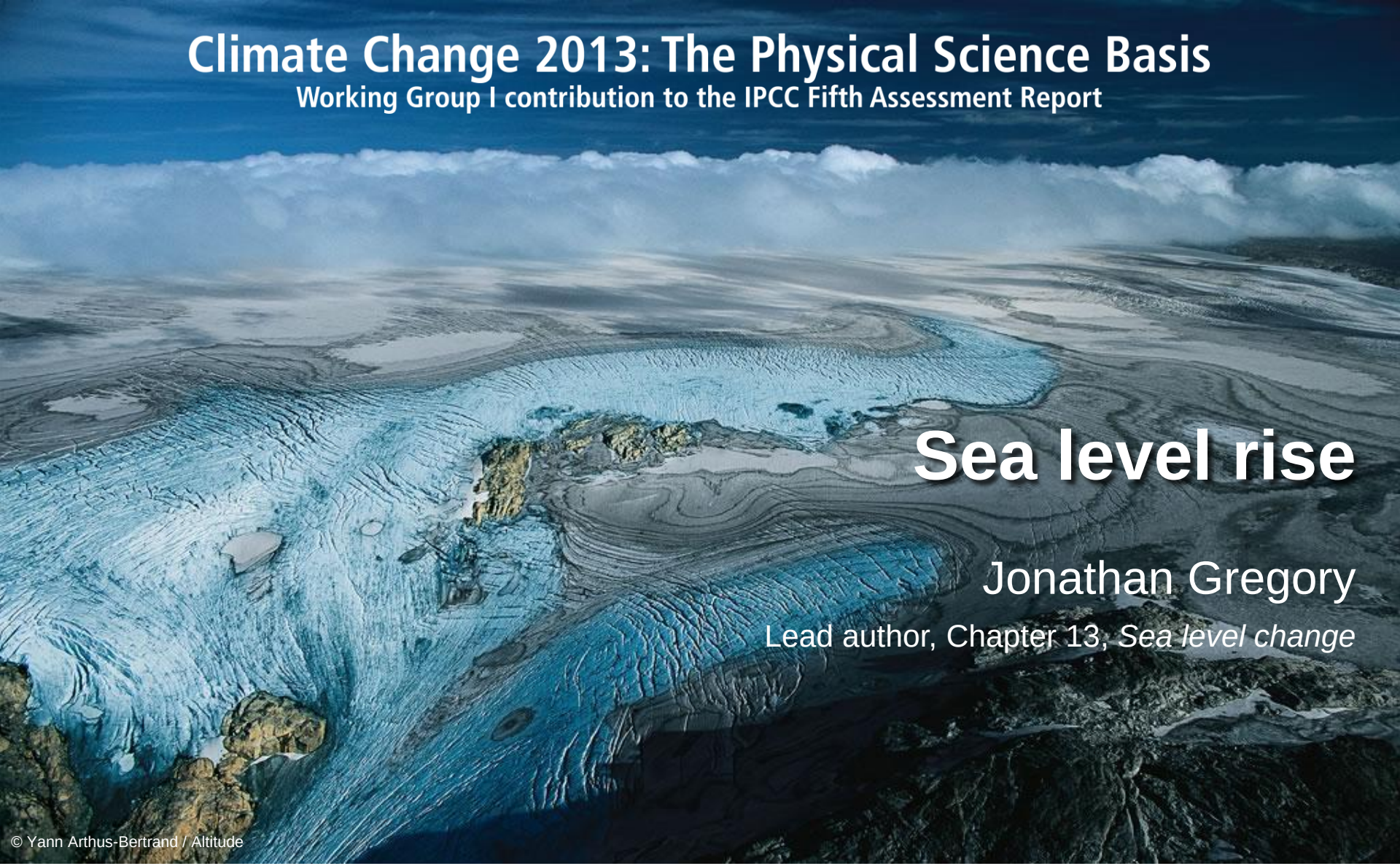
Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report



Sea level rise

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Lead author, Chapter 13, *Sea level change*

Causes of global mean sea level rise (GMSLR)

Global mean sea level rise is caused by an increase in the volume of the global ocean. This in turn is caused by:

Warming the ocean (thermal expansion).

Loss of ice by glaciers and ice sheets.

Reduction of liquid water storage on land.

High confidence in projections of thermal expansion

Good observational estimates

Consistency of historical simulations with observations

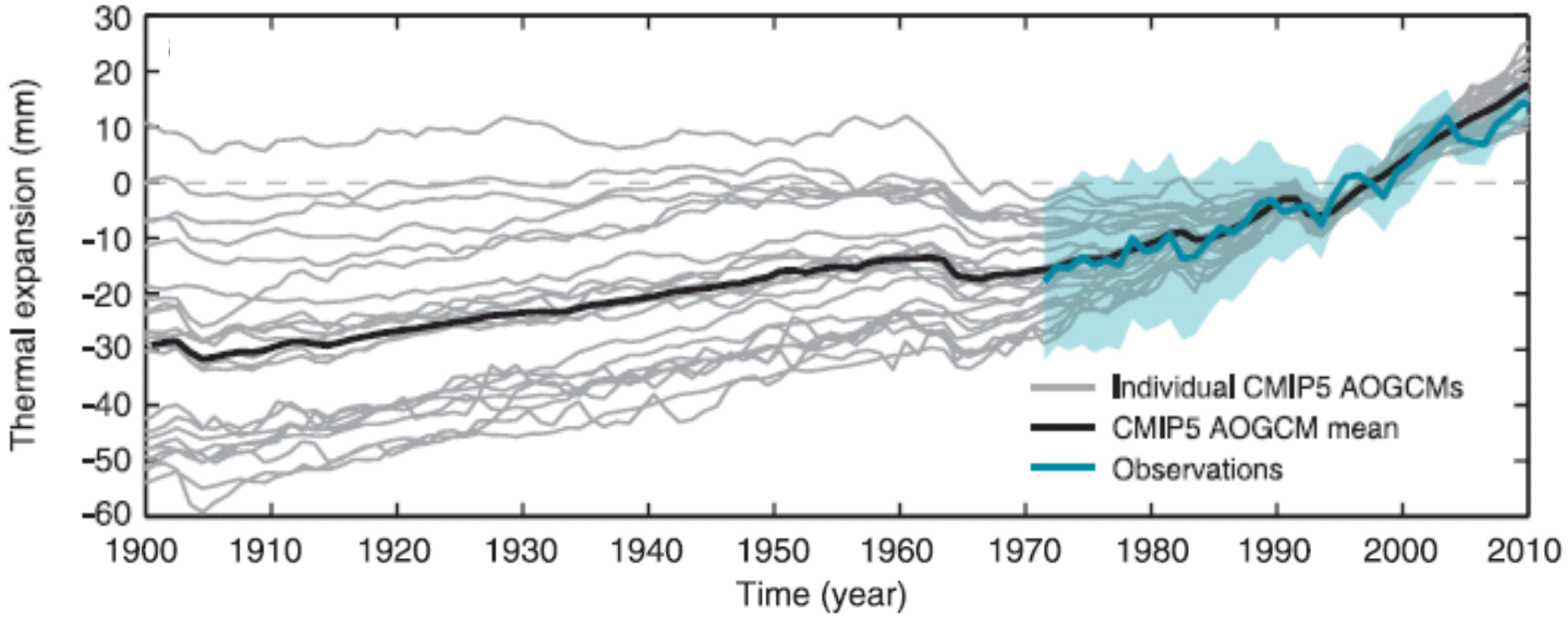


Fig 13.4a, change relative to 1986-2005

Medium confidence in projections of glacier mass loss

Consistency of historical simulations with observations.

Process-based understanding.

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

By the end of the 21st century, the global glacier volume is projected to decrease by 15 to 55% for RCP2.6, and by 35 to 85% for RCP8.5 (*medium confidence*).

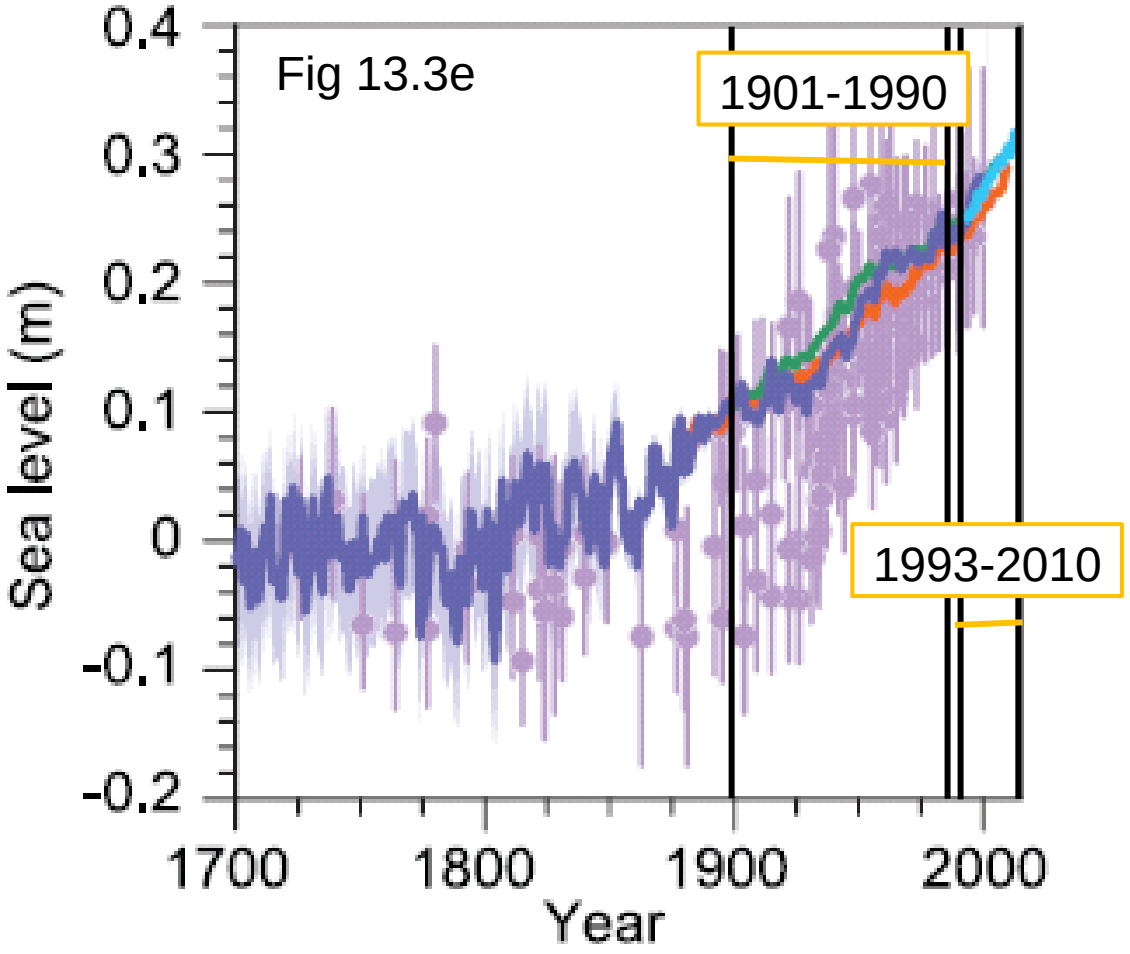
Projections of mass loss from the ice sheets

High confidence in projections of increasing Greenland surface mass loss.

Medium confidence in projections of increasing Antarctic snow accumulation.

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

Rate of GMSLR has been greater since the mid-19th century than in the last two millennia



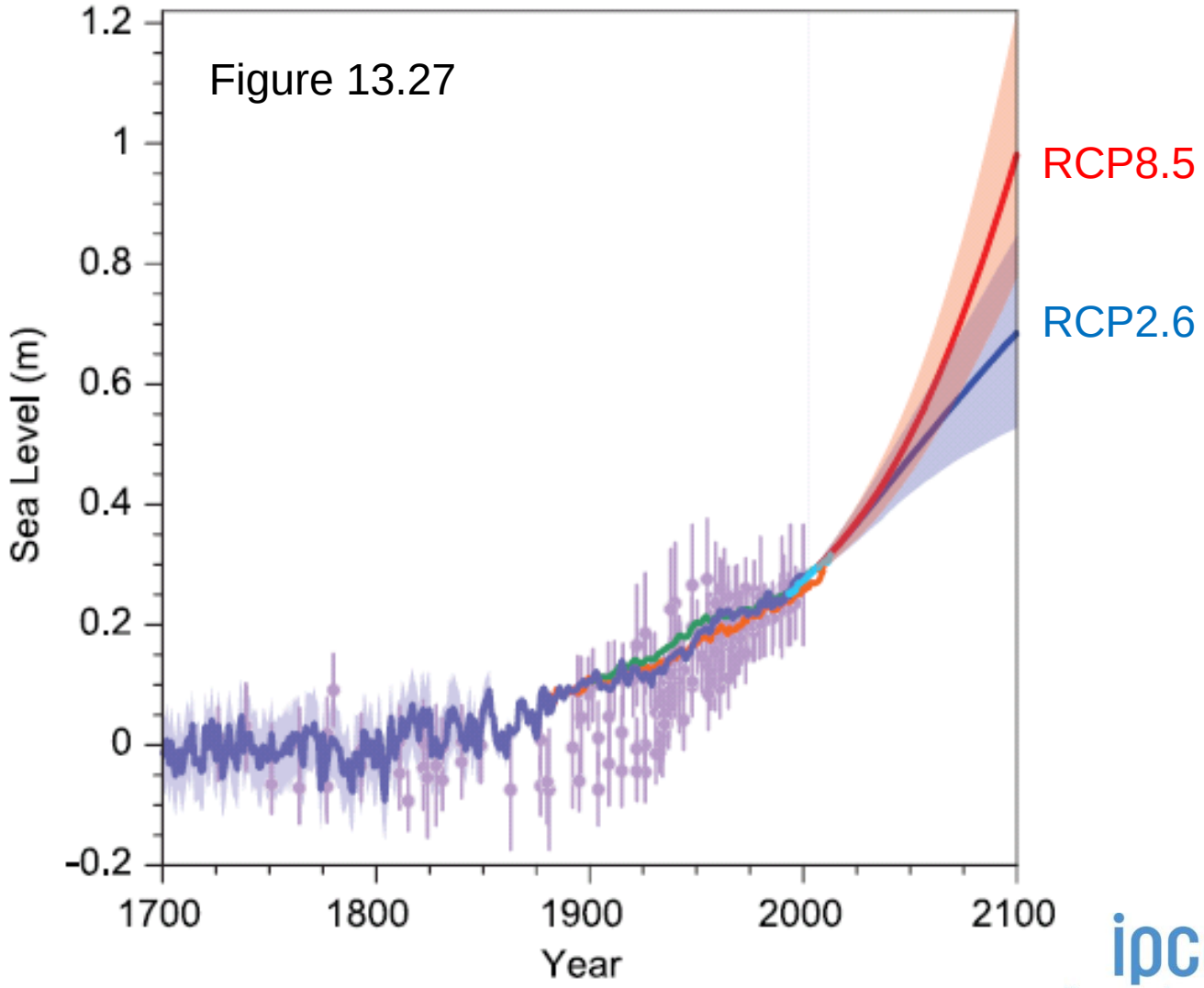
Rate during 1901-1990 was 1.5 [1.3 to 1.7] mm yr^{-1}.

Expansion + glaciers can account for most of this.

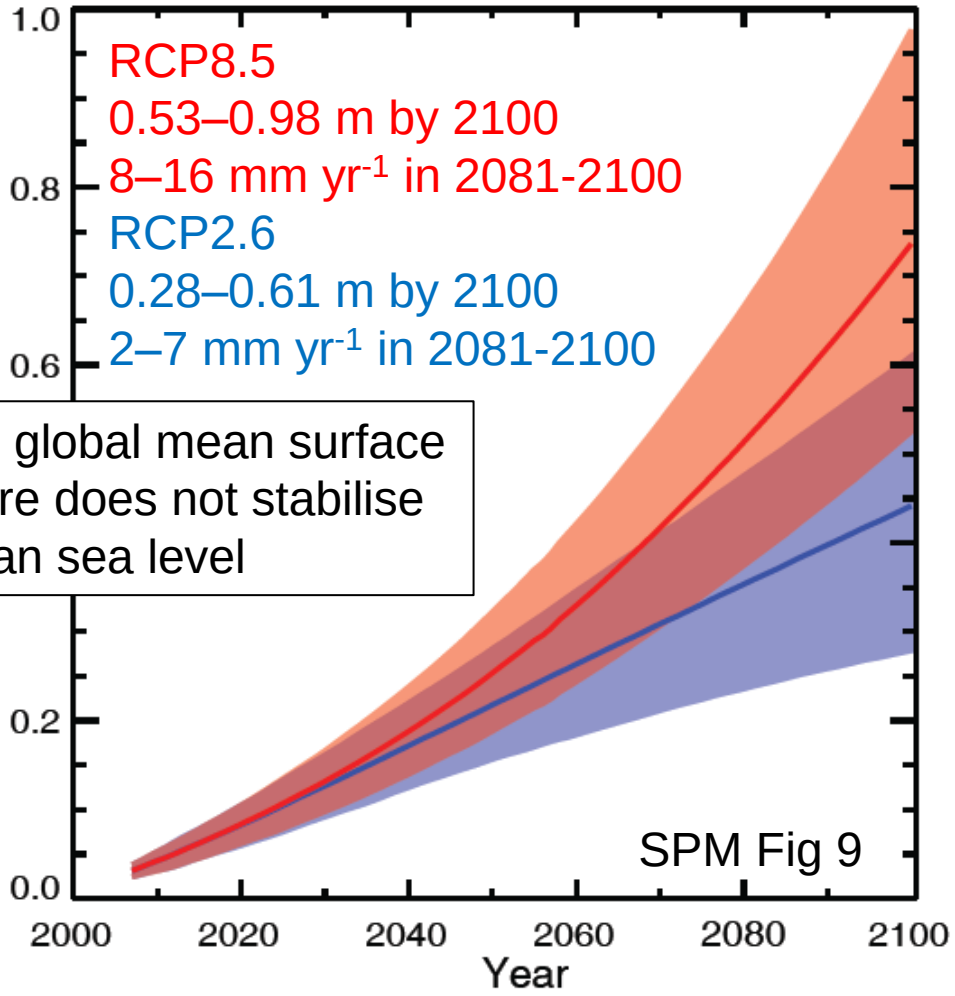
Rate during 1993-2010 was 3.2 [2.8 to 3.6] mm yr^{-1}.

Consistent with the sum of the observed contributions (*high confidence*).

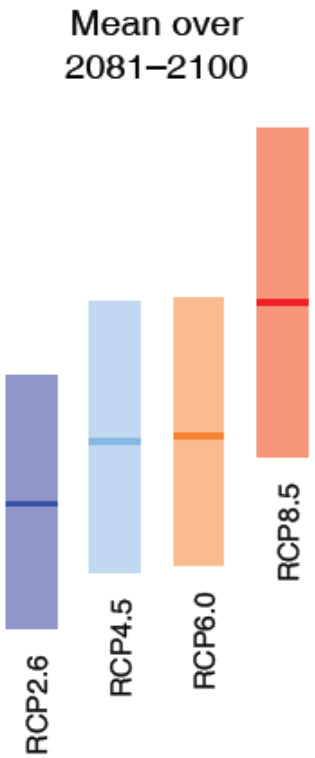
Very likely that the 21st-century mean rate of GMSLR will exceed that of 1971-2010 under all RCPs



Projections of 21st-century GMSLR under RCPs



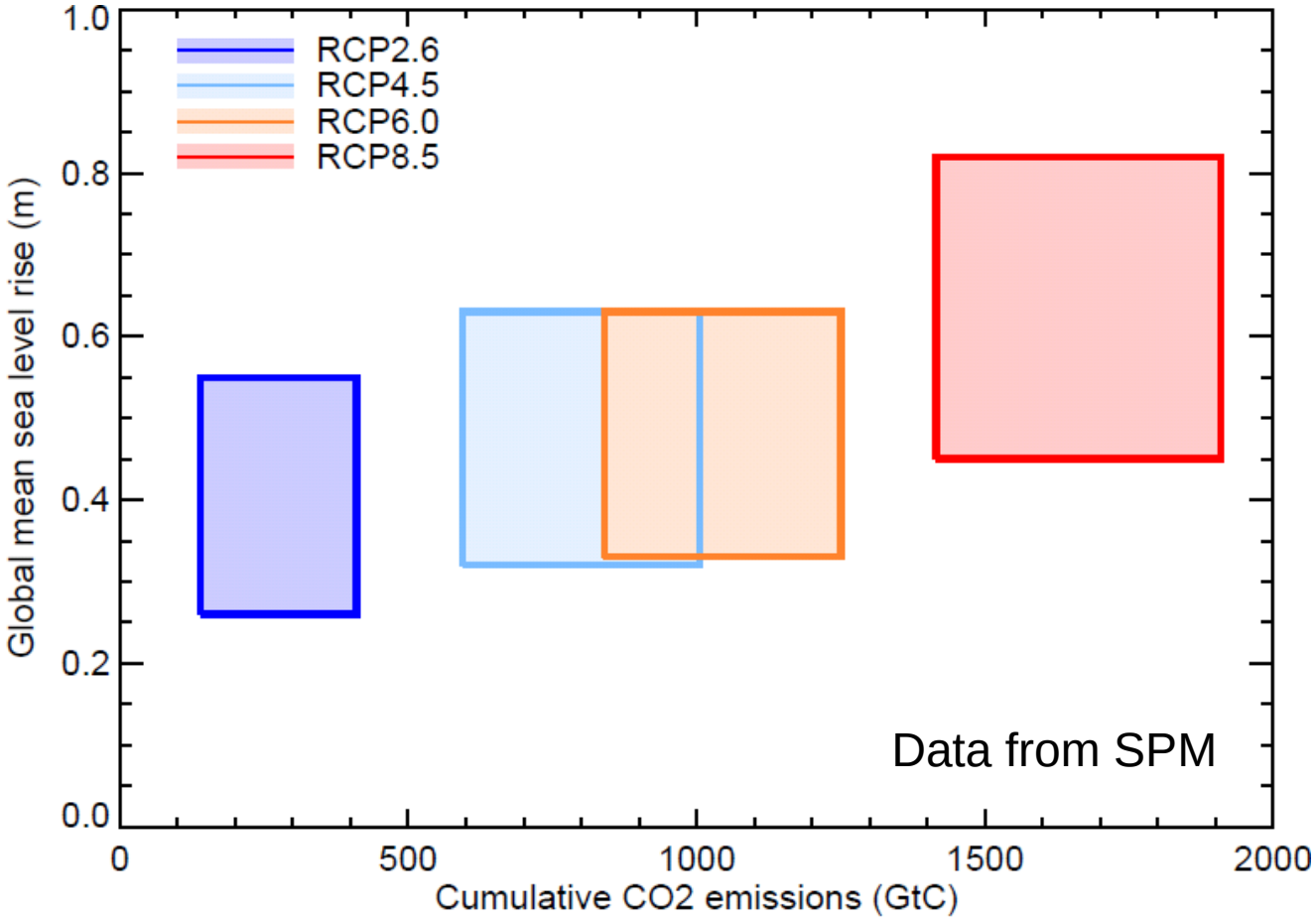
Stabilising global mean surface temperature does not stabilise global mean sea level



Medium confidence in *likely* ranges

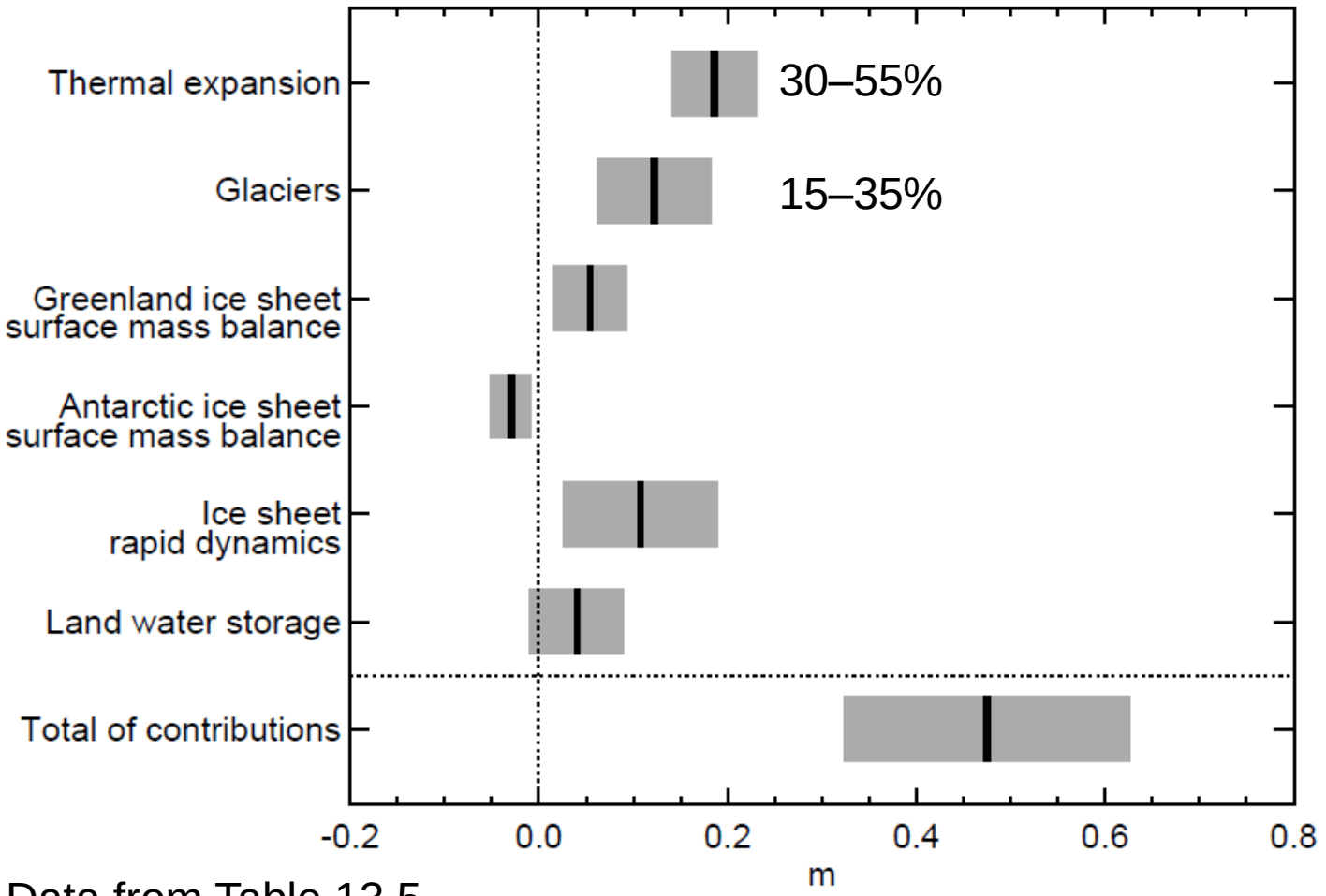
GMSLR is not proportional to global mean surface warming.

Relationship between GMSLR and CO_2 emissions



Unlike surface temperature change, GMSLR depends on the pathway of CO_2 emissions, not only on the total. Earlier emissions lead to greater GMSLR.

Projection for 2081-2100 under RCP4.5



Data from Table 13.5

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.

Commitment to sea level rise and irreversibility

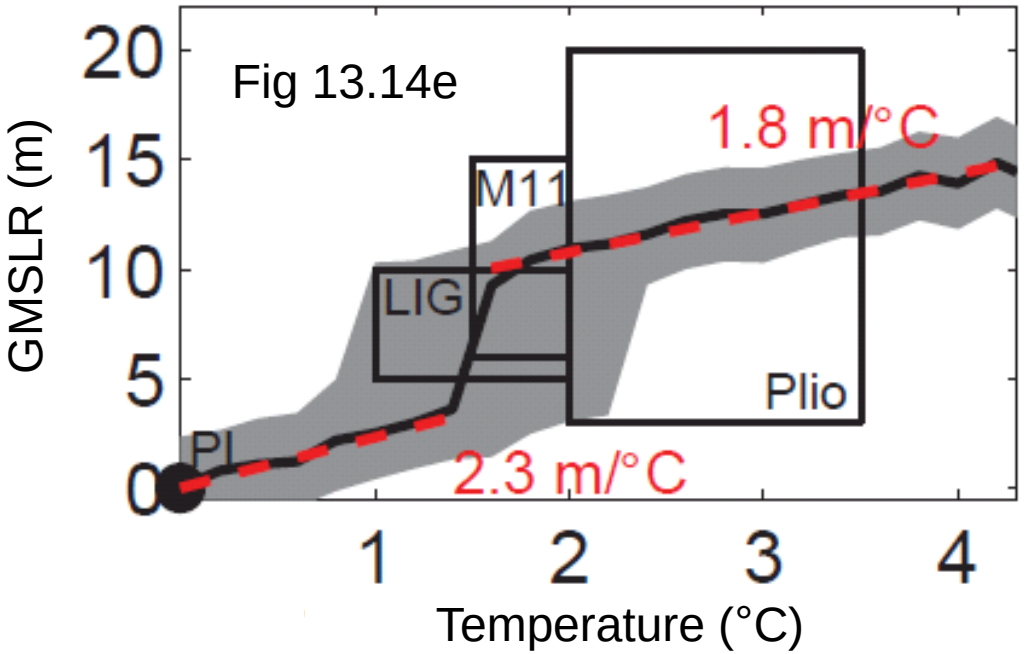
It is *virtually certain* that global mean sea level rise will continue for many centuries beyond 2100, with the amount of rise dependent on future emissions.

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 (about 3 W m^{-2}, like RCP2.6), but 1 to more than 3 m for 700–1500 ppm (about 5–9 W m^{-2}).

The amount of ocean thermal expansion increases with global warming (0.2 to 0.6 m $°C^{-1}$) but the rate of the glacier contribution decreases over time as their volume (currently 0.41 m sea level equivalent) decreases.

Larger sea level rise could result from sustained mass loss by ice sheets. Sea level rise of 1 to 3 m per degree of warming is expected if the warming is sustained for several millennia (*low confidence*). Some part of the ice sheet mass loss might be irreversible.

Commitment to sea level rise and irreversibility



GMSL during the Last Interglacial was 5-10 m above present for several 1000 years. High-latitude surface temperature was at least 2°C warmer than present.

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 (*low confidence*) but less than 4°C (*medium confidence*) global mean warming with respect to preindustrial.

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

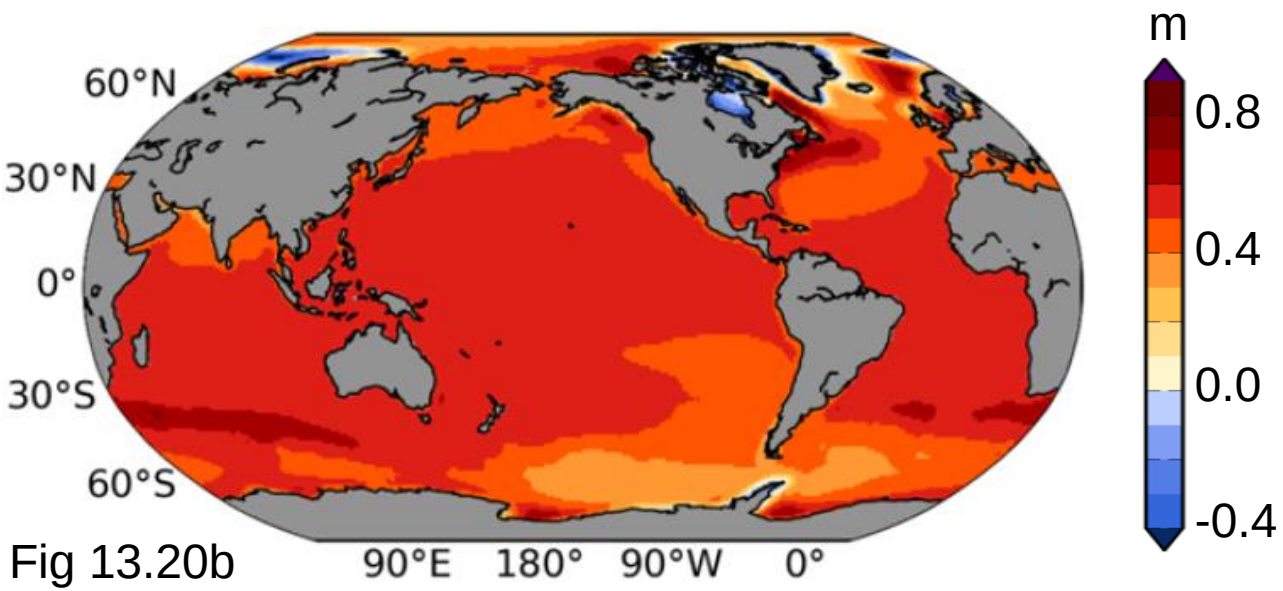


Fig 13.20b

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

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 (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*. GMSLR is not proportional to global mean surface warming. Earlier CO_2 emissions lead to greater GMSLR. 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, and that there will be a significant increase in the occurrence of extremes.

Stabilising global mean surface temperature does not stabilise global mean sea level in the 21st century. It is *virtually certain* that global mean sea level rise will continue for many centuries beyond 2100. GMSLR could eventually reach several metres above pre-industrial, with the amount dependent on future emissions, and including possibly irreversible mass loss by the ice sheets.

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Further Information

www.climatechange2013.org

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