Projections of climate change
Climate sensitivity, cumulative carbon
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CLA chapter 12
Scenarios and projections
Representative Concentration Pathways (RCP)

- **RCP8.5**
- **RCP6.0**
- **RCP4.5**
- **RCP2.6**

Total anthropogenic radiative forcing (Wm⁻²) vs. Year (2000-2100)

Box TS.6 for further details
Projections

Fig. SPM.7
Projections

Fig. SPM.8
Uncertainties in projections
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?

**Hatching:** changes are “small” compared with internal variability, and

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

**RCP8.5**

Precipitation change (%)
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\textsubscript{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.
Cumulative carbon determines warming
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.