

# **Climate change and its consequences on water resources**

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**CERIS Conference on the Geopolitics of Water,  
Université libre de Bruxelles, 9 June 2018**

**Thanks to the Walloon Government (funding the Walloon Platform for IPCC)  
and to my team at the Université catholique de Louvain for their support**



# Let us think about the future of these children from Machakos in a warming climate

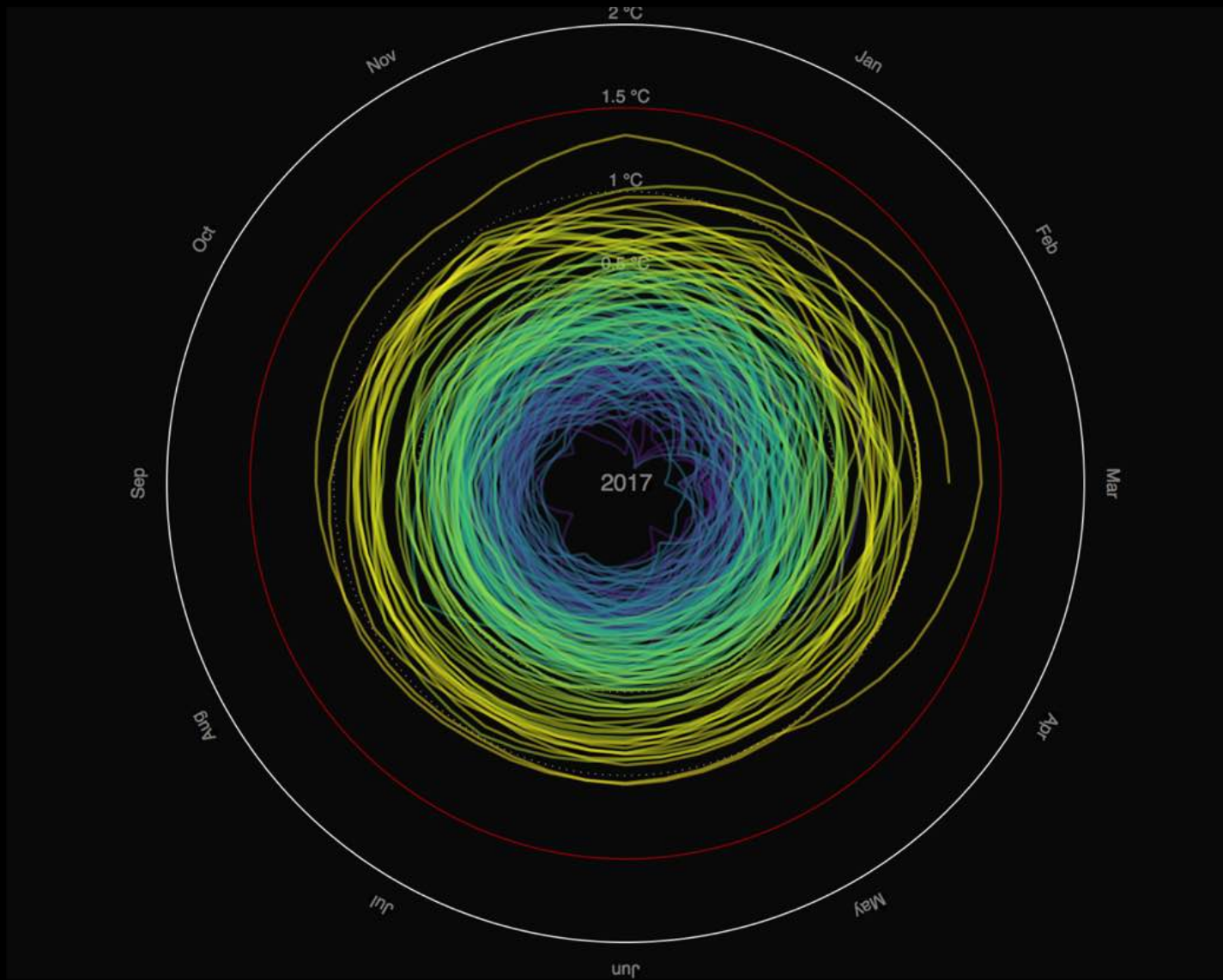




# In Puerto Rico, Hurricane Maria created the worst humanitarian crisis in the US for decades



# Temperature spiral

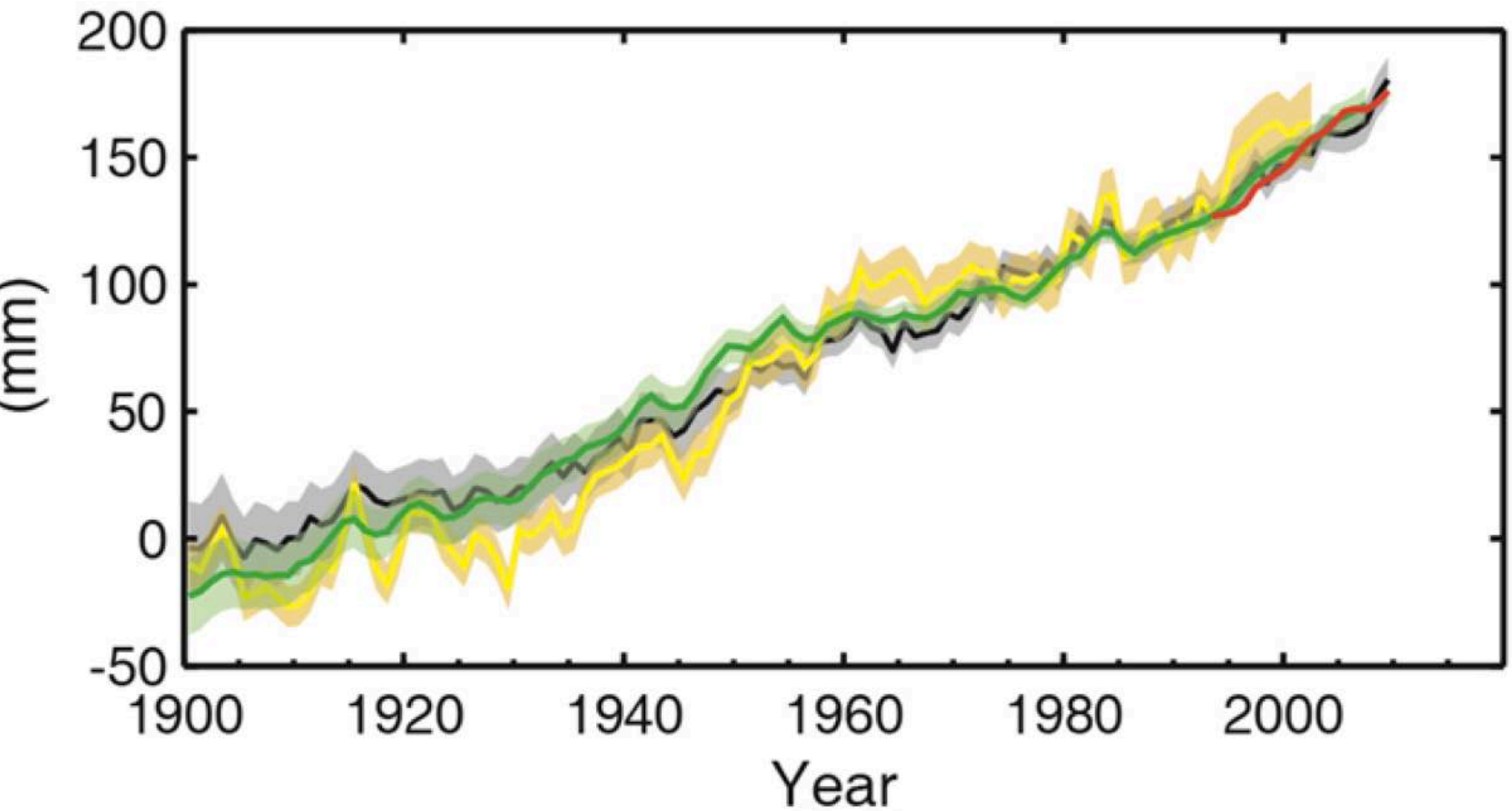


Global Mean Temperature in °C relative to 1850 – 1900

Graph: Ed Hawkins (Climate Lab Book) – Data: HadCRUT4 global temperature dataset

Animated version available on <http://openclimatedata.net/climate-spirals/temperature>

# Change in average sea-level change





Since 1950, extreme hot days and heavy precipitation have become more common



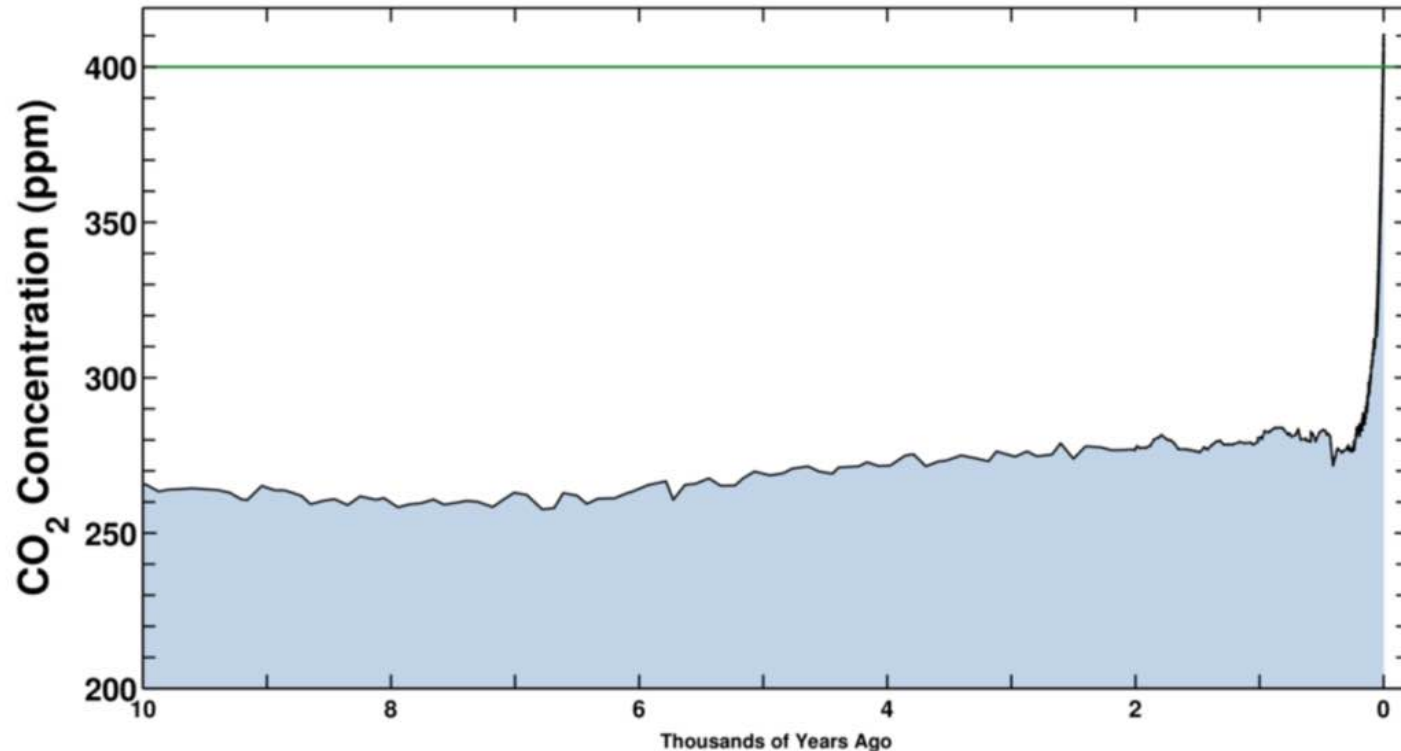
There is evidence that anthropogenic influences, including increasing atmospheric greenhouse gas concentrations, have changed these extremes

# CO<sub>2</sub> Concentration, 28 May 2018 (Keeling curve)

Latest CO<sub>2</sub> reading  
May 28, 2018

411.98 ppm

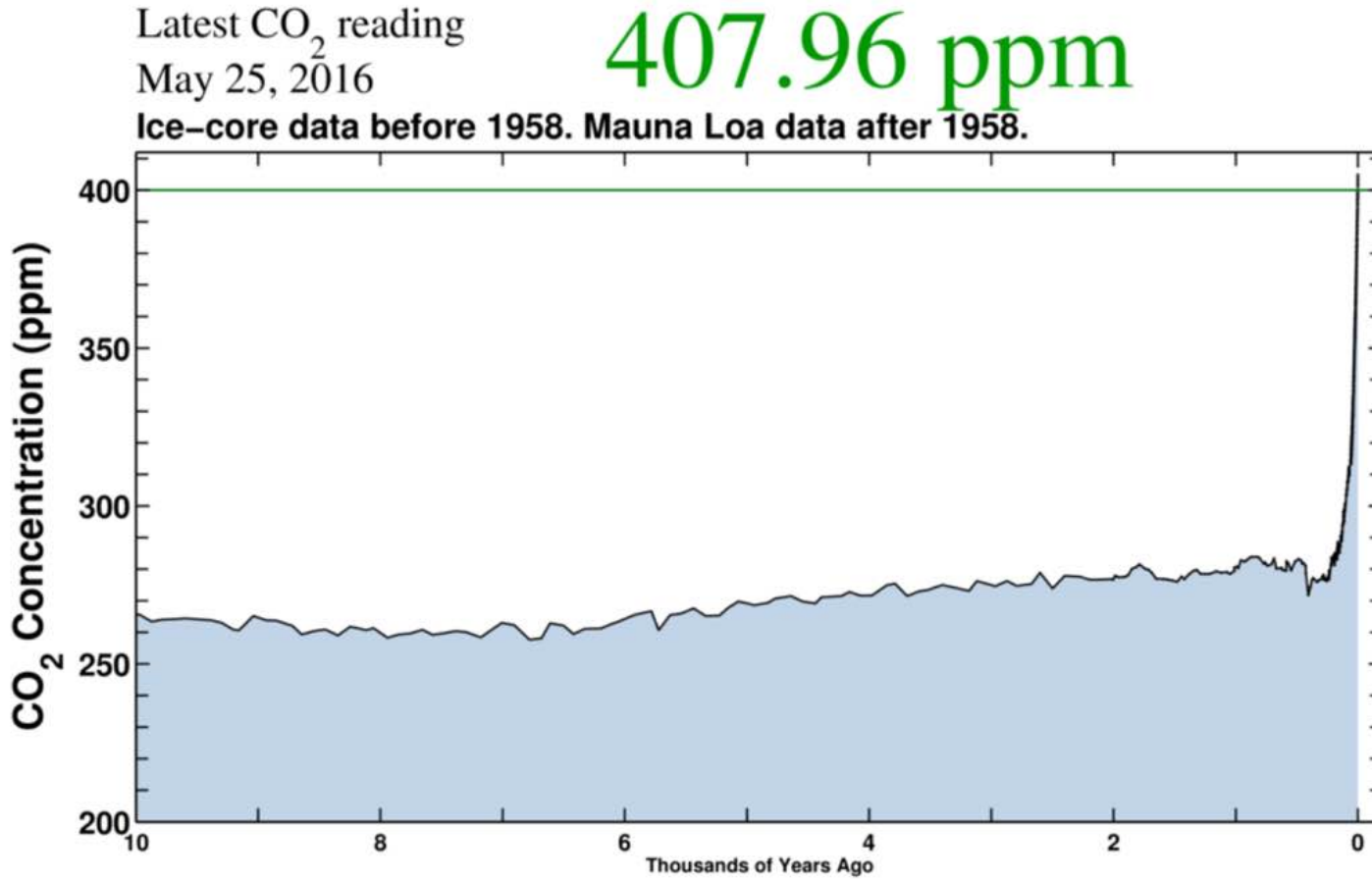
Ice-core data before 1958. Mauna Loa data after 1958.



Source: [scripps.ucsd.edu/programs/keelingcurve/](https://scripps.ucsd.edu/programs/keelingcurve/)

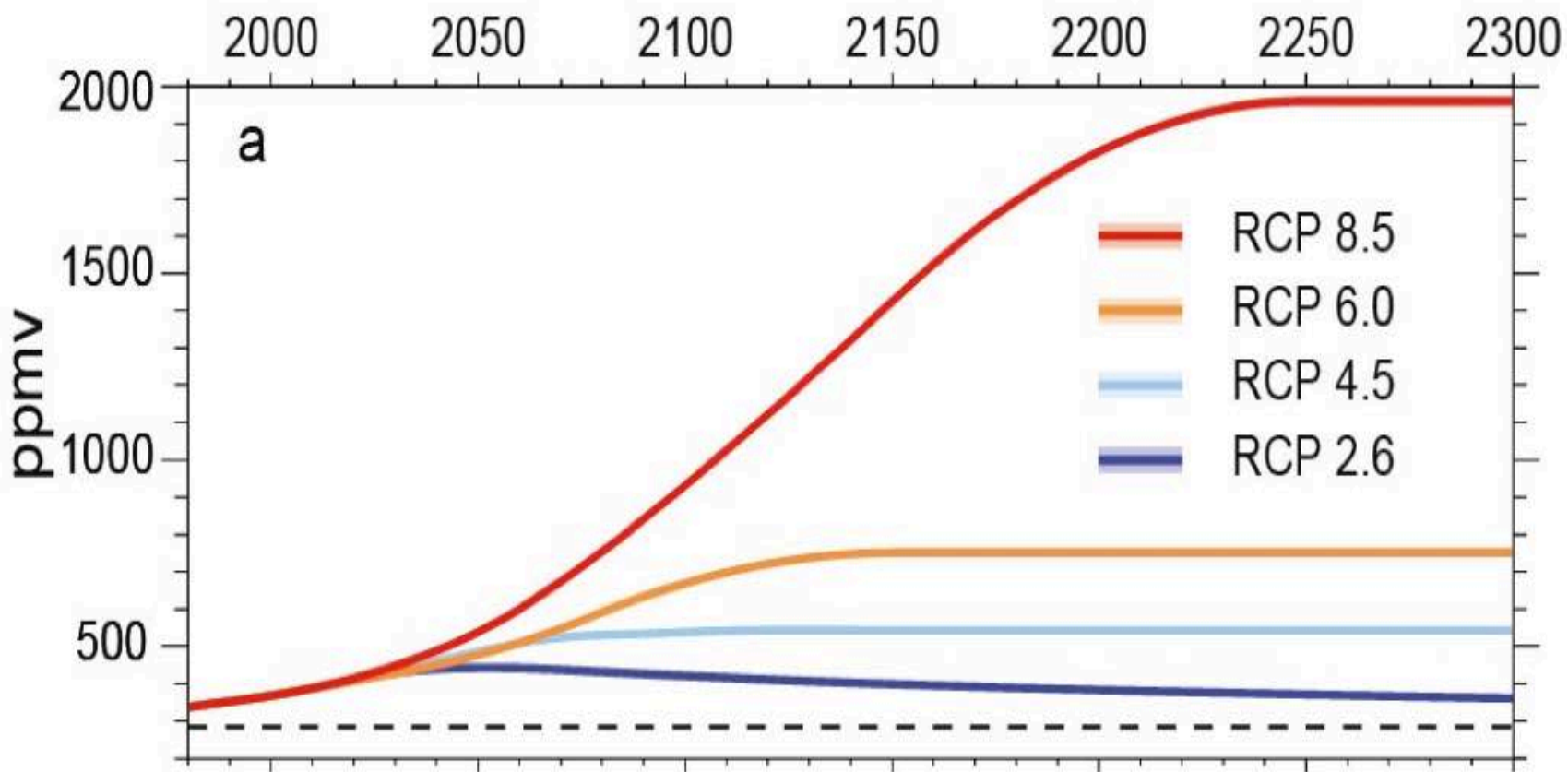


# CO<sub>2</sub> Concentration, 25 May 2016 (Keeling curve)



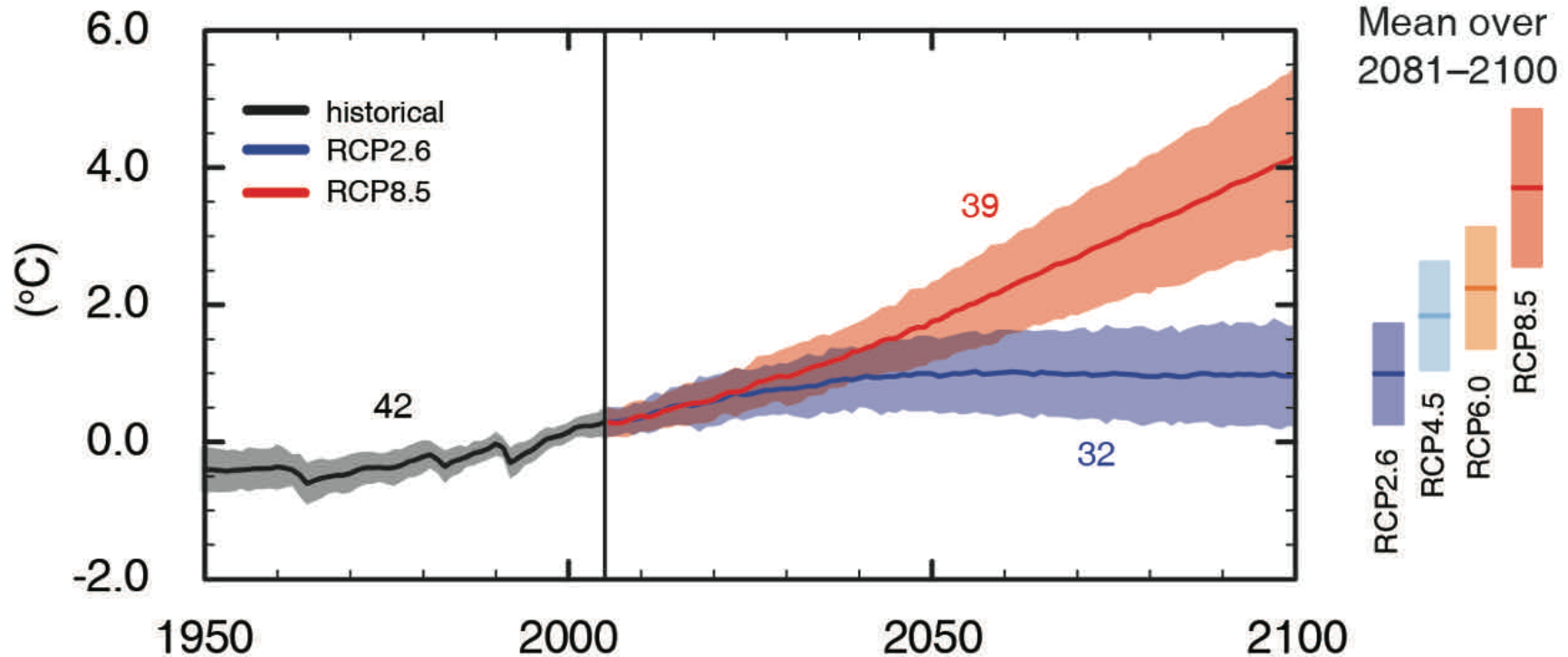
Source: [scripps.ucsd.edu/programs/keelingcurve/](http://scripps.ucsd.edu/programs/keelingcurve/)

# RCP Scenarios: Atmospheric CO<sub>2</sub> concentration



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

## Global average surface temperature change



(IPCC 2013, Fig. SPM.7a)

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



# **Consequences of Climate Change for Water**

- **Warming increases evaporation rates**
  - **Over oceans: it makes the atmosphere wetter**
    - **which increases maximum rainfall intensity**
  - **Over continents: it makes soils drier**
    - **which can increase drought intensity**
- **Warming melts ice**
  - **Melting glaciers will threaten water supplies, while contributing to sea-level rise (SLR)**
  - **Melting ice-sheets (Greenland and Antarctica) contribute to SLR**
    - **SLR produces salty water intrusions in freshwater reserves (eg: islands)**
- **Warming expands water**
  - **Which is another factor for SLR**
- **Warming changes some weather patterns**

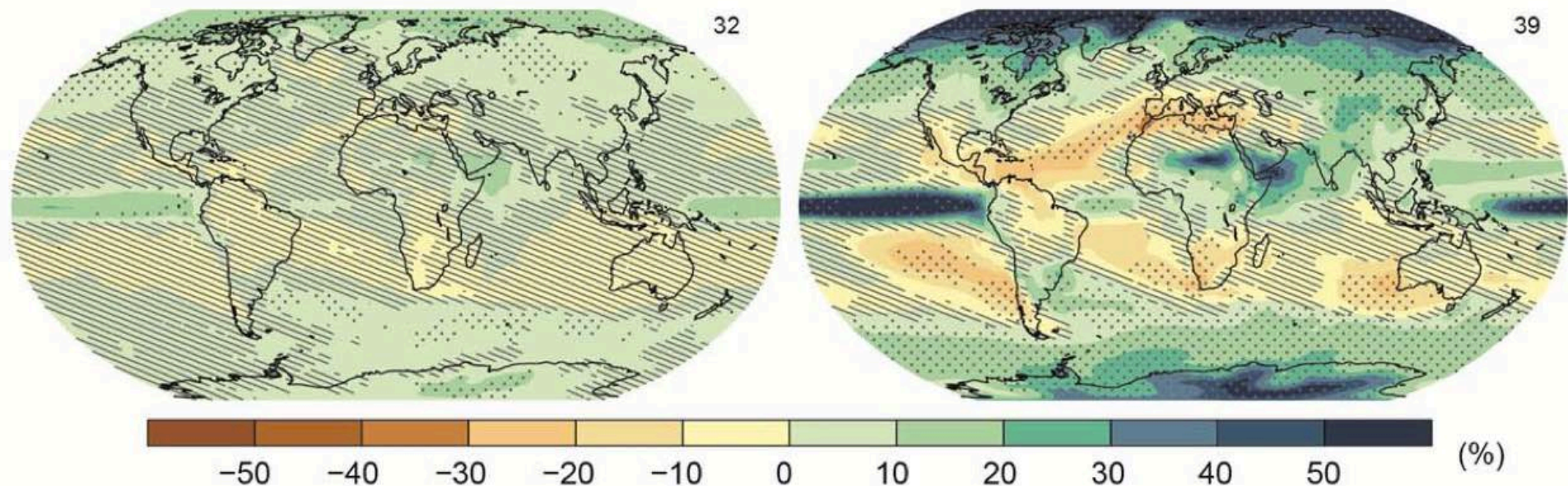
# Annual rainfall projections

**RCP2.6**

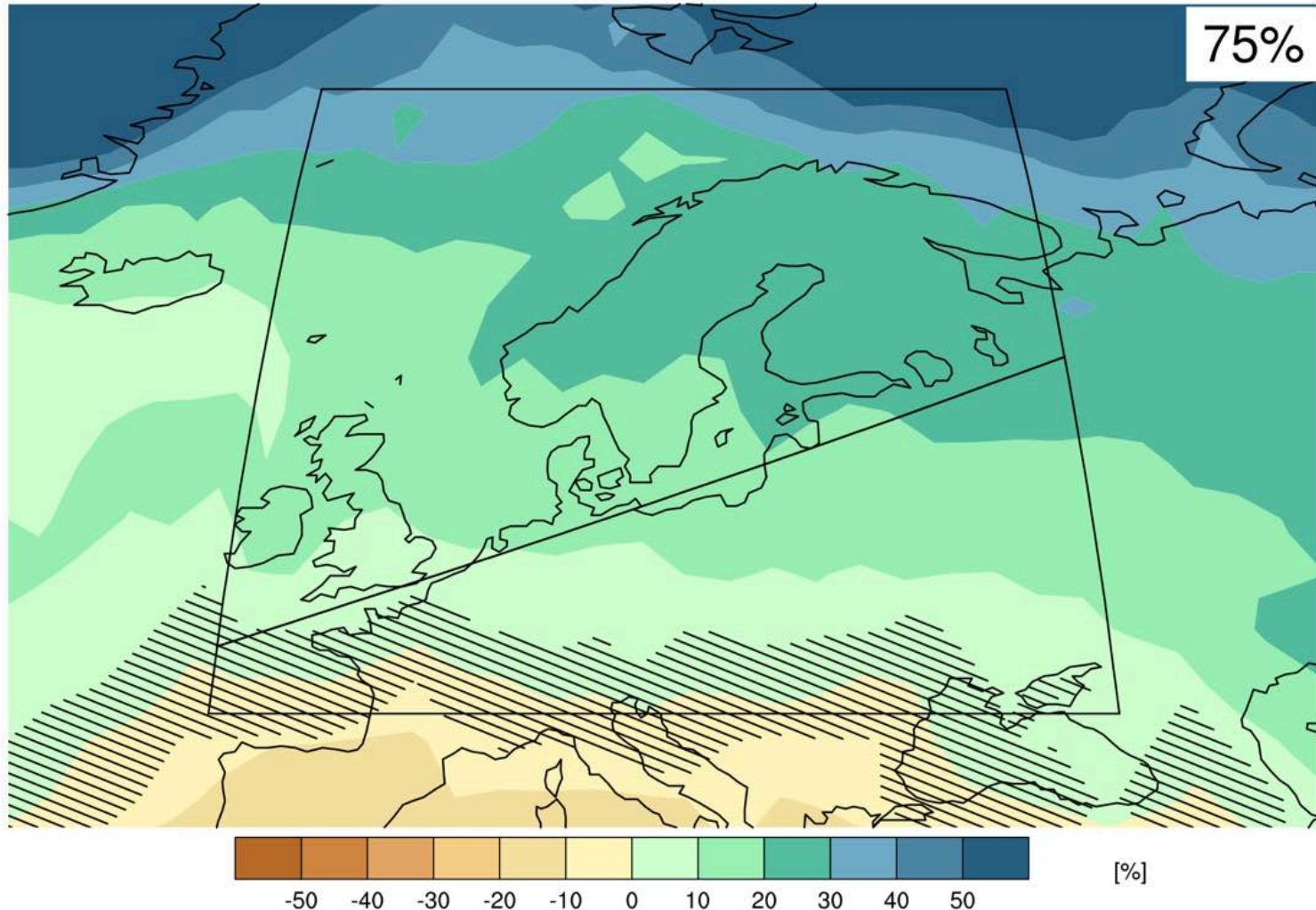
**RCP8.5**

(b)

Change in average precipitation (1986–2005 to 2081–2100)

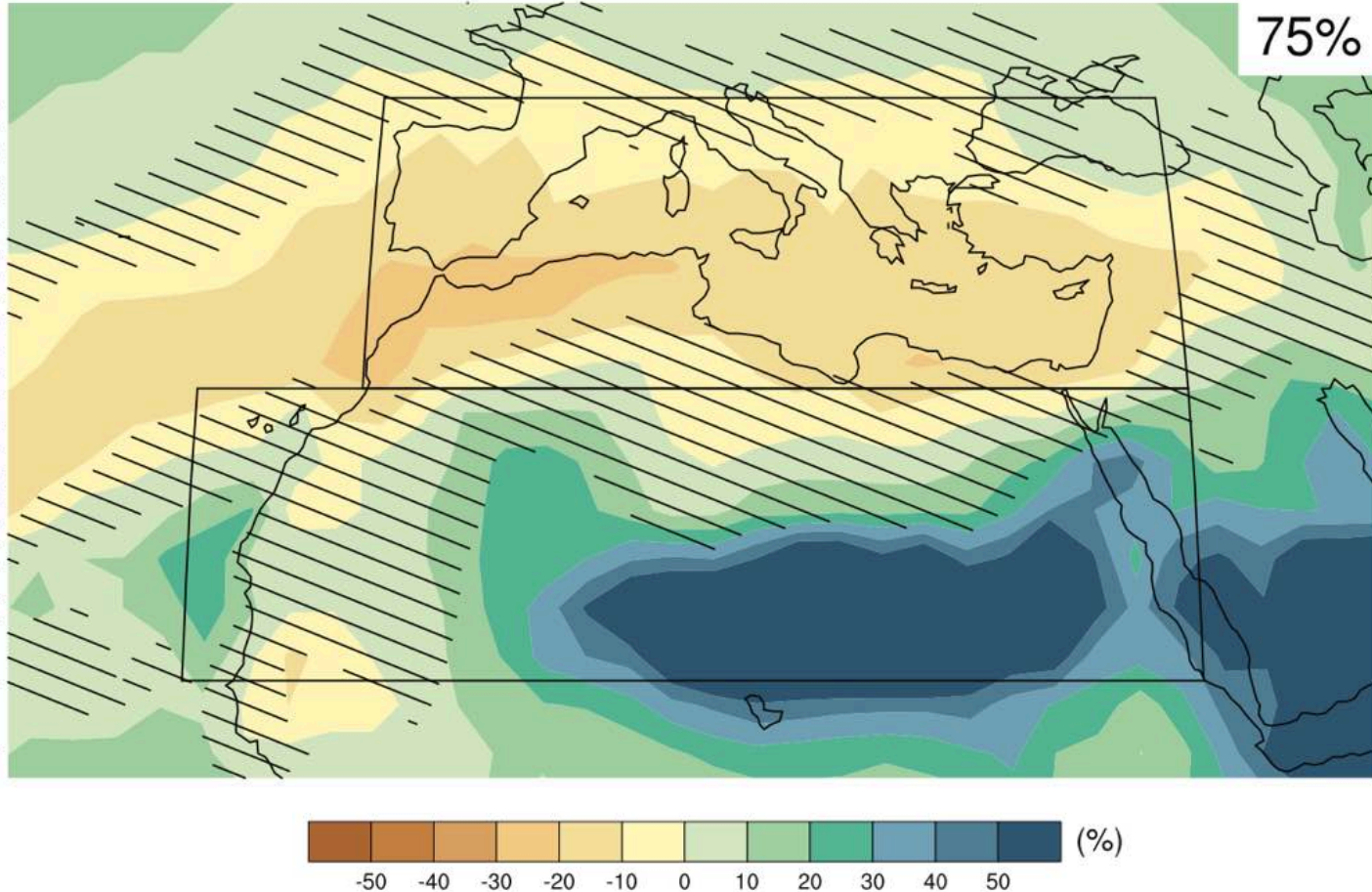


# North Europe - Map of precipitation changes in 2081–2100 with respect to 1986–2005 in the RCP8.5 scenario (annual)





# Evolution des précipitations en 2081-2100 par rapport aux valeurs de 1986-2005 (scénario RCP8.5)



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

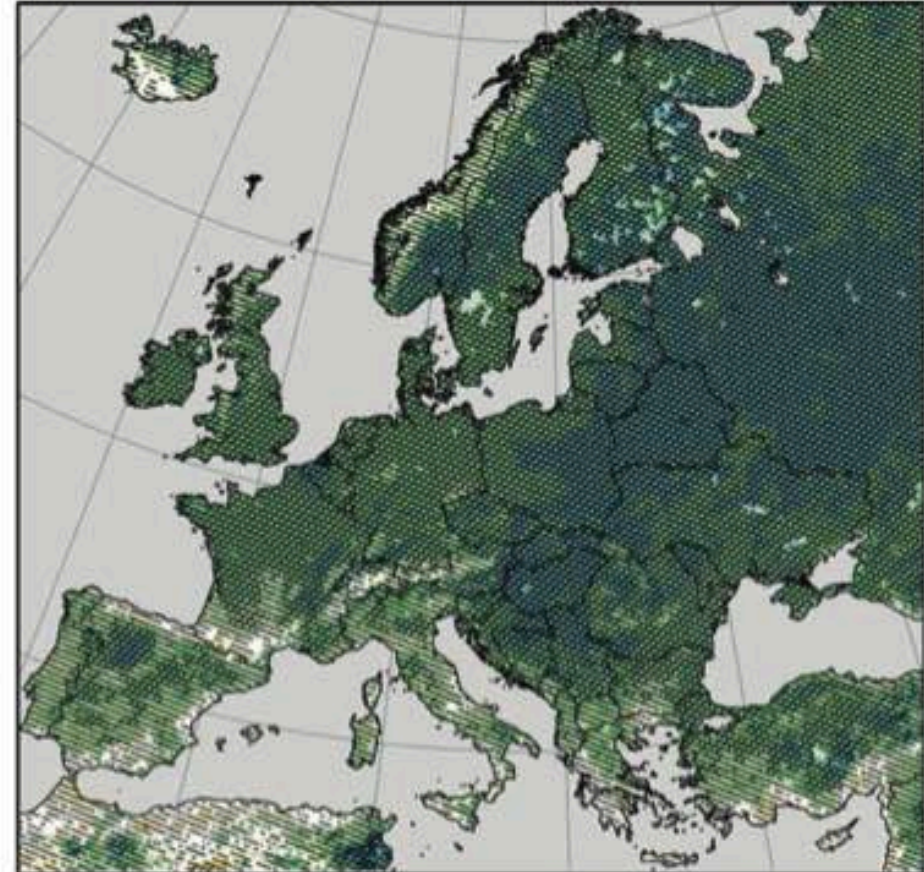


Regions where the projected change is large compared to natural internal variability, and where at least 90% of models agree on a sign of change

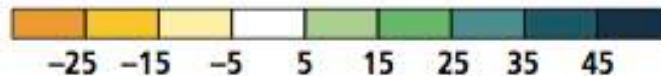
# DJF seasonal changes in heavy precipitation (%), 2071-2100 compared to 1971-2000

RCP4.5

RCP8.5



Seasonal changes in heavy  
precipitation in percent



//// Significant change

\\\\ Robust change



# 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

# Risk = Hazard x Vulnerability x Exposure (Katrina flood victim, New Orleans, 2005)



AP Photo - Lisa Krantz (<http://lisakrantz.com/hurricane-katrina/zspbn1k4cn17phidupe4f9x5t1mzdr>)

# National Assessments

**In Kenya**, a study by the Stockholm Environment Institute (SEI) estimated the economics of climate change under a range of scenarios and estimated that, **by 2050, more than 300,000 people could be flooded per year under a high-emissions scenario.**



# Six weeks worth of rain has fallen in three days over parts of France (May 2016)

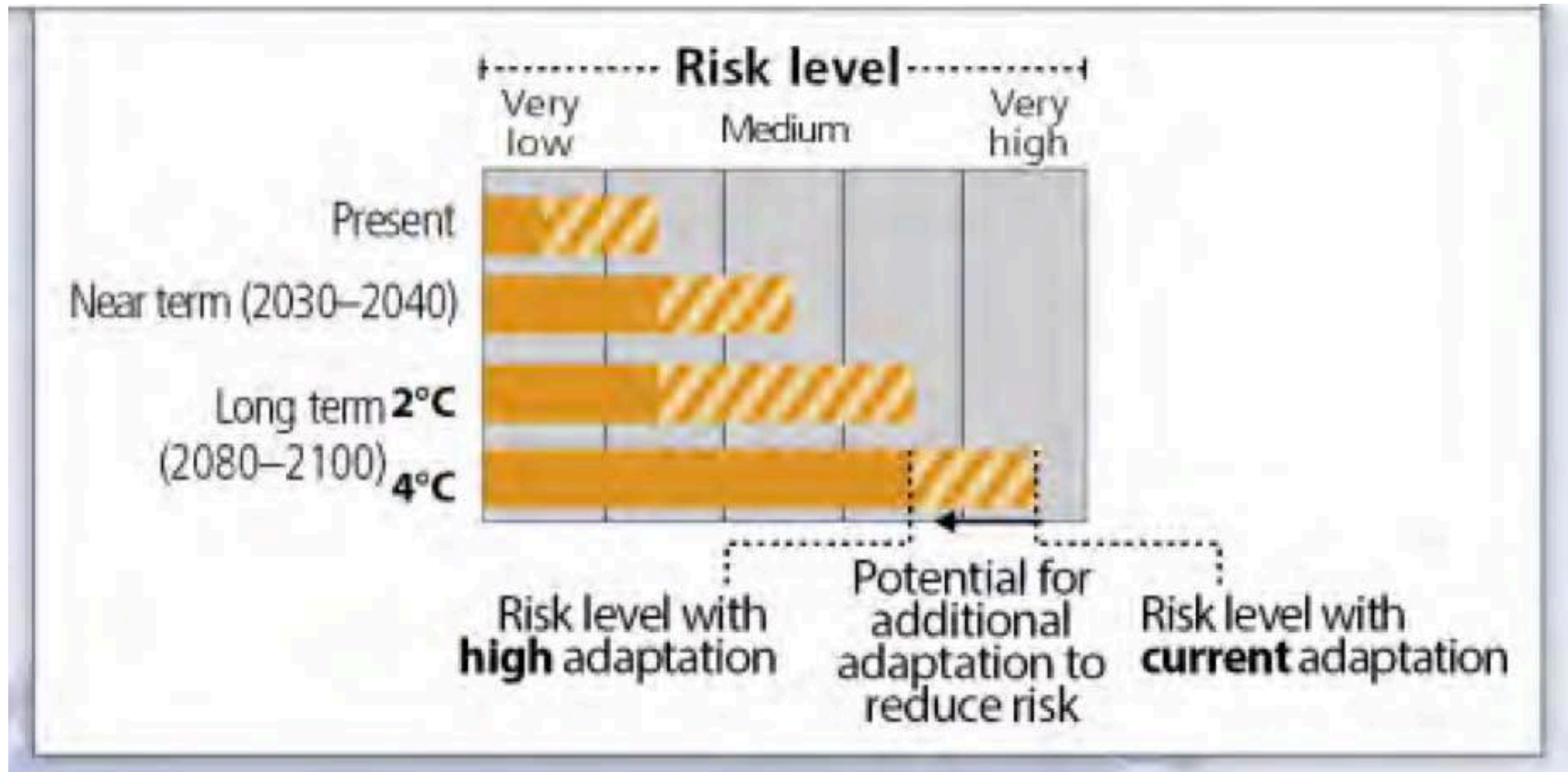


# In Germany, many residents weren't prepared for the mass flooding as the rain pelted down (May 2016)



# Regional key risks and potential for risk reduction through adaptation

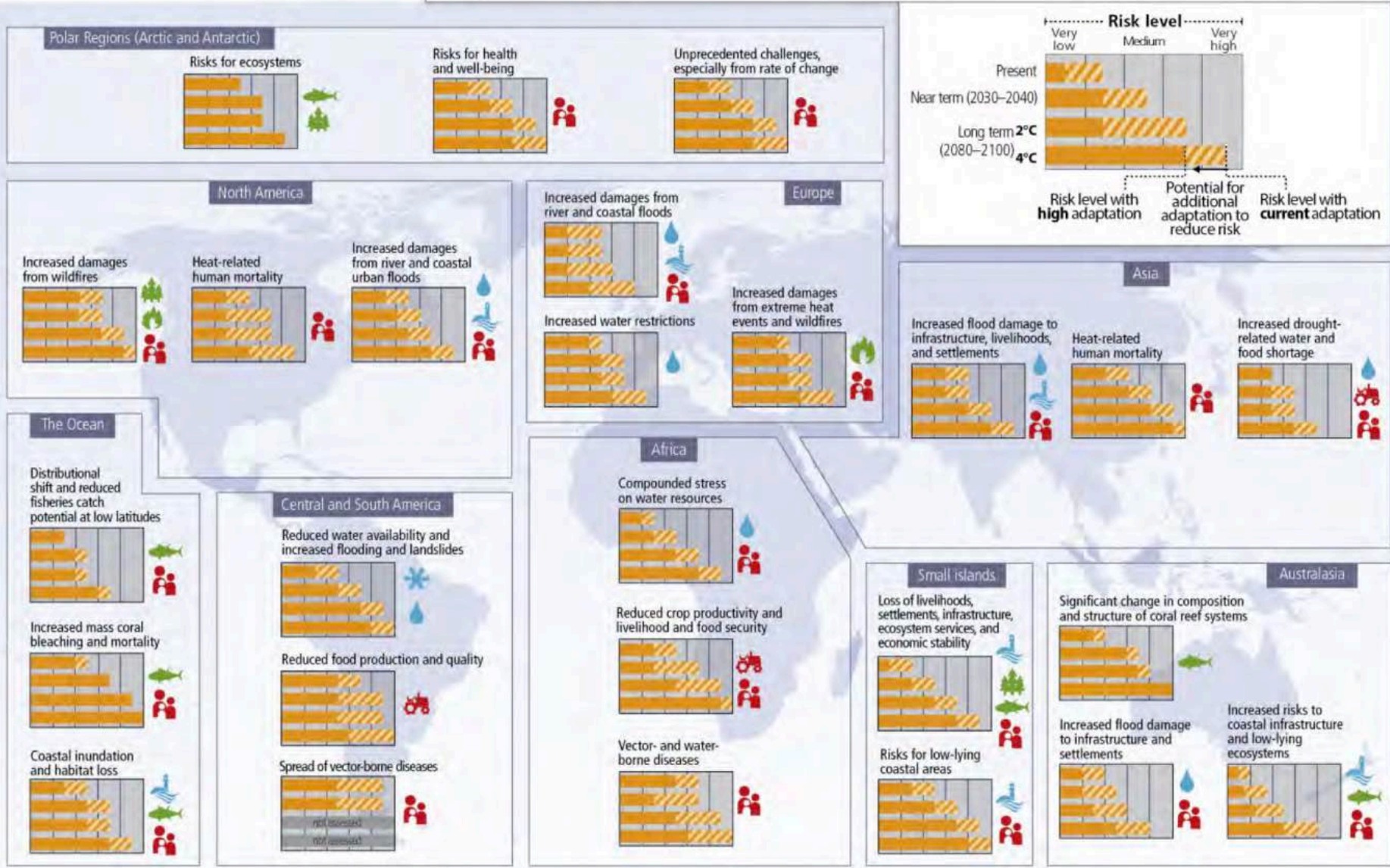
Representative key risks for each region for





# Regional key risks and potential for risk reduction

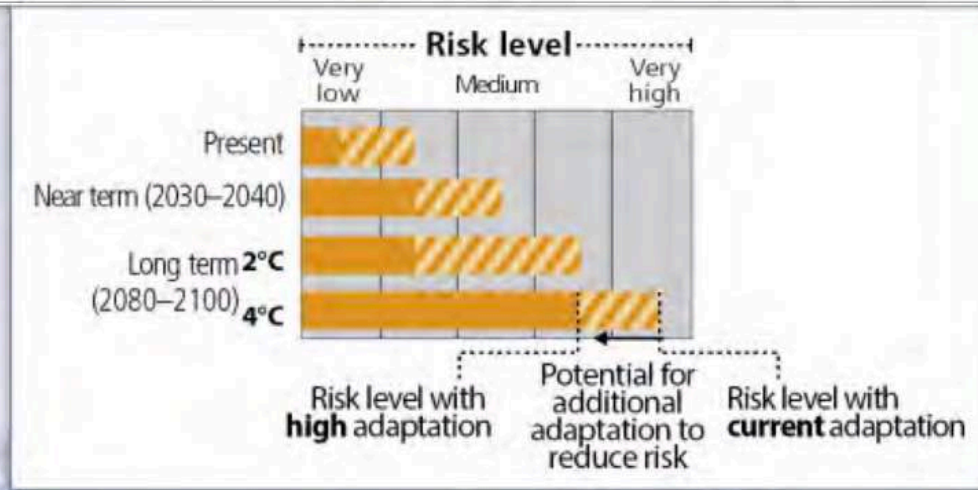
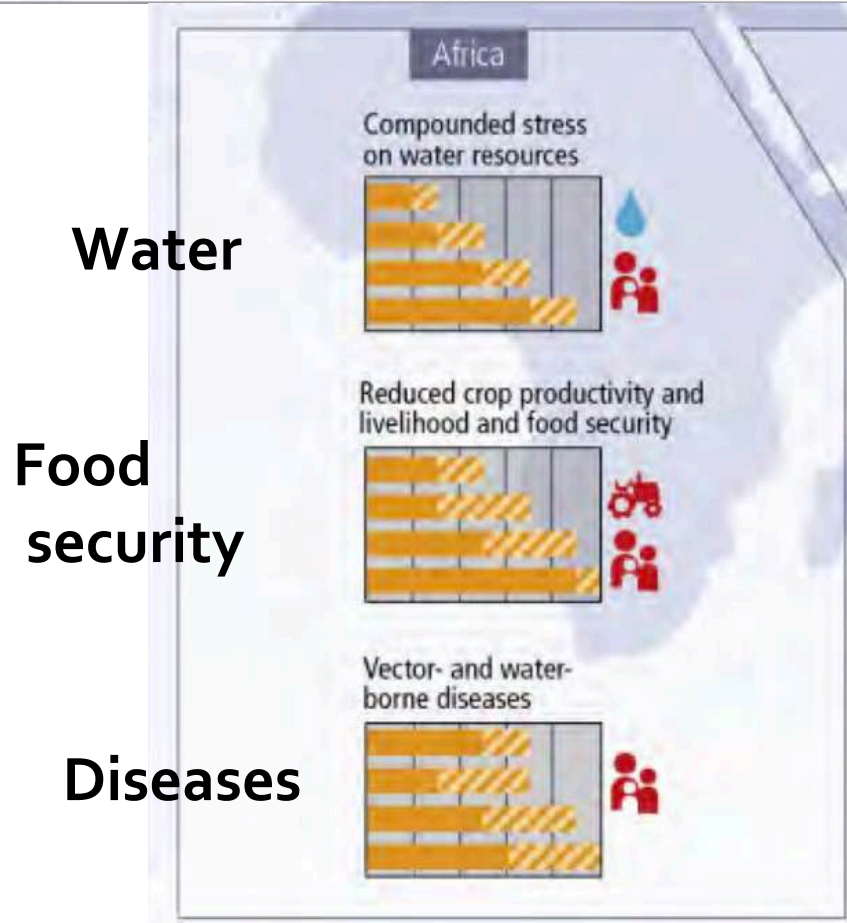
## Representative key risks for each region for



IPCC, AR5, SPM, Figure SPM.8










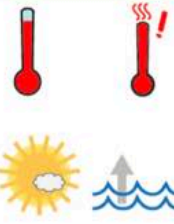












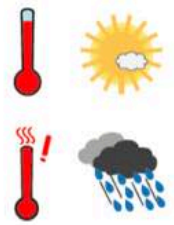

























# Regional key risks and risk reduction through adaptation: Africa

Representative key risks for each region for





# Selected key risks and potential for adaptation for Africa the present day to the long term

Climate-related drivers of impacts								Level of risk & potential for adaptation																
 Warming trend	 Extreme temperature	 Drying trend	 Extreme precipitation	 Damaging cyclone	 Sea level	 Ocean acidification	 Sea surface temperature	 <p>Potential for additional adaptation to reduce risk</p> <p>Risk level with <b>high</b> adaptation      Risk level with <b>current</b> adaptation</p>																
Key risk	Adaptation issues & prospects			Climatic drivers	Timeframe	Risk & potential for adaptation																		
<p>Compounded stress on water resources facing significant strain from overexploitation and degradation at present and increased demand in the future, with drought stress exacerbated in drought-prone regions of Africa (<i>high confidence</i>)</p> <p>[22.3-4]</p>	<ul style="list-style-type: none"> <li>Reducing non-climate stressors on water resources</li> <li>Strengthening institutional capacities for demand management, groundwater assessment, integrated water-wastewater planning, and integrated land and water governance</li> <li>Sustainable urban development</li> </ul>				<table border="1"> <tr> <td></td> <td>Very low</td> <td>Medium</td> <td>Very high</td> </tr> <tr> <td>Present</td> <td colspan="3"></td> </tr> <tr> <td>Near-term (2030-2040)</td> <td colspan="3"></td> </tr> <tr> <td rowspan="2">Long-term (2080-2100)</td> <td>2°C</td> <td colspan="2"></td> </tr> <tr> <td>4°C</td> <td colspan="2"></td> </tr> </table>		Very low	Medium	Very high	Present				Near-term (2030-2040)				Long-term (2080-2100)	2°C			4°C		
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	4°C																							
<p>Reduced crop productivity associated with heat and drought stress, with strong adverse effects on regional, national, and household livelihood and food security, also given increased pest and disease damage and flood impacts on food system infrastructure (<i>high confidence</i>)</p> <p>[22.3-4]</p>	<ul style="list-style-type: none"> <li>Technological adaptation responses (e.g., stress-tolerant crop varieties, irrigation, enhanced observation systems)</li> <li>Enhancing smallholder access to credit and other critical production resources; Diversifying livelihoods</li> <li>Strengthening institutions at local, national, and regional levels to support agriculture (including early warning systems) and gender-oriented policy</li> <li>Agronomic adaptation responses (e.g., agroforestry, conservation agriculture)</li> </ul>				<table border="1"> <tr> <td></td> <td>Very low</td> <td>Medium</td> <td>Very high</td> </tr> <tr> <td>Present</td> <td colspan="3"></td> </tr> <tr> <td>Near-term (2030-2040)</td> <td colspan="3"></td> </tr> <tr> <td rowspan="2">Long-term (2080-2100)</td> <td>2°C</td> <td colspan="2"></td> </tr> <tr> <td>4°C</td> <td colspan="2"></td> </tr> </table>		Very low	Medium	Very high	Present				Near-term (2030-2040)				Long-term (2080-2100)	2°C			4°C		
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	4°C																							
<p>Changes in the incidence and geographic range of vector- and water-borne diseases due to changes in the mean and variability of temperature and precipitation, particularly along the edges of their distribution (<i>medium confidence</i>)</p> <p>[22.3]</p>	<ul style="list-style-type: none"> <li>Achieving development goals, particularly improved access to safe water and improved sanitation, and enhancement of public health functions such as surveillance</li> <li>Vulnerability mapping and early warning systems</li> <li>Coordination across sectors</li> <li>Sustainable urban development</li> </ul>				<table border="1"> <tr> <td></td> <td>Very low</td> <td>Medium</td> <td>Very high</td> </tr> <tr> <td>Present</td> <td colspan="3"></td> </tr> <tr> <td>Near-term (2030-2040)</td> <td colspan="3"></td> </tr> <tr> <td rowspan="2">Long-term (2080-2100)</td> <td>2°C</td> <td colspan="2"></td> </tr> <tr> <td>4°C</td> <td colspan="2"></td> </tr> </table>		Very low	Medium	Very high	Present				Near-term (2030-2040)				Long-term (2080-2100)	2°C			4°C		
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# Regional key risks and potential for risk reduction: Asia (IPCC, AR5, SPM, Figure SPM.8)

Representative key risks for each region for

## Physical Systems

Glaciers, snow, ice and/or permafrost

Rivers, lakes, floods and/or drought

Coastal erosion and/or sea level effects

## Biological Systems

Terrestrial ecosystems

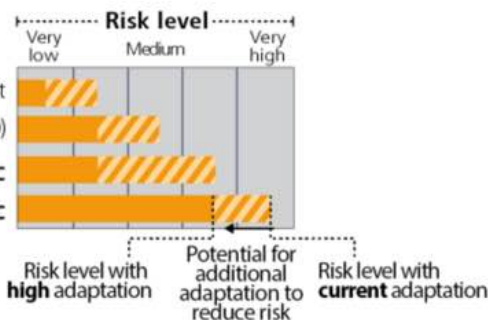
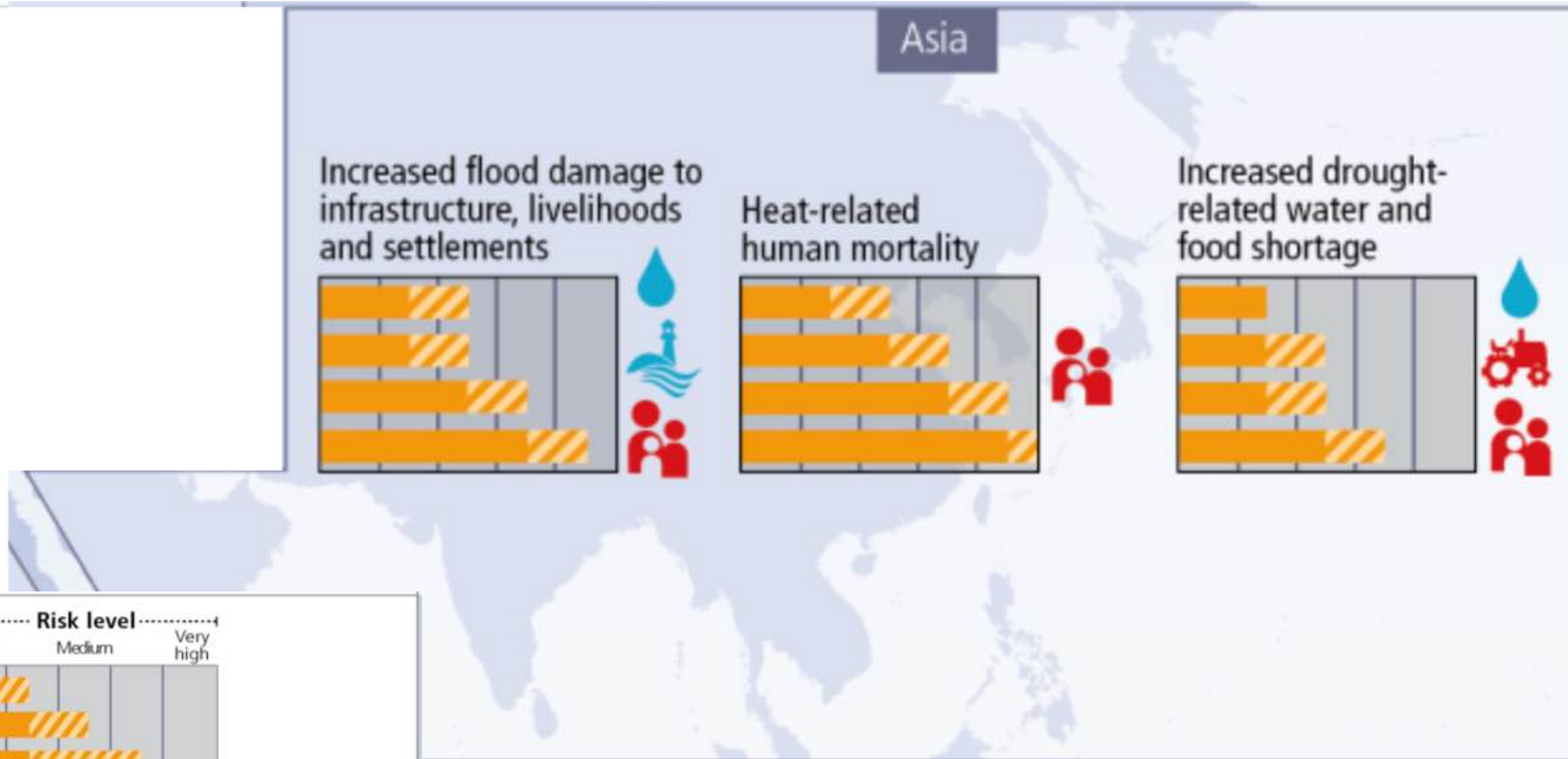
Wildfire

Marine ecosystems

## Human & Managed Systems

Food production

Livelihoods, health and/or economics





# Key Risk for Asia

Increased risk of drought-related water and food shortage causing malnutrition  
(*high confidence*)



Climatic drivers	Timeframe	Risk & potential for adaptation		
		Very low	Medium	Very high
	Present	[Bar chart showing low risk]		
	Near term (2030–2040)	[Bar chart showing increasing risk]		
	Long term 2°C (2080–2100) 4°C	[Bar chart showing high risk]		

Climate-related drivers of impacts									
Warming trend	Extreme temperature	Drying trend	Extreme precipitation	Precipitation	Snow cover	Damaging cyclone	Sea level	Ocean acidification	Carbon dioxide fertilization

# Adaptation issues and prospects

- 1. Disaster preparedness including early-warning systems and local coping strategies**
- 2. Adaptive/integrated water resource management**
- 3. Water infrastructure and reservoir development**
- 4. Diversification of water sources including water re-use**
- 5. More efficient use of water (e.g., improved agricultural practices, irrigation management, and resilient agriculture)**

**ipcc**

INTERGOVERNMENTAL PANEL ON climate change



# Adaptation issues and prospects:

## Water

### Reducing non-climate stressors on water resources

Demand management and conservation are methods that target **efficiency**.

Conservation begins by **reducing high losses from water supply** distribution systems. Demand



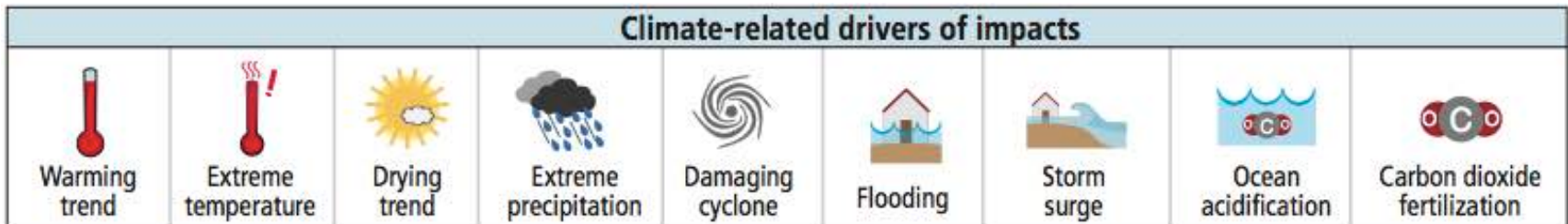
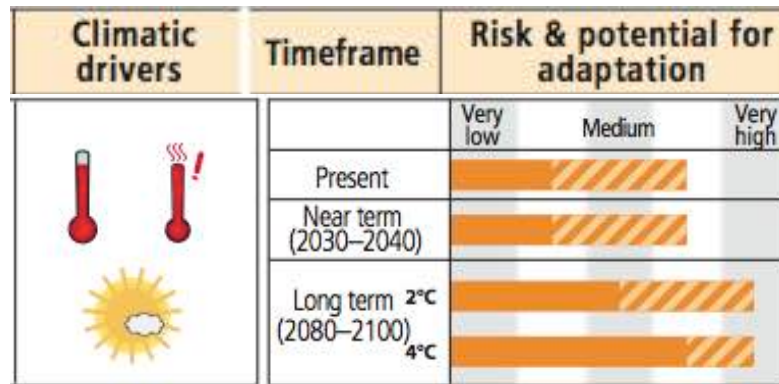
management has gone largely unaddressed since most water utilities still focus on infrastructure development rather than on conservation.

<http://www.greenfacts.org/en/water-resources/l-3/6-sustainable-management.htm#2p0>



# Key risk

**Reduced access to water for rural and urban poor people due to water scarcity and increasing competition for water (high confidence)**



# Adaptation issues and prospects

**Adaptation through reducing water use is not an option for the many people already lacking adequate access to safe water. Access to water is subject to various forms of discrimination, for instance due to gender and location. Poor and marginalized water users are unable to compete with water extraction by industries, large-scale agriculture, and other powerful users**

# Qori Kalis Glacier (Peru): July 1978



Source: Dr. Lonnie Thompson (OSU),  
via <http://climate.nasa.gov/images-of-change#543-melting-qori-kalis-glacier-peru>



# Qori Kalis Glacier (Peru): July 2011

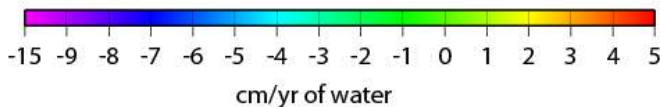
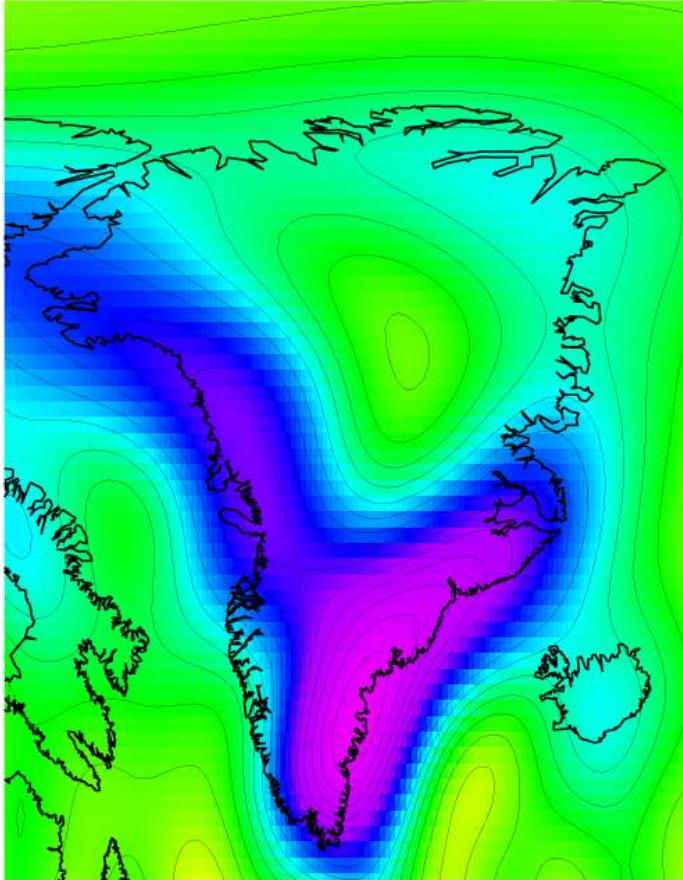


Source: Dr. Lonnie Thompson (OSU),  
via <http://climate.nasa.gov/images-of-change#543-melting-qori-kalis-glacier-peru>

# Greenland Ice Mass Loss 2002-2009

## Derived From NASA GRACE Gravity Mission

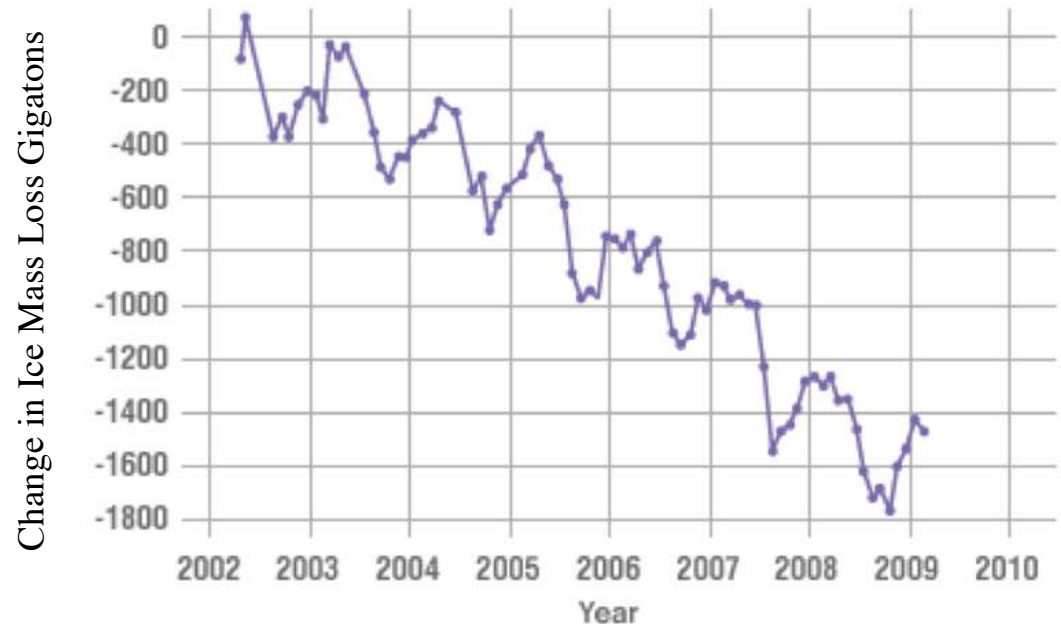
### Greenland



J. Wahr, U. Colorado

### GREENLAND MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.



Velicogna, Geophysical Research Letters, 2009

•Contributes to sea level rise



# 18-20000 years ago (Last Glacial Maximum)

With permission from Dr. S. Jousaume, in « Climat d'hier à demain », CNRS éditions.



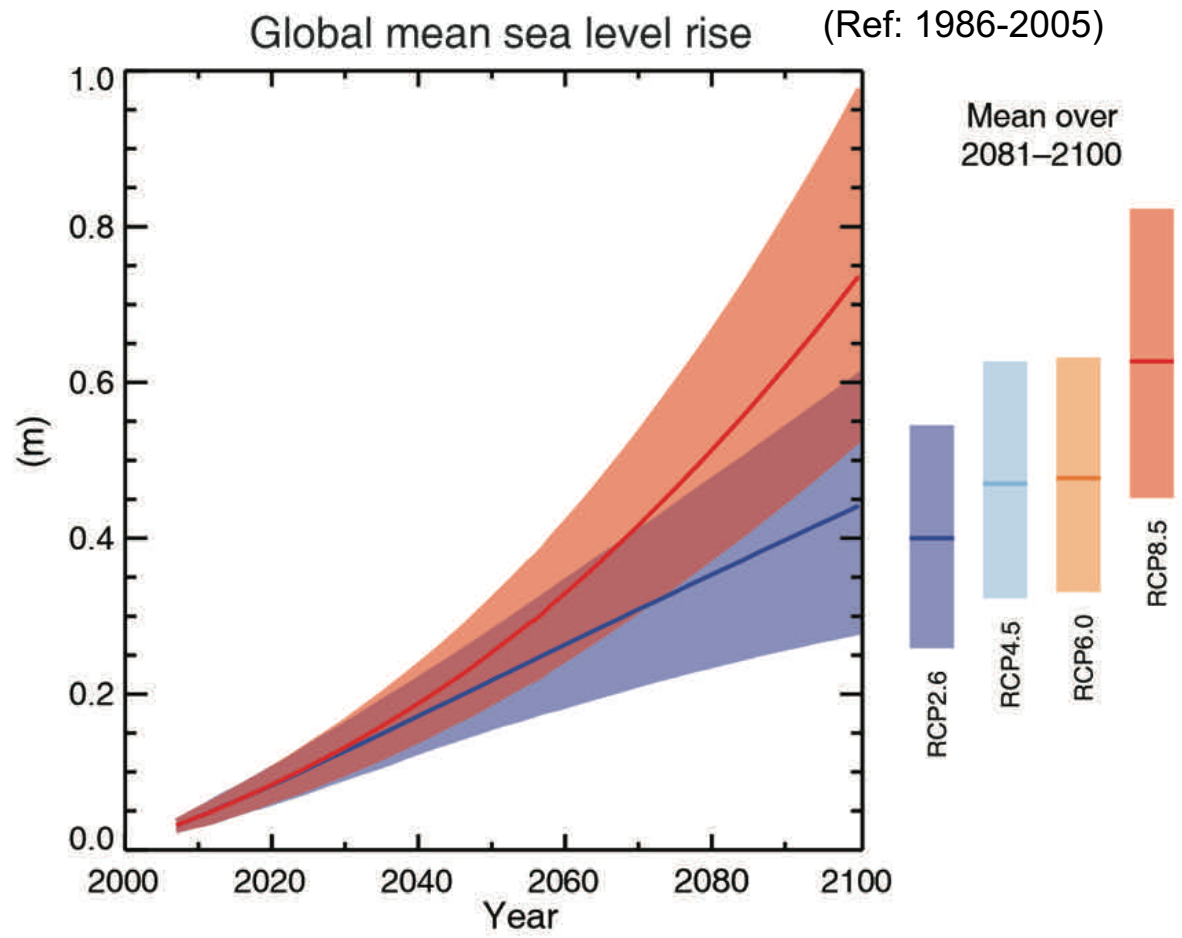


# Today, with +4-5° C globally

With permission from Dr. S. Joussaume, in « Climat d'hier à demain », CNRS éditions.



Sea level: +120m



(IPCC 2013, Fig. SPM.9)

Sea level due to continue to increase

# Effects on the Nile Delta, where more than 10 million people live at less than 1 metre above sea level



(Time 2001)



# In front of Ministry of Foreign Affairs, Maldives, Aug. 2015



دولت اسلامی افغانستان  
وزارت امور خارجہ

MINISTRY OF FOREIGN AFFAIRS



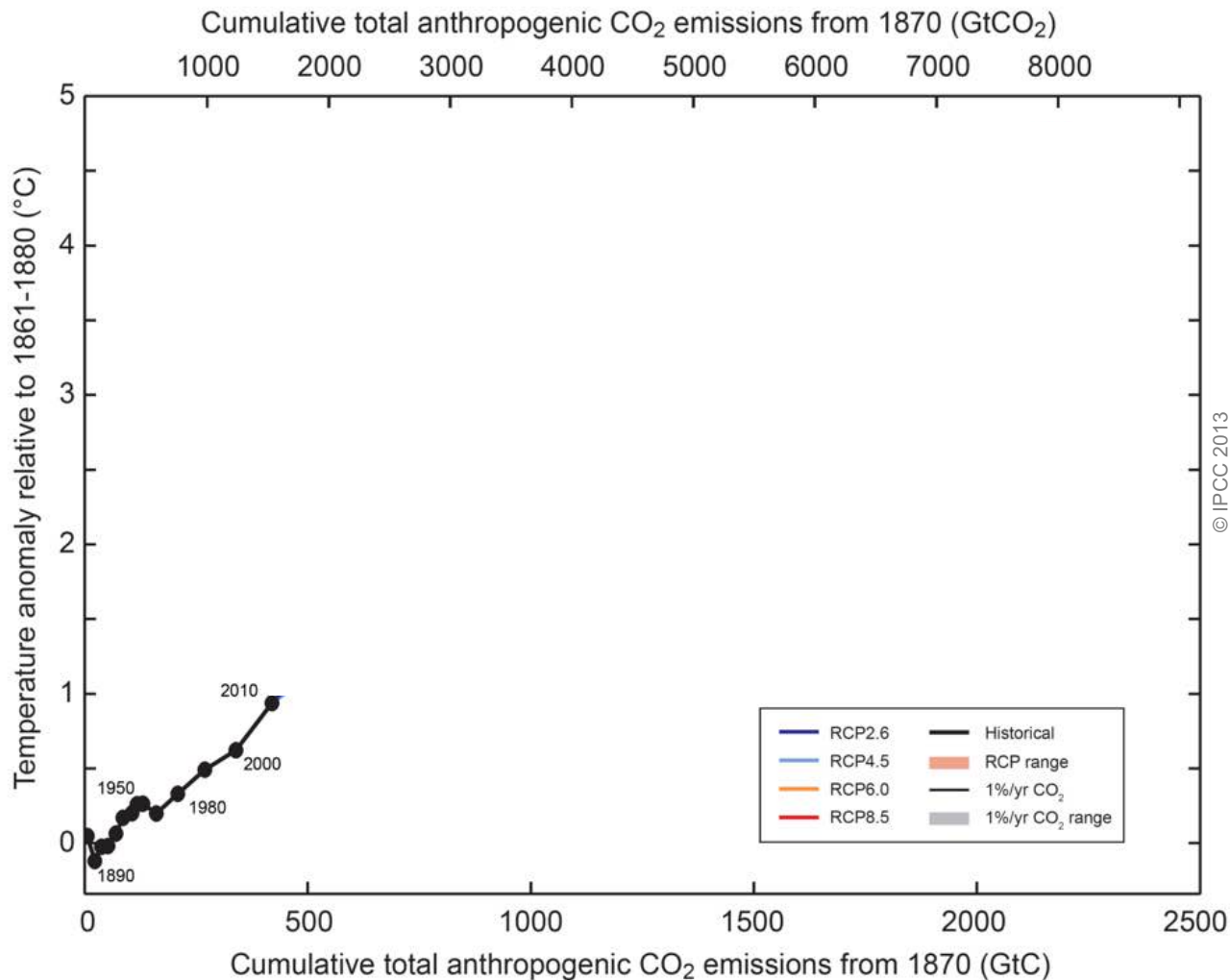
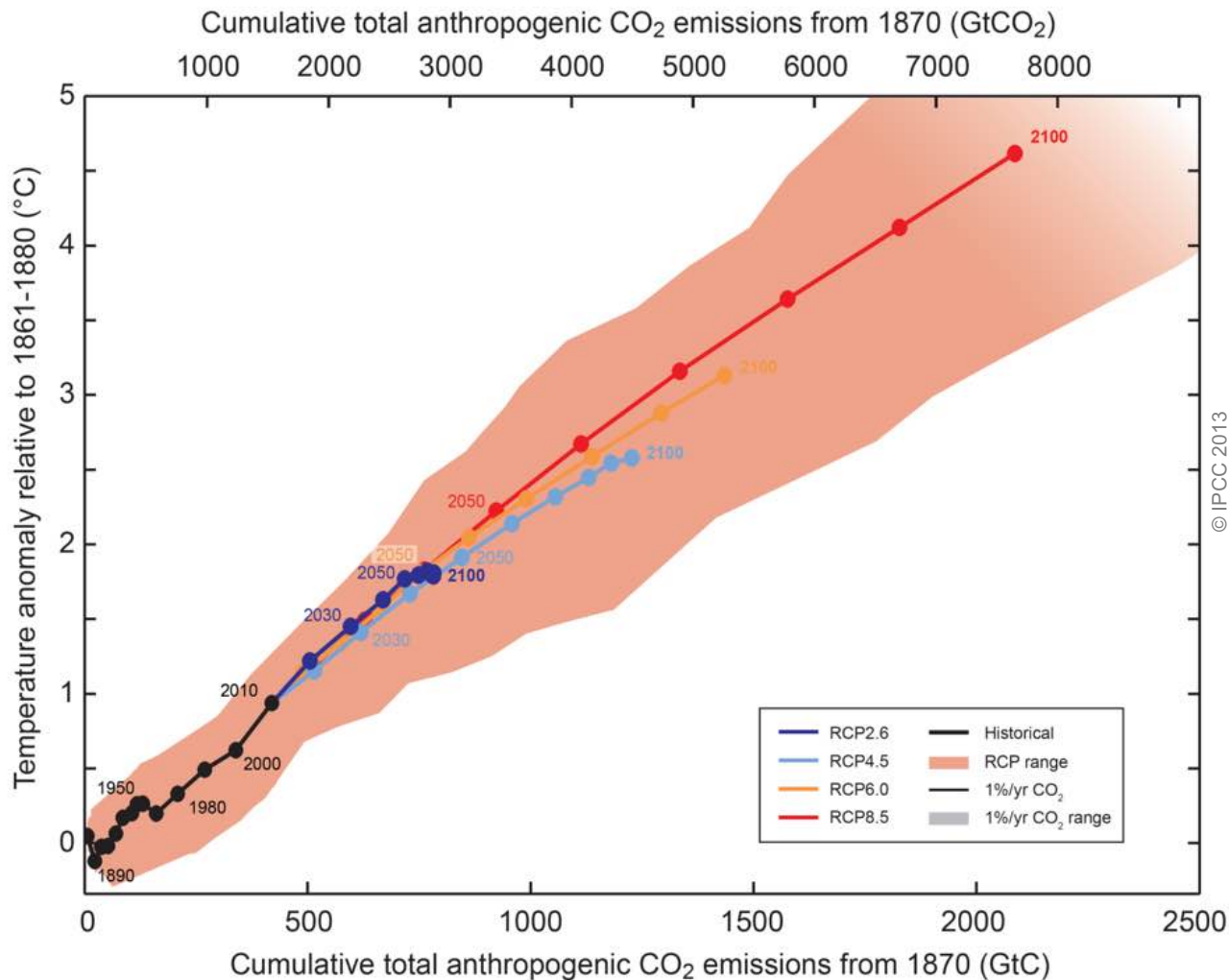


Fig. SPM.10

Cumulative emissions of CO<sub>2</sub> largely determine global mean surface warming by the late 21st century and beyond.





© IPCC 2013

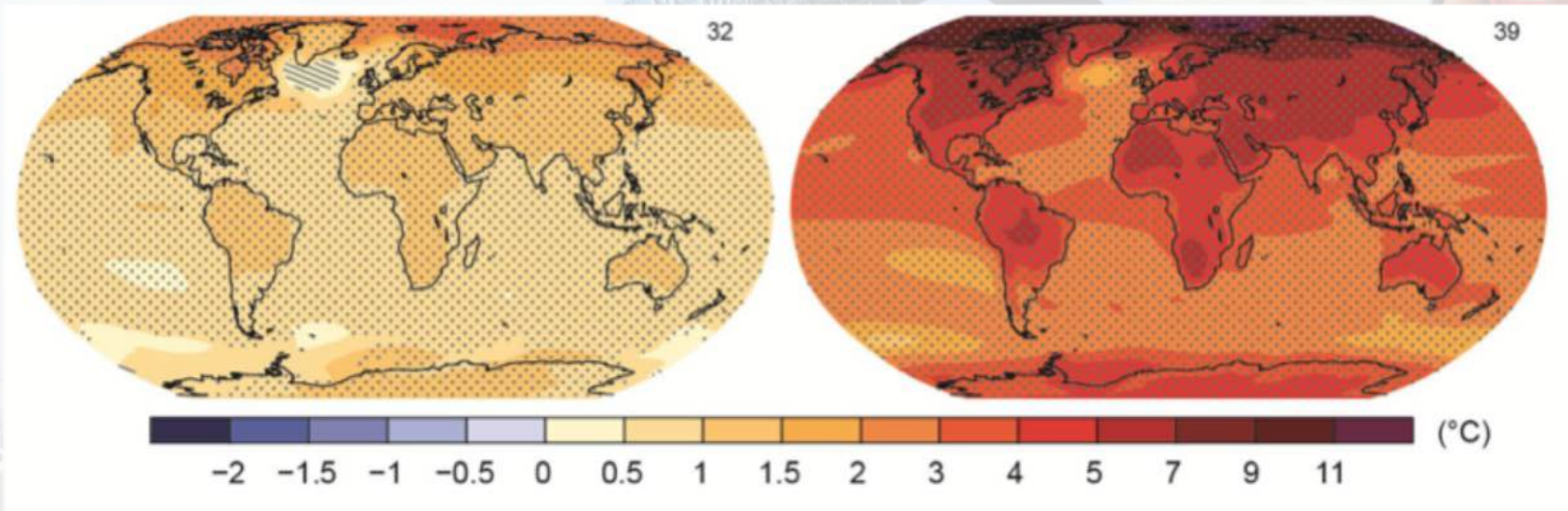
Fig. SPM.10

Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

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

With substantial mitigation

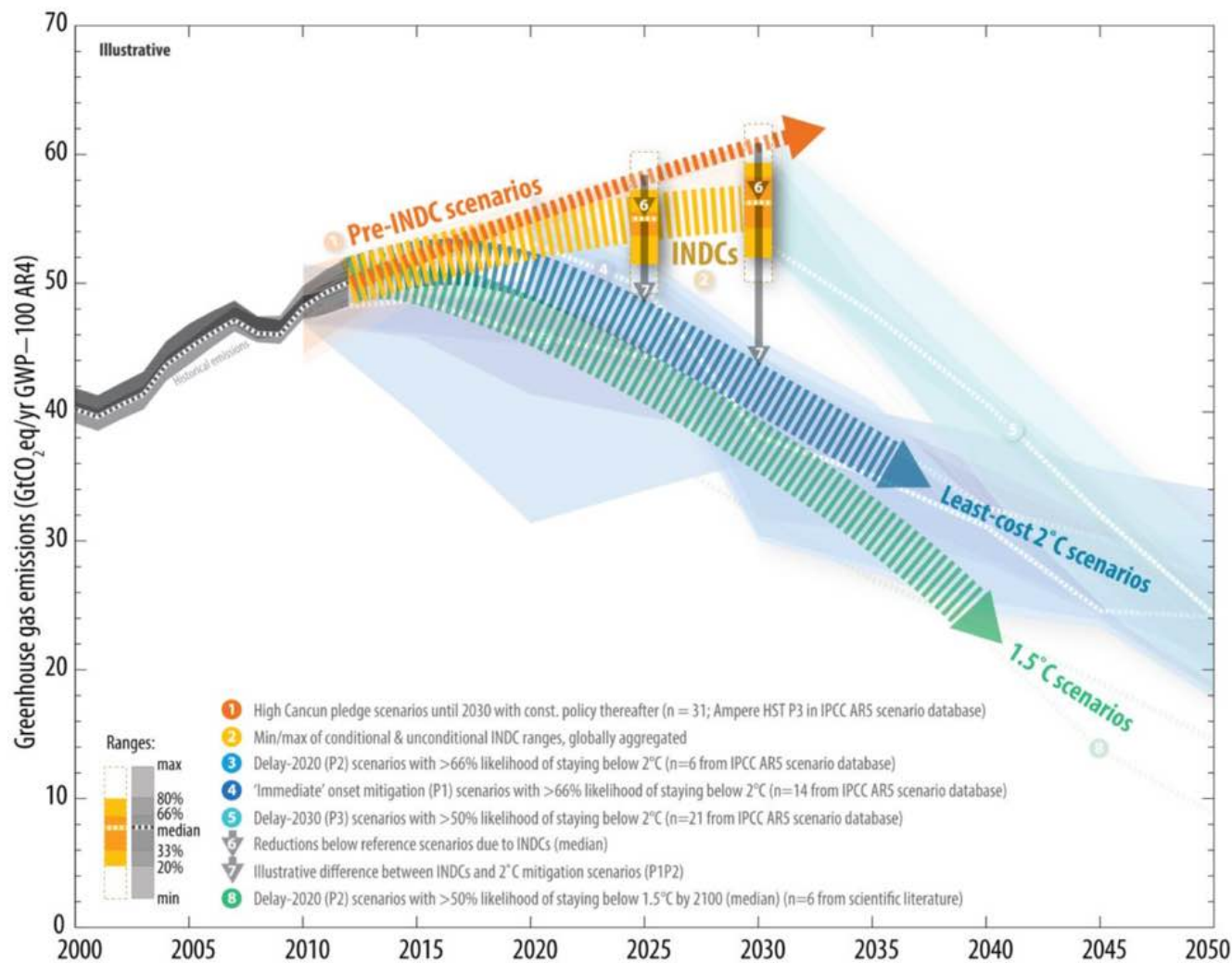
Without additional mitigation



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

AR5 WGI SPM

# 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>



# Conclusions

**Water, essential to life, is a key sector affected by climate change (threat multiplier)**

**Adaptation is key, and water needs to be much better shared and managed, but adaptation will not be sufficient at all**

**Stabilizing the temperature as close as possible to no more than 1.5°C above the pre-industrial is essential, and requires to move away quickly from fossil fuels, and to stop deforestation**

**The challenge is huge: transform the world in a few decades so that the whole world activities are decarbonized, while poverty and hunger are eliminated**

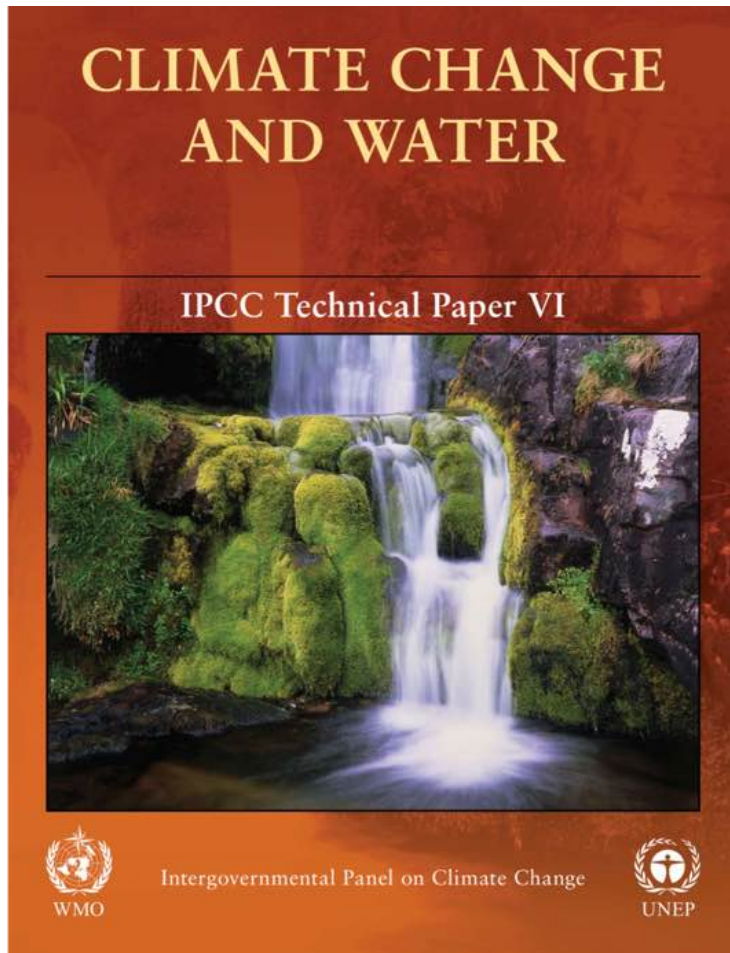
**Addressing this challenge opens so many opportunities, including opportunities to address in a synergistic manner other societal goals, such as the 17 Sustainable Development Goals.**



# SUSTAINABLE DEVELOPMENT GOALS



# From the IPCC



- Old (2008), but still an interesting summary of water – climate change issues. Available on [www.ipcc.ch](http://www.ipcc.ch)



Please go and see the  
latest movie with Al Gore

# An Inconvenient Sequel: Truth to Power

FIGHT LIKE YOUR WORLD DEPENDS ON IT

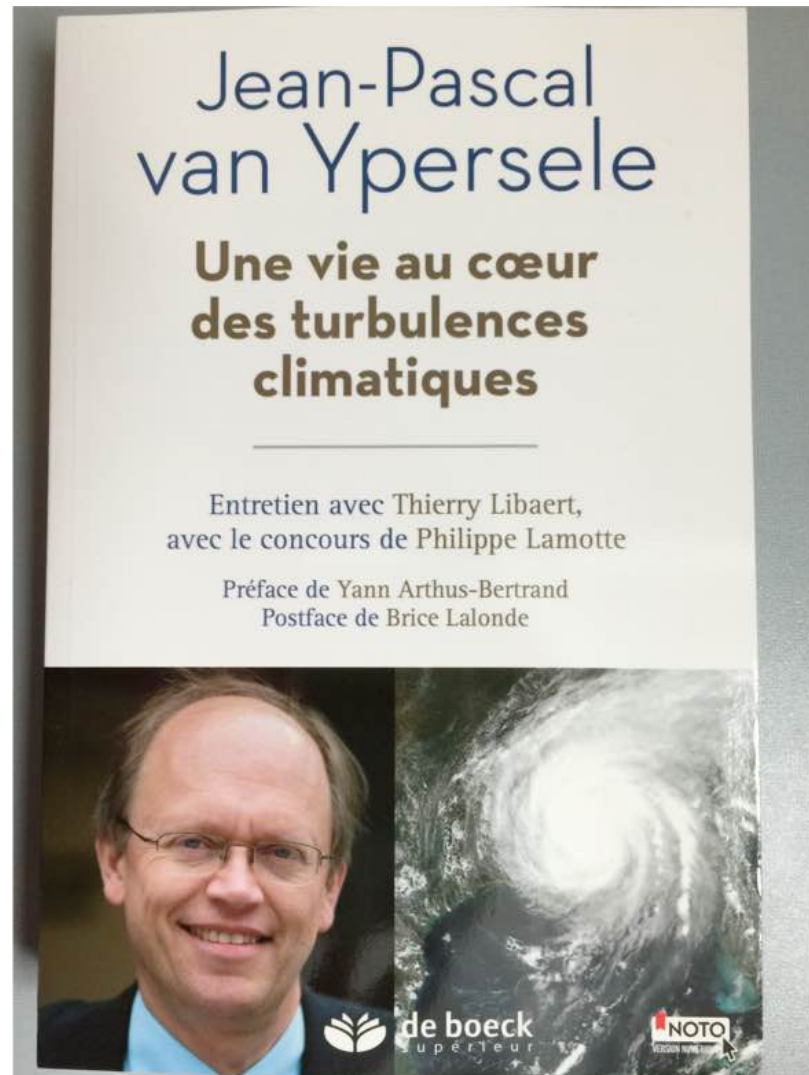


an **inconvenient** sequel  
**TRUTH TO POWER**

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**IN THEATRES JULY 28**

**Publié chez De Boeck  
supérieur,  
octobre 2015**



# Useful links:



- [www.ipcc.ch](http://www.ipcc.ch) : IPCC (reports and videos)
- [www.unfccc.int](http://www.unfccc.int) : Climate Convention
- [www.climate.be/vanyp](http://www.climate.be/vanyp) : my slides and other documents
- [www.skepticalscience.com](http://www.skepticalscience.com): excellent responses to contrarians arguments
- [www.pplateforme-wallonne-giec.be](http://www.pplateforme-wallonne-giec.be) : Platform
- **On Twitter: @JPvanYpersele  
and @IPCC\_CH**

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