Glacier melt and sea-level rise from the European perspective

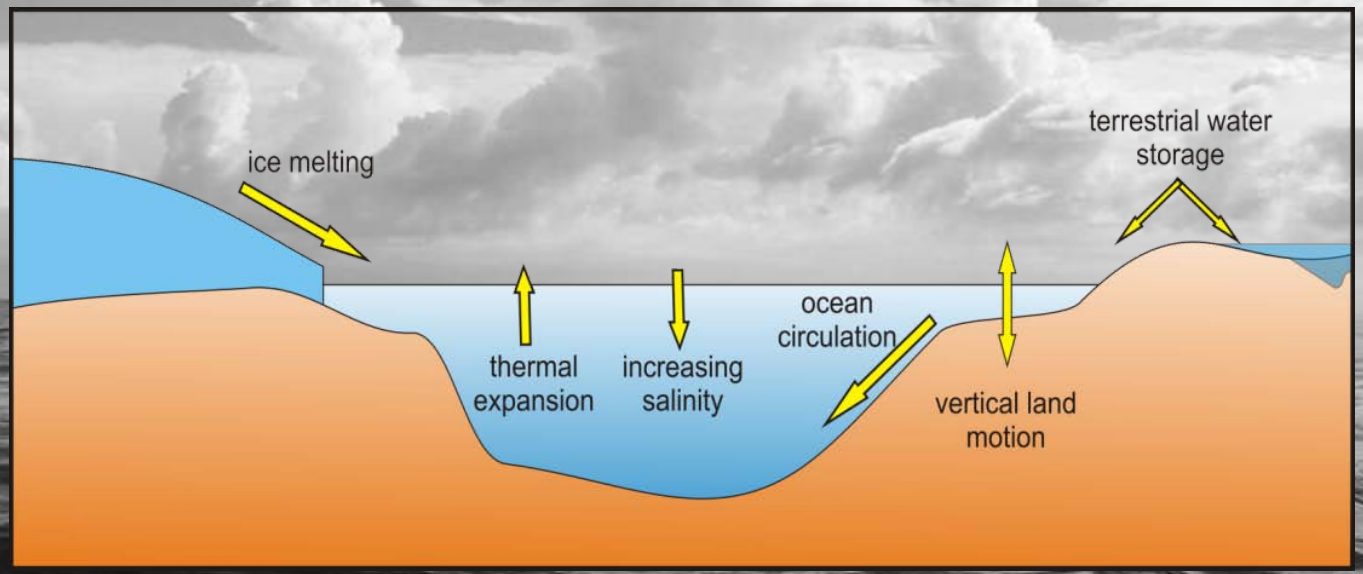
David Vaughan for ice2sea

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

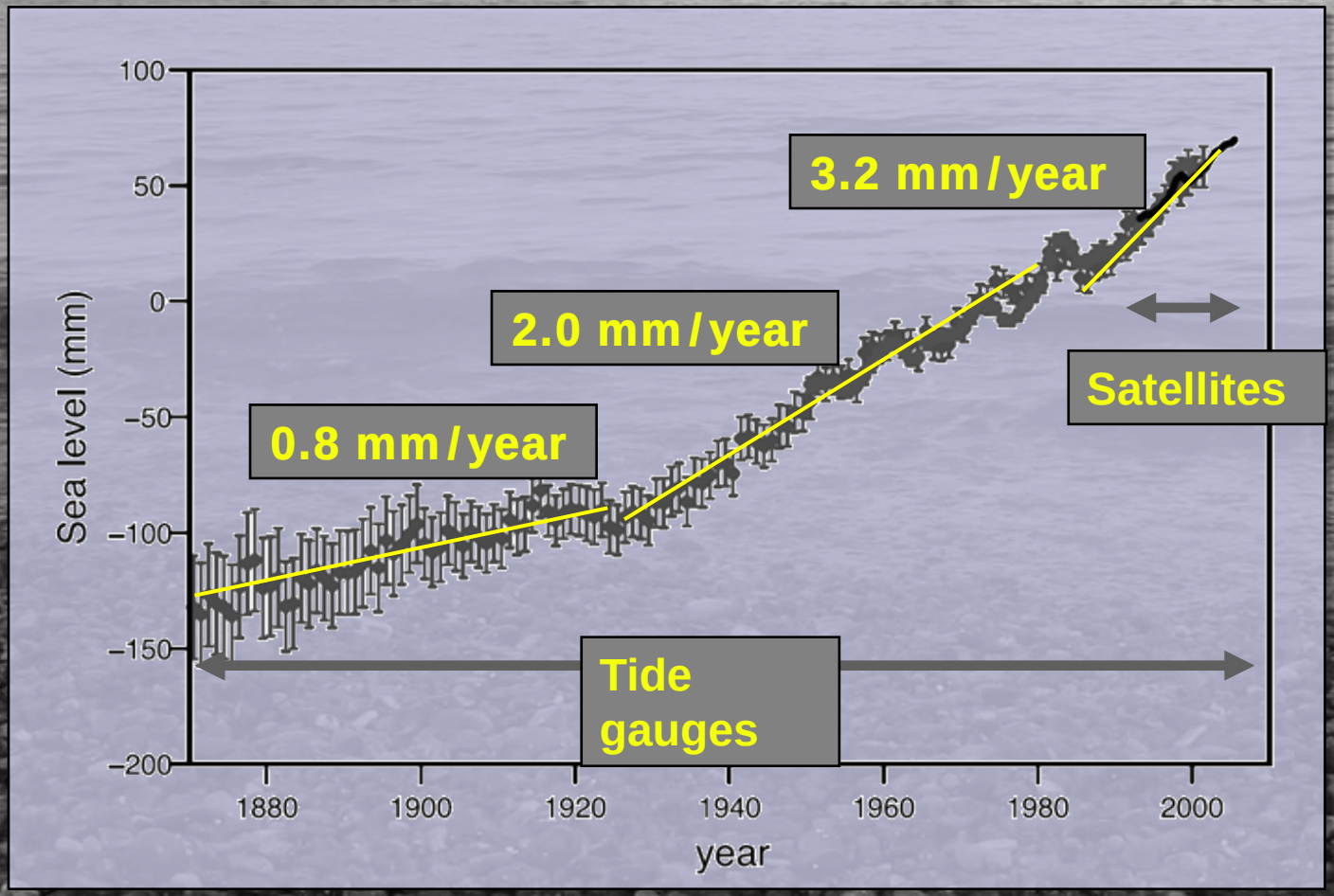
SEVENTH FRAMEWORK PROGRAMME


Background on sea-level rise

Contributions to sea-level change

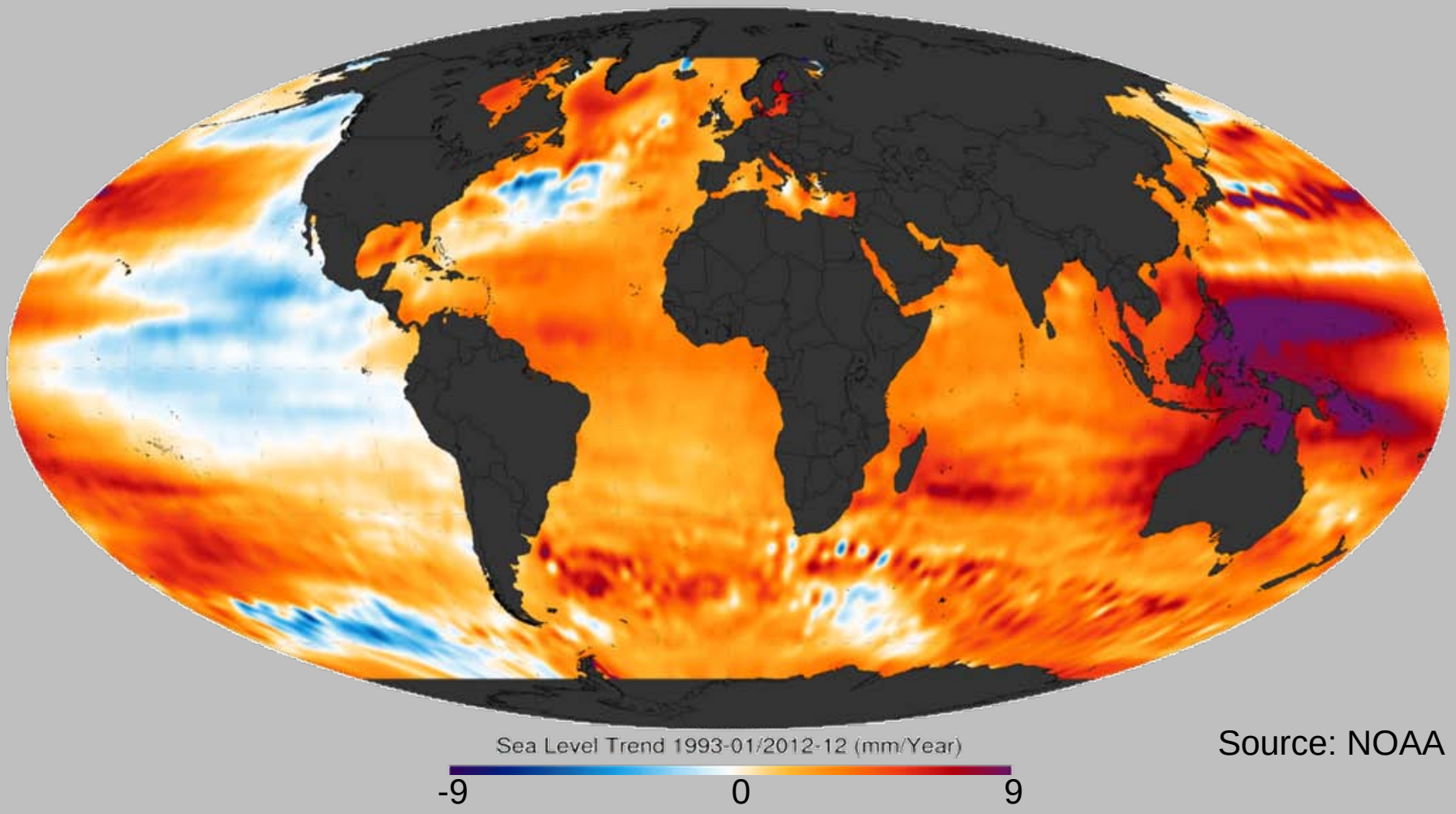


Recent observed global sea-level rise



Source – Steve Nerem

Regional sea-level rise 1993-2012



Source: NOAA

Impacts of sea-level rise

Unique coastal landscapes

e.g. Sand dunes in Solwinski National Park – Poland

Photo: QRT300

Unique coastal ecology

e.g. “Machair” environments in Ireland and Scotland

Photo: Alison Cook

Coastal investment

e.g. Sizewell B Nuclear Power Station (England)

Photo: William Connolley

Major coastal cities

e.g. Rotterdam

Photo: GoogleEarth

Major coastal cities

e.g. London

Photo: UK Environment Agency

Development of flood defences in London

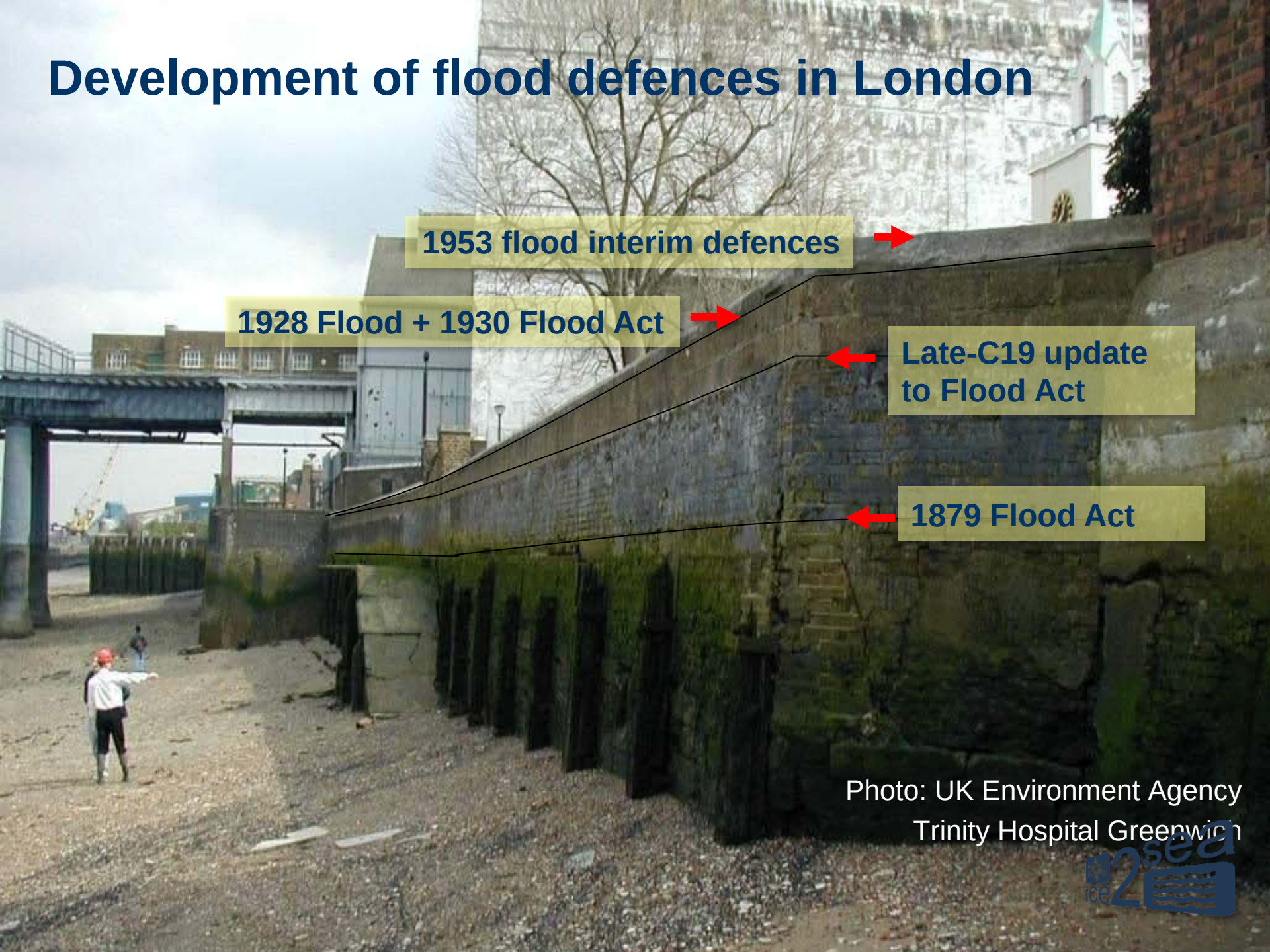


Photo: UK Environment Agency
Trinity Hospital Greenwich

100th closure of the Thames Barrier

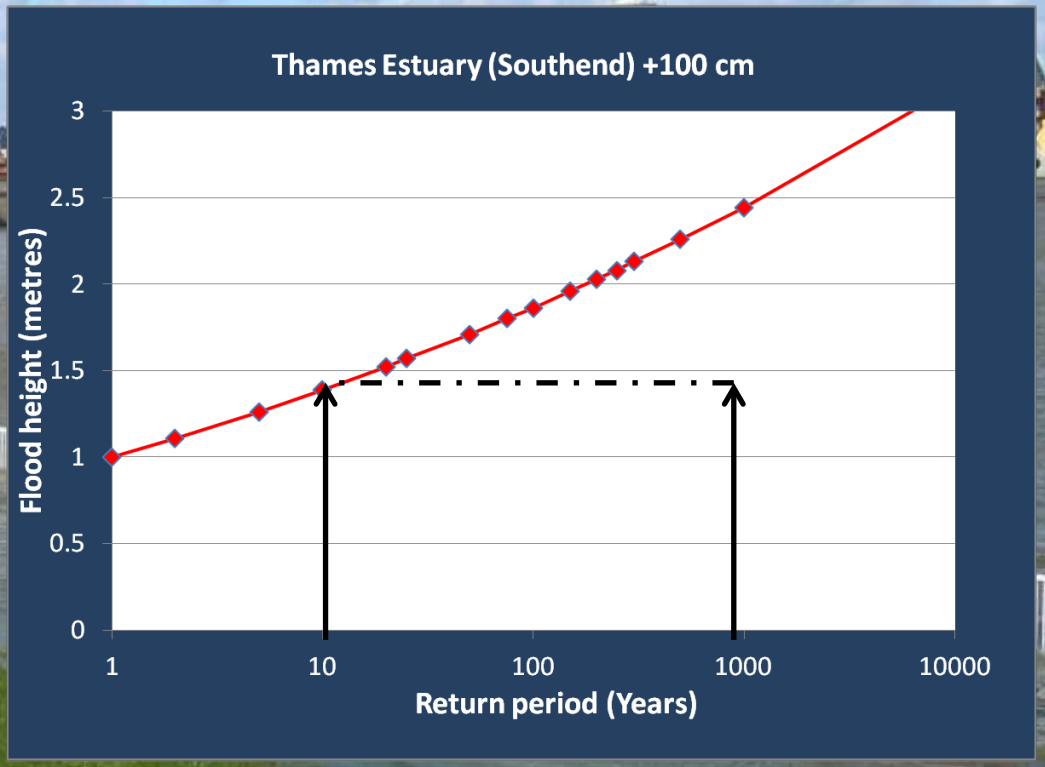


Photo: UK Environment Agency

Isle of Harris (Scotland)

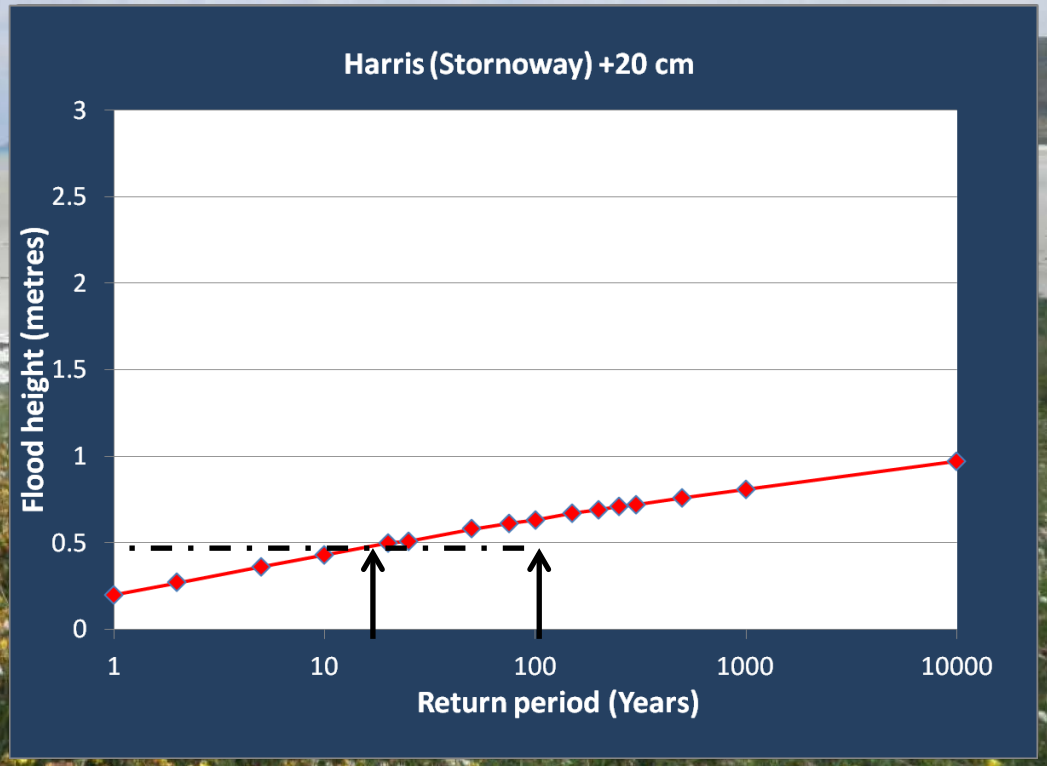
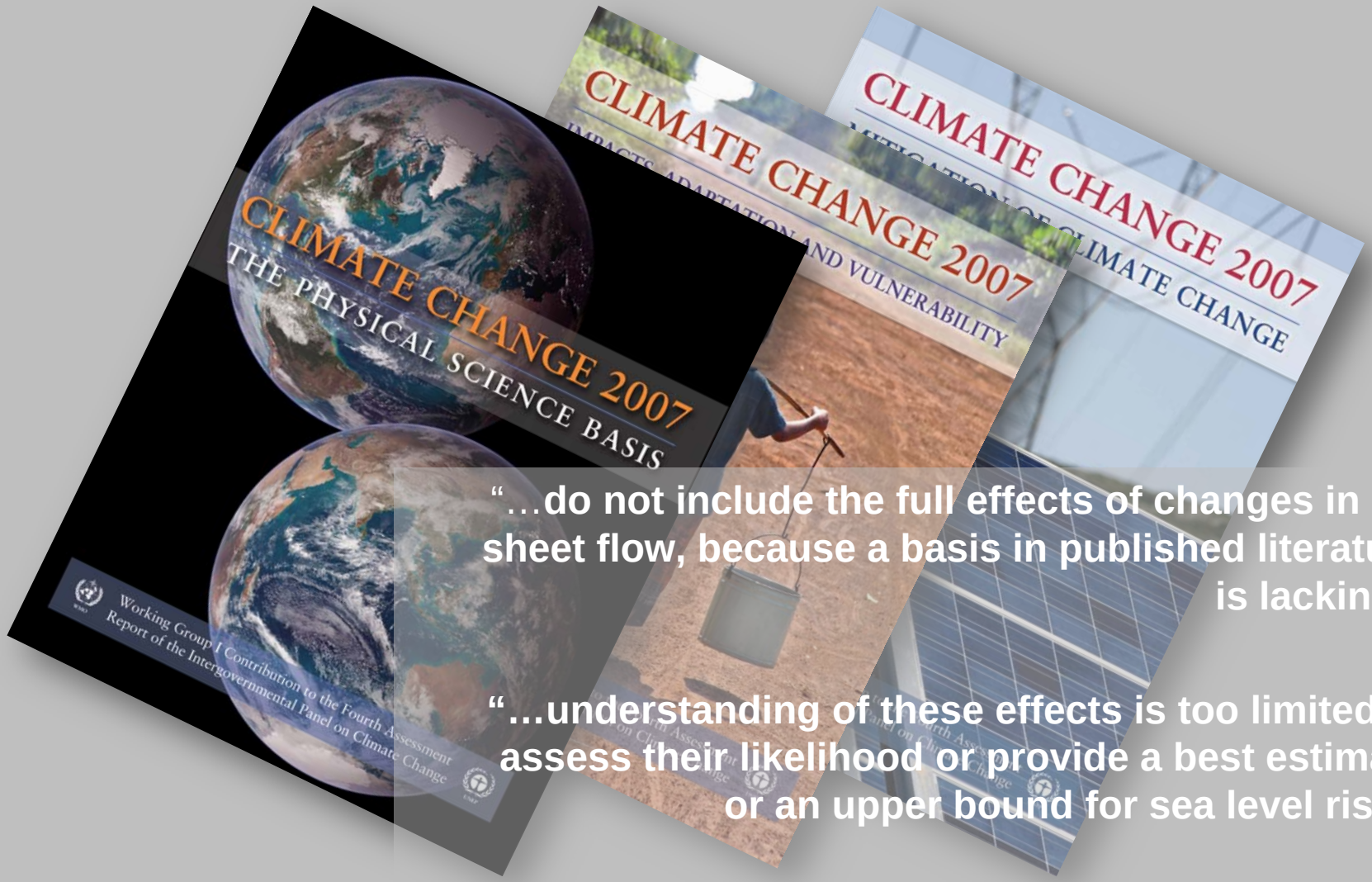


Photo: Alison Cook

Status of projections

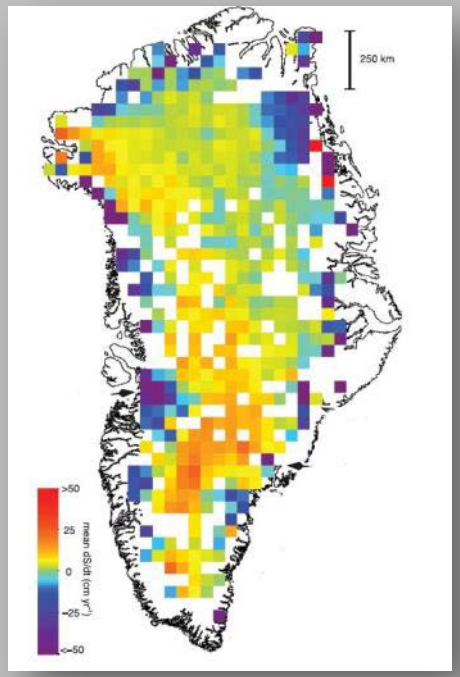
IPCC AR4 (2007) on sea-level rise



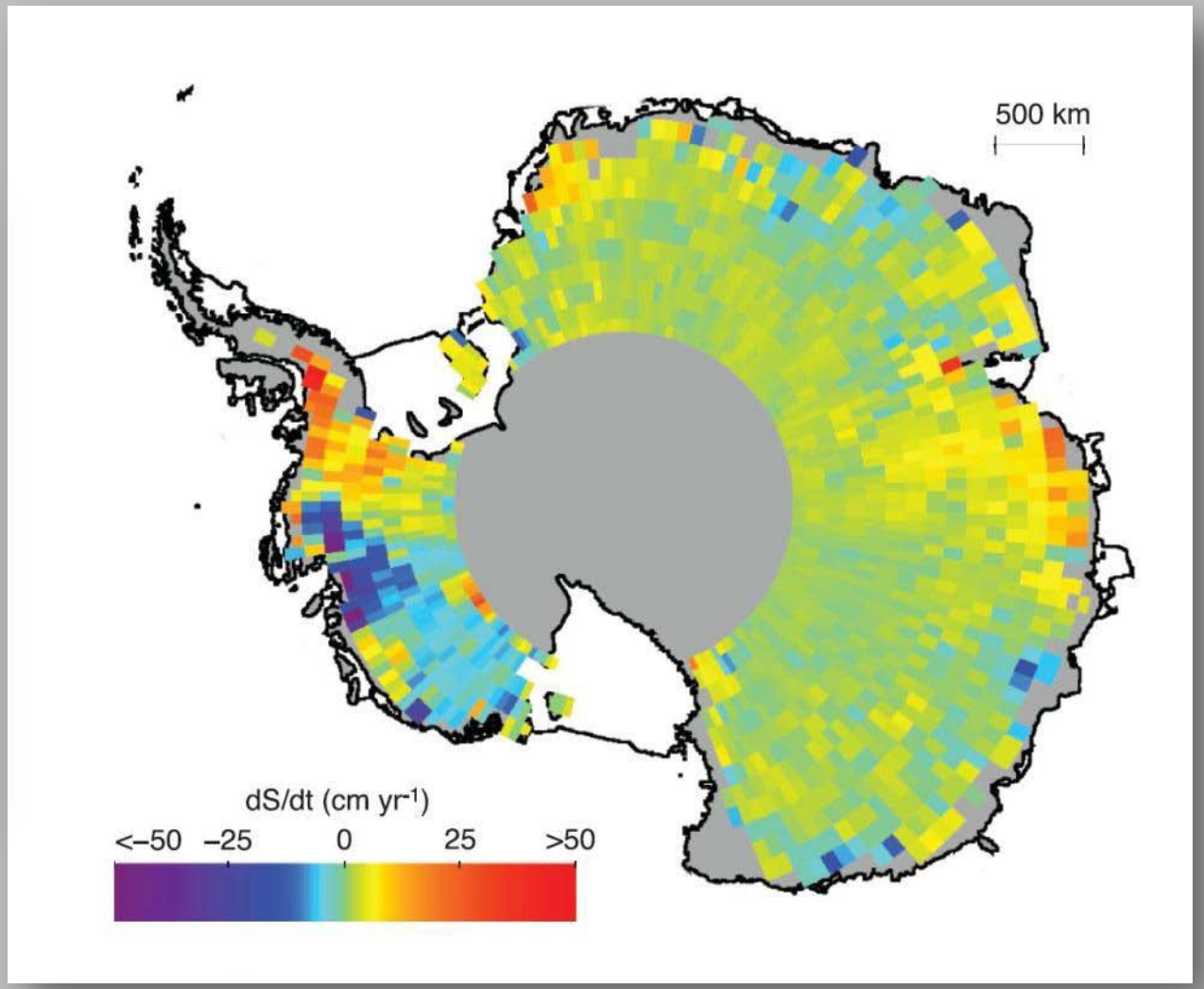
"…do not include the full effects of changes in ice sheet flow, because a basis in published literature is lacking".

"…understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise."

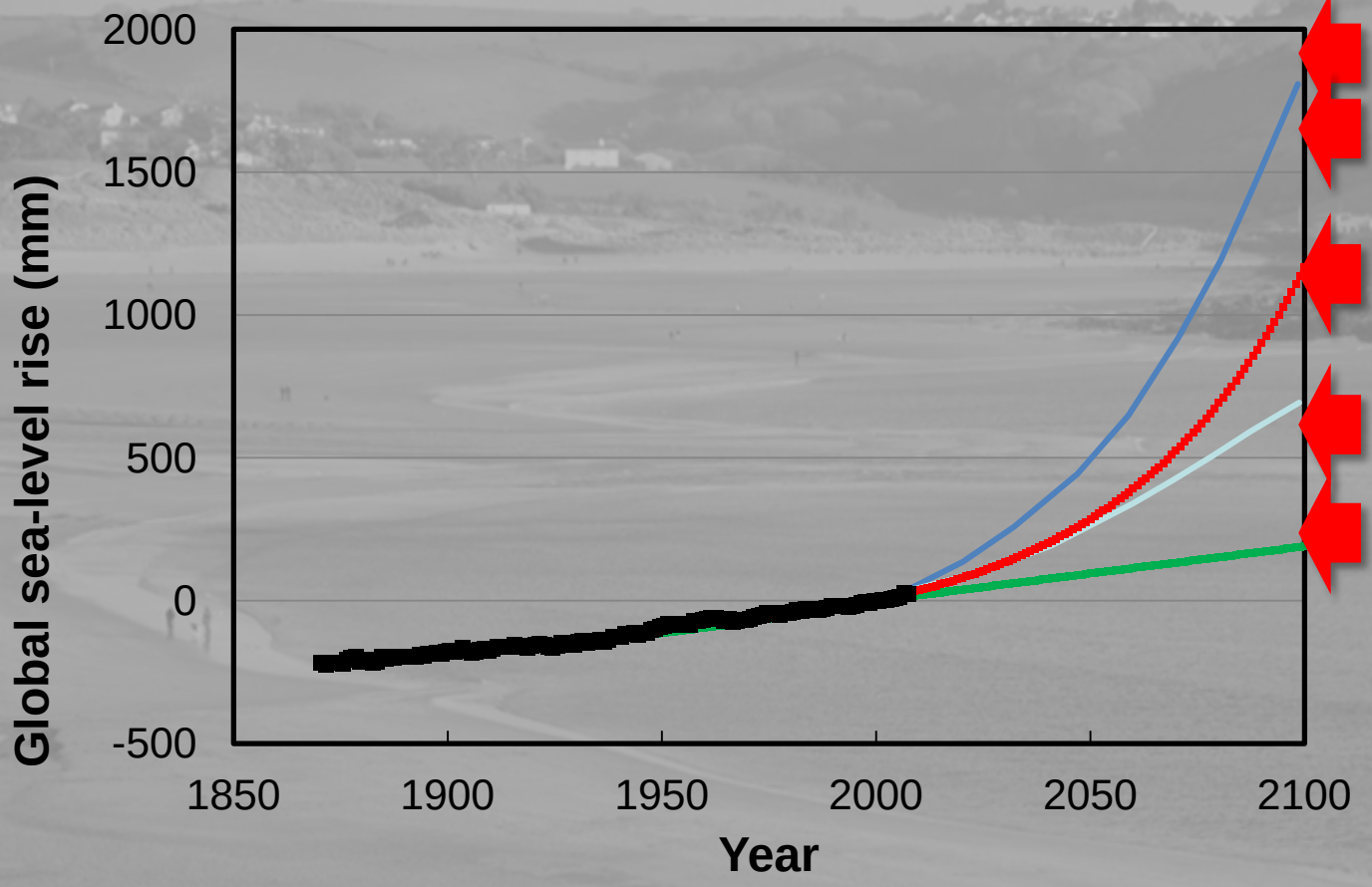
IPCC (2007) on sea-level rise



IPCC AR4 (2007)



Sea-level projections post-AR4 (2007)



Pfeffer "plausible limit"

Vermeer and Rahmsdorf, 2009 – Semi-Empirical

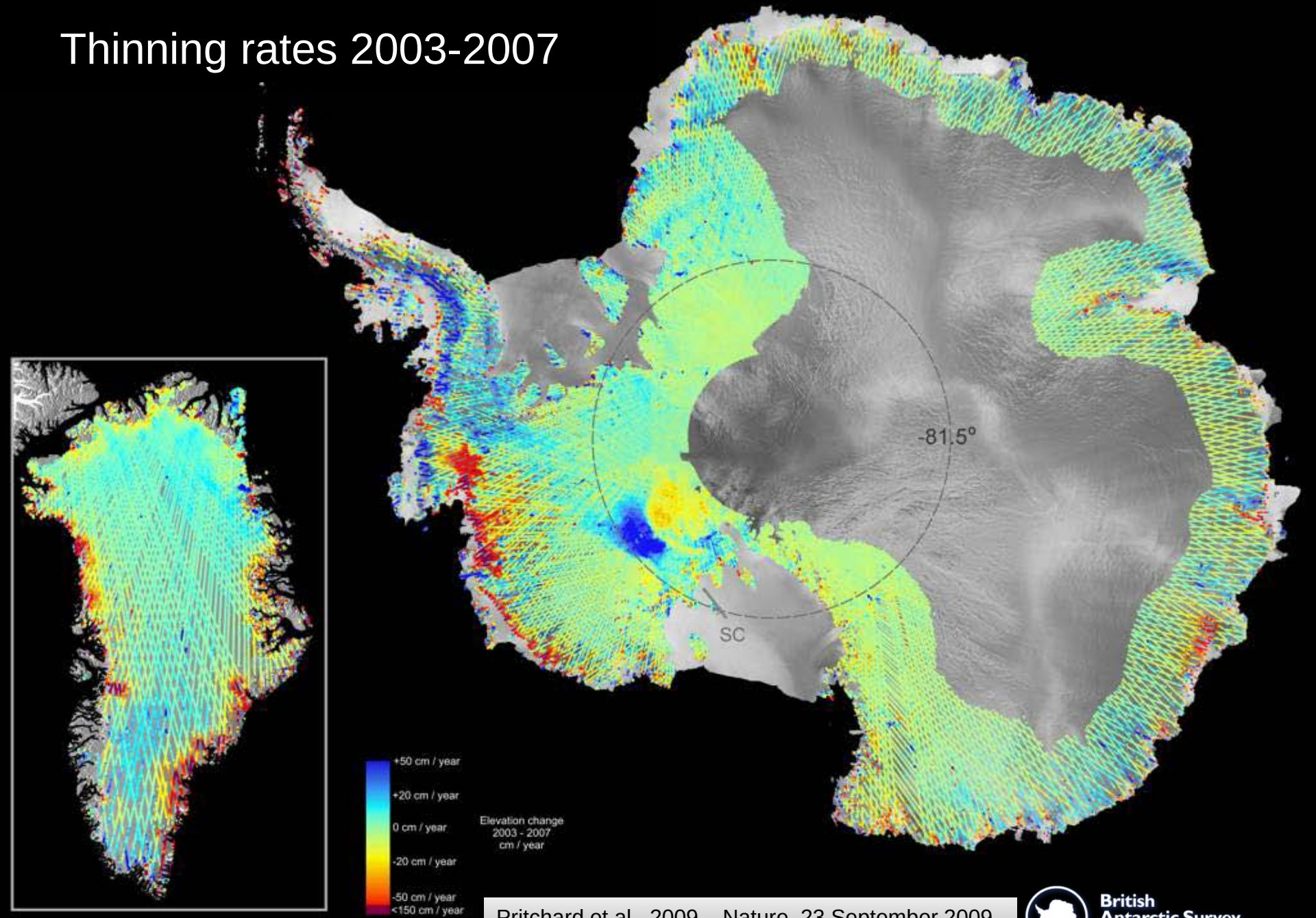
Deltacommisee upper

IPCC AR4 Upper

Continuation of 1870-present = IPCC AR4 lower


Advances prior to ice2sea

Thinning rates 2003-2007



Pritchard et al., 2009 – Nature, 23 September 2009

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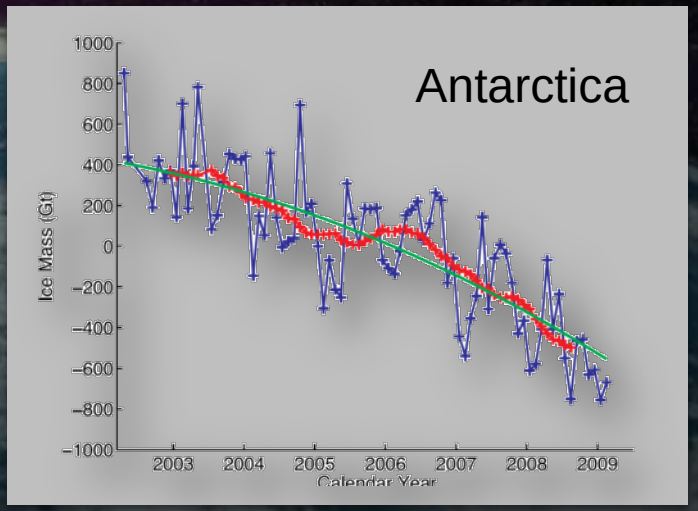
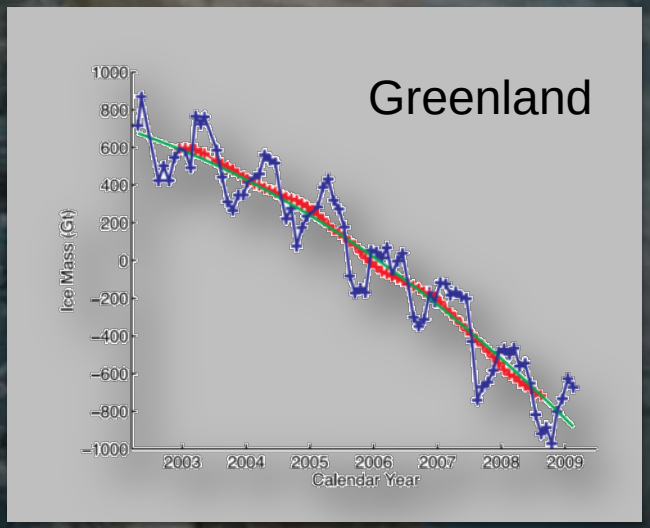
Grace – satellite gravity





Velicogna, 2010

Coordinator: David G. Vaughan
Information: www.ice2sea.eu

SEVENTH FRAMEWORK PROGRAMME

Partners in ice2sea

UNIVERSITY OF LEEDS

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

University of BRISTOL

Met Office Hadley Centre

UNIVERSITY OF COPENHAGEN

DTU

SIGILLUM UNIVERSITATIS ISLANDIAE

1506 UNIVERSITÀ DEGLI STUDI DI URBINO CARLO BO

UNIWERSYTET ŚLĄSKI W KATOWICACH

University of Zurich[UZH]

Universiteit Utrecht

ULB

NORSK POLARINSTITUTT

CECs CENTRO DE ESTUDIOS CIENTÍFICOS

Vrije Universiteit Brussel

cnrs

DMI

Université de Liège

UNIVERSITY OF OSLO

CSC

GEUS

ENEA

AWI

Russell Glacier, Greenland

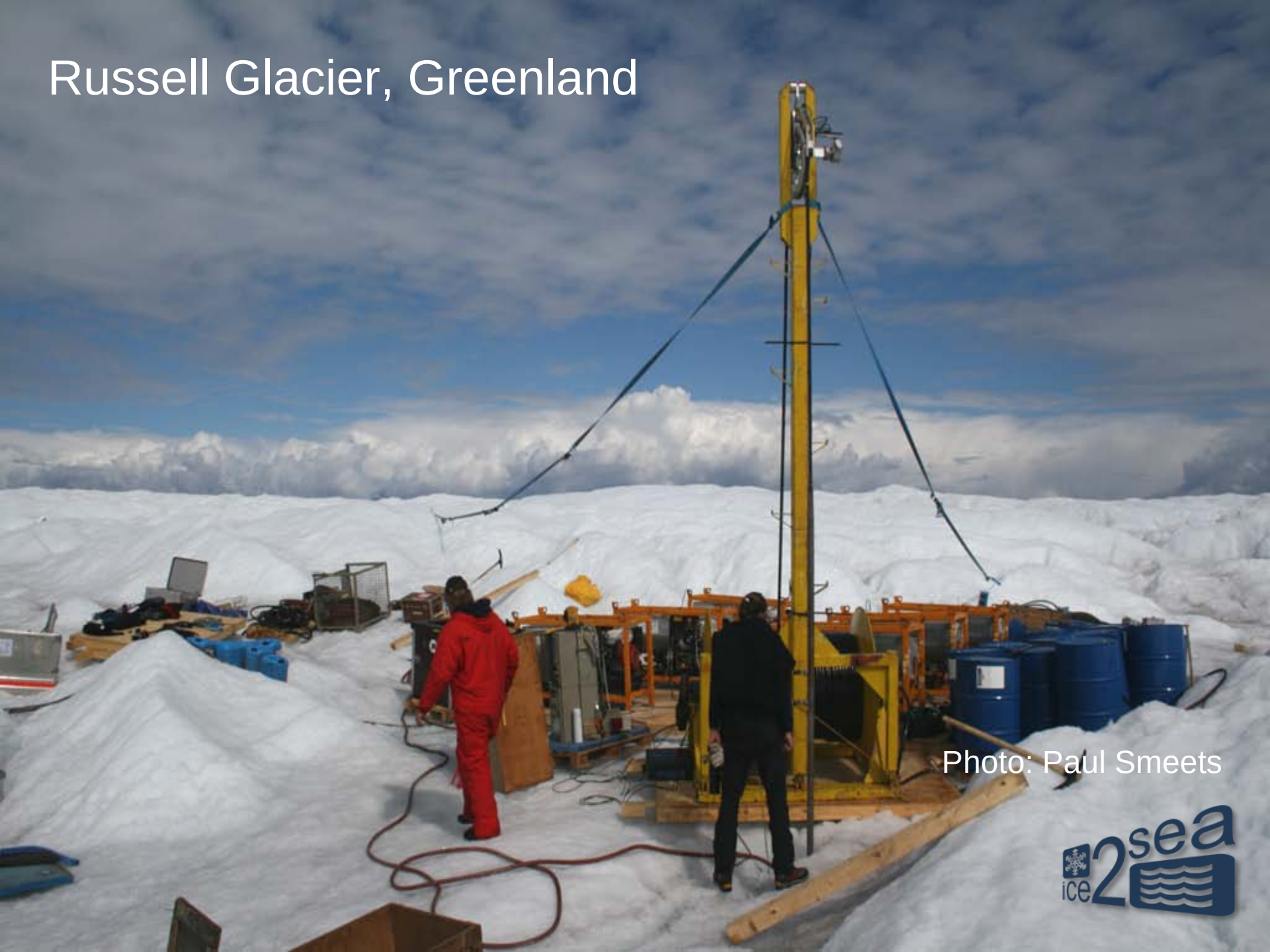
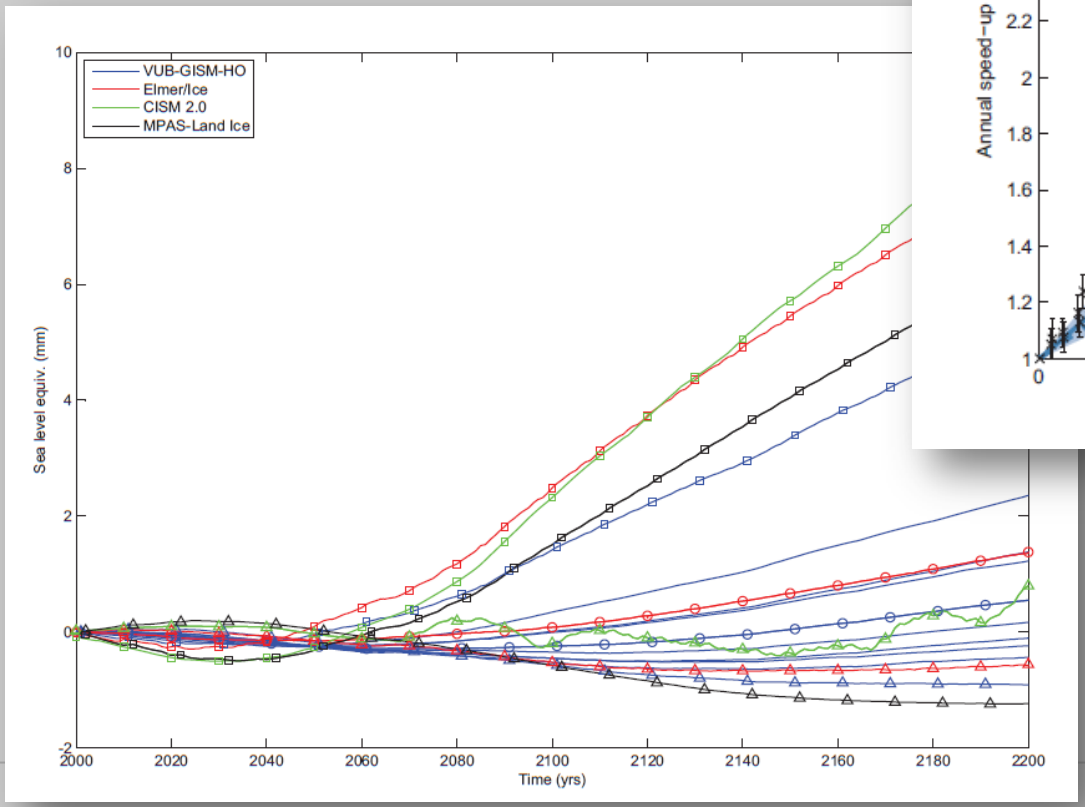
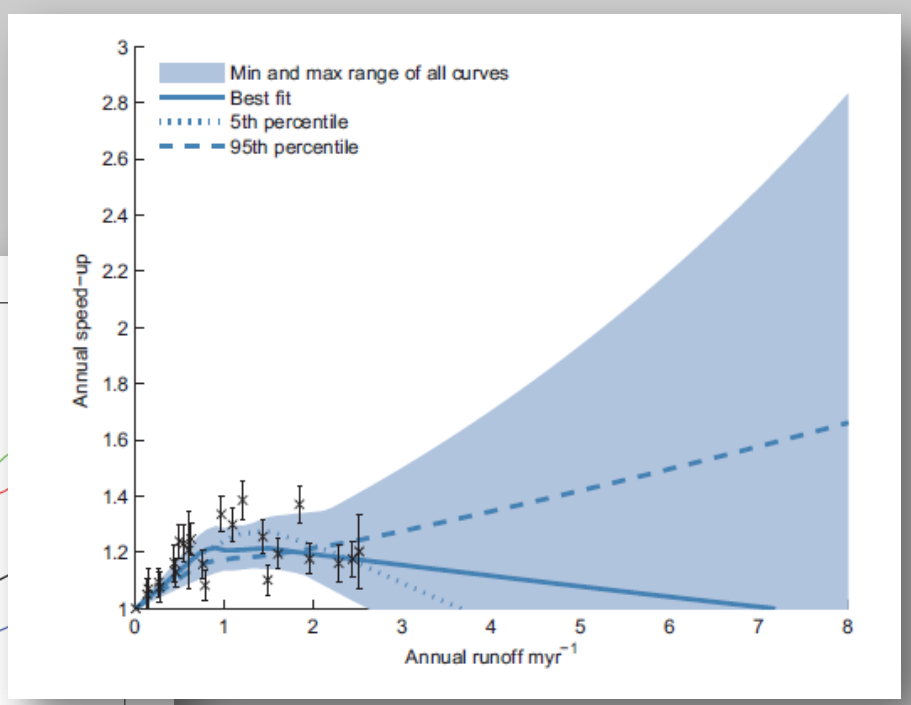


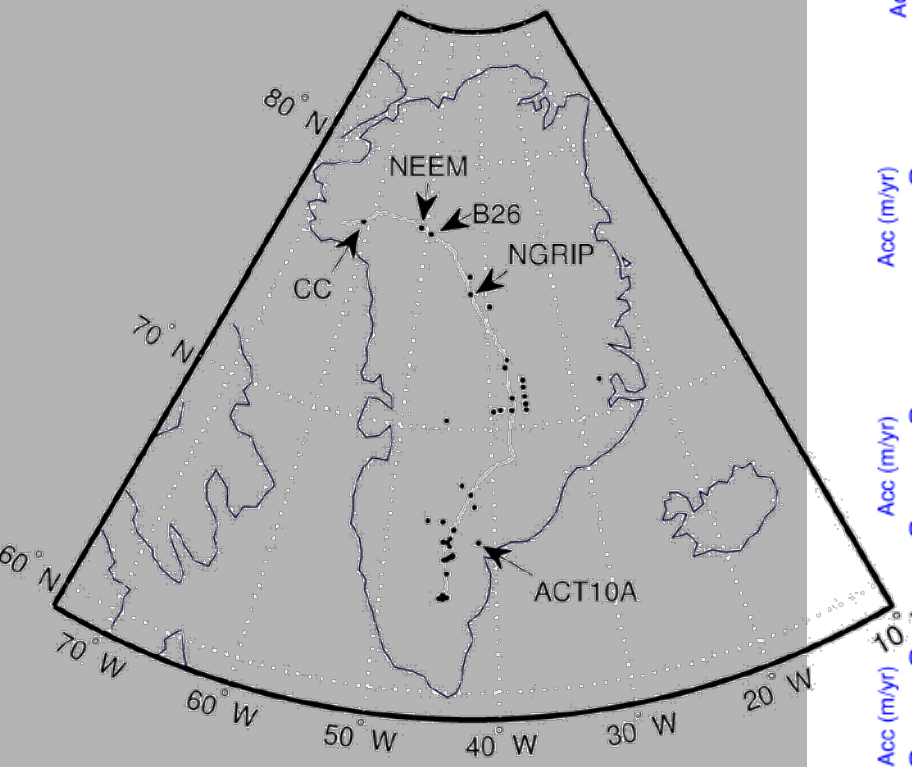
Photo: Paul Smeets

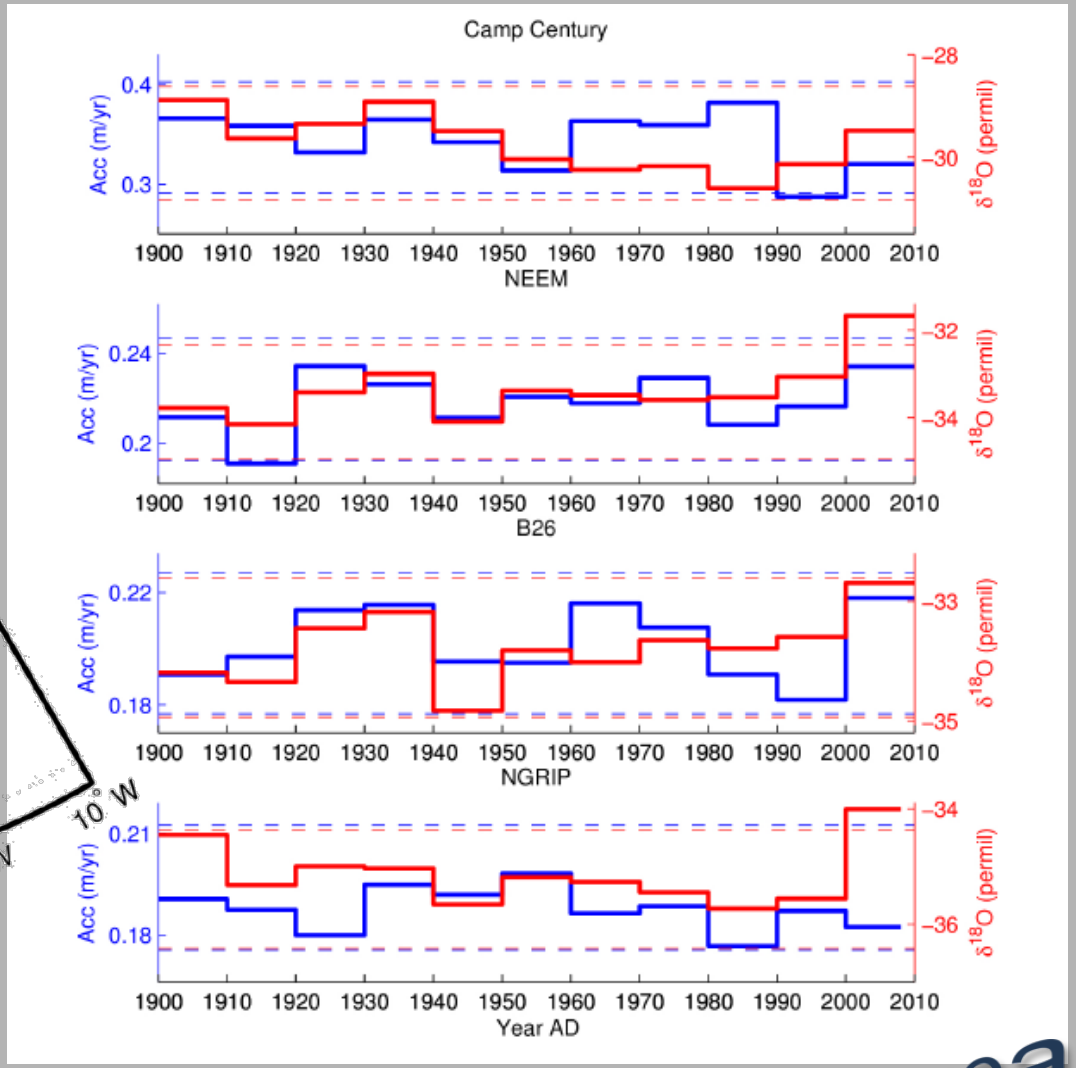
Surface melt lubrication, Greenland





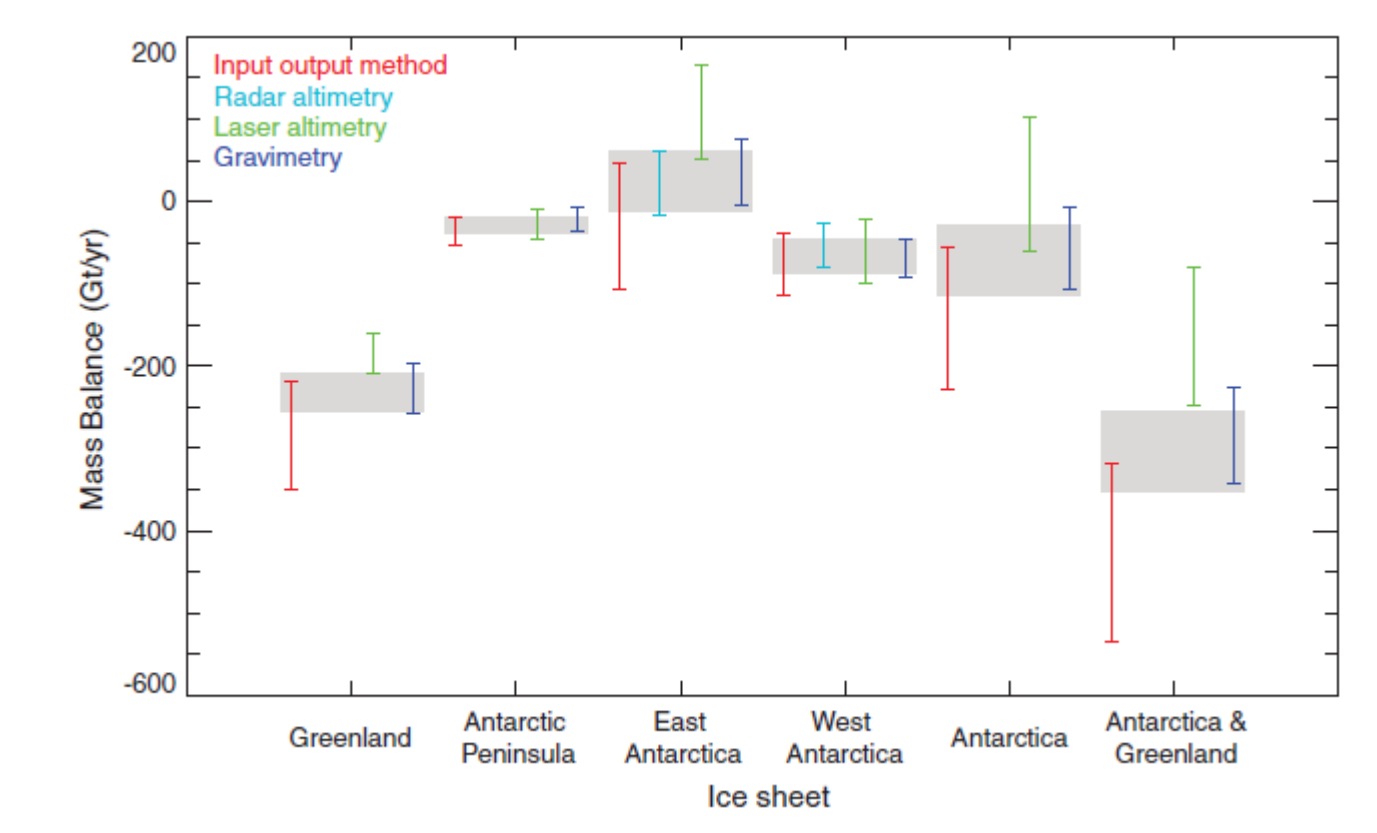
Accumulation vs. temperature, Greenland





Buchardt, ice2sea103

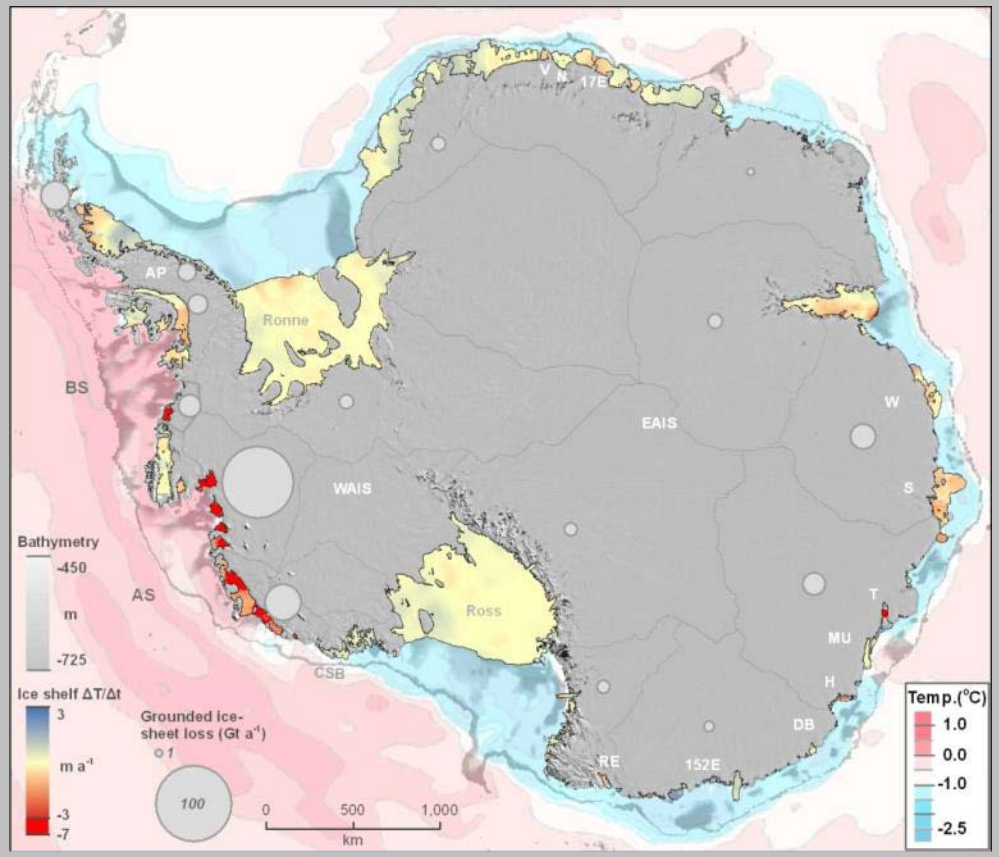
Reconciled estimates of mass balance



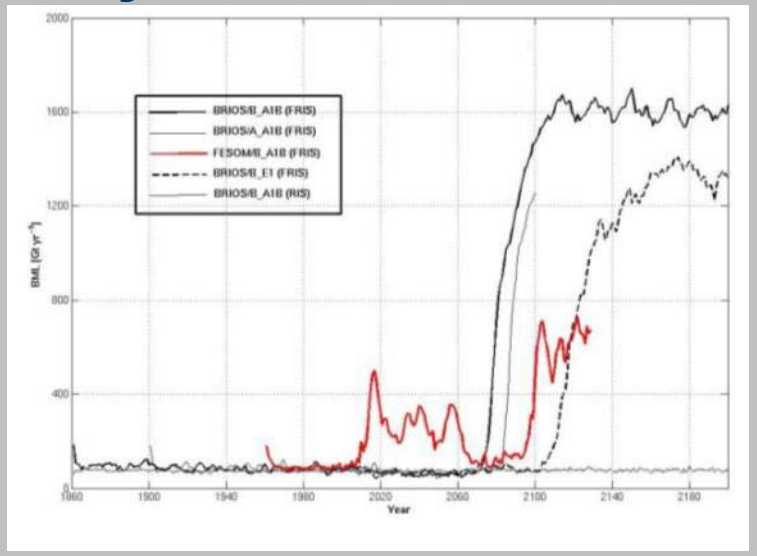
imbie

ice2sea

Antarctic ice sheet loss – driven by warm water

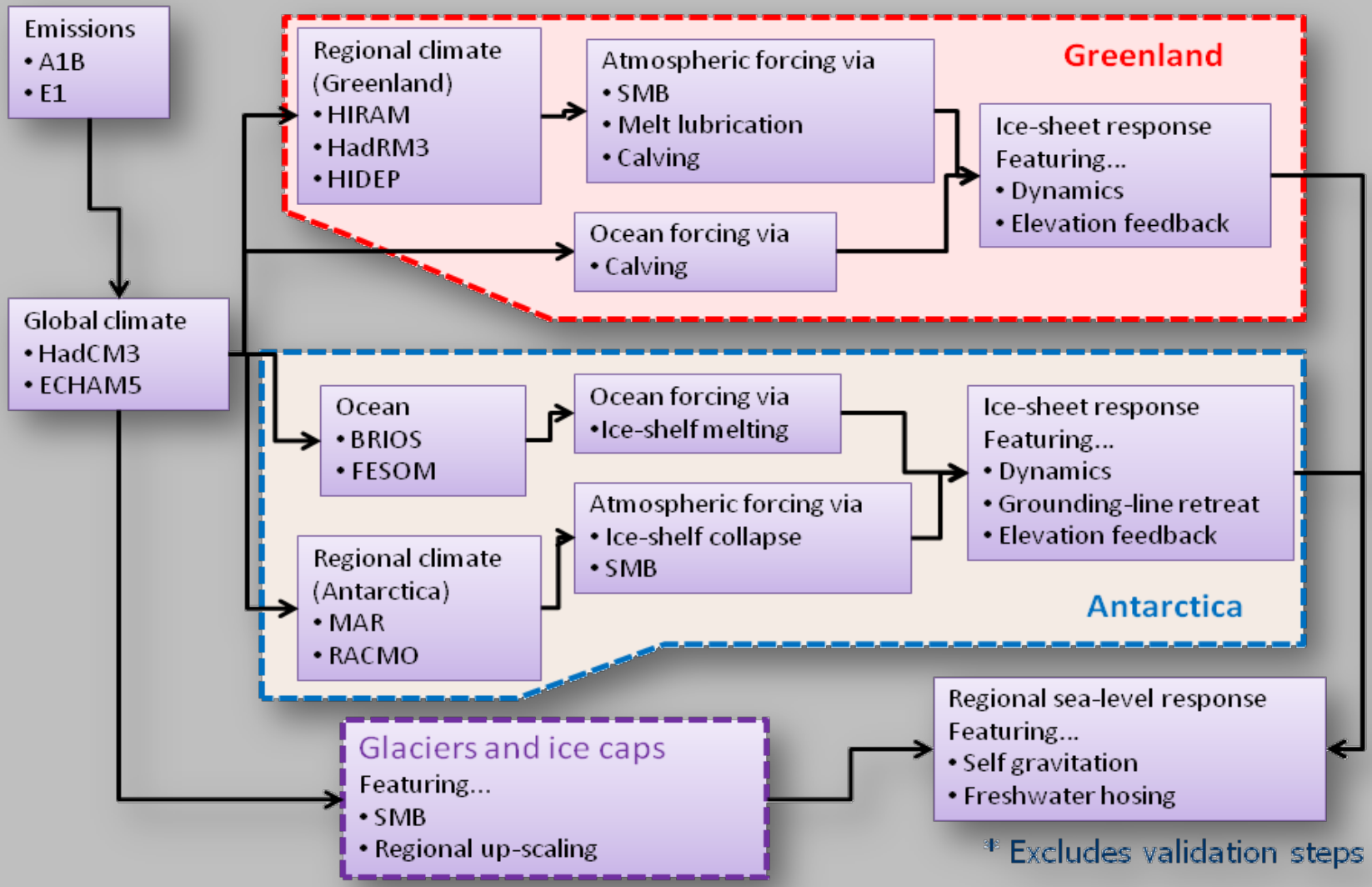


Pritchard et al., Nature, 2011.



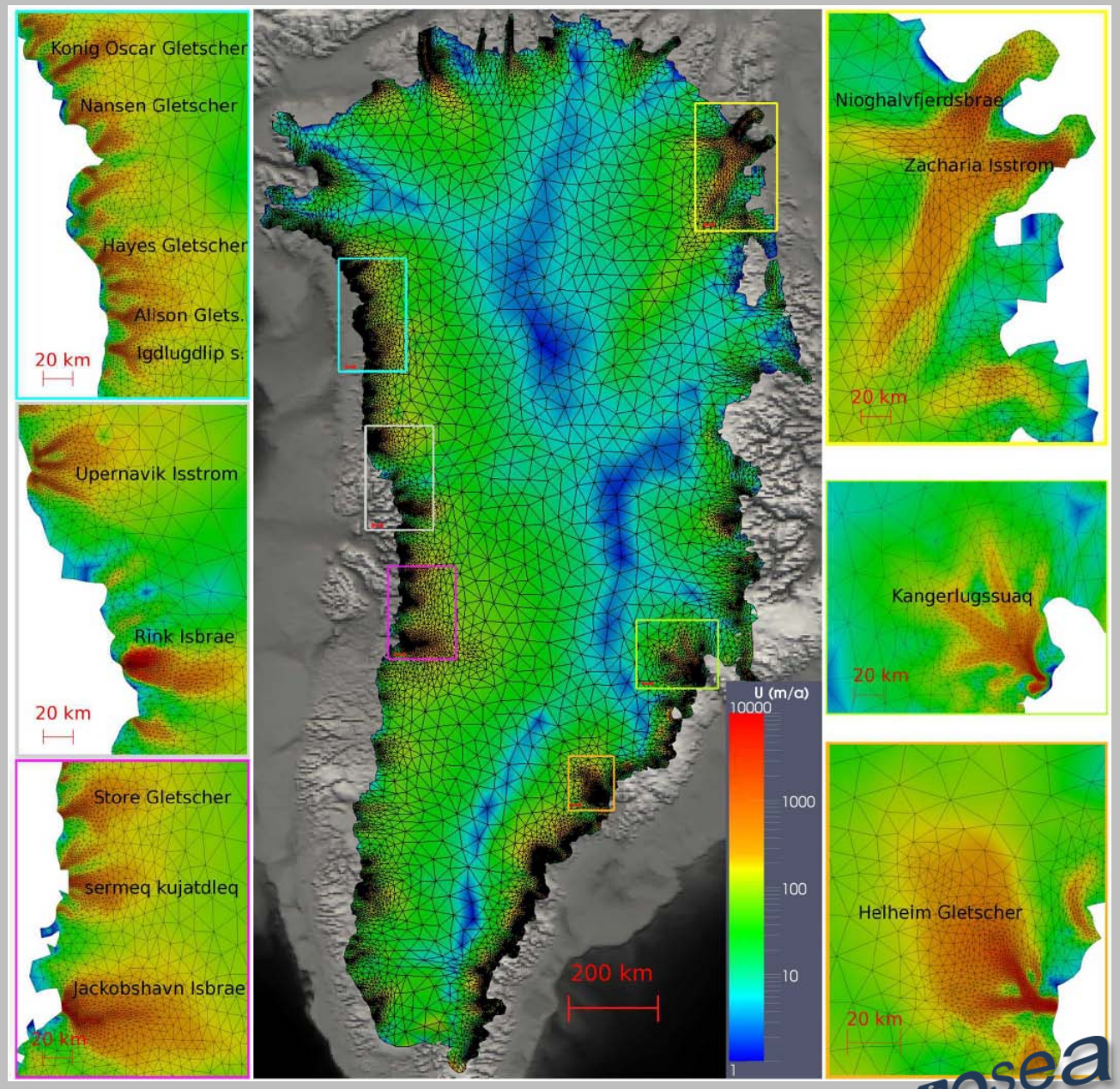
Hellmer et al., Nature, 2011.

Modelling in ice2sea *



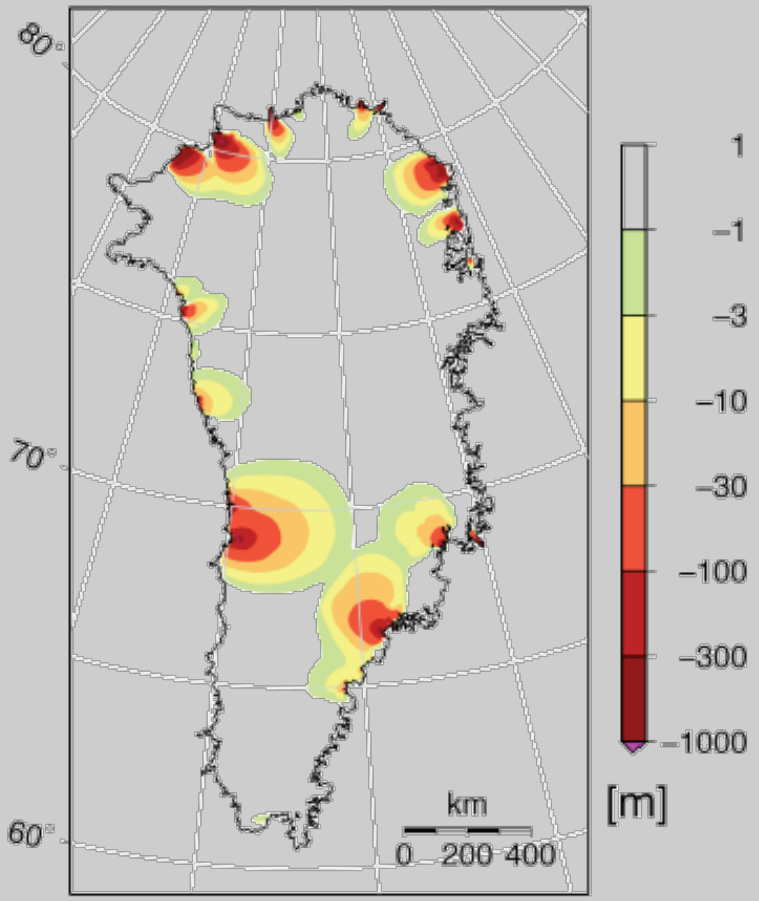
* Excludes validation steps

New generation of ice-sheet models

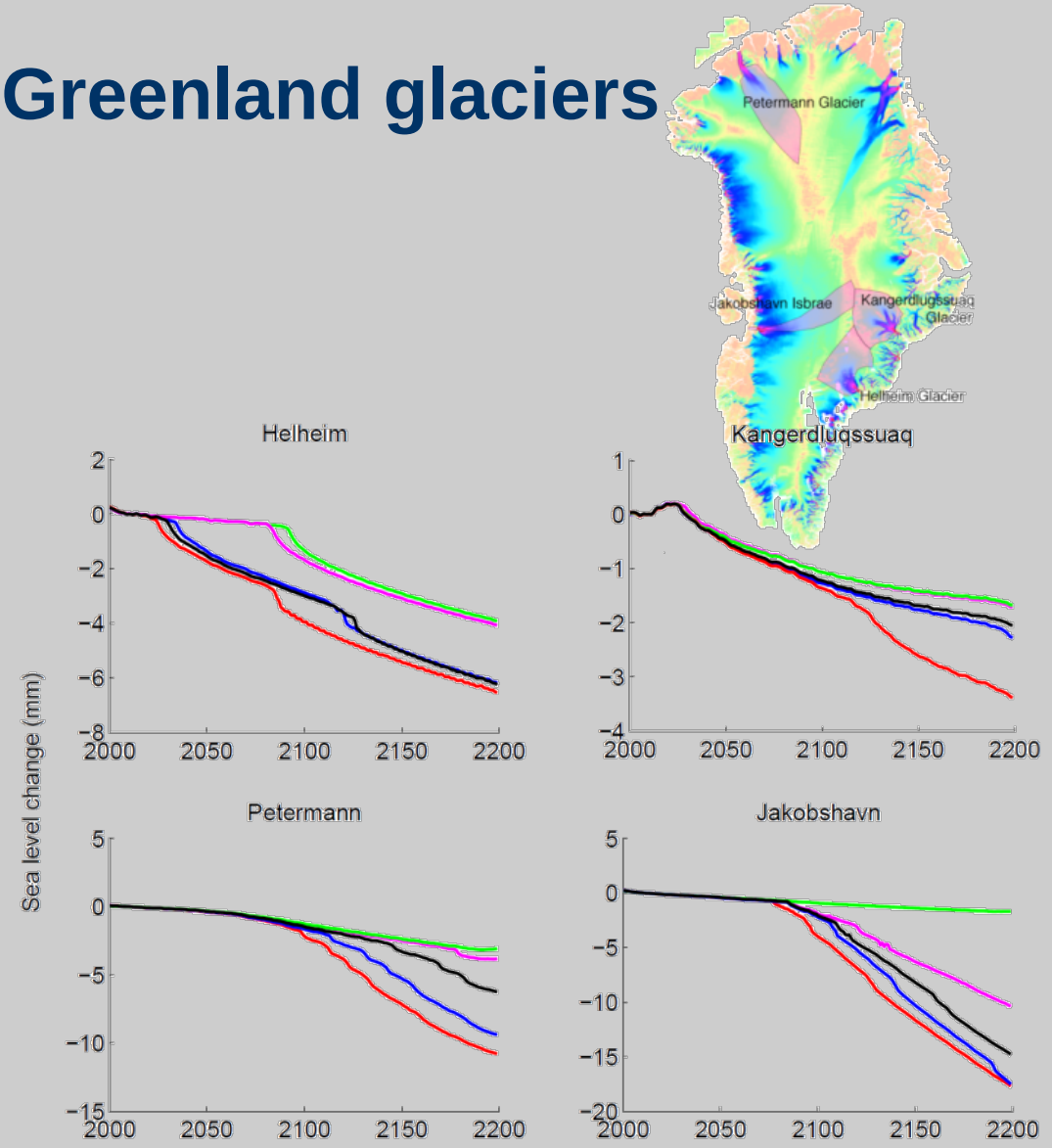


Gillet-Chaulet et al., in submission

Projection of calving Greenland glaciers



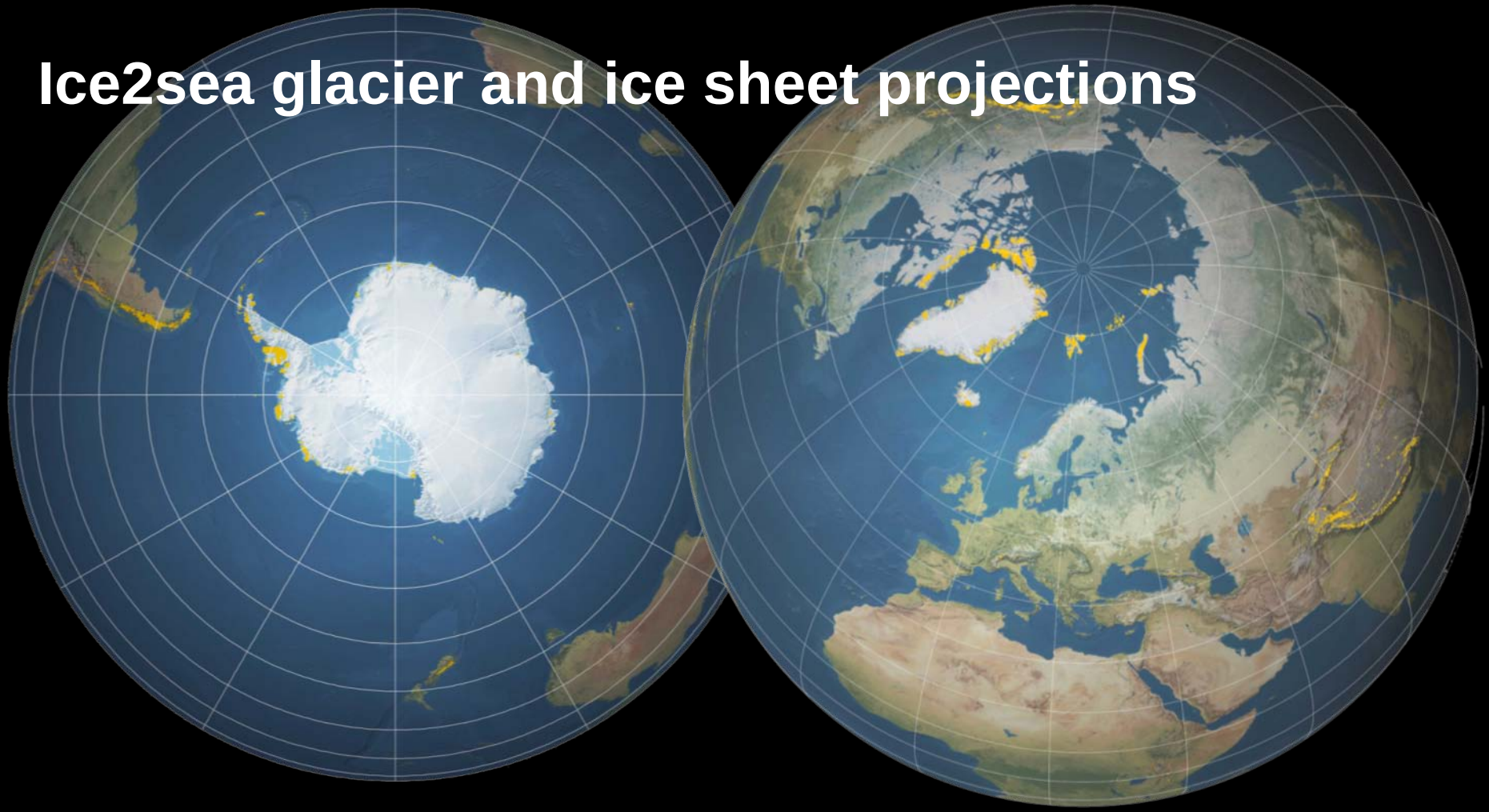
Goezler et al, 2013.



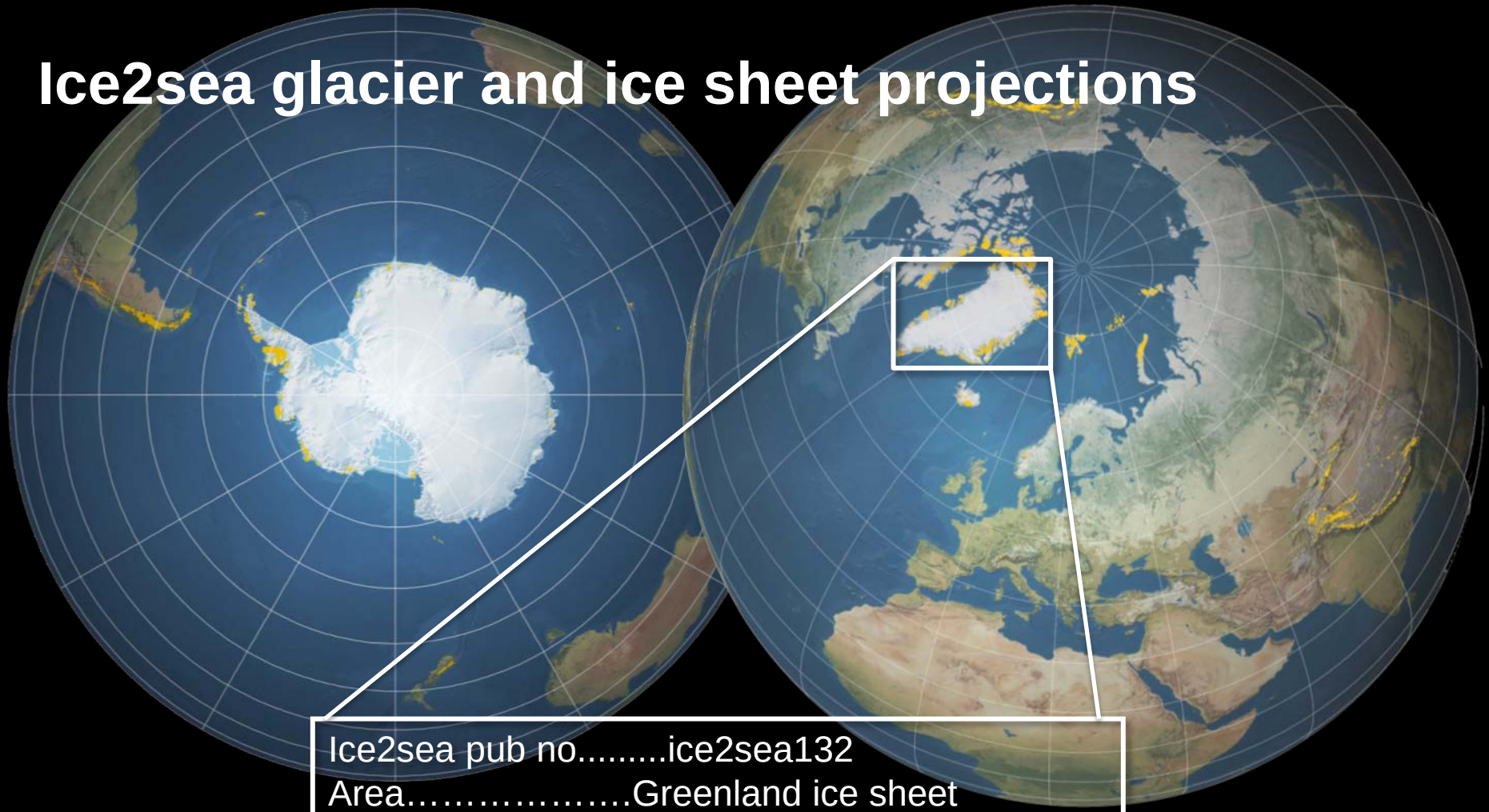
Nick et al, Nature 2013

ice2sea

Ice2sea glacier and ice sheet projections

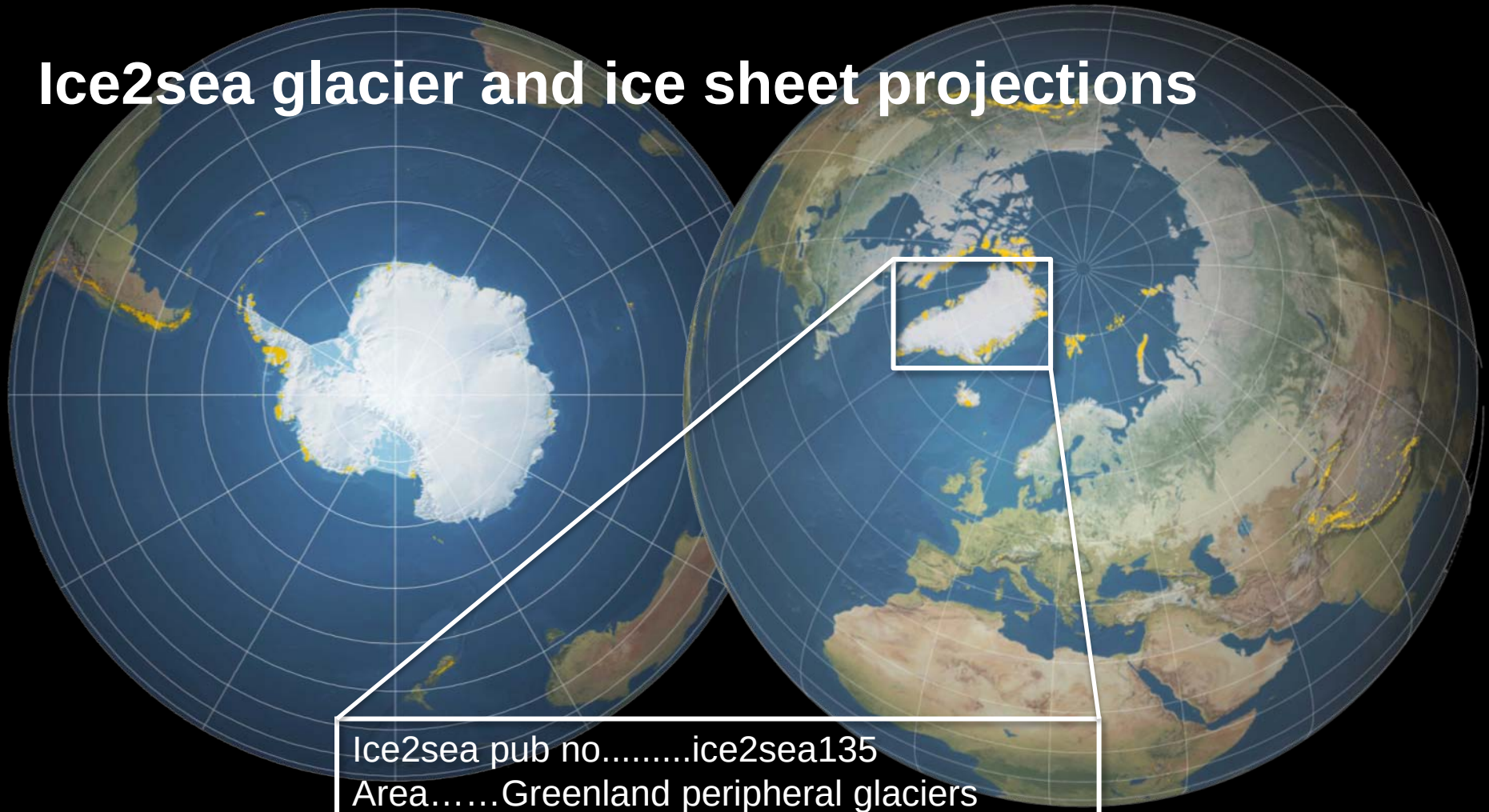


Ice2sea glacier and ice sheet projections



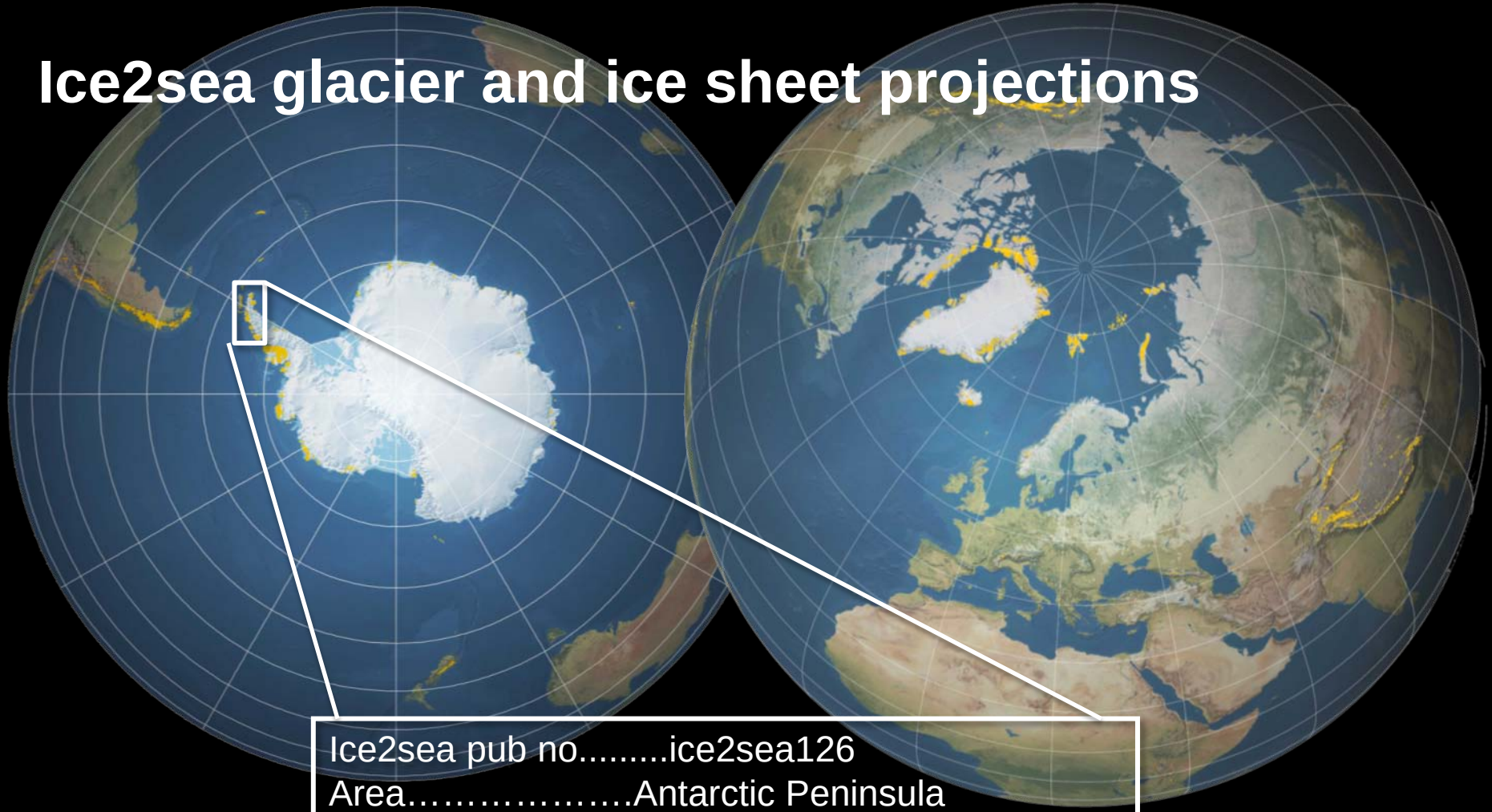
Ice2sea pub no.....ice2sea132
Area……Greenland ice sheet
Dominant process….Atmospheric and dynamics
Forcing……4xRCP Scenarios
SLR by 2100……5.1 – 7.6 cm
Modelling by……VUB

Ice2sea glacier and ice sheet projections



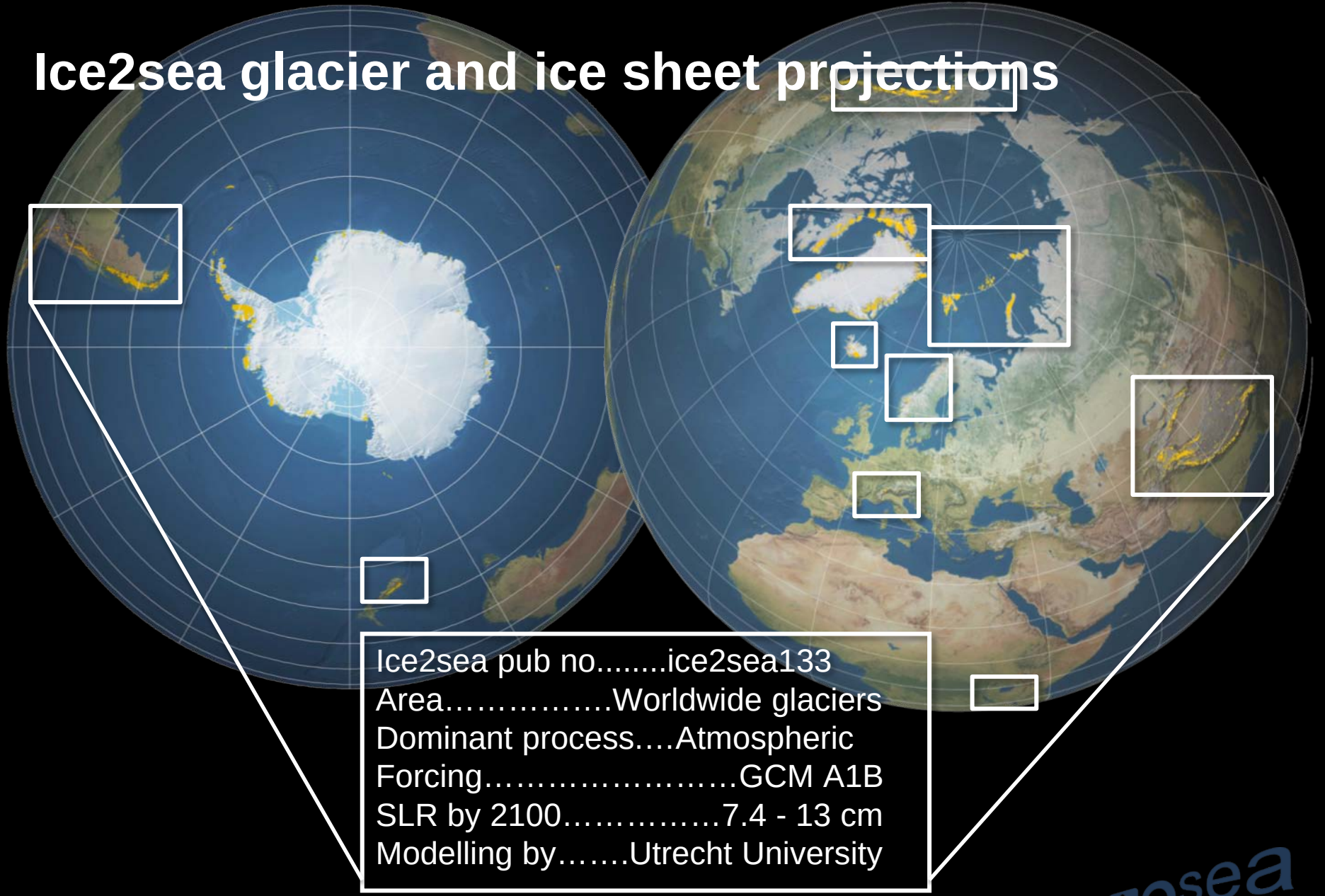
Ice2sea pub no.....ice2sea135
Area……Greenland peripheral glaciers
Dominant process….Atmospheric
Forcing……...RCM A1B
SLR by 2100……0.58 – 1.12 cm
Modelling by……GEUS / UZH / DTU

Ice2sea glacier and ice sheet projections



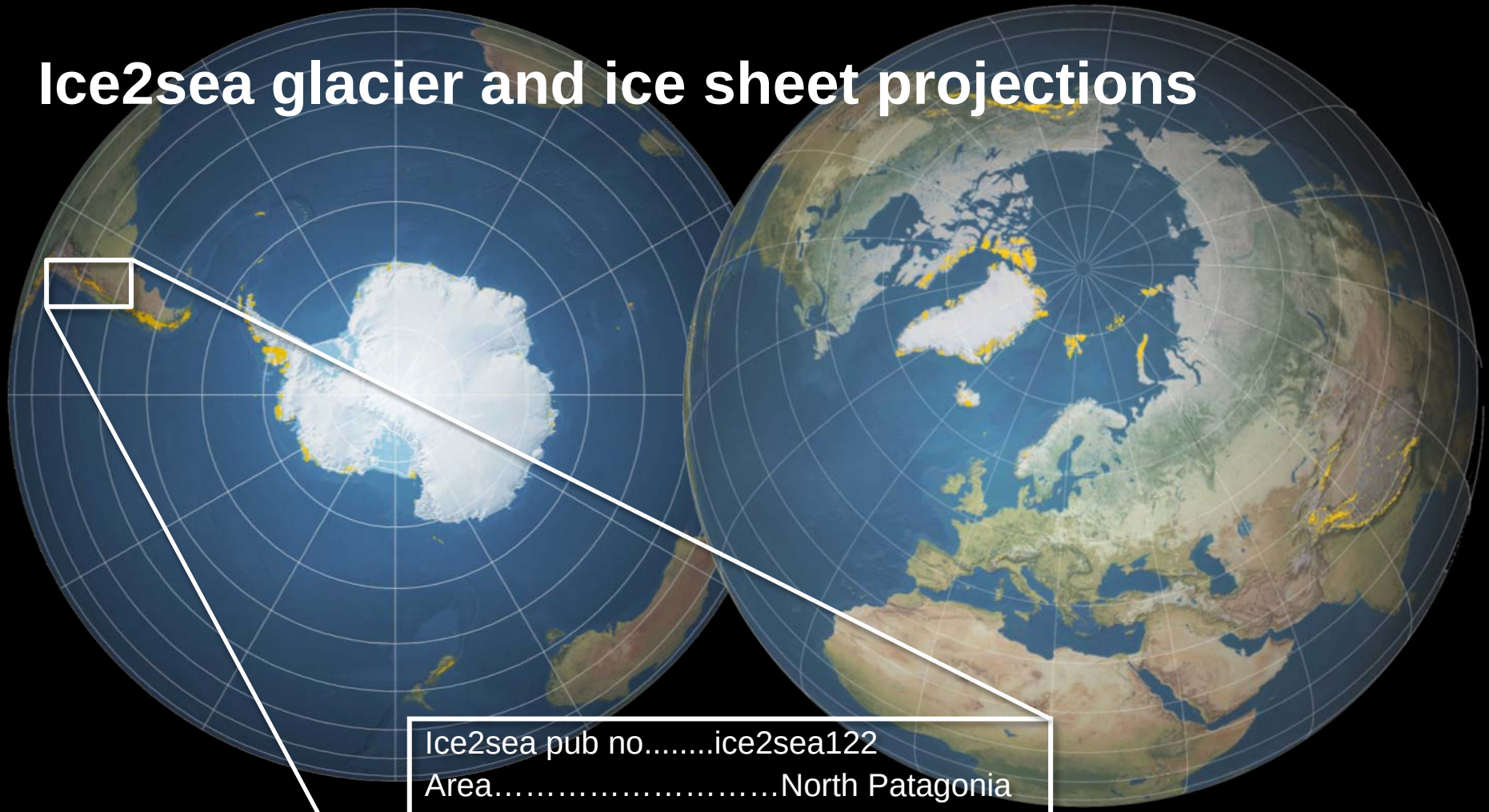
Ice2sea pub no.....ice2sea126
Area……Antarctic Peninsula
Dominant process…Atmospheric and GL retreat
Forcing……RCM A1B 2100
SLR by 2100……0.7 – 1.6 cm
Modelling by……NERC-BAS

Ice2sea glacier and ice sheet projections



Ice2sea pub no.....ice2sea133
Area……Worldwide glaciers
Dominant process….Atmospheric
Forcing……GCM A1B
SLR by 2100……7.4 - 13 cm
Modelling by…….Utrecht University

Ice2sea glacier and ice sheet projections



Ice2sea pub no.....ice2sea122
Area……North Patagonia
Dominant process…Atmospheric
Forcing……..ECHAM5 A1B
Modelling by……CECS

Synthesis of global sea-level rise estimates

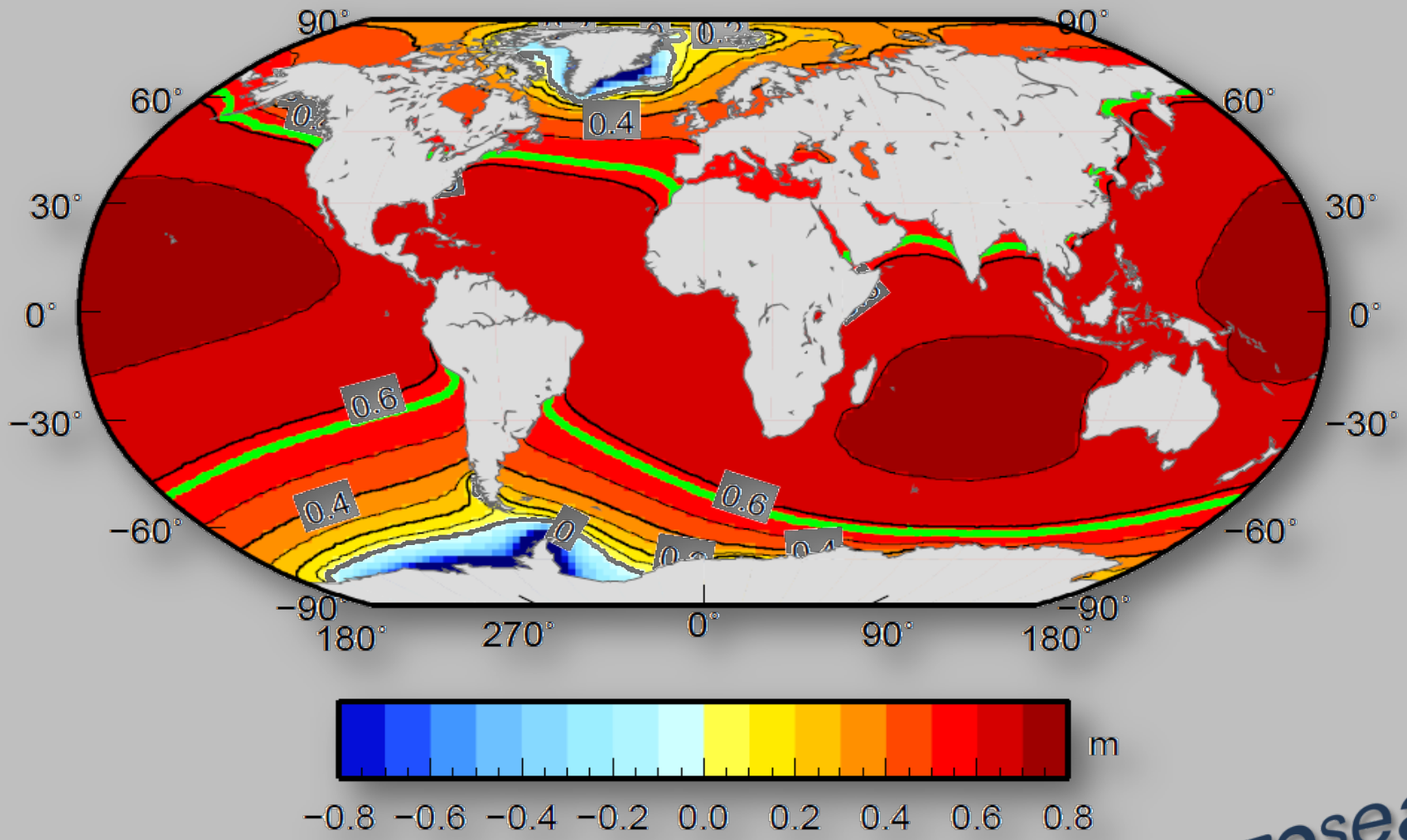
Ice2sea projections based on simulations of physical processes suggest lower overall contributions from melting ice to sea-level rise than many studies published since AR4.

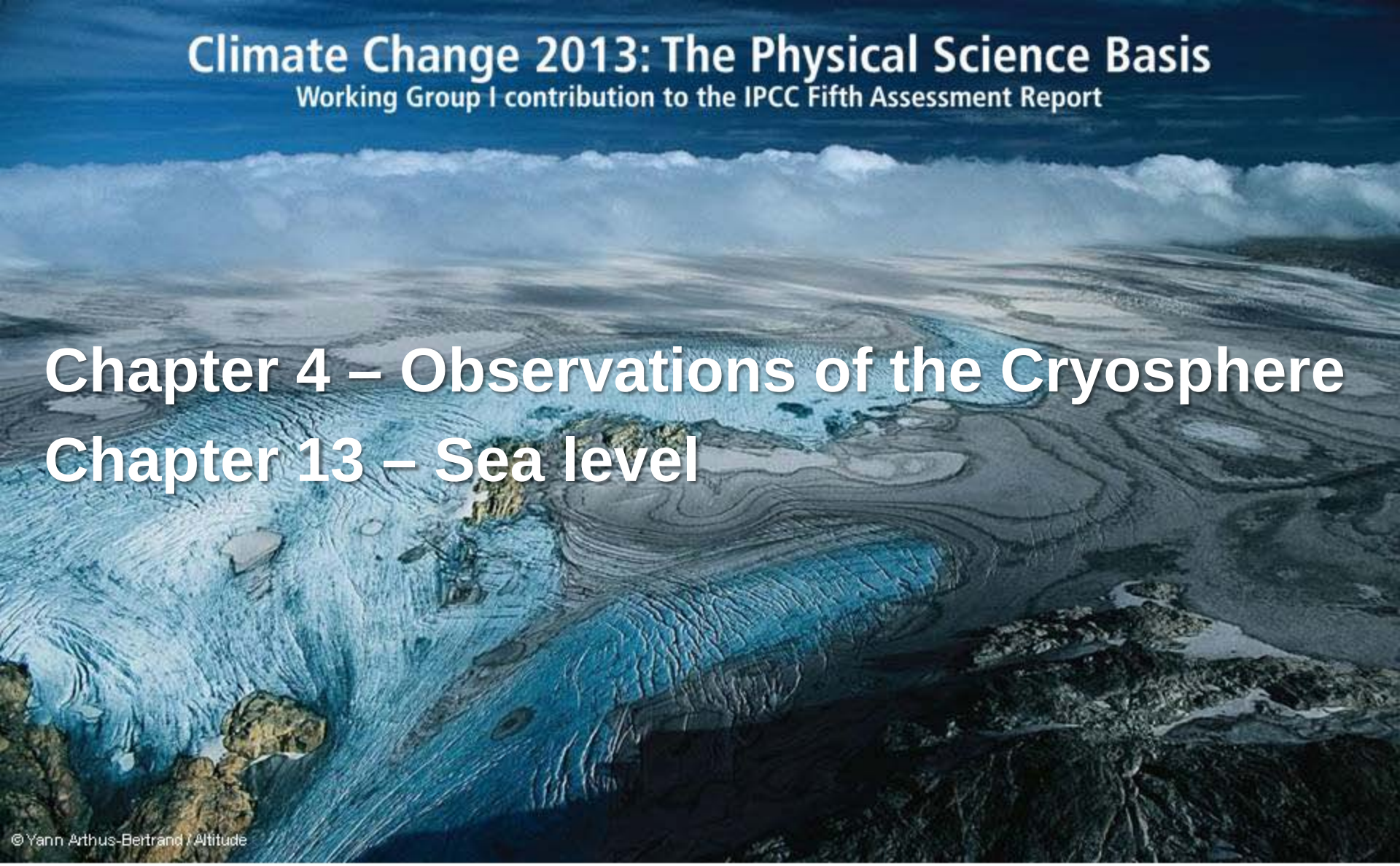
For A1B, these simulations suggest a contribution of 3.5 – 36.8 cm by 2100.

(+IPCC AR4, thermal expansion = 16.5 – 69 cm)

[For comparison, AR4 gave 21 – 43 cm]

Gravitational readjustment of sea-level





Chapter 4 – Observations of the Cryosphere
Chapter 13 – Sea level

IPCC WGI AR5 Summary for Policymakers – Key statements

- **E. Future Global and Regional Climate Change**
  - E.6 Sea Level
    - Confidence in projections of global mean sea level rise has increased since the AR4 because of the improved physical understanding of the components of sea level, the improved agreement of process-based models with observations, and the inclusion of ice-sheet dynamical changes.

IPCC WGI AR5 Summary for Policymakers – Key statements

- **E. Future Global and Regional Climate Change**
  - E.6 Sea Level
    - In the RCP projections, thermal expansion accounts for 30 to 55% of 21st century global mean sea level rise, and glaciers for 15 to 35%.

      The increase in surface melting of the Greenland ice sheet will exceed the increase in snowfall, leading to a positive contribution from changes in surface mass balance to future sea level (*high confidence*).

      While surface melting will remain small, an increase in snowfall on the Antarctic ice sheet is expected (*medium confidence*), resulting in a negative contribution to future sea level from changes in surface mass balance.

      Changes in outflow from both ice sheets combined will *likely* make a contribution in the range of 0.03 to 0.20 m by 2081−2100 (medium confidence).

Projections in AR5 are based on RCP Scenarios

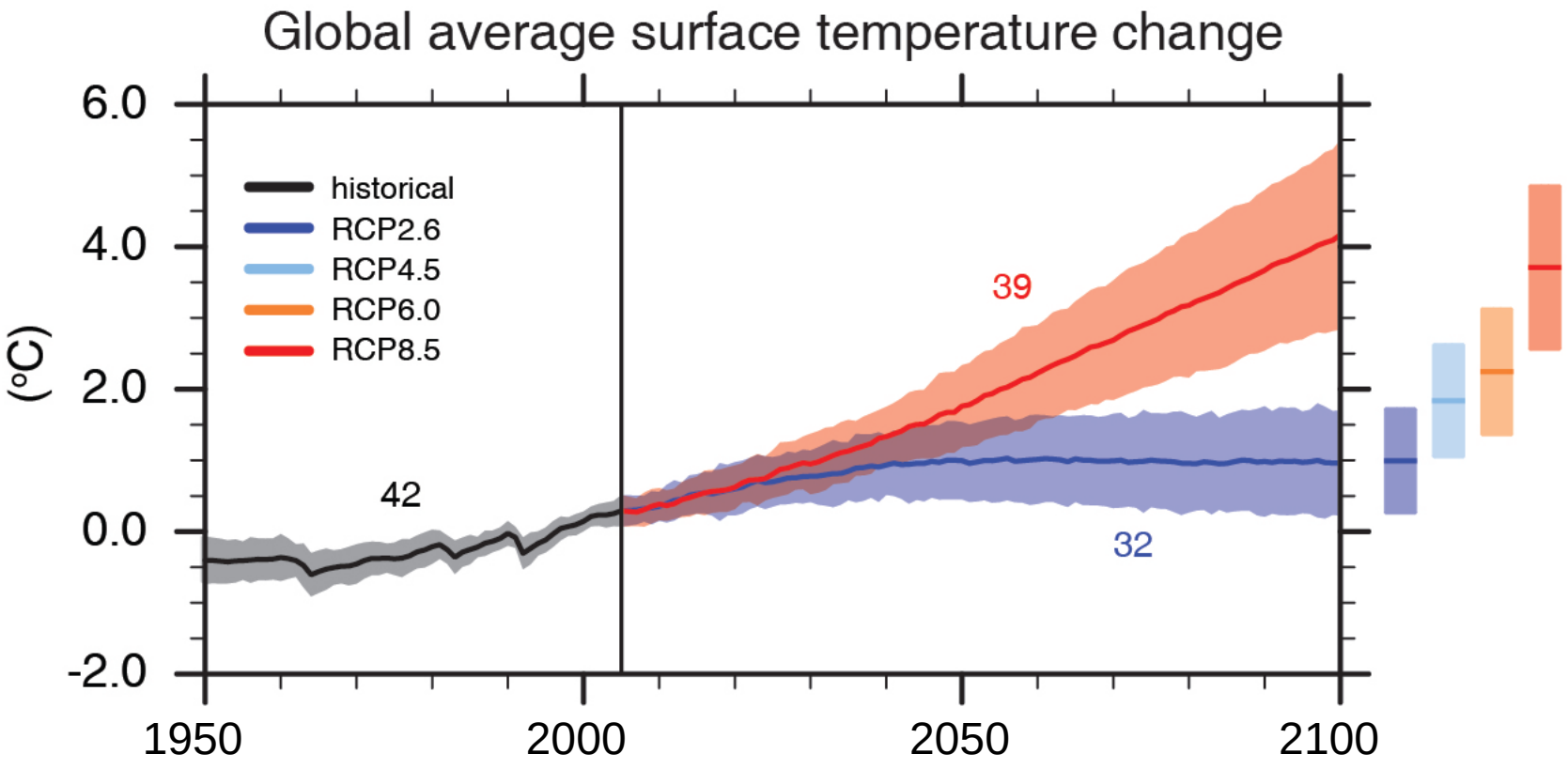
• RCP2.6 is based on aggressive reduction of CO2. Total CO2 decreasing immediately and near-zero emissions ~50 years from now.

• RCP4.5 (medium-low) and RCP6.0 (medium-high) are realistic scenarios.

•RCP8.5 – the 'business-as-usual' pathway – assumes no emissions reductions. By 2100, CO2 5 times higher than pre-industrial levels.

Projections of 21st-century Global temperature

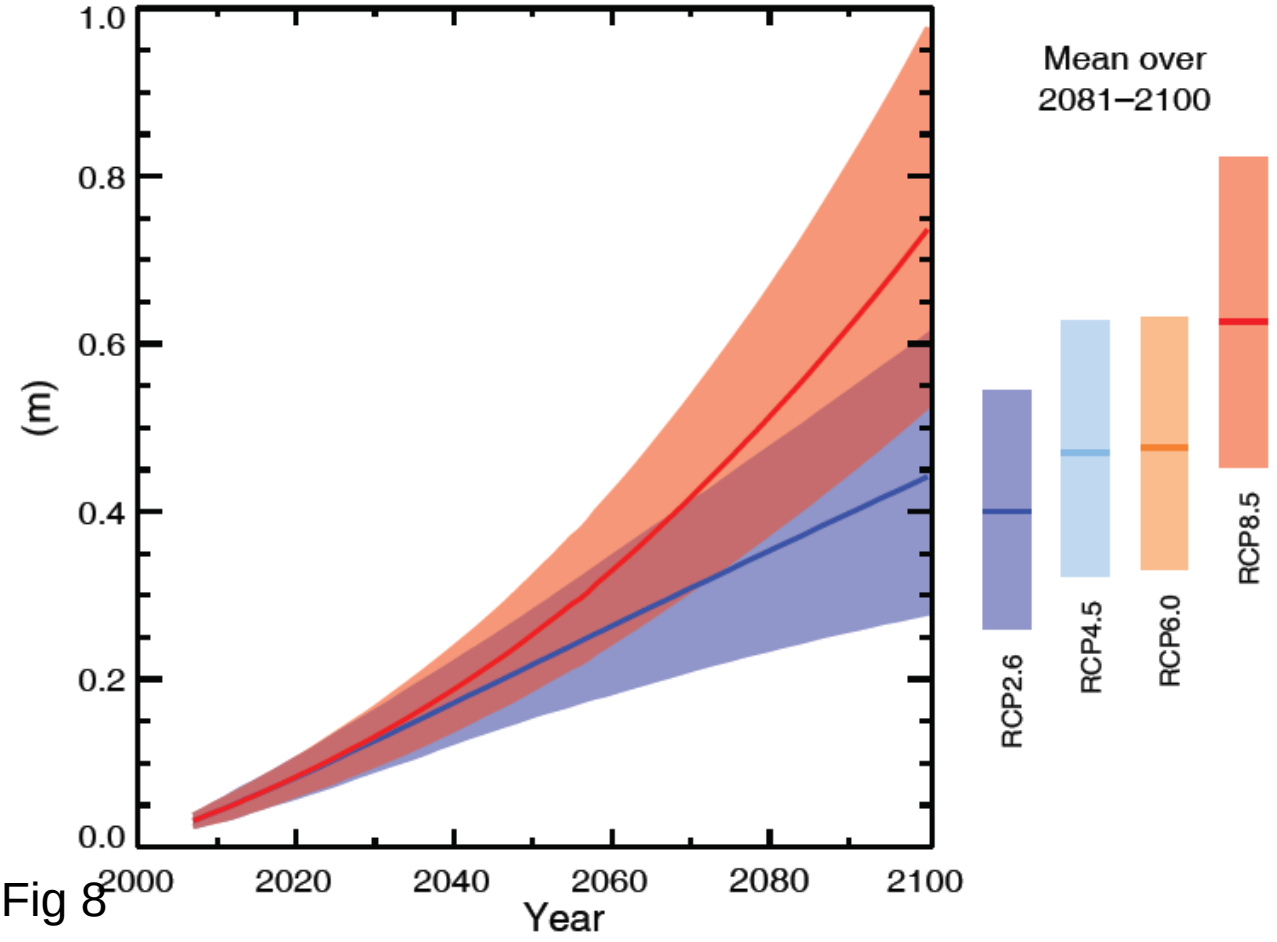
- *CMIP5 multi-model time series from 1950 to 2100 relative to 1986–2005*



SPM Fig 6

Projections of 21st-century GMSLR under RCPs

Medium confidence in *likely* ranges. *Very likely* that the 21st-century mean rate of GMSLR will exceed that of 1971-2010 under all RCPs.



SPM Fig 8

(Compared to ice2sea "best estimate" for A1B, including AR4 thermal expansion 0.16 – 0.69 m)

IPCC WGI AR5 Summary for Policymakers – Key statements

- **E. Future Global and Regional Climate Change**
  - E.6 Sea Level
    - Global mean sea level rise for 2081−2100 relative to 1986–2005 will *likely* be in the ranges
      0.26 to 0.55 m for RCP2.6,
      0.32 to 0.63 m for RCP4.5,
      0.33 to 0.63 m for RCP6.0,
      0.45 to 0.82 m for RCP8.5 (all *medium confidence*).

      For RCP8.5, the rise by the year 2100 is 0.52 to 0.98 m, with a rate during 2081–2100 of 8 to16 mm yr–1 (*medium confidence*).

      These ranges are derived from CMIP5 climate projections in combination with process-based models and literature assessment of glacier and ice sheet contributions.

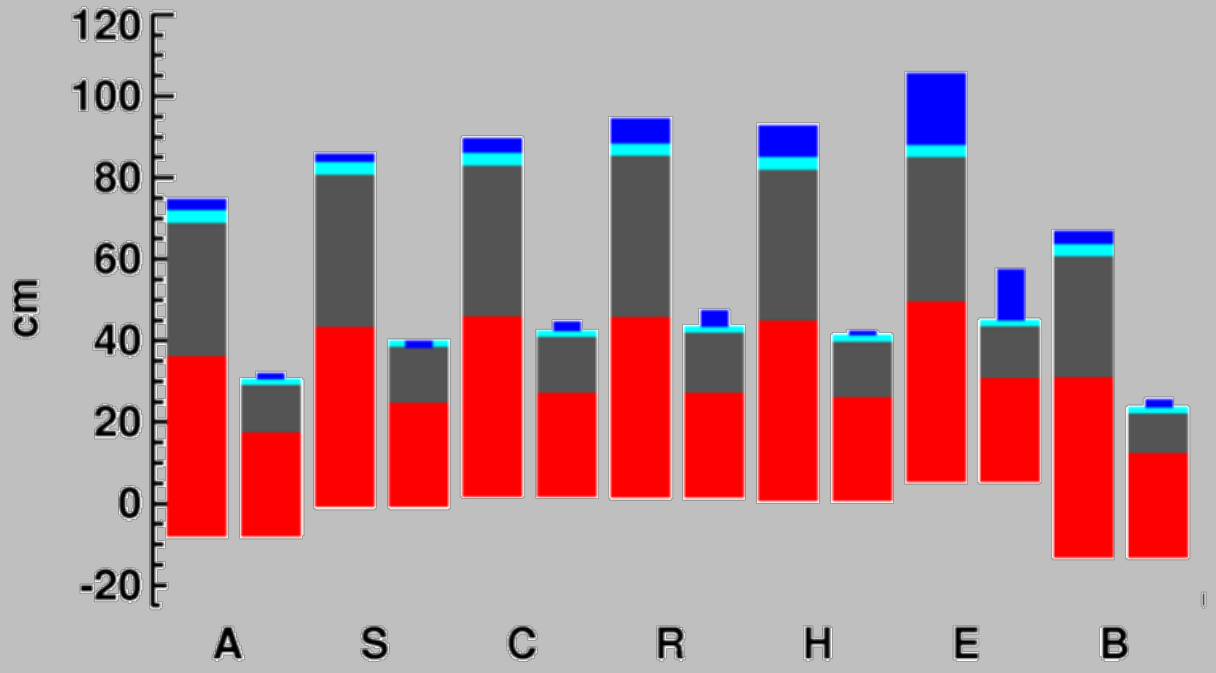
IPCC WGI AR5 Summary for Policymakers – Key statements

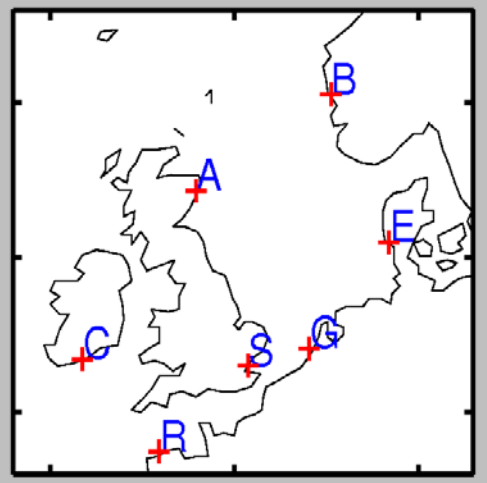
- **E. Future Global and Regional Climate Change**
  - E.6 Sea Level
    - Based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st century.

      However, there is *medium confidence* that this additional contribution would not exceed several tenths of a metre of sea level rise during the 21st century.

Forthcoming

Combined estimates for changes in 50-year storm





Storm surge climate

Ice melt

Thermal exp + ocean dynamics

Vertical land movement

IPCC Fifth Assessment Review (2013)

- Working Group I – Science of Climate Change (September, 27th, 2013)

- Working Group II – Impact, Adaptation, and Vulnerability (March, 29th, 2014)

- Working Group III – Mitigation of Climate Change (April, 2014)

Summary

- Risk to coastal assets is greatly magnified by sea-level rise
- Aim must be to manage risk to within levels that are acceptable to the public
- Uncertainty reduced by cooperative science (e.g. ice2sea)
- IPCC consensus projections in 2013 have reduced uncertainty of global mean change
- Development of regionally-specific projections is now required

Ice2sea Synthesis document

www.ice2sea.eu

For more information on ice2sea...

www.ice2sea.com

For more information on the IPCC AR5...

http://www.climatechange2013.org/