Sea-level variability and rise: Understanding the past, implications for the future

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John Church

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Australian Government
Bureau of Meteorology

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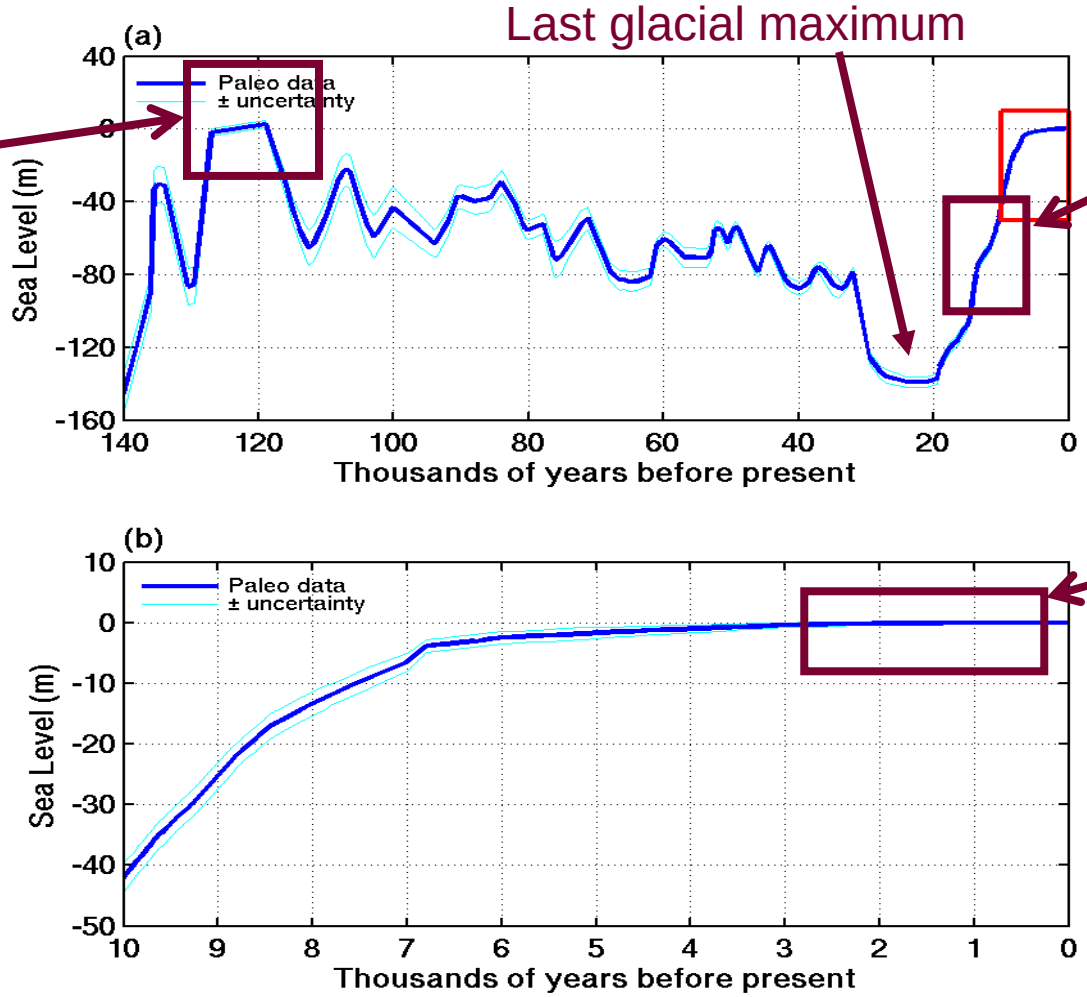
The paleo record tells us that Sea level has varied in the past

- Sea level higher than today,
- rates of rise about 1.5 m/century
- At temperature similar to what we expect by 2100



- Rates of rise up to 4 m/century
- Our coastal society developed in a time of stable sea level

Church et al. 2008

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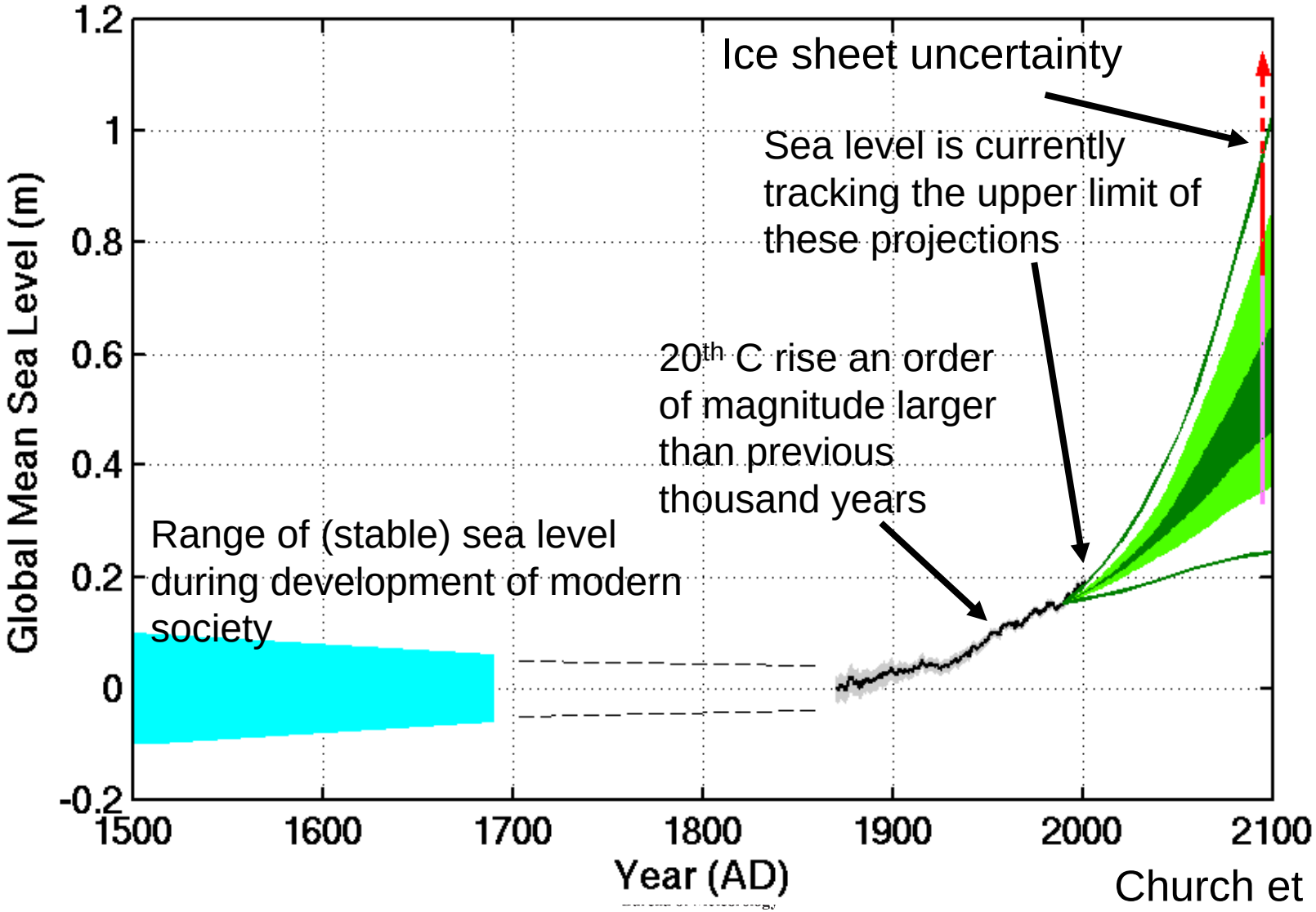
Today's sea level unprecedented during modern civilisation



Church et al. 2008

Bay of Bengal Major Surges

1737 300,000 killed
1864 100,000
1876 100,000
1897 175,000
1970 300,000
1971 (tide plus 6m surge)

1991 140,000 (10 Million homeless)

And at least 23 surge events with over 10,000 killed since 1737

These considered lower limits as economic damage adds to eventual total

(Murty, Flather and Henry, 1986 Progress In Oceanography
Murty and Flather, 1994 Journal of Coastal Research)

Lowe et al. 2008

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Developed nations are also vulnerable

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Research needs - WCRP Workshop



- Observing sea-level change
- Ice sheet and glacier change and models
- Ocean warming and models
- The regional distribution
- Terrestrial water storage
- Land motion
- Extreme events

(163 participants, 29 nations)

Summary Statement from the World Climate Research Programme Workshop

Understanding Sea-level Rise and Variability

THE WORKSHOP. 163 scientists from 29 countries attended the Workshop on Understanding Sea-level Rise and Variability,[1] hosted by the Intergovernmental Oceanographic Commission of UNESCO in Paris June 6-9, 2006. The Workshop was organized by the World Climate Research Programme (WCRP)[2] to bring together all relevant scientific expertise with a view towards identifying the uncertainties associated with past and future sea-level rise and variability, as well as the research and observational activities needed for narrowing these uncertainties. The Workshop was also conducted in support of the Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan;[3] as such, it helped develop international and interdisciplinary scientific consensus for those observational requirements needed to address sea-level rise and its variability.

The Issue – Since the beginning of high-accuracy satellite altimetry in the early 1990s, global mean sea-level has been observed by both tide gauges and altimeters to be rising at a rate of just above 3 mm/year, compared to a rate of less than 2 mm/year from tide gauges over the previous century. The extent to which this increase reflects natural variability versus anthropogenic climate change is unknown. About half of the sea-level rise during the first decade of the altimeter record can be attributed to thermal expansion due to a warming of the oceans; the other major contributions include the combined effects of melting glaciers and ice sheets. Changes in the storage of water on land (such as the depletion of aquifers and increases in dams and reservoirs) remain very uncertain.

The Motivation – The coastal zone has changed profoundly during the 20th century, primarily due to growing populations and increasing urbanization. In 1990, 23 percent of the world's population (or 1.2 billion people) lived both within a 100 km distance and 100 m elevation of the coast at densities about three times higher than the global average. By 2010, 20 out of 30 mega-cities will be on the coast, with many low-lying locations threatened by sea-level rise. With coastal development continuing at a rapid pace, society is becoming increasingly vulnerable to sea-level rise and variability—as Hurricane Katrina recently demonstrated in New Orleans. Rising sea levels will contribute to increased storm surges and flooding, even if hurricane intensities do not increase in response to the warming of the oceans. Rising sea levels will also contribute to the erosion of the world's sandy beaches, 70 percent of which have been retreating over the past century. Low-lying islands are also vulnerable to sea-level rise.



An improved understanding of sea-level rise and variability will help reduce the uncertainties associated with sea-level rise projections, thus contributing to more effective coastal planning and management. Adaptation measures, including enhanced building codes, restrictions on where to build, and developing infrastructures better able to cope with flooding, should help to minimize the potential losses.

Relation to the IPCC Assessments – The Third Assessment Report (TAR)[4] of the Intergovernmental Panel on Climate Change (IPCC) estimated that sea level will rise between 9 and 88 cm by the end of the 21st century. The Fourth Assessment Report (due in 2007) is currently being reviewed by governments. The Workshop complemented the TAR by starting with the set of uncertainties it identified, then focusing on the scientific and observational requirements needed to reduce those uncertainties, as well as uncertainties identified during the Workshop. The Workshop did not attempt to develop projections of future changes as the TAR did. The Workshop participants reached consensus that the increase in the rate of global mean sea-level rise towards the end of the 20th century, to just above 3 mm per year from less than 2 mm per year on average over the previous century, is a robust finding. The Extended Workshop Report[5] will address how the many uncertainties in understanding the causes of 20th century sea-level change and its recent acceleration could be reduced for input to future IPCC Assessment Reports.

WCRP World Climate Research Programme | WMO | UNESCO | IOC | ICSU International Council for Science

The Science Shows:

- **Ongoing sea-level rise is virtually inevitable! It is an issue for:**
  - Now, the 21st C and the long term.
- **Need to adapt**
  - Inundation, coastal erosion, wet land loss, aquifer contamination, etc
  - Extreme events – more frequent, more severe.
  - Least developed nations and the poor most at risk. Local and regional planning.
- **Need to mitigate to avoid the most extreme scenarios**
  - Without significant, urgent and sustained action, we could pass a threshold during the 21st C, committing the world to metres of sea-level rise! Urgent! Short term emission goals critical!
- **Environmental refugees**
  - Not “if” but “when, where and how will we respond?”
- **To minimise costs need to reduce uncertainty**
  - Observing, understanding and modelling the oceans and the ice sheets are key!
  - Need to implement/improve early warning systems
- **Essential and urgent that science/government/business/community partnerships are strengthened!**