Extremes and water on the edge: Including the human footprint

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The Earth…

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How do we affect the global climate ?
How do we affect extremes and water on regional scale?
Greenhouse gases, land use, water management…

2015 Paris agreement: 1.5C vs 2C

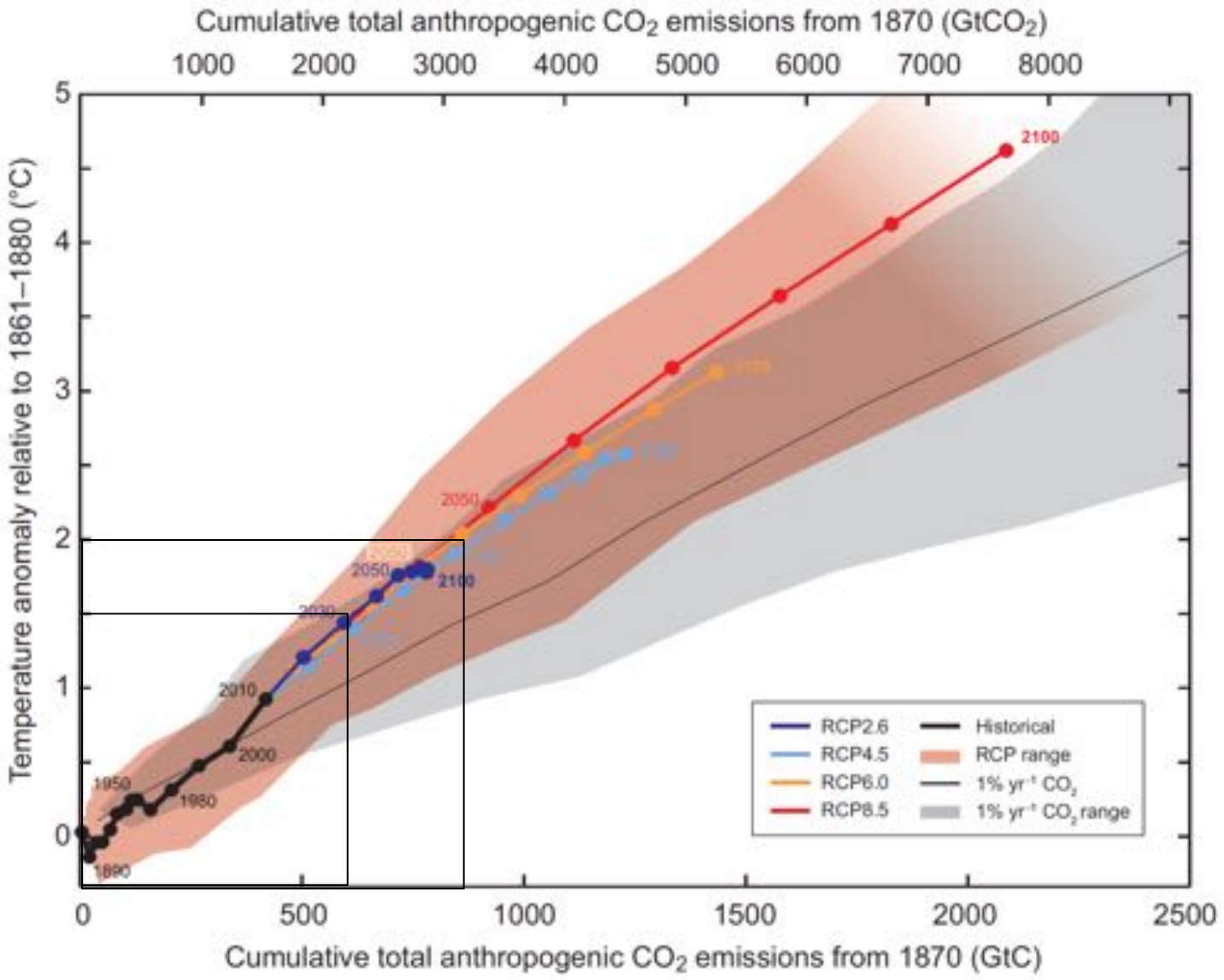
United Nations — FCCC/CP/2015/L.9

Framework Convention on Climate Change — Distr.: Limited, 12 December 2015

1. This Agreement, in enhancing the implementation of the Convention, including its objective, aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by:

(a) Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

Link between cumulative CO_2 emissions and global T°



Direct link between cumulative CO_2 emissions and climate response

A global T° target can be linked to cumulative emissions target

(IPCC 2013)

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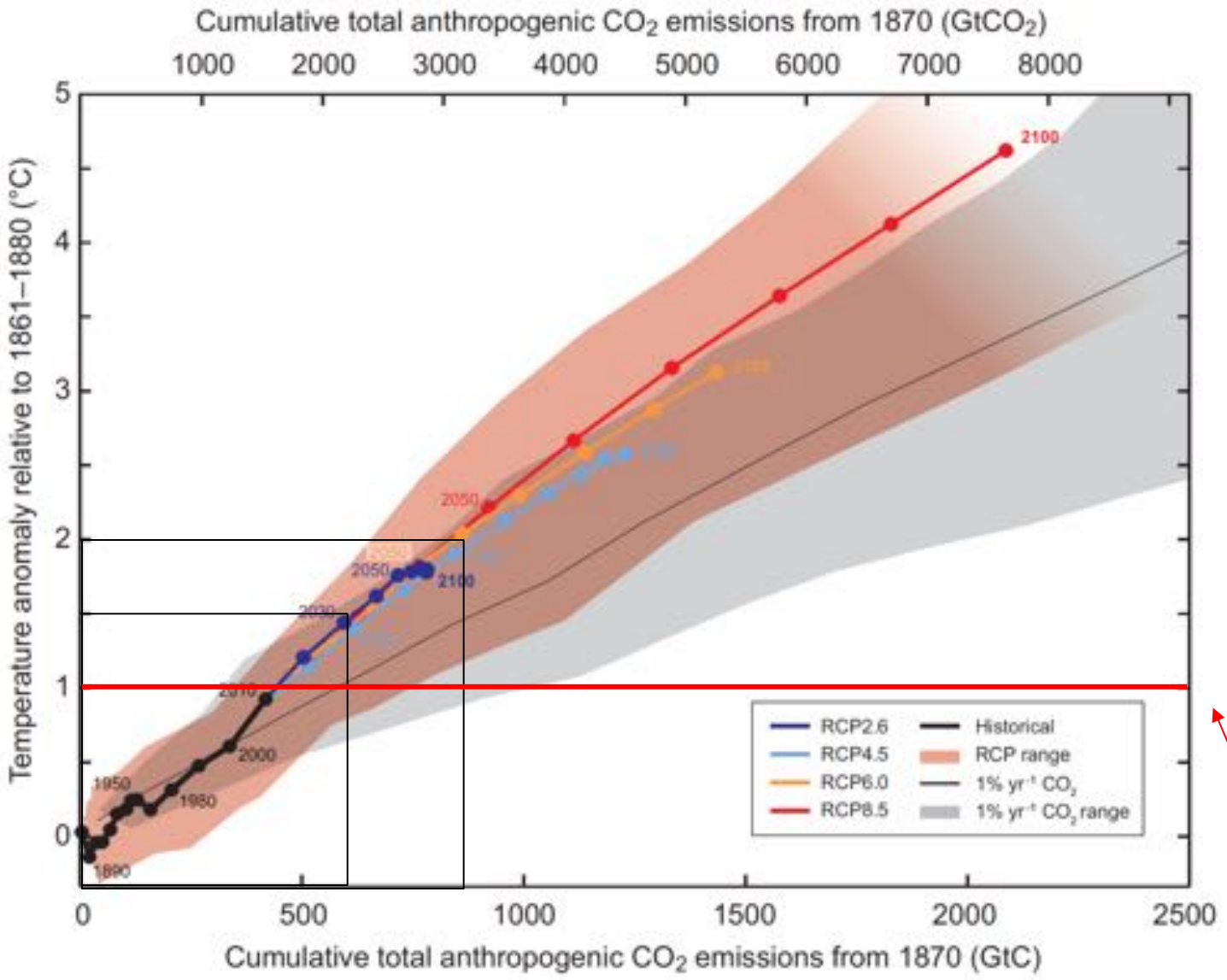

Direct link between cumulative CO_2 emissions and climate response

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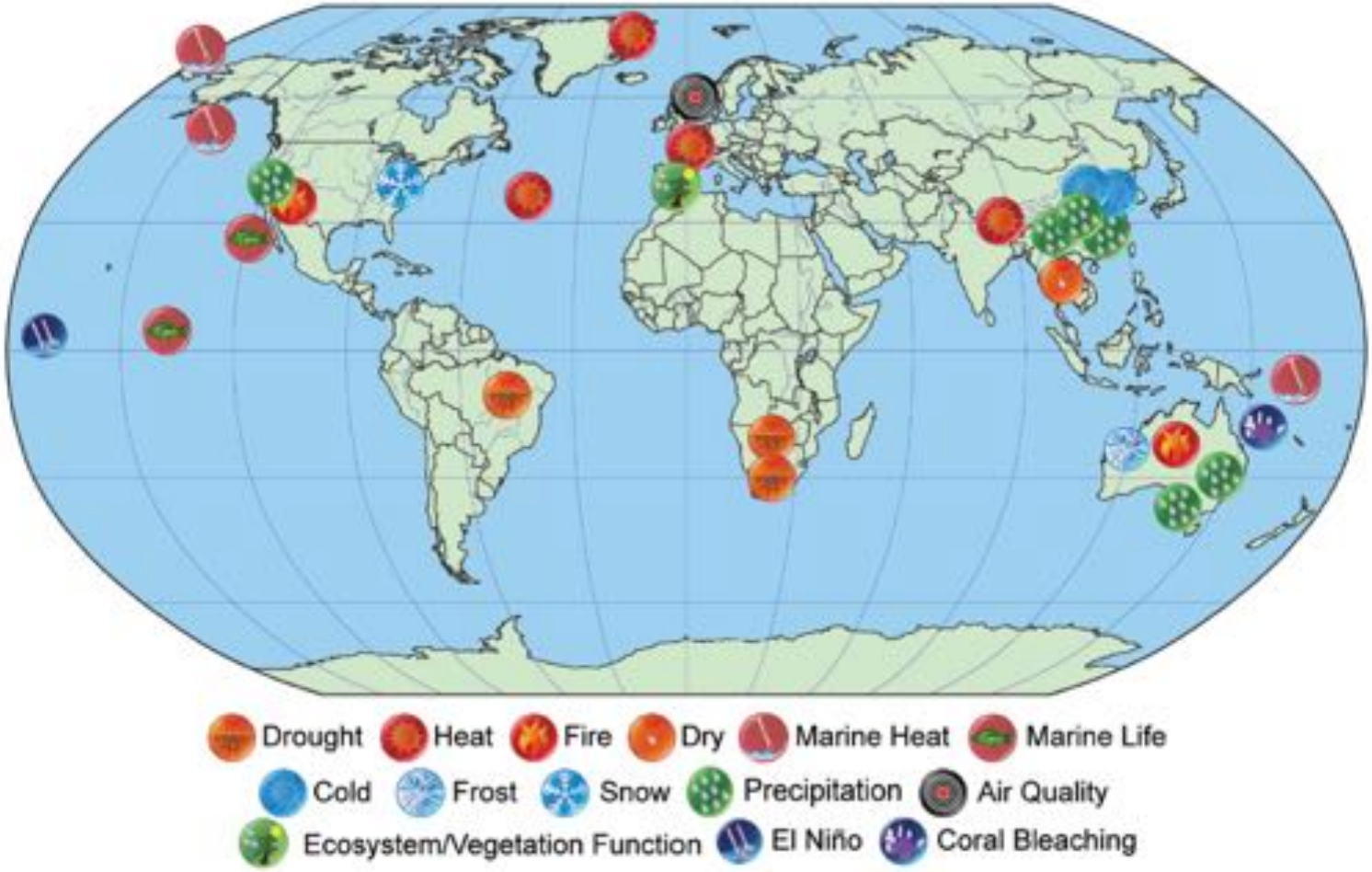
We have now reached 1C *(Haustein et al. 2017, Sci. Reports)*

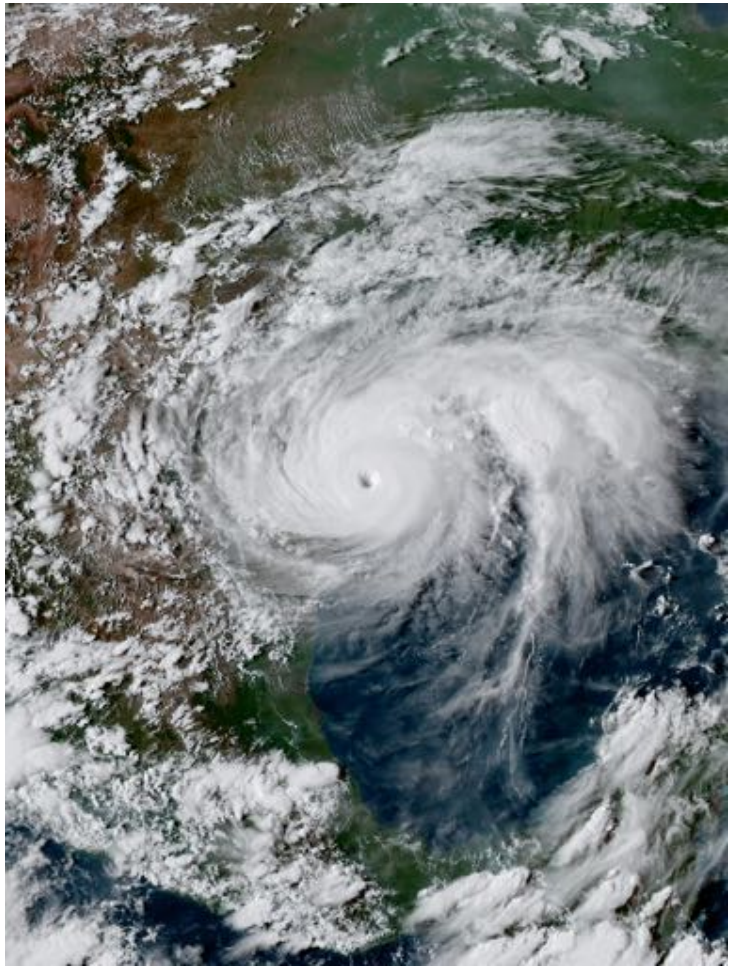
(IPCC 2013)

Extreme events in 2016: Majority of these events have been made more probable by greenhouse gas forcing



(Herring et al. 2018, BAMS)

Hurricane Harvey (August 2017)



Human-induced climate change likely increased the chances of the observed precipitation accumulations during Hurricane Harvey in the most affected areas of Houston by a factor of at least 3.5 *(Risser and Wehner 2017, GRL)*

Global warming made the precipitation about 15% higher and the experienced rainfall extreme event about 3 times more likely *(van Oldenborgh et al. 2017, ERL)*

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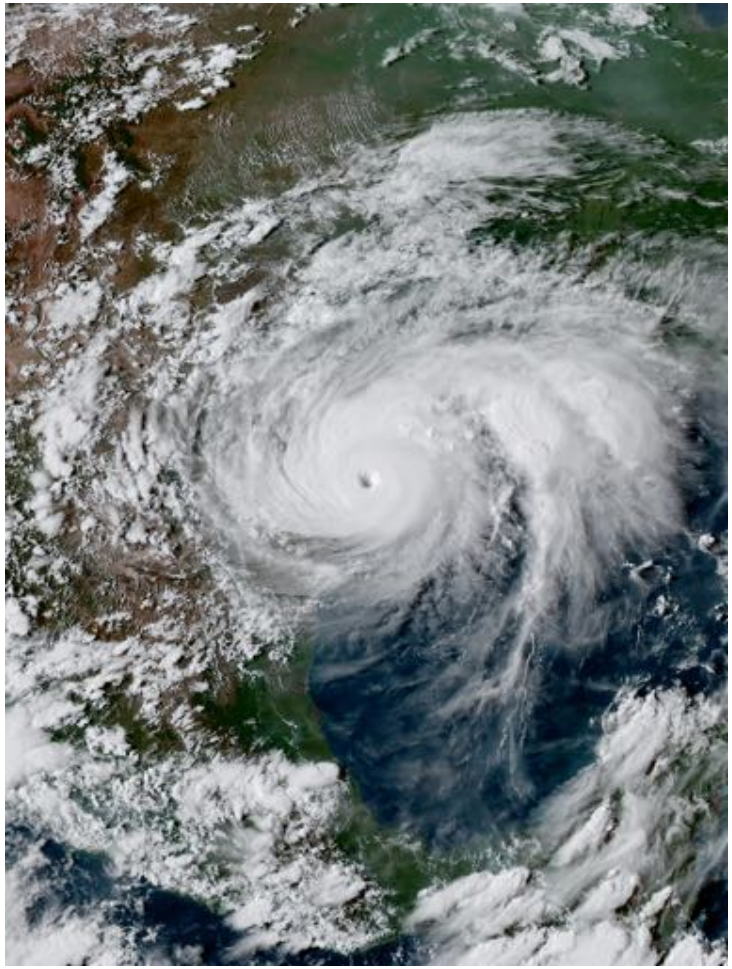

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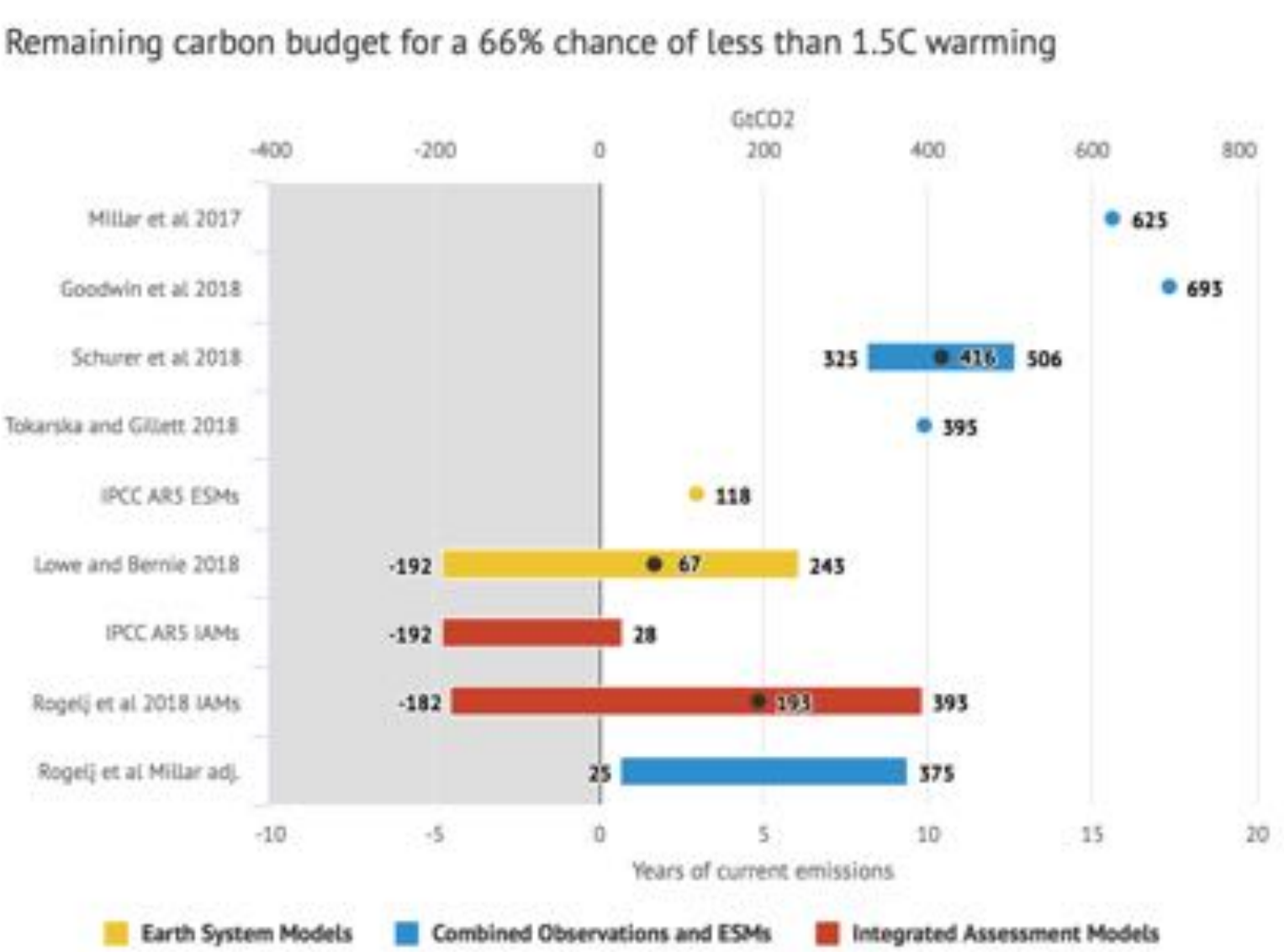
Climate change is happening now!
It has impacts now!

How much remaining CO_2 budget for 1.5C?



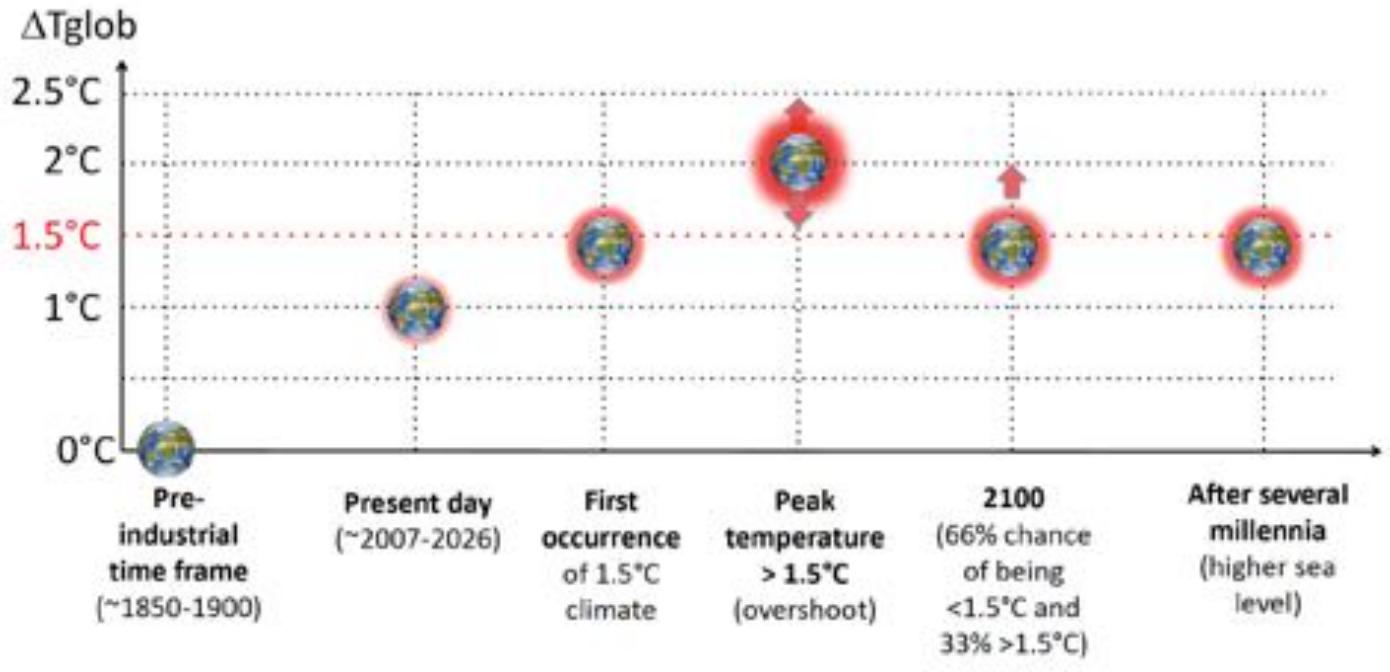
Final update: see upcoming IPCC SR15 report! (https://ipcc.ch/report/sr15/)

(https://www.carbonbrief.org)

Temporal dimension of «1.5C scenarios»

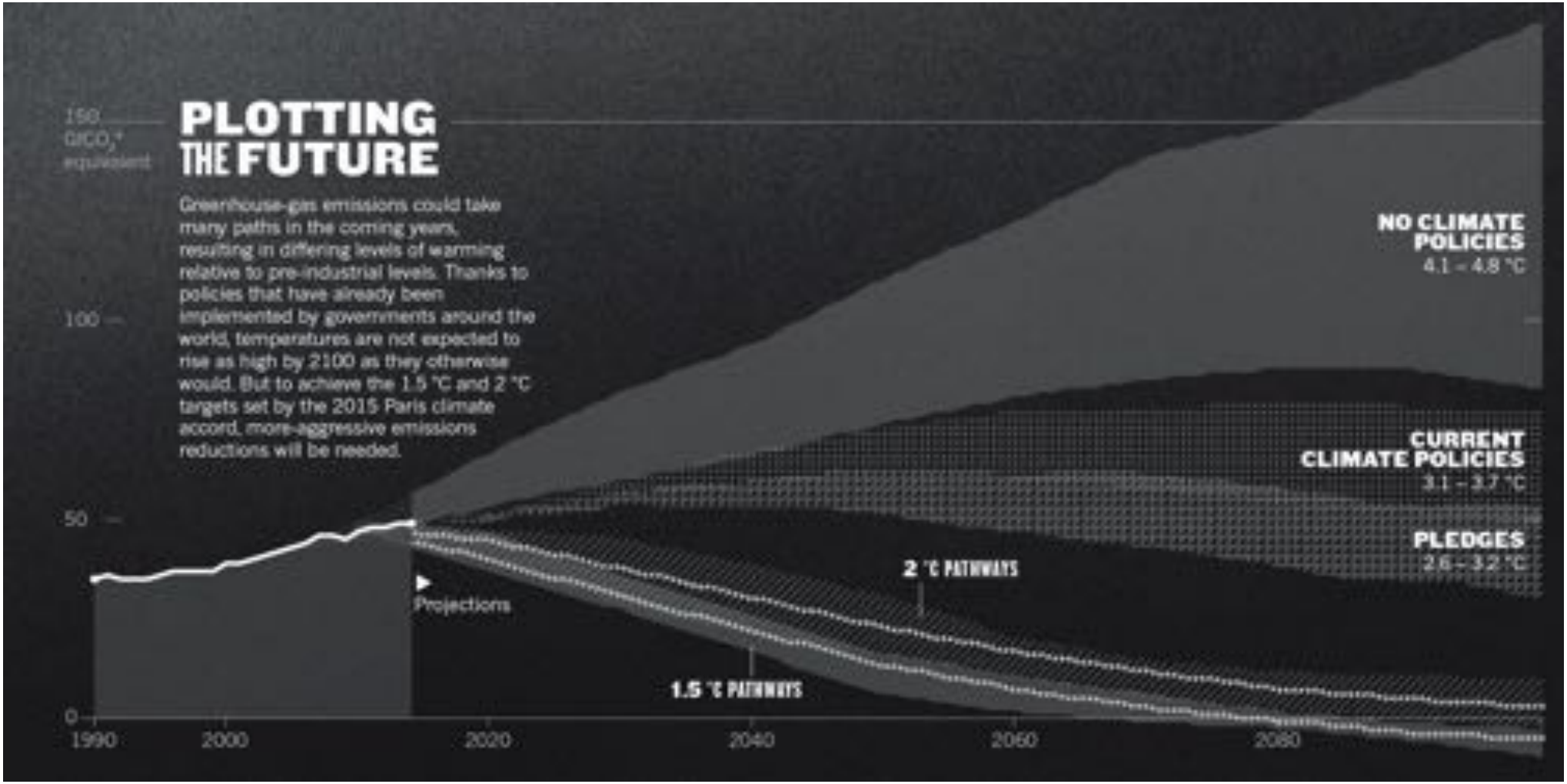
Because we are so close to the 1.5C thresholds, all scenarios currently considered compatible with a 1.5C target include an overshooting phase before returning to 1.5C until the end of the 21st century *(IPCC 2014)*

Requires «negative CO_2 emissions», i.e. reforestation and carbon capture and storage*, in addition to strong and immediate reduction of CO_2 emissions*.



(Seneviratne et al., in press)

Are we on track?



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(Tollefson, Nature 2018)

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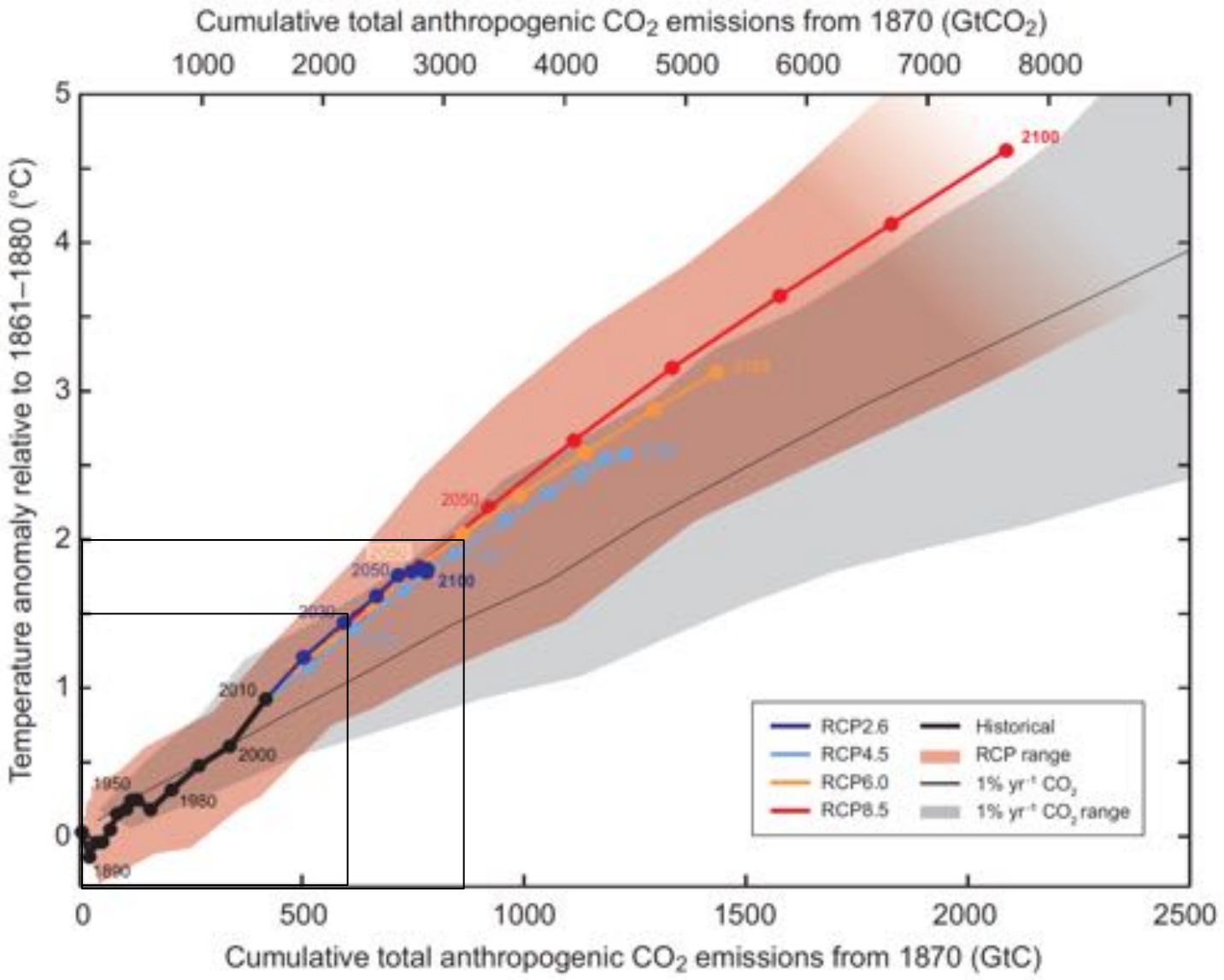

Direct link between cumulative CO_2 emissions and climate response

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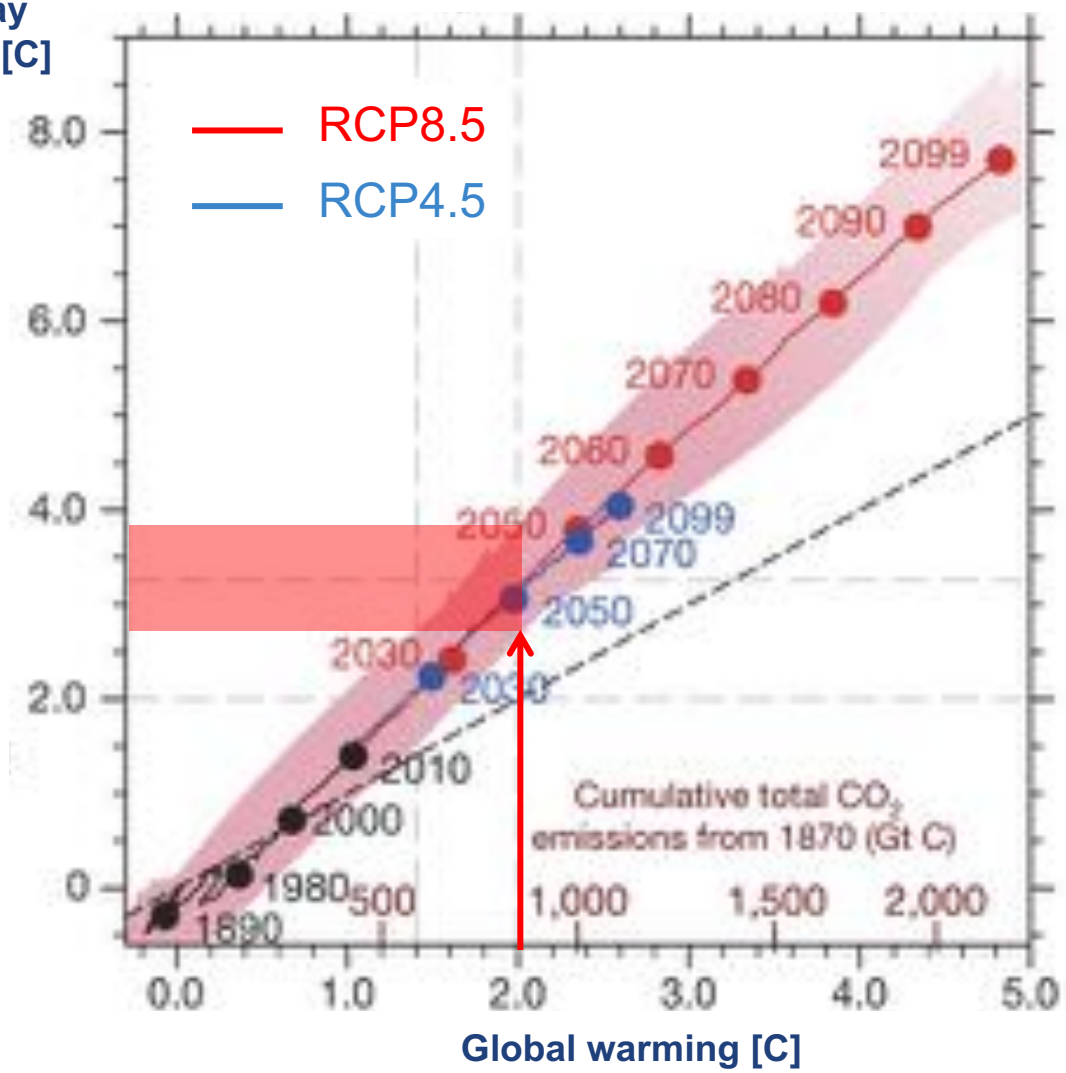
What are the implications for regional extremes?

(IPCC 2013)

Regional extremes vs global climate change

Mediterranean warming, warmest day of the year [C]

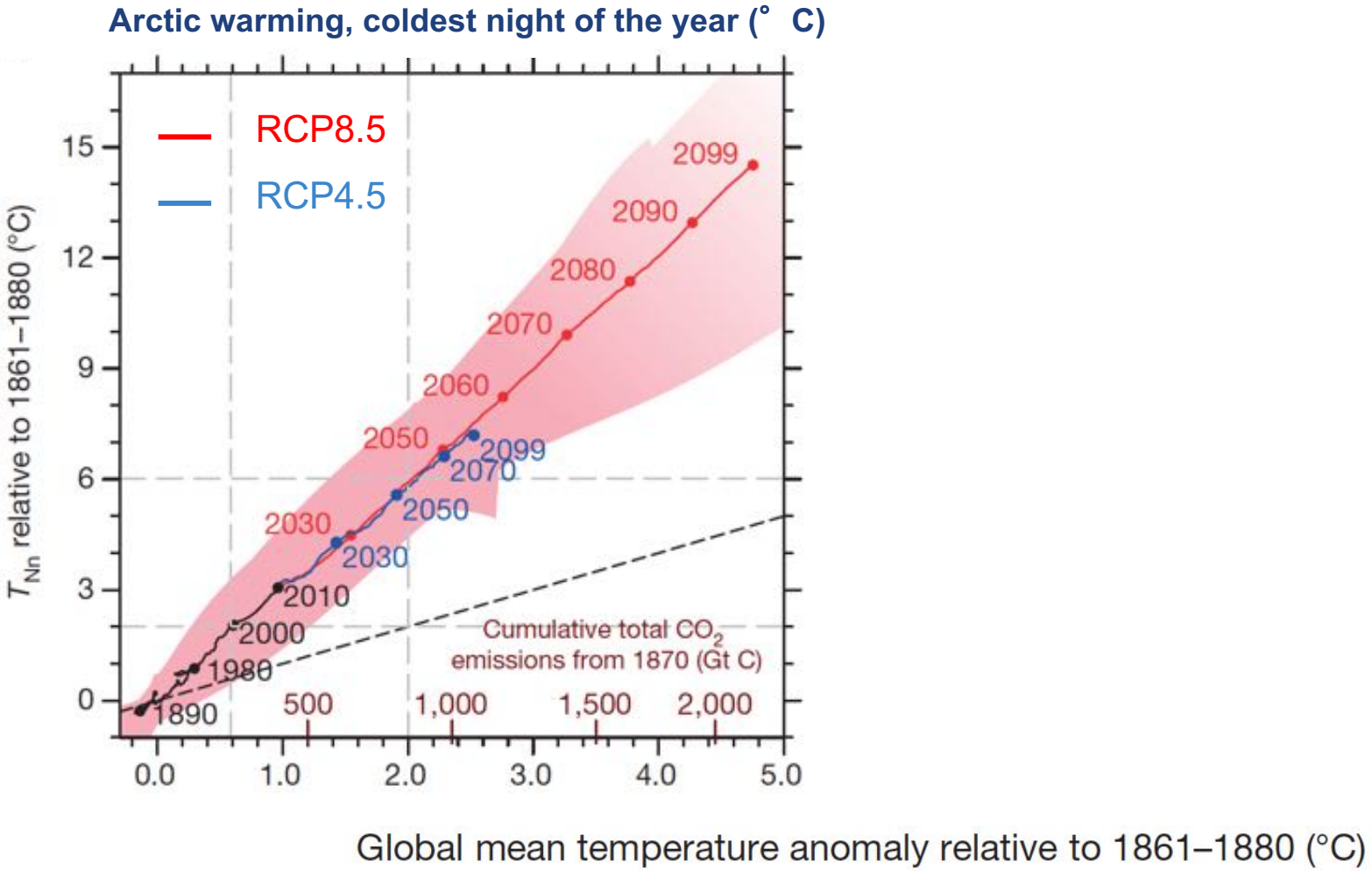


- Stronger warming of extremes in land hot spots vs global temperature
- Robust and almost linear scaling, mostly independent of emissions scenario!
  (see also Wartenburger et al. 2017, GMD)

(Seneviratne et al. 2016, Nature)

Regional extremes vs global climate change

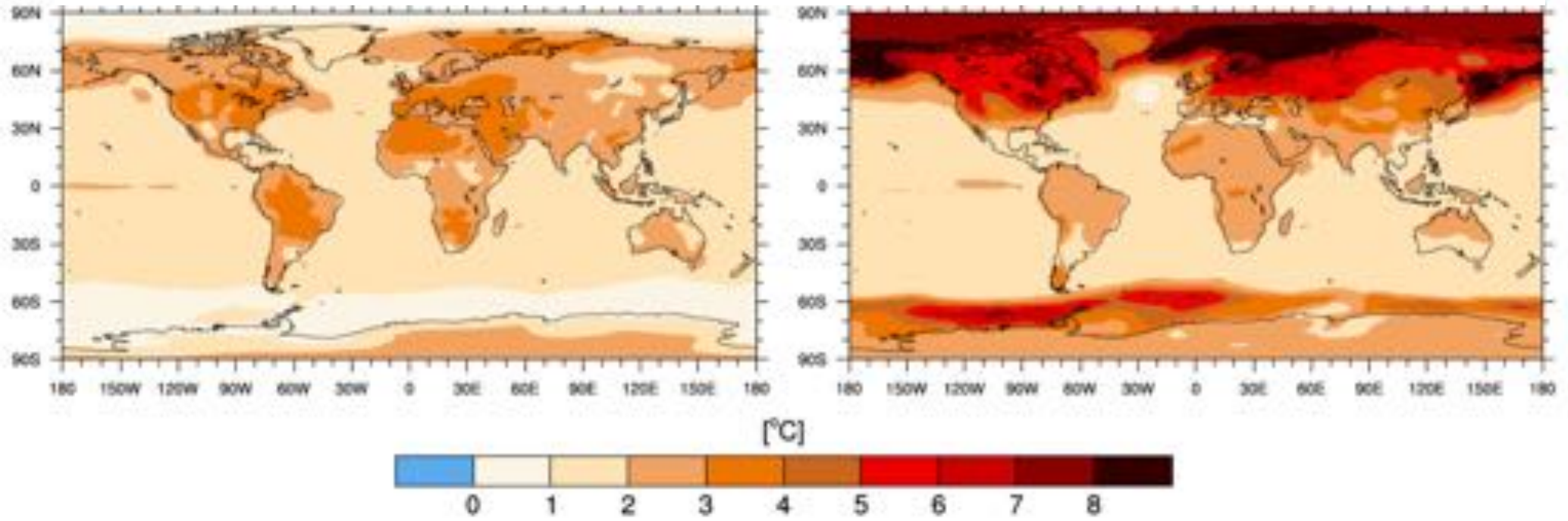
Warming of minimum temperatures in the Arctic



Scaling relationships for regional extremes

TXx local change when ΔTglob =2C

TNn local change when ΔTglob =2C



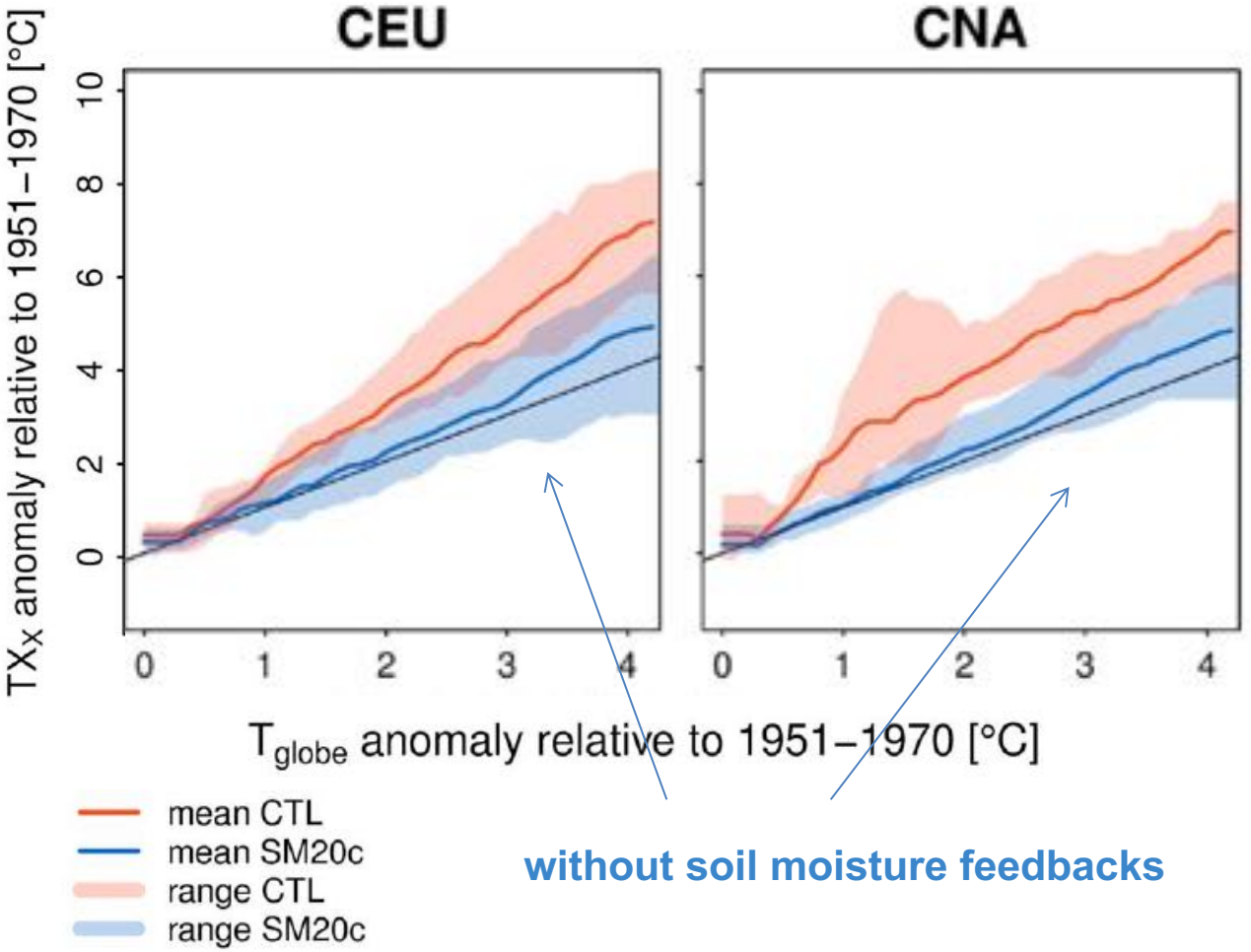
Does a 2C global warming target implies a 2C warming everywhere and all the time?

No! Stronger warming of land extremes compared to global temperature. Why?

(Seneviratne et al. 2016, Nature)

Soil moisture – temperature feedbacks: Projections

Scaling for GLACE-CMIP5 experiments (GEWEX-GLASS activity)



Soil moisture-temperature feedbacks are the main driver for the projected temperature extremes amplification in mid-latitudes!

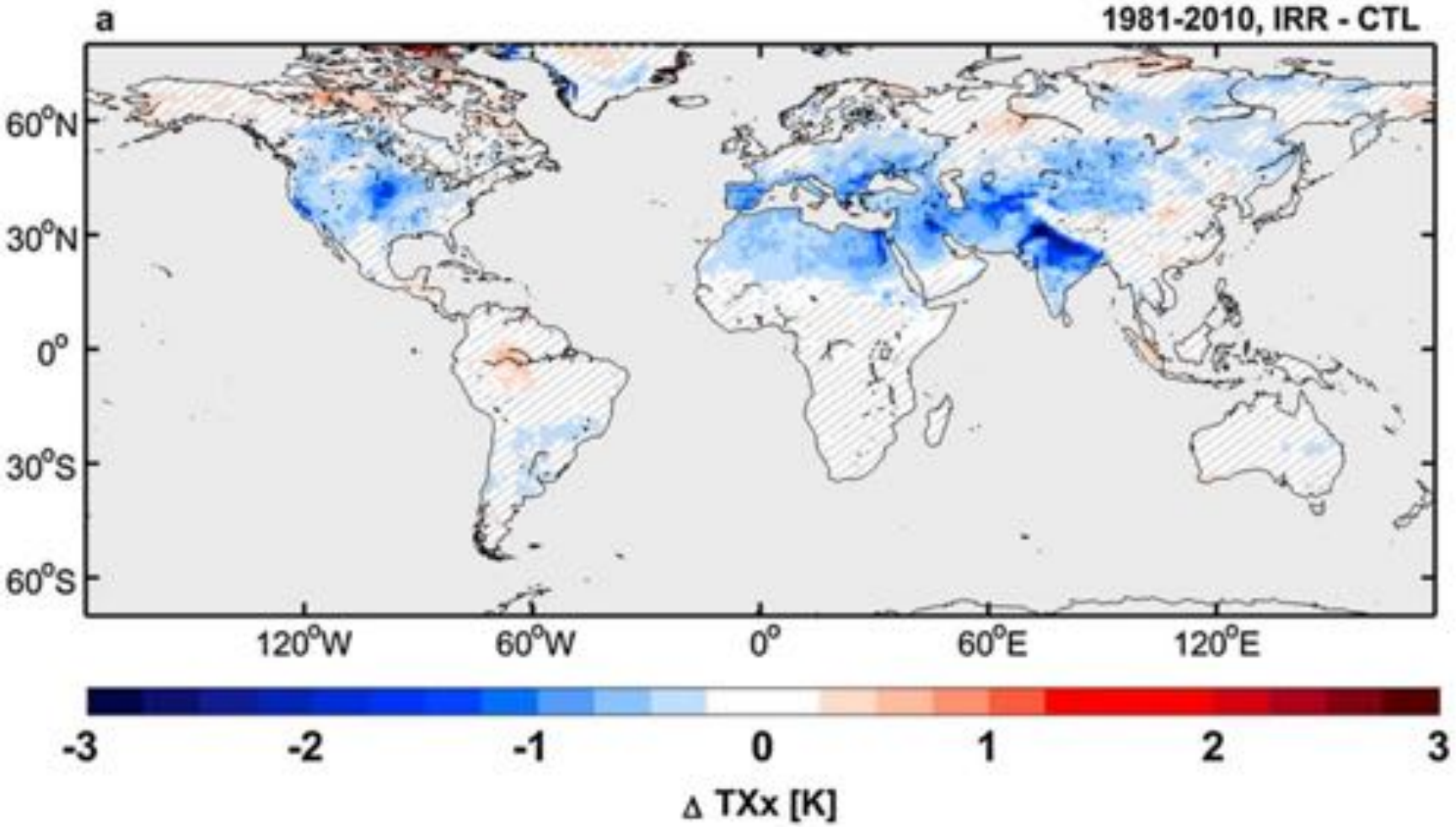
(Vogel et al. 2017, GRL)

Biophysical effects of land use changes

Some potential co-benefits or trade-offs (no-till farming, irrigation, afforestation)

Land use and climate change: Biophysical impacts

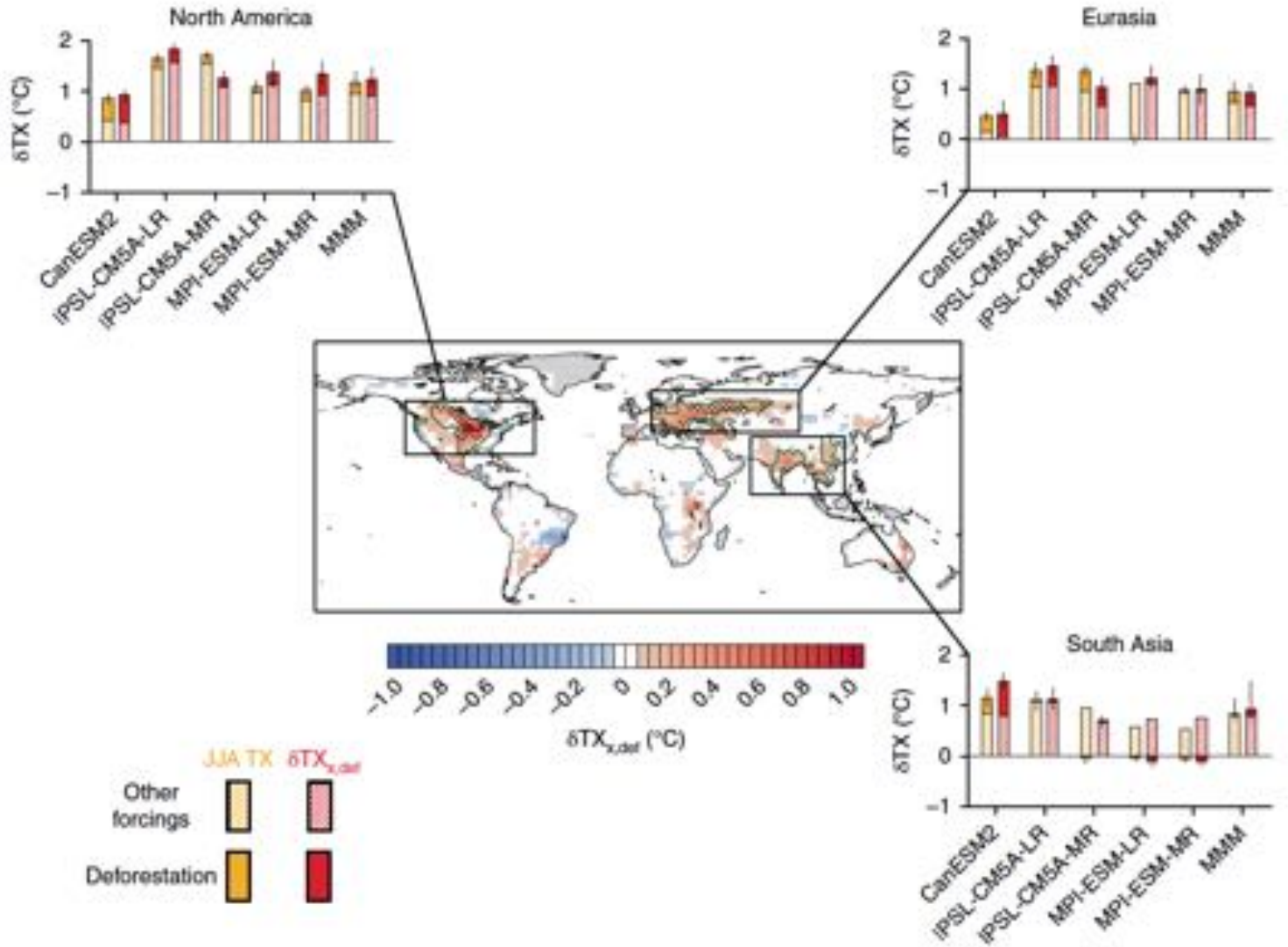
Present-day impacts of irrigation
(Human water use also new theme within Water GC!)



(Thiery et al. 2017, JGR)

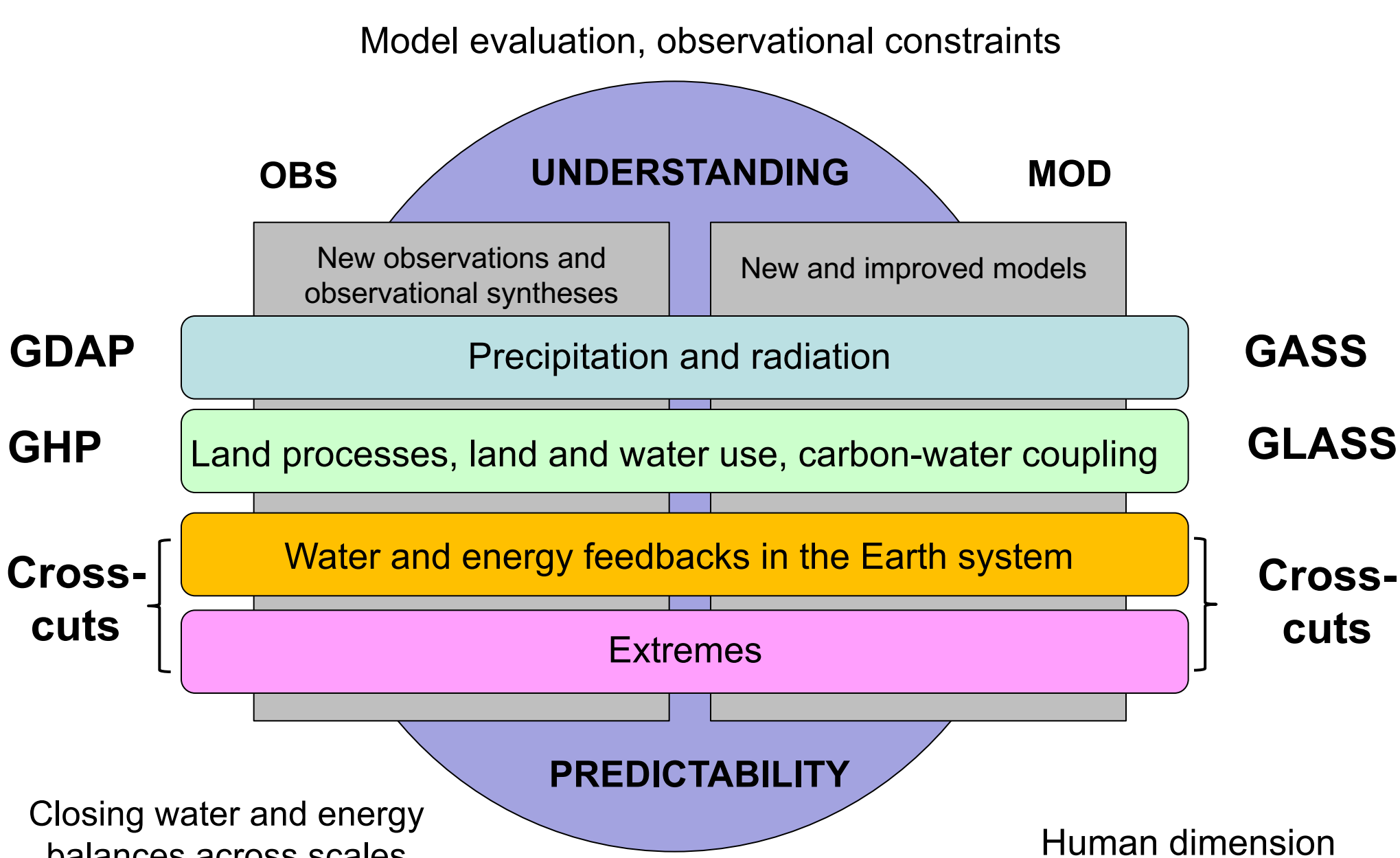
Land use and climate change: Biophysical impacts

Contribution of deforestation to trends in temperature (extremes)



(Lejeune et al. 2018, Nature Clim. Change)

New GEWEX science questions (WCRP strategic plan)



Extremes: A unifying theme

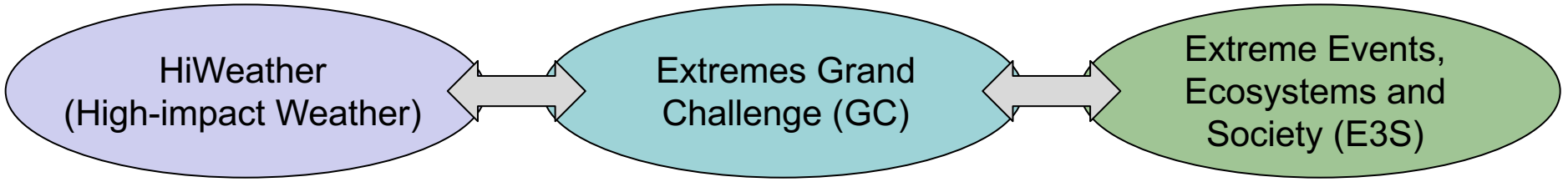
World Weather Research Programme (WWRP)

World Climate Research Programme (WCRP)

Future Earth

GEWEX
CLIVAR

ILEAPS



Some common themes: compound events, documenting extremes, modeling

New/other activities

IPCC AR6

- Coordinating lead author on extremes chapter (11) from Working group 1 together with Xuebin Zhang, Env. Canada (05/18-04/21)

Chapter 11:
Weather and climate extreme events in a changing climate
Executive Summary

- Extreme types, encompassing weather and climate timescales and compound events (including droughts, tropical cyclones)
- Observations for extremes and their limitations, including paleo
- Mechanisms, drivers and feedbacks leading to extremes
- Ability of models to simulate extremes and related processes
- Attribution of changes in extremes and extreme events
- Assessment of projected changes of extremes and potential surprises
- Case studies across timescales

Frequently Asked Questions

WCRP Grand Challenge on Extremes

- (with L. Alexander, G. Hegerl, X. Zhang): NB new crosscutting activities!

Conclusions and outlook

- We are substantially affecting climate through CO_2 emissions (already global warming of 1C). Aiming for a stabilization of global warming at 1.5C-2C by 2100 requires immediate efforts to reduce emissions.

- Regional warming of extremes is much larger than global warming in many regions (e.g. up to 4C in US and 6C in the Arctic at 2C global warming)

- Other human activities are also key in affecting regional climate, and in particular extremes: land use, water use (irrigation)

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Thanks for great time with GEWEX SSG! Looking forward to an exciting conference!

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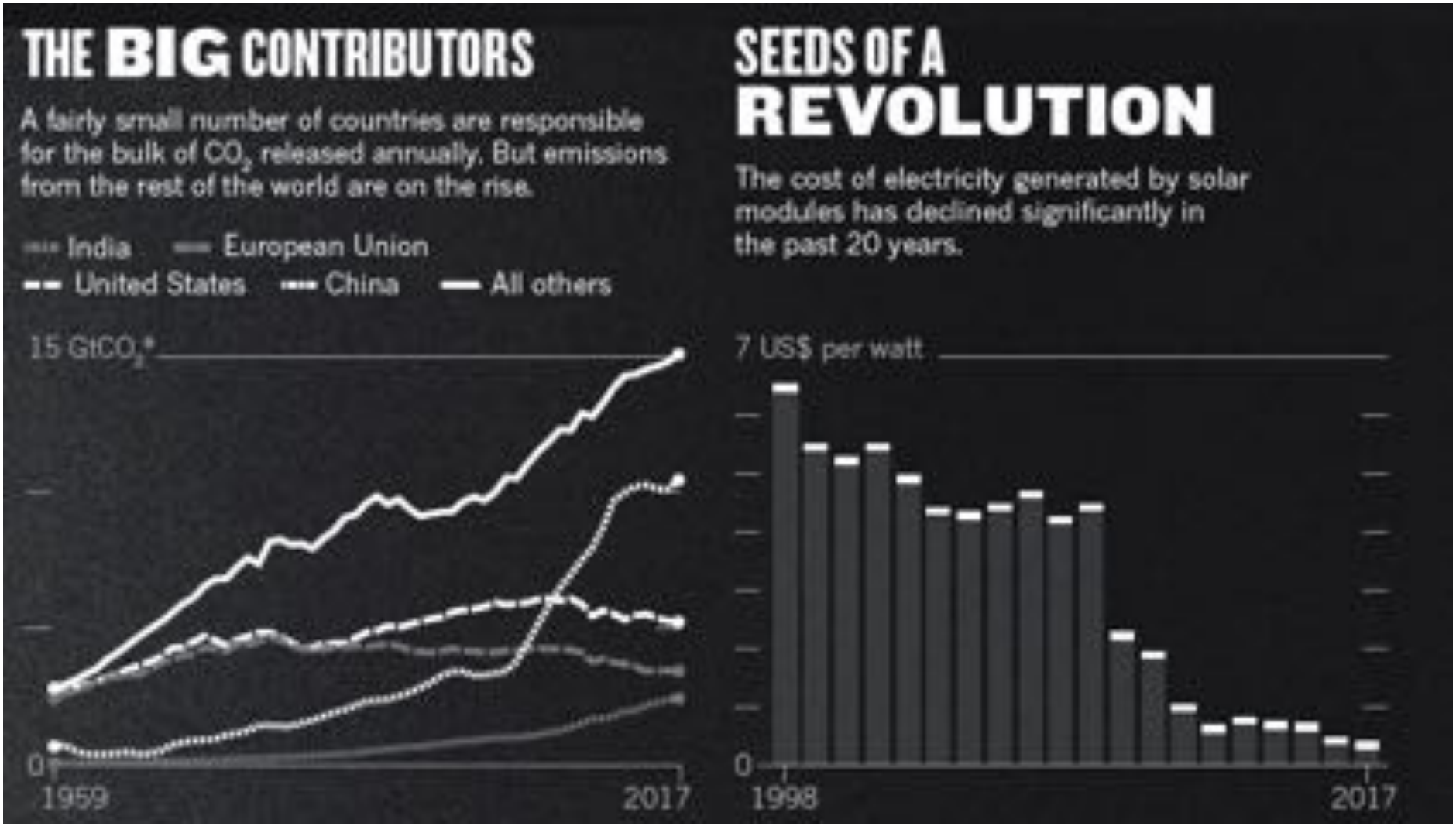
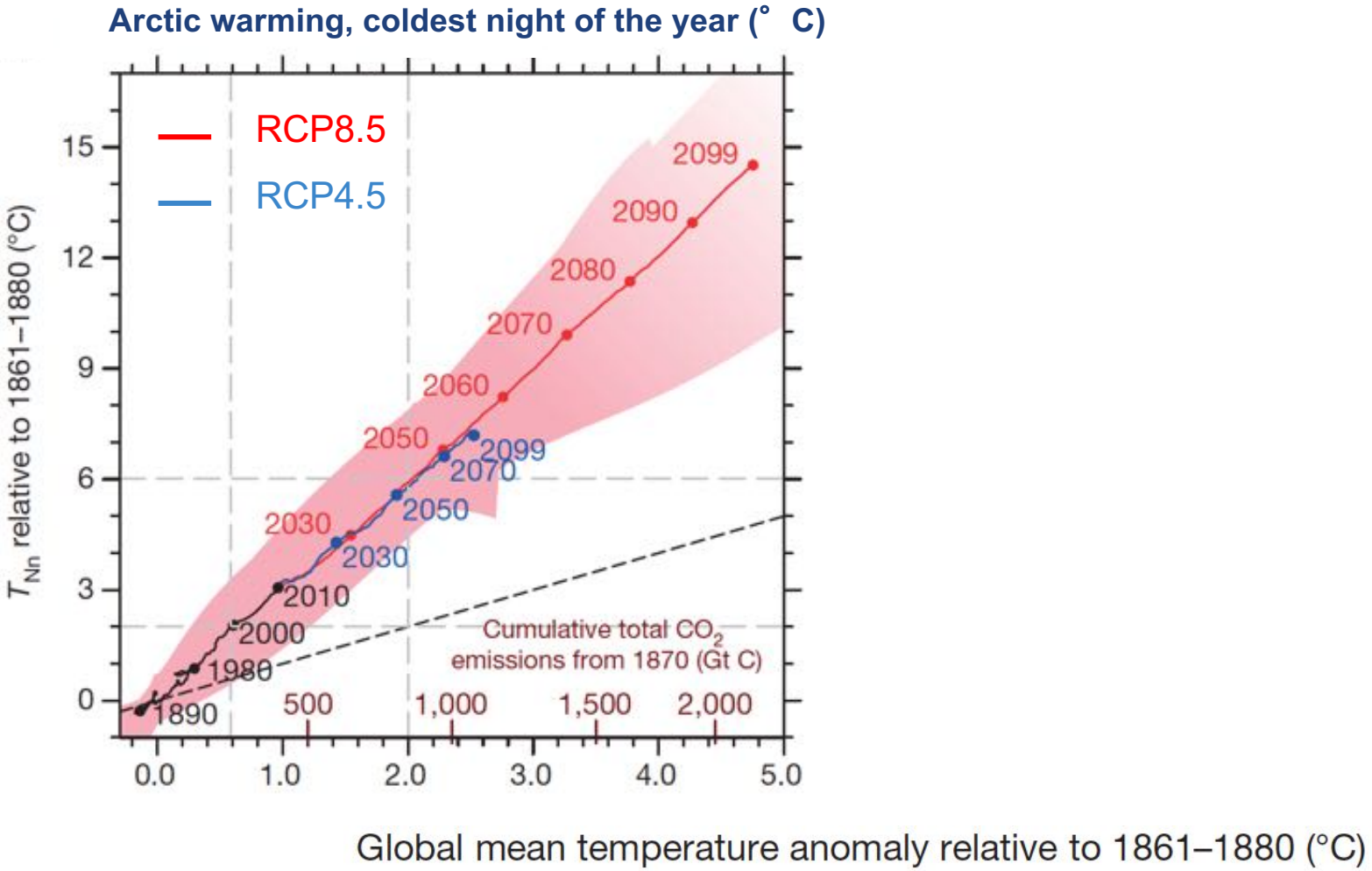
Are we on track?



(Tollefson, Nature 2018)

Regional extremes vs global climate change

Also scaling found for warming of minimum temperatures and changes in heavy precipitation



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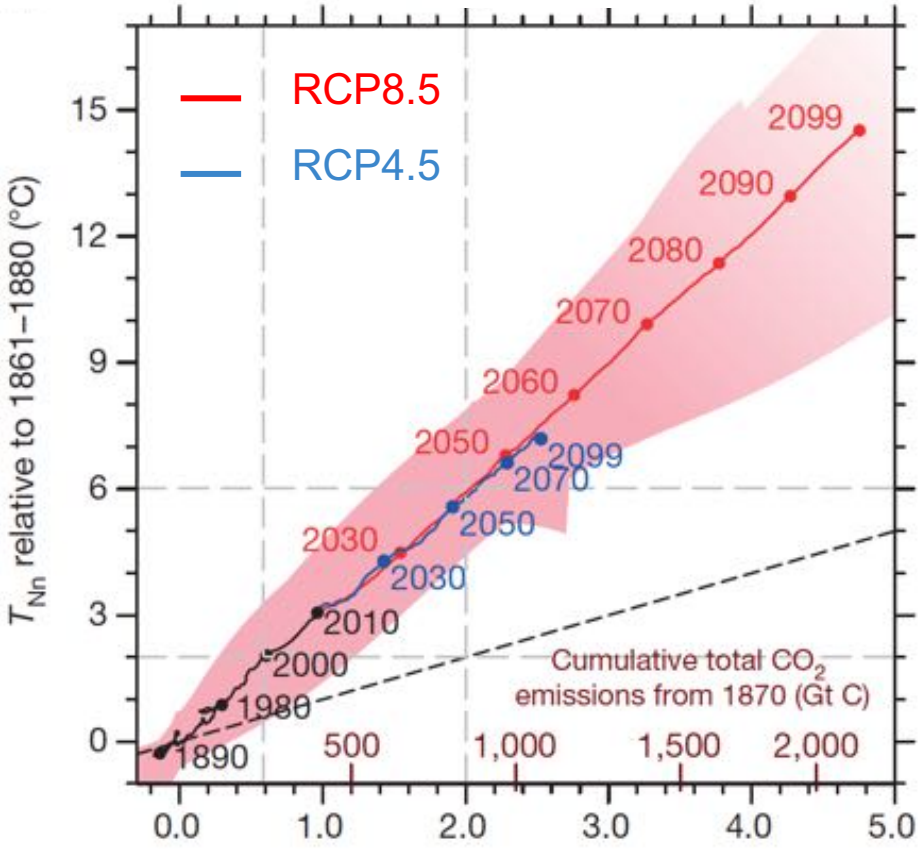
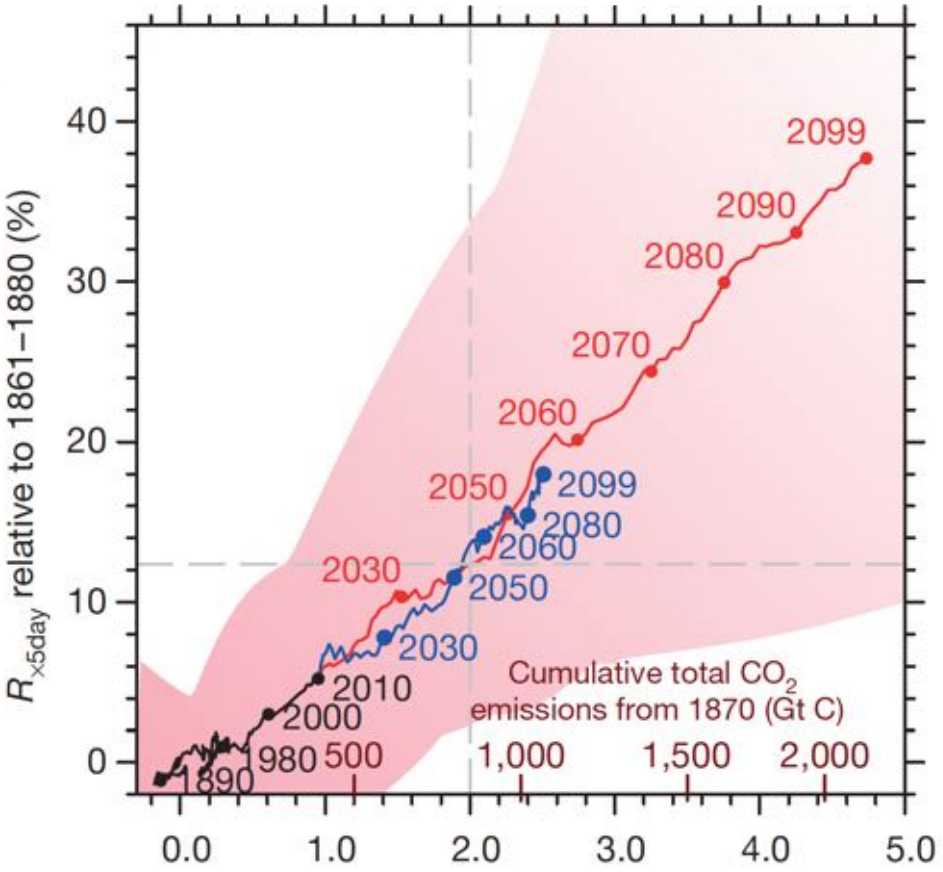
Arctic warming, coldest night of the year (° C)

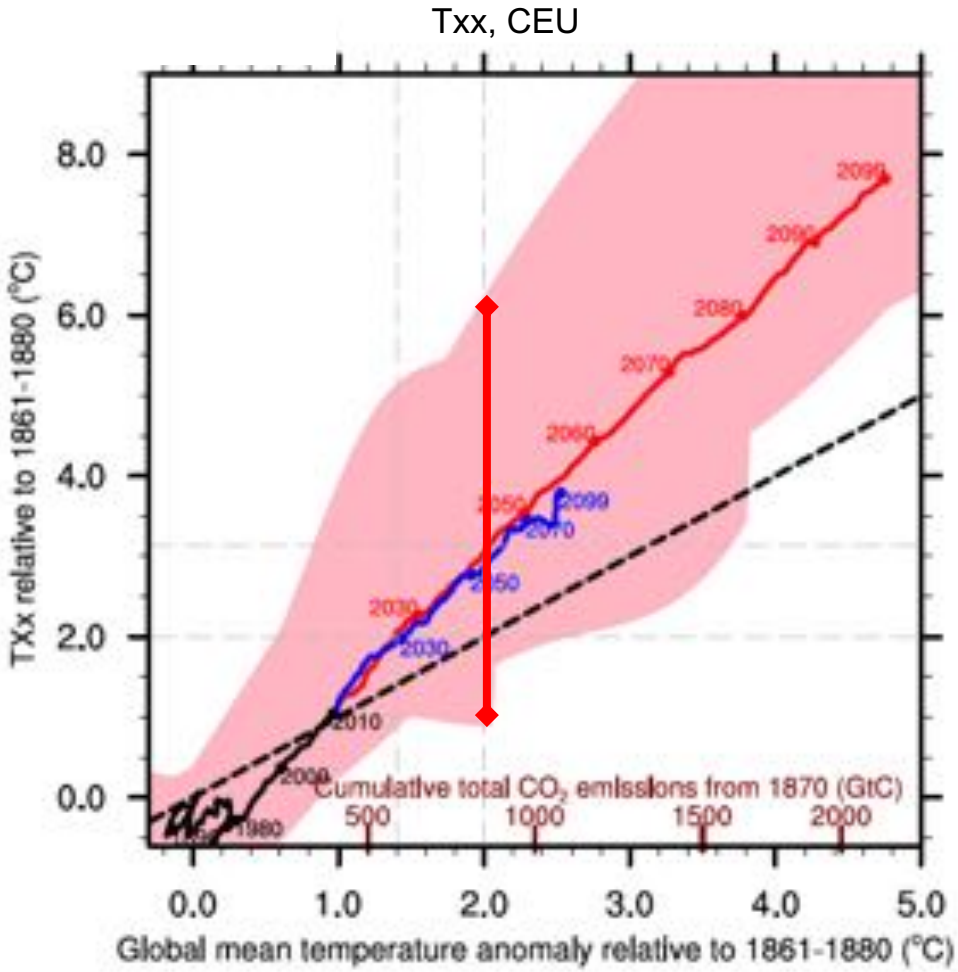


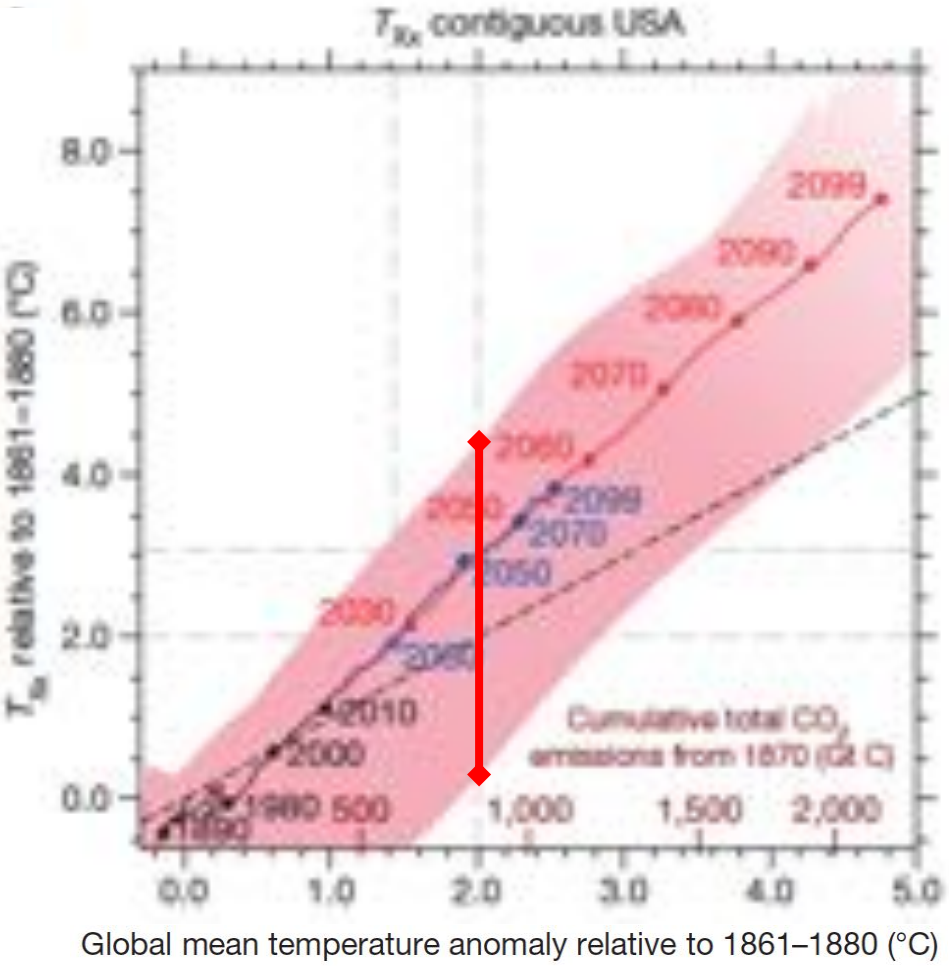
Southern Asia, changes in heaviest 5-day precipitation (%)



Global mean temperature anomaly relative to 1861–1880 (°C)

Complex regional scaling: Example from 2 regions





NB: Regions with large spread in regional responses are found in locations of known large soil moisture-temperature feedbacks