A continent-wide, monthly dataset of Antarctic surface meltwater area, 2006-2021

Peter Tuckett[1], Jeremy Ely[1], Andrew Sole[1], Stephen Livingstone[1], Julie Jones[1], James Lea[2], Ella Gilbert[3]

[1] Department of Geography, University of Sheffield, Sheffield, UK

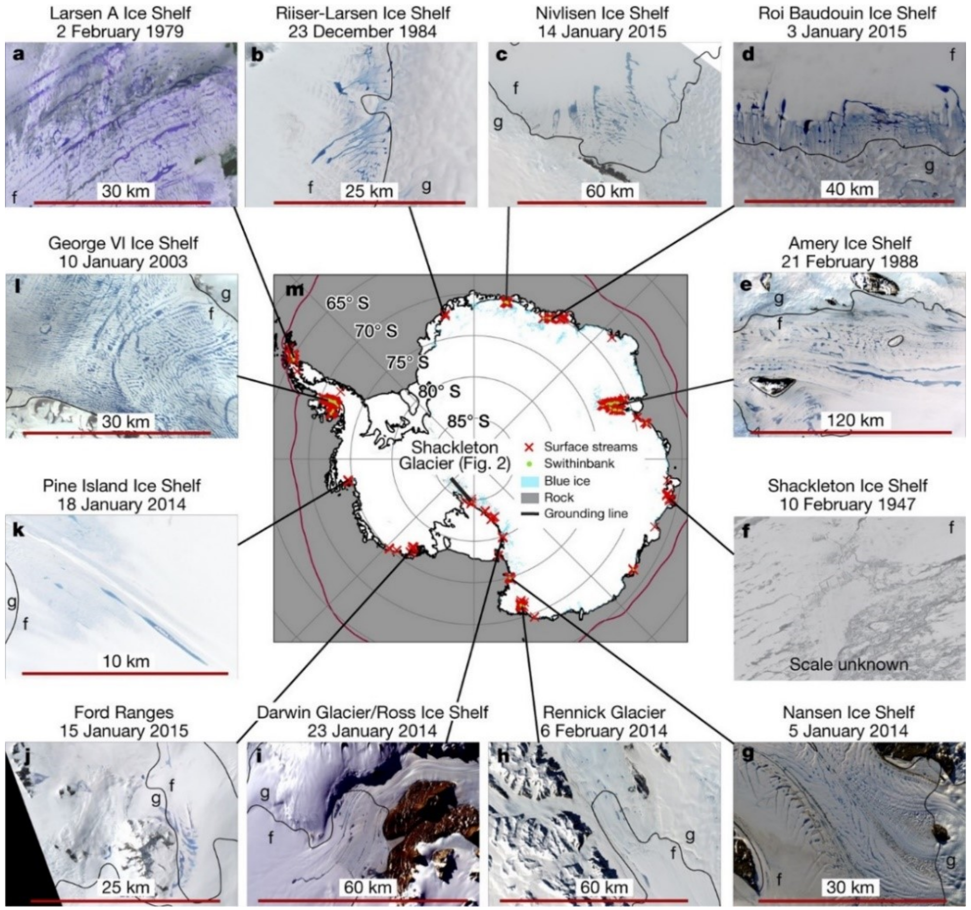
[2]Department of Geography, University of Liverpool, Liverpool, UK

[3]British Antarctic Survey, Cambridge, UK

@peter_tuckett

patuckett1@sheffield.ac.uk

Increasing research focus on Antarctic surface meltwater



Kingslake et al., 2017

Distribution and seasonal evolution of supraglacial lakes on Shackleton Ice Shelf, East Antarctica

Jennifer F. Arthur[1], Chris R. Stokes[1], Stewart S. R. Jamieson[1], J. Rachel Carr[2], and Amber A. Leeson[3]

Widespread distribution of supraglacial lakes around the margin of the East Antarctic Ice Sheet

Chris R. Stokes, Jack E. Sanderson, Bertie W. J. Miles, Stewart S. R. Jamieson & Amber A. Leeson

Seasonal evolution of Antarctic supraglacial lakes in 2015–2021 and links to environmental controls

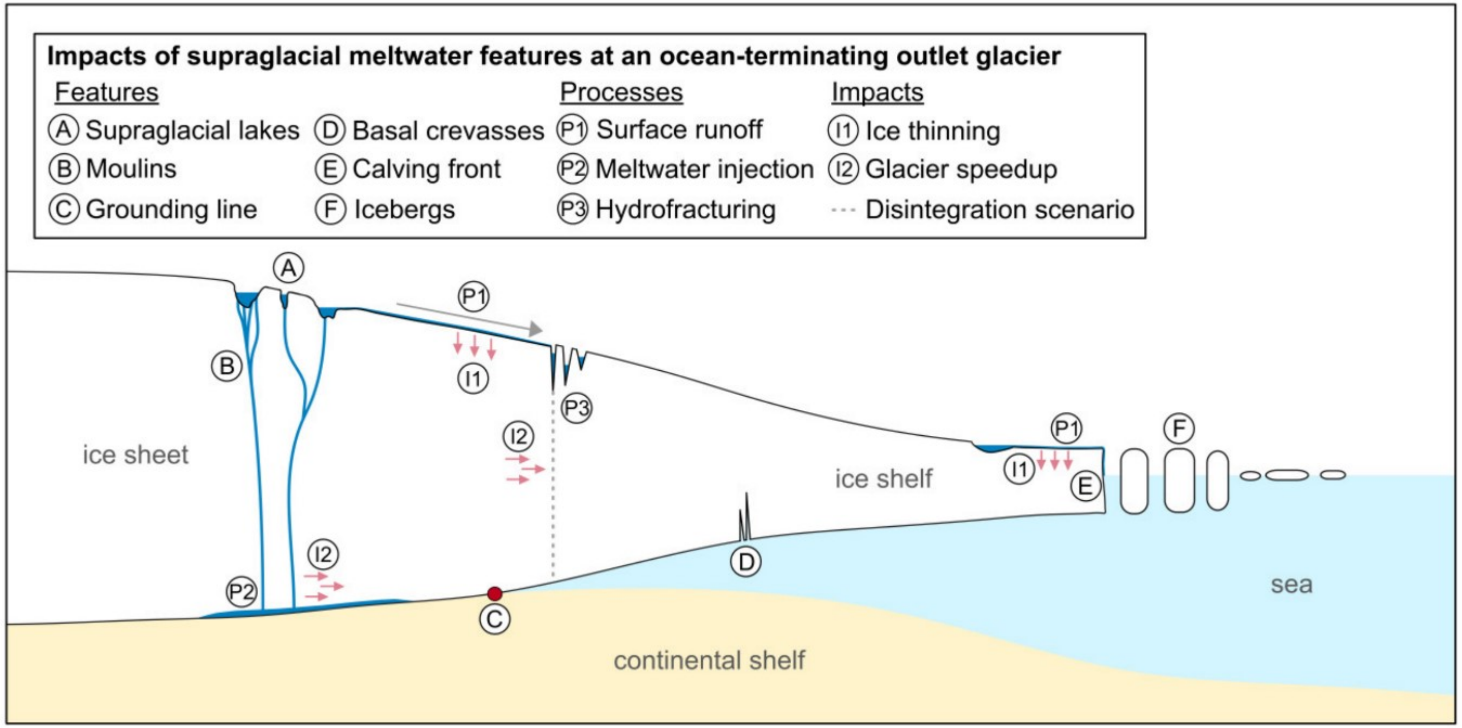
Mariel C. Dirscherl[1], Andreas J. Dietz[1], and Claudia Kuenzer[1,2]

Large interannual variability in supraglacial lakes around East Antarctica

Jennifer F. Arthur, Chris R. Stokes, Stewart S. R. Jamieson, J. Rachel Carr, Amber A. Leeson & Vincent Verjans

Surface meltwater influences on ice-sheet mass balance

1) Surface runoff and thinning
2) Melt-induced ice shelf collapse consequent acceleration of grounded ice
3) Speed-up due to meltwater injection to the subglacial environment
4) Plume enhanced submarine melting of ice shelf/front

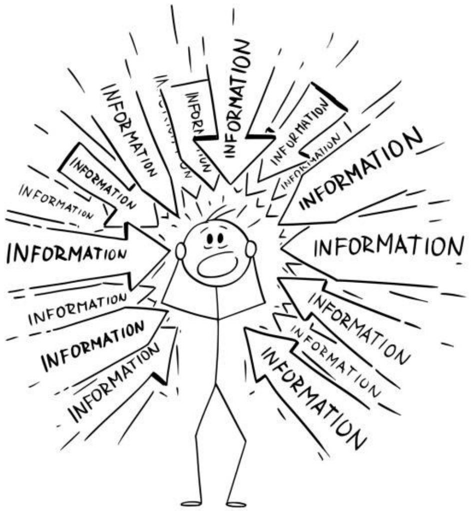


Albedo changes also important

Dirscherl et al., 2020

Despite its known importance, no continent-wide, long-term dataset of surface meltwater has been produced

Reason 1:
TOO MUCH DATA

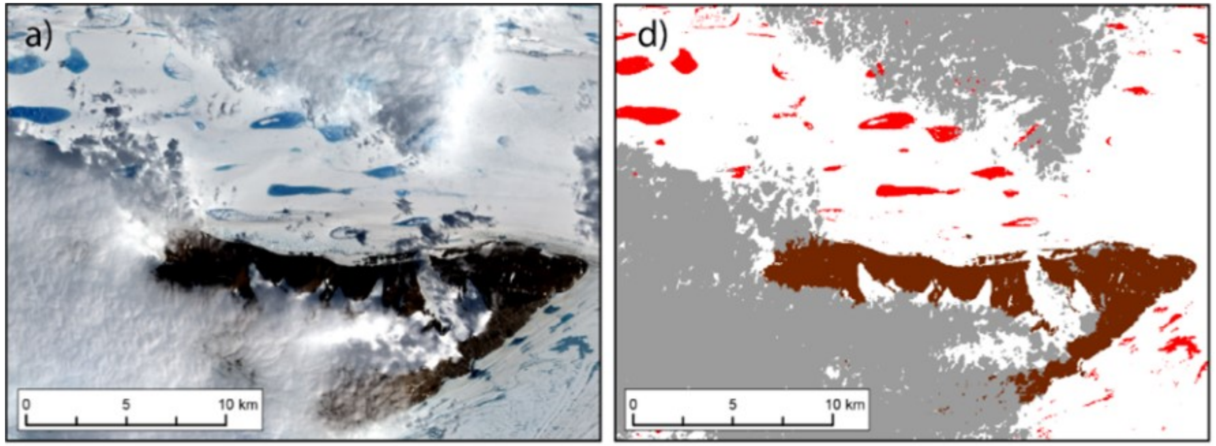


Reason 2:
CLOUDS

SOLUTION:

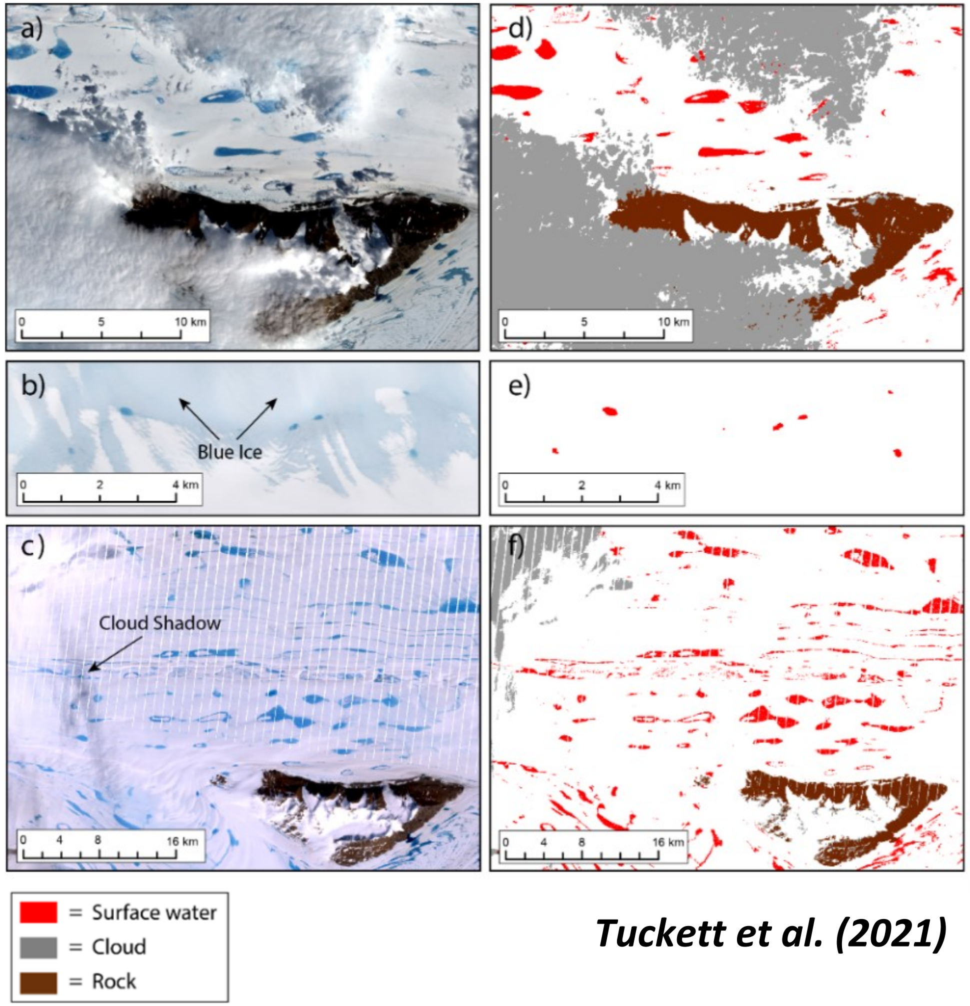
Google Earth Engine

- *Automatic meltwater detection*
- *Accounts for variability in cloud cover and image data coverage*

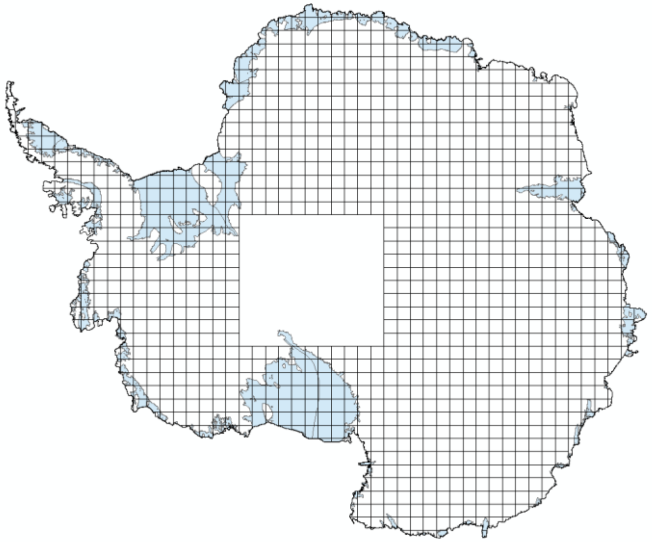


Method described in Tuckett et al., 2021

Google Earth Engine enables continent-wide processing



Tuckett et al. (2021)



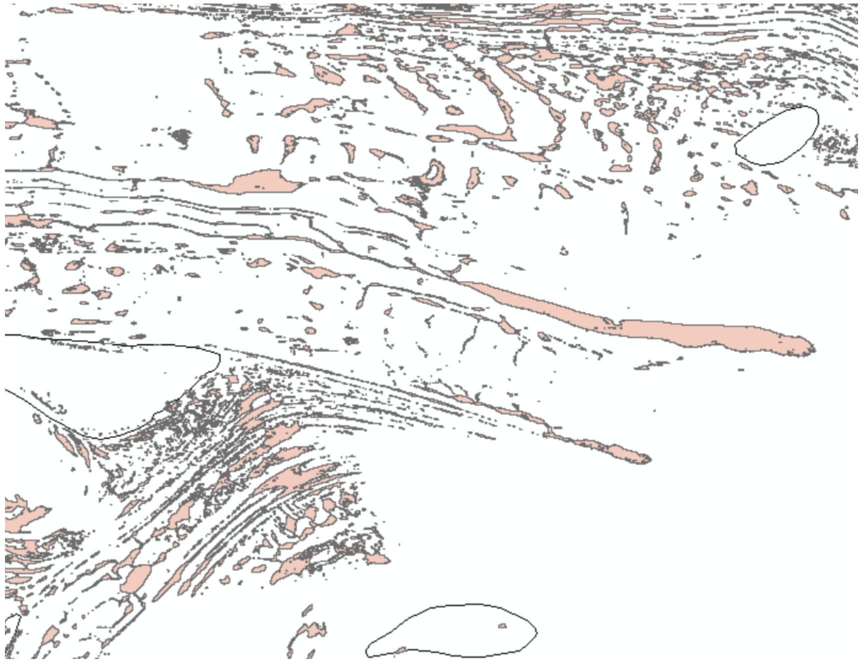
Google Earth Engine

- *Cloud based data catalogue*
- *Contains every Landsat image 'pre-loaded'*
- *Enables rapid, large-scale processing*

- Application of threshold-based method (Moussavi et al., 2020)
- **Every** Landsat 7/8 image over Antarctica between 2006-2021 used in analysis – **133,497 images**
- Incorporates 'visibility assessments' within method

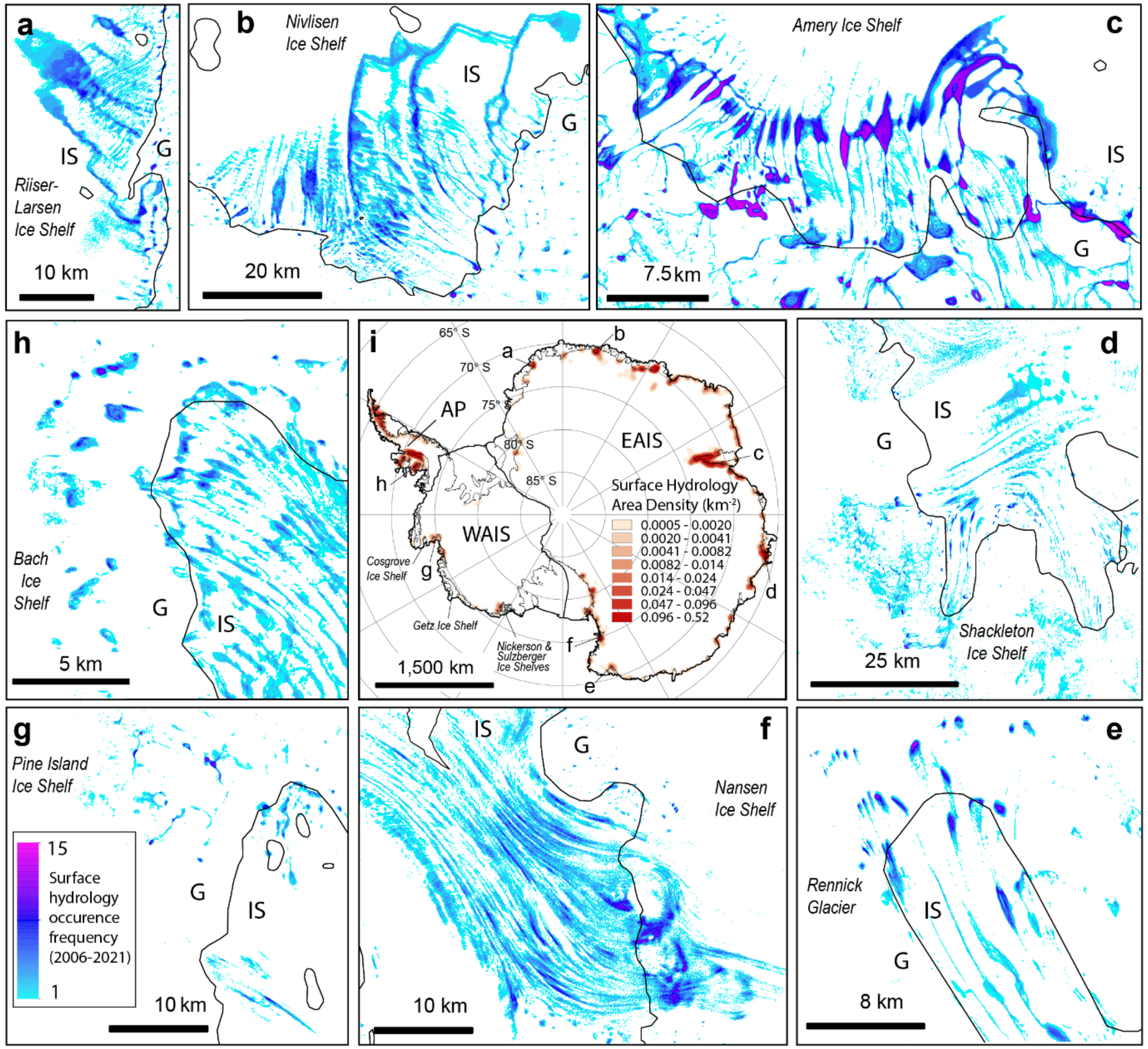
The dataset itself

- Monthly dataset, 2006 – 2021
- Consistent outputs from Nov-Feb
- Yearly ‘maximum extent’ dataset
- Easily reproducible at different temporal resolutions



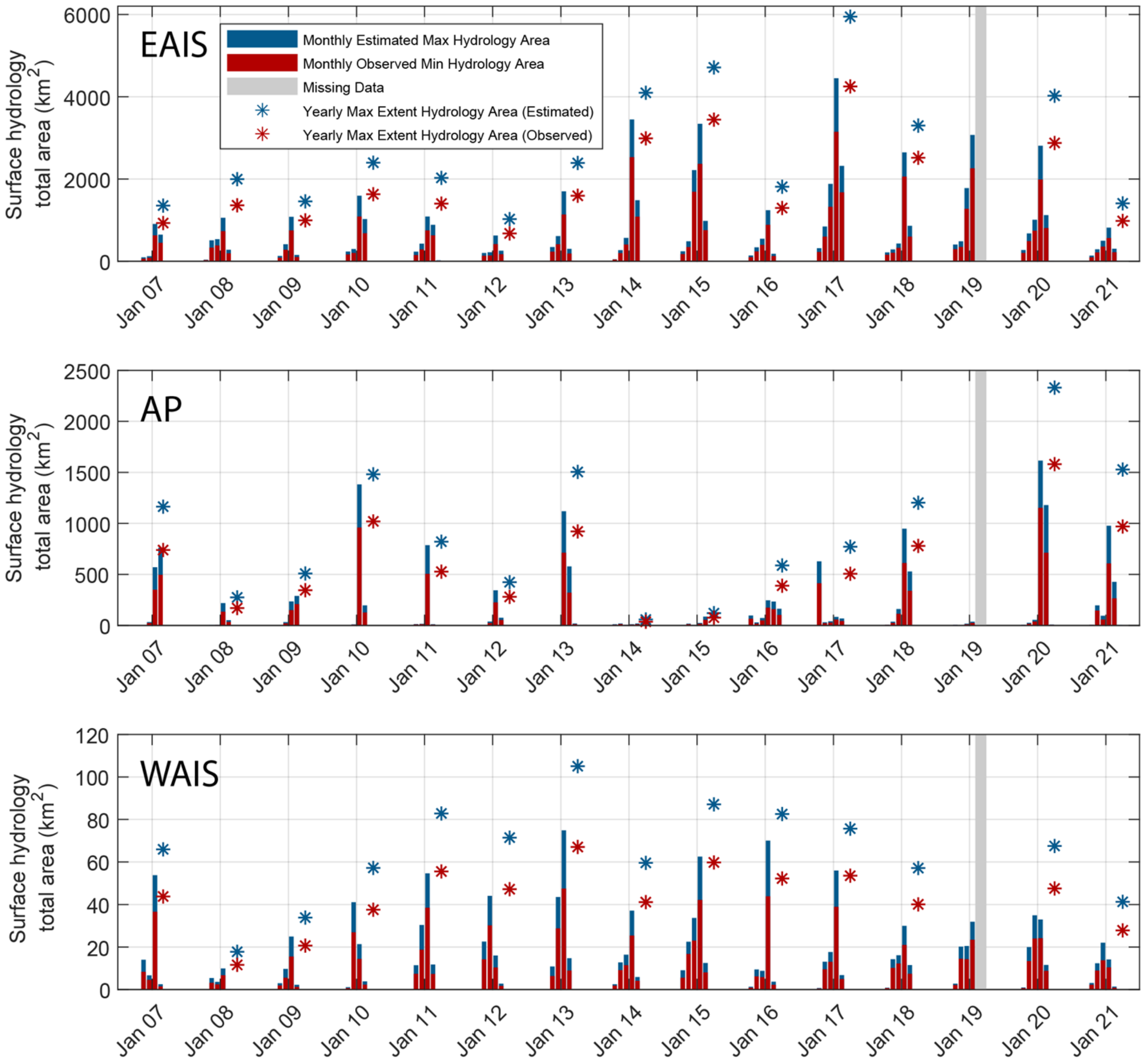
```
// Specifiy the Data products to by used:
var L9 = 'LANDSAT/LC09/C02/T2_TOA'; // NEW 12/04/23
var L8 = 'LANDSAT/LC08/C01/T2_TOA';
var L7 = 'LANDSAT/LE07/C01/T2_TOA';
//var S2 = 'COPERNICUS/S2'

// Set configuration variables
var startDate = '2021-07-01';
var endDate = '2022-06-30';
var startMonth = 1 // October (option to only run a set of months per year)
var endMonth = 12 // April
var timeUnit= 'year';
var timeStep = 1; //0.5
var L8bandsUsed = ['B2','B3','B4','B6','B10'];
var L7bandsUsed = ['B1','B2','B3','B5','B6_VCID_1'];
var L8_ndwiThreshold = 0.19; // L8 NDWI Threshold (Moussavi, 2020)
//var S2_ndwiThreshold = 0.18; // S2 NDWI Threshold (Moussavi, 2020)
var sunElev = 20; // Minimum sun elevation angle (Moussavi, 2020)
var cloudCover = 100; // 100 = Fully cloud, 0 = No cloud
var outputResln = 30; //spatial resolution of output
var testnumber = 5;
```

Continent-wide application, 2006-2021



Tuckett et al., in review

Ice sheet scale monthly time series of surface meltwater



Increasing surface hydrology area in East Antarctica

High variability on the Antarctic Peninsula

Relatively consistent in West Antarctica

Tuckett et al., in review

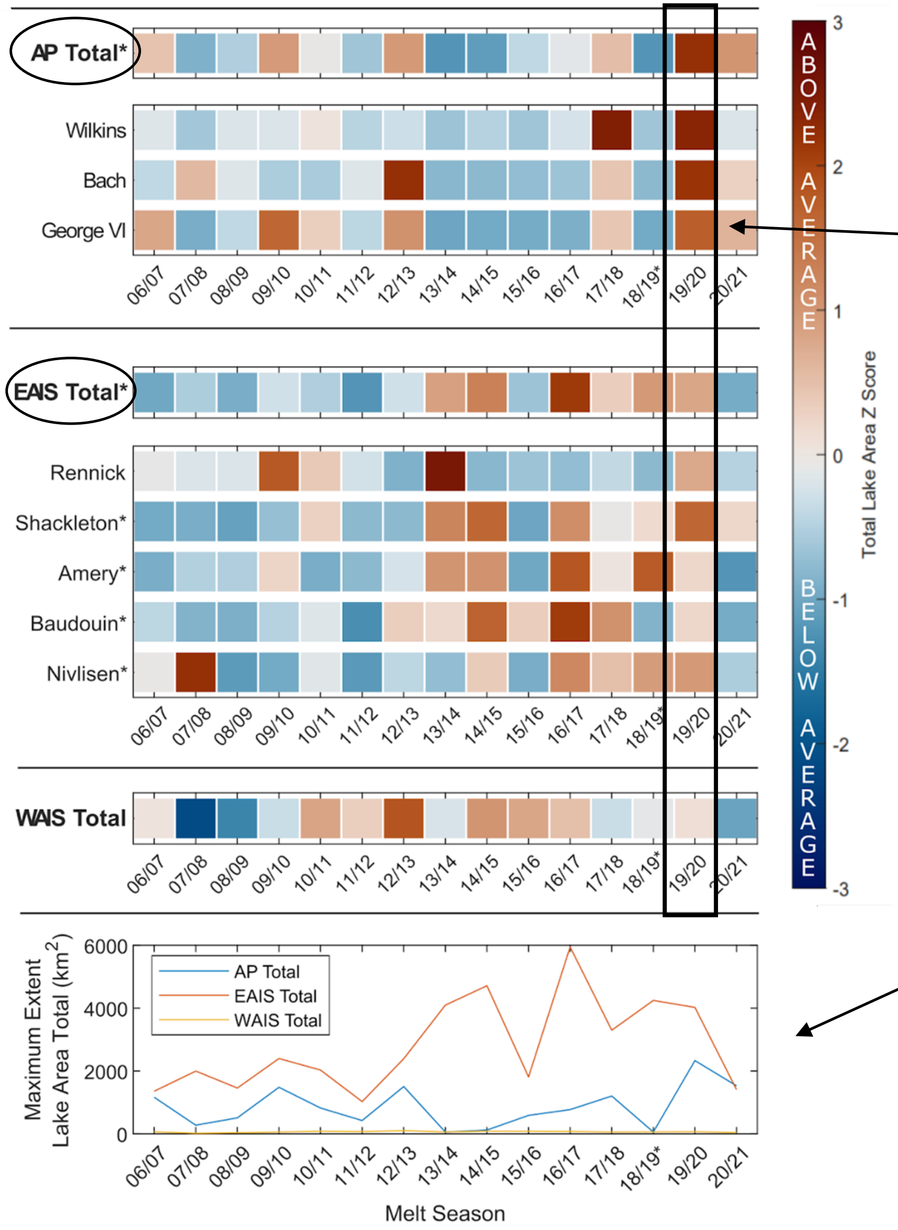
Increasing trend in surface hydrology area in East Antarctica

Asterisks indicate statistically significant increasing trends

Blue to red patterns shows increasing surface hydrology area

BLUE = Lower than average surface hydrology

RED = Greater than average surface hydrology



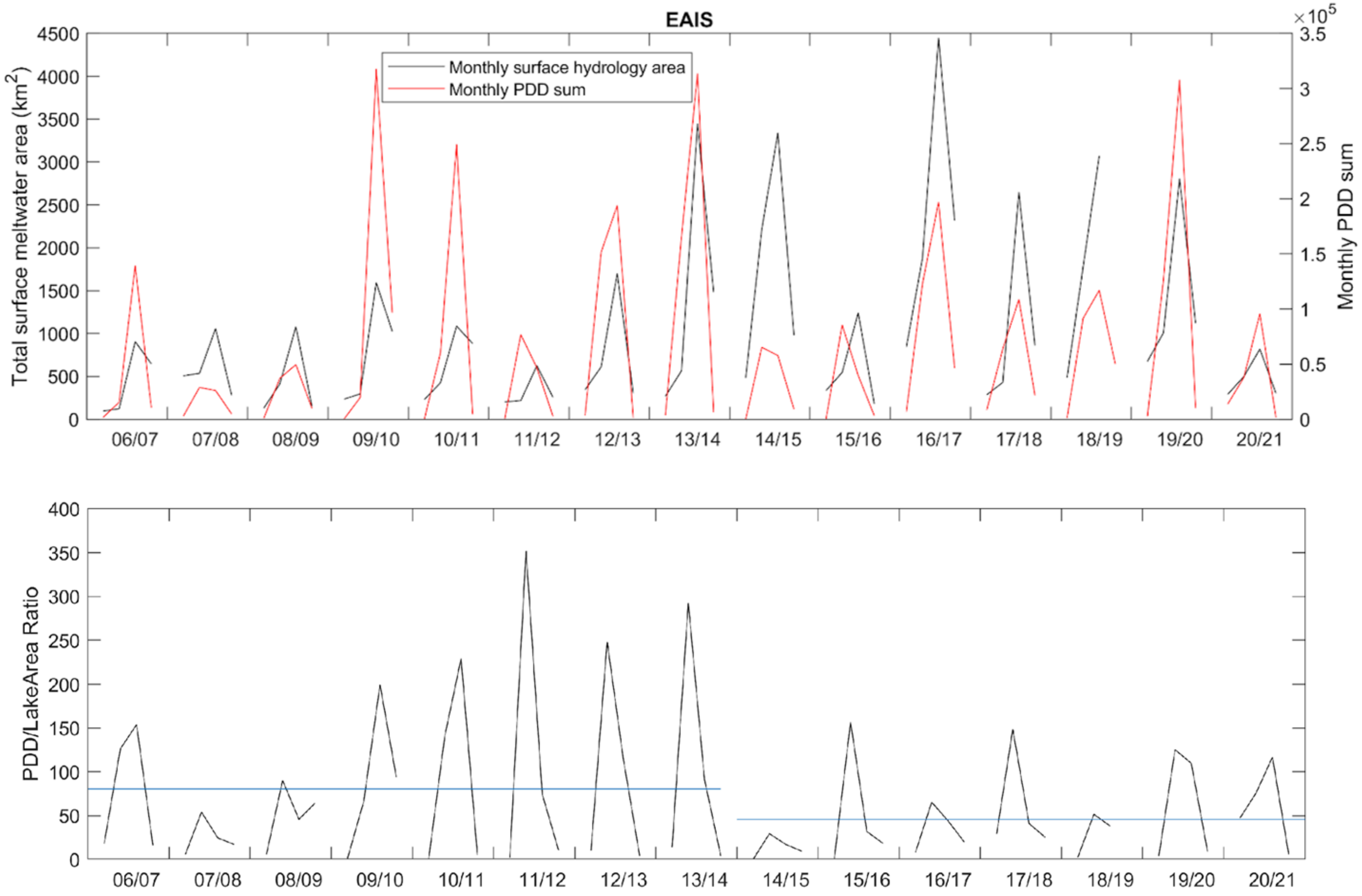
2019/2020 experienced higher than average surface hydrology across the whole continent

Total surface hydrology area is greatest for the EAIS, then AP, with WAIS much lower

Tuckett et al., in review

Opportunities for data comparison (modelled & EO data)

- Climatic mode indices
- Reanalysis data products
- Positive Degree Days (PDDs)
- Regional Climate Models:
  - Snowmelt
  - Albedo changes
  - Firn structure
  - Accumulation

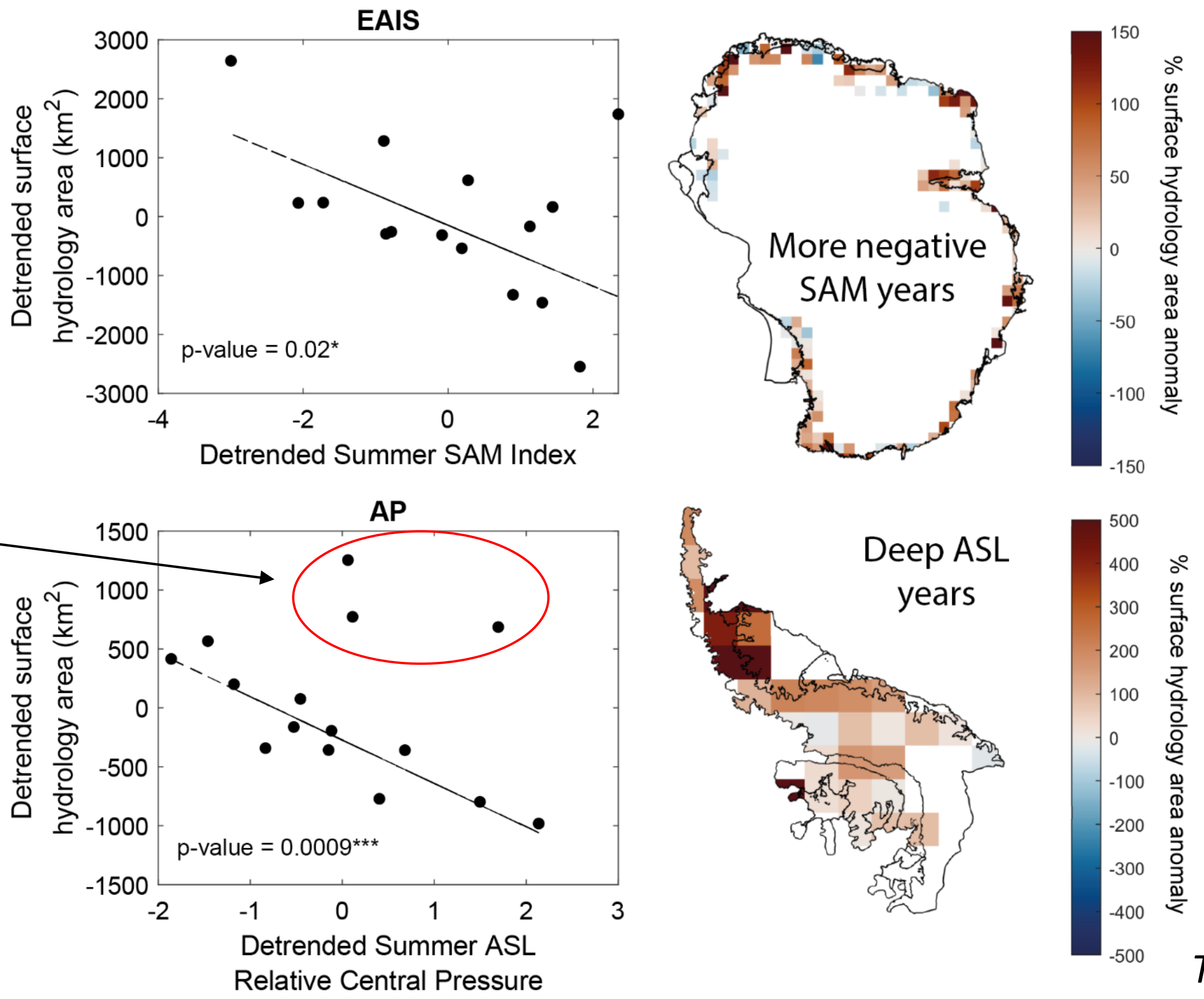


Variable temperature thresholds of melt pond formation on Antarctic ice shelves

J. Melchior van Wessem, Michiel R. van den Broeke, Bert Wouters & Stef Lhermitte

Summer SAM and Amundsen Sea Low (ASL) influence on annual surface hydrology area

Outlier years explained by regional climatic processes? E.g. Foehn, cloud, atmospheric rivers?

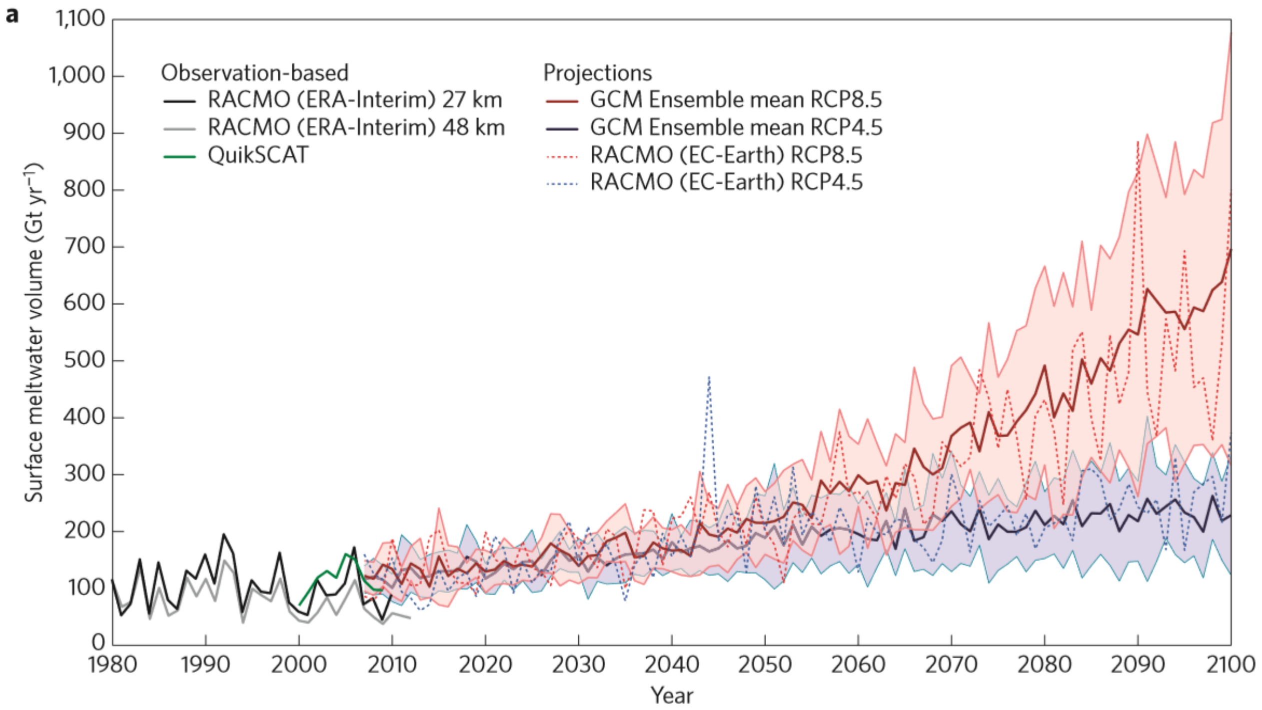


Composite map based on the six lowest summer SAM index years (< 0.7)

Composite map based on years when ASL relative central pressure < -8 (four years)

Tuckett et al., in review

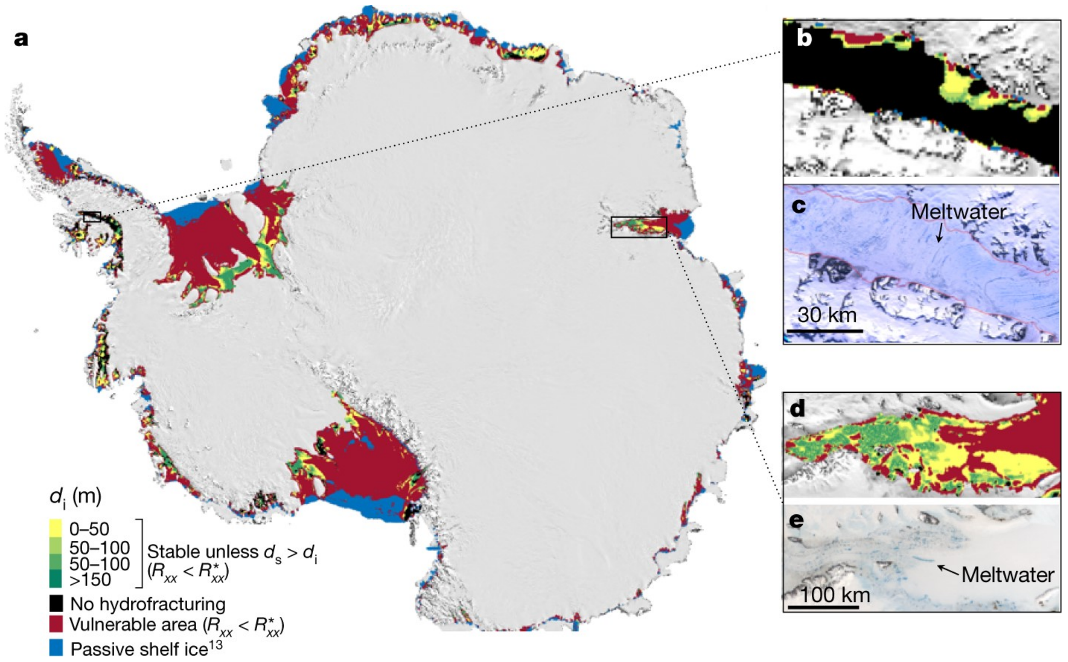
What can we expect to happen in the future?



Trusel et al. (2015)

- Firn air content reduced with increased melt
- Increased likelihood of meltwater ponding on vulnerable sections of ice shelves

- Antarctic-wide surface melt expected to double by 2050 (Trusel et al., 2015)
- Intense warming events expected to become longer and more frequent (Feron et al., 2021)



Lai et al. (2020)

Summary

- We have produced the first monthly, long-term time series of surface meltwater across the entire Antarctic continent.

- Results show an increasing trend in surface hydrology area in East Antarctica between 2006 and 2021.

- Very high interannual variability in surface hydrology on the Antarctic Peninsula.

- Southern Annular Mode appears to have a strong controlling influence in East Antarctica.

- Amundsen Sea Low strength and location partly controls Antarctic Peninsula surface hydrology.

- Opportunities for EO-model data comparison to help explain drivers of surface ponding.

References

Feron, S., Cordero, R. R., Damiani, A., Malhotra, A., Seckmeyer, G., & Llanillo, P. (2021). Warming events projected to become more frequent and last longer across Antarctica. *Scientific reports*. **11:** 1-9.

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