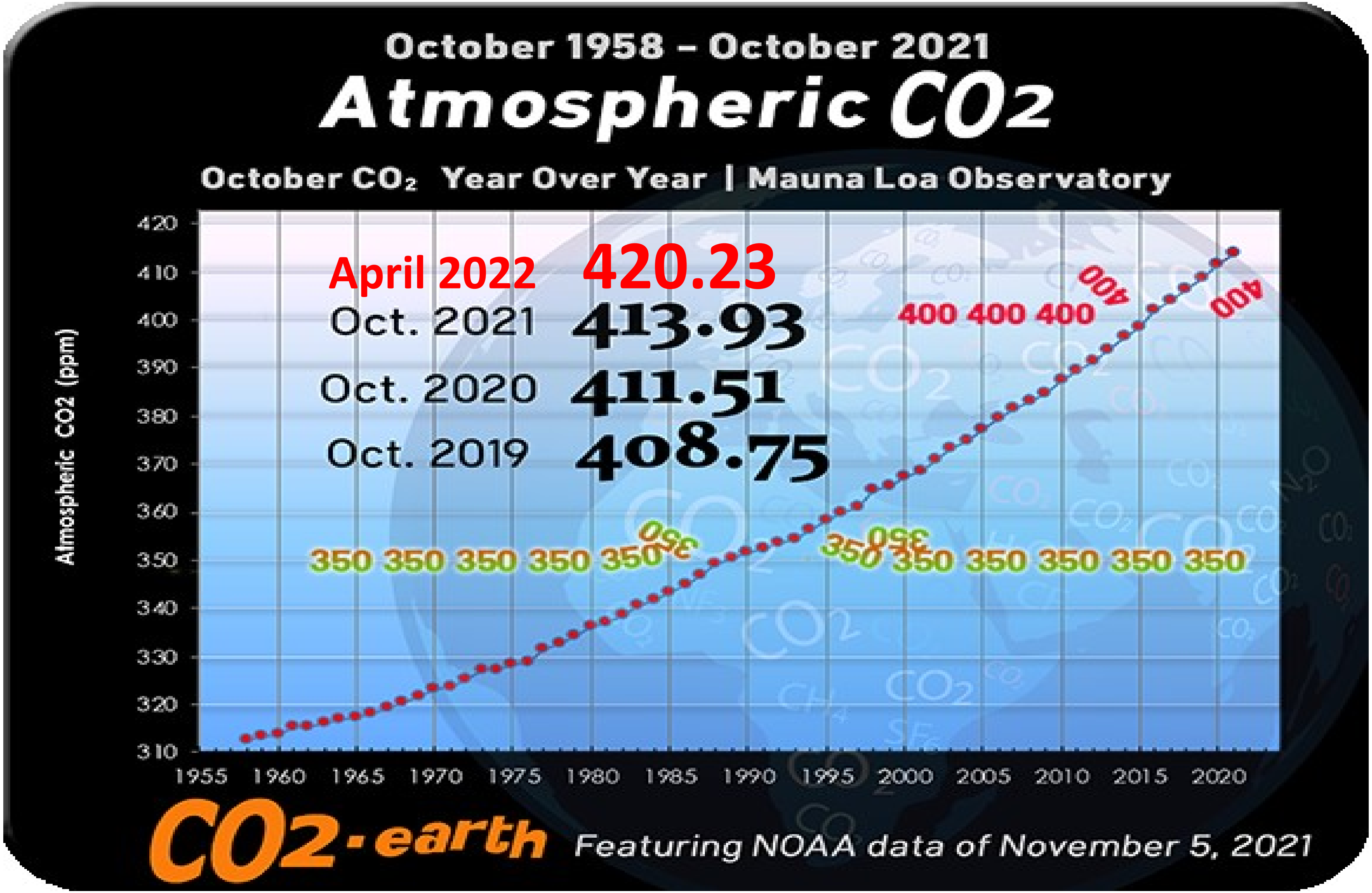
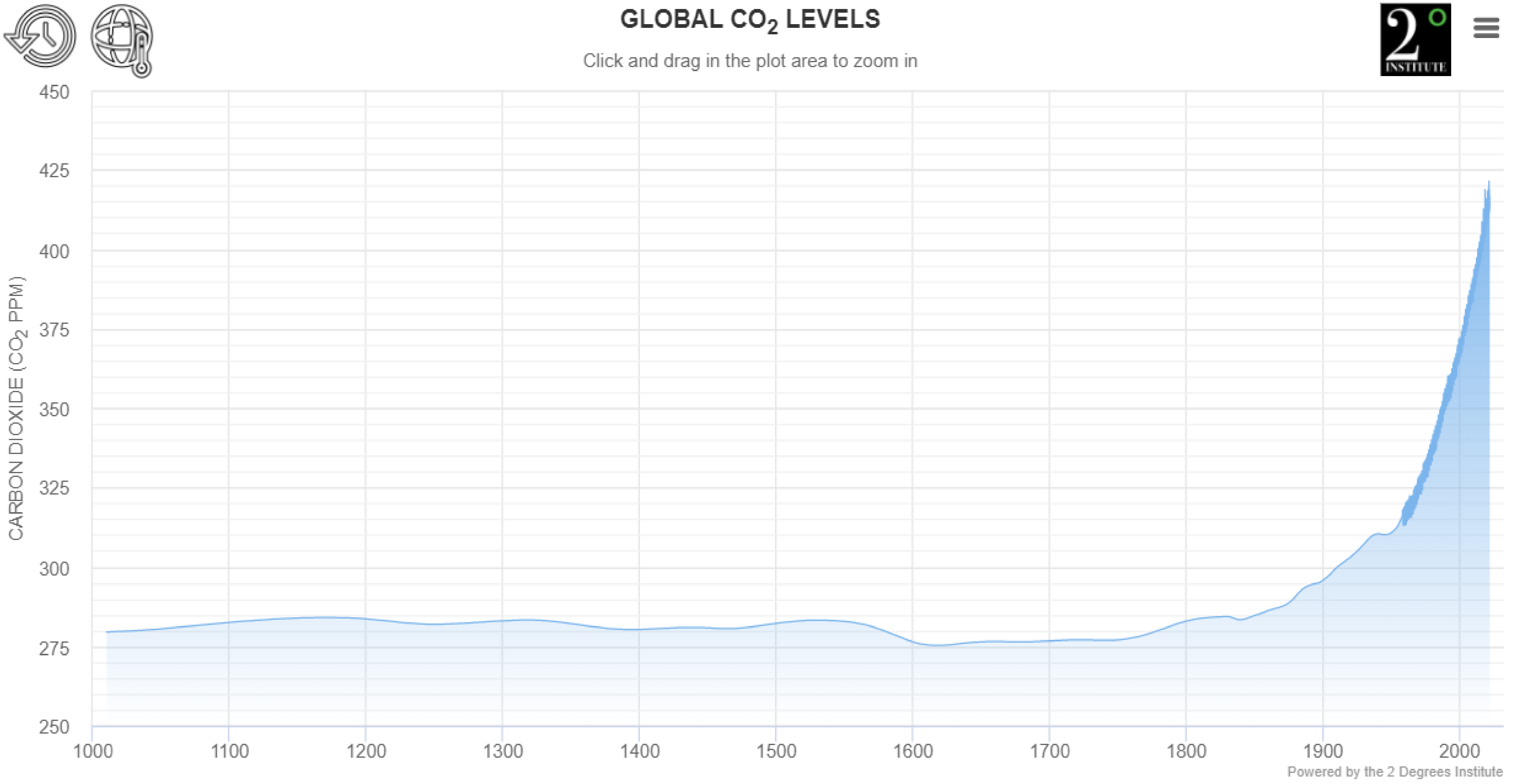
CLIMATE ACTION NETWORK International

Science and IPCC, where do we stand

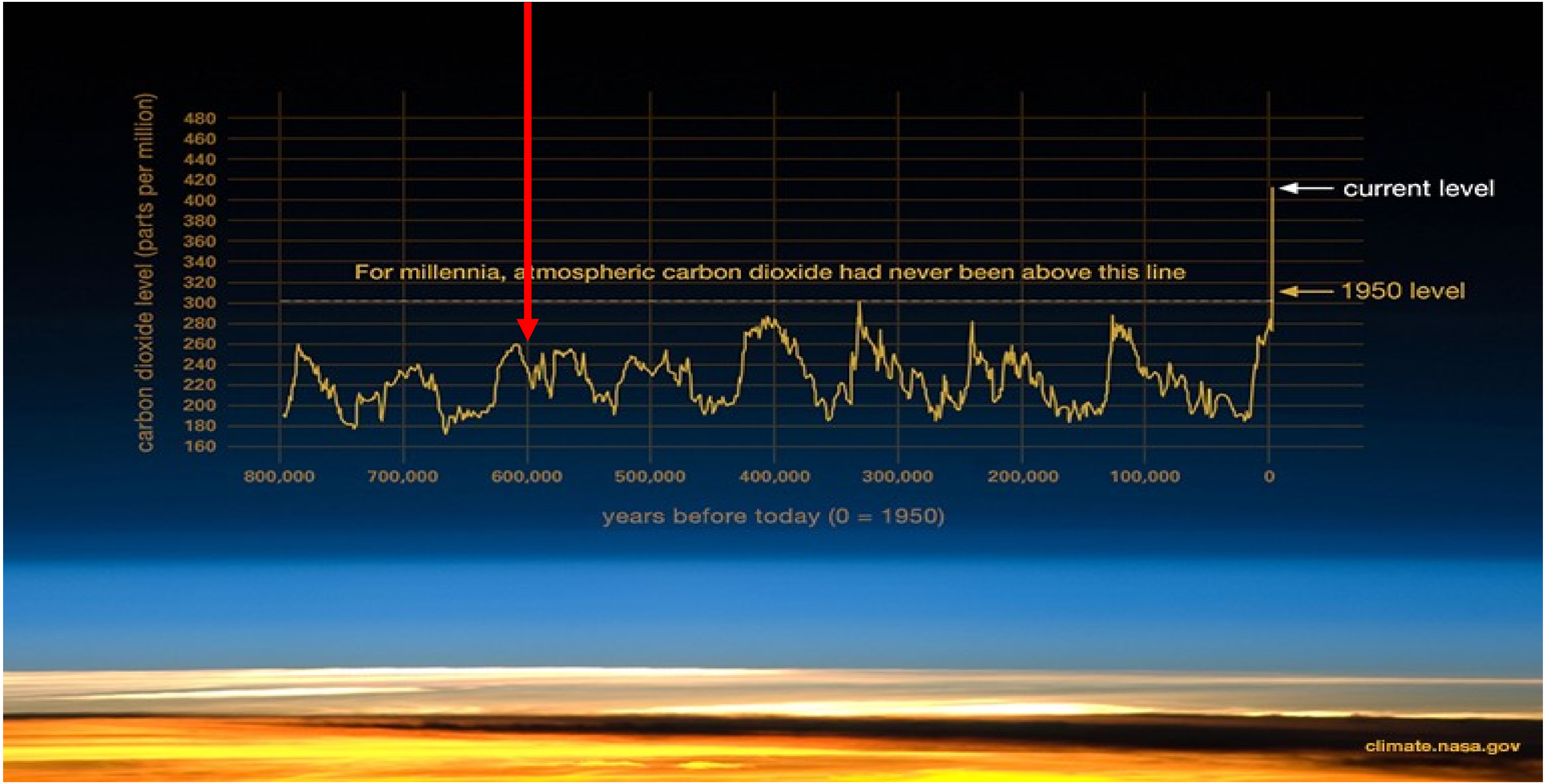
Dr Stephan Singer

May 2022

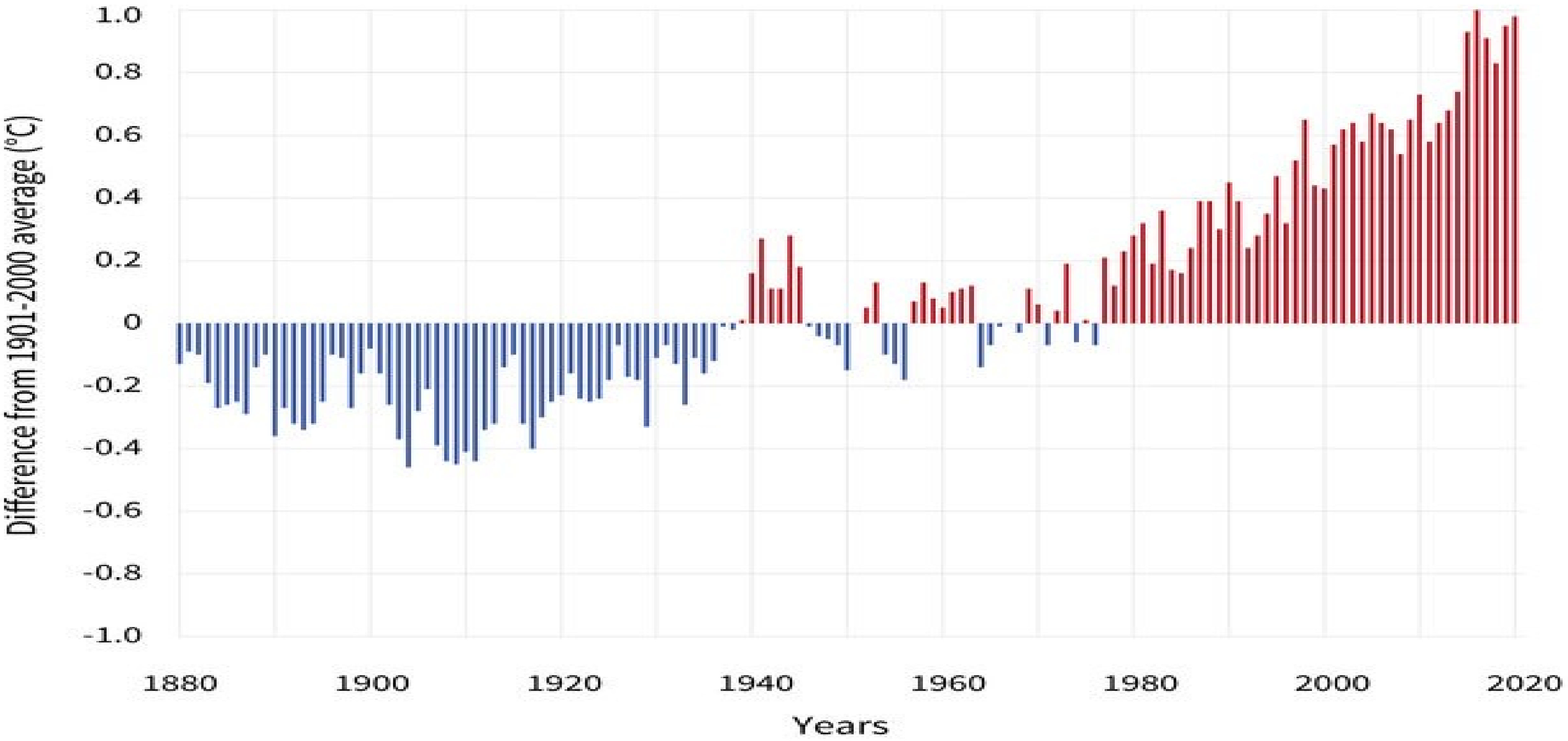

October 1958 – October 2021
Atmospheric CO2
October CO₂ Year Over Year | Mauna Loa Observatory
April 2022 420.23
Oct. 2021 413.93
Oct. 2020 411.51
Oct. 2019 408.75
400 400 400
350 350 350 350 350
350 350 350 350 350 350
Atmospheric CO2 (ppm)
420
410
400
390
380
370
360
350
340
330
320
310
1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020
CO2-earth
Featuring NOAA data of November 5, 2021


GLOBAL CO_2 LEVELS
Click and drag in the plot area to zoom in
INSTITUTE
CARBON DIOXIDE (CO_2 PPM)
450
425
400
375
350
325
300
275
250
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Powered by the 2 Degrees Institute

Early Homo Sapiens



GLOBAL AVERAGE SURFACE TEMPERATURE



"If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm.“ ***Jim Hansen, 2008***

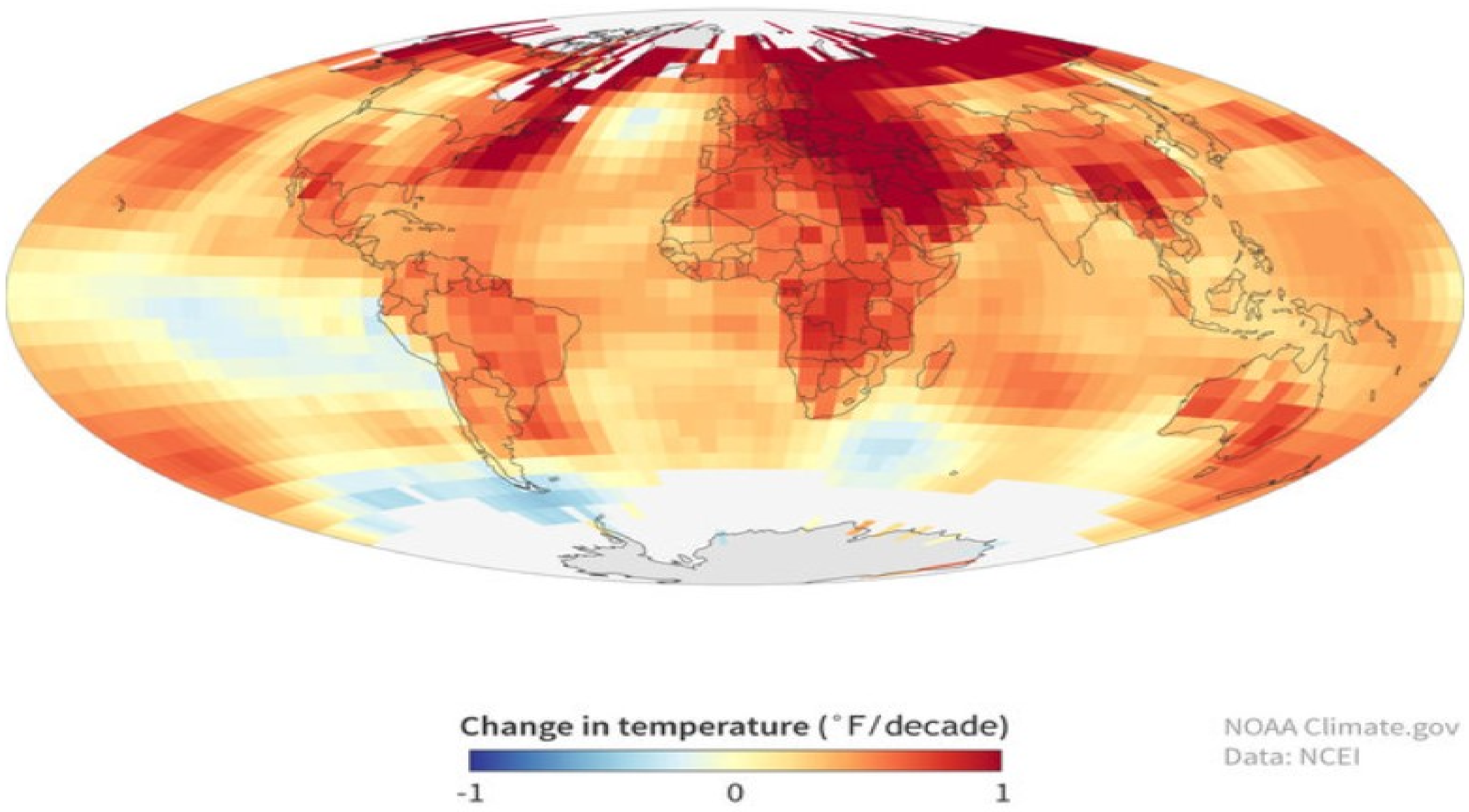
- **„CO2 atmospheric concentrations are likely the highest on Earth since at least 3 mio years“ (SCIENCE, Nov. 2019)“ or the highest since at least 2 mio years (IPCC, 2021)**
- University of Louisiana at Lafayette concluded 2020 that today's carbon dioxide (CO_2) levels are actually higher than they have been for the past 23 million years.

- **“About 15 to 40% of emitted CO2 will remain in the atmosphere longer than 1,000 years” (IPCC AR5 WGI, 2014)**
- **“In the past 200 years alone, ocean water has become 30 percent more acidic—faster than any known change in ocean chemistry in the last 50 million years” (Smithonian Institute, 2016)**
- **Rate of ocean surface water acidification is the highest since at least 2 mio years (IPCC, 2021)**

The rate of global warming today is about five to fifty times faster than in historic/palaeontological times of periods of rapid natural global warming

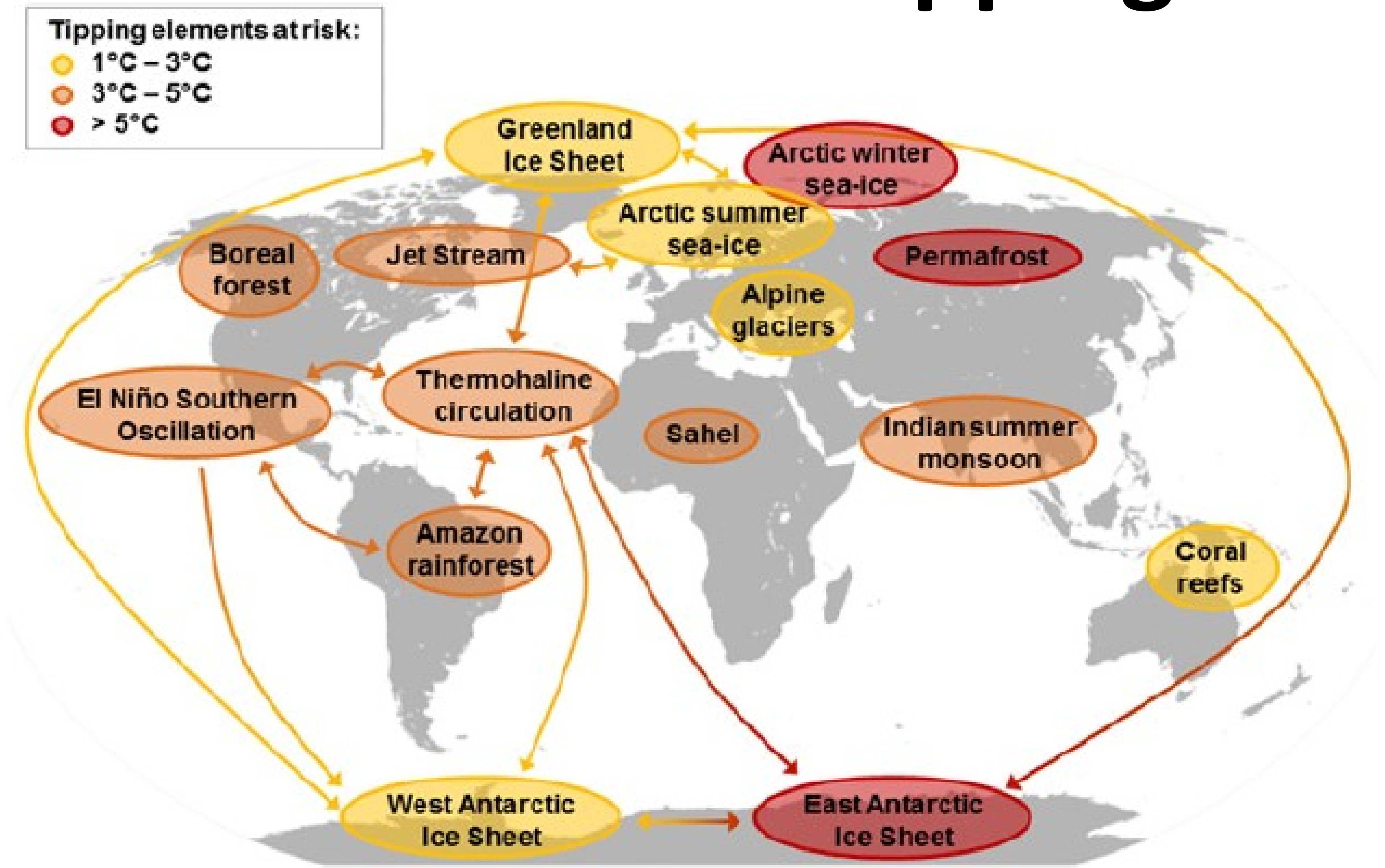
- **2019 and 2020, again as in in previous years, *global* warming of 1°C to 1.1°C (compared to the 1901 – 2000 average), has been much higher over *land* (1.42° C) than over the *oceans* (0.7°C) and stronger in the Northern (1.15° C) than in the Southern (0.7°C) hemisphere. But by now, oceans have accumulated the highest heat content since recordings started.**
- **Since about 20-30 years, annual regional warming with *up to 3°C and more* had been almost three times as high than global average in particular in regions in North, Central and Mediterranean Europe, in parts of the Middle East, and spread across the entire Arctic zone from Greenland to Northern Canada and Russia to Alaska.**

RECENT TEMPERATURE TRENDS (1990-2020)



Trends in global average surface temperature between 1990 and 2020 in degrees Fahrenheit per decade. Yellow indicates little to no change, while orange and red show places that warmed, and blue shows places that cooled. NOAA Climate.gov map, based on data from NOAA Centers for Environmental Information.

Global Tipping Points



Source: Steffen et al., 2018

- „The Greenland Ice Sheet (GrIS) and its outlying ice caps were losing mass at a rate of about 102 Gt/y in early 2003, but **10 y later** this rate had increased **nearly fourfold** to about 393 Gt/y, accounting for much of the observed acceleration in sea level rise…" (PNAS, Jan 2019)

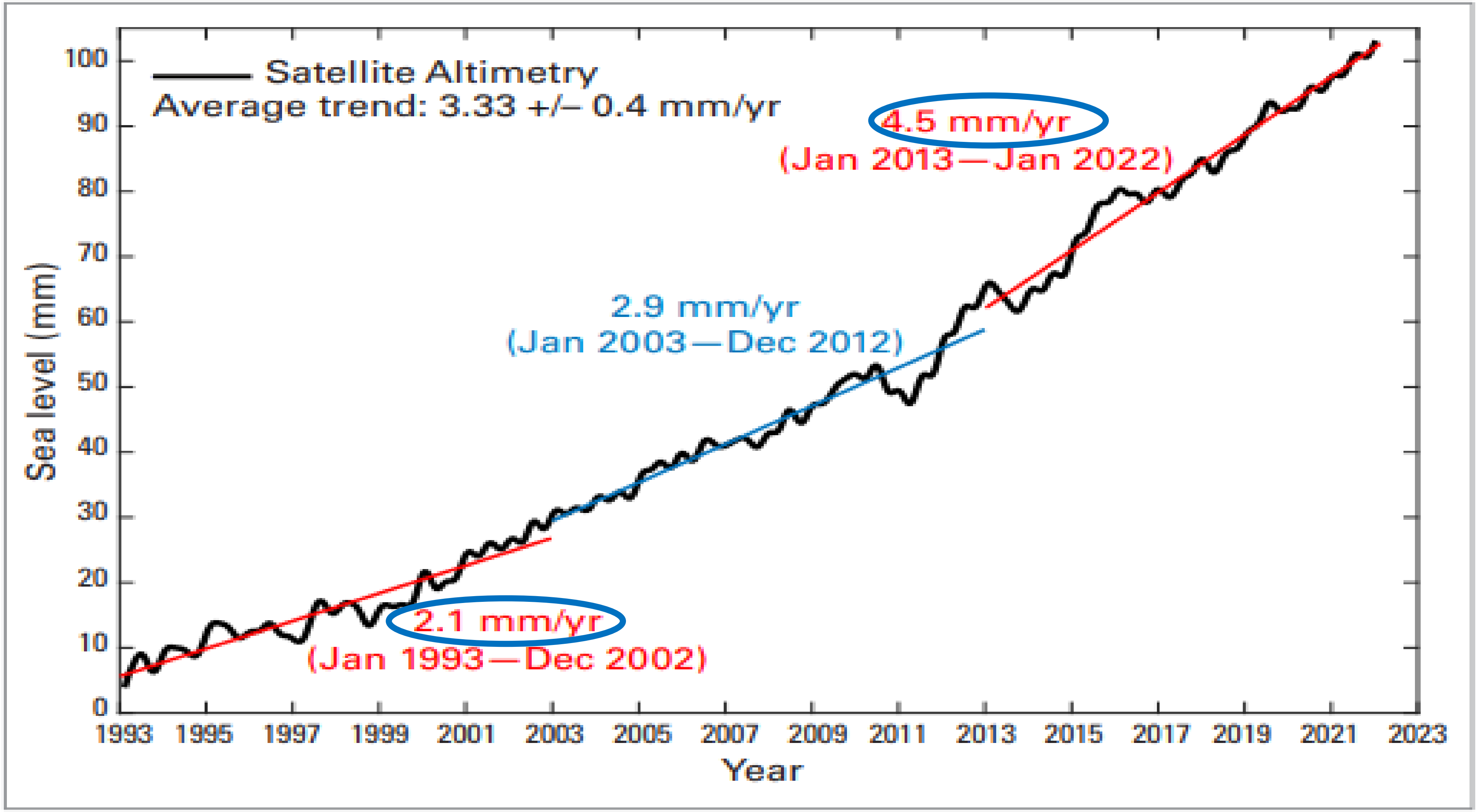
- While the Greenland ice melting had increased **six times between the 1980s and today** as a result of global warming, the contribution to sea level rise was about half of all in only the last eight years 2010 – 2018. In these eight years the net cumulative loss of ice from Greenland was about 2200 billion tons (April 2019: https://www.theatlantic.com/science/archive/2019/04/how-much-ice-has-greenland-lost-climate-change/587431/ https://www.pnas.org/content/early/2019/04/16/1904242116)

- "In the Antarctic, the total ice mass loss increased from 40 Gt/y on average in 1979–1990 to 50 Gt annually in 1989–2000, jumping to 166 Gt/y in 1999–2009, and were about 252 Gt annually in recent years of 2009–2017…." (PNAS, Jan 2019) - **An increase of 6 times (in 20-30 years).**

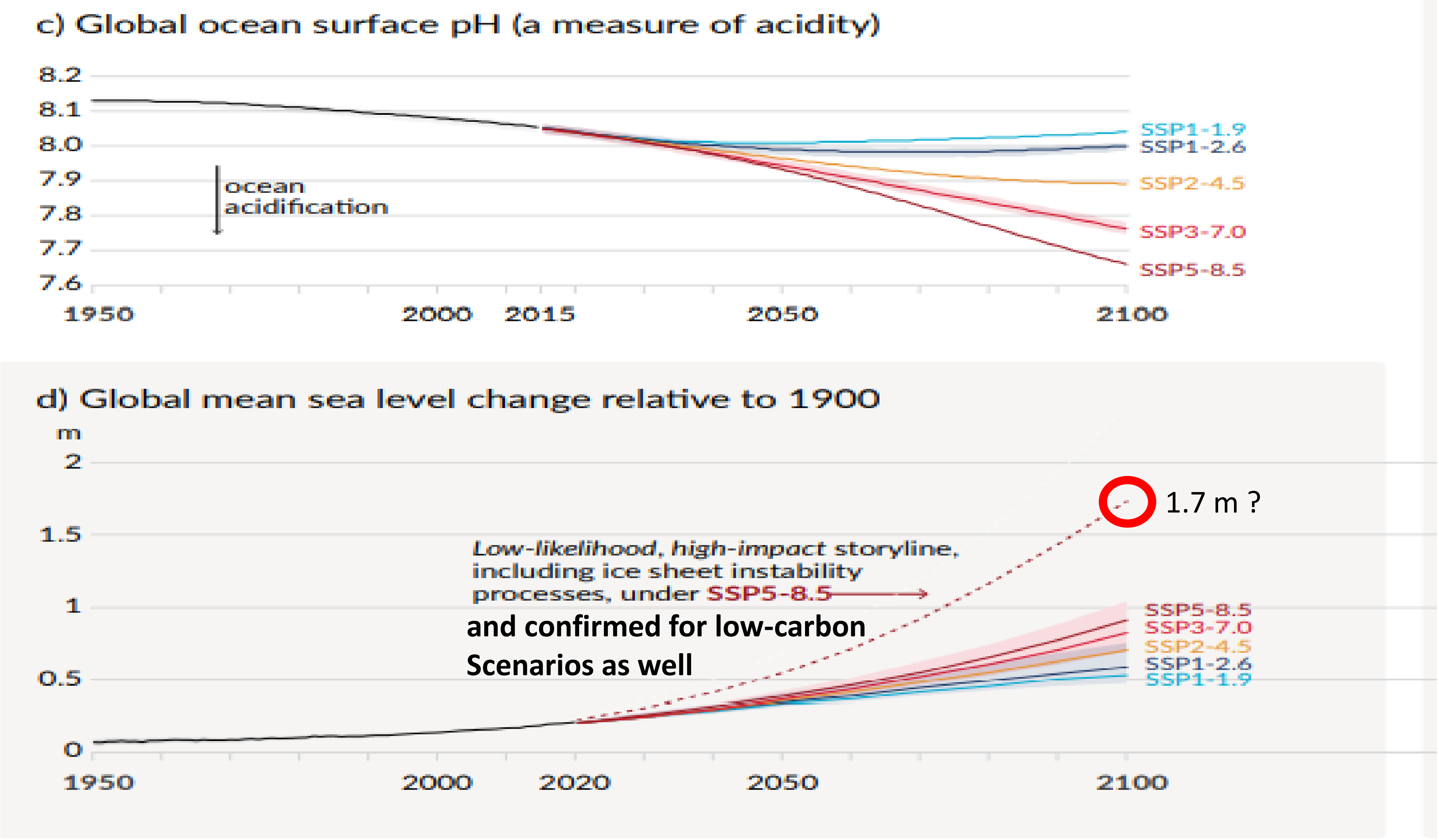
A non-linear but exponential trend – Sea level rise projections by IPCC are probably highly underestimated

Source:

Accelerating annual sea level rise 1993 - 2022



Source: "State of Climate 2021"; World Meteorological Organisation (WMO) 2022


c) Global ocean surface pH (a measure of acidity)
8.2
8.1
8.0
7.9
7.8
7.7
7.6
ocean acidification
SSP1-1.9
SSP1-2.6
SSP2-4.5
SSP3-7.0
SSP5-8.5
1950
2000
2015
2050
2100
d) Global mean sea level change relative to 1900
m
2
1.5
1
0.5
0
1.7 m ?
Low-likelihood, high-impact storyline, including ice sheet instability processes, under SSP5-8.5
and confirmed for low-carbon Scenarios as well
SSP5-8.5
SSP3-7.0
SSP2-4.5
SSP1-2.6
SSP1-1.9
1950
2000
2020
2050
2100

The dangers of uncontrollable carbon feed backs

"….permafrost is thawing much more quickly than models have predicted, with unknown consequences for greenhouse-gas release."

*" We estimate that abrupt permafrost thawing in lowland lakes and wetlands, together with that in upland hills, could release between 60 billion and 100 billion tonnes of carbon by 2300 (**200 – 370 billion tonnes CO_2**). This is in addition to the 200 billion tonnes of carbon (**740 billion tonnes CO_2**) expected to be released in other regions that will thaw gradually. Although abrupt permafrost thawing will occur in less than 20% of frozen land, it increases permafrost carbon release projections by about 50%. "*

"Furthermore, because abrupt thawing releases more methane than gradual thawing does, the climate impacts of the two processes will be similar. So, together, the impacts of thawing permafrost on Earth's climate could be twice that expected from current models"

Source: NATURE 2019 https://www.nature.com/articles/d41586-019-01313-4?utm_source=Nature+Briefing&utm_campaign=9d991fd363-briefing-dy-20190430&utm_medium=email&utm_term=0_c9dfd39373-9d991fd363-43943857

Direct quotes from the IPCC report on oceans and the cryosphere 1

- It is *virtually certain* that the global ocean has warmed unabated since 1970 and has taken up more than 90% of the excess heat in the climate system (*high confidence*).
- Datasets spanning 1970–2010 show that the open ocean has lost oxygen by a *very likely* range of 0.5–3.3% over the upper 1000 m, alongside a *likely* expansion of the volume of oxygen minimum zones by 3–8%. (***higher than observed before***)
- The ocean has taken up between 20–30% (*very likely*) of total anthropogenic CO2 emissions since the 1980s causing further ocean acidification. Open ocean surface pH has declined by a *very likely* range of 0.017–0.027 pH units per decade since the late 1980s (***means a 30% increase of ocean acidification***)
- Sea-level rise has accelerated (*extremely likely*) due to the combined increased ice loss from the Greenland and Antarctic ice sheets (*very high confidence*). Mass loss from the Antarctic ice sheet over the period 2007–2016 tripled relative to 1997–2006. For Greenland, mass loss doubled over the same period.

Source: IPCC report on Oceans and Cryosphere, September 2019; highlights by me

Direct quotes from the IPCC report on oceans and the cryosphere 2

- Acceleration of ice flow and retreat in Antarctica, which has the potential **to lead to sea-level rise of several metres** within a few centuries, is observed in the Amundsen Sea, Embayment of West Antarctica and in Wilkes Land, East Antarctica (*very high confidence*). These changes may be the onset of an **irreversible ice sheet instability.**
- The Greenland and Antarctic Ice Sheets are projected to lose mass at an increasing rate throughout the 21st century and beyond (*high confidence*). The rates and magnitudes of these cryospheric changes are projected to increase further in the second half of the 21st century in a high greenhouse gas emissions scenario (*high confidence*). Strong reductions in greenhouse gas emissions in the coming decades are projected to **reduce further changes after 2050** (*high confidence*).

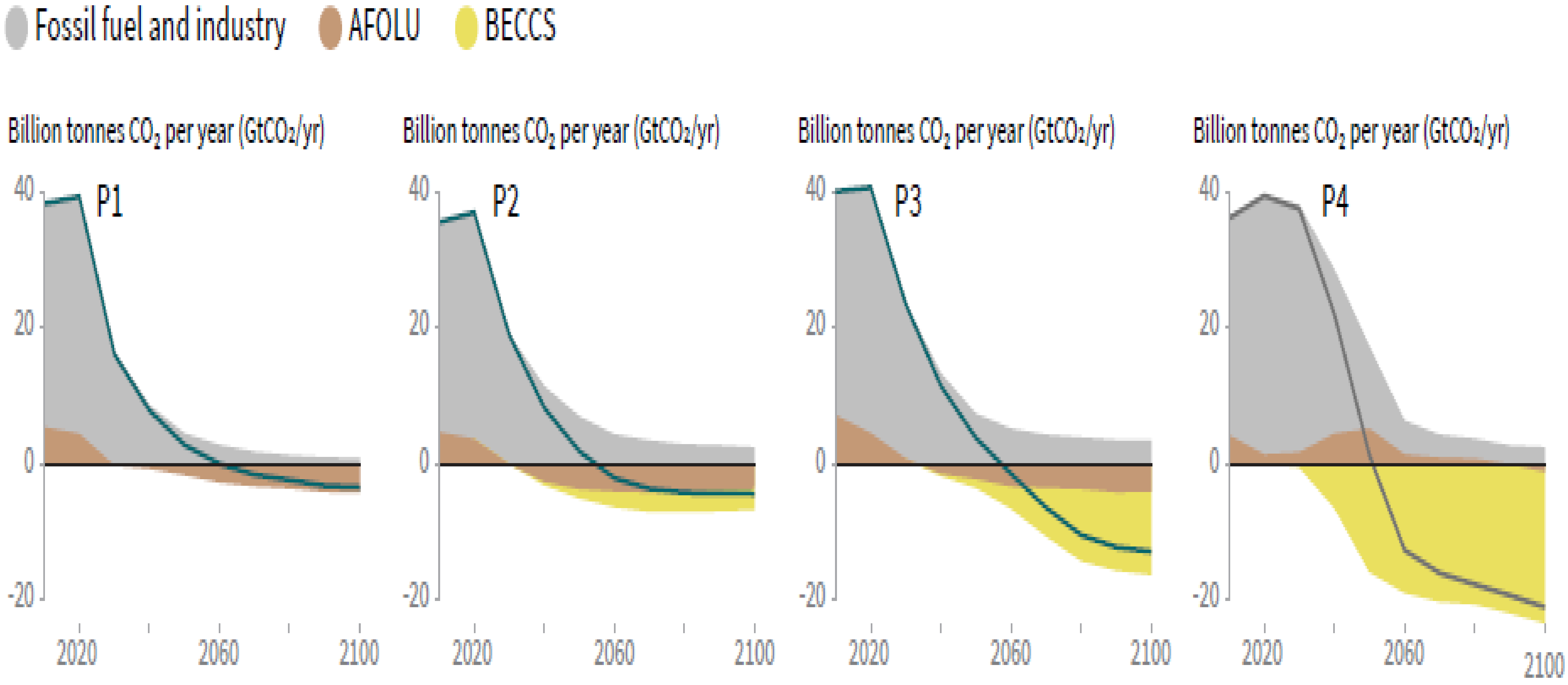
Source: IPCC report on Oceans and Cryosphere, September 2019; highlights by me

Direct quotes from the IPCC report on oceans and the cryosphere 3

- The RCP8.5 scenario leads to the cumulative release of **tens to hundreds of billions of tons (GtC) of permafrost carbon as CO2 and methane** to the atmosphere by 2100 with the potential to exacerbate climate change
- Sea level continues to rise at an increasing rate. Extreme sea level events that are **historically rare (once per century in the recent past)** are projected to occur frequently (**at least once per year**) at many locations by 2050 in **all** RCP scenarios, especially in tropical regions (*high confidence*).
- Many low-lying megacities and small islands (including SIDS) are projected to experience **historical centennial events at least annually by 2050** under RCP2.6, RCP4.5 and RCP8.5.
- In the absence of more ambitious adaptation efforts compared to today, and under current trends of increasing exposure and vulnerability of coastal communities, risks, such as erosion and land loss, flooding, salinization, and cascading impacts due to mean sea level rise and extreme events are **projected to significantly increase throughout this century under all greenhouse gas emissions scenarios** (*very high confidence*).

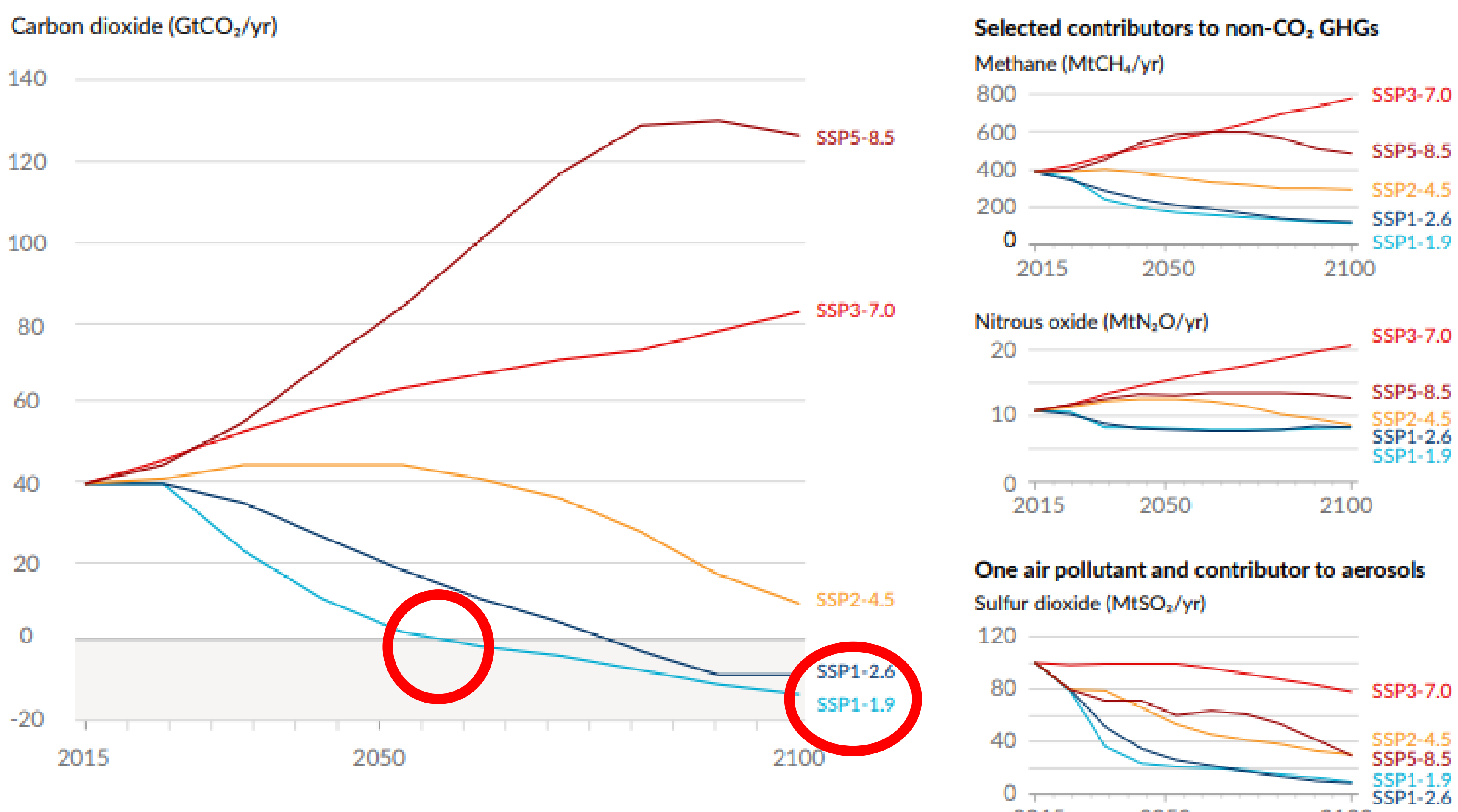
Source: IPCC report on Oceans and Cryosphere, September 2019; highlights by me

Breakdown of contributions to global net CO_2 emissions in four illustrative model pathways



Future emissions cause future additional warming, with total warming dominated by past and future CO_2 emissions

a) Future annual emissions of CO_2 (left) and of a subset of key non-CO_2 drivers (right), across five illustrative scenarios



The real temperature differences between high- and low emissions scenarios occur in the future decades

	Near term, 2021–2040		Mid-term, 2041–2060		Long term, 2081–2100	
Scenario	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)	Best estimate (°C)	*Very likely* range (°C)
SSP1-1.9	1.5	1.2 to 1.7	1.6	1.2 to 2.0	1.4	1.0 to 1.8
SSP1-2.6	1.5	1.2 to 1.8	1.7	1.3 to 2.2	1.8	1.3 to 2.4
SSP2-4.5	1.5	1.2 to 1.8	2.0	1.6 to 2.5	2.7	2.1 to 3.5
SSP3-7.0	1.5	1.2 to 1.8	2.1	1.7 to 2.6	3.6	2.8 to 4.6
SSP5-8.5	1.6	1.3 to 1.9	2.4	1.9 to 3.0	4.4	3.3 to 5.7

IPCC WG II – Highlights from SPM, direct quotes

In yellow – my emphasize

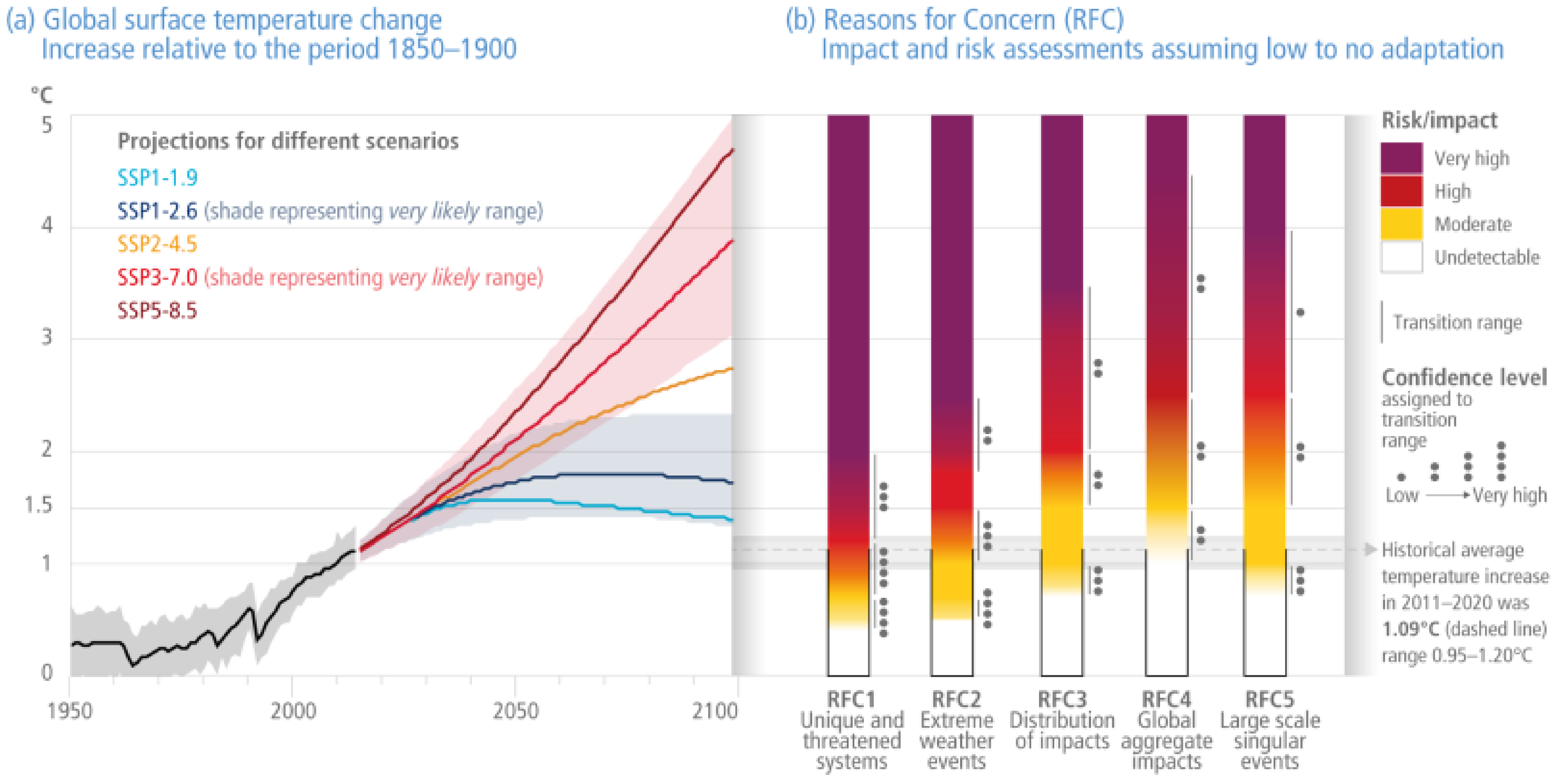
- Beyond 2040 and depending on the level of global warming, climate change will lead to numerous risks to natural and human systems (high confidence). For 127 identified key risks, assessed mid- and long-term impacts are up to multiple times higher than currently observed (high confidence). The magnitude and rate of climate change and associated risks depend strongly on near-term mitigation and adaptation actions, and projected adverse impacts and related losses and damages escalate with every increment of global warming (very high confidence).
- Global warming, reaching 1.5°C in the near-term, would cause unavoidable increases in multiple climate hazards and present multiple risks to ecosystems and humans (very high confidence). The level of risk will depend on concurrent near-term trends in vulnerability, exposure, level of socioeconomic development and adaptation (high confidence). Near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems, compared to higher warming levels, but cannot eliminate them all (very high confidence)
- Biodiversity loss, and degradation, damages to and transformation of ecosystems are already key risks for every region due to past global warming and will continue to escalate with every increment of global warming (very high confidence). In terrestrial ecosystems, 3 to 14% of species assessed will likely face very high risk of extinction at global warming levels of 1.5°C…….
- Globally, population change in low-lying cities and settlements will lead to approximately a billion people projected to be at risk from coastal-specific climate hazards in the mid-term under all scenarios, including in Small Islands (high confidence).

- Projected estimates of global aggregate net economic damages generally increase non-linearly with global warming levels (high confidence).
- Depending on the magnitude and duration of overshoot, some impacts will cause release of additional greenhouse gases (medium confidence) and some will be irreversible, even if global warming is reduced (high confidence).
- Additional warming, e.g., above 1.5°C during an overshoot period this century, will result in irreversible impacts on certain ecosystems with low resilience, such as polar, mountain, and coastal ecosystems, impacted by ice-sheet, glacier melt, or by accelerating and higher committed sea level rise (high confidence). Risks to human systems will increase, including those to infrastructure, low-lying coastal settlements, some ecosystem-based adaptation measures, and associated livelihoods (high confidence), cultural and spiritual values (medium confidence). Projected impacts are less severe with shorter duration and lower levels of overshoot (medium confidence).
- Most observed adaptation is fragmented, small in scale, incremental, sector-specific, designed to respond to current impacts or near-term risks, and focused more on planning rather than implementation (high confidence). Observed adaptation is unequally distributed across regions (high confidence), and gaps are partially driven by widening disparities between the estimated costs of adaptation and documented finance allocated to adaptation (high confidence). The largest adaptation gaps exist among lower income population groups (high confidence).

- Sea level rise poses a distinctive and severe adaptation challenge as it implies dealing with slow onset changes and increased frequency and magnitude of extreme sea level events which will escalate in the coming decades (high confidence). Such adaptation challenges would occur much earlier under high rates of sea level rise, in particular if low-likelihood, high impact outcomes associated with collapsing ice sheets occur (high confidence).
- Approximately 3.4 billion people globally live in rural areas around the world, and many are highly vulnerable to climate change. Integrating climate adaptation into social protection programs, including cash transfers and public works programmes, is highly feasible and increases resilience to climate change, especially when supported by basic services and infrastructure. Social safety nets are increasingly being reconfigured to build adaptive capacities of the most vulnerable in rural and also urban communities. Social safety nets that support climate change adaptation have strong co-benefits with development goals such as education, poverty alleviation, gender inclusion and food security.
- Within energy system transitions, the most feasible adaptation options support infrastructure resilience, reliable power systems and efficient water use for existing and new energy generation systems (very high confidence). Energy generation diversification, including with renewable energy resources and generation that can be decentralised depending on context (e.g., wind, solar, small scale hydroelectric) and demand side management (e.g., storage, and energy efficiency improvements) can reduce vulnerabilities to climate change, especially in rural populations (high confidence).
- Unsustainable land-use and land cover change, unsustainable use of natural resources, deforestation, loss of biodiversity, pollution, and their interactions, adversely affect the capacities of ecosystems, societies, communities and individuals to adapt to climate change (high confidence). Loss of ecosystems and their services has cascading and long-term impacts on people globally, especially for Indigenous Peoples and local communities who are directly dependent on ecosystems, to meet basic needs.

- With adaptation finance needs estimated to be higher than those presented in AR5, enhanced mobilization of and access to financial resources are essential for implementation of adaptation and to reduce adaptation gaps (high confidence). Building capacity and removing some barriers to accessing finance is fundamental to accelerate adaptation, especially for vulnerable groups, regions and sectors (high confidence). Public and private finance instruments include inter alia grants, guarantee, equity, concessional debt, market debt, and internal budget allocation as well as savings in households and insurance. Public finance is an important enabler of adaptation (high confidence)
- Levels of risk for all Reasons for Concern (RFC) *[graphic next slide]* are assessed to become high to very high at lower global warming levels than in AR5 (high confidence). Between 1.2°C and 4.5°C global warming level very high risks emerge in all five RFCs compared to just two RFCs in AR5 (high confidence).
- Climate resilient development pathways are progressively constrained by every increment of warming, in particular beyond 1.5°C, social and economic inequalities, the balance between adaptation and mitigation varying by national, regional and local circumstances and geographies, according to capabilities including resources, vulnerability, culture and values, past development choices leading to past emissions and future warming scenarios, bounding the climate resilient development pathways remaining, and the ways in which development trajectories are shaped by equity, and social and climate justice. (very high confidence).
- Recent analyses, drawing on a range of lines of evidence, suggest that maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30% to 50% of Earth’s land, freshwater and ocean areas, including currently near-natural ecosystems (high confidence).
- ***The cumulative scientific evidence is unequivocal: Climate change is a threat to human well-being and planetary health. Any further delay in concerted anticipatory global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a liveable and sustainable future for all. (very high confidence)***

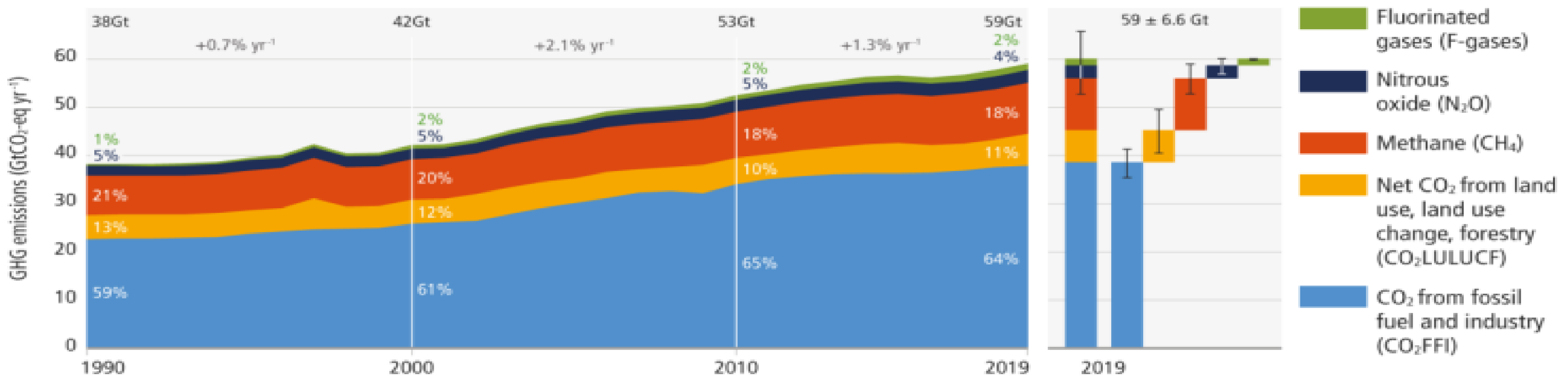
Global and regional risks for increasing levels of global warming



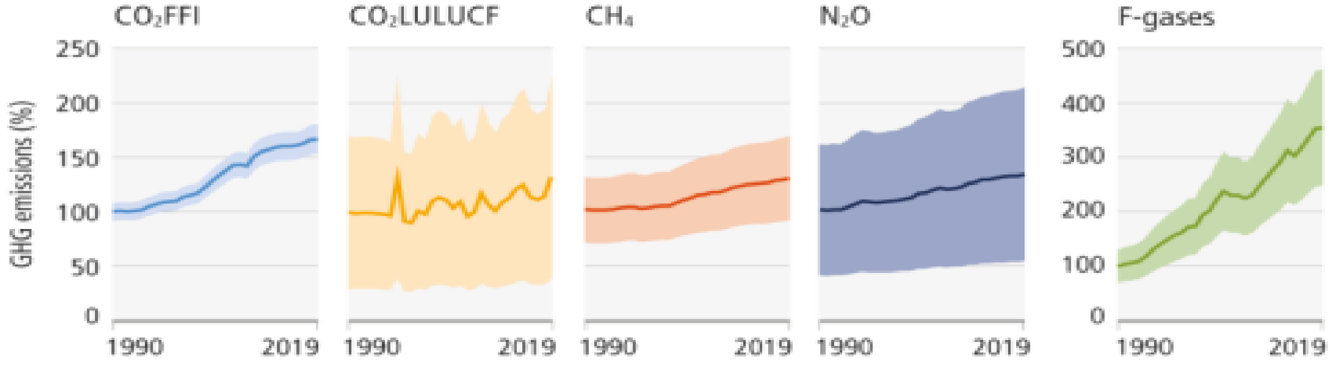
CO2 remains the largest GHG with about 75%, and fossil fuels the largest source

Global net anthropogenic emissions have continued to rise across all major groups of greenhouse gases.

a. Global net anthropogenic GHG emissions 1990–2019 [6]



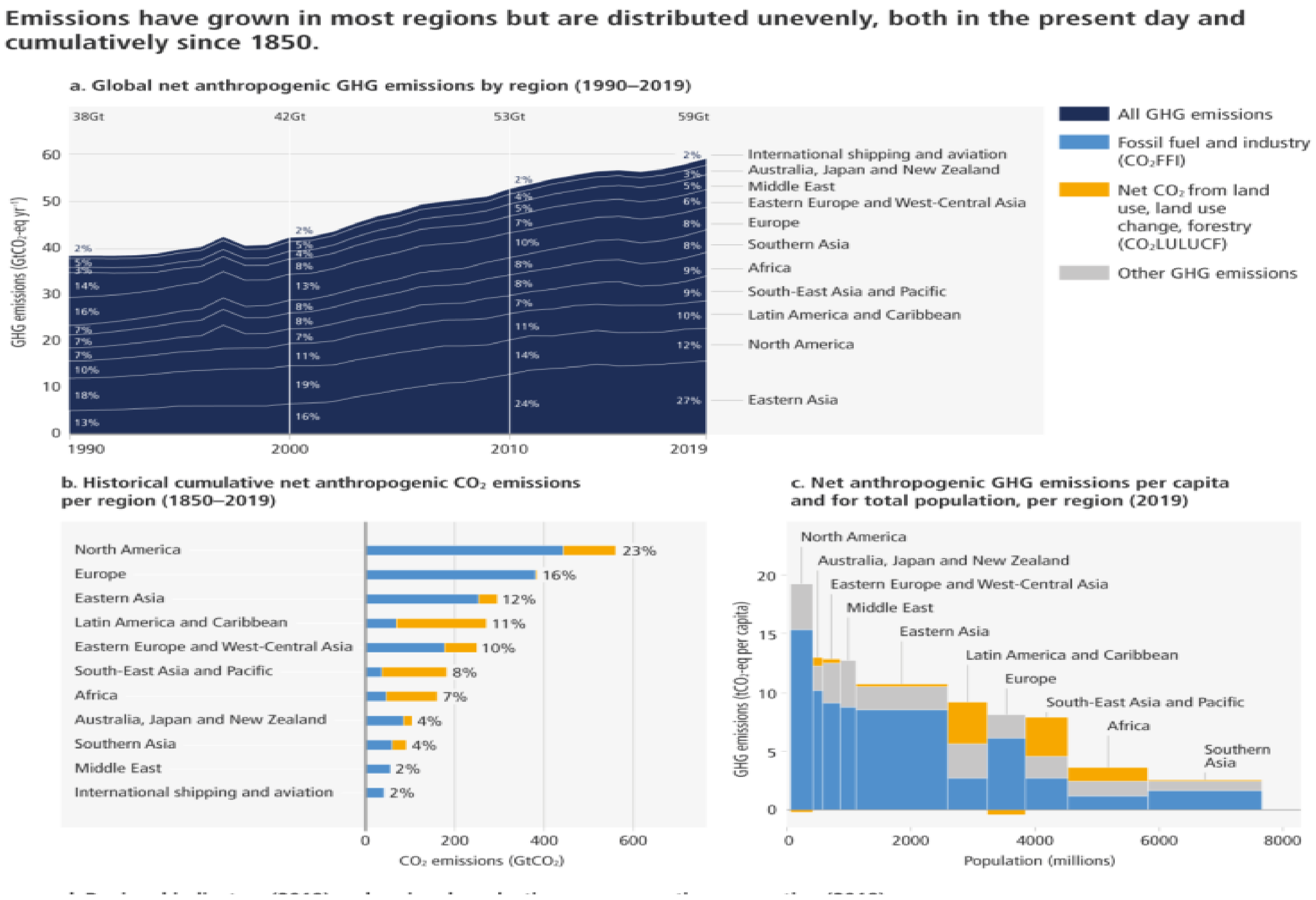
b. Global anthropogenic GHG emissions and uncertainties by gas – relative to 1990



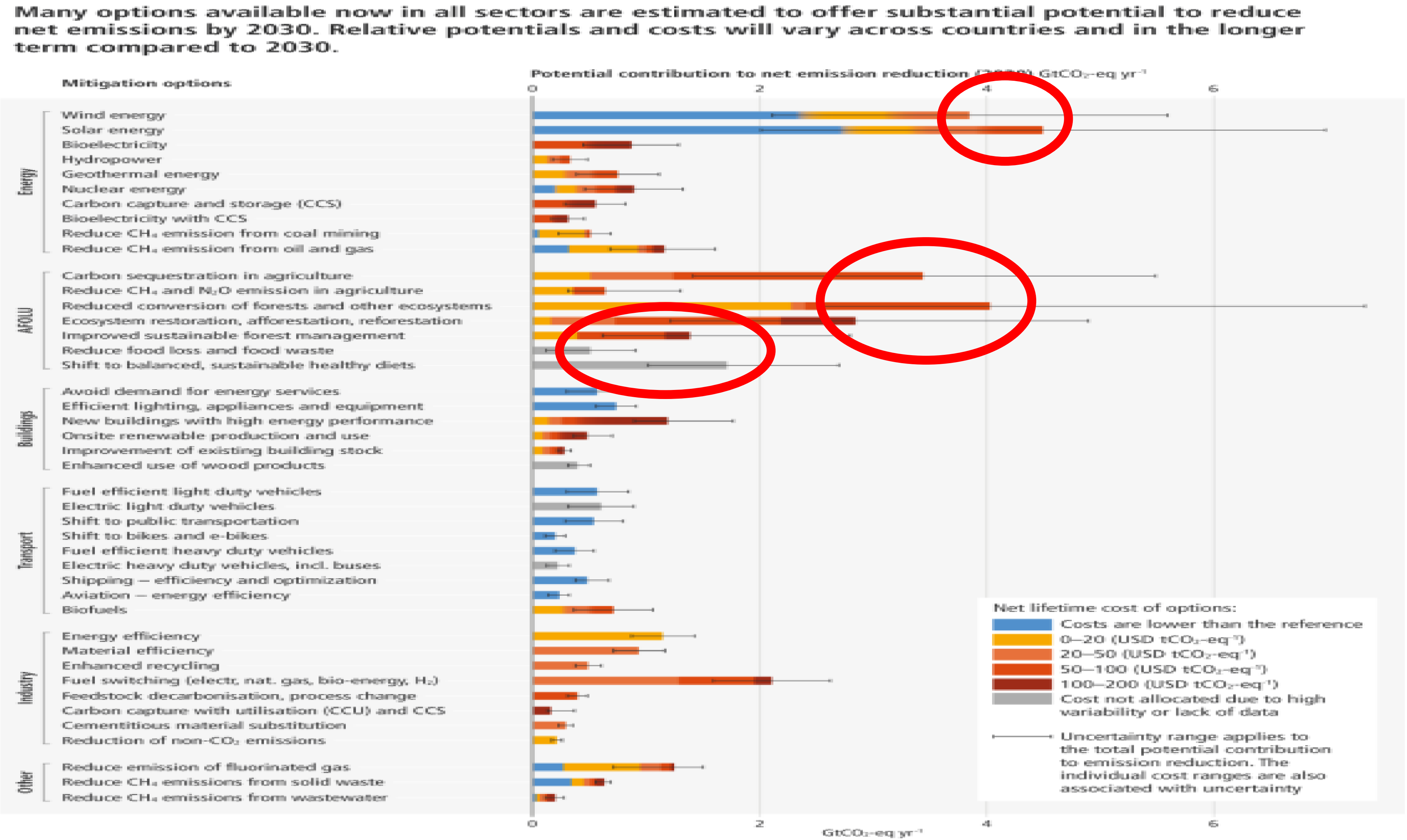
	2019 emissions ($GtCO_2$-eq)	1990–2019 increase ($GtCO_2$-eq)	Emissions in 2019, relative to 1990 (%)
CO_2 FFI	38±3	15	167
CO_2 LULUCF	6.6±4.6	1.6	133
CH_4	11±3.2	2.4	129
N_2O	2.7±1.6	0.65	133
F-gases	1.4±0.41	0.97	354
Total	59±6.6	21	154

The solid line indicates central estimate of emissions trends. The shaded area indicates the uncertainty range.

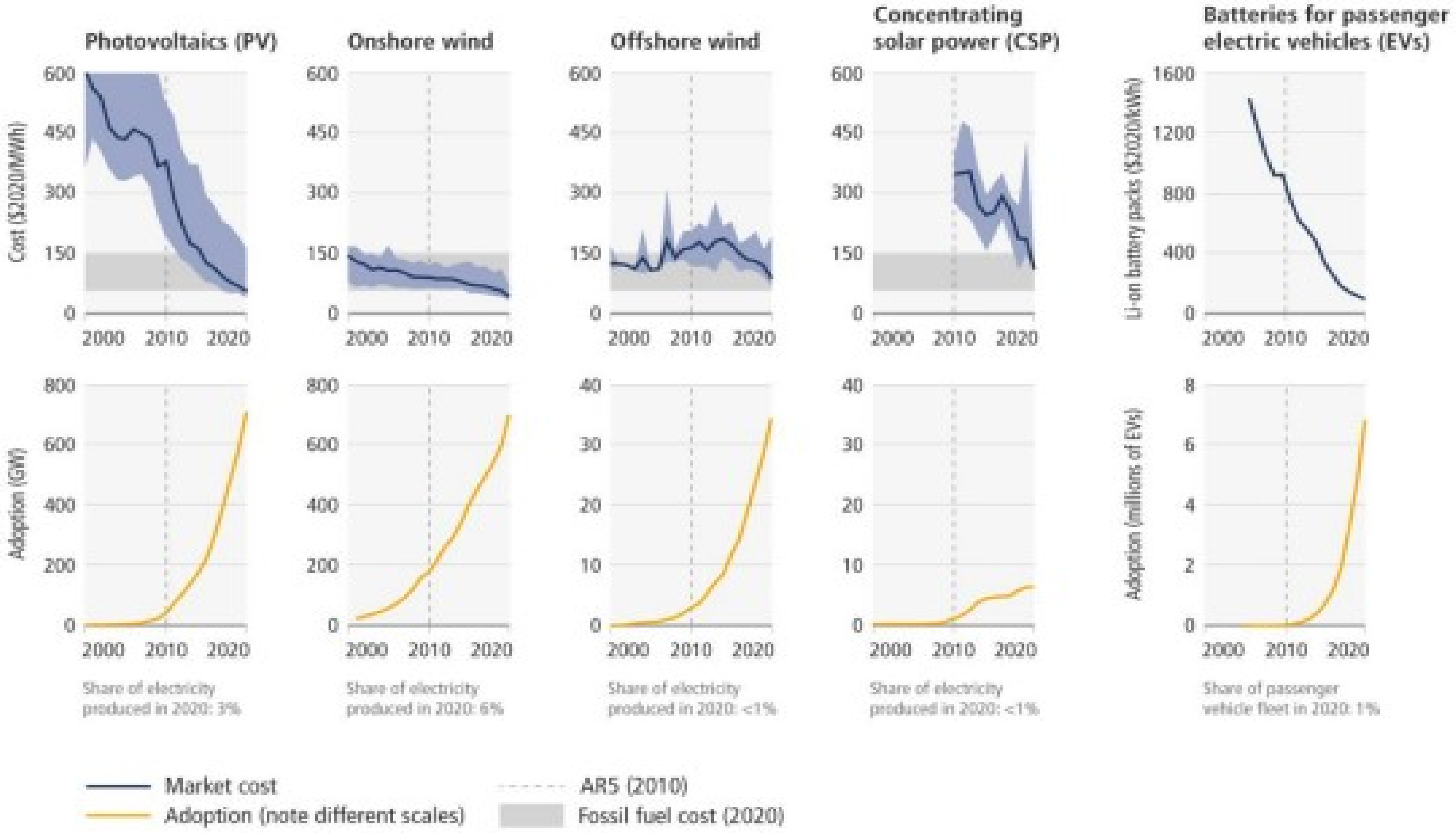
Largest historic total and per capita emissions in North America, lowest in Southern Asia



Largest mitigation potentials until 2030 for wind, solar, halting deforestation, energy efficiency, restoration, shifting diets, carbon sequestration in agriculture

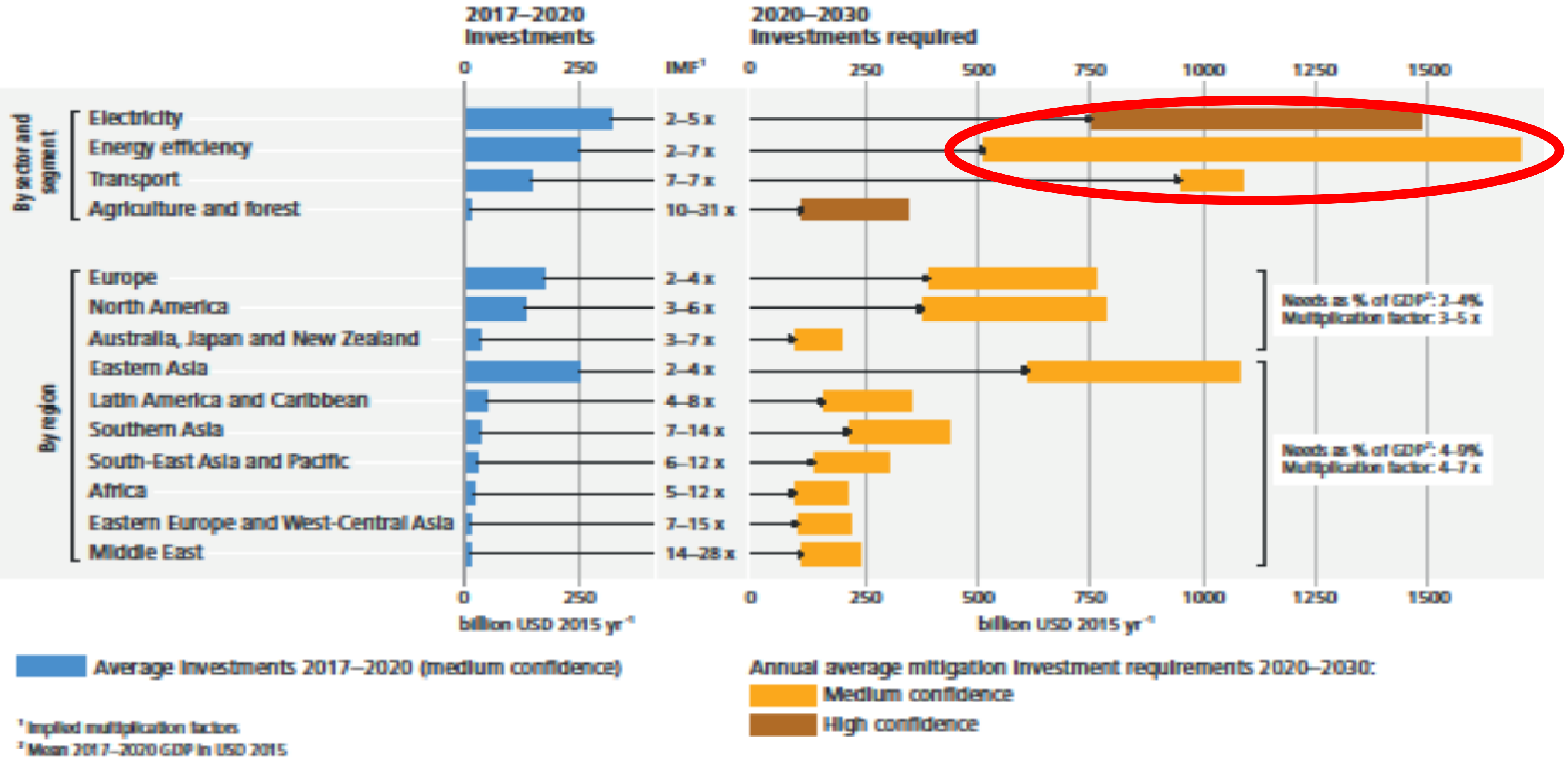


The unit costs of some forms of renewable energy and of batteries for passenger EVs have fallen, and their use continues to rise.



Did not make it in the IPCC WG III report – but showing that world needs to grow investments into clean technologies by up to six times annually between now and 2030

Mitigation investments need to increase significantly across all sectors and segments, particularly in developing countries.



Conclusions “Code red”

- **CO_2 concentrations are the highest since at least two million years**
- **Impacts across all continents do already and will happen faster, more extreme and exponential than thought earlier, from food security, forest fires, sea level rise to heat and flood extremes**
- **Exceeding 1.5°C increases the risks of irreversible changes and tipping points**
- **Temporary 1.5°C overshoot is unavoidable in next decades, but return to 1.4°C possible**
- **Much better and enhanced adaptation and Loss & Damage finance needed**
- **Deep, early, continued GHG reductions are necessary, so are negative emissions after net-zero in mid-century**
- **Fossil fuel phase out is mandatory, coal needs to be out of system in the 2030s**
- **Financing for both adaptation and mitigation needs to be in the trillions to avoid havoc**
- **Policies need to address the multiple crises of pollution, biodiversity loss, inequity etc.**
- **Largest technical and cost-effective potentials are solar, wind, ecosystem protection & restoration, energy efficiency in all economic sectors, diet shifts, reducing food waste**
- **Nuclear and CCS only very limited options**
- **Finance system and investment practices have to change radically – both internationally and nationally for drastically overcoming inequalities in almost all nations**