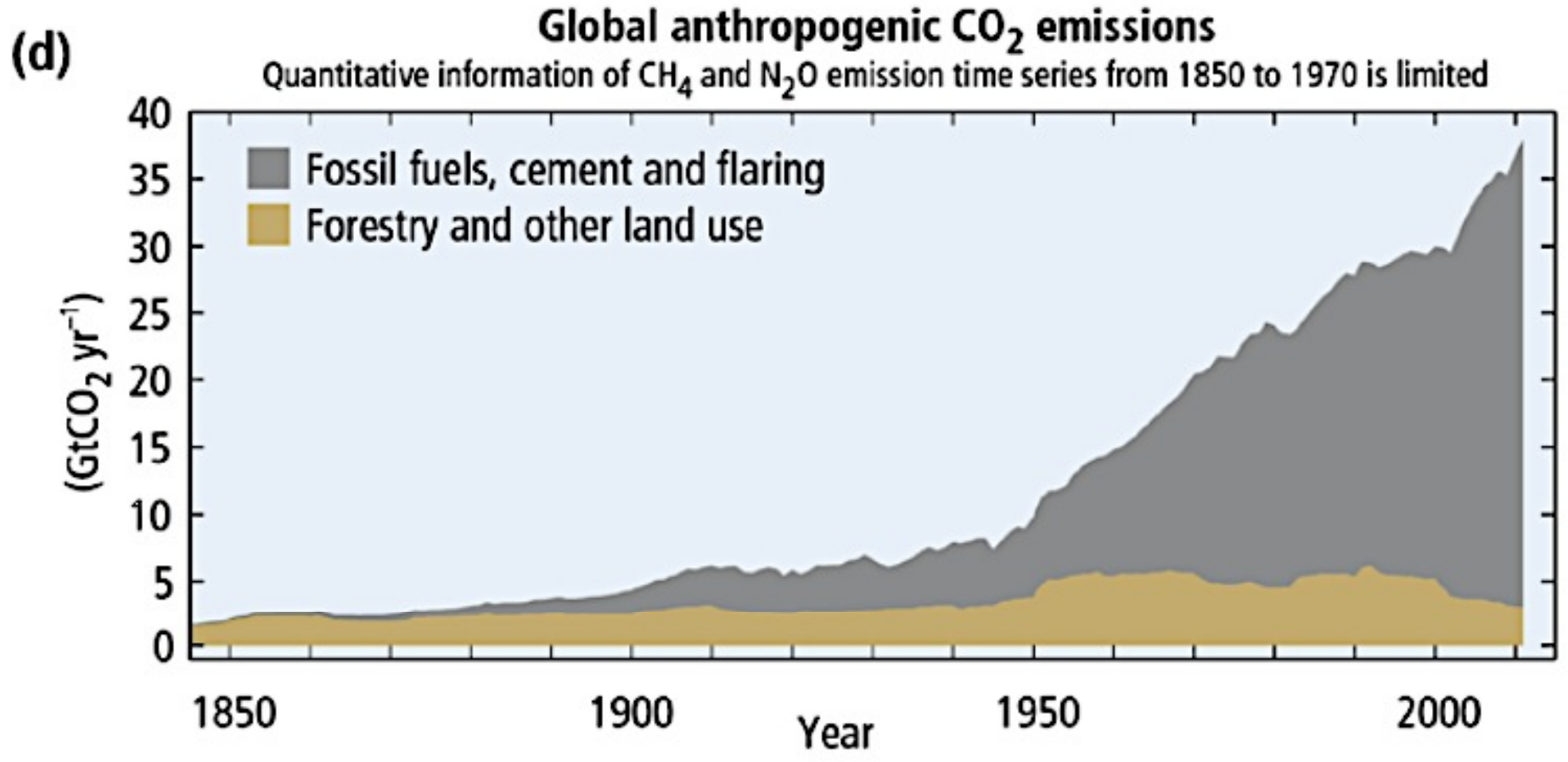
Science and impacts of climate change

1. Humans are causing climate change

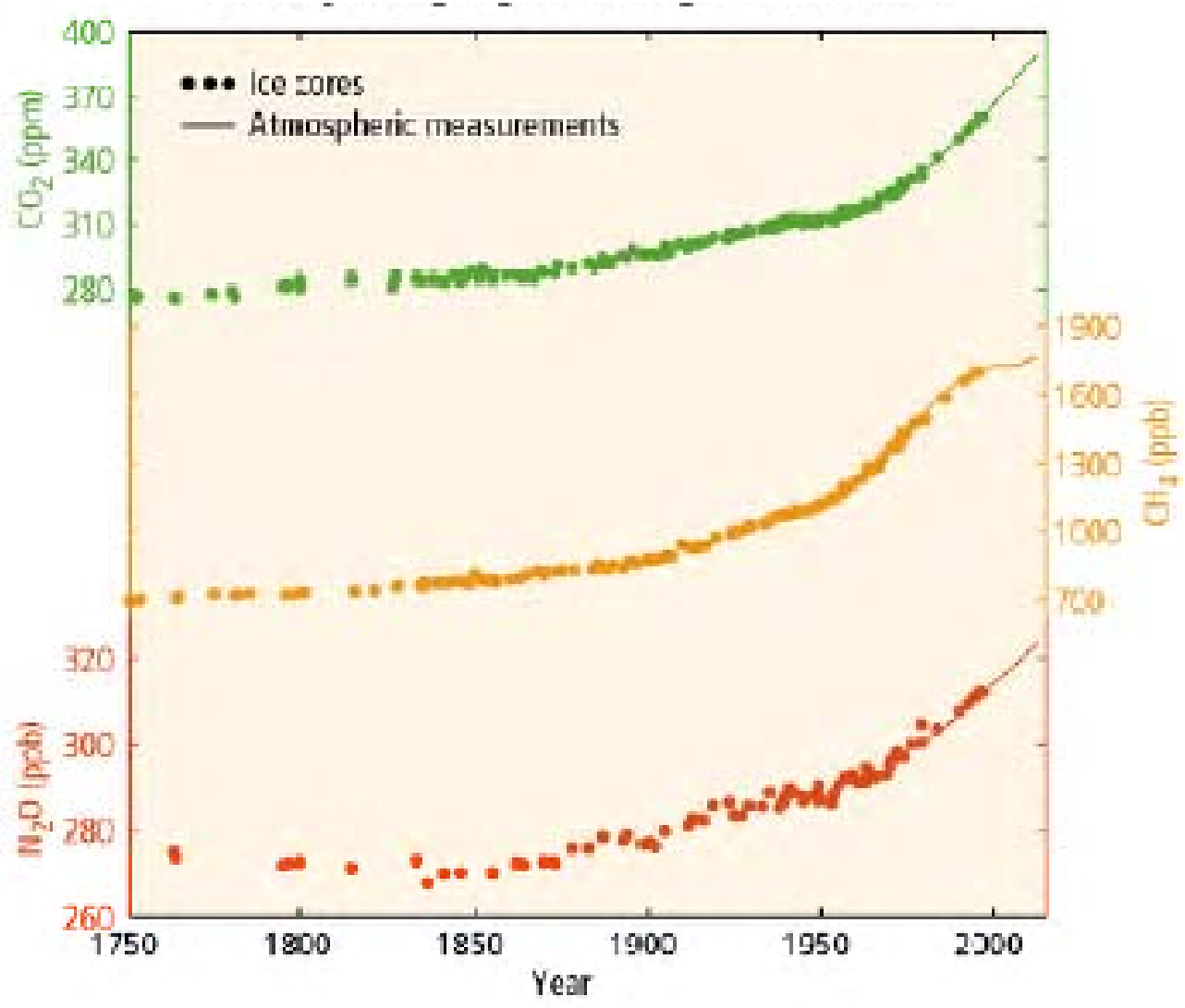
- Recent anthropogenic emissions of greenhouse gases are highest in history
- Atmospheric concentration of key greenhouse gases is “unprecedented” in at least the last 800,000 years,
- Warming of climate system is unequivocal

Increasing emissions: *1950 onwards*



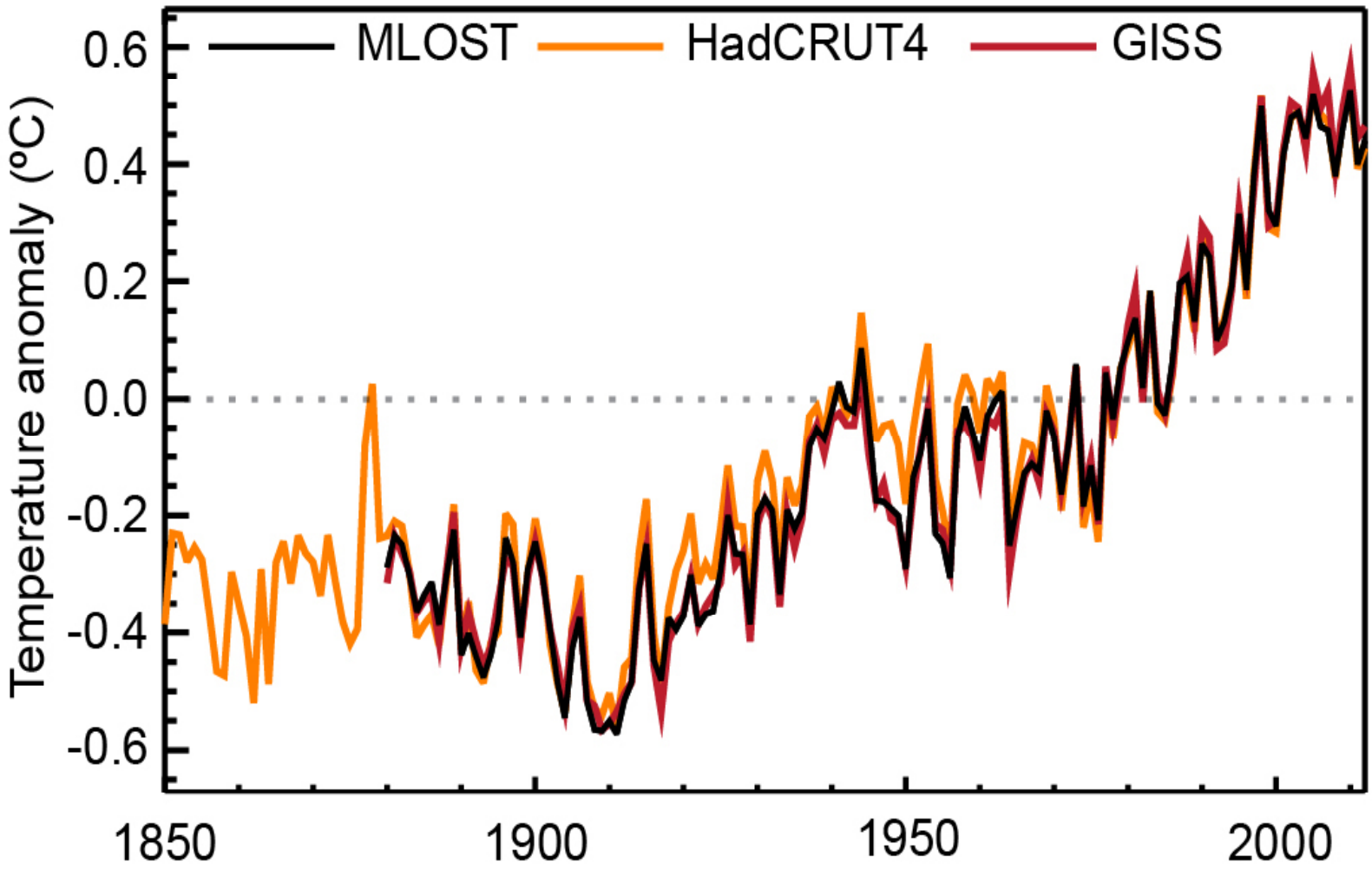
Rising concentration: *400 ppm*

CO_2 concentration in 2014



Since 1750, concentrations of CO_2, CH_4 and N_2O have increased by 40%, 150% and 20%, respectively

Temperature: *0.85^{O}C over 1880-2012; last 3 decades warmest*



2. Changes unprecedented

Since 1950s many of the observed changes are unprecedented over decades to millennia

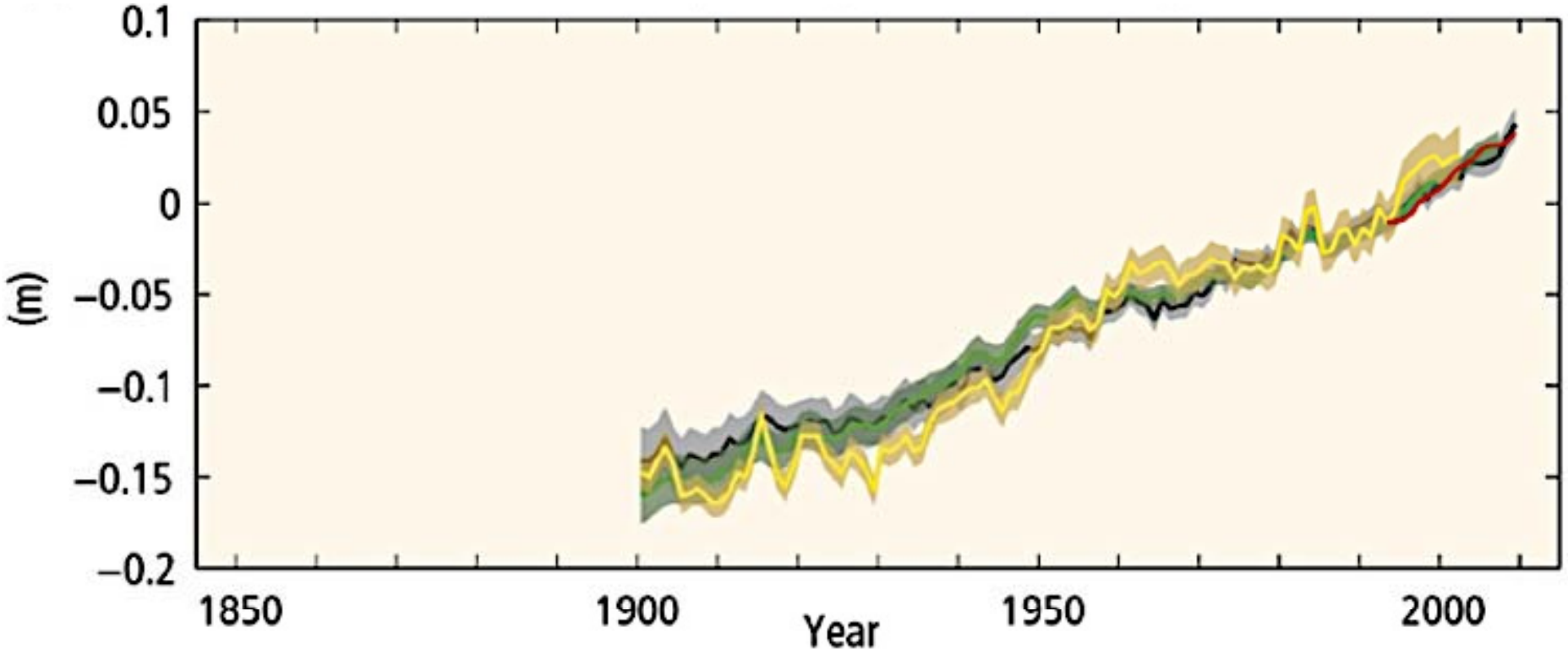
oOceans are acidifying and sea level is rising.

oArctic ice cover is shrinking.

oExtreme weather events are increasing in number and intensity.

oMany terrestrial, freshwater, and marine species have started to “adapt” (shifted their geographic ranges, seasonal activities, migration patterns etc.) in response to ongoing climate change

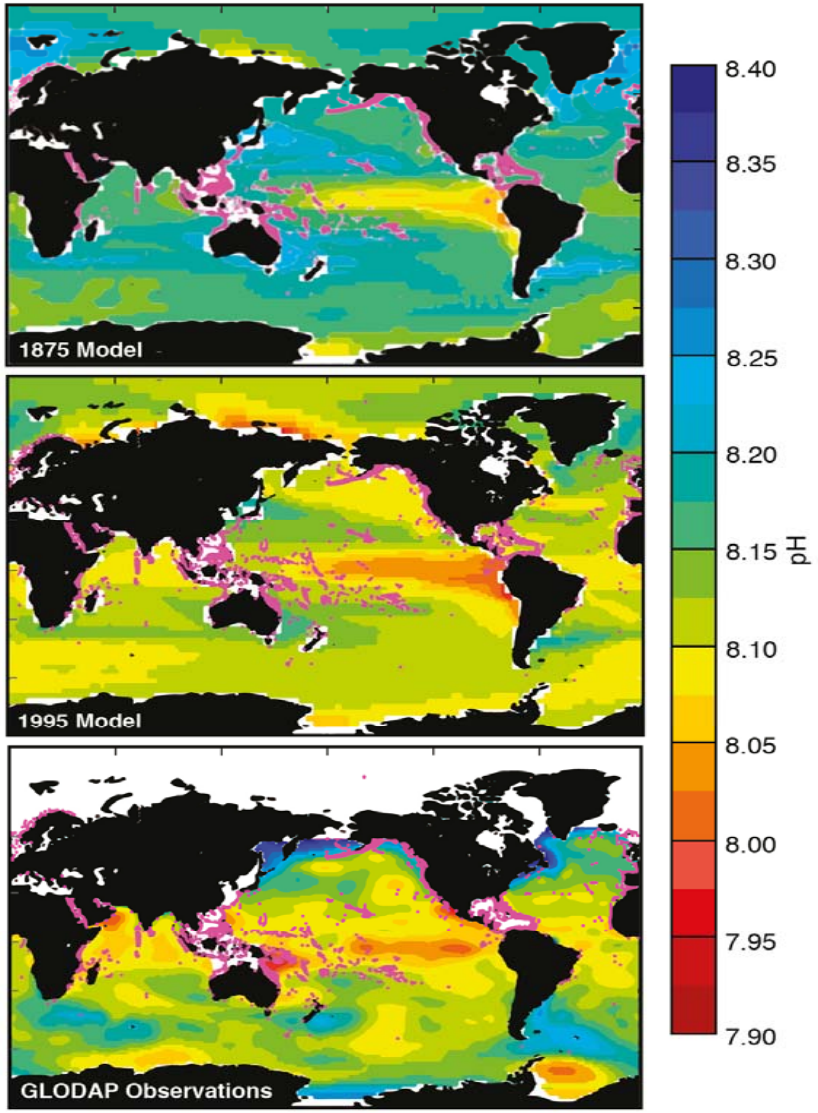
Sea level rise: *Over 1901–2010 by 0.19 m*



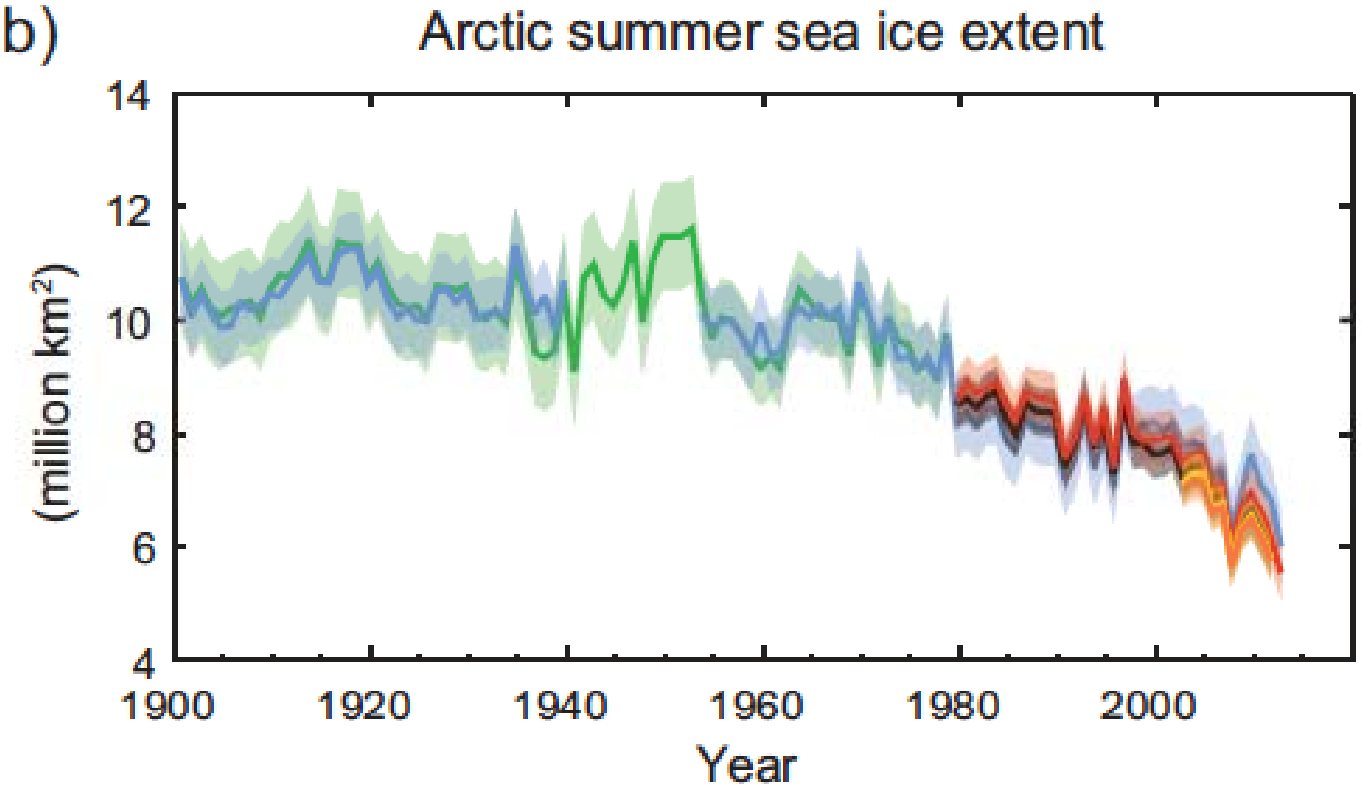
Global averaged sea-level rise was 1.7 mm/yr between 1901- 2010 and 3.2 mm/yr between 1993- 2010

Acidity of oceans is increasing

Since the industrial revolution, oceans have become 26 percent more acidic and their pH level is falling



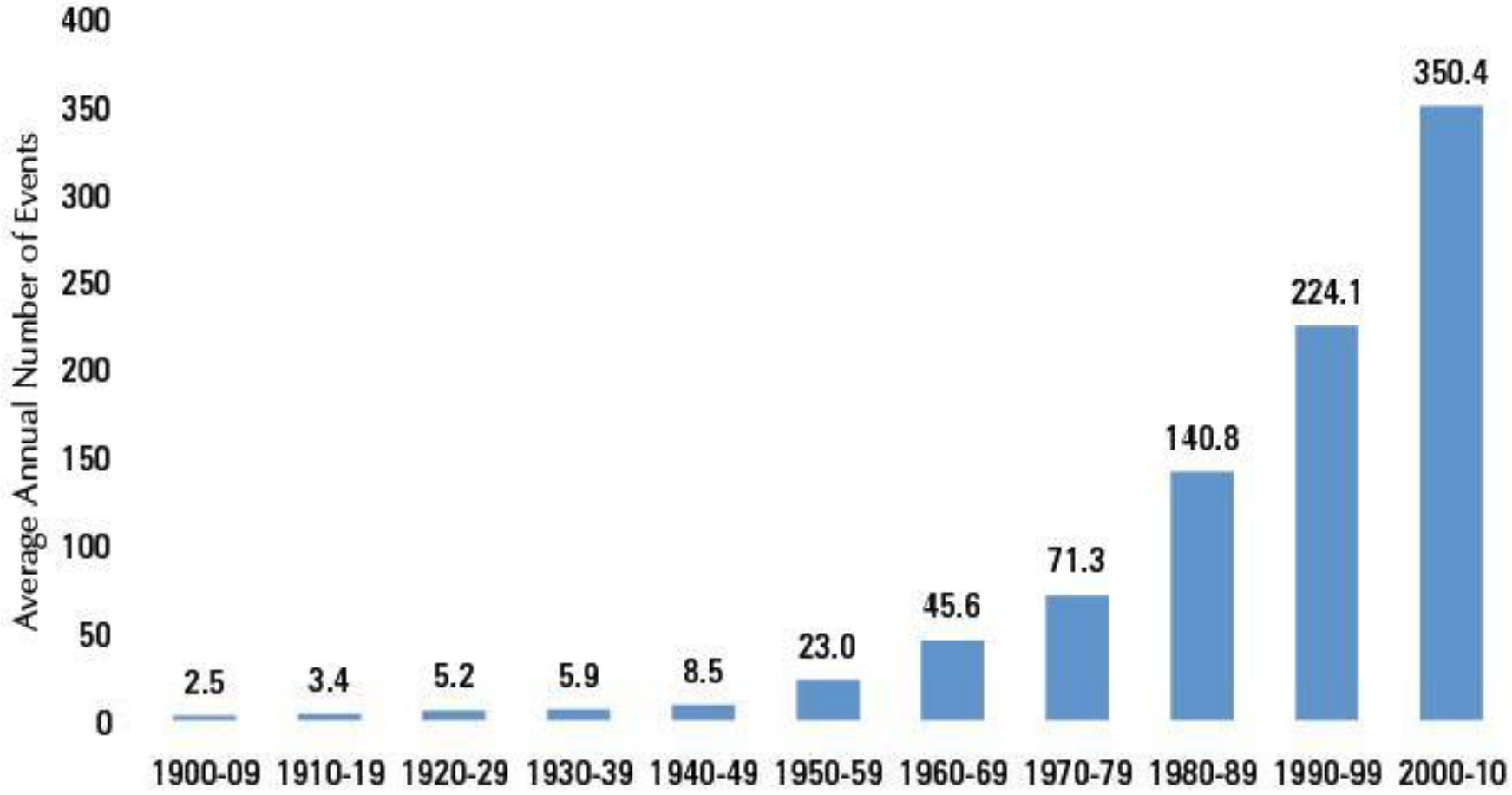
Shrinking Arctic Ice: *0.73-1.07 million km² per decade since 1979*



Greenland and Antarctic ice sheets have been losing mass. Glaciers have continued to shrink worldwide

Extreme weather events are increasing

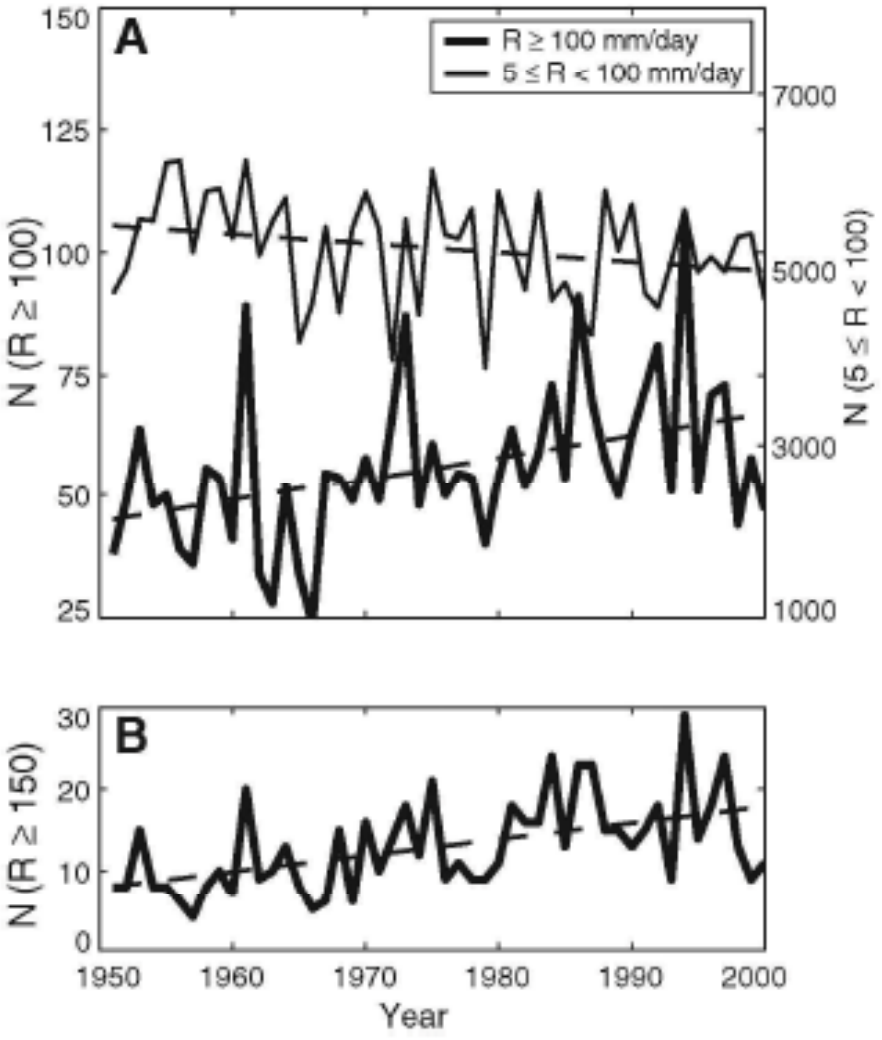
Figure 1: Average Number of Extreme Weather Events per Year by Decade, 1900–2010



India battered by extreme rainfall events

- 2005, 994 mm of rainfall in 24-hours in Mumbai. One of the highest ever recorded. 5000 dead
- 2010, “cloudburst” 150-250 mm of rainfall in 30 minutes in around Leh town (cold desert). 255 dead
- 2013 Uttarakhand, 340 mm in 24-hours; 850% more rain than normal in a week. 5700 dead
- 2014, Jammu & Kashmir, 200 mm in 24-hours. More than 300 dead

Increase in extreme rainfall events



Heavy rainfall events (> 100 mm/day) and very heavy events (>150 mm/day) are increasing and moderate events (5-100 mm/day) are decreasing.

Source: Goswami B N et.al, 2006

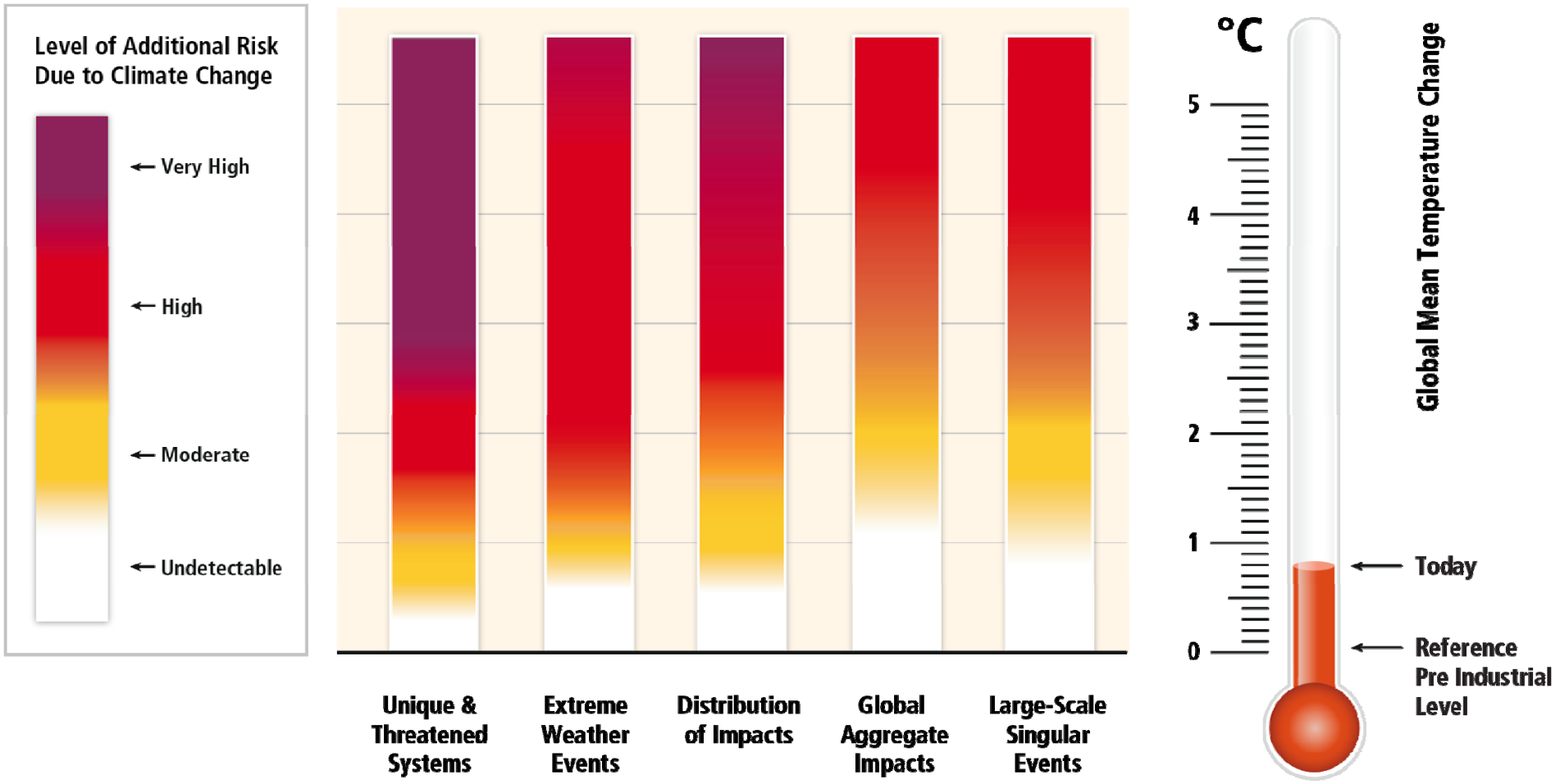
3. Poor countries and poor communities have suffered the most

- Climate change has started to erode “developmental” gains
- Between 2001 and 2006 low income countries lost about 0.3% GDP due to extreme events; developed nations lost only about 0.1%. Rapidly developing countries, India and China, lost about 1% of their GDP
- Climate change has already affected the hydrological systems and reduced crop yields

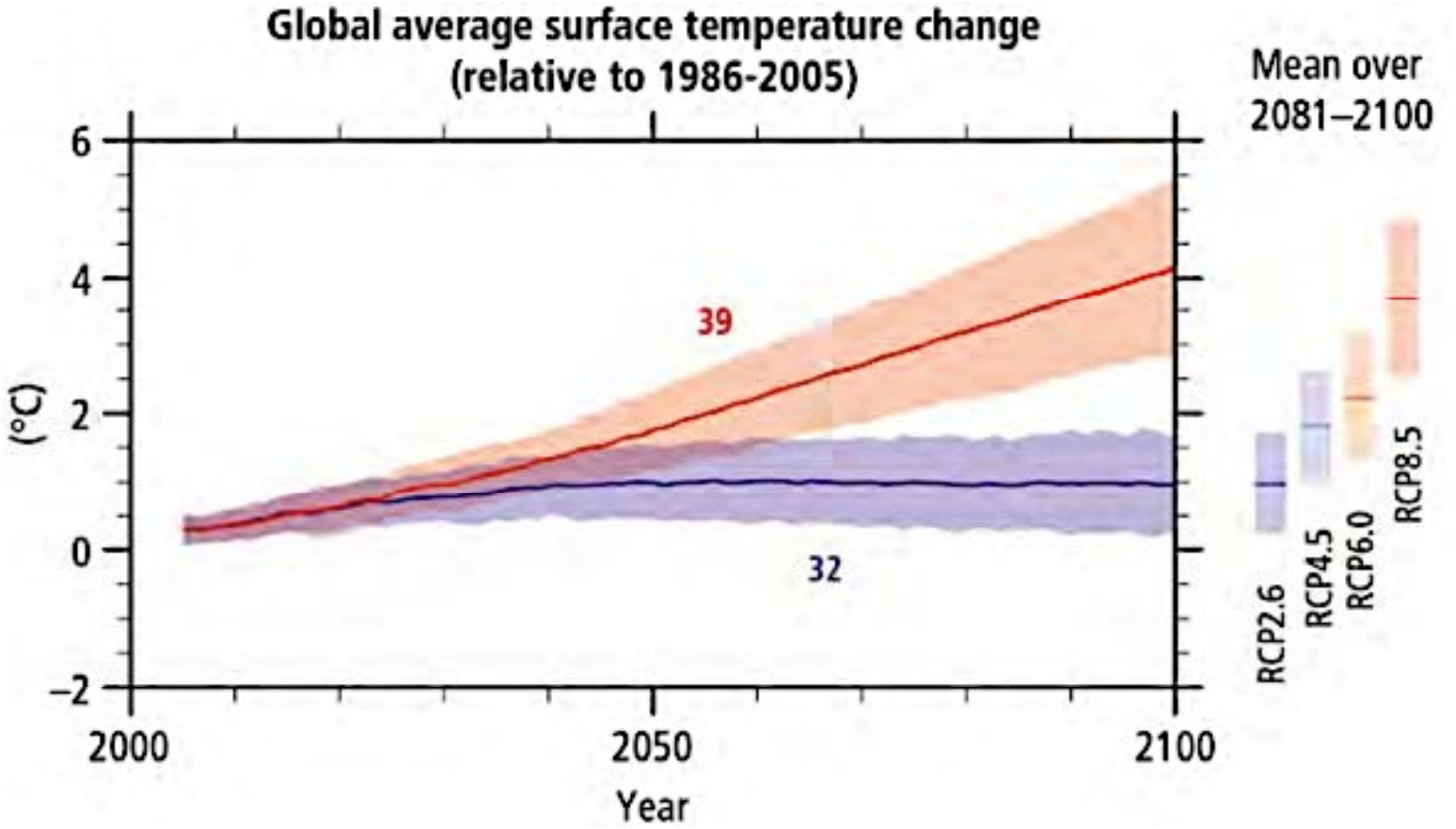
4. Impacts are going to get worse

- Surface temperature is projected to rise over the 21st century under all scenarios.
- Heat waves will occur more often and last longer
- Extreme precipitation events will become more intense and frequent in many regions.
- Ocean will continue to warm and acidify, and global mean sea level to rise.
- Increasing magnitudes of warming increase the likelihood of severe, pervasive, and irreversible impacts for people, species and ecosystems.

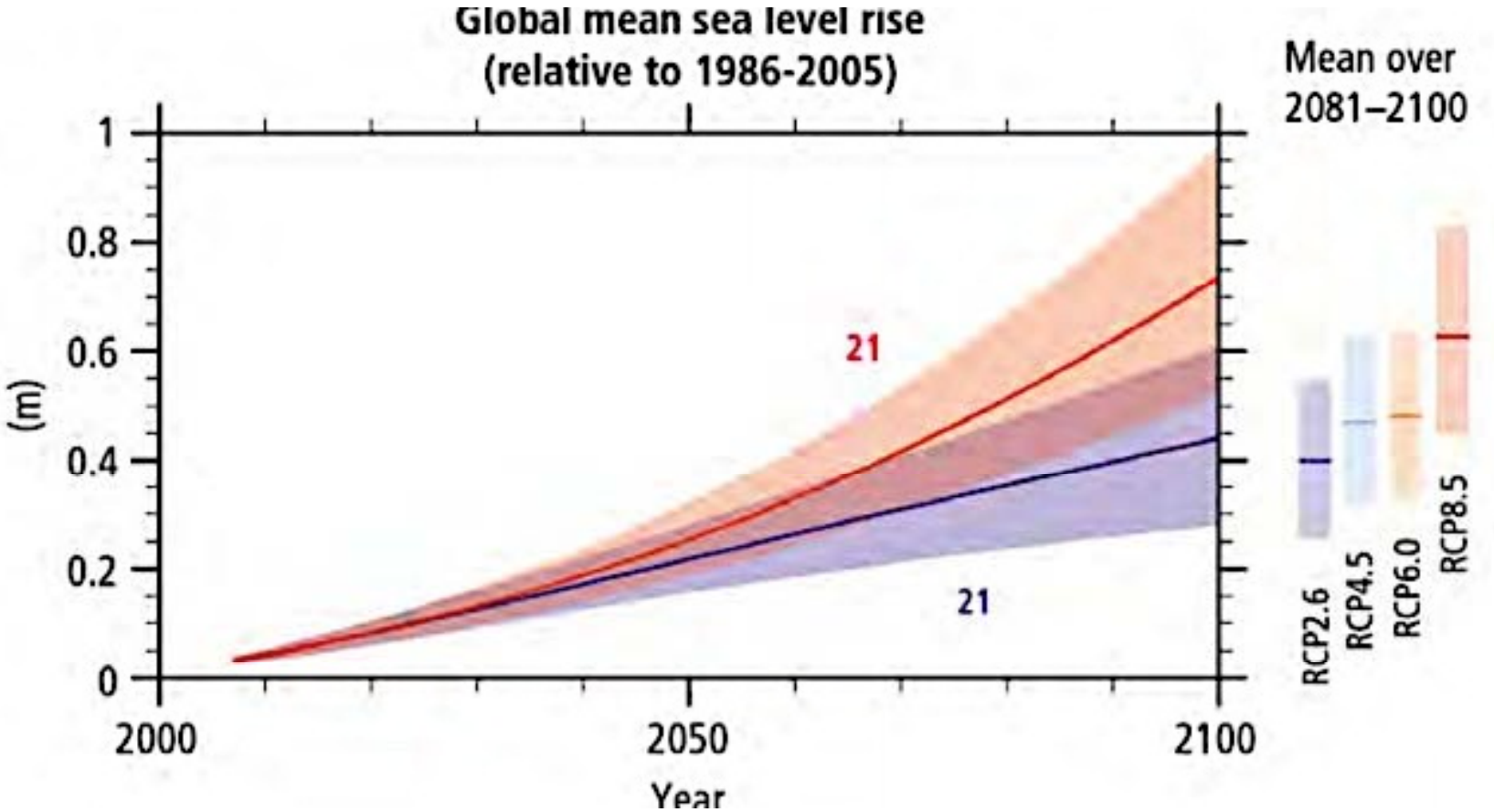
Severe, pervasive, and irreversible impacts



Additional temperature increase of 0.3˚C-0.7˚C certain till 2016-35



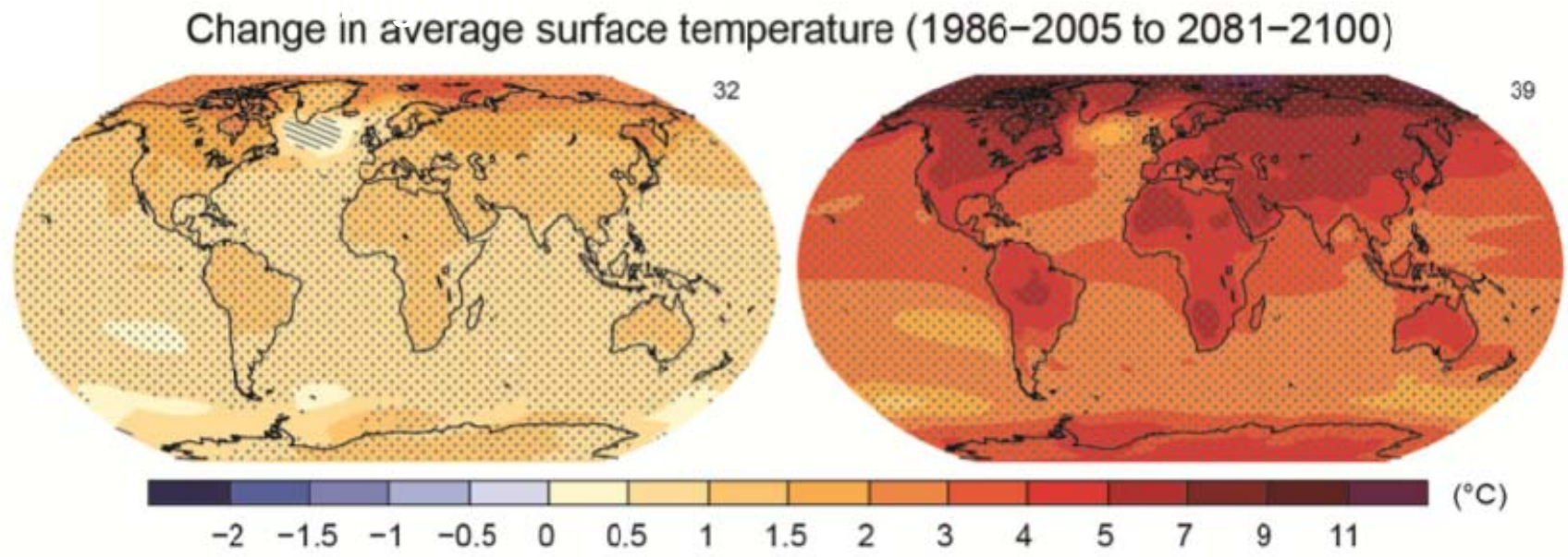
Sea level to rise by at least 2 mm/ year



The Atlas of Our Changing World

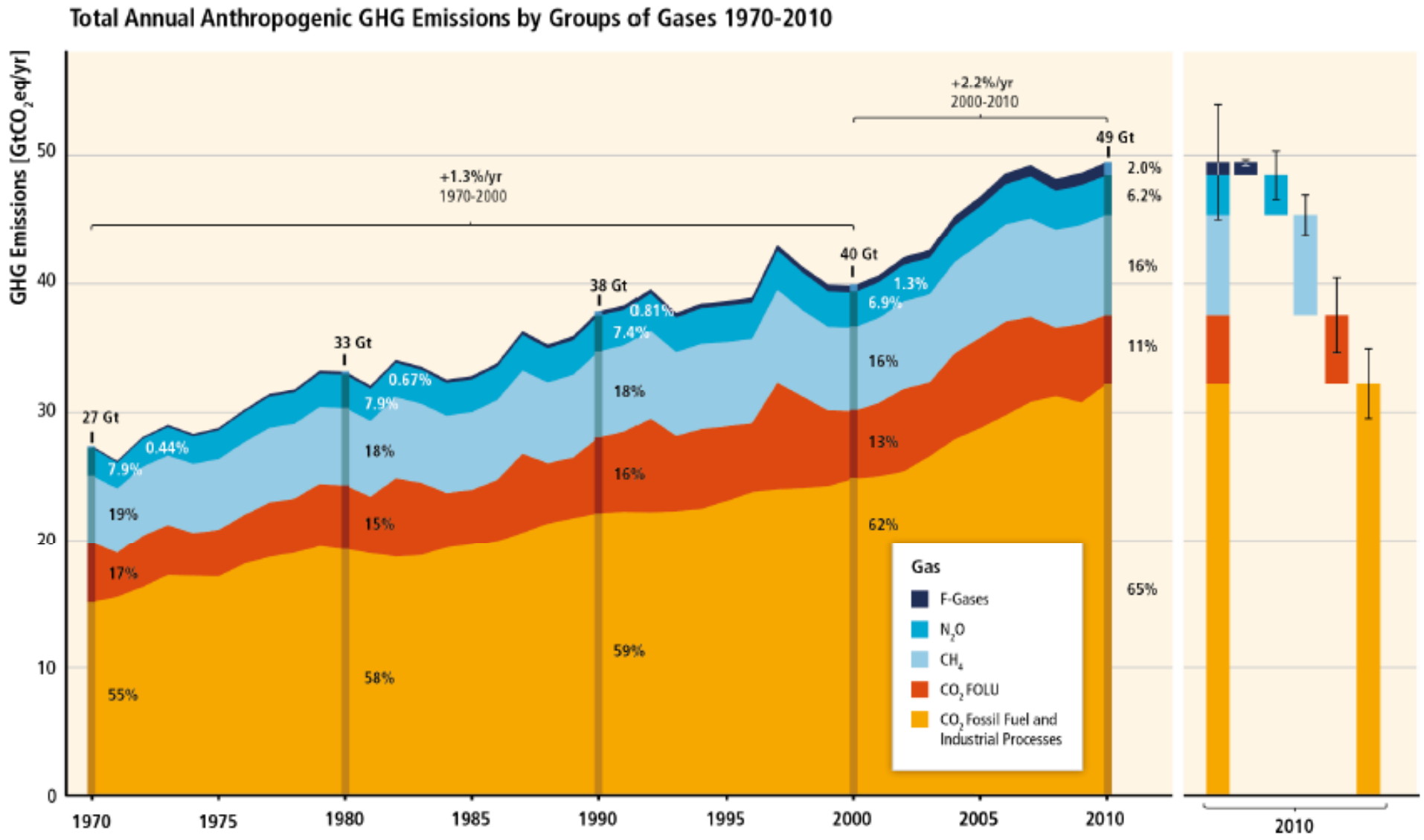
Without substantial

Without additional mitigation

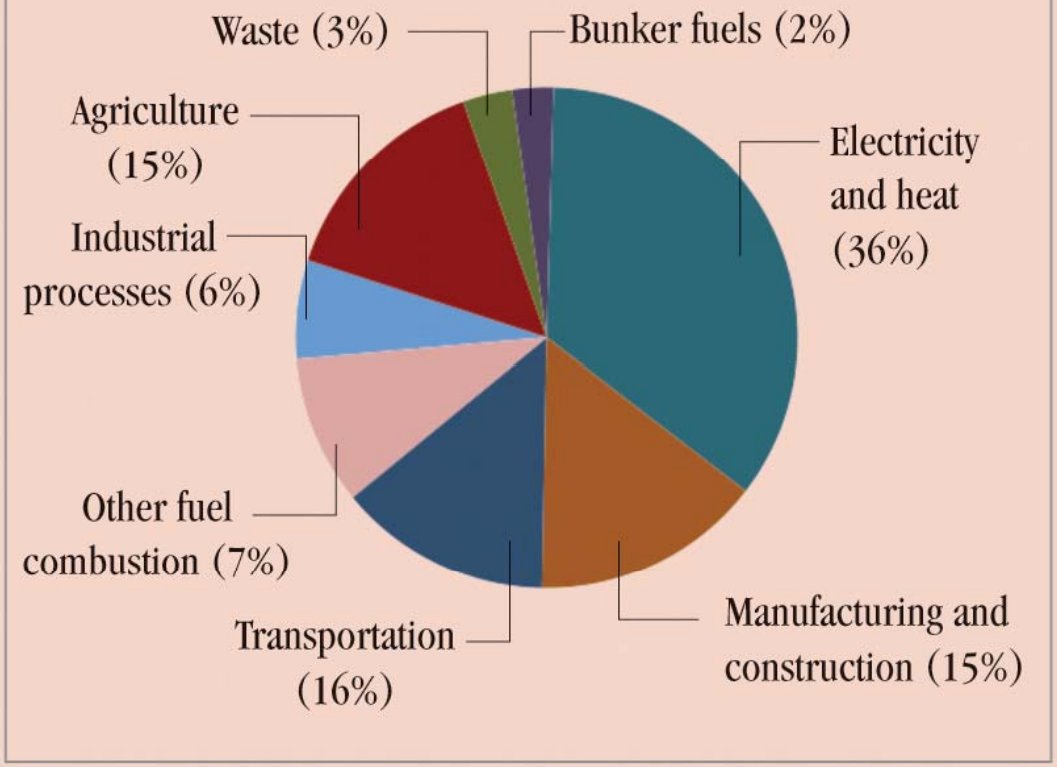


What is contributing and who is responsible ?

75% warming due to CO_2



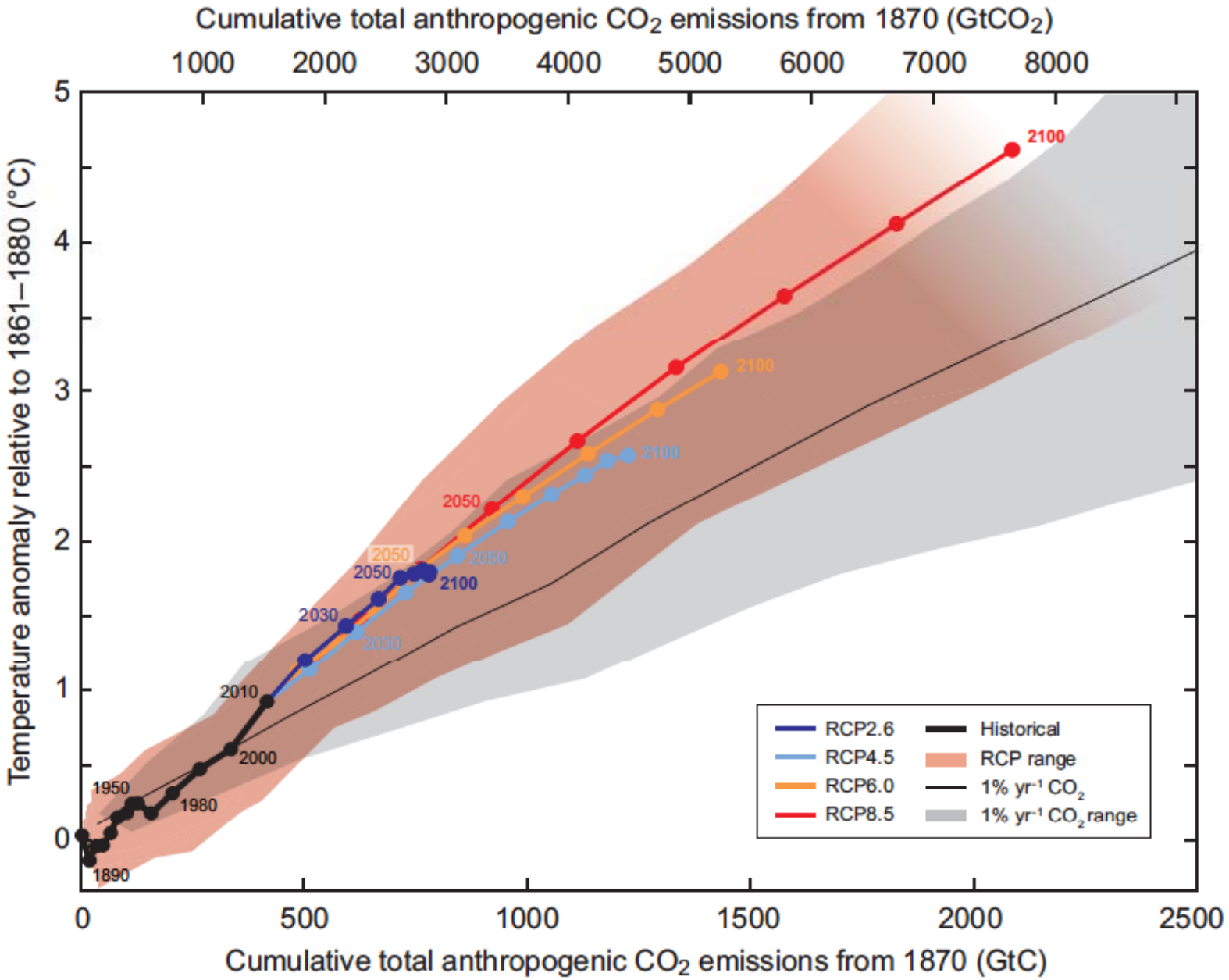
Electricity sector single largest contributor



Source: Climate Analysis Indicators Tool (CAIT) Version 2.0 BETA (Washington, DC: WRI, 2014)

Carbon budget, equity, CBDRRC and others

Emissions vs. temperature



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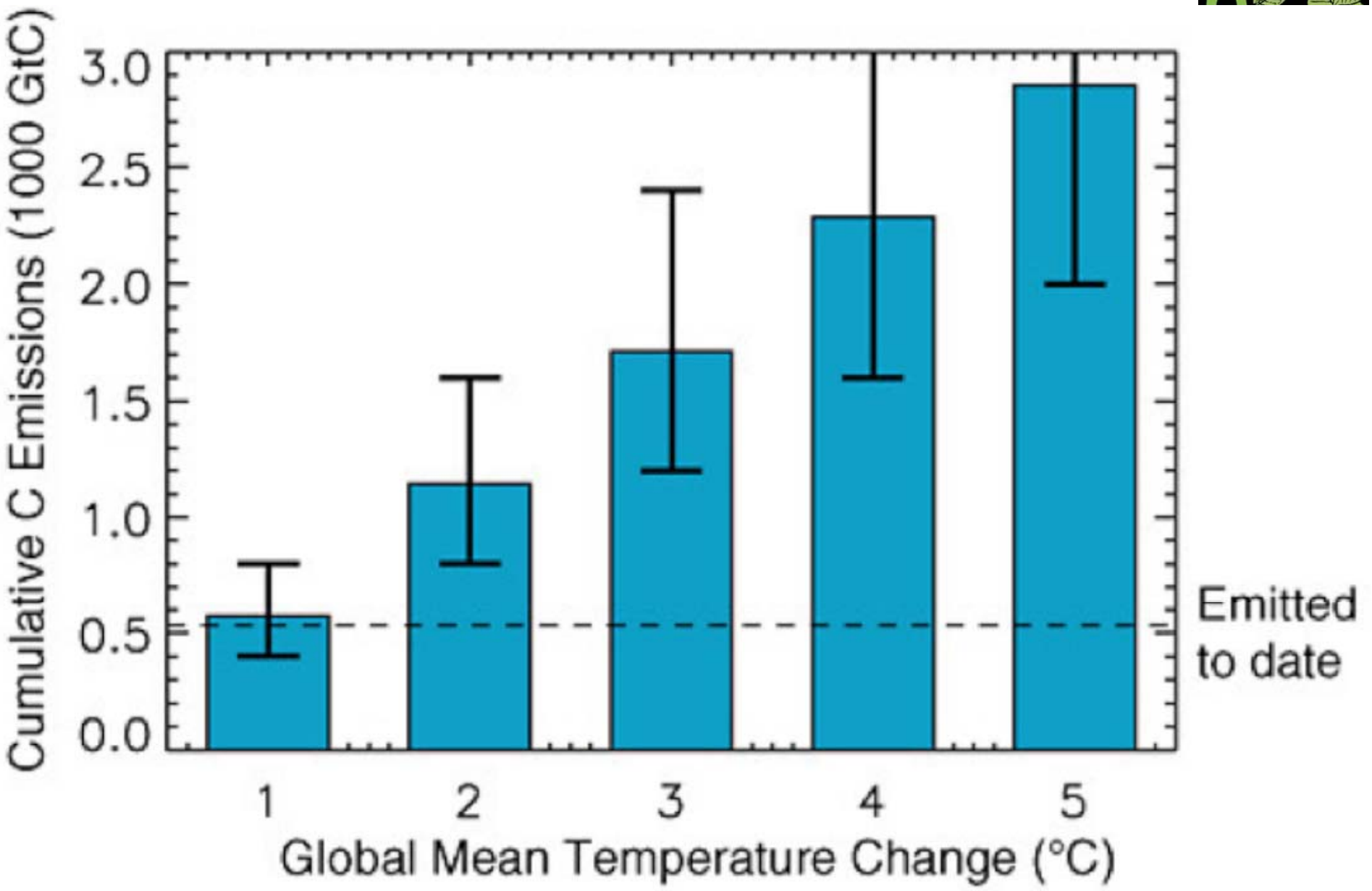
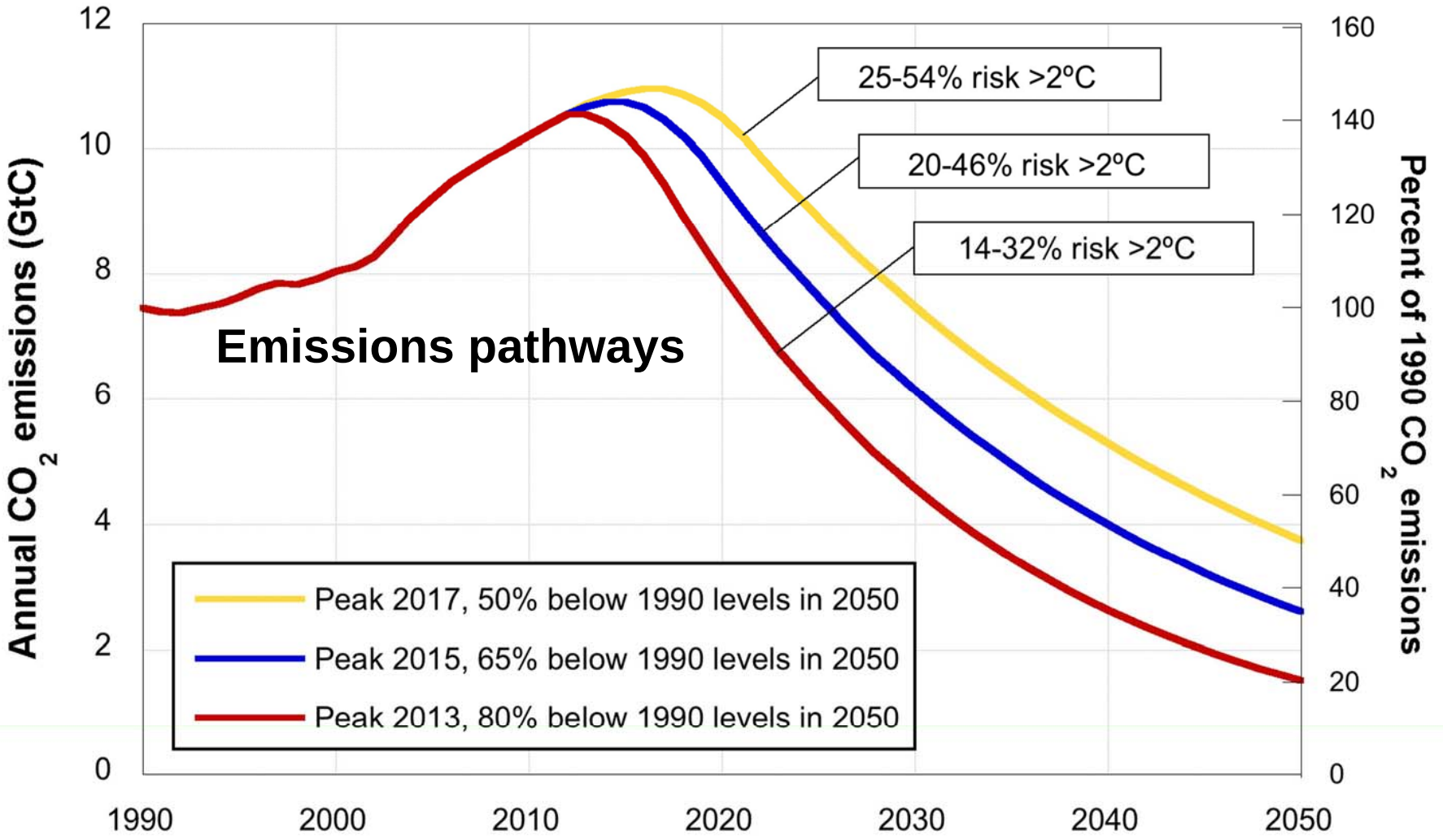


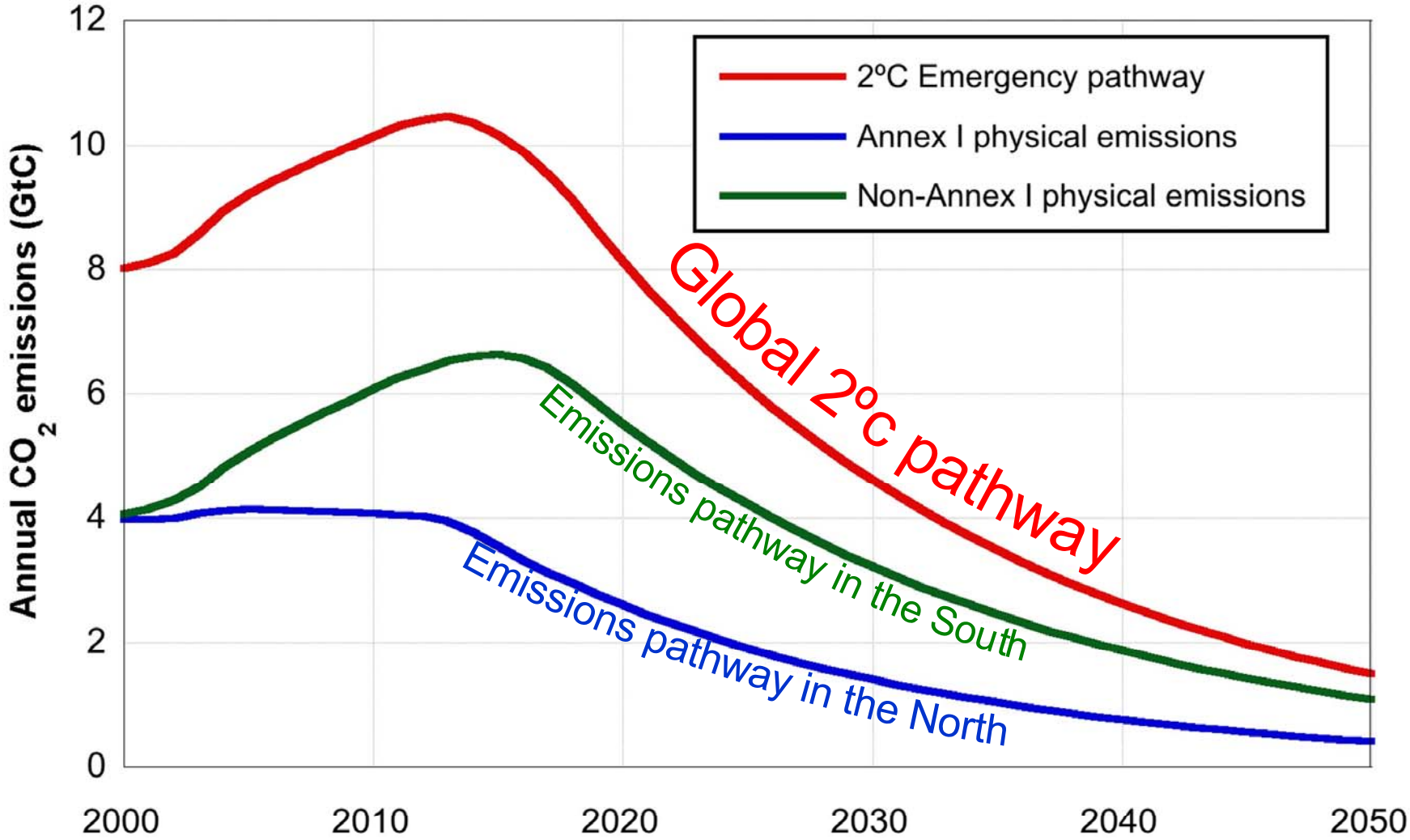
Carbon budget for 2^{O} C

Gt CO_2e	Probability of staying within 2° C		
	>33%	>50%	>66%
Total anthropogenic CO_2 budget: 1861-1880 to 2100	5762	4441	3670
Estimated Non-CO_2 forcing: 1861-1880 to 2100	2459	1432	771
Total anthropogenic CO_2 budget remaining after excluding Non-CO_2 forcing: 1861-1880 to 2100	3303	3009	2899
Total anthropogenic CO_2 emitted: 1861-1880 to 2011	1890	1890	1890
Total anthropogenic CO_2 budget remaining: 2012 - 2100	1413	1119	1009

How to remain within the budget?



How to divide the budget?



What kind of climate regime can enable this to happen…?

Climate regime?

Distribution of burden of transition and the budget between countries

<u>BASIS</u>

1. Equity

2. Common but differentiated responsibilities and respective capabilities

3. Potential to mitigate – *who has the most reduction at the cheapest cost*

How to define responsibility?

Responsibility related to emissions

Indicator 1a: Total historical emissions – 1850-2010

US: 33%; EU 27: 19%; China: 6.3%; India: 0.5%

Indicator 1b: Total historical emissions – 1970-2010

US: 22%; EU 27: 13%; China: 15%; India: 2.5%

Indicator 1c: Current emissions –2012

China: 26.7%; US: 17; EU 27: 11%; India: 5.3%

How to define responsibility?

Indicator 1d: Per capita emissions – 2012

US: 22 MT; EU: 10 MT; China: 8 MT; India: 2 MT

Indicator 1e: Per capita historical emissions – 1850-2012

US: 1200 MT; EU: 750 MT; China: 100 MT; India: 30 MT

How to define capability?

Capability is multifaceted – GDP, poverty, HDI, technology capability

Indicator 2a: GDP (PPP, 2005 USD) – 2012

US: 13 trillion; EU: 14 trillion; China: 9 trillion; India: 3.7 trillion

Indicator 2b: Per capita GDP (PPP, 2005 USD) – 2012

US: 42000; EU: 28000; China: 7000; India: 3000

How to define potential?

<u>Potential to mitigate related to inefficiencies and consumption</u>

Indicator 3a: Energy intensity of GDP (toe per US$1000 GDP)

US: 0.15; EU: 0.1; China: 0.35; India: 0.4

Indicator 3b: Per capita energy consumption (toe per capita)

US: 7; EU: 3.5; China: 2.0; India: 0.7

Technology & efficiency conundrum

- Emission (E) = Population (P) x Consumption (C) x Emission intensity of Technology(T)

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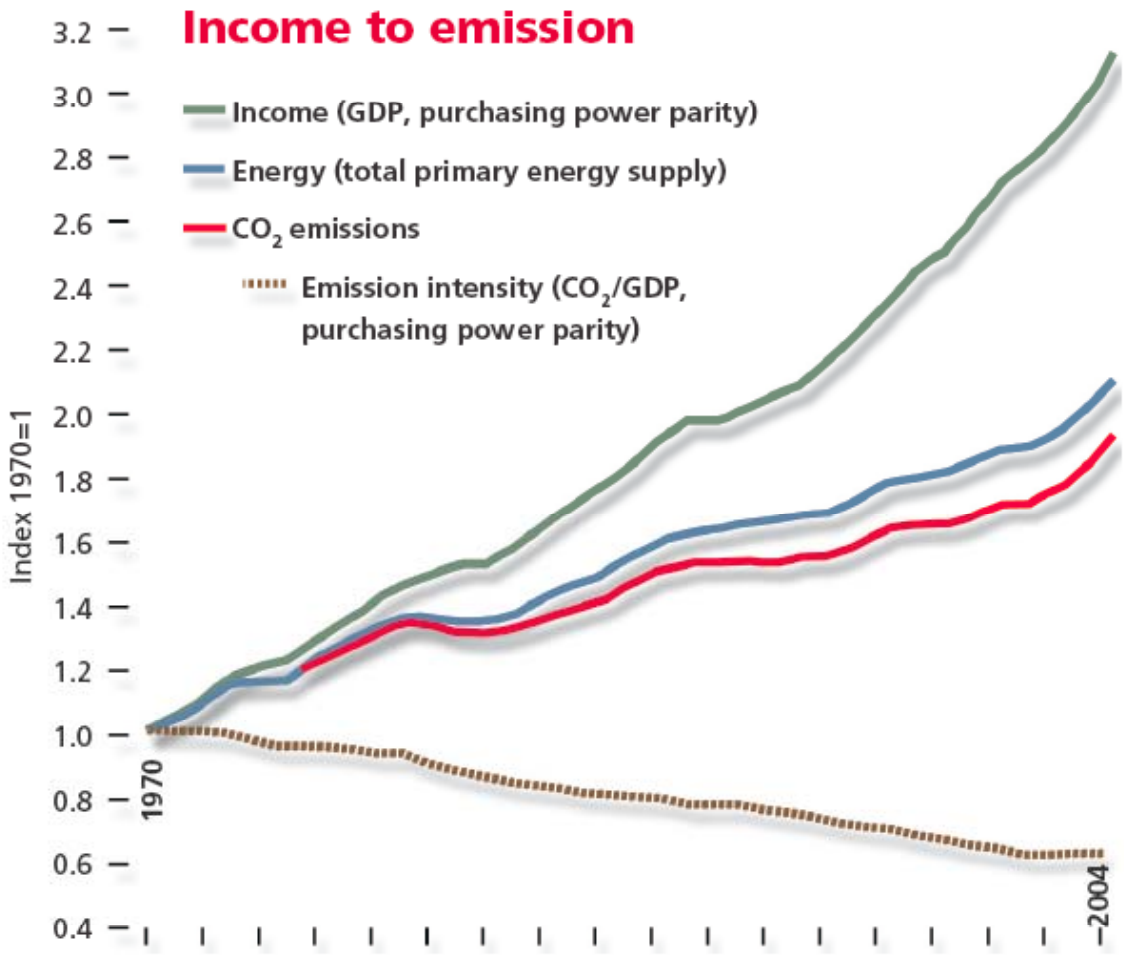
- $T_{2050} = 1/13\ T_{2000}$ (7%/yr. improvement)

Technology & efficiency conundrum



Source: Fourth Assessment Report 2007, Intergovernmental Panel on Climate Change

Total Annual CO_2 Emissions from Fossil Fuel Combustion by Country Income Groups from a Territorial and Consumption-Based Perspective 1990-2010