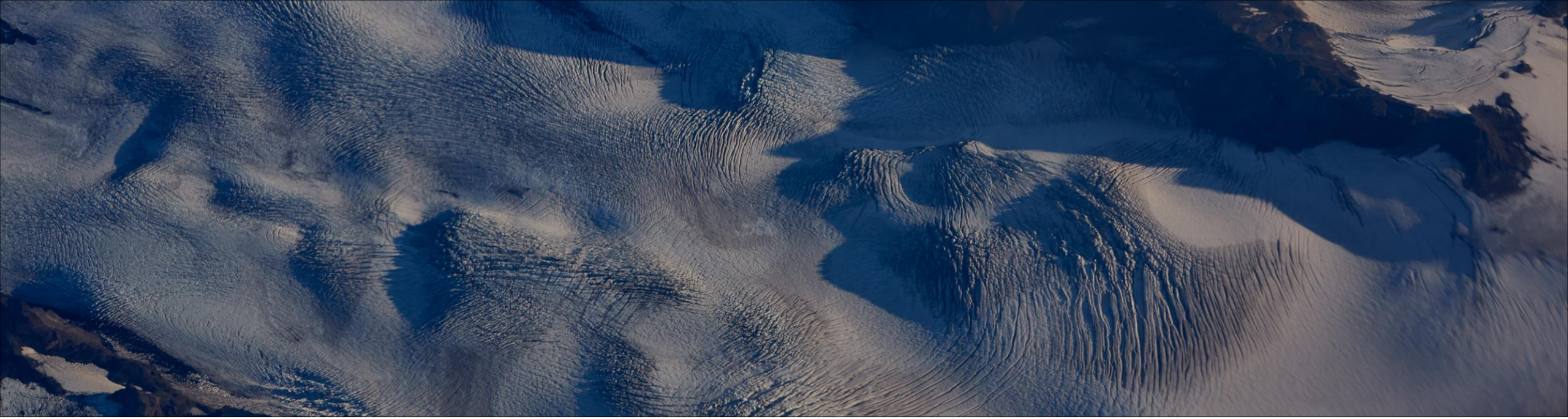


From in-situ to satellite data: insights from Earth observations to better model future changes in ice shelf freshwater fluxes

R. Millan, R. Charrassin, J.B. Barré, F. Moncada, E. Rignot, P. Mathiot, M. Scheinert, J. Mouginot, G. Durand, M. Morlighem

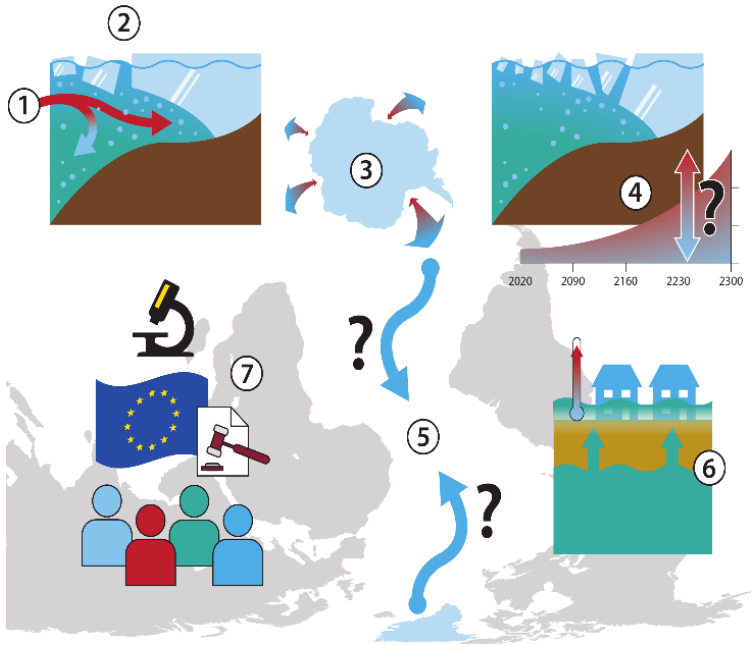
Introduction

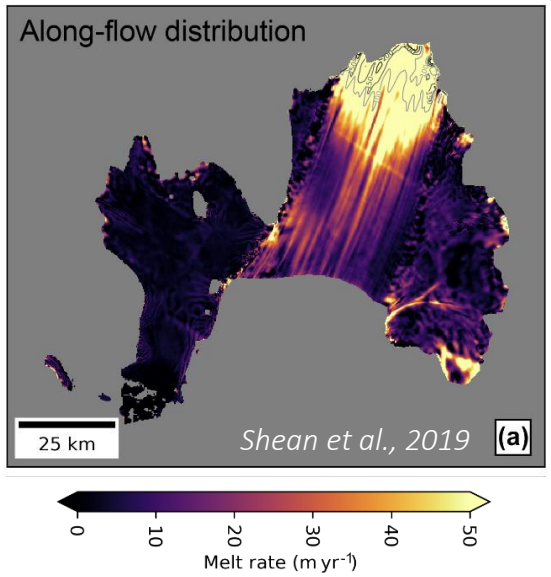
Broad impact

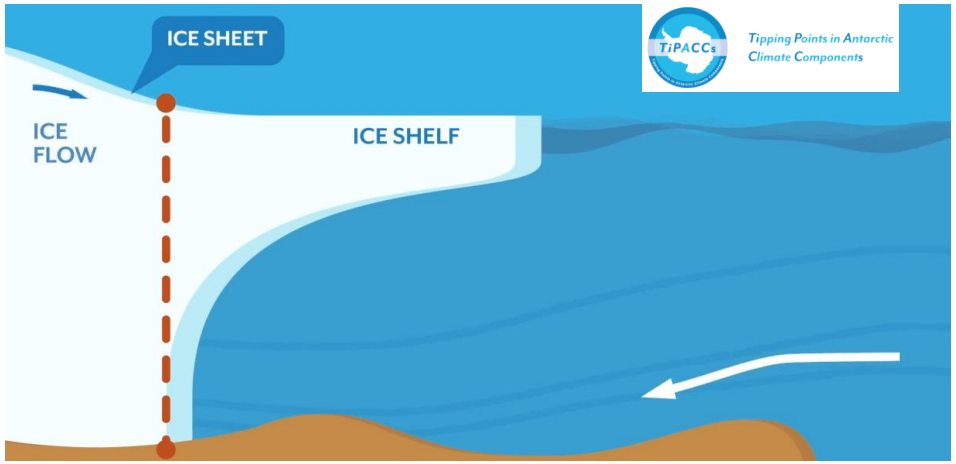
- Impact of freshwater fluxes on the southern ocean and global ocean at large (Zhou *et al*., 2023; Li et al., 2023)

Modelling challenges

- Correctly advect CDW onto the continental shelf and under ice shelves: control of bathymetry
- Validate absolute melt rates and spatial patterns







Schematic view of ice sheet – ocean interactions (source: tipaccs.com)

Monitoring ice shelves freshwater fluxes

OCEAN:ICE

Antarctic ice-sheet loss driven by basal melting of ice shelves

H. D. Pritchard[1], S. R. M. Ligtenberg[2], H. A. Fricker[3], D. G. Vaughan[1], M. R. van den Broeke[2] & L. Padman[4]

Ice-Shelf Melting Around Antarctica

E. Rignot,[1,2]* S. Jacobs,[3] J. Mouginot,[1] B. Scheuchl[1]

Calving fluxes and basal melt rates of Antarctic ice shelves

M. A. Depoorter[1], J. L. Bamber[1], J. A. Griggs[1], J. T. M. Lenaerts[2], S. R. M. Ligtenberg[2], M. R. van den Broeke[2] & G. Moholdt[1]

ENVIRONMENTAL STUDIES

Annual mass budget of Antarctic ice shelves from 1997 to 2021

Benjamin J. Davison[1]*, Anna E. Hogg[1], Noel Gourmelen[2,3], Livia Jakob[3], Jan Wuite[4],

Article

Antarctic calving loss rivals ice-shelf thinning

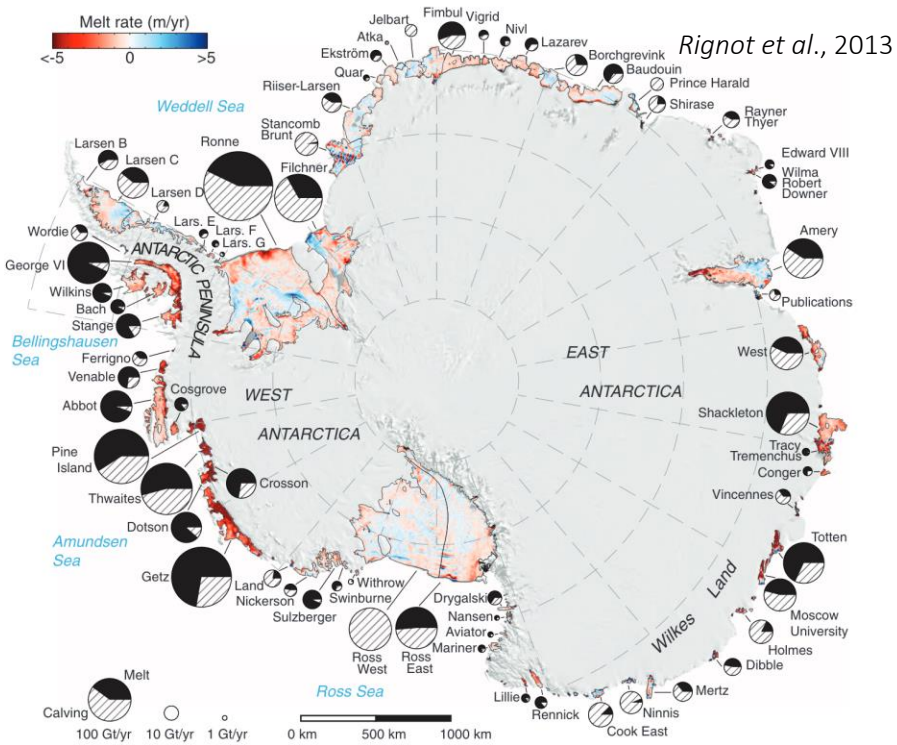
Interannual variations in meltwater input to the Southern Ocean from Antarctic ice shelves

Susheel Adusumilli[1✉], Helen Amanda Fricker[1], Brooke Medley[2], Laurie Padman[3] and

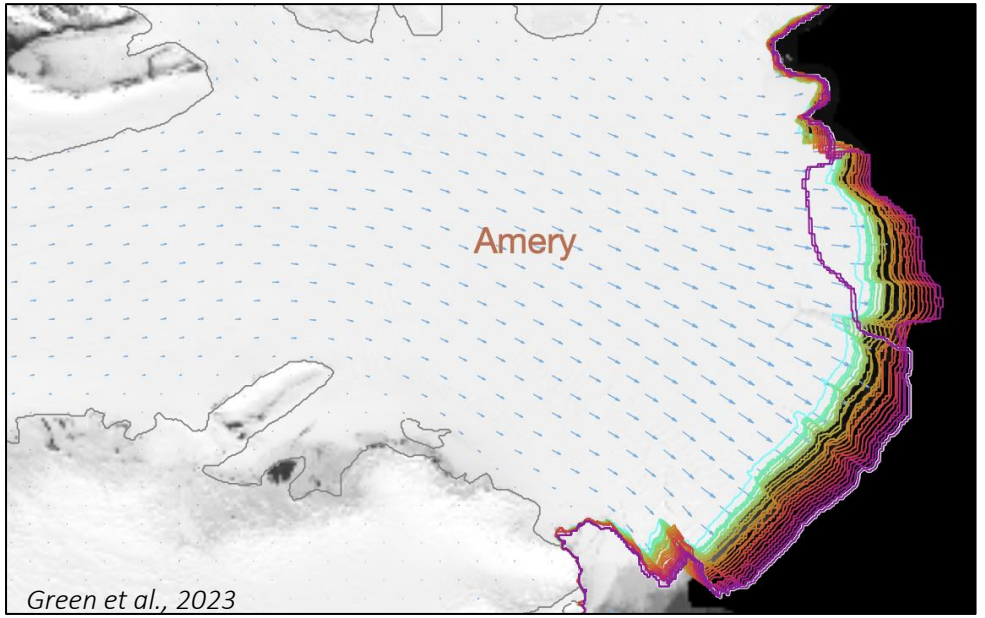
Widespread slowdown in thinning rates of West Antarctic Ice Shelves

Fernando S. Paolo[1], Alex S. Gardner[1], Chad A. Greene[1], Johan N. Nilsson[1], Michael P. Schodlok[1], Nicole-Jeanne Schlegel[1], Helen A. Fricker[2]

2012 → 2013 → 2020 → 2023 → *Publication date*



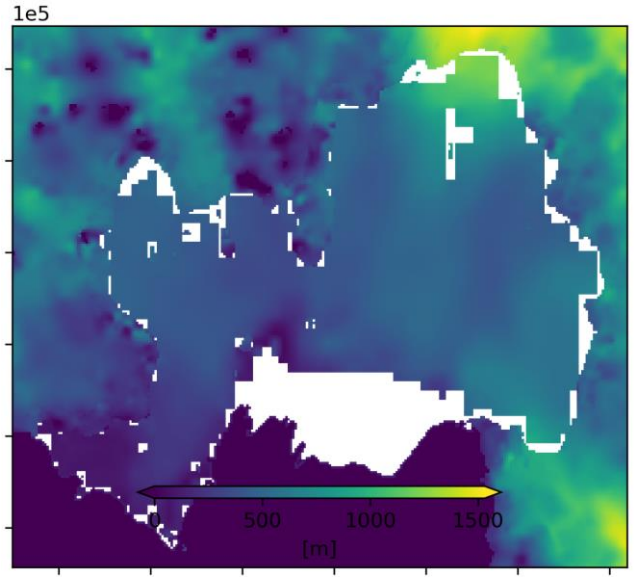
Rignot et al., 2013



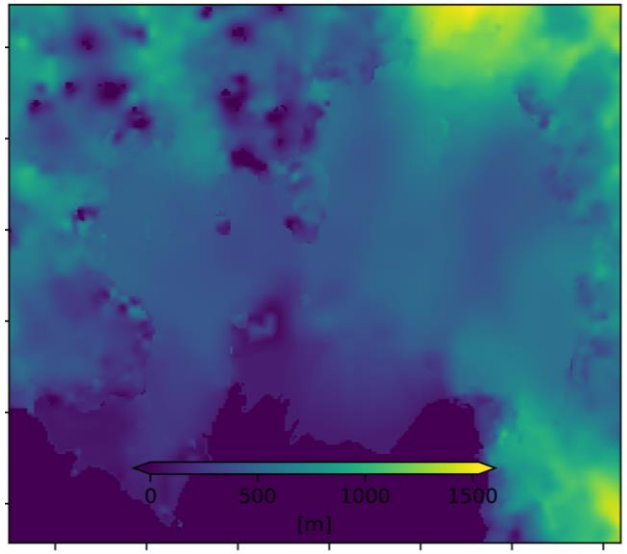
Green et al., 2023

Standardized – state of the art - ice dynamics variable

Raw thickness data (2008)

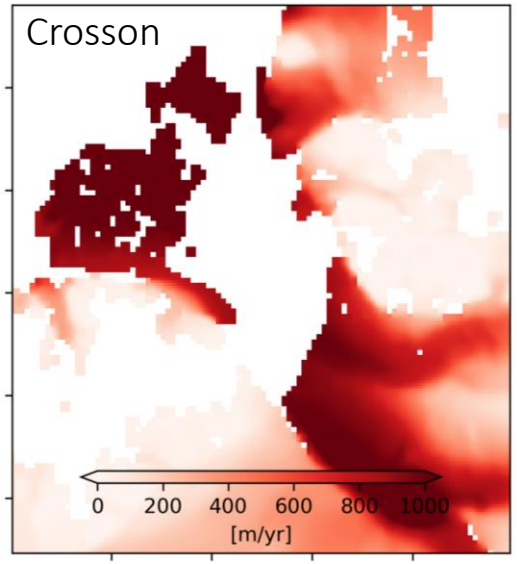


Interpolated thickness data (2008)

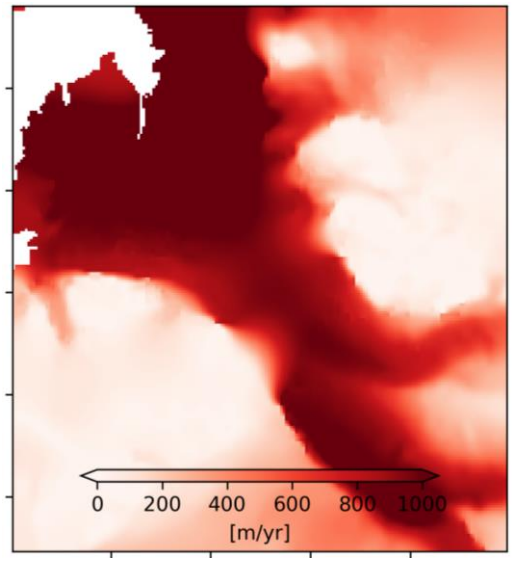


Common ice shelf extent between dataset

Raw ice velocity (2006)



Interpolated ice velocity (2006)

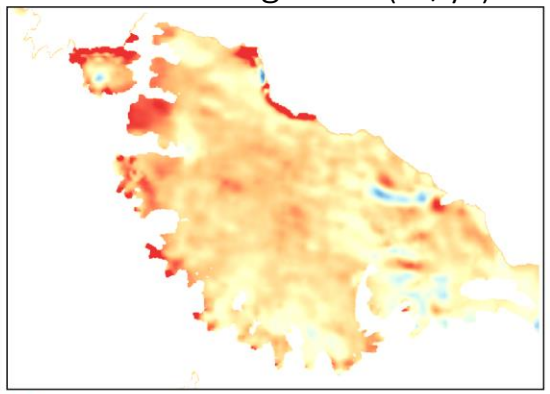


Interpolate missing data across time and space

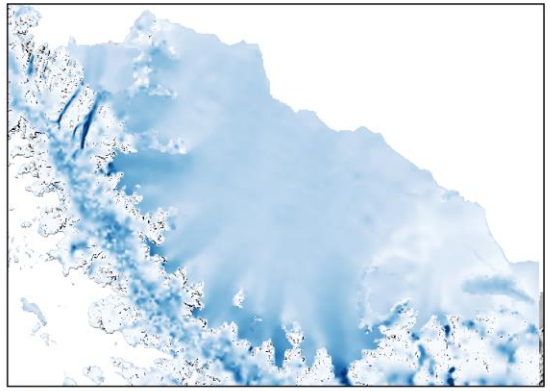
Standardized – state of the art - ice dynamics variable

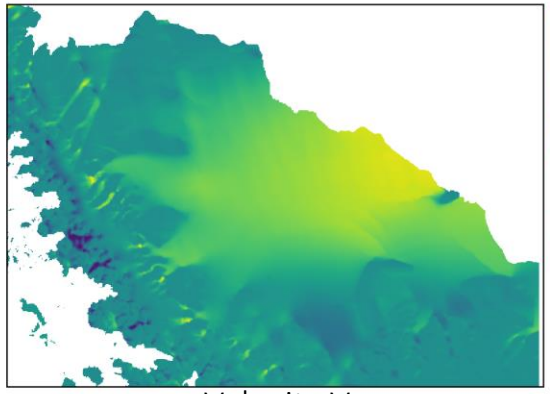
Ice mask

Basal melting rates (m/yr)

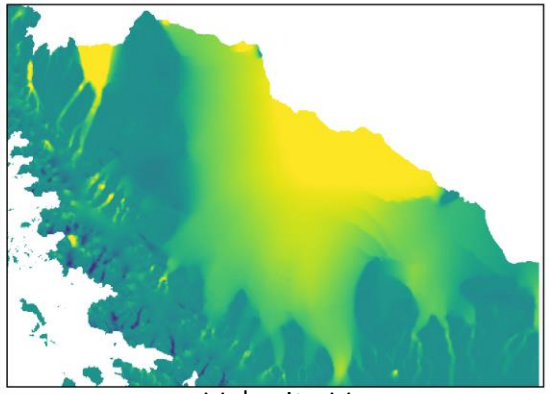


Ice thicknesses (m)

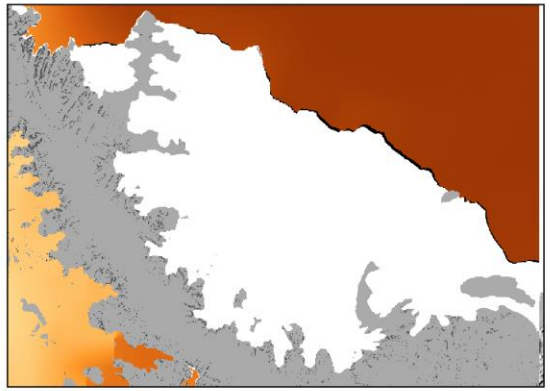




Velocity Vx (m/yr)

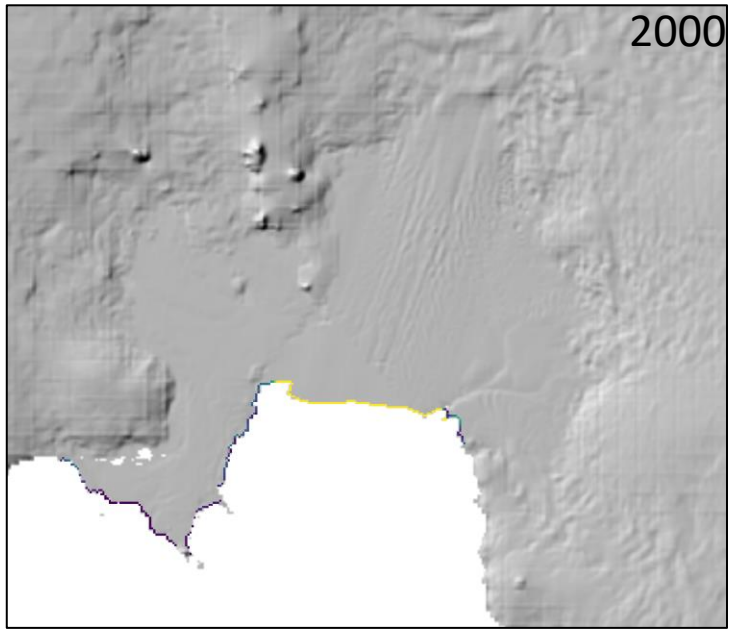


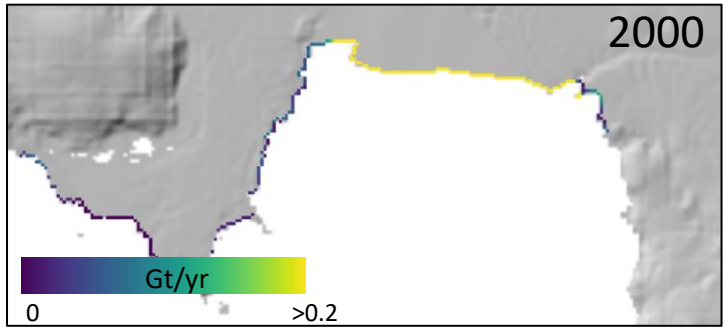
Velocity Vy (m/yr)



Bonus: Sea ice concentration

Where are the biggest icebergs released?

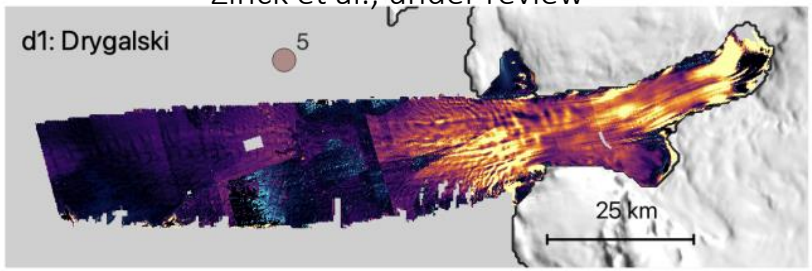




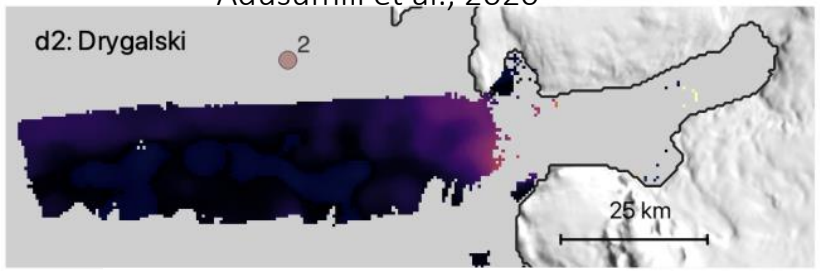
- Same projection convention, ground resolution and coverage period
- Related uncertainty grid

Ongoing challenges and limitations

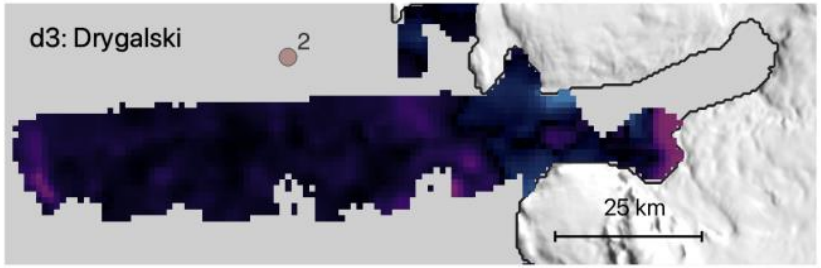
Zinck et al., under review

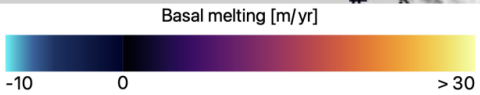


Adusumili et al., 2020



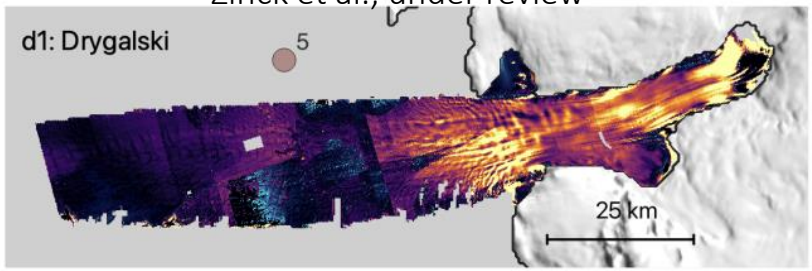
Davison et al., 2023



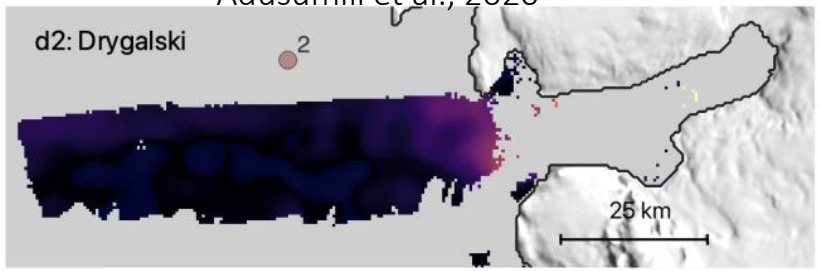


Ongoing challenges and limitations

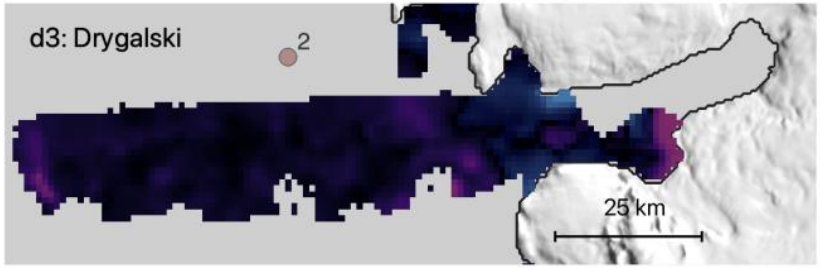
Zinck et al., under review



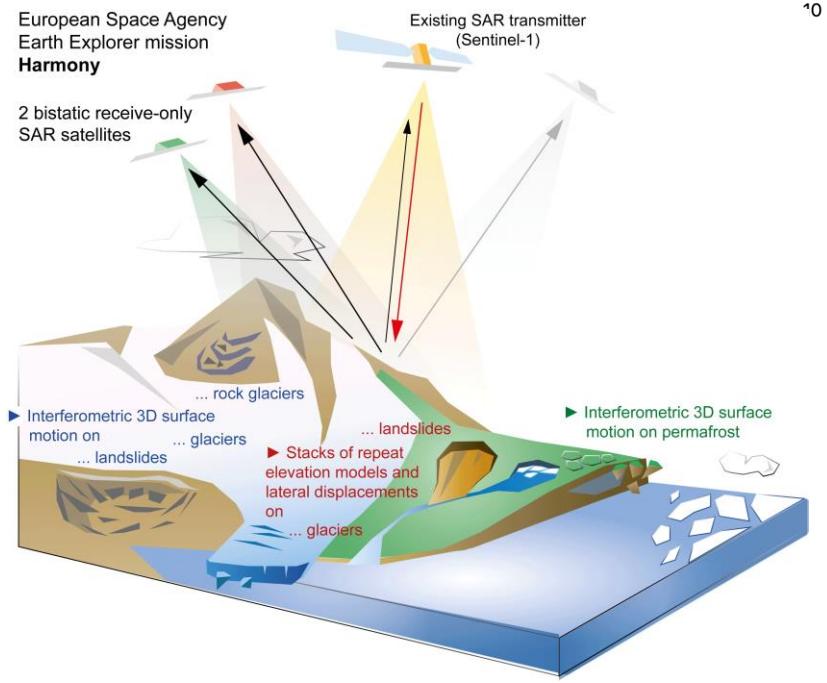
Adusumili et al., 2020



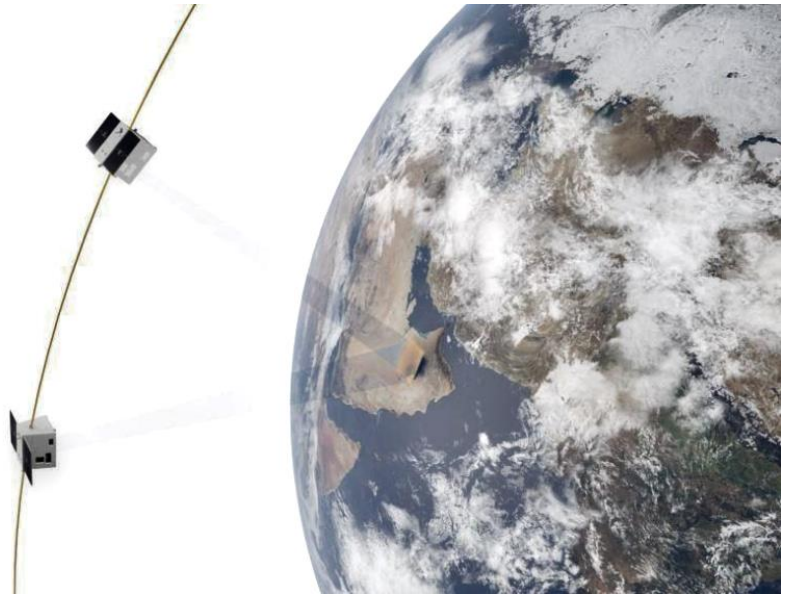
Davison et al., 2023



Source: Ann Sofie Zinck, pers. comm.



The Harmony mission

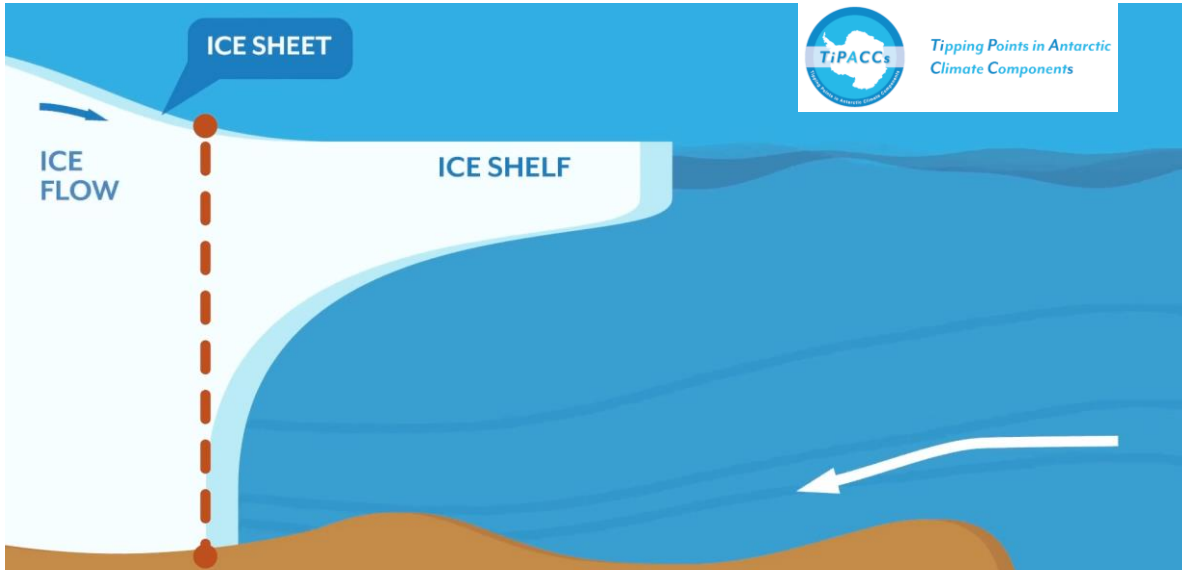


4D-Earth: Future EarthExplorer candidate

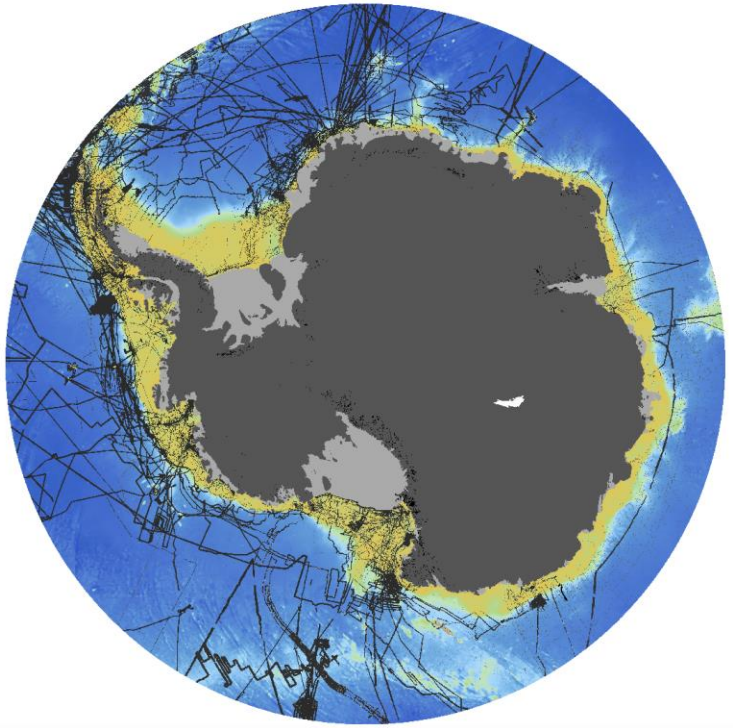
Unravelling warm water pathways in Antarctica

Modelling challenges

- Correctly advect CDW onto the continental shelf and under ice shelves: control of bathymetry



Schematic view of ice sheet – ocean interactions (source: tipaccs.com)



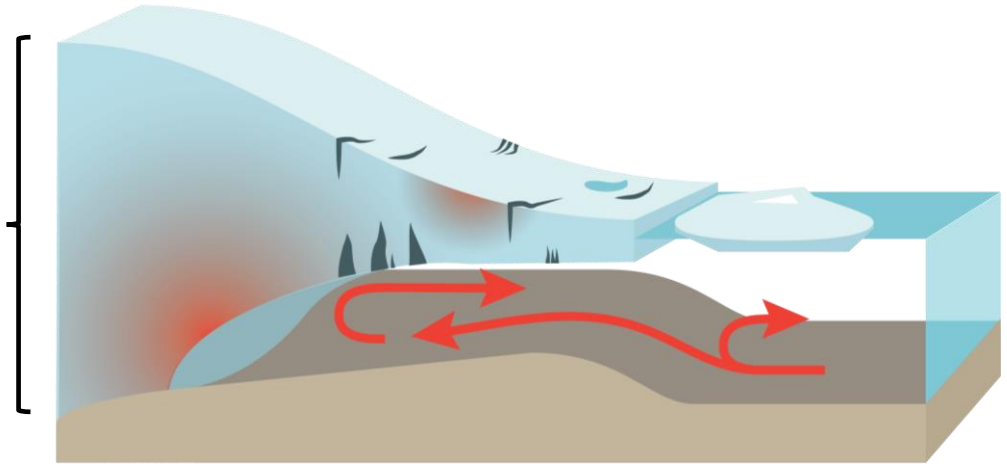
Existing multibeam ship measurements of bathymetry around Antarctica

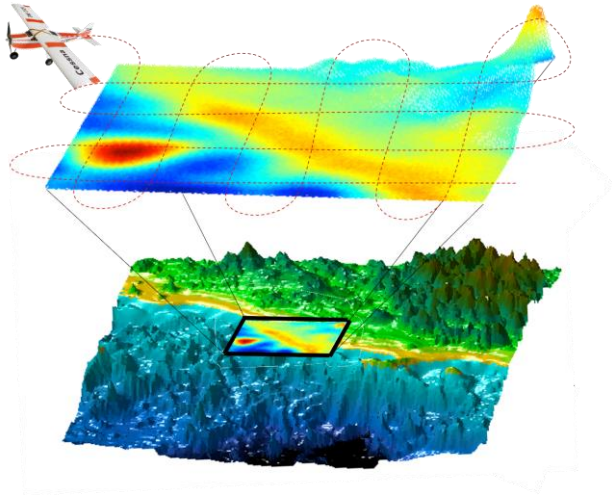
Unravelling warm water pathways in Antarctica

Ice shelf and glacial fjords
airborne gravimetry

Fusion of multiple satellite, airborne and ground measurements

Grounded ice
surface elevation (meters) - thickness

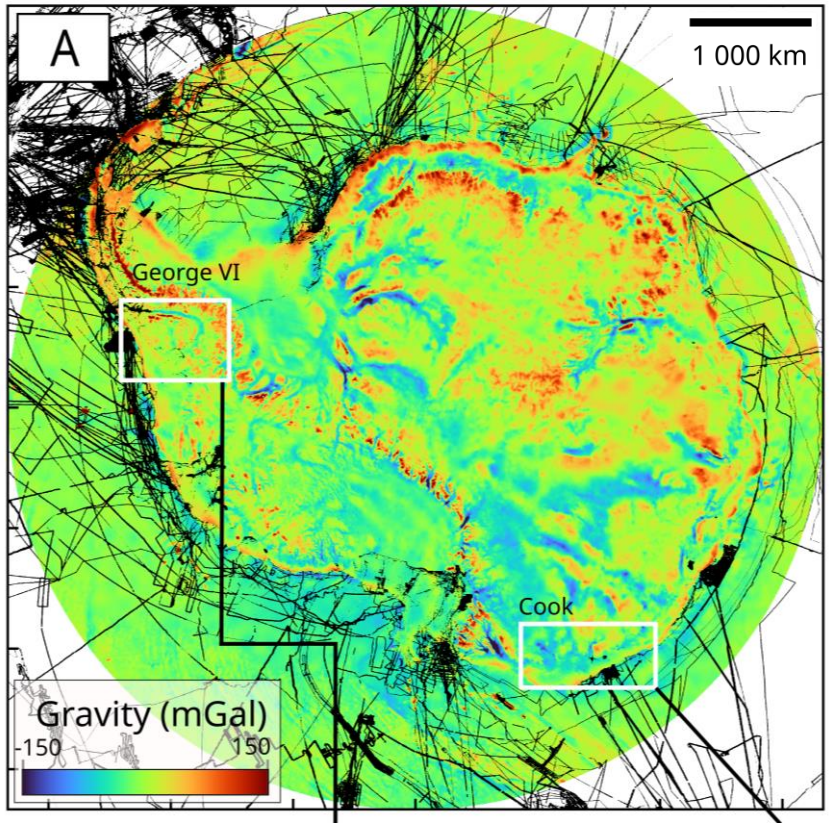


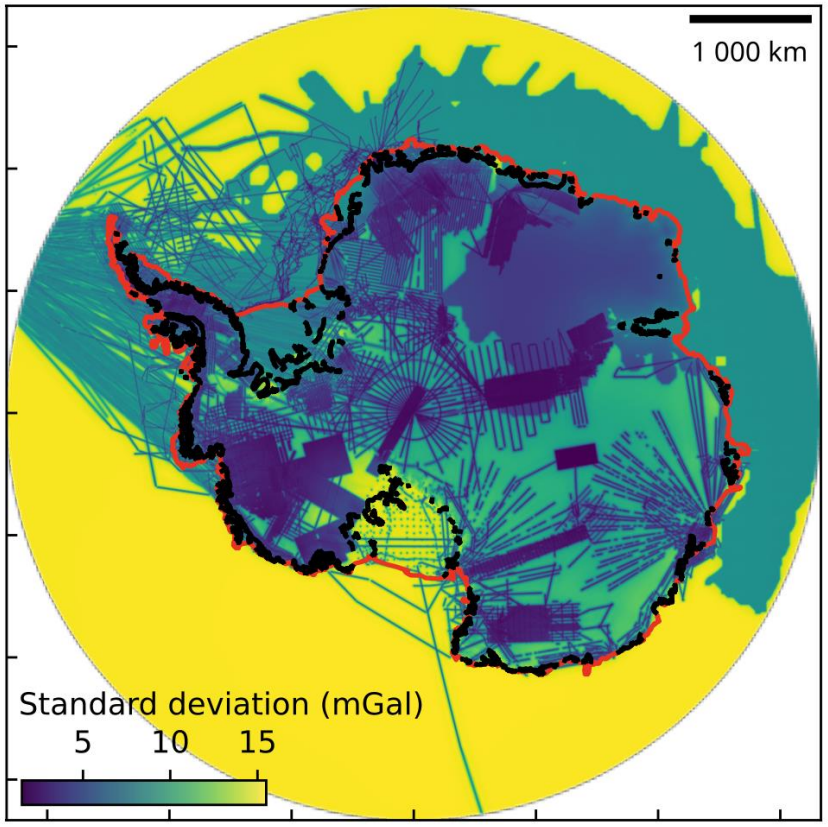


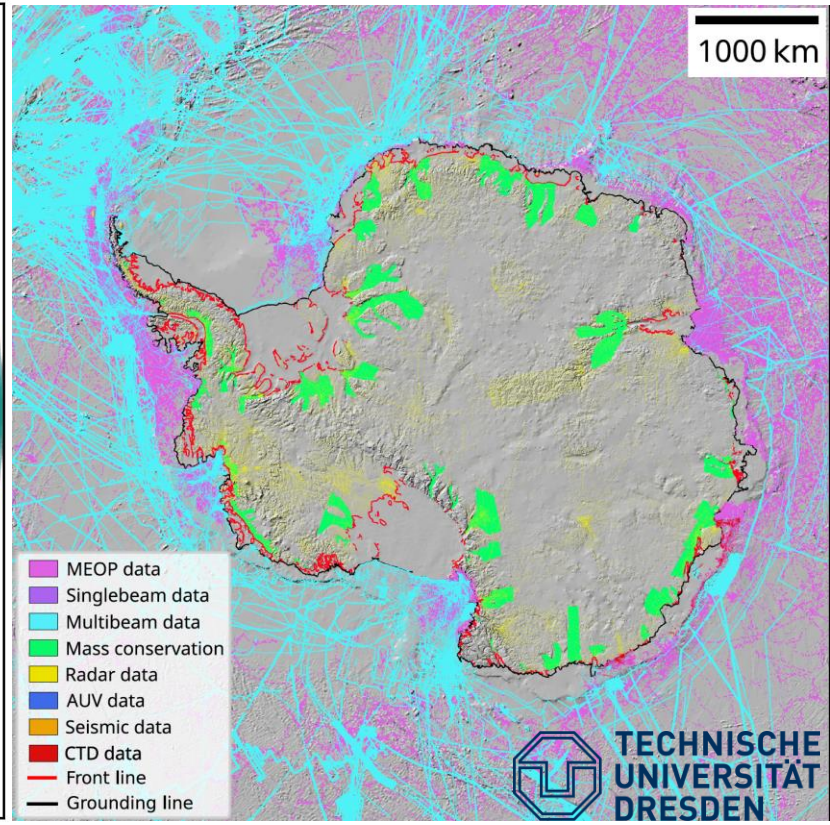
Open ocean
multi-beam echo sounding, seal data

- Uncertainties ranging between 60-150 meters depending on the amount in-situ data

Unravelling warm water pathways in Antarctica





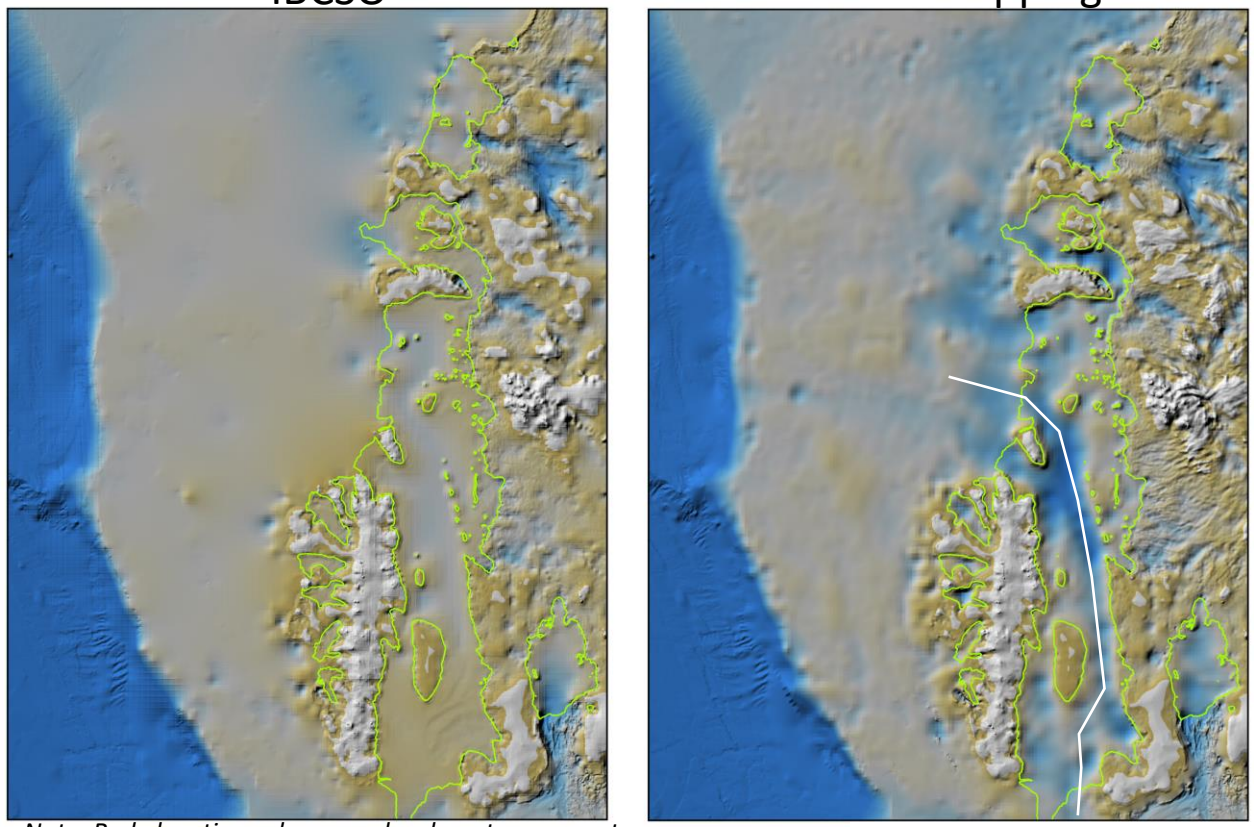


Charrassin et al., in review

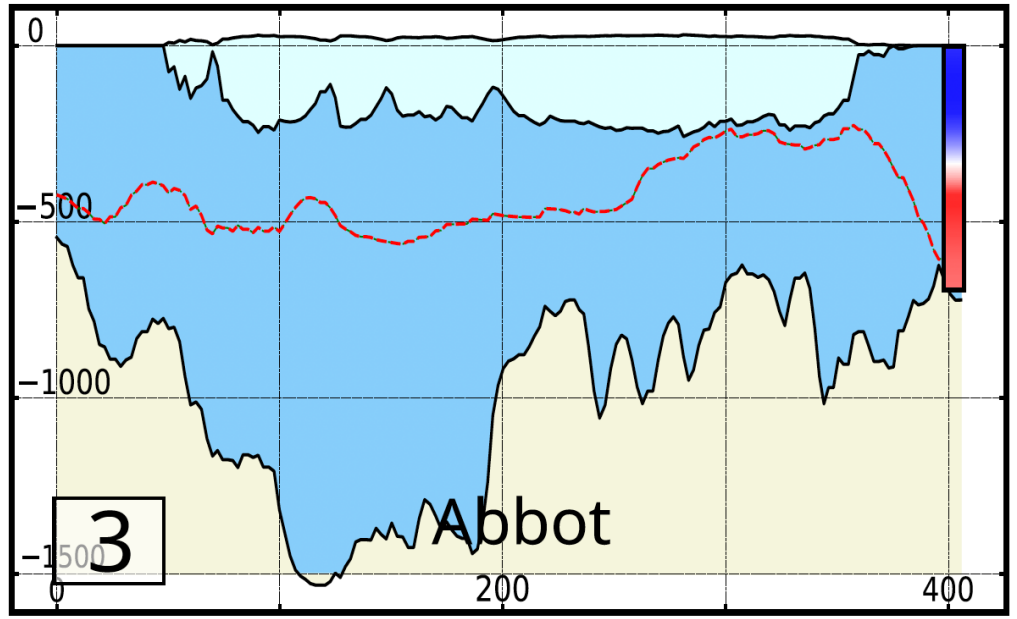
Unravelling warm water pathways in Antarctica

IBCSO

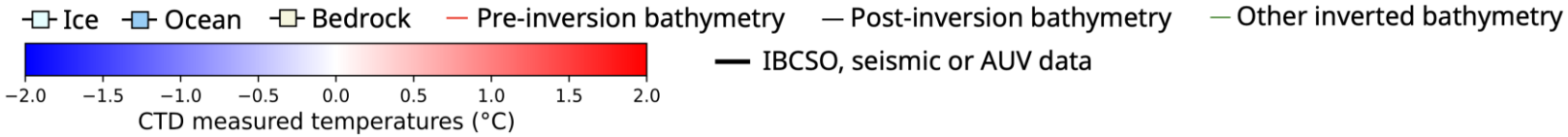
New mapping



Note: Bed elevations above sea level are transparent



Charrassin et al., in review



Unravelling warm water pathways in Antarctica

IBCSO

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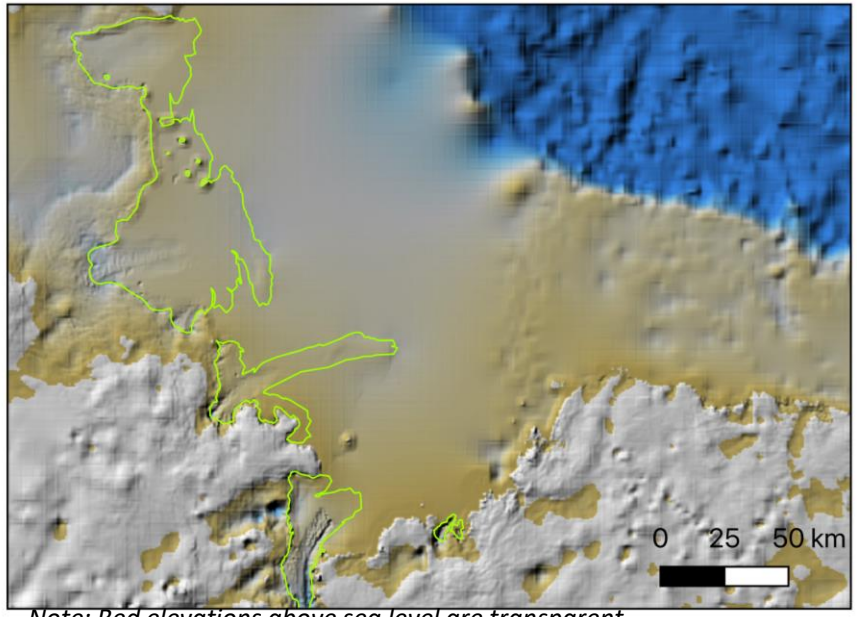
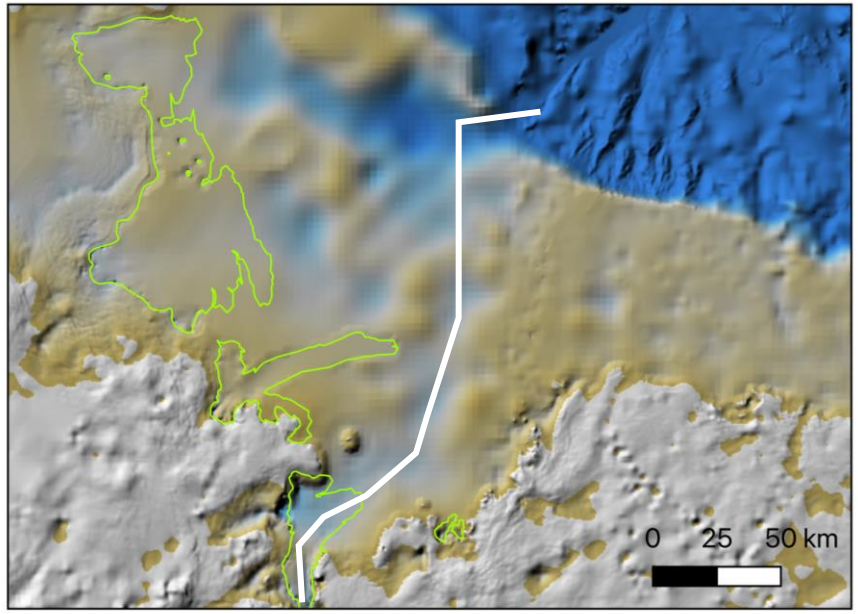
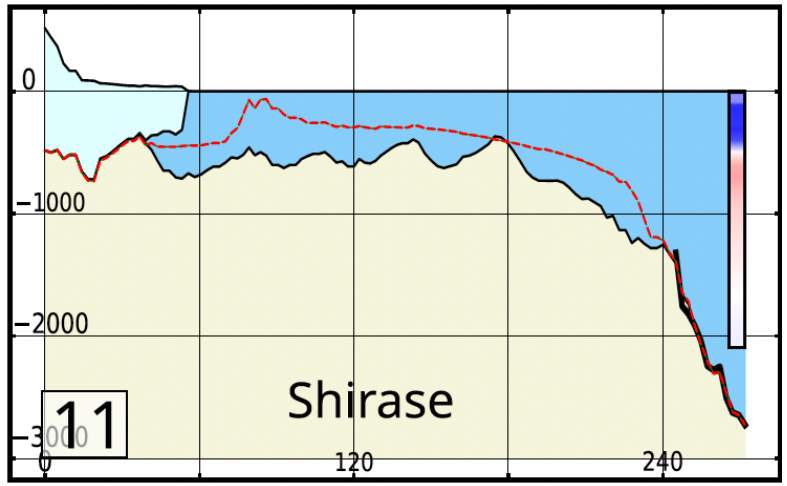


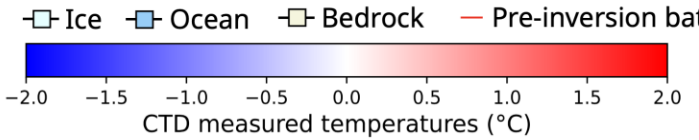




Charrassin et al., in review

Note: Bed elevations above sea level are transparent

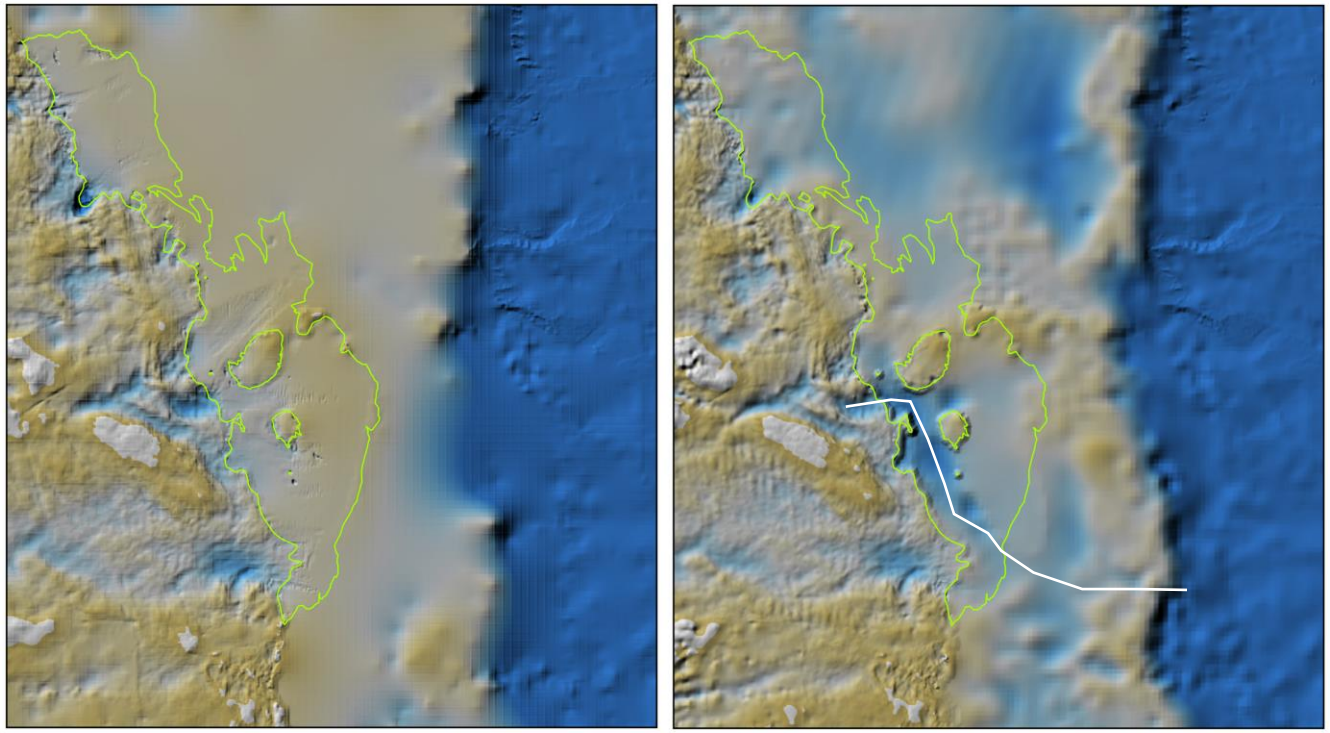
Bed elevation (m)



Unravelling warm water pathways in Antarctica

IBCSO

New mapping



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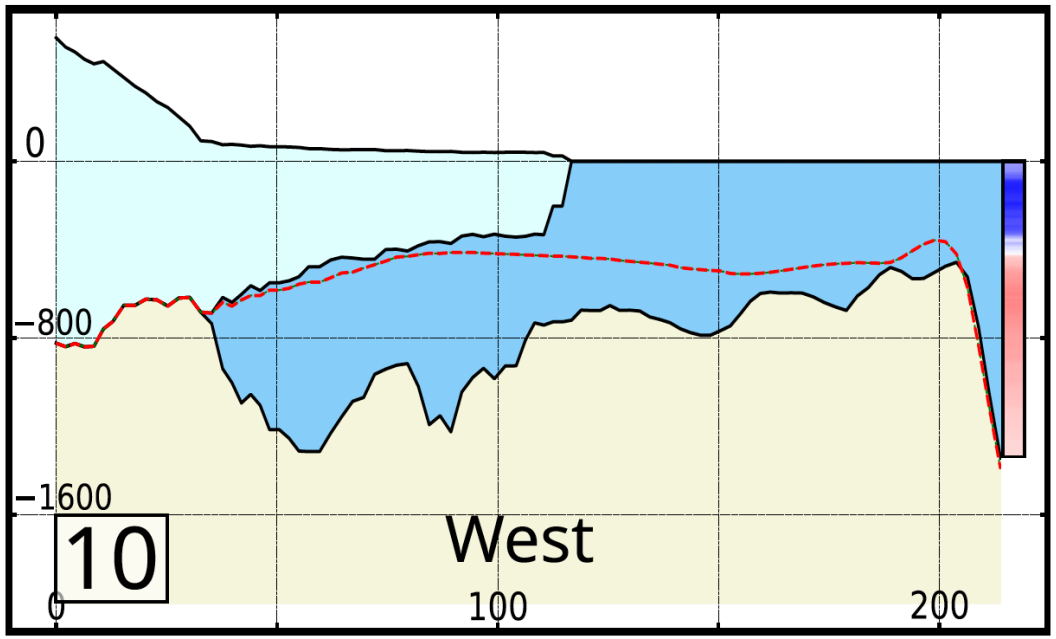
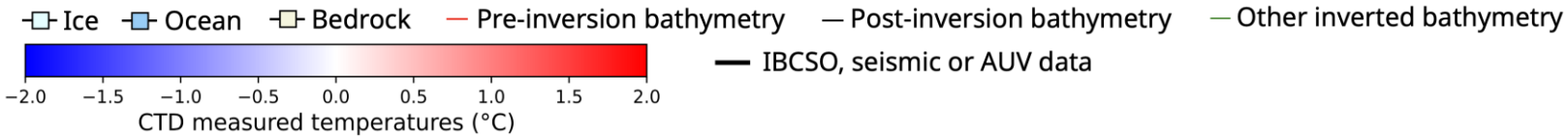
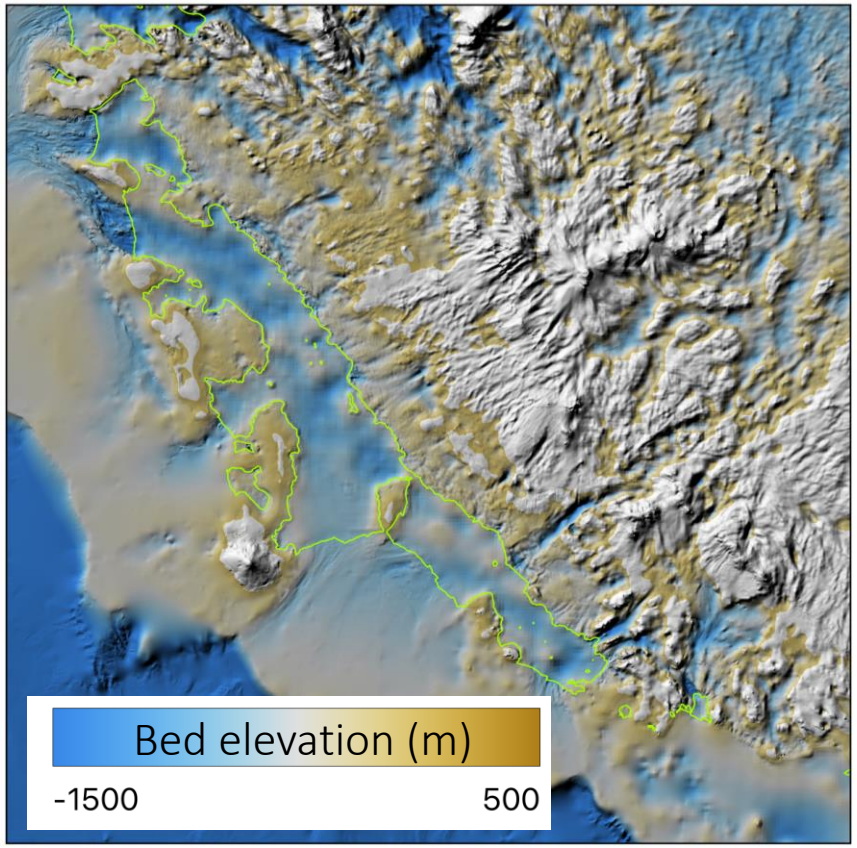


Charrassin et al., in review



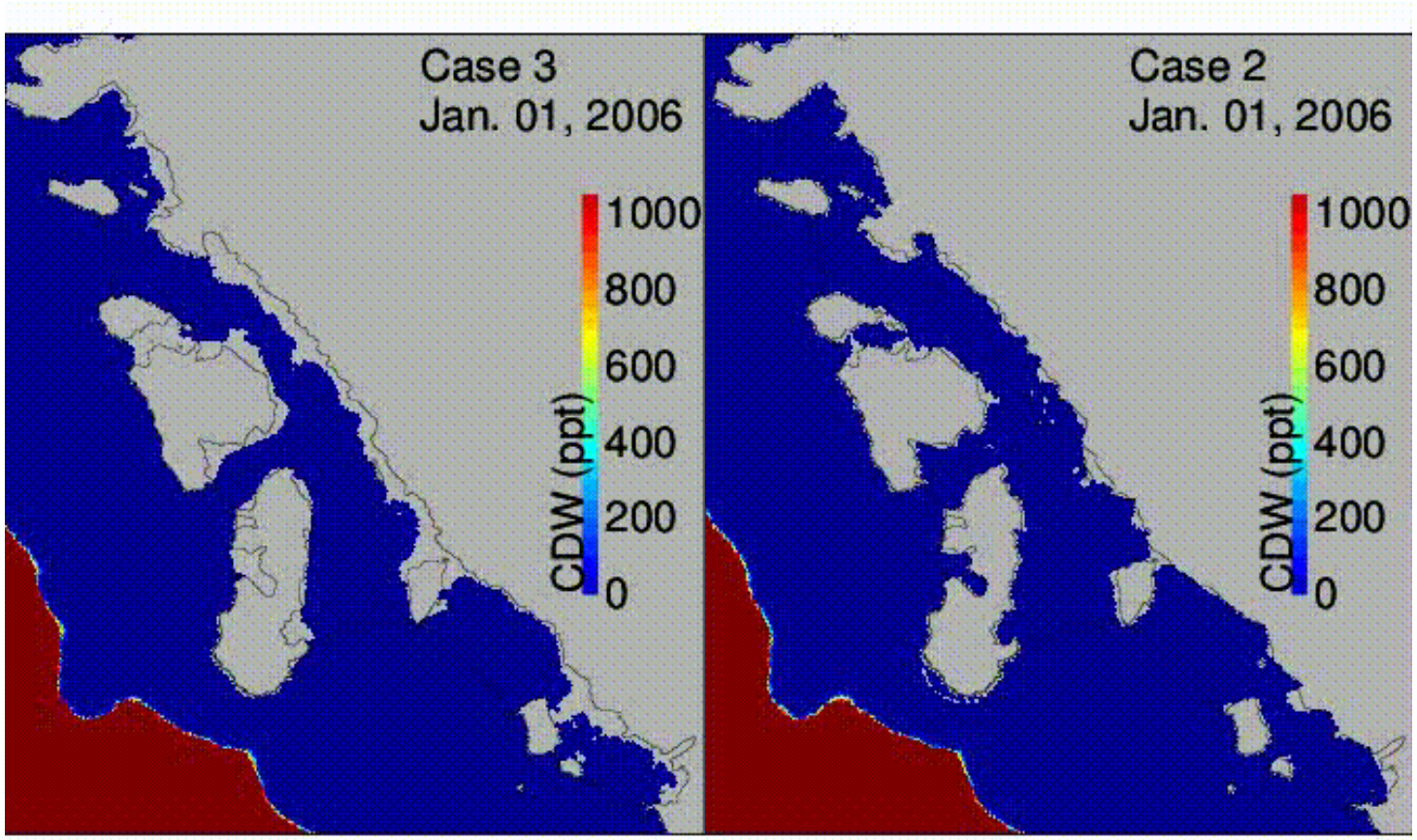
Unravelling warm water pathways in Antarctica



Note: Bed elevations above sea level are transparent

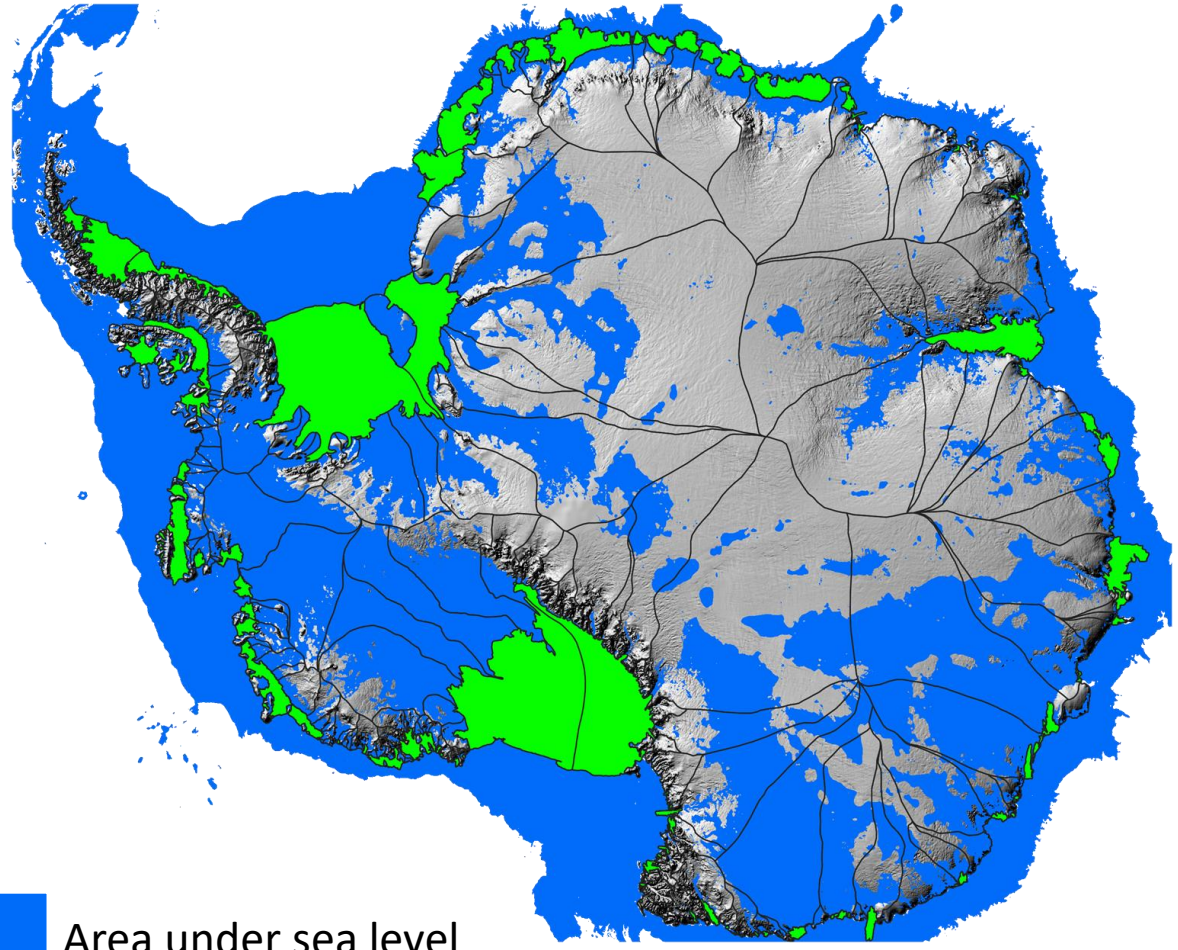
IBCSO

New mapping



source: Millan et al., 2020

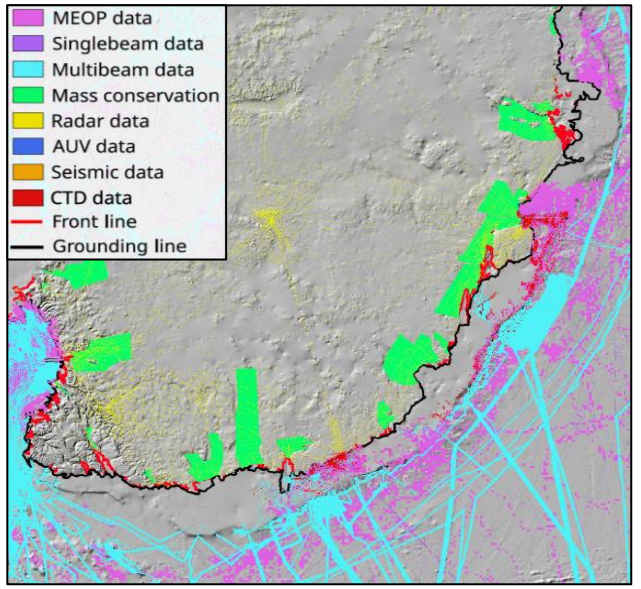
Providing insights for future monitoring campaign

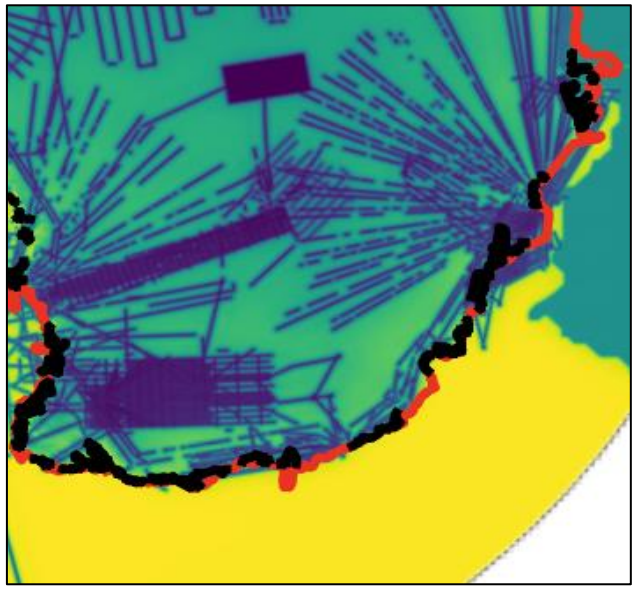


Area under sea level

Ice shelves

George V and Wilkes land





- Large basins below sea level
- Almost non existing observations on continental shelf and below ice shelves

Future opportunities

Applications welcomed !

romain.millan@univ-grenoble-alpes.fr

erc Starting Grants

European Research Council

Established by the European Commission

IceDaM

Ice Shelf Damage Characterization and Monitoring around Antarctica

IGE Institut des géosciences de l'environnement

cnrs

DARTMOUTH