CLIMATE CHANGE IMPACTS ON OCEANS AND RELATED ECOSYSTEMS

Expert Group Meeting on Oceans, Seas and Sustainable Development:
Implementation and follow-up to Rio+20
18-19 April 2013

Climate Analytics

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Acknowledgements
Sophie Adams (CA), Klaus Bittermann (PIK), Mahé Perrette (PIK), Marcia Rocha (CA)
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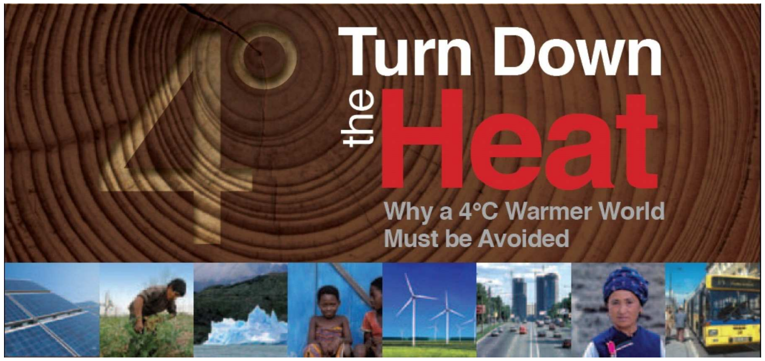

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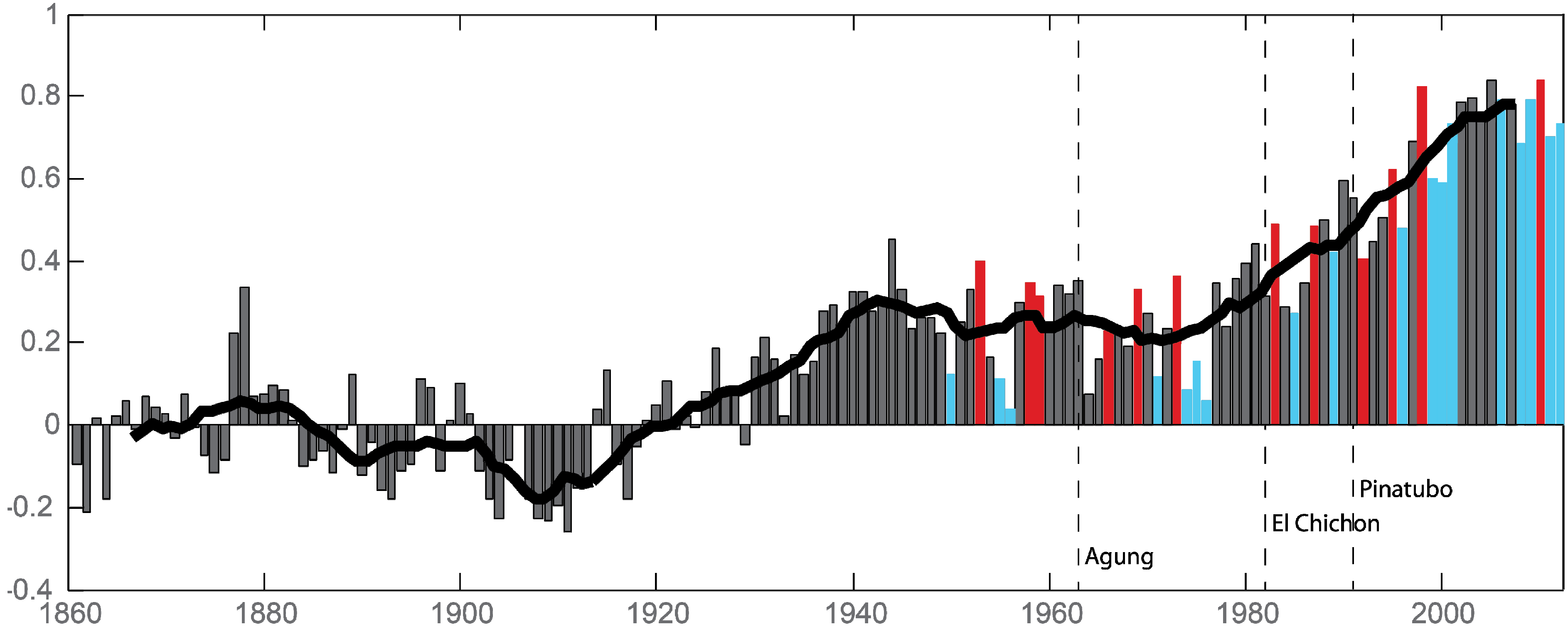
Observed warming:
Land and Ocean annual temperature (°C)
(anomalies relative to 1851-1880)



Long-term warming trend modified by internal (e.g. red – El Niño and blue – La Niña) and external (e.g. volcanic eruptions) variability

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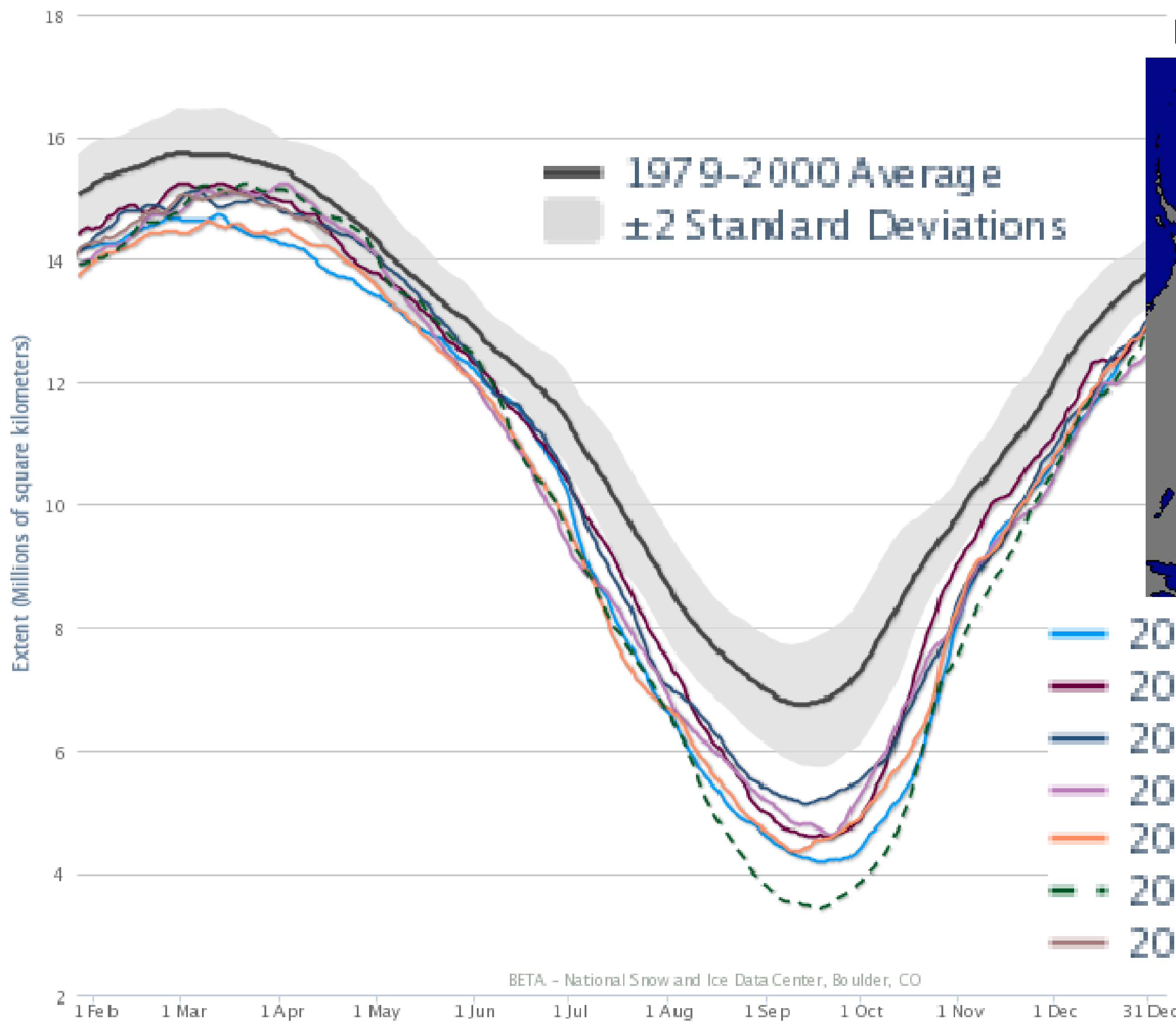
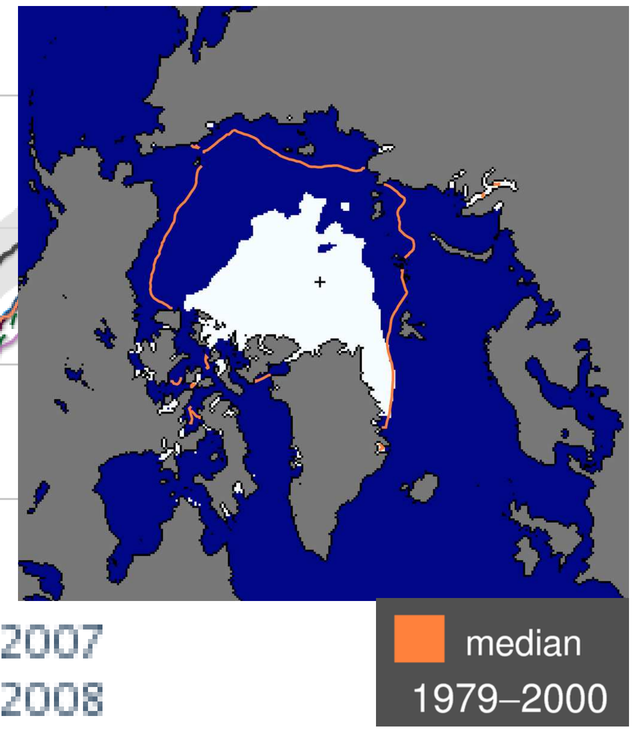
Jones et al. (2012); Morice et al. (2012) for temperature record, ENSO years from NOAA

Arctic Sea Ice Extent

(area of ocean with at least 15% ice)

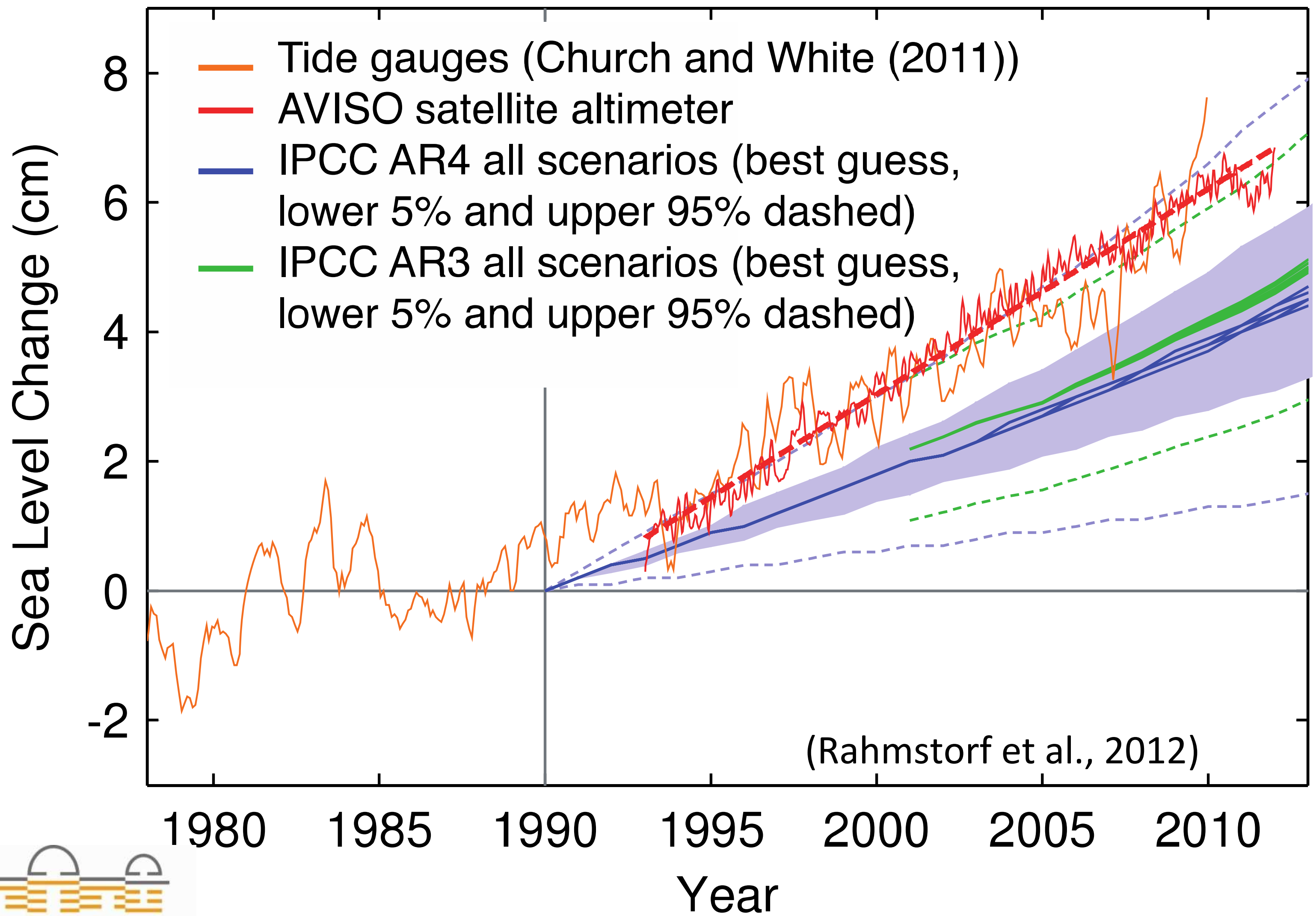


Late-summer minimum of 2012



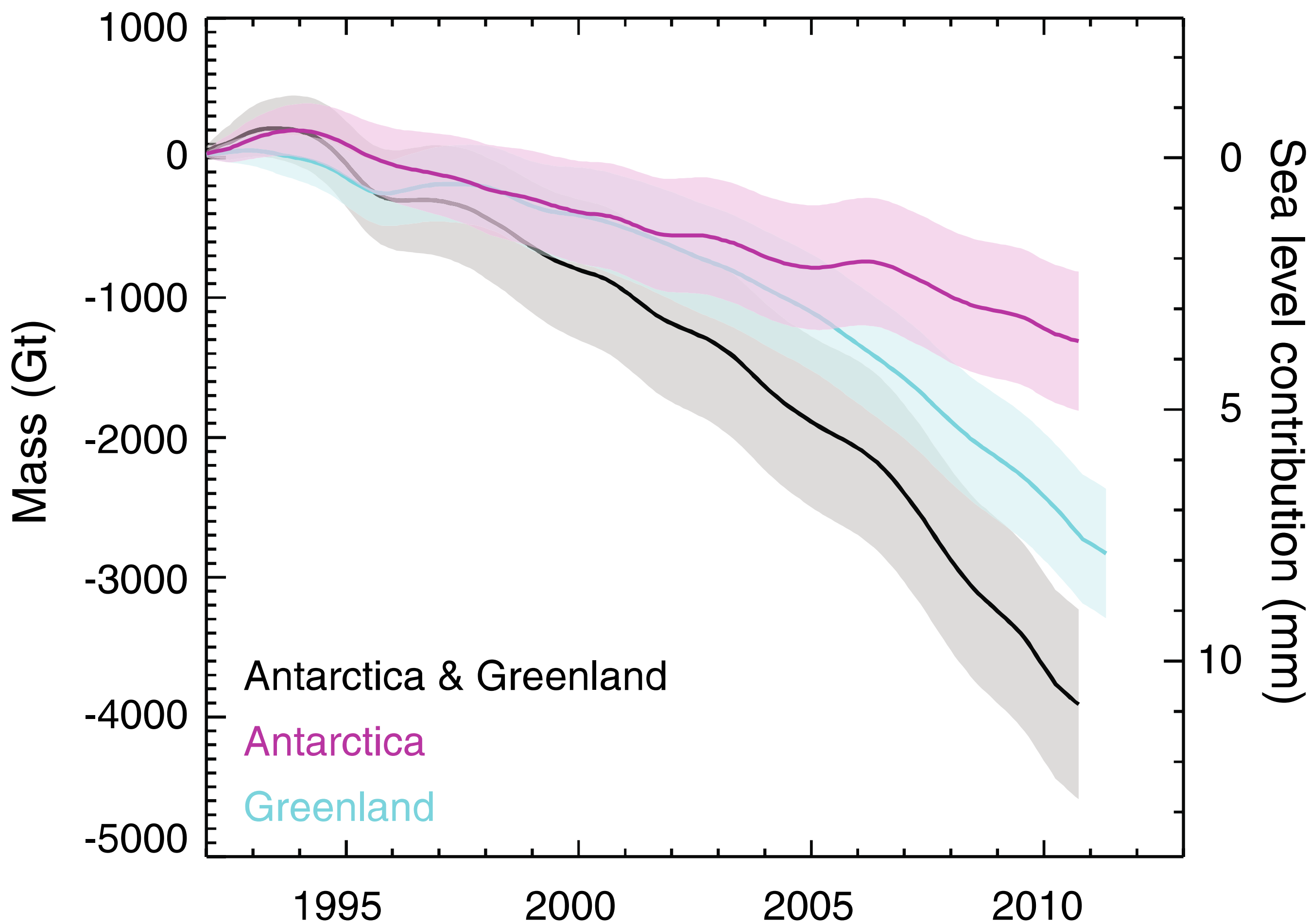
http://nsidc.org/arcticseaicenews/

Observed sea level change at top of range projected in IPCC assessment reports



Rahmstorf et al., 2012

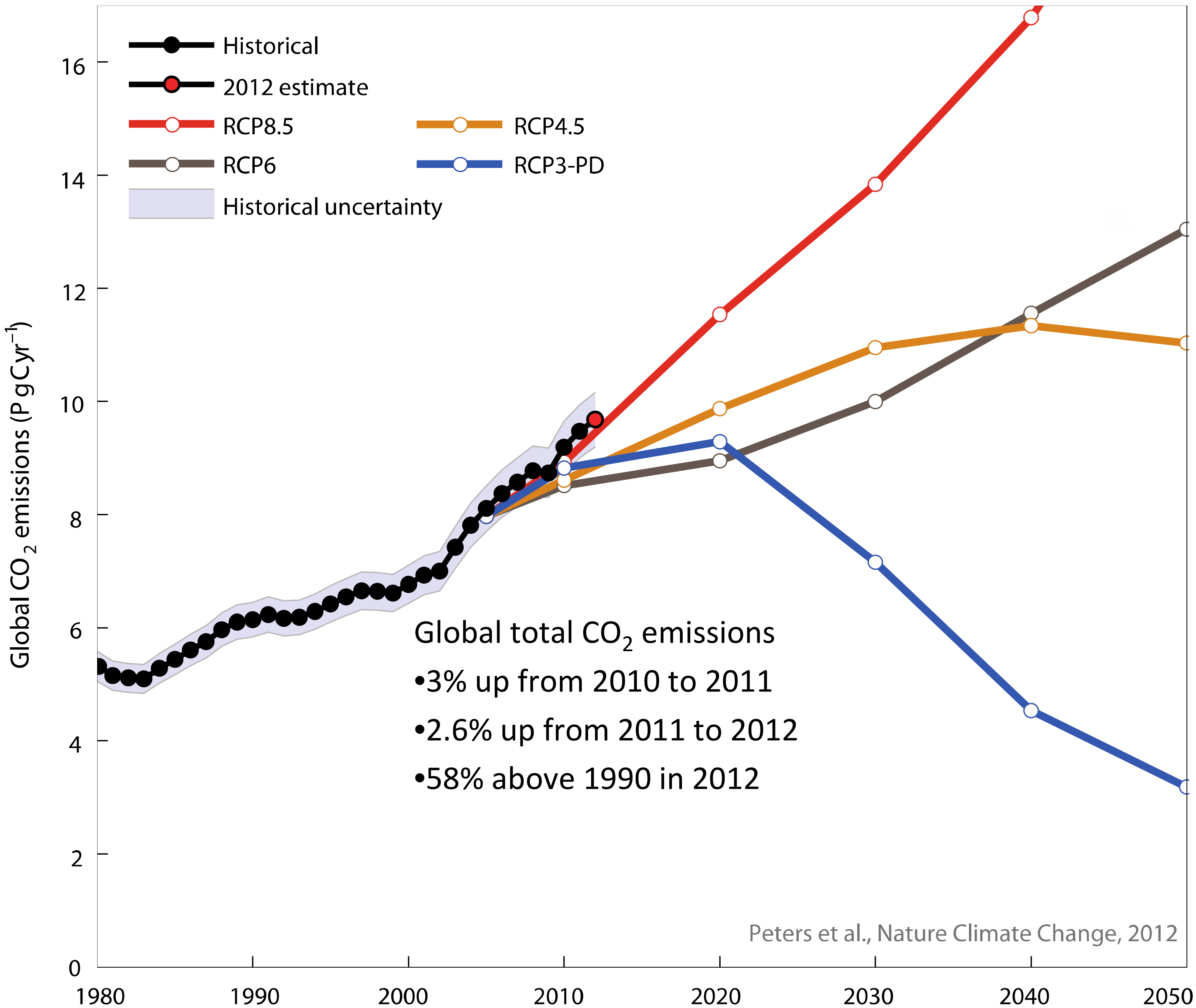
Accelerating loss from ice-sheets



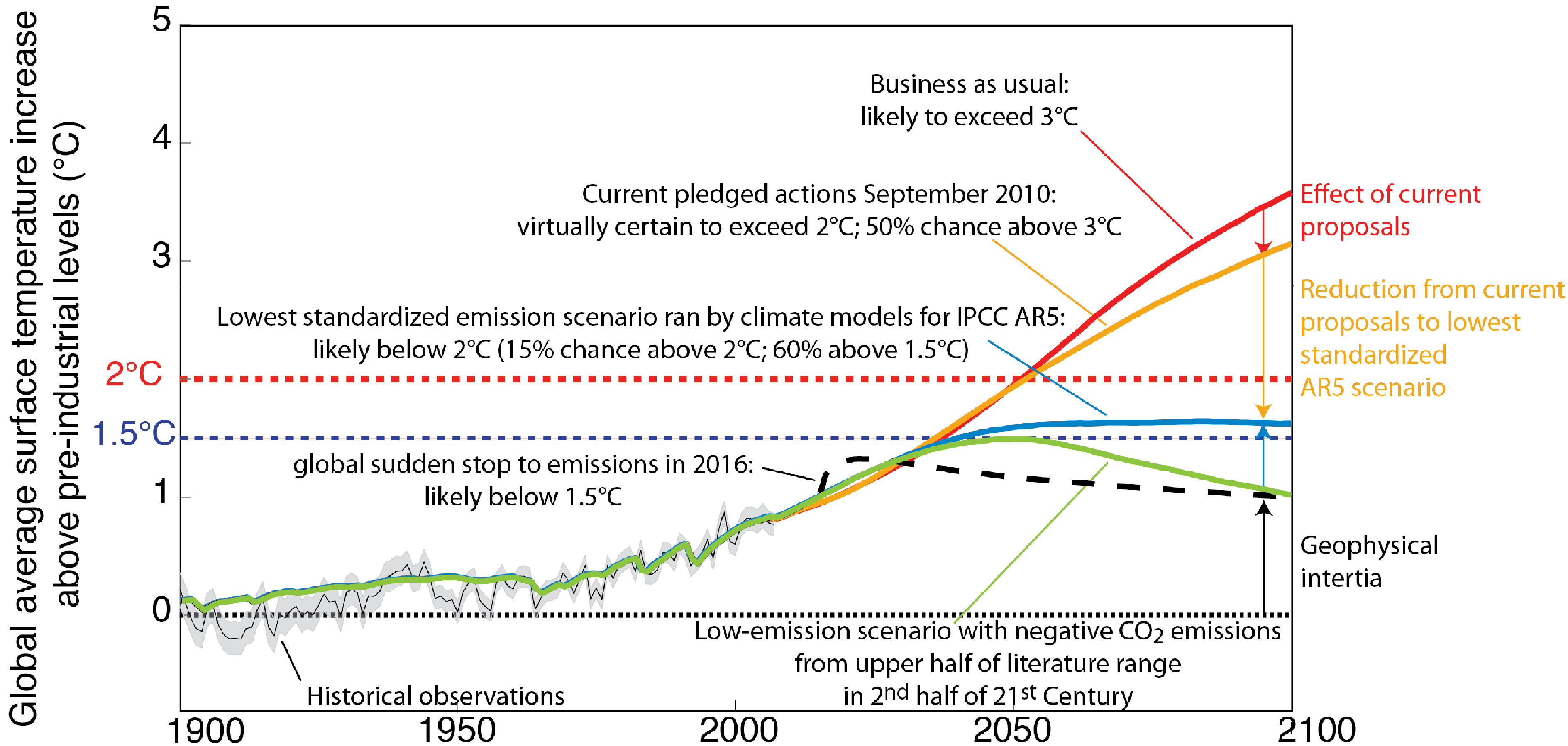
- A recent review revealed accelerating mass loss from both polar ice sheets Greenland and Antarctia
- Contributes 20% to total sea-level rise since 1992

Shepherd et al. 2012

Global Carbon Project: Emissions on the rise



Warming projections: Heading towards 4ºC?



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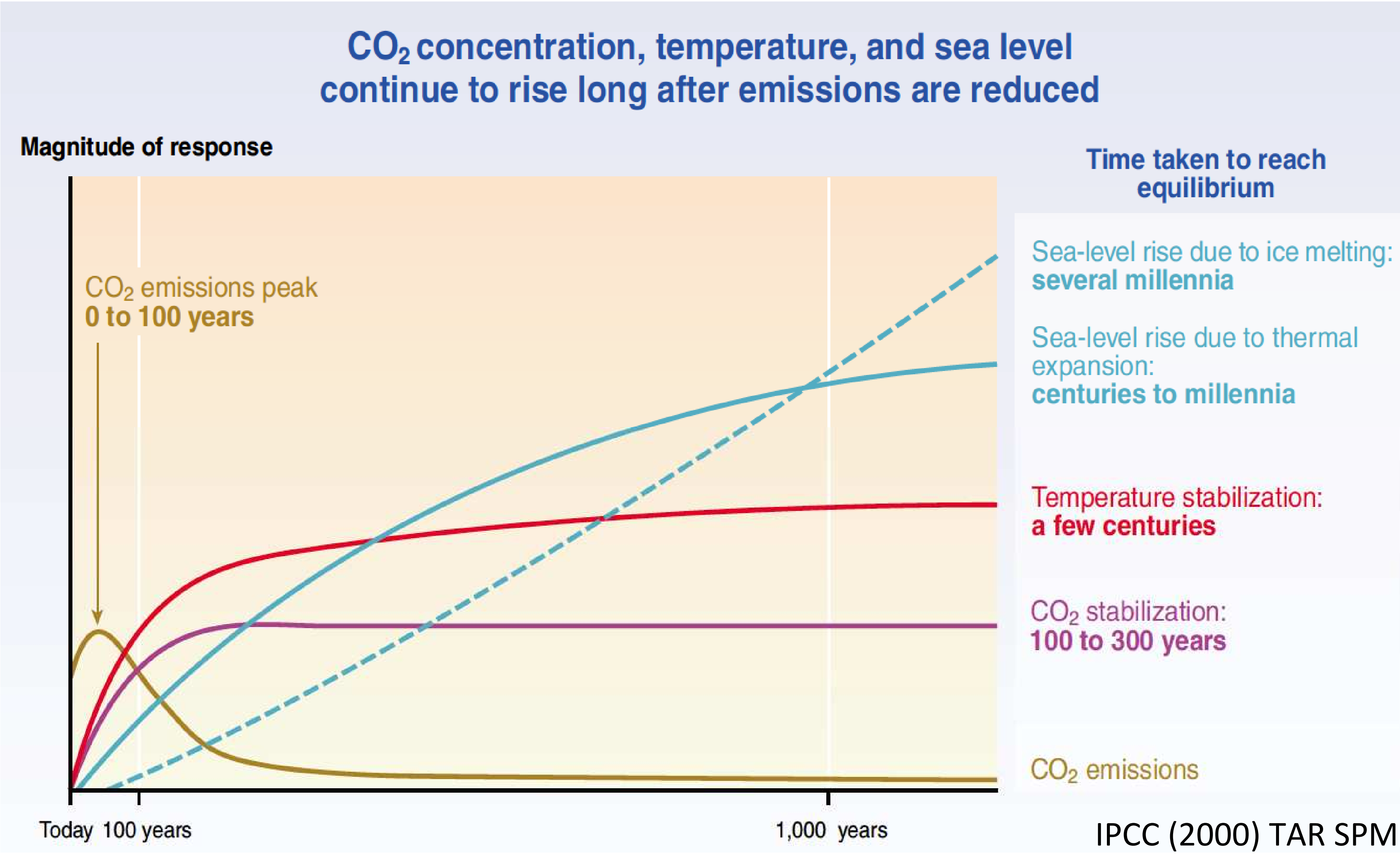
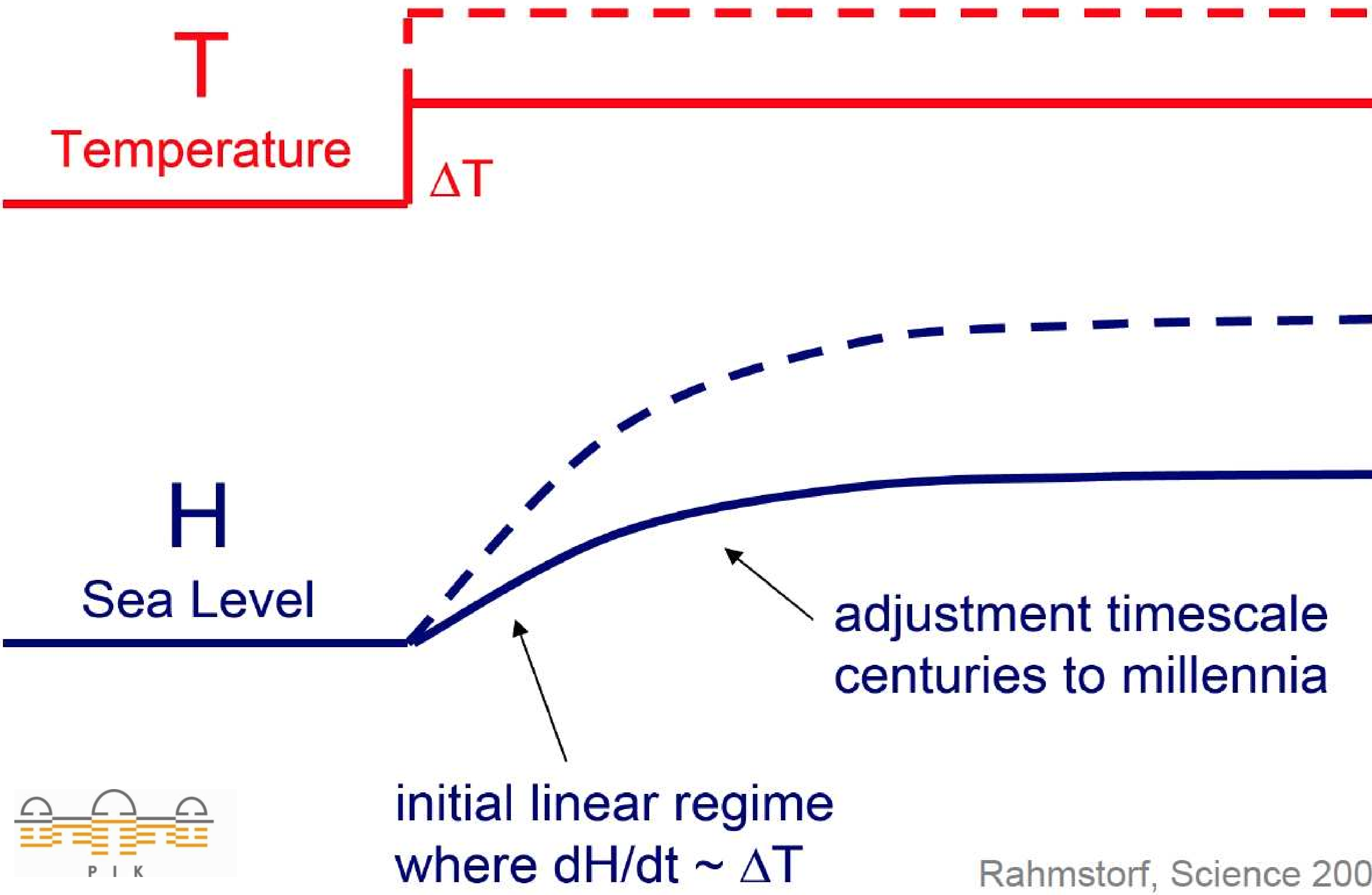
Schellnhuber et al., 2012

Delays and time scales in the climate system's response to greenhouse-gas emissions



IPCC (2000) TAR SPM

How are temperature and sea level linked?



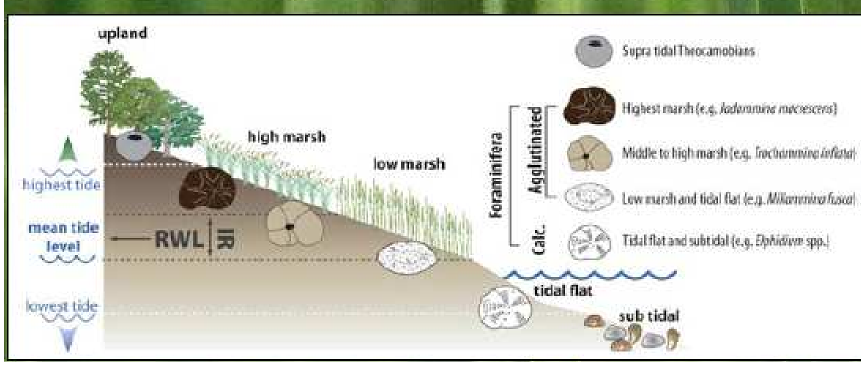
Rahmstorf, Science 2007

Reconstruction of past Sea Level

Distribution intrinsically linked to sea level and the tides

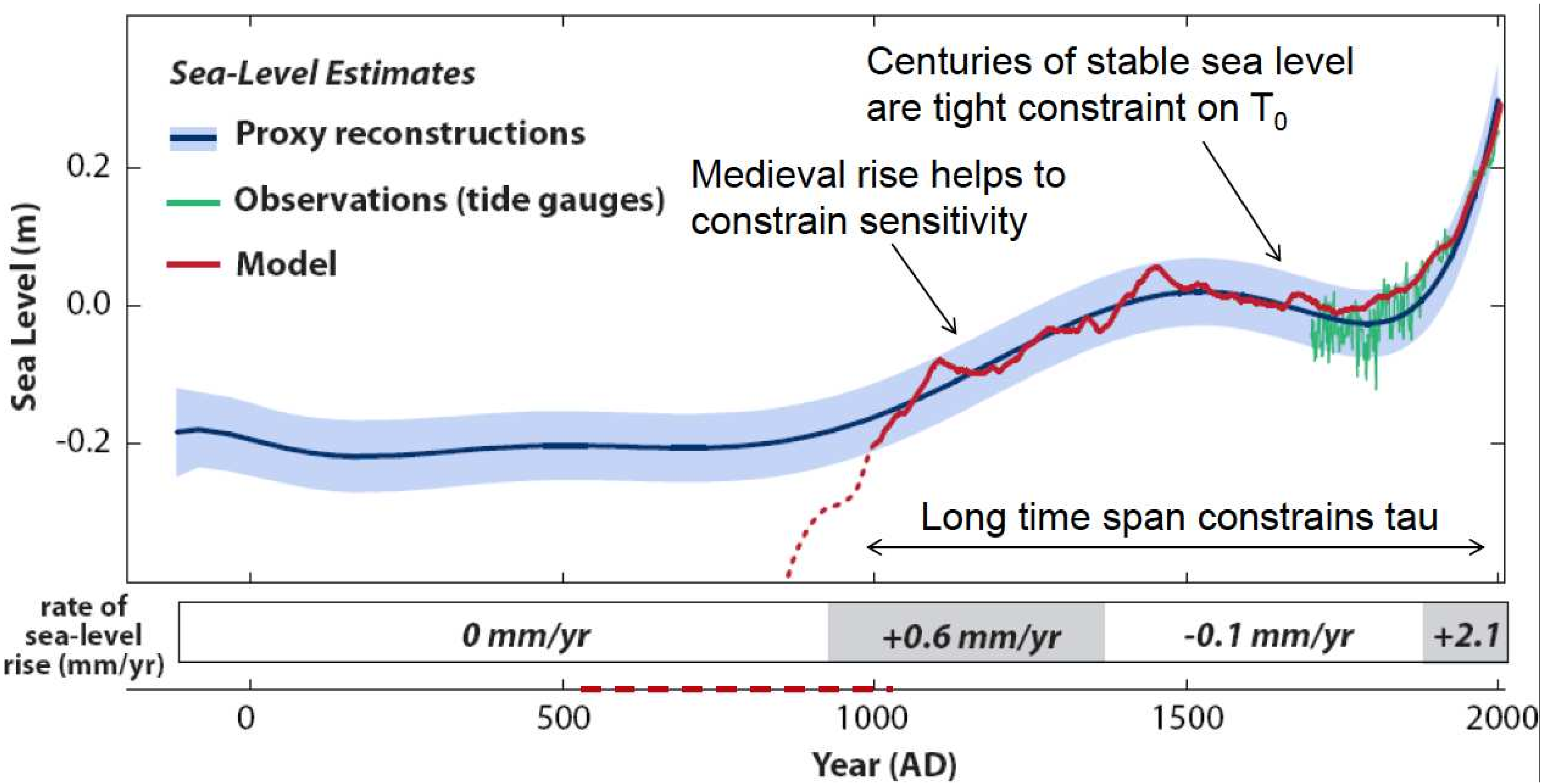
Distinctive pattern of floral zonation (tolerance of frequency and duration of inundation)

Thick sedimentary sequences are archives of sea-level change



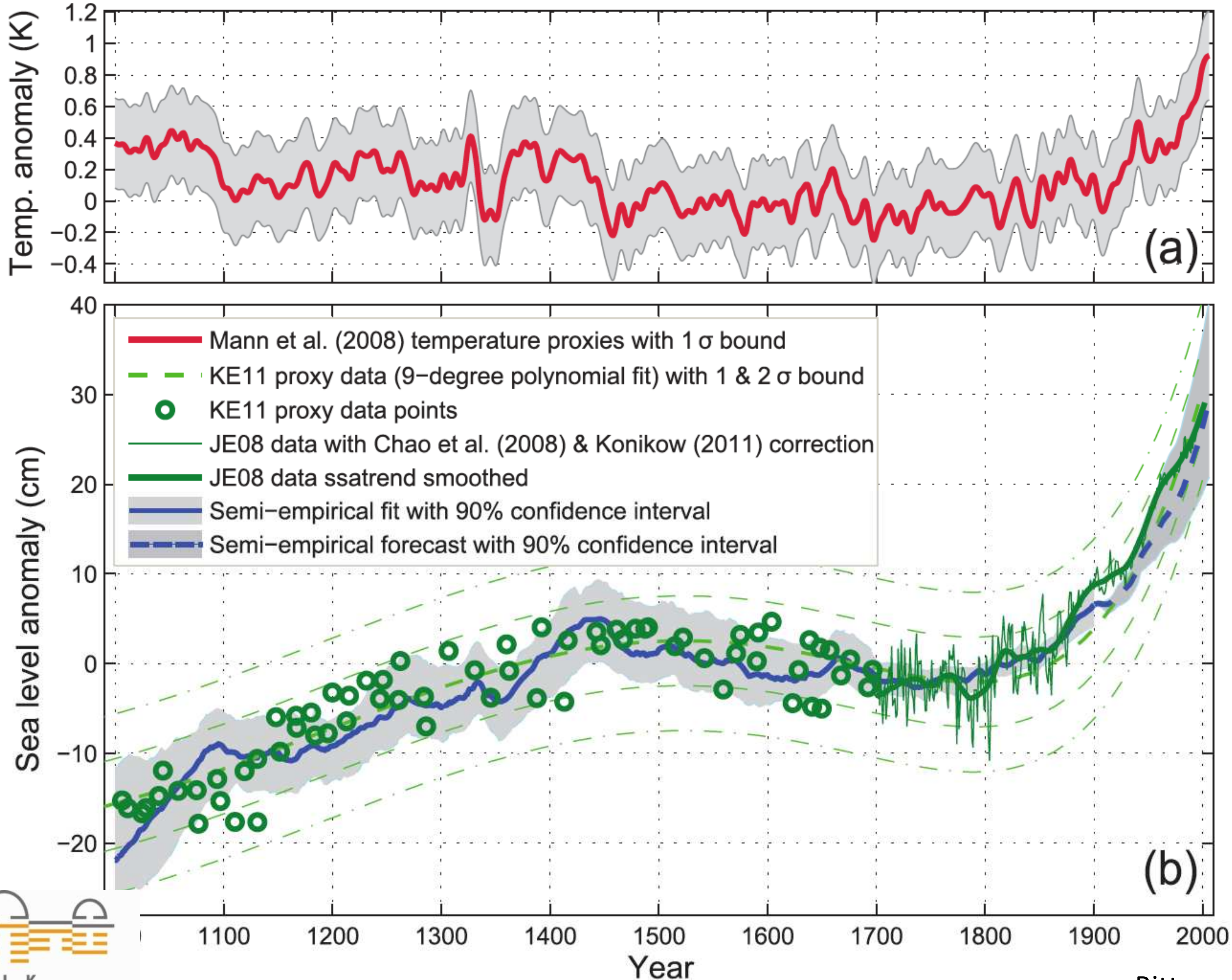
Fotos: S. Rahmstorf

Sea Level reconstruction vs semi-empirical model



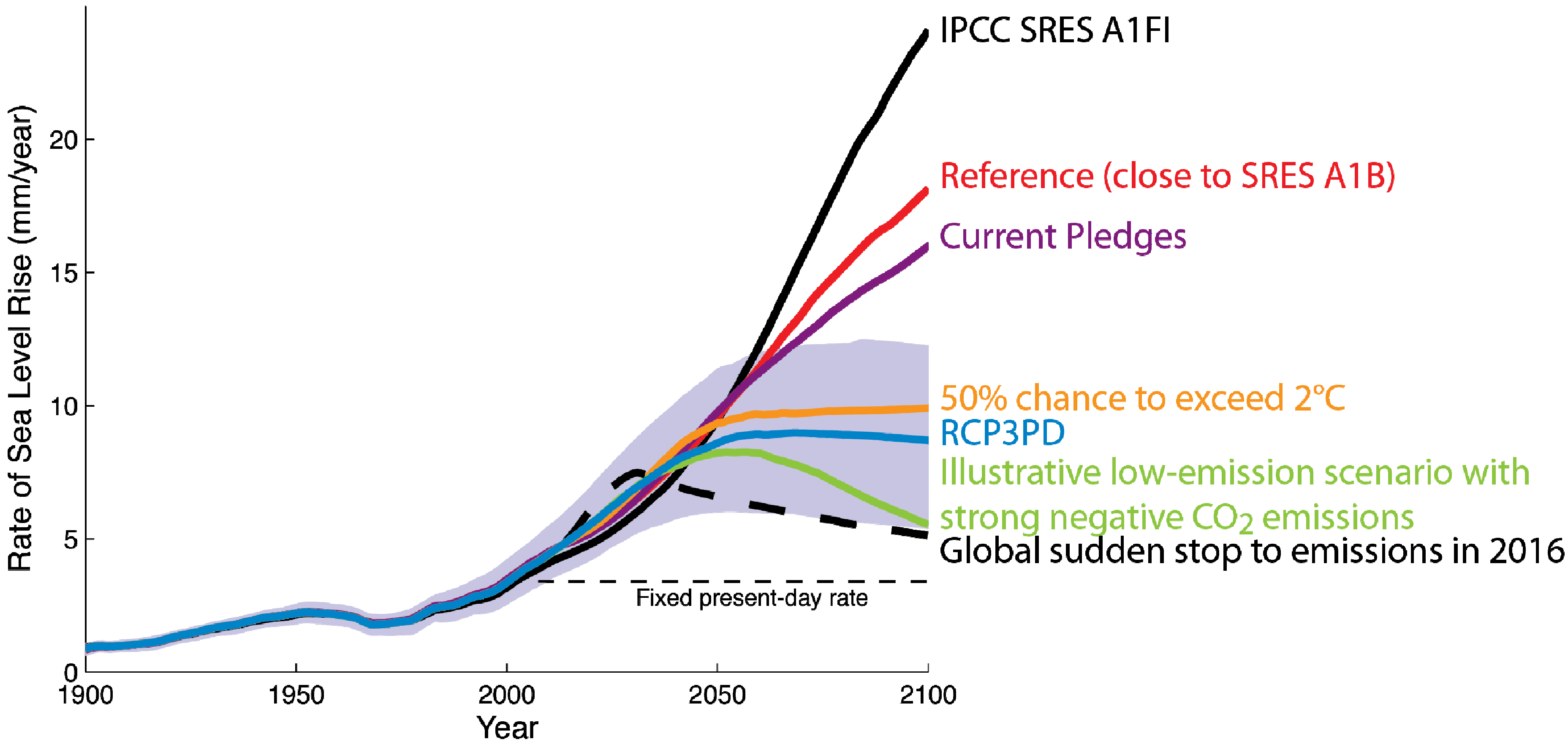
Kemp et al., 2011

Validation for 20th century



Bittermann et al., 2013

Rate of Sea-level rise projections 21st century



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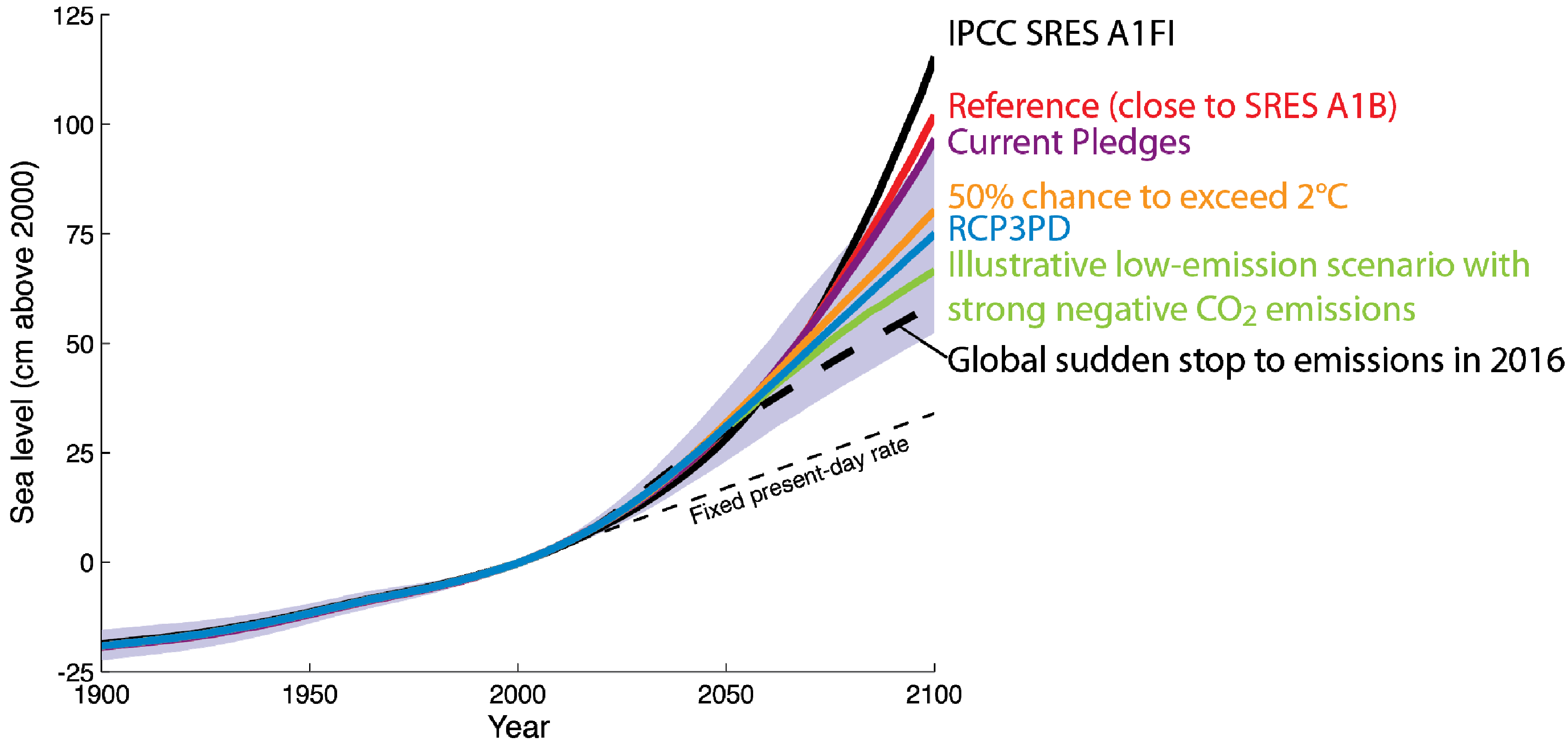
Schaeffer et al., 2012; Schellnhuber et al., 2012

Sea-level rise projections 21st century



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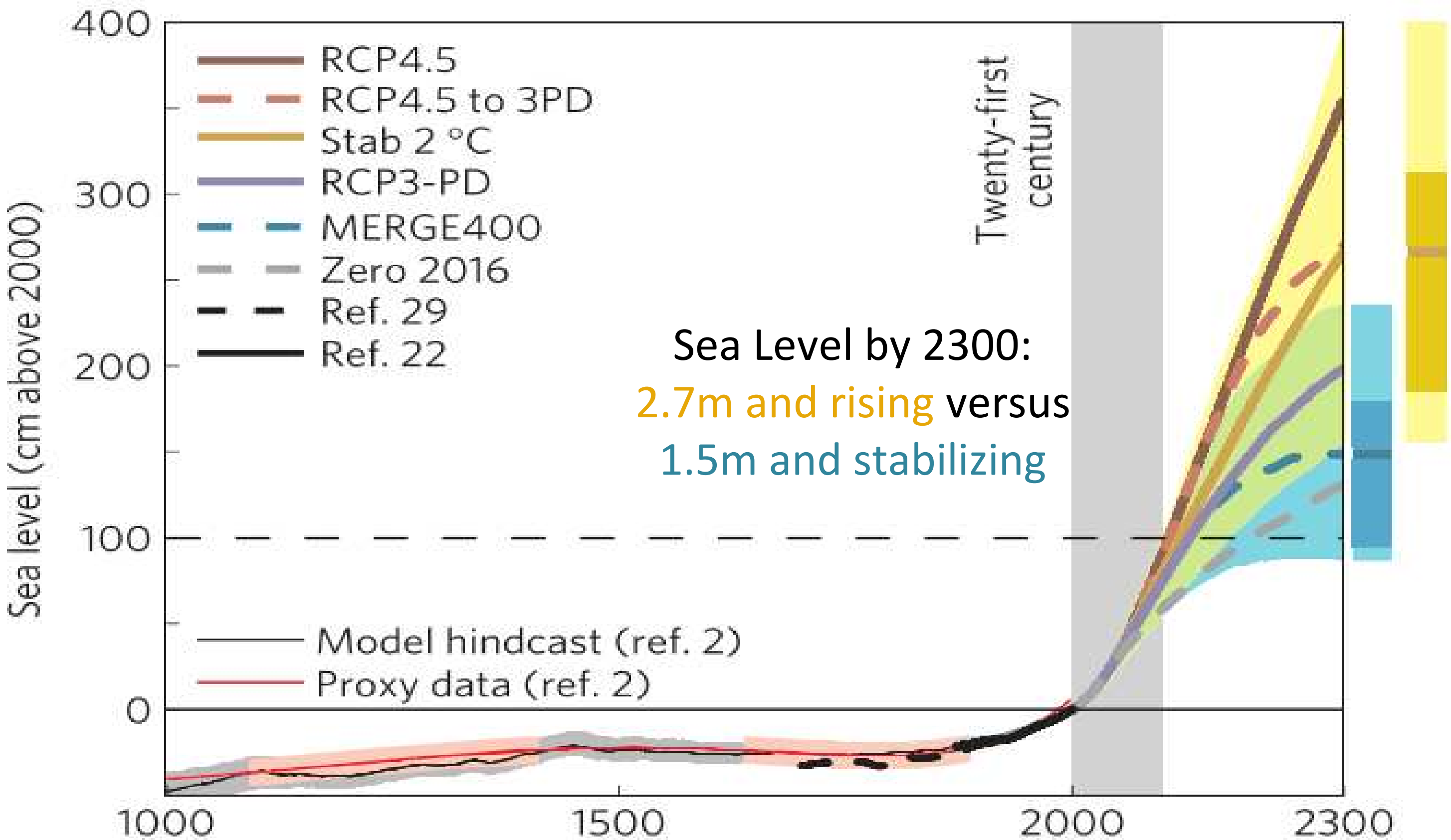
Schaeffer et al., 2012; Schellnhuber et al., 2012

Can sea level rise be held below 1m?



- The difference in sea-level rise between a stabilized 2°C and a "well below" 1.5°C scenario is less than 10 cm by 2100, but *rate* of rise is very different by then, so that difference in sea-level rise between scenarios diverges to over 1 m by 2300
- **Sea-level rise may be halted in 2300 for a "well below" 1.5°C scenario, in sharp contrast to a 2°C stabilization scenario**.

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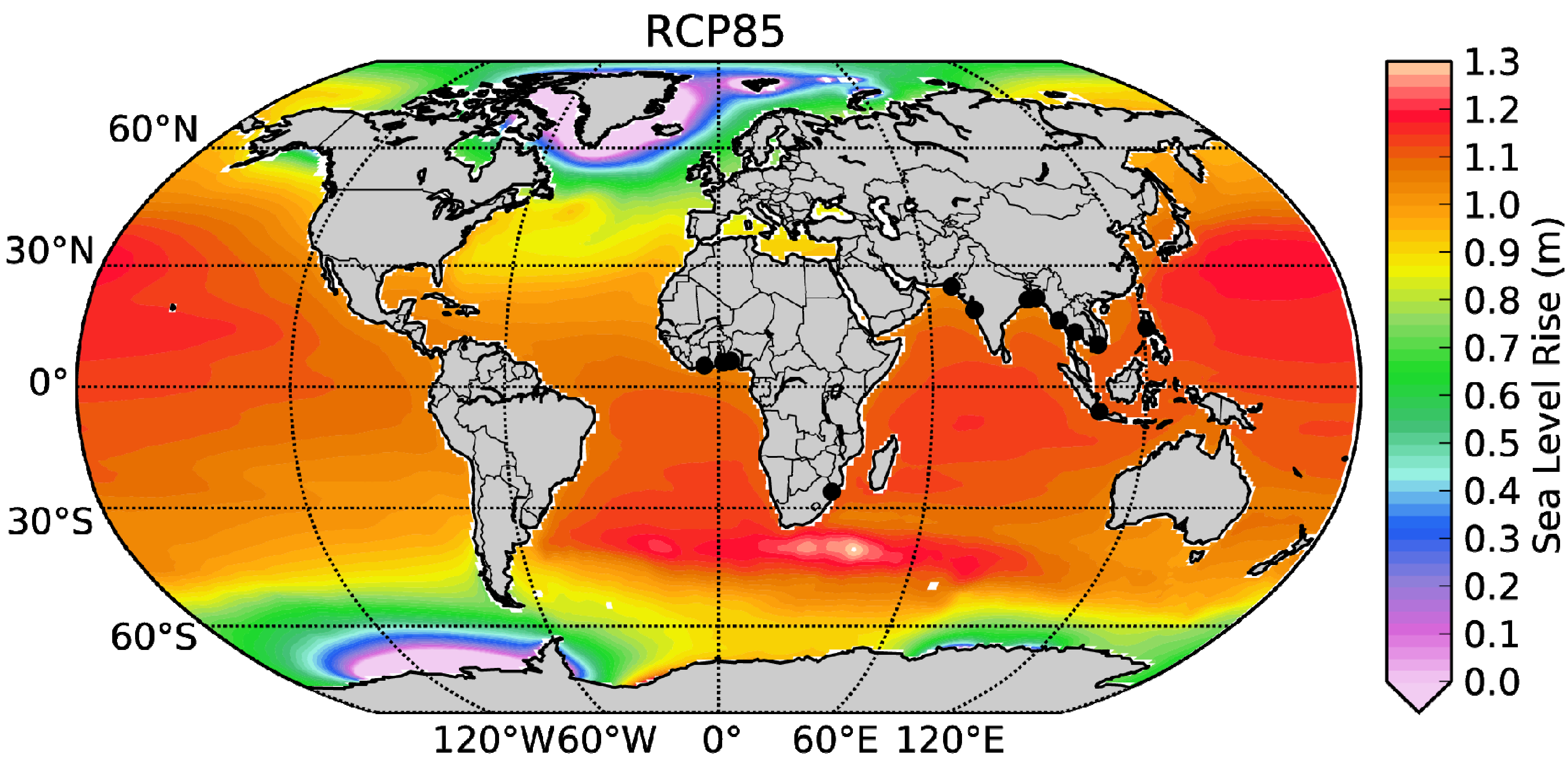
Schaeffer et al., 2012

Regional deviations from global SLR



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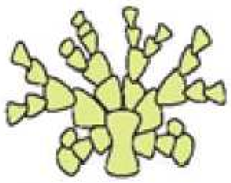
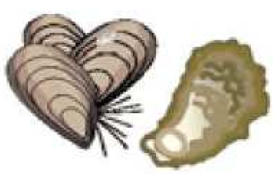
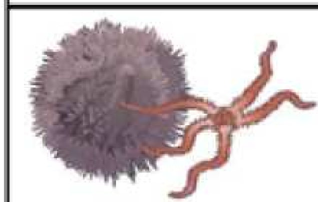
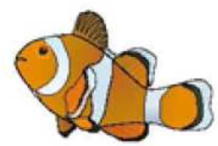
Perrette et al., 2012; Schellnhuber et al., 2012

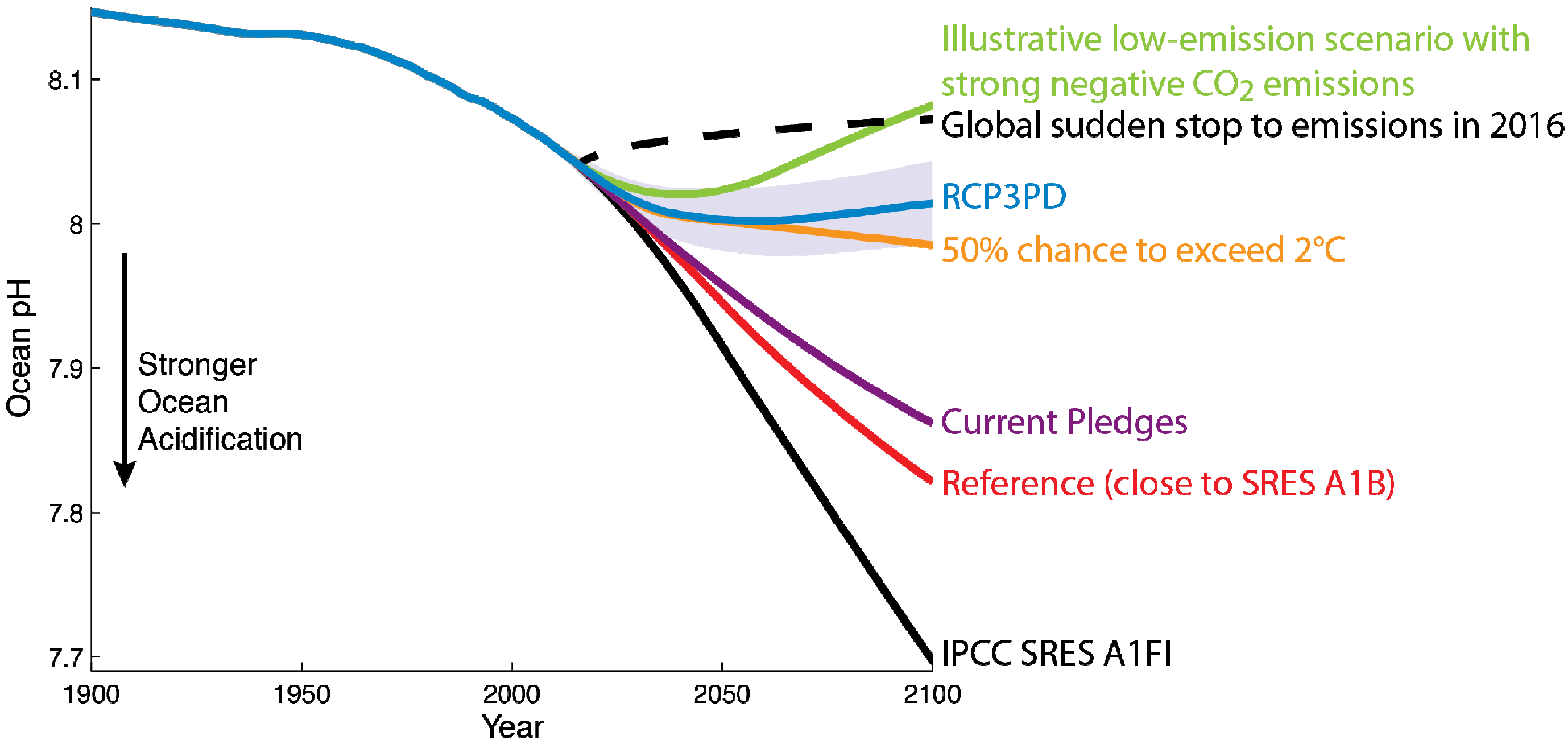
How are species affected by ocean acidificaton?

Not tested or too few studies
Enhanced <25%
95% CI overlaps 0
Reduced <25%
Reduced >25%

Taxa	Response	Mean Effect
 Calcifying algae	Survival	
	Calcification	
	Growth	
	Photosynthesis	-28%
	Abundance	-80%
 Corals	Survival	
	Calcification	-32%
	Growth	
	Photosynthesis	
	Abundance	-47%
 Coccolithophores	Survival	
	Calcification	-23%
	Growth	
	Photosynthesis	
	Abundance	
 Molluscs	Survival	-34%
	Calcification	-40%
	Growth	-17%
	Development	-25%
	Abundance	
 Echinoderms	Survival	
	Calcification	
	Growth	-10%
	Development	-11%
	Abundance	
 Crustaceans	Survival	
	Calcification	
	Growth	
	Development	
	Abundance	
 Fish	Survival	
	Calcification	
	Growth	
	Development	
	Abundance	
 Fleshy algae	Survival	
	Calcification	
	Growth	+22%
	Photosynthesis	
	Abundance	
 Seagrasses	Survival	
	Calcification	
	Growth	
	Photosynthesis	
	Abundance	
 Diatoms	Survival	
	Calcification	
	Growth	+17%
	Photosynthesis	+12%
	Abundance	

Kroeker et al (2013)

How rapidly does acidification increase?



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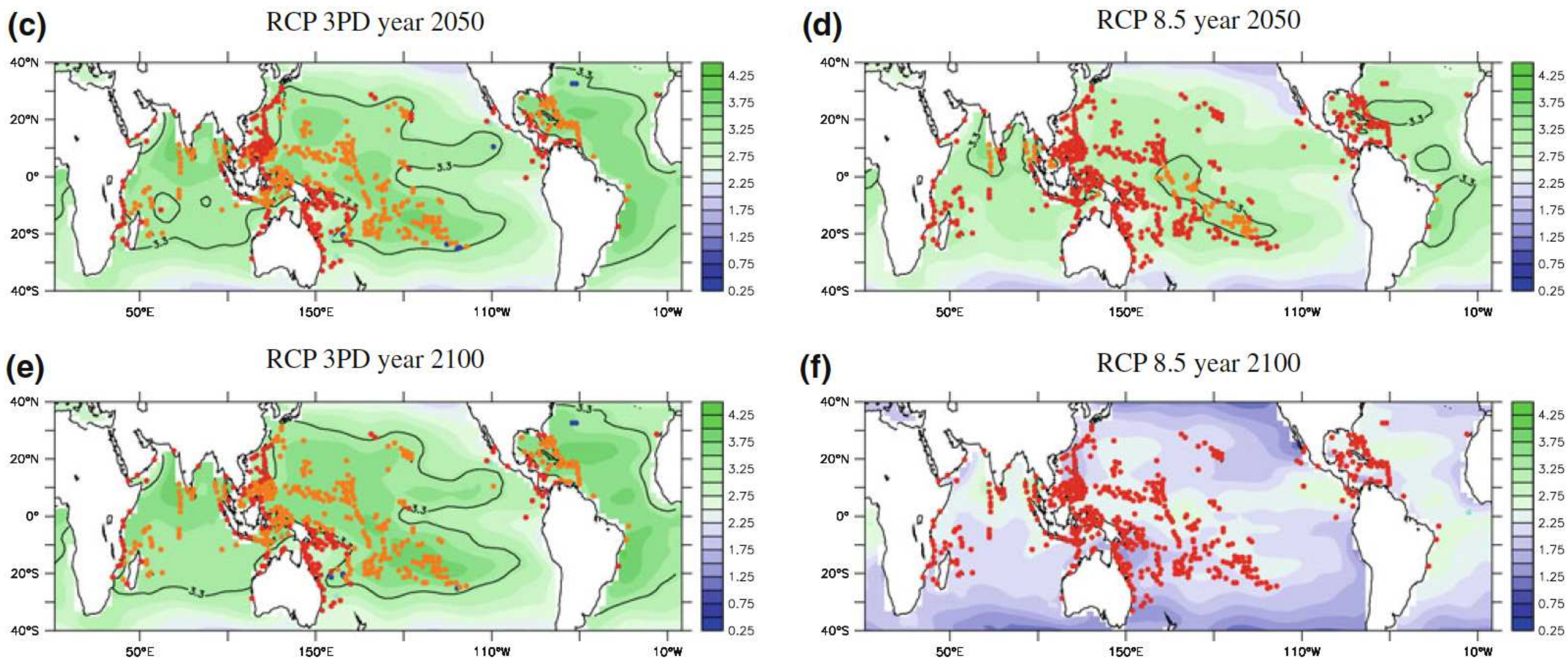
Schellnhuber et al., 2012

Coral reefs projected “chemical” and “thermal” stress



Reefs in blue have a less-than-10% probability of experiencing a severe bleaching event and live in areas with annual mean open ocean seawater aragonite saturation above 3.3. Orange reefs are thermally stressed experiencing a severe bleaching event at least once every 10 years. Light blue reefs are chemically stressed (annual mean seawater aragonite saturation below 3.3), and reefs in red are both thermally and chemically stressed

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Meissner et al (2012)

Closing remarks

- Climate change poses a risk to ocean-based or ocean-dependent systems through warming, sea-level rise and acidification
- Several aspects (Backup Slides) not discussed here, e.g.:
  - Tropical cyclone intensity
  - Weakening Thermohaline circulation
  - Changes in patterns of variability in ocean, atmosphere and combined (e.g. ENSO, NAO)
- Current emission trends, observations and inadequacy of proposed emission reductions lead to projected high risks

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Thank you

www.climateanalytics.org

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Backup slides

further information and "other aspects" of climate change & oceans

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Correlation between hurricane power and tropical sea-surface temperatures

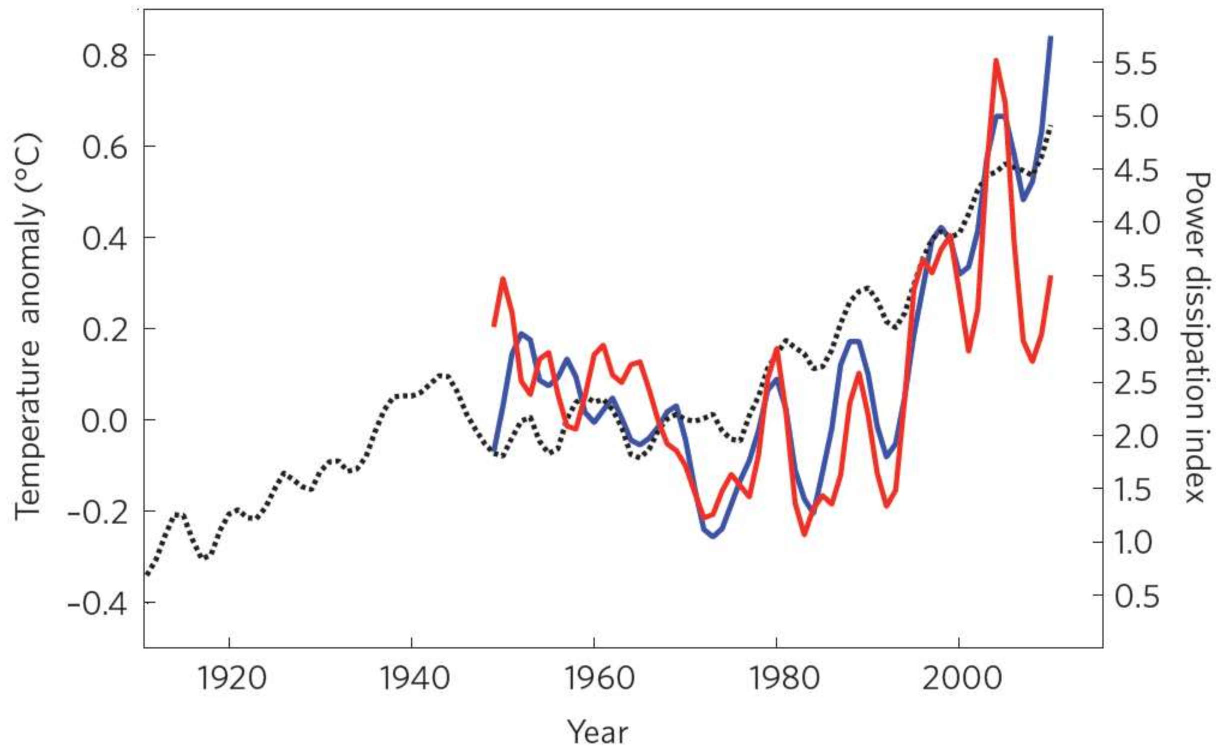
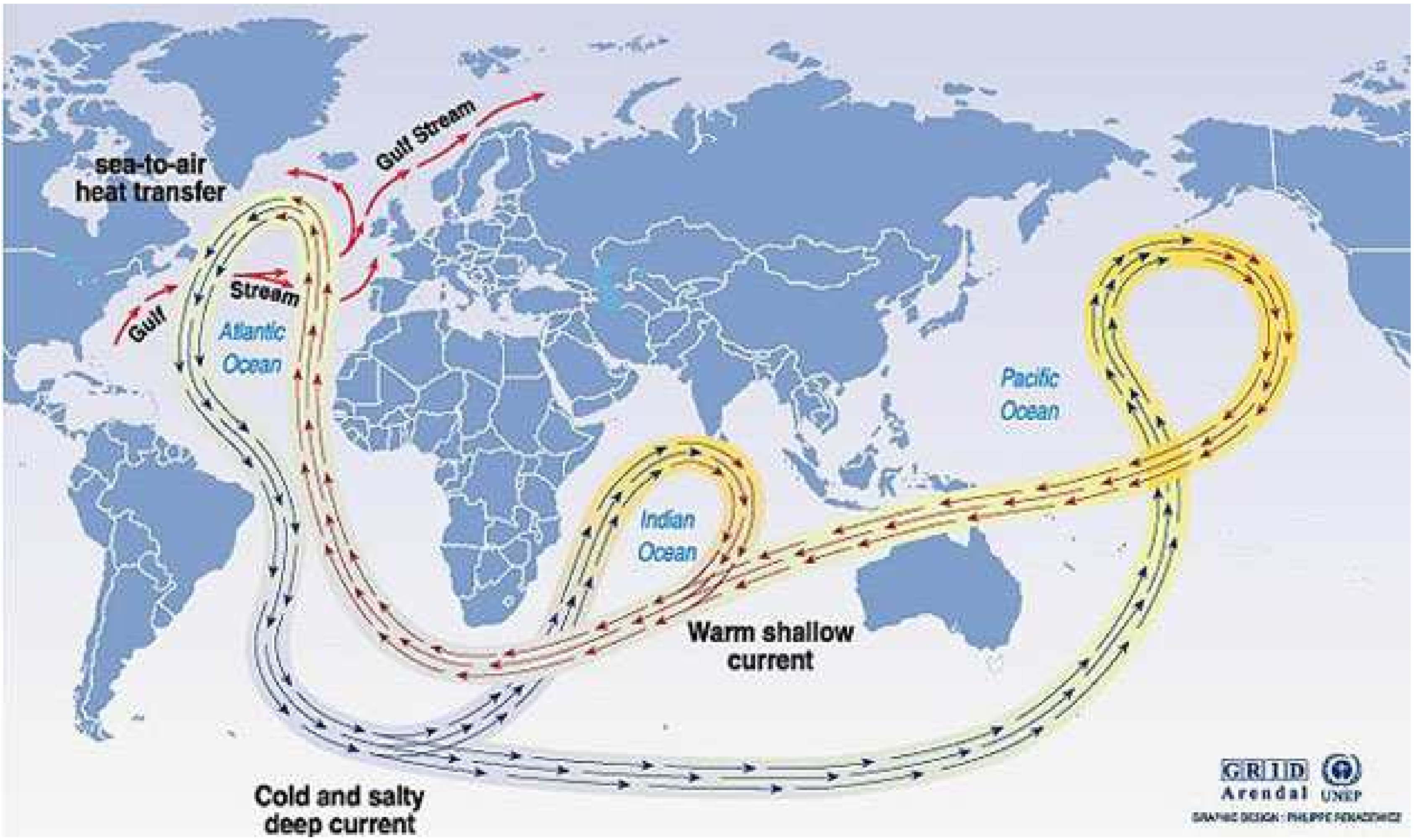


Figure 3 | Power dissipation index for North Atlantic tropical storms linked to tropical sea surface temperature in the main development region for Atlantic hurricanes. Red line denotes North Atlantic tropical storms; blue line denotes tropical Atlantic sea surface temperature. For comparison, the evolution of Northern Hemisphere mean temperature from NASA Goddard Institute for Space Studies is also shown (dotted line).

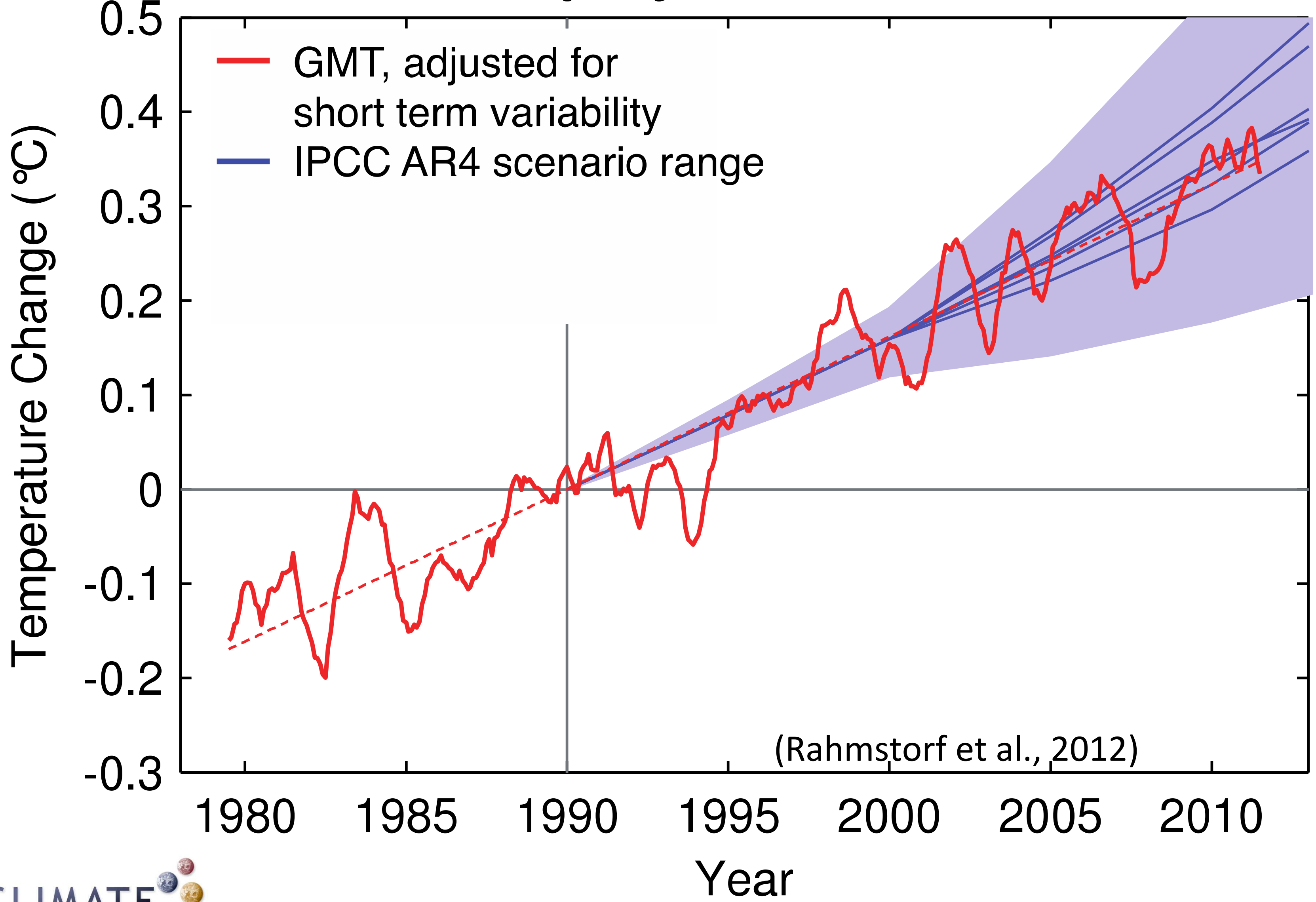
Coumou and Rahmstorf (2012)

Thermohaline circulation or "great conveyor belt"



Observations and model projections show weakening.
Affects SLR, plankton/fisheries, land climate

Consistent global warming signal in line with IPCC projections



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CO_2 emissions at record level

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Global carbon-dioxide emissions increase by 1.0 Gt in 2011 to record high

24 May 2012

Global carbon-dioxide (CO2) emissions from fossil-fuel combustion reached a record high of 31.6 gigatonnes (Gt) in 2011, according to preliminary estimates from the International Energy Agency (IEA). This represents an increase of 1.0 Gt on 2010, or 3.2%. Coal accounted for 45% of total energy-related CO2 emissions in 2011, followed by oil (35%) and natural gas (20%).

Copyright: GraphicObsession

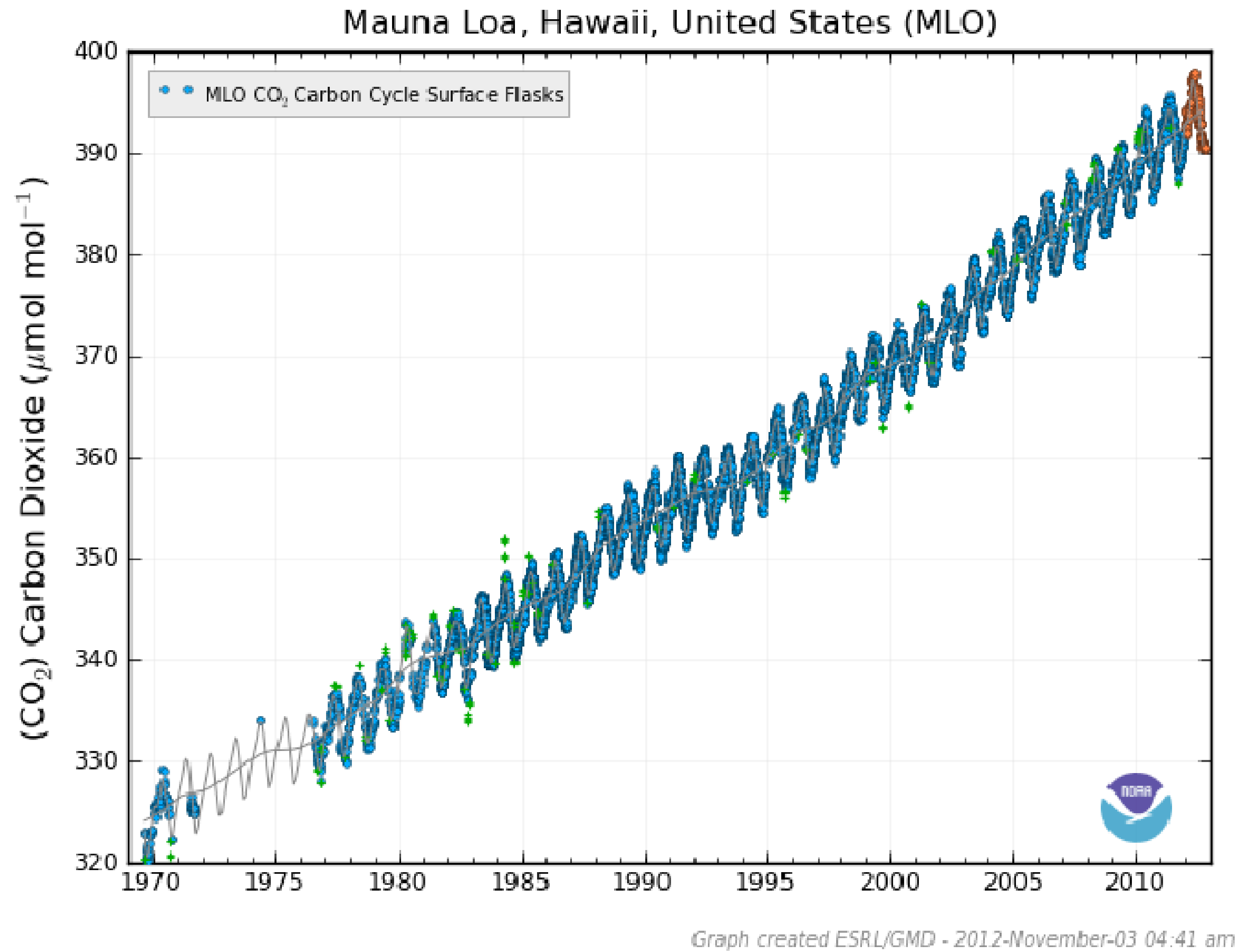
The 450 Scenario of the IEA's *World Energy Outlook 2011*, which sets out an energy pathway consistent with a 50% chance of limiting the increase in the average global temperature to 2°C, requires CO2 emissions to peak at 32.6 Gt no later than 2017, *i.e.* just 1.0 Gt above 2011 levels. The 450 Scenario sees a decoupling of CO2 emissions from global GDP, but much still needs to be done to reach that goal as the rate of growth in CO2 emissions in 2011 exceeded that of global GDP. "The new data provide further evidence that the door to a 2°C trajectory is about to close," said IEA Chief Economist Fatih Birol.

RECENT NEWS

- A need for reform in India
- Collaboration between IEA, UNFCCC will lead to improved data and analysis on climate issues
- Dutch astronaut visits IEA after six months in space
- Sustainable energy is the focus of an international training event for policy makers from Latin America and the Caribbean
- New edition of Key World Energy Statistics offers a host of critical figures for free

http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html

…and so is CO_2 concentration



http://www.esrl.noaa.gov/gmd/dv/iadv/

The Emissions Gap Report 2012

A UNEP Synthesis Report

UNEP

Core findings:

- 2010 global total emissions: 50 GtCO2e/yr (95% range: 45.6-54.6)
- Current "emissions gap" for 2°C (>66% chance) 8 to 13 GtCO2e/yr, depending on:
  - unconditional/conditional pledges: 2 GtCO2e/yr improvement
  - lenient/strict accounting rules: 3 GtCO2e/yr improvement
- Emissions gap increased by ca. 2 GtCO2e/yr relative to 2011 estimate
  - due to updated BaUs for developing countries (higher expected emissions)
  - due to inclusion and accounting for the effect of double counting of offsets
- 2020 emissions:
  - in line with 2°C (>66% chance) remain at 44 GtCO2e/yr (41-47 GtCO2e/yr)
  - in the few 1.5°C scenarios emerging in literature: around 43 GtCO2e/yr
  - Based on the pledges: 52-57 GtCO2e/yr, depending on conditionality and accounting rules
- Also "later action" pathways emerge in literature
  - higher near-term emissions (lower near-term costs)
  - Higher technology dependence on any mitigation option (for example, CCS)
  - Higher long-term (and overall) costs
  - Higher pressure on future policy requirements (participation, climate vs water/biodiversity)
  - Increased climatic risks: emission budget used more quickly, temperature rate and overshoot
- Highlights importance of energy efficiency to keep many options open

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The Emissions Gap Report 2012

A UNEP Synthesis Report

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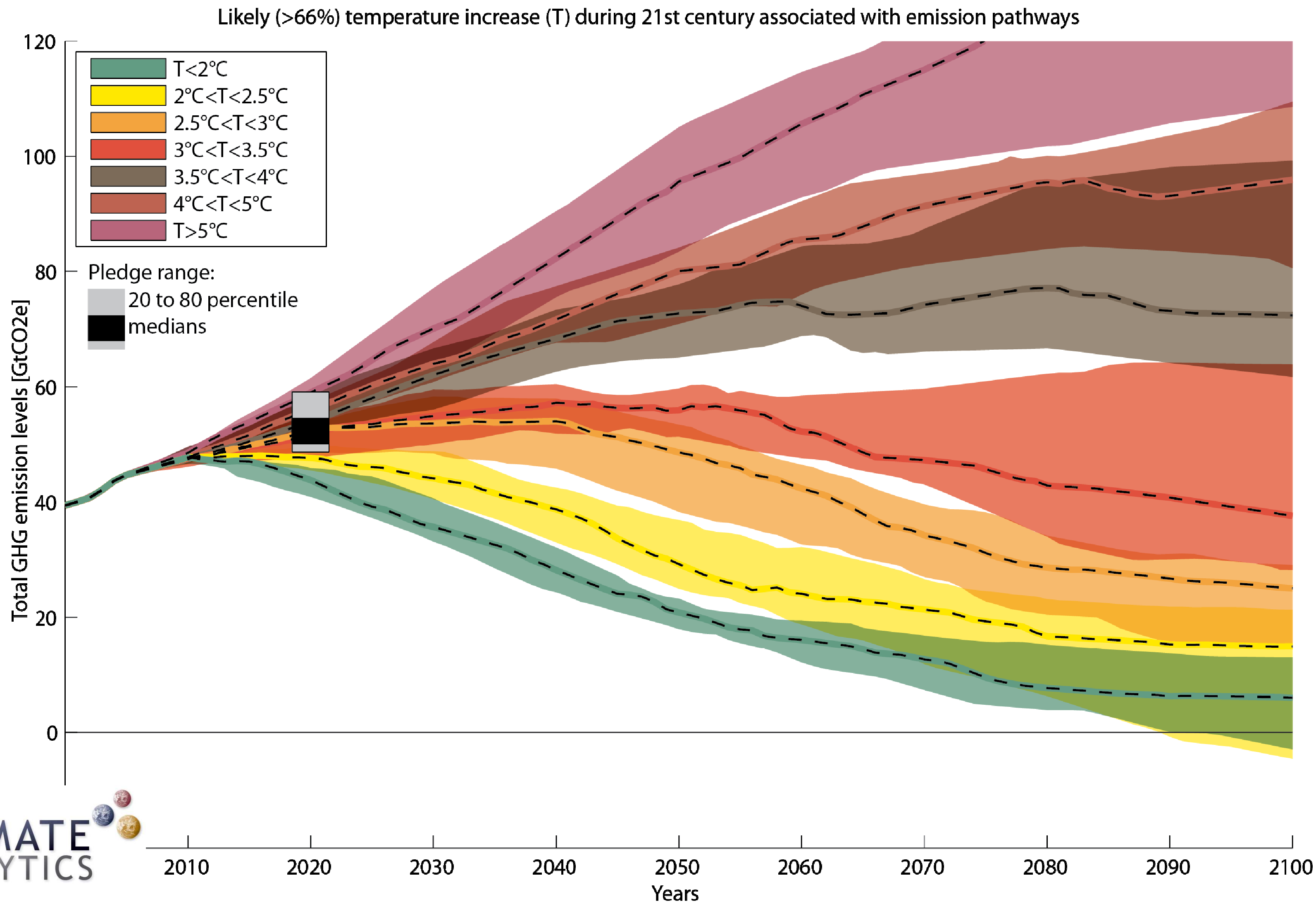

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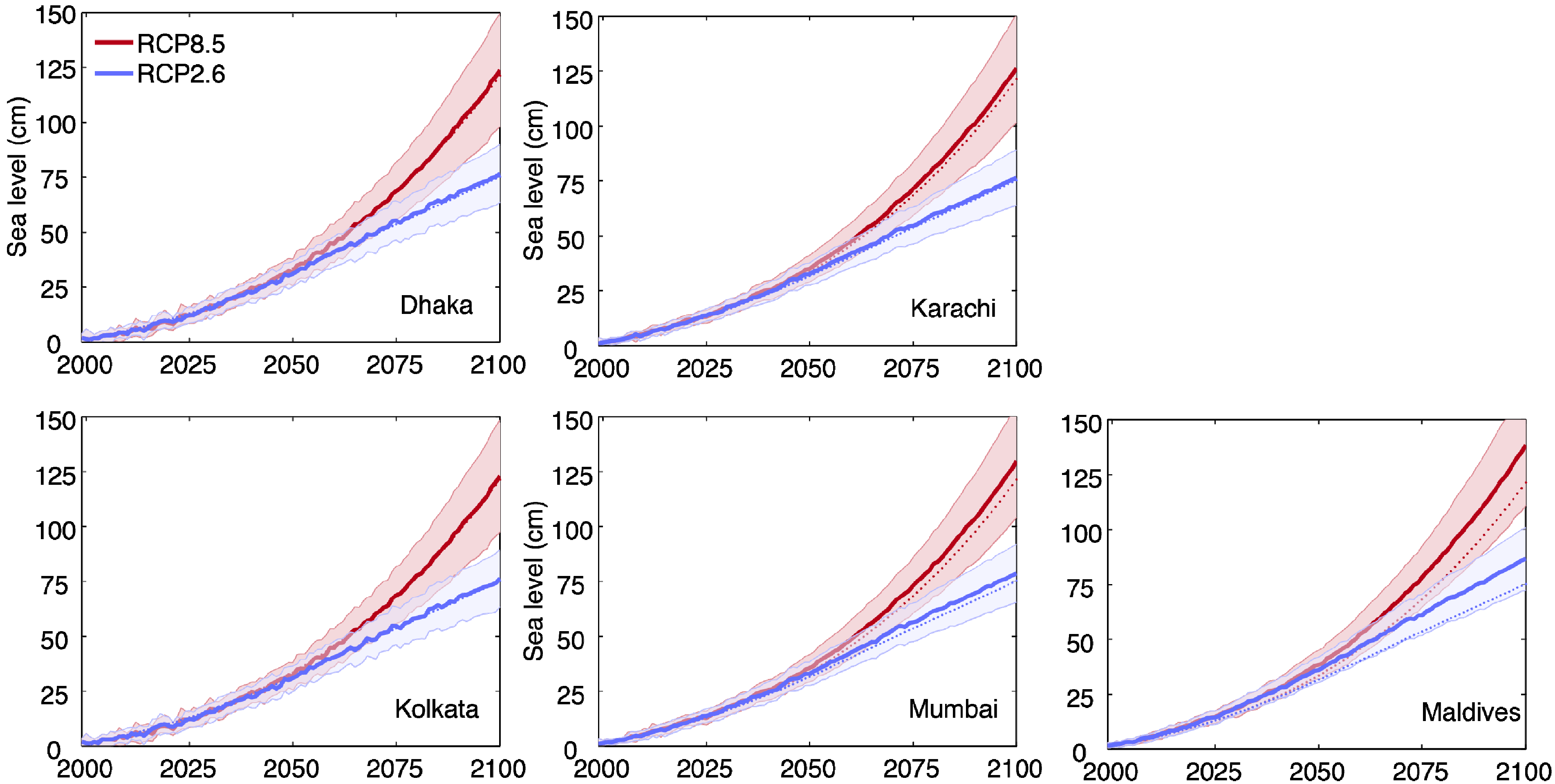
Regional SLR projection time series



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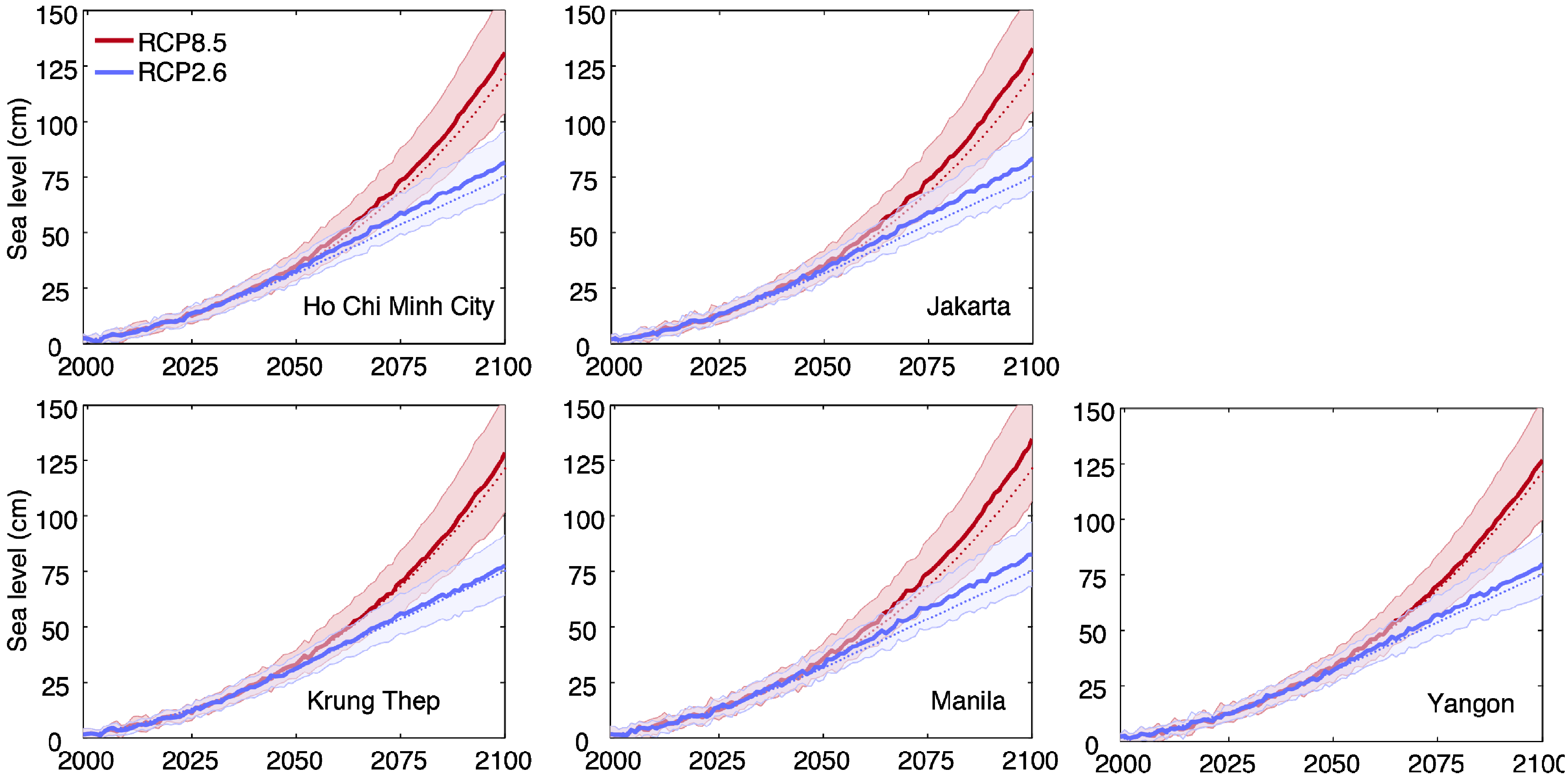
Schellnhuber et al., 2012

Regional SLR projection time series



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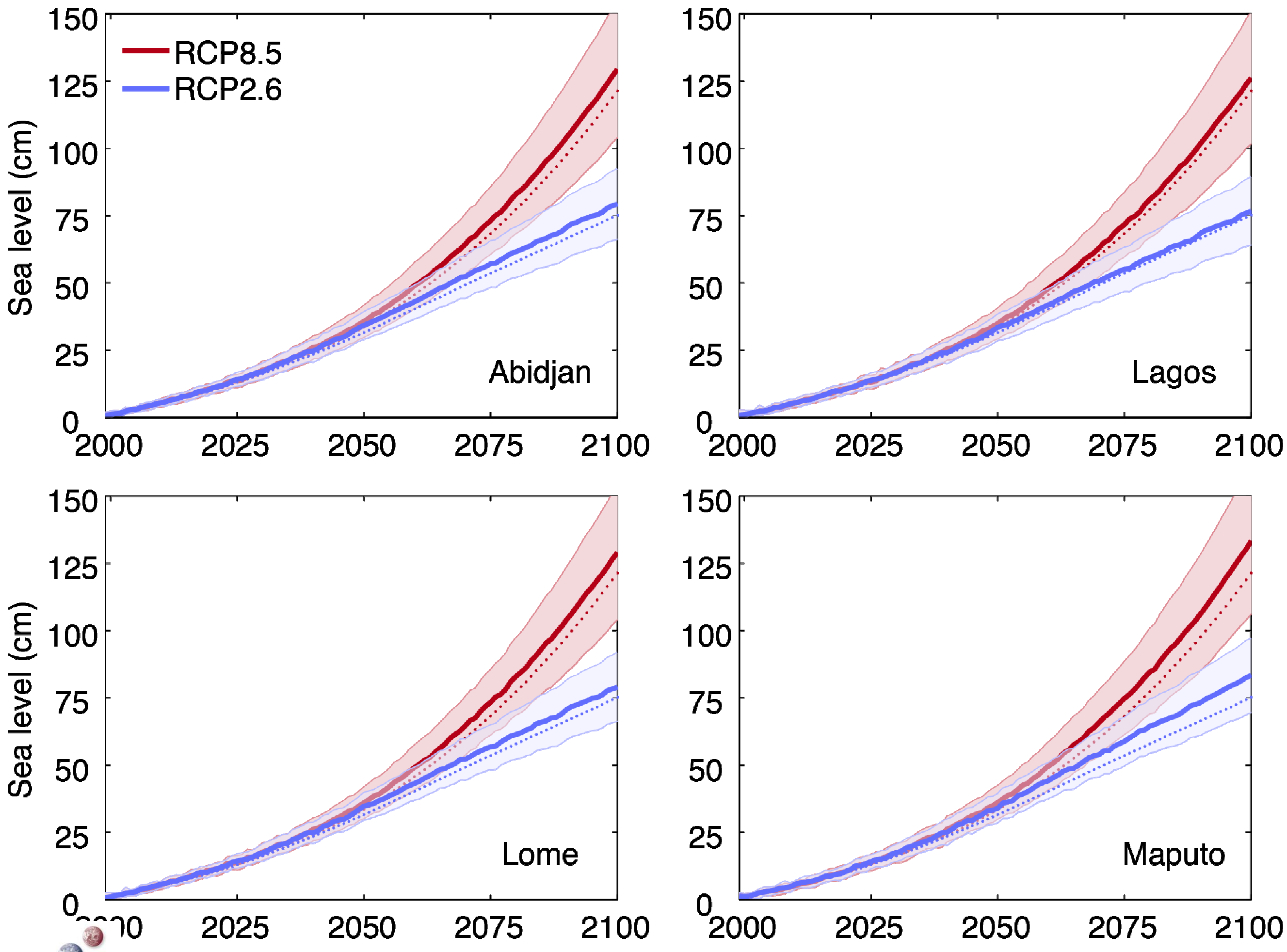

Schellnhuber et al., 2012