Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

# Changes in the Earth system and response to perturbations of the Earth's energy balance

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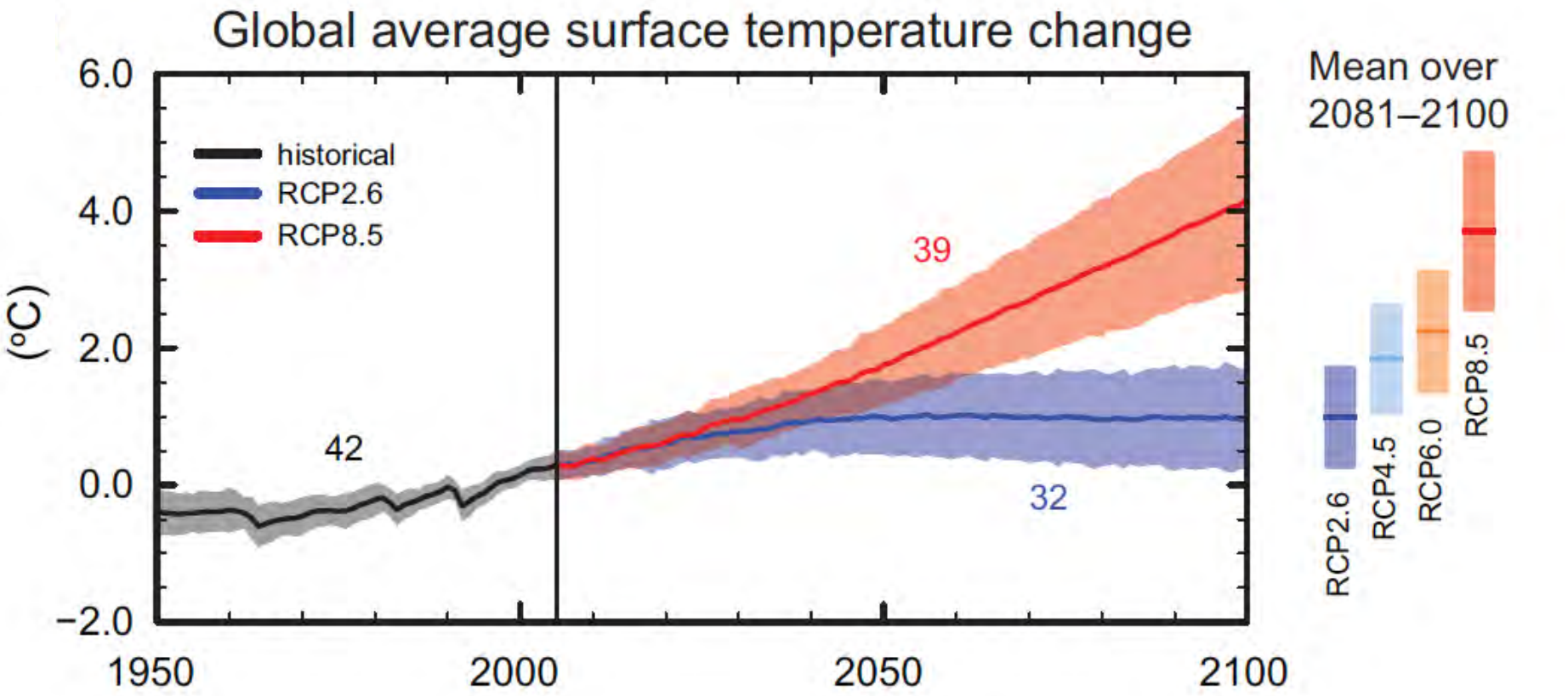
IPCC SR15 scoping meeting, August 15, 2016

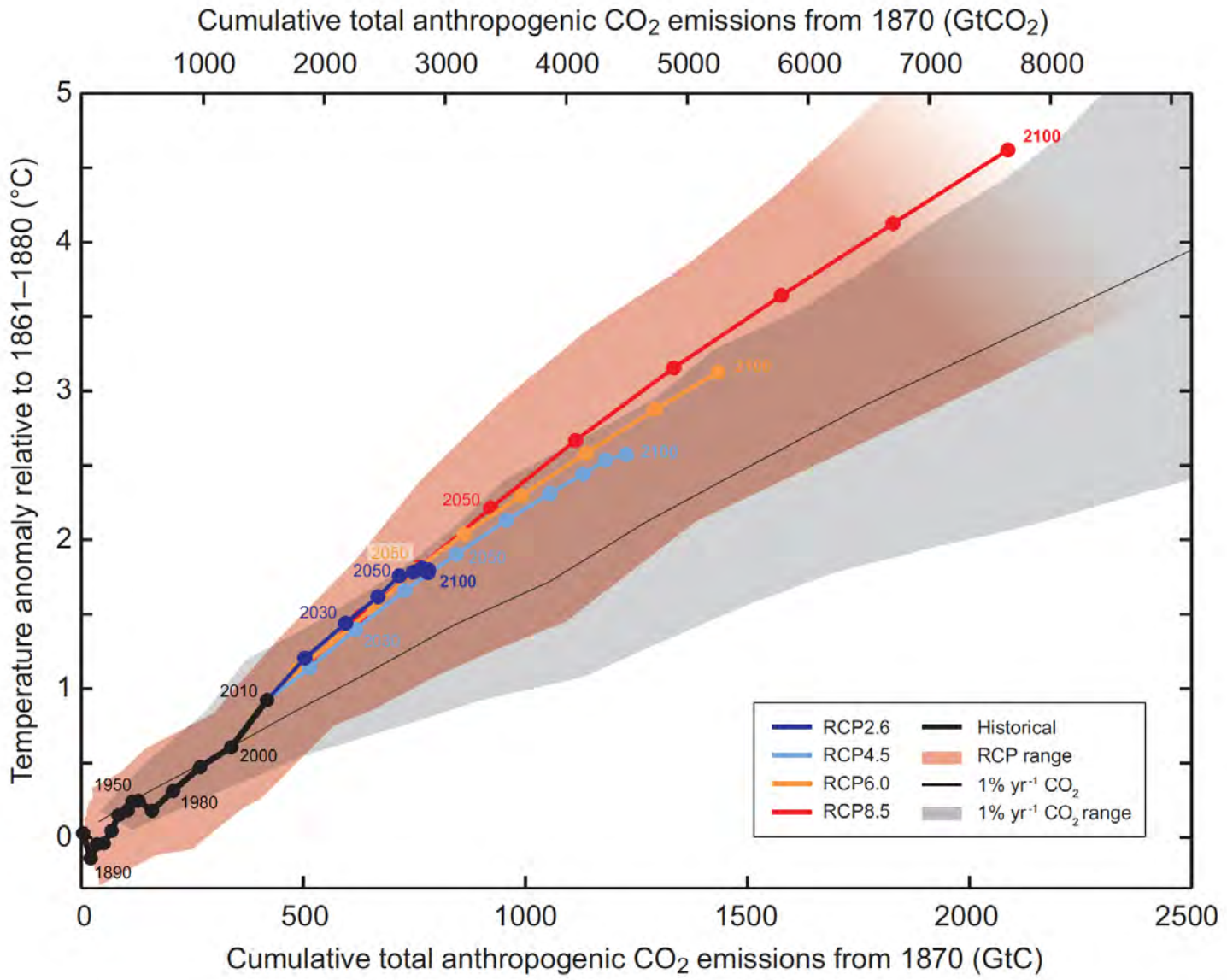
# Climate projections




Agreement at COP21 to hold the increase in global temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit increases to 1.5°

*(IPCC 2013)*

# 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 a cumulative emissions target

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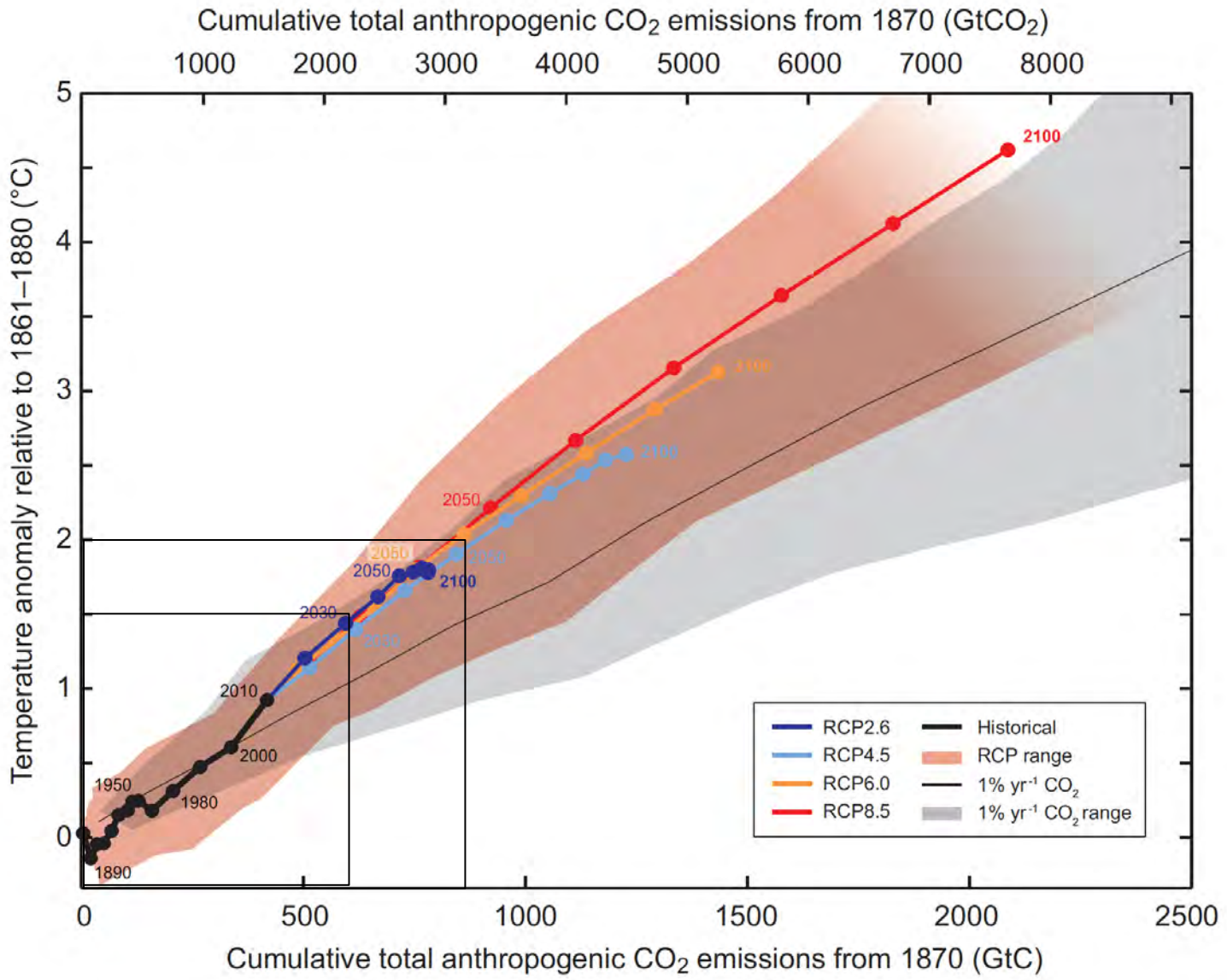


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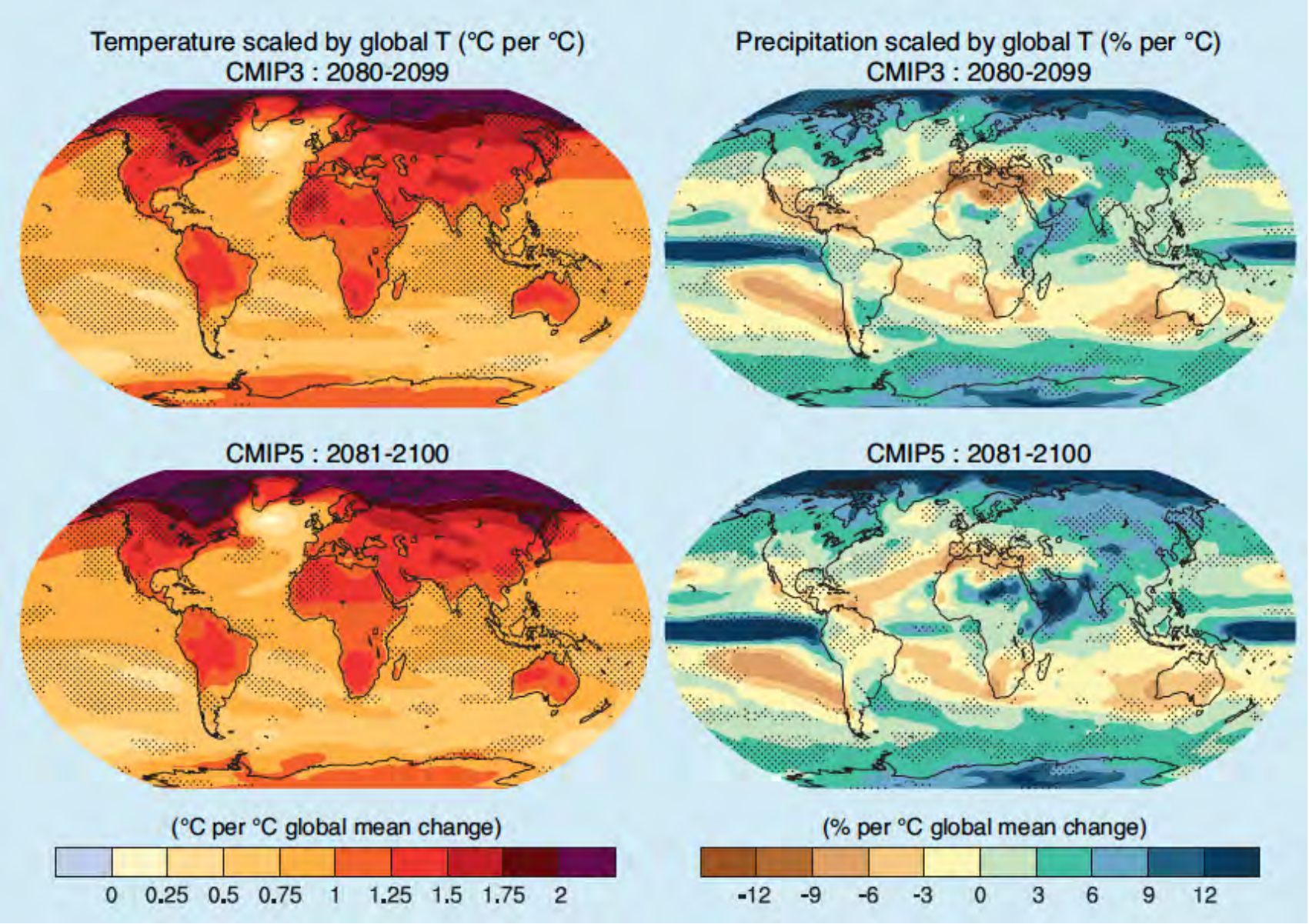
# What are the implications of a 1.5 vs 2° world?




*(IPCC 2013, Tech. Summary)*

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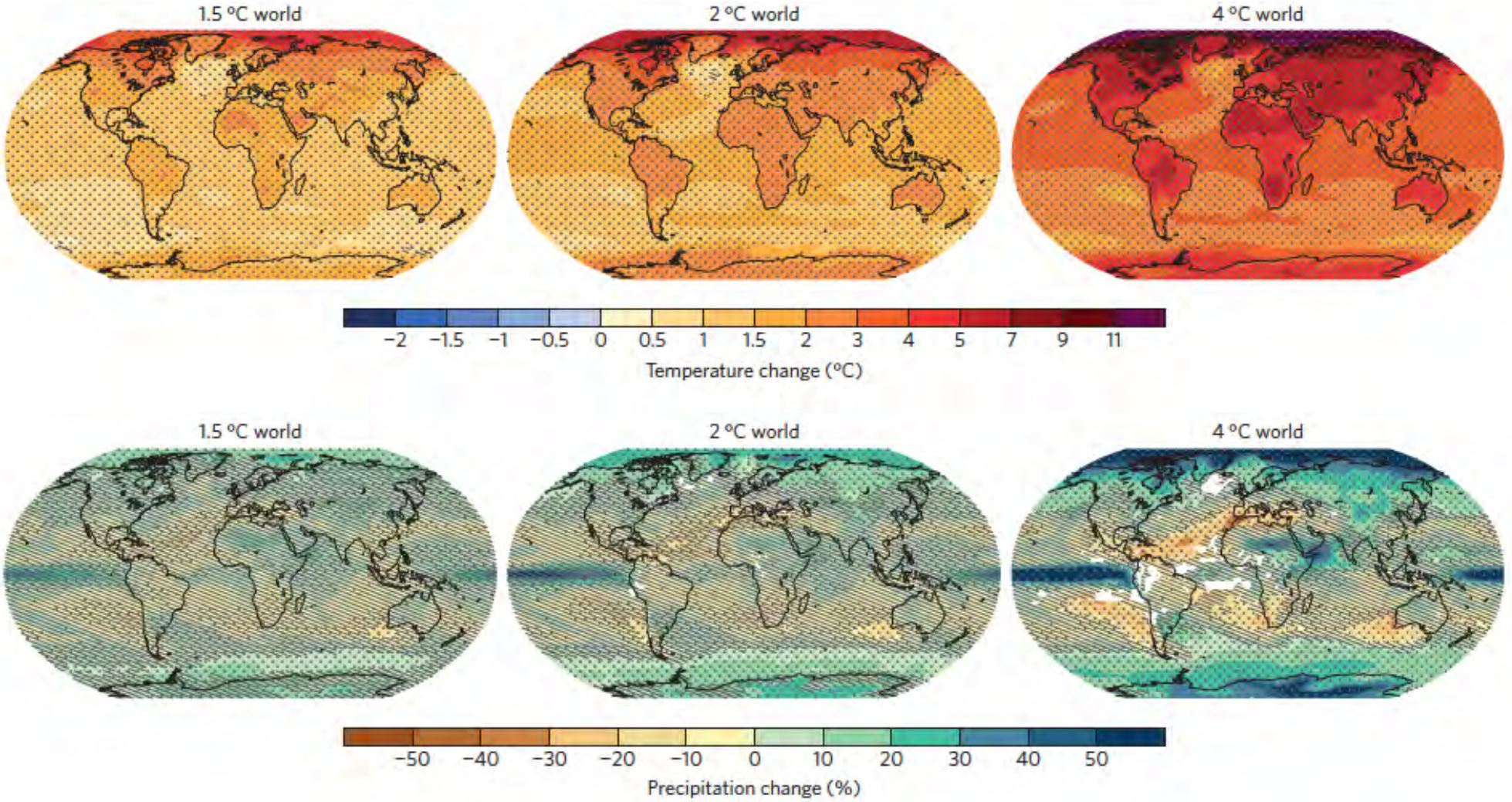


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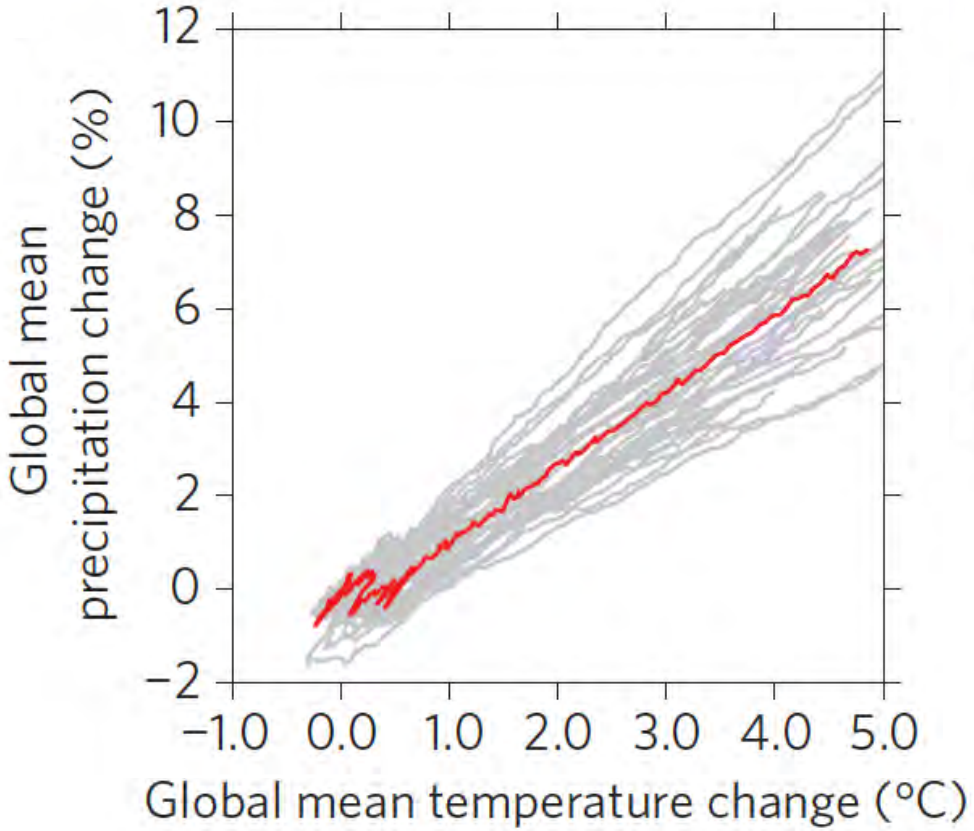


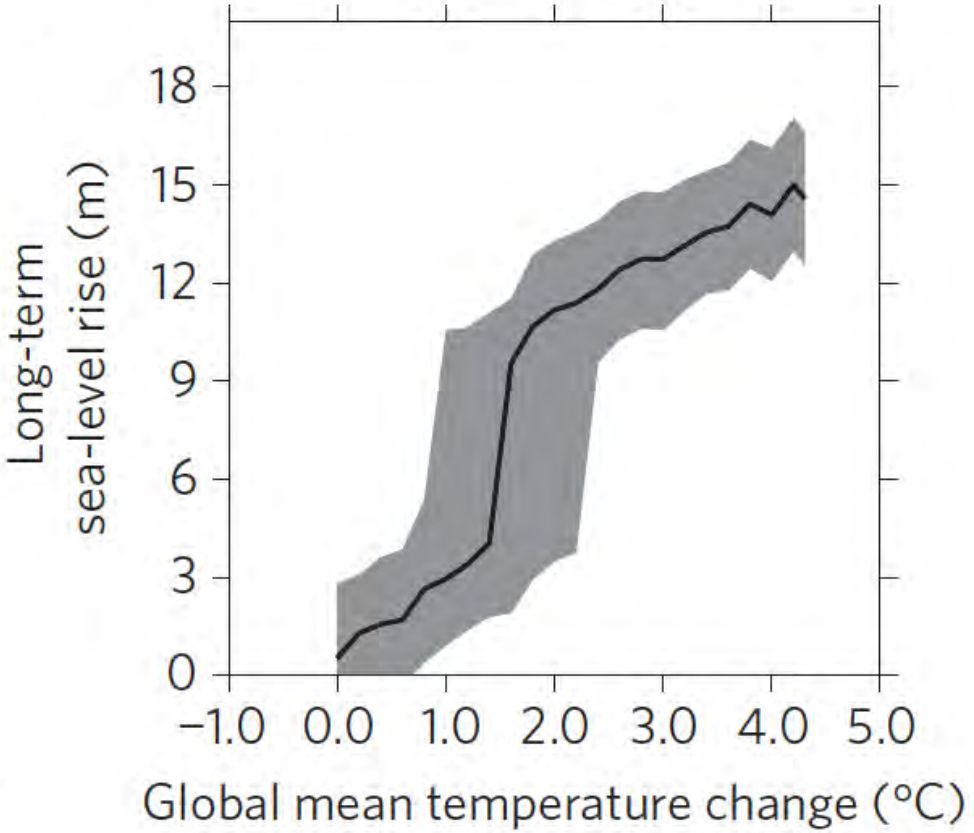


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***How about regional extremes and impacts?***

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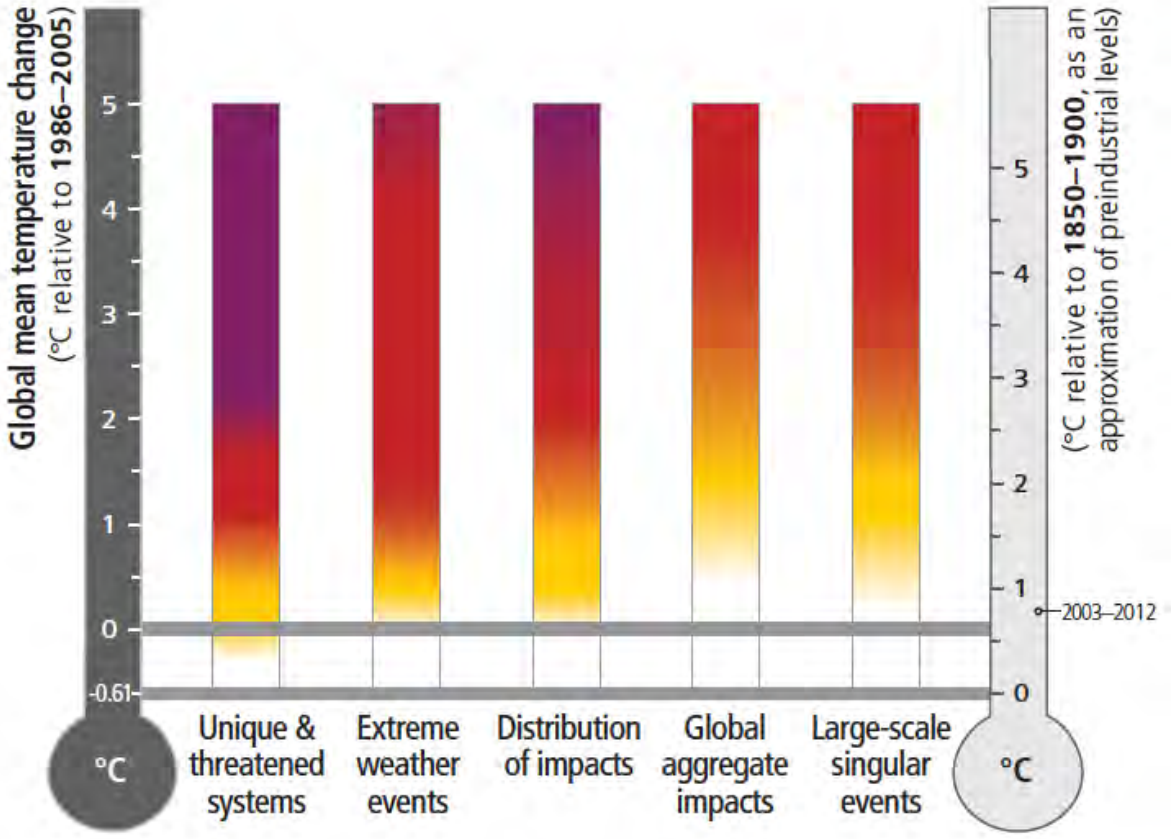
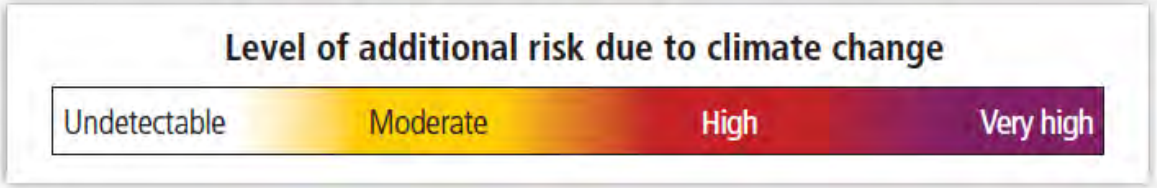
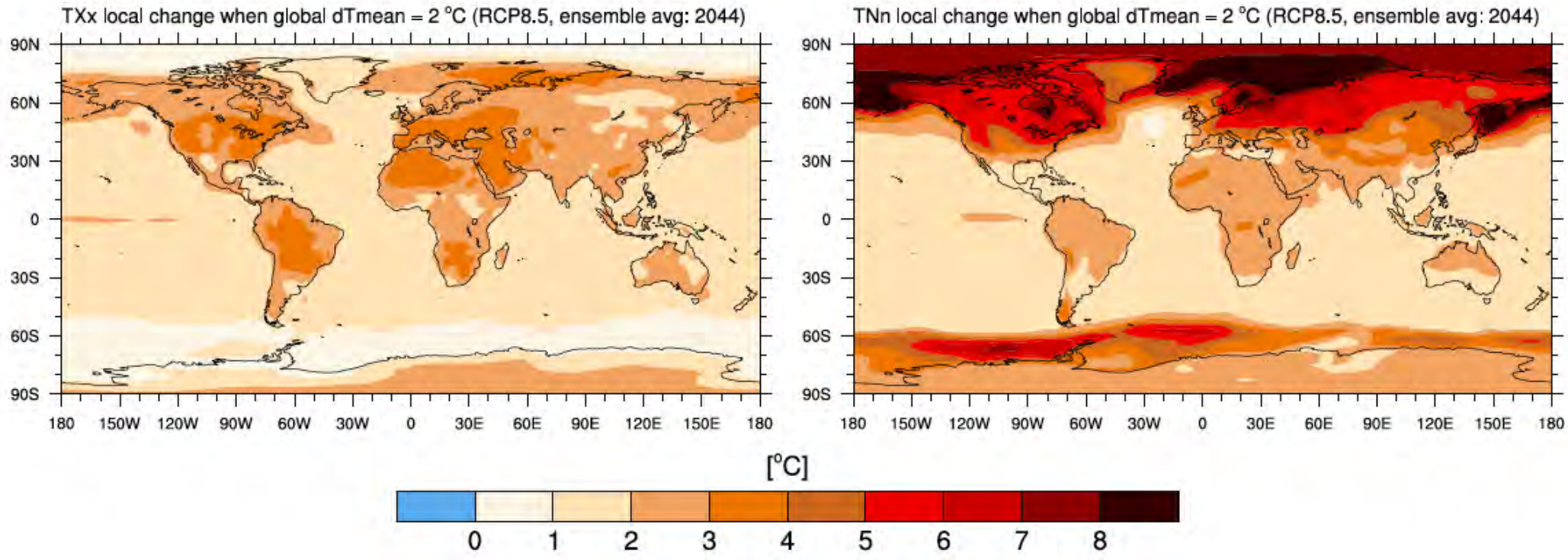



**Can we be more quantitative?**

*(IPCC 2014, WG2)*

# What are the *regional* implications of Tglob changes?




Stronger warming of land extremes compared to global temperature

*(Seneviratne, Donat, Pitman, Knutti, Wilby, 2016, Nature;* doi:10.1038/nature16542*)*

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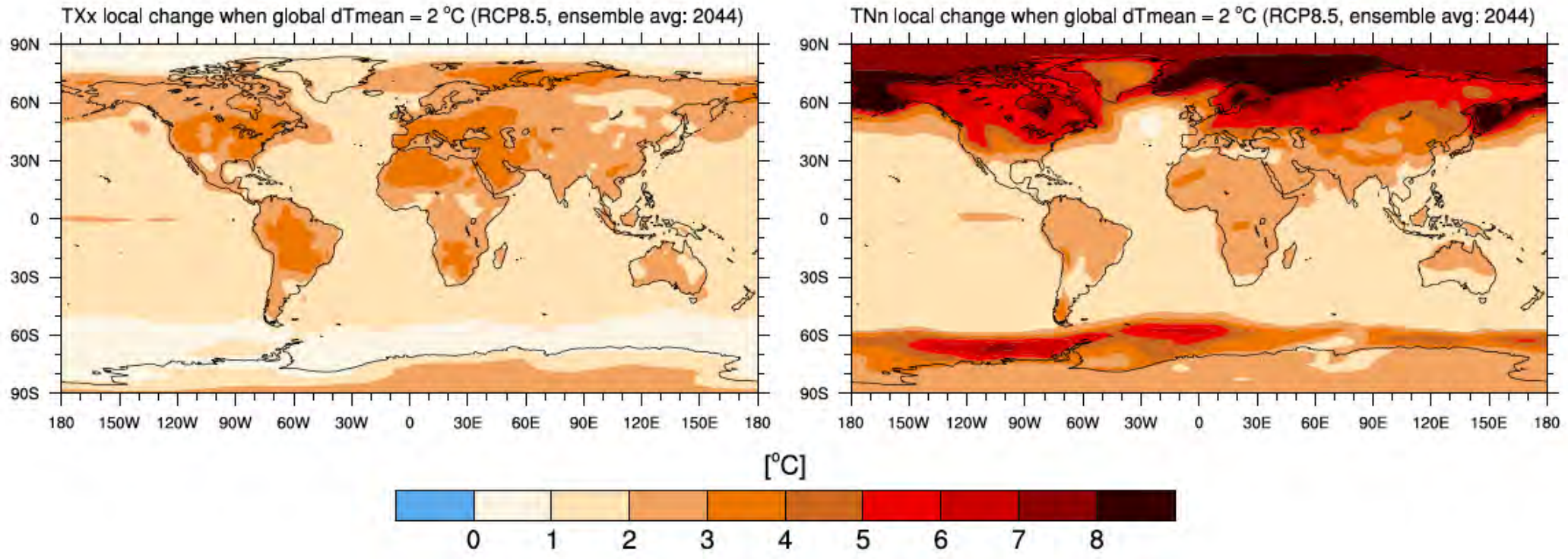


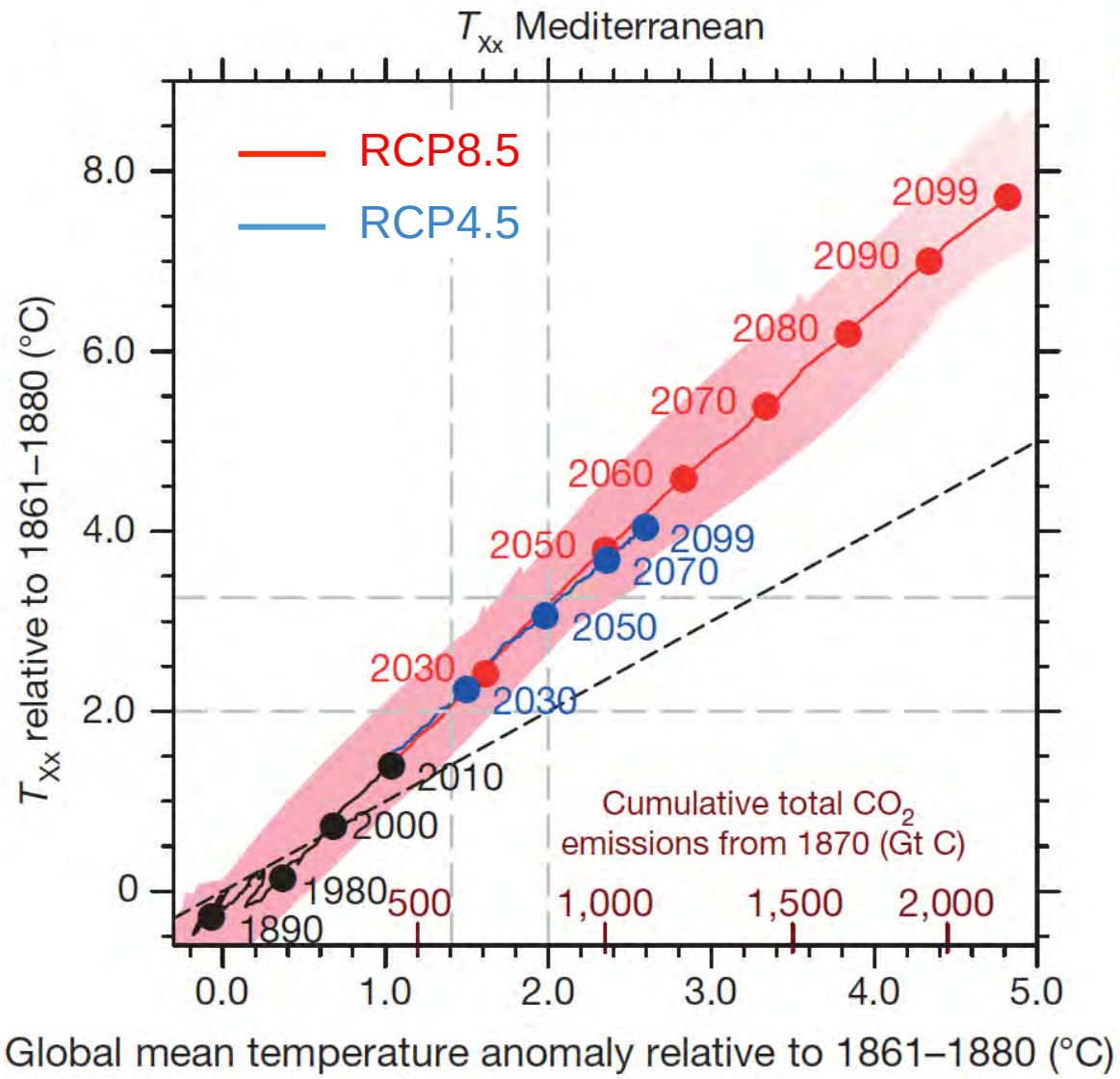

Stronger warming of land extremes compared to global temperature

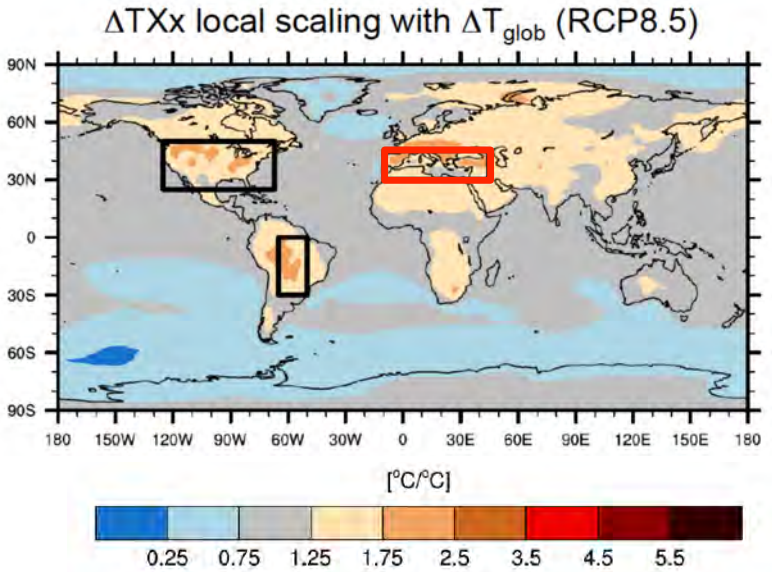
How does this scaling vary with different:

- ΔTglob values
- Emissions scenarios ?

*(Seneviratne, Donat, Pitman, Knutti, Wilby, 2016, Nature;* doi:10.1038/nature16542*)*

# Relating regional climate targets with $CO_2$ emissions

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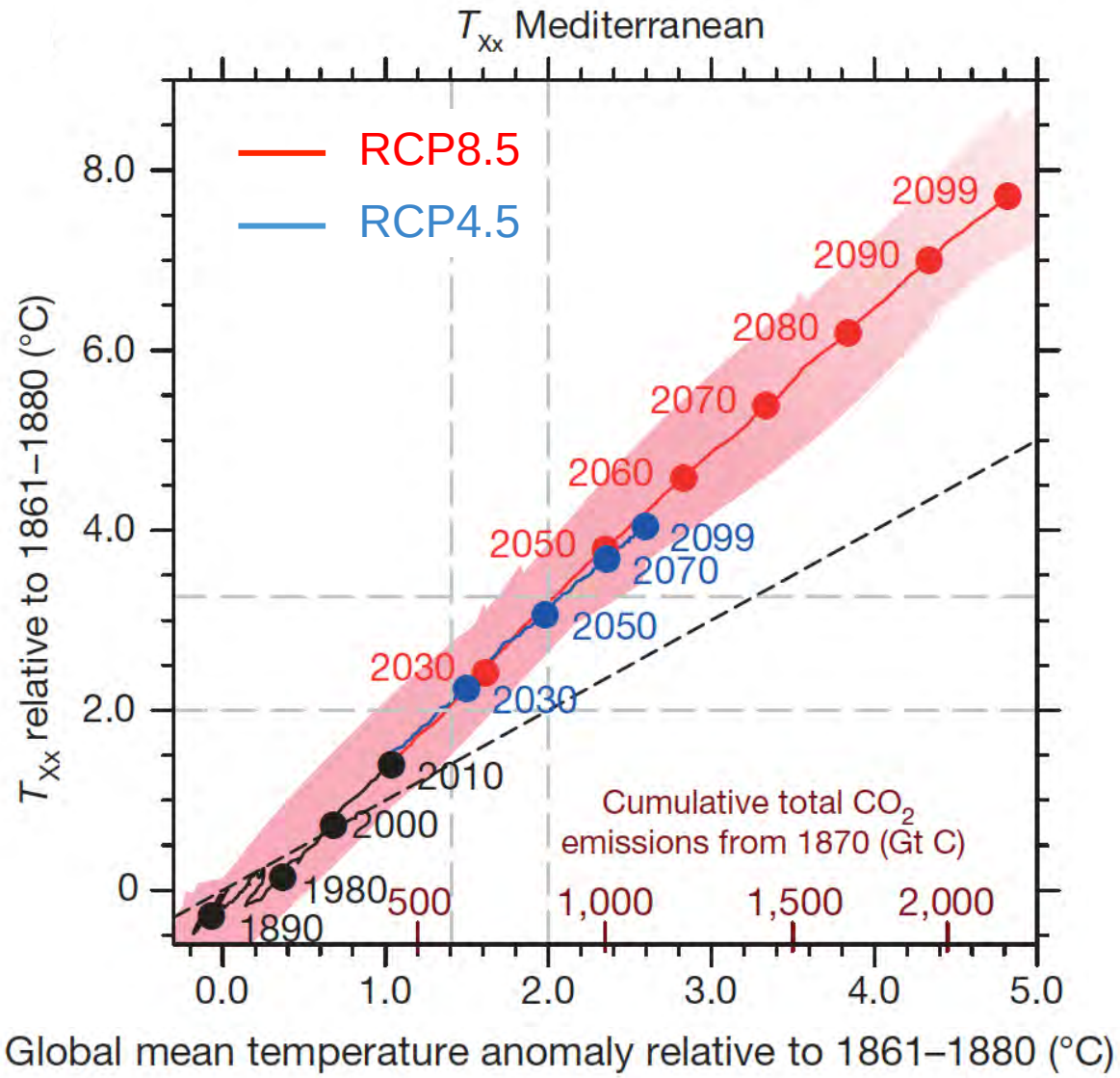


Results:

- Almost linear scaling for multi-model mean
  *(see also Fischer et al. 2014, GRL)*
- Pattern independent of emissions scenario!

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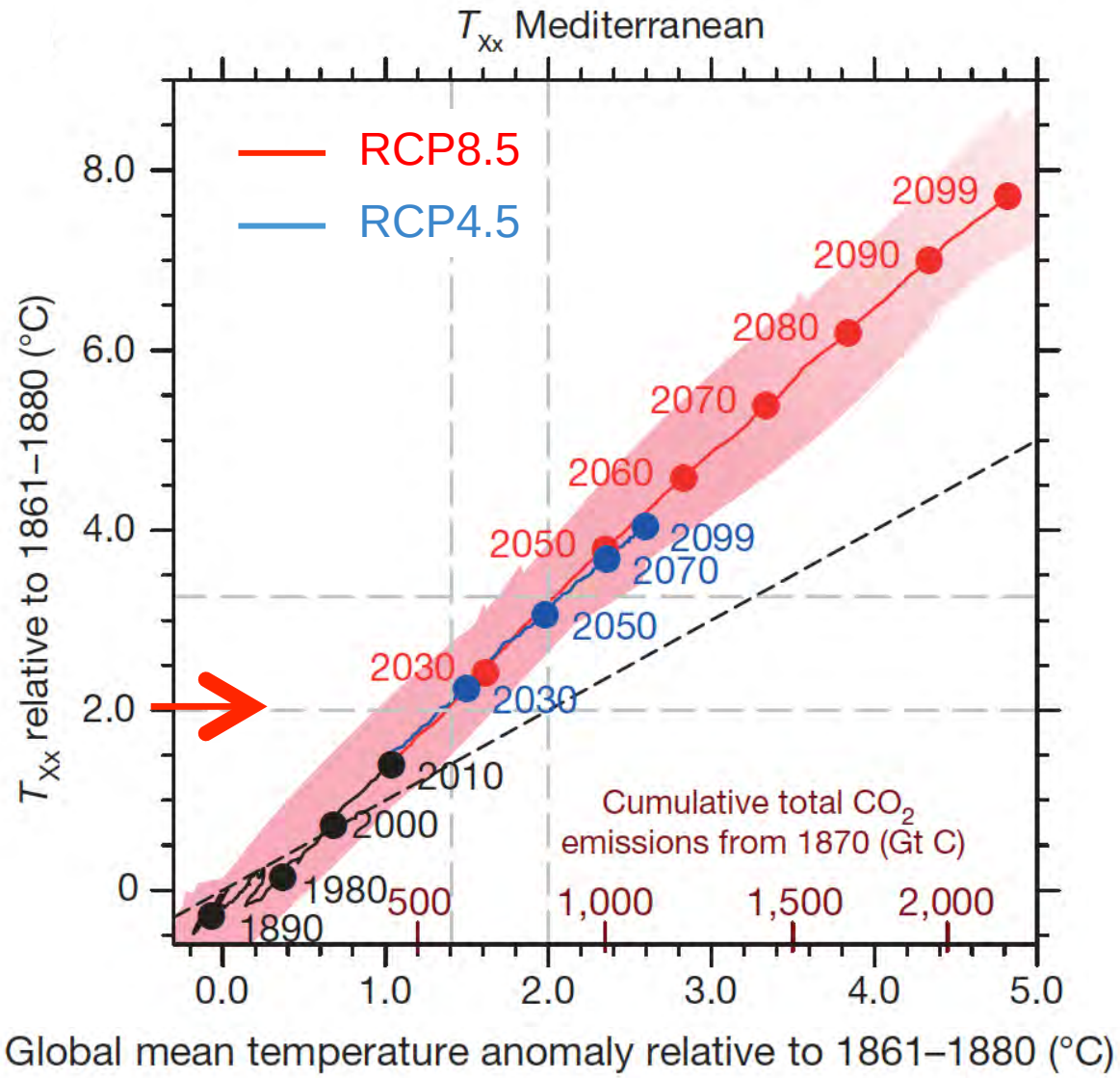


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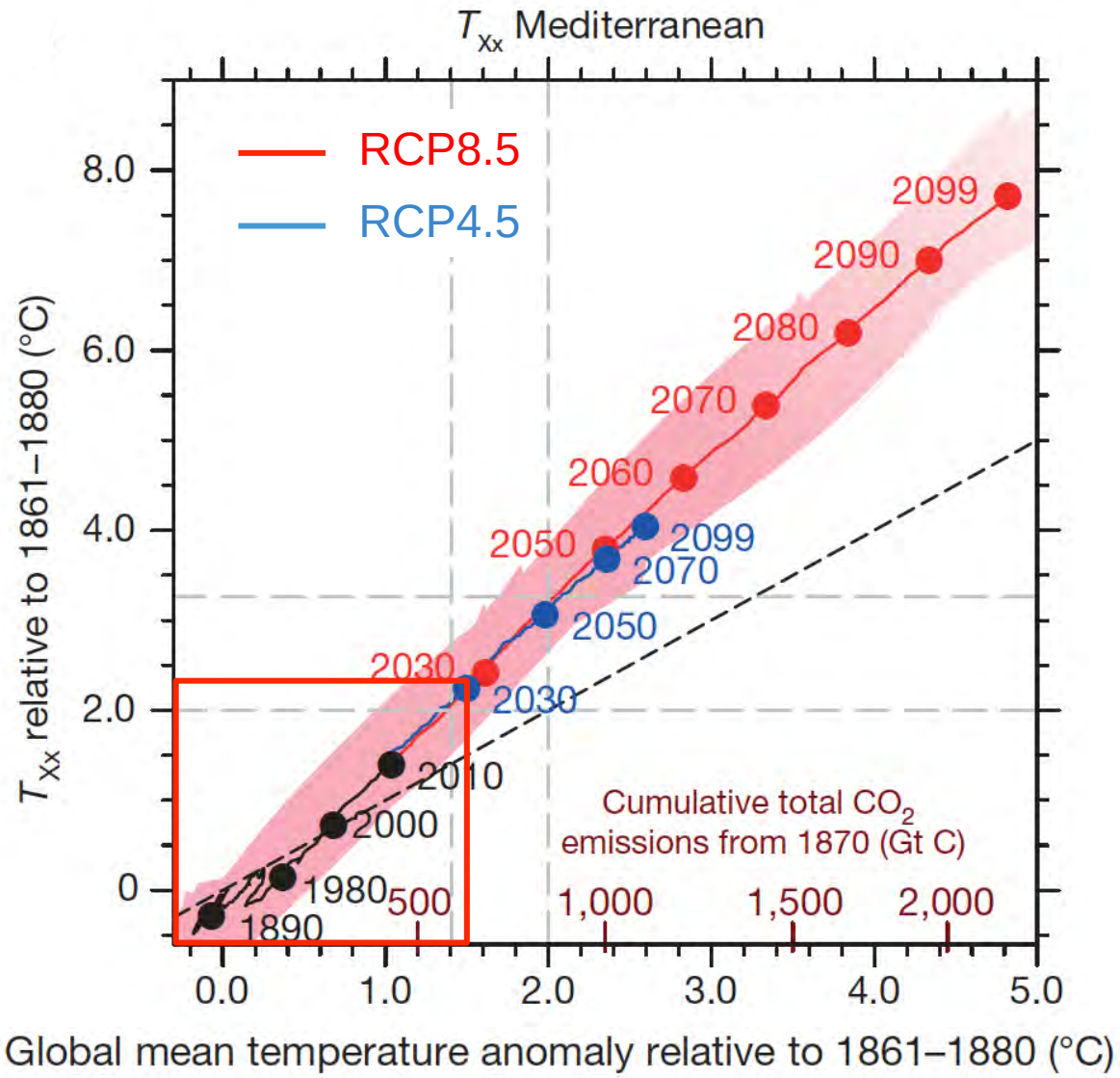


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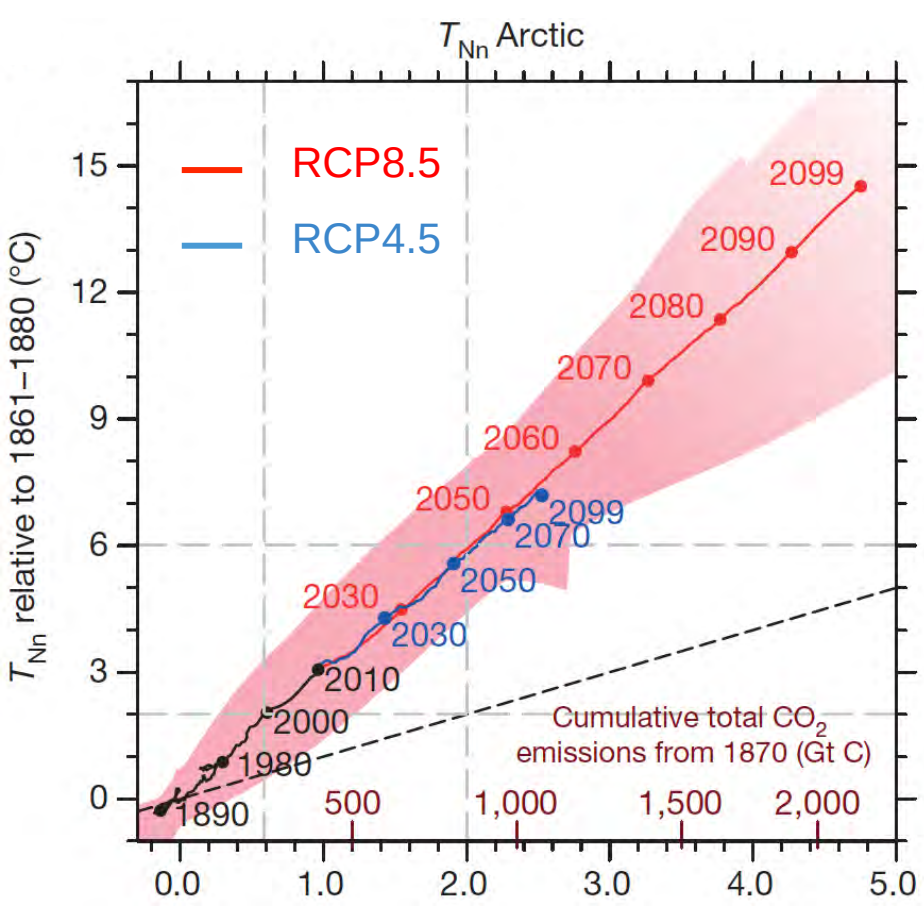
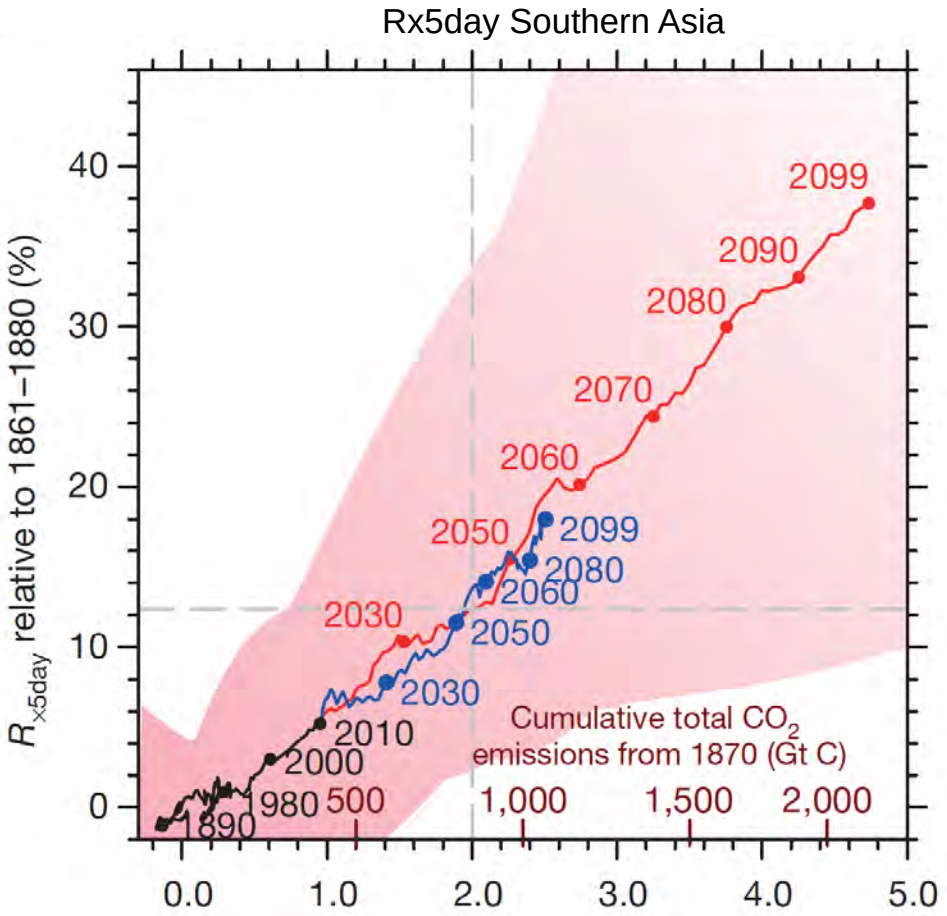
# Relating regional climate targets with $CO_2$ emissions

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




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

*(Seneviratne et al. 2016, Nature)*

# Relating regional climate targets with $CO_2$ emissions

Advantages:

1. Provides a better *quantitative* understanding of relation between emissions and impacts for stakeholders
2. Independent of emissions scenario, direct link between political decisions and impacts
3. Help linkage between costs of emissions reduction and avoided costs of impacts?

Caveats:

- Large uncertainty ranges in some cases (e.g. some regions, droughts)
- Shared model biases
- Does not consider the impact of local forcing (land use, aerosols)
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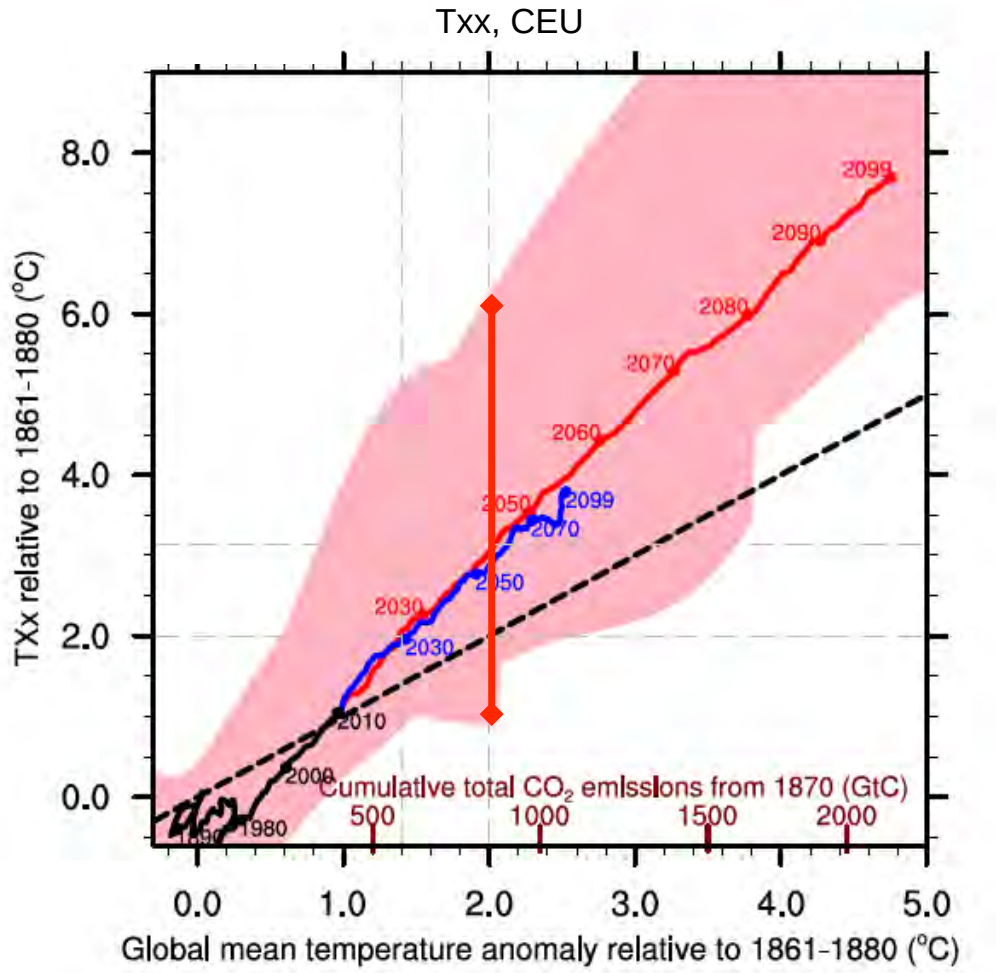
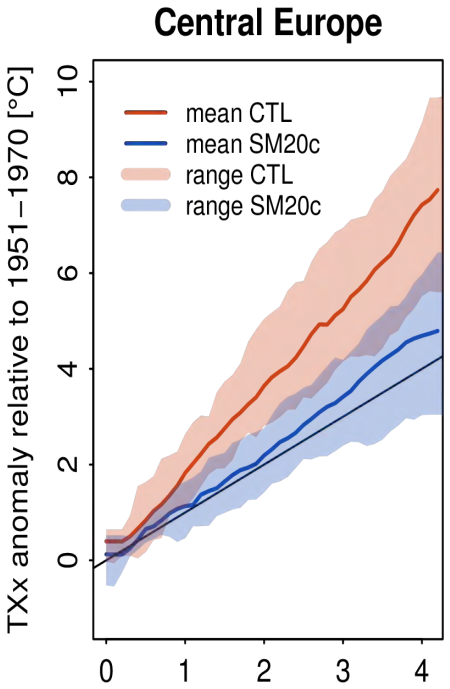
# Uncertainties in scaling



# Range of model projections: Role of feedbacks

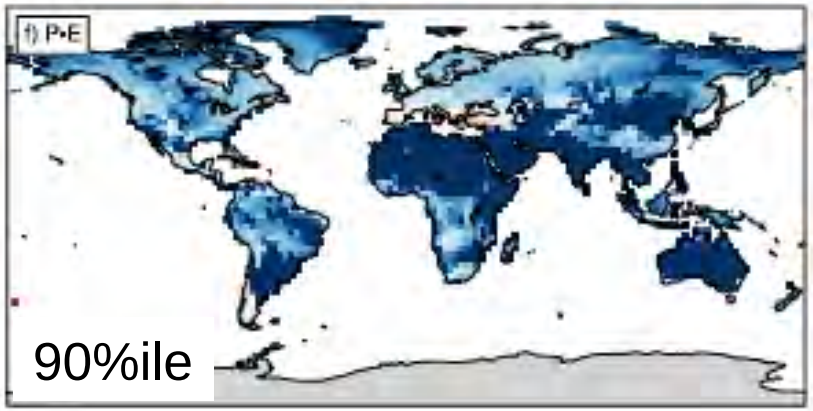
## Scaling for GLACE-CMIP5 experiments

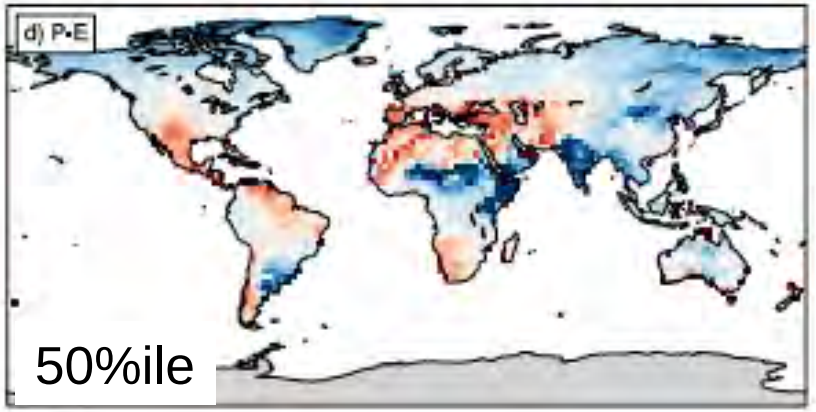



Soil moisture feedbacks (mean projected drying) explain much of the departure from the global mean response for regional temperature extremes in mid-latitudes

*(M. Vogel, ETH Zurich)*

# Uncertainties: Changes in water availability (P and P-E)

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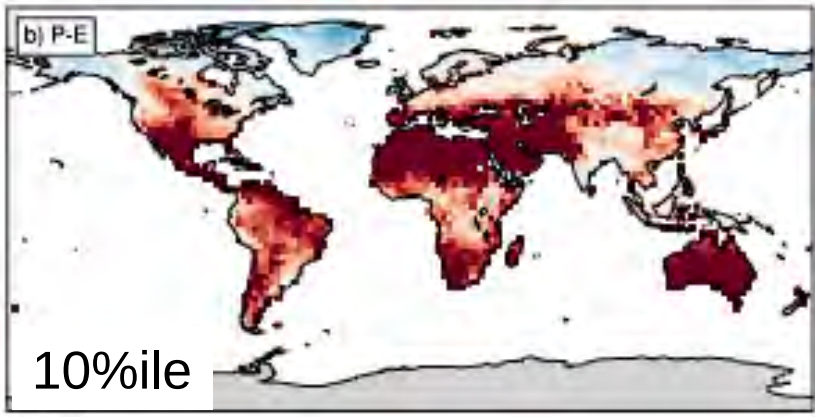


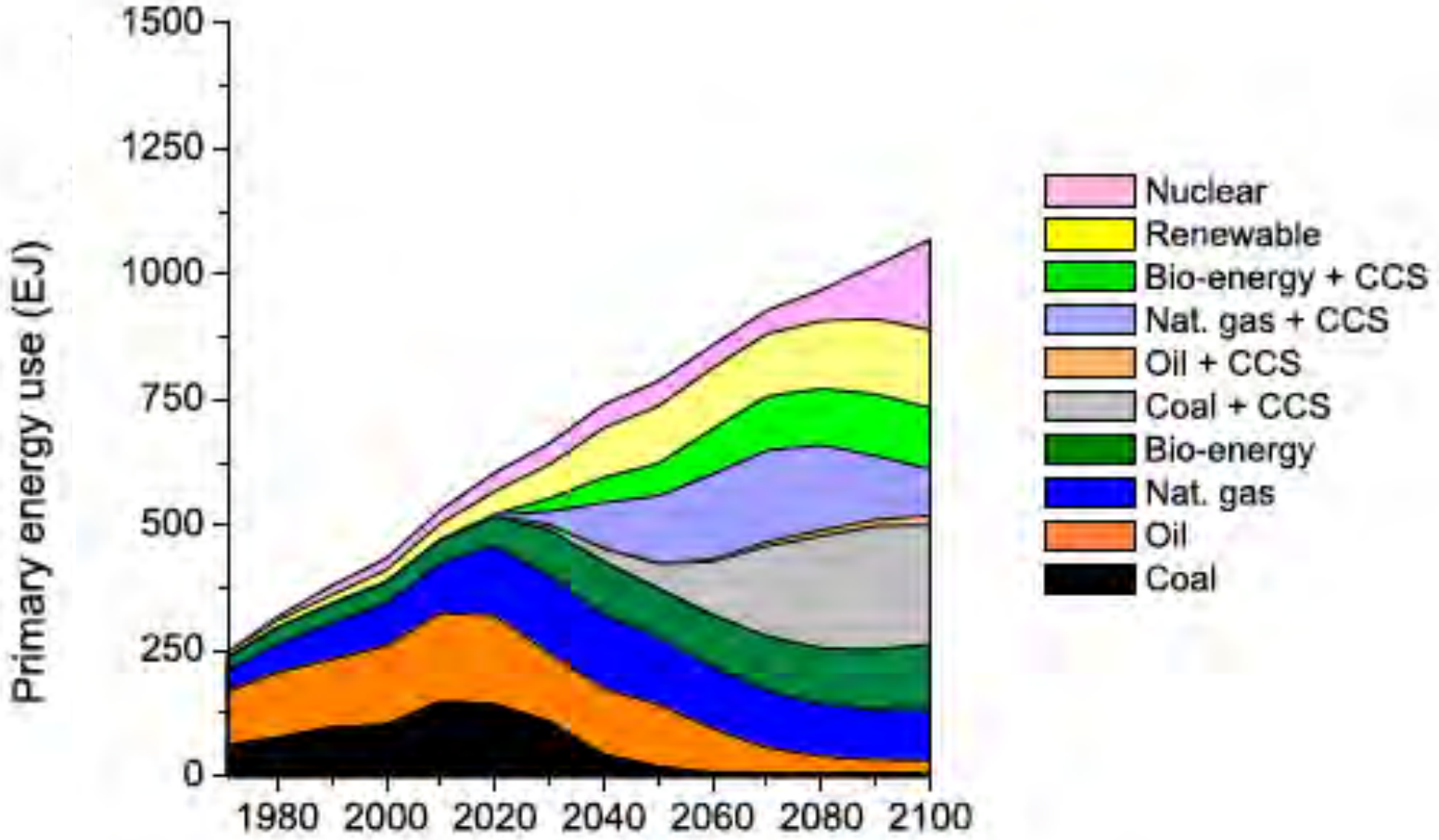


10% of the simulations display a large decrease in P-E as a function of the global temperature change (up to 25% per °C)

P-E: [% change/°C]

*(P. Greve, ETH Zurich)*

# RCP2.6 scenario




These measures (specifically the use of bio-energy and reforestation measures) also have clear consequences for global land use.

*(VanVuuren et al. 2011, Clim. Change)*

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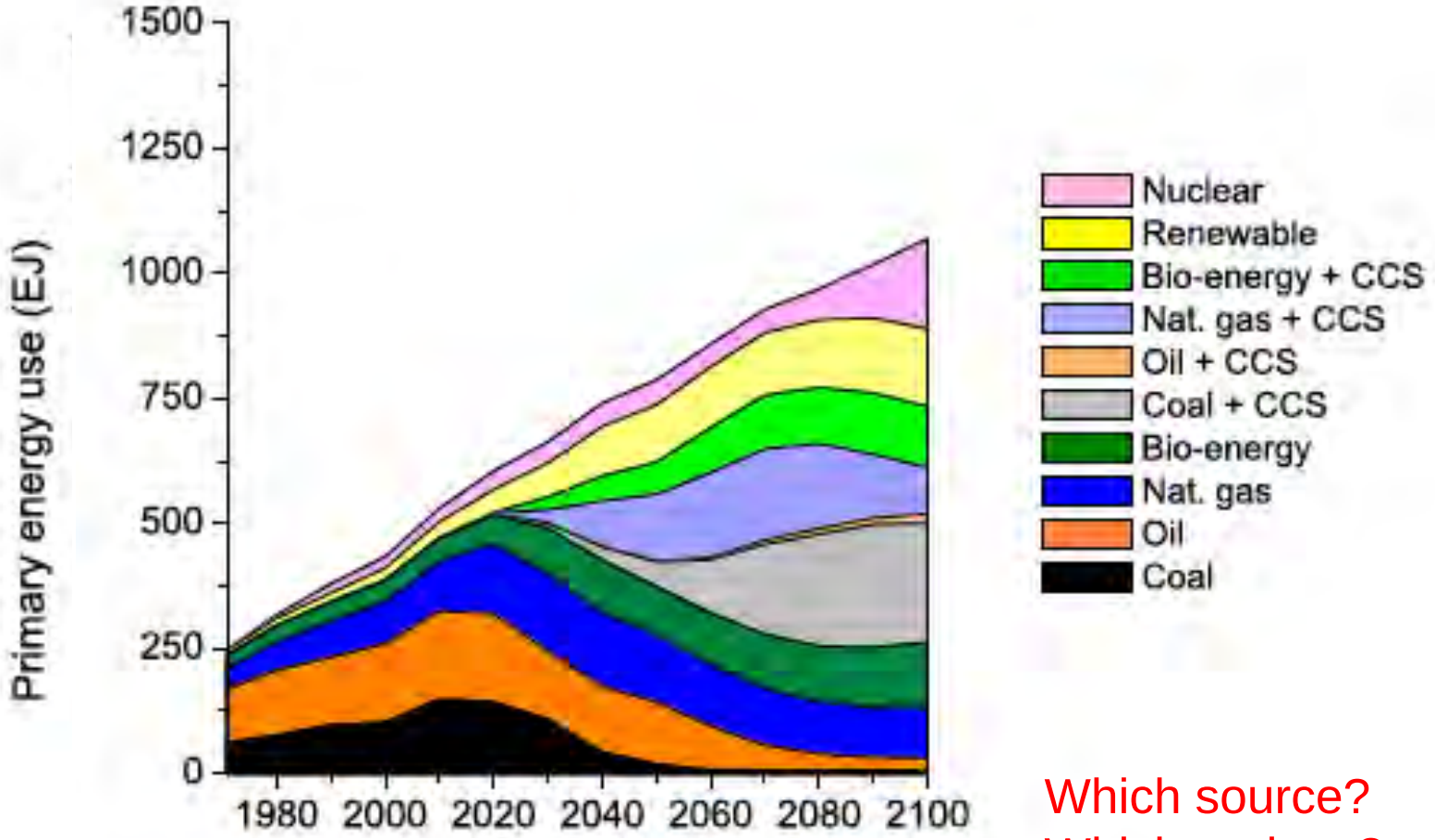



Which source?
Which regions?

These measures (specifically the use of bio-energy and reforestation measures) also have clear consequences for global land use.

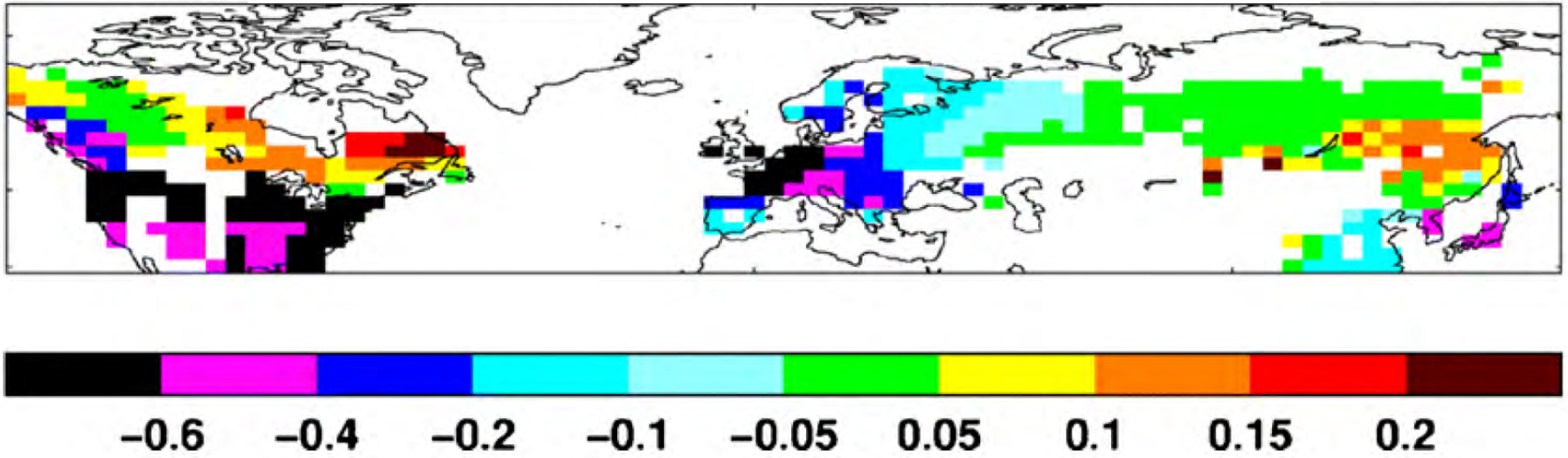
Land use can have substantial impacts on regional temperatures

*(VanVuuren et al. 2011, Clim. Change)*

# Land cover-climate interactions

## Reforestation/afforestation leads to a warming in boreal regions!

Net radiative forcing [nW/m$^2$] for 1 ha of plantation

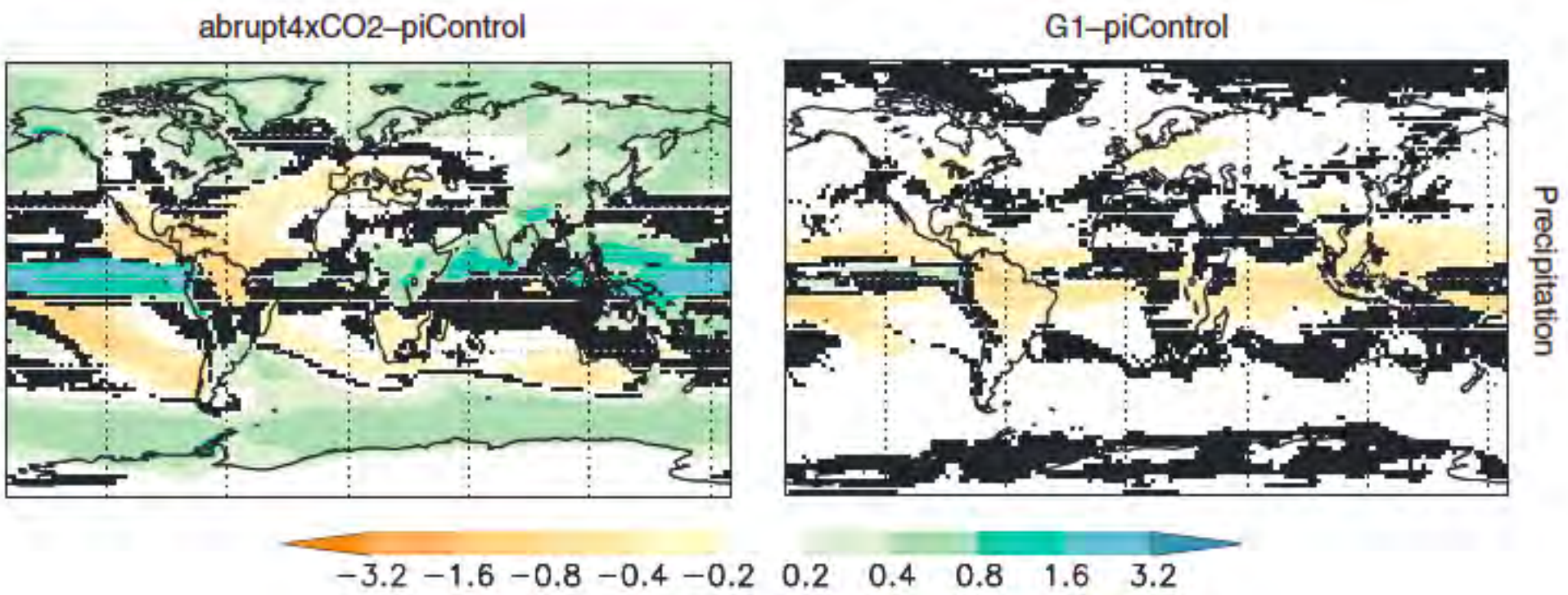



Effects of carbon sequestration vs. surface albedo change

*(Betts et al., Agr. For. Met. 2007)*

**Climate engineering:**

- Carbon capture and storage: realistic?
- Sulphate aerosols injections: creates novel climate, winners and losers
- Regional scale (e.g. through land use/albedo changes): Could help adaptation?




*(Kravitz et al. 2013, JGR)*

# Conclusions

- **Analyses relating changes in regional extremes with global temperature changes:**
  - For temperature extremes and heavy precipitation: Mostly linear scaling & independent of emissions scenario
  - Some large uncertainties in some regions and for some quantities (e.g. droughts, P-E)
  - Provide first assessments of differences between 1.5° and 2° global warming scenarios

- **Other important contributions of WG1 science for IPCC SR15 report:**
  - Mitigation: Role of land use/cover changes (bioenergy)
  - Climate engineering (CCS, risks/limitations, regional-scale land use/albedo contributing to adaptation?)