Oceans and Climate Change: Key messages from the IPCC reports

Prof. Jean-Pascal van Ypersele
Université catholique de Louvain, Belgium
Former IPCC Vice-Chair
Twitter: @JPvanYpersele

« Our Seas: Theories, Data, and Policies »
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Thanks to the Walloon government for its support to the « Plateforme wallonne pour le GIEC » and to my team at the Université catholique de Louvain for their support

Apollo 17,
7 Dec. 1972

Why the IPCC ?

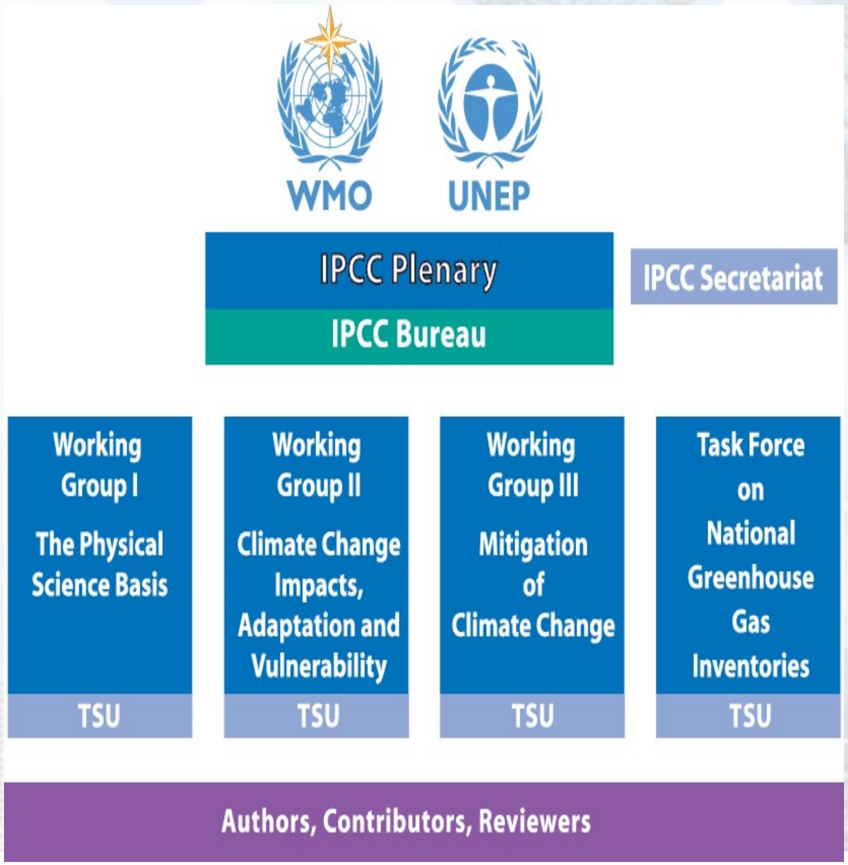
Established by WMO and UNEP in 1988

to provide policy-makers with an objective source of information about

- causes of climate change,
- potential environmental and socio-economic impacts,
- possible response options (adaptation & mitigation).

WMO=World Meteorological Organization
UNEP= United Nations Environment Programme

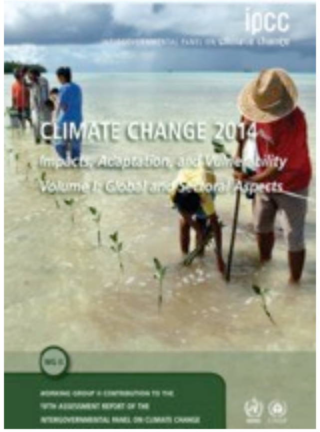
Inter-governmental Panel on Climate Change (IPCC): Organization Structure

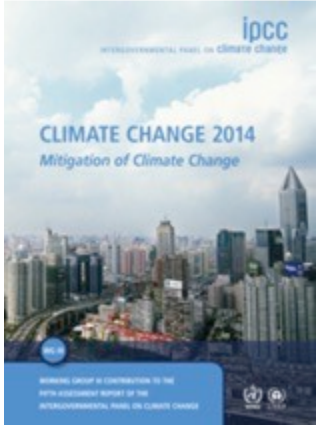


- **IPCC plenary comprises of all countries in the world**
- **IPCC Bureau comprises of 34 elected members; IPCC elects its Bureau every 6-7 years**
- **3 Working Groups & a Task Force on National Greenhouse Gas Inventories**
- **Authors, Contributors, Reviewers, Review Editors**

IPCC AR5 Synthesis Report

INTERGOVERNMENTAL PANEL ON climate change





What is happening in the climate system?

What are the risks?

What can be done?

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Key messages from IPCC AR5

- ➜ Human influence on the climate system is clear
- ➜ Continued emissions of greenhouse gases will increase the likelihood of severe, pervasive and irreversible impacts for people and ecosystems
- ➜ While climate change is a threat to sustainable development, there are many opportunities to integrate mitigation, adaptation, and the pursuit of other societal objectives
- ➜ Humanity has the means to limit climate change and build a more sustainable and resilient future

IPCC AR5 cycle: coastal areas & small islands

WGI

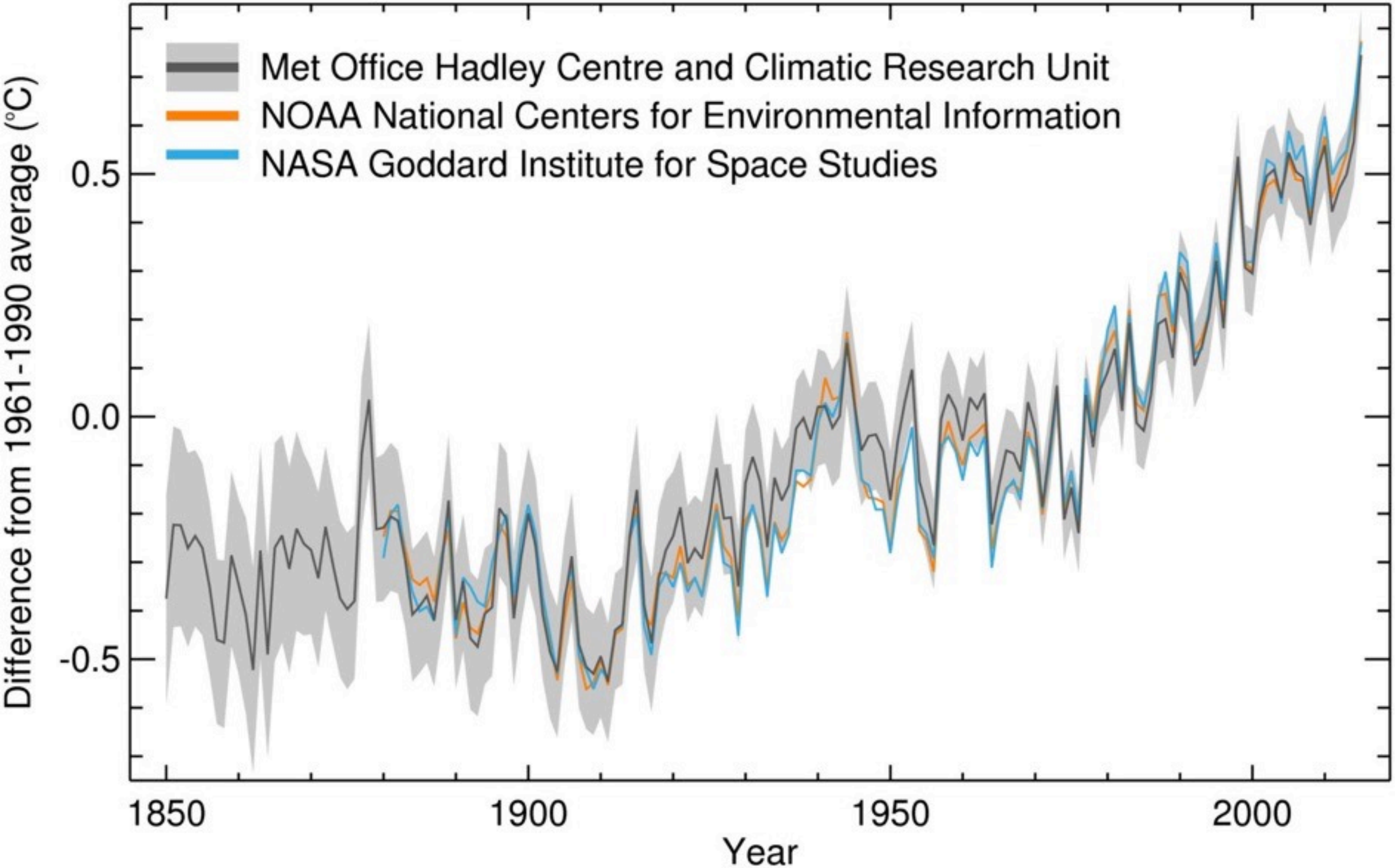
- Ocean Observations (Ch. 3), sea-level change (Ch.13)…
- FAQs (13.1: regional sea-level…)
  and TFEs (2: SLR uncertainties, 5: irreversibility…)

WGII

- Coastal Systems and Low-Lying Areas (Ch.5)
- Regional part: Small Islands (Ch.29), Oceans (Ch.30)
- Cross-chapter boxes : coral reefs, ocean acidification, tropical cyclone resilience, upwelling ecosystems

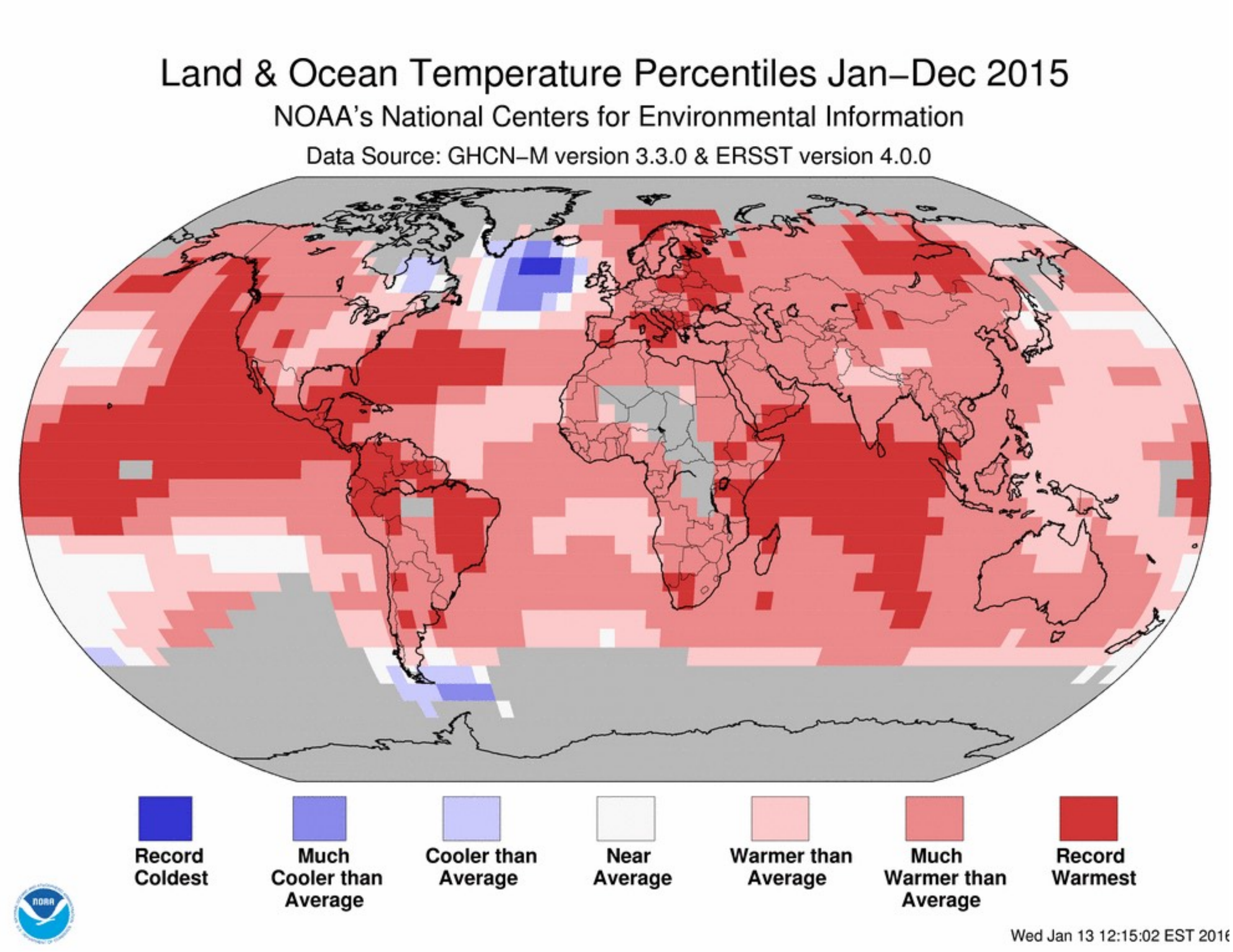
+ SRREN (Wind energy, ocean energy), SREX

Global average temperature anomaly (1850-2015)



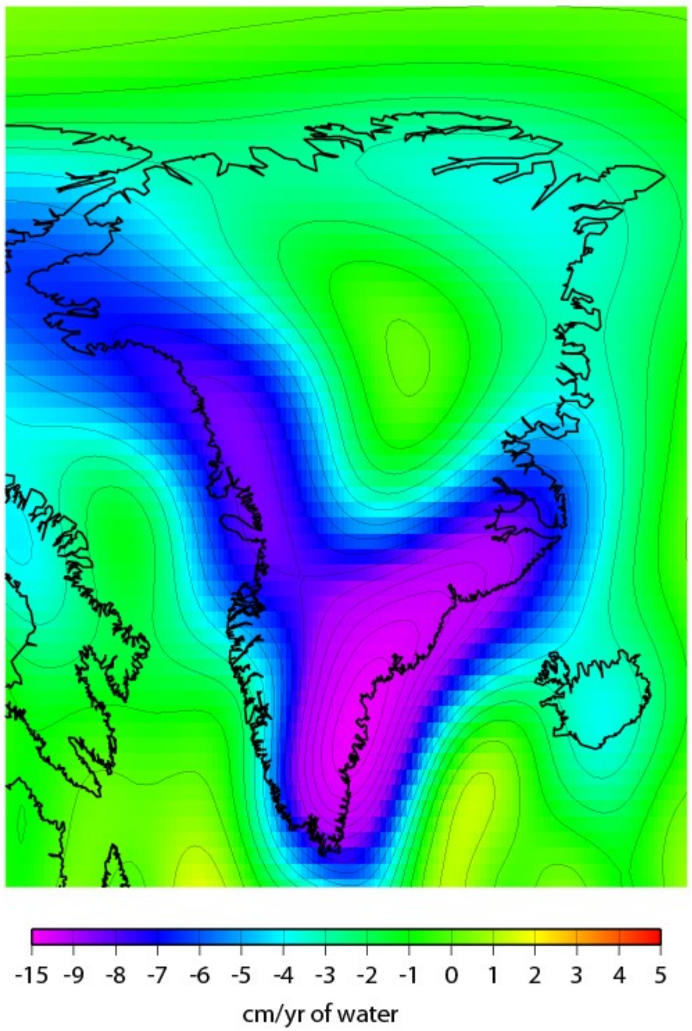
Source: NASA GISS

2014, 2015, 2016= warmest years since 1880

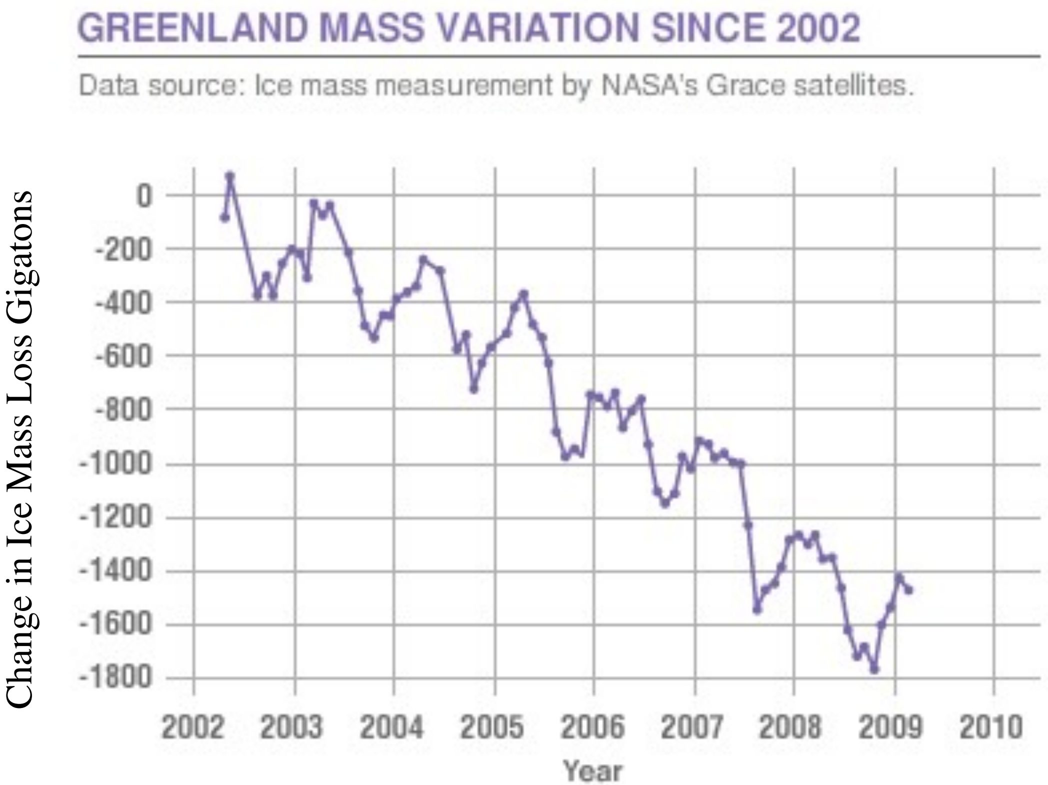


Greenland Ice Mass Loss 2002-2009
Derived From NASA GRACE Gravity Mission

Greenland



J. Wahr, U. Colorado

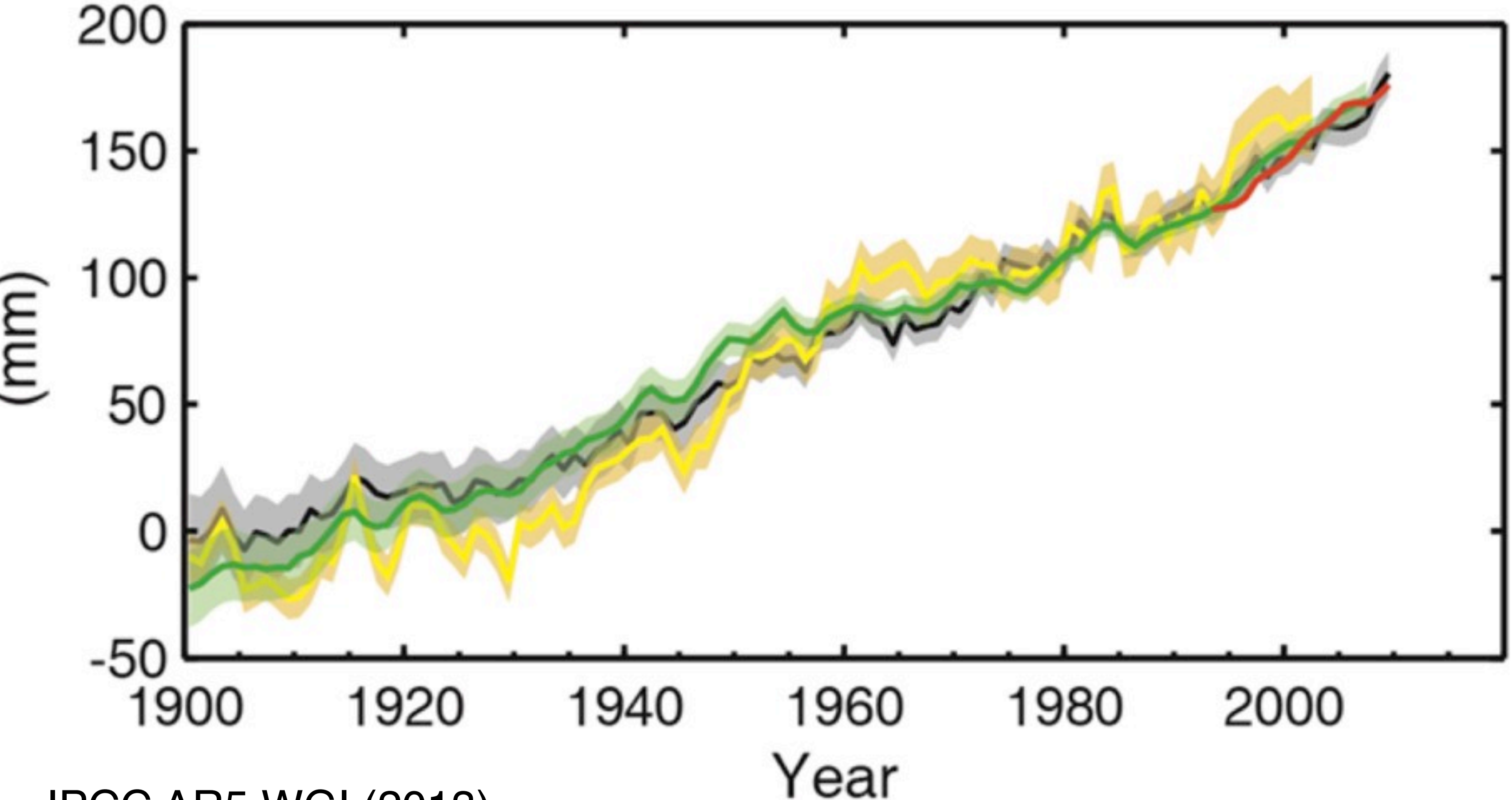


Velicogna, Geophysical Research Letters, 2009

•Contributes to sea level rise

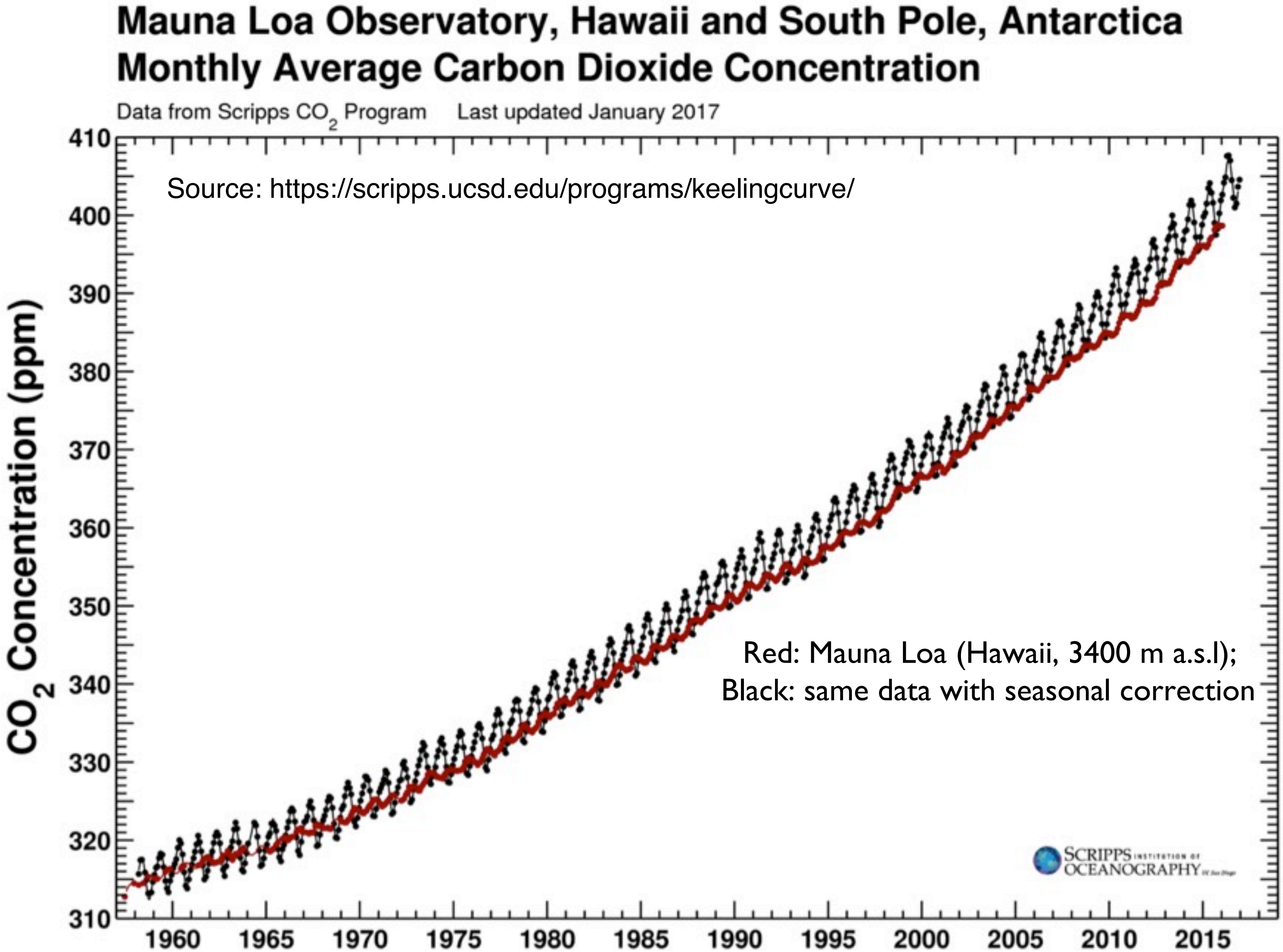
B. Holt - JPL

Change in average sea-level change

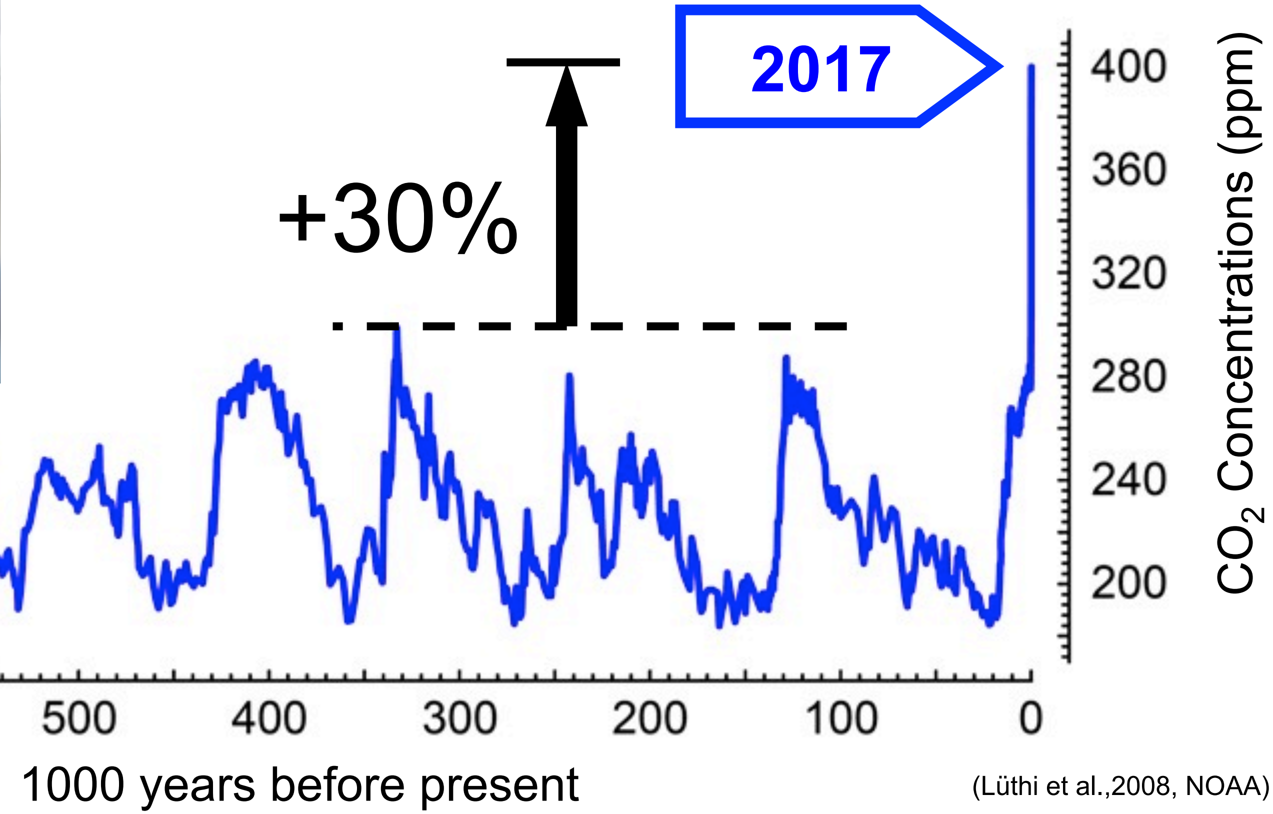


IPCC AR5 WGI (2013)

Atmospheric CO_2 concentration: the Keeling curve

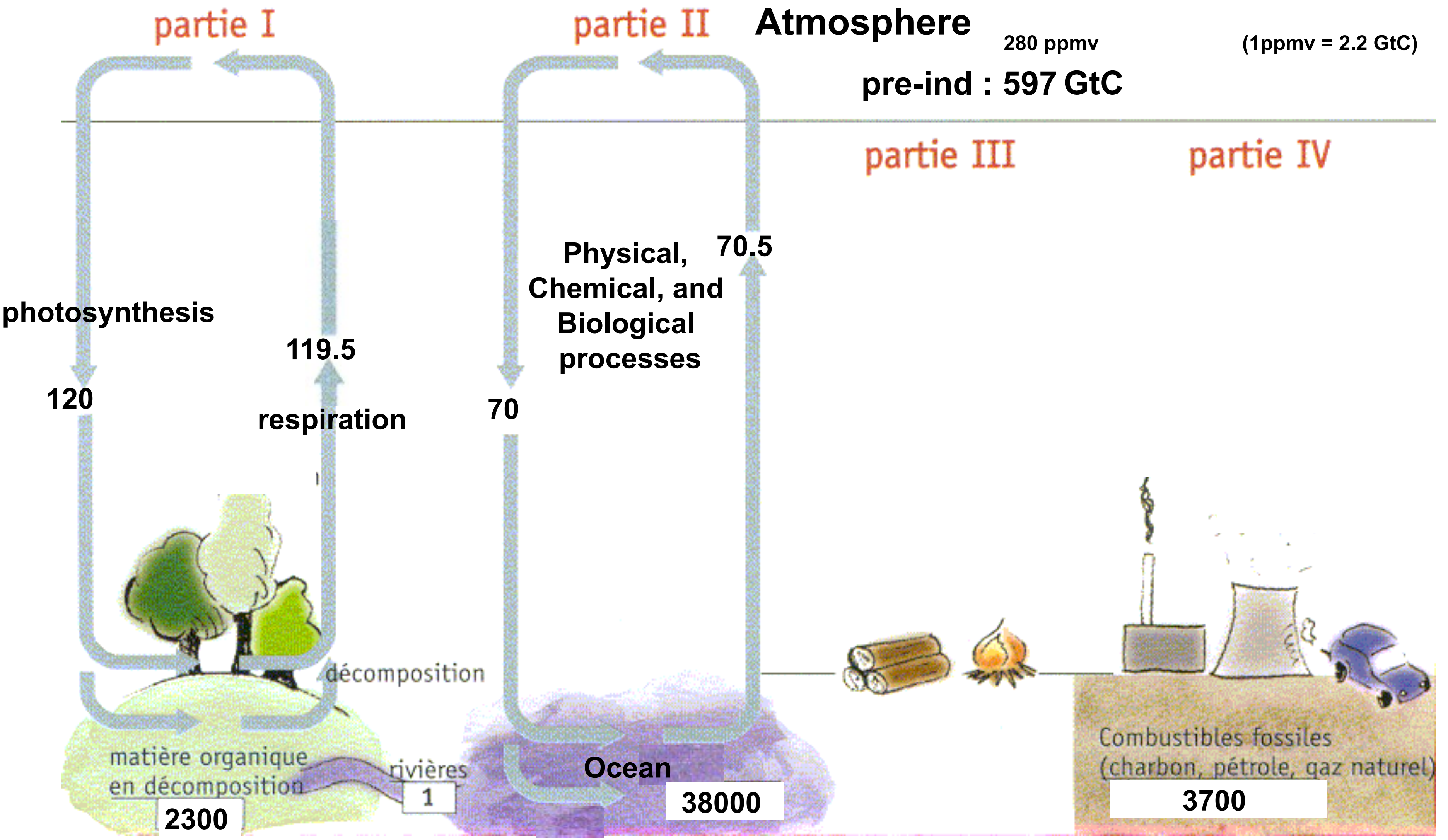


Atmospheric concentrations of CO_2



The concentrations of CO_2 have increased to levels unprecedented in at least the last 800,000 years.

Carbon cycle: unperturbed fluxes

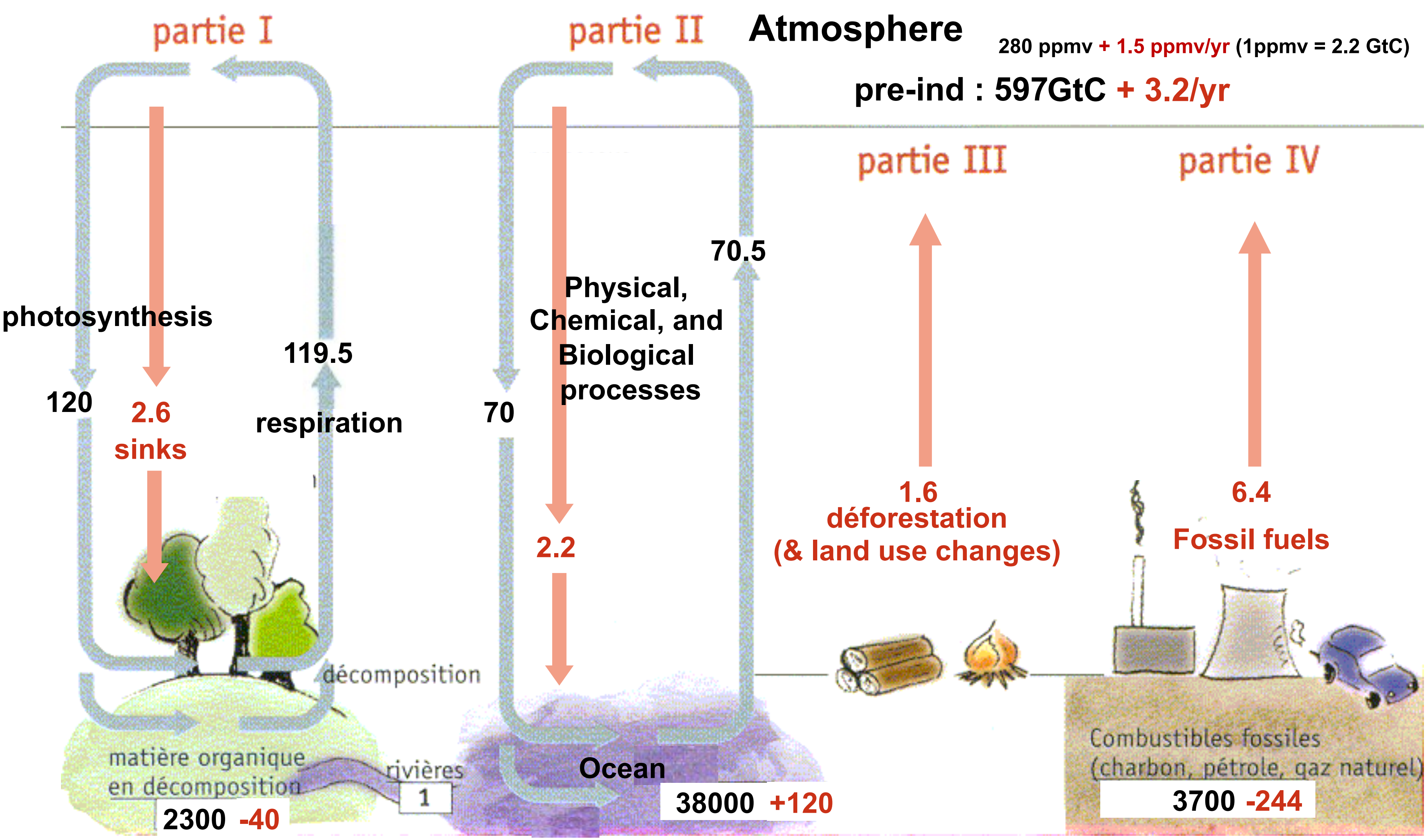


Units: GtC (billions tons of carbon) or GtC/year (multiply by 3.7 to get $GtCO_2$)

vanyp@climate.be

Carbon cycle: perturbed by human activities

(numbers for the decade 1990-1999s, based on IPCC AR4)

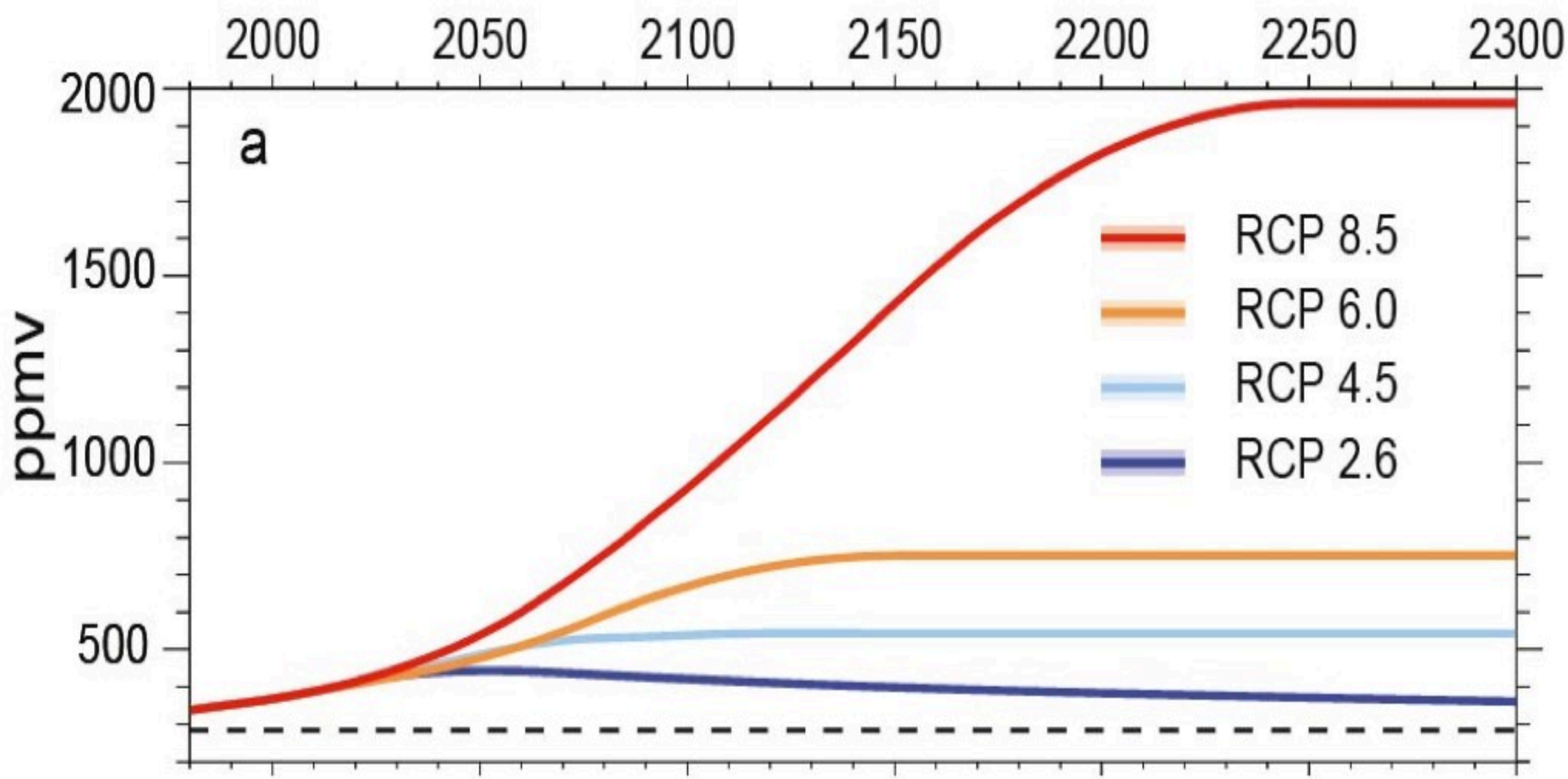


Units: GtC (billions tons of carbon) or GtC/year

Stocks!

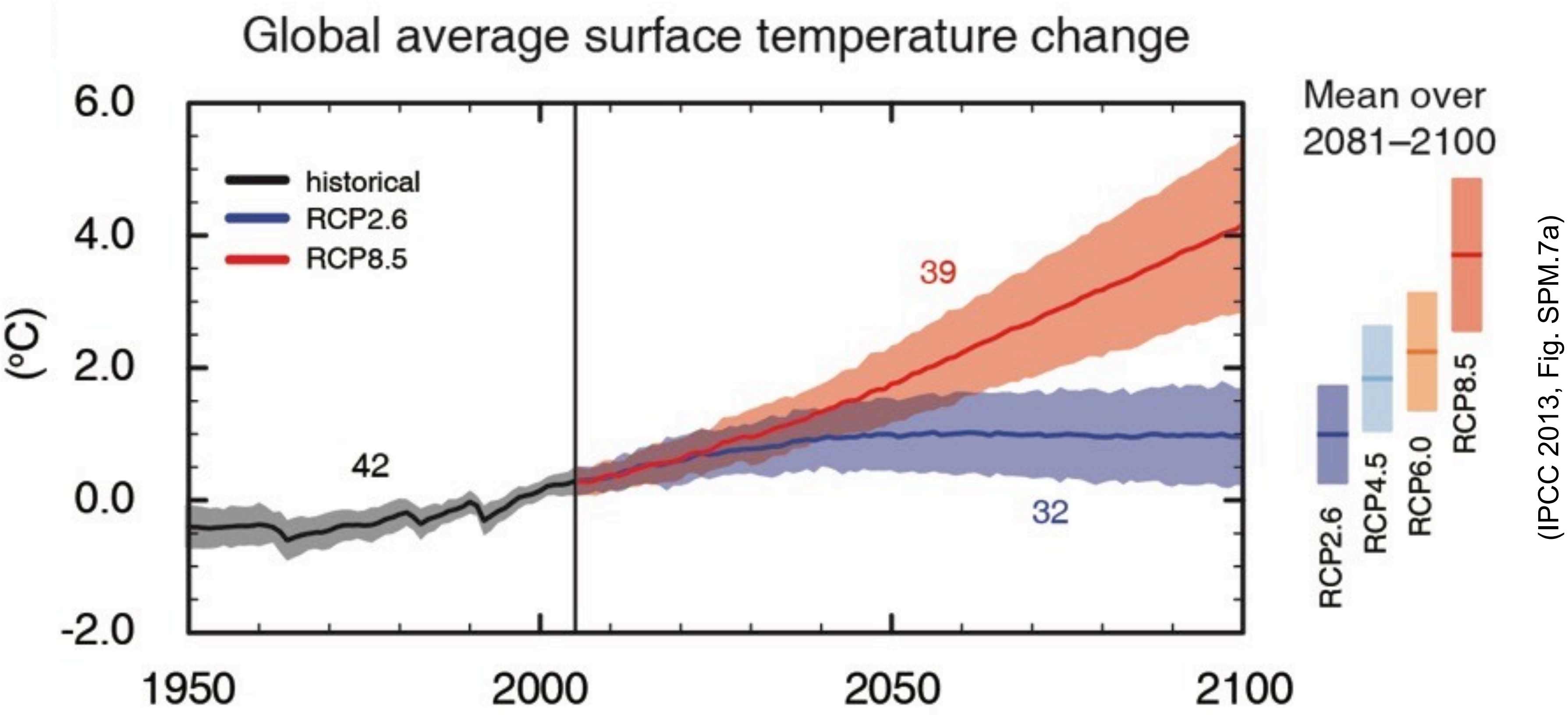
vanyp@climate.be

RCP Scenarios: Atmospheric CO_2 concentration



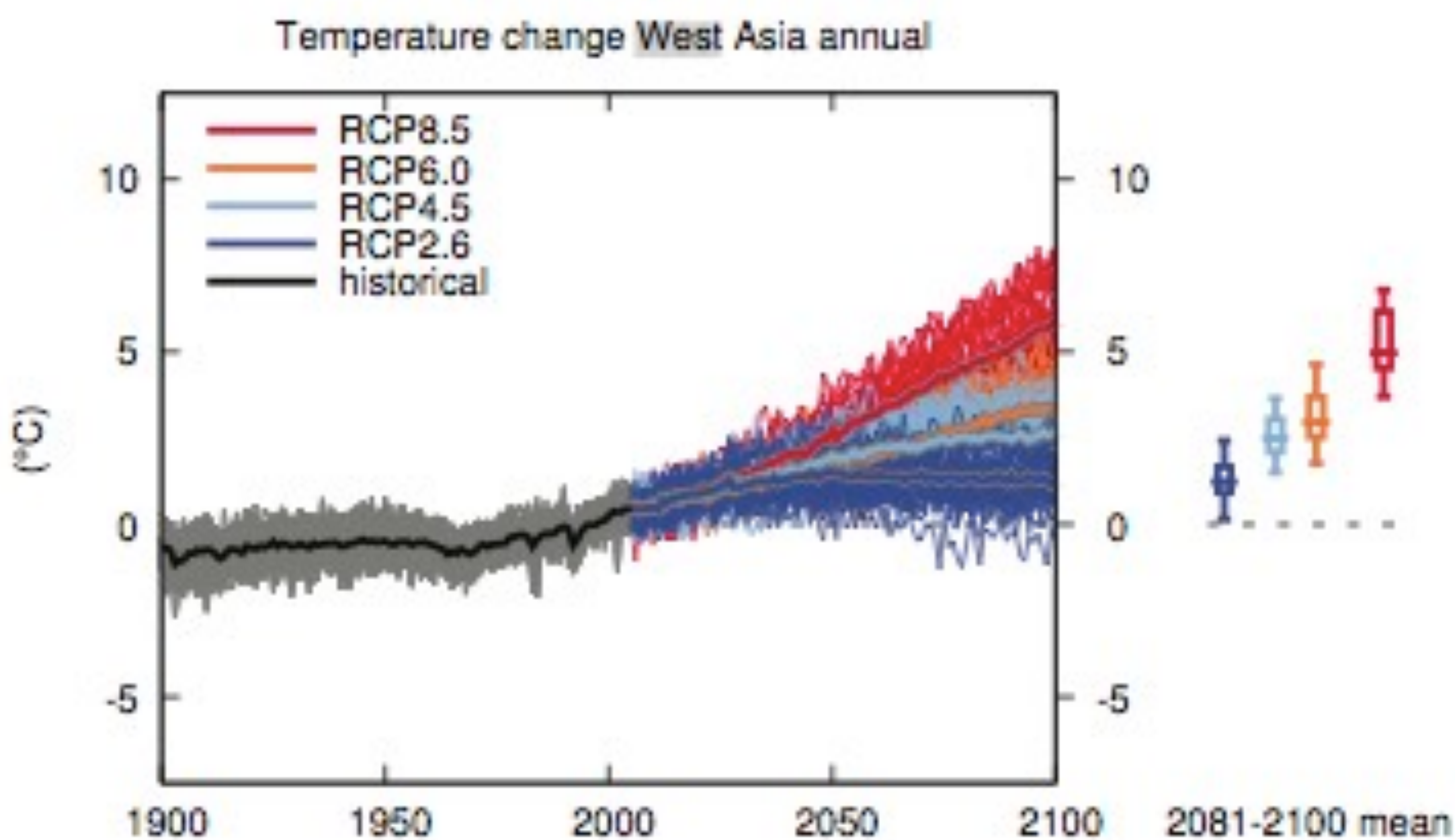
Three stabilisation scenarios: RCP 2.6 to 6
One Business-as-usual scenario: RCP 8.5

AR5, chapter 12. WGI- Adopted version / subject to final copyedit

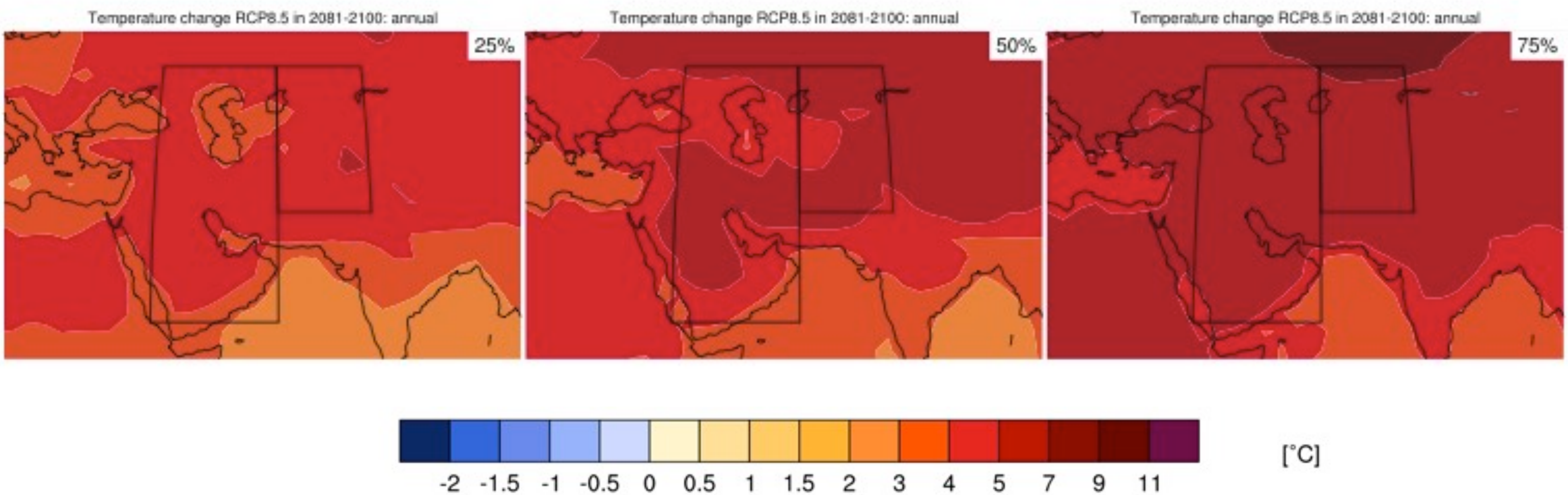


Only the lowest (RCP2.6) scenario maintains the global surface temperature increase above the pre-industrial level to less than 2°C with at least 66% probability

Time series of annual temperature change relative to 1986–2005 averaged over land grid points in West Asia



West Asia: Maps of temperature changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario



Regions where the projected change is less than one standard deviation of the natural internal variability

Regions where the projected change is large compared to natural internal variability, and where at least 90% of models agree on a sign of change

IPCC WG1 Fifth Assessment Report (Final Draft)

Future Regional Climate Change

West Asia: This region extends from the Mediterranean to the western fringes of South Asia, covering the Middle East and the **Arabian Peninsula** and includes large areas of barren desert. **The climate over this region varies from arid to semi-arid and precipitation is primarily received in the cold season.**

Land-falling Tropical Cyclones that **occasionally influence the eastern part of the Arabian Peninsula are notable extreme events**.

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IPCC, AR5, WG I, Chap.2, p.1271

Projected Major Changes

Increased rainfall extremes of landfall cyclones on the Arabian Peninsula.

http://www.ecoseeds.com/juicy.gossip.fourteen.html

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IPCC, AR5, WG I, TS, p.106

Sea Level

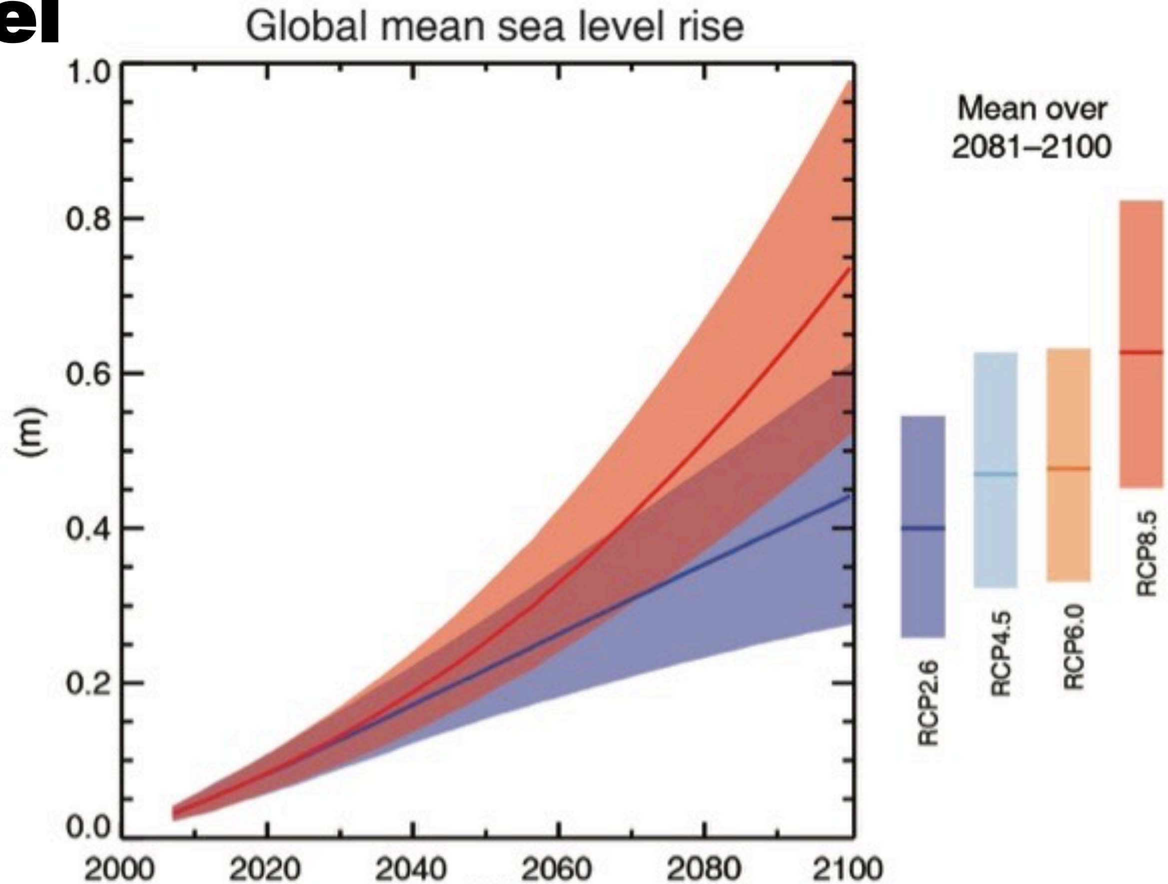


Fig. SPM.9

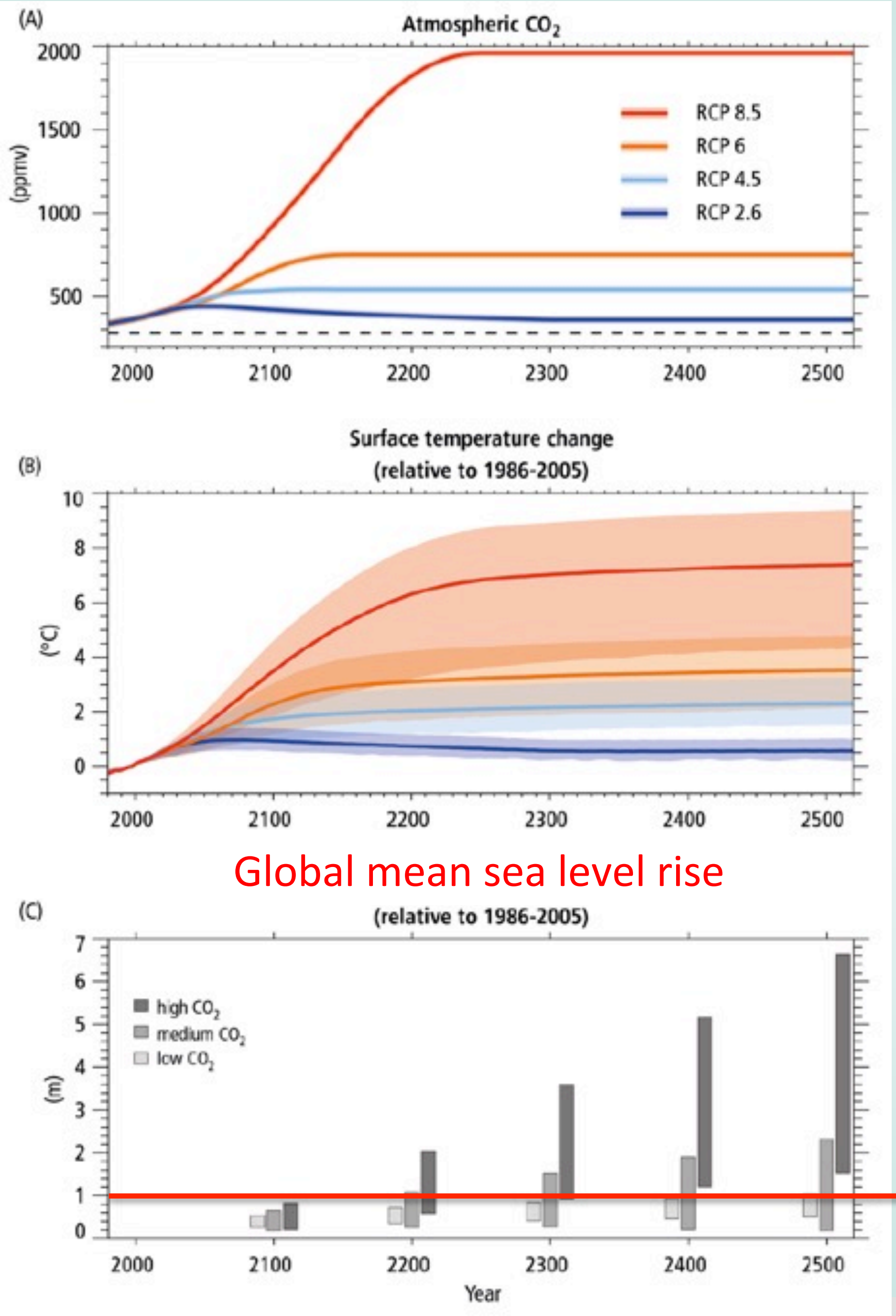
RCP2.6 (2081-2100), *likely* range: 26 to 55 cm

RCP8.5 (in 2100), *likely* range: 52 to 98 cm

(Reference level: 1986-2005)

Sea level rise beyond 2100 may challenge natural and human systems:

1.5°C



....affecting habitat, freshwater resources, human society through flood events

Paleo-observations as a reference

5-9 m : ...during the last interglacial (Eemian, 125.000 ya, at 0.7-2°C above pre-industrial)

>7m : ...last time when the atmosphere had 400 ppm CO_2 (in Pliocene, 3-5 Mya)

RCP6.0, 8.5

RCP4.5

~1.5°C

RCP2.6

WGI Figure 12.43 and Table 13.8 SYR 2.8

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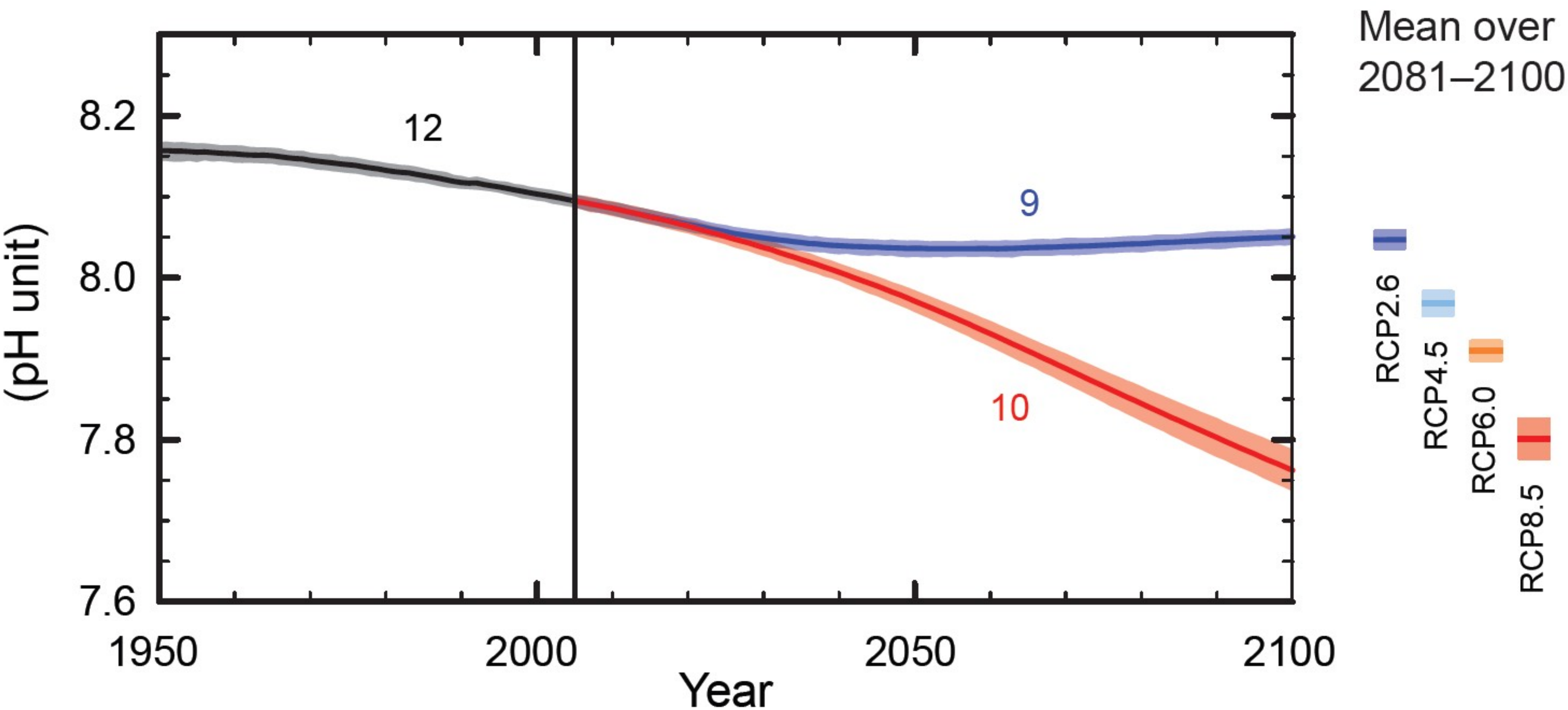
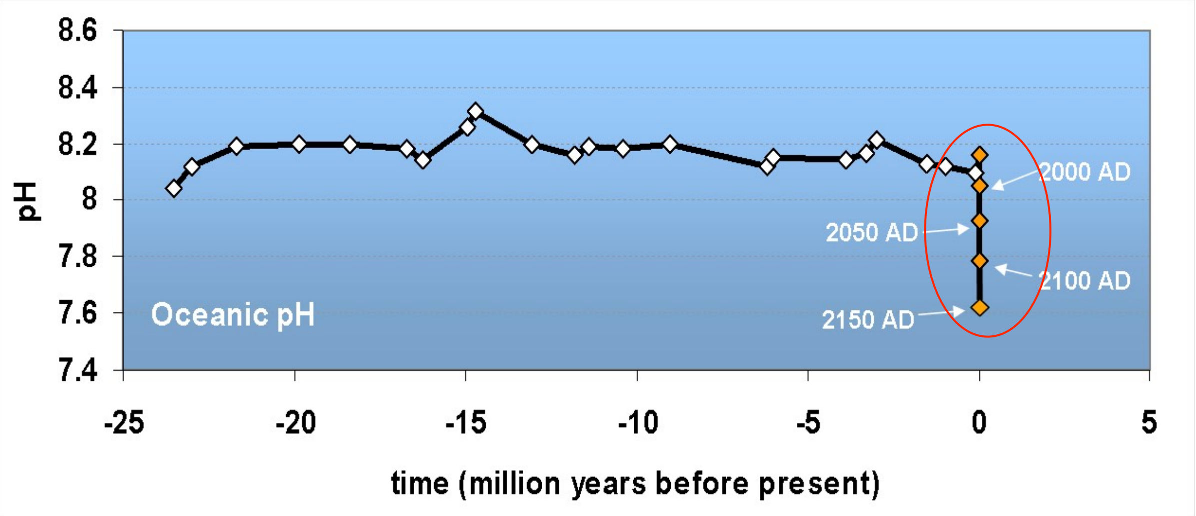
Figure SPM.7c
Global ocean surface pH

Acidification: the lower the pH, the more acid



Oceans are Acidifying Fast ....

Changes in pH over the last 25 million years



"Today is a rare event in the history of the World"

- **It is happening now, at a speed and to a level not experienced by marine organisms for about 60 million years**

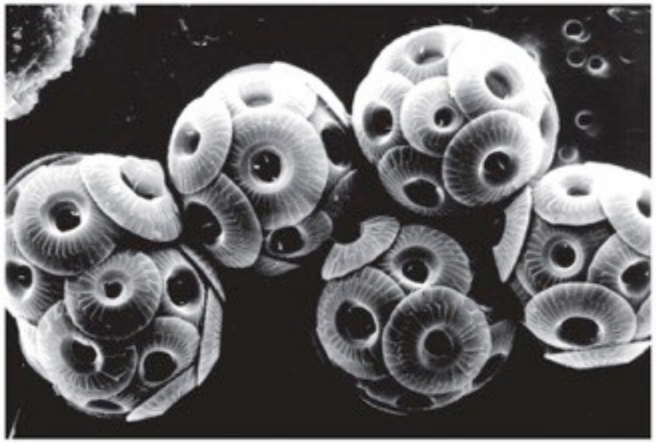
- **Mass extinctions linked to previous ocean acidification events**

- **Takes 10,000's of years to recover**

Turley et al. 2006

Slide courtesy of Carol Turley, PML

Organisms Threatened by Increased Marine Acidity



(a) Coccolithophores (diameter of each = 20 microns, or 0.0008 in.)

(b) Pteropod (diameter = 2 mm, or 0.08 in.)

(c) Sea urchins

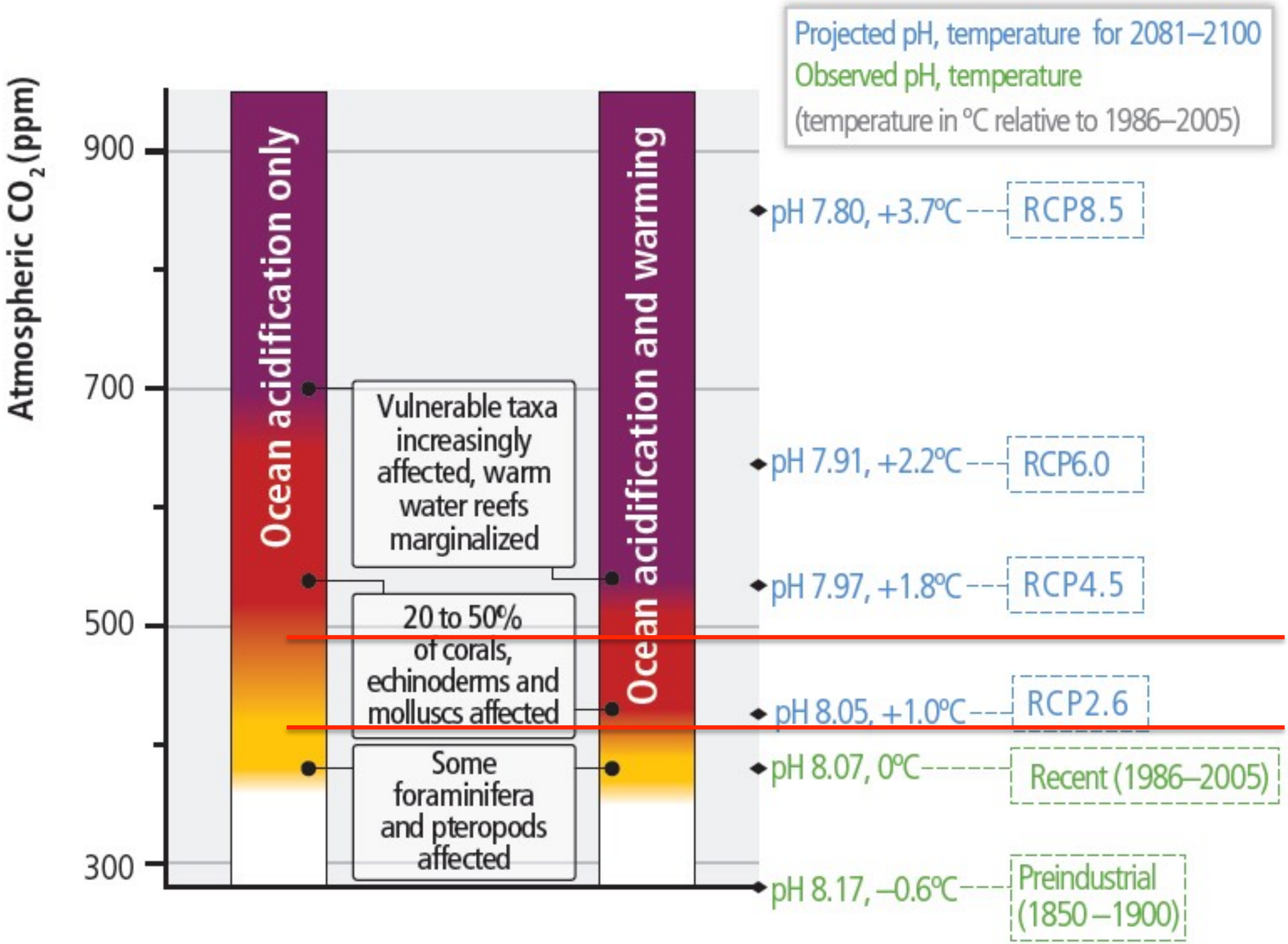
(d) Corals

Coral reefs are dying

American Samoa (from www.globalcoralbleaching.org)

(B) Risk for marine species impacted by ocean acidification only, or additionally by warming extremes

1.5°C
2°C



SYR 2.5

Slide: H.O. Pörtner

(A) Risk for terrestrial and freshwater species impacted by the rate of warming

1.5°C
2°C

..... **2°C:**

climate change velocity becomes too fast for terrestrial and freshwater organisms to follow in flat landscapes

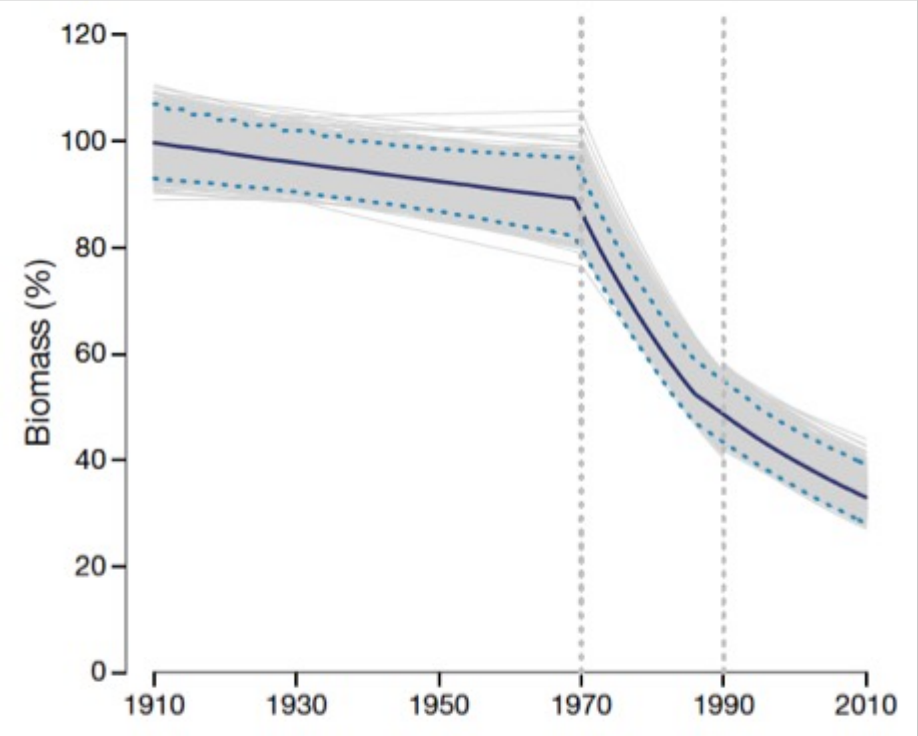
Food security constrained: ....Fisheries

2°C

2051-60: displaced and reduced fish and invertebrate biodiversity

..... 2°C:

Combined human pressures: oceans are warming, acidifying, losing oxygen, affecting presently overexploited stocks.



BACKGROUND:
OVERFISHING caused predatory fish biomass to decline
(by ≈ 70%!)

MEPS 512: 155–166, 2014

Impacts are already underway

- Tropics to the poles
- On all continents and in the ocean
- Affecting rich and poor countries (but the poor are more vulnerable everywhere)

AR5 WGII SPM

Potential Impacts of Climate Change

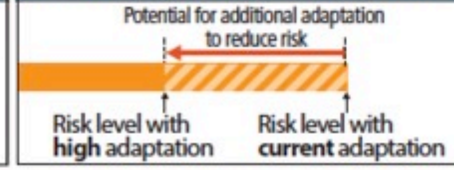
- Food and water shortages
- Increased displacement of people
- Increased poverty
- Coastal flooding

AR5 WGII SPM

Table 29-4 | Selected key risks and potential for adaptation for small islands from the present day to the long term.

Climate-related drivers of impacts							
Warming trend	Extreme temperature	Drying trend	Extreme precipitation	Damaging cyclone	Sea level	Ocean acidification	Sea surface temperature

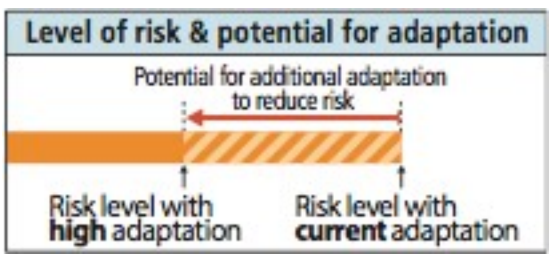
Level of risk & potential for adaptation

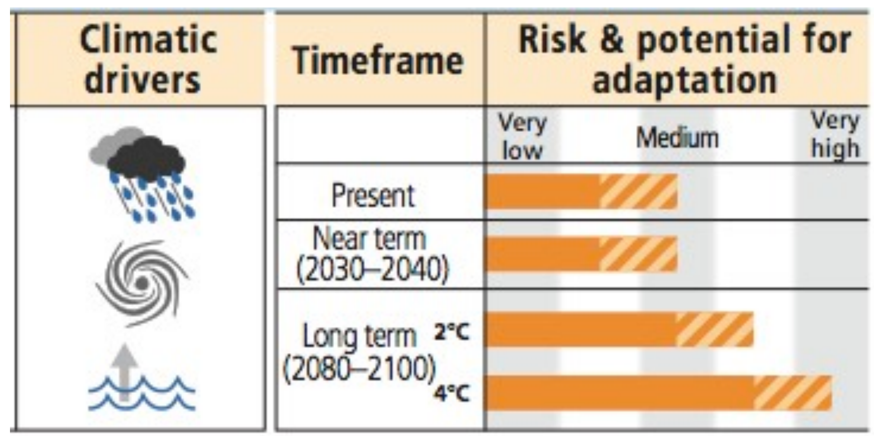


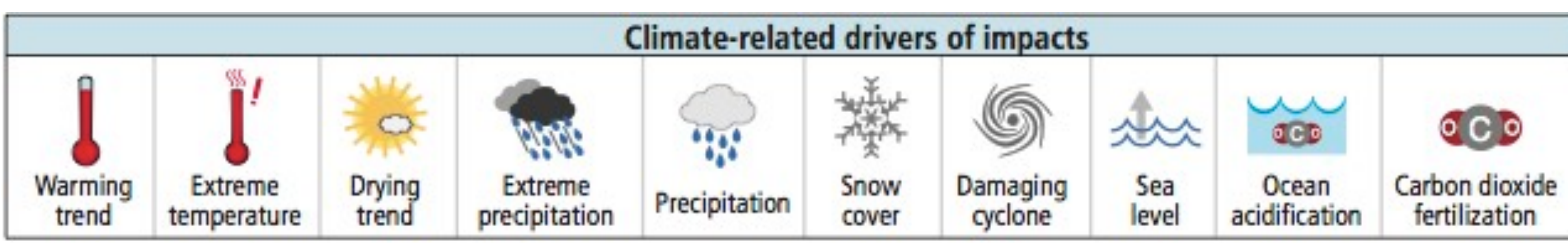
Key risk	Adaptation issues & prospects	Climatic drivers	Timeframe	Risk & potential for adaptation
Loss of livelihoods, coastal settlements, infrastructure, ecosystem services, and economic stability (*high confidence*) [29.6, 29.8, Figure 29-4]	• Significant potential exists for adaptation in islands, but additional external resources and technologies will enhance response. • Maintenance and enhancement of ecosystem functions and services and of water and food security • Efficacy of traditional community coping strategies is expected to be substantially reduced in the future.		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low – Medium – Very high
Decline and possible loss of coral reef ecosystems in small islands through thermal stress (*high confidence*) [29.3.1.2]	Limited coral reef adaptation responses; however, minimizing the negative impact of anthrogopenic stresses (ie: water quality change, destructive fishing practices) may increase resilience.		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low – Medium – Very high
The interaction of rising global mean sea level in the 21st century with high-water-level events will threaten low-lying coastal areas (*high confidence*) [29.4, Table 29-1; WGI AR5 13.5, Table 13.5]	• High ratio of coastal area to land mass will make adaptation a significant financial and resource challenge for islands. • Adaptation options include maintenance and restoration of coastal landforms and ecosystems, improved management of soils and freshwater resources, and appropriate building codes and settlement patterns.		Present Near term (2030–2040) Long term (2080–2100) 2°C / 4°C	Very low – Medium – Very high

Key Risk for Asia: Floods

Increased riverine, coastal, and urban flooding leading to widespread damage to infrastructure, livelihoods, and settlements in Asia (medium *confidence)*







IPCC, AR5, WG II, SPM, p. 22

Nile Delta, where more than 10 millions people live at less than 1 m above sea level (red zone)

(Time 2001)

Risks from sea-level rise

Coastal and low-lying areas will experience **more flooding and coastal erosion**

Local sea-level rise can differ substantially from global, due to e.g. subsidence, glacial isostatic adjustment, sediment transport, coastal development

Population exposed and pressure from human activities will increase significantly in the coming decades due to population growth, economic development, and urbanization

AR5 ch 5 (ExSum)

Sea-level rise: costs and adaptation

The relative costs of coastal adaptation vary strongly among and within regions and countries for the 21st century

For the 21st century**, the benefits of protecting** against increased coastal flooding and land loss due to submergence and erosion at the global scale **are larger than the social and economic costs of inaction** (limited evidence, high agreement)

Some low-lying developing countries and small island states are **expected to face very high impacts** that, in some cases, could have associated damage and adaptation costs of several percentage points of GDP

Small islands: risks

Projected increases < 2100 + extreme sea level events
-> **severe sea *flood and erosion risks*** for low-lying coastal areas and atoll islands

seawater will **degrade fresh groundwater** resources

coral reef ecosystem degradation will negatively impact coastal protection, subsistence fisheries, and tourism, thus affecting livelihoods

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AR5 ch 29 (ExSum)


ADAPTATION IS
ALREADY OCCURRING
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Small islands: adaptation

Adaptation generates **larger benefit to small islands when delivered in conjunction with other development activities**, such as disaster risk reduction and community-based approaches to development

- address current social, economic, environmental issues,
- raise awareness, communicate future risks to local communities

Adaptation and mitigation on small islands are not always trade-offs - they **can be complementary**

- examples include energy supply, tourism infrastructure, coastal wetland services

Appropriate **assistance from the international community may help**

AR5 ch 29

The approaches available to help coastal communities adapt to the impacts of climate change fall into three general categories:

1. **Protection** of people, property, and infrastructure is a typical first response. This includes **"hard"** measures such as building seawalls and other barriers, along with various measures to protect critical infrastructure. **"Soft" protection measures are increasingly favored.** These include enhancing coastal vegetation and other coastal management programs to reduce erosion and enhance the coast as a barrier to storm surges.

IPCC, AR5, WG II, Chap. 5, p. 387

The approaches available to help coastal communities adapt to the impacts of climate change fall into three general categories:

2. **Accommodation** is a more adaptive approach involving changes to human activities and infrastructure. These **include retrofitting buildings to make them more resistant** to the consequences of sea level rise, raising low-lying bridges, or increasing physical shelter capacity to handle needs caused by severe weather. Soft accommodation measures include adjustments to land use planning and insurance programs.

IPCC, AR5, WG II, Chap. 5, p. 387

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Flood risk adaptation in Bangladesh (example): cyclone shelters, awareness raising, forecasting and warning

photo: Dr Thorsten Klose/German Red Cross (2010), evaluation of the Community Based Disaster Preparedness Programme run by the Red Cross in1996-2002

The approaches available to help coastal communities adapt to the impacts of climate change fall into three general categories:

3. **Managed retreat** involves moving away from the coast and may be the only viable option when nothing else is possible.

Community-based adaptation measures
(examples from WGII ch5 table 5.4)

Impact	Measures
Increased salinity	*Saline-tolerant crop cultivation*
Flooding/ inundation	*Disaster management committees (discuss preparedness and response)* *Early flood warning systems*
Cyclones/ storm surges	*Low-cost retrofitting to strengthen household structures,* *Plantation of specific fruit trees around homestead area*
Sea level rise	*Farmers educated on comprehensive risk insurance*
Multi-coastal impacts	*Integrating climate change into education* *Integrated coastal zone management (ICZM) plan*

Adaptation issues and prospects

1. Exposure reduction via structural and non-structural measures, effective land-use planning, and selective relocation
2. Reduction in the vulnerability of lifeline infrastructure and services (e.g., water, energy, waste management, food, biomass, mobility, local ecosystems, telecommunications)
3. Construction of monitoring and early warning systems; Measures to identify exposed areas, assist vulnerable areas and households, and diversify livelihoods
4. Economic diversification

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IPCC, AR5, WG II, SPM, p. 22

Adaptive capacity (1)

Adaptive capacity is the ability of a system to evolve in order to accommodate climate changes or to expand the range of variability with which it can cope.

The adaptive capacity of coastal communities to cope with the effects of severe climate impacts declines if there is a lack of physical, economic and institutional capacities to reduce climate-related risks and hence the vulnerability of high-risk communities and groups.

But even a high adaptive capacity may not translate into effective adaptation if there is no commitment to sustained action.

AR4, WGII, § 6.6.4

Adaptive capacity (2)

Current pressures are likely to adversely affect the integrity of coastal ecosystems and thereby their ability to cope with additional pressures, including climate change and sea-level rise.
This is a particularly significant factor in areas where there is a high level of development, large coastal populations and high levels of interference with coastal systems.

Natural coastal habitats, such as dunes and wetlands, have a buffering capacity which can help reduce the adverse impacts of climate change. Equally, improving shoreline management for non-climate change reasons will also have benefits in terms of responding to sea-level rise and climate change.

AR4, WGII, § 6.6.4

Adaptive capacity (3)

Adopting a static policy approach towards sea-level rise conflicts with sustaining a dynamic coastal system that responds to perturbations via sediment movement and long-term evolution.

In the case of coastal megacities, maintaining and enhancing both resilience and adaptive capacity for weather-related hazards are critically important policy and management goals.

The dual approach brings benefits in terms of linking analysis of present and future hazardous conditions. It also enhances the capacity for disaster prevention and preparedness, disaster recovery and for adaptation to climate.

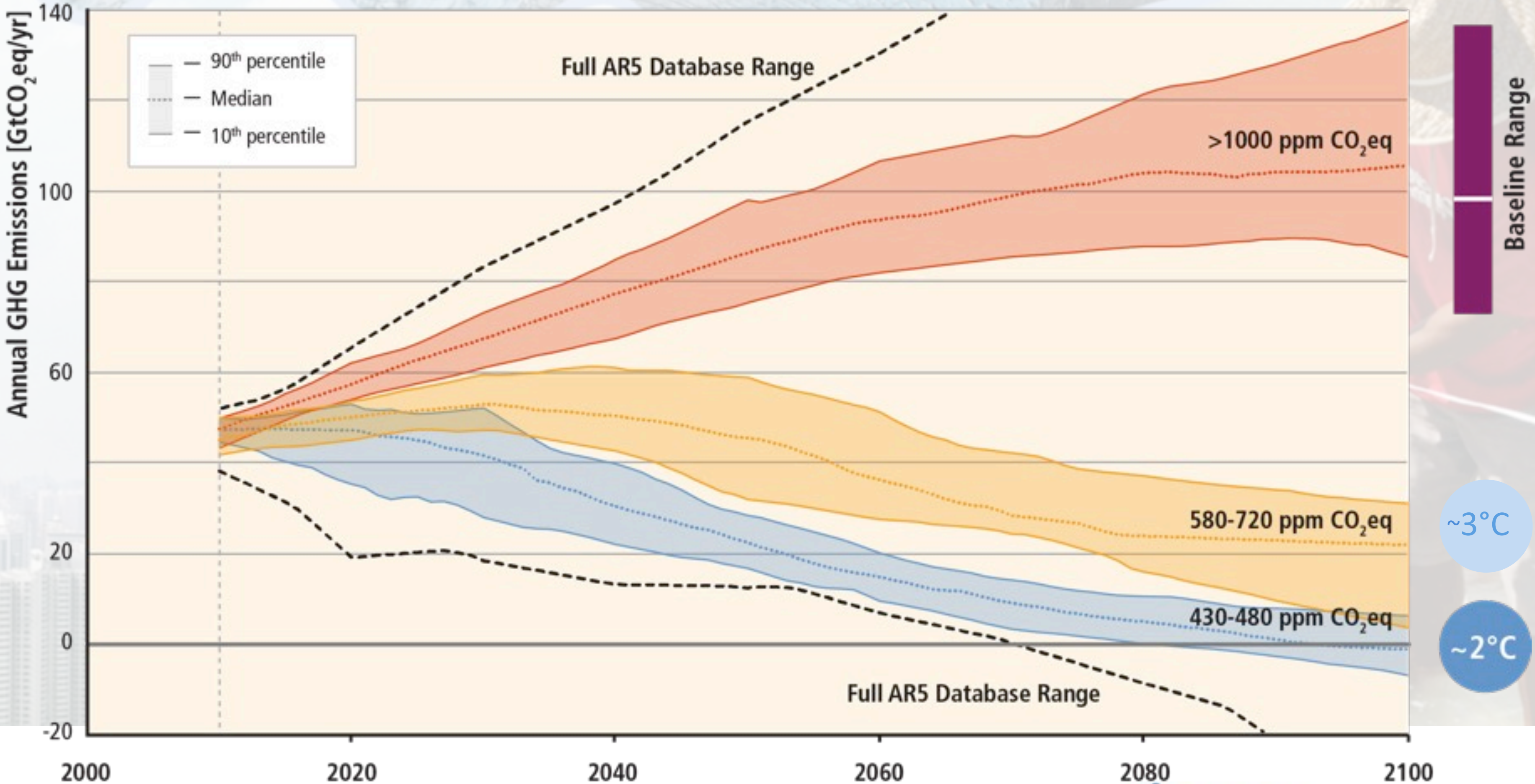
AR4, WGII, § 6.6.4

Coastal and low lying areas: Impacts in Asia

Coastal erosion and inundation of coastal lowland: Erosion is the main process that will occur to land as sea level continues to rise. As a consequence, **coast-protection structures built by humans will usually be destroyed by the sea while the shoreline retreats**. Climate change and sea-level rise will tend to worsen the currently eroding coasts

AR4, WGII, § 10.4.3, p.484

Stabilization of atmospheric concentrations requires moving away from the baseline – regardless of the mitigation goal.



Based on Figure 6.7

AR5 WGIII SPM

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Limiting Temperature Increase to 2˚C

Measures exist to achieve the substantial emissions reductions required to limit likely warming to 2°C

A combination of adaptation and substantial, sustained reductions in greenhouse gas emissions can limit climate change risks

Implementing reductions in greenhouse gas emissions poses substantial technological, economic, social, and institutional challenges

But delaying mitigation will substantially increase the challenges associated with limiting warming to 2°C

AR5 WGI SPM, AR5 WGII SPM,AR5 WGIII SPM

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Mitigation Measures

More efficient use of energy

Greater use of low-carbon and no-carbon energy

- Many of these technologies exist today

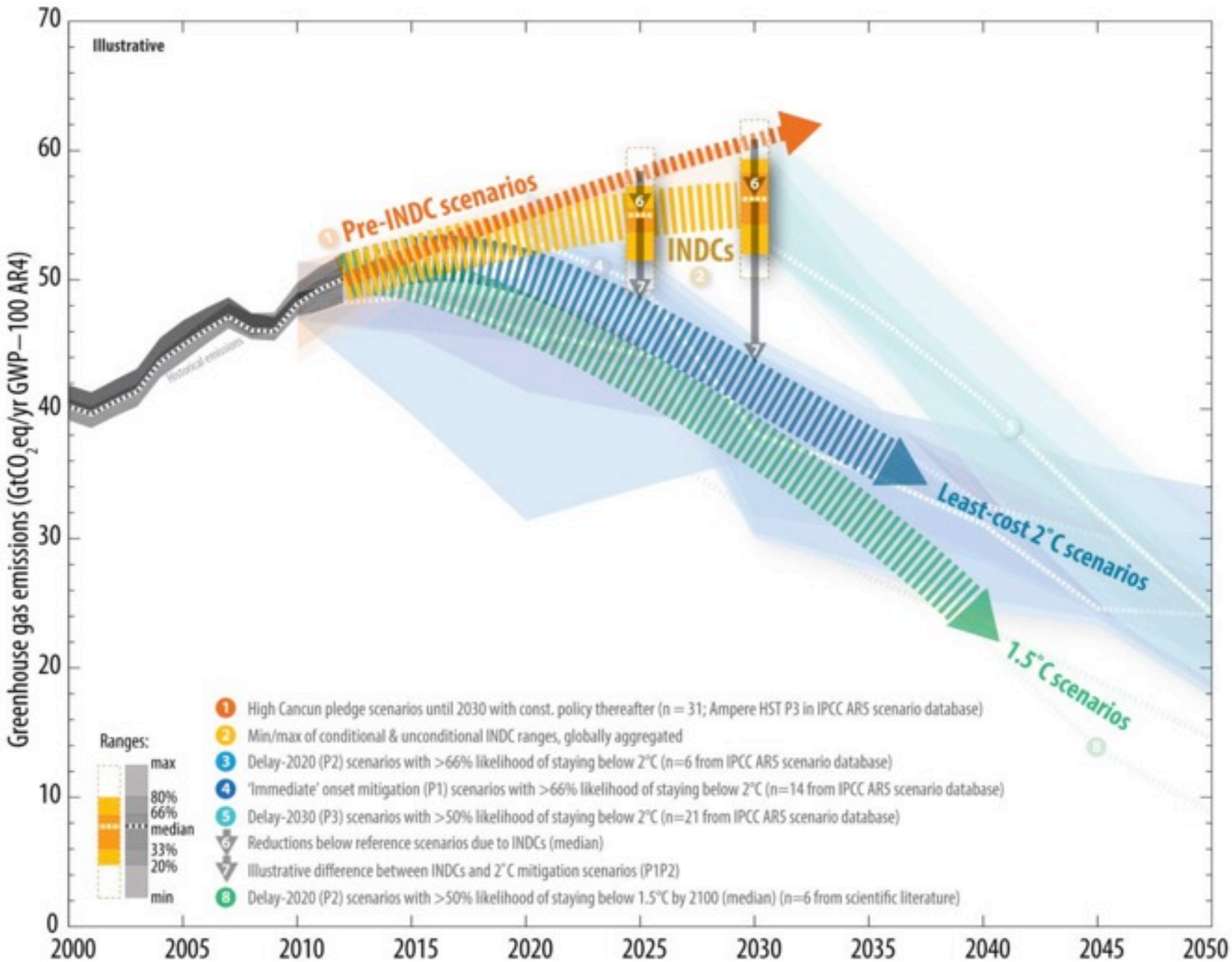
Improved carbon sinks

- Reduced deforestation and improved forest management and planting of new forests
- Bio-energy with carbon capture and storage

Lifestyle and behavioural changes

AR5 WGIII SPM

Comparison of global emission levels in 2025 and 2030 resulting from the implementation of the intended nationally determined contributions

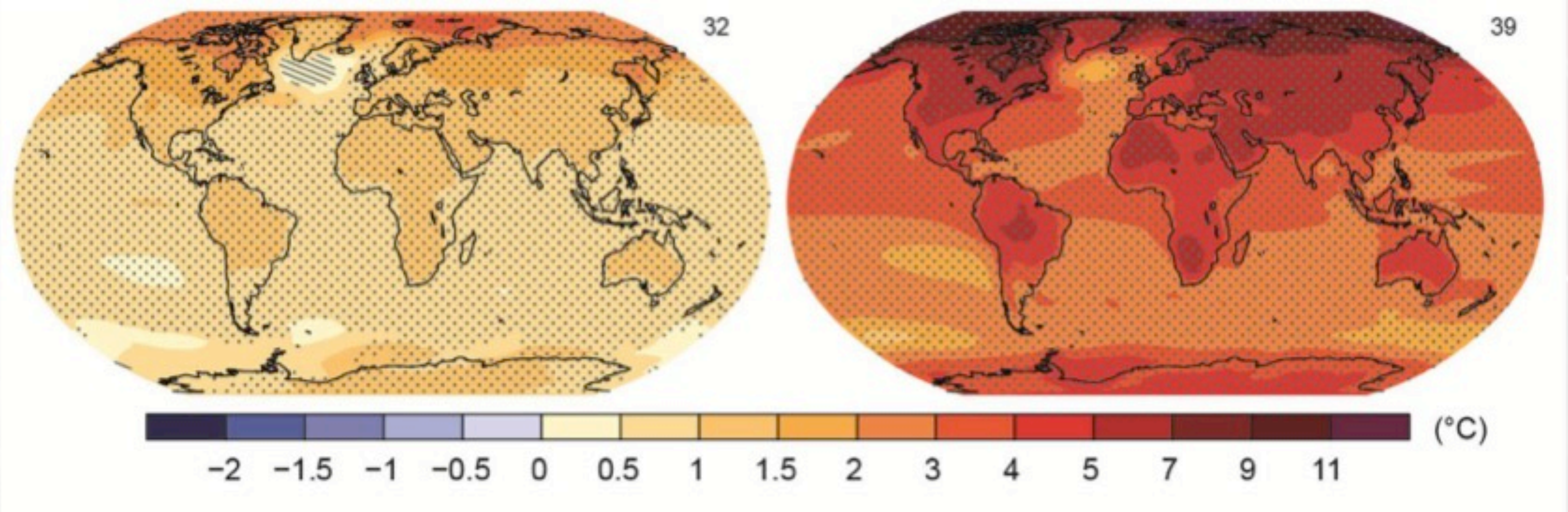


UNFCCC, Aggregate effect of the intended nationally determined contributions: an update
http://unfccc.int/resource/docs/2016/cop22/eng/02.pdf

The Choices Humanity Makes Will Create Different Outcomes (and affect prospects for effective adaptation)

With substantial mitigation

Without additional mitigation



Change in average surface temperature (1986–2005 to 2081–2100)

AR5 WGI SPM

- **Sustainable development and equity provide a basis for assessing climate policies and highlight the need for addressing the risks of climate change**

- **Issues of equity, justice, and fairness arise with respect to mitigation and adaptation**

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SUSTAINABLE DEVELOPMENT GOALS

Useful links:

- www.ipcc.ch : IPCC (reports and videos)
- www.climate.be/vanyp : my slides and other documents
- www.skepticalscience.com: excellent responses to contrarians arguments
- **On Twitter: @JPvanYpersele**

  and @IPCC_CH