British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNIVERSITY OF CAMBRIDGE

Northumbria University NEWCASTLE

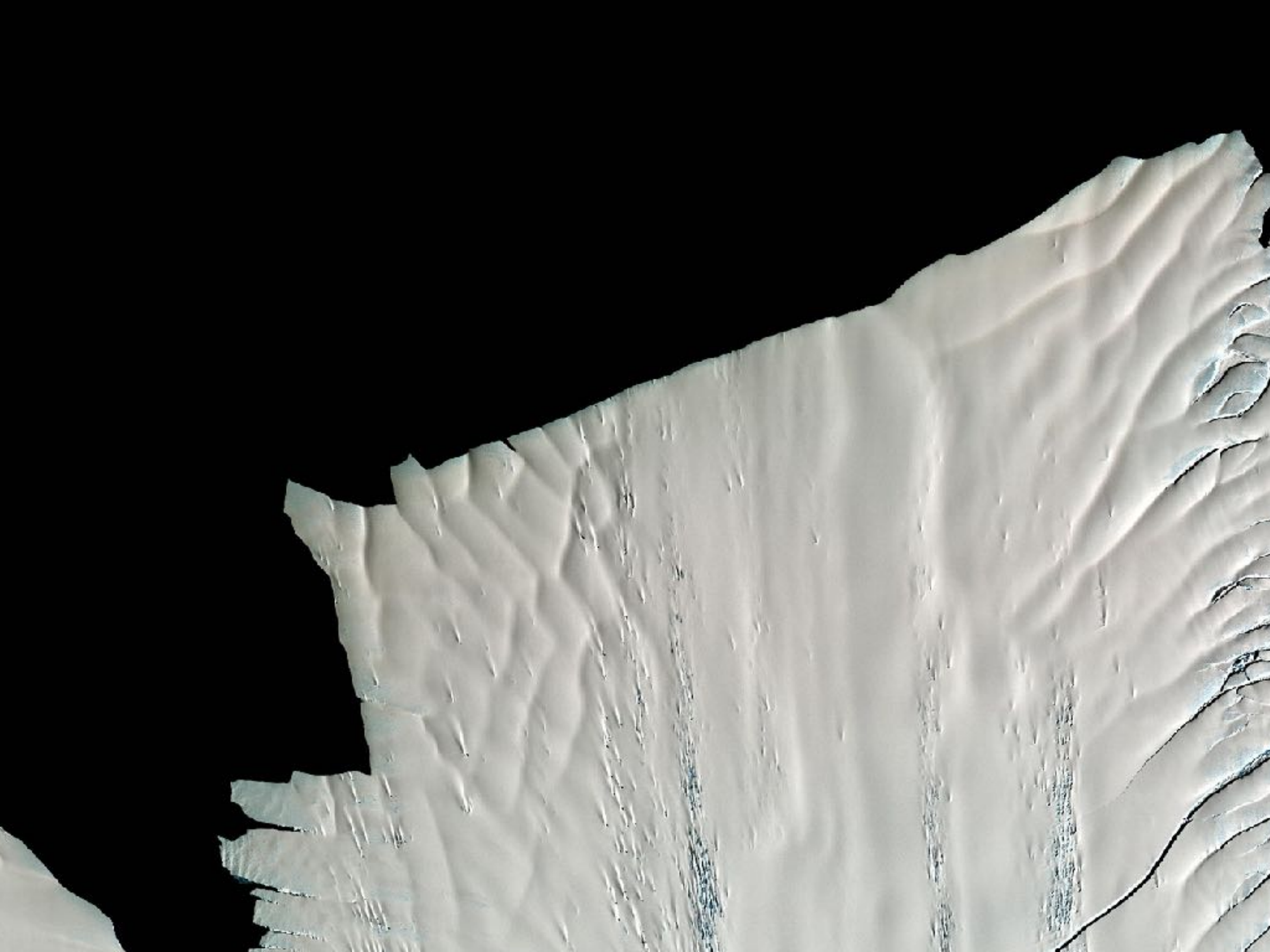
New JGR paper

@abraleey

aleey@bas.ac.uk

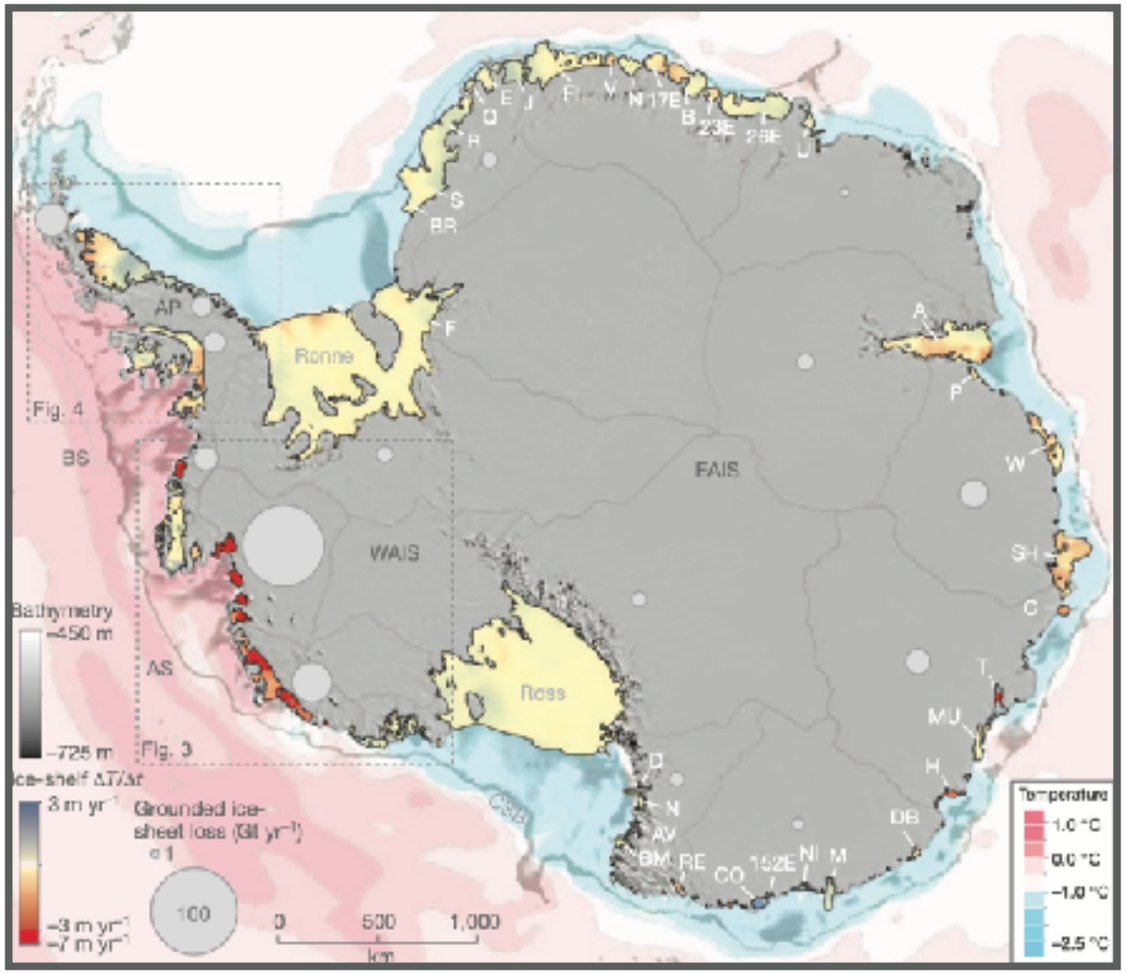
The influence of Pine Island Ice Shelf calving on basal melting

Alex Bradley, David Bett, Pierre Dutrieux, Jan De Rydt, Paul Holland



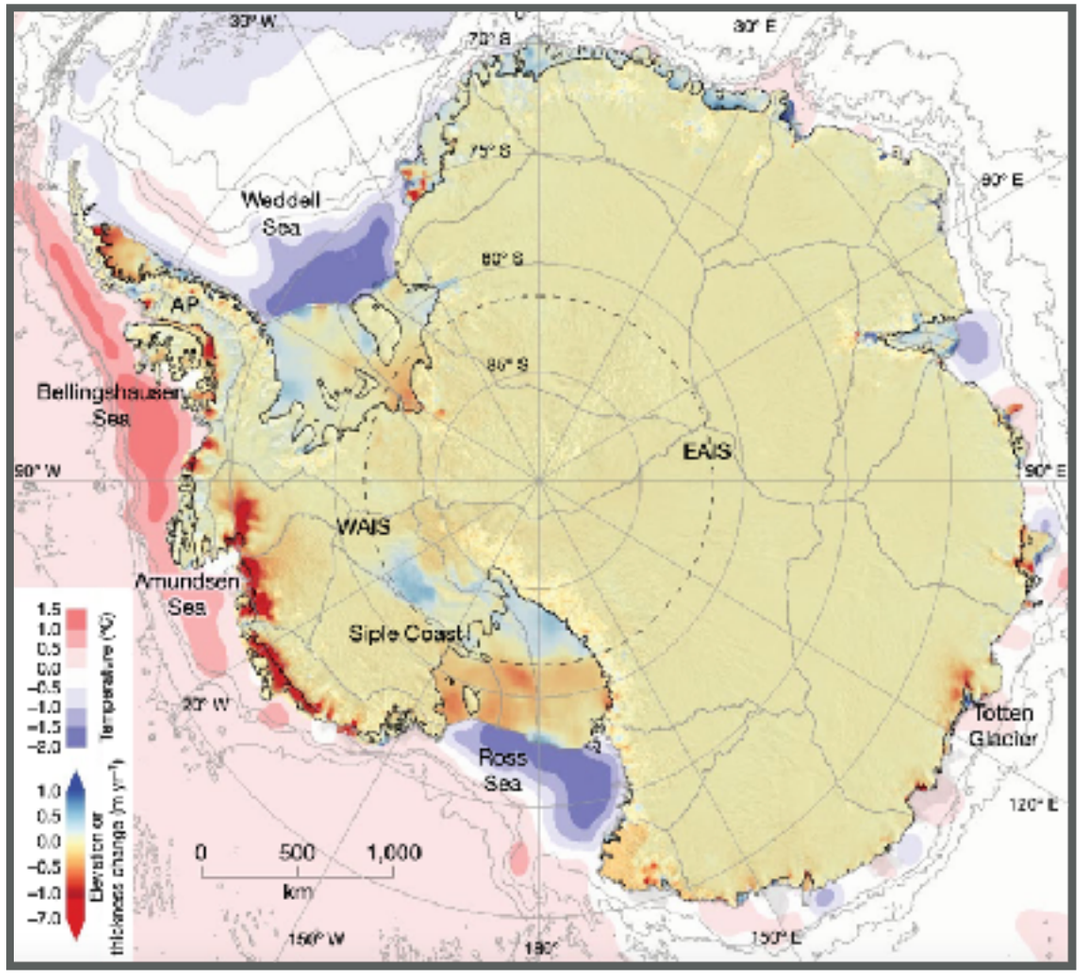
Melting implicated in long term changes to WAIS

Pritchard et al. 2012



2003-2008 average

Shepherd et al. 2018

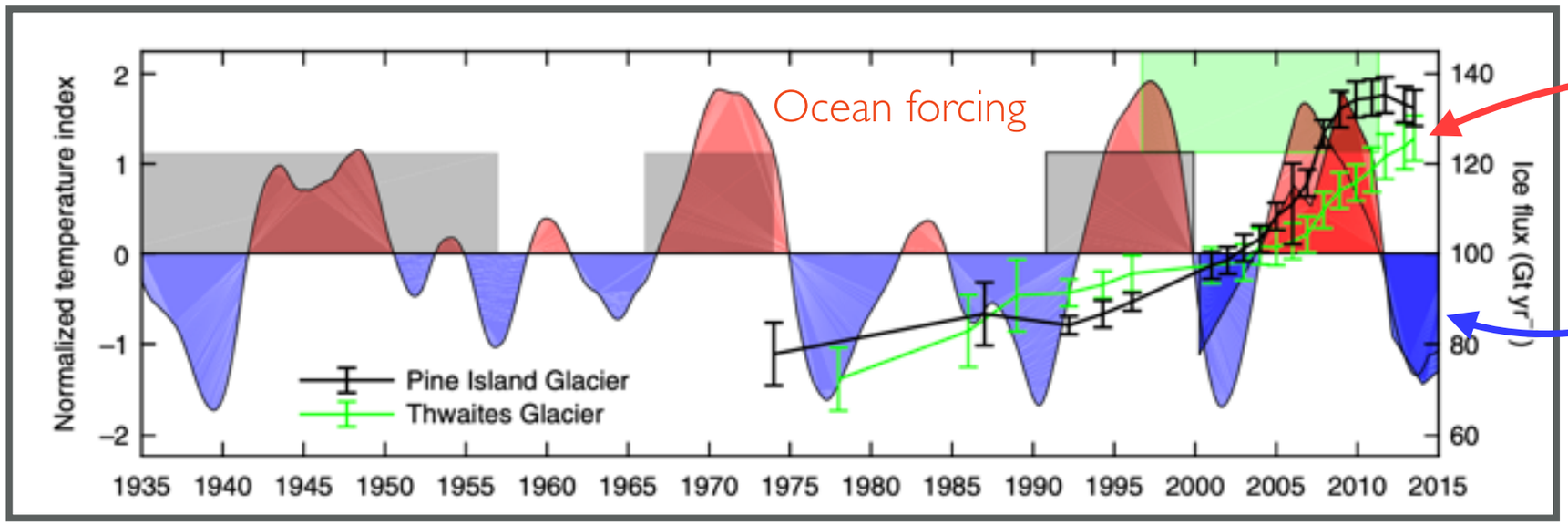


1992-2017 average

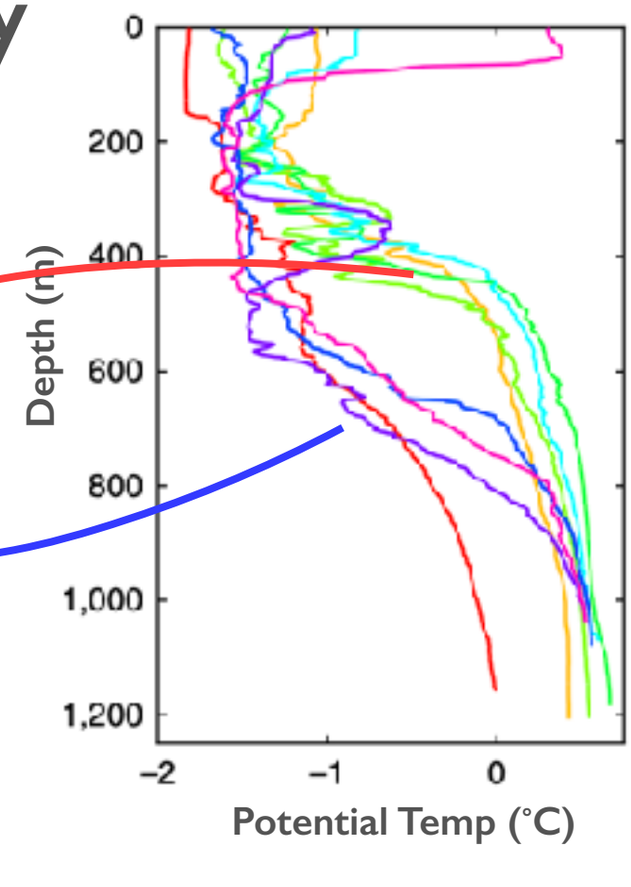
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

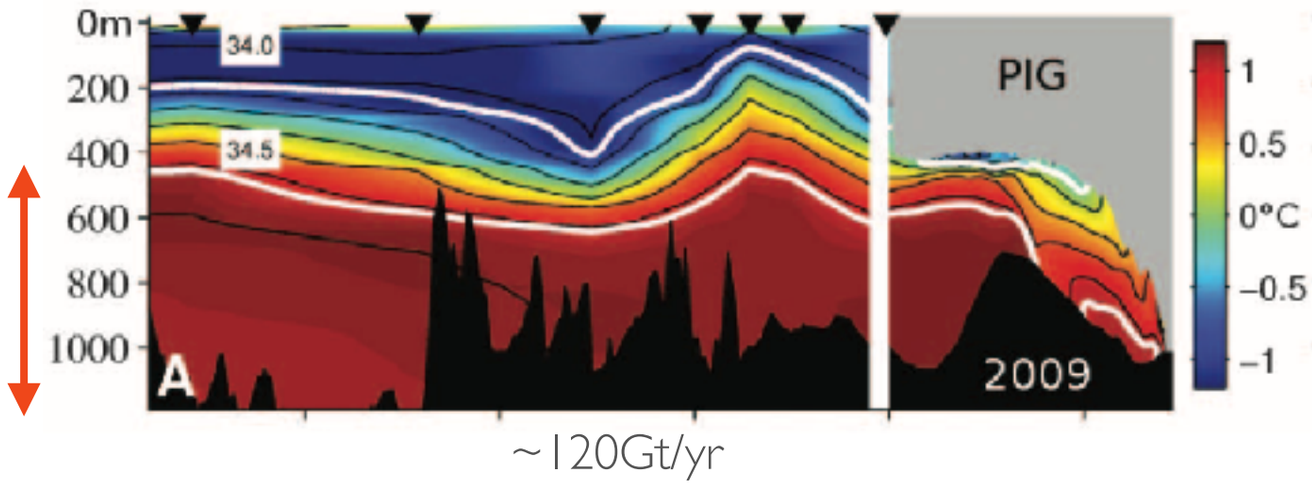
POLAR SCIENCE FOR PLANET EARTH

WAIS also shows significant decadal variability

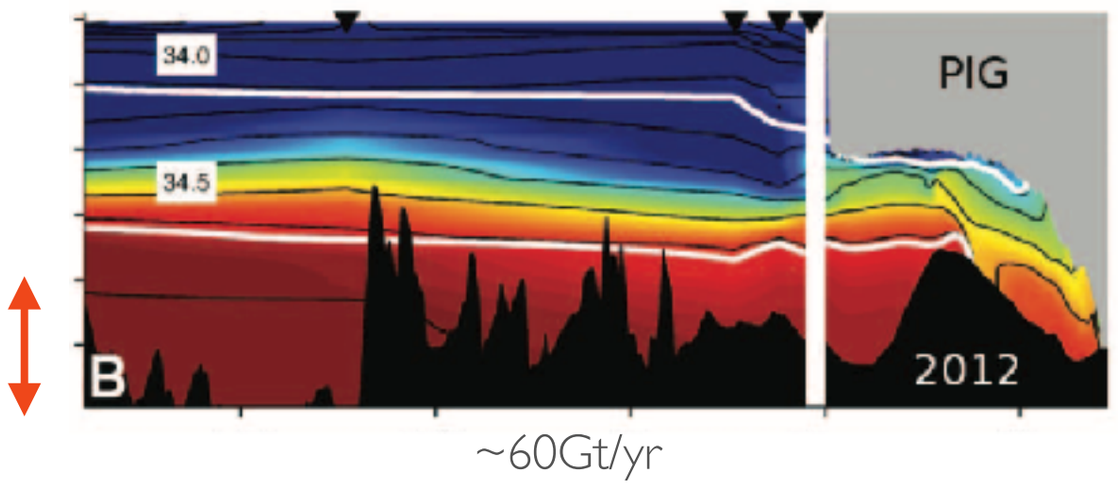


Jenkins et al. 2018





~120Gt/yr



~60Gt/yr

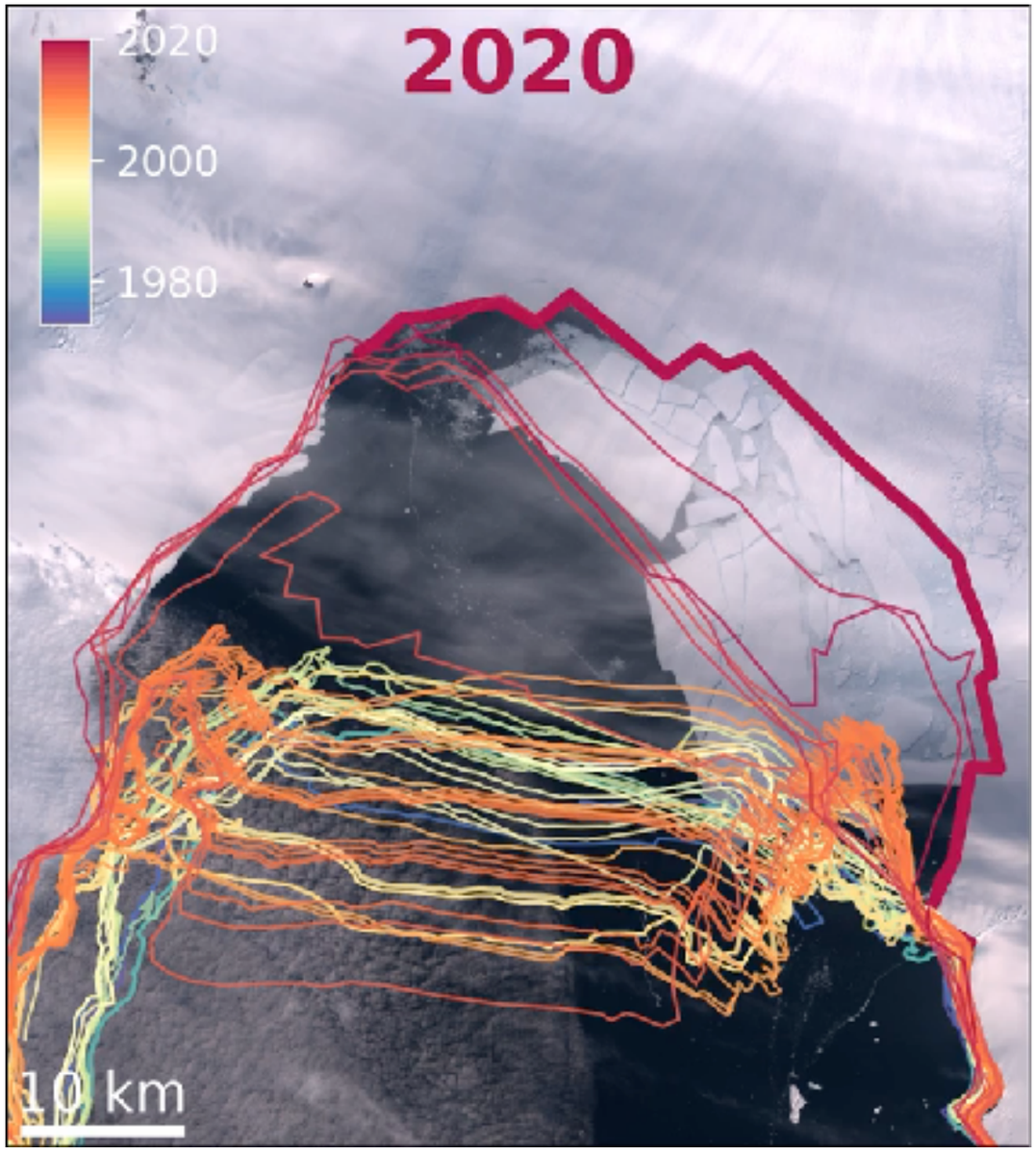
Dutrieux et al. 2014

Seabed **ridge in combination with shelf** acts as a **topographic barrier** to the inflow of **warm water**

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

Pine Island has undergone significant calving recently



Lhermitte et al. 2020

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

Presence of **ice shelf** in combination with **seabed ridge restricts warm water access**

Ice shelf front has **retreated** significantly by calving

?

Key question: have **past** and how might **future calving change melt rates?**

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

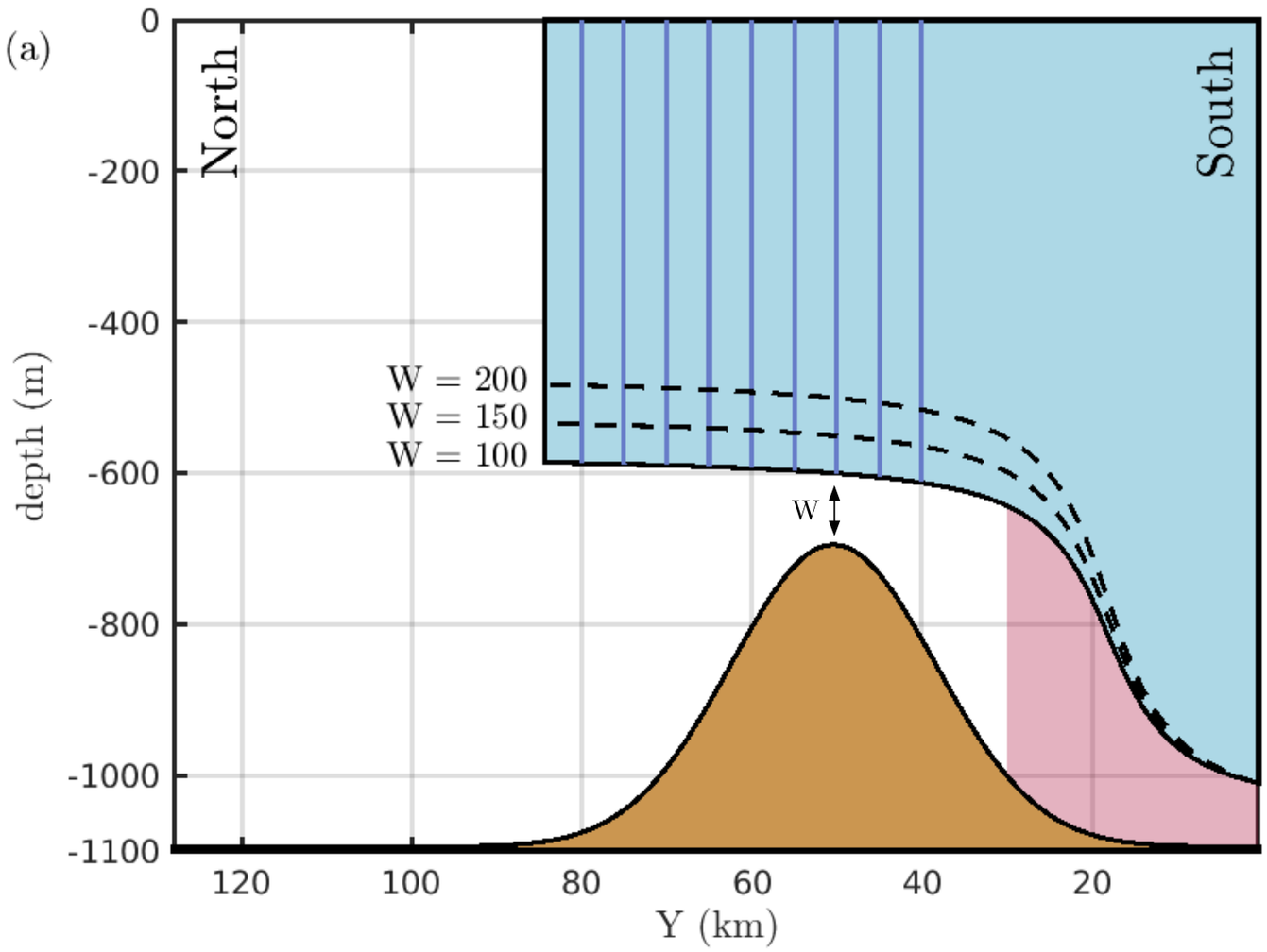
POLAR SCIENCE FOR PLANET EARTH

Numerical simulations in both **realistic** and **idealised geometries**

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

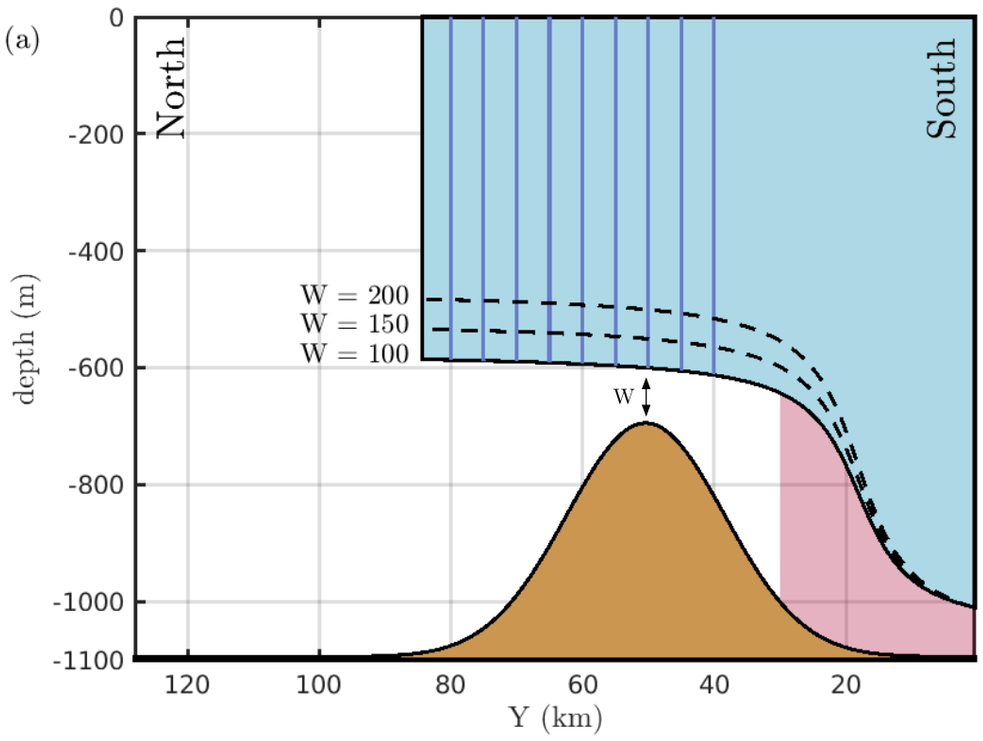
Numerical simulations in both **realistic** and **idealised geometries**



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

Numerical simulations in both **realistic** and **idealised geometries**



topographic barriers

&

potential vorticity

velocity vs thermal driving

so many goodies!

sensitivity to:

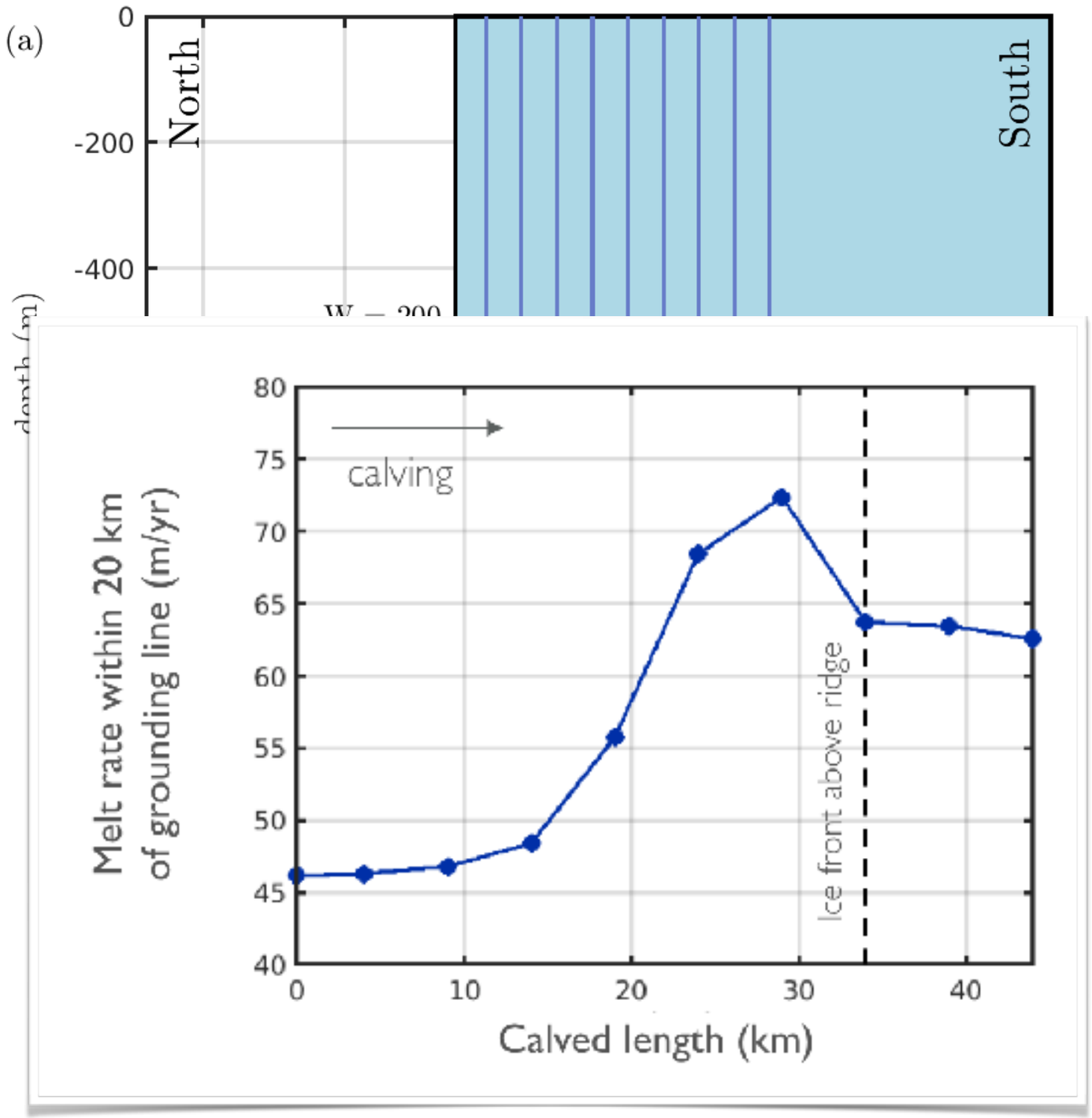
hydrographic forcing

gap width

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

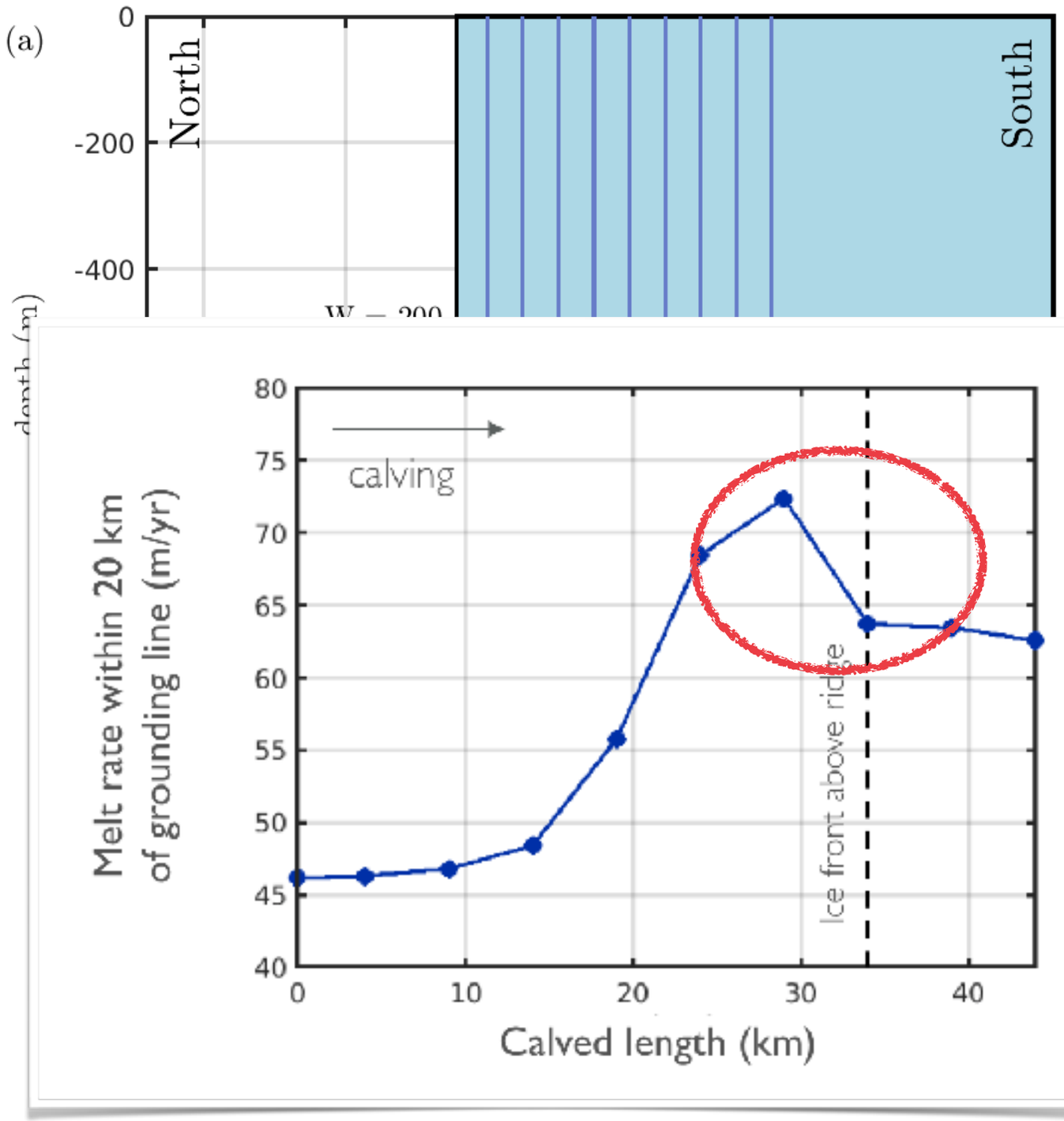
Numerical simulations in both **realistic** and **idealised geometries**



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

Numerical simulations in both **realistic** and **idealised geometries**

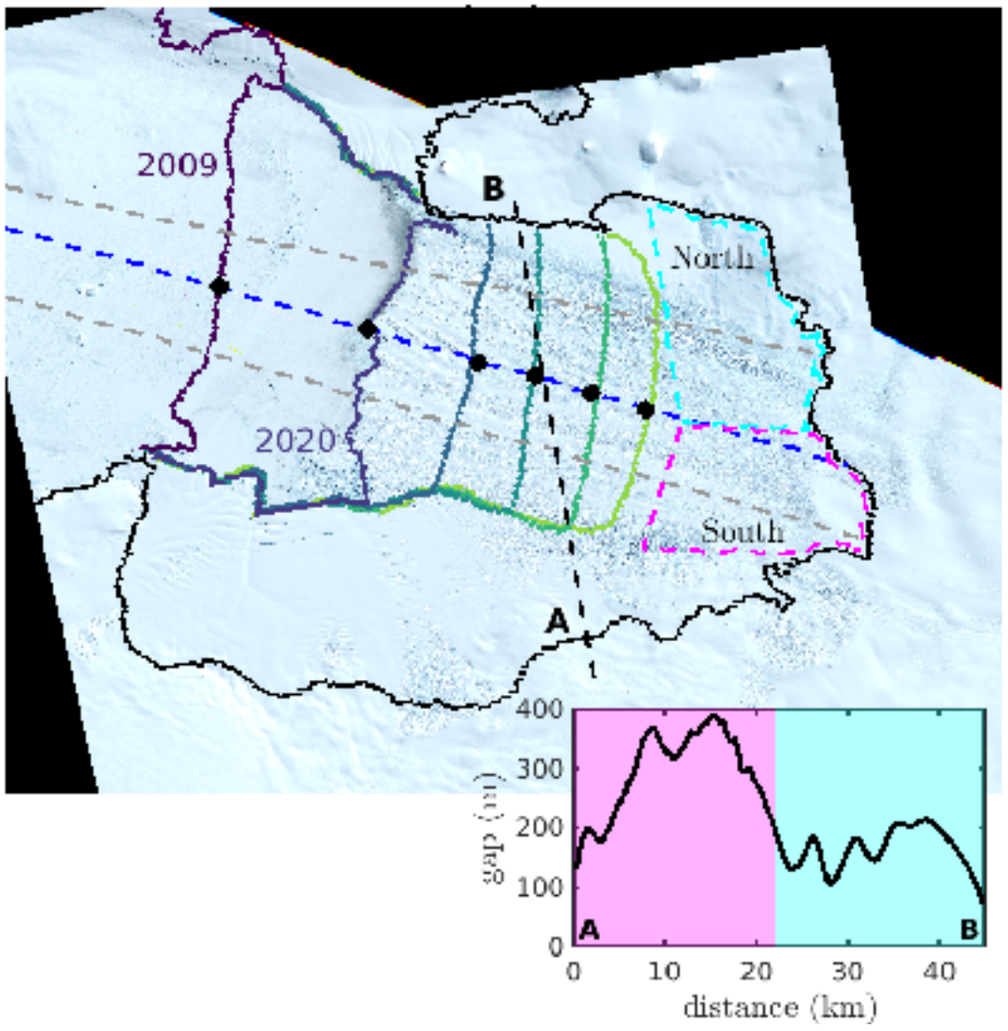


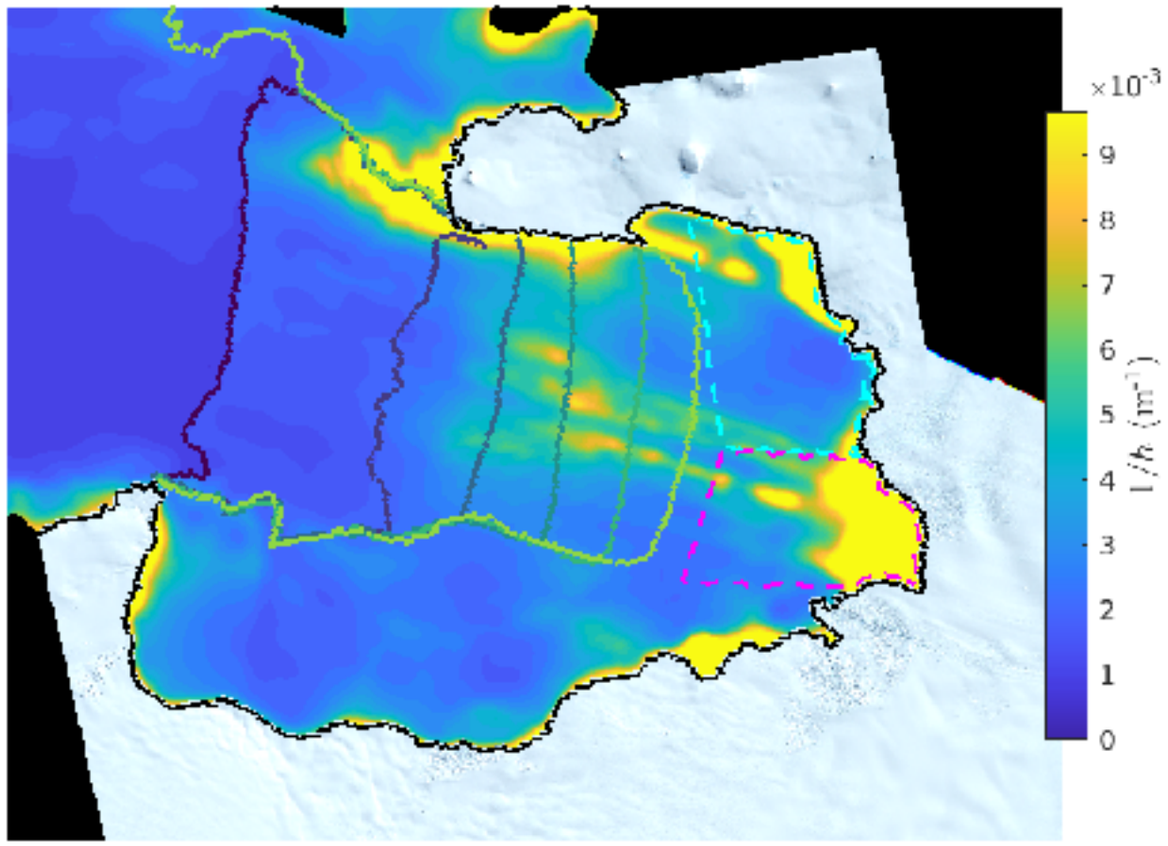
circulation slow down reduces melt rate

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

Numerical simulations in both **realistic** and **idealised** **geometries**

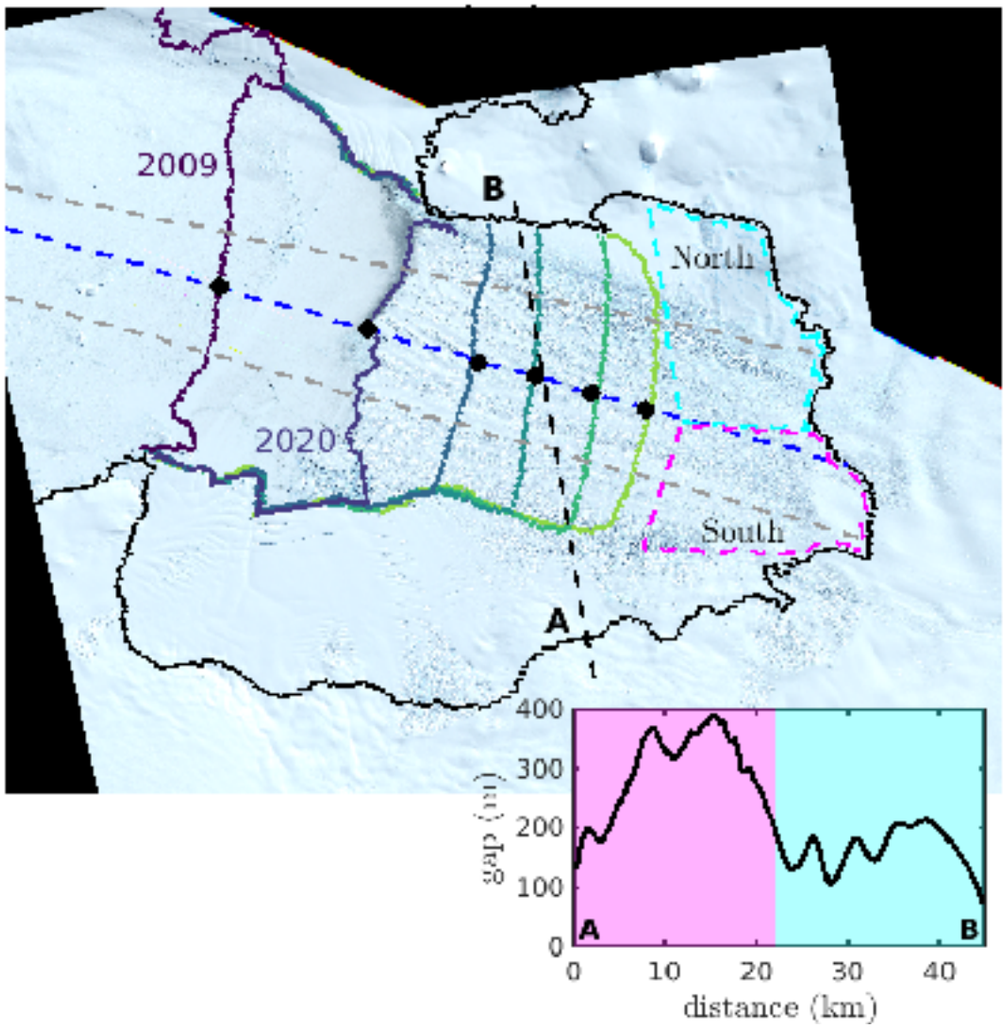


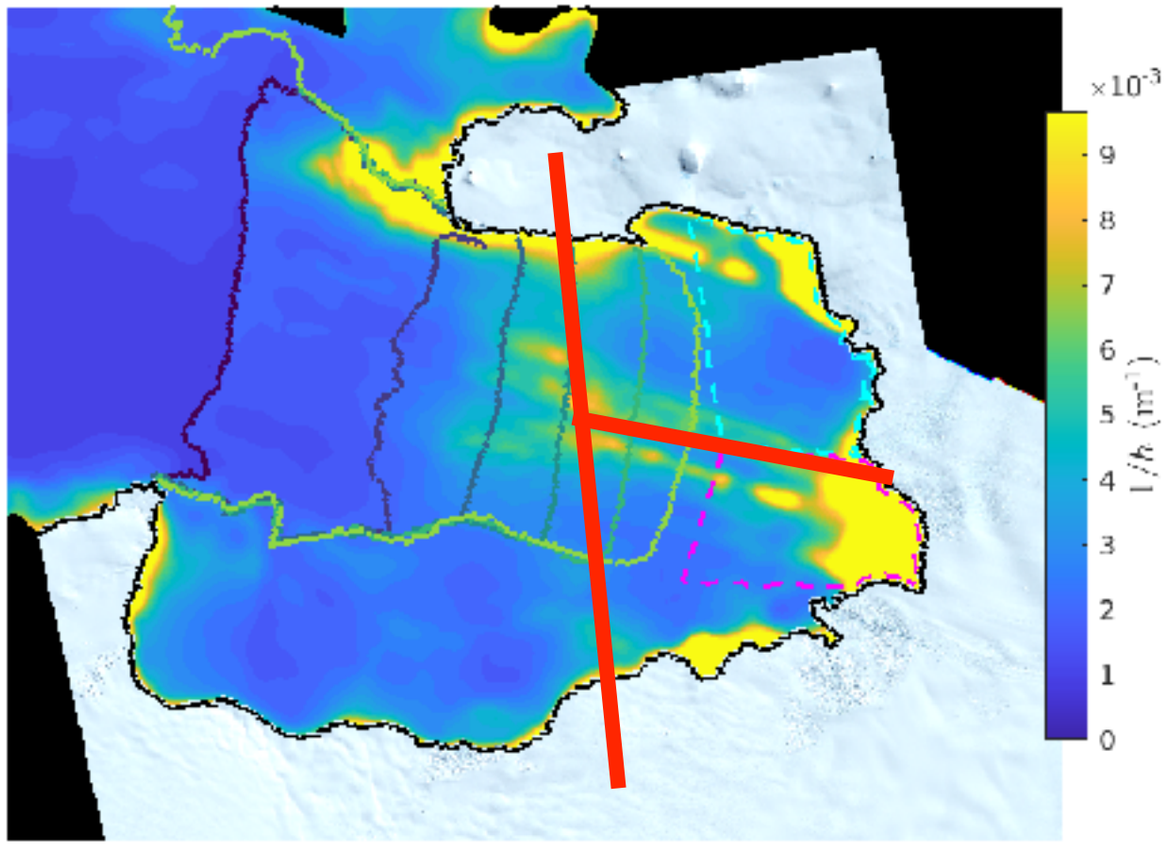


British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

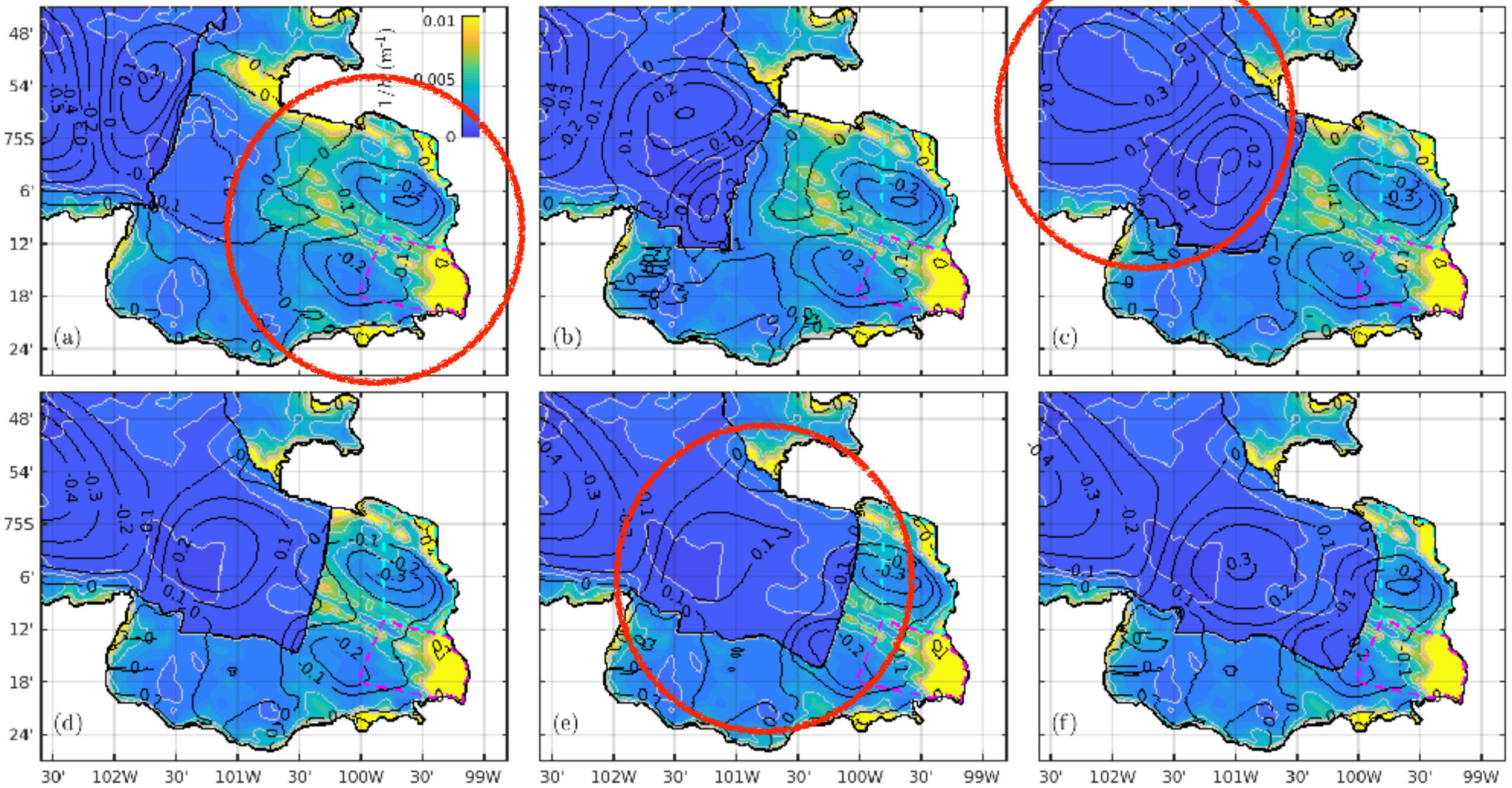
Numerical simulations in both **realistic** and **idealised** **geometries**





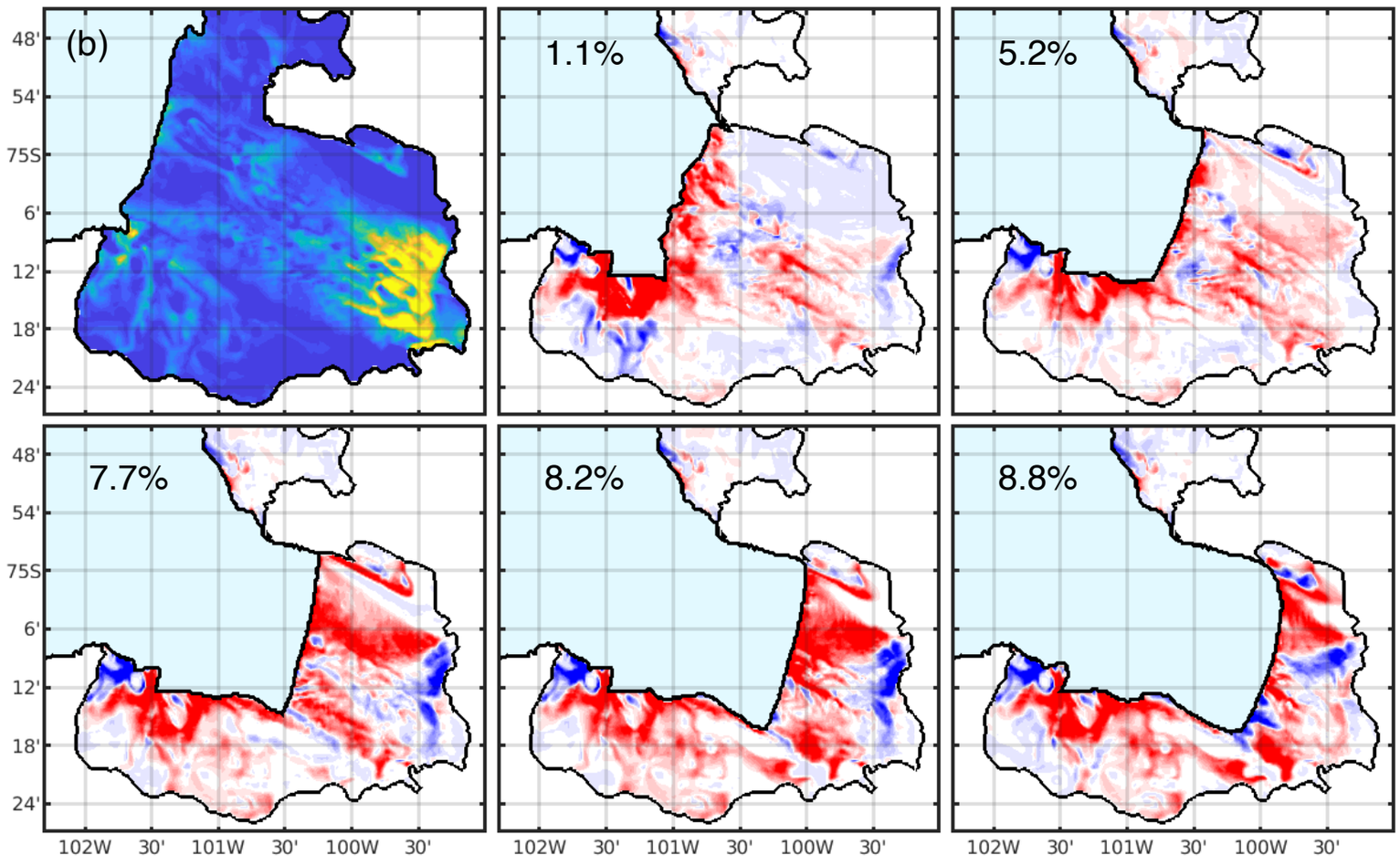
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

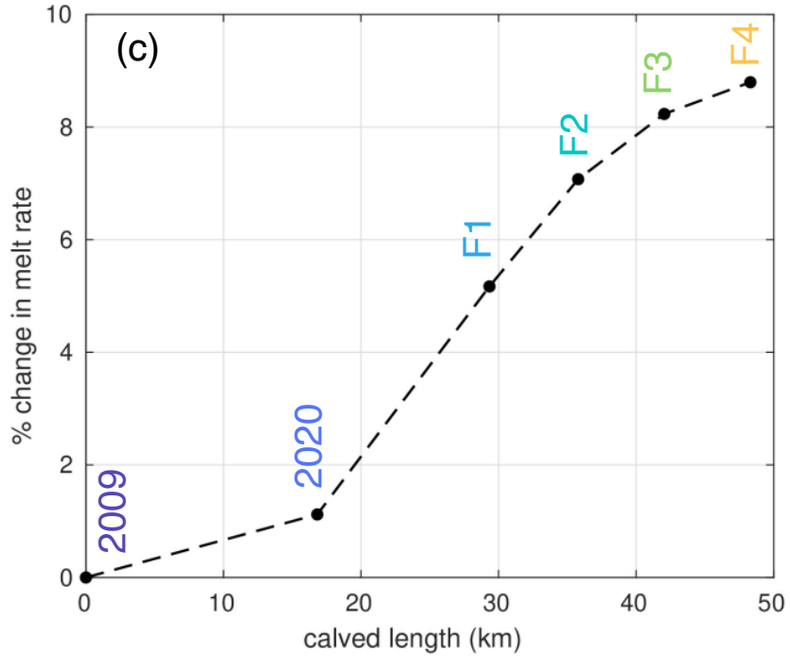
POLAR SCIENCE FOR PLANET EARTH

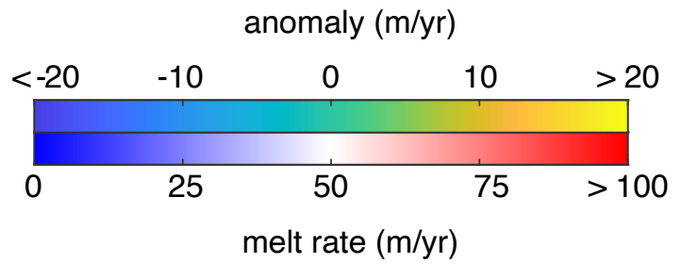


British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH



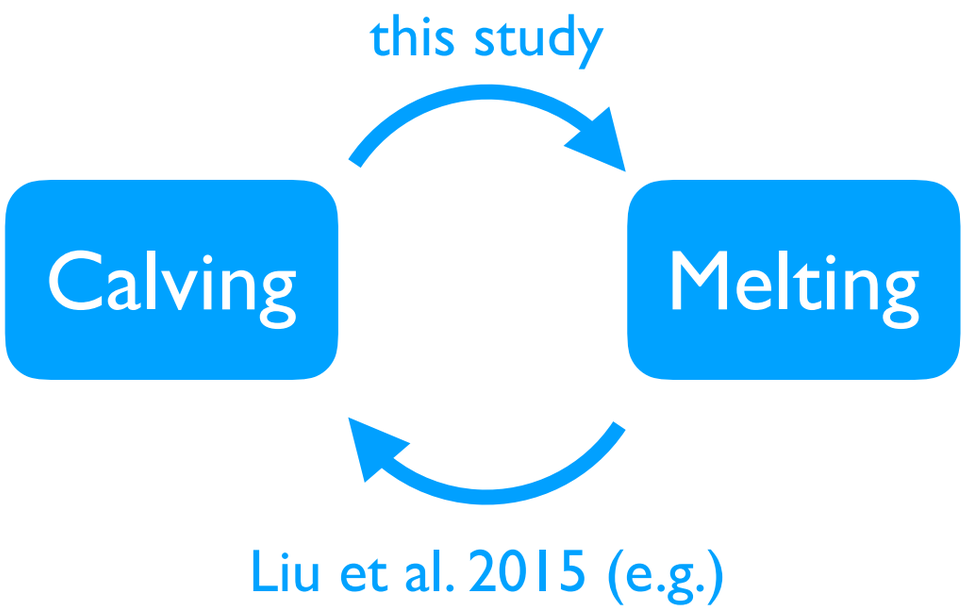


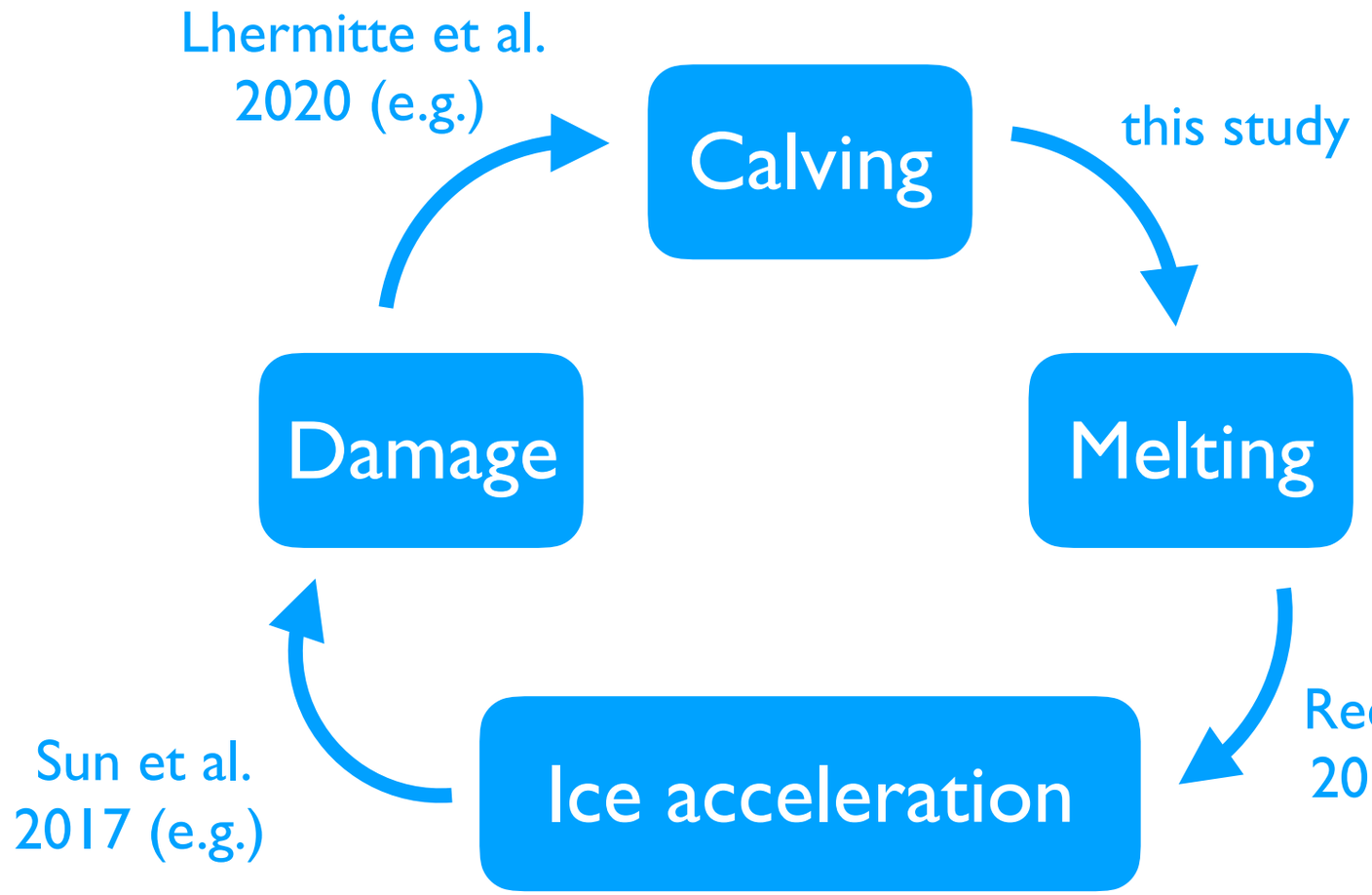


British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

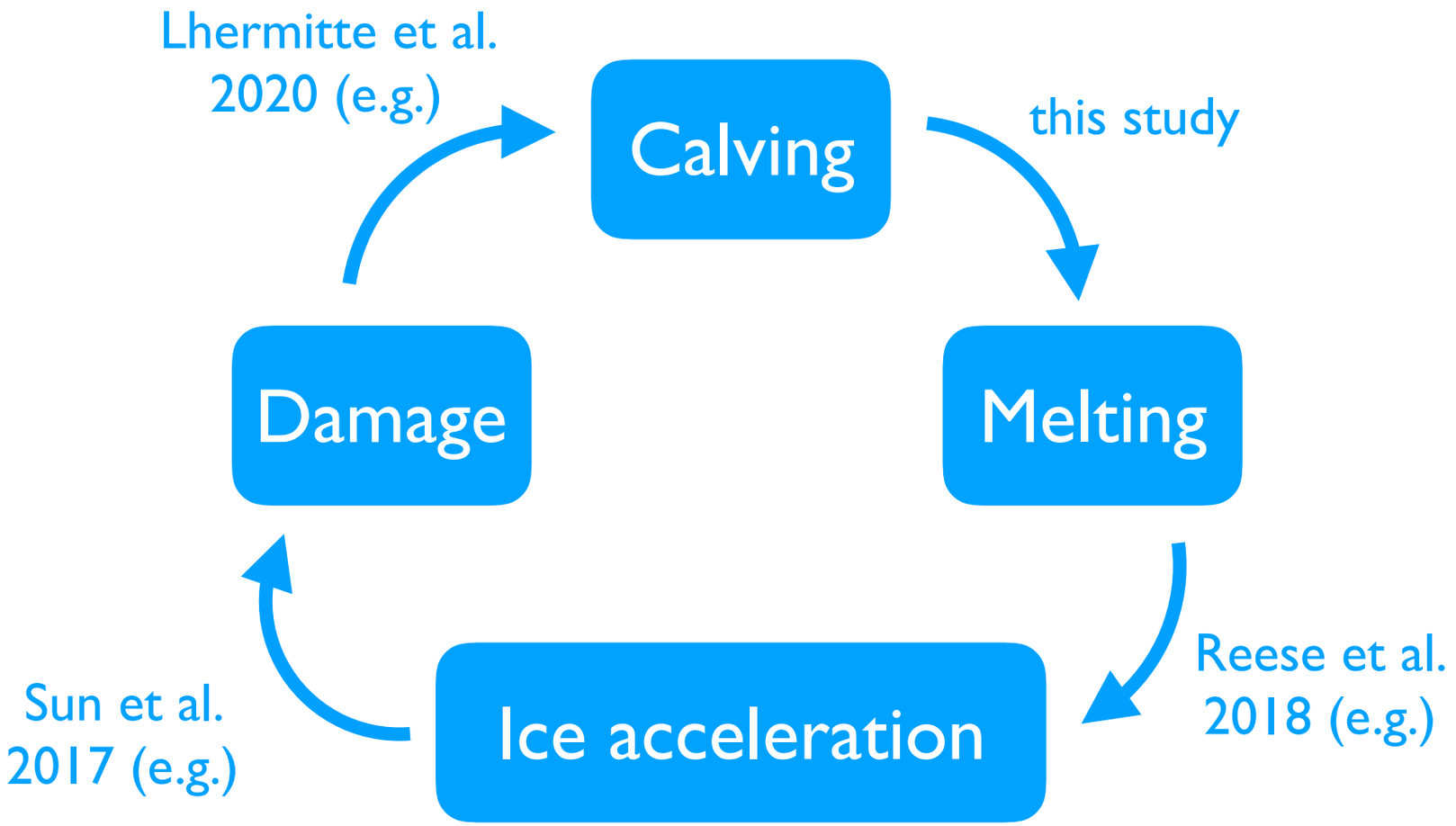
If calving always enhances melting…





British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

A glaciological context to melt perturbations?

$$\frac{\partial h}{\partial t} + \nabla.(h\mathbf{u}) = \dot{m} + \dot{a}$$

thickness changes

ice divergence

melting

accumulation

A glaciological context to melt perturbations?

ice divergence

accumulation

$$\frac{\partial h}{\partial t} + \nabla.(h\mathbf{u}) = \dot{m} + \dot{a}$$

thickness changes

melting

$$\dot{m} - \nabla.(h\mathbf{u}) < 0$$ thinning

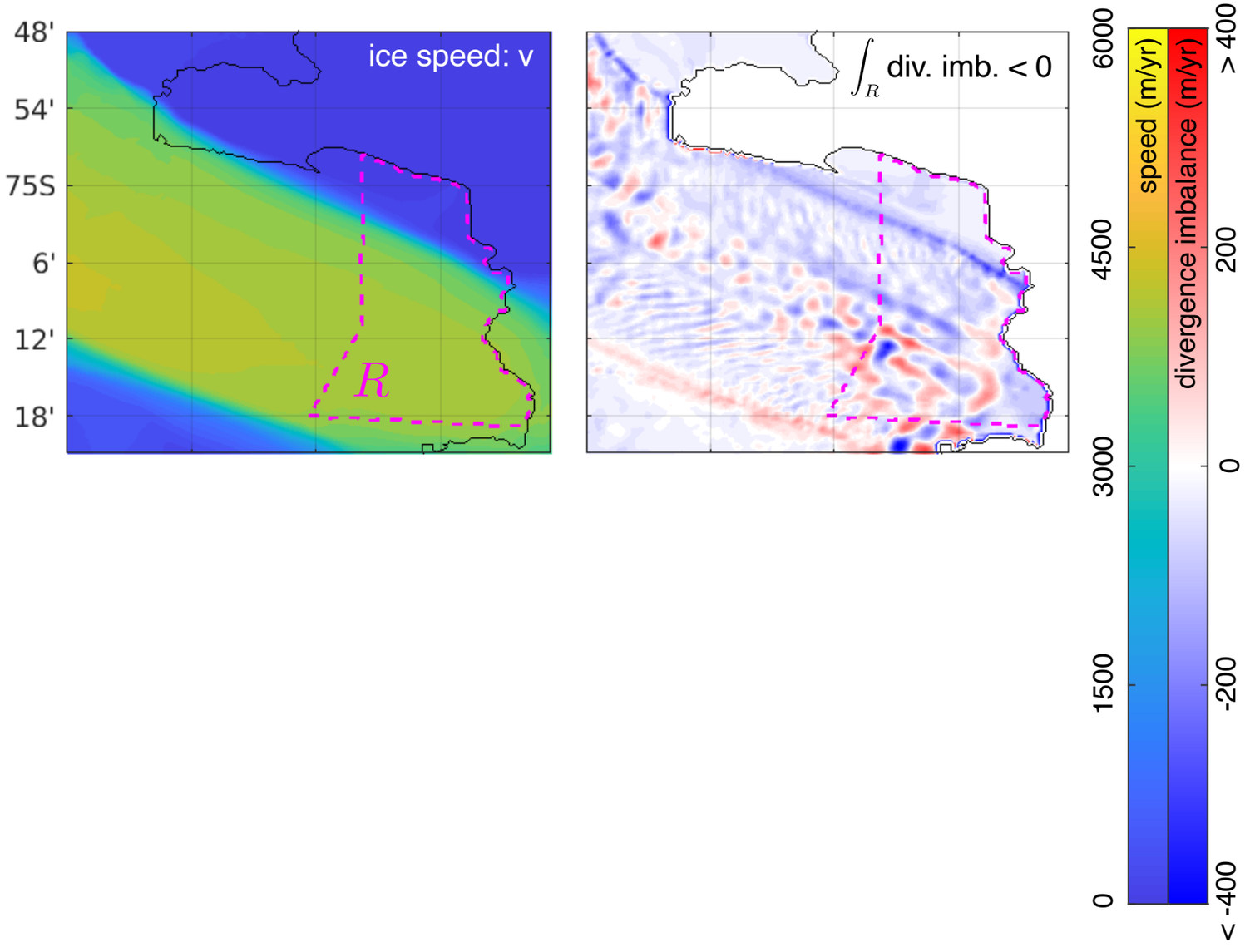
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

A glaciological context to melt perturbations?

$$\dot{m} - \nabla.(h\mathbf{u}) < 0$$ thinning

observed ice velocity



British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

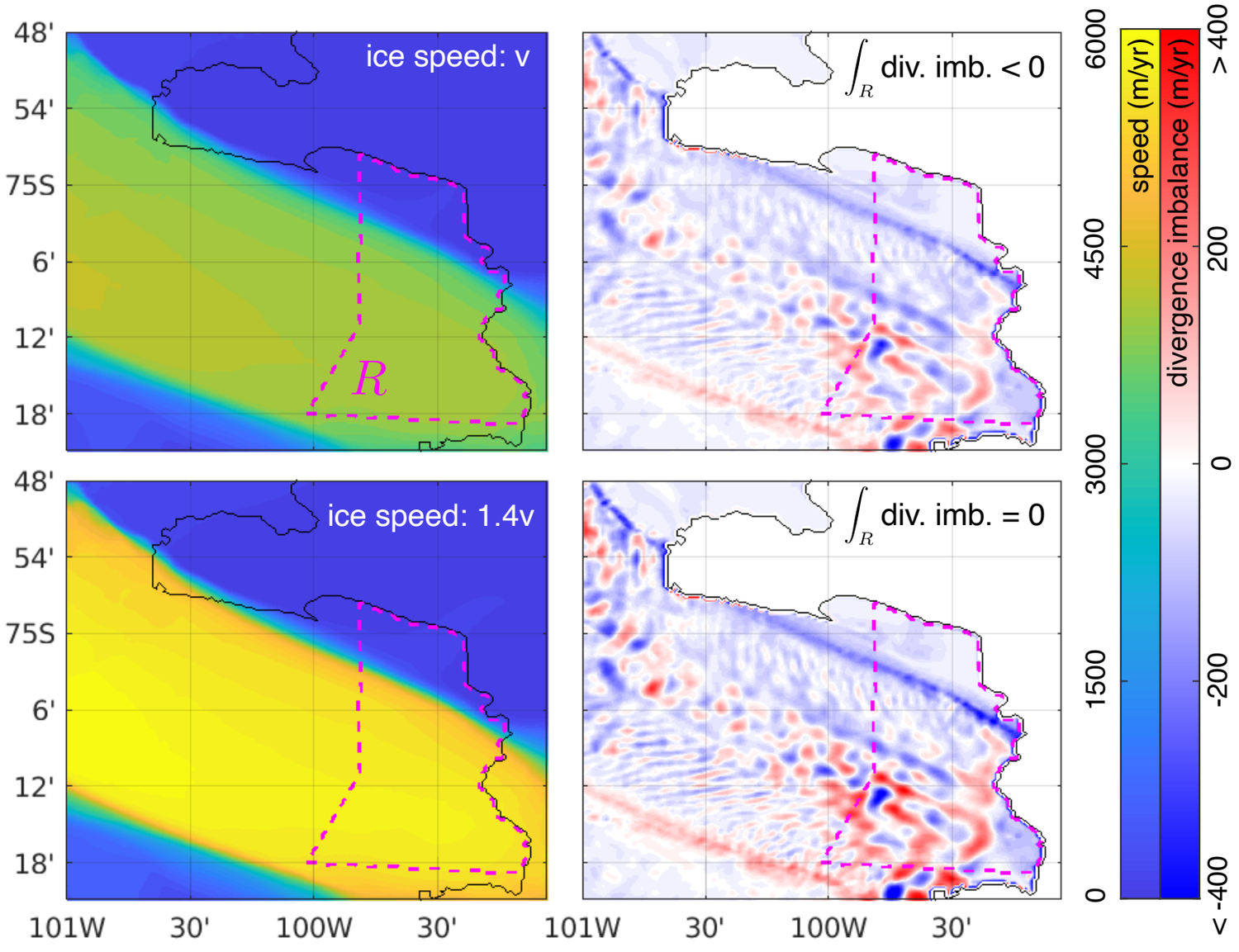
POLAR SCIENCE FOR PLANET EARTH

A glaciological context to melt perturbations?

$$\dot{m} - \nabla.(h\mathbf{u}) < 0$$ thinning

observed ice velocity

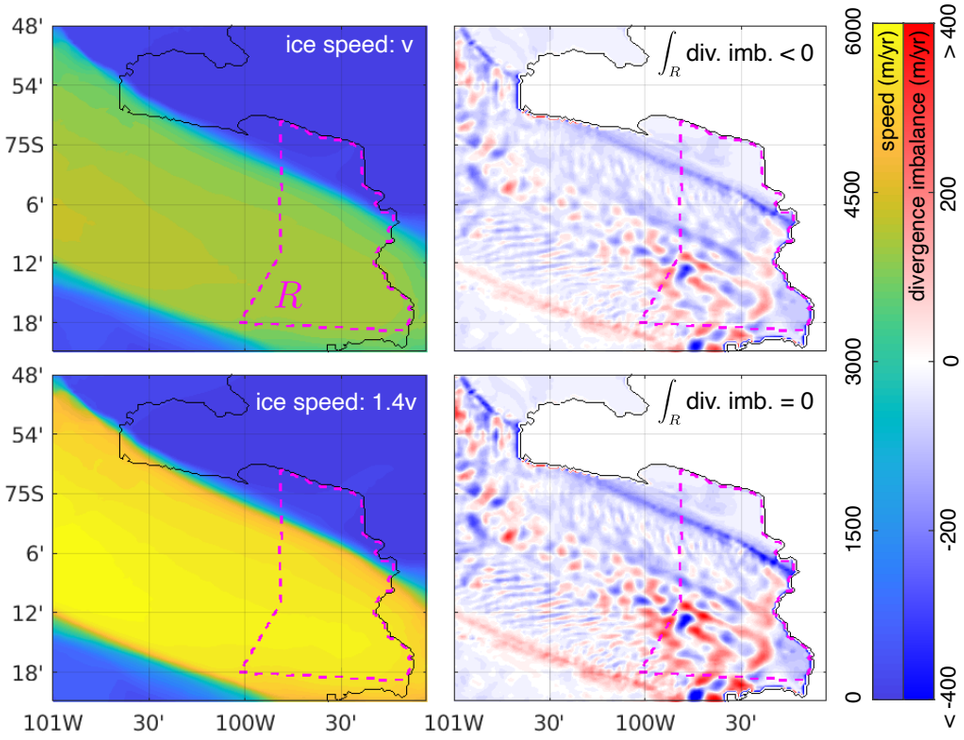
observed ice velocity
scaled 1.4x

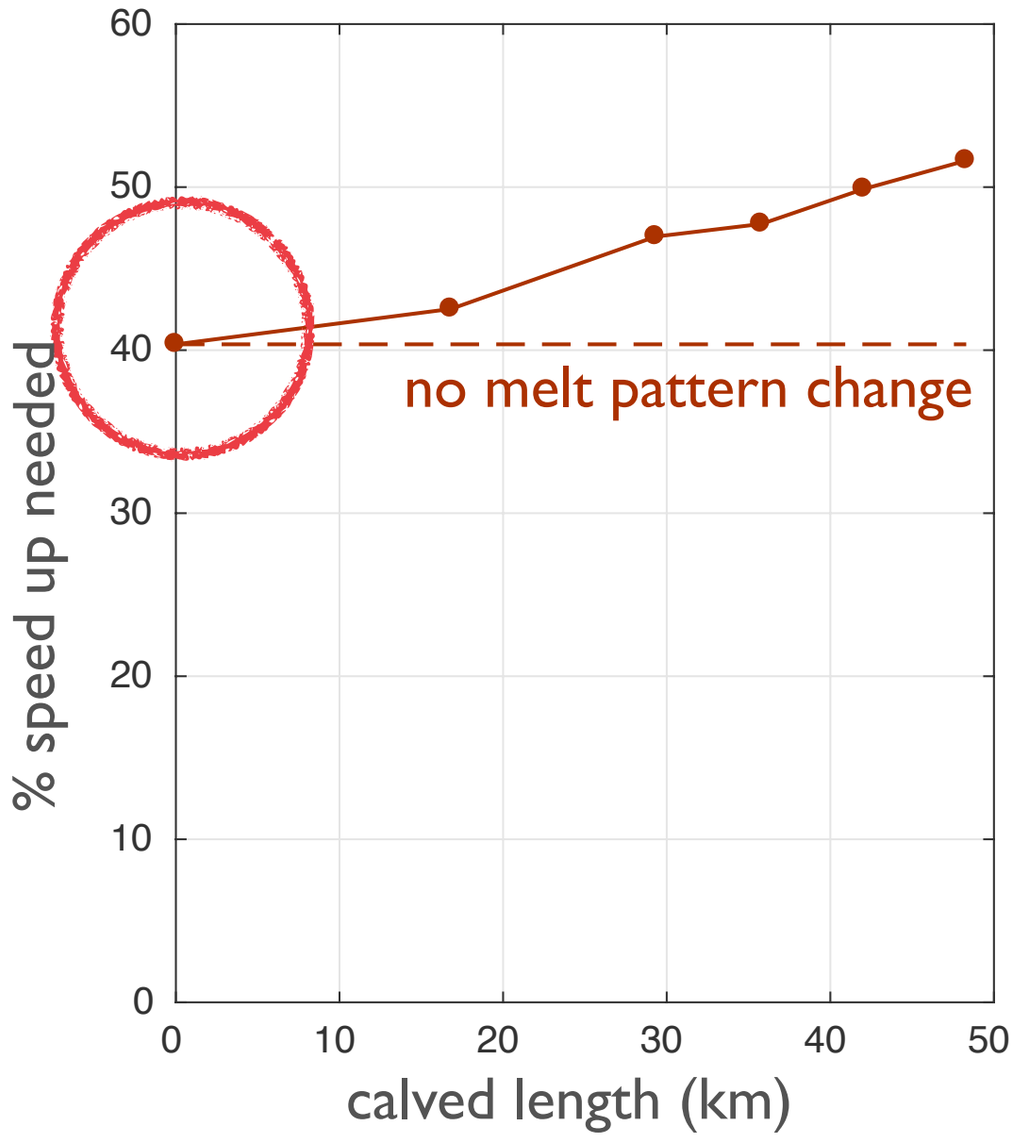


British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

A glaciological context to melt perturbations?

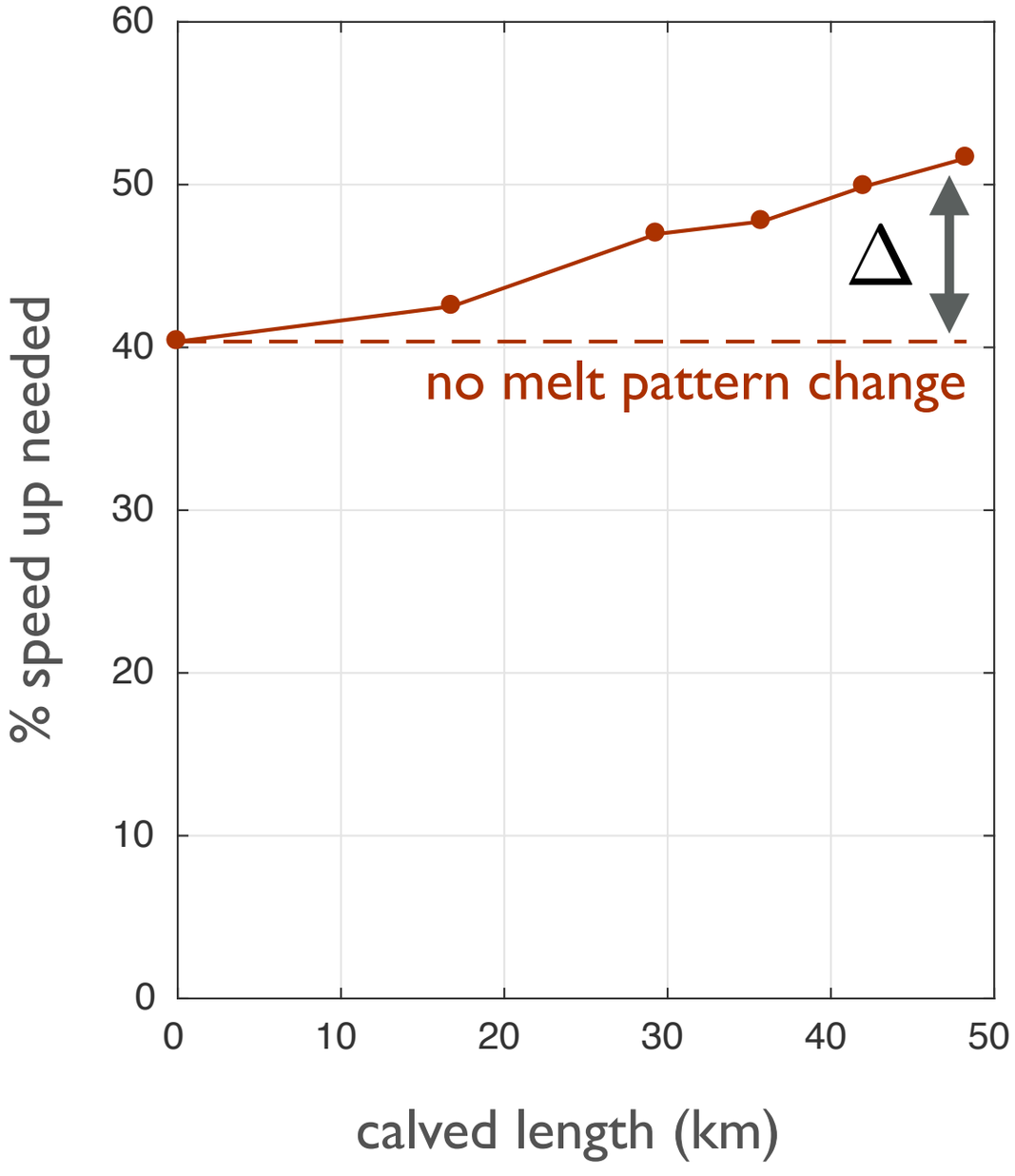


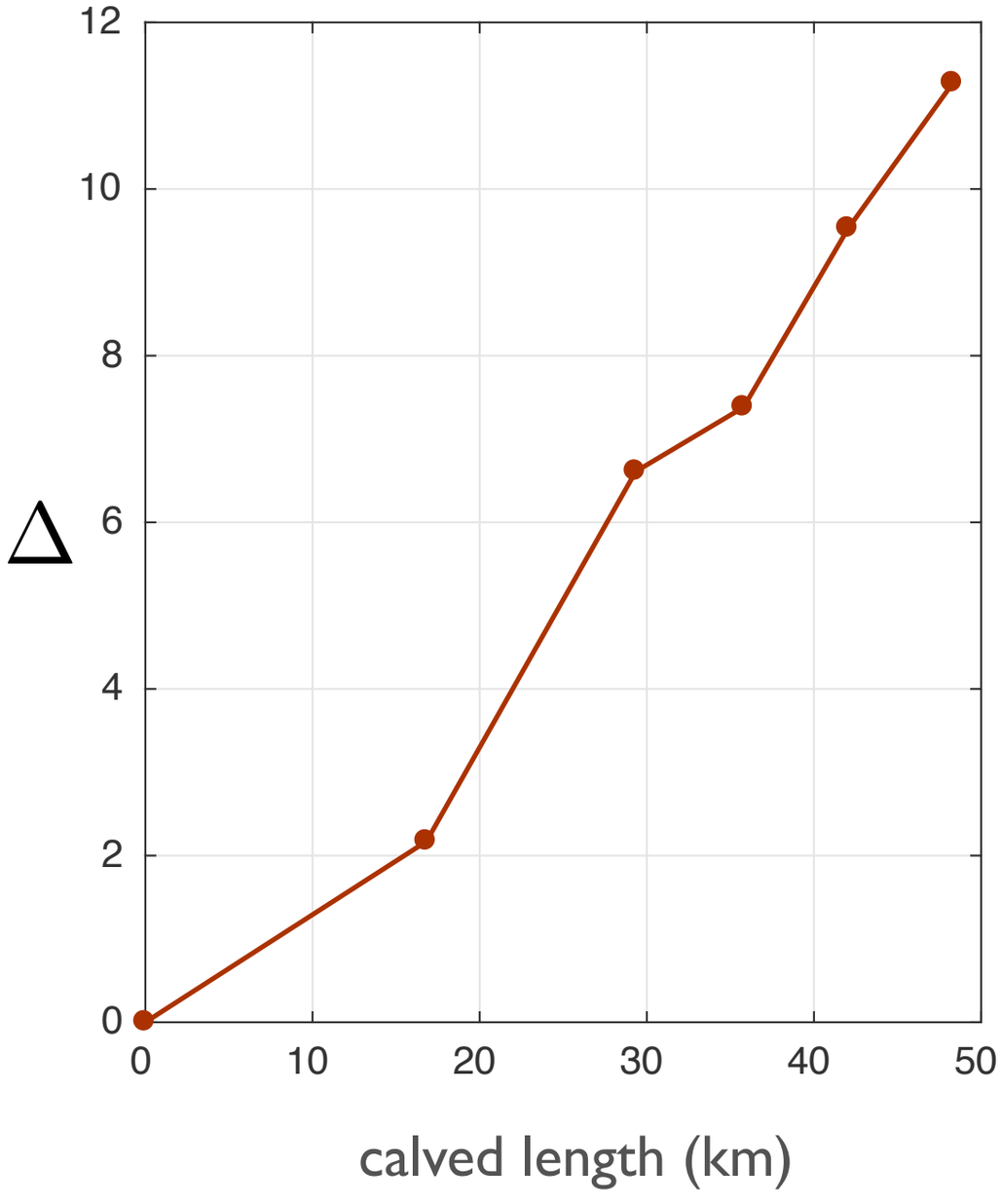


British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

A glaciological context to melt perturbations?

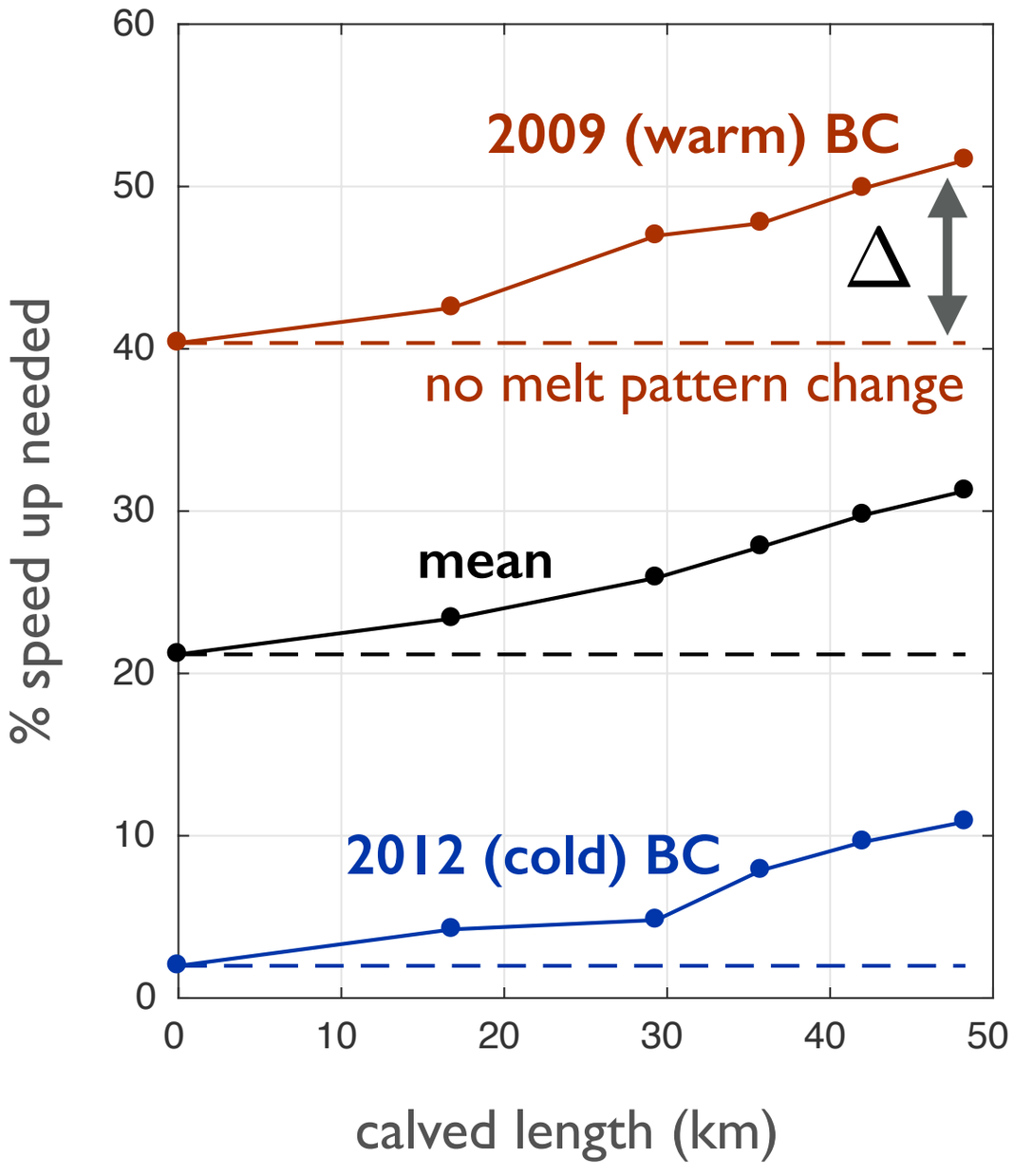


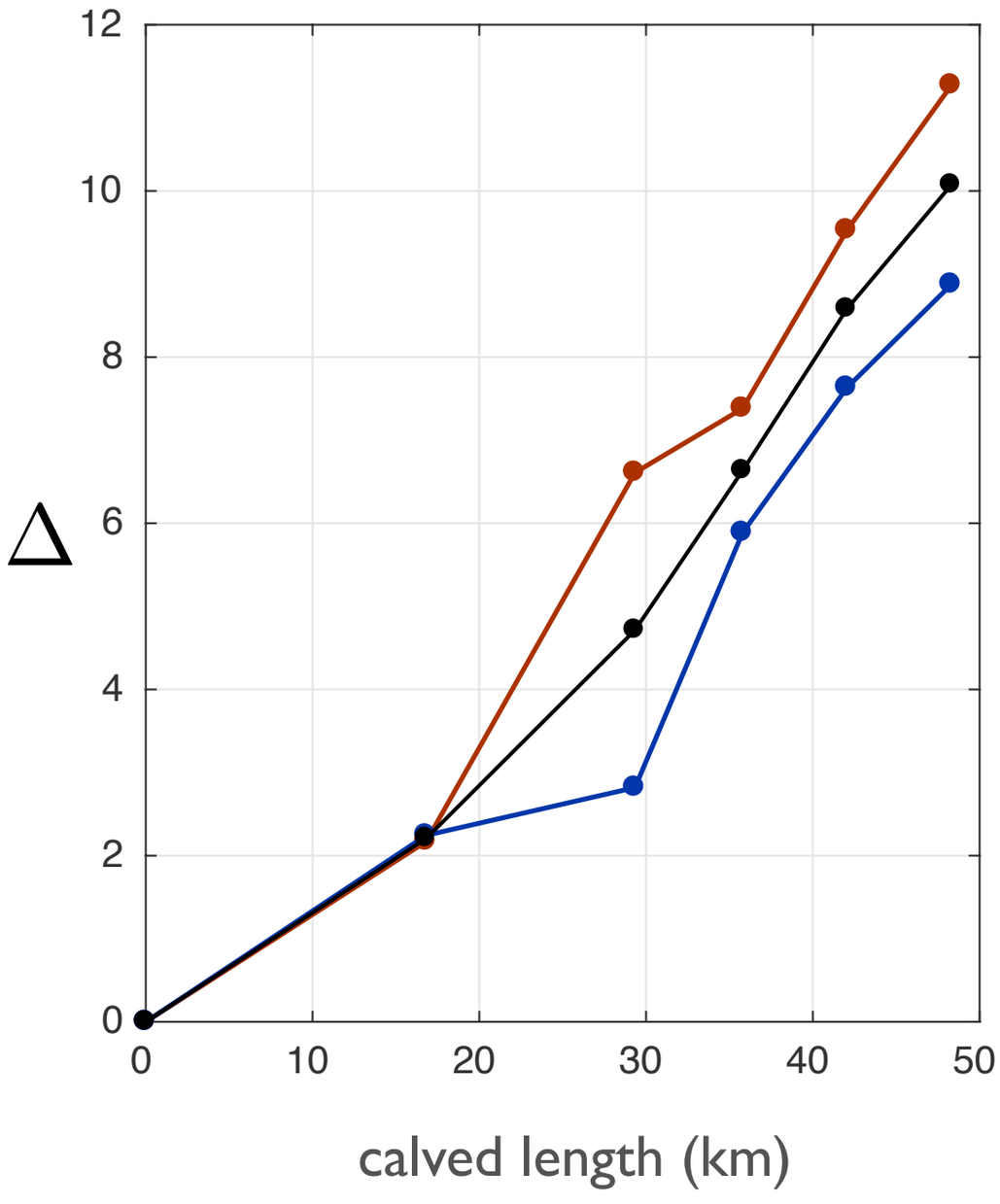


British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

A glaciological context to melt perturbations?





British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

POLAR SCIENCE FOR PLANET EARTH

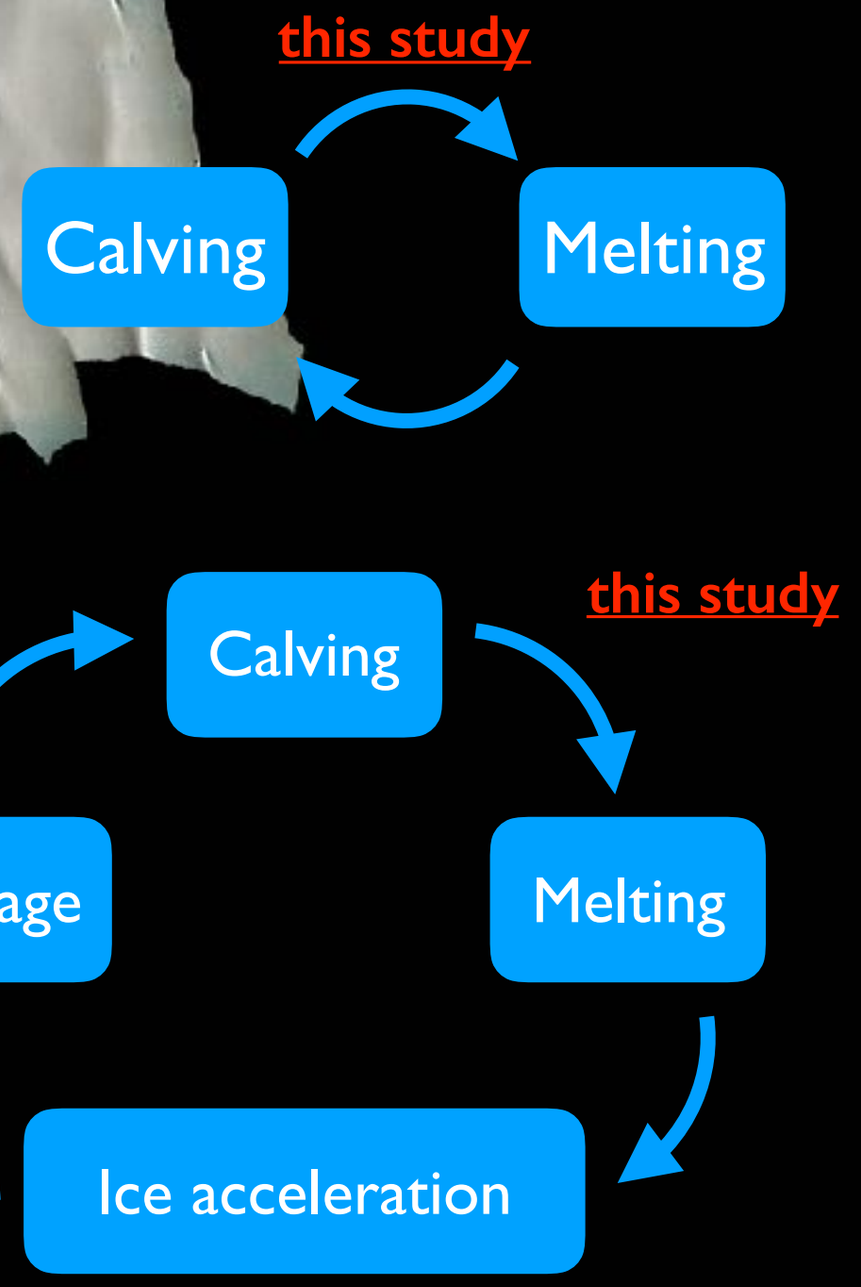
British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

UNIVERSITY OF CAMBRIDGE

Northumbria University NEWCASTLE

Alex Bradley, David Bett, Pierre Dutrieux, Jan De Rydt, Paul Holland

New JGR paper



aleey@bas.ac.uk @abraleey