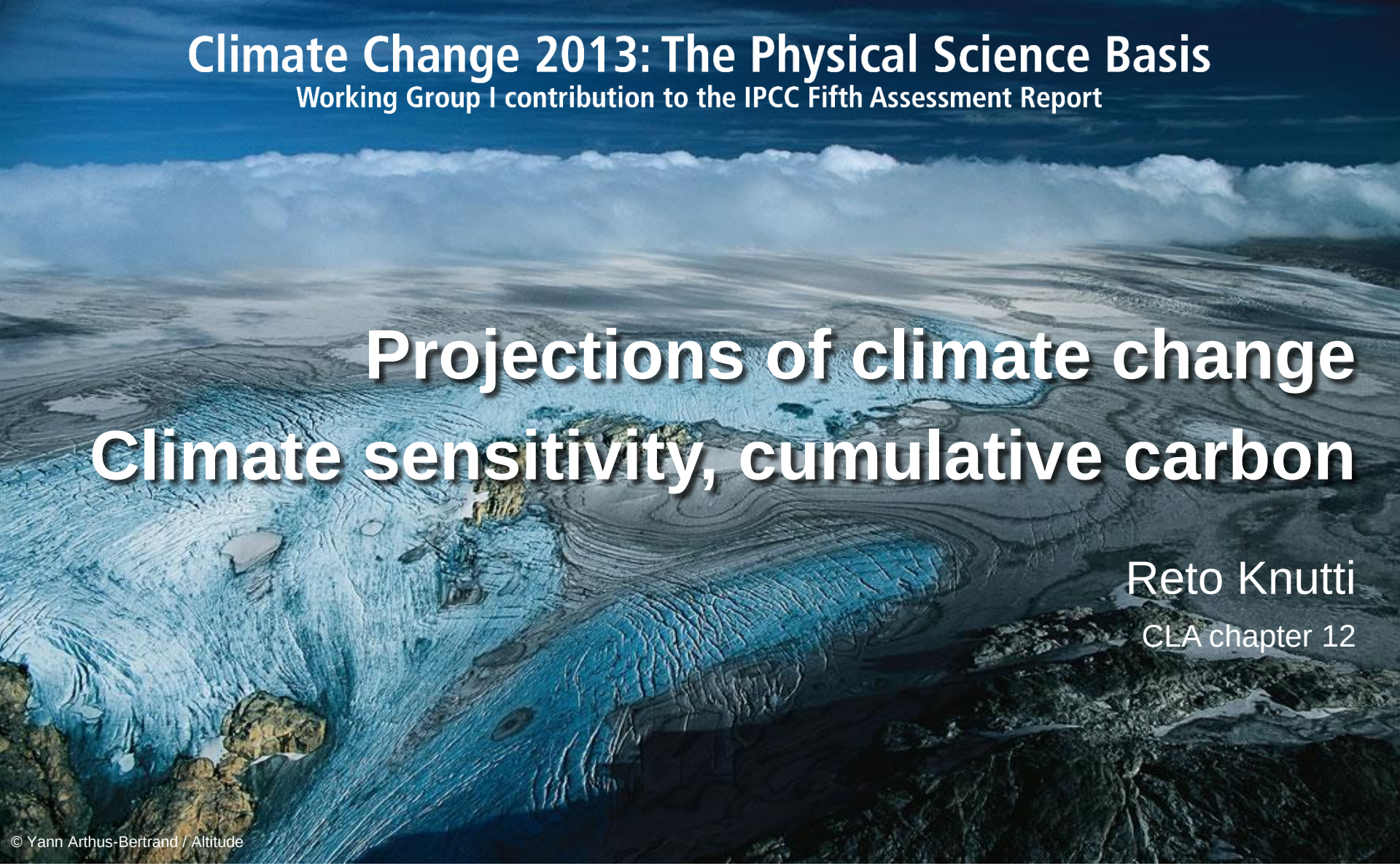
Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report



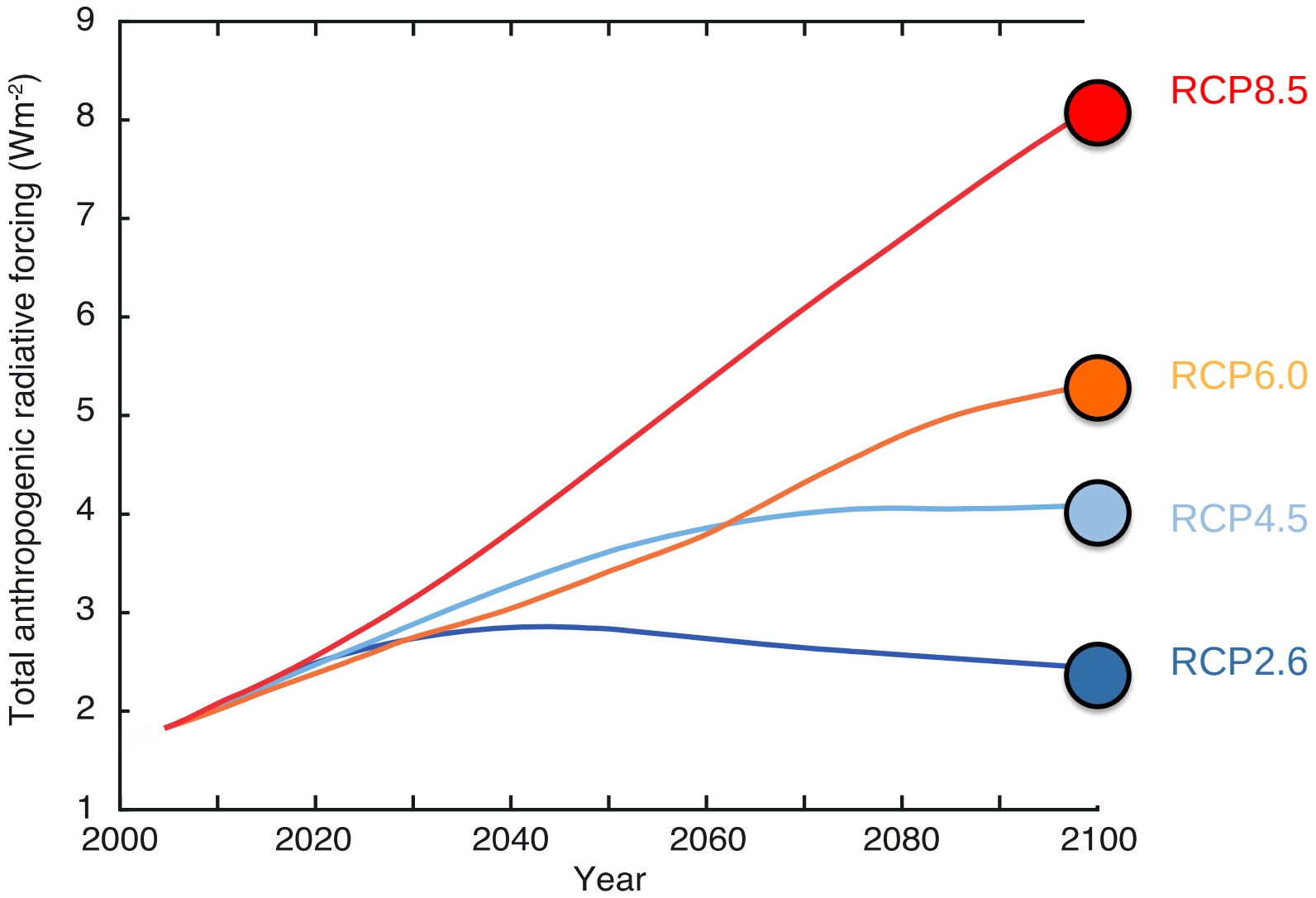
Projections of climate change
Climate sensitivity, cumulative carbon

Reto Knutti

CLA chapter 12

Scenarios and projections

Representative Concentration Pathways (RCP)



Box TS.6 for further details

Projections

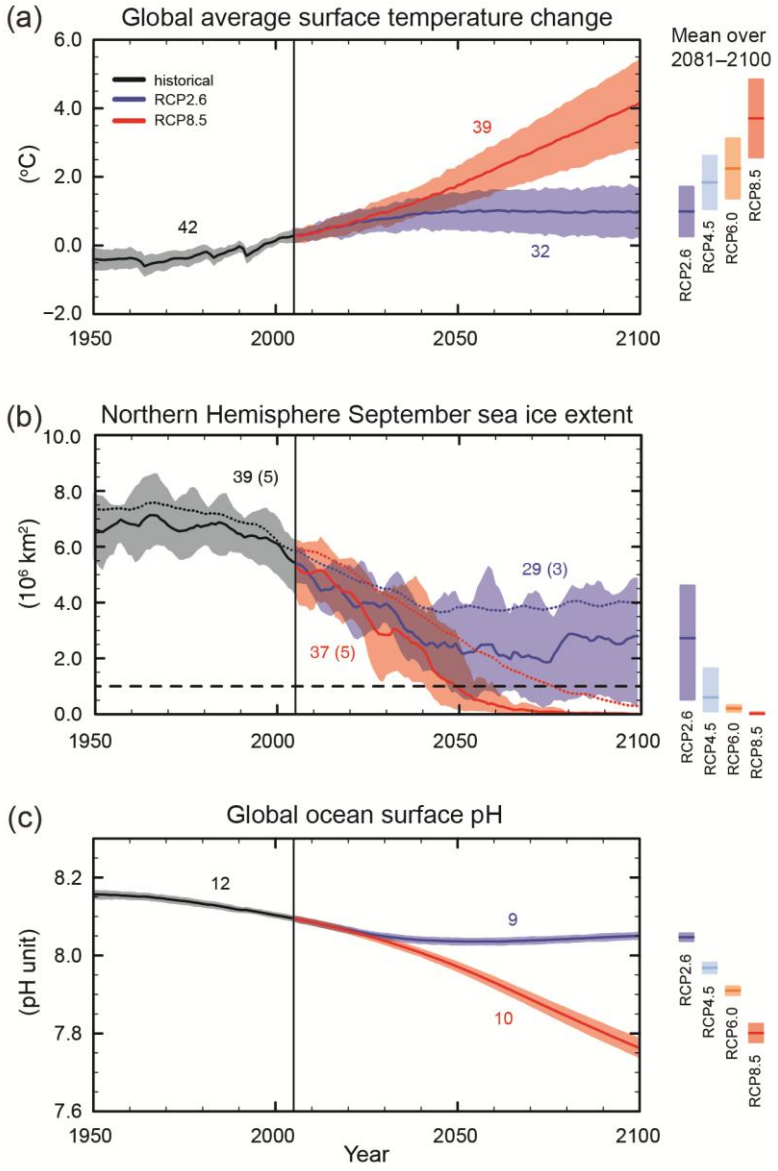


Fig. SPM.7

Projections

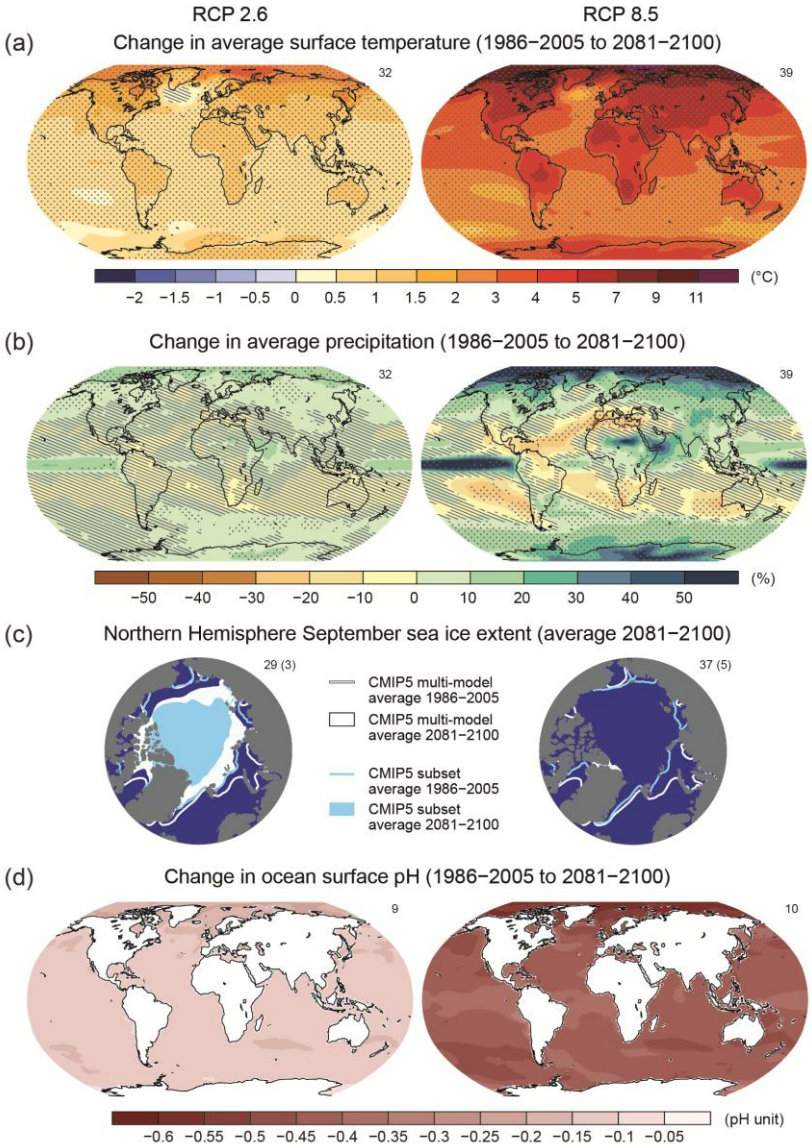


Fig. SPM.8

Uncertainties in projections

Internal variability – an important source of climate variability

Future climate change is a sum of:

- An externally forced response, due to changes in radiative forcing arising from human activity, variations in the sun and major volcanic eruptions
- Internal variability, e.g. the El Niño-Southern Oscillation (ENSO) and other patterns, and year-to-year and decade-to-decade fluctuations in winds, precipitation, temperature, …

Internal variability – an important source of climate variability

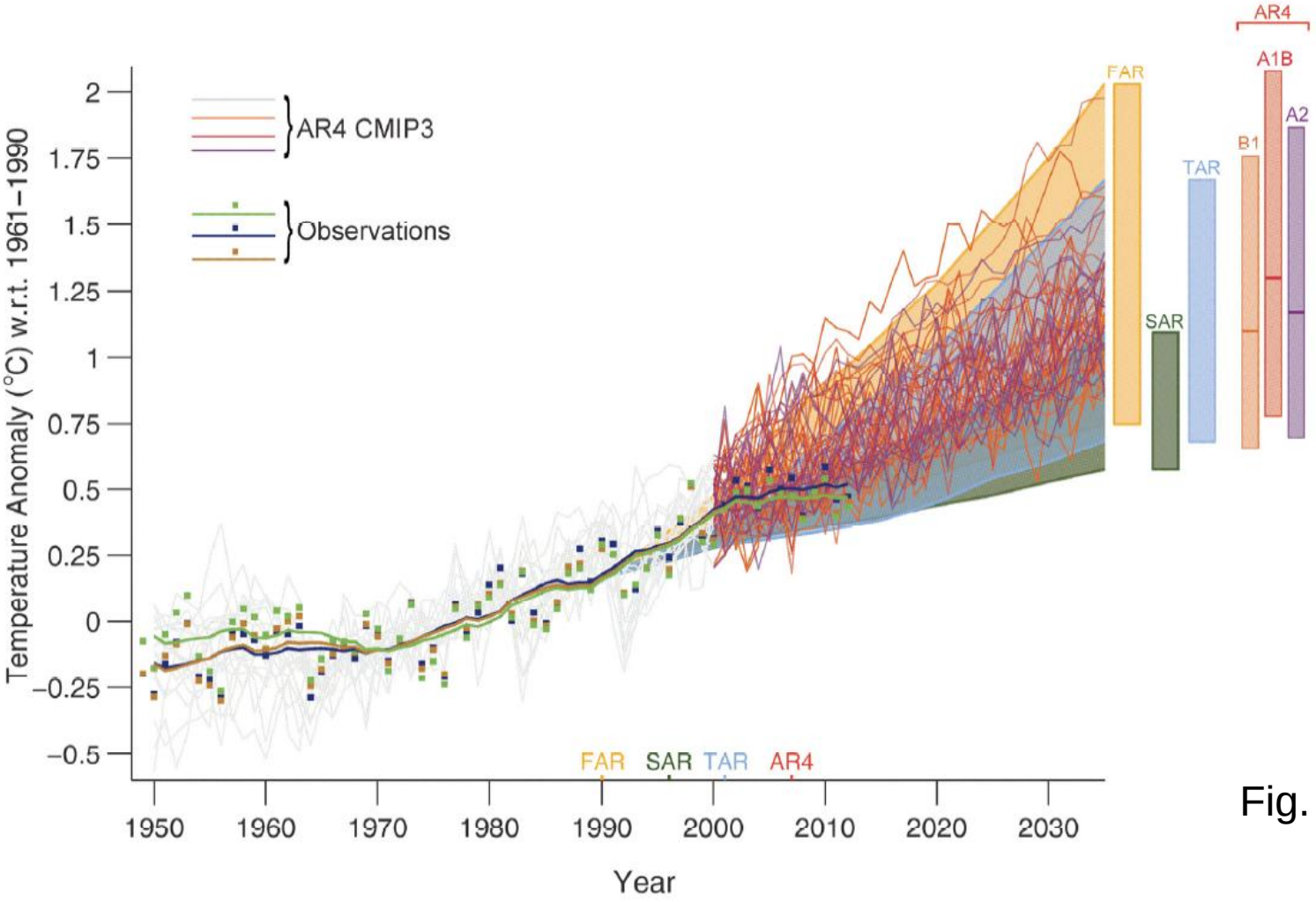
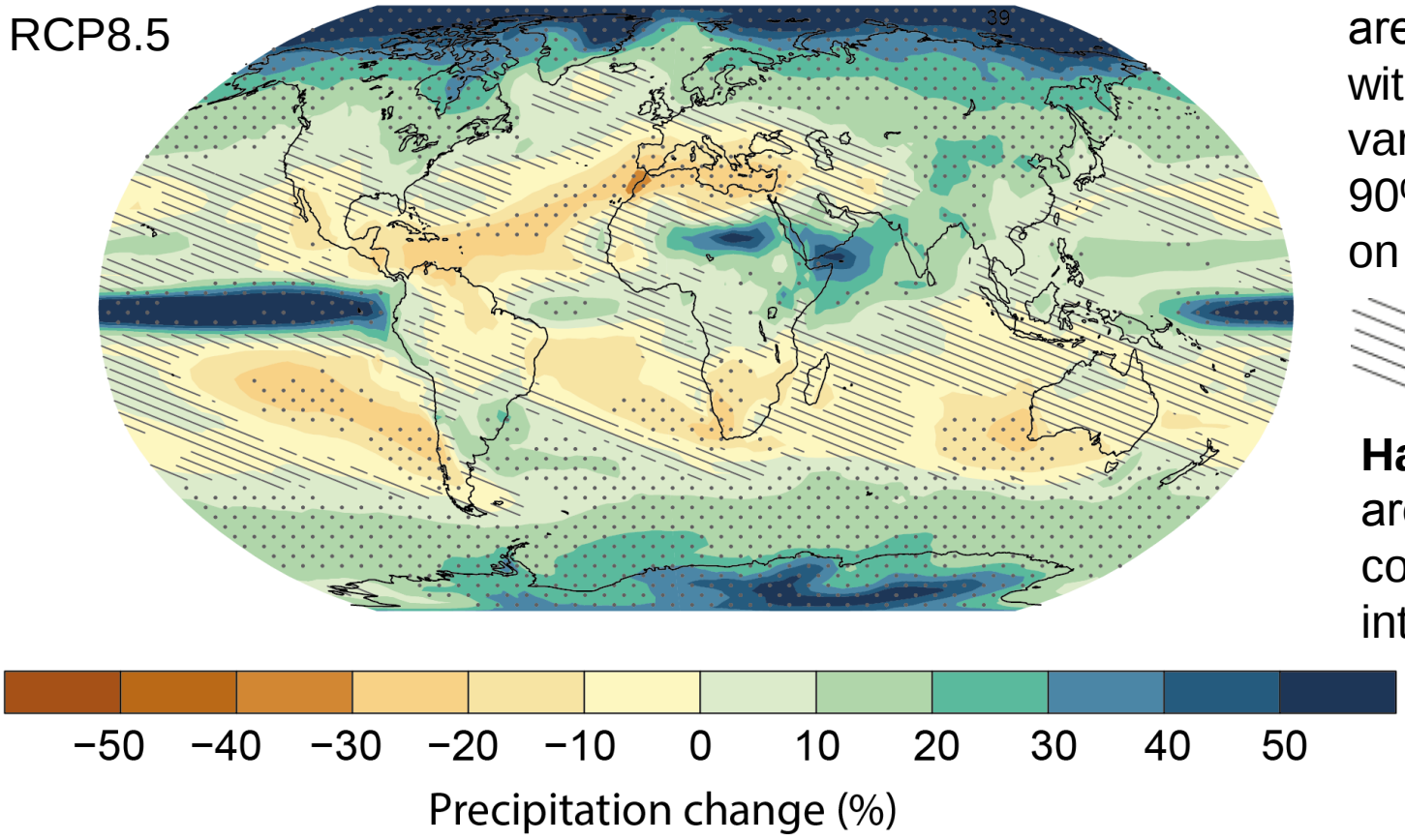


Fig. 1.4

How large is the projected change compared to internal variability?

RCP8.5



Stippling: changes are “large” compared with internal variability, and at least 90% of models agree on sign of change

Hatching: changes are “small” compared with internal variability

AR4 and AR5 projections are very similar when accounting for scenario differences

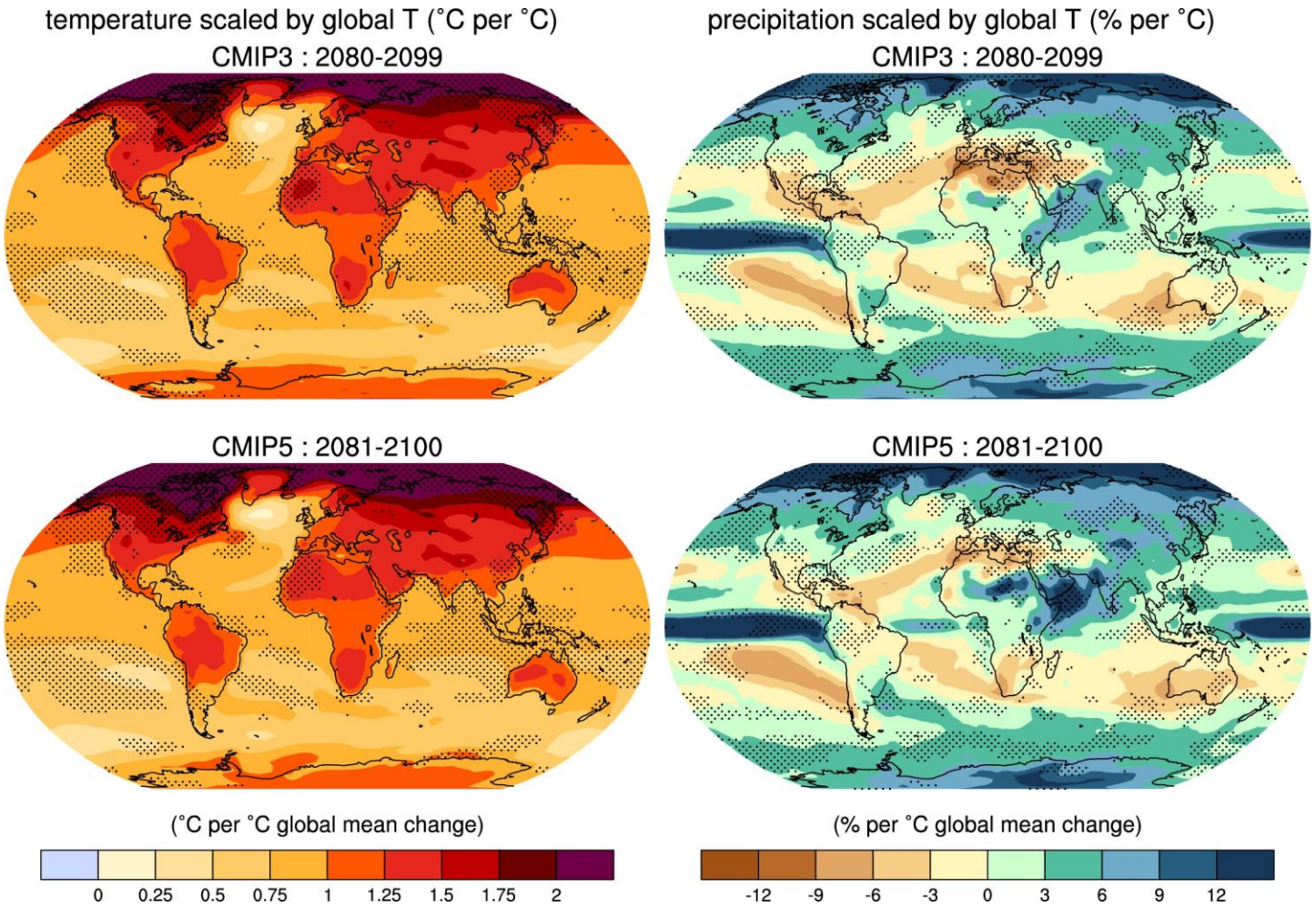
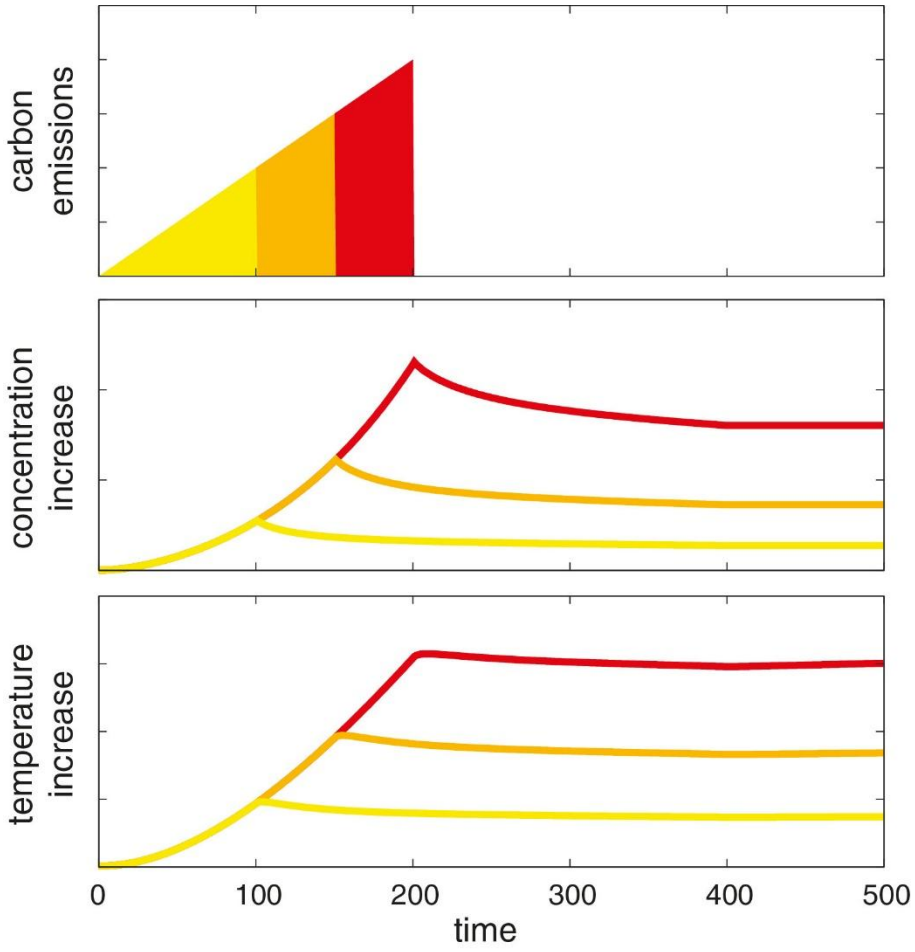


Fig. 12.41

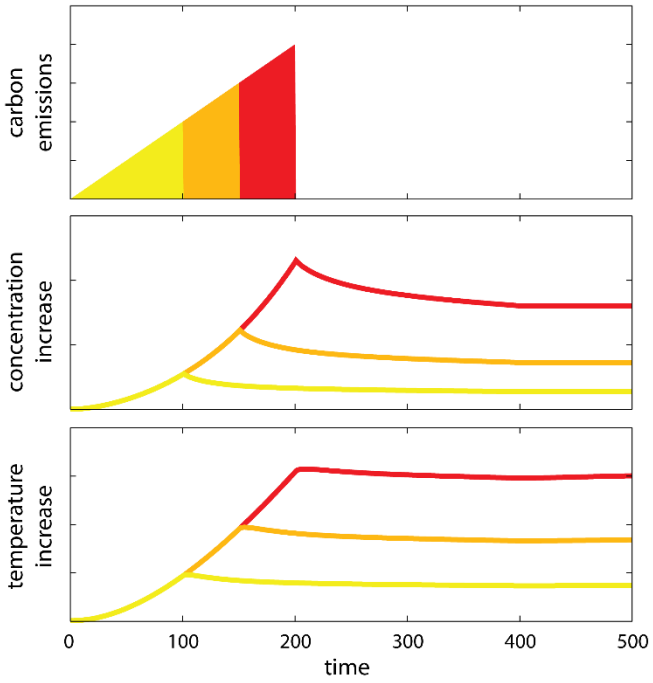
Long term climate change and cumulative carbon

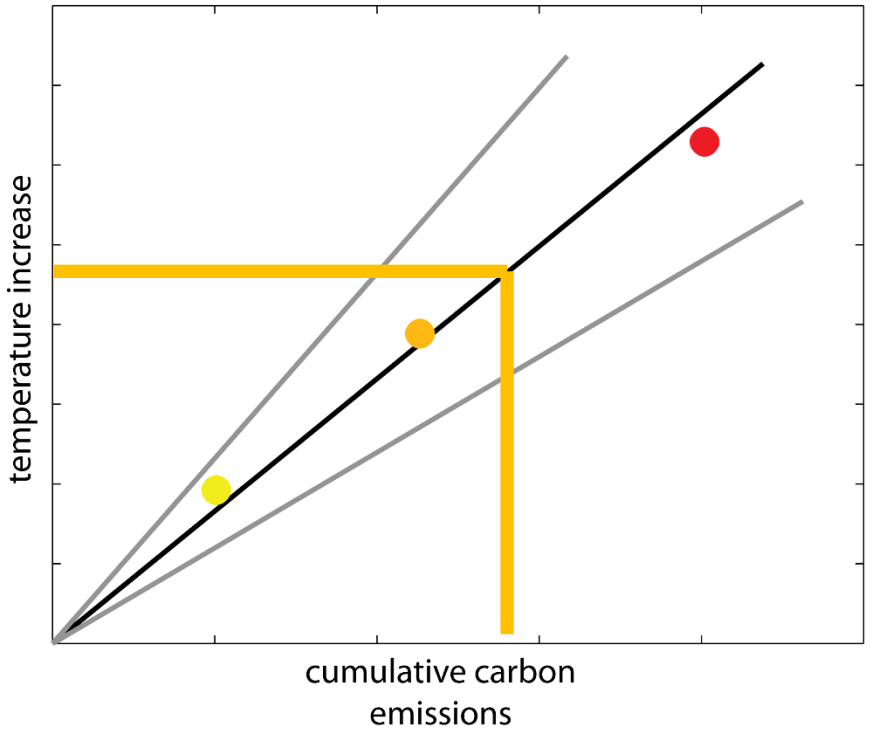
Warming will persist for centuries



- Zero CO_2 emissions lead to near constant surface temperature.
- A large fraction of climate change persists for many centuries.
- Depending on the scenario, about 15-40% of the emitted carbon remains in the atmosphere for 1000 yrs.

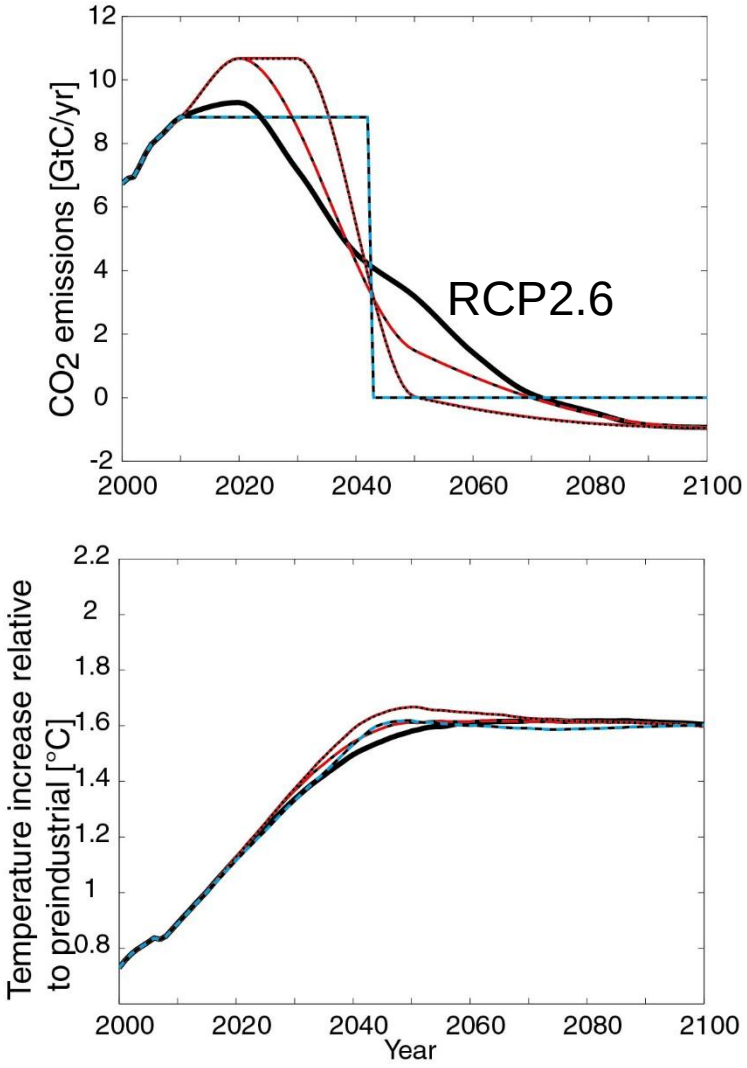
Cumulative carbon determines warming





- Peak warming is approximately proportional to cumulative (total) emissions.
- Transient climate response to cumulative carbon emissions TCRE = Warming per 1000 PgC

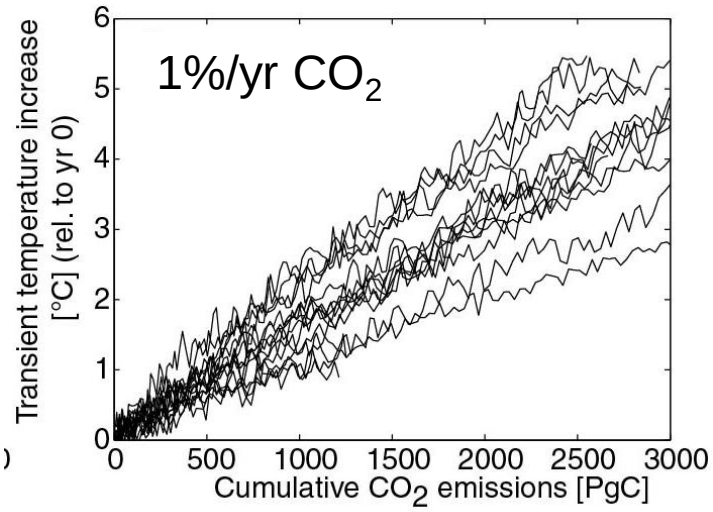
Cumulative carbon determines warming

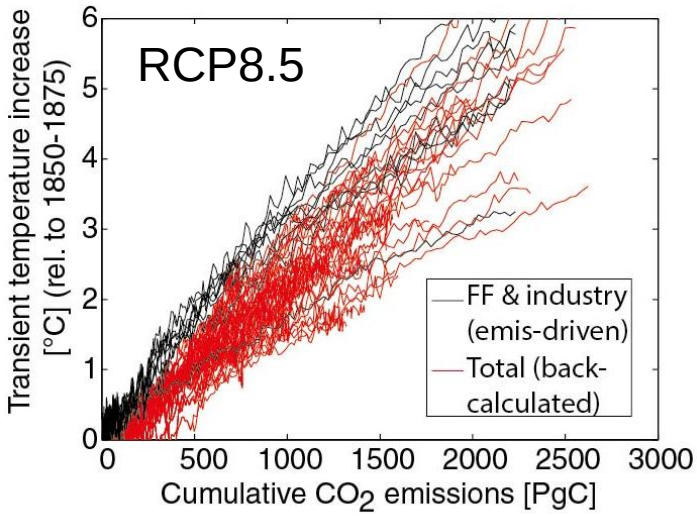


- Warming is largely independent of the emission profile. Only the total matters.
- More emissions early imply stronger reductions later.
- Any temperature target implies a maximum in cumulative CO_2 emissions. This is purely a physical and carbon cycle problem.
- Allocation over time is a economic and policy question.
- Overshooting the budget will overshoot the target.

Fig. 12.46

Cumulative carbon determines warming

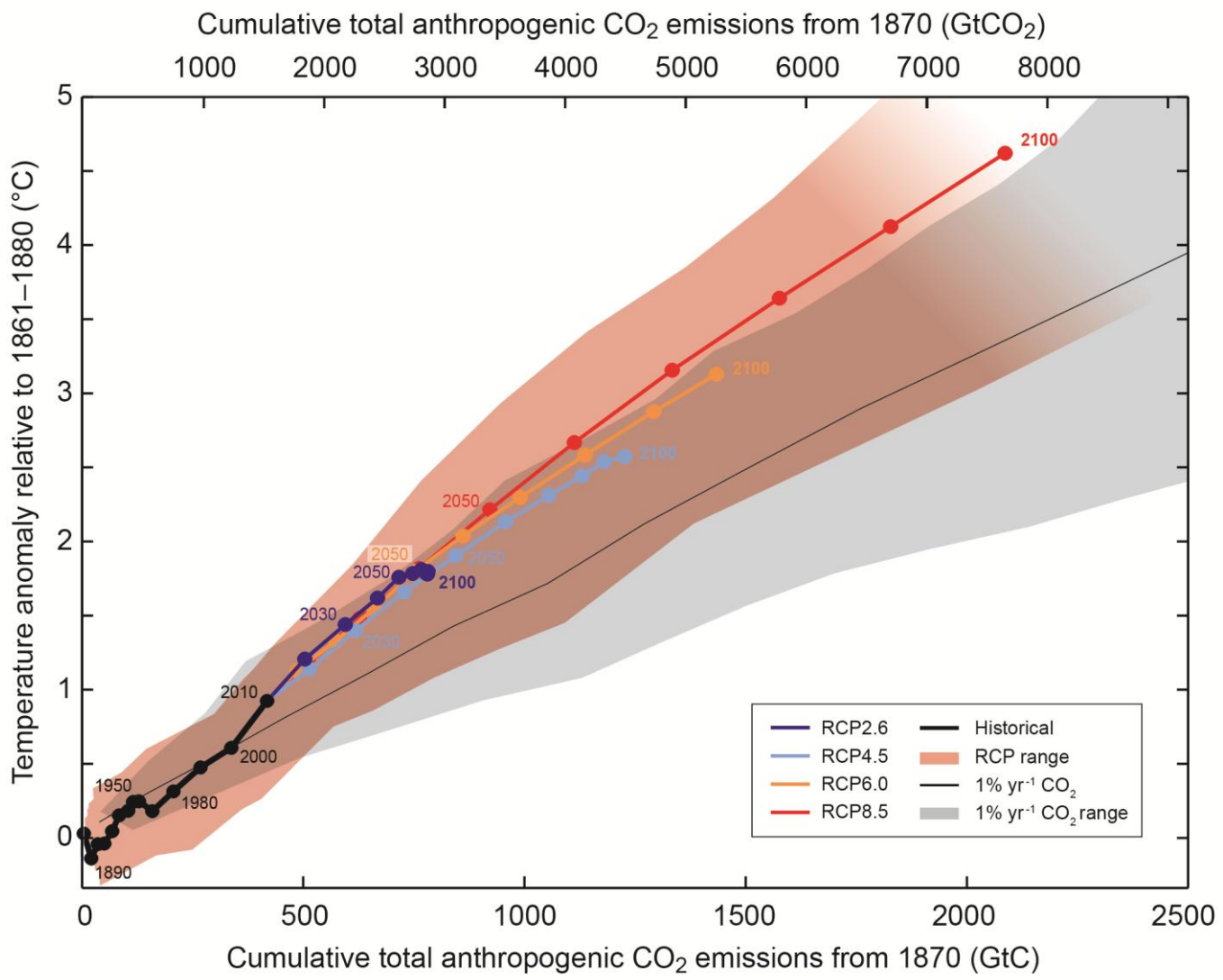




- Evidence from observations, and from simple to complex models for many scenarios.
- Near linear in all models, but the slope is uncertain.
- Any temperature target implies a maximum amount of carbon that can be emitted.
- Due to non CO_2, RCP warming is larger than from CO_2 only.

Fig. 12.45

Cumulative carbon determines warming



SPM.10

Summary

- “Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.”
- Changes are projected throughout all climate components, in most cases exceeding natural variations by far. Changes in AR5 are similar to those in AR4 for similar scenarios.
- Every ton of CO_2 causes about the same amount of warming, no matter when and where it is emitted.
- To limit warming to *likely* less than 2°C as in RCP2.6 requires total emissions since preindustrial to be limited to less than about 790 PgC. 515 PgC were emitted by 2011.

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Further Information

www.climatechange2013.org

ipcc
INTERGOVERNMENTAL PANEL ON climate change
WMO UNEP