



living planet symposium BONN 23-27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

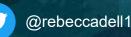
Rebecca Dell

EUMETSAT CECMWF

A record of surface meltwater ponding and slush on Antarctic ice shelves from 2013 to 2021 using Landsat 8

10

Neil Arnold, Ian Willis, Alison Banwell, Stef Lhermitte, Bert Wouters, Ruthie Halberstadt, Anna Maria Trofaier, Marcus Engdahl



rld46@cam.ac.uk

26/05/22

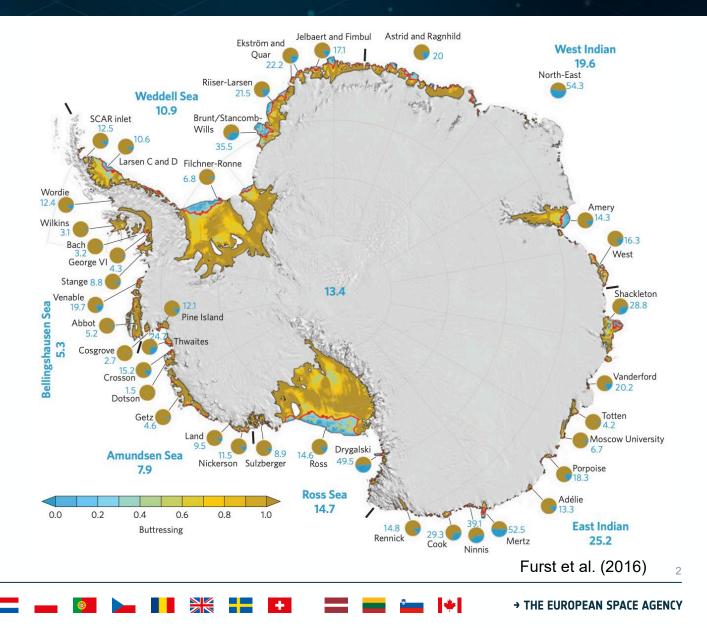
ICLASSIFIED – For ESA Official Use Only



Ice Shelf Buttressing



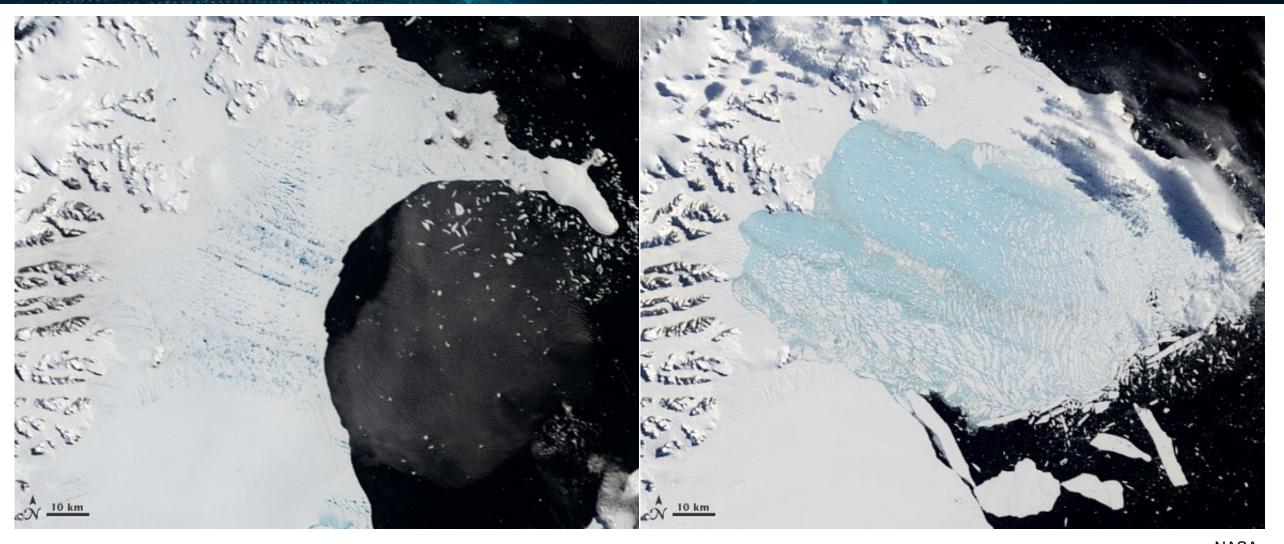
- Ice shelves border ~ 75% of Antarctica
- Furst et al. (2016) determined which parts of each shelf are passive shelf ice vs. active shelf ice.
- The Bellingshausen Sea has the lowest regional percentage of Passive Shelf Ice (i.e., it is actively buttressing much of the upstream grounded ice).



How Dangerous is Meltwater?







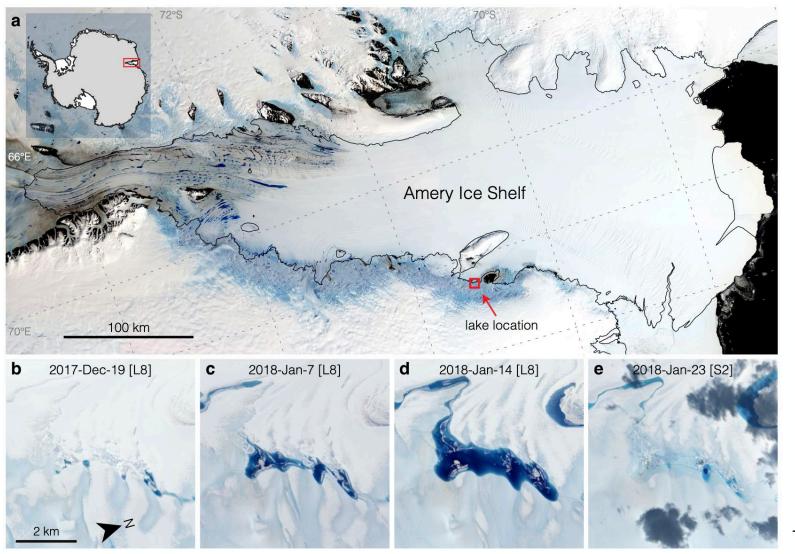
NASA

💳 🔜 📲 🚍 💳 🛶 📲 🔚 🔚 🔚 🔚 🔚 🔚 🔚 🔤 🛻 🚳 🛌 📲 🖬 🖬 📲 💏 🐜

How Dangerous is Meltwater?







Trusel et al. (2022)

💳 🔜 🖬 🚛 💳 🛶 📲 🔚 🔚 📰 🔜 📲 🔚 🔤 🐜 🚺 😹 🖬 🛨 🔤 📾 🛶 👘

How Dangerous is Meltwater?



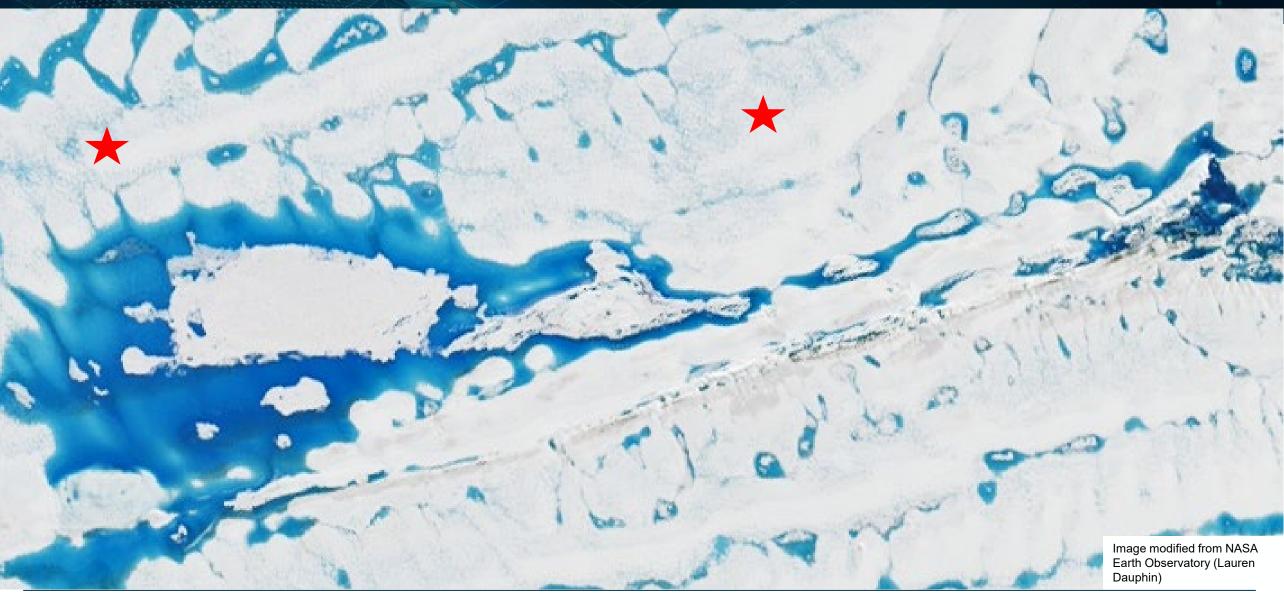




Bell et al. (2017)





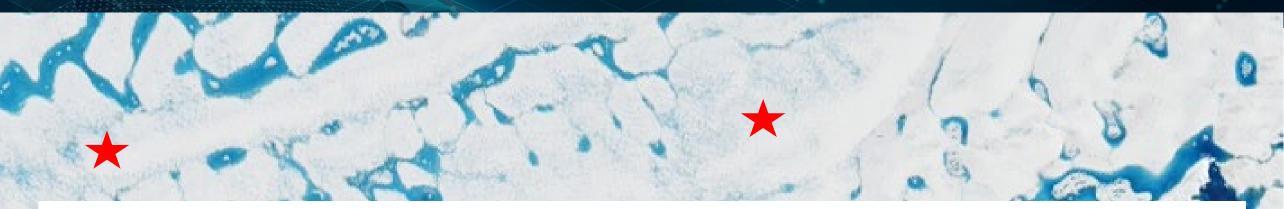


💳 🔜 🖬 🚛 💳 📥 📲 🔚 🔚 🔚 🔚 🔚 🗮 🔚 📾 🚱 🛌 🚺 👫 🚛 🖬 📰 📾 🏜 🛊 🔸 🗰 the European space agency



Image modified from NASA Earth Observatory (Lauren

Dauphin)



- Alters the ice shelf surface energy balance (albedo and latent heat of re-freezing)
- Can lead to a reduction in firn air content
- A precursor to lake formation, and therefore to potential ice shelf collapse





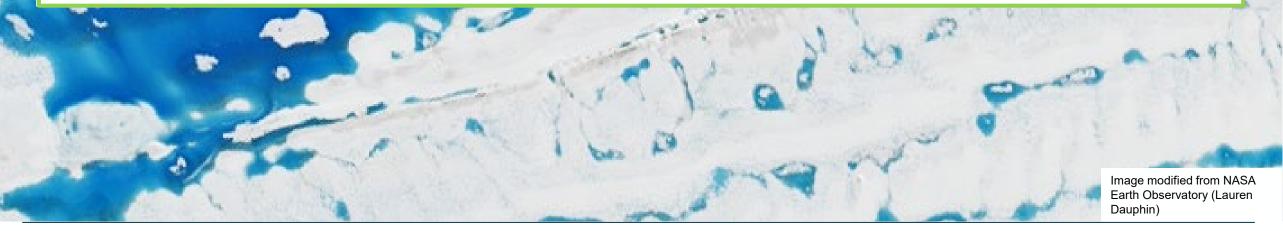




AIM

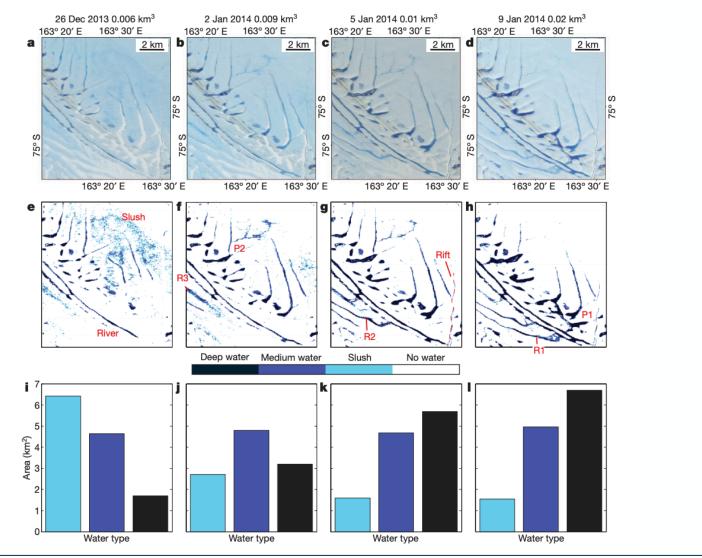
Develop a continent-wide dataset of surface meltwater extent on ice shelves (2000's-present day)

- Do this using classification algorithms in Google Earth Engine
 - Ultimately want to classify two classes: Ponded Water and Slush



💻 🔜 📲 🚍 💳 🕂 📲 🔚 📰 📰 📲 📰 📲 📰 🛶 🚳 🛌 📲 🚼 🖬 🖬 ன 🛶 🍬 🖬

Mapping Slush: Threshold Base Approach



Bell et al. (2017)

*

55. 55 UNIVERSITY OF 55. 55 CAMBRIDGE

→ THE EUROPEAN SPACE AGENCY

 $\cdot eesa$

Mapping Slush: Random Forest Approach



Pre-processing

Select training and validation scenes from the Landsat 8 record (2013-2020) for each ice shelf

Convert scenes from TOA to perpixel TOA

Clip scenes to ice shelf boundaries using shapefiles from the SCAR Antarctic Digital Database

Apply threshold-based rock mask

Apply threshold-based cloud mask

Apply NDWI_{ice} > 0.1 to select pixels that are likely wet

Training

Sample 100000* pixels from each validation scene (Grid Size: 30m) for bands 1-7.

Unsupervised k-means clustering (min N clusters: 5, max N clusters: 70)

Manually interpret k-means clusters. If clusters overlap two interpreted classes, re-run k-means on a sample (N Pixels: 10000*, Grid Size: 30m) of the class (Min N clusters: 8, Max N clusters: 12. Then form final interpreted classes.

Manually mask out areas of obvious error

Sample 1000 pixels per class Train the Random Forest Classifier (N Trees: 150)

Validation

Apply Random Forest Classifier to the six L8 validation scenes Sample 200 pixels per classified scene Expert Elicitation – four experts each interpret 100 pixels per scene. The first 50 are shared between experts (intercomparison dataset)

and the second 50 are individual to each expert (main validation dataset).

Produce Confusion Matrix

Application

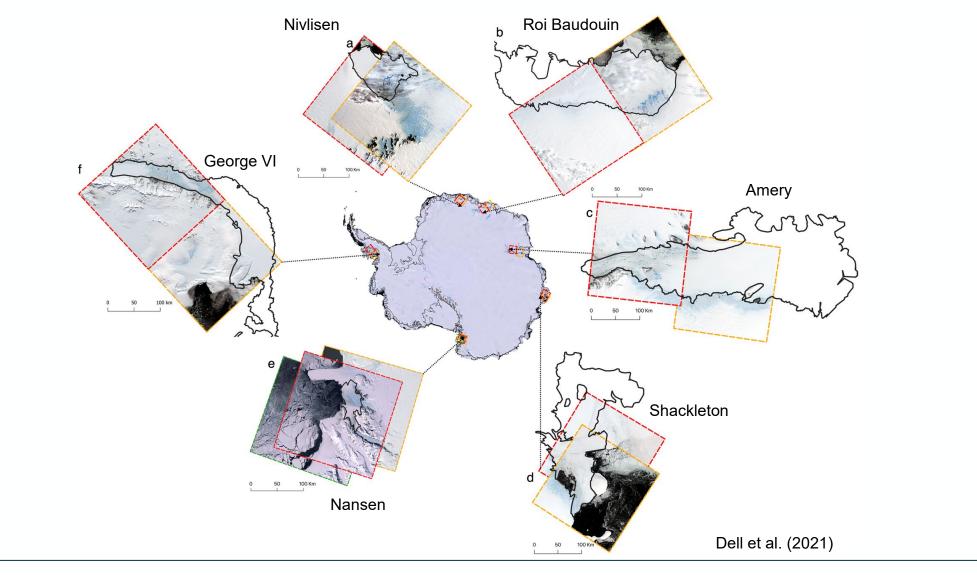
影 影 影

> Search the full L8 collection for scenes over each ice shelf, filtering only for a solar angle $> 20^{\circ}$ Per-pixel TOA correction Clip to ice shelf boundaries Threshold-based rock mask Threshold-based cloud mask Apply NDWlice > 0.1 to select pixels that are likely wet Quality mosaic (using NDWlice values) to create monthly images (Nov-Mar) Classify Post Process (using slope and velocity)

> > Modified from Dell et al. (2022) 10

= ___ ₽ ₽ ₽ = __ ₽ ₽ ↓ ₽ 🔚 🔚 ___ ₽ ₽ ₽ ₽ ₩ = ₩ = ₩ ₩ ₽ ₩ ₽ ₽ ₩ ₩ → THE EUROPEAN SPACE AGENCY

Mapping Slush: Random Forest Approach



YOF

CAMBRIDGE

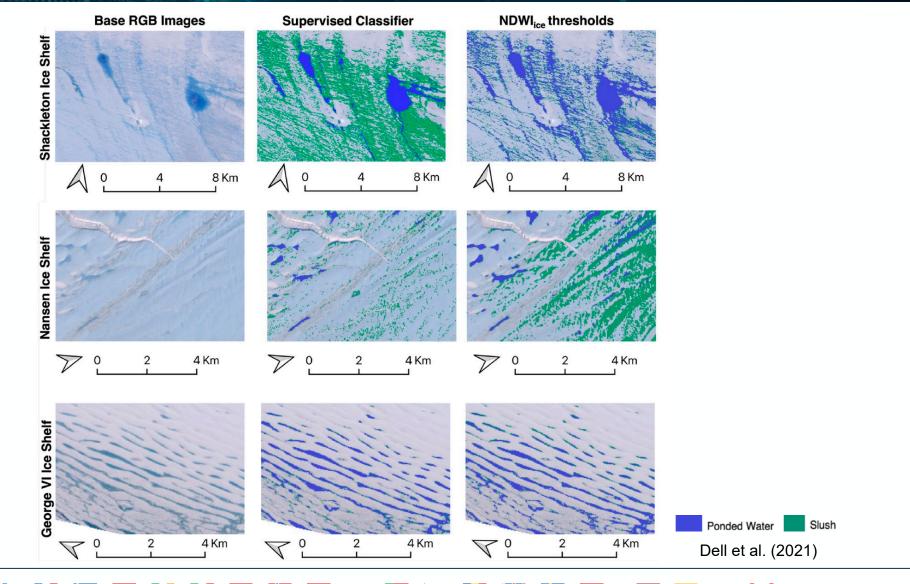
·eesa

11

·SS ·SS ·SS ·SS

Mapping Slush: RF vs. NDWI

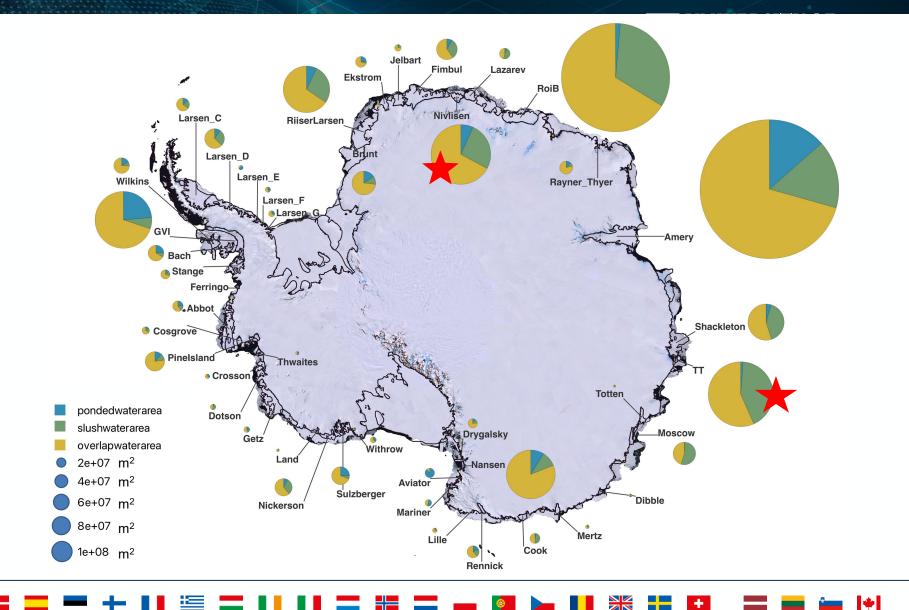
CAMBRIDGE CONSTRUCTION



→ THE EUROPEAN SPACE AGENCY

Results

CAMBRIDGE COSA

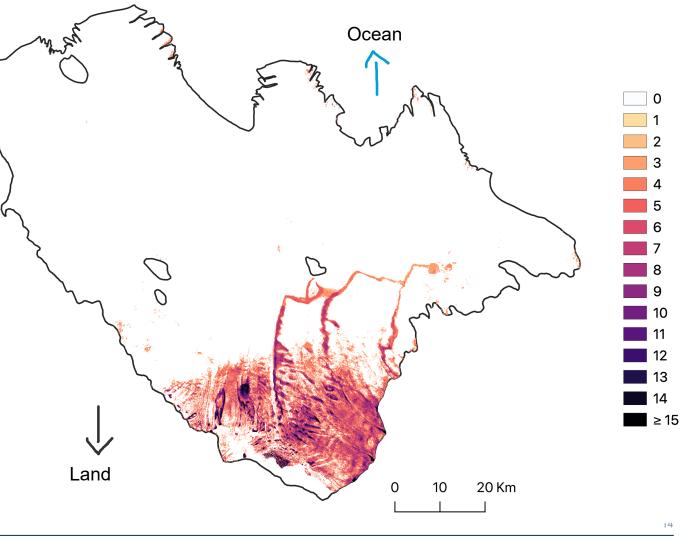


→ THE EUROPEAN SPACE AGENCY

Nivlisen Ice Shelf



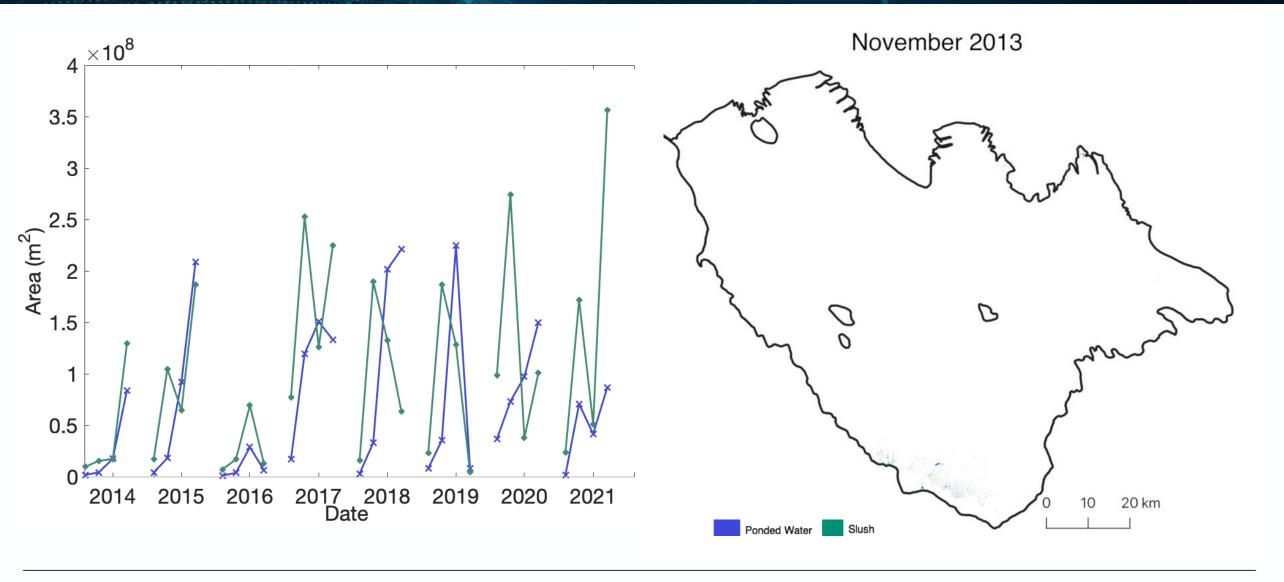
- From 2013-2021
 - 900 km² of surface meltwater (slush and ponded).
 - 7% ponded water only
 - 27% slush only
 - 66% both slush and ponded water.
 - Maximum melt extent covers 12% of the total ice shelf area.



🛢 🚍 💳 🕂 📲 🔚 📰 🎫 📲 🔚 🚛 📲 💳 🛶 🔯 🍉 📲 🚼 🛨 📰 📾 🔤 🛊 🔸 🔹 the European space agency

Nivlisen Ice Shelf



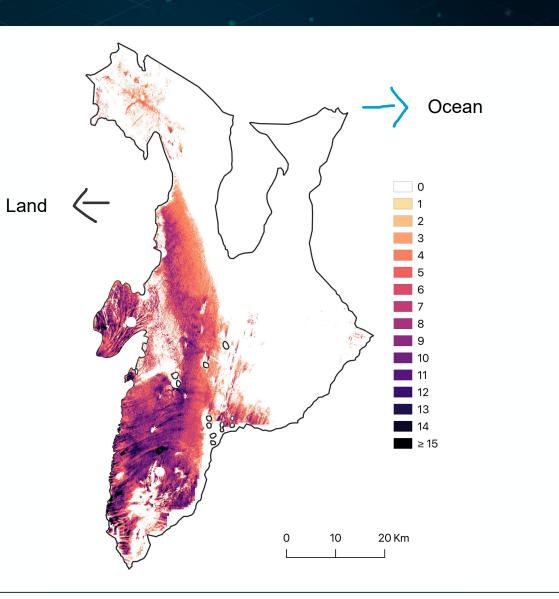


→ THE EUROPEAN SPACE AGENCY

*

Tracy Tremenchus

- 40% of the size of Nivlisen
- From 2013-2021
 - 1000 km² of surface meltwater (slush and ponded).
 - 1% ponded water only.
 - 42% slush only
 - 57% both slush and ponded water.
 - Maximum melt extent covers 35% of the total ice shelf area.



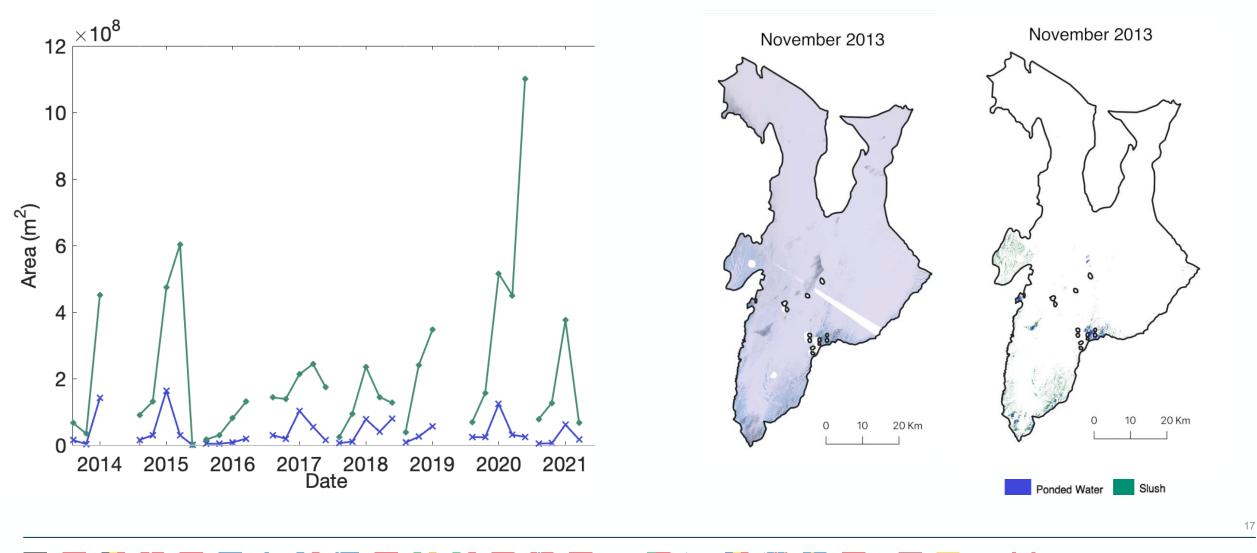
CAMBRIDGE

💶 📕 🚛 💳 🛶 🛯 🖉 🔤 💶 🖉 🖉 📲 🔜 🛻 🚳 🛌 📲 🗮 💶 🗰 🖬 👫

· eesa

Tracy Tremenchus





|

Conclusions

CAMBRIDGE COSA

- We have an established method to map all surface meltwater (slush and ponded water) on a pan-Antarctic scale.
- This has been applied to the full Landsat 8 record
- Future work will extend the dataset to include Landsat 7 scenes, extending our record back to 2000.
- & trends on individual and regional scales will be investigated.

rld46@cam.ac.uk

@rebeccadell1

