

# Climate change, mitigation and related perspectives

Prof. Petteri Taalas  
Secretary-General



WMO OMM

World Meteorological Organization  
Organisation météorologique mondiale

# Petteri Taalas



## Secretary General of the WMO 2016-19, 2020-23

- Historical reform, enhanced efficiency: Integrated Earth observations, multihazard services
- Engagement of private sector & academic sector, development & UN partnerships

## Director at the WMO Development & Regional Activities 2005-7

## Director General of the Finnish Meteorological Institute 2002-15, 700 staff, ~80 M€/year

- Doubling of external funding, tripling of scientific publications
- Very high customer & staff satisfaction, best public sector organization in Finland
- Modern weather, marine & climate services and atmospheric science

## Professor & scientist 1986-2002: climate, atmospheric chemistry, satellites, Arctic/Antarctica

## Chairman of EUMETSAT Council 2010-, 500 staff, ~400 M€/year

- Effective management of Council meetings, New polar satellite programme (~1.5 B€)

## Univ. of Eastern Finland, Chairman of the Board 2009-15, 2800 staff, 15000 students, 260 M€

- Merging of two universities & a new semi-private administrative model

## Fortum energy company, board member 2014-16, advisory board 2011-, 11000 staff, 6100 M€

- Emphasis on low carbon energy solutions, business in ~10 countries

## PhD & MSc Helsinki Univ/meteorology, management training Uni. Pierre & Marie Curie etc.

## Military service at Naval Academy, reserve captain

English, Finnish, Swedish, German, French, Russian



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FMI



EUMETSAT



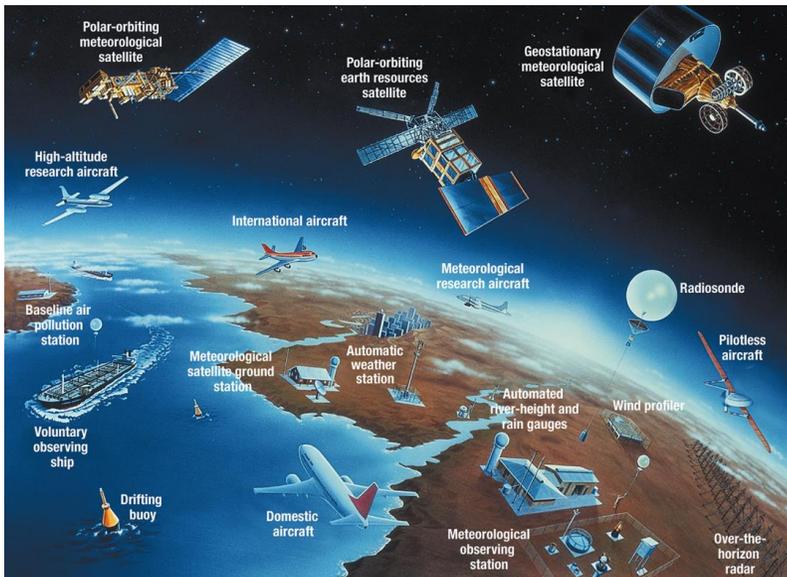
UNIVERSITY OF  
EASTERN FINLAND

Fortum

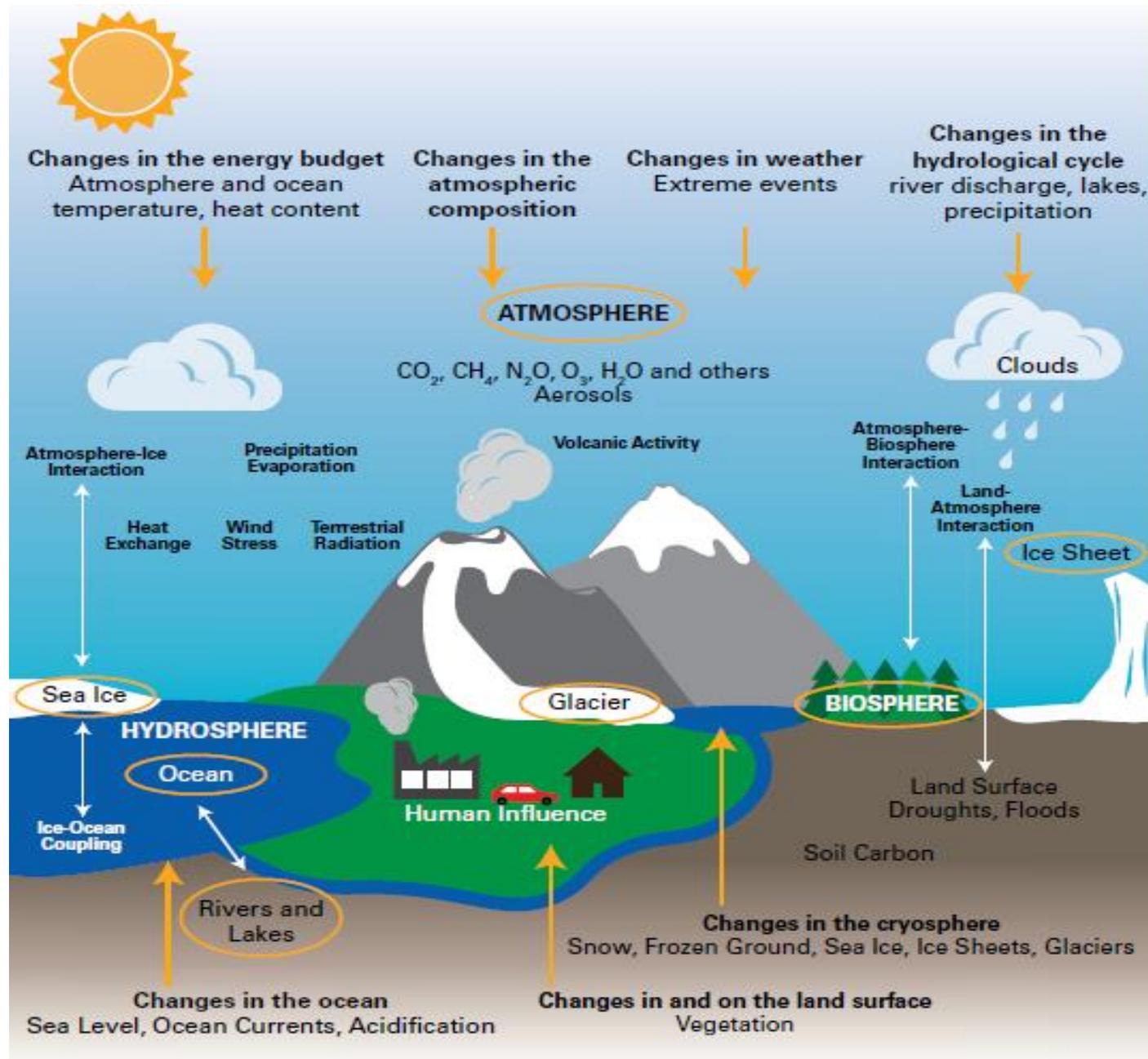
# World Meteorological Organization



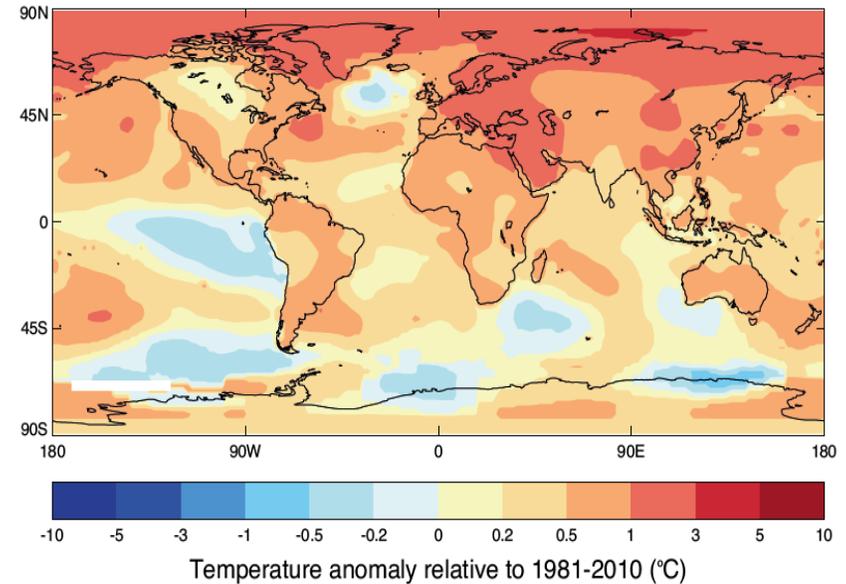
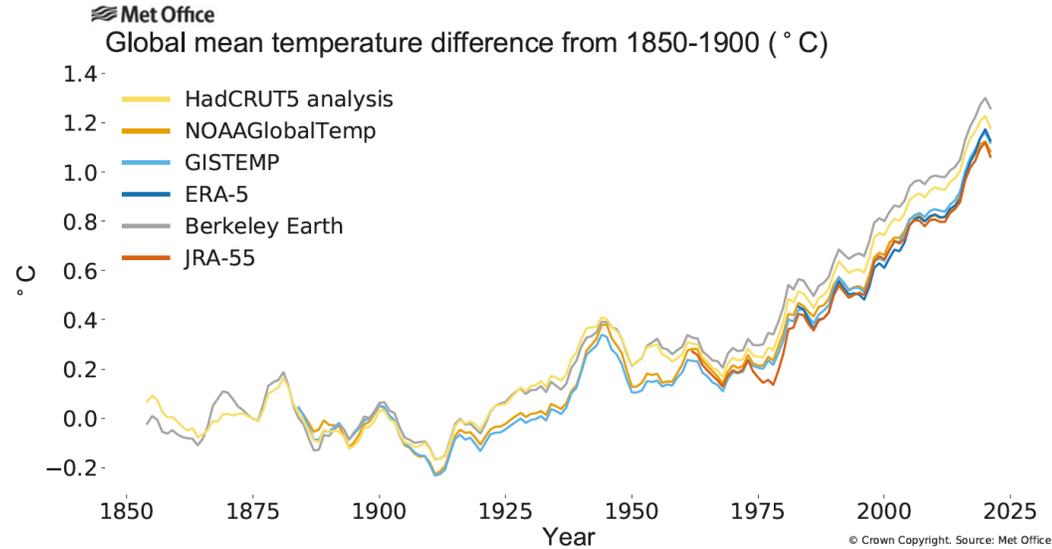
- UN Specialized Agency on weather, climate & water
- 193 Members, HQ in Geneva
- 2<sup>nd</sup> oldest UN Agency, 1873-
- Coordinates work of > 300 000 national experts from meteorological & hydrological services, academia & private sector
- Co-Founder and host agency of IPCC (1<sup>st</sup> World Climate Conference)
- WMO SG UNSG Guterres' Climate Core Group Member (1/4)



# The climate system



# 2017-2021 is the warmest period on record

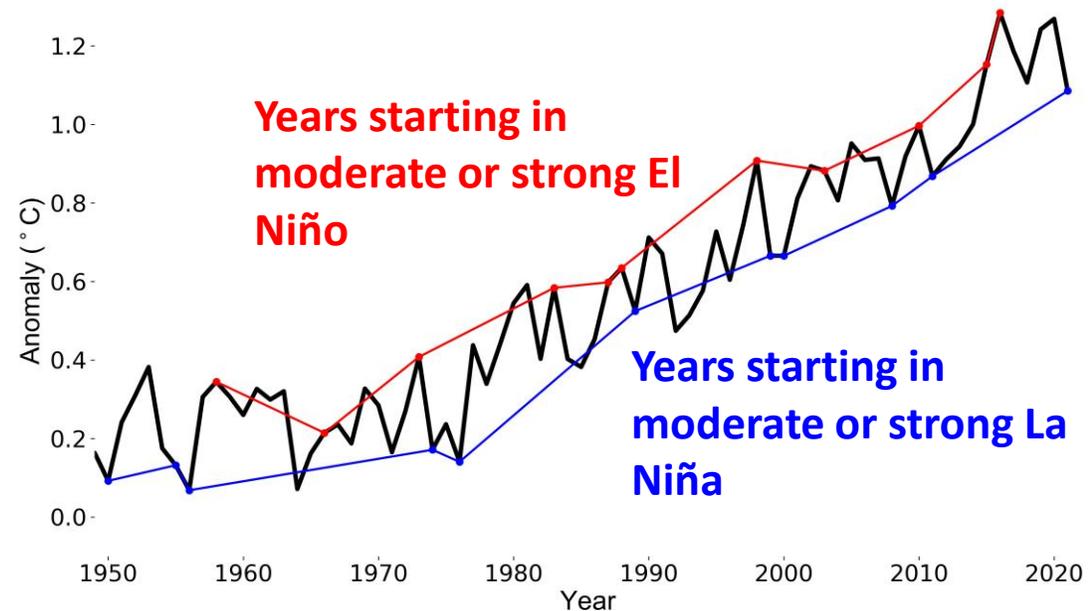


**2017-2021 is estimated to be 1.06 °C to 1.26 °C warmer than pre-industrial (1850-1900) levels**



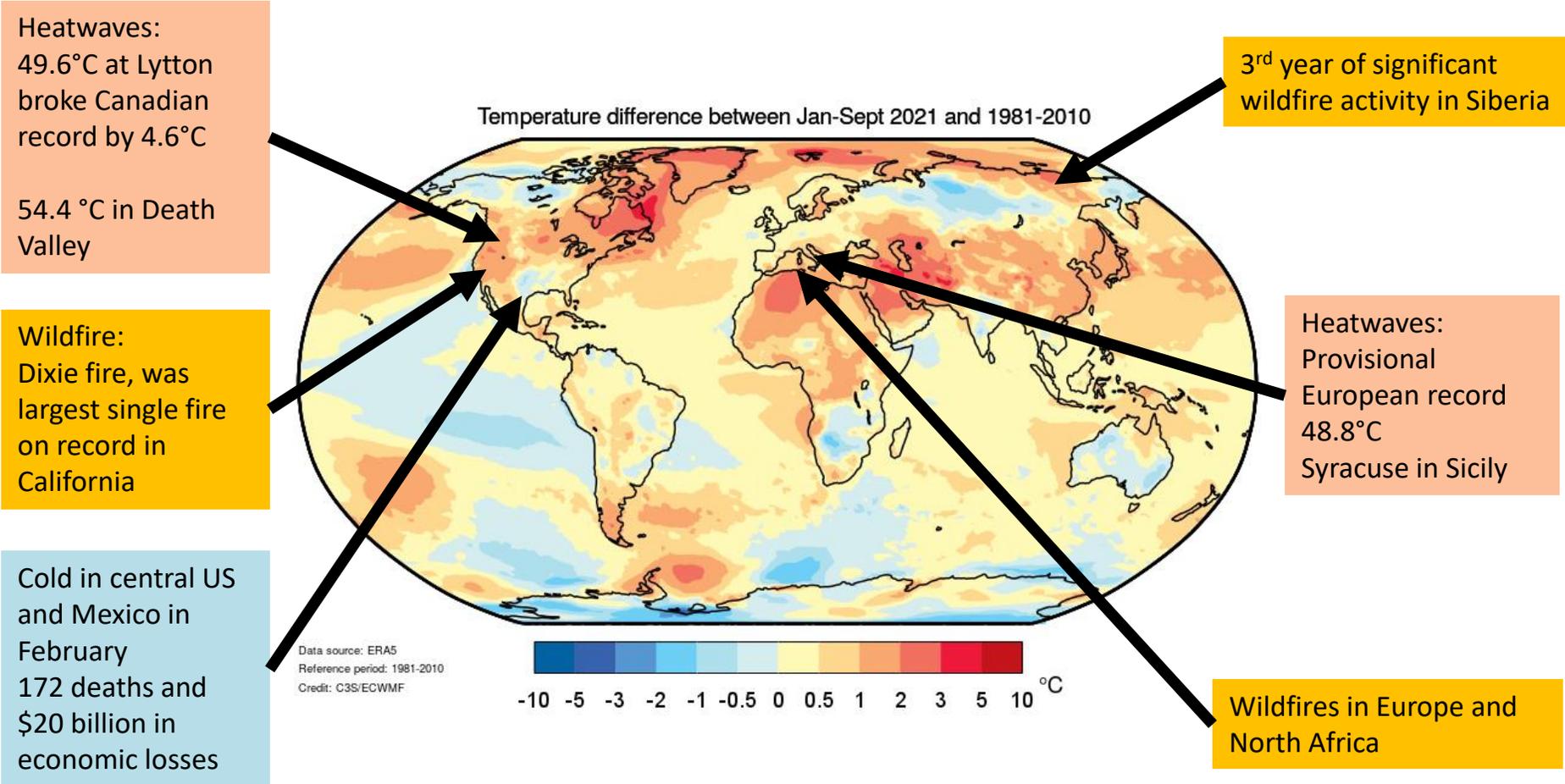
# Effect of La Niña on global temperature

- Years starting in La Niña conditions are typically cooler
- Years starting in El Niño conditions are typically warmer
- The difference is between 0.1 and 0.3°C
- Last moderate or strong La Niña was in 2011

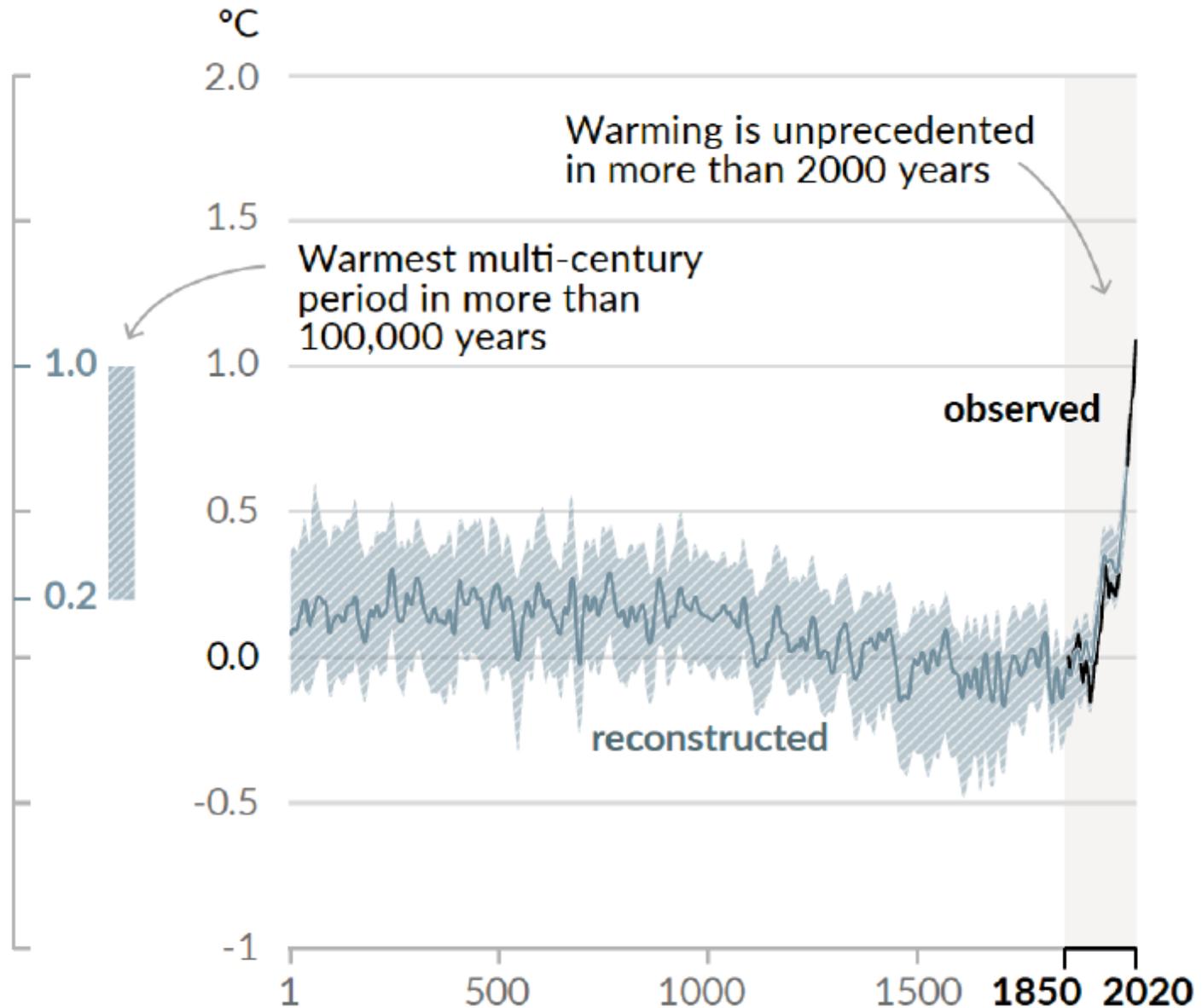


John Kennedy (Met Office Hadley Centre)

# Temperature anomalies 2021

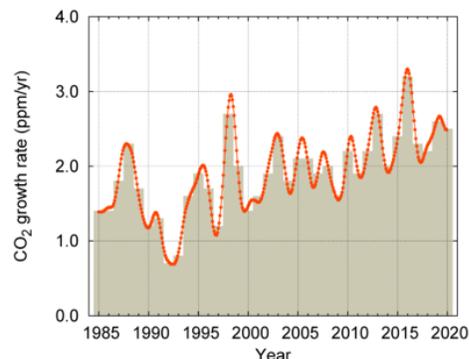
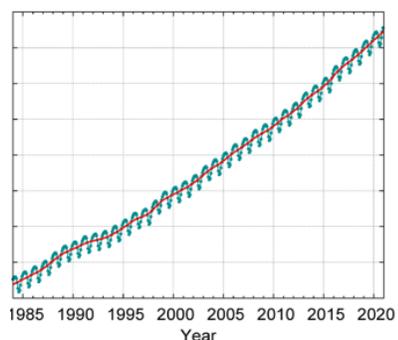


# Unusual warming 1900-2020 vs. 0-2020



# Greenhouse gas concentrations (CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O) continue to rise to new record highs

## Carbon dioxide (CO<sub>2</sub>)



413.2 ± 0.2 ppm in 2020

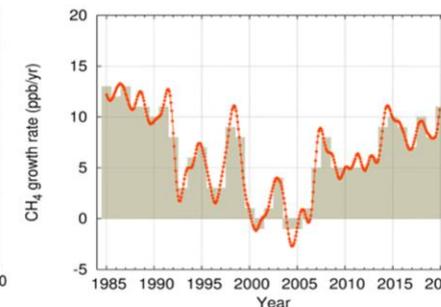
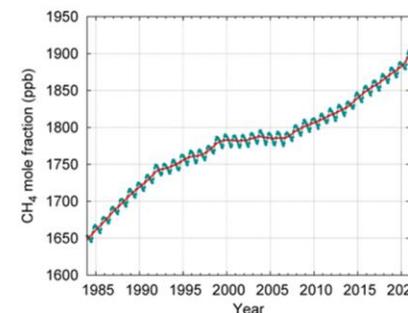
**2.5 ppm increase from 2019 to 2020** (2.6 ppm increase from 2018 to 2019) - comparable increase despite 5.6% fossil fuel CO<sub>2</sub> emission reduction in 2020  
2019 value was updated to 410.7 ppm due to change in the reference scale

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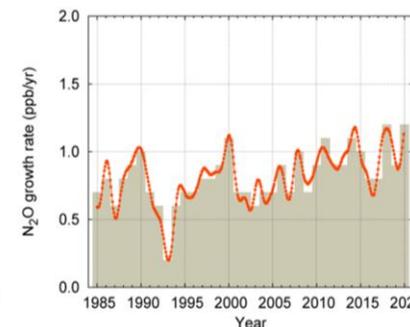
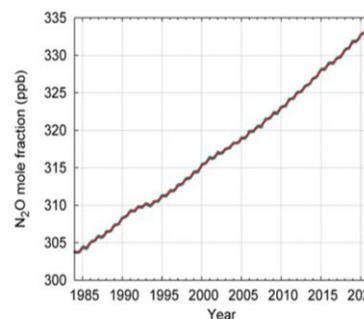
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## Methane (CH<sub>4</sub>)



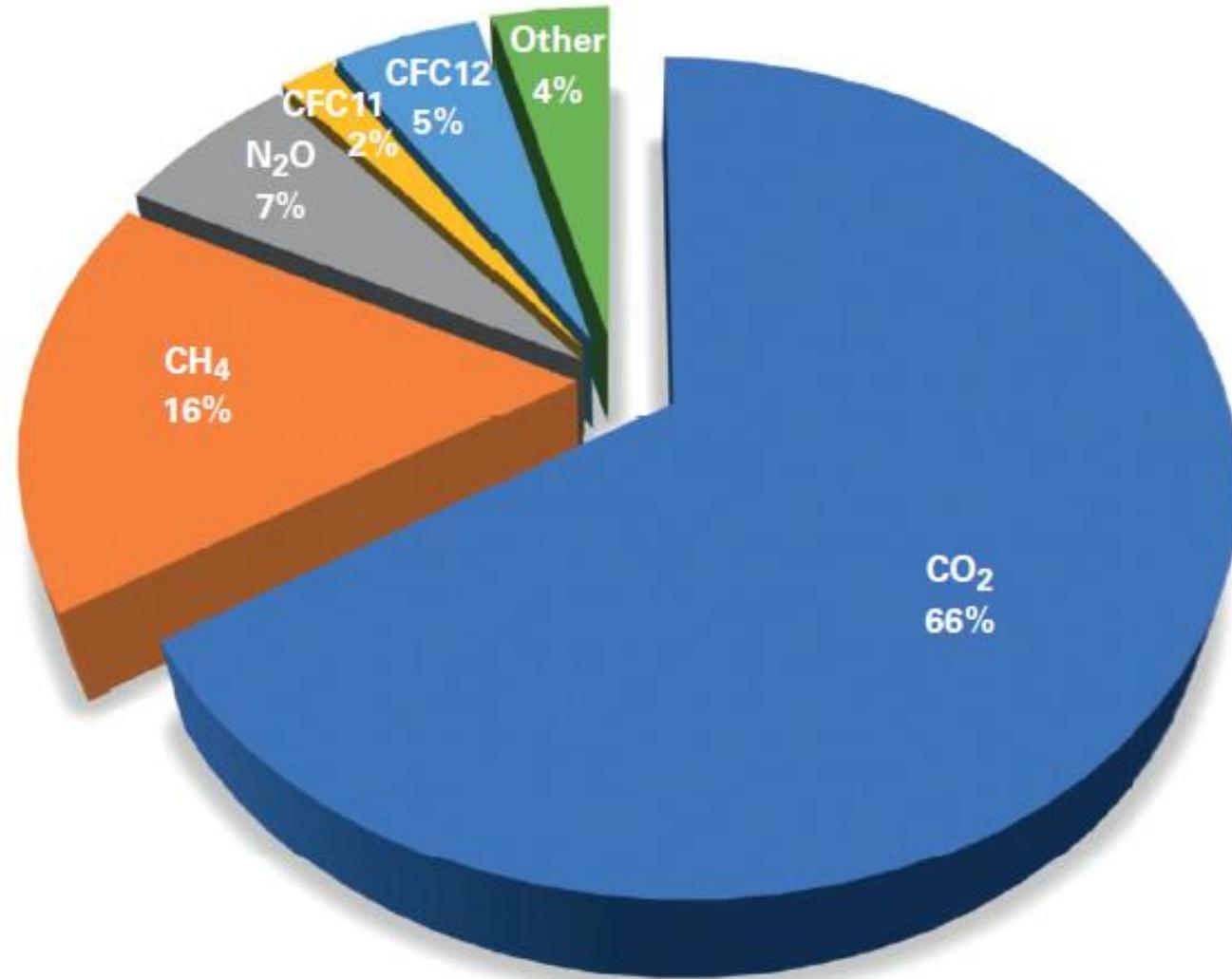
- 1889 ± 2 ppb in 2020
- An increase of 11 ppb with respect to the previous year
- The **largest increase** since renewed CH<sub>4</sub> growth in 2006

## Nitrous oxide (N<sub>2</sub>O)



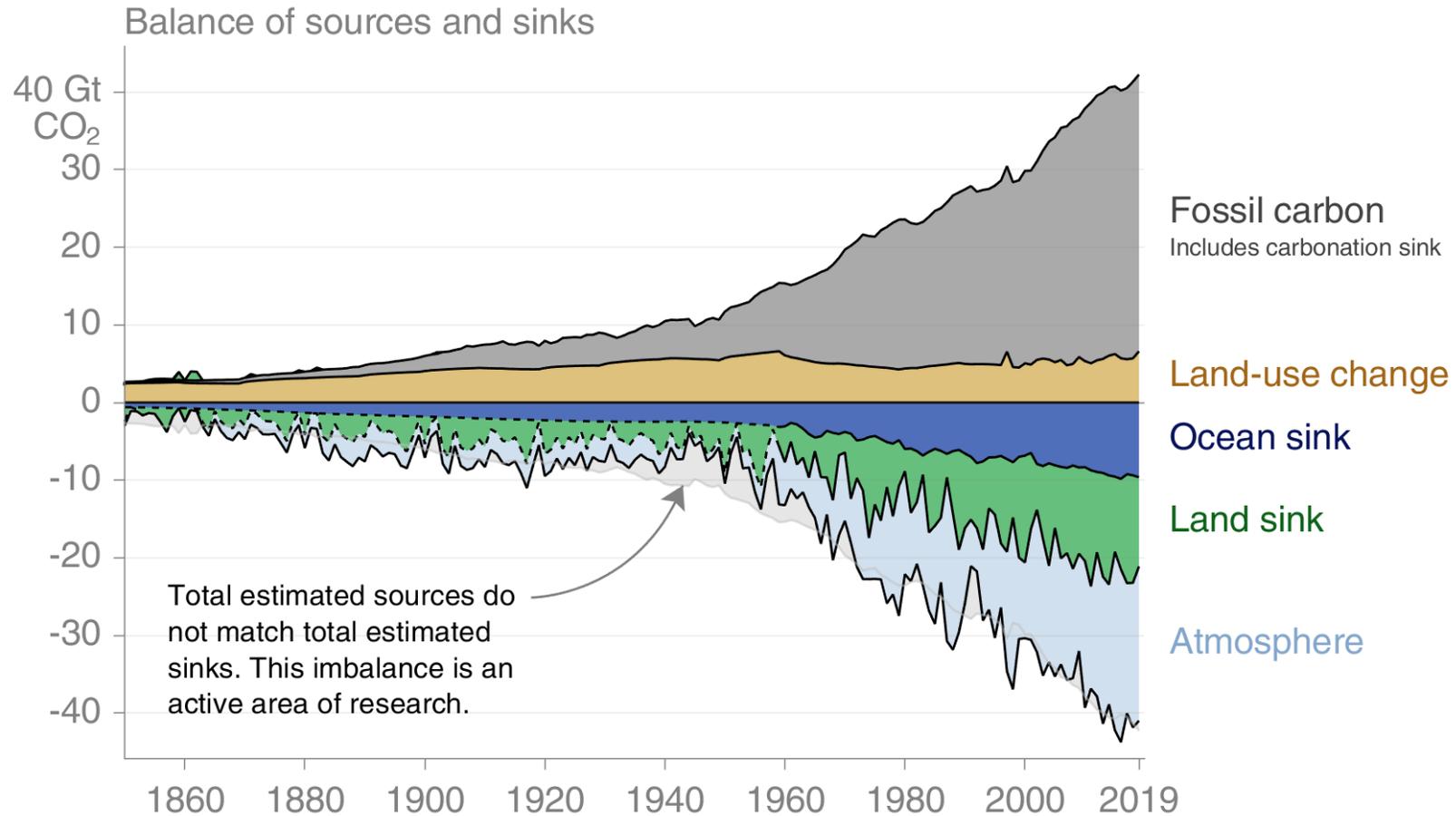
- 333.2 ± 0.1 ppb in 2020
- An increase of 1.2 ppb with respect to the previous year
- N<sub>2</sub>O is becoming of the growing concern: Global human-induced N<sub>2</sub>O emissions increased by 30% over the past four decades to 7.3 (range: 4.2–11.4) Teragrams of nitrogen per year. **Agriculture**, owing to the use of nitrogen fertilizers and manure, **contributes 70%** of all anthropogenic N<sub>2</sub>O emissions.

# Warming impact of greenhouse gases



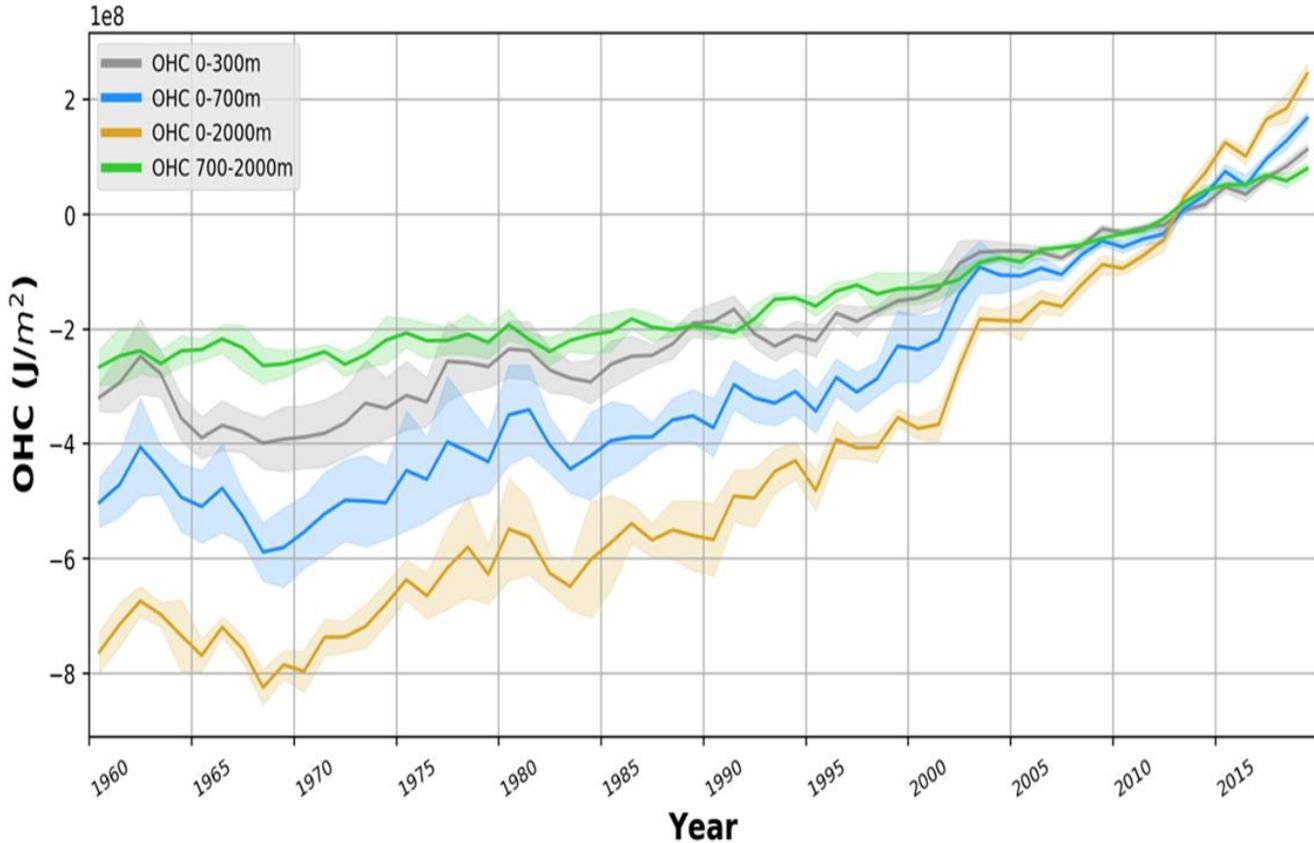
# Global carbon budget

Carbon emissions are partitioned among the atmosphere and carbon sinks on land and in the ocean  
 The “imbalance” between total emissions and total sinks is an active area of research

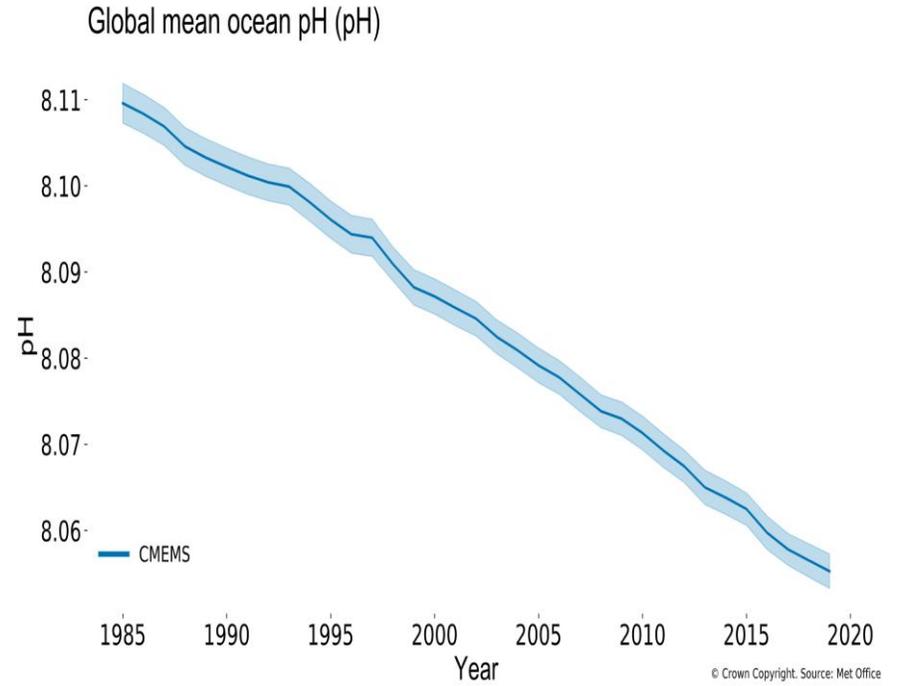


© Global Carbon Project • Data: GCP/CDIAC/NOAA-ESRL/UNFCCC

# Ocean heat & pH



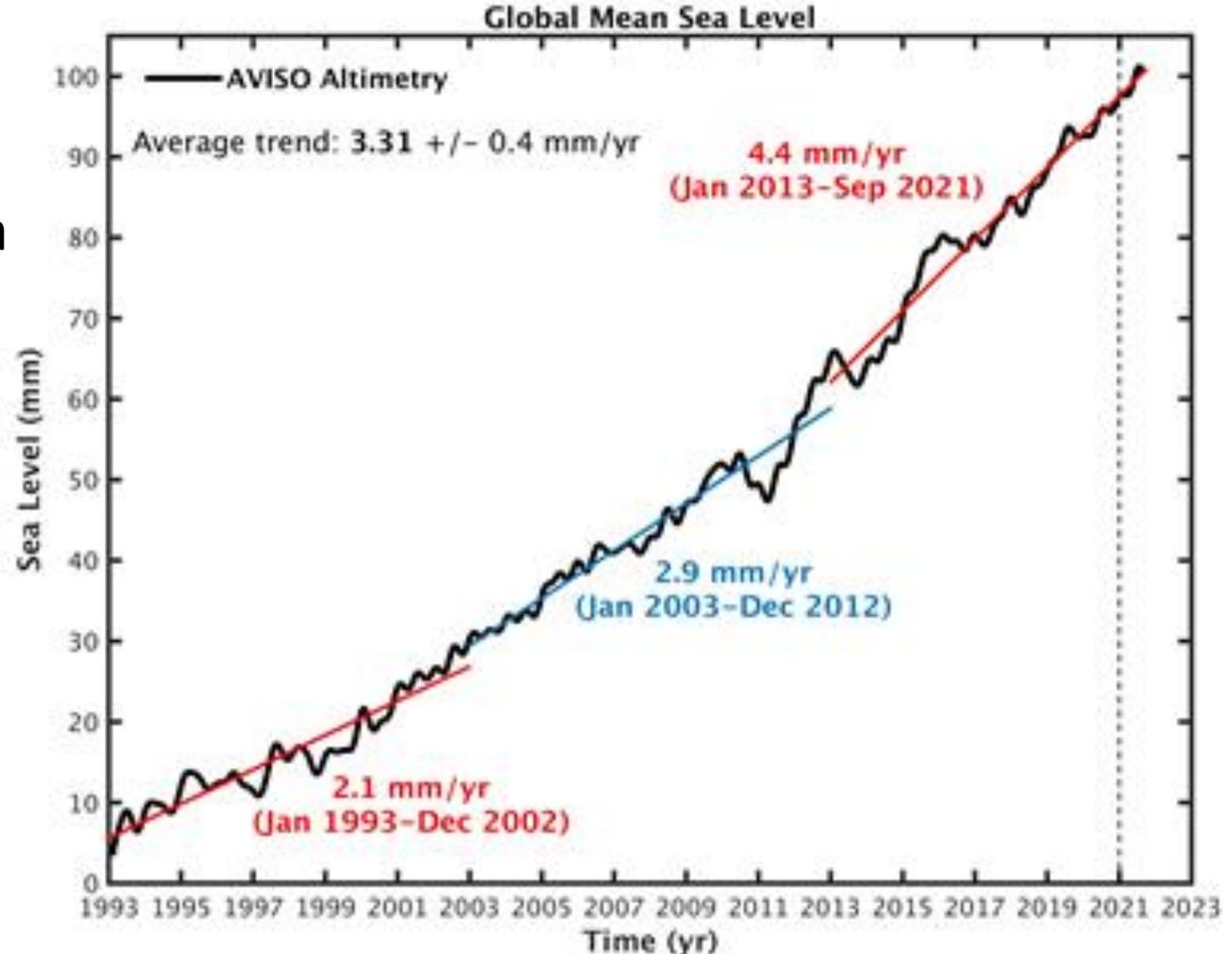
Record high ocean heat, at various depths



Ocean acidification is increasing

# Sea level

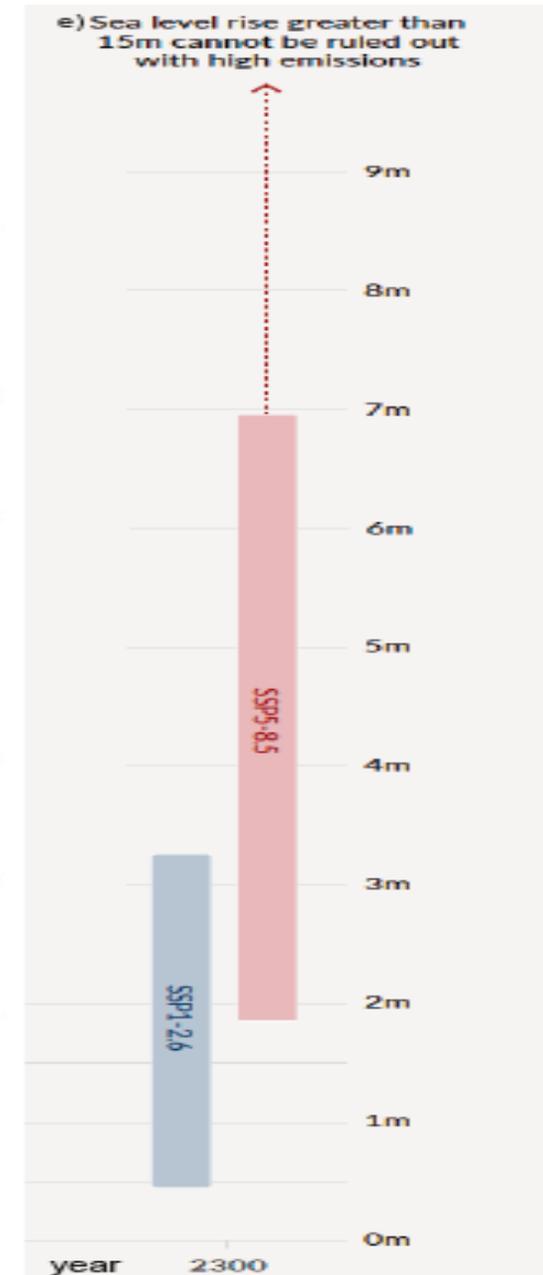
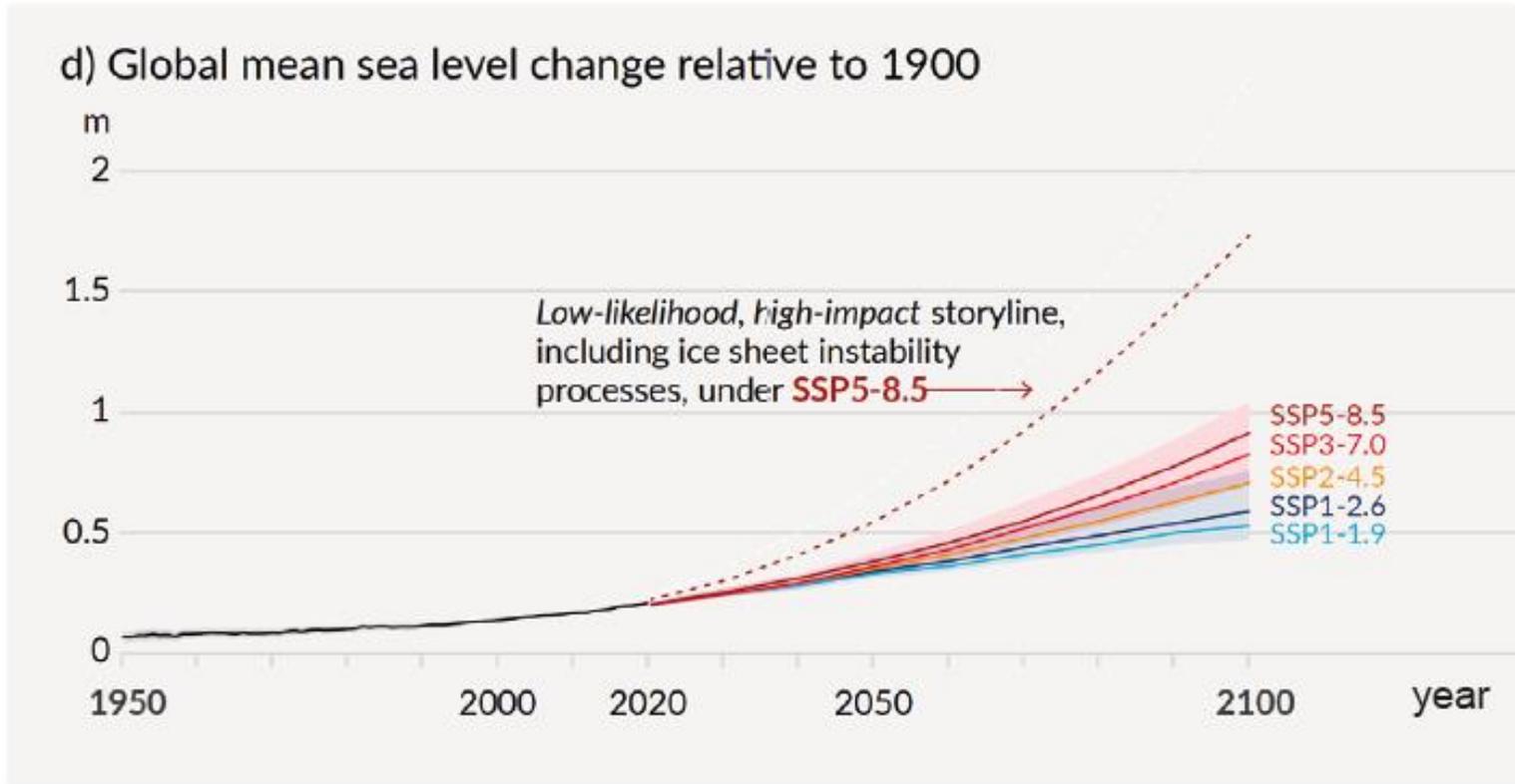
- Sea level reached a new high in 2021
- The rate of sea level rise has increased over time
- Increased rate is due to accelerated loss of mass from the ice sheets



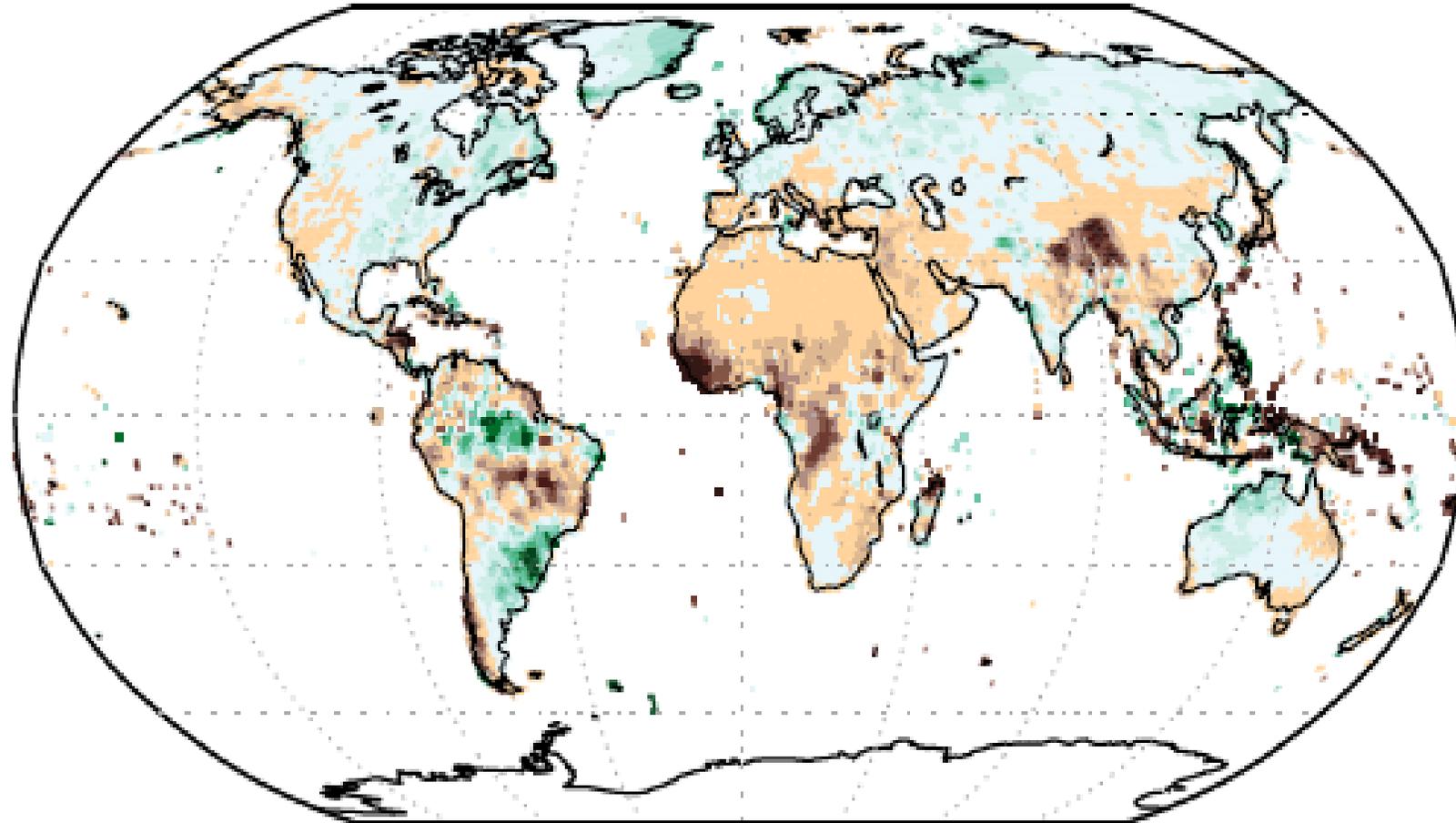
Anny Cazenave (LEGOS CNES and OMP) Yvan Gouzenes (LEGOS and OMP)



# Sea level rise 1950-2100 and -2300



# Global precipitation 1986–2015 vs. 1901–1960



Change in Precipitation (inches)



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# Rainfall anomalies 2021

Western Europe floods 14-15 July. 162.4 mm in 24 hours at Wipperfürth-Gardenau >200 deaths and US\$20 billion in losses

Flooding. Rio Negro highest level on record. Brazil, Guyana, Colombia, Venezuela

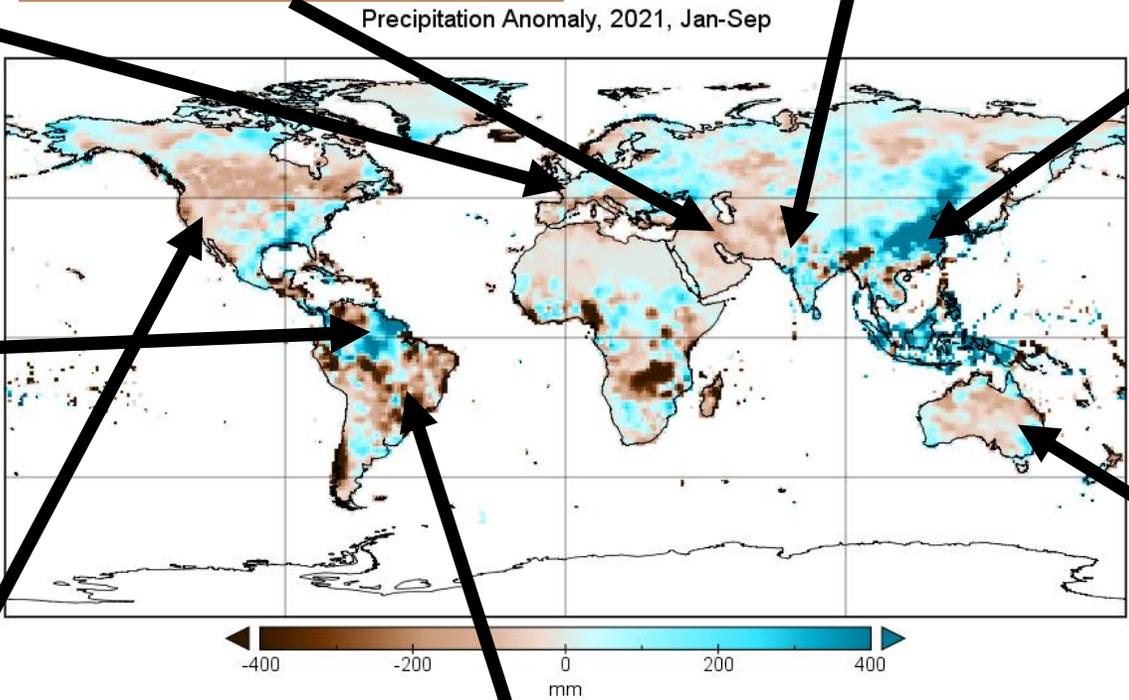
Drought: 20 months from January 2020 to August 2021 was the driest on record for the southwestern United States

Drought Iran, Afghanistan, Pakistan, southeast Turkey, and Turkmenistan. Pakistan had its third-driest February on record.

Afghanistan flash flooding in May and July. Over 170 dead

Flooding Henan Province, 17-21 July 720mm of rain. Greater than the annual average. Over 300 deaths and US\$17.7 billion in losses

Flooding in New South Wales in March At least US\$2.1 billion in economic losses

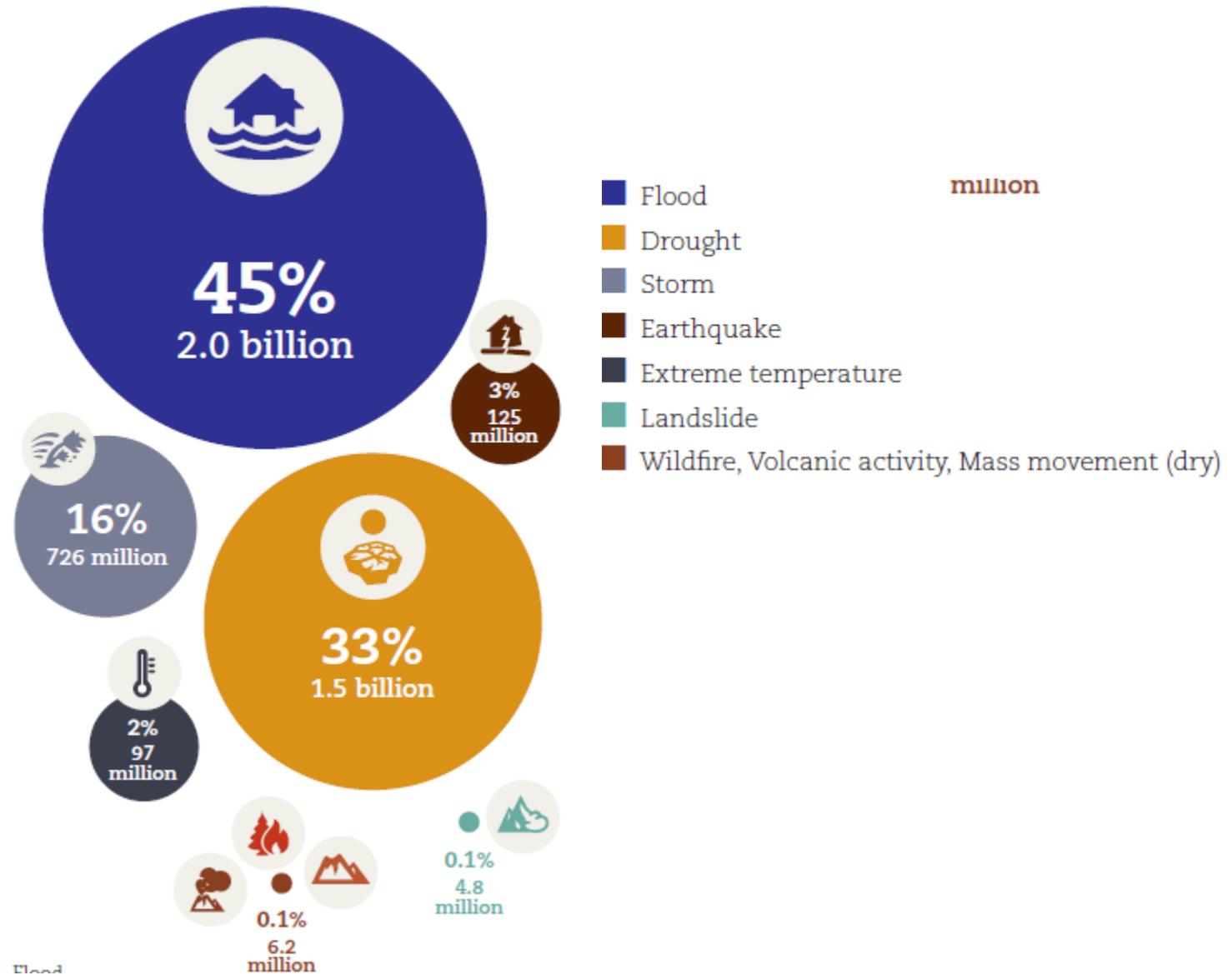


Drought Brazil, Paraguay, Uruguay and northern Argentina. Affected river levels and energy generation Paraguay River at Asuncion fell to a record low

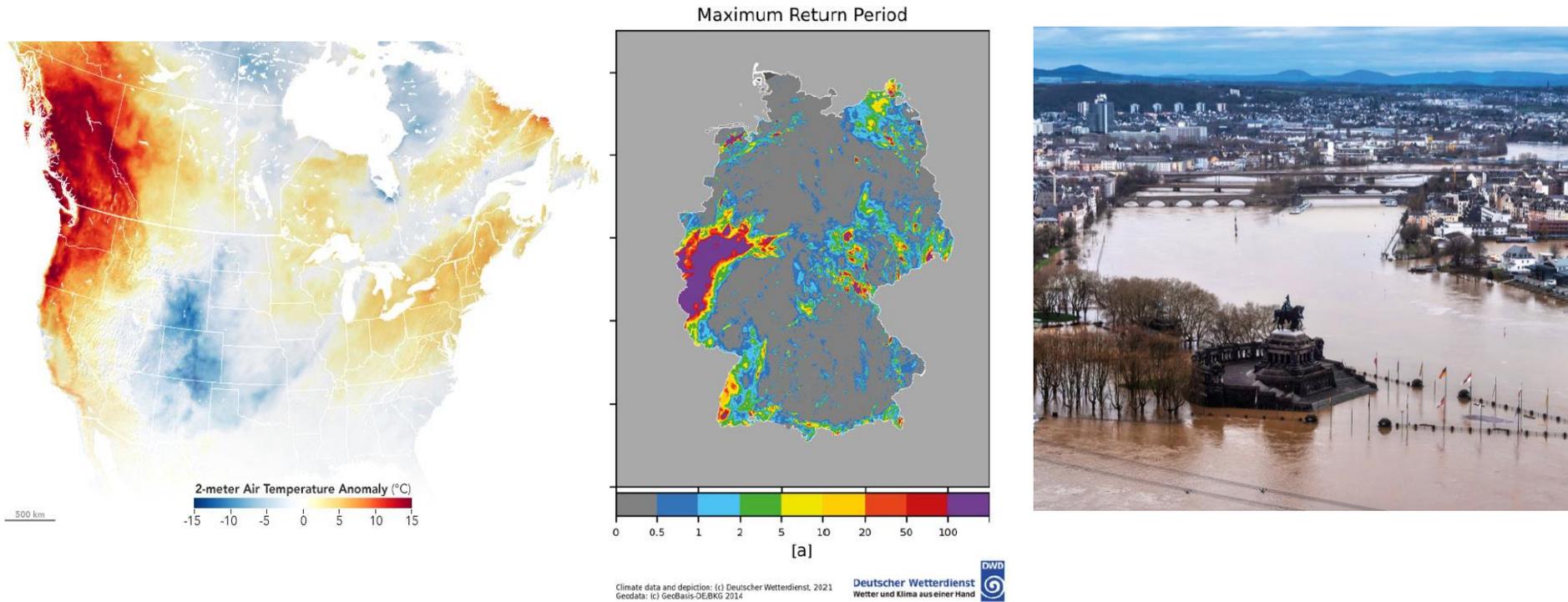
Markus Ziese  
(Global Precipitation  
Climatology Centre, DWD)

# ~4.5 billion people affected 1998-2017

## 96% of disasters weather related



# Devastating extreme weather and climate events have been recorded in 2021



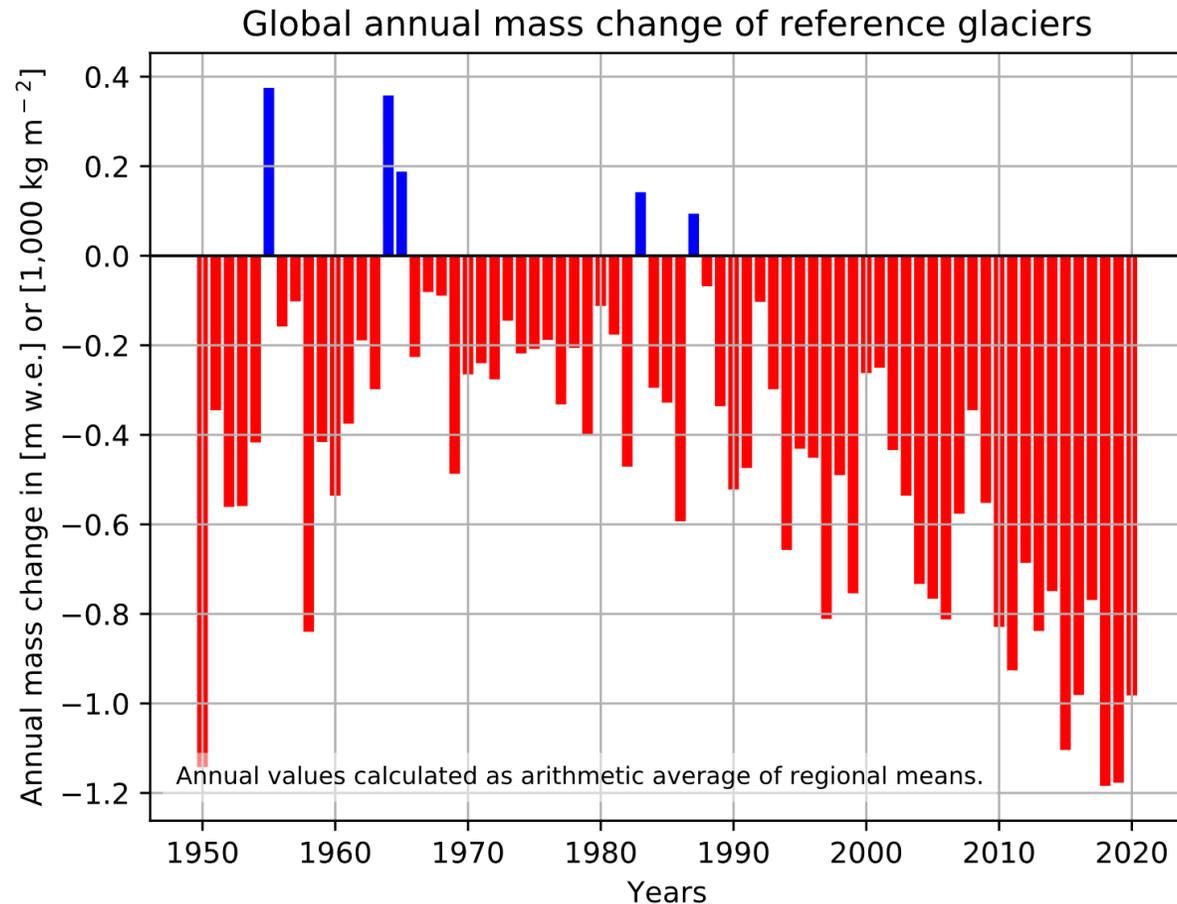
**A signature of human-caused climate change has been identified in the North American heatwave and west European floods**



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# Glaciers

- Mass balance of reference glaciers reported by WGMS
- Negative mass balance for the 33<sup>rd</sup> consecutive year
- Average annual loss since 2015 is over 1 m w.e.
- Fifth largest loss on record



World Glacier Monitoring Service

<https://wgms.ch/>

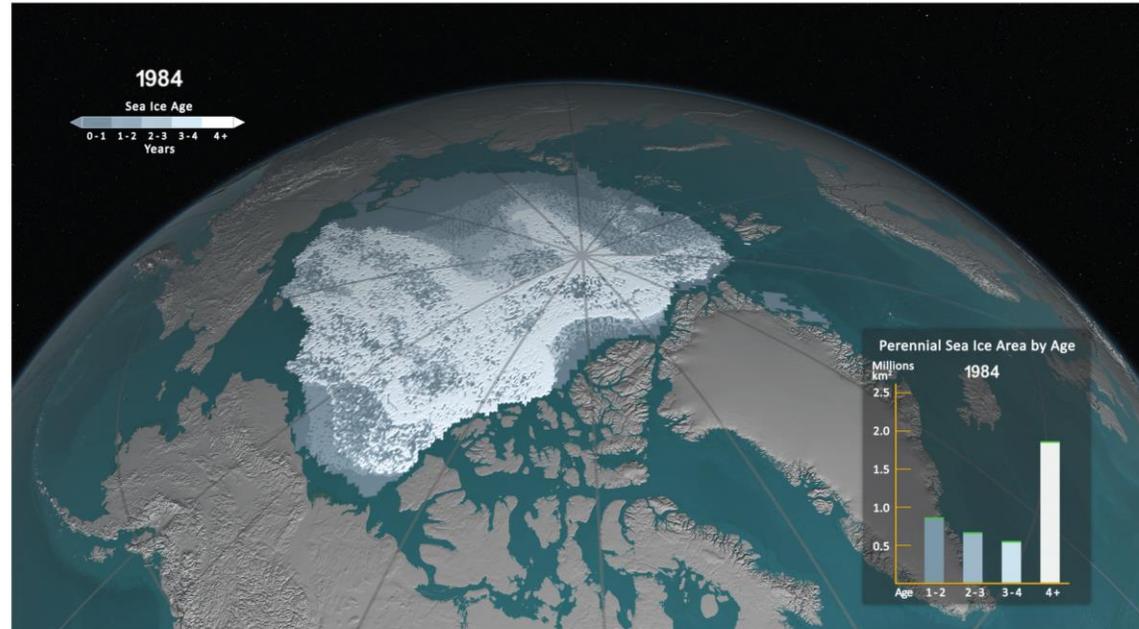


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# Largest changes in the Arctic

## Multi-year ice

### 1984



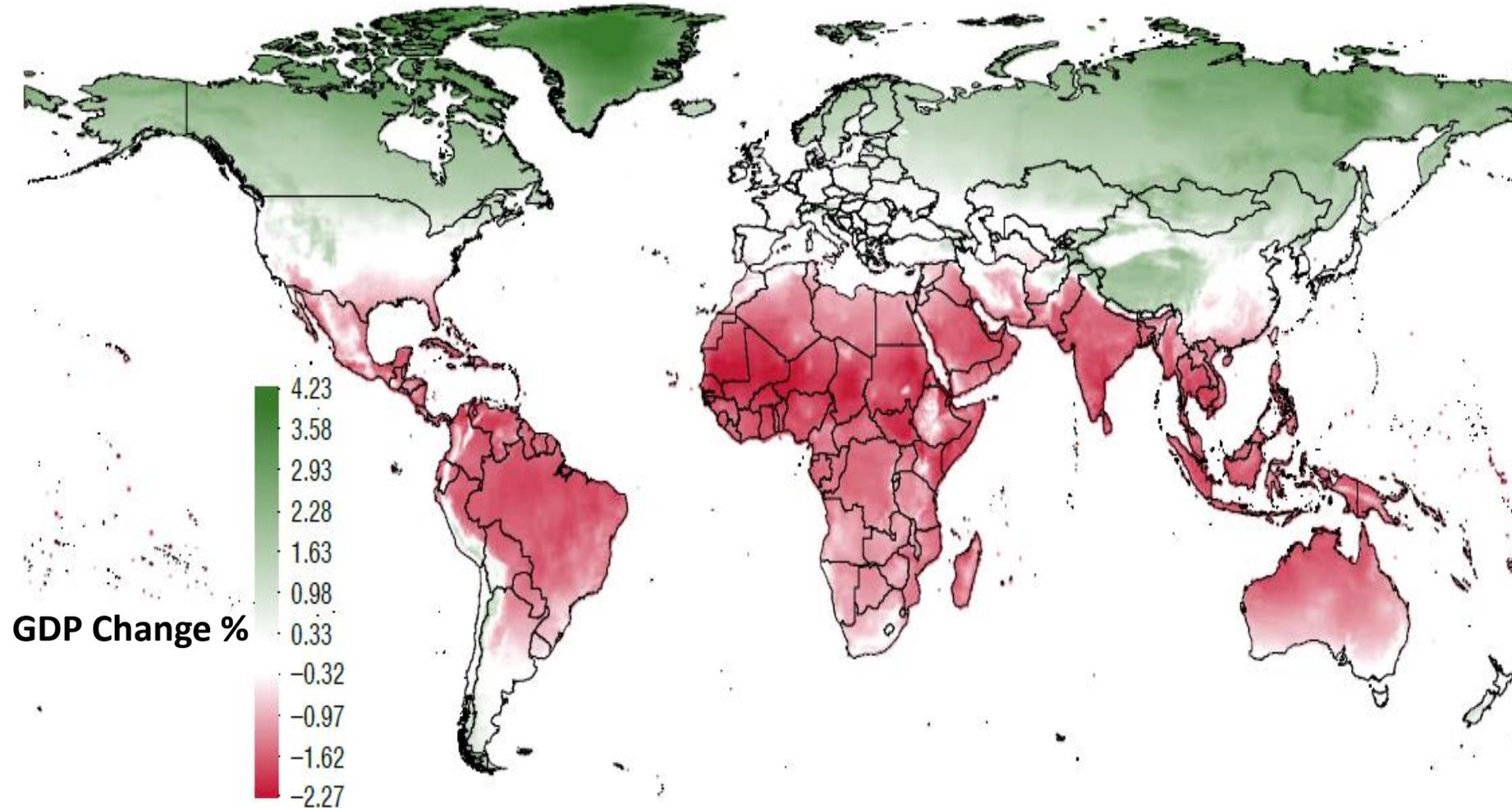
### 2016



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# Uneven economic impact of current warming

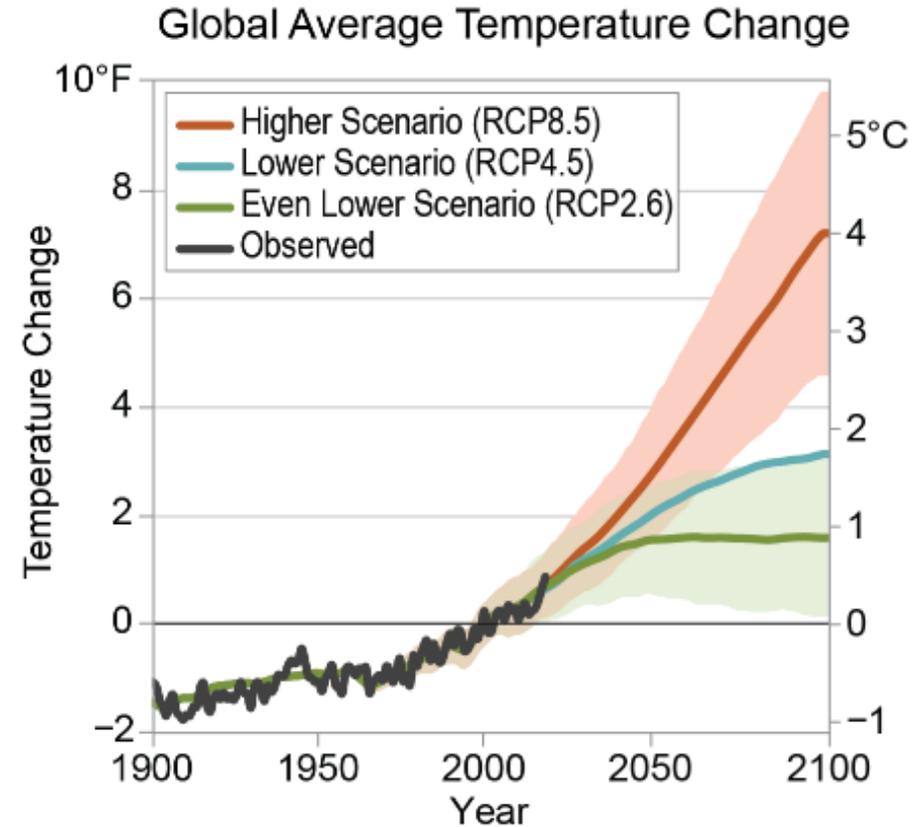
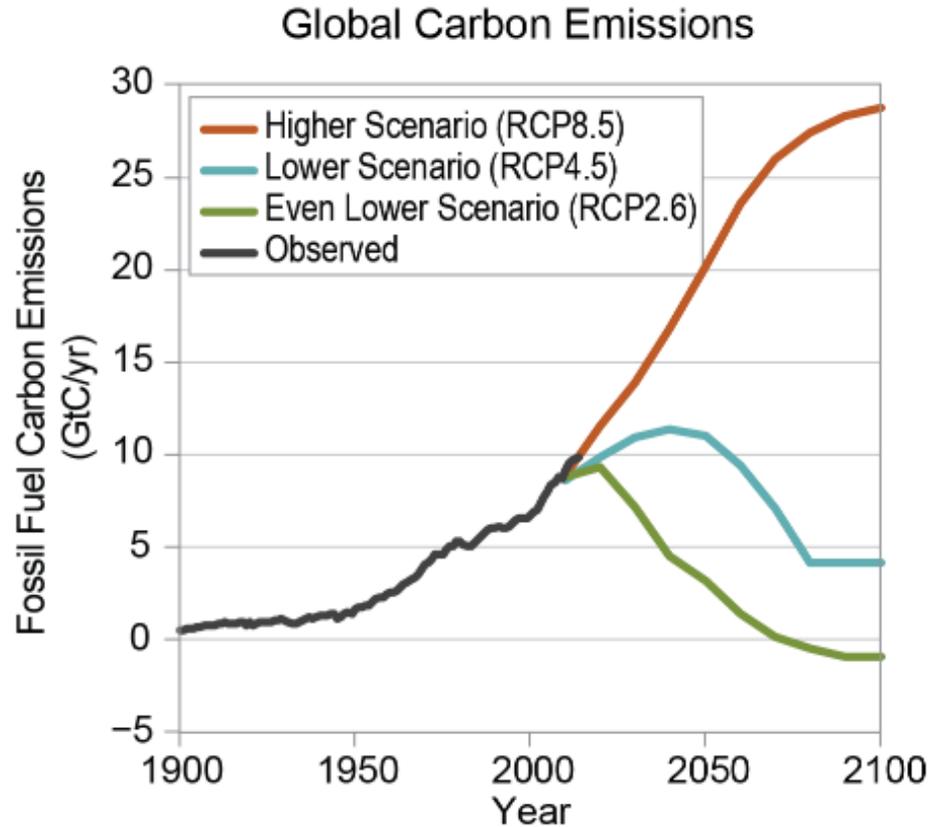
## Impact of 1°C temperature increase on per capita output



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Source: International Monetary Fund (IMF) World Economic Outlook

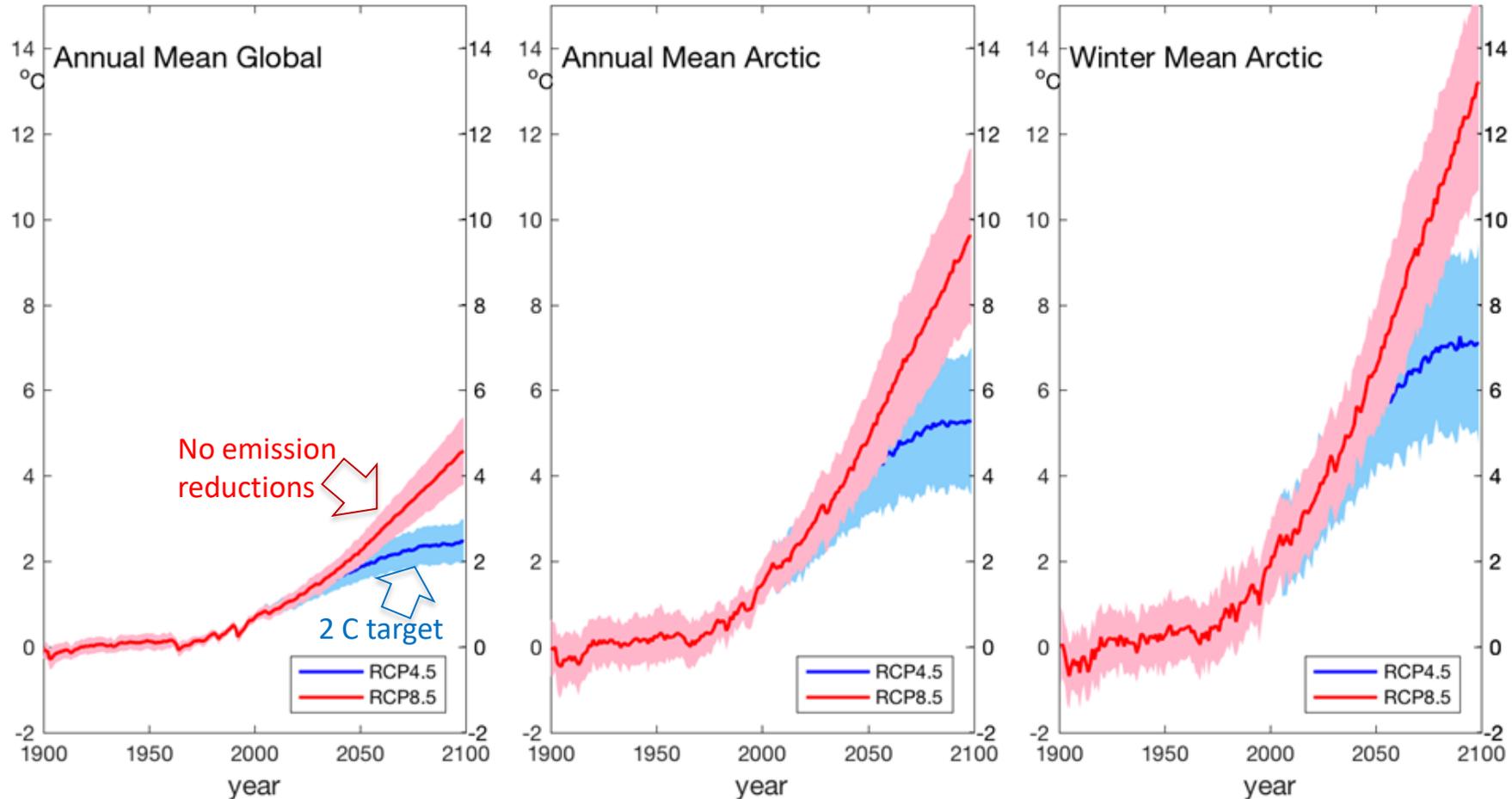
# Carbon emissions-temperature



# Arctic and global temperatures 1900-2100

Averaged over 36 global climate models

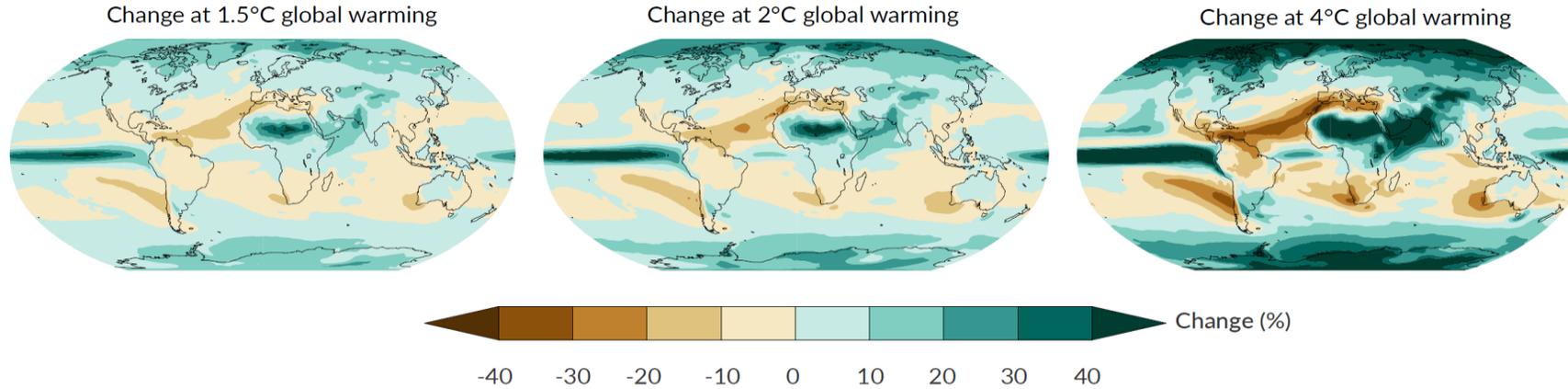
RCP 4.5 (blue)= upper end of Paris COP21 Agreement , RCP 8.5 (red)= business as usual



# Rainfall & soil moisture versus future warming

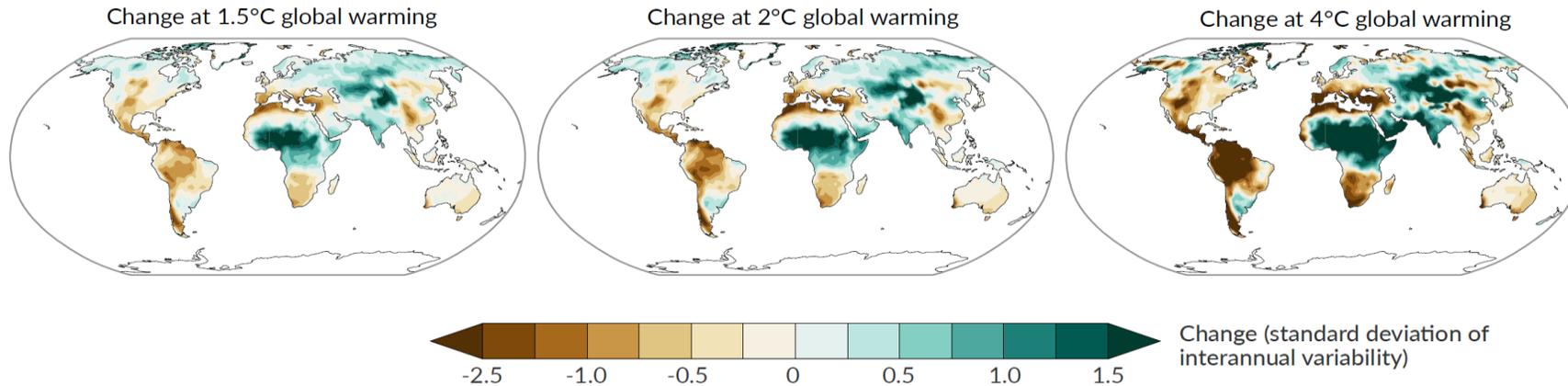
c) Annual mean precipitation change (%) relative to 1850-1900 at three global warming levels

Precipitation increases over high latitudes, tropical oceans and parts of the monsoon regions but decreases over parts of the subtropics.



d) Annual mean soil moisture change (sd) (standard deviation of interannual variability) relative to 1850-1900 at three global warming levels

Across warming levels changes in soil moisture largely follow changes in precipitation but also show some differences due to the influence of evapotranspiration.



# Global water stress hotspots



Global Water Stress Hotspot

World Meteorological Organization 2021

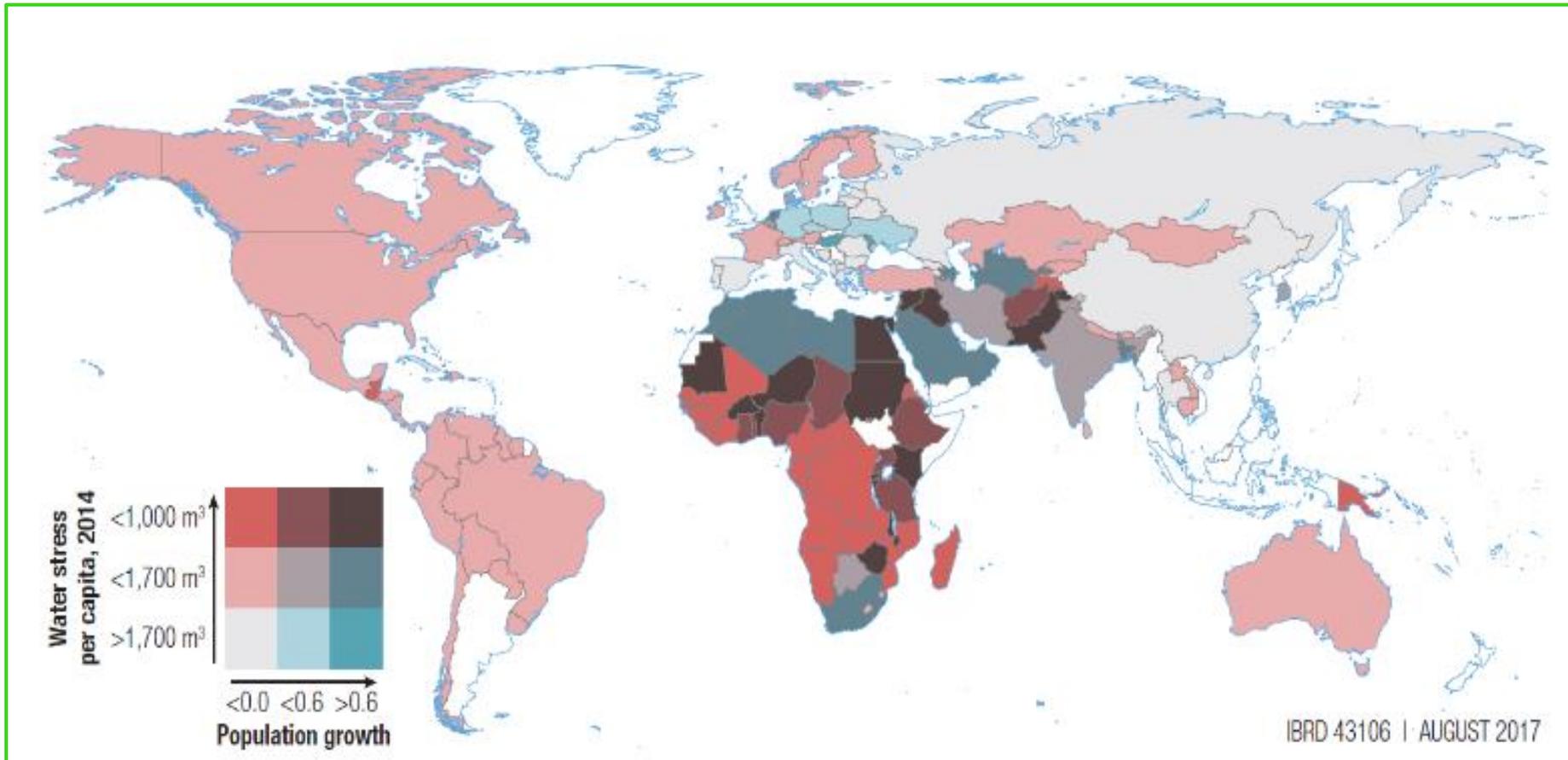
Based on data from the Food and Agriculture Organization and the World Resources Institute



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- 2.3 Billion people live in water-stressed countries
- The World is seriously behind schedule on SDG6

# Water availability & population growth 2050



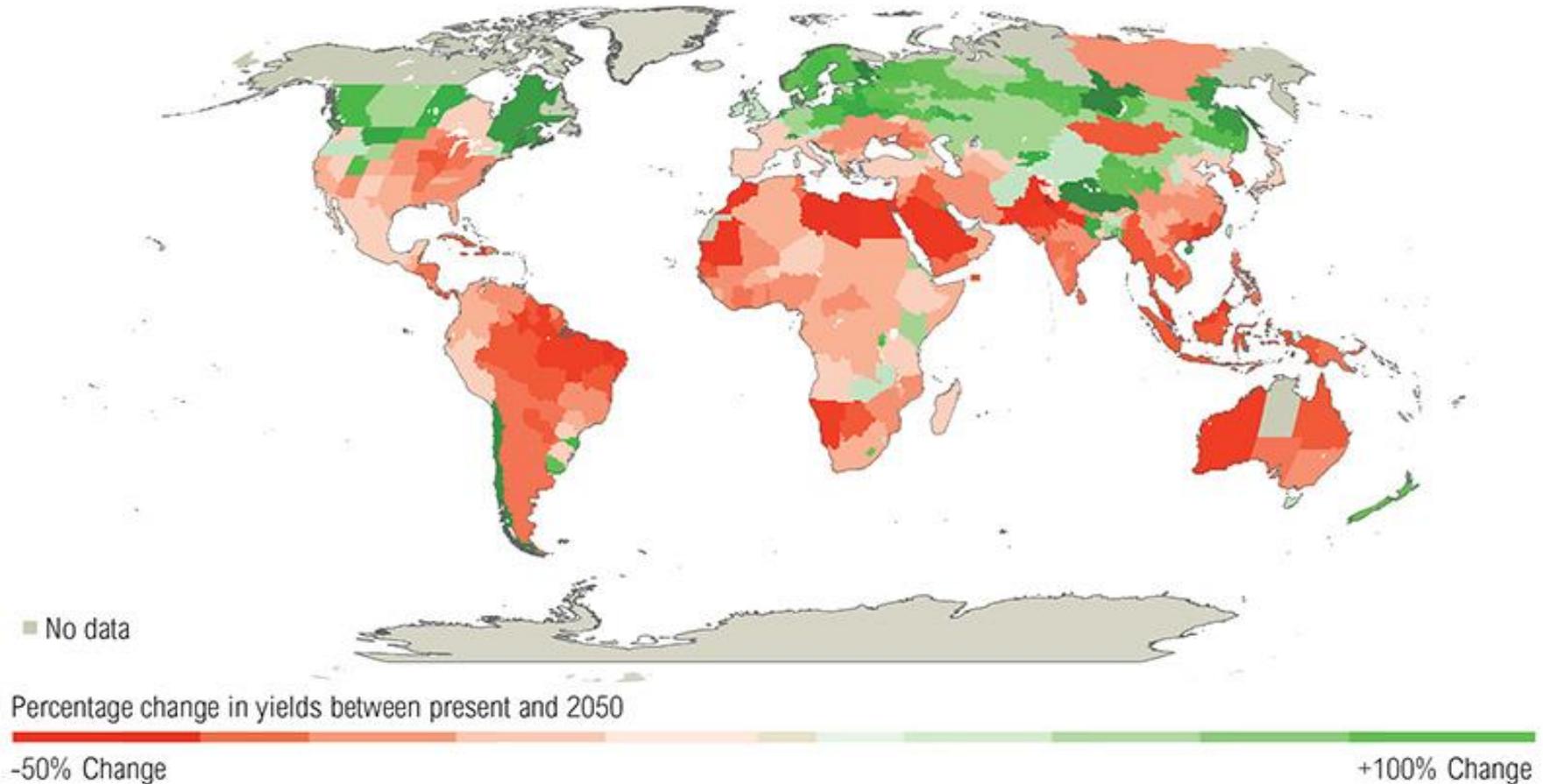
About **4 billion people**, representing nearly two-thirds of the world population, experience **severe water scarcity** during at least **one month of the year**



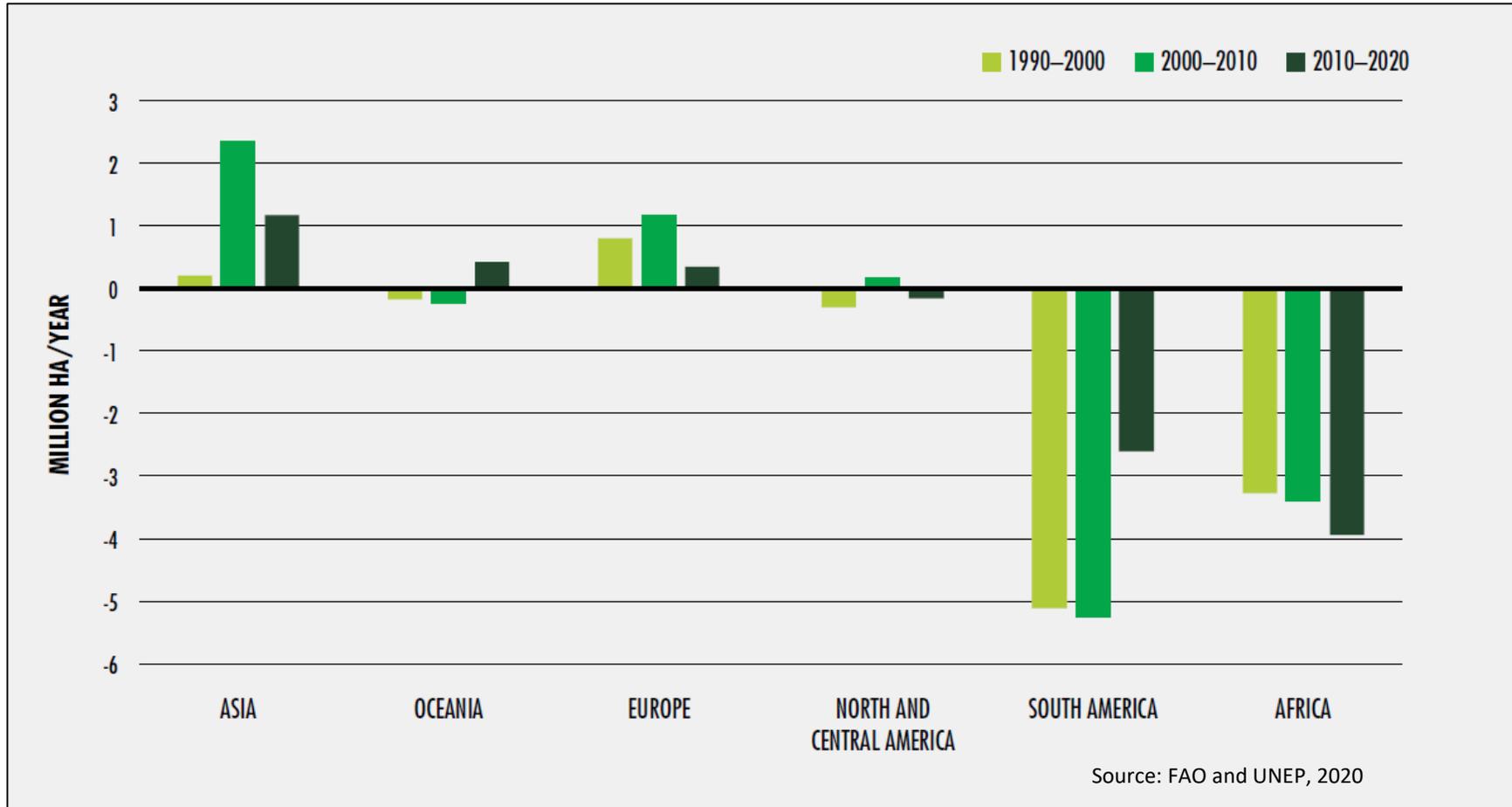
# 3 C warming is a major risk for food security

## Loss of crop yield in most parts of the world

Most studies now project adverse impacts on crop yields due to climate change (3°C warmer world)

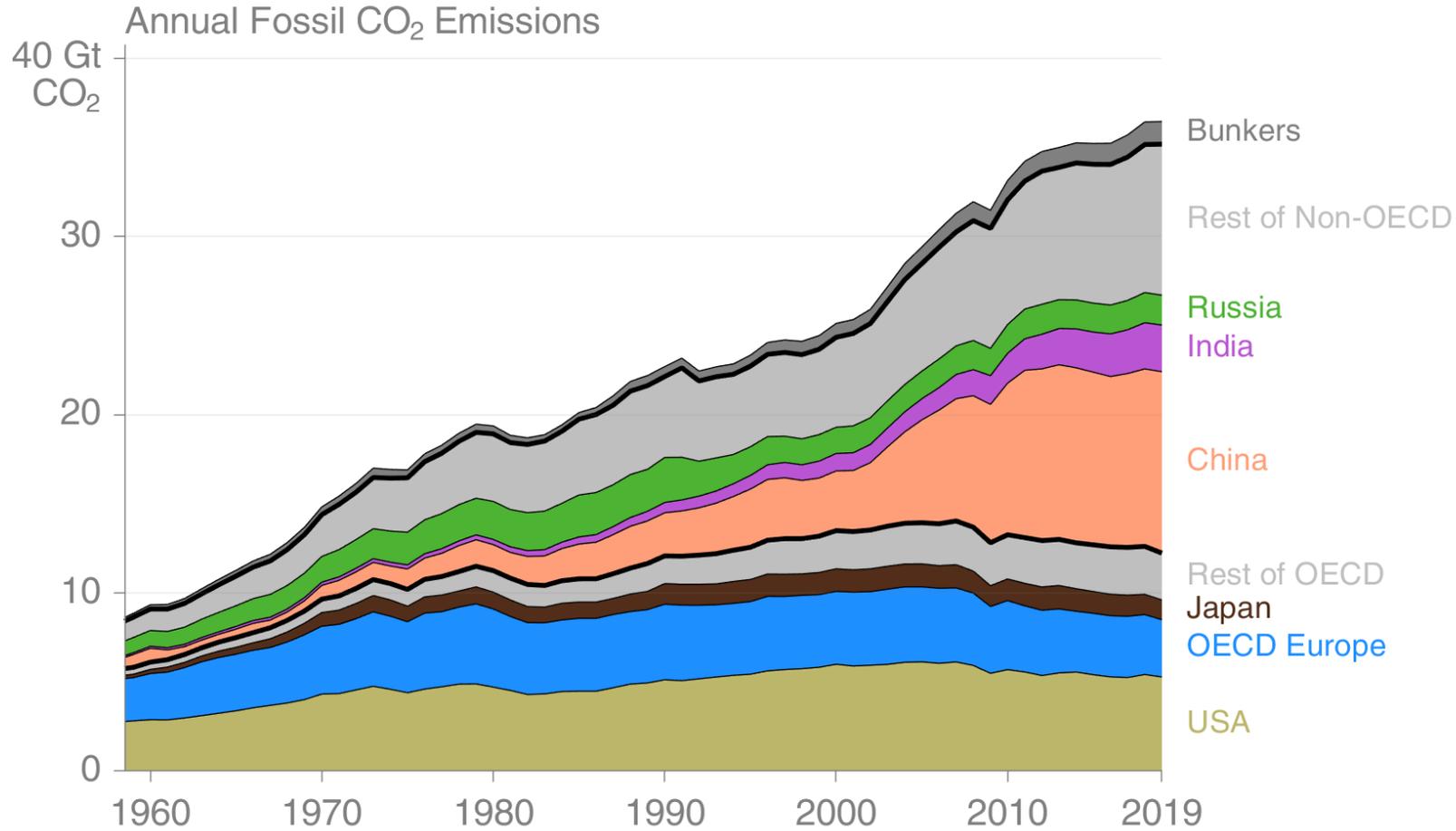


# Net forest area change by region in 1990–2020



# Global fossil CO<sub>2</sub> emissions by country

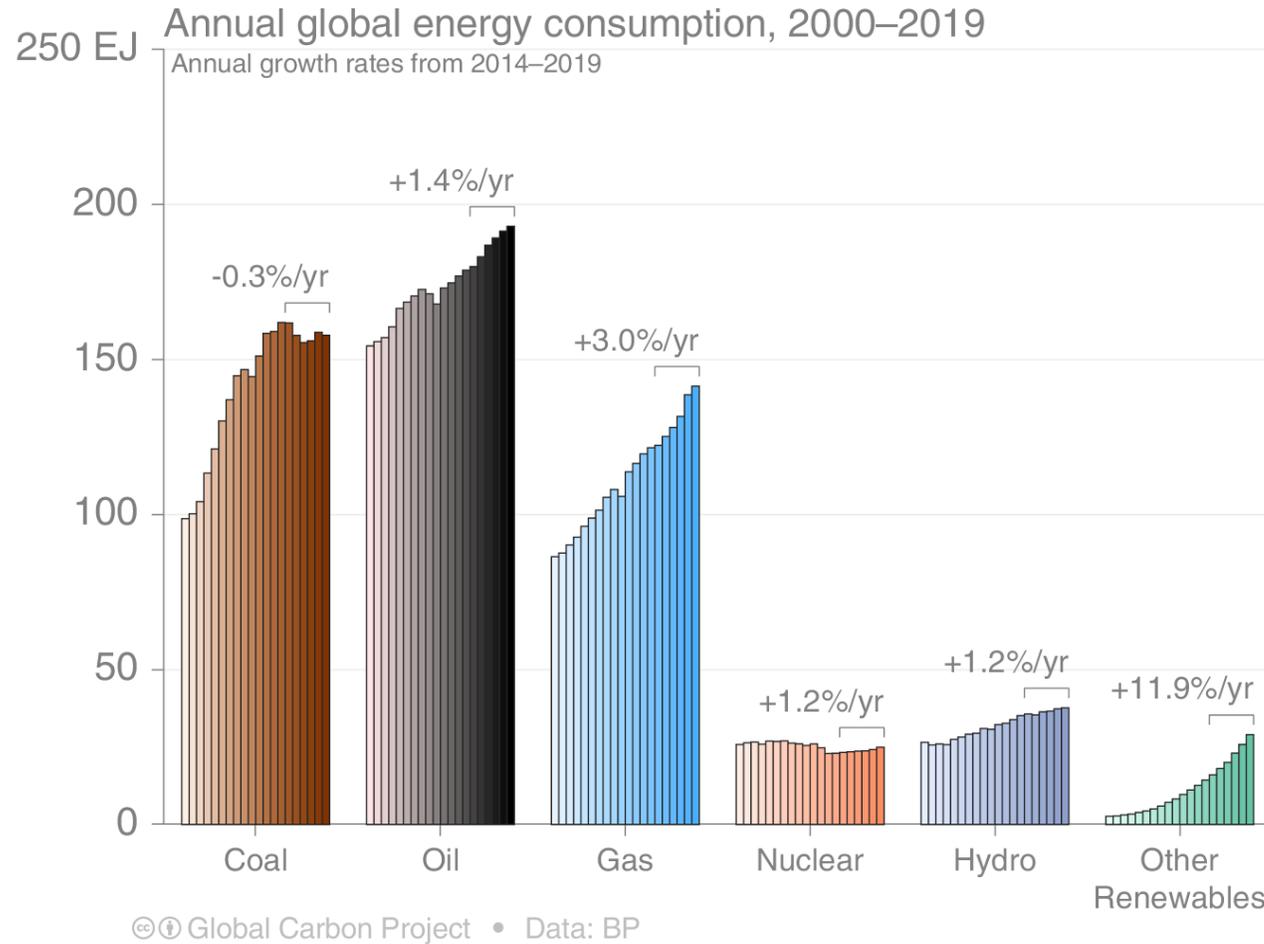
Emissions in OECD countries have increased by 1% since 1990, despite declining 13% from their maximum in 2007  
 Emissions in non-OECD countries have more than doubled since 1990



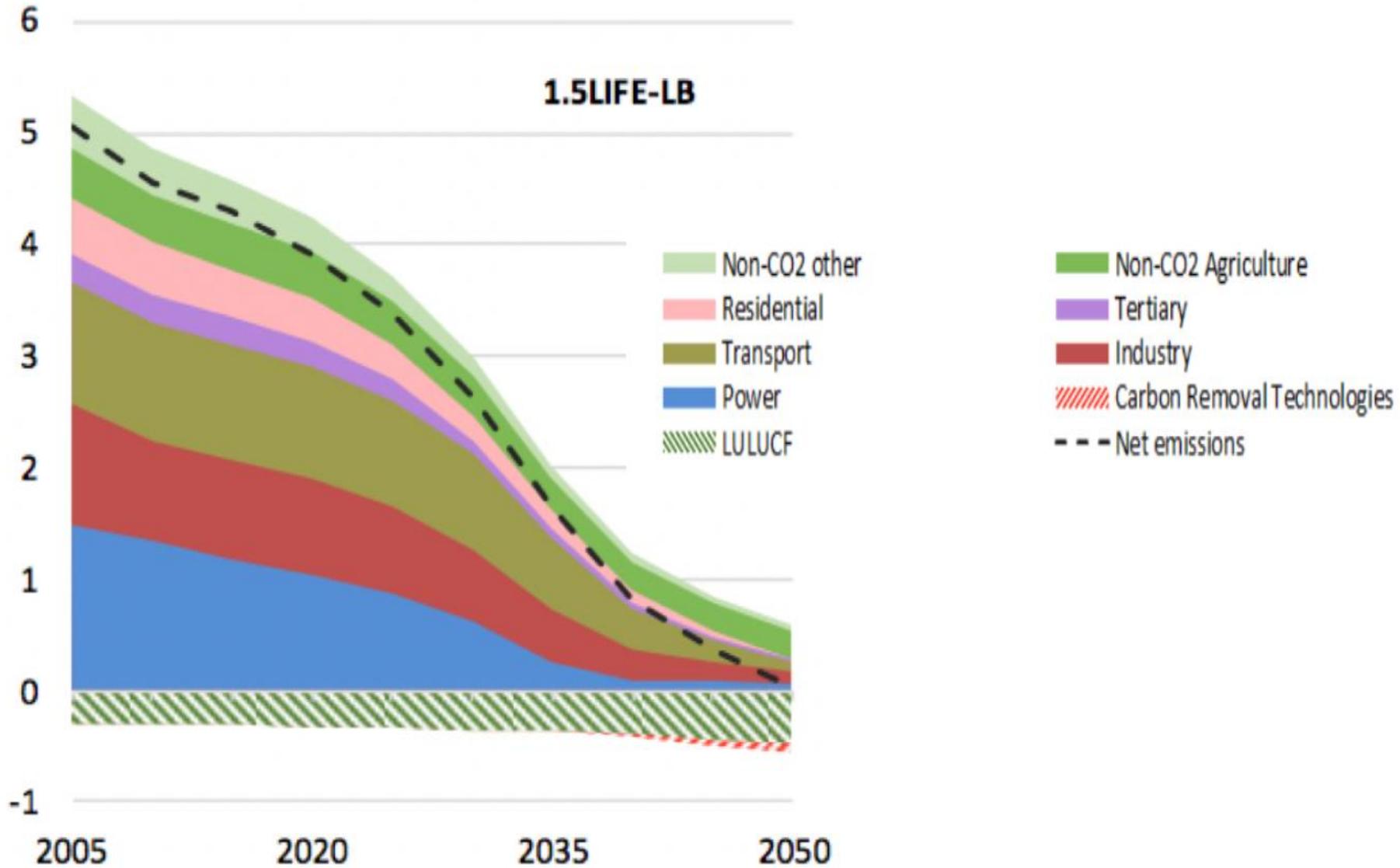
© Global Carbon Project • Data: CDIAC/UNFCCC/BP/USGS

# Fossil/other energy use by source

Energy consumption by fuel source from 2000 to 2019, with growth rates indicated for the more recent period of 2014 to 2019

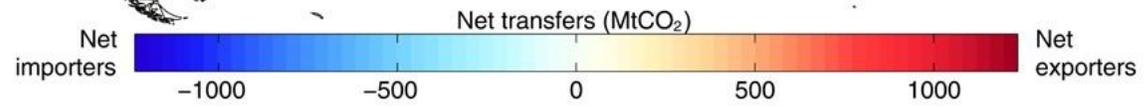
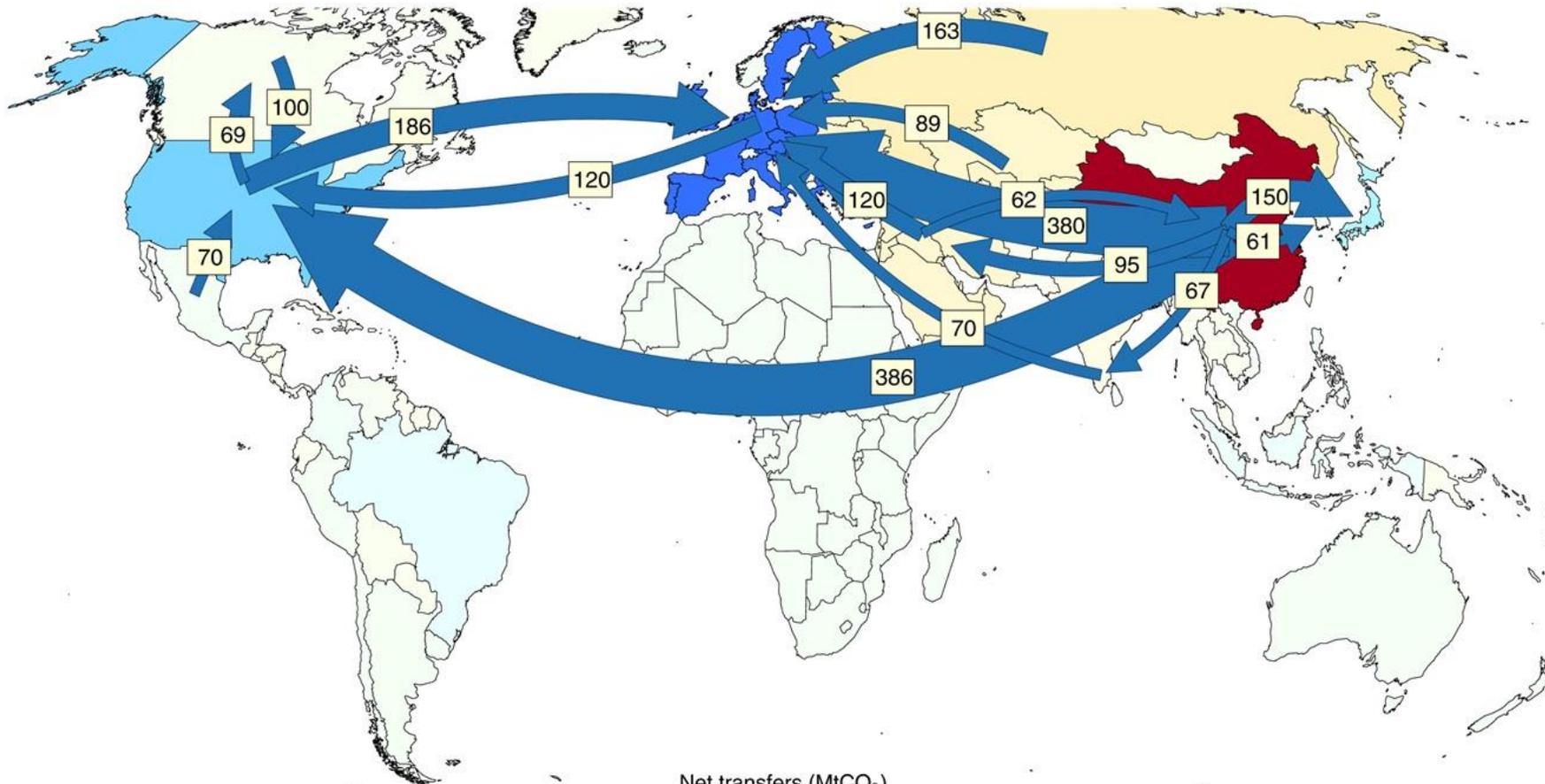


# How to become carbon neutral by 2050?



# Major flows production -> consumption

Flows from location of generation of emissions to location of consumption of goods and services

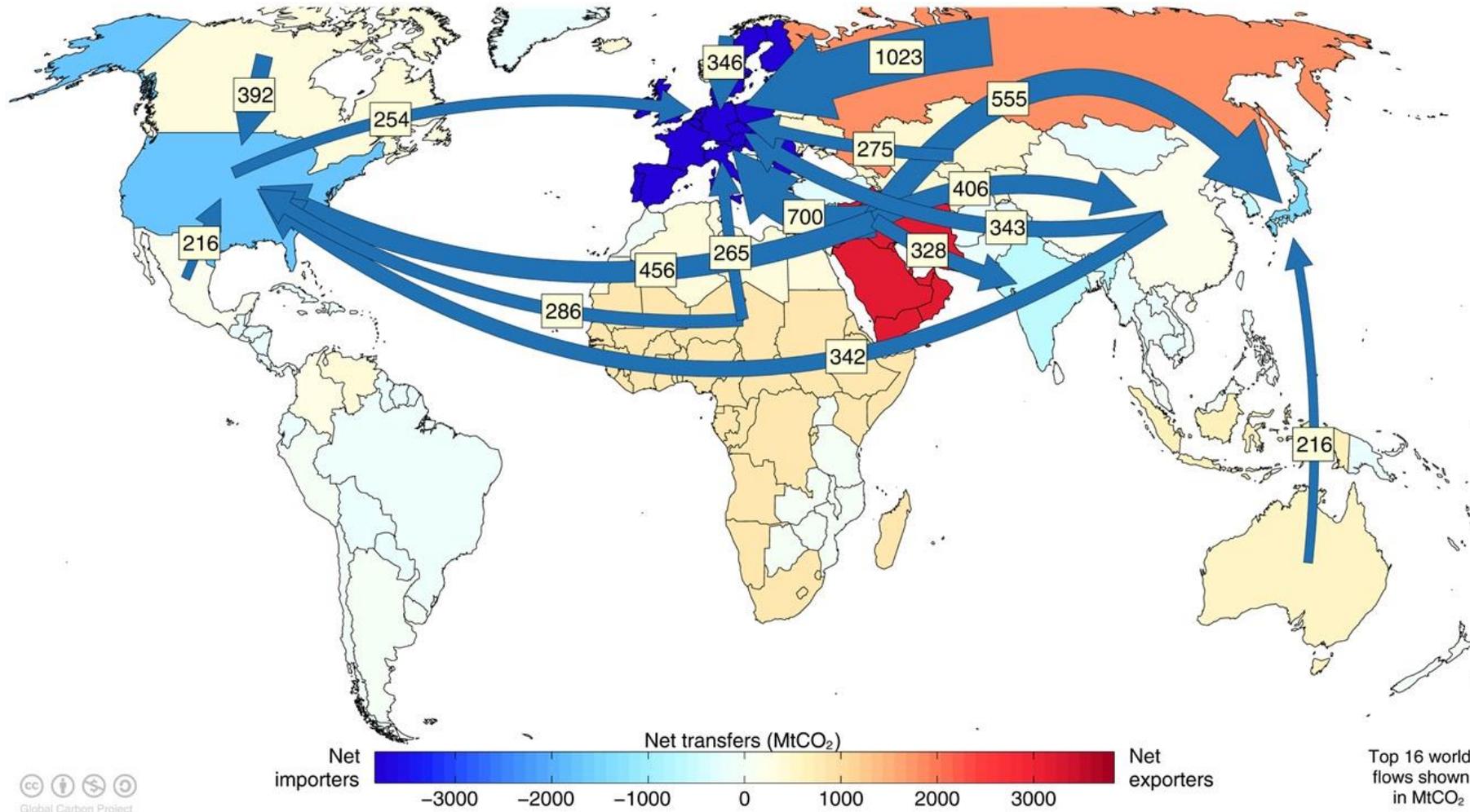


Top 16 world flows shown in MtCO<sub>2</sub>



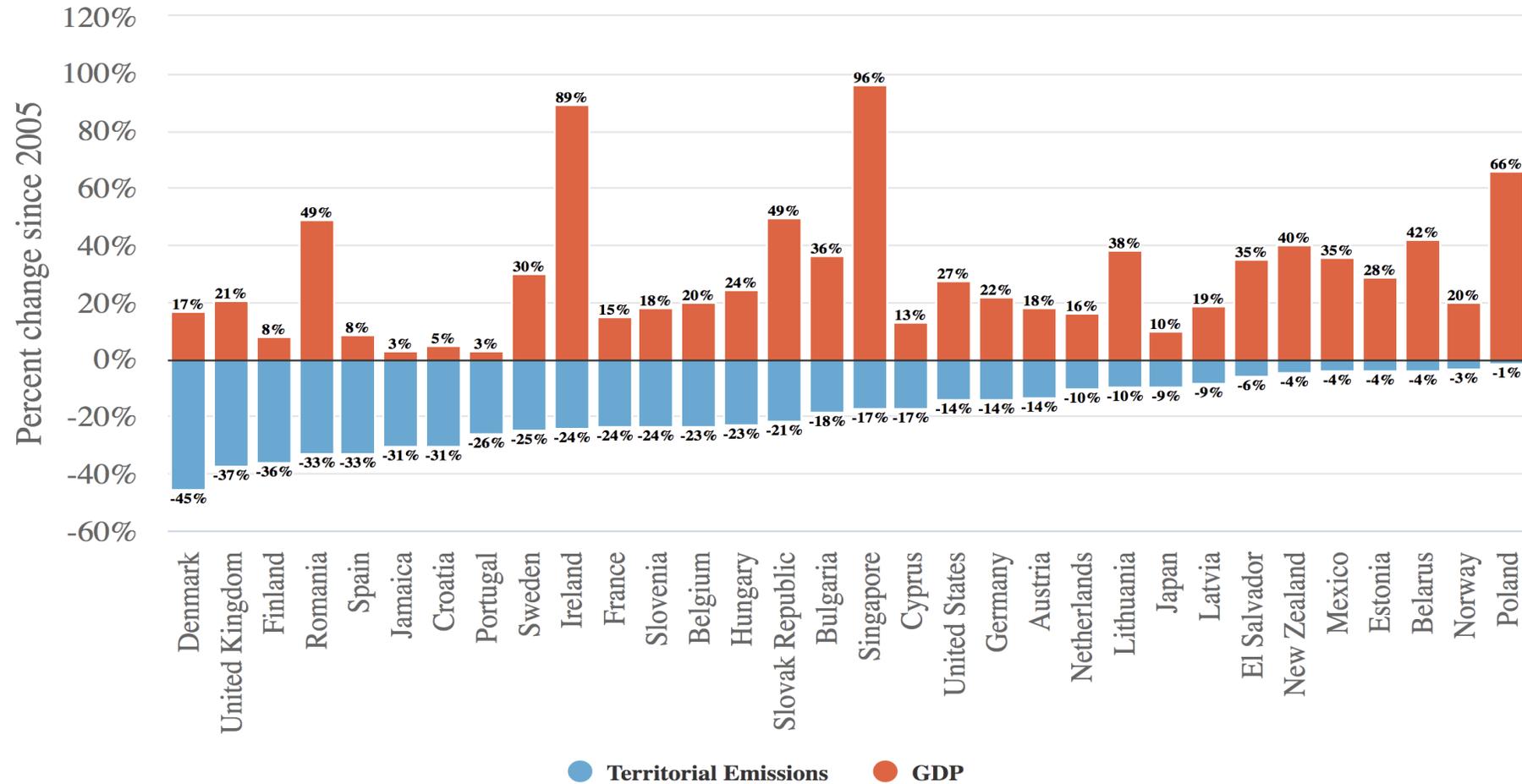
# Major flows extraction -> fossil energy

Flows from location of fossil fuel extraction to location of consumption of goods and services



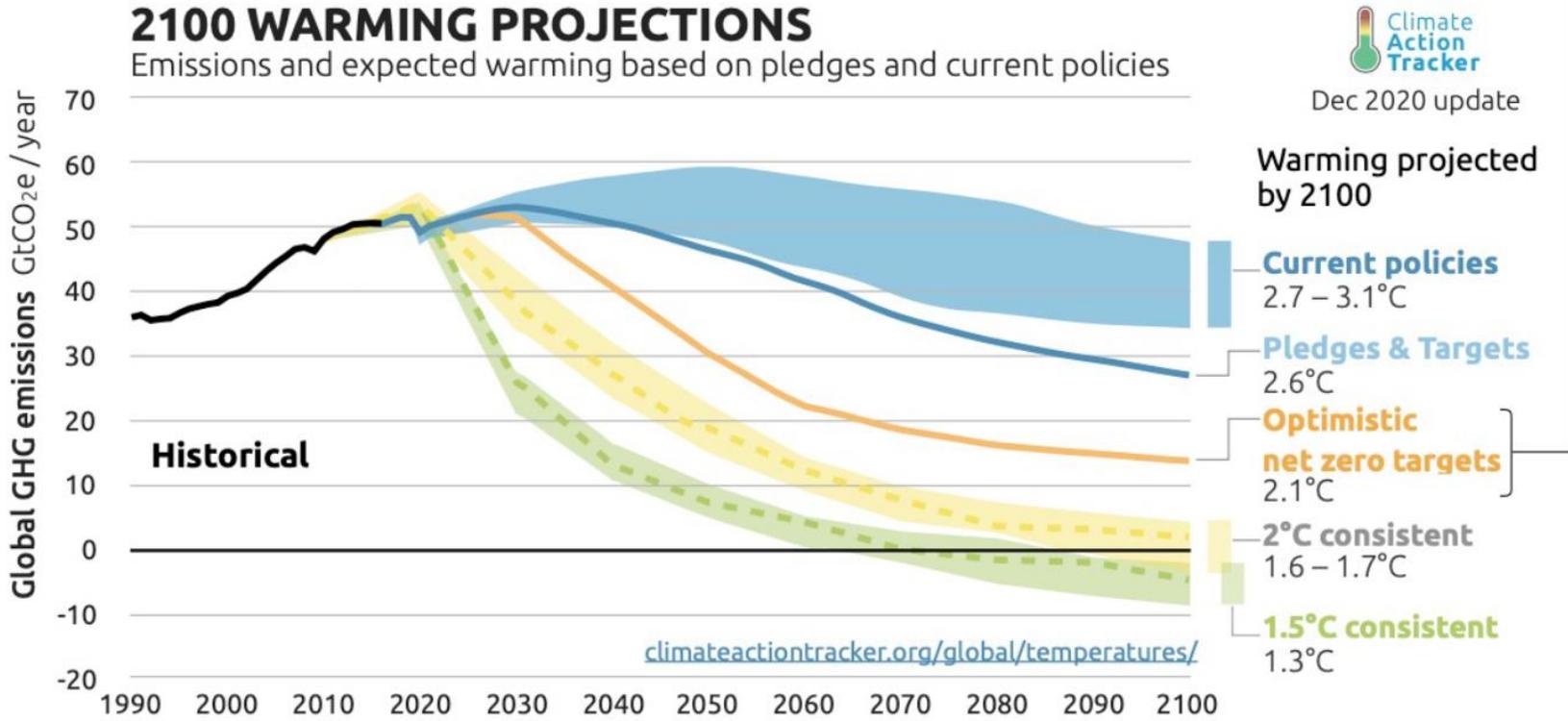
# 32 countries have decoupled emissions/GDP

Decoupling of territorial emissions and GDP: 2005-2019



# Emissions vs. warming

Optimistic net zero targets scenario projects that warming will be limited to 2.1°C by 2100 and is based on the successful achievement of all announced net zero targets



Source: Climate Action Tracker 2020 Global Update

# Climate change/political dimensions

1. **Agriculture:** great difficulties in Africa, Mediterranean region, Americas, India, China. High northern latitudes are gaining, but can not compensate losses in more fertile areas.
2. **World economy.** Climate mitigation to reach 1.5-2.0 C ~twenty fold cheaper than inaction. Economic losses rapidly growing, island and African economies hit hardest. Absolute losses greatest in USA & Eastern Asia.
3. **Oil & gas dependent economies.** E.g. Russia, Arabic countries etc. highly dependent on fossil energy income. Transition towards non-fossil economy is a challenge.
4. **Africa.** Economies, employment and food security highly dependent on rain-fed agriculture. Population growth 1 => 4 billion by 2100 expected: source of crisis, refugees and death of hunger.
5. **Europe.** Mediterranean countries will suffer. Potential for immigration great, political impacts already visible; a challenge for European Union.

# Suomiperspektiivejä

- 1. Ilmastonmuutoksen torjunta ja sopeutuminen tulee olemaan valtavirtaa:** Kysyntää uusille tuotteille & osaamiselle, kuten polttoaineet, tekniset ratkaisut, kulutuksen ratkaisut, rakentaminen, metsien käyttö, maatalous sekä ruokatuotteet. Myös sopeutmisosaamiselle on kysyntää: sääpalvelut, vesivarojen hallinta & metsät
- 2. Suomi on jo ollut mallioppilas, muuta maailmaa tiukemmat tavoitteet (2035) ovat mahdollisuus ja riski.** 2050 hiilineutraalius on IPCC:n tieteeseen perustuva 1.5 C tavoite. Suomelle mm. lentoliikenneyhteydet ovat Keski-Euroopan maita kriittisempiä.
- 3. Keskeisin haaste on fossiilienergiasta luopuminen.** Suomessa metsien käyttöön liittyy suuria intohimoja myös muista kuin ilmastosyistä.
- 4. Muutos on myös haaste.** Riskinä on maailman ravinnontuotannon häiriintyminen, jolloin maatalousomavaraisuudella on erityistä arvoa. Samoin pakolaisuuden potentiaali.
- 5. Talousvaikutukset.** Venäjän fossiilibusineksen merkittävä kutistuminen? Maailmantalouden ja –kaupan häiriöt?

WEATHER CLIMATE WATER  
TEMPS CLIMAT EAU



شكرا لكم  
Thank you  
Gracias  
Merci  
Спасибо  
谢谢



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