Future Sea Level Rise and its Implications for SIDS and LDCs

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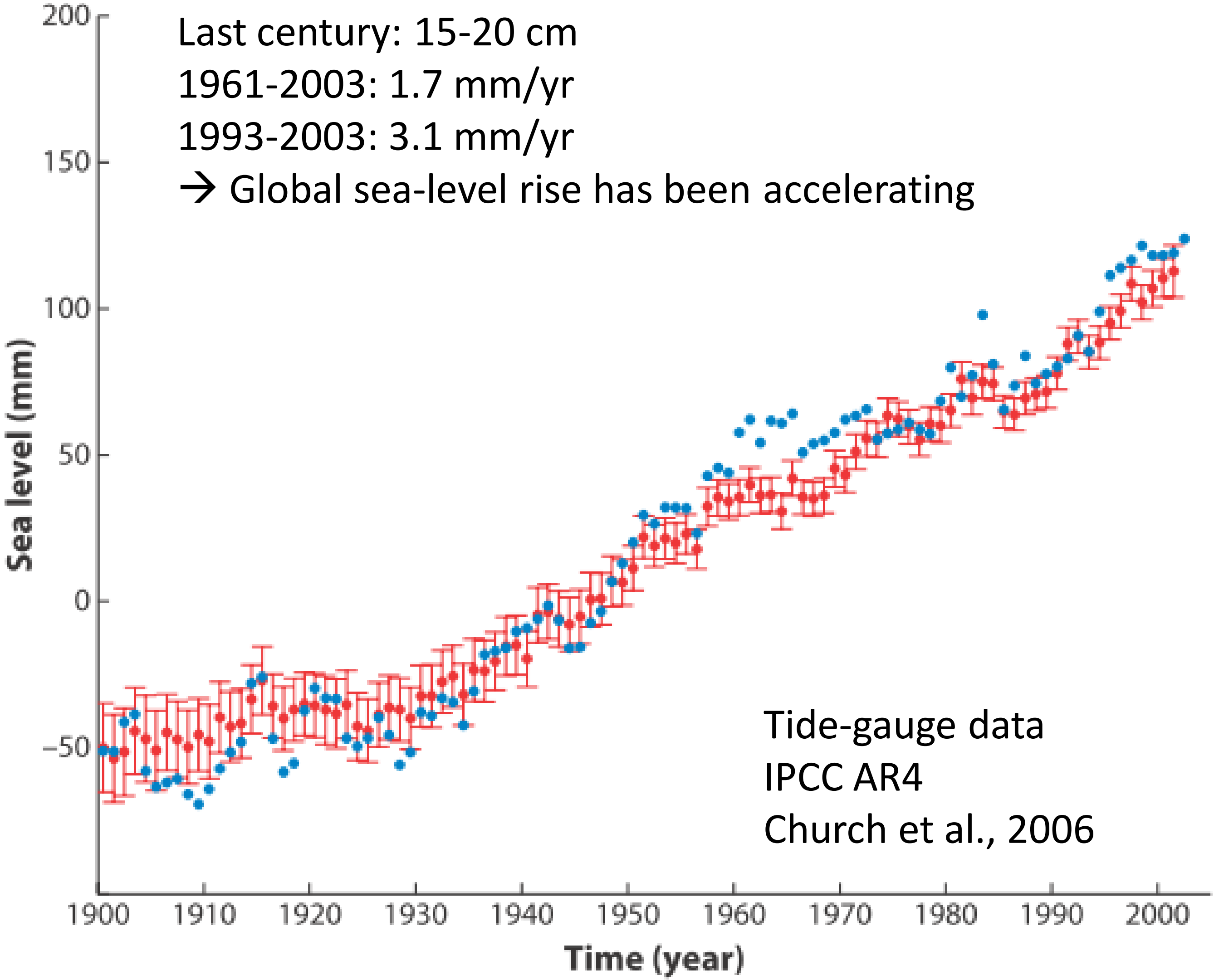
Overview

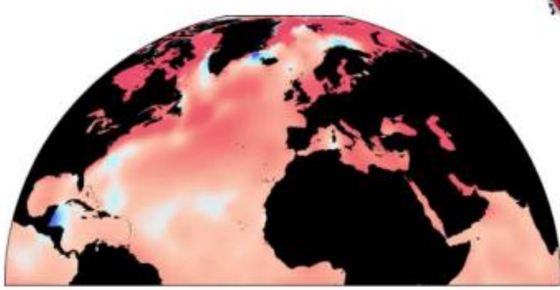
- Part 1: Global sea level: past and future
- Part 2: Spatial variations of sea level
- Part 3: Sea-level rise impacts
- Part 4: Persistence of Atoll islands under recent and projected sea-level rise

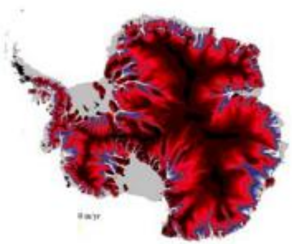
Part 1: global sea level

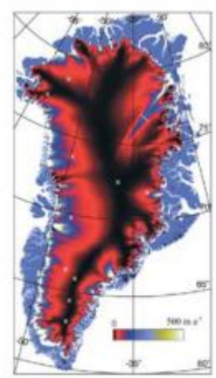


Observations: increasing contribution from ice-sheets

1961-2003: 1.6 mm/year: (Domingues et al., 2008)	2003-2008: 2.5 mm/yr: (Cazenave et al., GPC 2008)
• Ocean warming (~40 %)	• Ocean warming (~20 %)
• Mountain glaciers (~35 %)	• Mountain glaciers (~40 %)
• Ice sheets (~25 %)	• Ice sheets (~40 %)

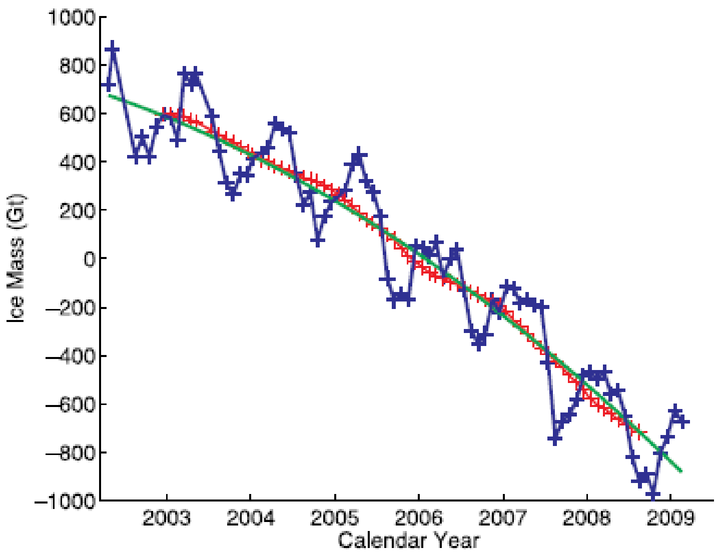




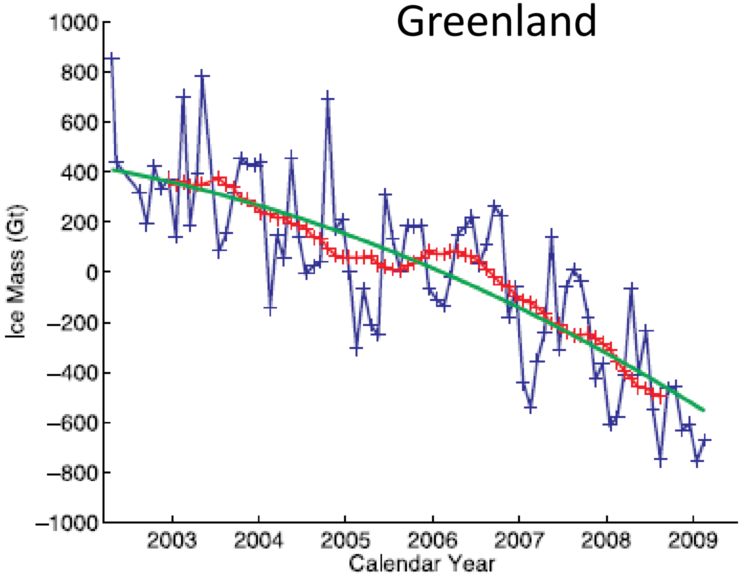


Accelerating loss from ice-sheets

Antarctica loses as much mass as Greenland



Greenland



Antarctica

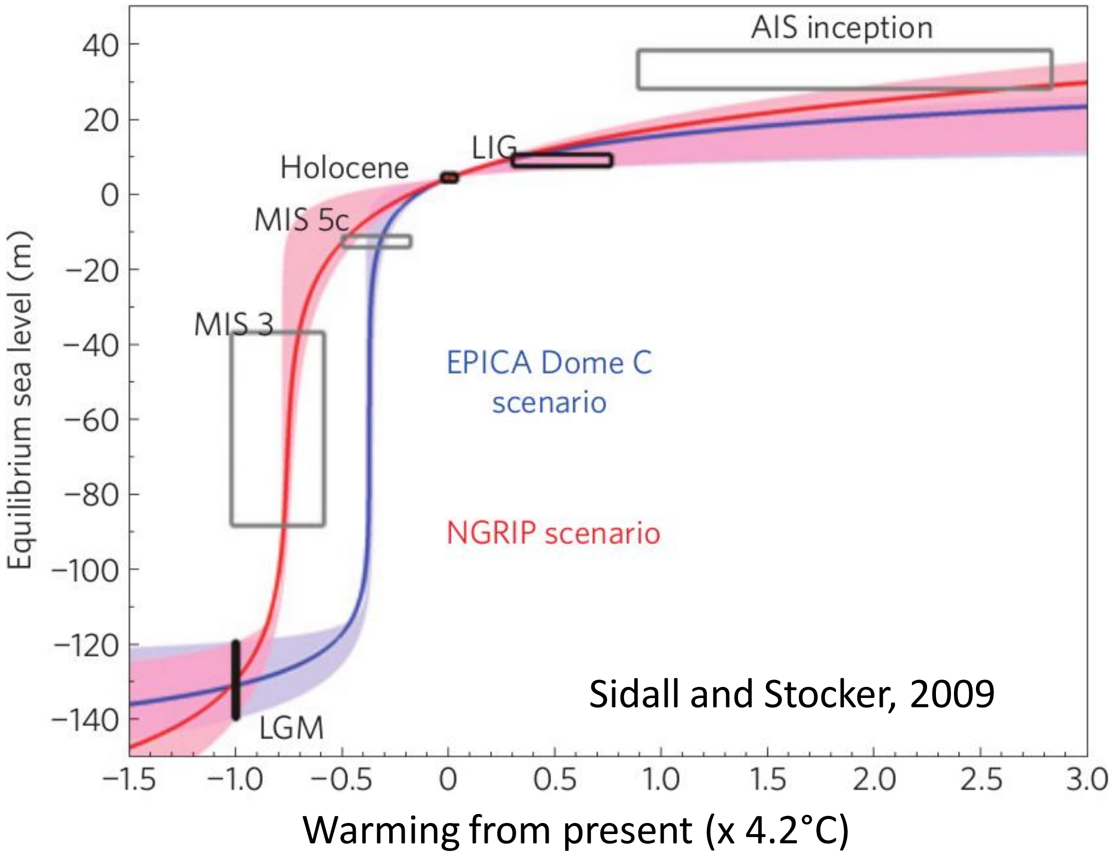
Velicogna, 2009

Numbers from Rignot et al., 2011

Extrapolation to 2100:

- constant *rate* 13 cm
- continued *acceleration* 56 cm

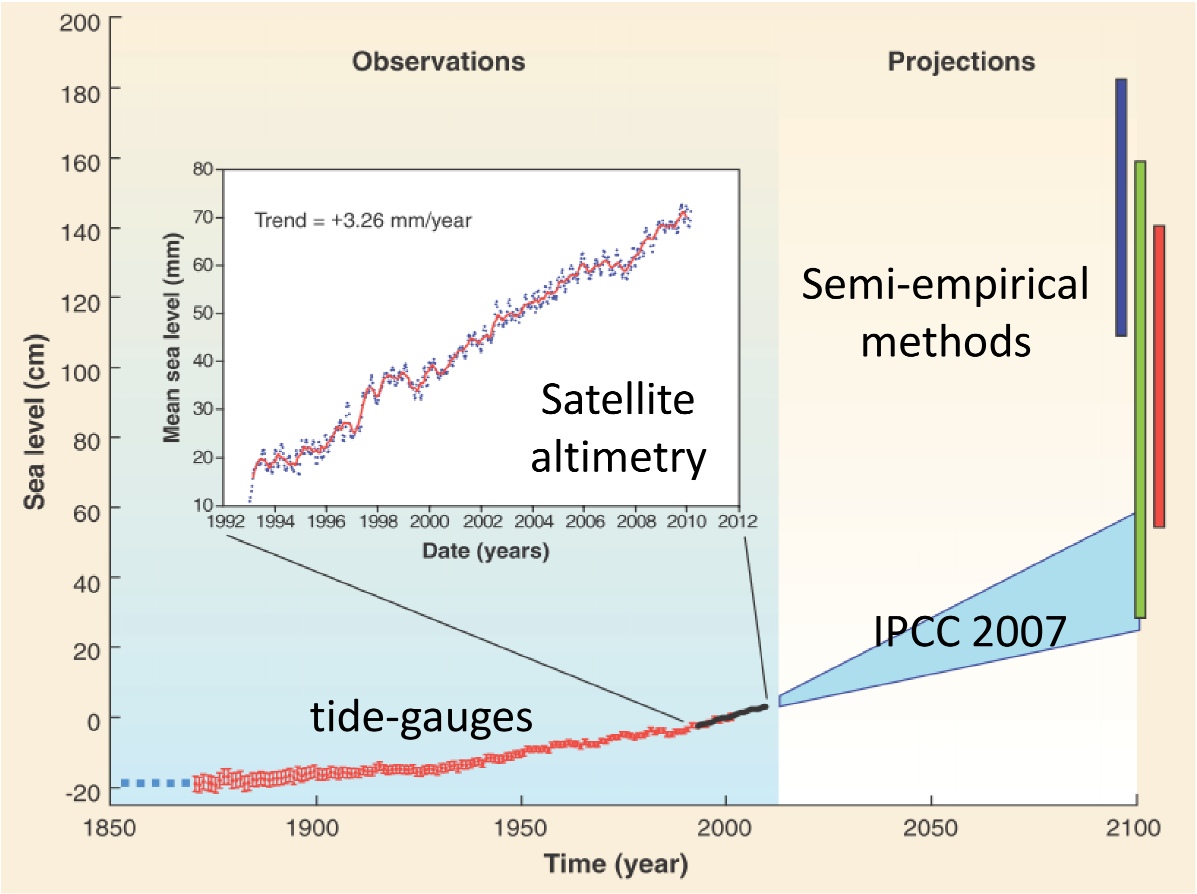
Sea-level in the past



Caveat: different insolation, no perfect anologue for future warming

10-15 m per degree during warm period (as today)

Future Projections



←Projections based on recent observations

Our working assumption:
~1m by 2100
(despite many caveats)

←Ice-sheet models are not able to reproduce current observations

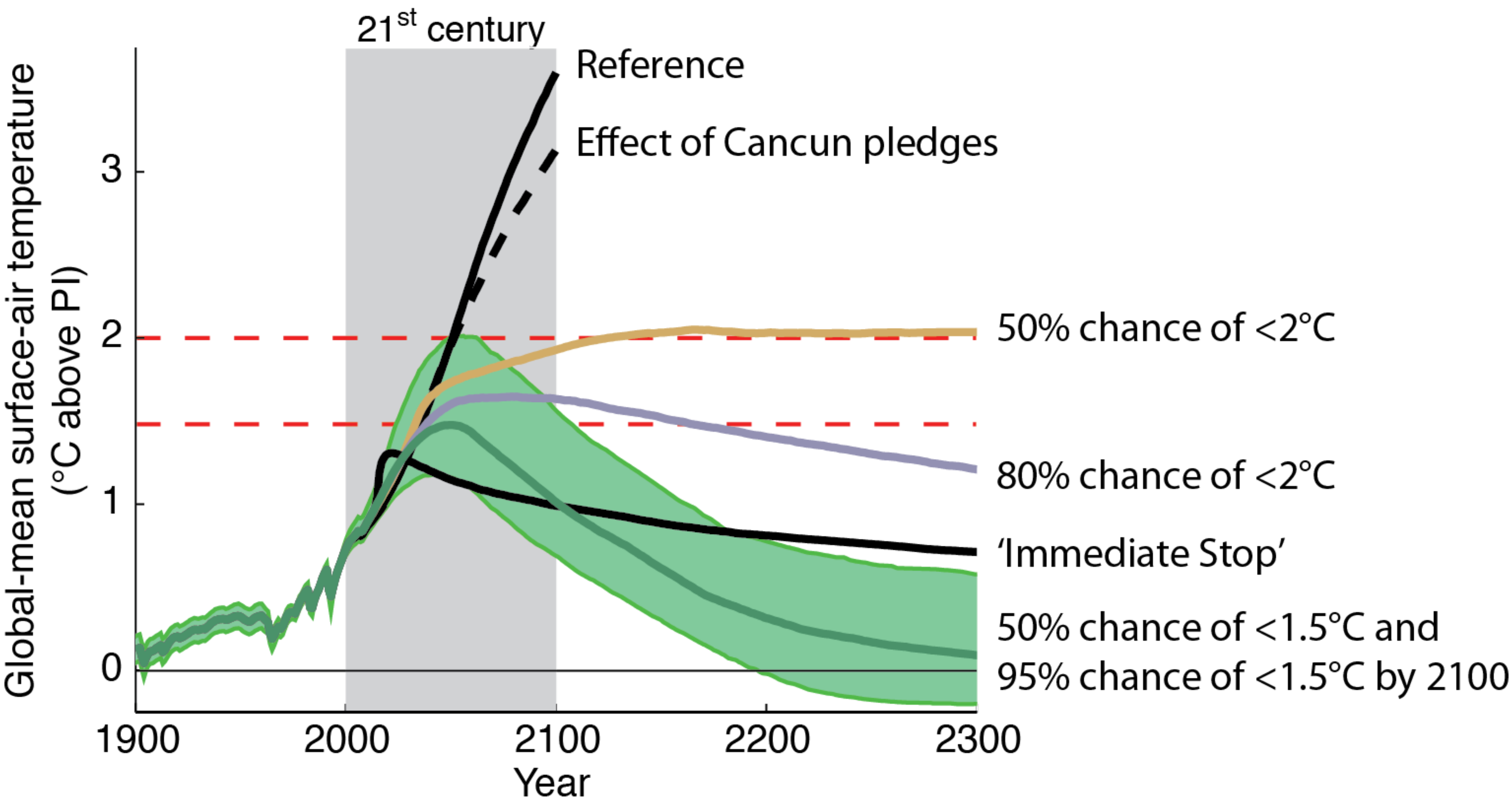
Nicholls and Cazenave, Science, 2010

Lines of evidence for 1m rise by 2100

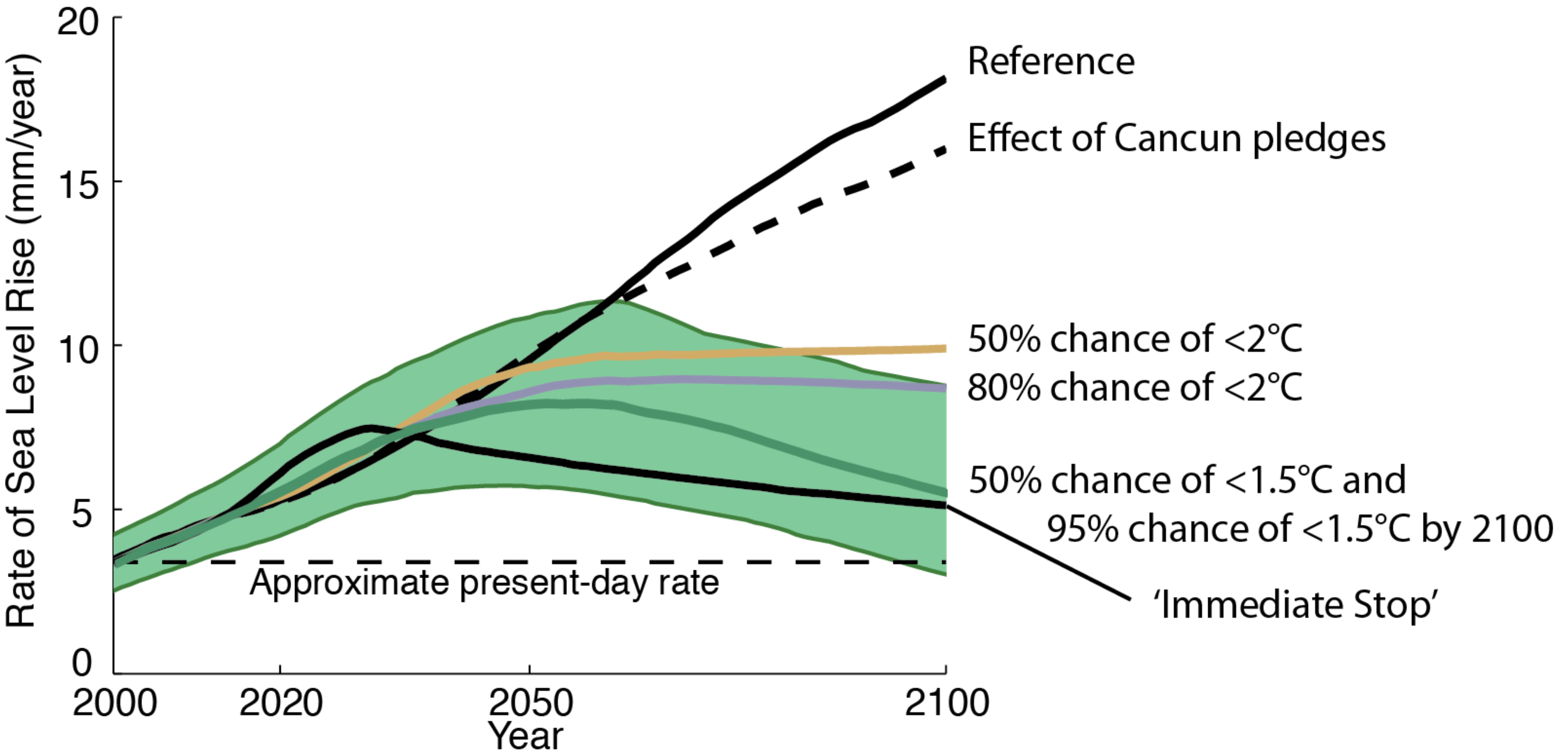
- IPCC AR4 **did not include rapid ice sheet losses over the next century,** and **does not reproduce recent observations**
- **Current trends suggest 13-56 cm from ice-sheets**, and topographic constraints cannot exclude 117 cm
- Mountain glaciers: 12 cm (6-37cm), thermal expansion: 15-40cm
- **Past changes in sea level show risk of large, meter-scale rise per century** (but no perfect analogue for future warming)
- Instability of the west antarctic ice sheet (~3 m), unknown rate
- Decay of Greenland ice sheet for 1.9-4.6 °C warming above pre-industrial over centuries to millenia (6-7 m)

Latest scenario projections:

Global temperature increase drives global SLR



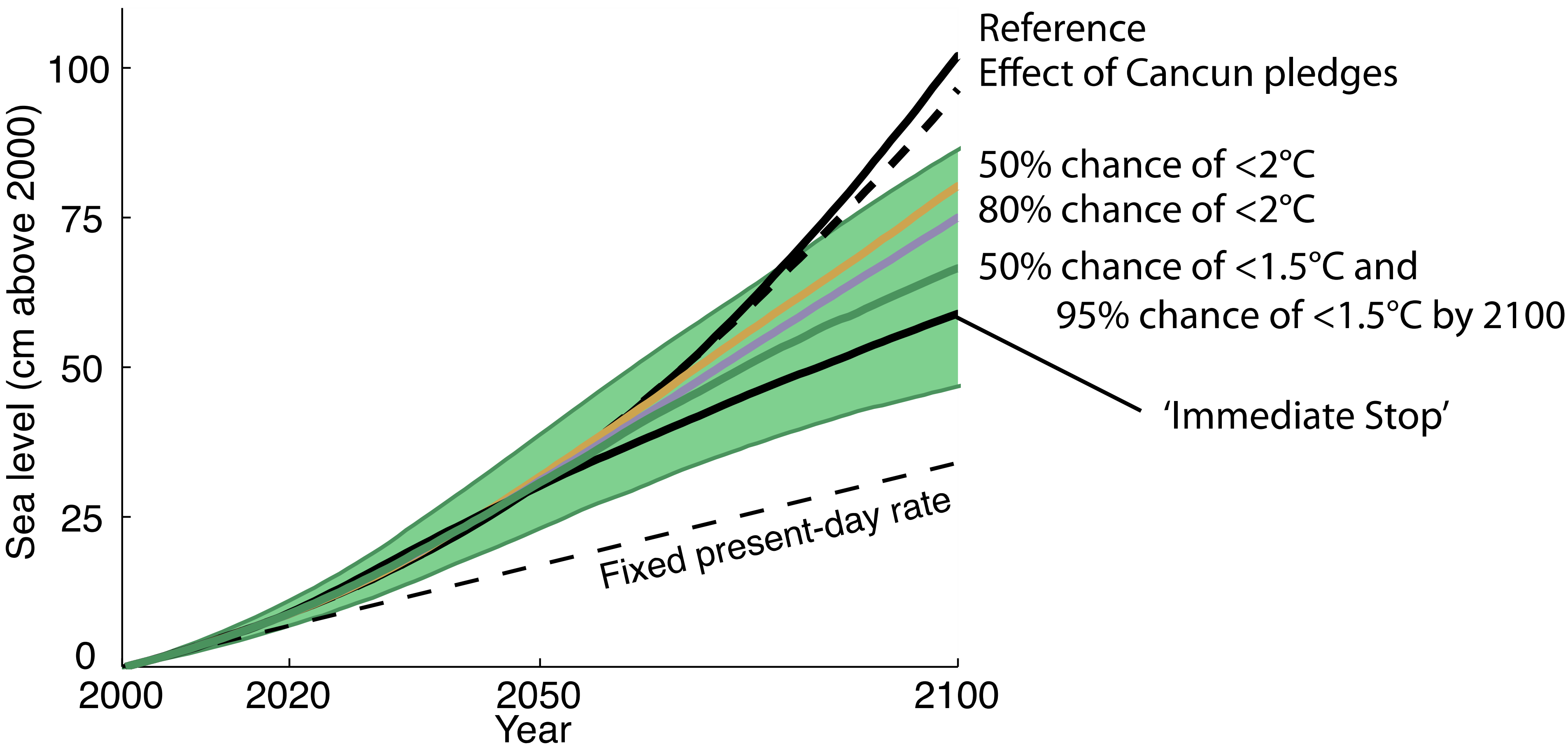
Latest scenario projections:
Global temperature increase drives **global SLR (rate of global SLR in 21st century)**



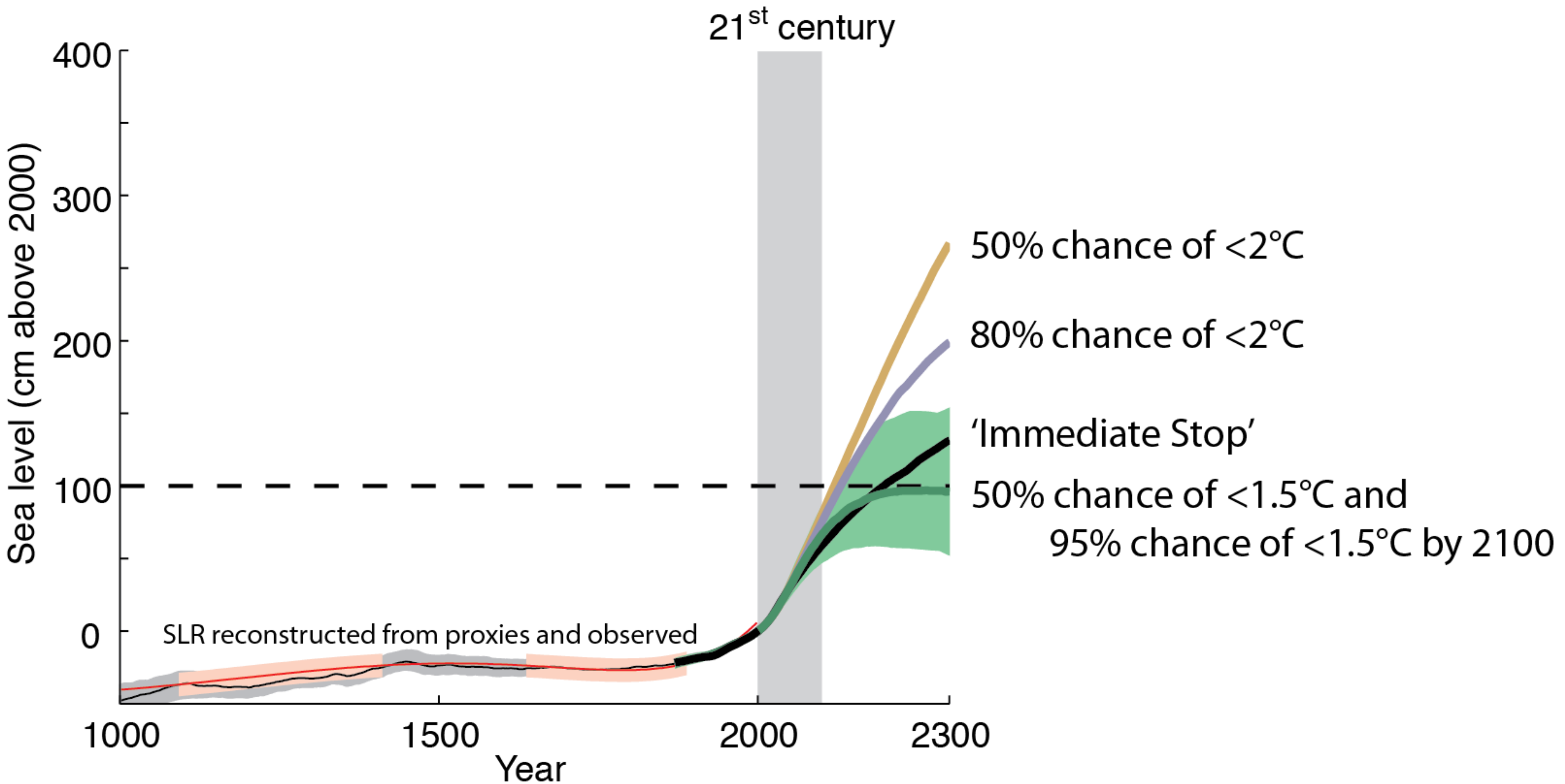
Latest scenario projections:

Global temperature increase drives **global SLR**

(total global SLR in 21st century)

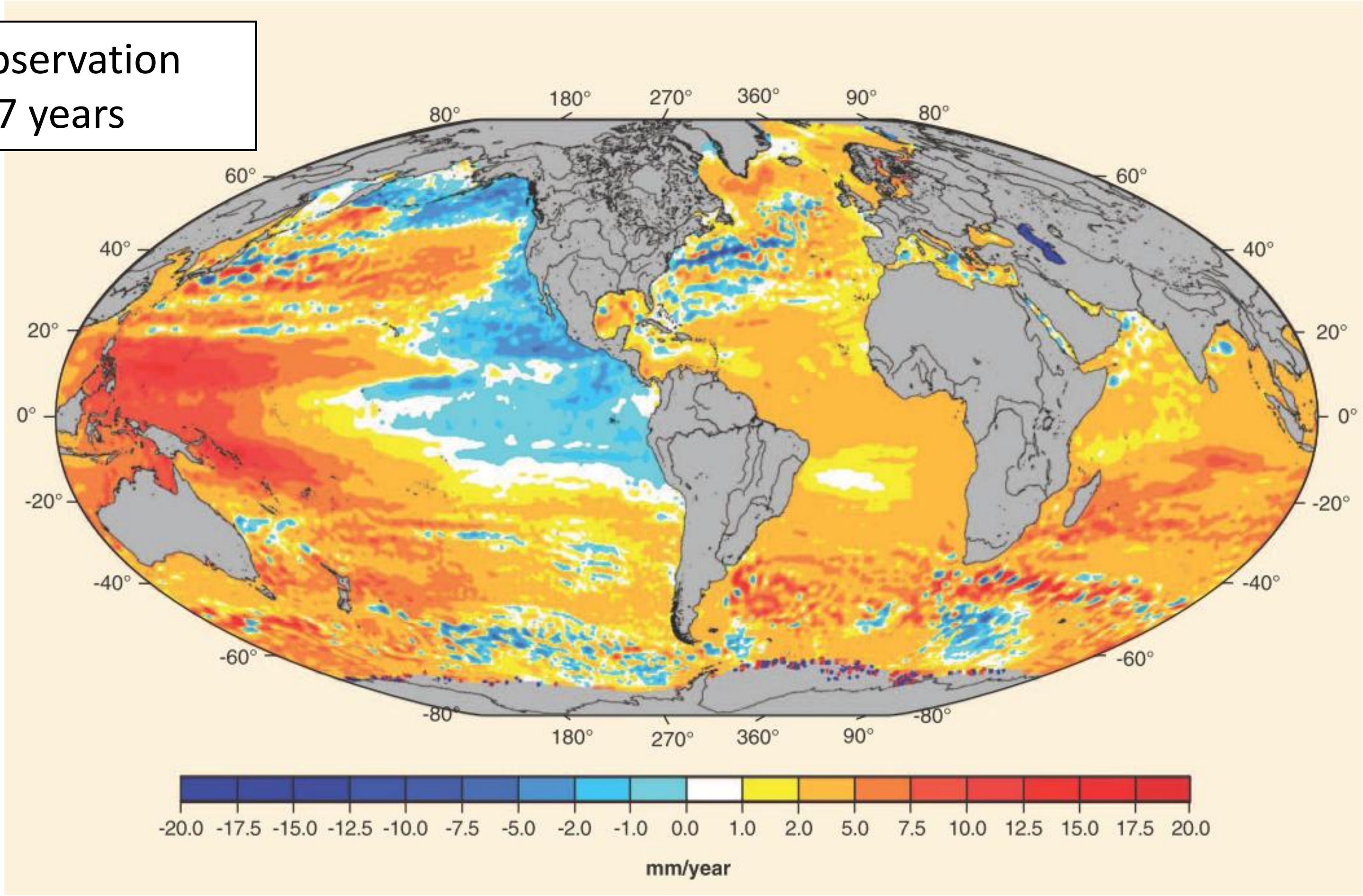


Latest scenario projections:
Global temperature increase drives **global SLR (total global SLR in LONG TERM)**



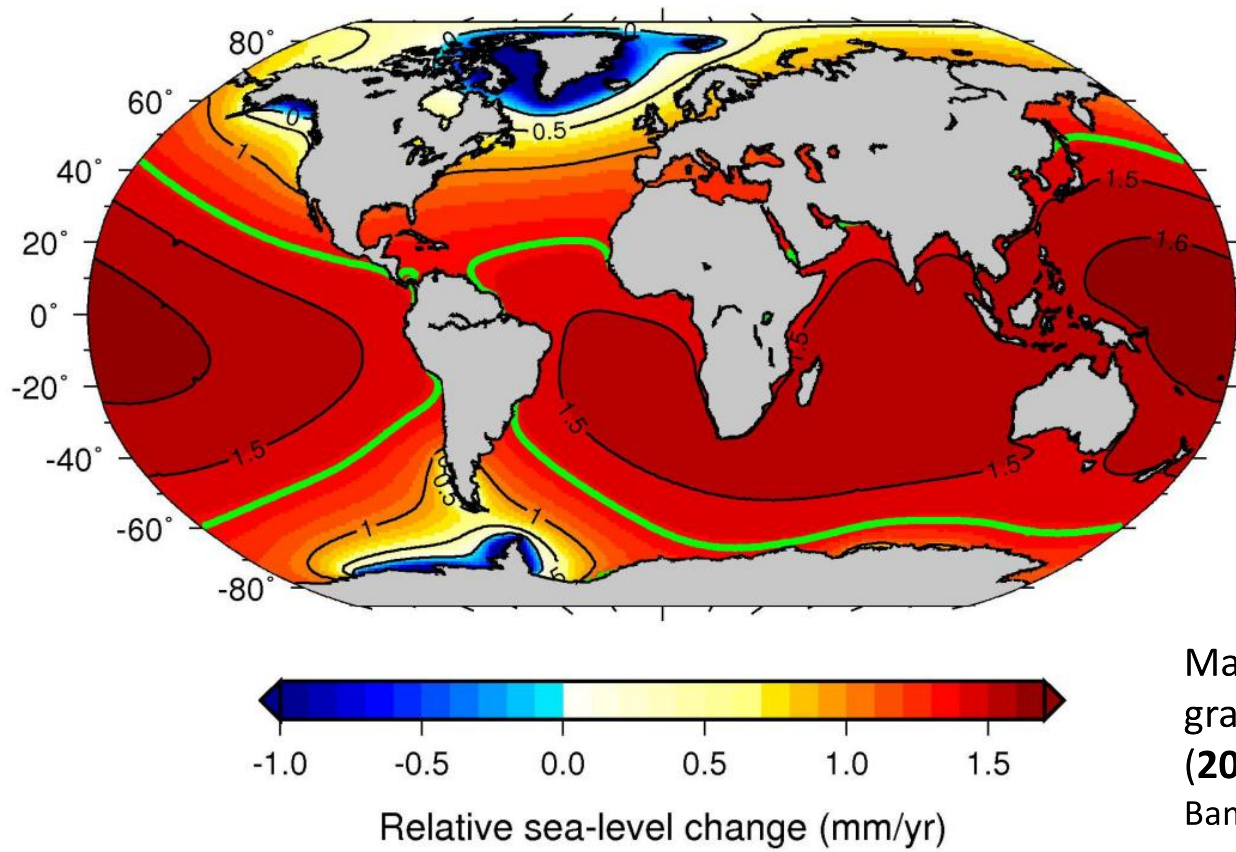
Part 2: Spatial variations of sea level

Satellite observation over last 17 years



Local sea-level trends up to 10 times higher than the global mean rise (but very likely **transient phenomena**)

Sea-level rise due to land-ice melt and gravity effects



Mass change + gravitational effects (**2000-2008**)
Bamber and Riva, 2010

Water migrates away from melting ice → Higher rise at low latitudes where vulnerable islands are (+10-20%)

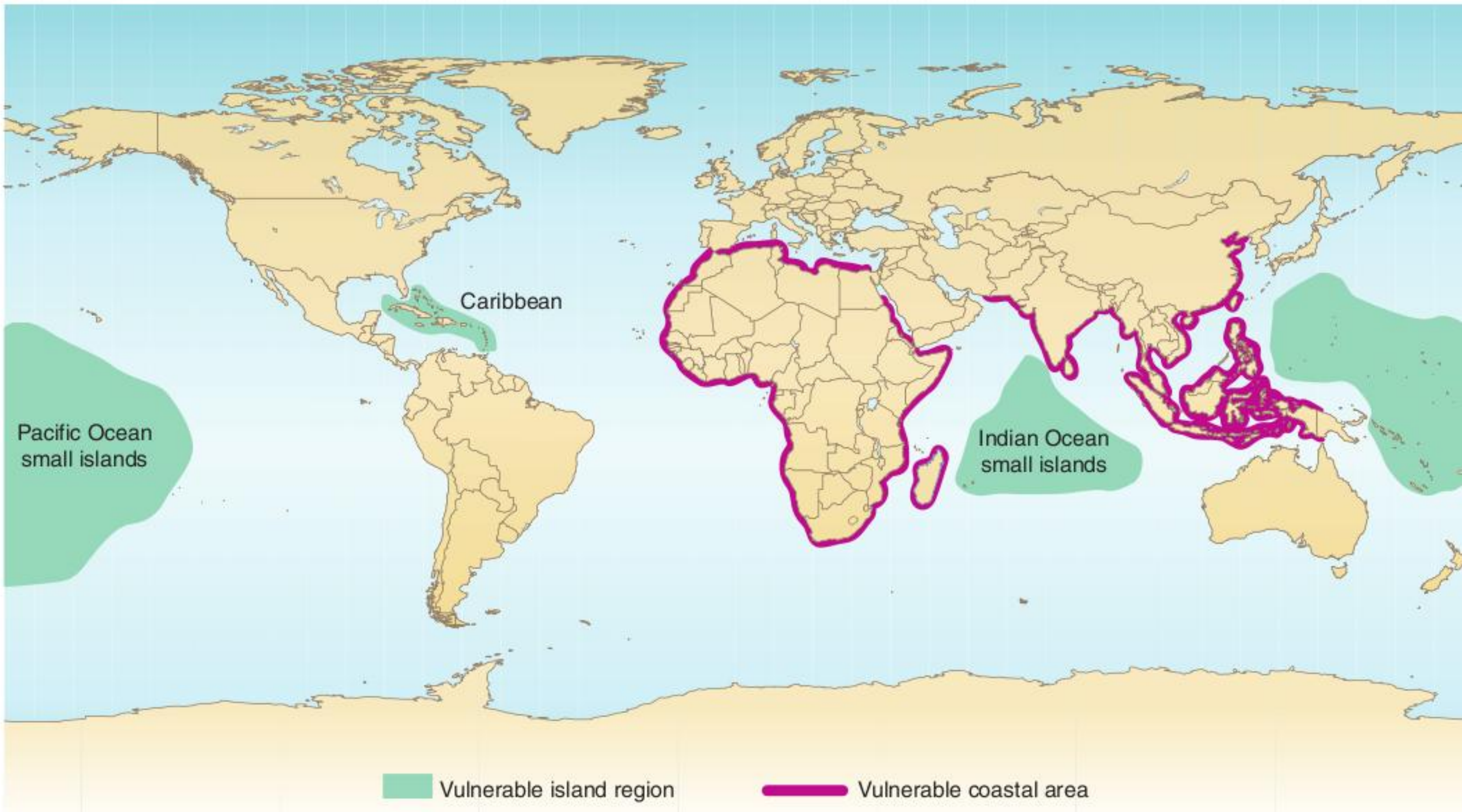
Spatial variations of sea-level: summary

- New research topic, overlooked previously
- Observed with satellite altimetry (past 17 years):
  - local sea-level rise up to 10 times faster than global
    (but large role of natural variability → flattens on the longer term)
- What drives local changes?
  - Changing local currents, salt and temperature
  - **Gravity changes due to ice melt**
  - Other factors: local subsidence due to mining…
- For the future ?
  - Anticipated large ice contributions → ice-related pattern dominates
  - Above-average (+10-20%) rise at low latitudes (far from polar ice mass loss), especially western pacific (far from Greenland)

Part 3: Sea-level impacts

Most Vulnerable Regions:

risk = exposure * adaptive capacity * sensitivity



Overview of impacts

- Very likely that sea level rise will contribute to upward trends in coastal flooding

  (coupled effect of increasing sea level and stronger storms)
- Enhanced coastal erosion and inundation
- Seawater intrusion into freshwater lenses
  - decline in water supply, soil salinisation → affects agriculture
- Large fraction of urban centers lie at coasts
  - severe impacts particularly in low-income countries
- Threats for tourism
  - Most tourism infrastructure at coasts
  - Tourism major economic factor
- In some cases relocation may be necessary

Most affected bigger countries under 1m sea level rise

Population	GDP
Vietnam (10.79)	Vietnam (10.21)
A.R. Egypt (9.28)	Mauritania (9.35)
Mauritania (7.95)	A.R. Egypt (6.44)
Suriname (7.00)	Suriname (6.35)
Guyana (6.30)	Benin (5.64)
French Guiana (Fr) (5.42)	The Bahamas (4.74)
Tunisia (4.89)	Guyana (4.64)

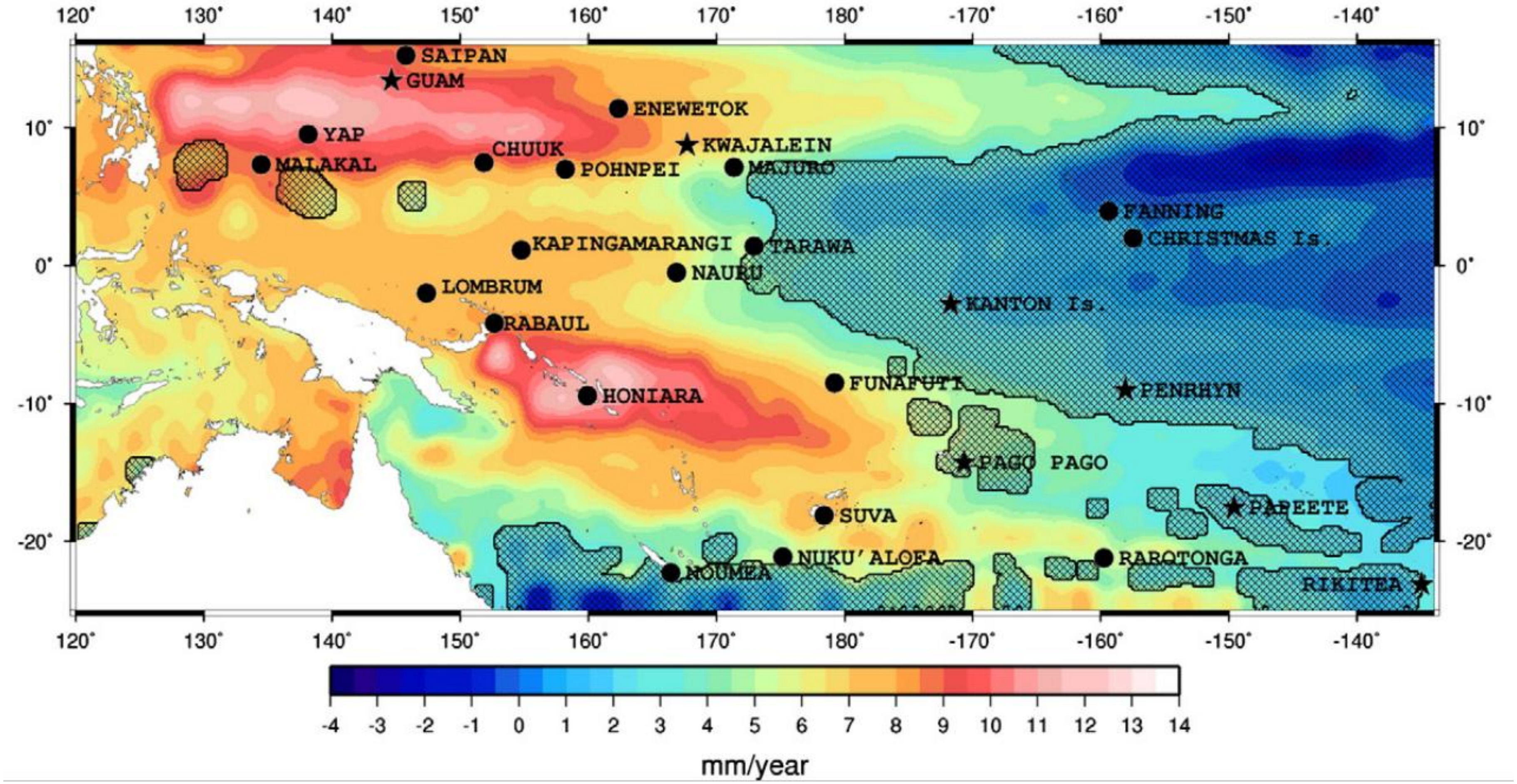
Dasgupta et al. 2009
(SIDS not included in analysis)

(exposure in percent)

- for a number of countries sea level rise is potentially catastrophic
- heavily impact that their national integrity may be threatened

→ Sea level rise also high threat for bigger countries

a) Map of altimetry-based sea level trends in the tropical western Pacific (1993-2009)



Funafuti Island, Tuvalu (last 60 years observations):

- rate of rise up to 3 times larger than the global trend
- 30 cm rise in total

Becker et al. 2011

Part 4: Persistence of Atoll islands under recent and projected sea-level rise

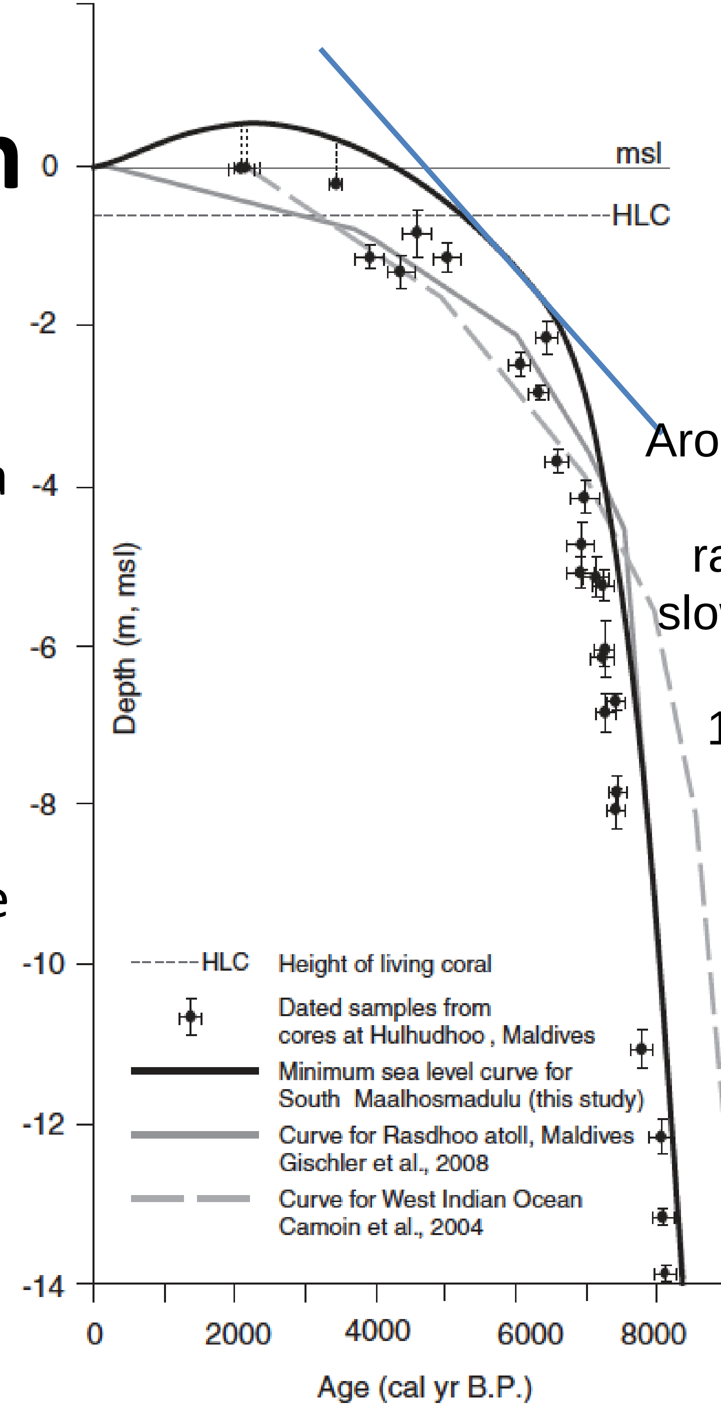
- A study published in 2010 show that 43% of 27 central-Pacific Atoll islands have grown in <u>net</u> area over recent decades, with only 14% of these studied islands decreasing in <u>net</u> land area
- This has led to claims that risks to these islands from projected sea level rise due to global warming have been overstated.
- However, the authors or the original study warn:
  “While the islands are coping for now, any acceleration in the rate of sea-level rise could overtake the sediment build up” (New Scientist, 2 June 2010).

Persistence of Atoll islands under recent and projected sea-level rise

- Atoll islands have persisted in the past 10,000 years during periods of sea level variations at rates not very different from those observed in recent decades. It is to be expected that these islands can respond dynamically to limited sea level rise and fall.
- However, the dynamics of atoll islands formation and persistence depends strongly on local conditions and morphology, as well as anthropogenic influence on shorelines, including infrastructure. Hence even **net** increases in area may not correspond to enhancement of present resources and could also be associated with significant loss of useable area and/or infrastructure.

SLR Maldives region

- EXAMPLE In the region of the Maldives, reef growth after LGM resumed at around 8,000 years before present, as the rate of sea level rise slowed sufficiently
- Following a further significant slow down to 1 mm/year about 6,500 years ago, islands started to form 5,500 to 4,500 years ago and have persisted since
- The rate of sea level rise over the past several decades was about 2 mm/year and in recent years over 3 mm/year
- Projected average rates over the 21st century for unmitigated climate change are of order 8-18 mm/year



Around 6,500 years ago rate of SLR slowed down to about 1 mm/year

Thank you.
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CLIMATE ANALYTICS

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