Commitment, irreversibility, targets, and cumulative CO₂ emissions

Reto Knutti (CLA chapter 12)
Myles Allen, Pierre Friedlingstein, Nathan Gillett, Jonathan Gregory,
Gabriele Hegerl, Chris Jones, Joeri Rogelj
Climate change commitment

- Stable CO$_2$ concentration will result in further warming over centuries.
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 $\text{TCRE} = \text{Warming per 1000 PgC}$
Cumulative carbon determines warming

- Warming is largely independent of the emission profile. Only the total matters.
- More emissions early imply stronger reductions later.
- A 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.

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 CO₂, RCP warming is larger than from CO₂ only.

Fig. 12.45
Controls on the carbon budget

- Higher likelihood to achieve target implies lower budget
- Lower temperature target implies lower budget
Figure SPM.9
Summary

- 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 from CO$_2$ alone, total emissions since preindustrial need to be limited to less than 1000 PgC.
- Accounting for non-CO$_2$ forcing as in RCP2.6 reduces the allowed cumulative emissions to about 800 PgC.
- About 550 PgC were emitted by 2011.
- CO$_2$ emissions from permafrost or a higher likelihood require a lower budget.
Climate Change 2013: The Physical Science Basis
Working Group I contribution to the IPCC Fifth Assessment Report

Further Information

www.climatechange2013.org