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Association Actuarielle Internationale



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**21st Global
Conference
of Actuaries**

17th - 19th February 2020 | Mumbai, India

THE SCIENCE OF CLIMATE CHANGE

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Indian Institute of Science**

18 February 2020

Take Home Messages

Climate Change is already underway (1°C)

Strong link between Climate Change, CO₂ and our energy usage (our life style)

Climate change impacts could be severe and long lasting

Climate change adaptation and mitigation could bring new opportunities

Current Climate Change

Climate change: IPCC 2013 report



Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.

1.5 deg Special report (2018)

ipcc

INTERGOVERNMENTAL PANEL ON climate change

Global Warming of 1.5°C

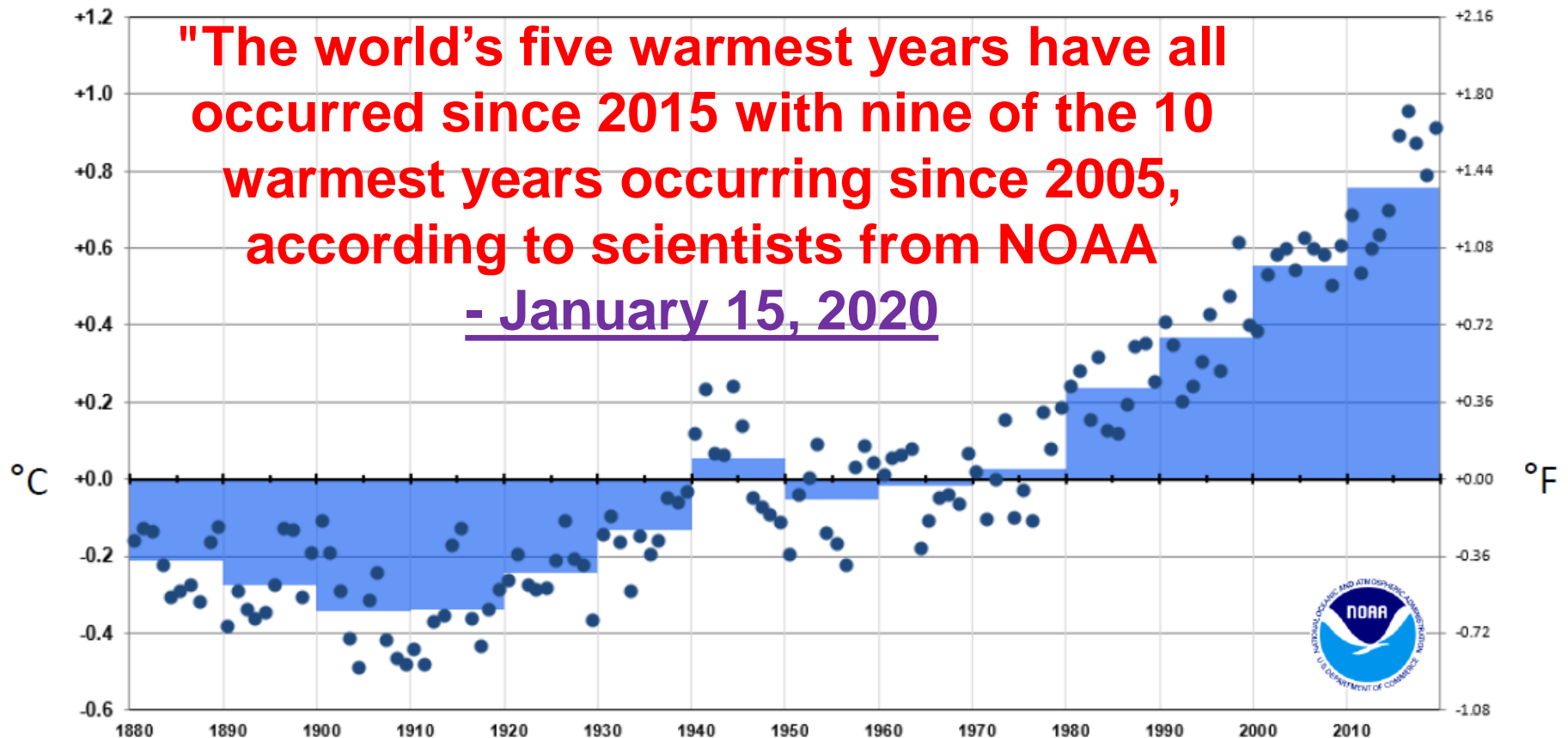
An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. (*high confidence*)

Warming from anthropogenic emissions from the pre-industrial period to the present will persist for centuries to millennia and will continue to cause further long-term changes in the climate system, such as sea level rise, with associated impacts (*high confidence*), but these emissions alone are unlikely to cause global warming of 1.5°C (*medium confidence*).

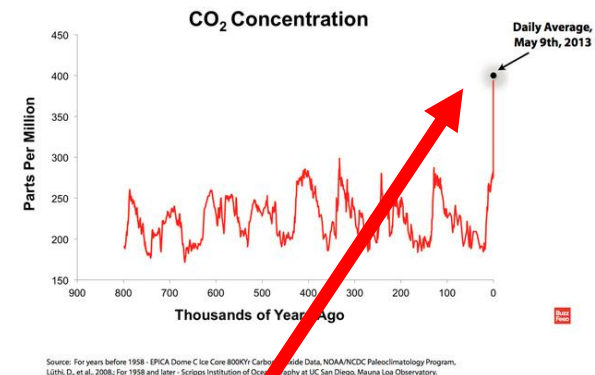
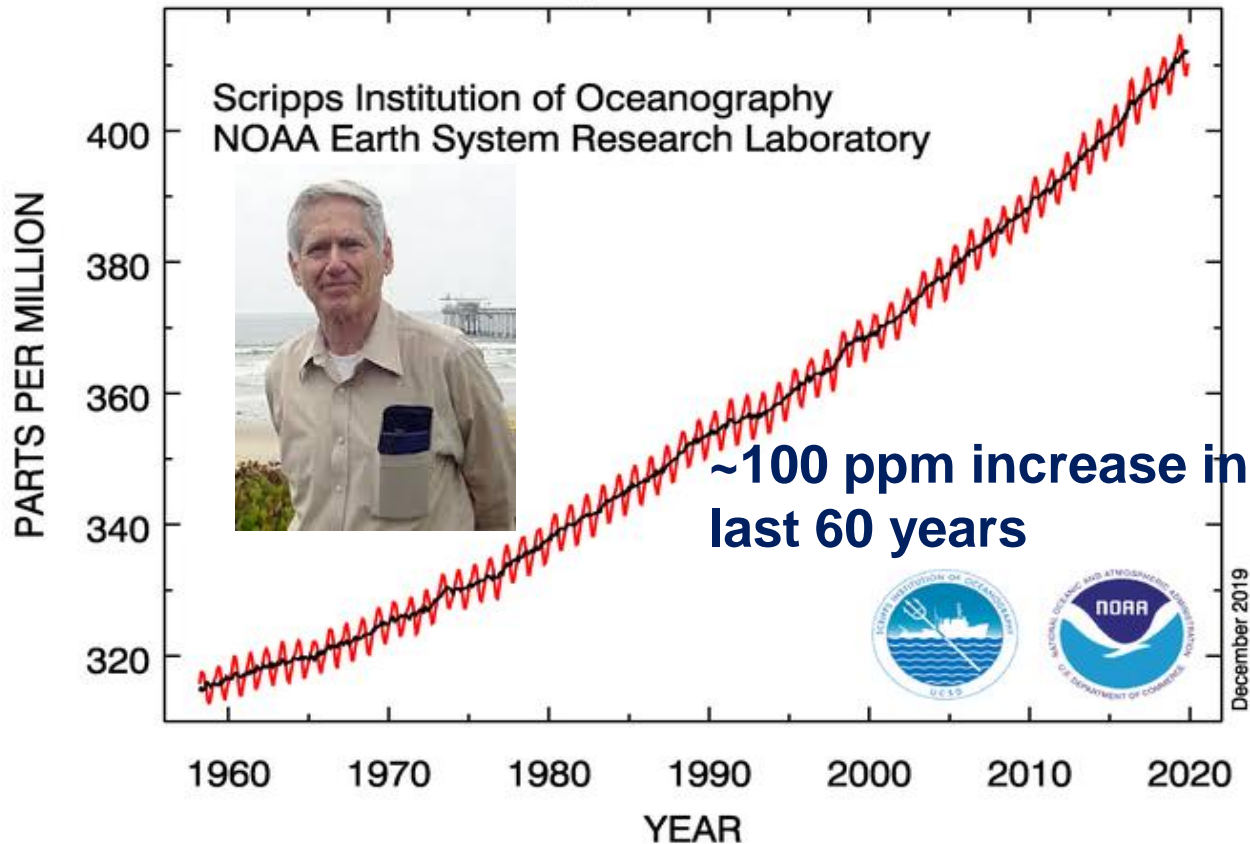
2019 is the 2nd warmest on record

Annual Global Temperature: Difference From 1951-80 Average



Atmospheric CO₂ is now well above 400 ppm : 120 ppm above the pre-industrial level

Atmospheric CO₂ at Mauna Loa Observatory

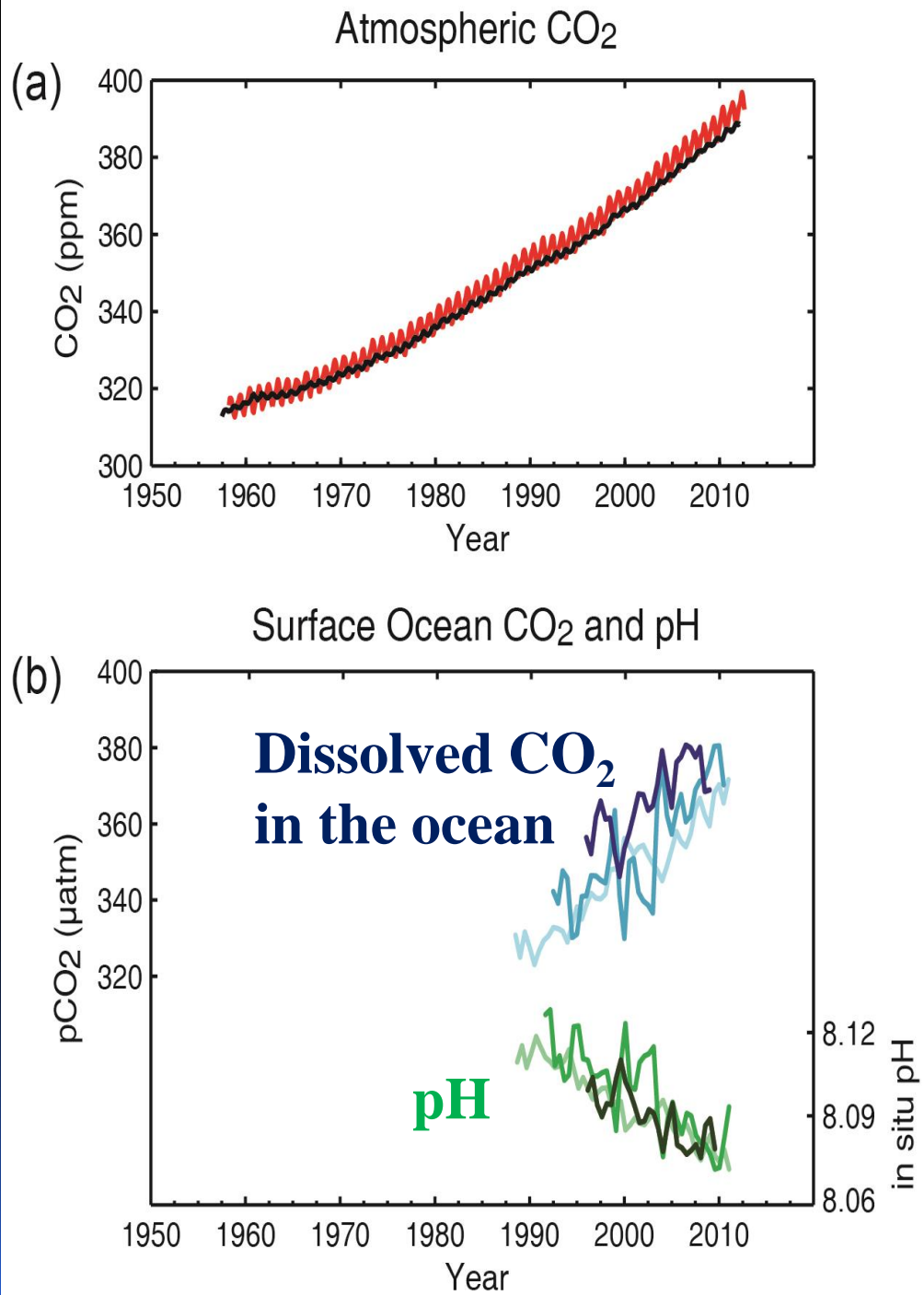


Source: For years before 1958 - EPICA Dome C Ice Core 800KY Carbon Dioxide Data, NOAA/NCDC Paleoclimatology Program, Lohr, D., et al., 2008; For 1958 and later - Scripps Institution of Oceanography at UC San Diego, Mauna Loa Observatory.

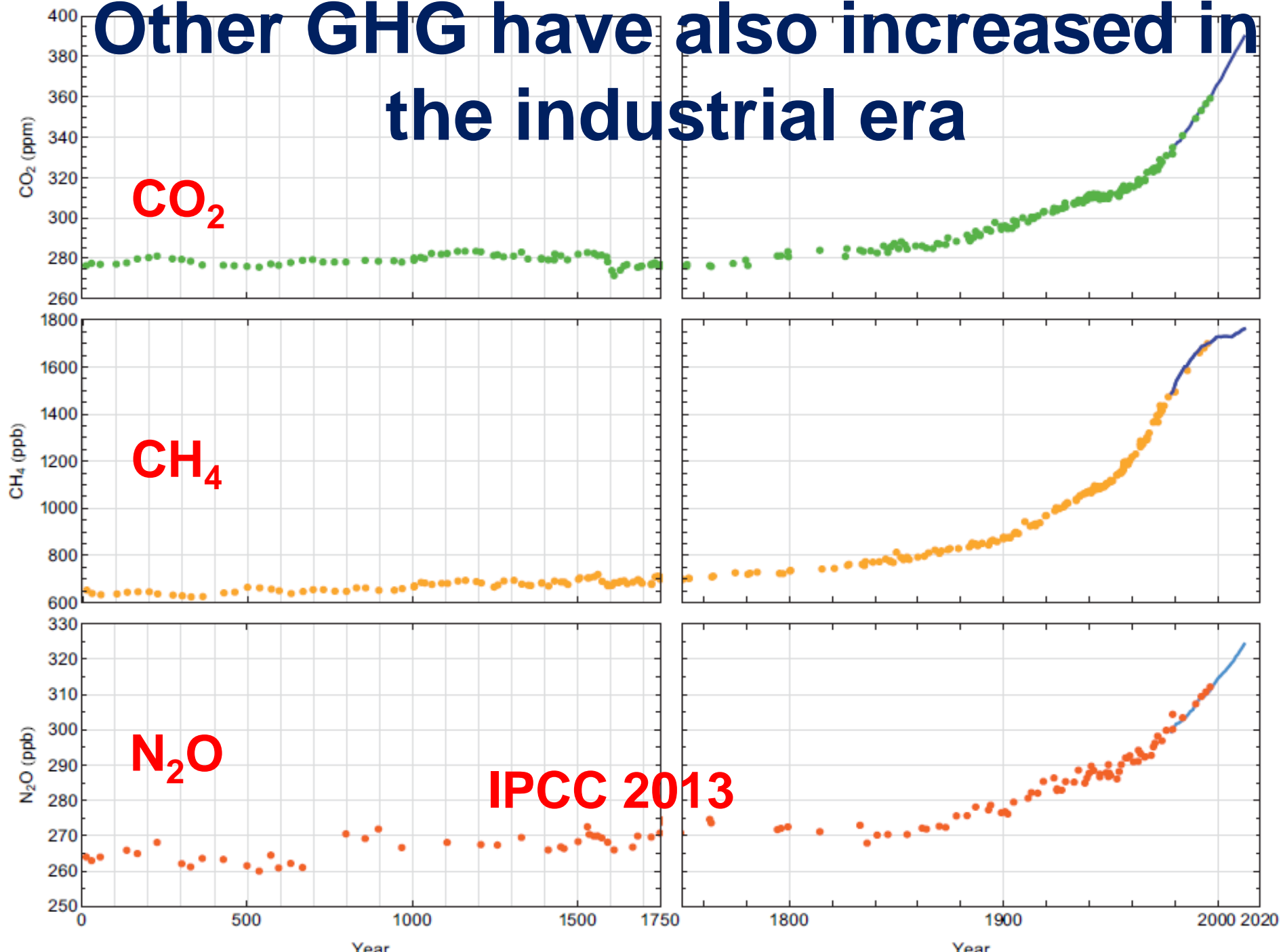
Unprecedented in the last 1 million years and possibly in the last 20 M years.

The atmospheric CO₂ has increased and the ocean is acidifying

IPCC, 2013



Other GHG have also increased in the industrial era



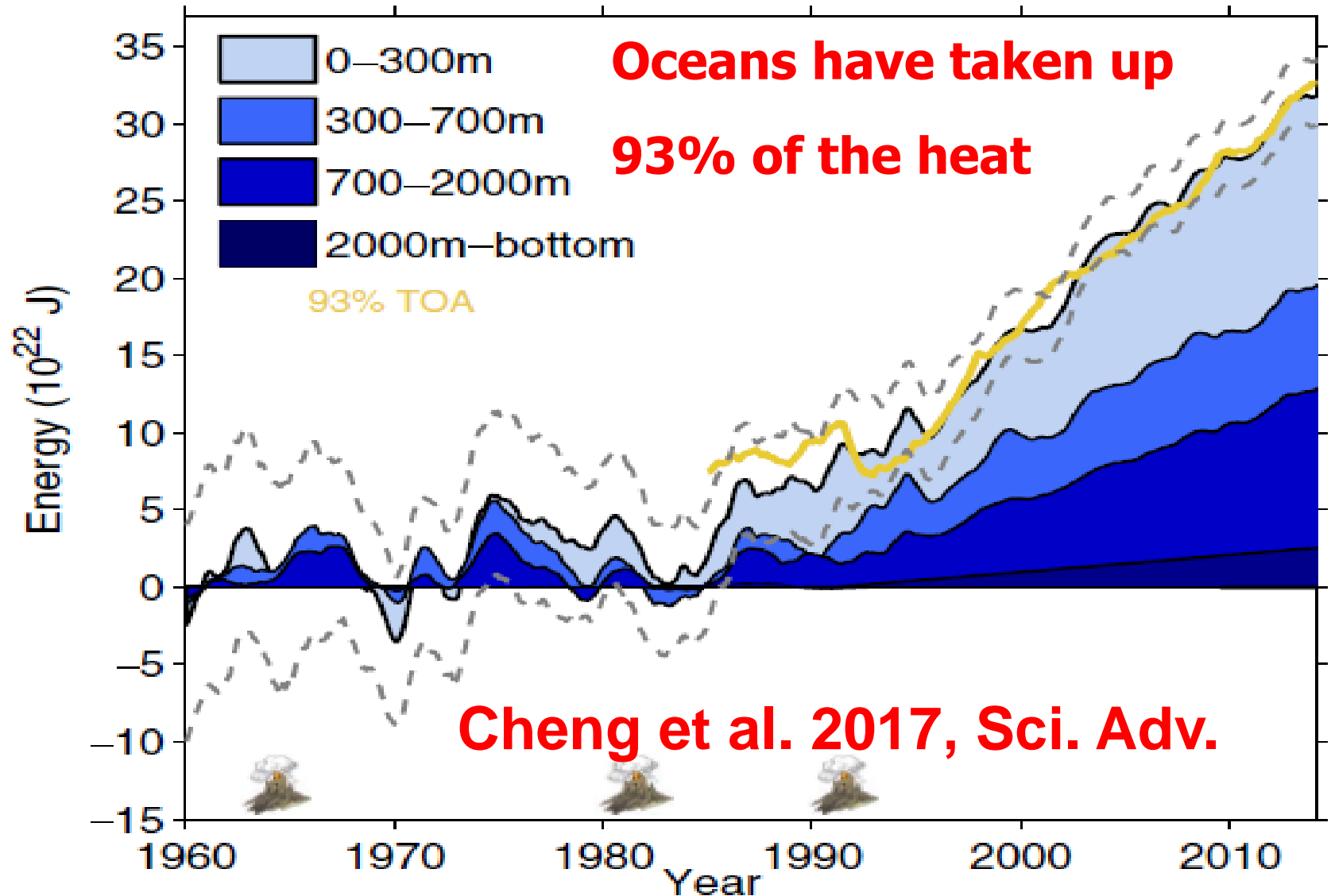
CO₂

CH₄

N₂O

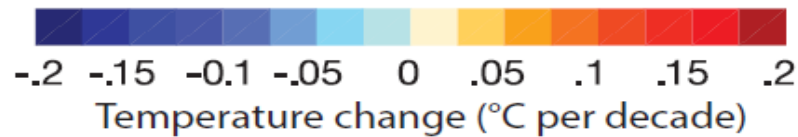
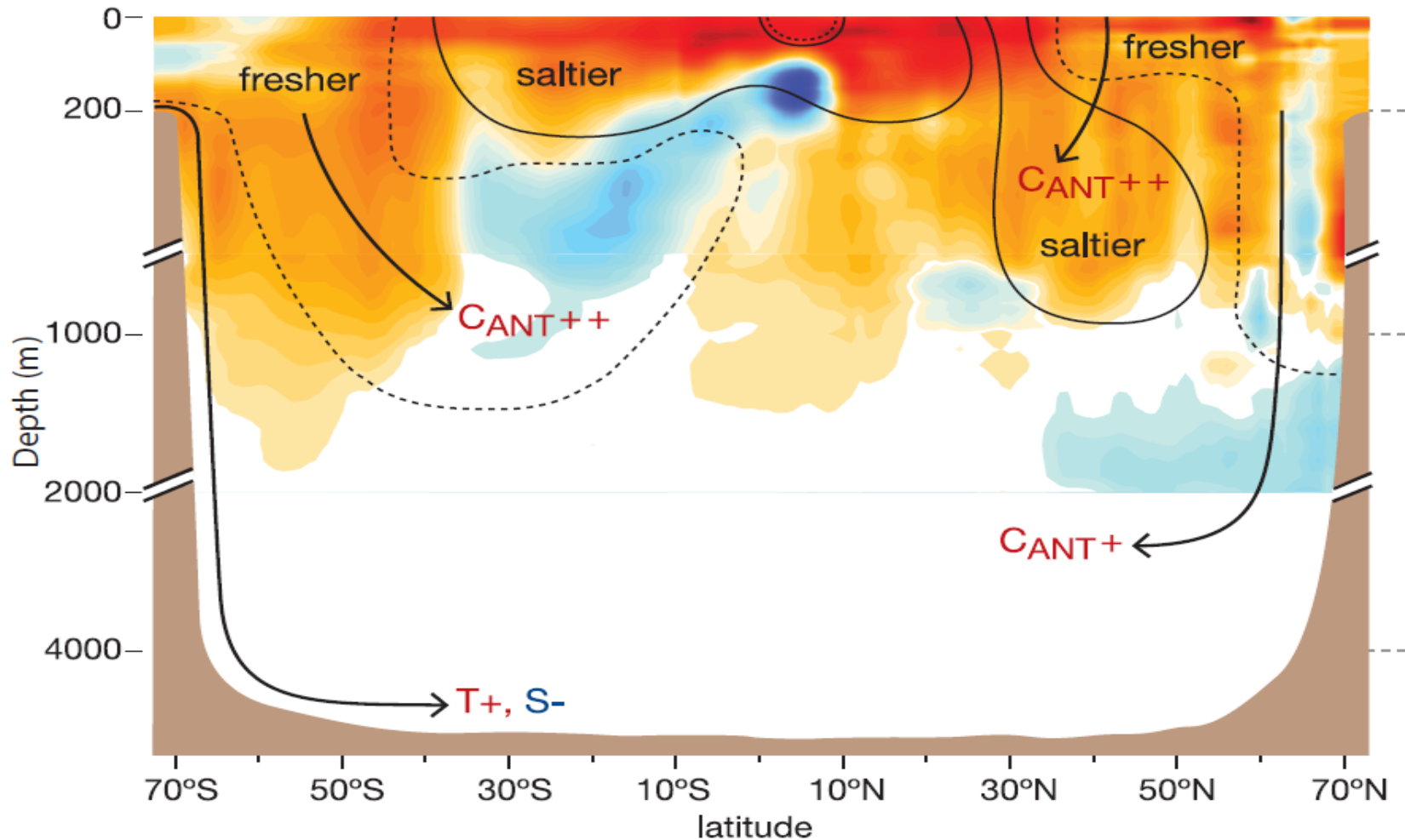
IPCC 2013

Oceans have soaked up 100s of zeta (10^{21}) joules of heat in recent decades



Heat has penetrated to only a km deep

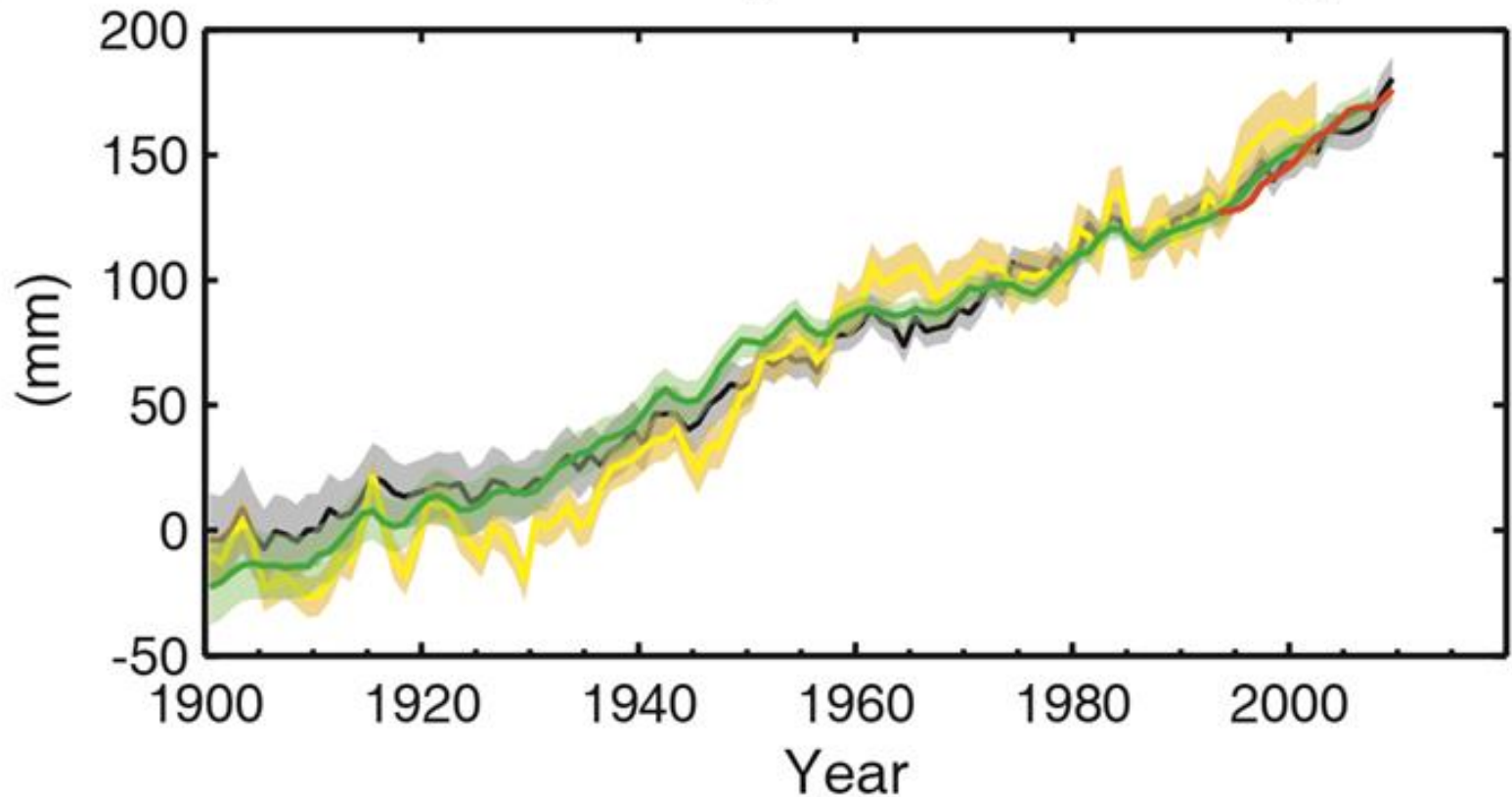
Oceans could take a lot more in the future



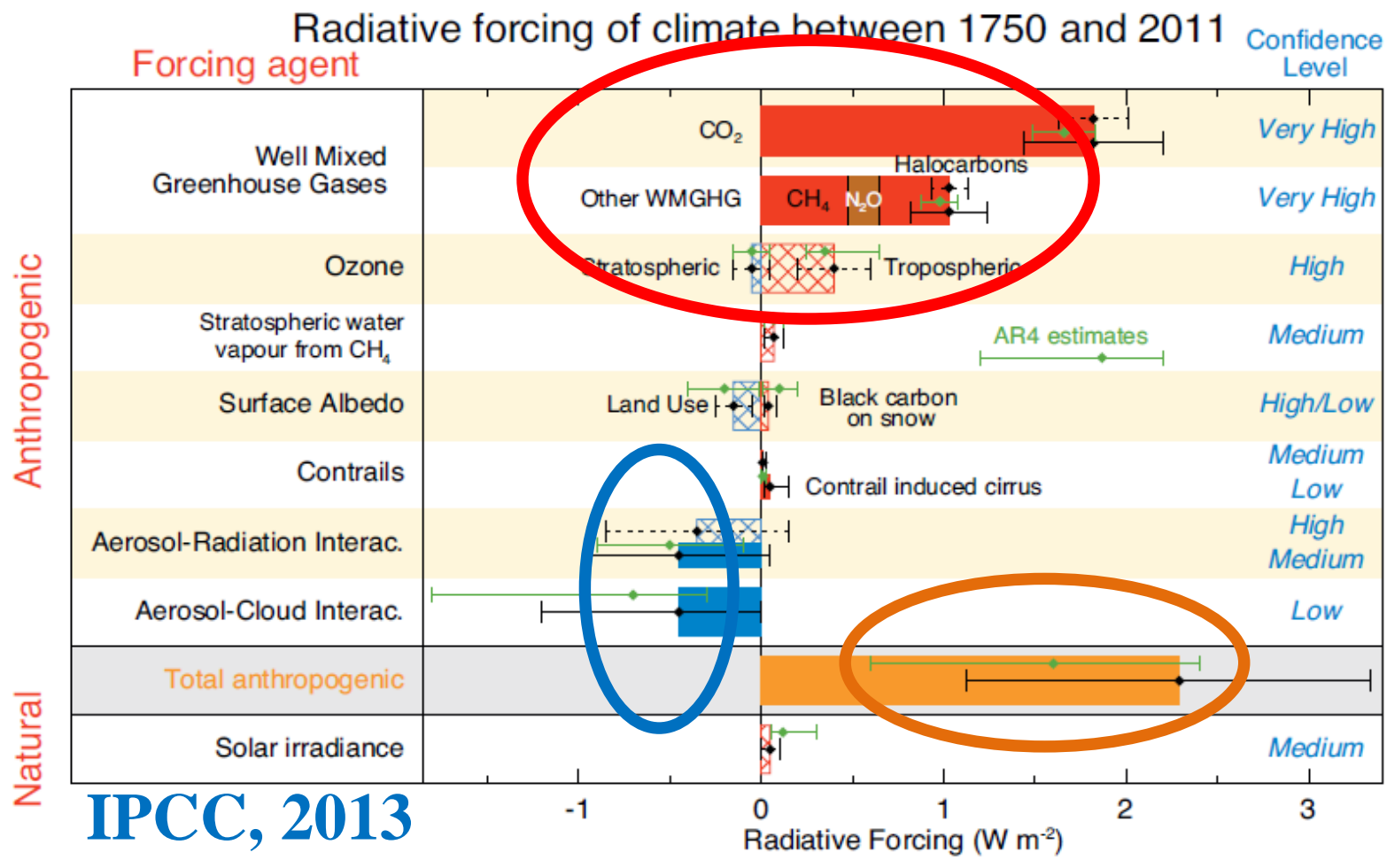
IPCC 2013

Sea level has increased by 20 cm since 1900

(d) Global average sea level change



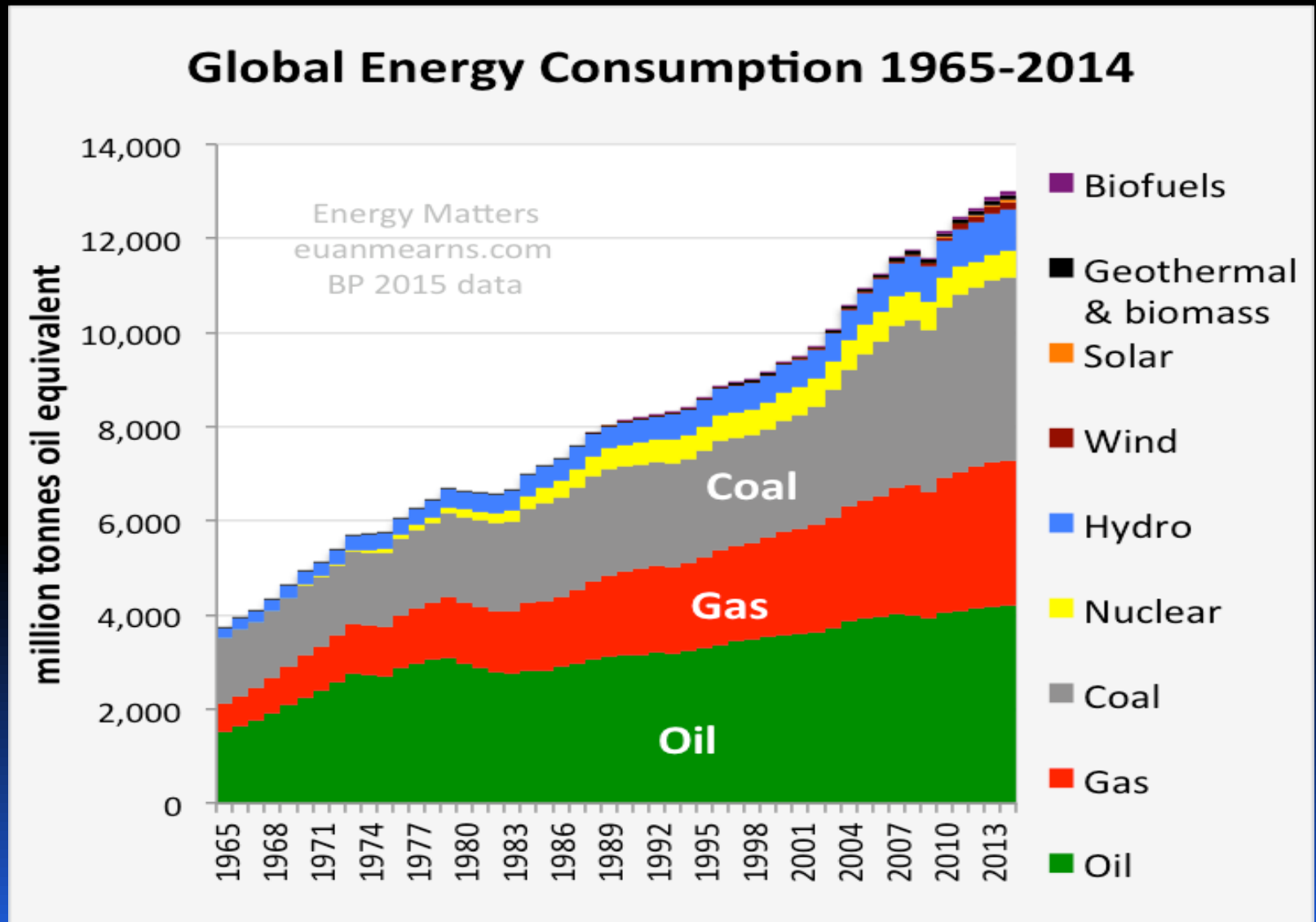
Greenhouse gases are the dominant warming agents



The largest contribution to total radiative forcing is caused by the increase in the atmospheric concentration of CO₂ since 1750 (see Figure SPM.5)

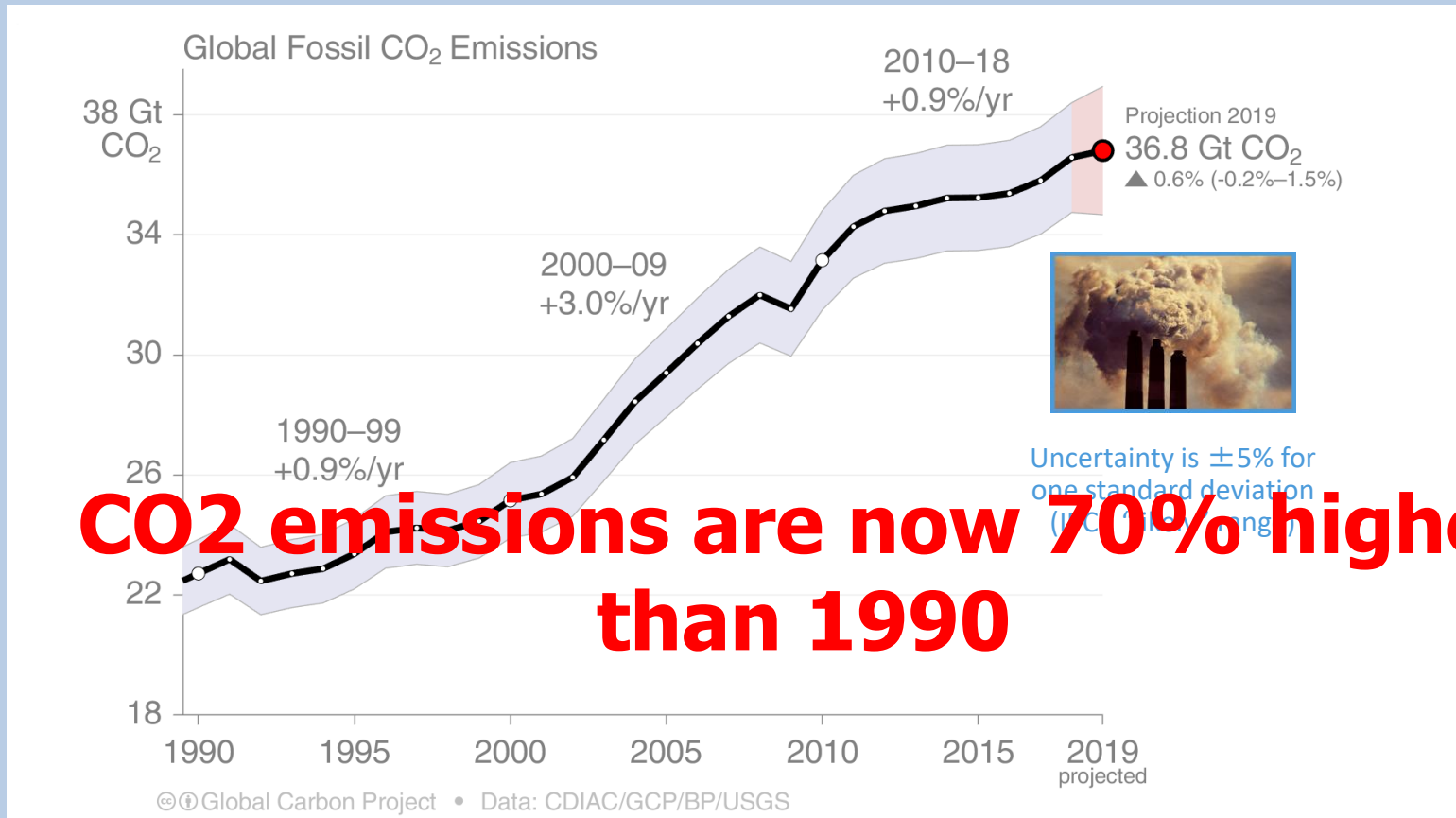
**CO₂ emissions are the
main drivers of
Current Climate
Change**

Global Energy consumption tripled in 50 years



Global Fossil CO₂ Emissions

Global fossil CO₂ emissions: 36.6 ± 2 GtCO₂ in 2018, 61% over 1990
 Projection for 2019: 36.8 ± 2 GtCO₂, 0.6% higher than 2018 (range -0.2% to 1.5%)
 Fossil CO₂ emissions will likely be more than 4% higher in 2019 than the year of the Paris Agreement in 2015

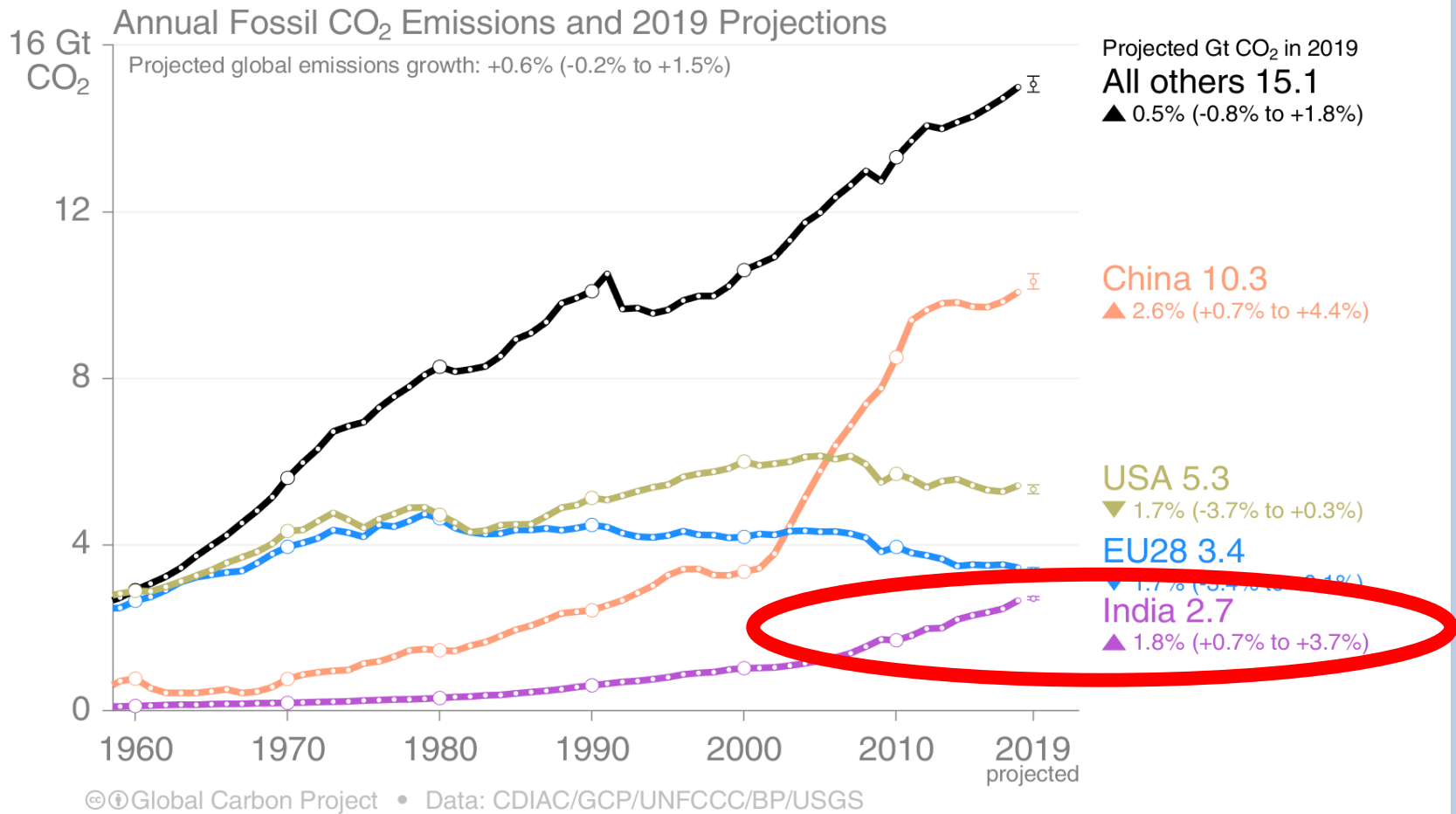


CO₂ emissions are now 70% higher than 1990

The 2019 projection is based on preliminary data and modelling.
 Source: [CDIAC](#); [Friedlingstein et al 2019](#); [Global Carbon Budget 2019](#)

Emissions Projections for 2019

Global fossil CO₂ emissions are projected to rise by 0.6% in 2019
 The global growth is driven by the underlying changes at the country level.



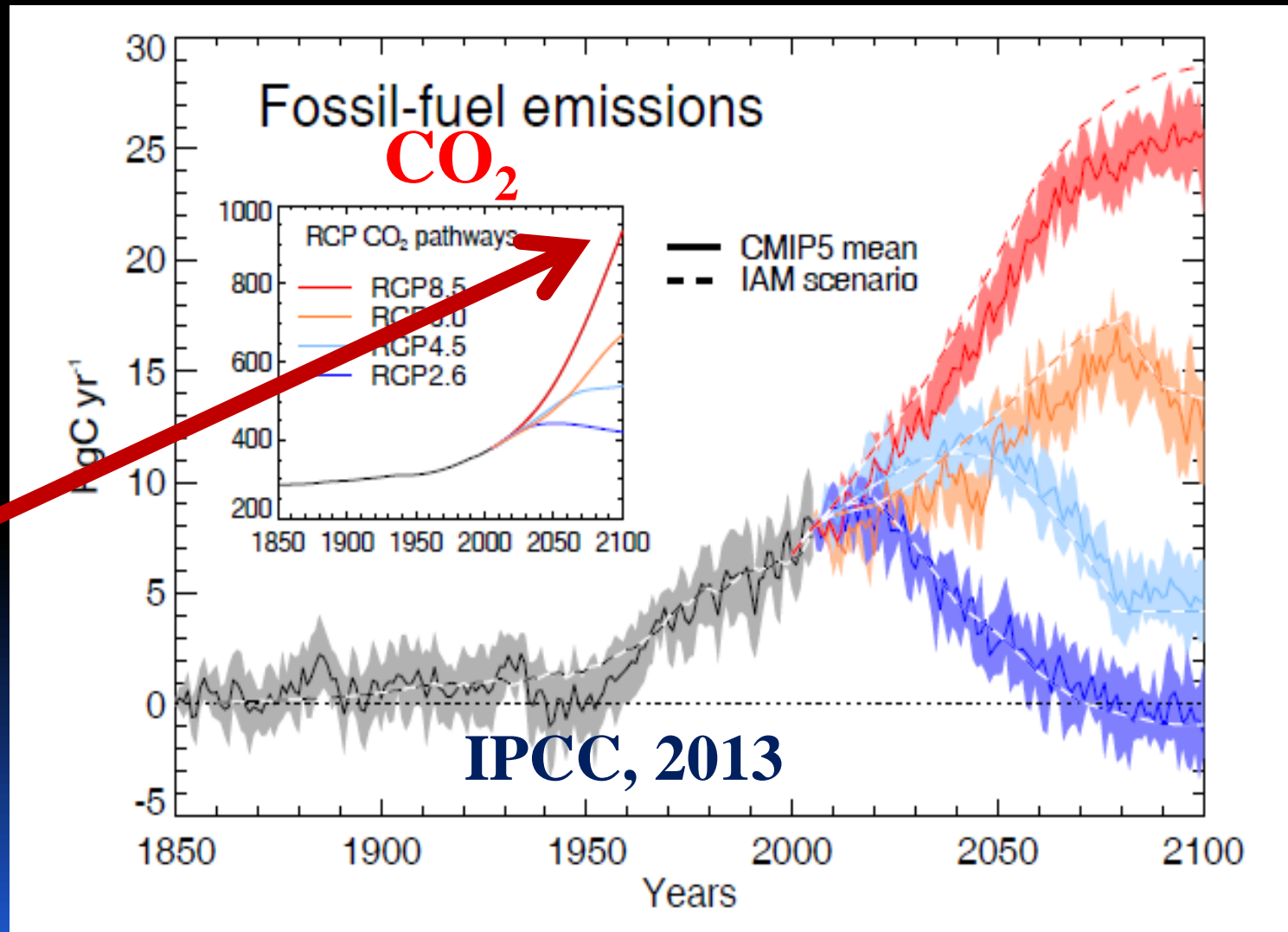
Source: [CDIAC](#); [Peters et al 2019](#); [Friedlingstein et al 2019](#); [Global Carbon Budget 2019](#)

**As a country, India is
number 3 now in CO₂
emissions after China
and USA today**

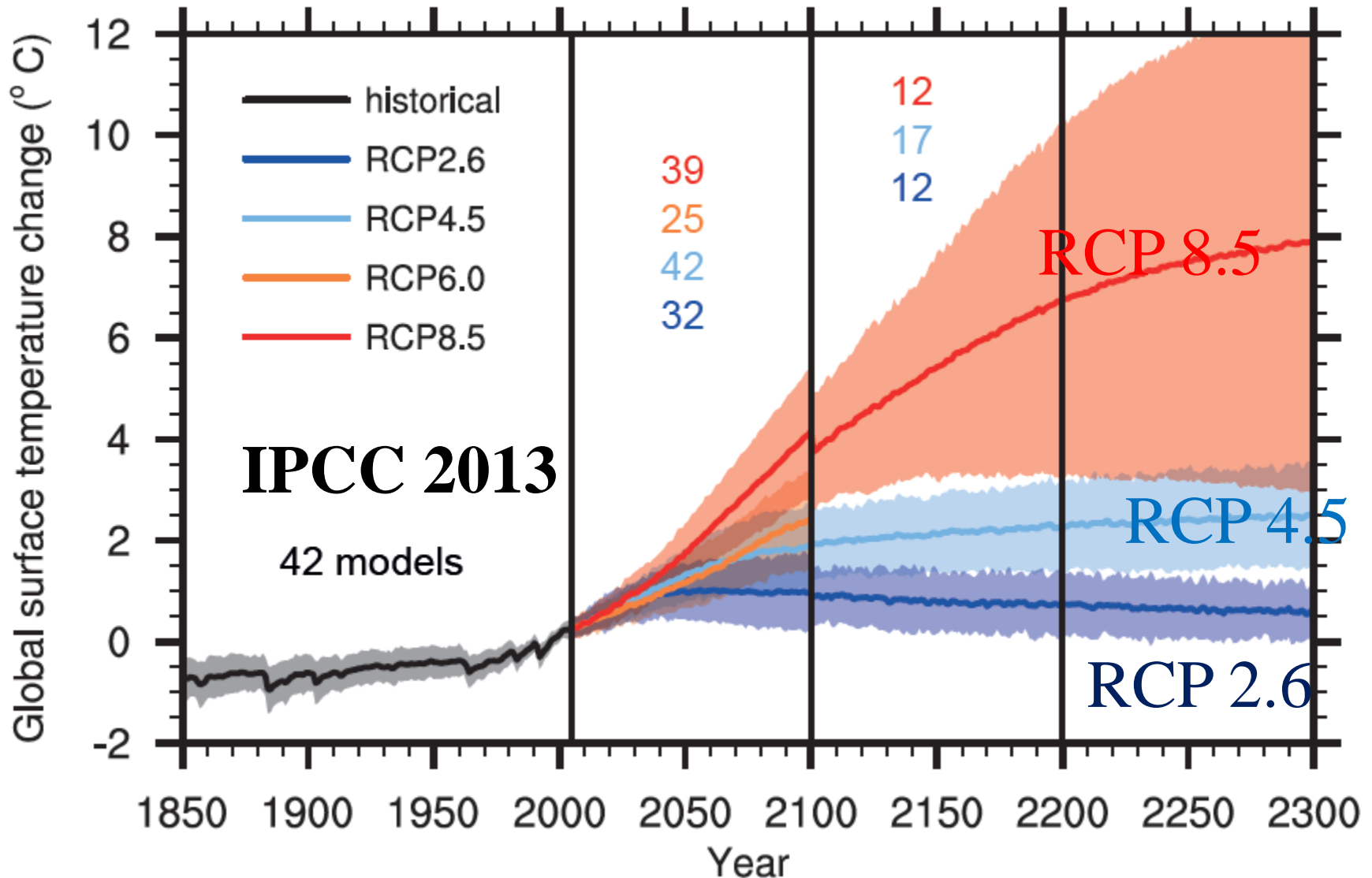
Future Climate Change

CO₂ emissions by 2100 could more than double from today

1000 ppm
By 2100?



Long term (2300) warming could be huge

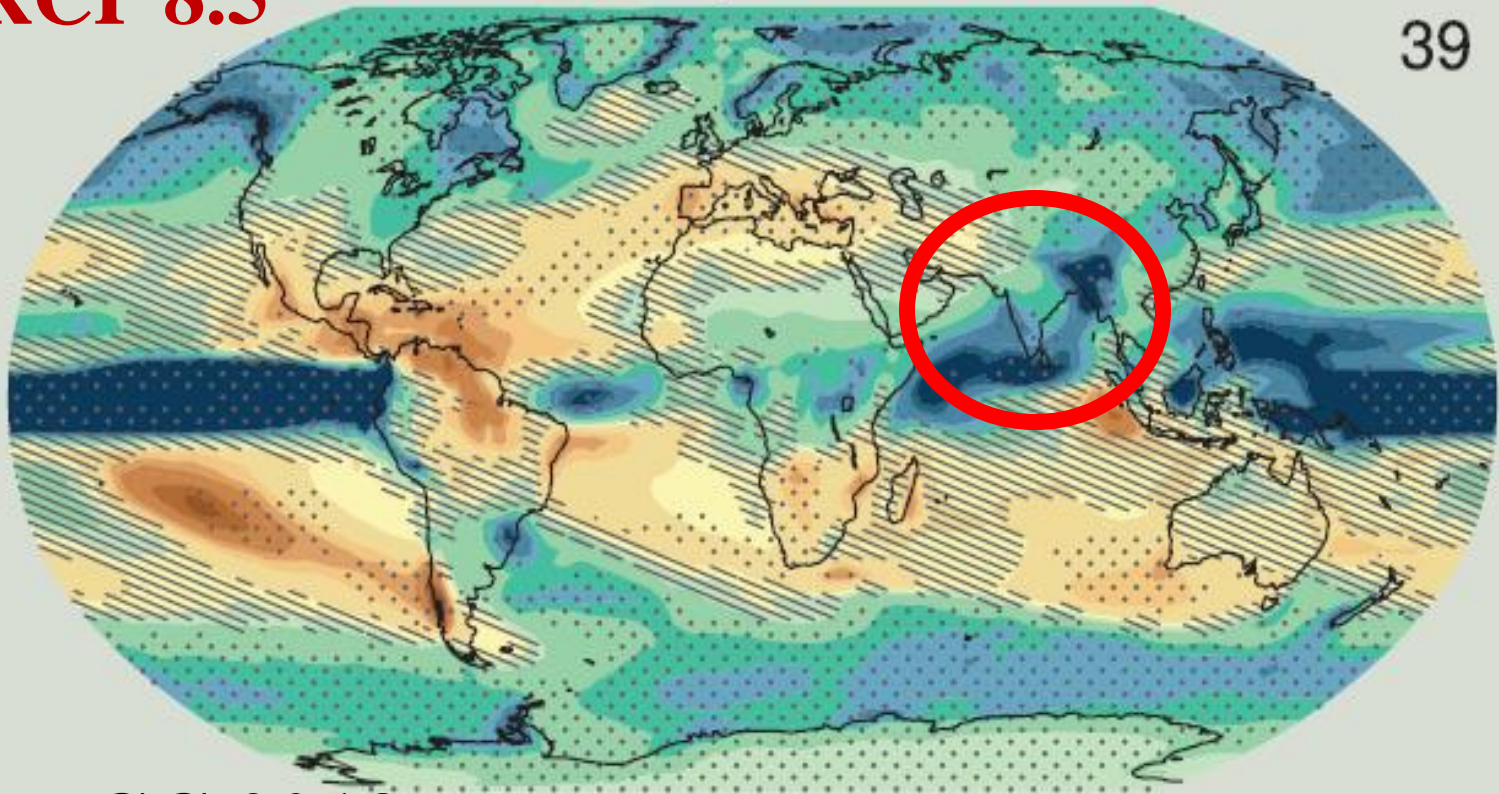


Rainfall Change (2081-2100)

RCP 8.5

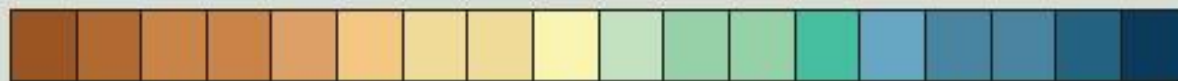
Precipitation

39



IPCC 2013

(mm day⁻¹)



-0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8

Extremes Increase

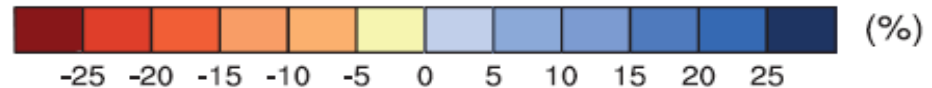
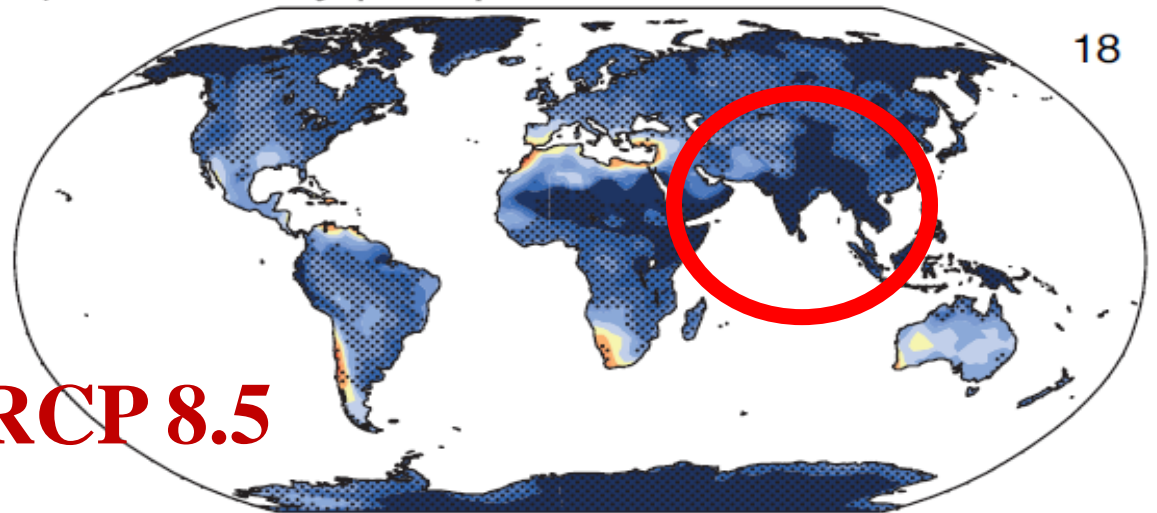
IPCC 2013

b) max. 5 day precip

RCP8.5: 2081-2100

18

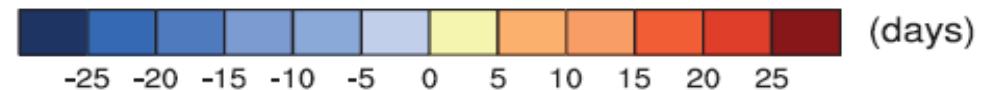
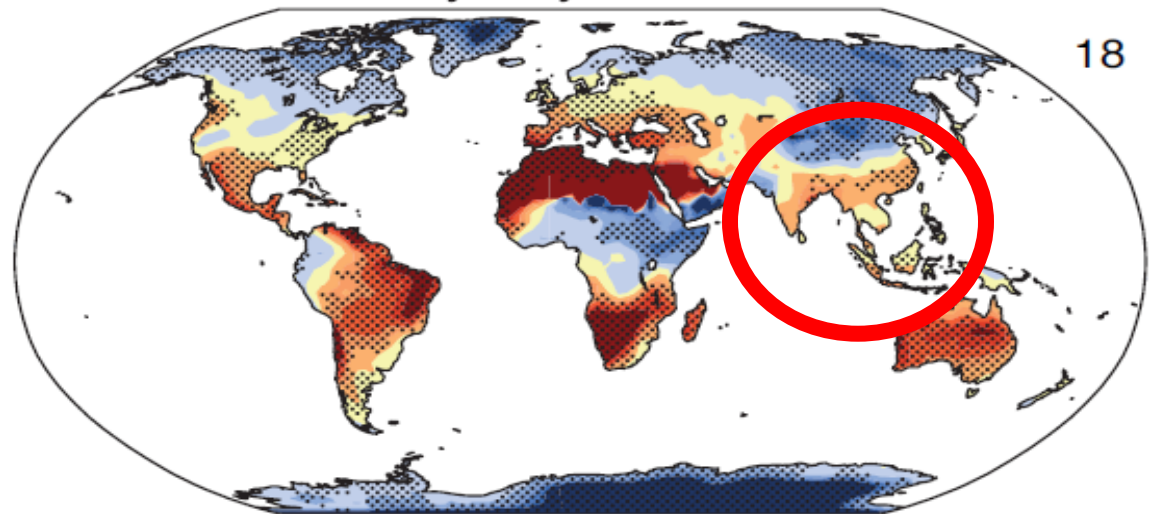
RCP 8.5



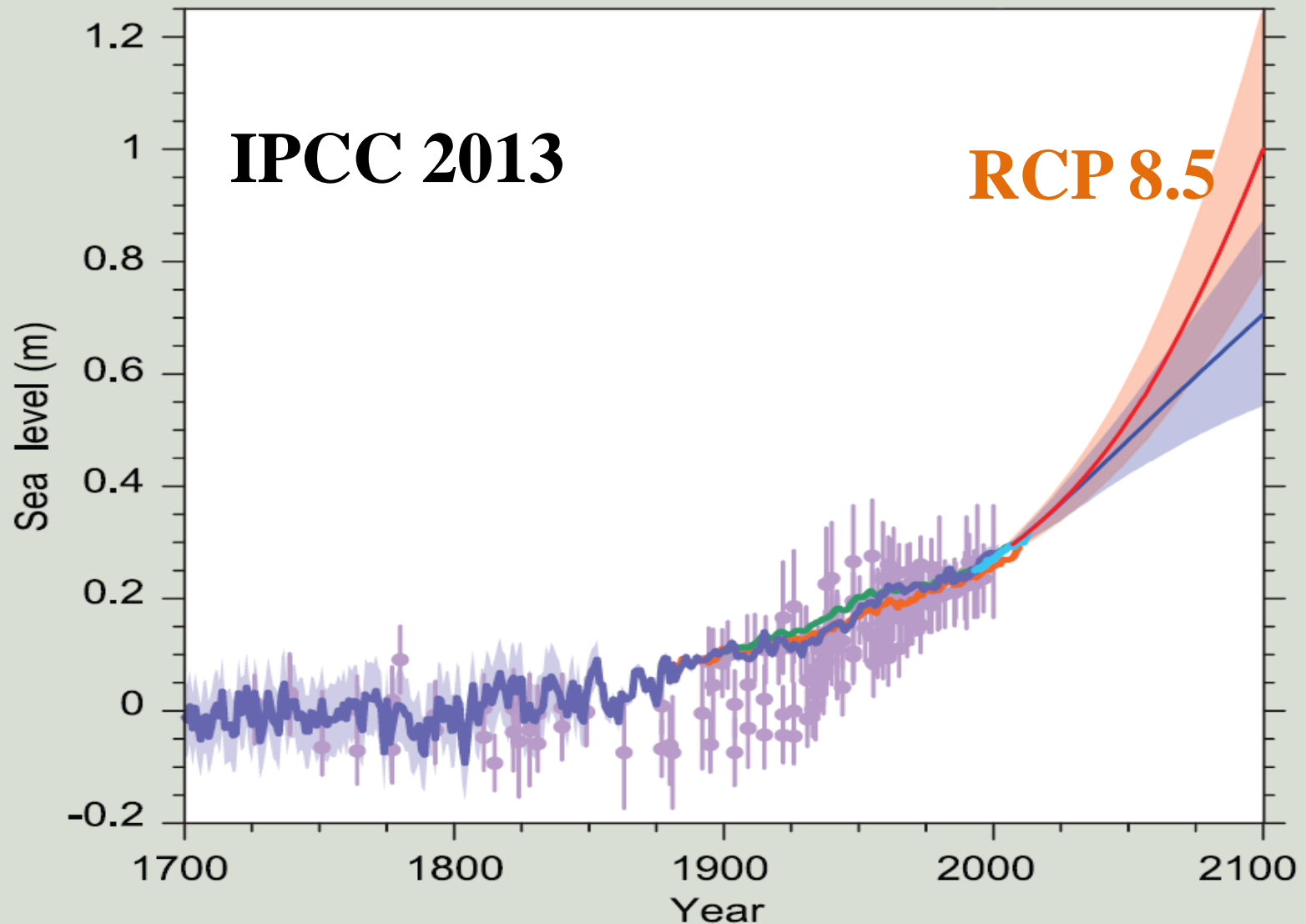
c) Consecutive Dry Days

RCP8.5: 2081-2100

18

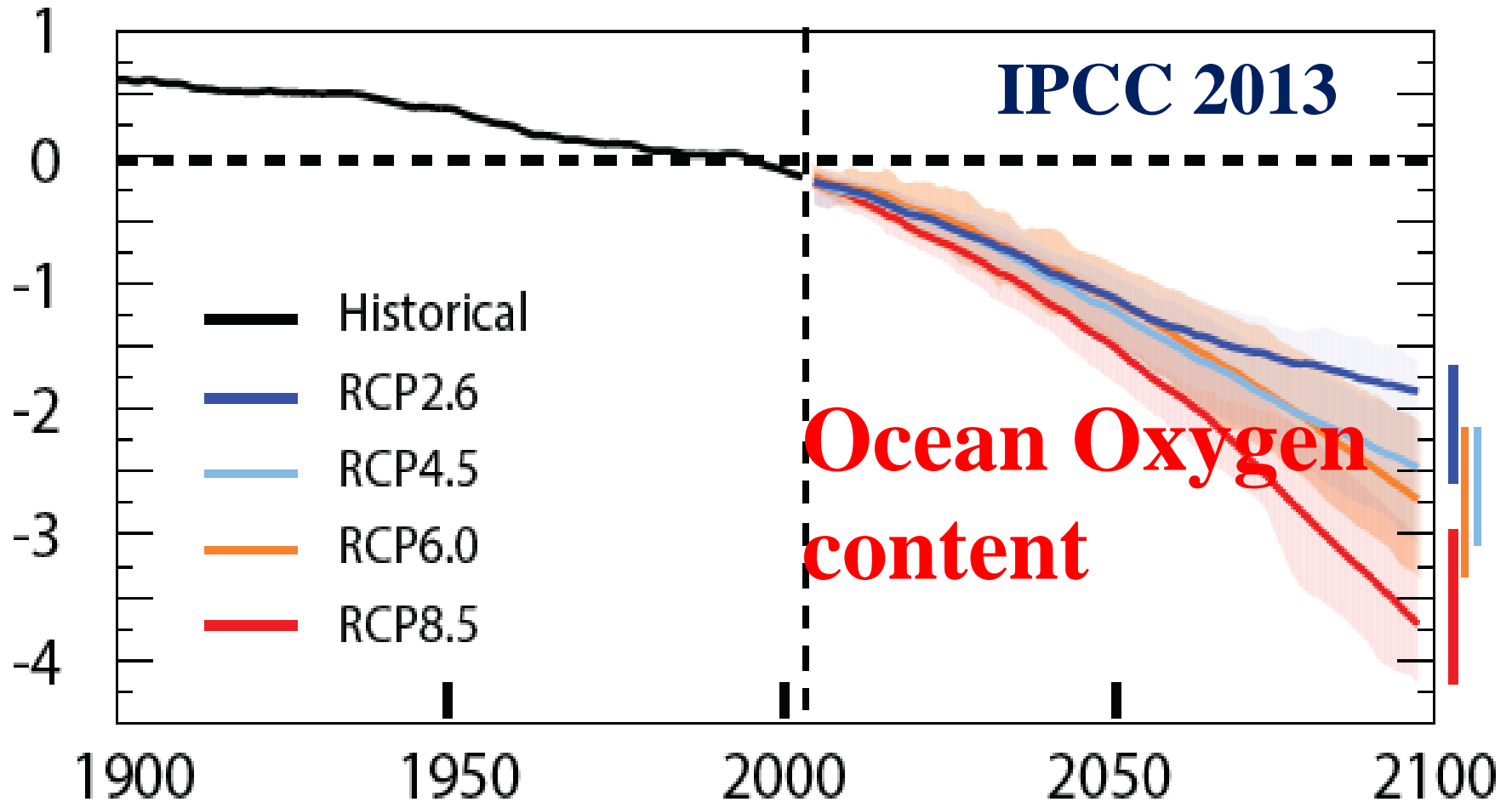


Sea level could rise by a meter this century



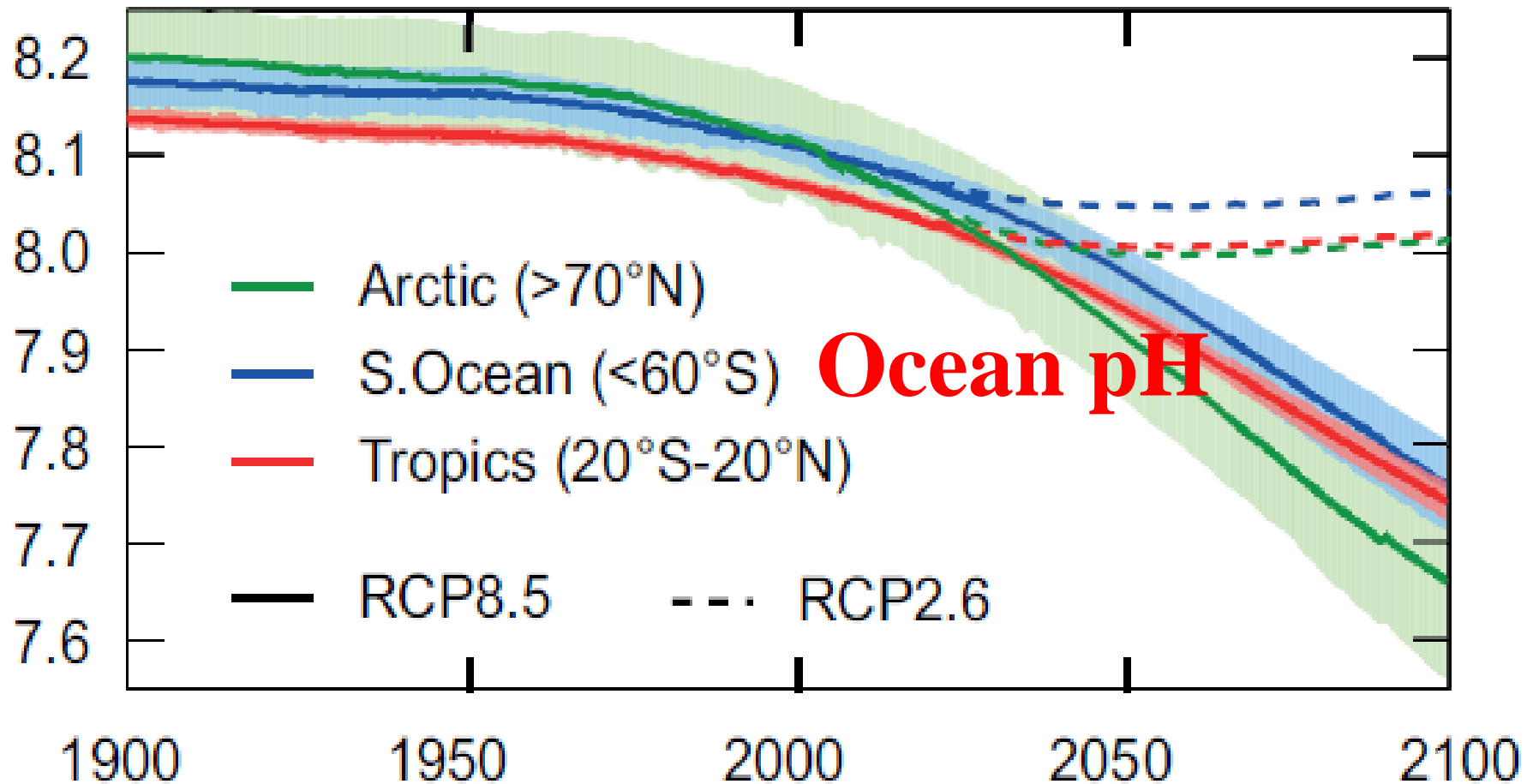
Oxygen content of seawater would decline

a. Ocean oxygen content change (%)



Oceans would get acidified

a. Surface pH

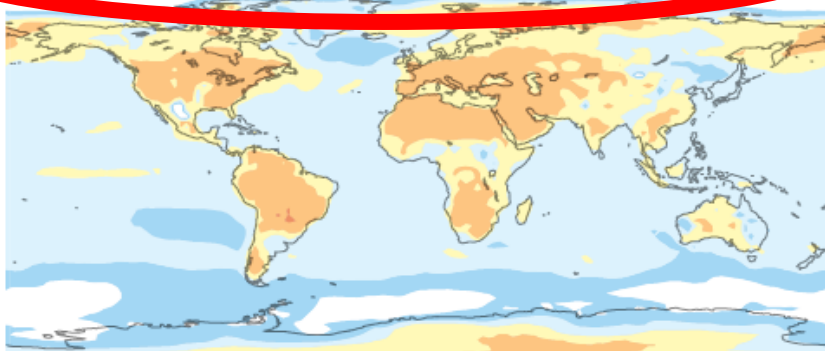


Every 0.5 deg C of global warming matters

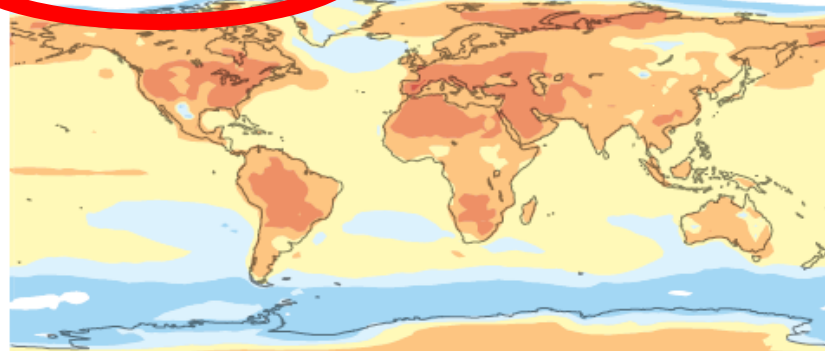
FAQ3.1: Impact of 1.5°C and 2.0°C global warming

Temperature rise is not uniform across the world. Some regions will experience greater increases in the temperature of hot days and cold nights than others.

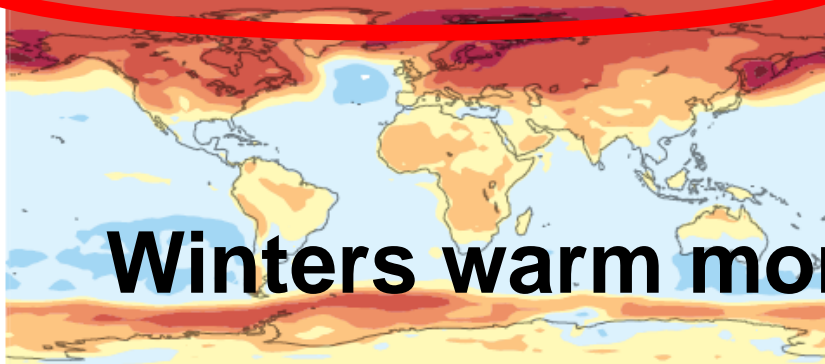
+ 1.5°C: Change in average temperature of hottest days



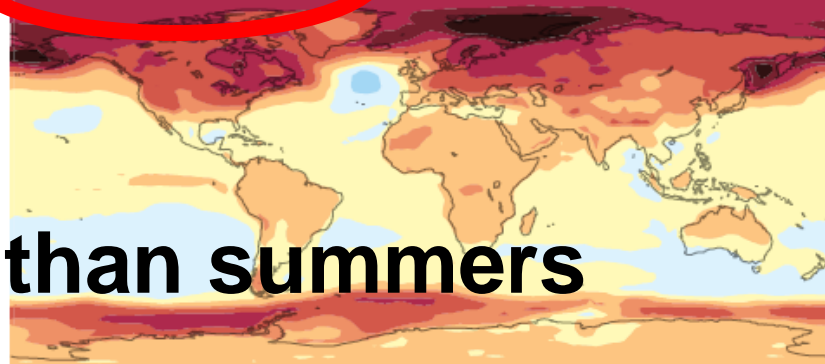
+ 2.0°C: Change in average temperature of hottest days



+ 1.5°C: Change in average temperature of coldest nights



+ 2.0°C: Change in average temperature of coldest nights



Winters warm more than summers

°C



Climate Change Impacts



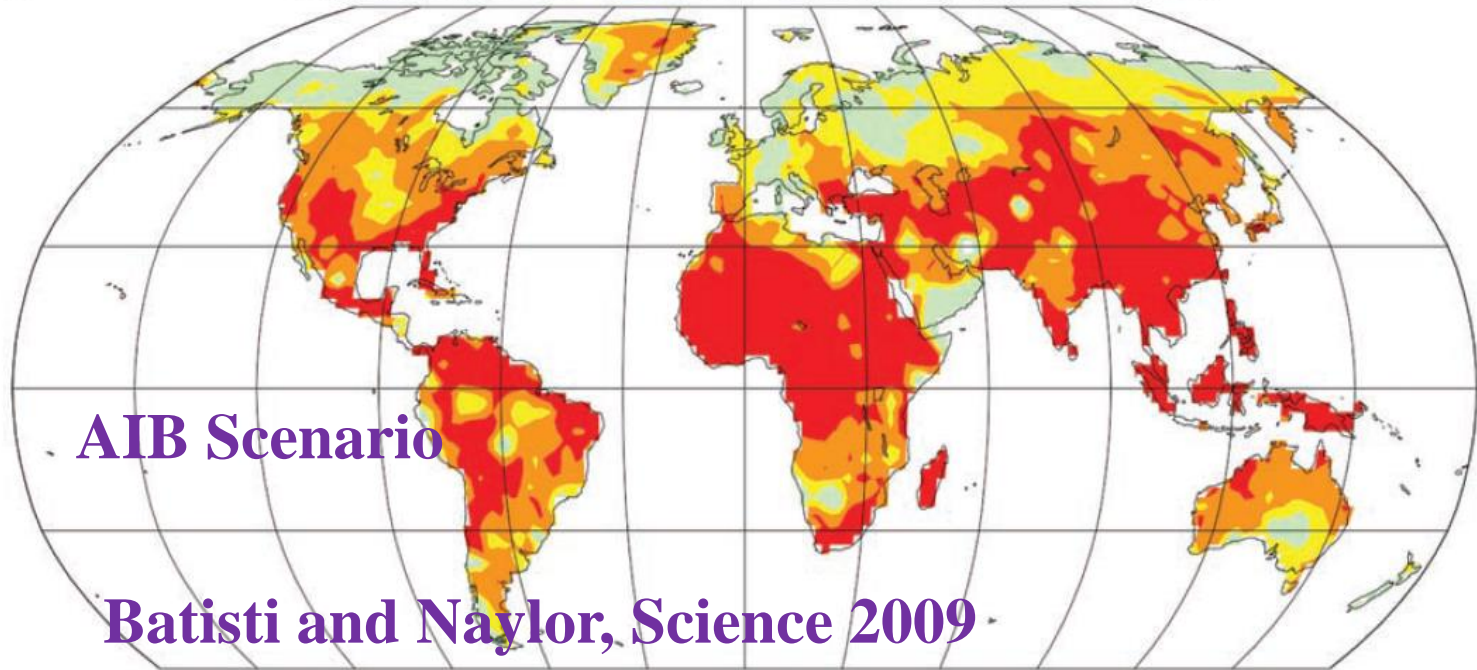
Climate Change Impacts

- More intense heat waves
- Frequent floods and droughts
- Intense hurricanes
- Sea Level rise ~ 1 meter per century
- Glaciers melt away → water resources?
- Loss of plants and animal species (biodiversity)
- Infectious disease spread and Human health
- Ocean acidification → extinction of marine life
- Climate refugees



Big concern for us: >90% chance that summer-mean T will exceed the warmest T on record (1900-2006) by 2100 in most tropical regions

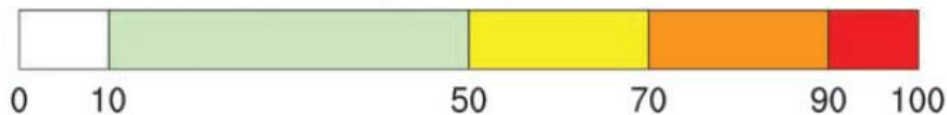
B Summers in 2080-2100 Warmer than Warmest on Record



AIB Scenario

Batisti and Naylor, Science 2009

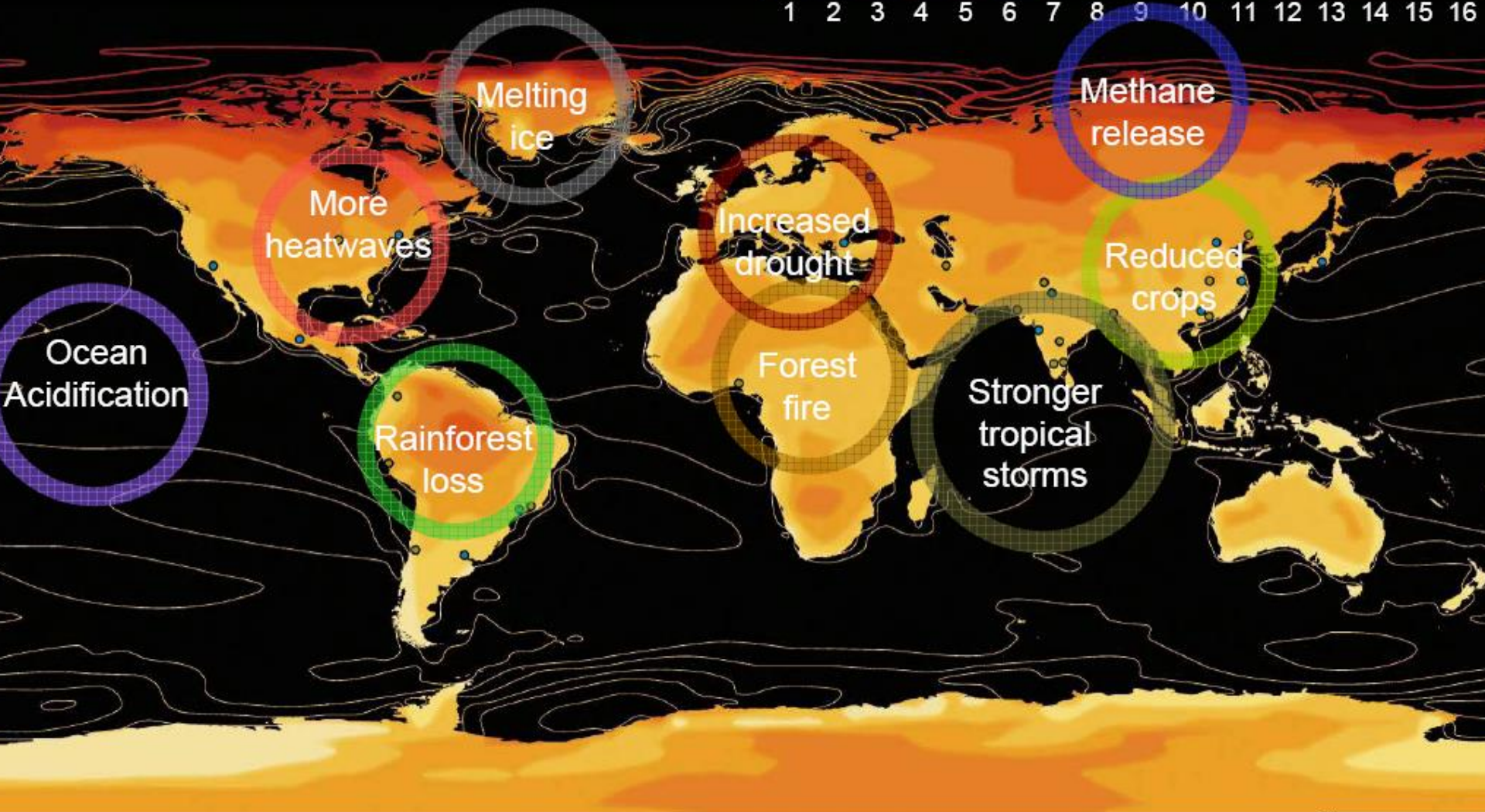
percent (%)



The impact of a global temperature rise of 4 °C

Change in temperature from pre-industrial climate

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16



Conventional Solution

Adaptation involves modifying our decisions, activities and ways of thinking to adjust to a changing climate

Mitigation aims to reduce the causes of climate change

Goals



Increasing our capacity to adapt



Improving our ability to thrive under different climate conditions



Building resilience to extreme weather and climate changes

Examples



Forest protection



Infrastructure and building design



Flood protection



Changing agricultural practices
Planting different crops to respond to changing growing seasons and temperatures, or planting a variety of crops to reduce damage from pests that could migrate northward

Overlapping examples



Green infrastructure



Water and energy conservation

Goal



Cut down greenhouse gas emissions



Energy efficient technology



Sustainable transportation



Industrial process improvements



Renewable energy



Creating community and home gardens
Increasing local agricultural capacity helps reduce the need to import food over long distances, and by extension the consumption of fossil fuels

Climate Change: Adaptation and Mitigation

Take Home Messages

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Strong link between Climate Change, CO₂ and our energy usage (our life style)

Climate change impacts could be severe and long lasting

Climate change adaptation and mitigation could bring new opportunities



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Thank You