

Sea-level rise and the Earth's Warming

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John Church

Greenhouse 2011

Cairns Convention Centre, Cairns, QLD

4 April 2011



Australian Government
Bureau of Meteorology



The Centre for Australian Weather and Climate Research
A partnership between CSIRO and the Bureau of Meteorology



CSIRO

Outline



- Climate is changing, the ocean is warming, sea level is rising
- Do we understand why?
- How is sea level likely to change in the future?
- The Earth's energy budget
- The longer term, impacts, adaptation & implications.



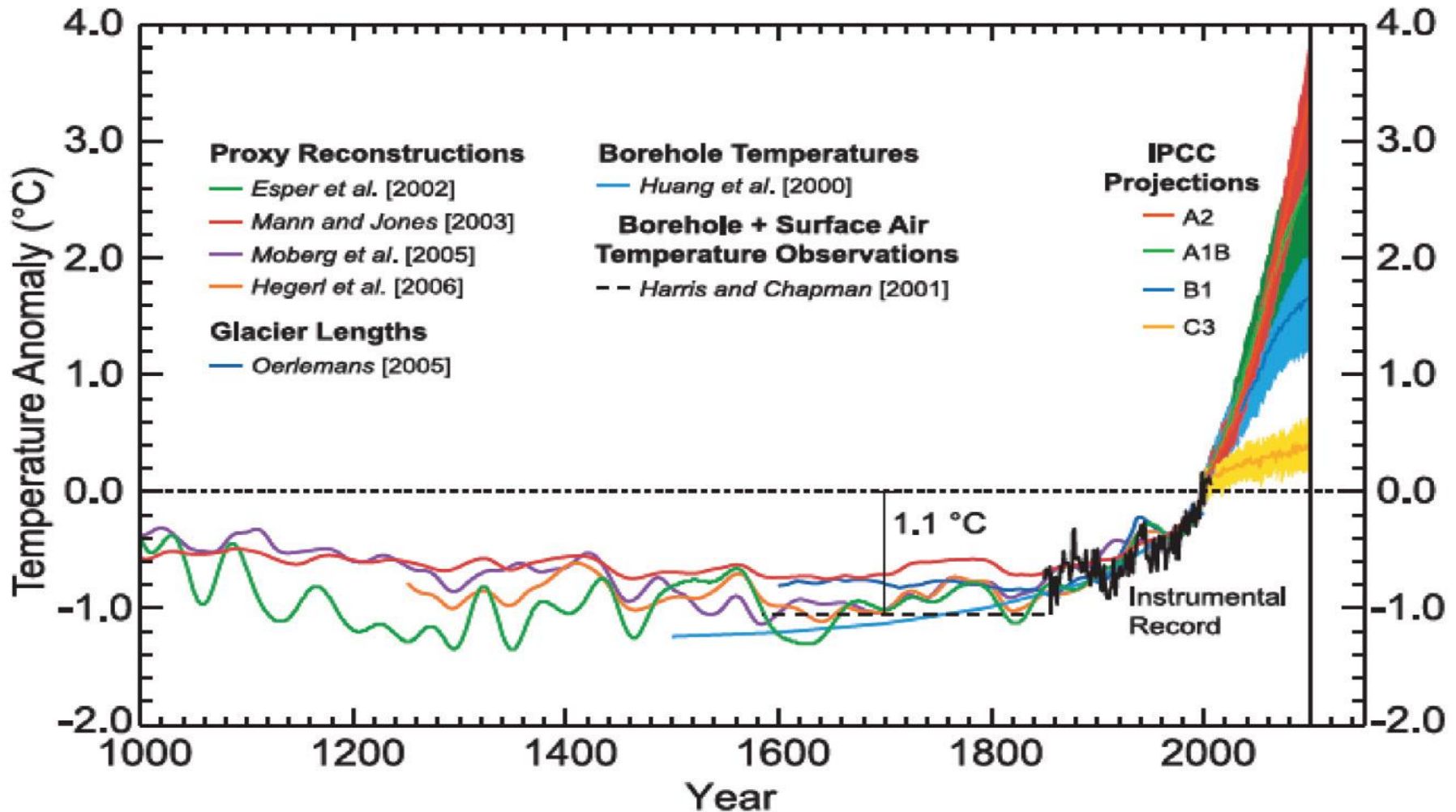
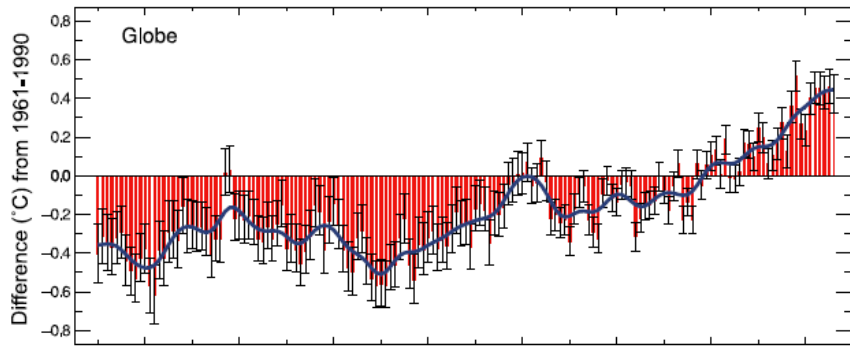
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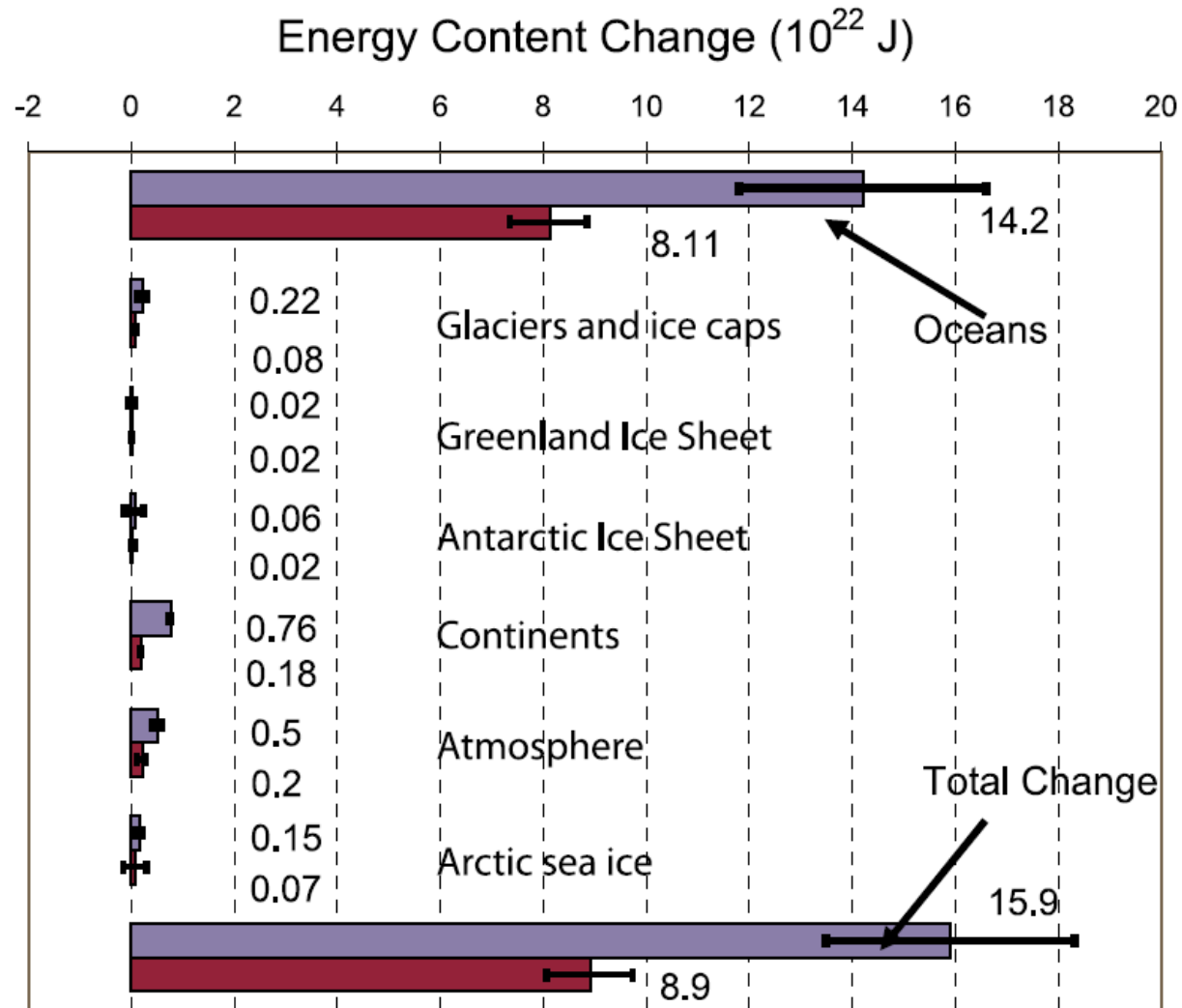


CSIRO

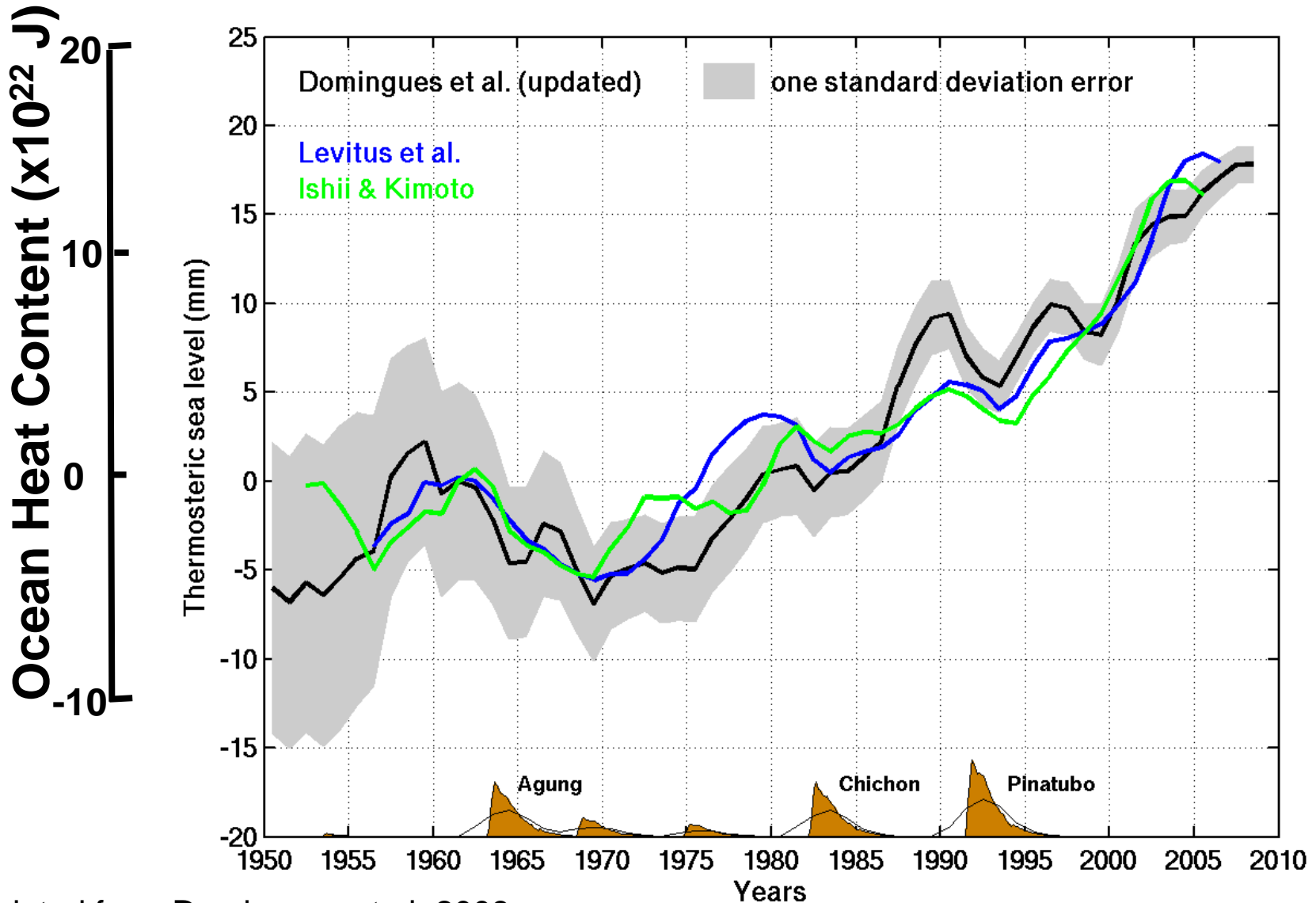
Many records of a warming Earth



Most important is the energy stored in the climate system – over 90% in the ocean

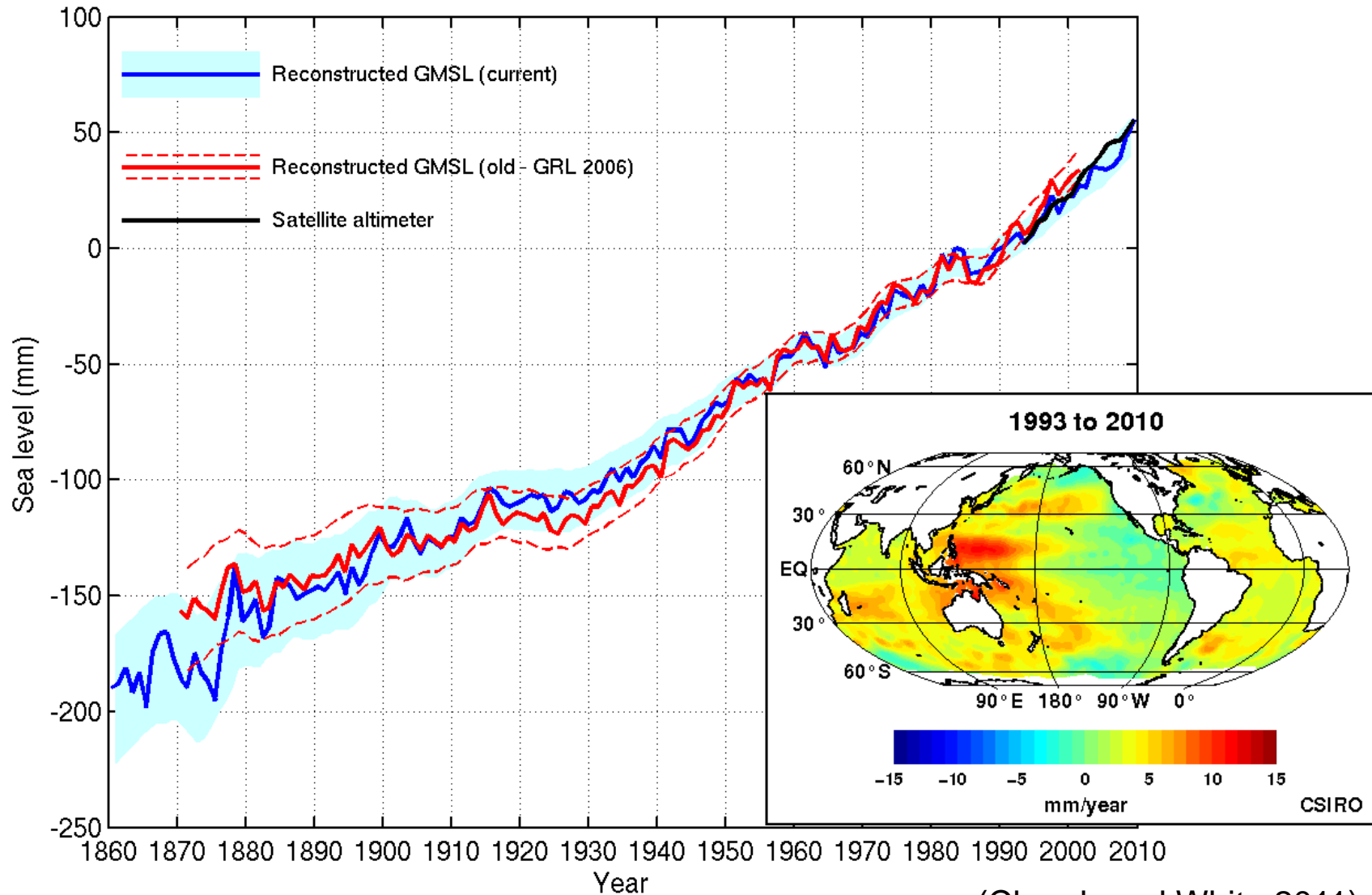


The Ocean is continuing to warm and expand



Updated from Domingues et al. 2008

Sea-level rise accelerated during the 20th century – rise is continuing

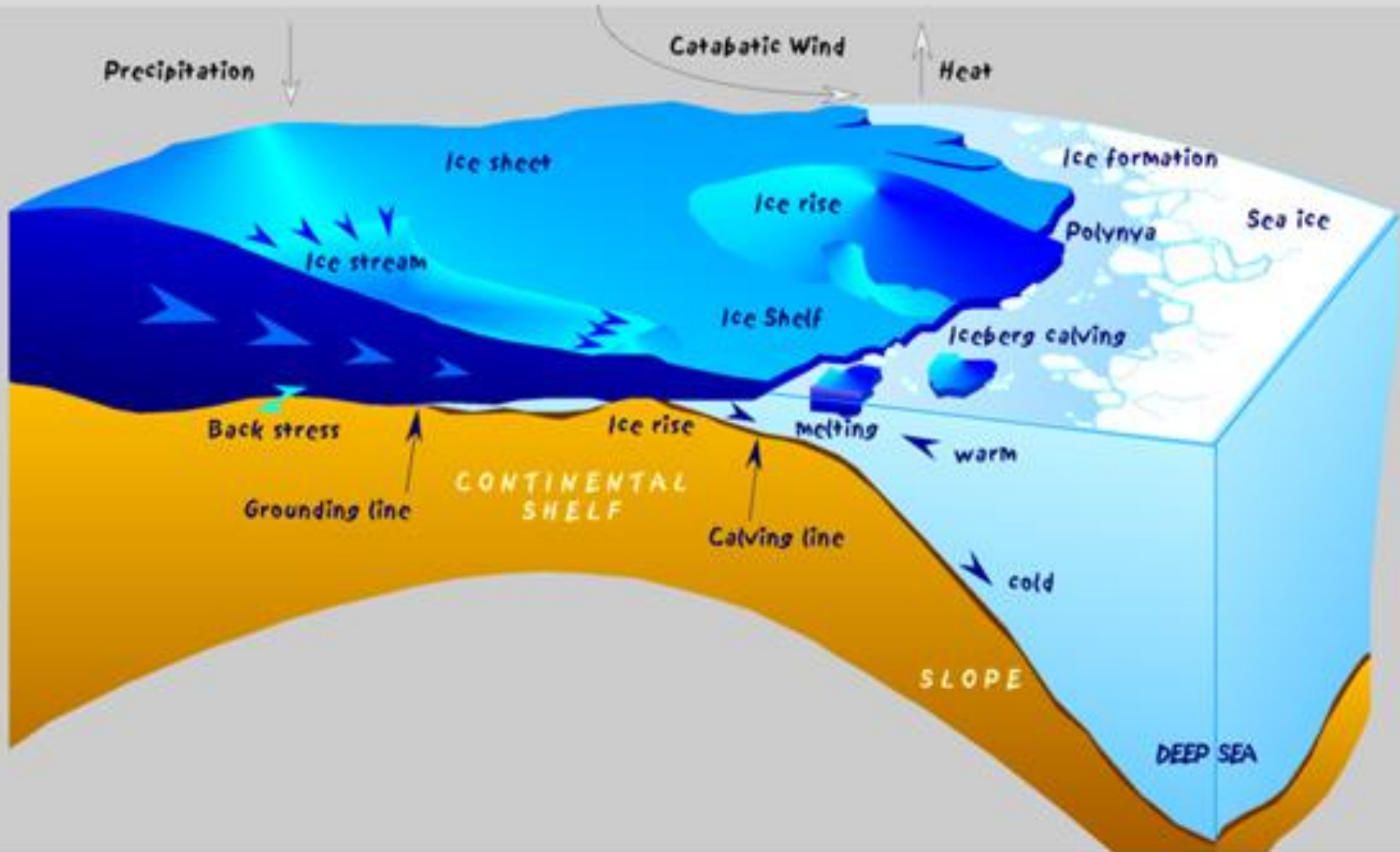


(Church and White 2011)

Worldwide, glaciers are melting

The Rhone Glacier 1900 and 2000

The ice sheets are showing signs of instability



Antarctic coast with glaciological and oceanographic processes

Water is stored in dams and mined from aquifers



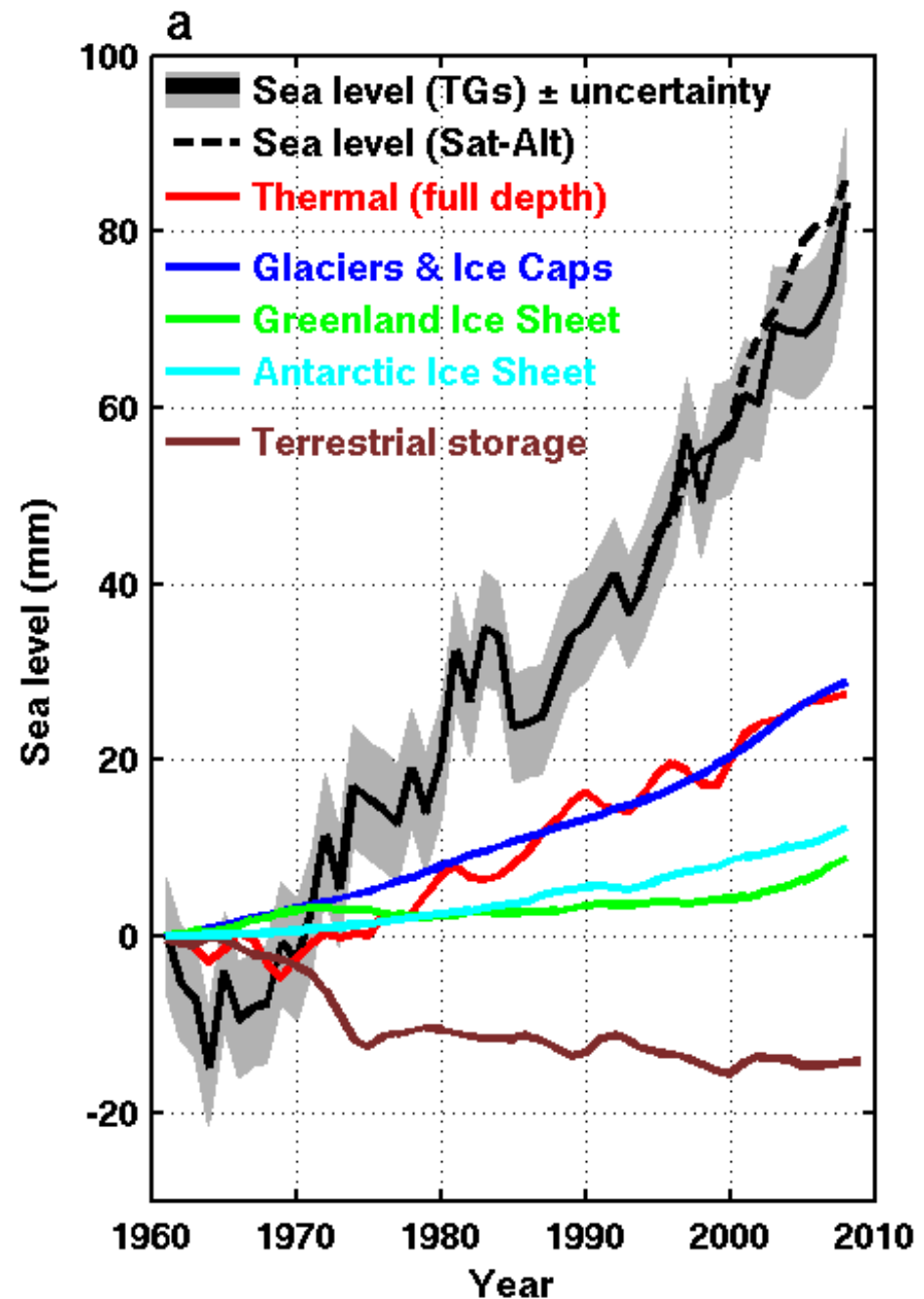
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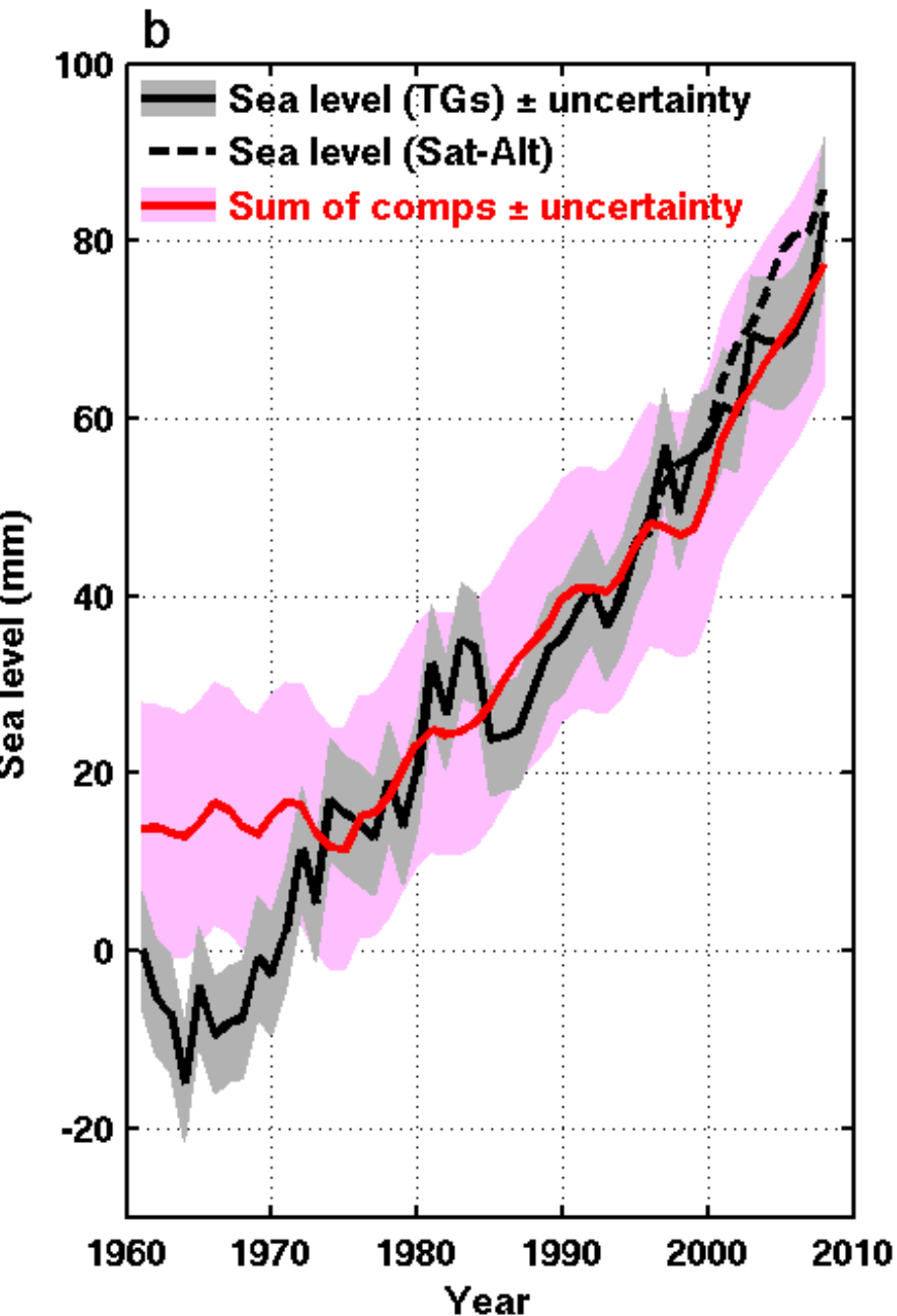


Three gorges Dam, China

Observed sea level and the contributions

Glaciers, thermal expansion and Greenland the largest contributions





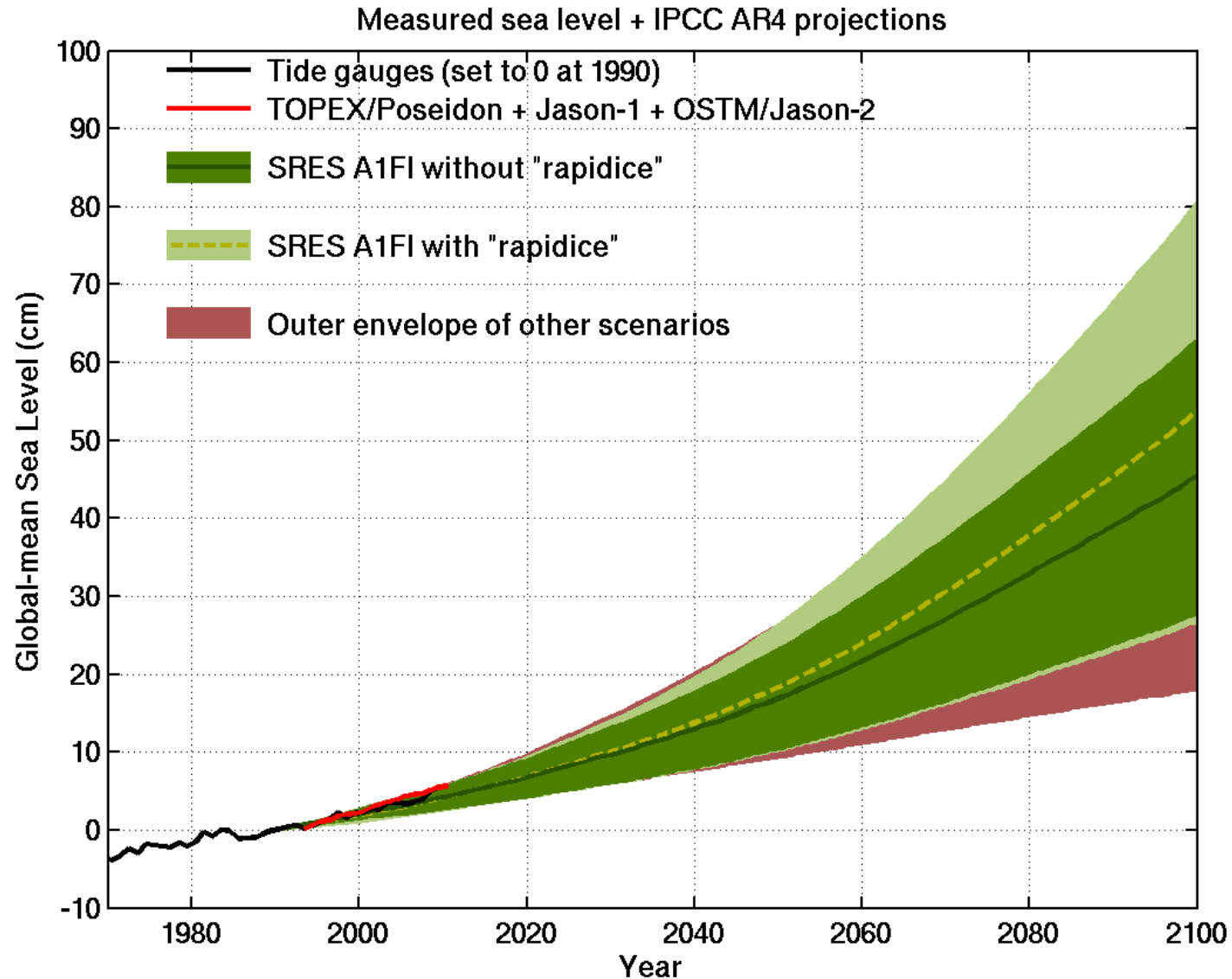
Observed sea level and the contributions are almost equal.

The observed sea level and the sum of contribution has accelerated.

Opens door for using observations to constrain projections.

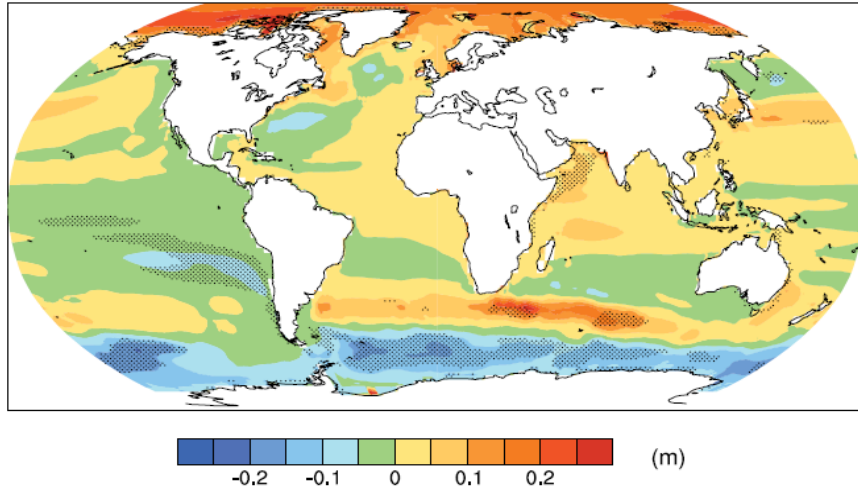
Church et al.
In prep

Sea-level rise will continue during the 21st C



Sea-level rise will not be uniform because of ocean changes and gravitational changes

Glacier and ice cap Fingerprint

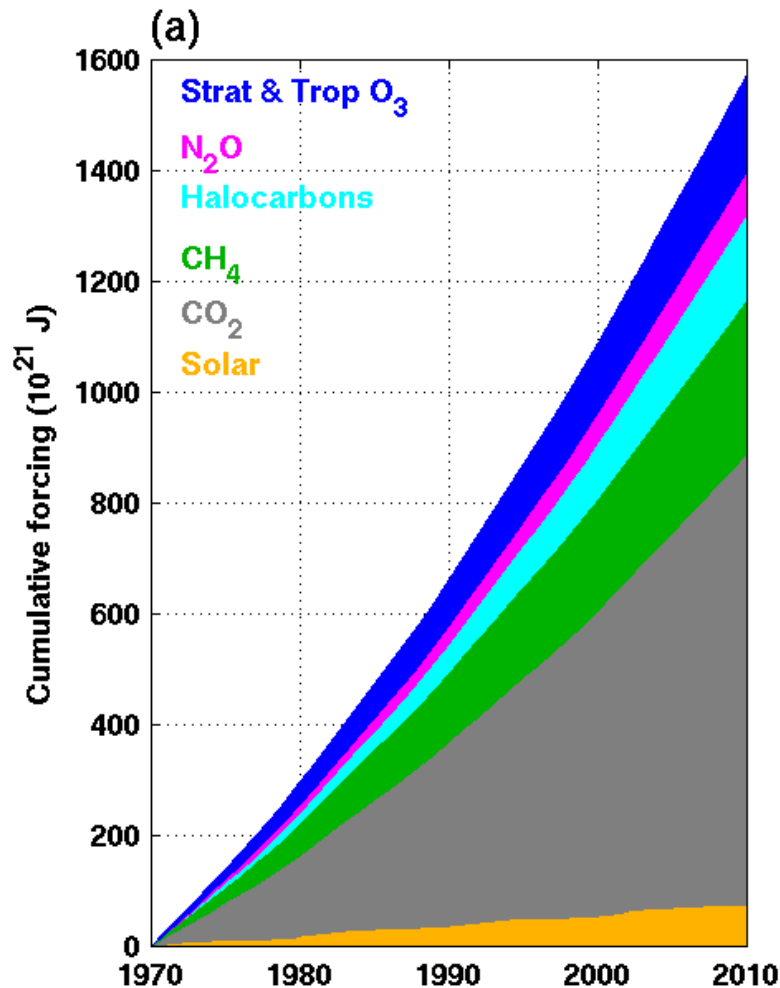


Greenland Fingerprint

Antarctic Fingerprint

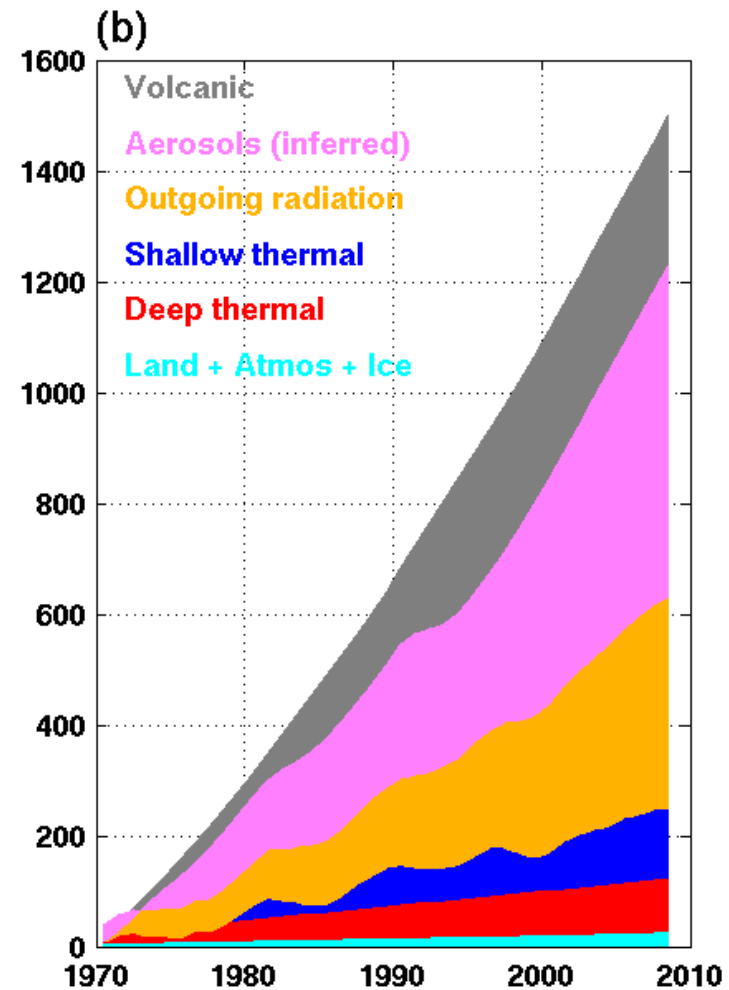
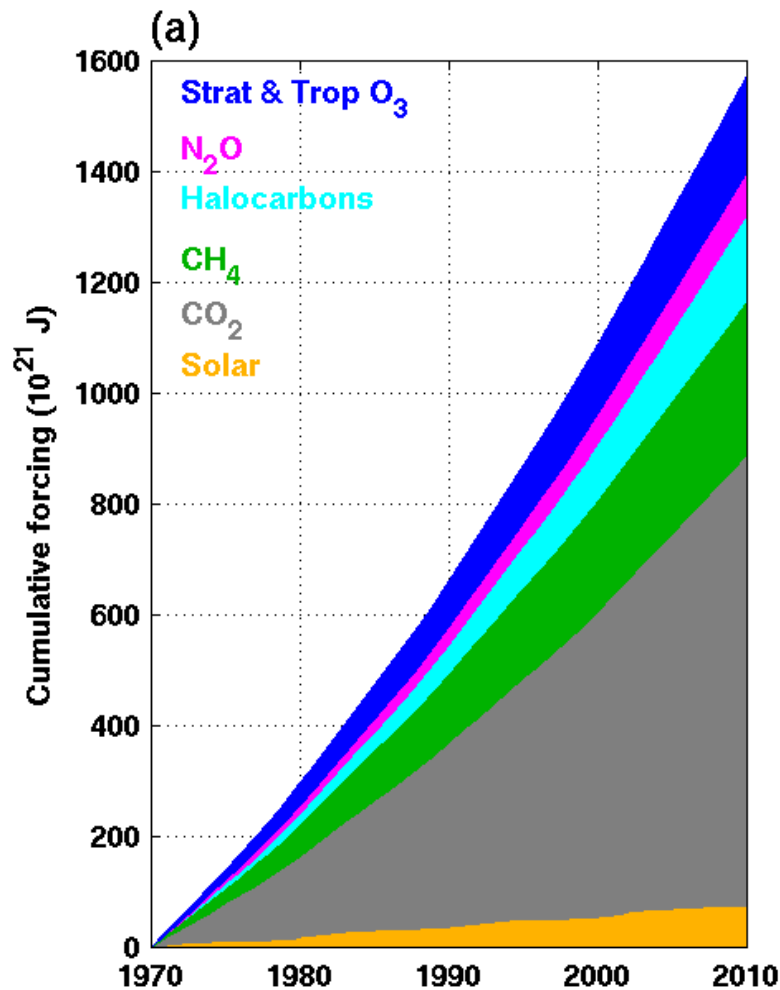


Why is the Earth warming?



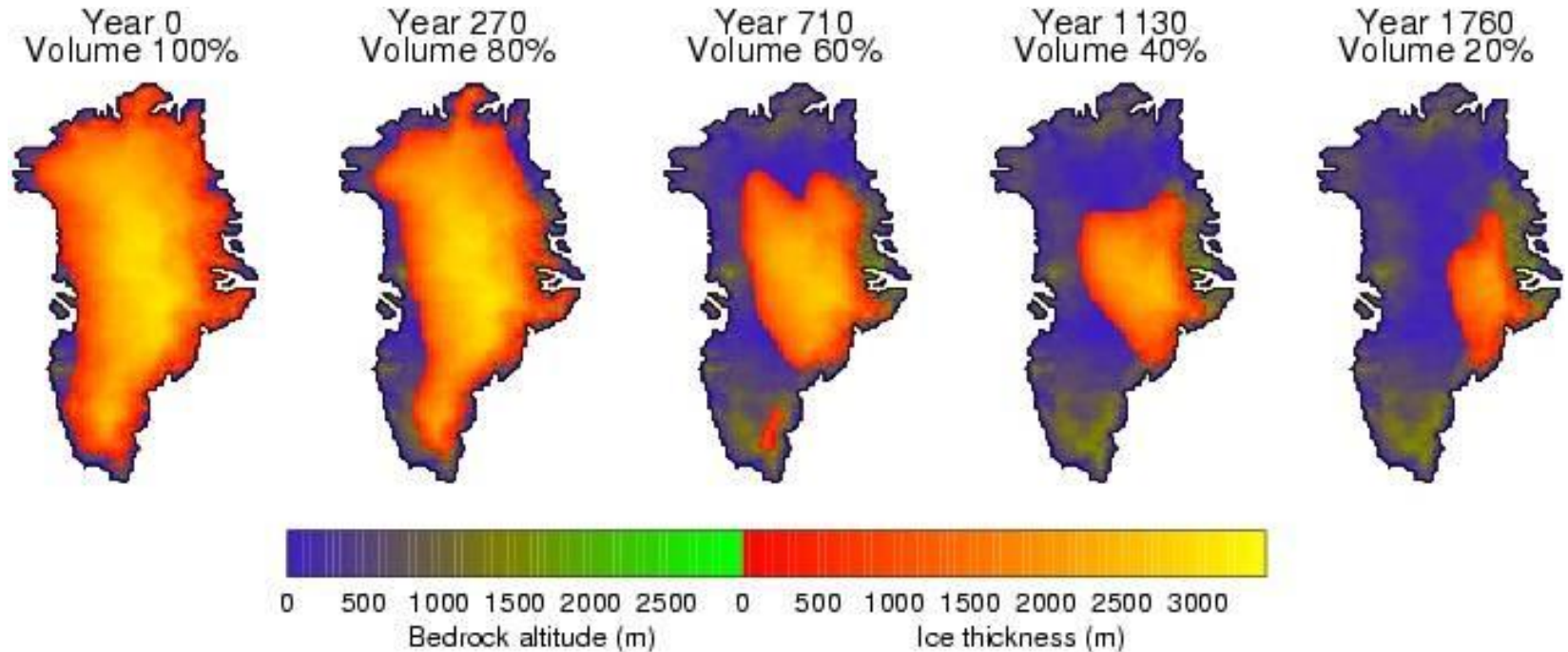
**Greenhouse gases
dominate the increased
radiation of the earth**

What happens to this energy?



Approaching a threshold for Greenland melting

Greenland ice sheet evolution under $4\times\text{CO}_2$



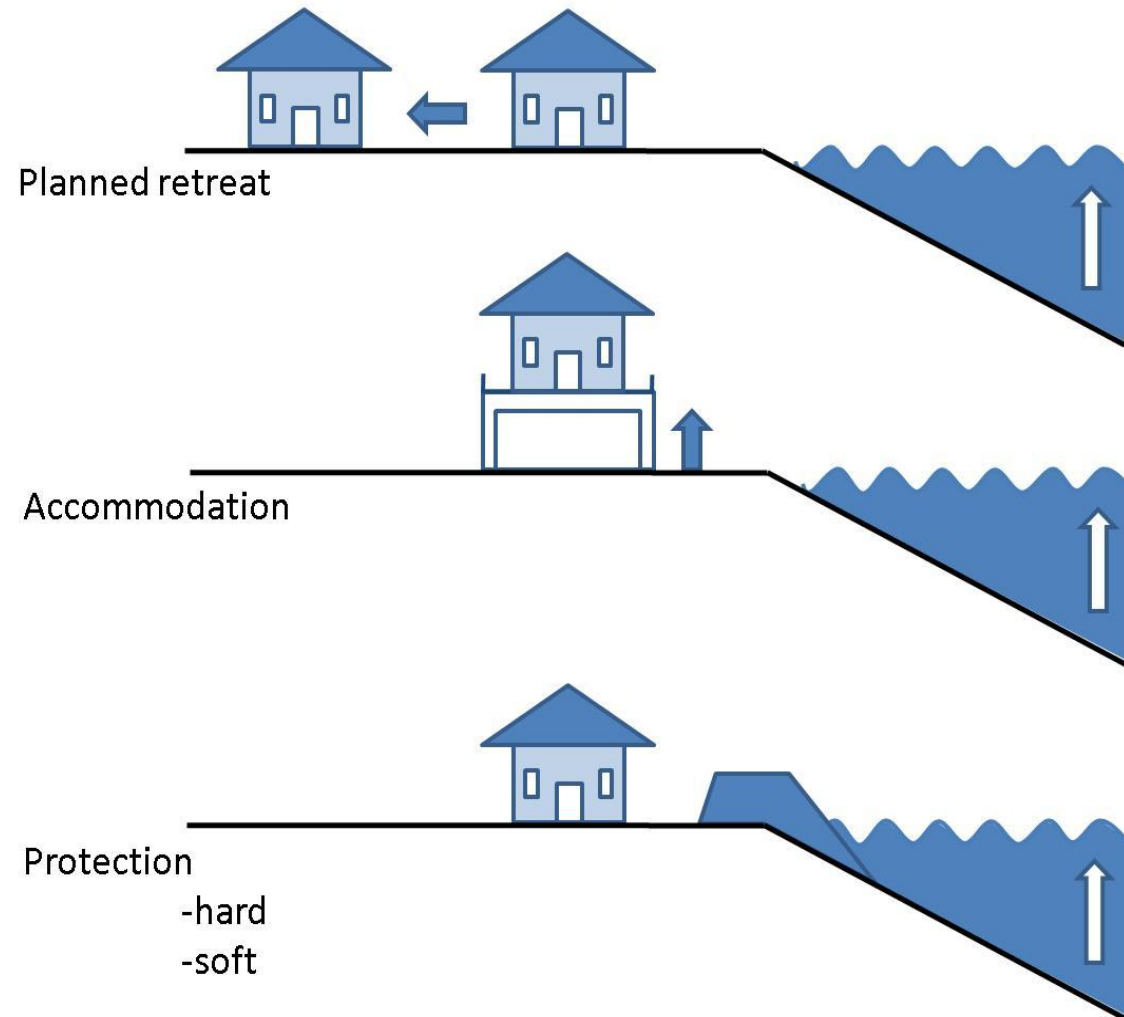
Simulated using the HadCM3 AOGCM coupled to the ice sheet model of Huybrechts and De Wolde (Ridley et al., 2005)

**The last interglacial may be a useful analogue for the future:
Sea level > 6.6 m (95%) above today.**

Extreme events: 150 Million people, \$1 Trillion GDP

Inundation and erosion

Will need to Adapt - Options

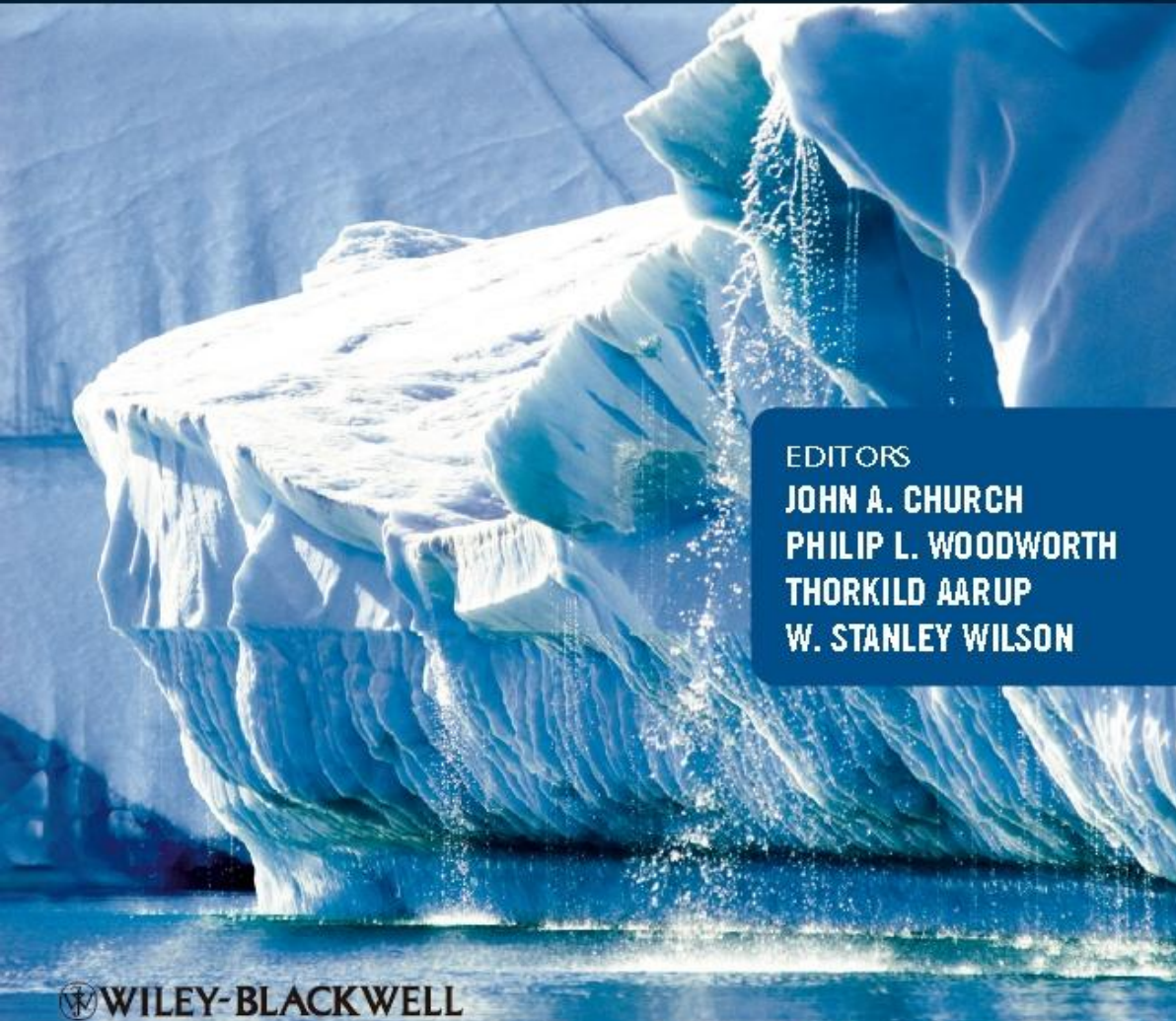


Summary and Implications



- **Oceans are warming, sea level is rising. Ongoing sea-level rise is virtually certain. Initiating long-term changes.**
- **Current mitigation efforts are insufficient to avoid critical thresholds**
Without significant, urgent and sustained action, we are likely to pass a threshold during the 21st C, committing the world to metres of sea-level rise! Urgent!
- **We will need to adapt**
Inundation, coastal erosion, wet land loss, aquifer contamination
Coastal flooding events – more frequent, more severe.
Least developed nations and the poor most at risk. Local and regional planning. Environmental refugees will be an issue for the 21st century.
- **To minimise costs need to reduce uncertainty**
Observing, understanding and modelling the oceans and the ice sheets are key!
- **Essential and urgent that science/government/business/community partnerships are strengthened!**

UNDERSTANDING SEA-LEVEL RISE and VARIABILITY



EDITORS
JOHN A. CHURCH
PHILIP L. WOODWORTH
THORKILD AARUP
W. STANLEY WILSON

**Current status of
Understanding,
impacts,
research
recommendations
and monitoring
requirements**

**Wiley-Blackwell
2010**



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John Church

Phone: 03 6232 5207

Email: john.church@csiro.au

Web: www.cmar.csiro.au/sealevel/

Thank you

www.cawcr.gov.au

