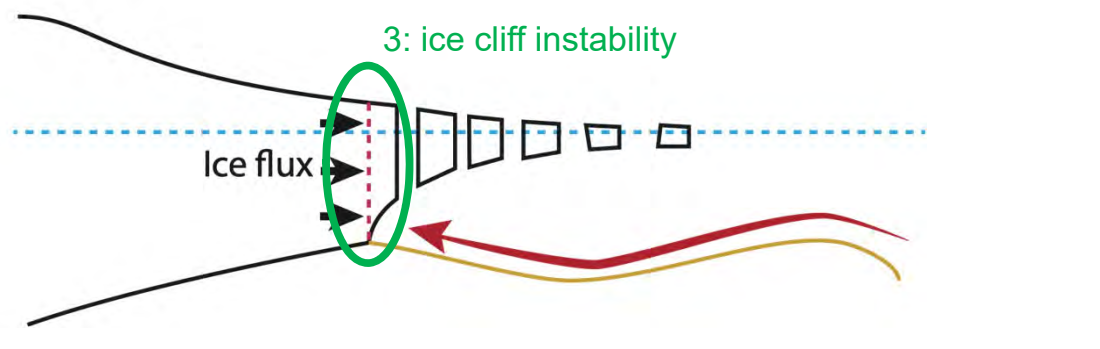
Ice shelves: gatekeepers to Antarctica's ice



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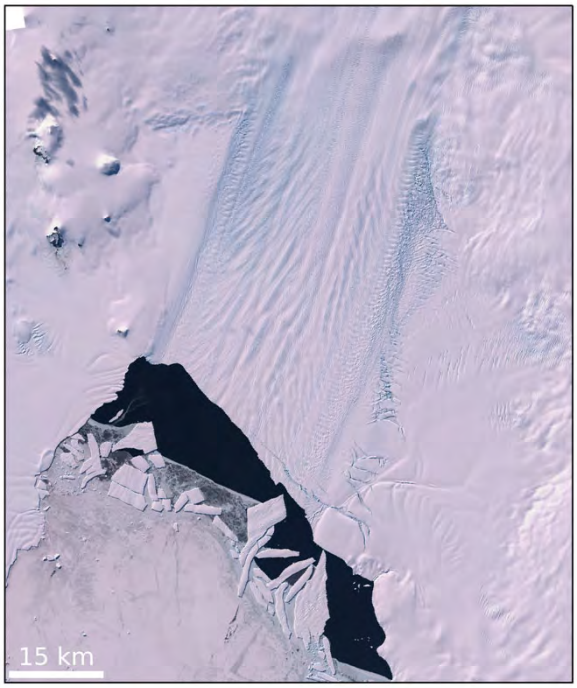

4: damage

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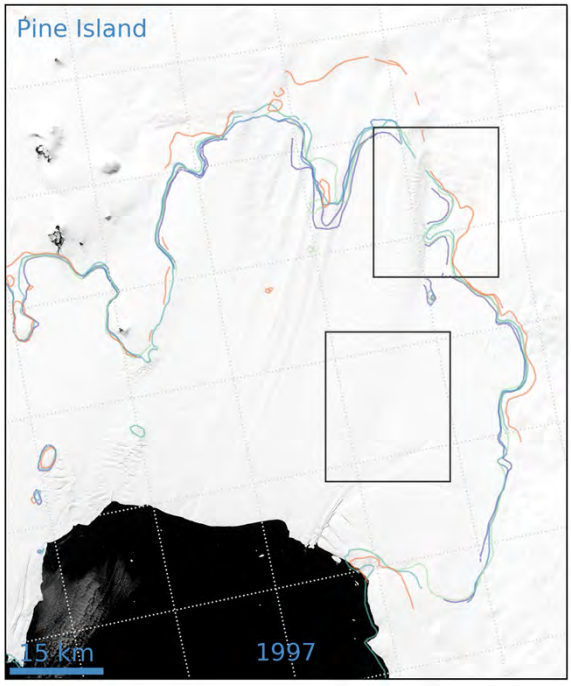

4: damage

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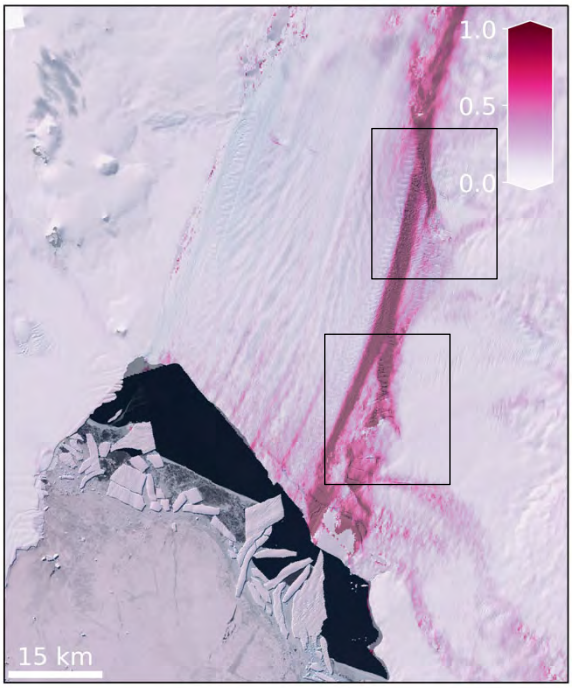

4: damage

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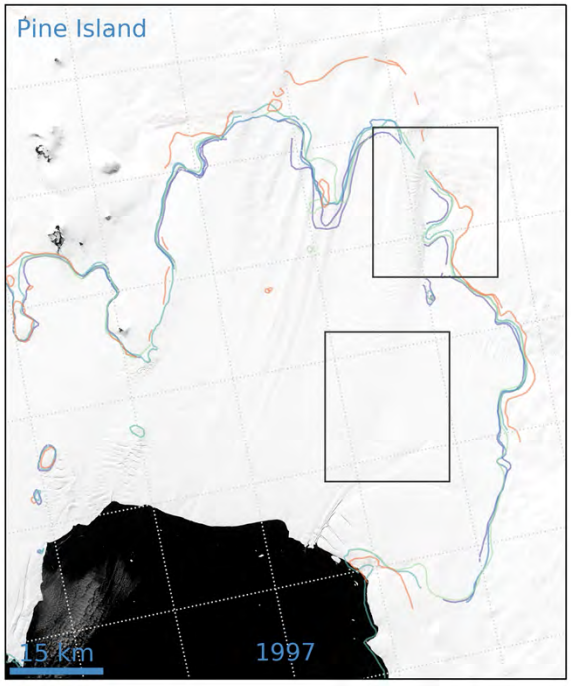
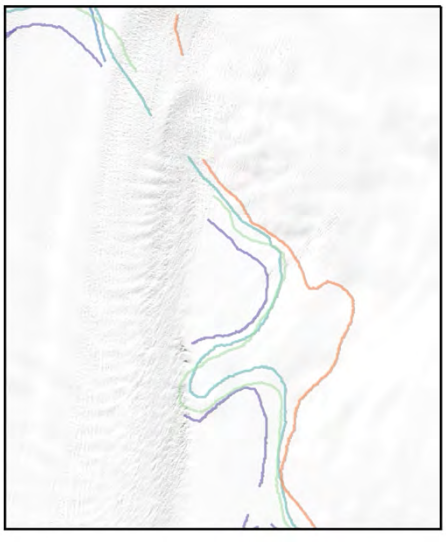
17





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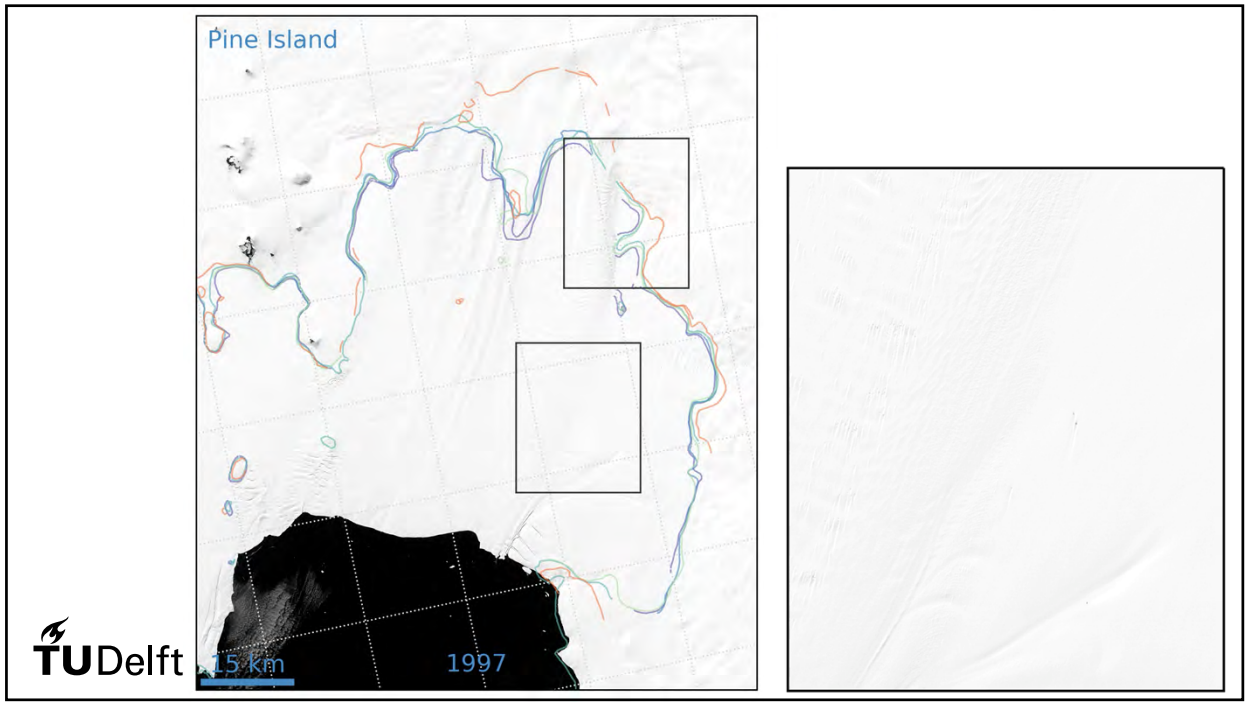

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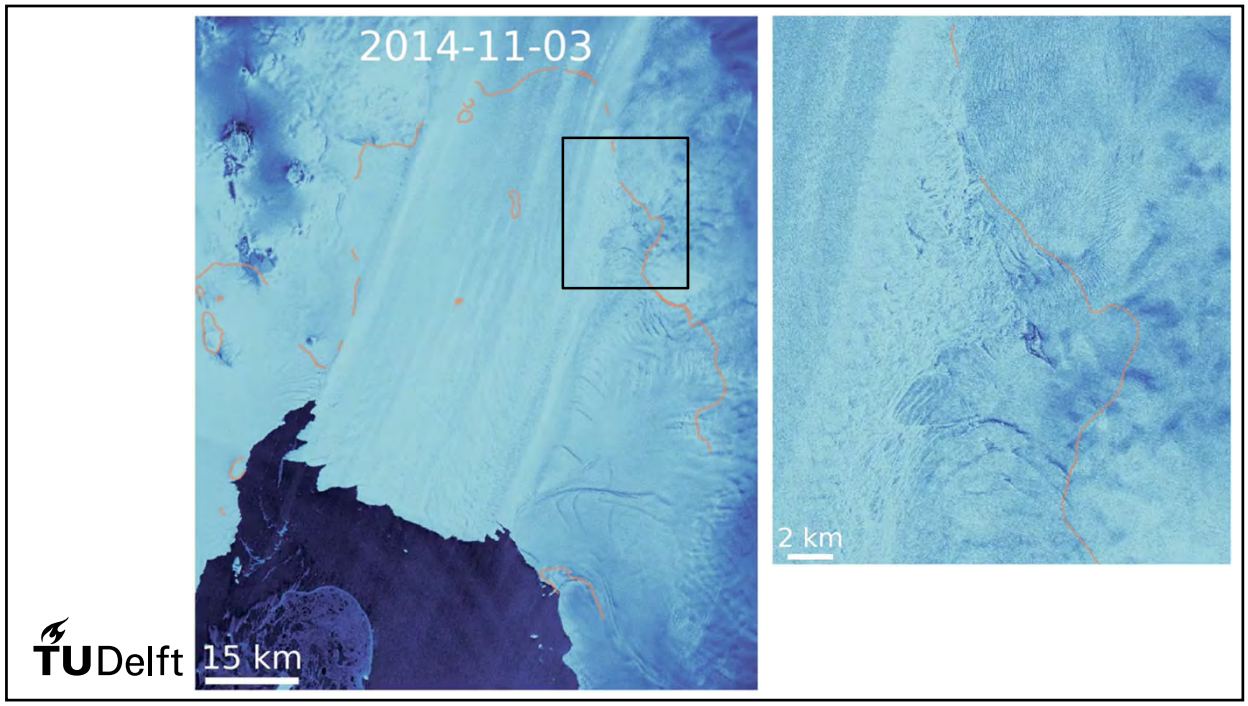

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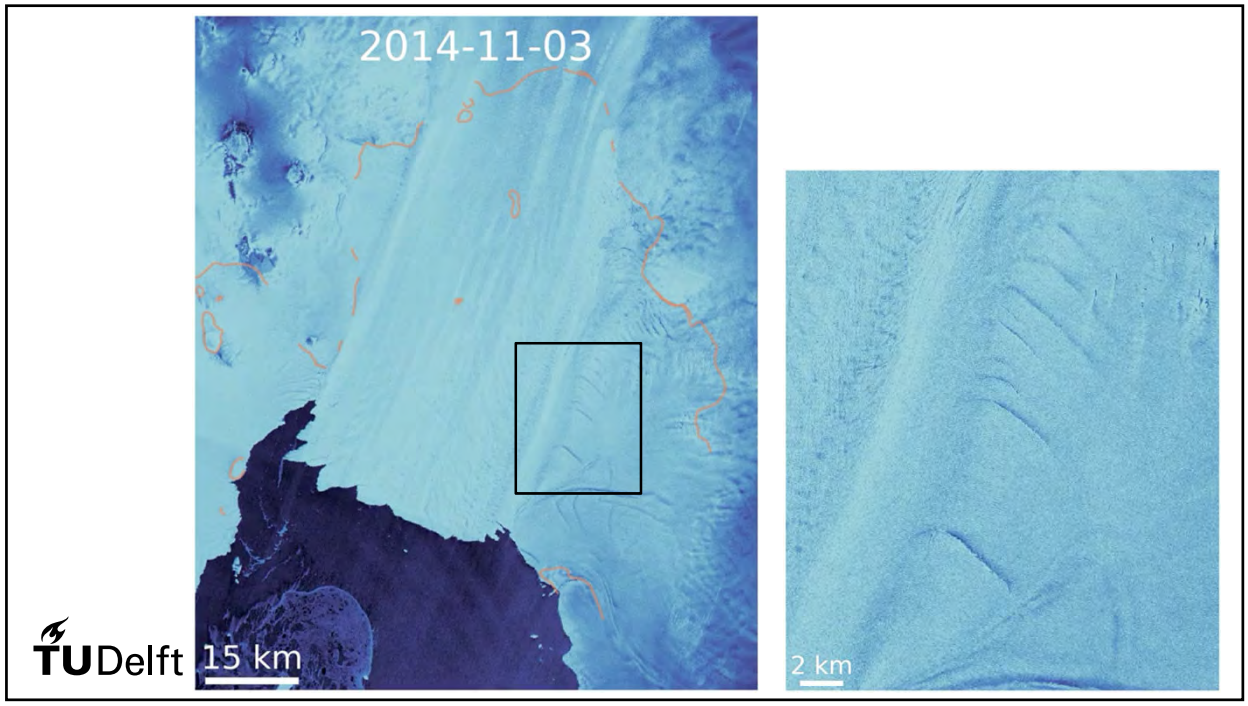

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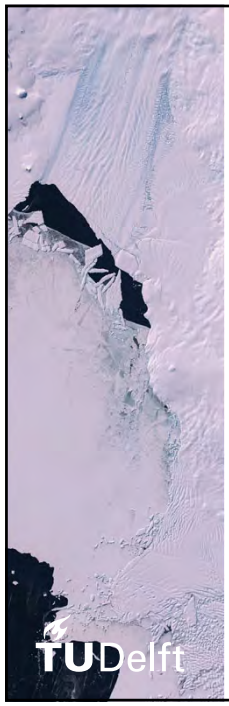

Potential of remote sensing

- High spatial resolution
- Short revisit times
- Satellite complementarity

Yet a method is lacking

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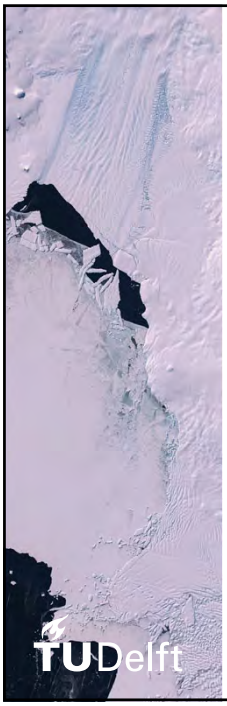
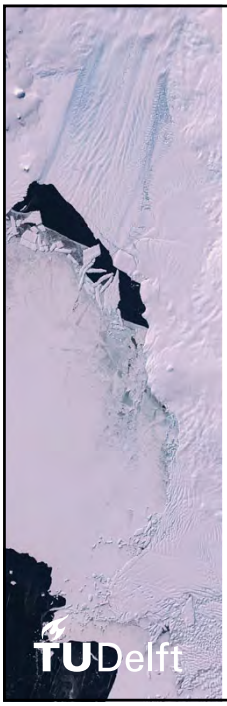


Goal

Use remote sensing to

- develop damage indicators across all Antarctic ice shelves
- assess damage impact on future ice shelf instability

23

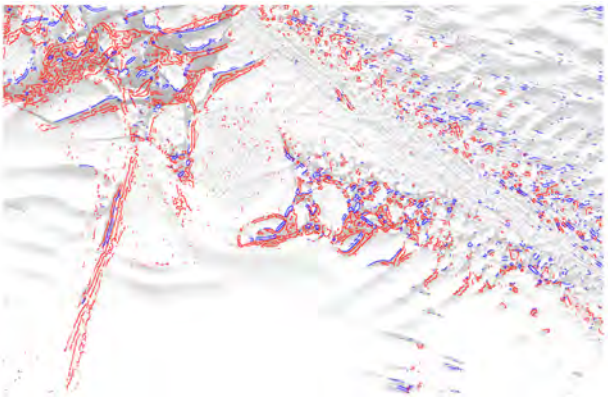


Damage indicators

- From multi-source remote sensing data
  - Optical (Landsat/Sentinel-2/…)
  - SAR (Sentinel-1)
  - Altimetry (Cryosat/Icesat)
- Combined with
  - Ice velocity (Feature tracking SAR/Optical)
  - Elevation change (altimetry/stereo-images)
  - Model output

24

Damage indicators



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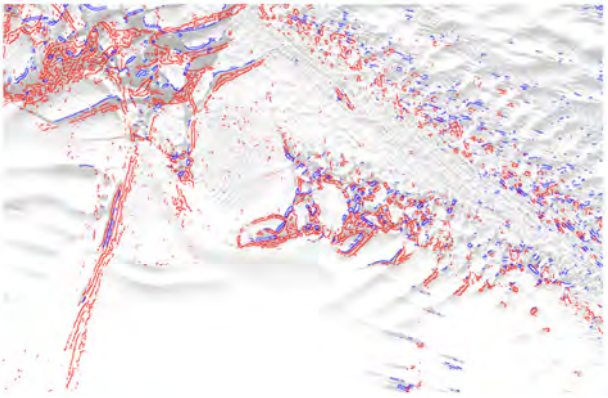
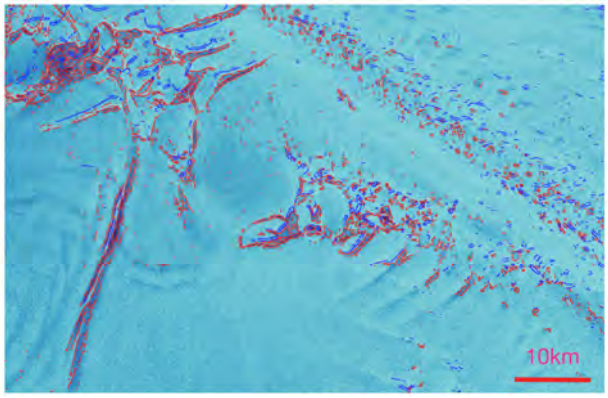
Landsat 8 edges

25

25

Damage indicators





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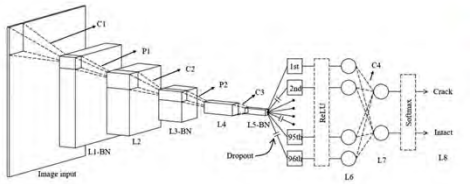
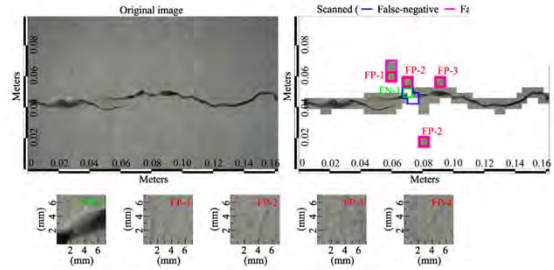
Landsat 8 edges Sentinel-1 edges

26

26

Damage indicators





COMPUTER-AIDED CIVIL AND INFRASTRUCTURE ENGINEERING
Computer-Aided Civil and Infrastructure Engineering **32** (2017) 361–378

Deep Learning-Based Crack Damage Detection Using Convolutional Neural Networks

Young-Jin Cha* & Wooram Choi

27

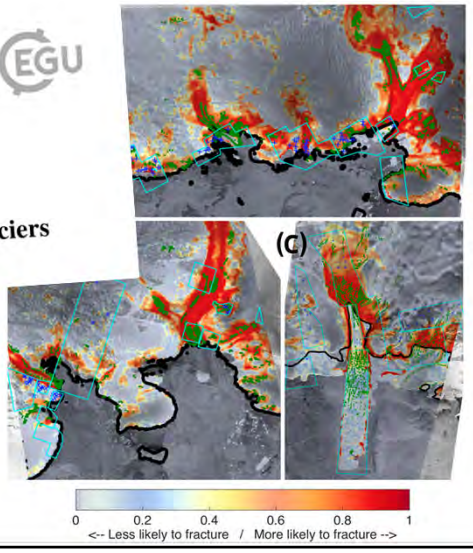
Training / evaluation

The Cryosphere, 12, 3187–3213, 2018
https://doi.org/10.5194/tc-12-3187-2018

The Cryosphere Open Access EGU

A statistical fracture model for Antarctic ice shelves and glaciers

Veronika Emetc[1], Paul Tregoning[1], Mathieu Morlighem[2], Chris Borstad[3], and Malcolm Sambridge[1]



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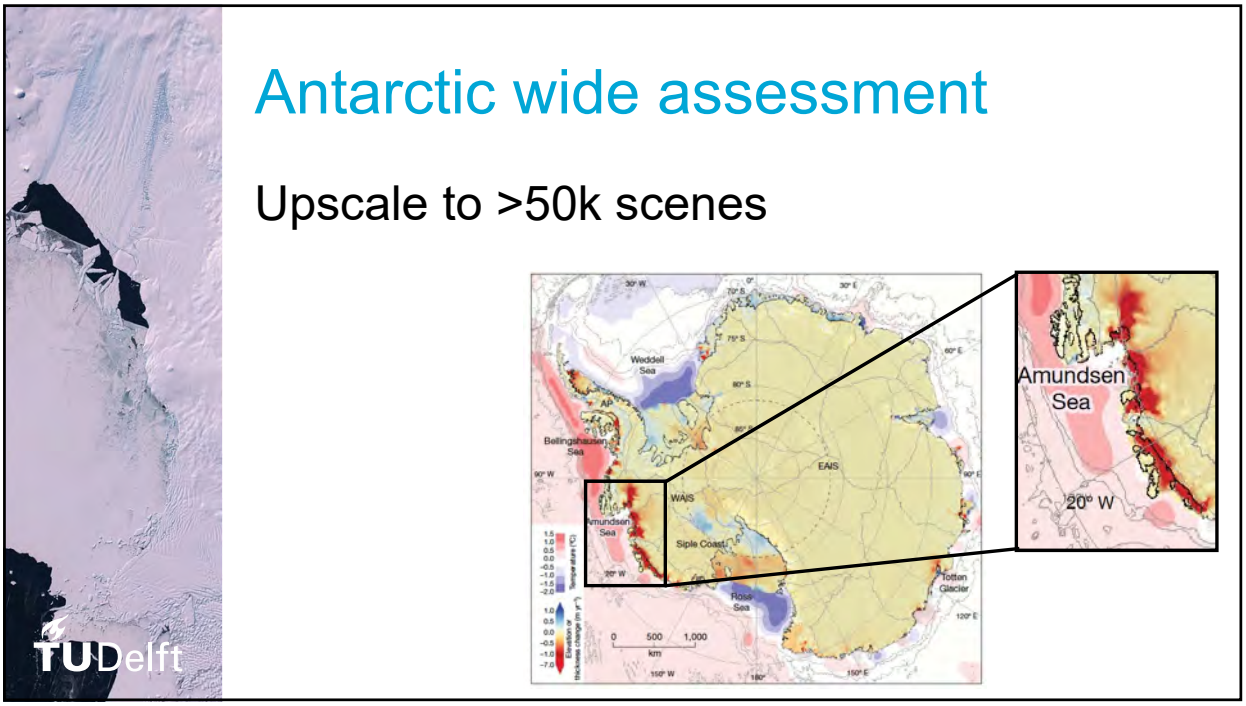
Antarctic wide assessment
Upscale to >50k scenes
Weddell Sea
Bellingshausen Sea
Amundsen Sea
WAIS
EAIS
Siple Coast
Ross Sea
Totten Glacier
0 500 1,000
km
Amundsen Sea
20° W
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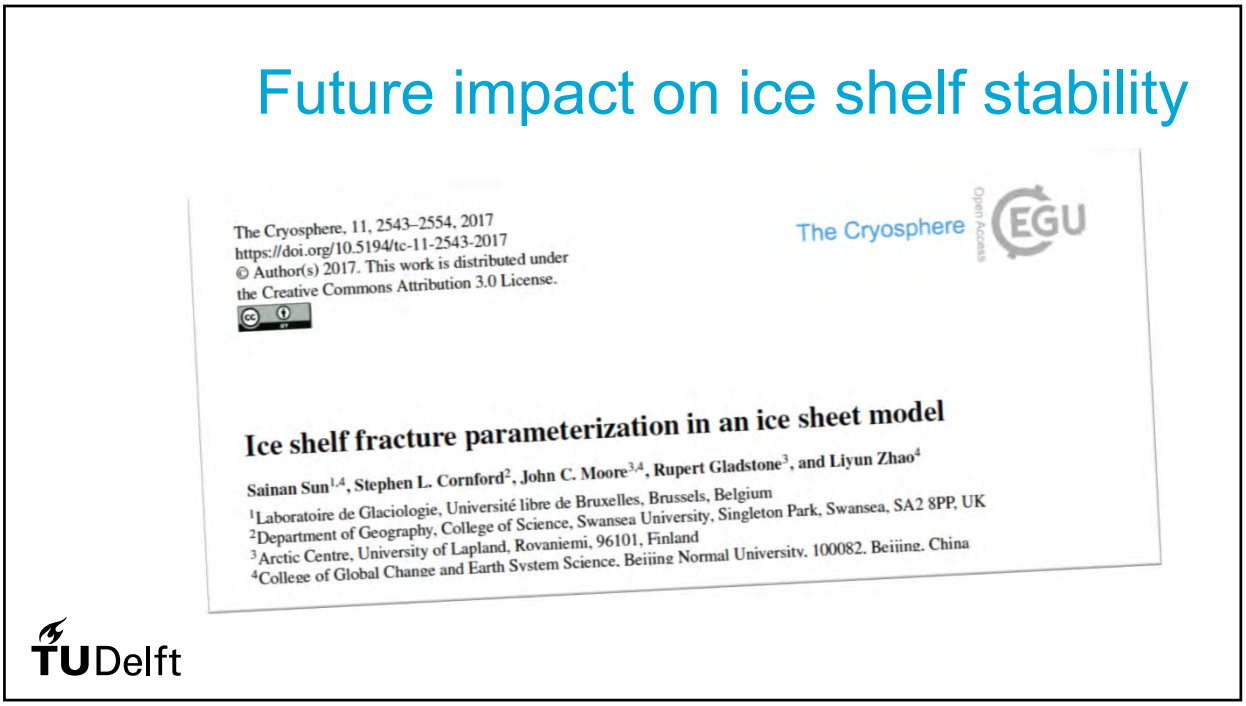
29


Future impact on ice shelf stability
The Cryosphere, 11, 2543–2554, 2017
https://doi.org/10.5194/tc-11-2543-2017
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the Creative Commons Attribution 3.0 License.
The Cryosphere
Open Access
EGU
Ice shelf fracture parameterization in an ice sheet model
Sainan Sun[1,4], Stephen L. Cornford[2], John C. Moore[3,4], Rupert Gladstone[3], and Liyun Zhao[4]
[1]Laboratoire de Glaciologie, Université libre de Bruxelles, Brussels, Belgium
[2]Department of Geography, College of Science, Swansea University, Singleton Park, Swansea, SA2 8PP, UK
[3]Arctic Centre, University of Lapland, Rovaniemi, 96101, Finland
[4]College of Global Change and Earth System Science, Beijing Normal University, 100082, Beijing, China
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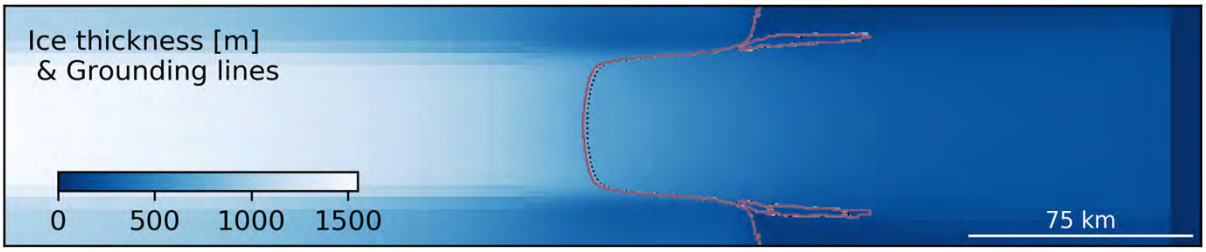
30

Damage simulations



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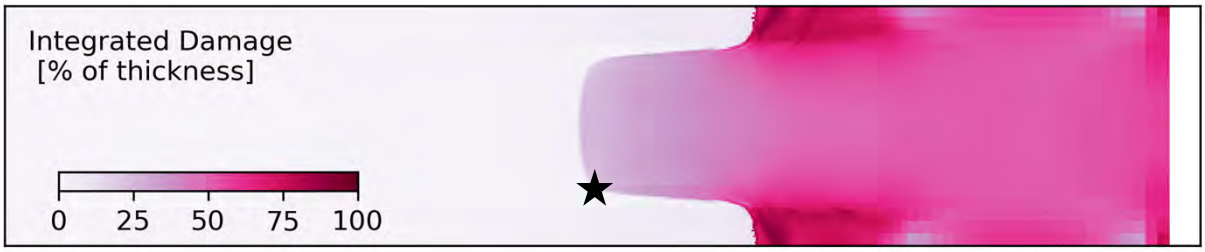
Lhermitte *et al (in review)*

31

Damage simulations



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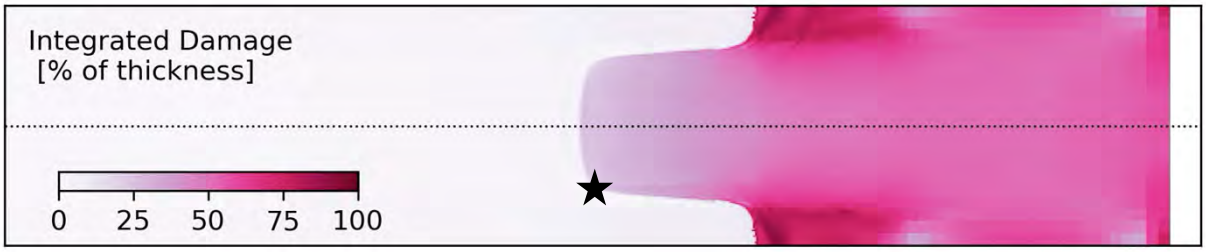
Damage simulations



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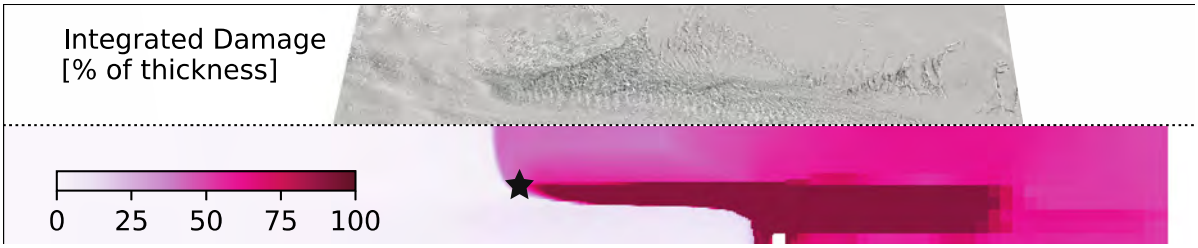
33

Evaluation with observations



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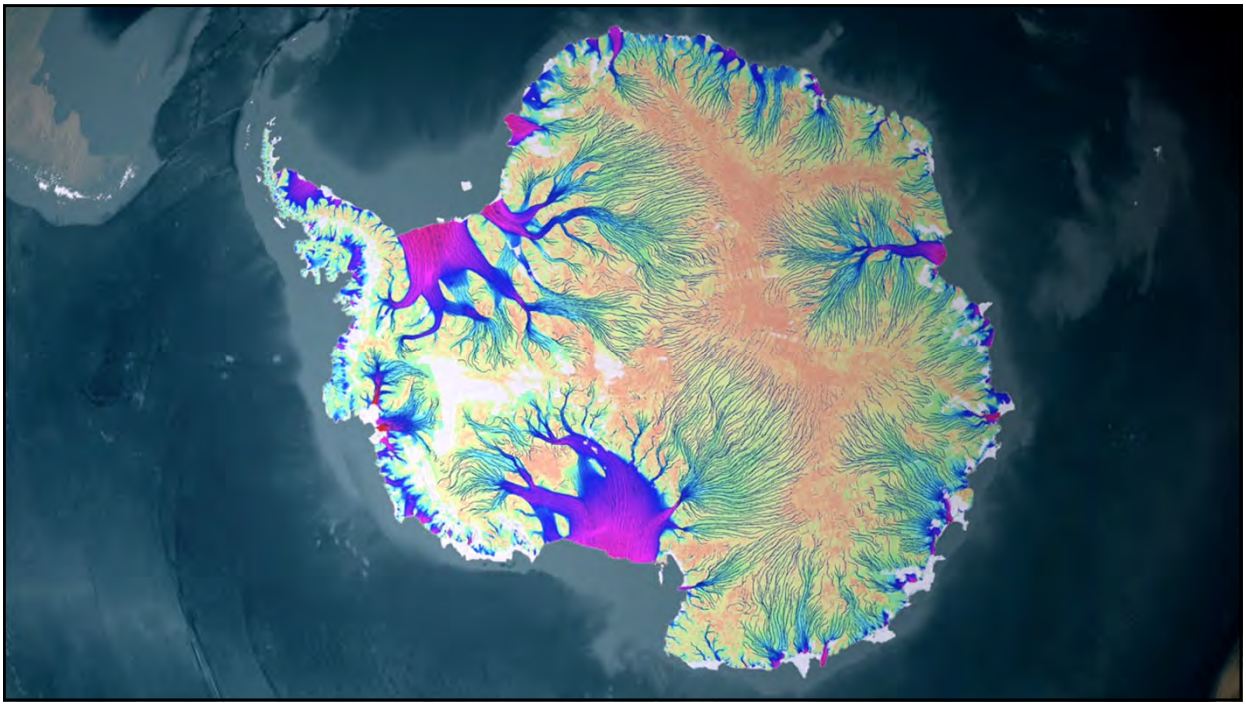
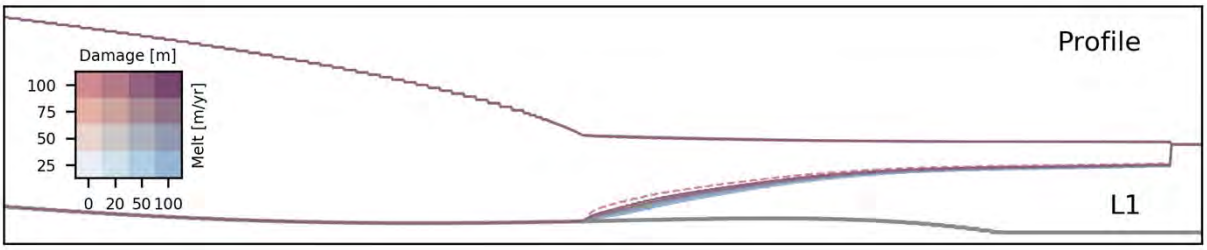
34



35

Future simulations



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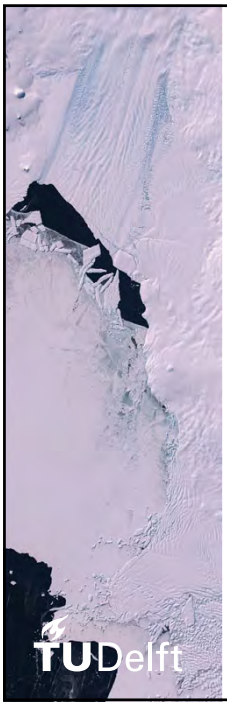
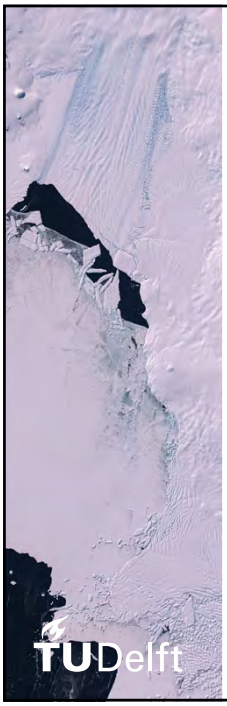


eScience?

- Advanced image processing and machine learning
- Optimized data handling and big data approaches
- Data assimilation and efficient computing

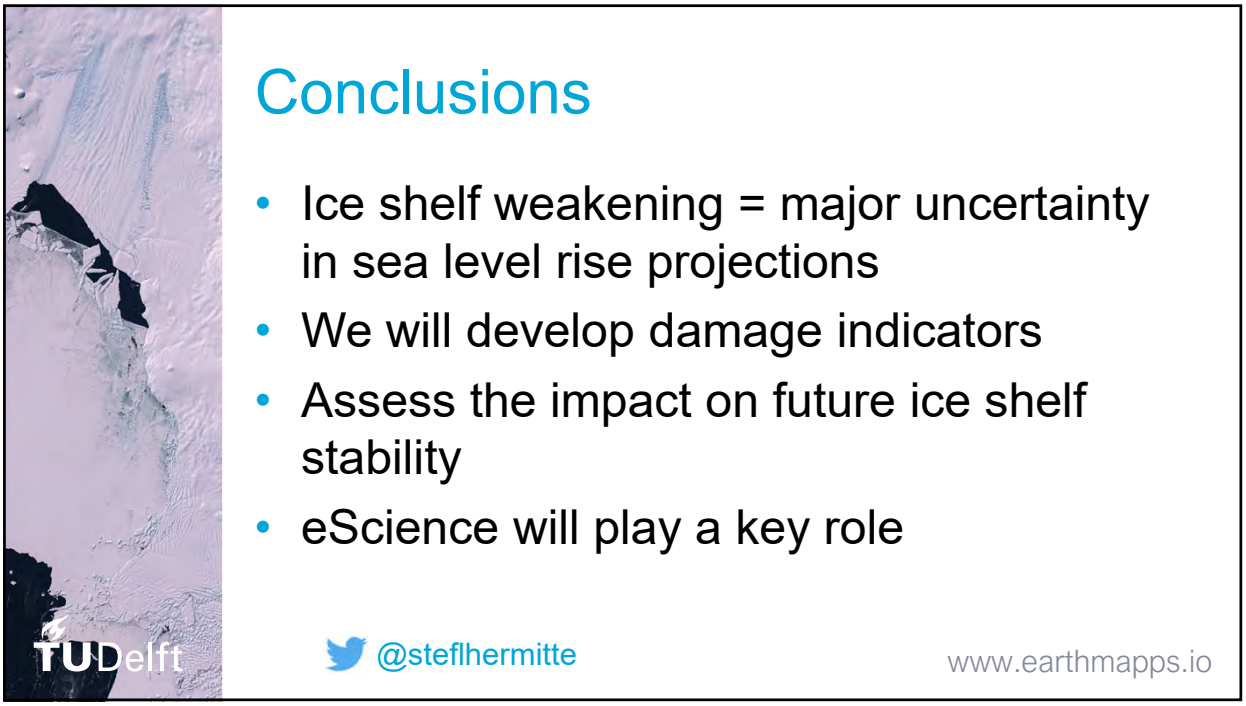
37



What is in it for you?

- Re-use:
  - Tools to process Landsat/Sentinel archives
  - Tools for machine learning of wider interest
- Sustainability:
  - Open source
  - Workshop -> gather a community
- Dissemination
  - Workshop
  - Teaching tool (i.e. Copernicus academy)

38


Conclusions
• Ice shelf weakening = major uncertainty in sea level rise projections
• We will develop damage indicators
• Assess the impact on future ice shelf stability
• eScience will play a key role
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39


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BRUSSELS 2021
KEEPING AN EYE ON THE WORLD
FROM THE HEART OF EUROPE
11 - 16 July 2021
in Brussels
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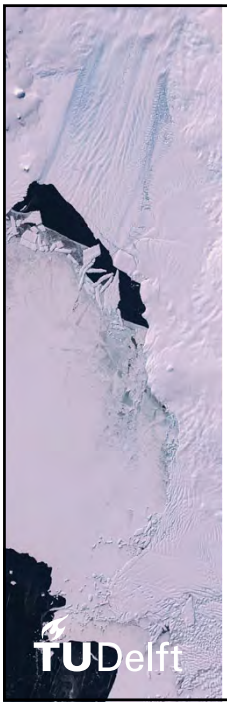

Conclusions

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41