Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Understanding and Projecting Sea Level Change: An Overview of the IPCC 5th Assessment Report (AR5)

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Working Group I Contribution to the IPCC Fifth Assessment Report, Climate Change 2013: The Physical Science Basis

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Chapter 4: Observations: Cryosphere

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IPCC AR5 Confidence Definitions

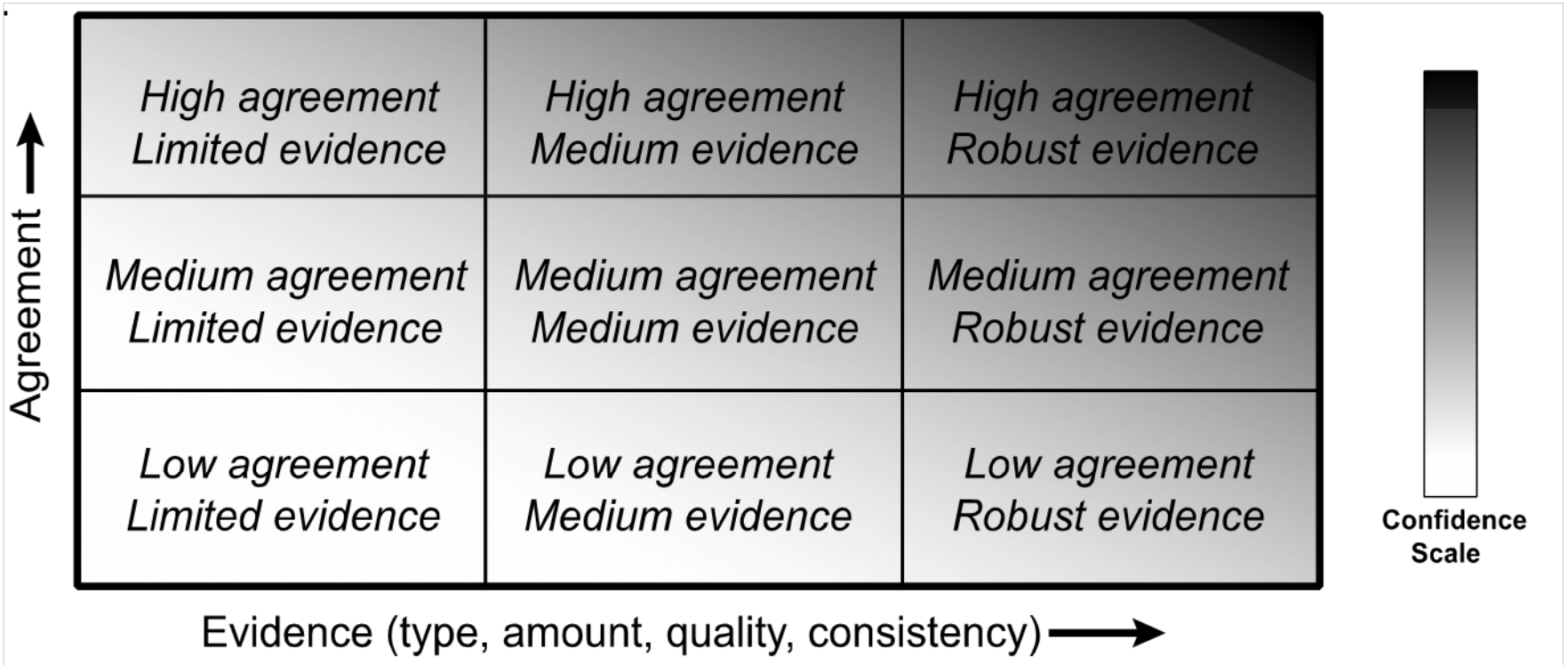


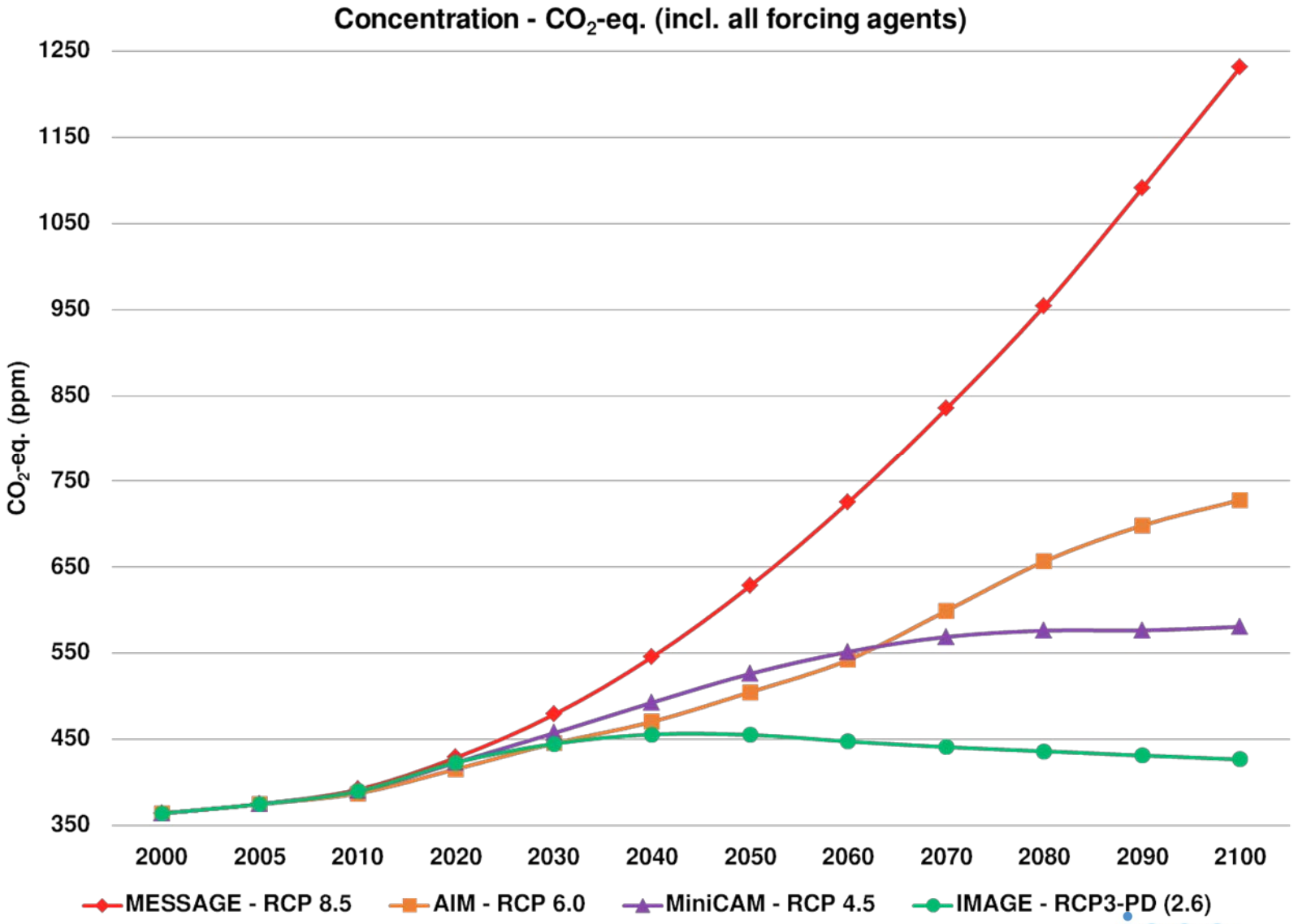
Figure 1: A depiction of evidence and agreement statements and their relationship to confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Generally, evidence is most robust when there are multiple, consistent independent lines of high-quality evidence.

IPCC AR5 Likelihood Definitions

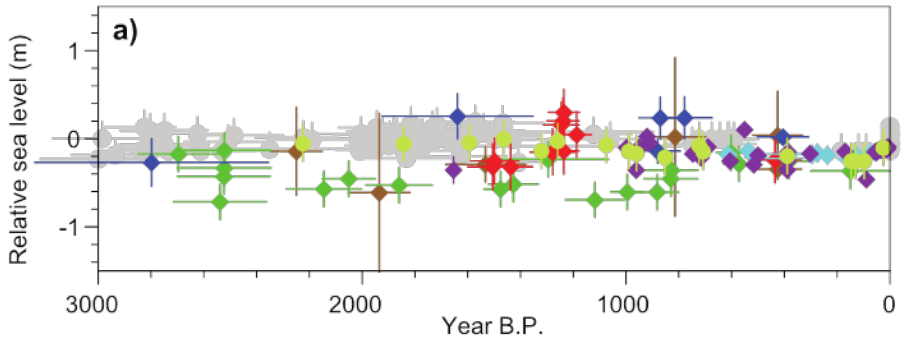
Table 1. Likelihood Scale	
Term*	**Likelihood of the Outcome**
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

* Additional terms that were used in limited circumstances in the AR4 (*extremely likely* – 95-100% probability, *more likely than not* – >50-100% probability, and *extremely unlikely* – 0-5% probability) may also be used in the AR5 when appropriate.

Representative Concentration Pathways (RCPs)

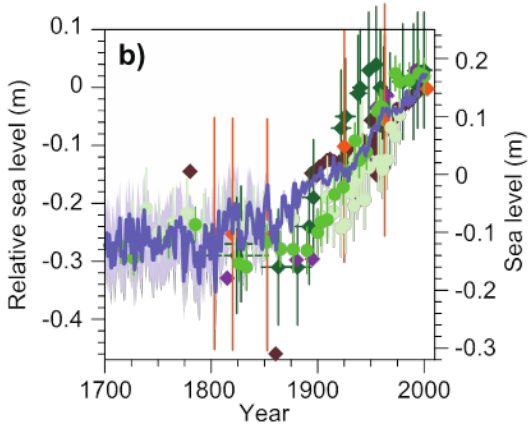


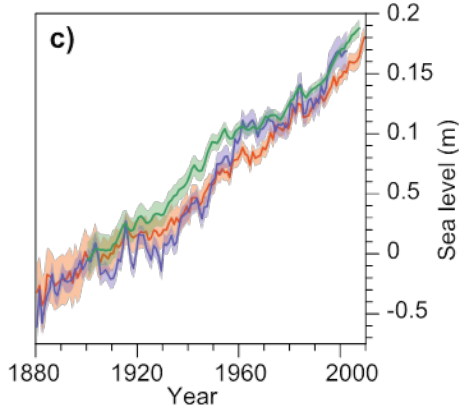
GMSL Observations – Figure 13.3



Paleo sea level data

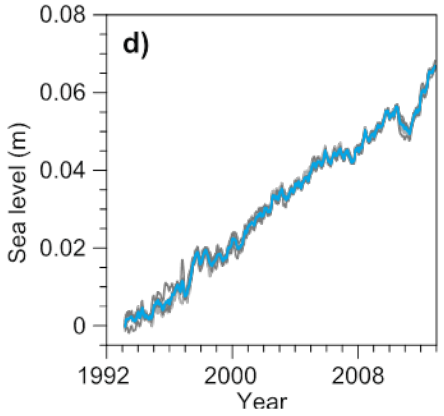
Paleo sea level data from salt marshes

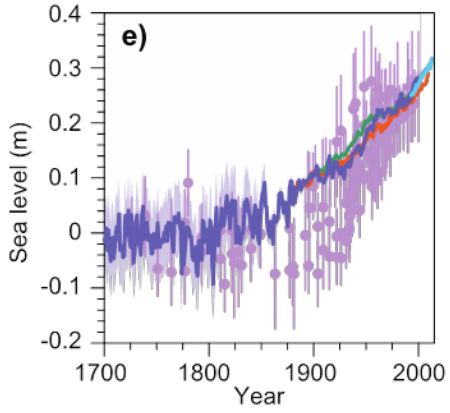




Tide Gauge Reconstructions

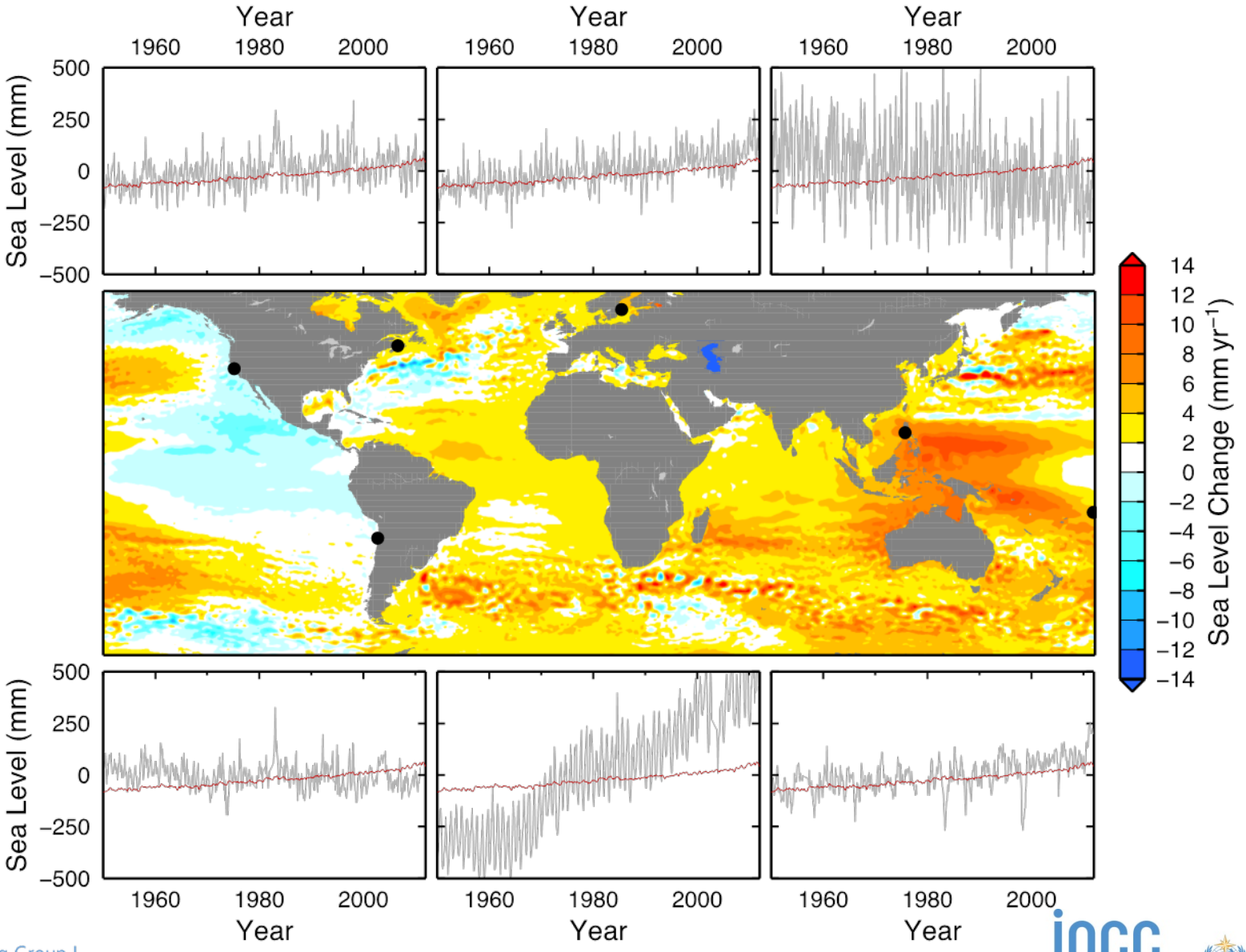
Satellite Altimetry



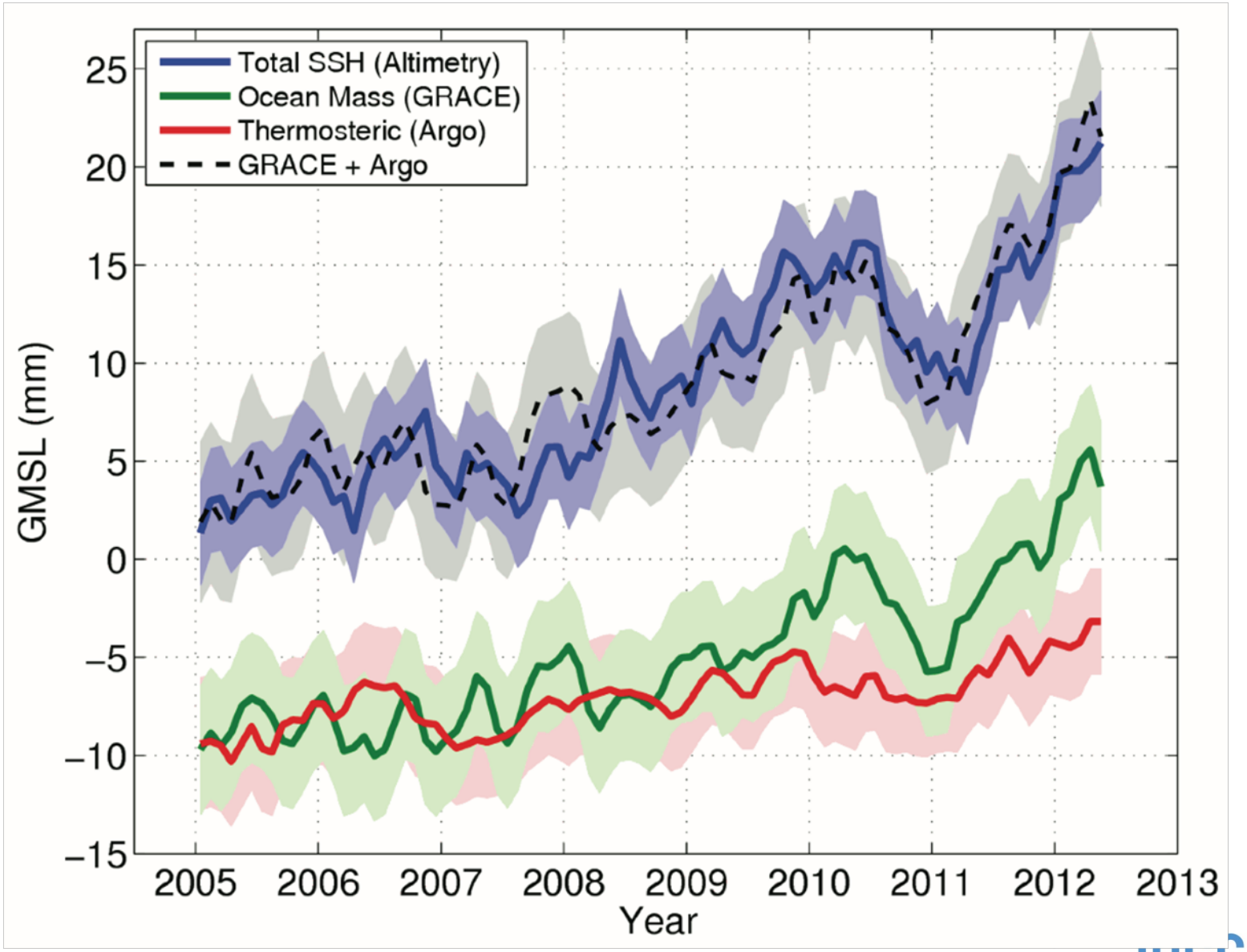


Comparison

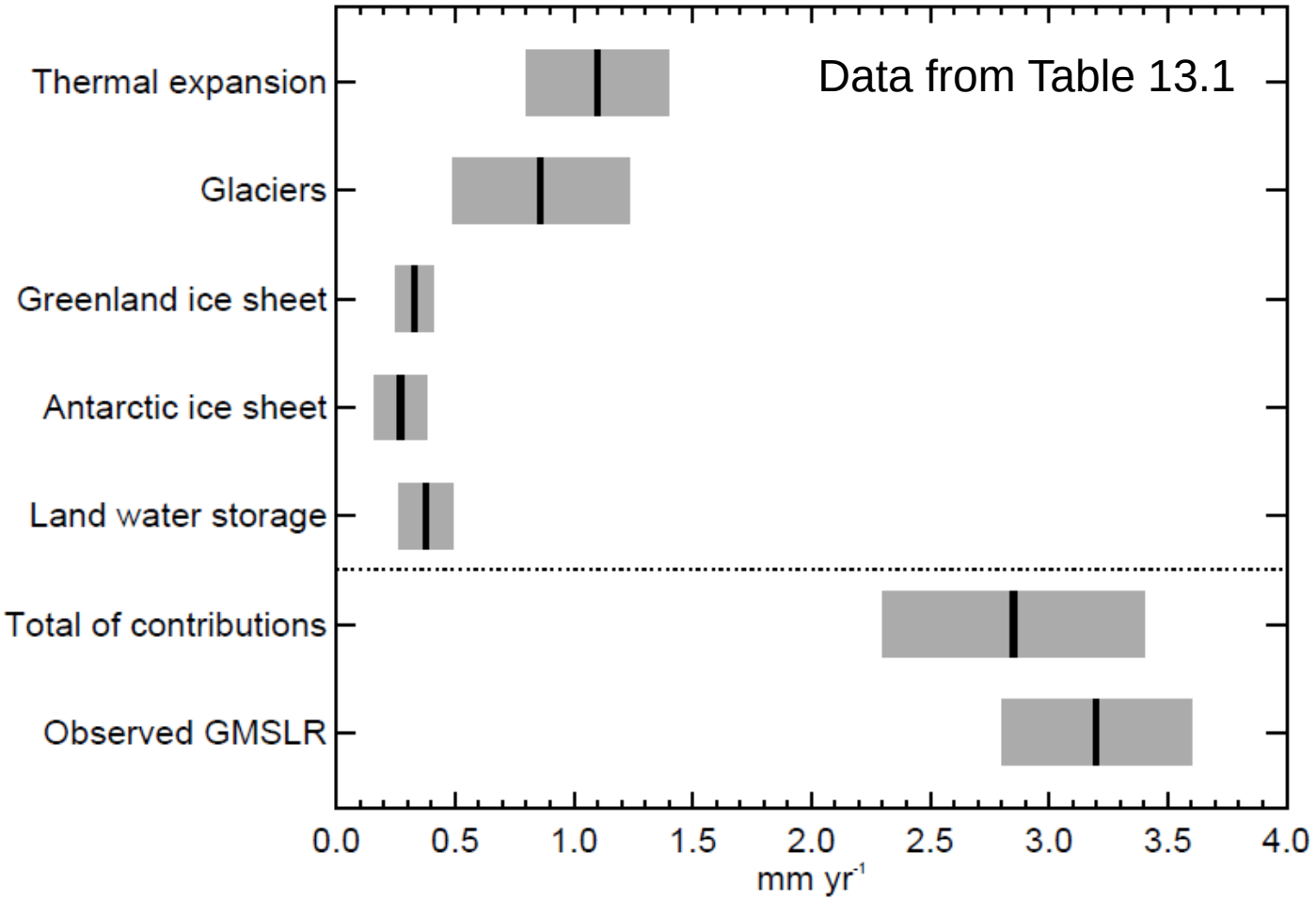
Regional Sea Level Change – FAQ13.1 Figure 1



GMSL Contributions (2005-2012) – Figure 13.6

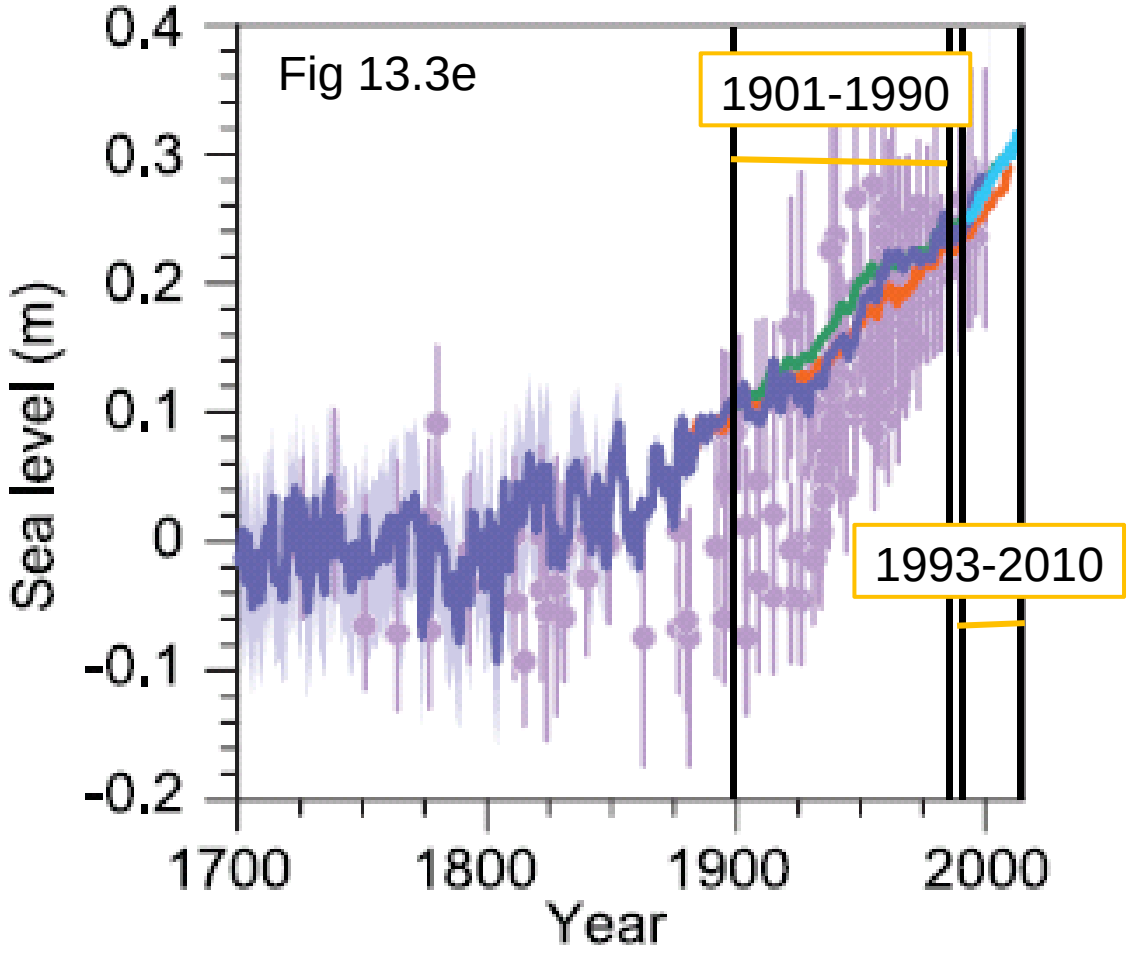


Observed contributions explain observed GMSLR 1993-2010



Rate of GMSLR has been greater since the mid-19th century

Rate during the last two millennia was of order a few tenths of mm yr^{-1}.



Rate during 1901-1990 was 1.5 [1.3 to 1.7] mm yr^{-1}.

Likely that the rate has increased since the early 1900s

Rate during 1993-2010 was 3.2 [2.8 to 3.6] mm yr^{-1}.

High confidence in projections of thermal expansion

Good observational estimates

Consistency of historical simulations with observations

Better understanding of the Earth energy budget

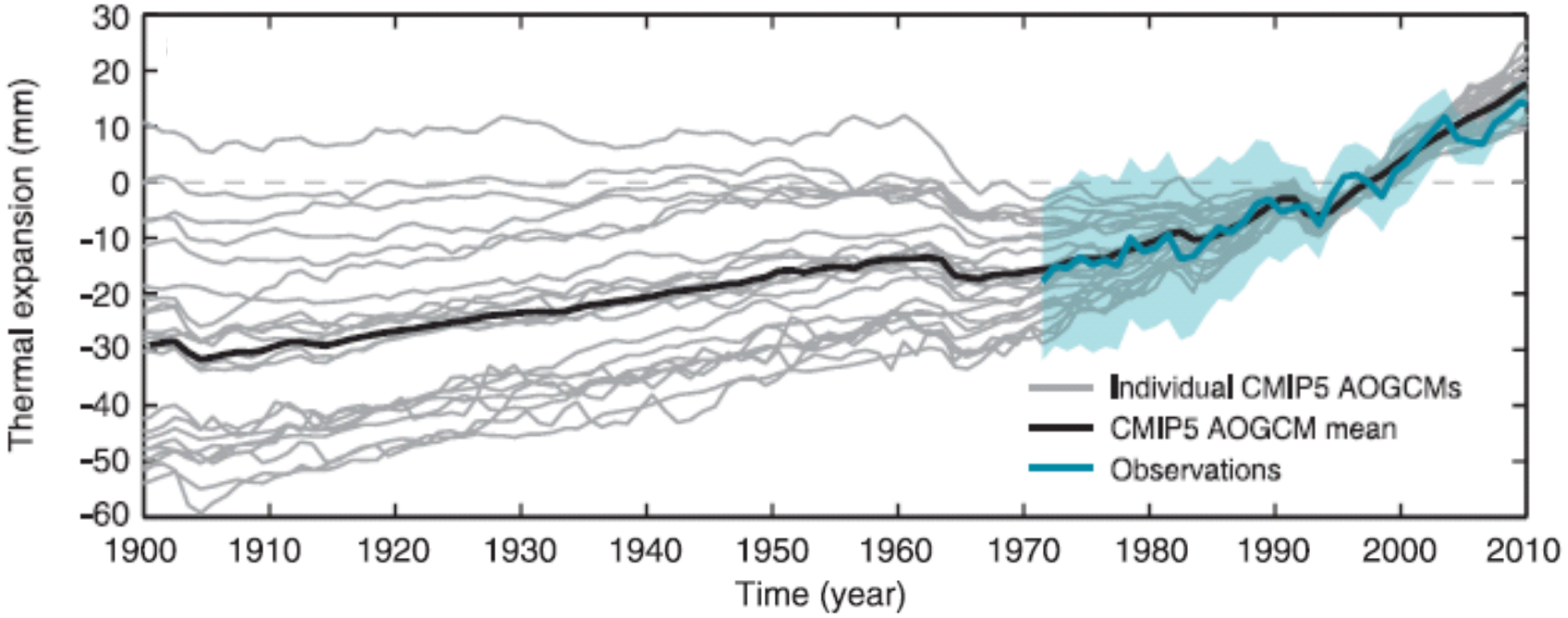
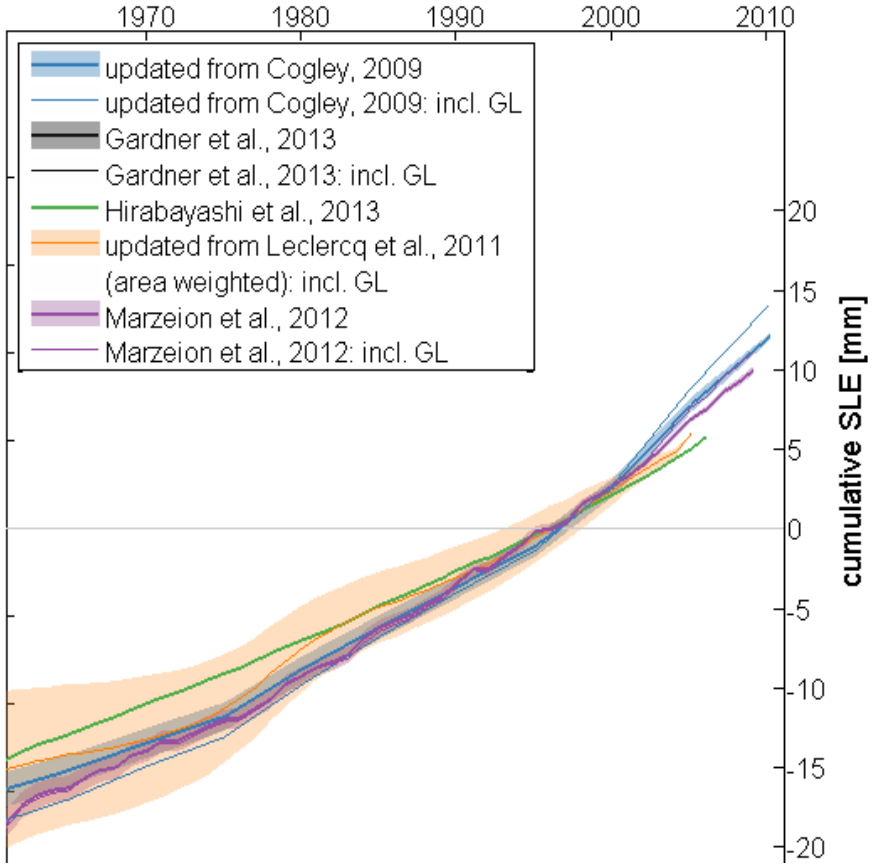


Fig 13.4a, change relative to 1986-2005

Medium confidence in projections of glacier mass loss



Observationally based estimates of past glacier mass loss, Figure 4.12b

Consistency of historical simulations with observations

Process-based understanding

But the set of well-observed glaciers is a very small fraction of the total.

Projections of the mass loss from the Greenland ice sheet

Good agreement between observational and model-based estimates of recent changes in the mass balance of the Greenland ice sheet.

About half of the increase in mass loss is due to surface mass loss.

High confidence in projections of increasing surface mass loss.

Likely range (*medium confidence*) for the projected contribution from dynamical change, estimated by modelling the main outlet glaciers.

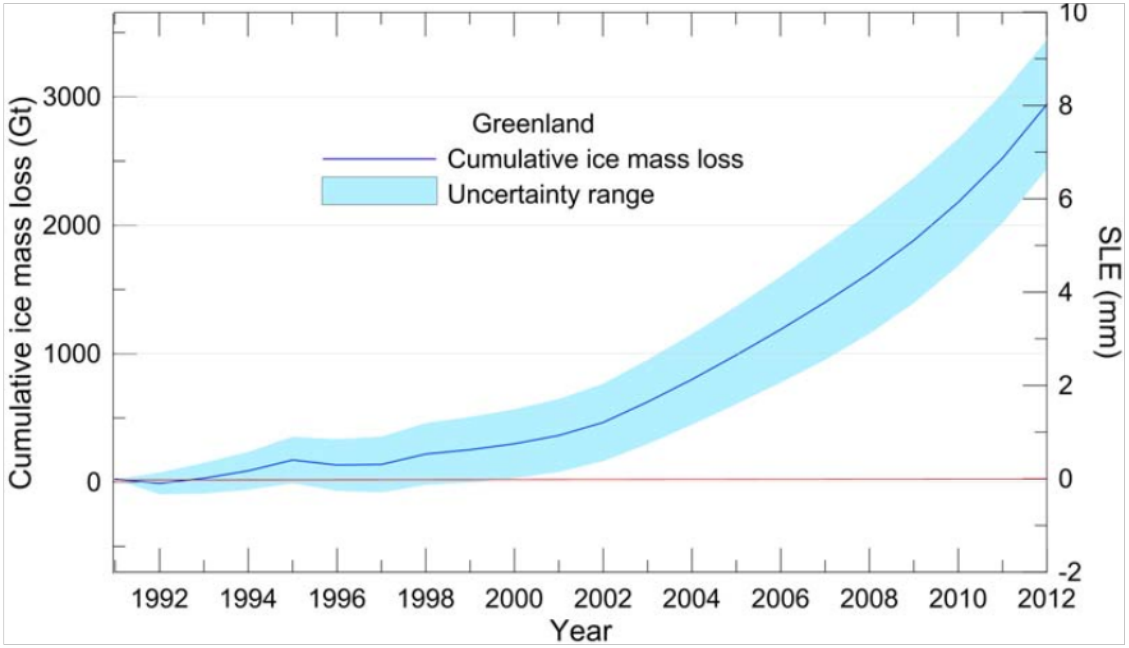


Figure 4.15

Projections of the mass loss from the Antarctic ice sheet

Medium confidence in model simulation of Antarctic snow accumulation.

High confidence that snowfall will increase if Antarctica becomes warmer.

Observed temperature trends to date are weak. Therefore *medium confidence* in projections of increasing snow fall and consequent mass accumulation.

Likely range (*medium confidence*) for the projected contribution from dynamical change, estimated from a combination of process-based modelling, statistical extrapolation of recent trends, and informed judgement.

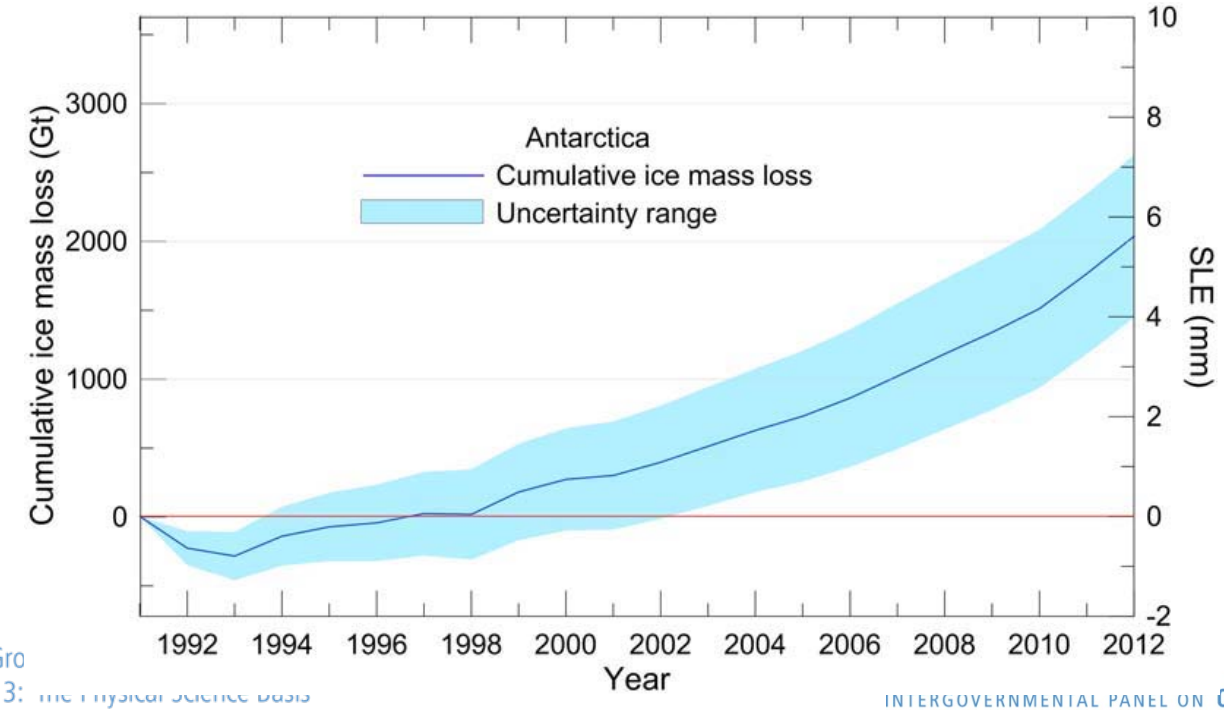
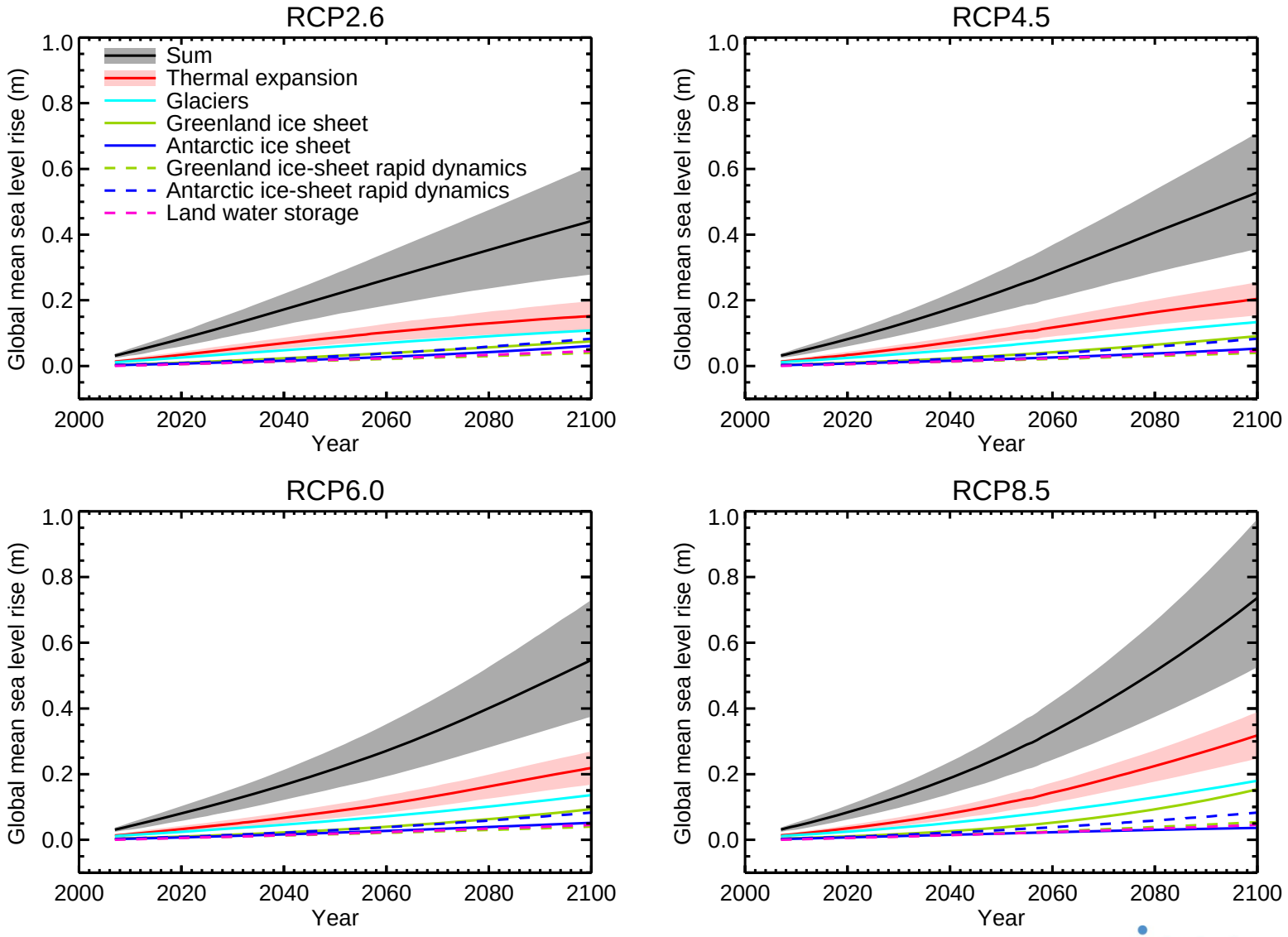
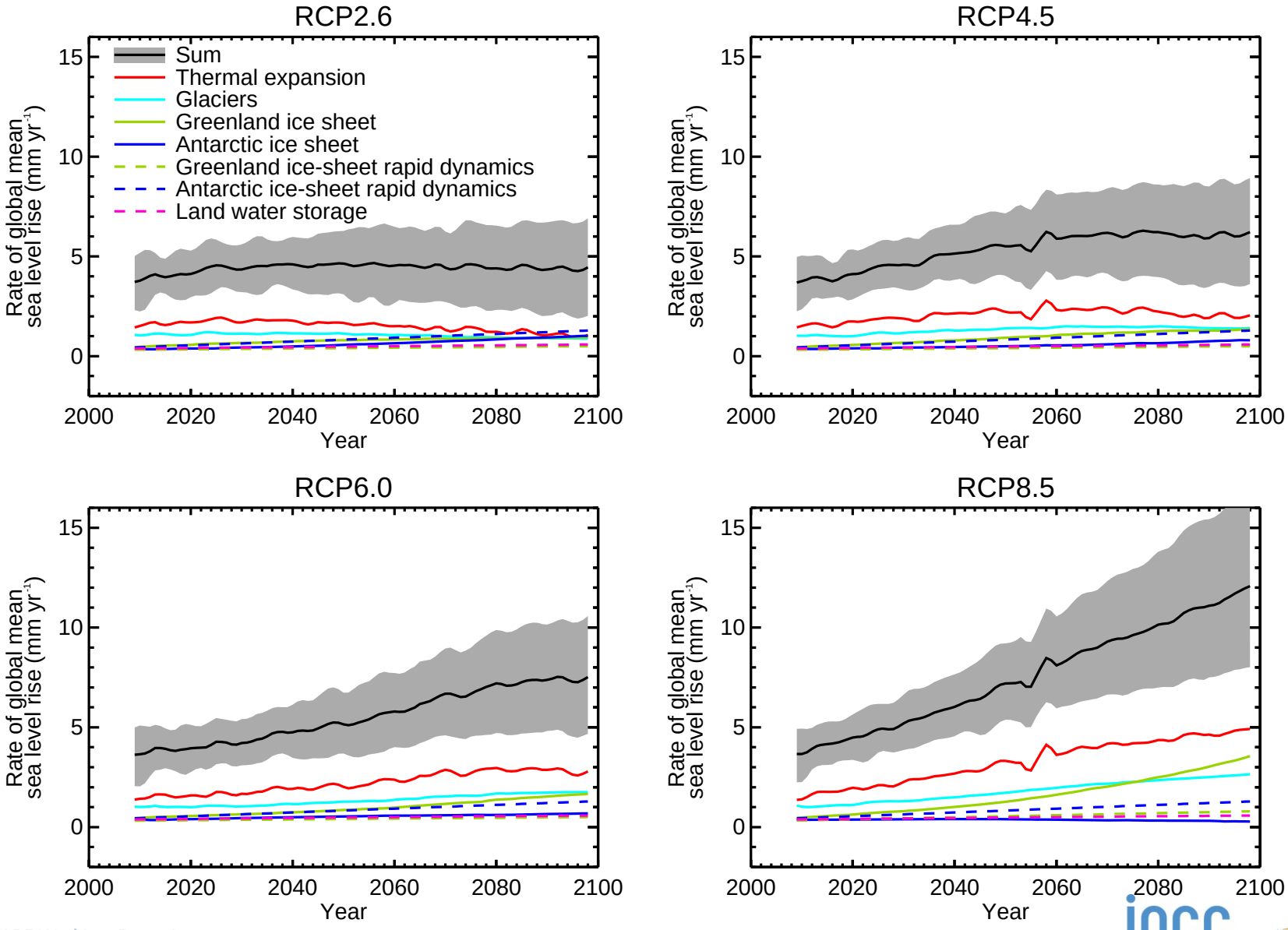


Figure 4.16

Projected GMSL Change – Figure 13.11a

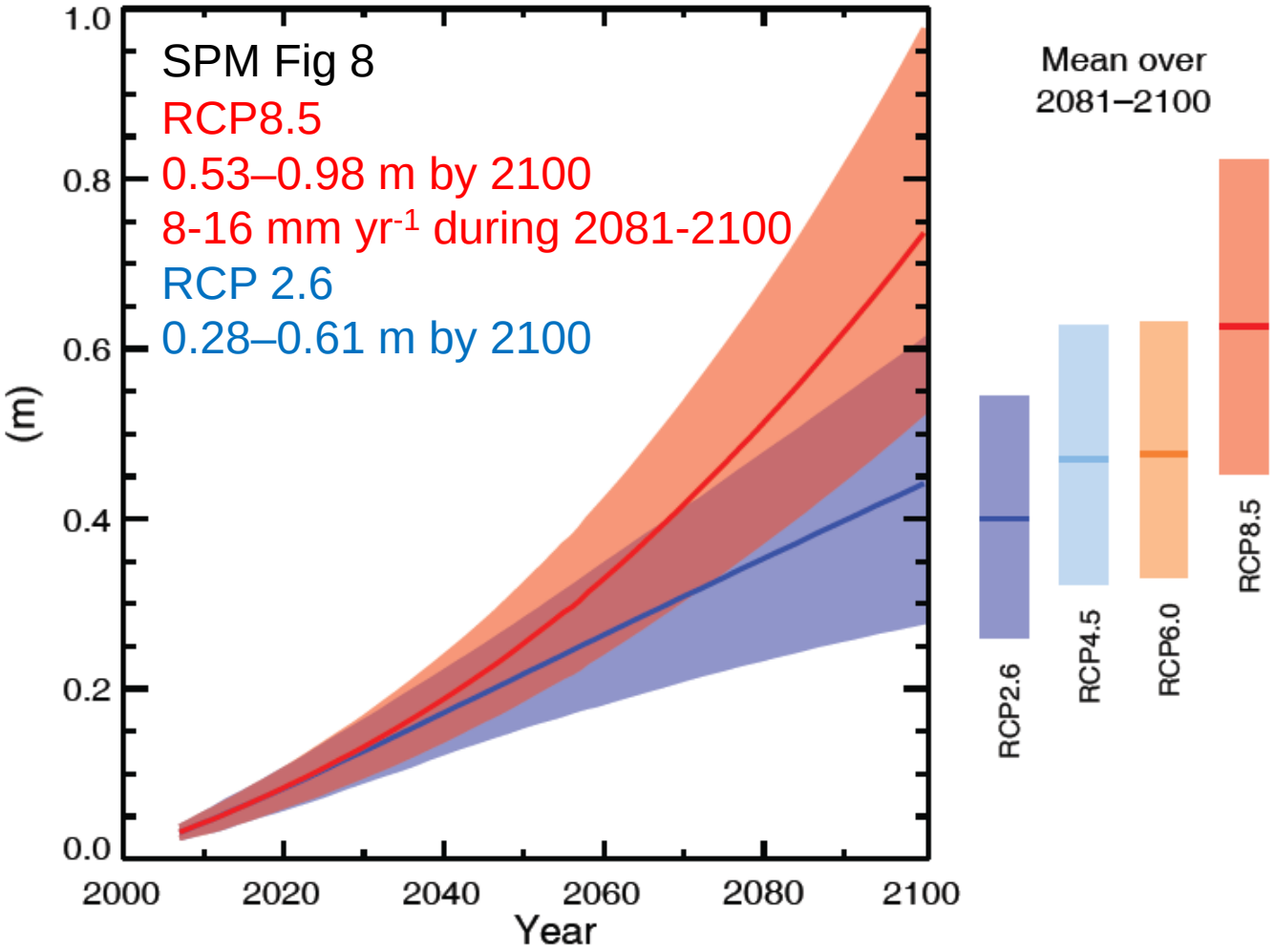


Projected Rate of Sea Level Change – Figure 13.11b

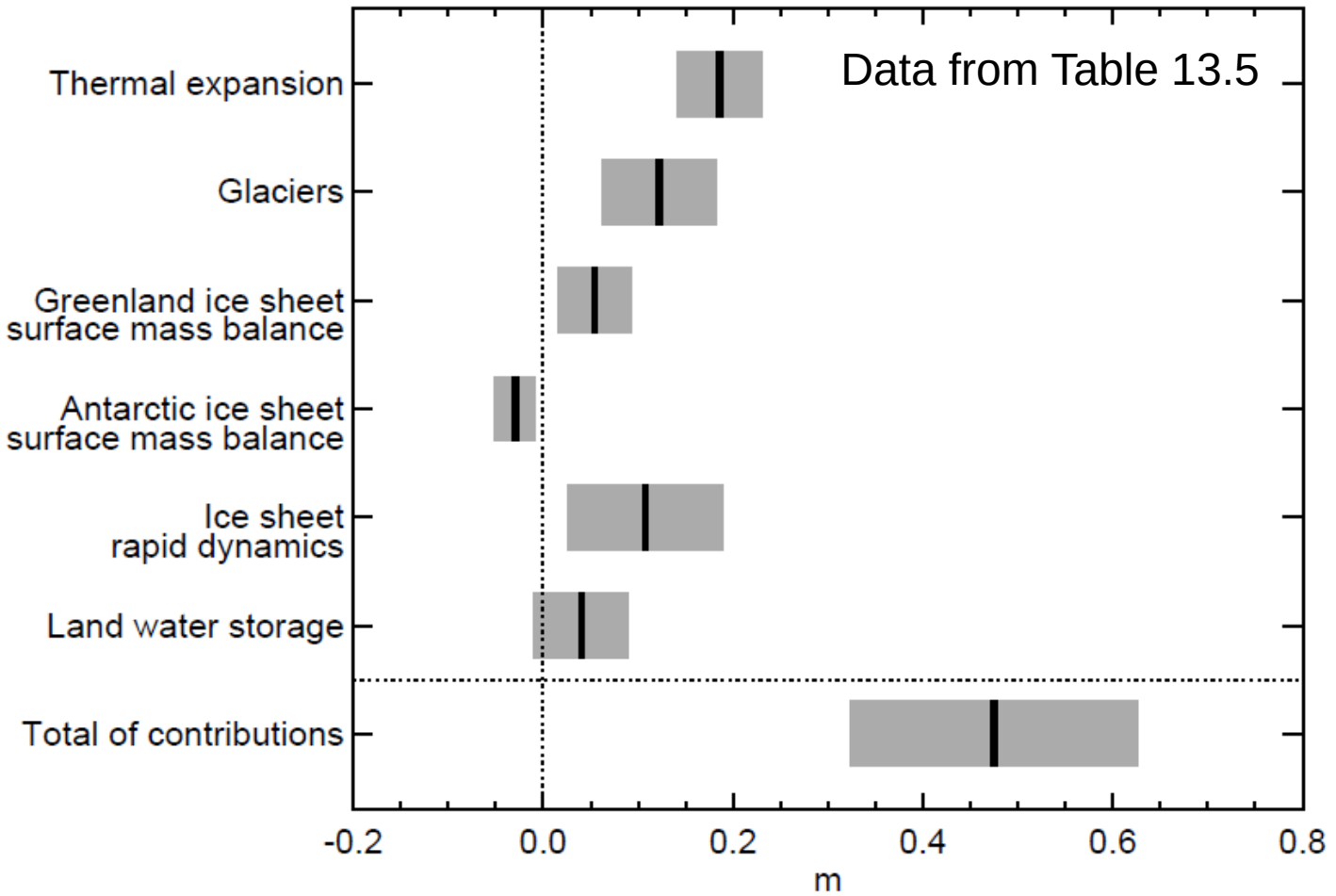


Projections of 21st-century GMSLR under RCPs

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

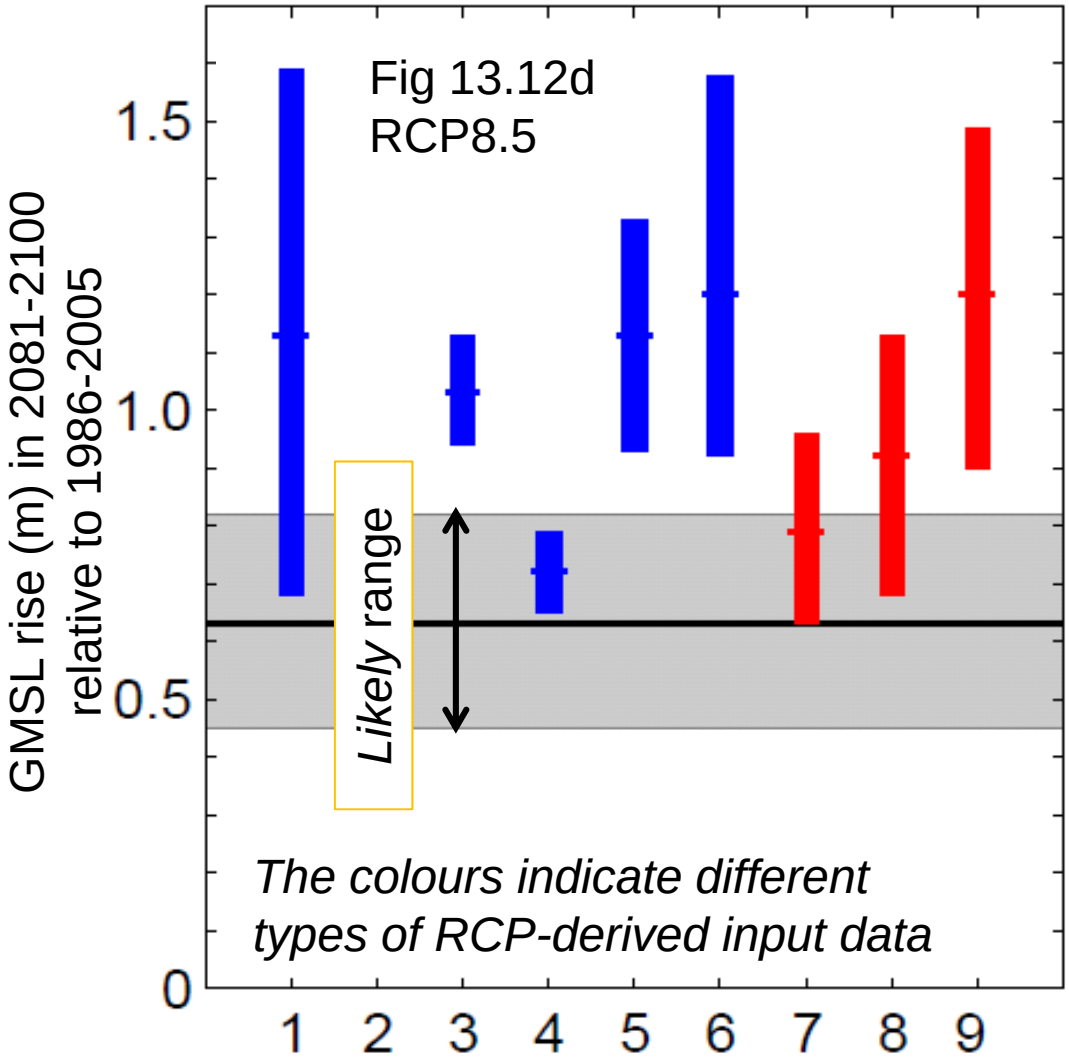


Projection for 2081-2100 under RCP4.5



For a given scenario, the largest increase compared with AR4 is from the inclusion of rapid changes in Greenland and Antarctic ice-sheet outflow.

Low confidence in the projections of semi-empirical models

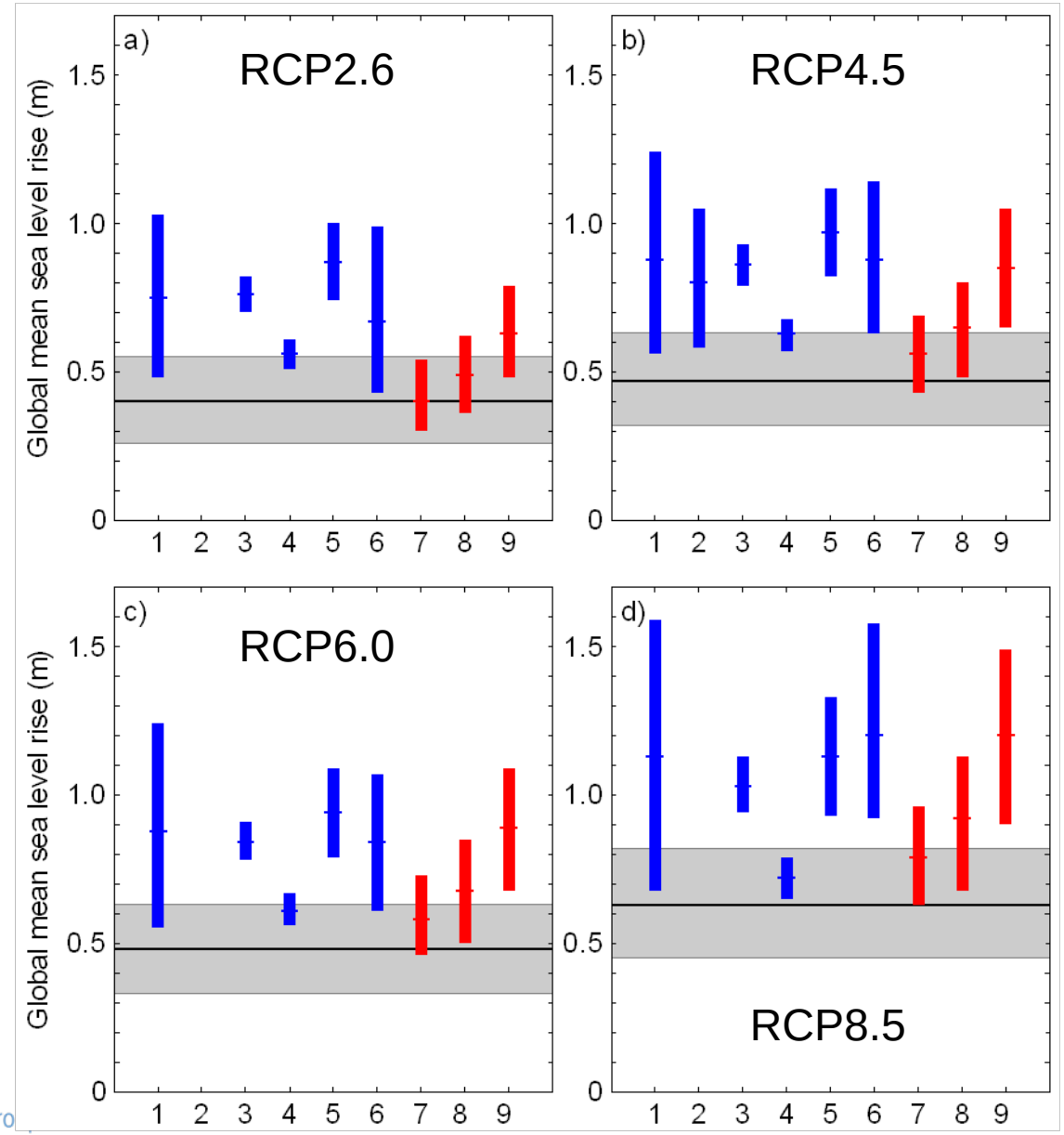


In nearly every case, the semi-empirical model 95-percentile is higher than the process-based *likely* range.

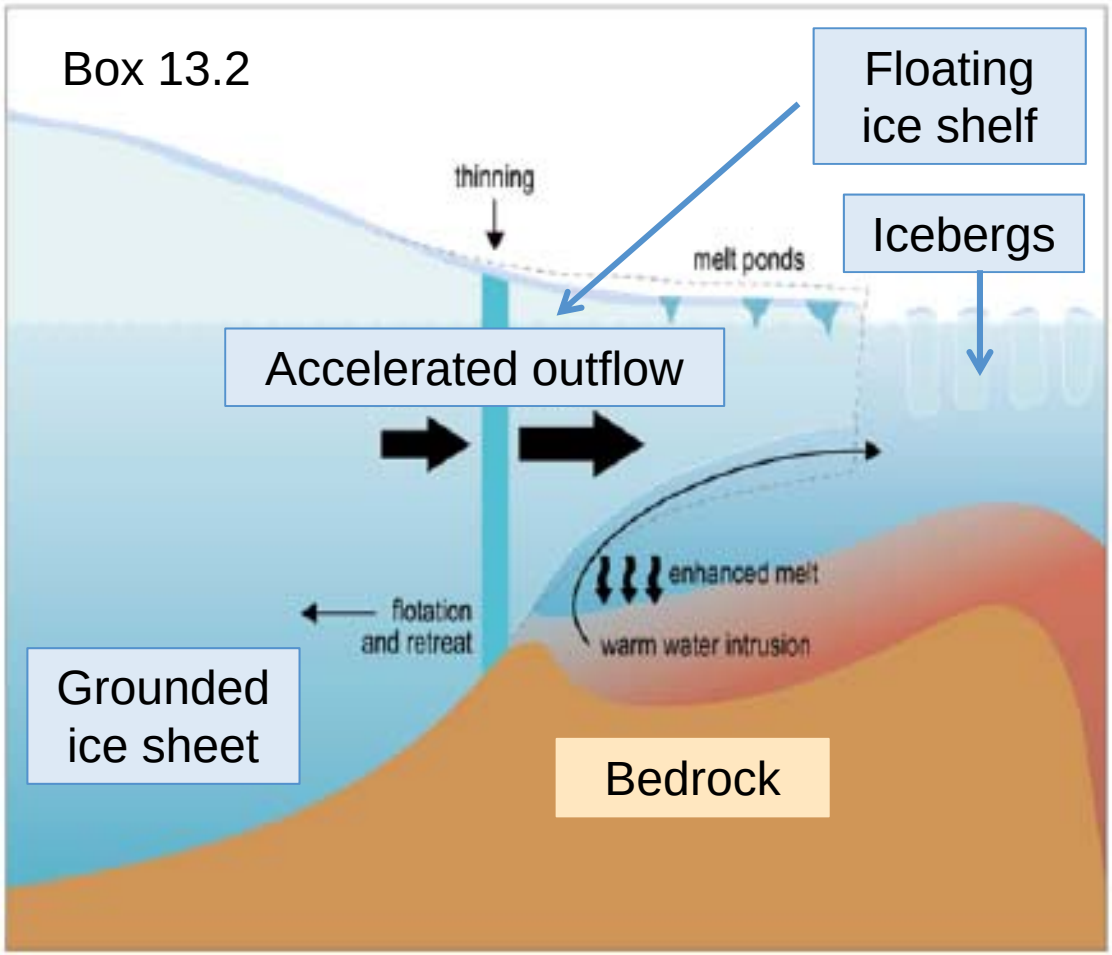
There is no consensus in the scientific community about the reliability of semi-empirical model projections.

There is no evidence that ice-sheet dynamical change is the explanation for the higher projections.

Semi-Empirical Model GMSL Projections – Figure 13.12



Rapid increase in ice sheet outflow

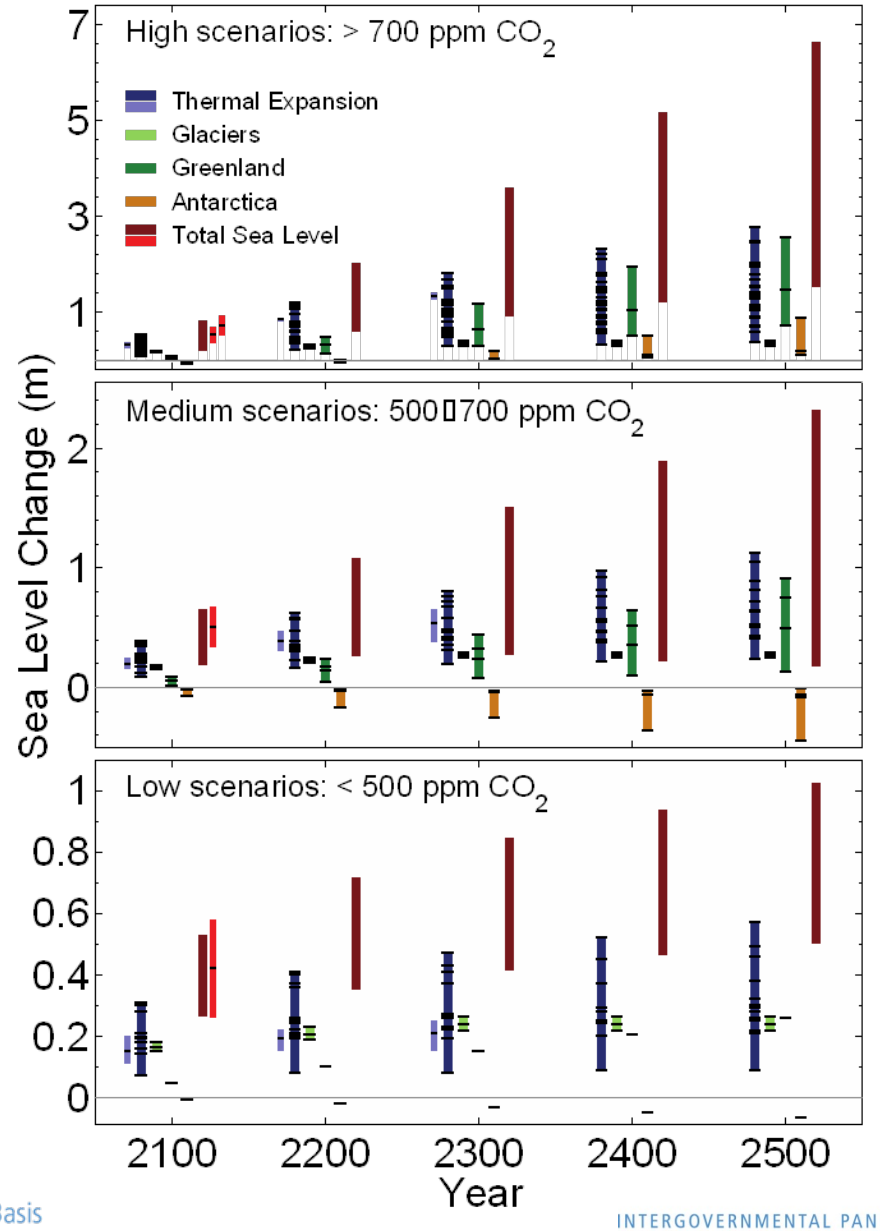


Only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause GMSL to rise substantially above the *likely* range during the 21st century.

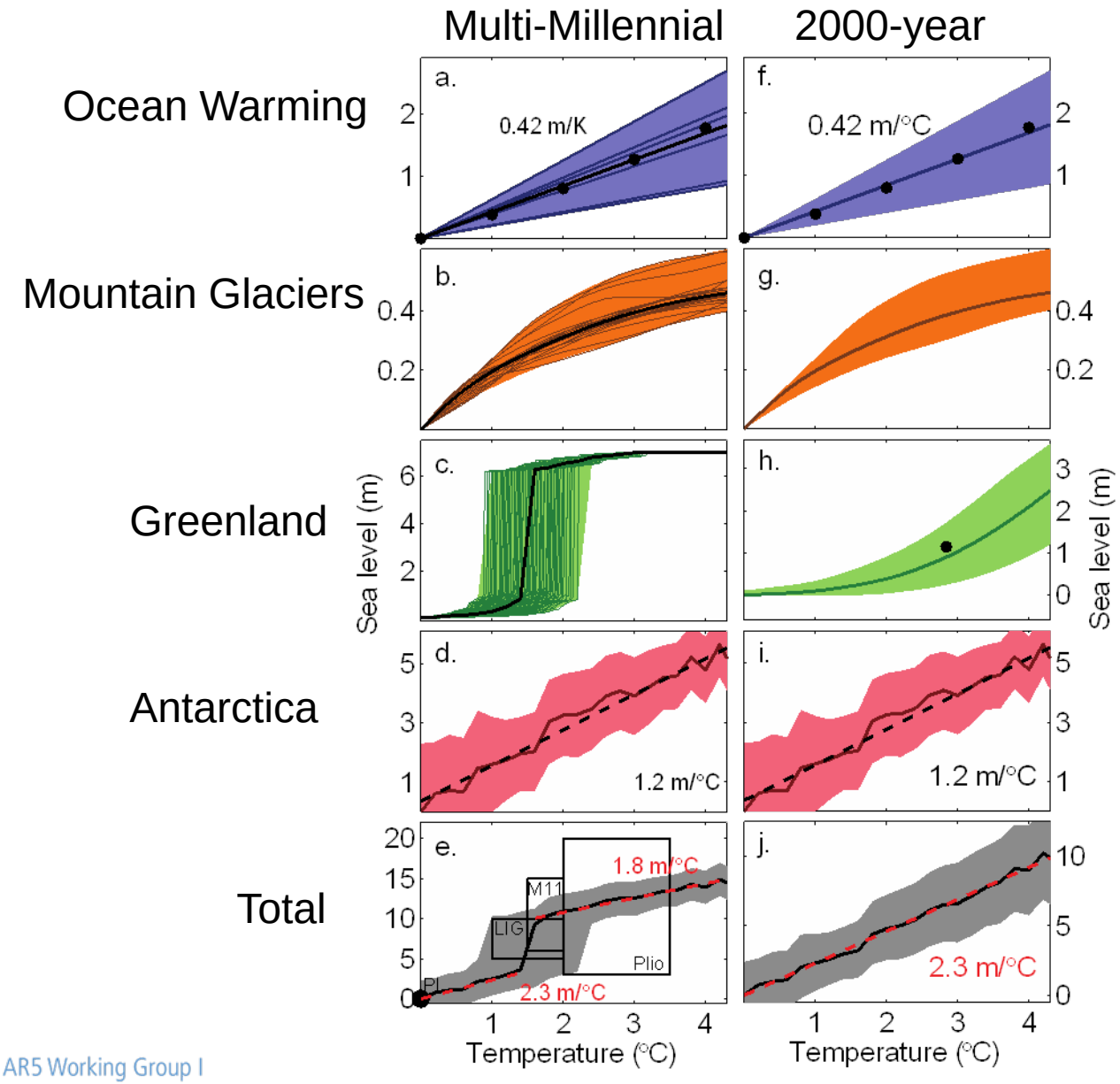
Medium confidence that this additional contribution would not exceed several tenths of a metre.

Current evidence and understanding do not allow a quantification of either the timing of its onset or of the magnitude of its multi-century contribution.

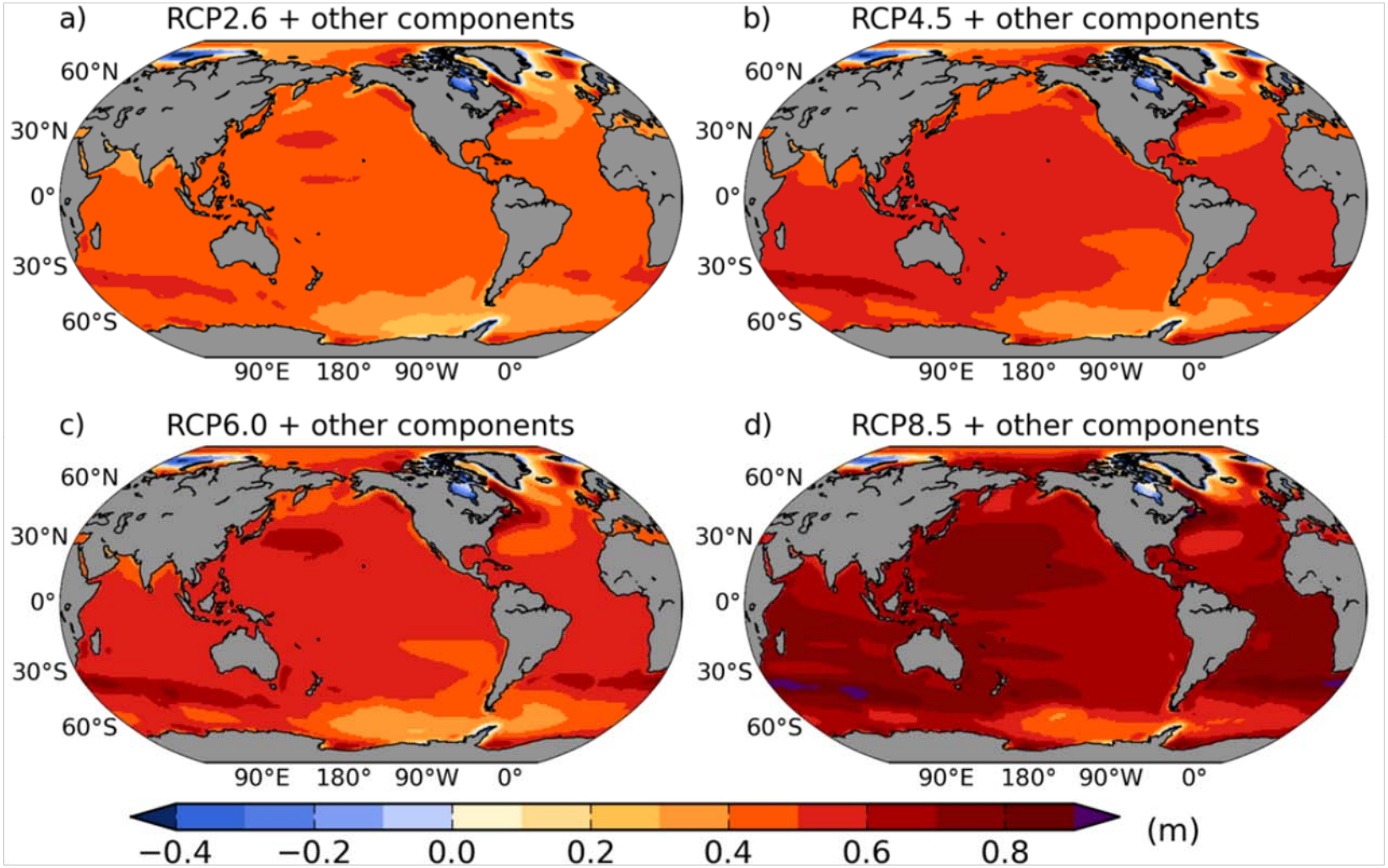
GMSL Projections Beyond 2100 – Figure 13.13



Sea Level Commitment – Figure 13.14



Regional Variations in Sea Level Change between 1986-2005 and 2081-2100 – Figure 13.20



Regional sea level rise by the end of the 21st century

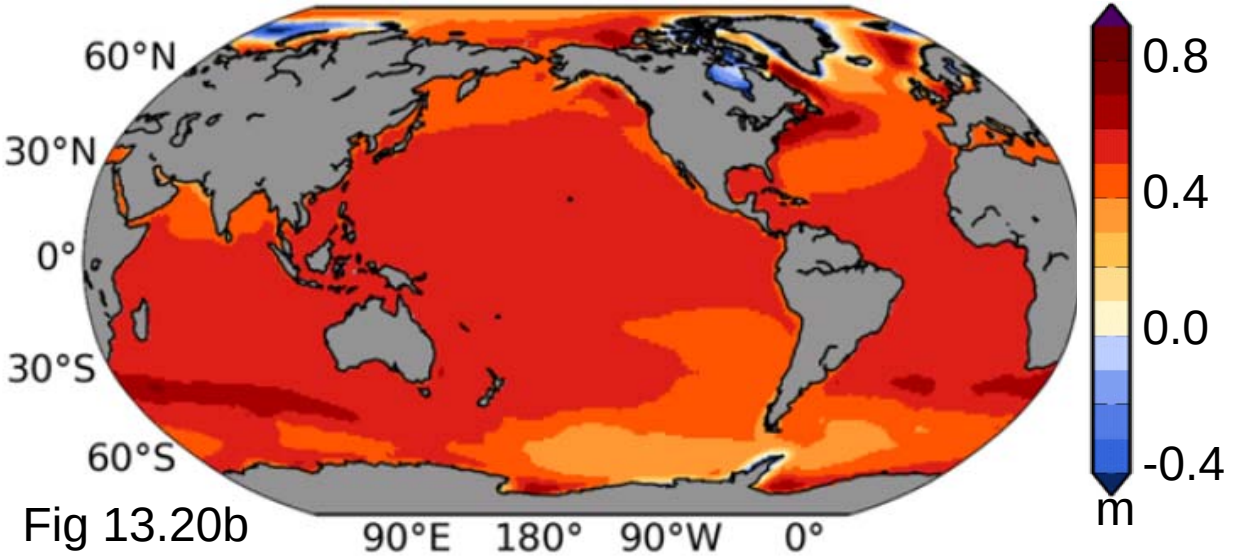


Fig 13.20b

It is *very likely* that sea level will rise in more than about 95% of the ocean area.

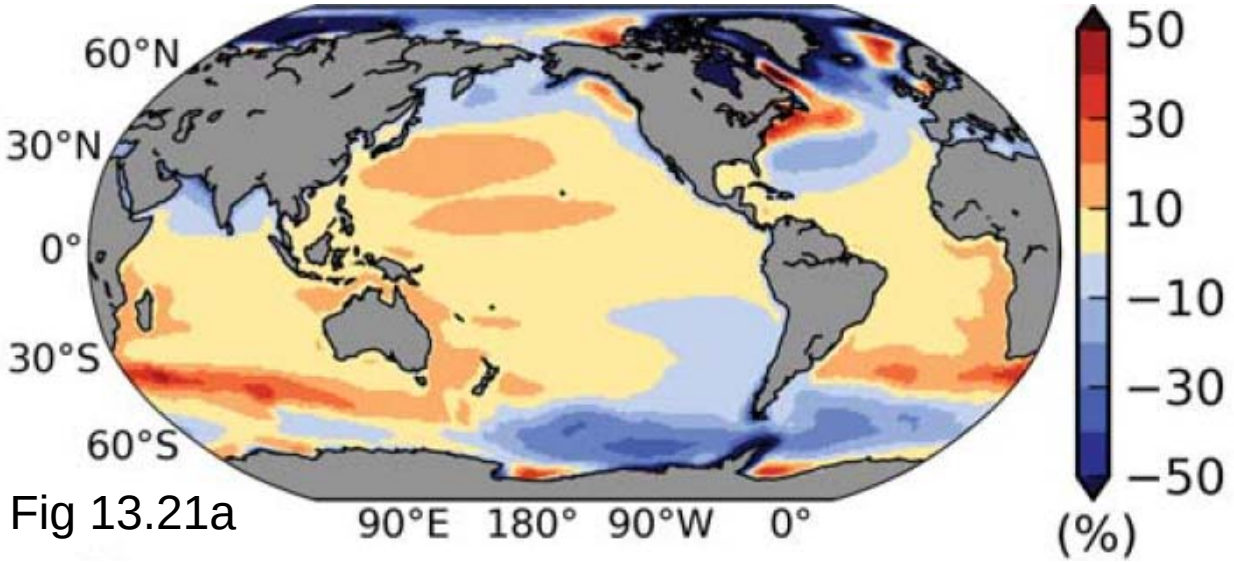


Fig 13.21a

About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change.

Summary of main points

GMSLR during 1901–2010 can be accounted for by ocean thermal expansion, ice loss by glaciers and ice sheets, and change in liquid water storage on land.

It is *very likely* that the 21st-century mean rate of GMSLR under all RCPs will exceed that of 1971–2010, due to the same processes.

A *likely* range of GMSLR for 2081–2100 compared with 1986–2005, depending on emissions (0.40 [0.26–0.55] m for RCP2.6, 0.63 [0.45–0.82] m for RCP8.5), can be projected with *medium confidence*, including the contribution from ice-sheet rapid dynamics. The collapse of marine-based sectors of the Antarctic Ice Sheet, if initiated, would add no more than several tenths of a meter during the 21st century (*medium confidence*).

It is *very likely* that sea level will rise in more than about 95% of the ocean area.

It is *very likely* that there will be a significant increase in the occurrence of future sea level extremes.

It is *virtually certain* that global mean sea level rise will continue for many centuries beyond 2100, with the amount of rise dependent on future emissions.

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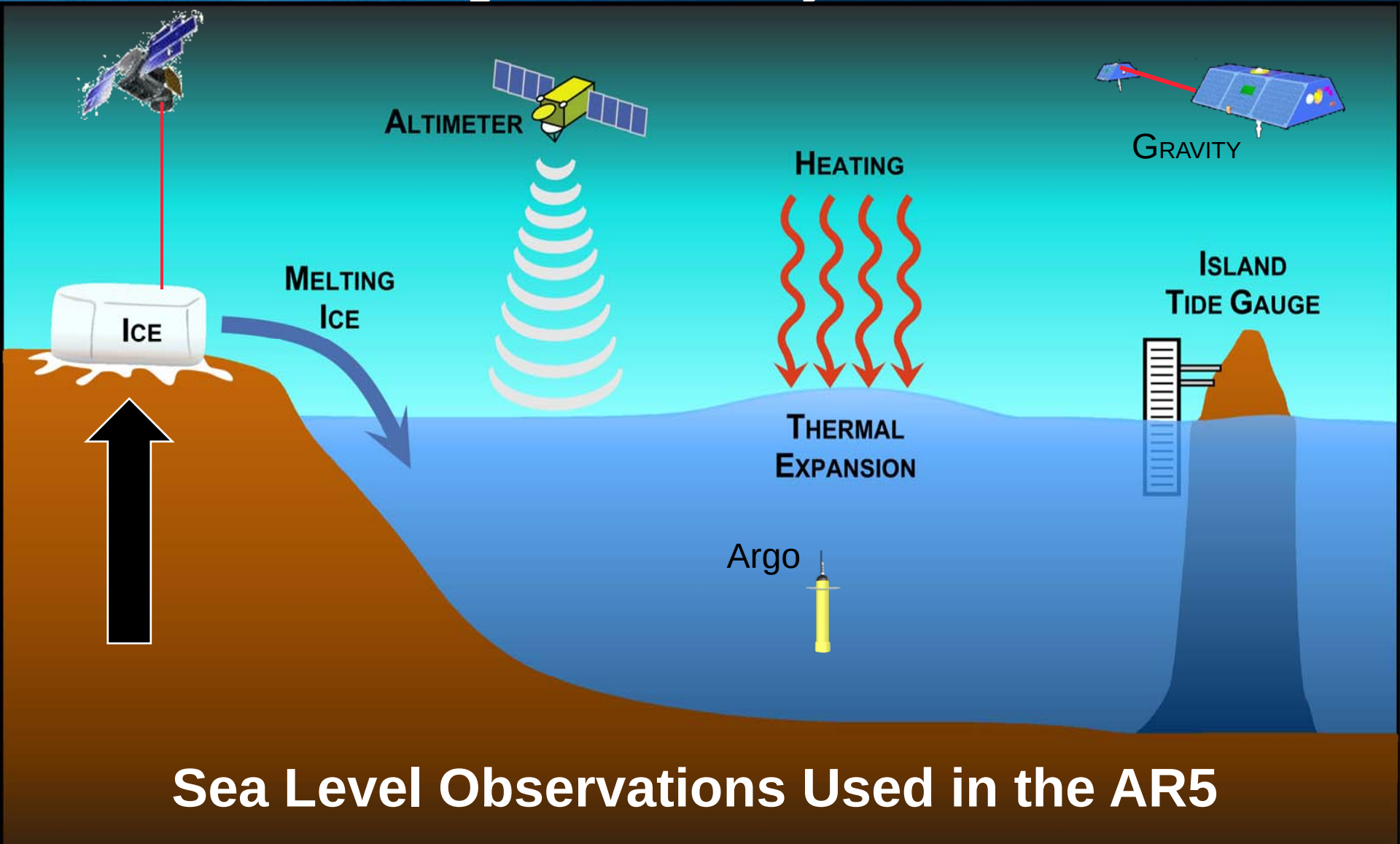
Working Group I contribution to the IPCC Fifth Assessment Report

Further Information

www.climatechange2013.org

Backup Slides

Climate Change 2013: The Physical Science Basis



Sea Level Observations Used in the AR5

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP

Commitment to sea level rise and irreversibility

It is *virtually certain* that global mean sea level rise will continue for many centuries beyond 2100, with the amount of rise dependent on future emissions.

Medium confidence that GMSL rise by 2300 will be less than 1 m for a radiative forcing corresponding to CO_2 concentrations below 500 ppm, but 1 to more than 3 m for 700–1500 ppm.

Larger sea level rise could result from sustained mass loss by ice sheets, and some part of the mass loss might be irreversible.

Sustained warming greater than a certain threshold above preindustrial would lead to the near-complete loss of the Greenland ice sheet (*high confidence*). The threshold is estimated to be greater than 1°C but less than 4°C global mean warming with respect to preindustrial.

Collapse of marine-based sectors of the Antarctic ice sheet

Only this effect, if initiated, could cause GMSL to rise substantially above the *likely* range during the 21st century.

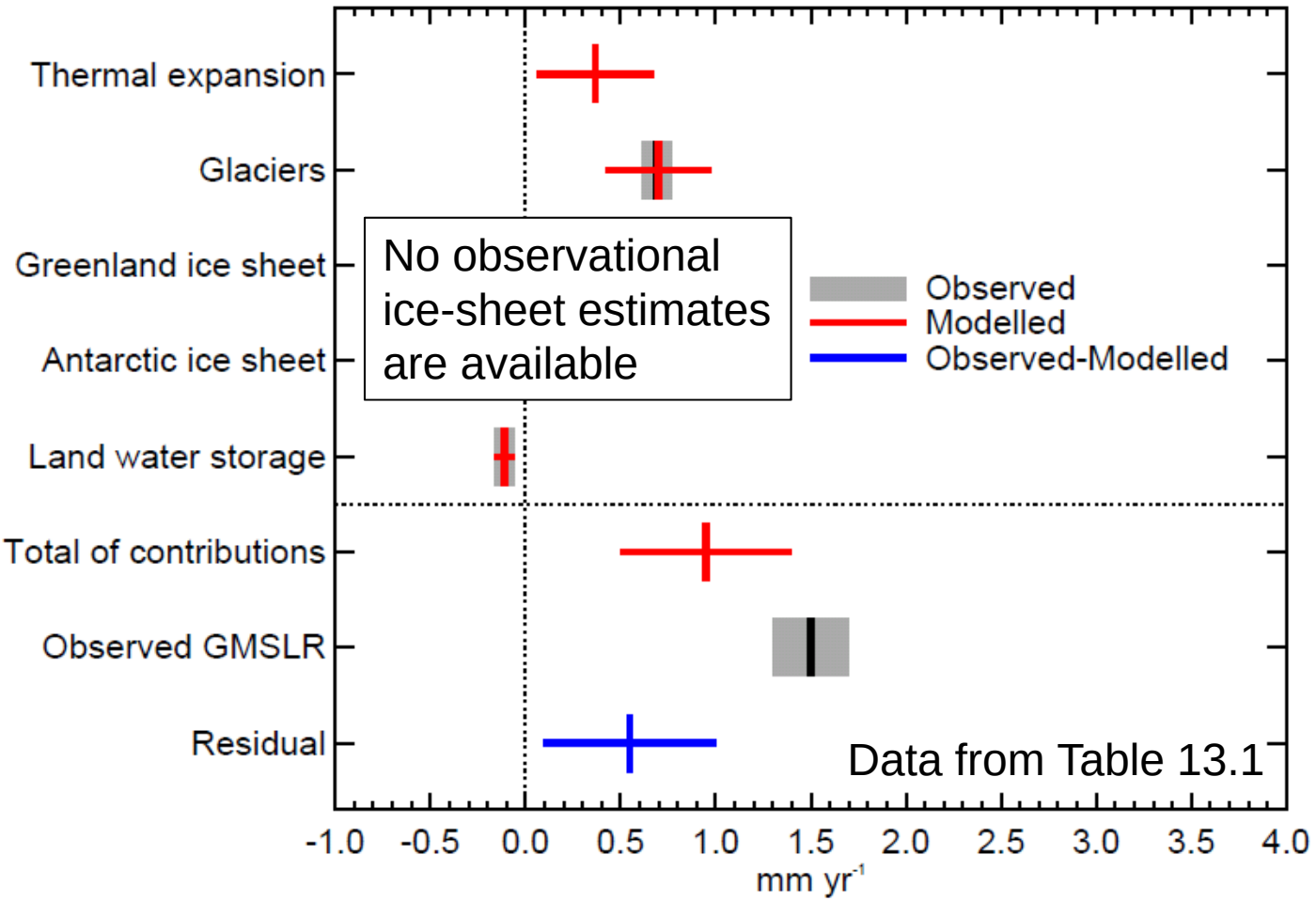
Medium confidence that this additional contribution would not exceed several tenths of a metre.

Current evidence and understanding do not allow a quantification of either the timing of its onset or of the magnitude of its multi-century contribution.

Expansion + glaciers explain most of GMSLR 1901-1990

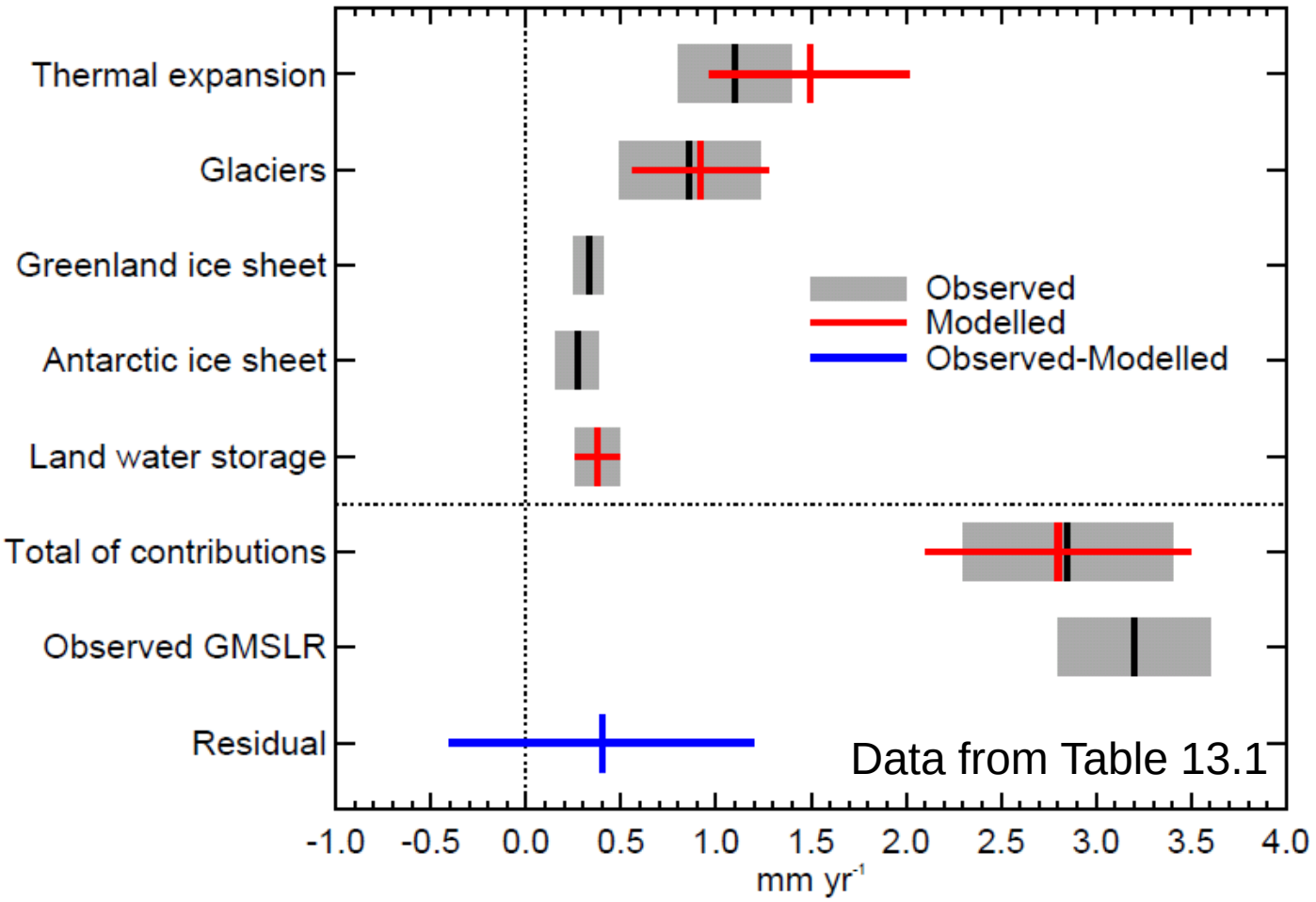
The remainder could be explained by mass loss from the Greenland ice sheet (especially during the early 20th century) and the Antarctic ice sheet (long-term).

Expansion + glaciers explain most of GMSLR 1901-1990

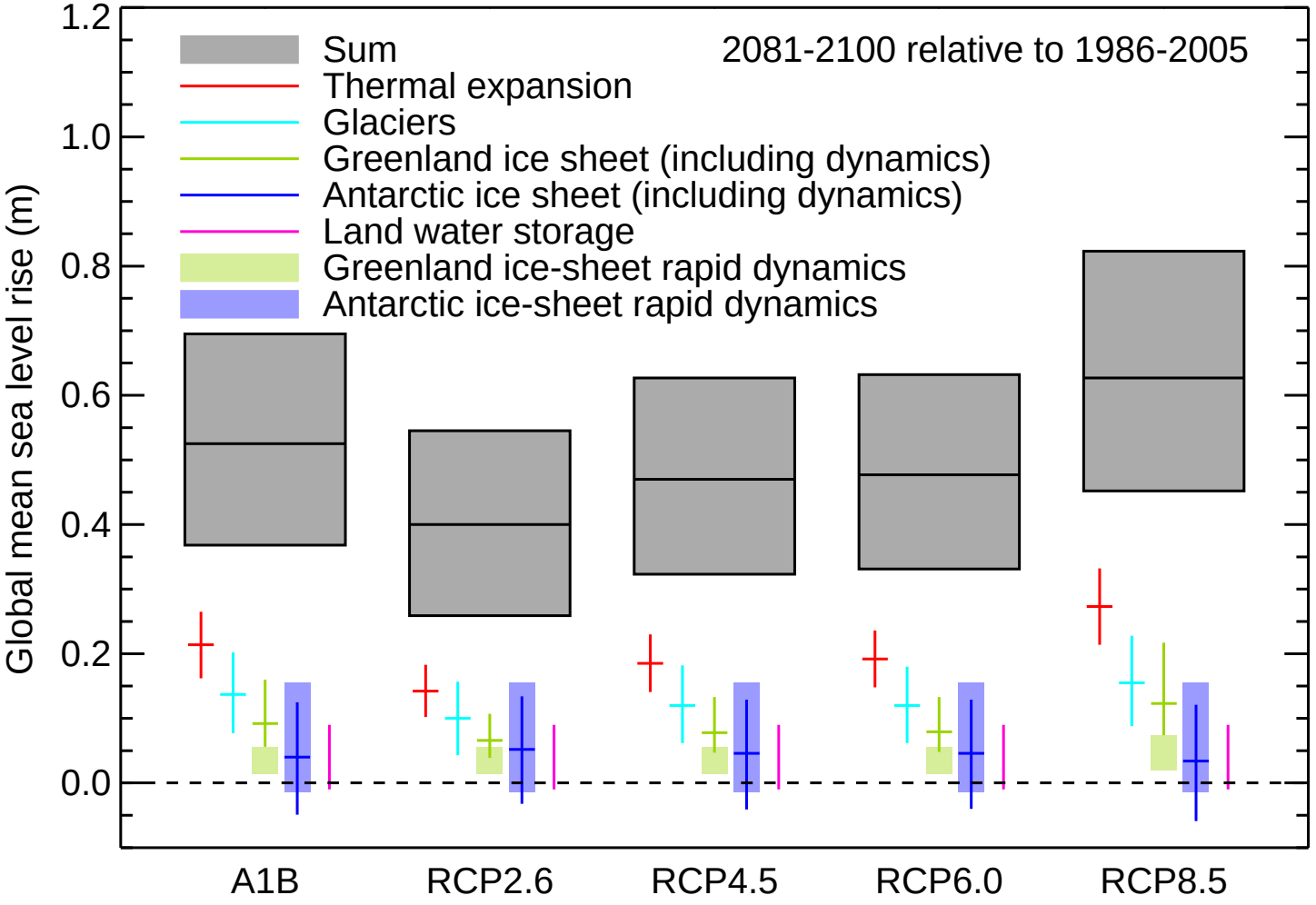


The remainder could be explained by mass loss from the Greenland ice sheet (especially during the early 20th century) and the Antarctic ice sheet (long-term).

Observed contributions explain observed GMSLR 1993-2010



Projected GMSL Change – Figure 13.10



Regional sea level rise by the end of the 21st century

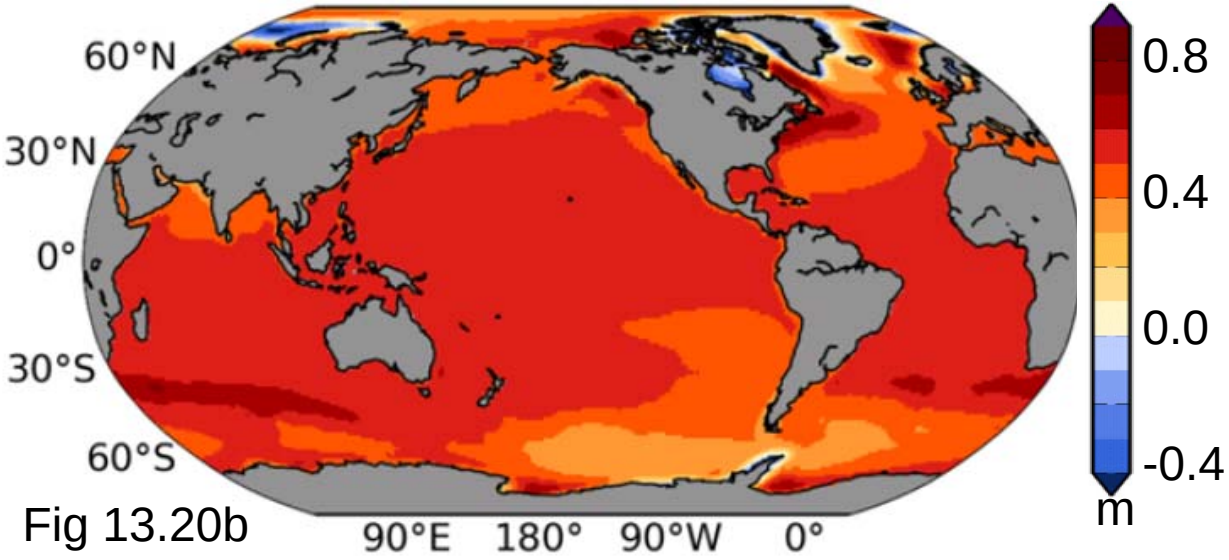


Fig 13.20b

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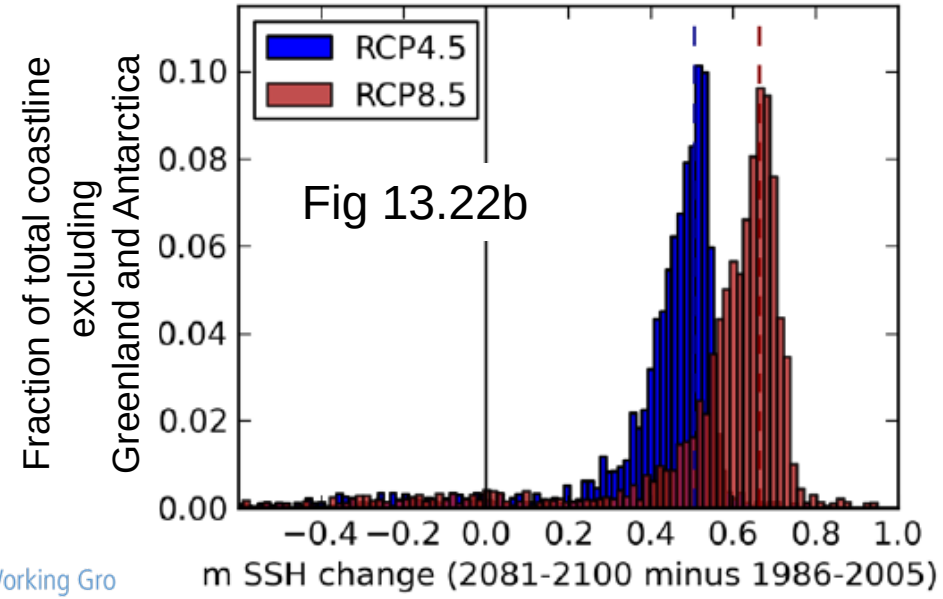
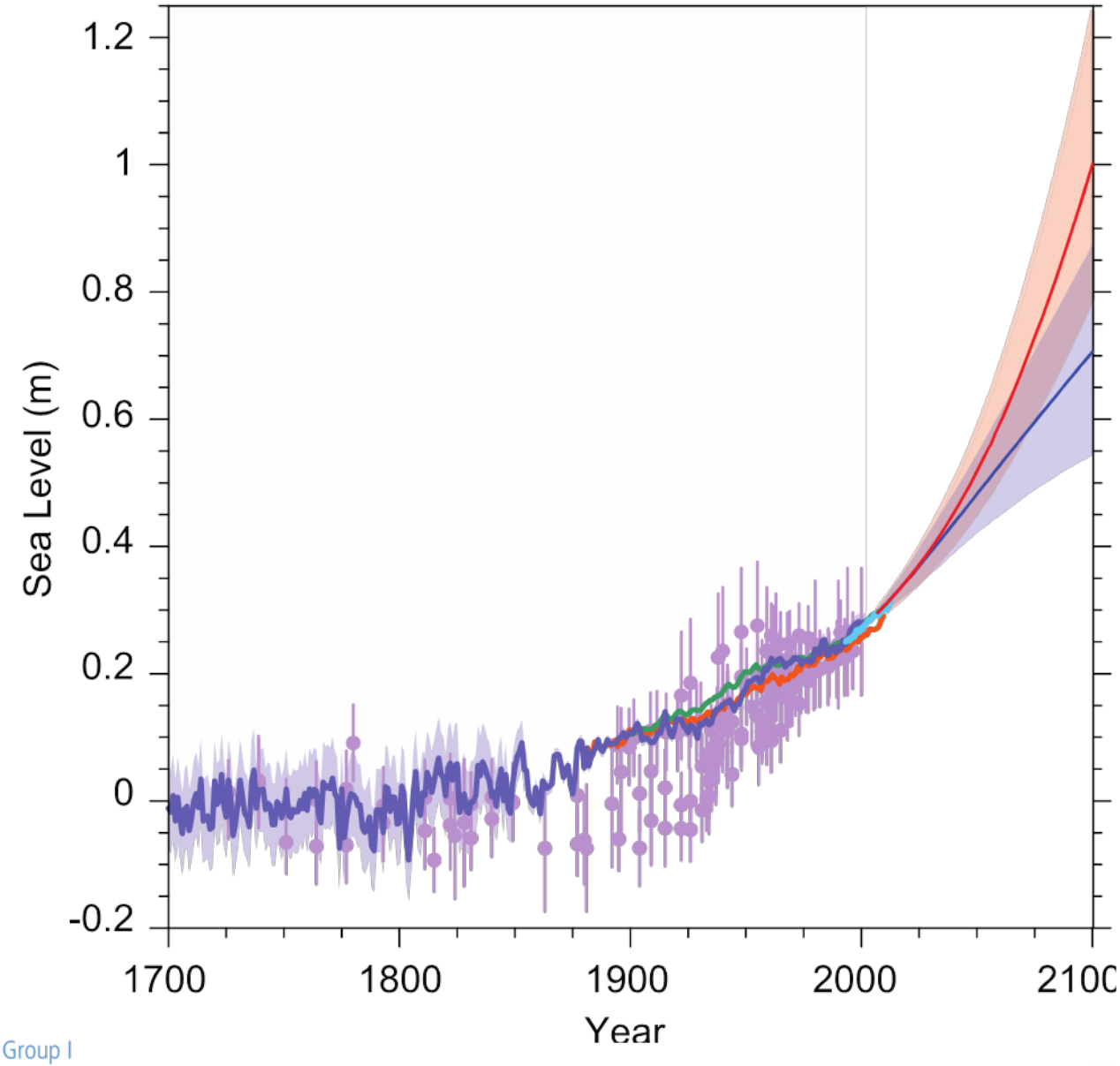


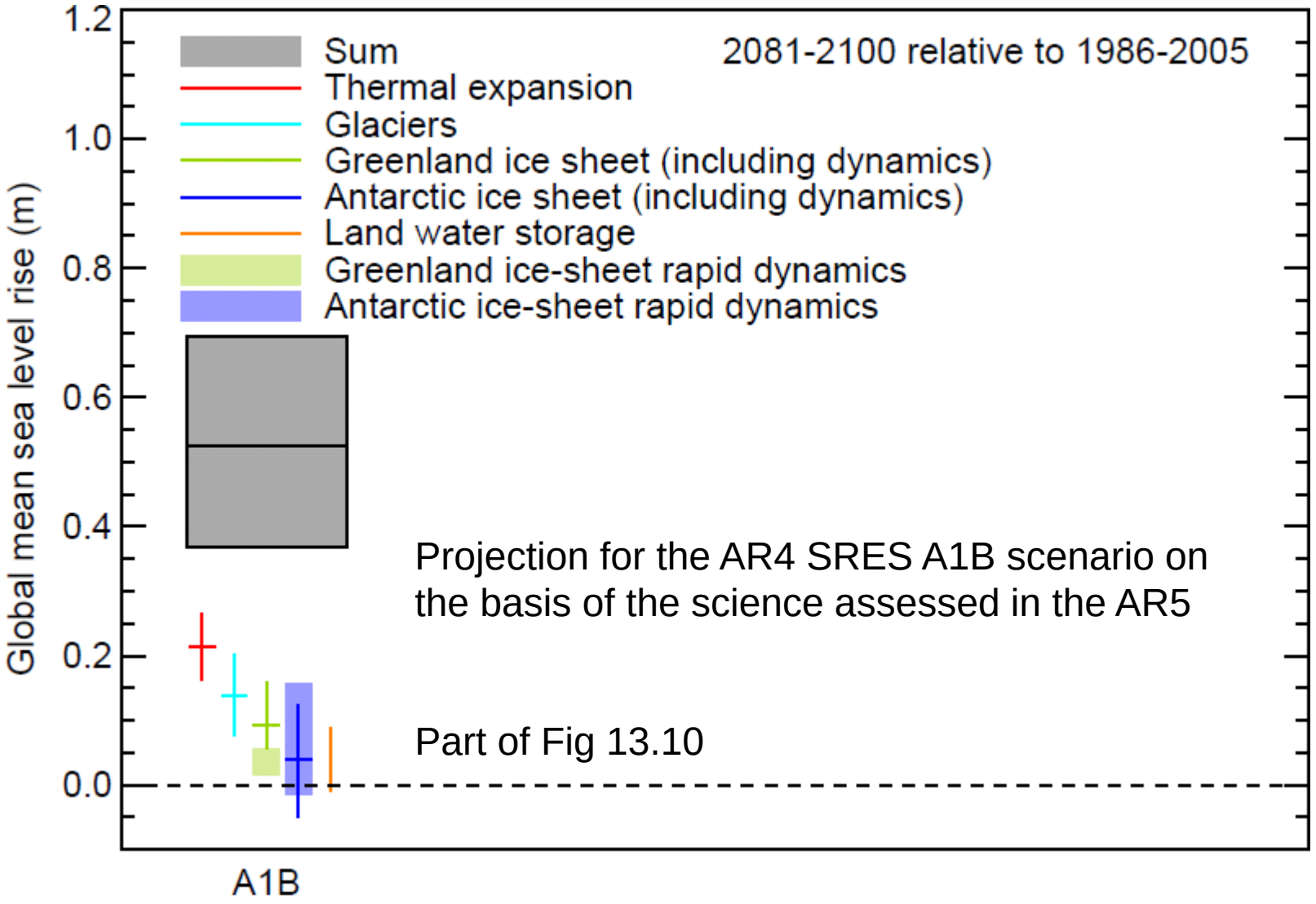
Fig 13.22b

About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change.

GMSL Variations – Past and Future – Figure 13.27



Comparison with AR4 projections



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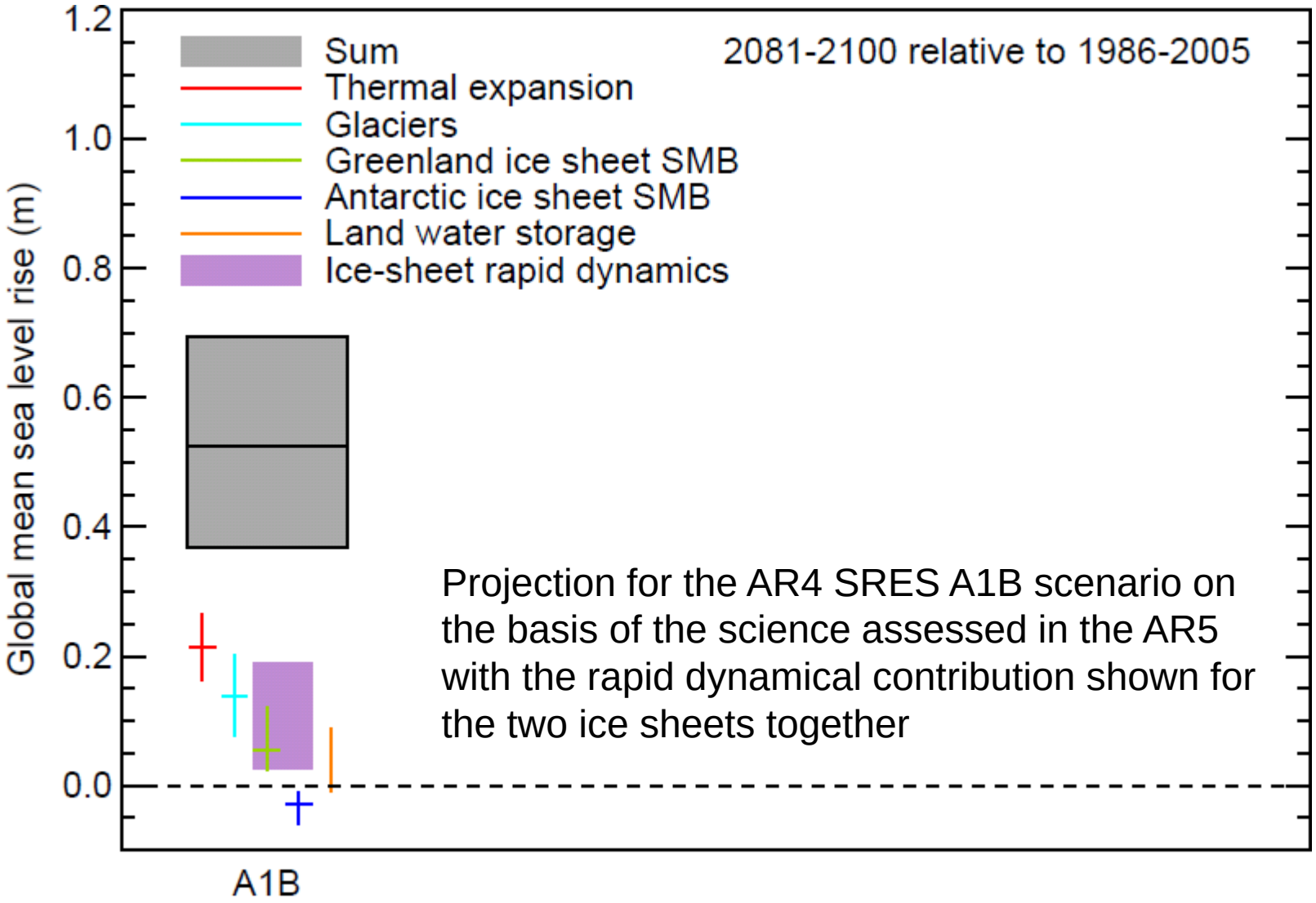
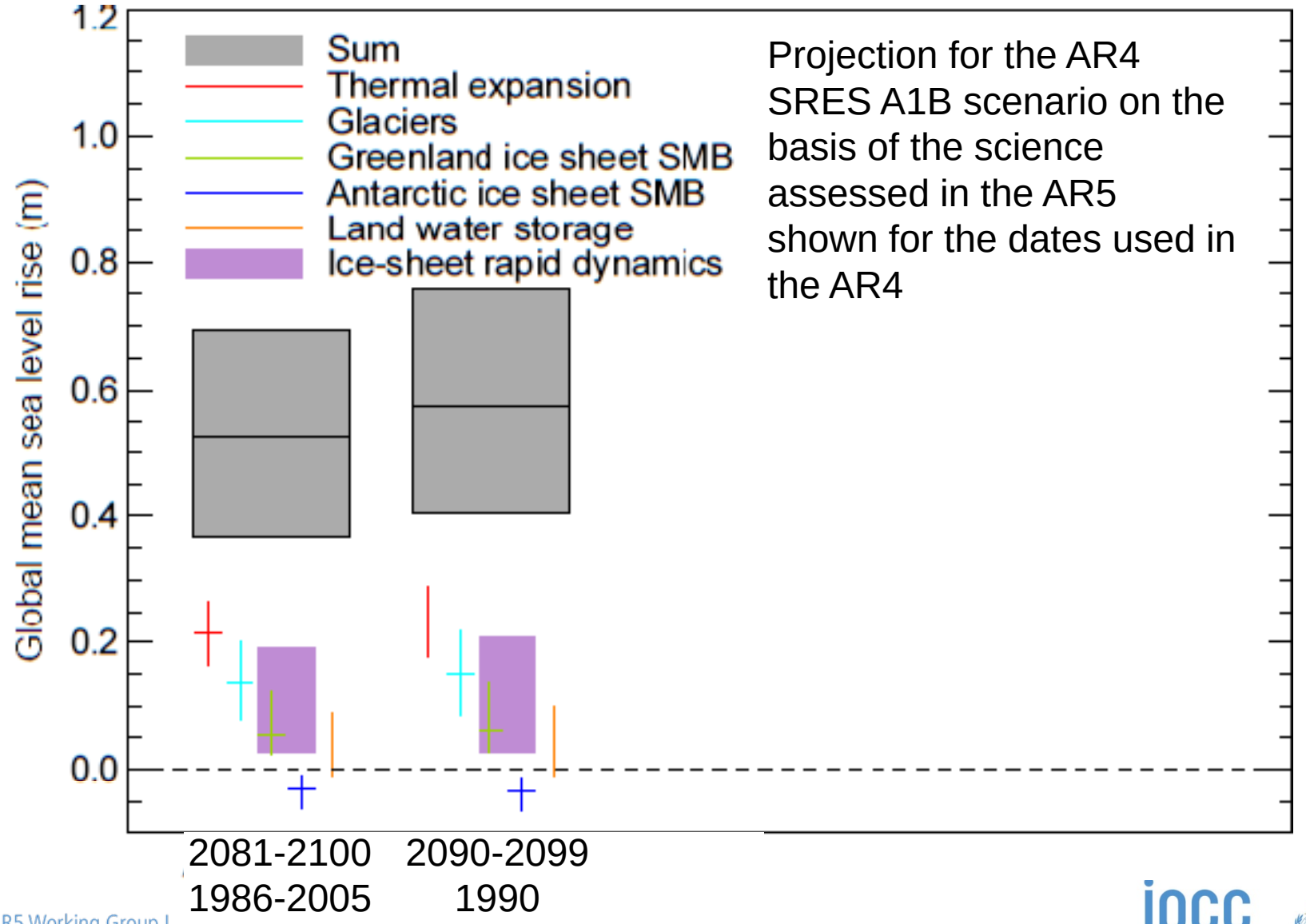
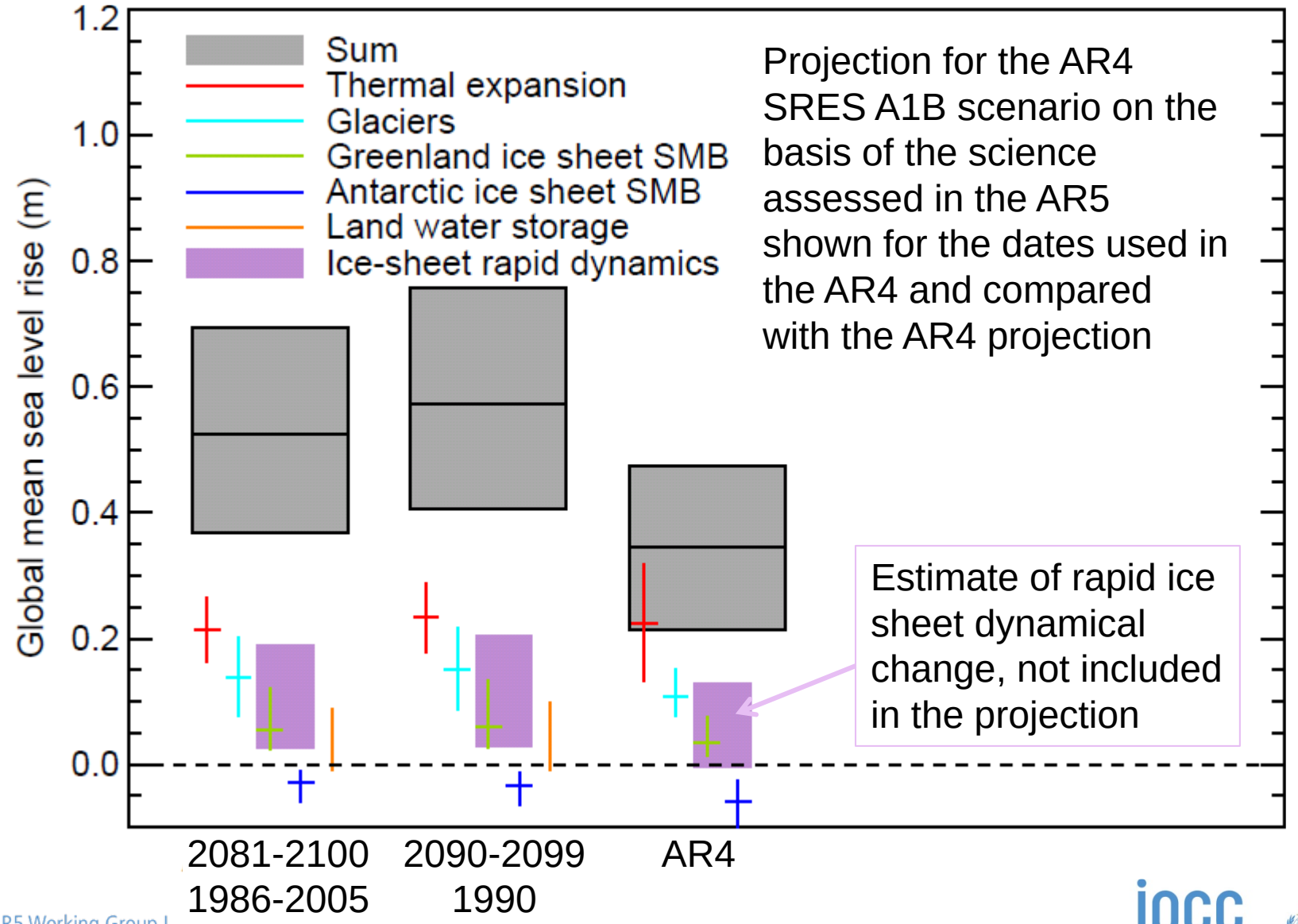


Comparison with AR4 projections



Projection for the AR4 SRES A1B scenario on the basis of the science assessed in the AR5 shown for the dates used in the AR4

Comparison with AR4 projections

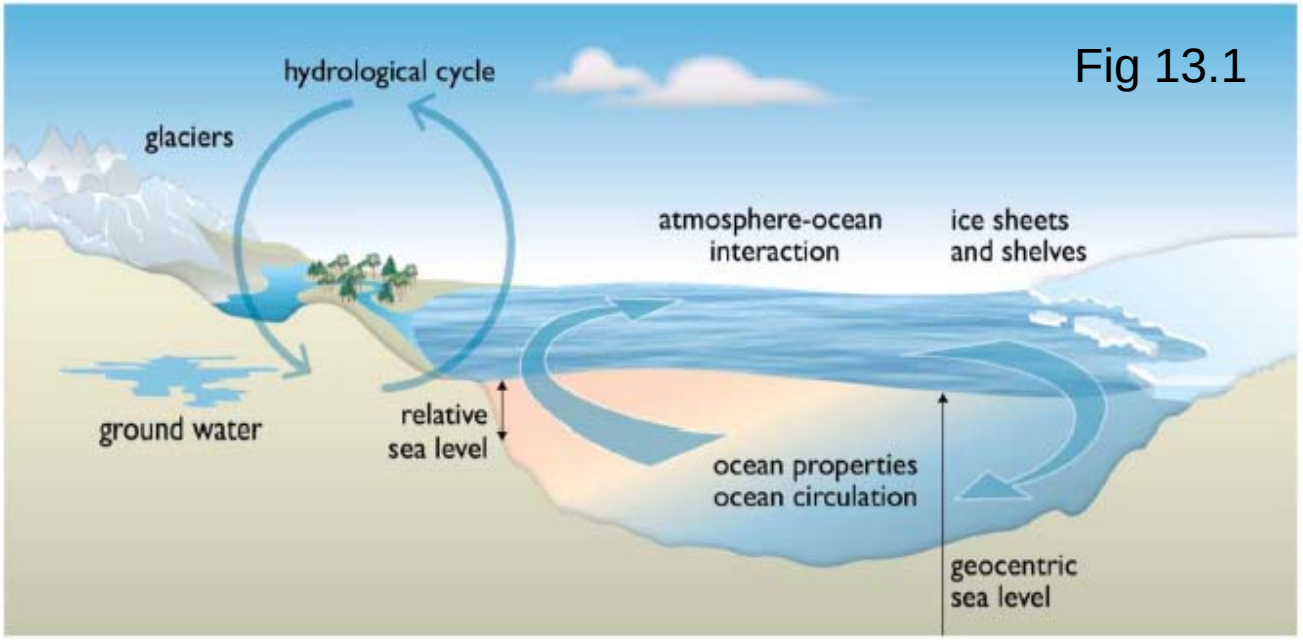


Causes of global mean sea level rise (GMSLR)

Warming the ocean (thermal expansion)

Loss of ice by glaciers and ice sheets

Reduction of liquid water storage on land



Relative sea level is also affected by land movement, ocean density and circulation, and distribution of mass on the Earth