Europa-Universität
Flensburg

Where We Are

Europa-Universität Flensburg

Climate Change

Is there a need for sustainable energy systems

What do you know about climate change?

Agenda

1. Introduction
2. The greenhouse effect
3. IPCC / UNFCCC
4. Climate change facts
5. Drivers of climate change
6. Climate change projections
7. Mitigation of climate change
8. climate change adaption

Introduction

Sustainable development

Definition of the Brundtland Commission (WCED 1987):

“A development satisfying the needs of the present generation without impairing the needs of future generations.”

Climate Change

"[…] **a change of climate which is attributed directly or indirectly to human activity** that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

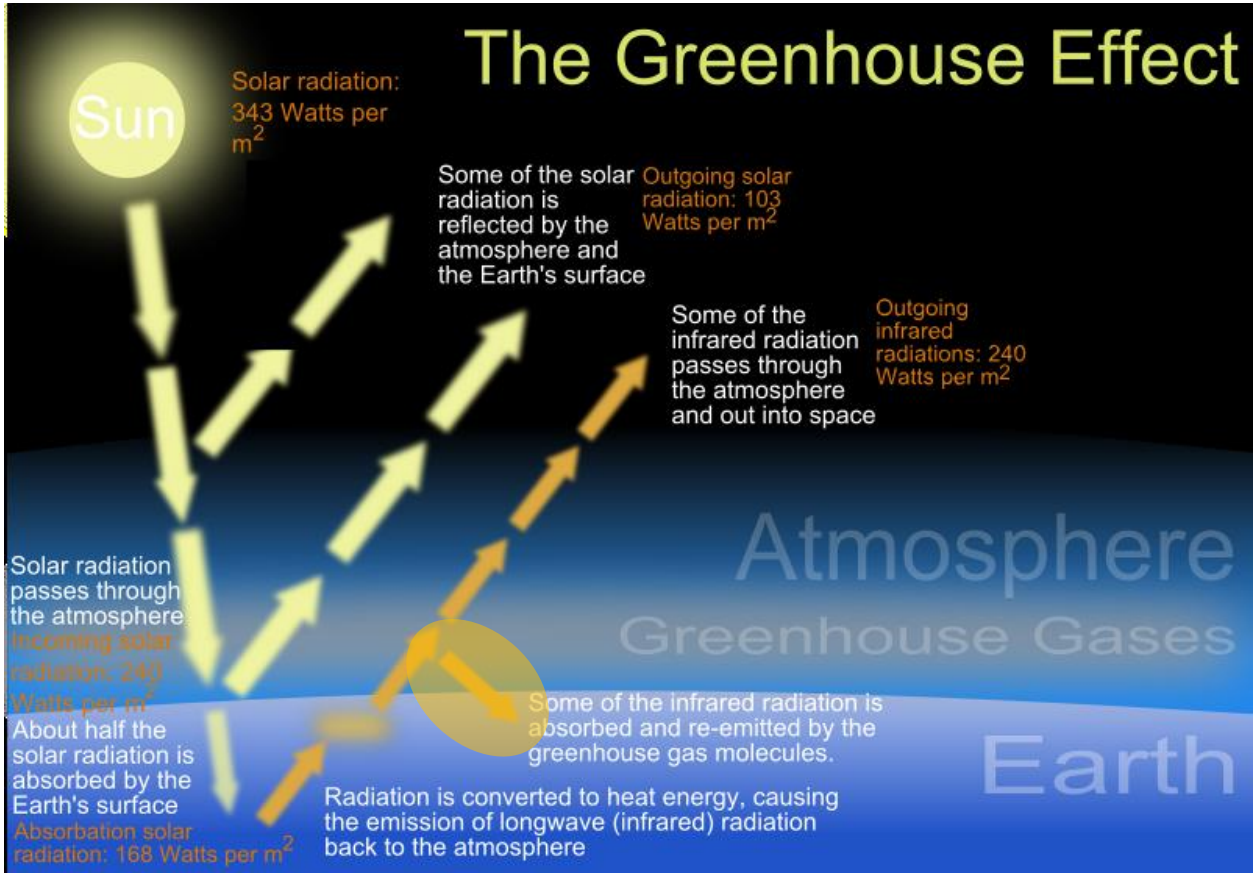
(UNFCCC, Article 1)

Terms

Term	Explanation
Adaptation	*"The process of **adjustment to actual or expected climate and its effects**. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects."* Source: IPCC 2013 (WG II), TS, p. 40
Mitigation	*"Mitigation, in the context of climate change, is **a human intervention to reduce the sources or enhance the sinks of greenhouse gases** (GHGs)"* Source: IPCC 2013 (WG II), TS, p. 40
Resilience	*"The **capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance**, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation."* Source: IPCC 2013 (WG III), TS, p. 40

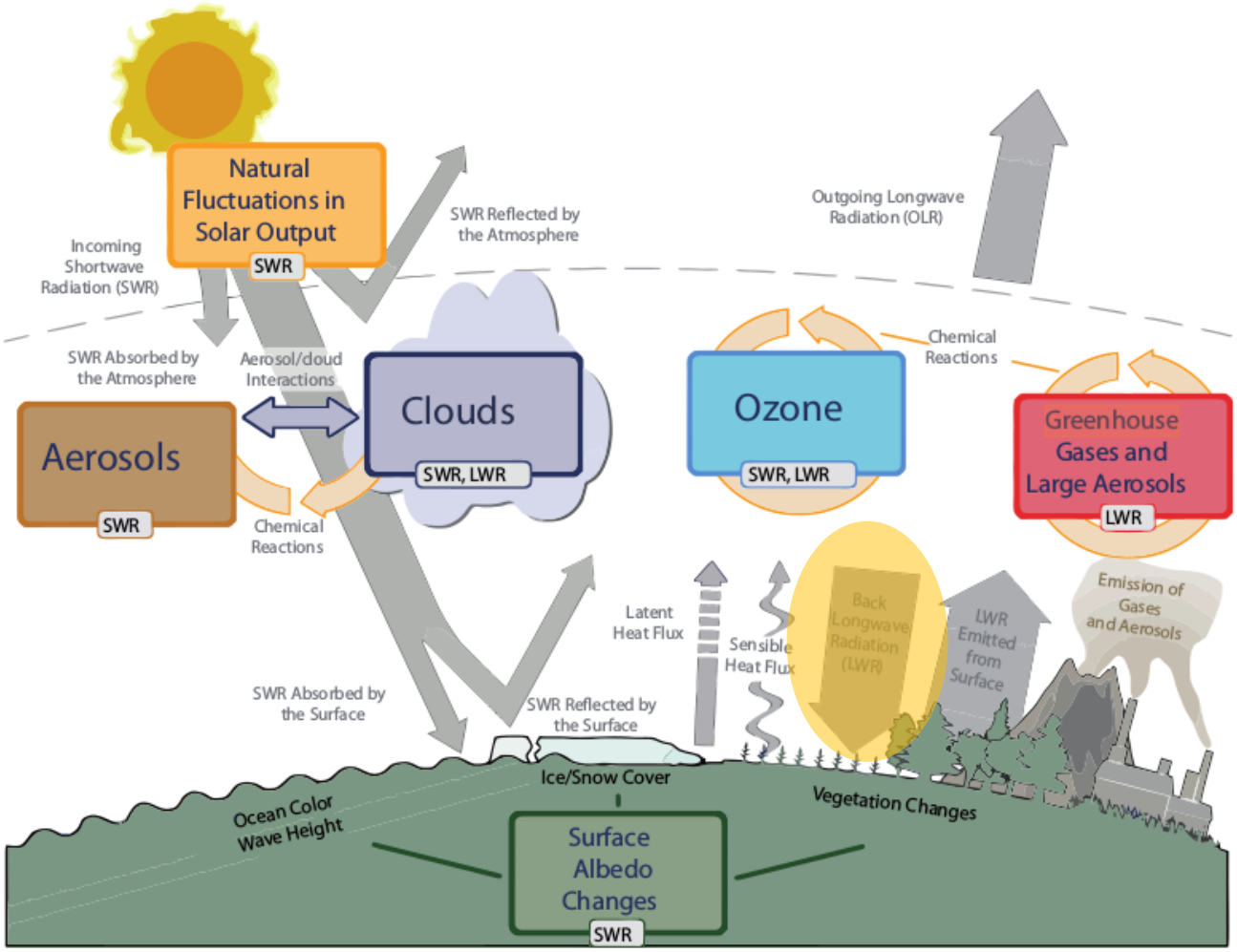
The greenhouse effect

The greenhouse effect/radiative forcings



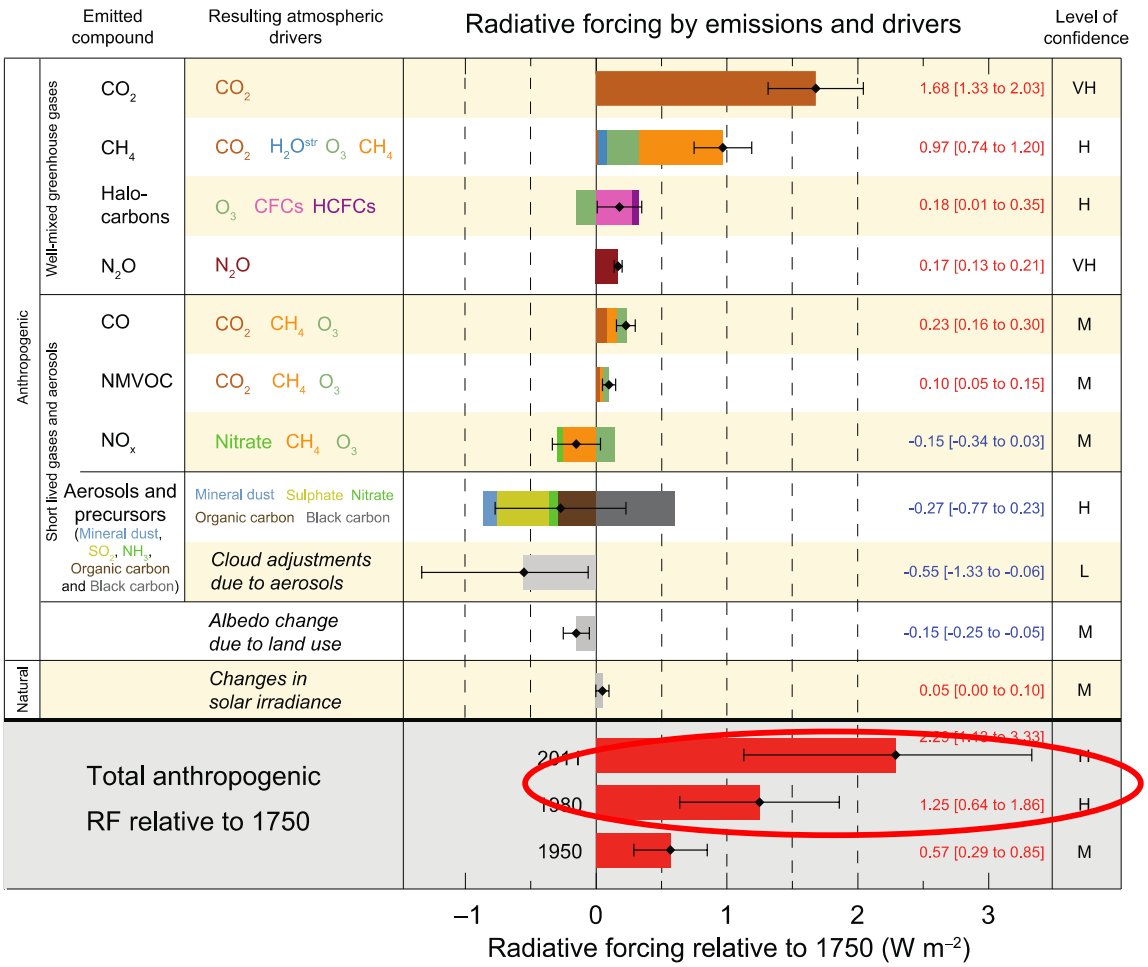
Source: ZooFari - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=5776439

The greenhouse effect/ radiative forcings



Source: IPCC 2013, p. 124

Components of radiative forcings



AR4: 1,66W/m²

AR5: 2,29W/m²

Source: IPCC 2013 (WG I), SPM, p.12

IPCC

IPCC

- Founded 1988 by WMO and UNEP
- Task: Providing the world with an objective, scientific view of climate change and its political and economic impacts
- Assess scientific information relevant to
  - Human-induced climate change
  - The impacts of human-induced climate change
  - Options for adaptation and mitigation
- Hundrets of scientists nominated by the member countries of IPCC regularly assess the state of the latest research on climate change (five reports 1991, 1995, 2001, 2007, 2014)

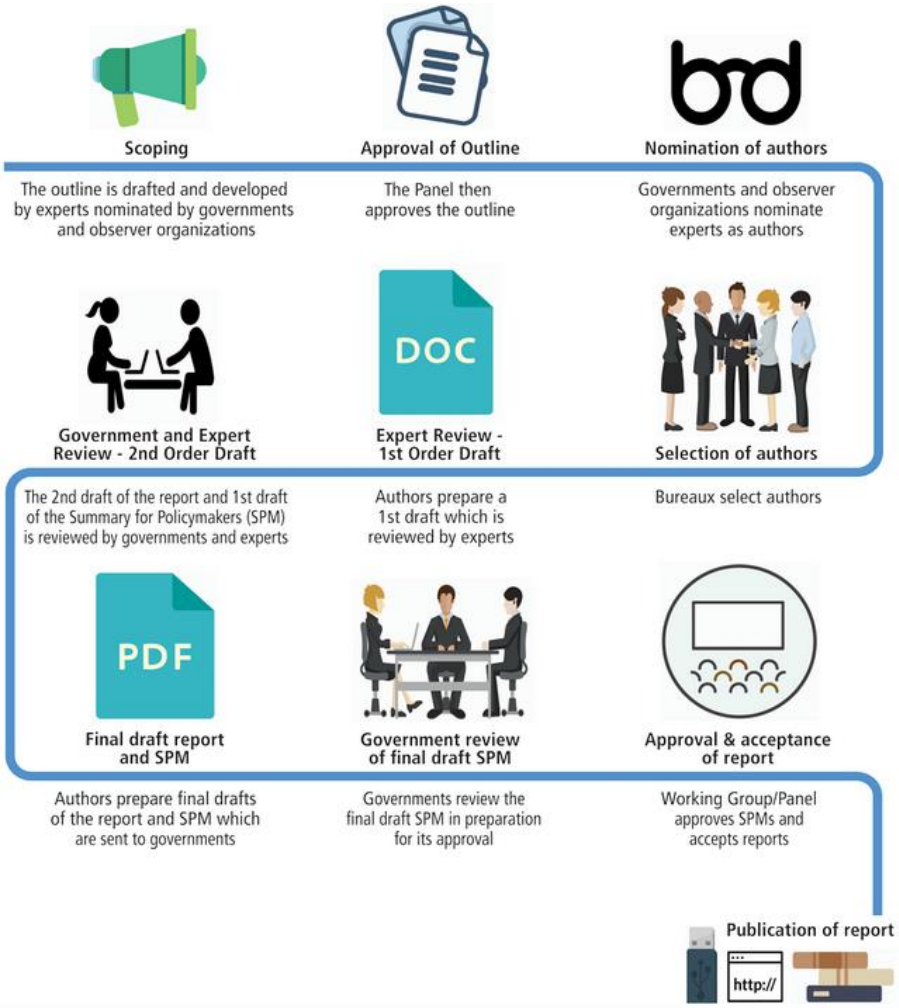
UNFCCC – the united nations framework convention on climate change

Article 2

Objective

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is **to achieve**, in accordance with the relevant provisions of the Convention, **stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system**. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

IPCC – writing and review process



Communication of the Degree of Certainty in IPCC

Term: Likelihood of the outcome	probability
Virtually certain	99–100% probability
Extremely likely	95–100% probability
Very likely	90–100% probability
Likely	66–100% probability
More likely than not	>50–100% probability
About as likely as not	33–66% probability
Unlikely	0–33% probability
Very unlikely	0–10% probability
Extremely unlikely	0–5% probability
Exceptionally unlikely	0–1% probability

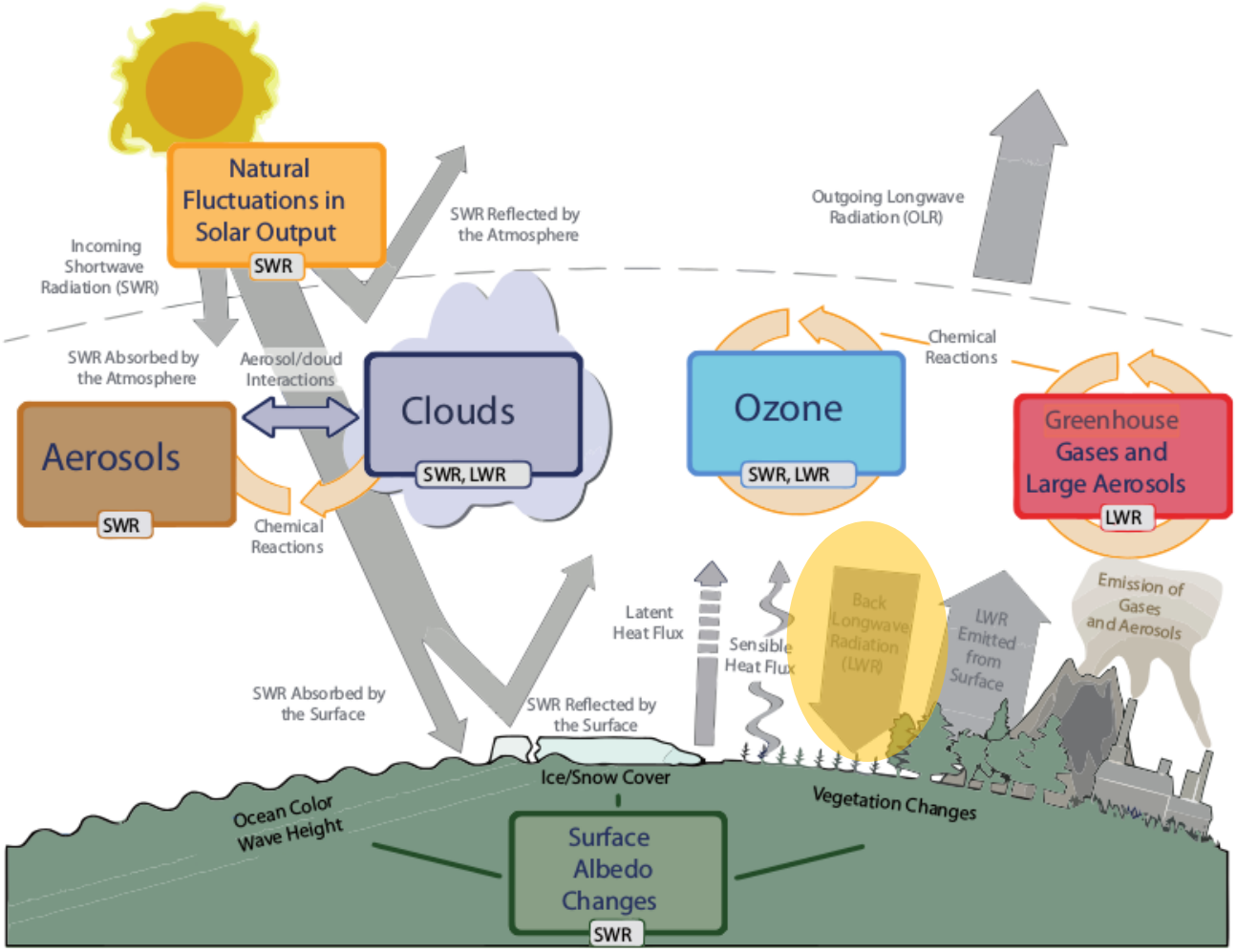
Source: IPCC 2014 (WG II), TS, p.41)

Scenarios in 5th IPCC report (RCP)

Representative **C**oncentration **P**athways – **RCP**

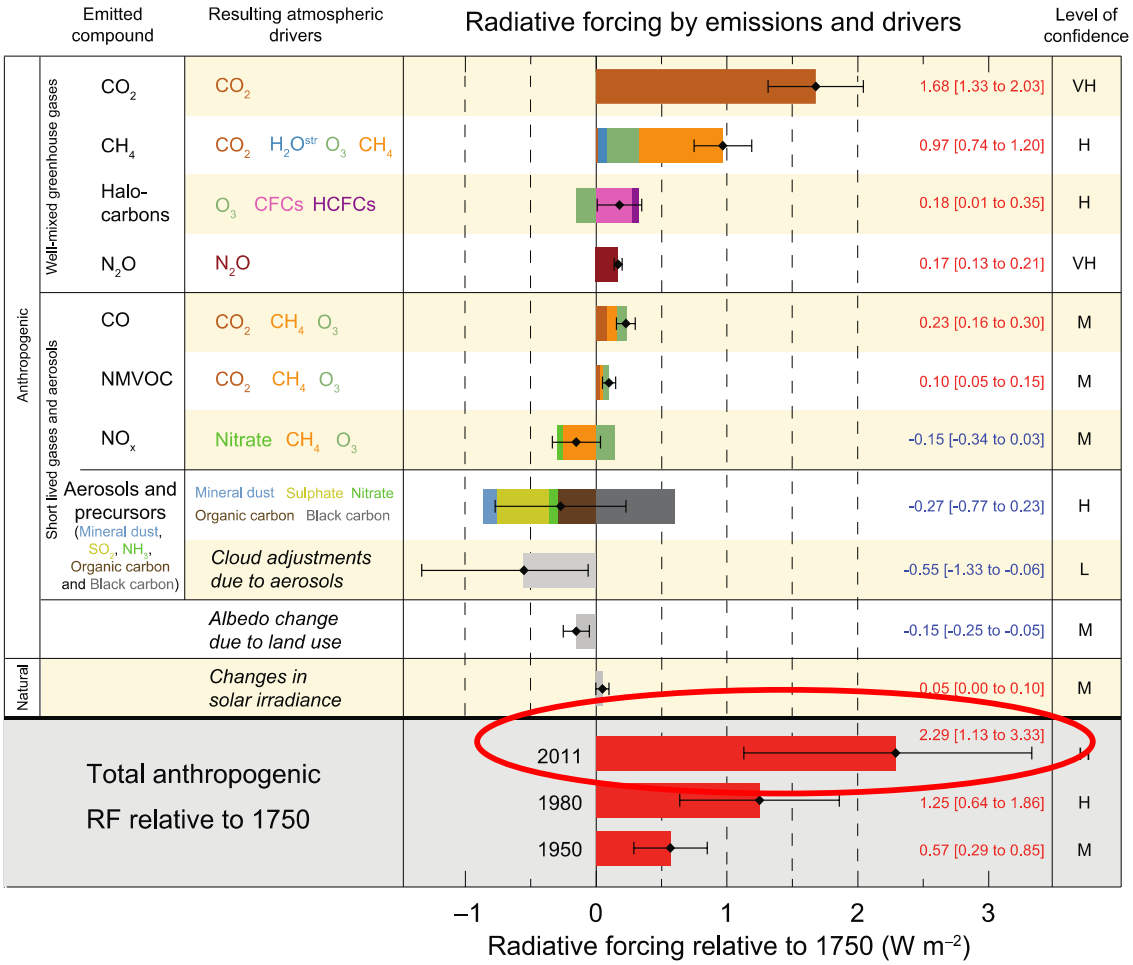
- Radiative forcing in 2100 compared to 1750 [W/m²]
  - RCP 2.6 -> + 2.6 W/m²
  - RCP 4.5 -> + 4.5 W/m²
  - RCP 6.0 -> + 6.0 W/m²
  - RCP 8.5 -> + 8.5 W/m²

The greenhouse effect/ radiative forcings



Source: IPCC 2013, p. 124

Components of radiative forcings



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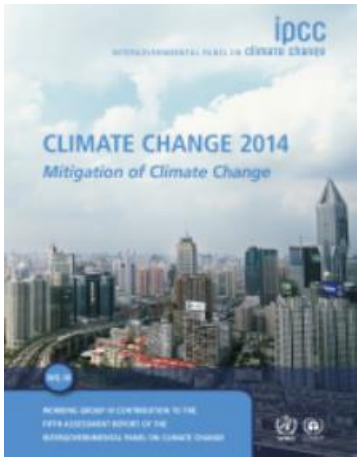
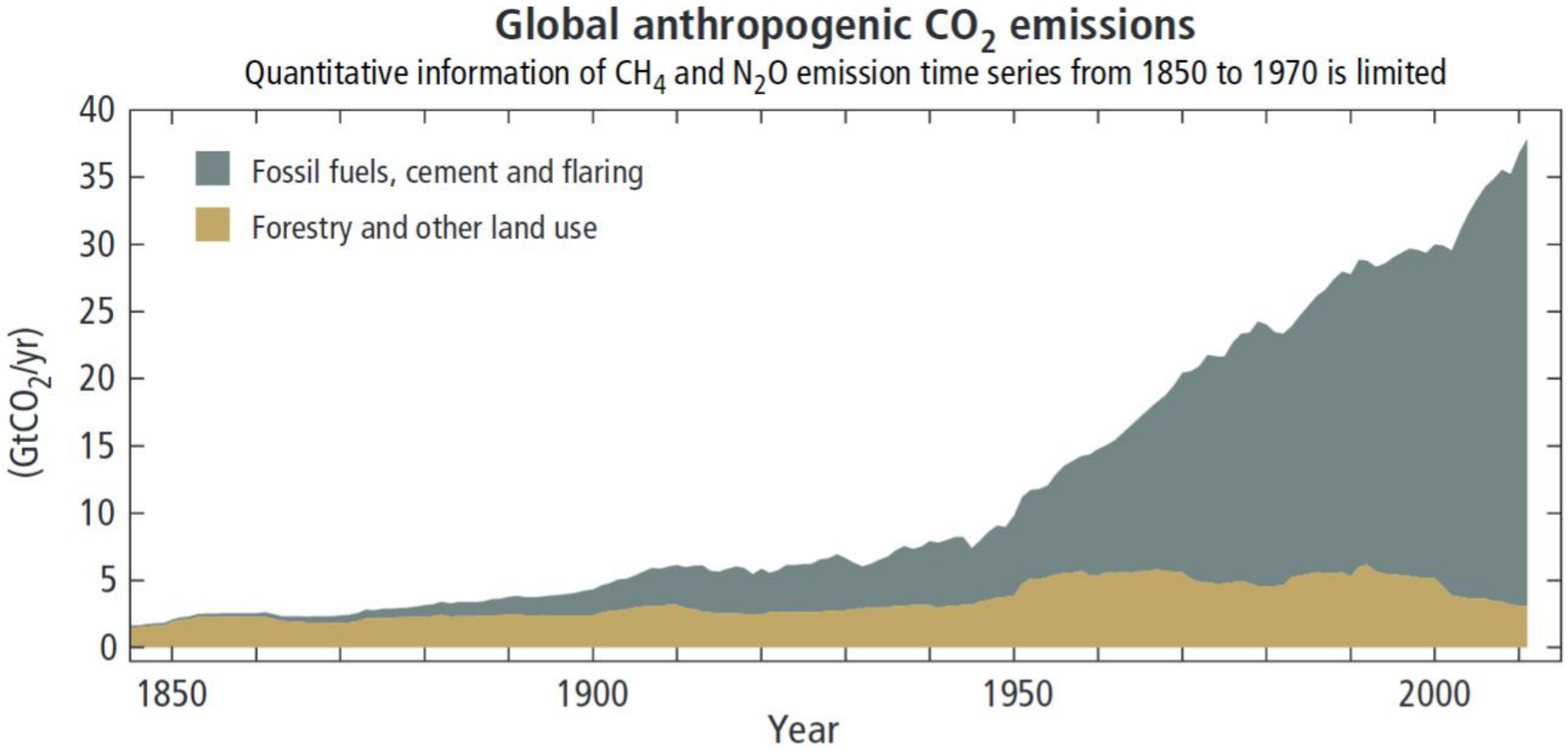
IPCC

- IPCC consists out of three working groups
  - WG I: Climate science
  - WG II: Impacts and adaptation
  - WG III: Mitigation



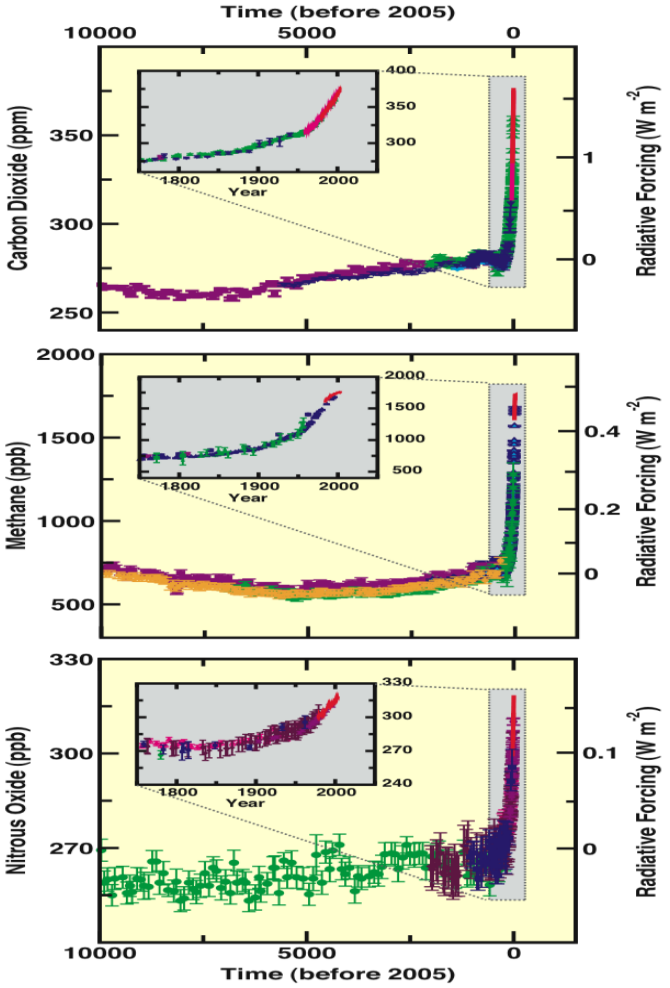
Drivers of climate change

Anthropogenic influences on climate change



Anthropogenic influences on climate change (mid term)

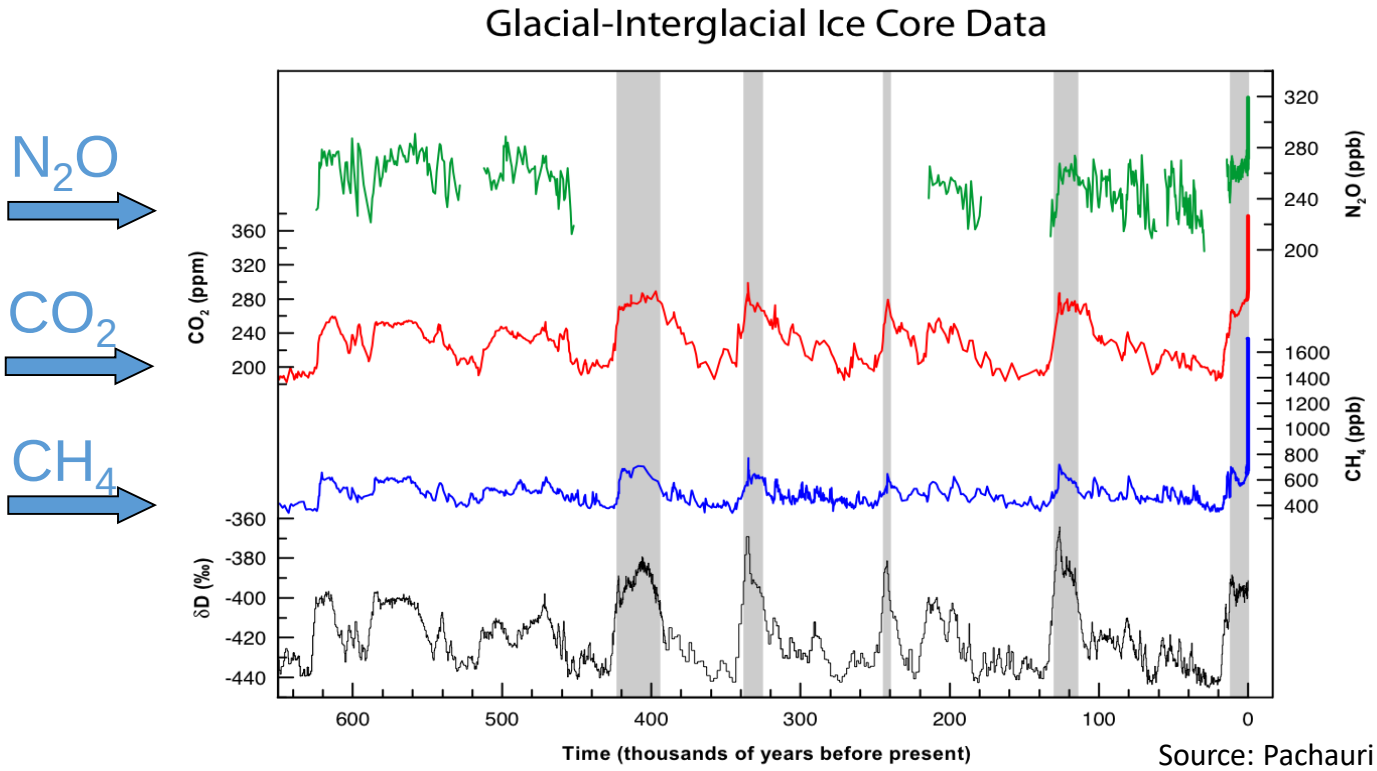
- CO2, CH4 and N2O Concentrations
  - far exceed pre-industrial values
  - increased markedly since 1750 due to human activities
  - Relatively little variation before the industrial era



Source: IPCC 2007 (WG I, SPM, p.3)

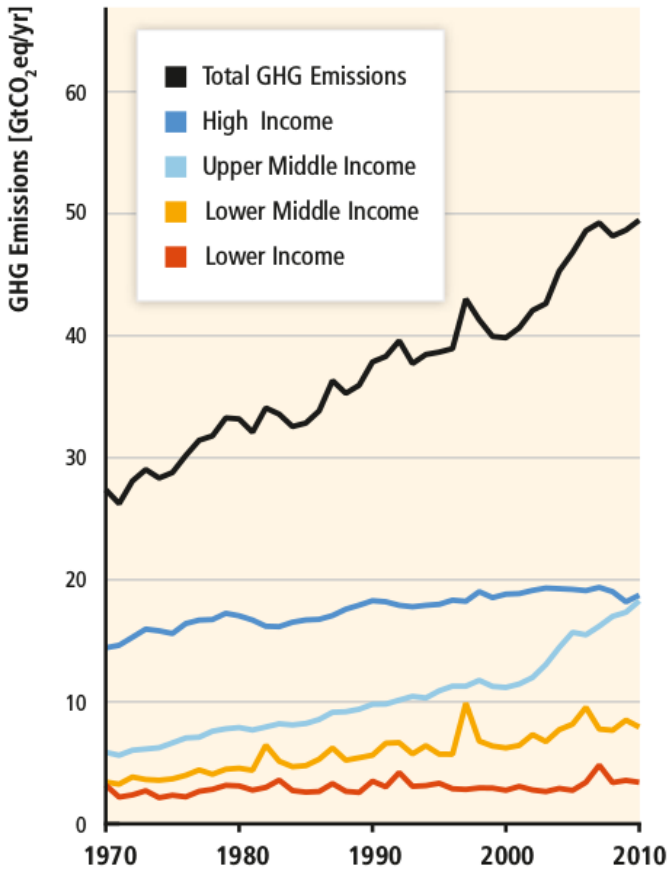
Anthropogenic influences on climate change (long term)

The atmospheric concentration of CO_2 and CH_4 in 2005 exceeds by far the natural range of the last 650,000 years



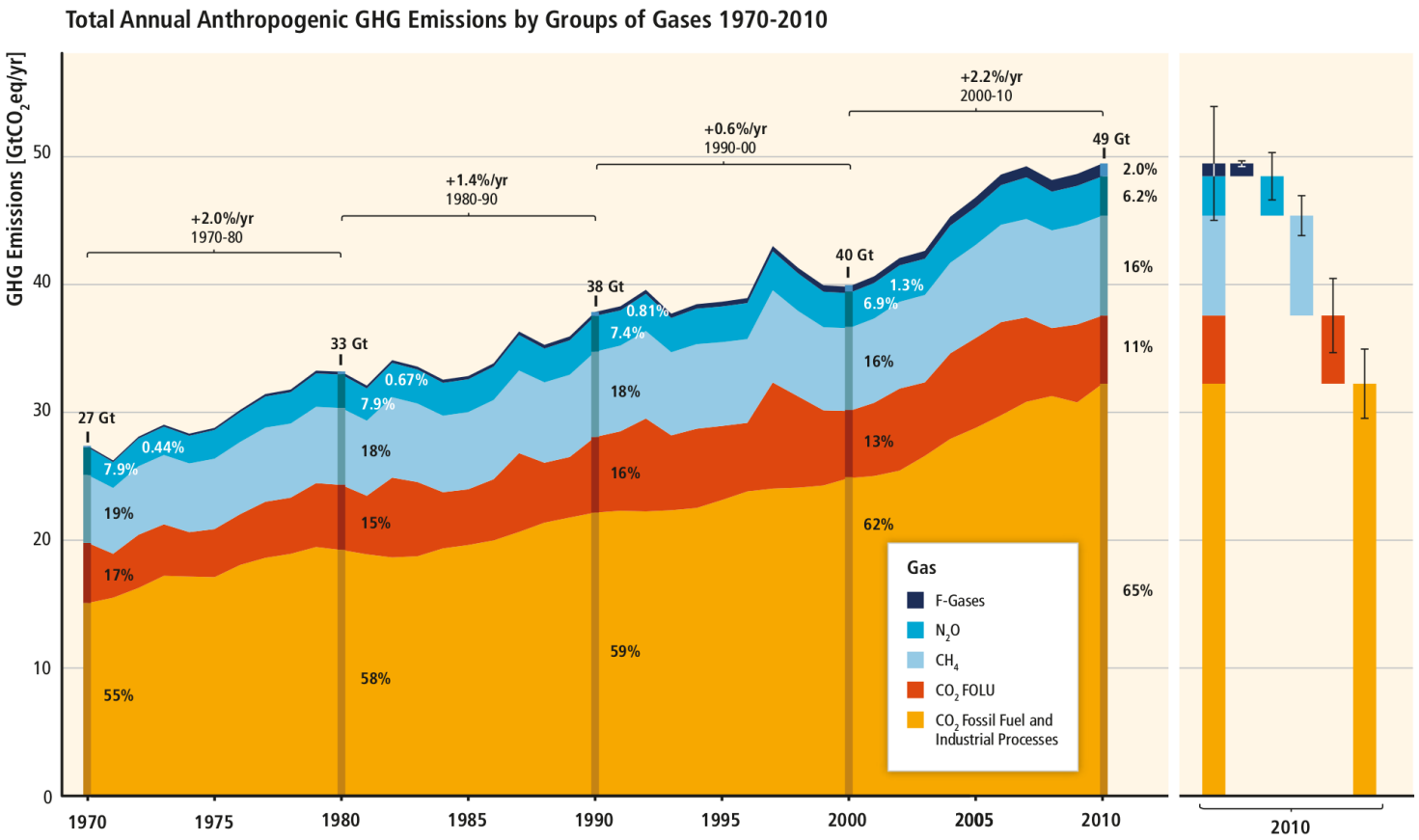
Source: Pachauri and Jallow 2007

GHG emissions by county income groups



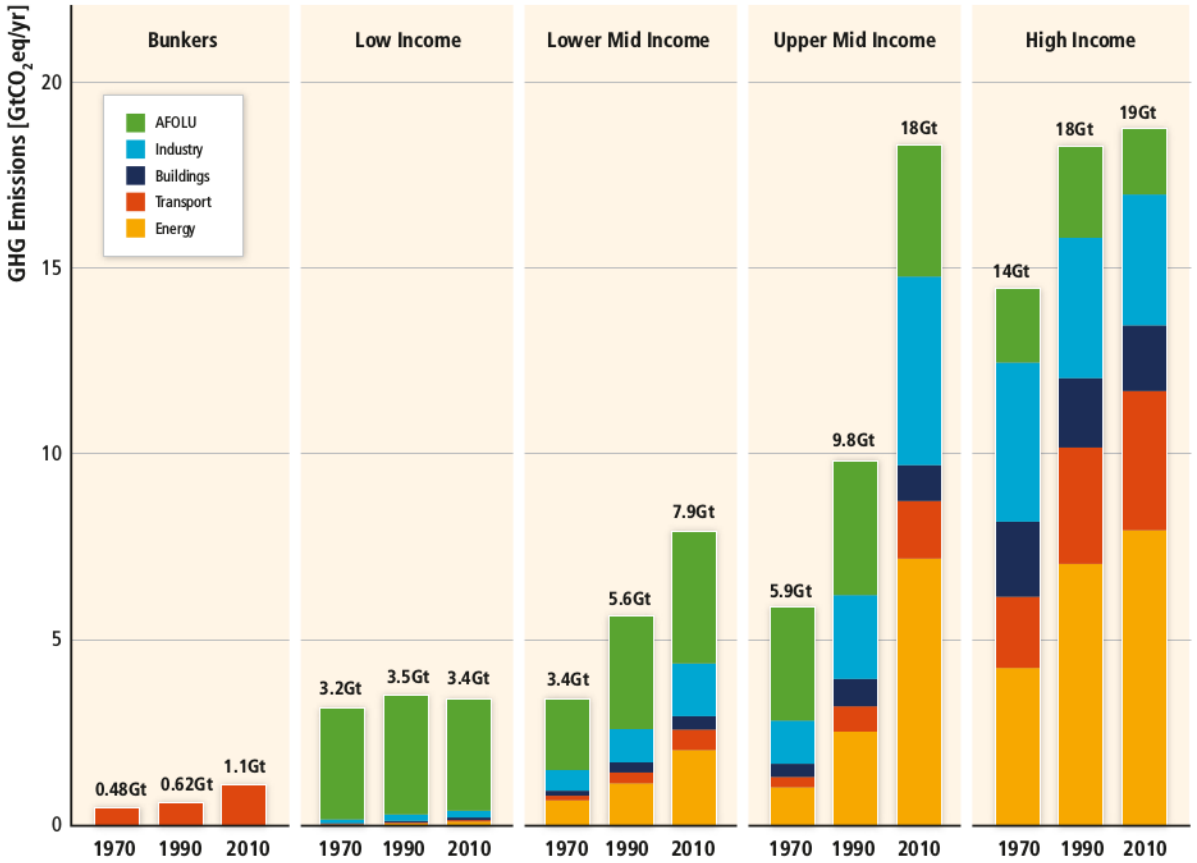
Source: IPCC 2014 (WG III), TS, S.45)

Different greenhouse gases



Source: IPCC 2014 (WG III), TS, p.42

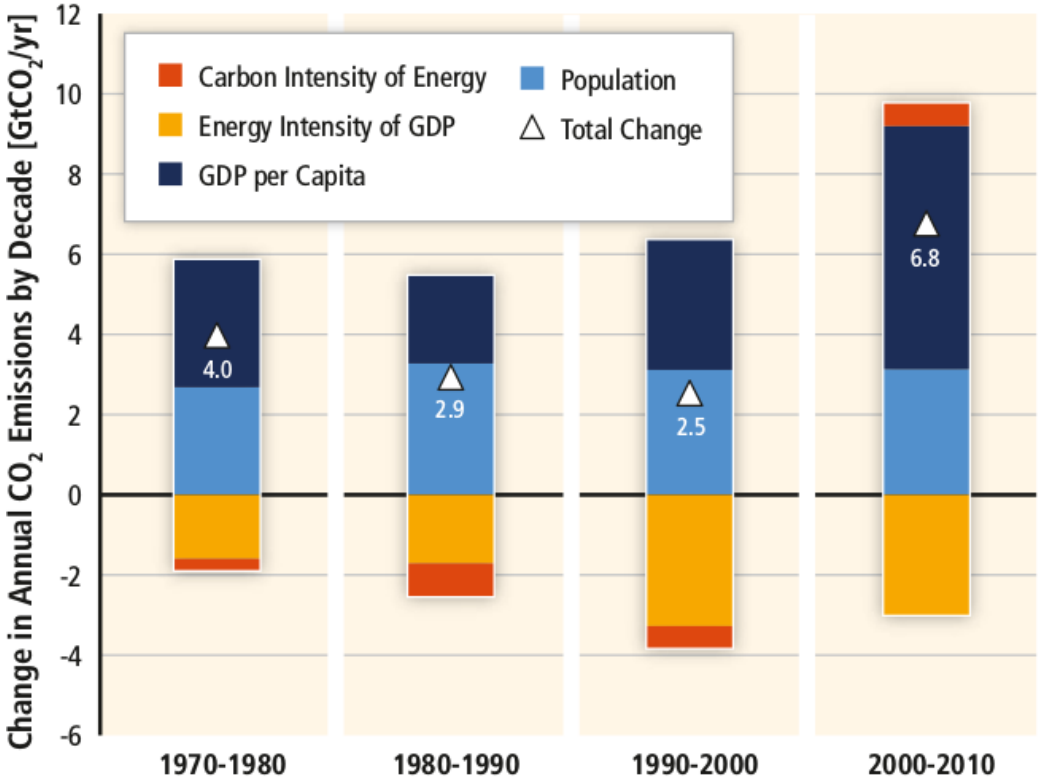
Greenhouse gas emissions by sector



Source: IPCC 2014 (WG III), TS, p.44)

GHG emission drivers

*"**Globally, economic and population growth continue to be the most important drivers** of increases in CO 2 emissions from fossil fuel combustion. The contribution of population growth between 2000 and 2010 remained roughly identical to the previous three decades, while the contribution of economic growth has risen sharply."* (IPCC 2014 (WG III), TS, p.47)

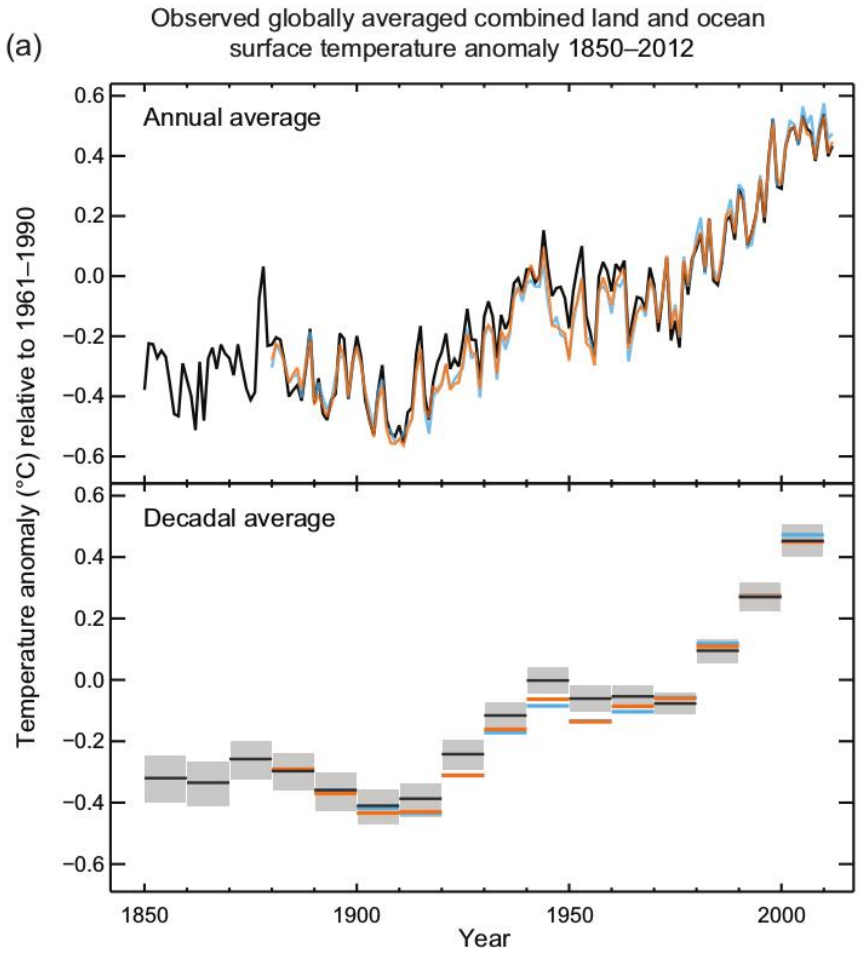


Source: IPCC 2014 (WG III), TS, p.48)

Population growth as a driver of climate change

Climate change facts

Climate facts - athmosphere



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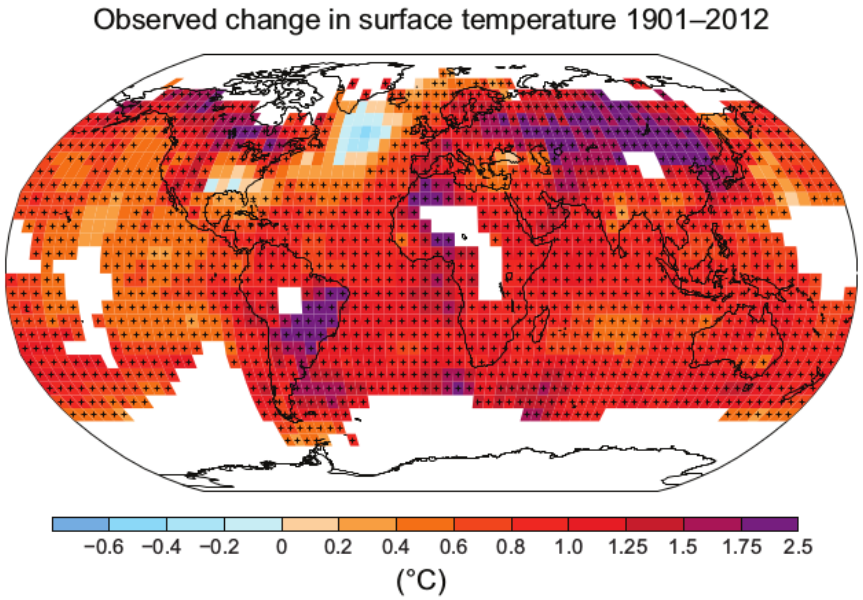
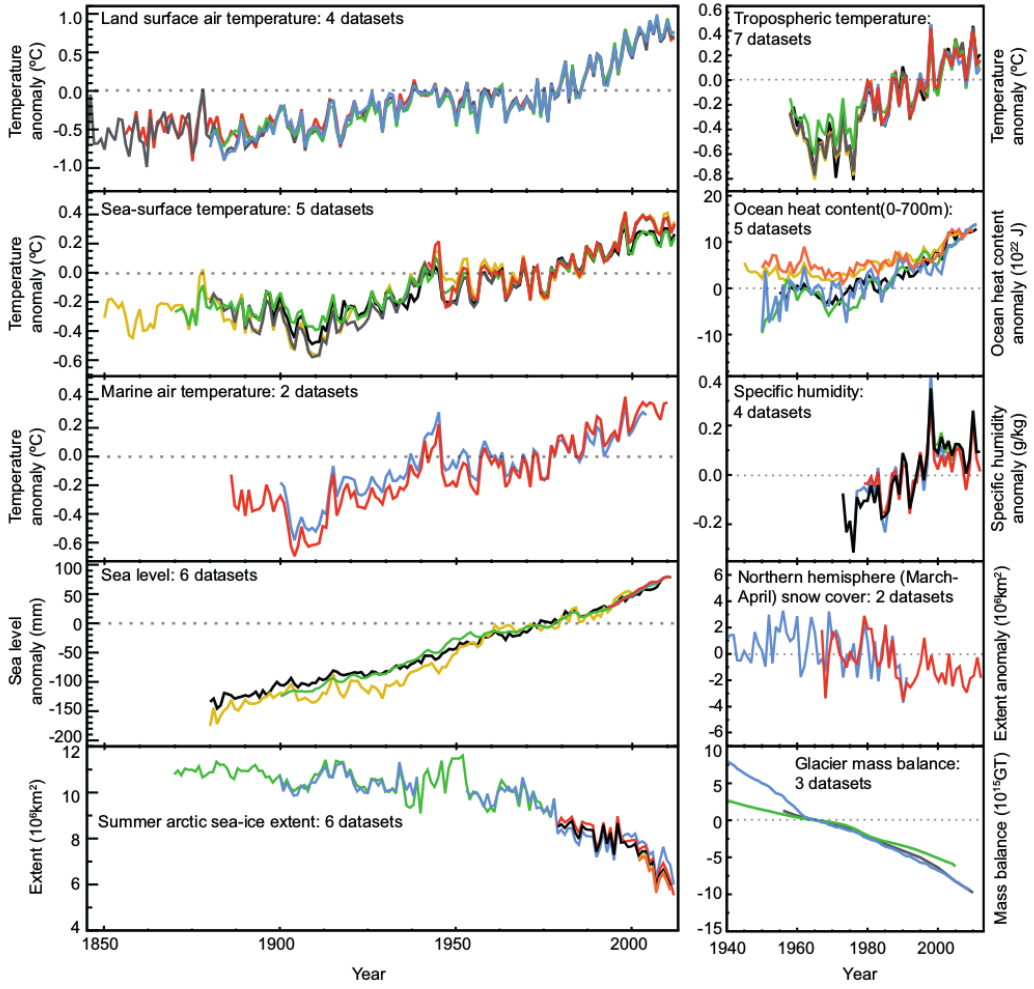
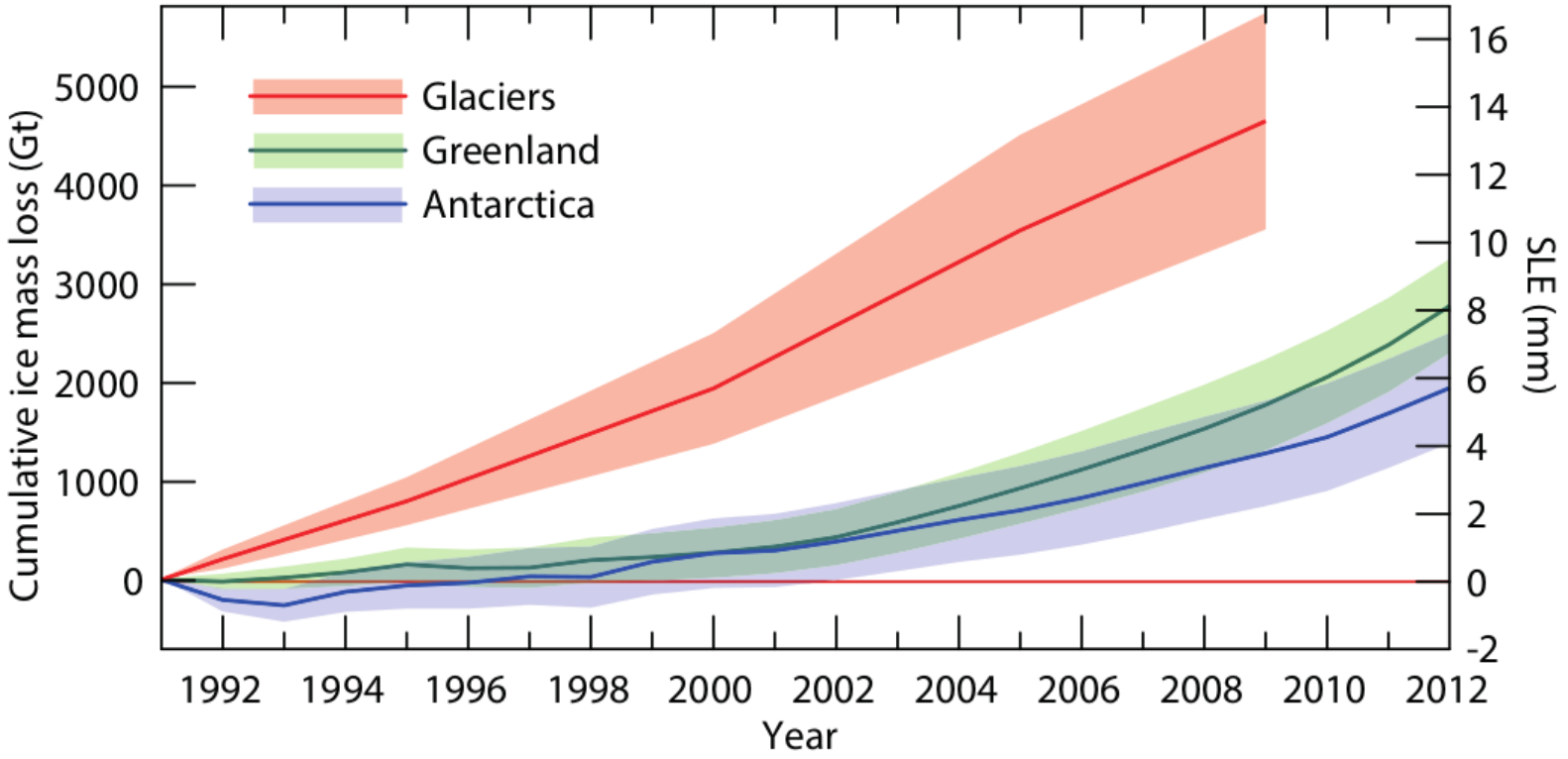


Source: IPCC 2013, p. 6

Climate facts – temperature rise



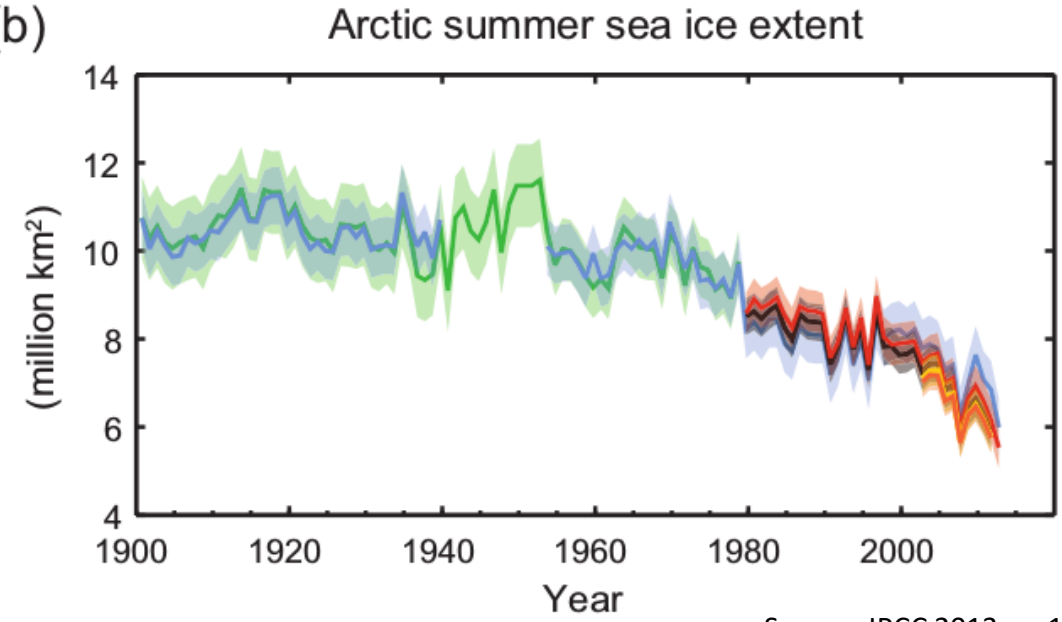
Climate facts – crytosphere



Source: IPCC 2013, p. 41

Climate facts – cryosphere

"Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent (high confidence)" (IPCC 2013, p. 10)



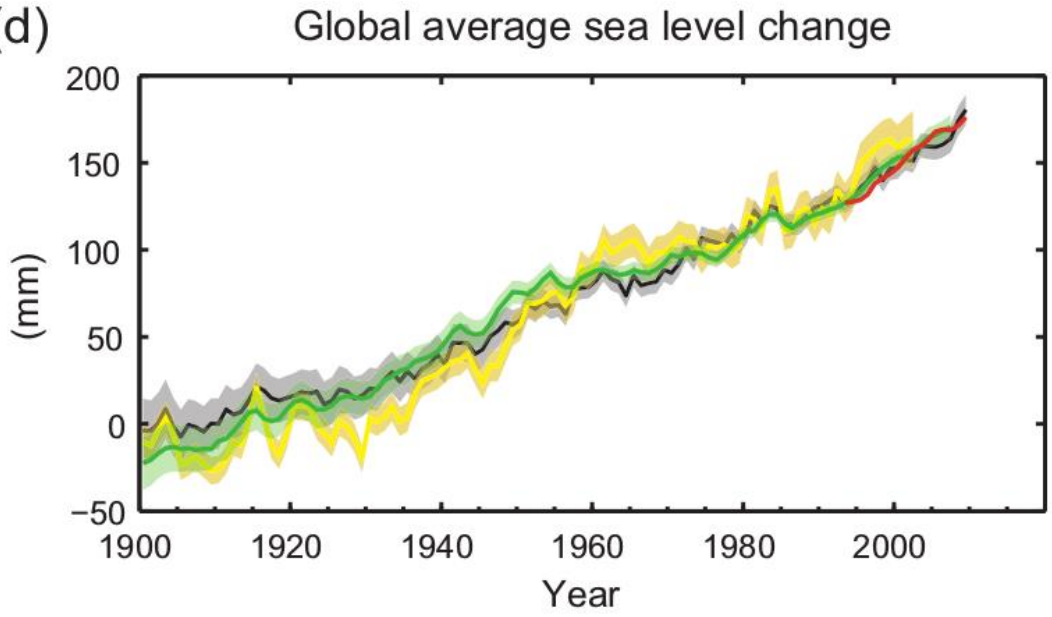
Source: IPCC 2013, p. 10

Climate facts – ocean

“Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90% of the energy accumulated between 1971 and 2010 (high confidence). It is virtually certain that the upper ocean (0–700 m) warmed from 1971 to 2010 and it likely warmed between the 1870s and 1971.” (IPCC 2013, p.8)

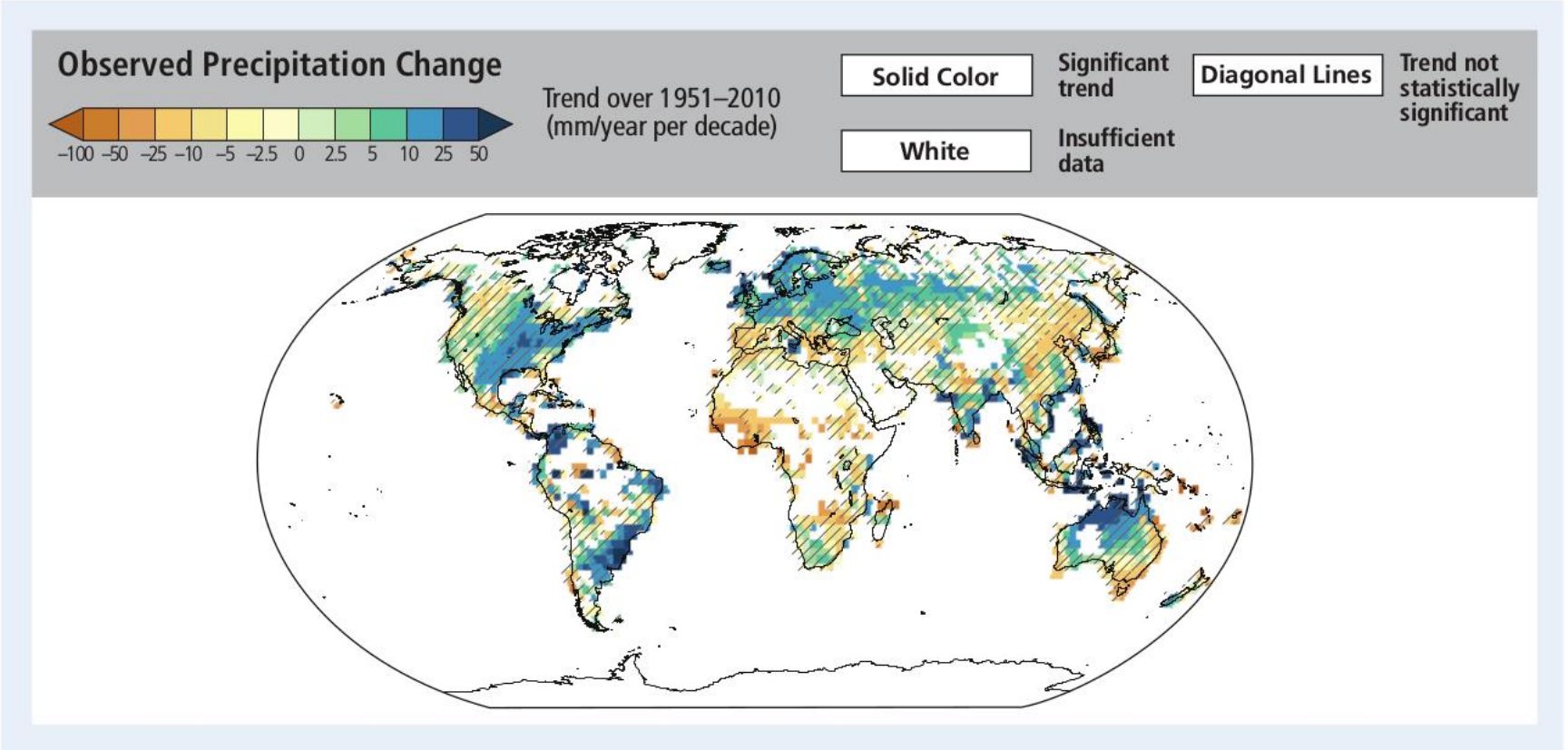
Climate facts – sea level

"The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia (high confidence). Over the period ***1901 to 2010, global mean sea level rose by 0.19*** *[0.17 to 0.21] m"* (IPCC 2013, p. 11)



Source: IPCC 2013, p. 10

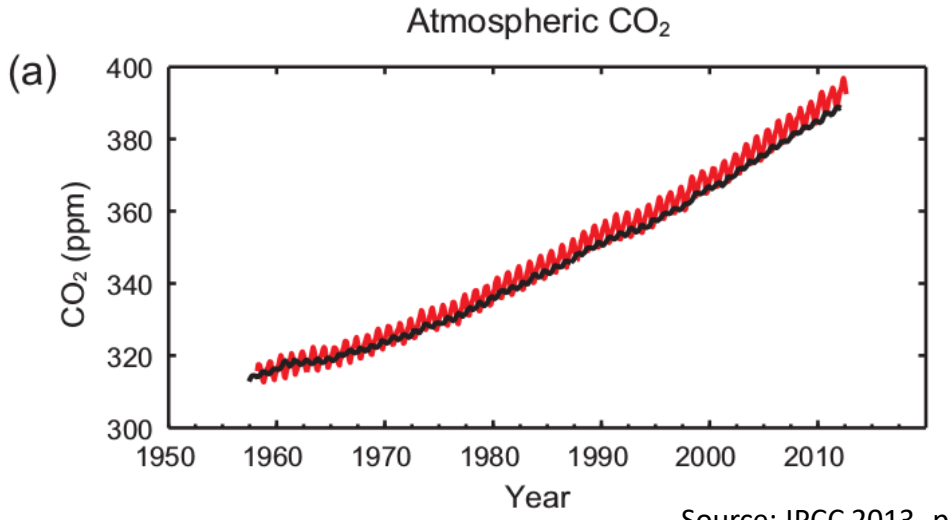
Climate facts - precipation



Source: IPCC 2014 (WG II), TS, p.58)

Climate facts - carbon and other biogeochemical cycles

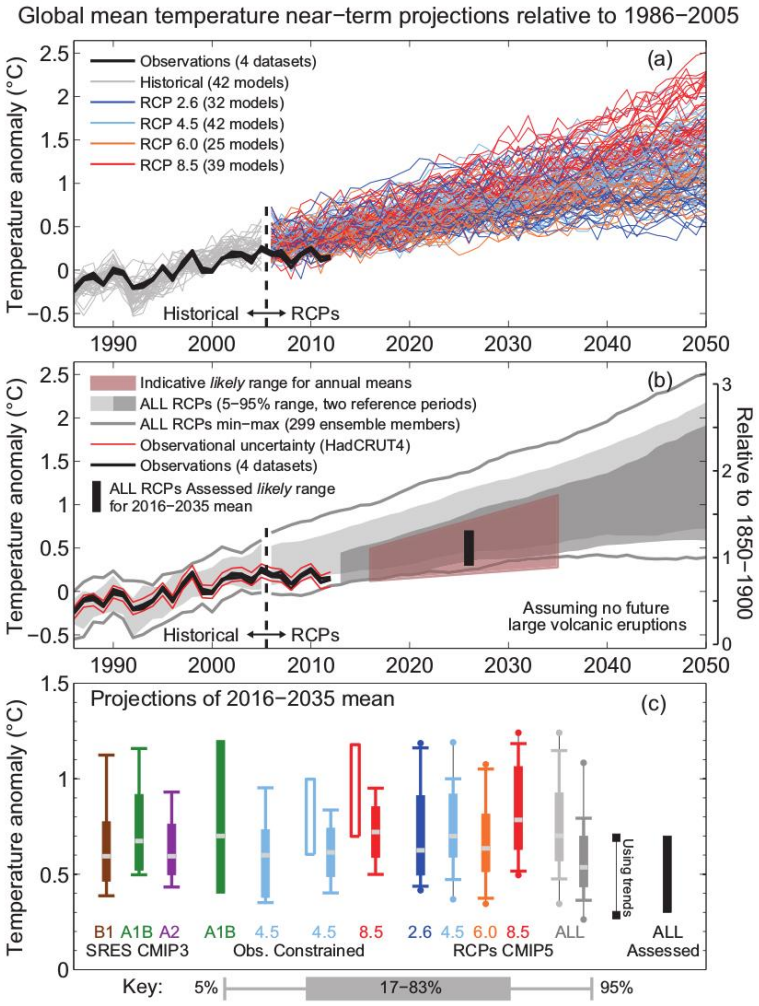
"The atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years. ***Carbon dioxide concentrations have increased by 40% since pre-industrial times****, primarily from fossil fuel emissions and secondarily from net land use change emissions. The ocean has absorbed about 30% of the emitted anthropogenic carbon dioxide, causing ocean acidification"* (IPCC 2013, p. 11)



Source: IPCC 2013, p. 10

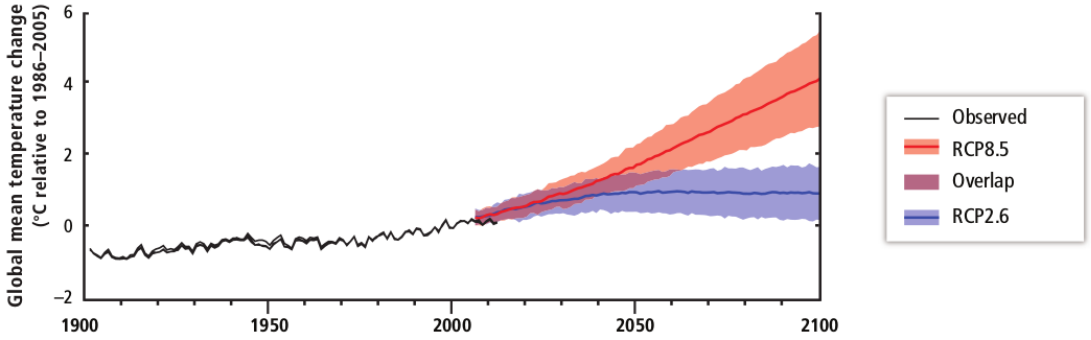
Projections of climate change

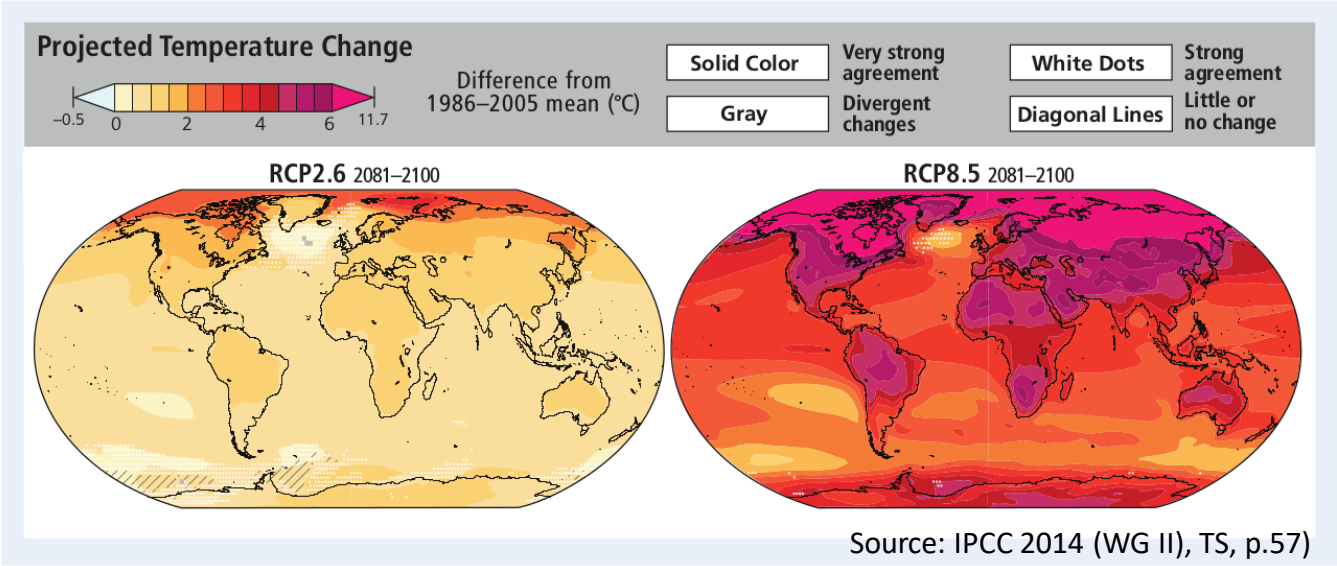
Near term projections - temperature



Source: IPCC 2013 (WG I), TS, S.87

Long term projections - temperature

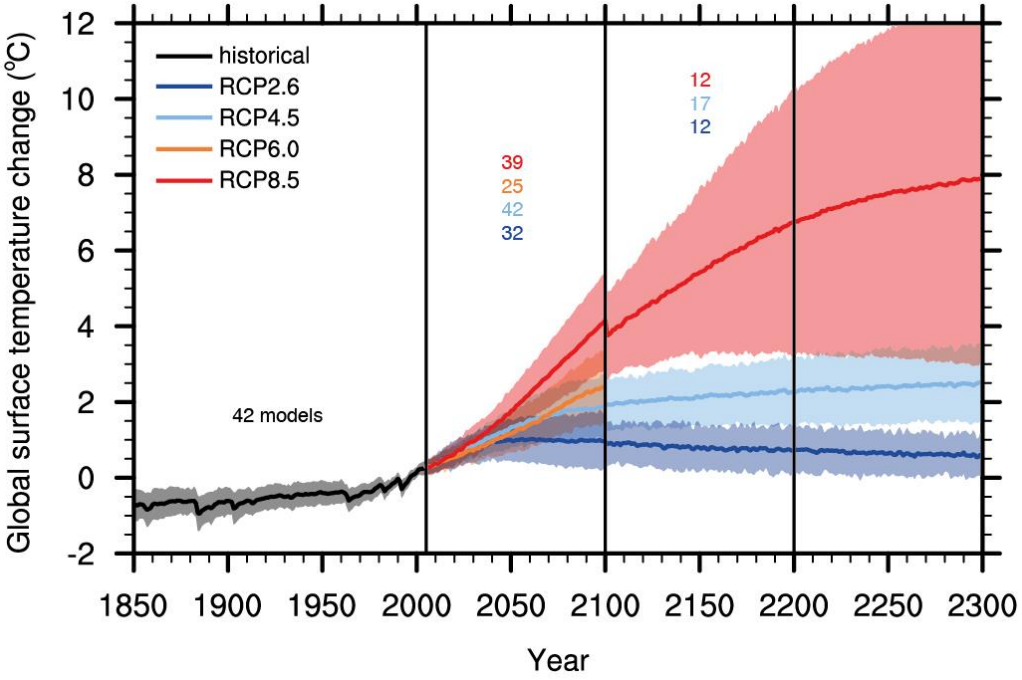




Source: IPCC 2014 (WG II), TS, p.57)

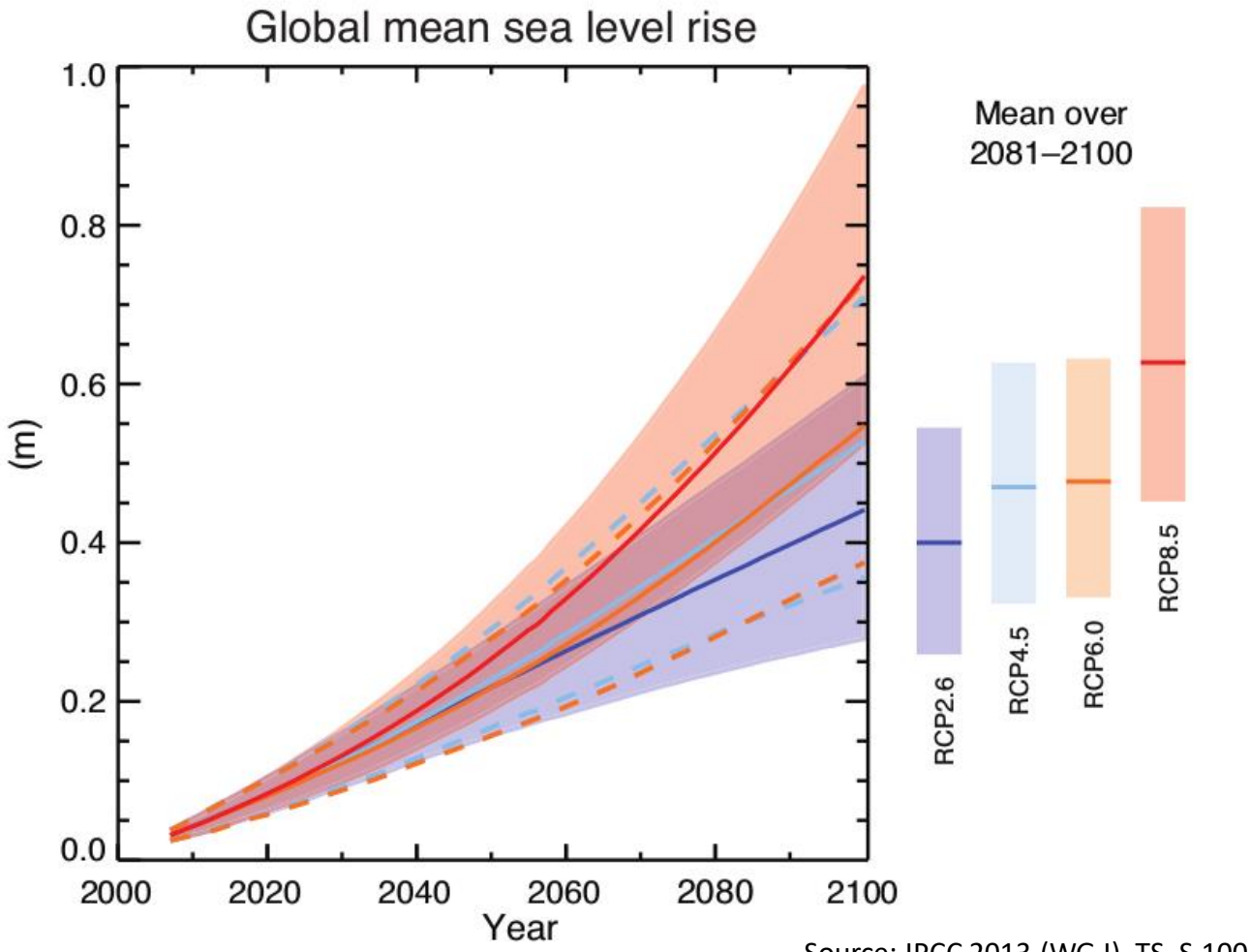
Long term projections - temperature

Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. {6, 11–14}



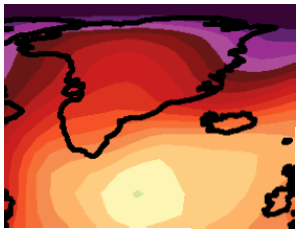
Source: IPCC 2013 (WG I), TS, S.89)

Projection – sea level rise (mid term)



Source: IPCC 2013 (WG I), TS, S.100

IPCC: Business as usual (A2) will induce at least 7m global sea level rise by melting Greenland

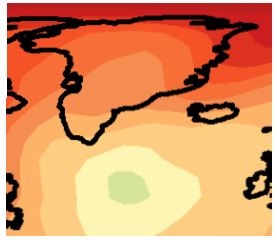


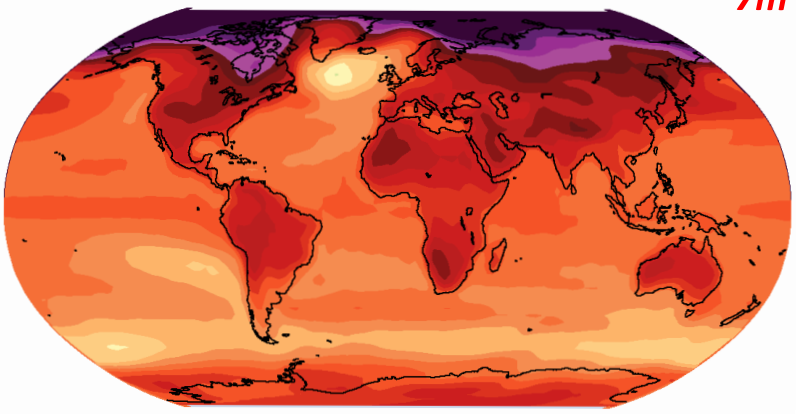
A2

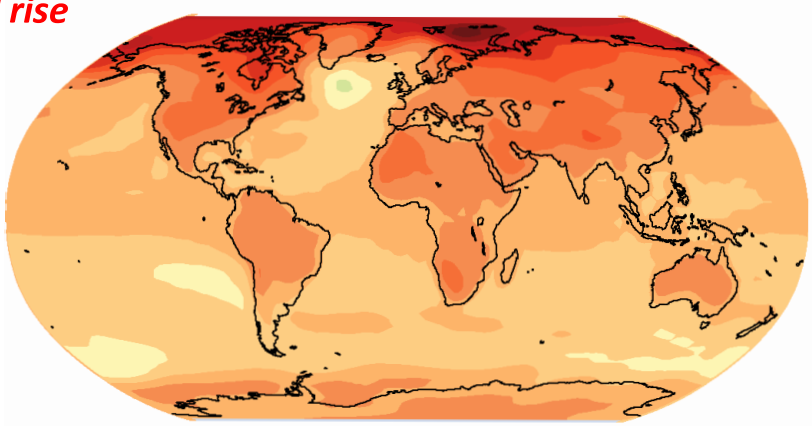
Warming over Greenland 2090-2099:
- B1: 1 – 3°C (southern- to northern tip)
- A2: 2,5 – 7,5°C (‚BAU!')

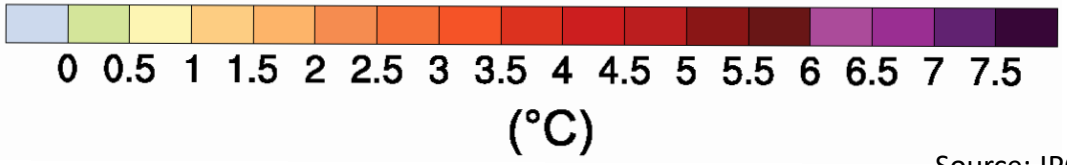
Critical value 3°C (TAR)
Ice volume for
7m global sea level rise

B1



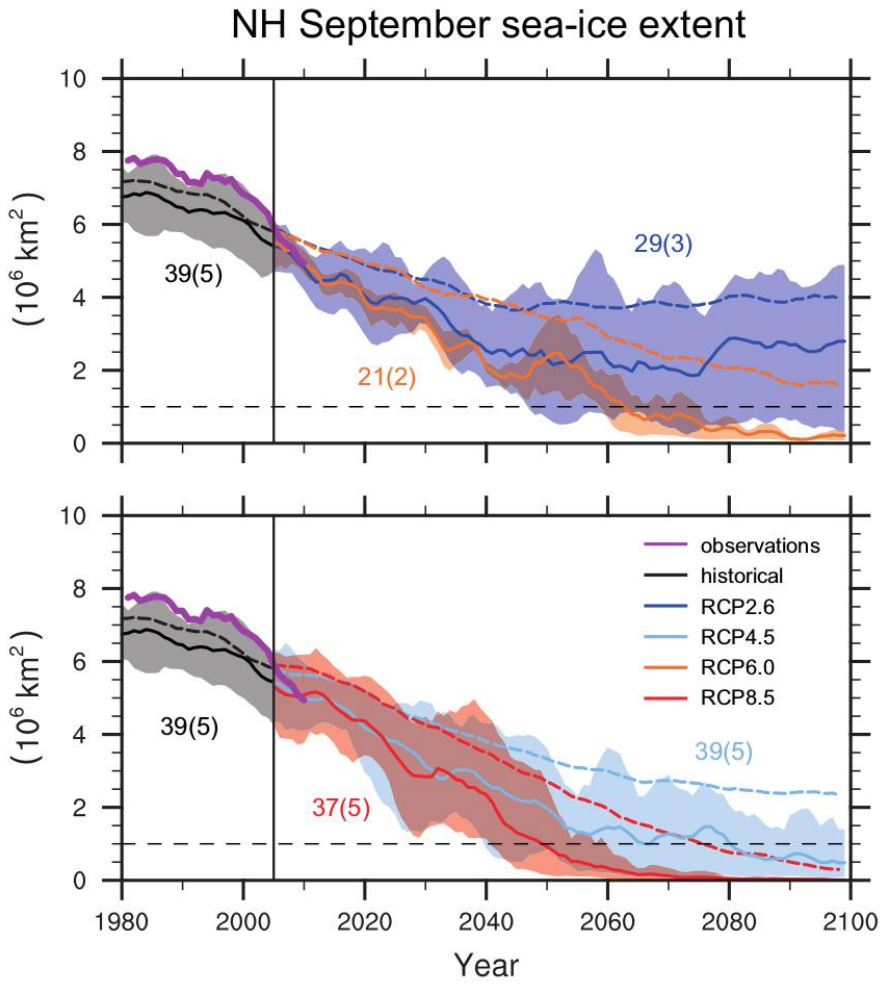


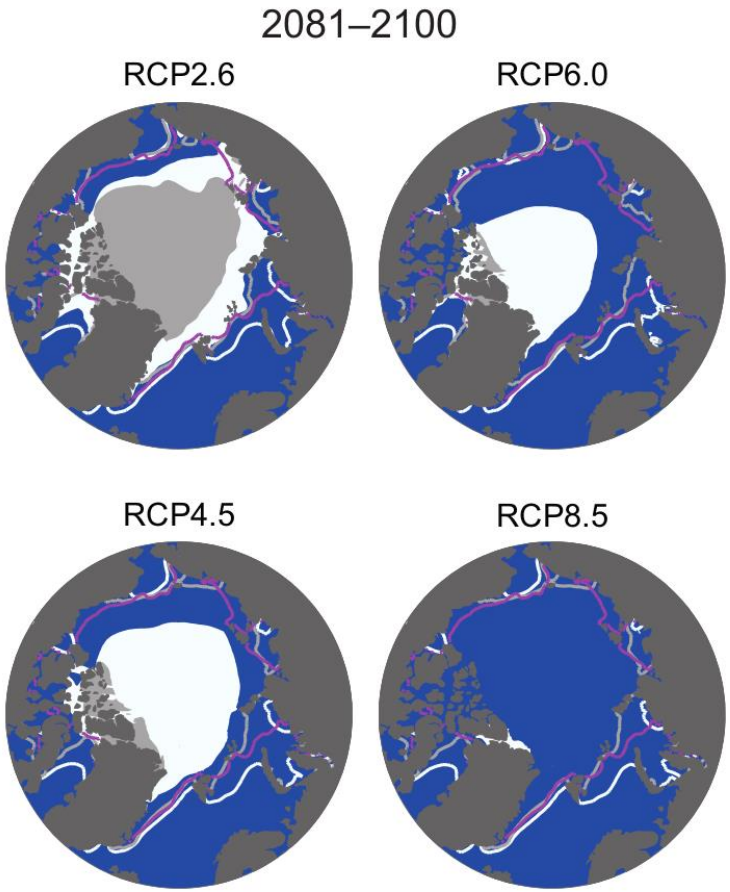




Source: IPCC 2007 (WG I, SPM S.15)

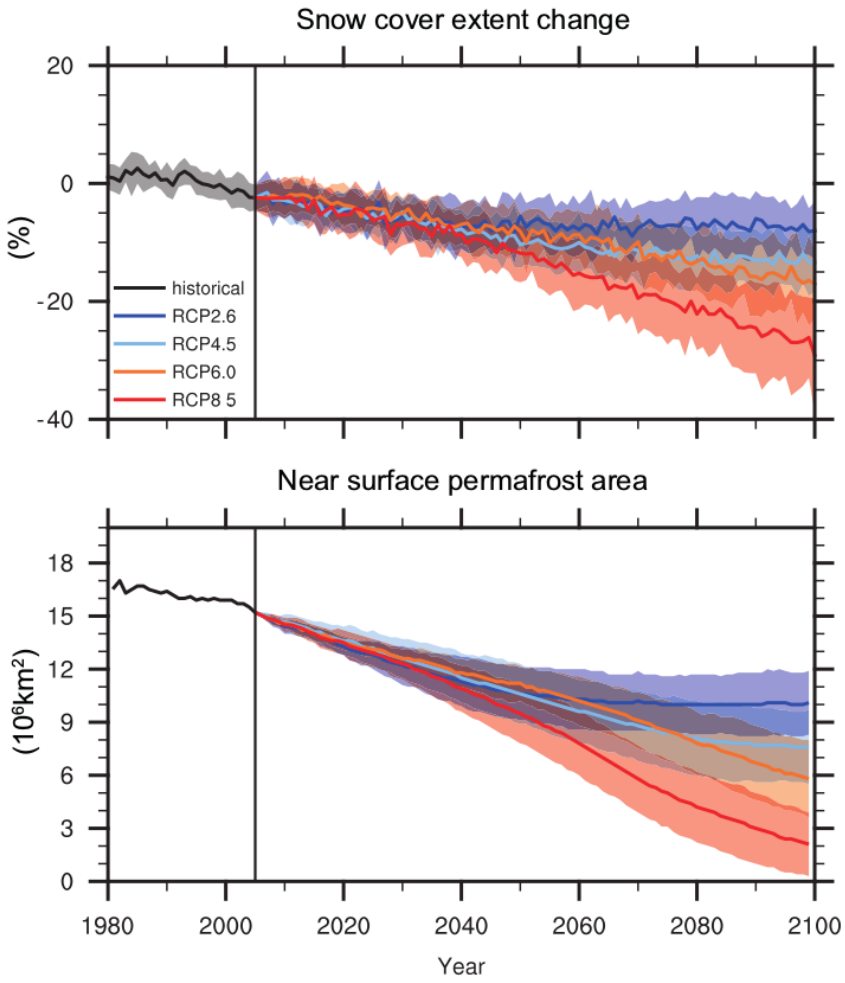
Projection - crytosphere





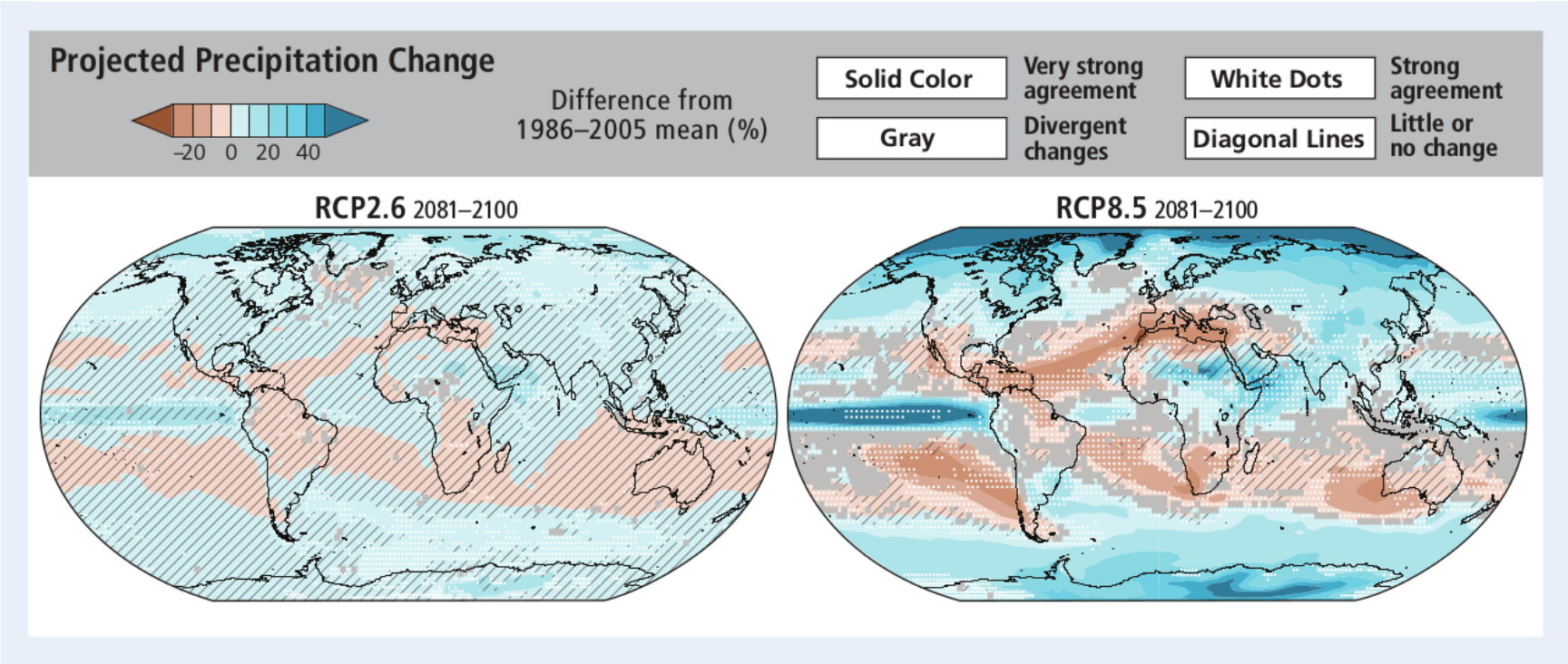
Source: IPCC 2013 (WG I), TS, S.92

Projection - crytosphere



Source: IPCC 2013 (WG I), TS, S.93

Projection - precipation



Source: IPCC 2014 (WG II), TS, p.58)

Mitigation of climate change

Mitigation strategies

	GHG emissions intensity reduction	Energy intensity reduction by improving technical efficiency	Production and resource efficiency improvement	Structural and systems efficiency improvement	Activity indicator change
Energy [Section 7.5]	*Emissions/ secondary energy output*	*Energy input/ energy output*	*Embodied energy/ energy output*	–	*Final energy use*
	Greater deployment of renewable energy (RE), nuclear energy, and (BE)CCS; fuel switching within the group of fossil fuels; reduction of fugitive (methane) emissions in the fossil fuel chain	Extraction, transport and conversion of fossil fuels; electricity/ heat/ fuel transmission, distribution, and storage; Combined Heat and Power (CHP) or cogeneration (*see Buildings and Human Settlements*)	Energy embodied in manufacturing of energy extraction, conversion, transmission and distribution technologies	Addressing integration needs	Demand from end-use sectors for different energy carriers (*see Transport, Buildings and Industry*)
Transport [8.3]	*Emissions/ final energy*	*Final energy/ transport service*	–	*Shares for each mode*	*Total distance per year*
	Fuel carbon intensity (CO_2eq/megajoule (MJ)): Fuel switching to low-carbon fuels e.g., electricity/hydrogen from low-carbon sources (*see Energy*); specific biofuels in various modes (*see AFOLU*)	**Energy intensity (MJ/passenger-km, tonne-km):** Fuel-efficient engines and vehicle designs; more advanced propulsion systems and designs; use of lighter materials in vehicles	Embodied emissions during vehicle manufacture; material efficiency; and recycling of materials (*see Industry*); infrastructure lifecycle emissions (*see Human Settlements*)	Modal shifts from light-duty vehicles (LDVs) to public transit, cycling/walking, and from aviation and heavy-duty vehicles (HDVs) to rail; eco-driving; improved freight logistics; transport (infrastructure) planning	Journey avoidance; higher occupancy/loading rates; reduced transport demand; urban planning (*see Human Settlements*)

Source: IPCC 2014 (WG III), TS, p.68)

Mitigation strategies

	GHG emissions intensity reduction	Energy intensity reduction by improving technical efficiency	Production and resource efficiency improvement	Structural and systems efficiency improvement	Activity indicator change
Buildings [9.3]	*Emissions/ final energy*	*Final energy/ useful energy*	*Embodied energy/ operating energy*	*Useful energy/ energy service*	*Energy service demand*
	Fuel carbon intensity (CO_2eq/MJ): Building-integrated RE technologies; fuel switching to low-carbon fuels, e.g., electricity (*see Energy*)	**Device efficiency:** heating/ cooling (high-performance boilers, ventilation, air-conditioning, heat pumps); water heating; cooking (advanced biomass stoves); lighting; appliances	Building lifetime; component, equipment, and appliance durability; low(er) energy and emission material choice for construction (*see Industry*)	**Systemic efficiency:** integrated design process; low/zero energy buildings; building automation and controls; urban planning; district heating/cooling and CHP; smart meters/grids; commissioning	Behavioural change (e.g., thermostat setting, appliance use); lifestyle change (e.g., per capita dwelling size, adaptive comfort)
Industry [10.4]	*Emissions/ final energy*	*Final energy/ material production*	*Material input/ product output*	*Product demand/ service demand*	*Service demand*
	Emissions intensity: Process emissions reductions; use of waste (e.g., municipal solid waste (MSW)/sewage sludge in cement kilns) and CCS in industry; HFCs replacement and leak repair; fuel switching among fossil fuels to low-carbon electricity (*see Energy*) or biomass (*see AFOLU*)	**Energy efficiency/ best available technologies:** Efficient steam systems; furnace and boiler systems; electric motor (pumps, fans, air compressor, refrigerators, and material handling) and electronic control systems; (waste) heat exchanges; recycling	**Material efficiency:** Reducing yield losses; manufacturing/construction: process innovations, new design approaches, re-using old material (e.g., structural steel); product design (e.g., light weight car design); fly ash substituting clinker	**Product-service efficiency:** More intensive use of products (e.g., car sharing, using products such as clothing for longer, new and more durable products)	Reduced demand for, e.g., products such as clothing; alternative forms of travel leading to reduced demand for car manufacturing
Human Settlements [12.4]	*Emissions/ final energy*	*Final energy/ useful energy*	*Material input in infrastructure*	*Useful energy/ energy service*	*Service demand per capita*
	Integration of urban renewables; urban-scale fuel switching programmes	Cogeneration, heat cascading, waste to energy	Managed infrastructure supply; reduced primary material input for infrastructure	Compact urban form; increased accessibility; mixed land use	Increasing accessibility: shorter travel time, and more transport mode options

Source: IPCC 2014 (WG III), TS, p.68)

Mitigation strategies

	Supply-side improvements			Demand-side measures
	Emissions/ area or unit product (conserved, restored)			*Animal/crop product consumption per capita*
Agriculture, Forestry and Other Land Use (AFOLU) [11.3]	**Emissions reduction:** of methane (e.g., livestock management) and nitrous oxide (fertilizer and manure management) and prevention of emissions to the atmosphere by conserving existing carbon pools in soils or vegetation (reducing deforestation and forest degradation, fire prevention/control, agroforestry); reduced emissions intensity (GHG/unit product).	**Sequestration:** Increasing the size of existing carbon pools, thereby extracting CO_2 from the atmosphere (e.g., afforestation, reforestation, integrated systems, carbon sequestration in soils)	**Substitution:** of biological products for fossil fuels or energy-intensive products, thereby reducing CO_2 emissions, e.g., biomass co-firing/CHP (*see Energy*), biofuels (*see Transport*), biomass-based stoves, and insulation products (*see Buildings*)	**Demand-side measures:** Reducing losses and wastes of food; changes in human diets towards less emission-intensive products; use of long-lived wood products

Source: IPCC 2014 (WG III), TS, p.68)

Mitigation pathways/ IPCC scenarios

CO_2eq Concentrations in 2100 [ppm CO_2eq] Category label (concentration range)[9]	Subcategories	Relative position of the RCPs[5]	Cumulative CO_2 emissions[3] [$GtCO_2$]		Change in CO_2eq emissions compared to 2010 in [%][4]		Temperature change (relative to 1850–1900)[5,6]				
								Likelihood of staying below temperature level over the 21st century[8]			
			2011–2050	2011–2100	2050	2100	2100 Temperature change [°C][7]	1.5 °C	2.0 °C	3.0 °C	4.0 °C
< 430	Only a limited number of individual model studies have explored levels below 430 ppm CO_2eq										
450 (430–480)	Total range[1,10]	RCP2.6	550–1300	630–1180	−72 to −41	−118 to −78	1.5–1.7 (1.0–2.8)	*More unlikely than likely*	*Likely*		
500 (480–530)	No overshoot of 530 ppm CO_2eq		860–1180	960–1430	−57 to −42	−107 to −73	1.7–1.9 (1.2–2.9)	*Unlikely*	*More likely than not*	*Likely*	*Likely*
	Overshoot of 530 ppm CO_2eq		1130–1530	990–1550	−55 to −25	−114 to −90	1.8–2.0 (1.2–3.3)		*About as likely as not*		
550 (530–580)	No overshoot of 580 ppm CO_2eq		1070–1460	1240–2240	−47 to −19	−81 to −59	2.0–2.2 (1.4–3.6)		*More unlikely than likely*[12]		
	Overshoot of 580 ppm CO_2eq		1420–1750	1170–2100	−16 to 7	−183 to −86	2.1–2.3 (1.4–3.6)				
(580–650)	Total range	RCP4.5	1260–1640	1870–2440	−38 to 24	−134 to −50	2.3–2.6 (1.5–4.2)				
(650–720)	Total range		1310–1750	2570–3340	−11 to 17	−54 to −21	2.6–2.9 (1.8–4.5)		*Unlikely*	*More likely than not*	
(720–1000)[2]	Total range	RCP6.0	1570–1940	3620–4990	18 to 54	−7 to 72	3.1–3.7 (2.1–5.8)	*Unlikely*[11]		*More unlikely than likely*	
>1000[2]	Total range	RCP8.5	1840–2310	5350–7010	52 to 95	74 to 178	4.1–4.8 (2.8–7.8)		*Unlikely*[11]	*Unlikely*	*More unlikely than likely*

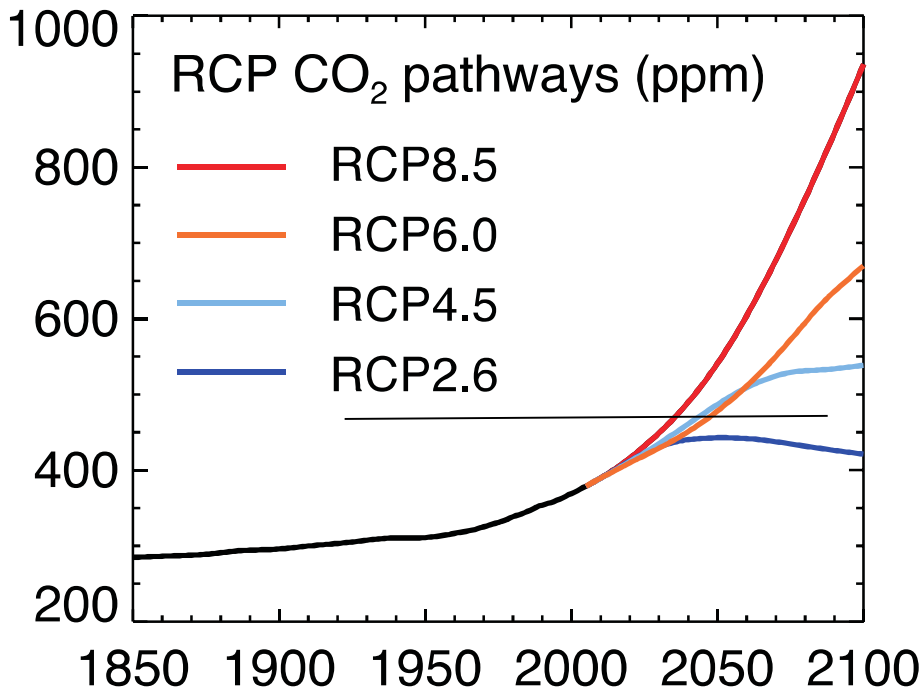
Source: IPCC 2014 (WG III), TS, p.54)

Time is running out

•GHG concentration is fast approaching the maximum tolerable level, necessary for a temperature stabilization below the **2° C threshold (< 450 ppm CO_2)**

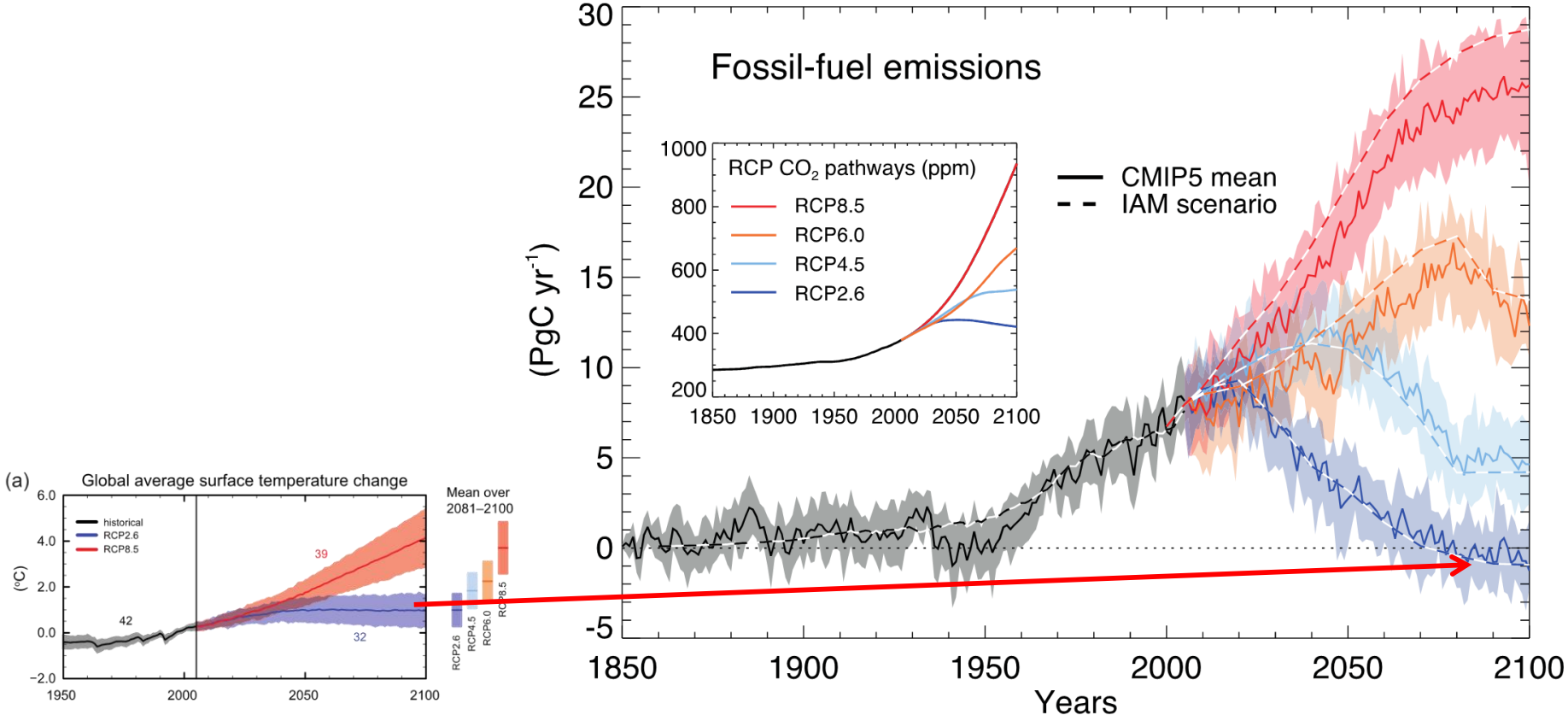
•Increase since 2000 from 369 to 391 ppm in 2011

•If we don't reduce our annual emissions we will have passed **450 ppm by 2040**



source: IPCC 2013 (WG I), TS, p.94)

IPCC: Without fast emission reductions we need negative fossil fuel-emissions after 2080 (2°C)



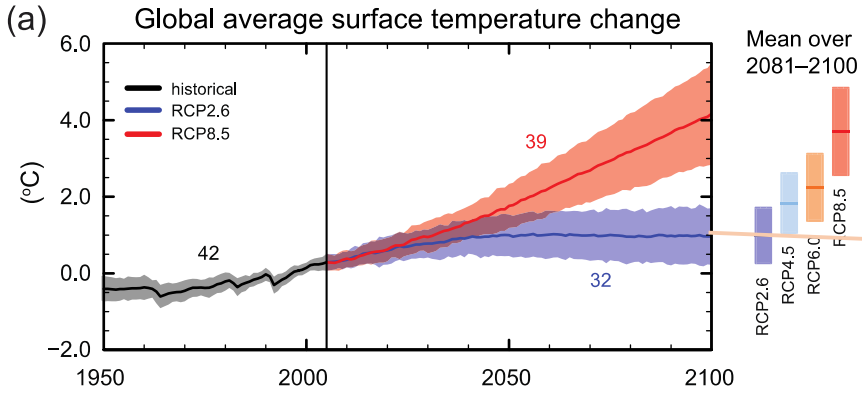
Source: IPCC 2013 (WG I), TS, S.94)

GHG Emissions have to be drastically limited

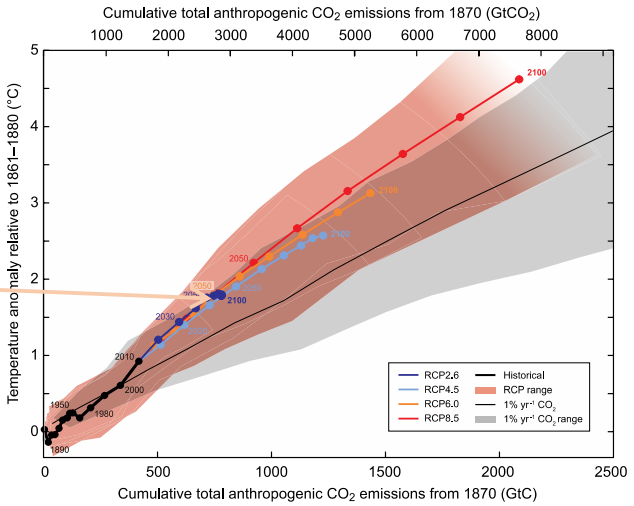
Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. {6, 11–14}

source: IPCC 2013 (WG I), SPM, p.17

- RCP2.6 reqiures limiting global emissions till 2100 to 790 $GtCO_2$
- 515 $GtCO_2$ have already been emitted, leaving a rest of 275 $GtCO_2$



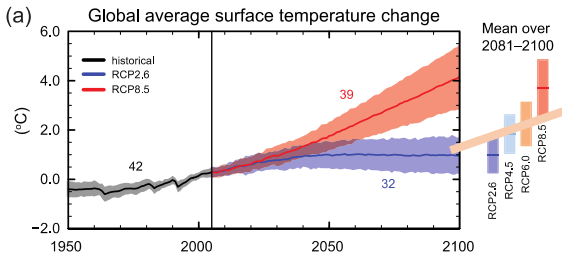
source: IPCC 2013 (WG I), SPM, p.19



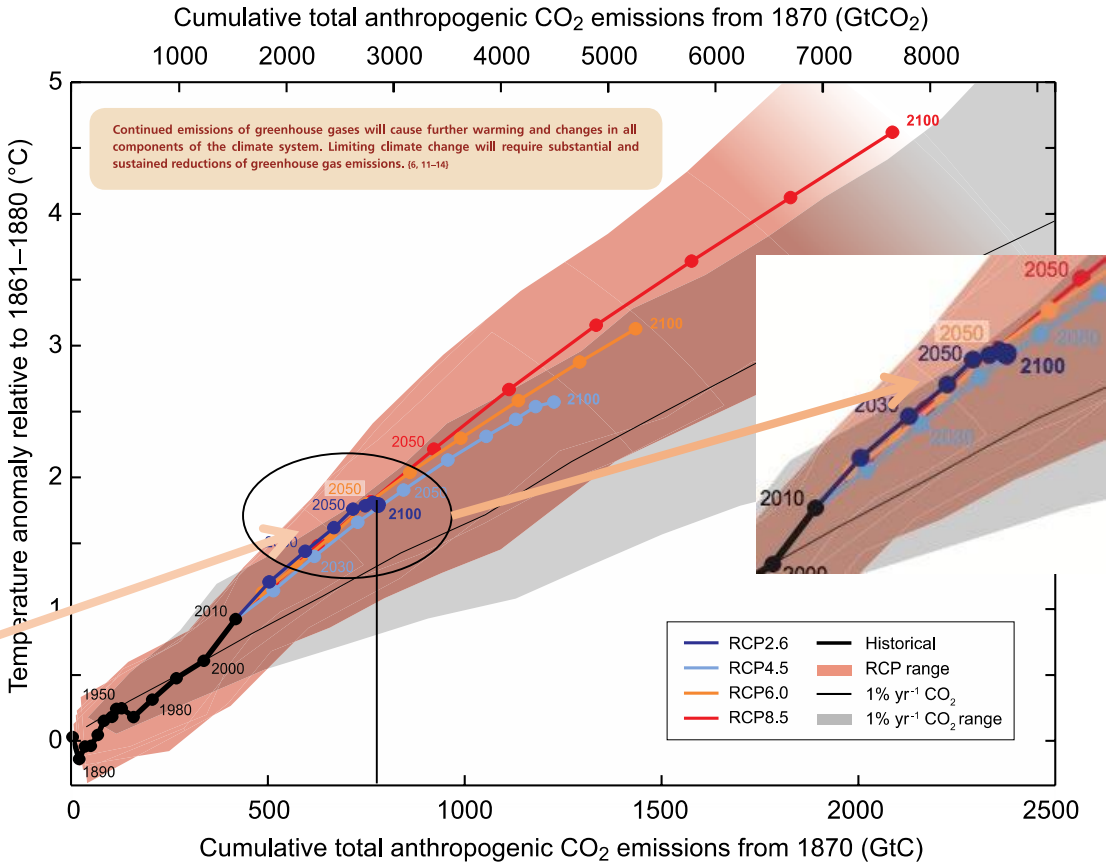
source: IPCC 2013 (WG I), SPM, p.26

By 2100 global emissions have to be reduced to zero

- Between 2050 and 2100 there are hardly any possible emissions left



source: IPCC 2013 (WG I), SPM, S.19)



source: IPCC 2013 (WG I), SPM, S.26)

Policy instruments by sector

Policy Instruments	Energy [7.12]	Transport [8.10]	Buildings [9.10]	Industry [10.11]	AFOLU [11.10]	Human Settlements and Infrastructure
Economic Instruments—Taxes (Carbon taxes may be economy-wide)	• Carbon taxes	• Fuel taxes • Congestion charges, vehicle registration fees, road tolls • Vehicle taxes	• Carbon and/or energy taxes (either sectoral or economy wide)	• Carbon tax or energy tax • Waste disposal taxes or charges	• Fertilizer or Nitrogen taxes to reduce nitrous oxide	• Sprawl taxes, Impact fees, exactions, split-rate property taxes, tax increment finance, betterment taxes, congestion charges
Economic Instruments—Tradable Allowances (May be economy-wide)	• Emissions trading (e.g., EU ETS) • Emission credits under CDM • Tradable Green Certificates	• Fuel and vehicle standards	• Tradable certificates for energy efficiency improvements (white certificates)	• Emissions trading • Emission credit under CDM • Tradable Green Certificates	• Emission credits under the Kyoto Protocol's Clean Development Mechanism (CDM) • Compliance schemes outside Kyoto protocol (national schemes) • Voluntary carbon markets	• Urban-scale Cap and Trade

Source: IPCC 2014 (WG III), TS, p.97)

Policy instruments by sector

Policy Instruments	Energy [7.12]	Transport [8.10]	Buildings [9.10]	Industry [10.11]	AFOLU [11.10]	Human Settlements and Infrastructure
Economic Instruments—Subsidies	• Fossil fuel subsidy removal • Feed-in-tariffs for renewable energy • Capital subsidies and insurance for 1st generation Carbon Dioxide Capture and Storage (CCS)	• Biofuel subsidies • Vehicle purchase subsidies • Feebates	• Subsidies or Tax exemptions for investment in efficient buildings, retrofits and products • Subsidized loans	• Subsidies (e.g., for energy audits) • Fiscal incentives (e.g., for fuel switching)	• Credit lines for low carbon agriculture, sustainable forestry.	• Special Improvement or Redevelopment Districts
Regulatory Approaches	• Efficiency or environmental performance standards • Renewable Portfolio standards for renewable energy • Equitable access to electricity grid • Legal status of long term CO_2 storage	• Fuel economy performance standards • Fuel quality standards • GHG emission performance standards • Regulatory restrictions to encourage modal shifts (road to rail) • Restriction on use of vehicles in certain areas • Environmental capacity constraints on airports • Urban planning and zoning restrictions	• Building codes and standards • Equipment and appliance standards • Mandates for energy retailers to assist customers invest in energy efficiency	• Energy efficiency standards for equipment • Energy management systems (also voluntary) • Voluntary agreements (where bound by regulation) • Labelling and public procurement regulations	• National policies to support REDD+ including monitoring, reporting and verification • Forest law to reduce deforestation • Air and water pollution control GHG precursors • Land-use planning and governance	• Mixed use zoning • Development restrictions • Affordable housing mandates • Site access controls • Transfer development rights • Design codes • Building codes • Street codes • Design standards

Source: IPCC 2014 (WG III), TS, p.97)

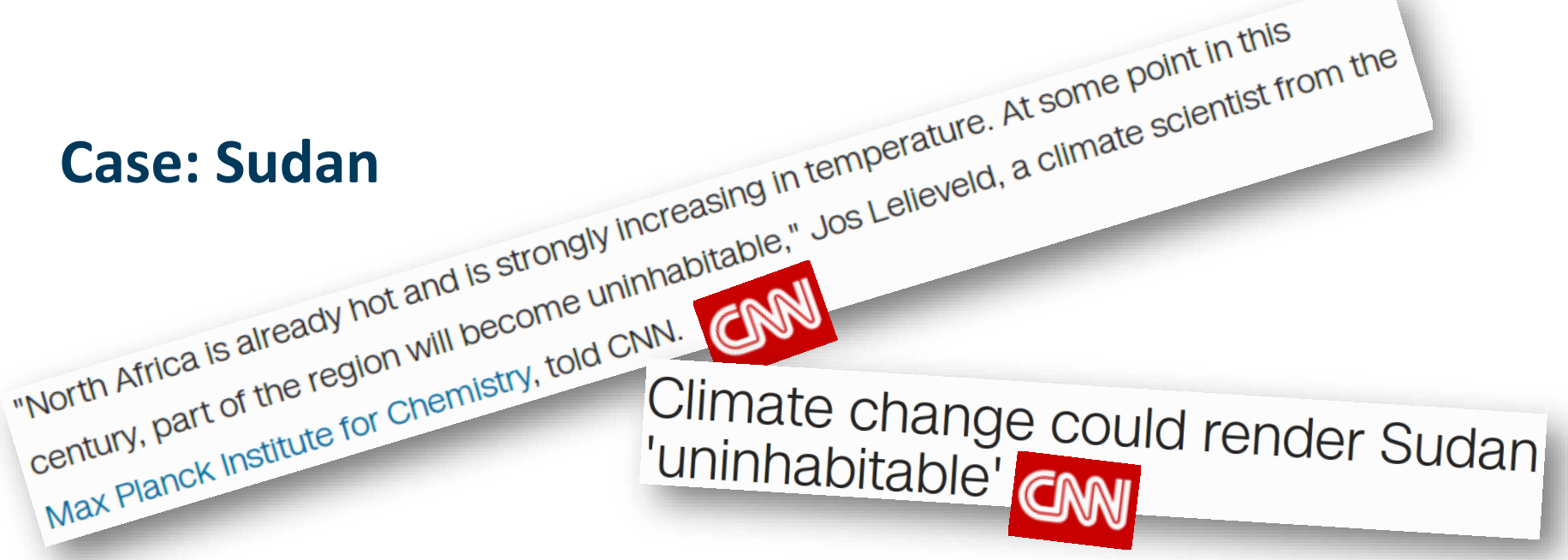
Policy instruments by sector

Policy Instruments	Energy [7.12]	Transport [8.10]	Buildings [9.10]	Industry [10.11]	AFOLU [11.10]	Human Settlements and Infrastructure
Information Programmes		• Fuel labelling • Vehicle efficiency labelling	• Energy audits • Labelling programmes • Energy advice programmes	• Energy audits • Benchmarking • Brokerage for industrial cooperation	• Certification schemes for sustainable forest practices • Information policies to support REDD+ including monitoring, reporting and verification	
Government Provision of Public Goods or Services	• Research and development • Infrastructure expansion (district heating/cooling or common carrier)	• Investment in transit and human powered transport • Investment in alternative fuel infrastructure • Low emission vehicle procurement	• Public procurement of efficient buildings and appliances	• Training and education • Brokerage for industrial cooperation	• Protection of national, state, and local forests. • Investment in improvement and diffusion of innovative technologies in agriculture and forestry	• Provision of utility infrastructure such as electricity distribution, district heating/cooling and wastewater connections, etc. • Park improvements • Trail improvements • Urban rail
Voluntary Actions			• Labelling programmes for efficient buildings • Product eco-labelling	• Voluntary agreements on energy targets or adoption of energy management systems, or resource efficiency	• Promotion of sustainability by developing standards and educational campaigns	

Source: IPCC 2014 (WG III), TS, p.97)

Impacts of climate change

Case: Sudan



- 70 percent of the rural population are reliant on traditional rain-fed agriculture
- Sudan is one of the most vulnerable countries to climate change because of the issue of food security, it ranks 98th out of 113 countries on the Global Hunger Index

Source: CNN 2016, url:http://edition.cnn.com/2016/12/07/africa/sudan-climate-change/

Thanks for your attention!