EGU General Assembly 2020 CR5.7/OS1 – Ice Shelves and tidewater glaciers – dynamics, interactions, observations, modelling

Increased ice flow in the Getz region of West Antarctica, from 1994 to 2018

Heather L. Selley[1], Anna E. Hogg[2], Stephen Cornford[3], Pierre Dutrieux[4], Andrew Shepherd[1], Jan Wuite[5], Dana Floricioiu[6], Anders Kusk[7], Thomas Nagler[5], Lin Gilbert[8], Thomas Slater[1]

eehls@leeds.ac.uk

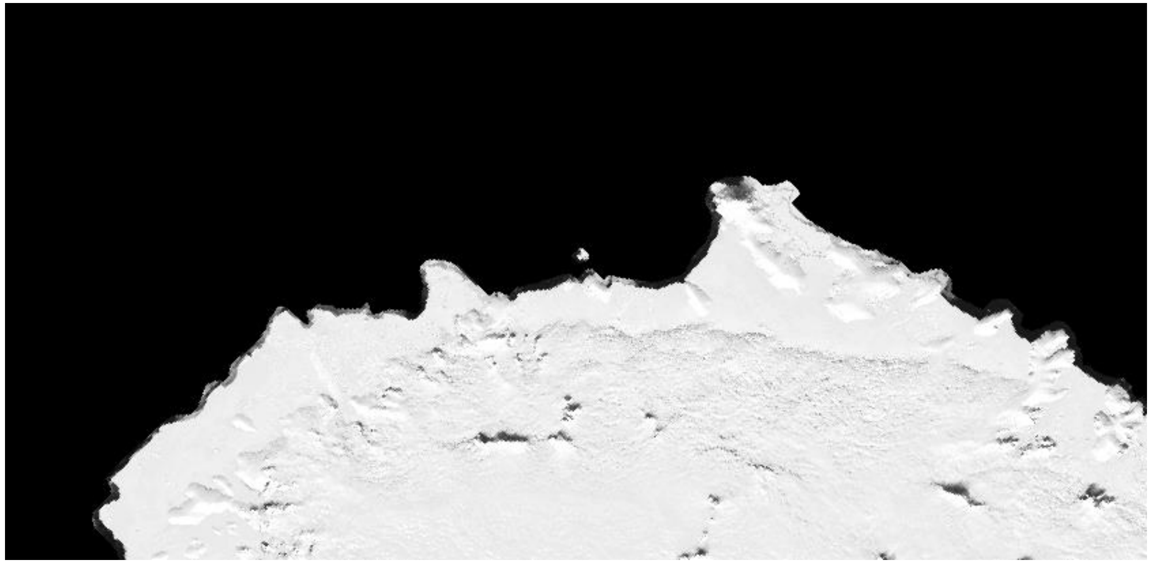
[1]Centre for Polar Observation and Modelling, School of Earth and Environment, University of Leeds, UK, [2]School of Earth and Environment, University of Leeds, UK, [3]Department of Geography, Swansea University, Swansea, UK, [4]Lamont-Doherty Earth Observatory, Colombia University, USA, [5]ENVEO IT GmbH, Innsbruck, Austria, [6]German Aerospace Centre (DLR), Remote Sensing Technology Institute, SAR Signal Processing, Wessling, Germany, [7]DTU Space, National Space Institute, Technical University of Denmark, Lyngby, Denmark, [8]Centre for Polar Observation and Modelling, University College London, London, UK.

The Getz Basin

- The Getz drainage basin covers 10.2% of the West Antarctic Ice Sheet (Shepherd et al., 2019).

- The Getz ice shelf is the eighth largest in Antarctica, 650 km long and varies from 25 to 110 km wide.

- It is Anchored by 8 large islands and over 23 pinning points on it's seaward margin stabilising the calving front.

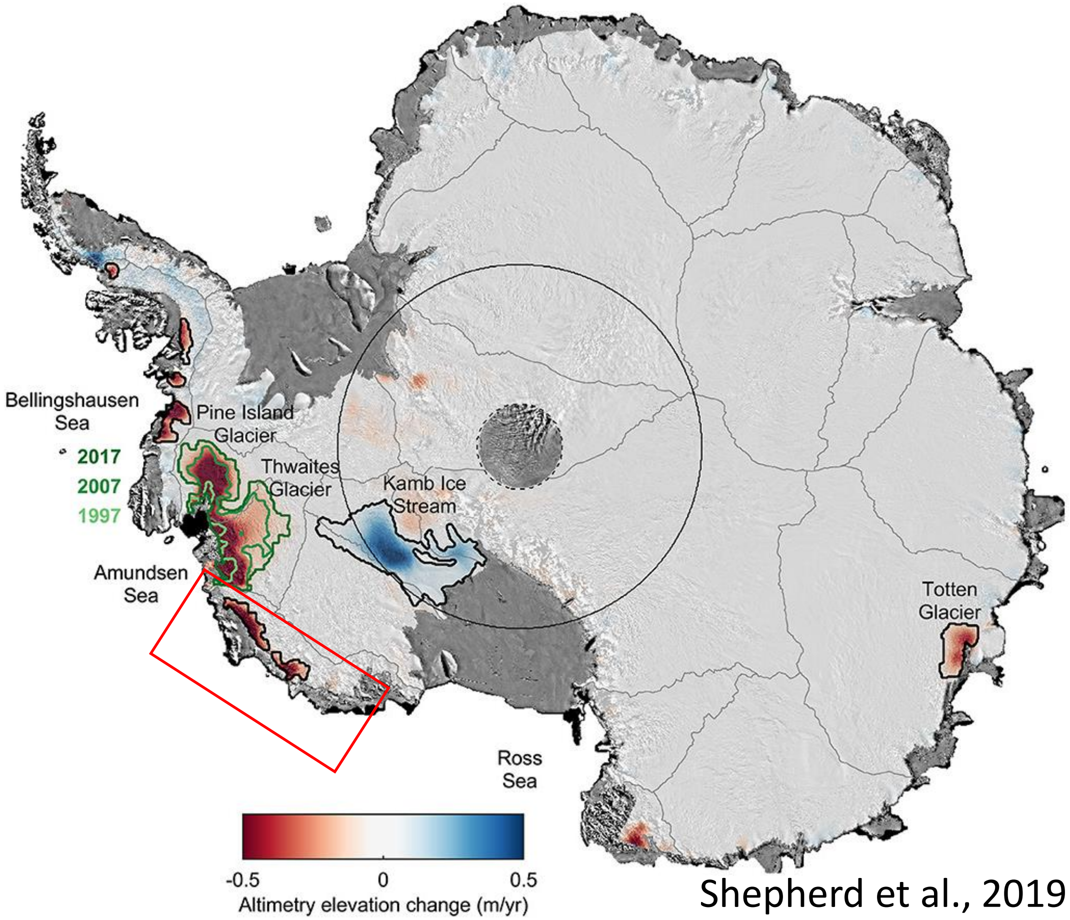


Adapted from: Haran et al., 2005

Motivation

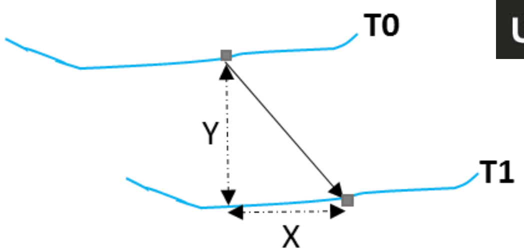
UNIVERSITY OF LEEDS

- The majority of Getz drainage basin is grounded well below sea level. While the Getz ice shelf has thinned it's calving has remained relatively stable since the early 90's.
- Strong thinning of both the ice sheet and ice shelf over the past 25-years, mass balance studies have shown that the sector is negatively imbalanced (−16.4 ± 4.0 Gt/year).
- The pace and timing of the onset of dynamic imbalance is poorly constrained and there remains uncertainty about the physical mechanisms driving change.



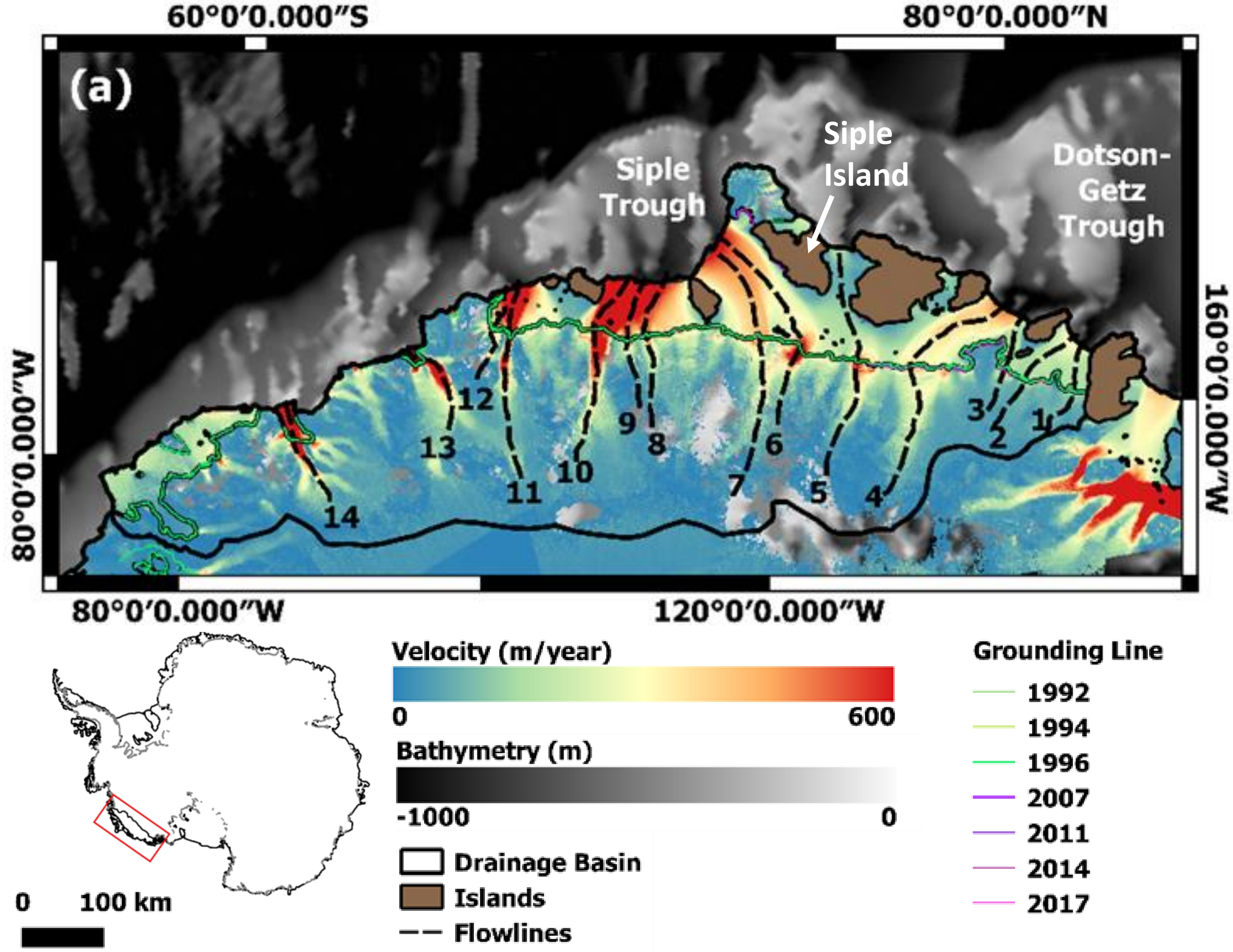
Shepherd et al., 2019

Methods



- Feature tracked Synthetic Aperture Radar (SAR) and optical satellite imagery covering 25 years .
- Historical ERS-1 and ERS-2 satellites, PALSAR, MEaSUREs Antarctic annual ice velocity measurements (Mouginot et al., 2017).
- Extended the record using Sentinel-1 using intensity feature tracking technique at 6 day intervals.
- Final velocity measurements mosaicked and averaged to produce annual ice speed maps.
- 21 annual velocity maps 1994 to 2018.

Results

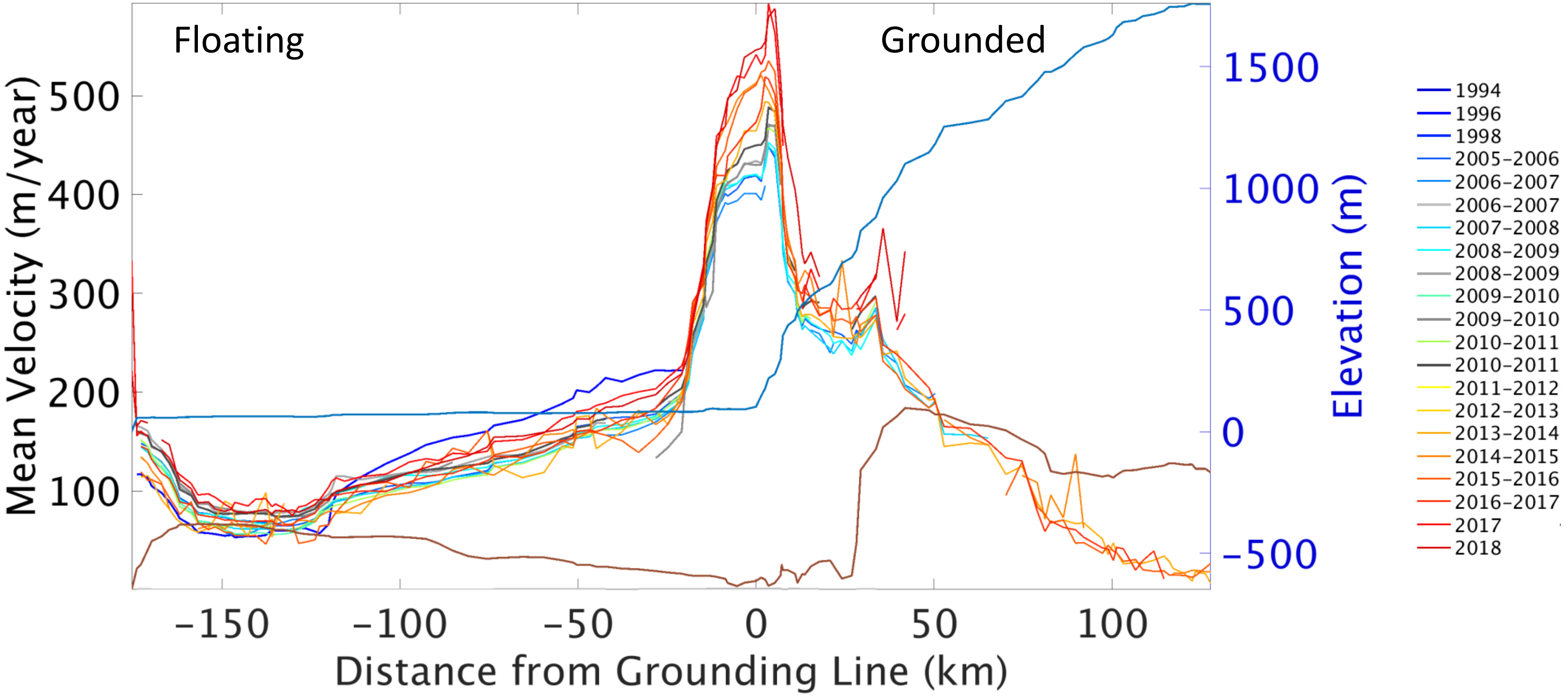


- 14 distinct flow units.
- 11 glaciers reaching maximum speeds > 1 km/year.
- Fastest ice streams to the west of the ice shelf.
- Largest change in speed in the central region behind Siple Island.

Results

Flow Unit 5

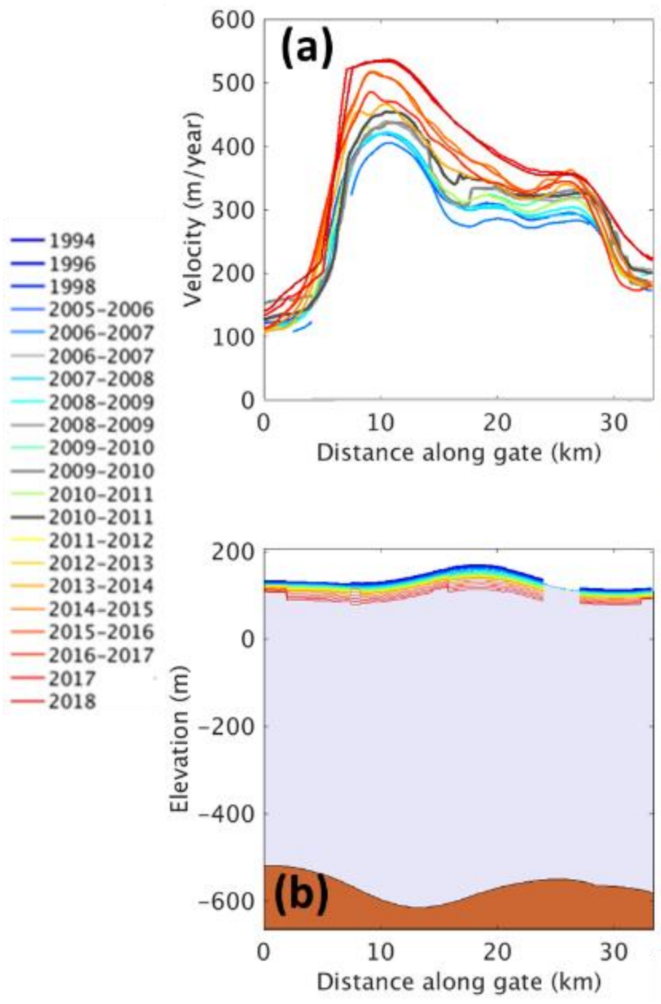
- Central region shows the most substantial speed up
- 1996 ~40% lower than 2018

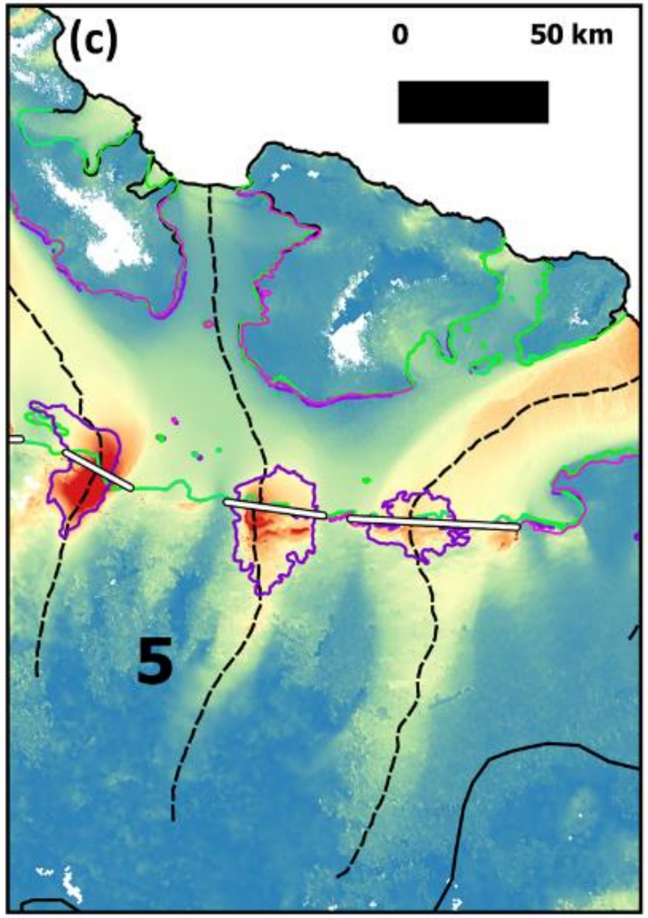


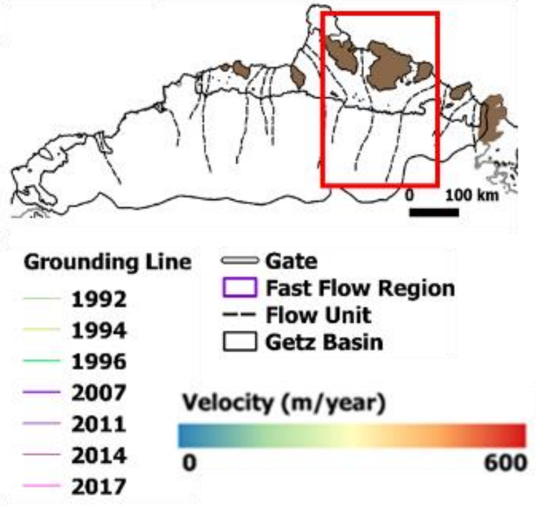
Average surface velocities (1994 – 2019) extracted from flow unit 5 in the Getz region. Along-flow profiles of ice velocity, surface elevation (light blue line) and bed elevation (brown line) from BEDMAP2 (Fretwell et al. 2013), and the grounding line location from Rignot et al., 2016.

Results

Flow Unit 5







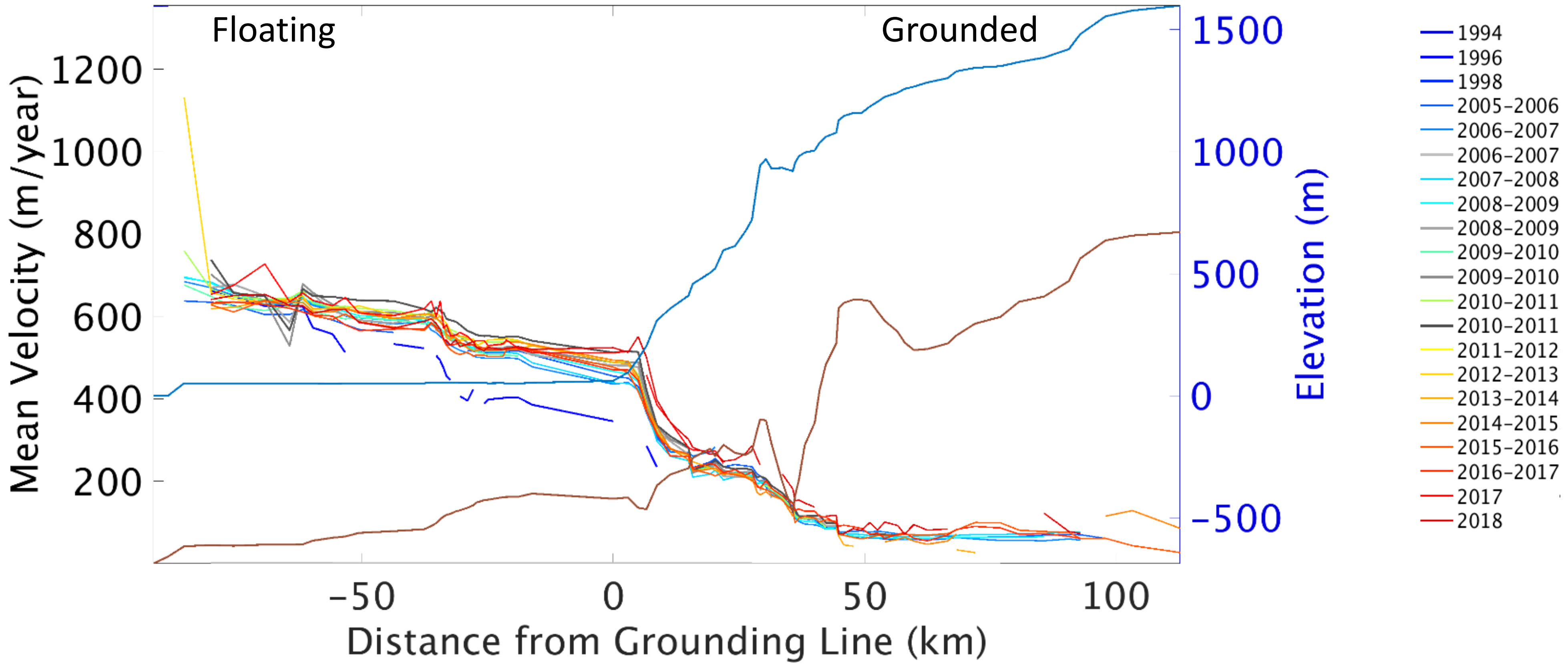
- Profiles shown are taken across the gate
- Spatially variable change in speed

a) Annual velocities across the flux gate located at the grounding line (see D) orientated perpendicular to the dominant direction of flow. ALOS-PALSAR velocities are identified in greyscale. b) Bed and surface elevation across the flux gate of the flowline. Annual elevations (rainbow coloured) calculated using the SEC dhdt rates over the study period scaling Bedmap2 DEM surface elevation with estimated baseline year of 2000 based on the average age of inputted products in DEM production within the Getz region. c) A map of 2018 velocity derived from Sentinal-1 data. Also shown are the fast flow regions (purple), the grounding line (grey), flux gate (pink), Getz basin extent (black), dominant flowlines (dashed black).

Results

Flow Unit 6

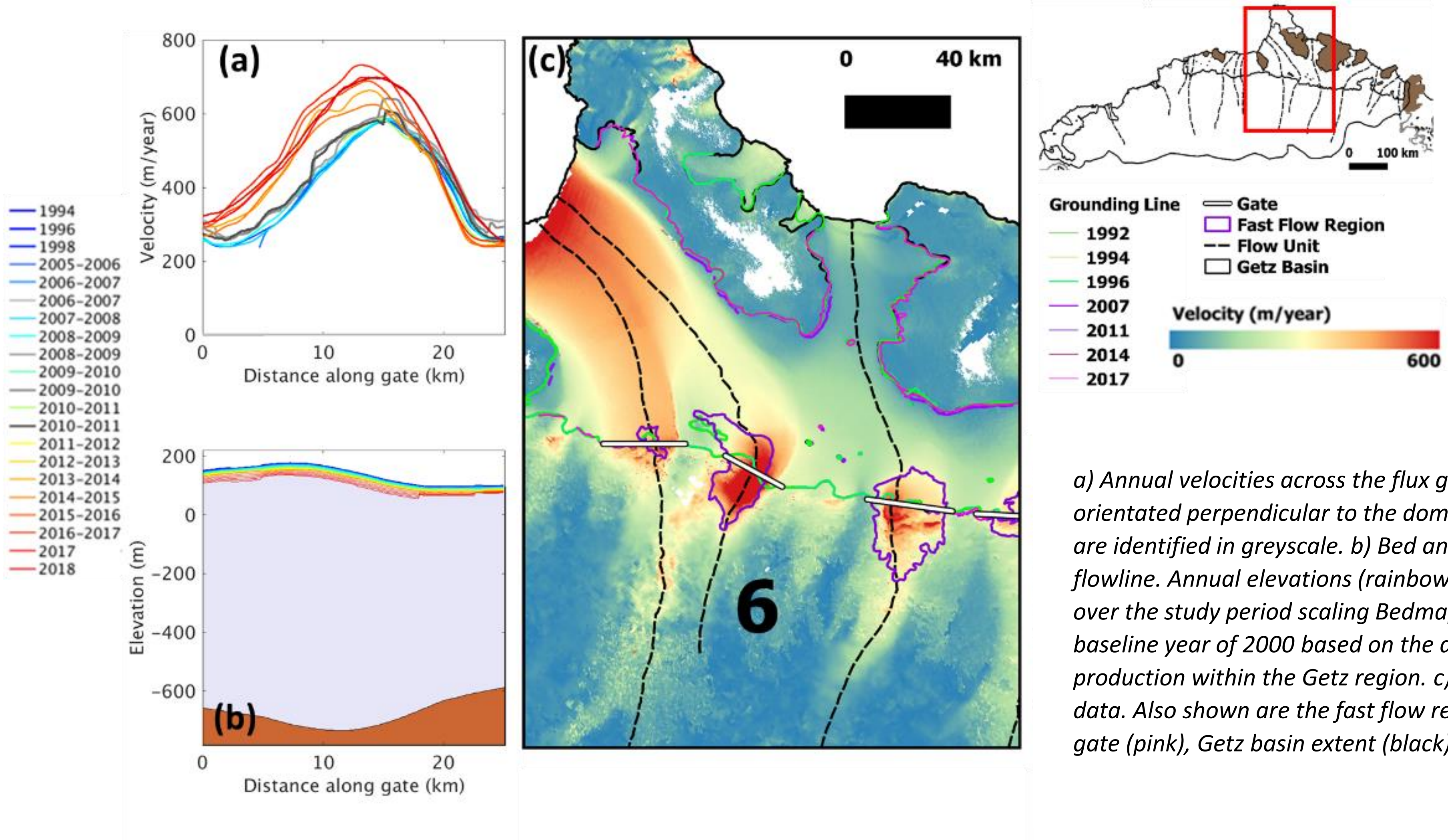
- ~60% change in speed at the grounding line over the 25 year period



Average surface velocities (1994 – 2019) extracted from flow unit 6 in the Getz region. Along-flow profiles of ice velocity, surface elevation (light blue line) and bed elevation (brown line) from BEDMAP2 (Fretwell et al. 2013), and the grounding line location from Rignot et al., 2016.

Results

Flow Unit 6

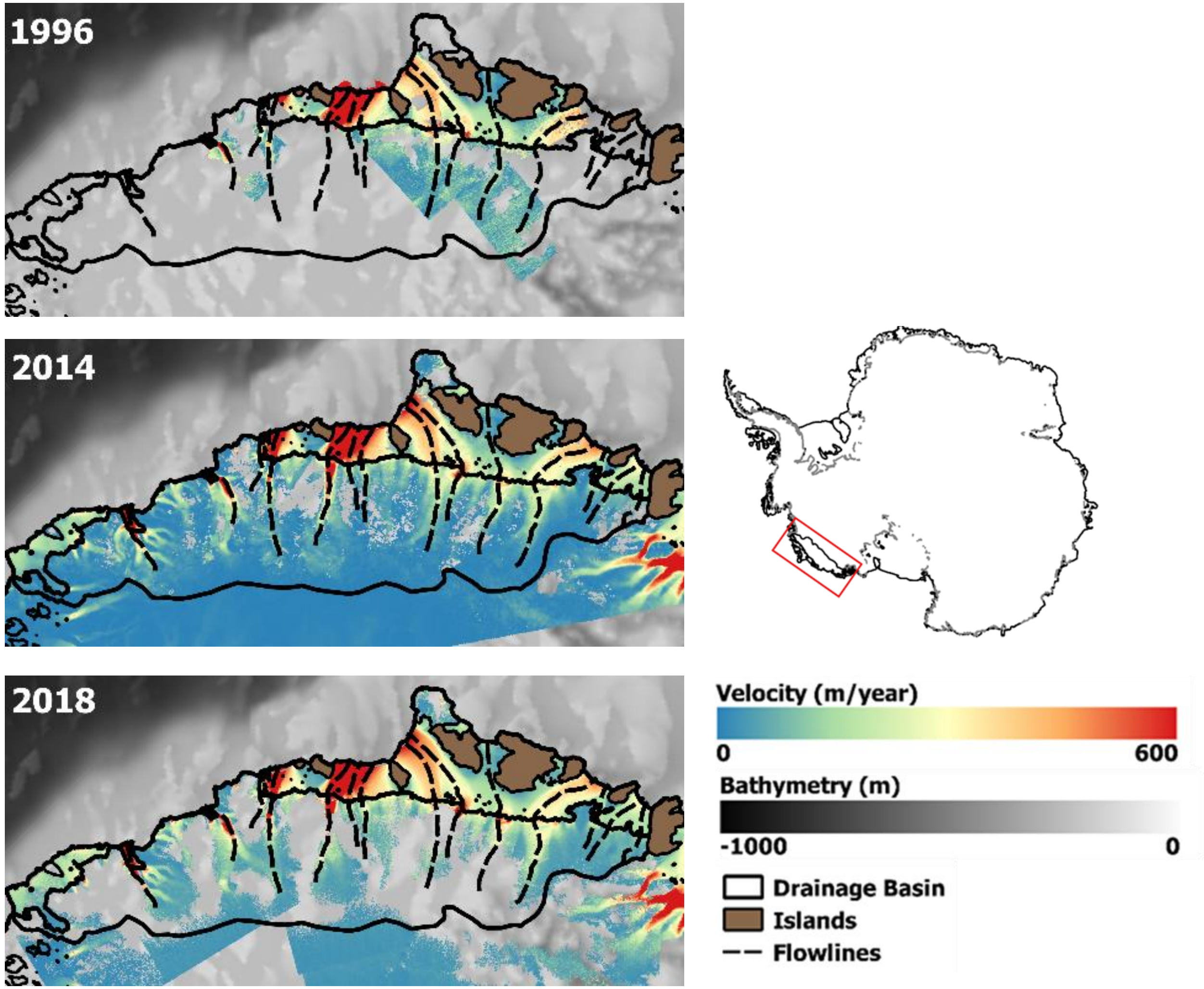


- Profiles shown are taken across the gate

a) Annual velocities across the flux gate located at the grounding line (see D) orientated perpendicular to the dominant direction of flow. ALOS-PALSAR velocities are identified in greyscale. b) Bed and surface elevation across the flux gate of the flowline. Annual elevations (rainbow coloured) calculated using the SEC dhdt rates over the study period scaling Bedmap2 DEM surface elevation with estimated baseline year of 2000 based on the average age of inputted products in DEM production within the Getz region. c) A map of 2018 velocity derived from Sentinal-1 data. Also shown are the fast flow regions (purple), the grounding line (grey), flux gate (pink), Getz basin extent (black), dominant flowlines (dashed black).

Implications

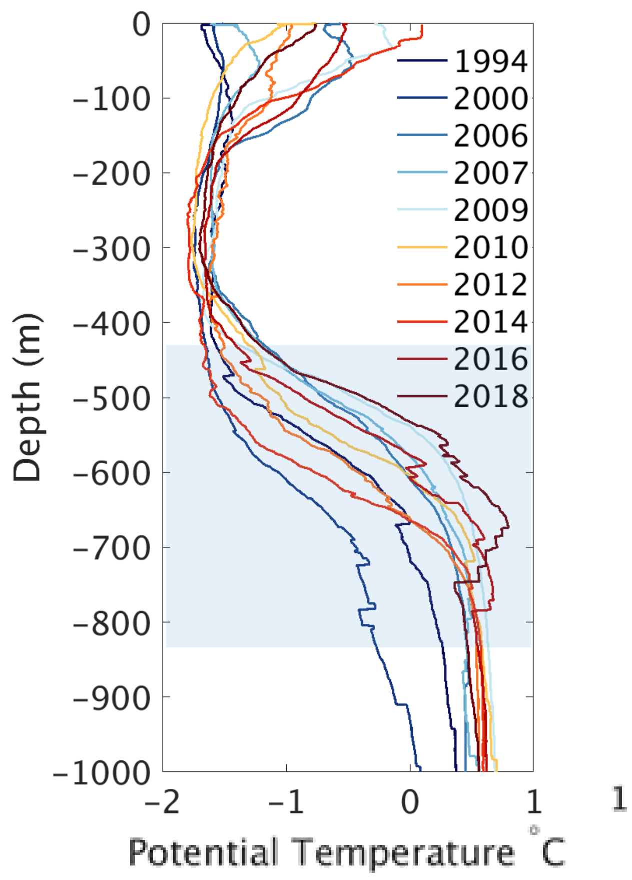
UNIVERSITY OF LEEDS



- Spatial coverage of ice velocity variable
  - Density of satellite data acquisitions
  - Performance of image processing techniques
- Getz absence of physical features and susceptibility of snow surface change due to local weather events
- Ice speed measurements limited to within ~ 200 km of the calving front
- Sparse coverage of the interior of the ice sheet limits knowledge of progression of speed up inland

Implications

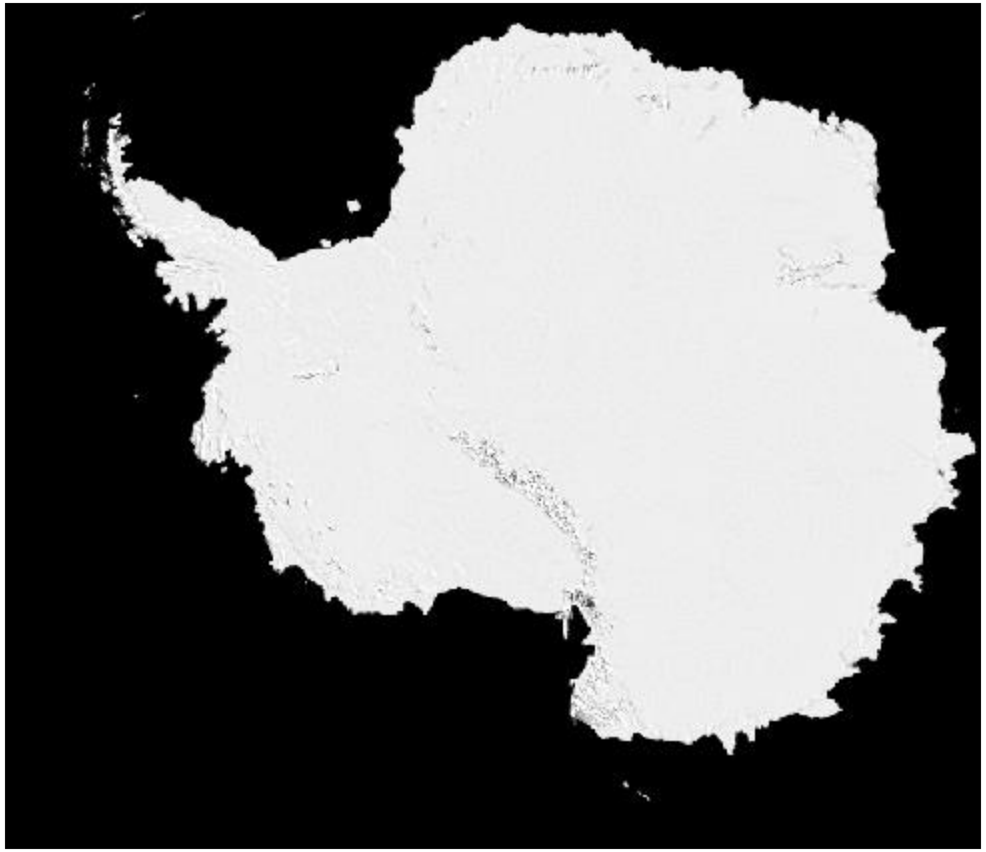
- The spatial pattern of speed up is greatest where ice is thickest (> 700 m) and grounded most deeply.
- The pattern of thinning matches that of speed up which indicates that the Getz basin is in dynamic imbalance.
- Ocean temperature measurements show periodic presence of circumpolar deep water. Generally there has been a linear trend of speed increase which indicates there has not been a pause in speed up that could be attributed to ENSO related variability.



Annual mean temperature depth profiles from 1994 to 2018, from CTD measurements made at sampling sites along the Getz coastline. Light blue shaded region contains the mean elevation of the flow units at the grounding line.

Summary

- A new record of change for a rapidly evolving region of Antarctica
- In the future, it will be important to use both ocean models and observations to improve our understanding of how ocean forcing is driving dynamic imbalance in the region
- This will help better our understanding of physical mechanisms driving change in Antarctica, aiding up to better constrain ice sheets contribution to sea level rise



Adapted from: Haran et al., 2005

References

- Fretwell, P., Pritchard, H., Vaughan, D., Bamber, J., Barrand, N., Bell, R., . . . Zirizzotti, A. (2013). Bedmap2: Improved ice bed, surface and thickness datasets for Antarctica. *Cryosphere, 7*(1), 375-393.
- Haran, T., J. Bohlander, T. Scambos, T. Painter, and M. Fahnestock. 2005, updated 2019. *MODIS Mosaic of Antarctica 2003-2004 (MOA2004) Image Map, Version 1*. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. doi: https://doi.org/10.7265/N5ZK5DM5. [10/15/2019].
- Mouginot, J., Rignot, E., Scheuchl, B., & Millan, R. (2017, 4 12). Comprehensive Annual Ice Sheet Velocity Mapping Using Landsat-8, Sentinel-1, and RADARSAT-2 Data. *Remote Sensing, 9*(4), 364.
- Rignot, E., J. Mouginot, and B. Scheuchl. 2016. *MEaSUREs Antarctic Grounding Line from Differential Satellite Radar Interferometry, Version 2*. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi: https://doi.org/10.5067/IKBWW4RYHF1Q. [04/02/2018].
- Shepherd, A., Gilbert, L., Muir, A., Konrad, H., McMillan, M., Slater, T., . . . Engdahl, M. (2019, 7 28). Trends in Antarctic Ice Sheet Elevation and Mass. *Geophysical Research Letters, 46*(14), 8174-8183.