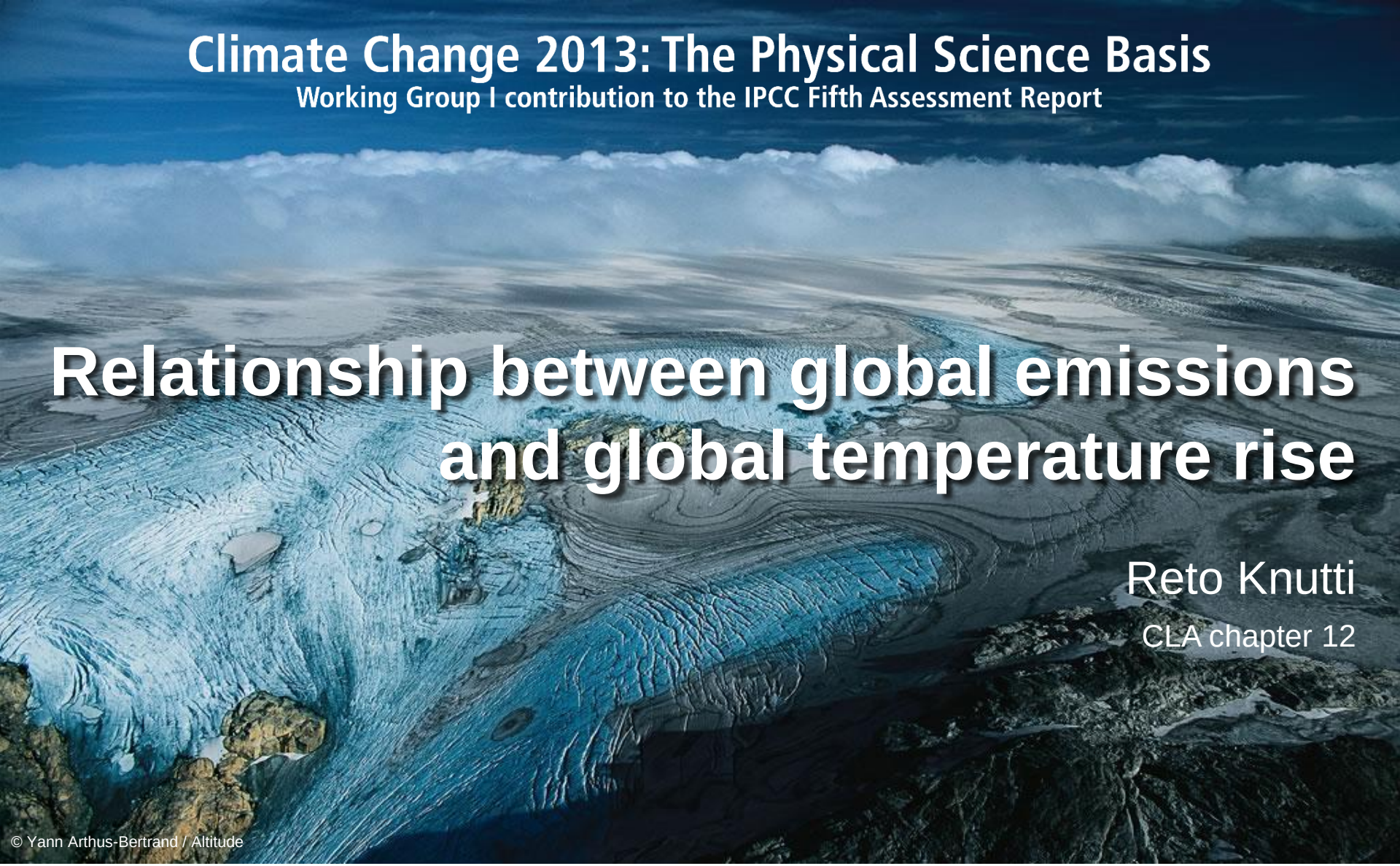
Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

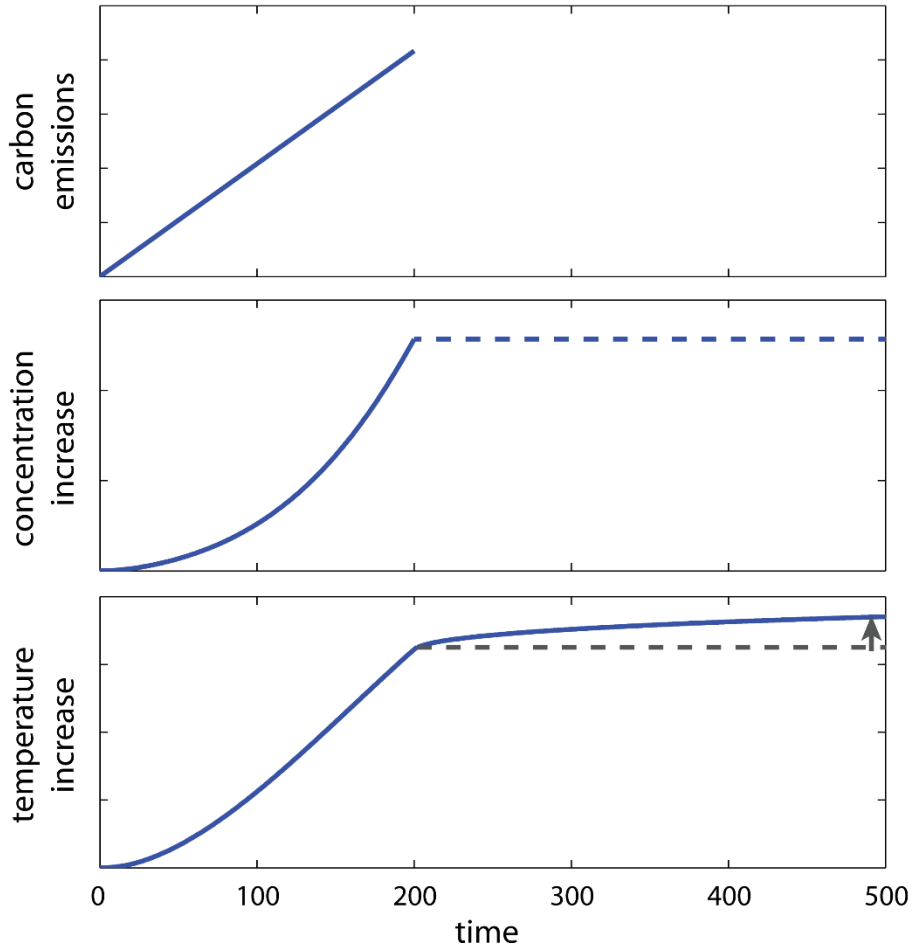
Relationship between global emissions and global temperature rise

Reto Knutti

CLA chapter 12

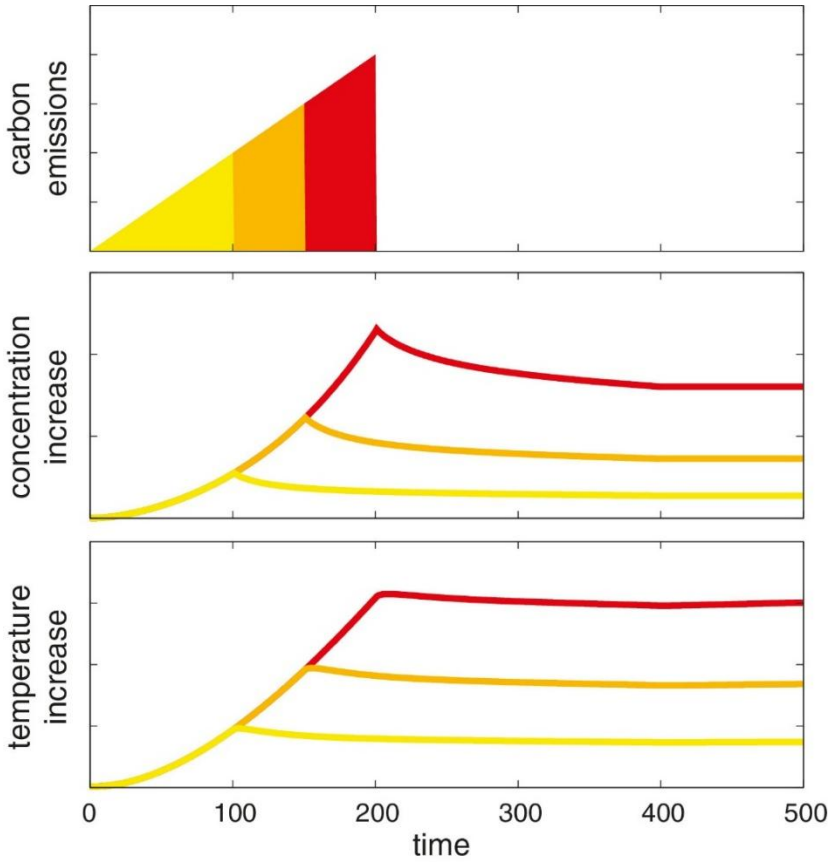


Climate change commitment



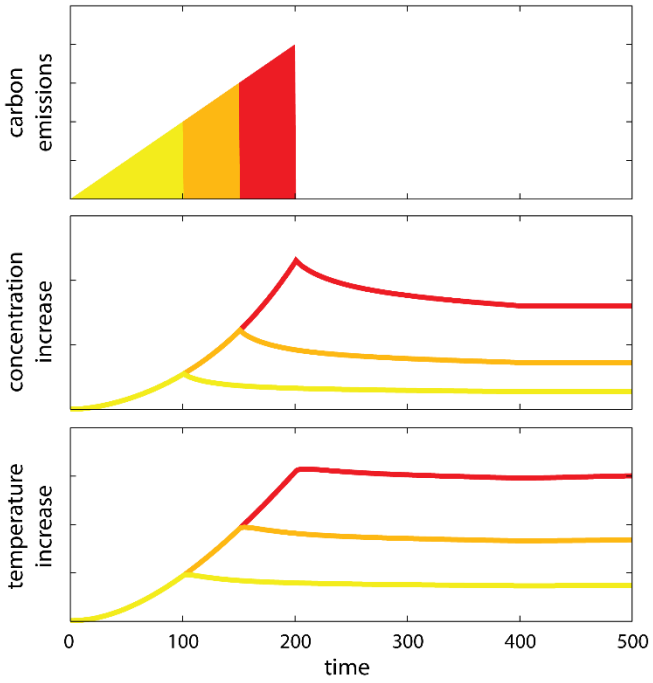
- Stable CO_2 concentration will result in further warming over centuries.

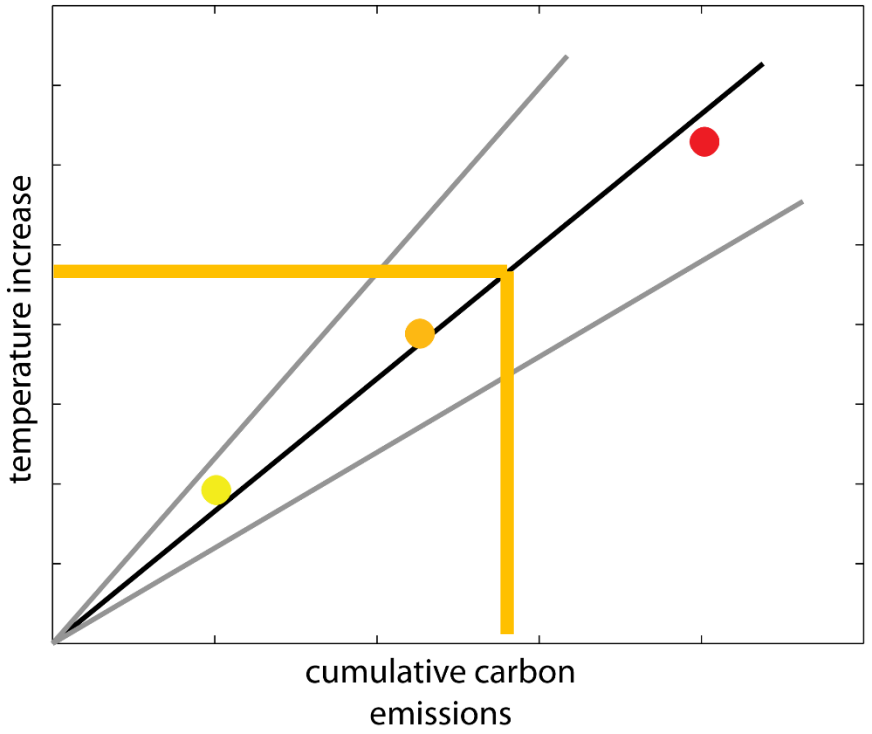
Warming will persist for centuries



- 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.
- This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2. But there is no commitment to *further* surface warming *in the climate system*, it's only in society.

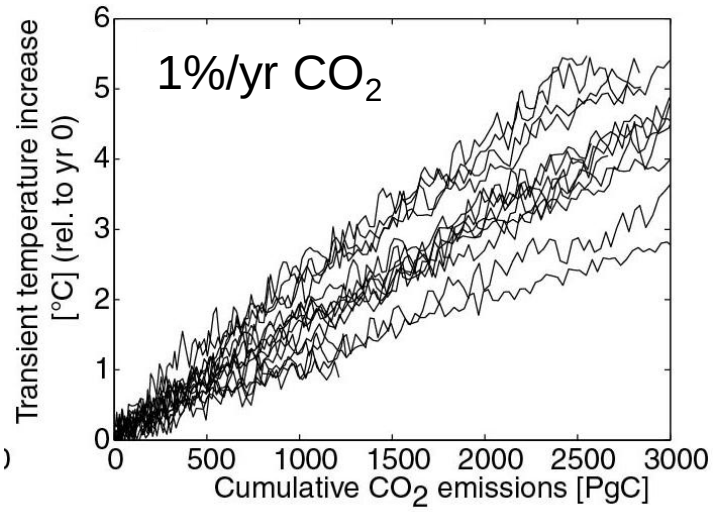
Cumulative carbon determines warming

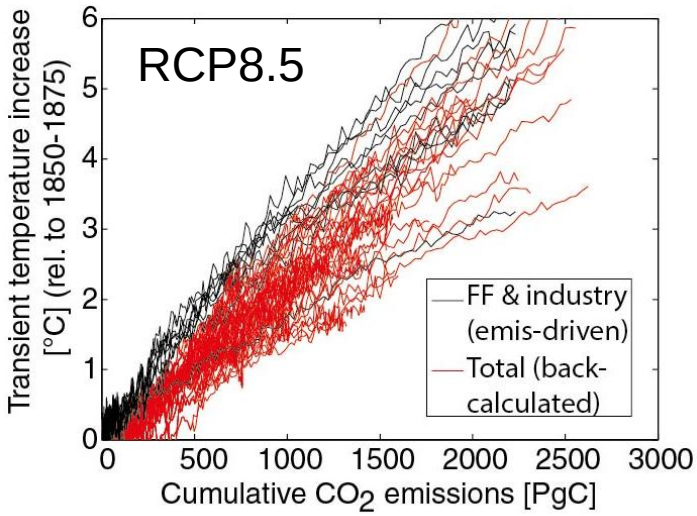




- Peak warming is approximately proportional to cumulative (total) emissions.
- Transient climate response to cumulative carbon emissions TCRE = Warming per 1000 PgC: *likely* 0.8-2.5˚ C

Cumulative carbon determines warming

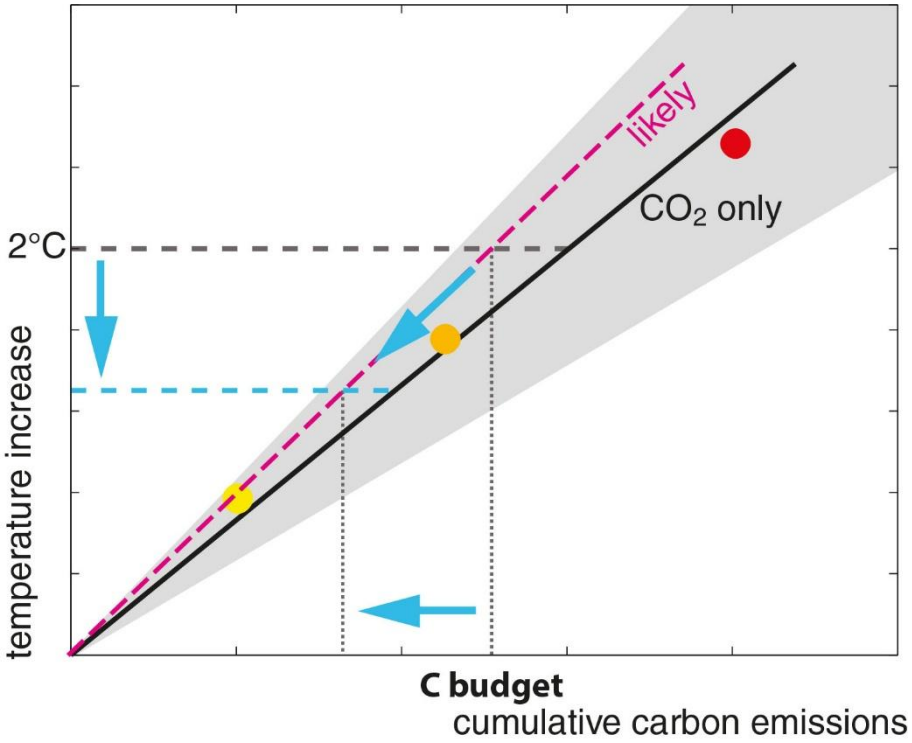




- Evidence from observations, and from simple to complex models for many scenarios.
- Near linear in all models, but the slope is uncertain.
- Any temperature target implies a maximum amount of carbon that can be emitted.
- Due to non CO_2, RCP warming is larger than from CO_2 only.

Fig. 12.45

Controls on the carbon budget



- Higher likelihood to achieve target implies lower budget
- Lower temperature target implies lower budget
- 2˚ C budgets **for CO_2 only** are (90%/66%/50%/33%/10%): 730/1000/1212/1567/3567 GtC
- 1.5˚ C budgets **for CO_2 only** are (90%/66%/50%/33%/10%): 548/750/ 909/1176/2675 GtC
- Non-CO2 implies lower budget: *likely* <2˚ C budget from 1000 PgC down to about 790 GtC for RCP2.6, 515 GtC emitted.

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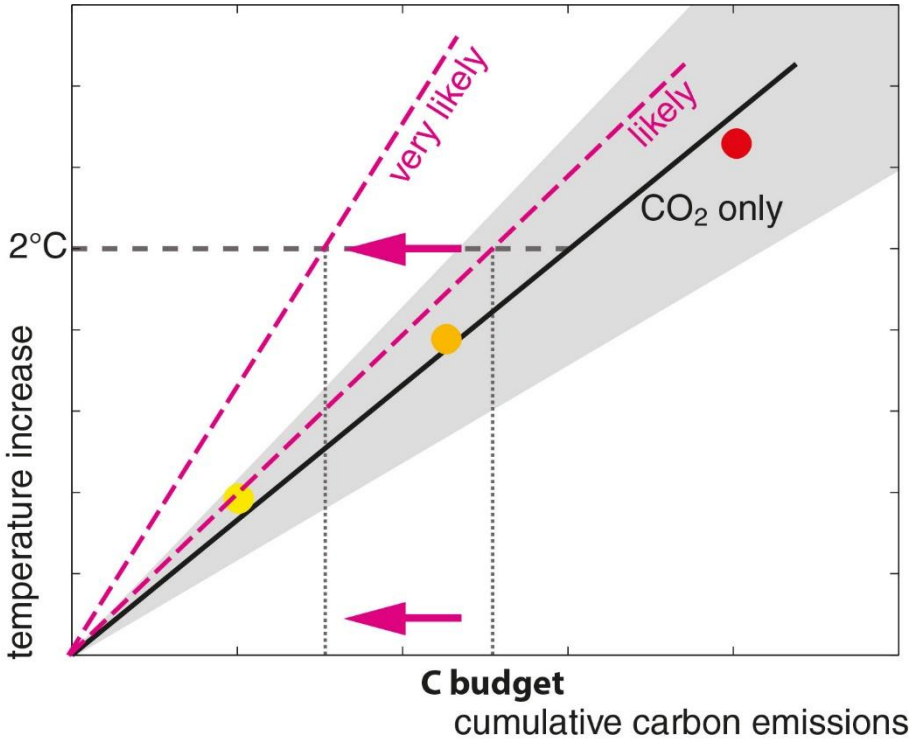

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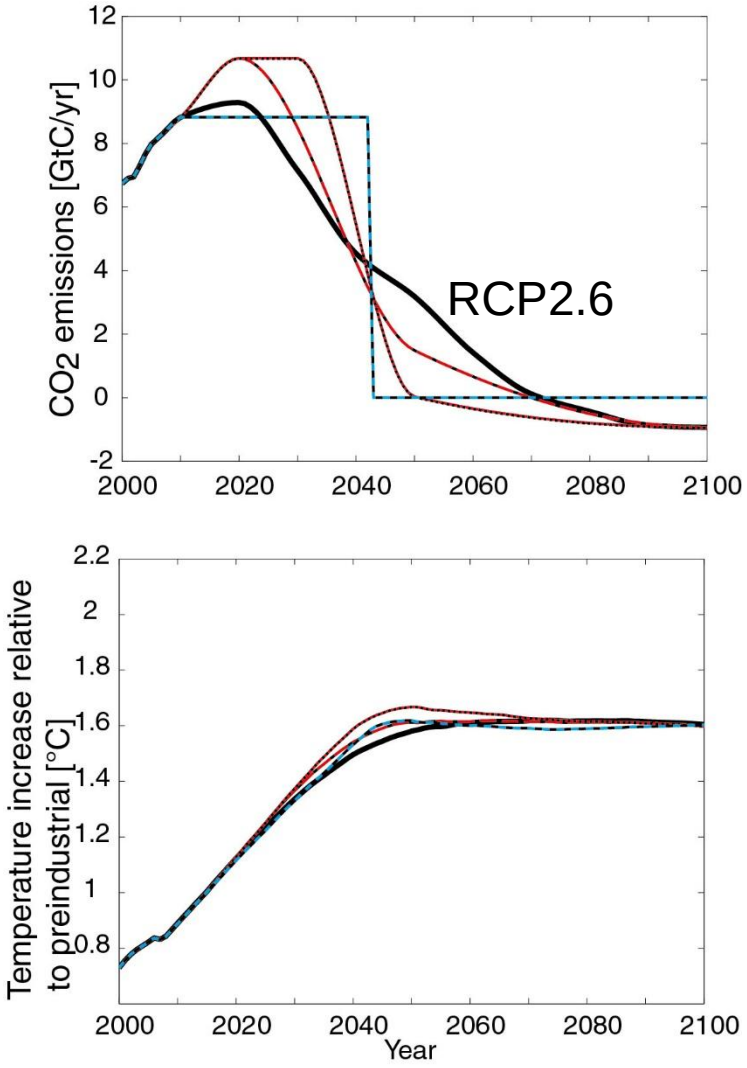
Cumulative carbon determines warming



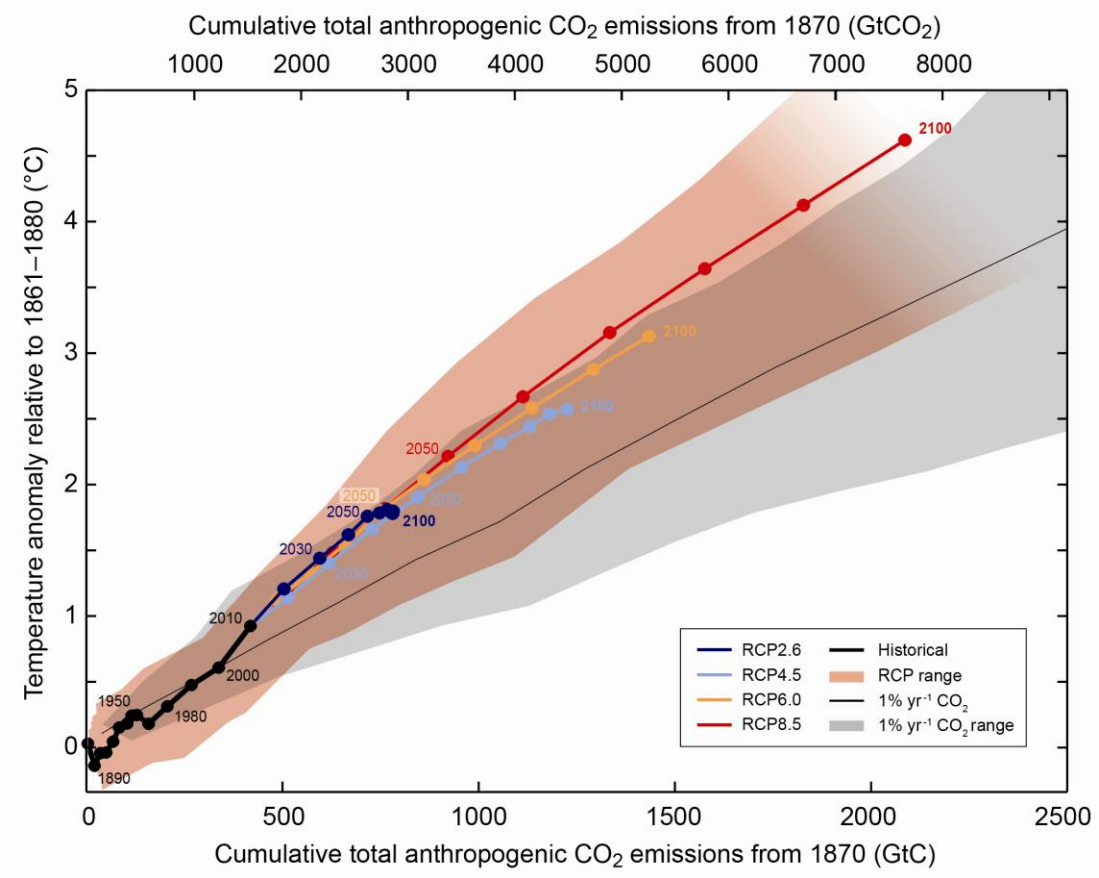
- Warming is largely independent of the emission profile. Only the total matters.
- More emissions or delay early imply stronger reductions later.
- Any temperature target implies a maximum in cumulative CO_2 emissions. This is purely a physical and carbon cycle problem.
- Overshooting the budget will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

Fig. 12.46

Implications

- Taking into account historical carbon emissions, a maximum of about 270 GtC remains if warming is to *likely* be kept below 2˚ c..
- With emissions at current levels, that remaining budget would be used in less than three decades.
- Higher emissions earlier imply lower emissions later on to stay within the budget. Exceeding the budget implies actively removing emissions at a later point to return to the target.
- Without a large-scale technology to actively remove carbon dioxide from the atmosphere, exceeding the budget in the coming years implies a that one actually commits the world to more warming than the chosen threshold, and higher associated climate-related risks for decades to centuries.

Cumulative carbon determines warming



- Every ton of CO_2 causes about the same amount of warming, no matter when and where it is emitted.

SPM.10

Temperature targets and the RCP scenarios

- Global surface temperature change for the end of the 21st century is likely to exceed 1.5°C relative to 1850 to 1900 for all RCP scenarios except RCP2.6. It is likely to exceed 2°C for RCP6.0 and RCP8.5, and more likely than not to exceed 2°C for RCP4.5.
- Warming will continue beyond 2100 under all RCP scenarios except RCP2.6, which will likely stay below 2°C above 1850 to 1900.

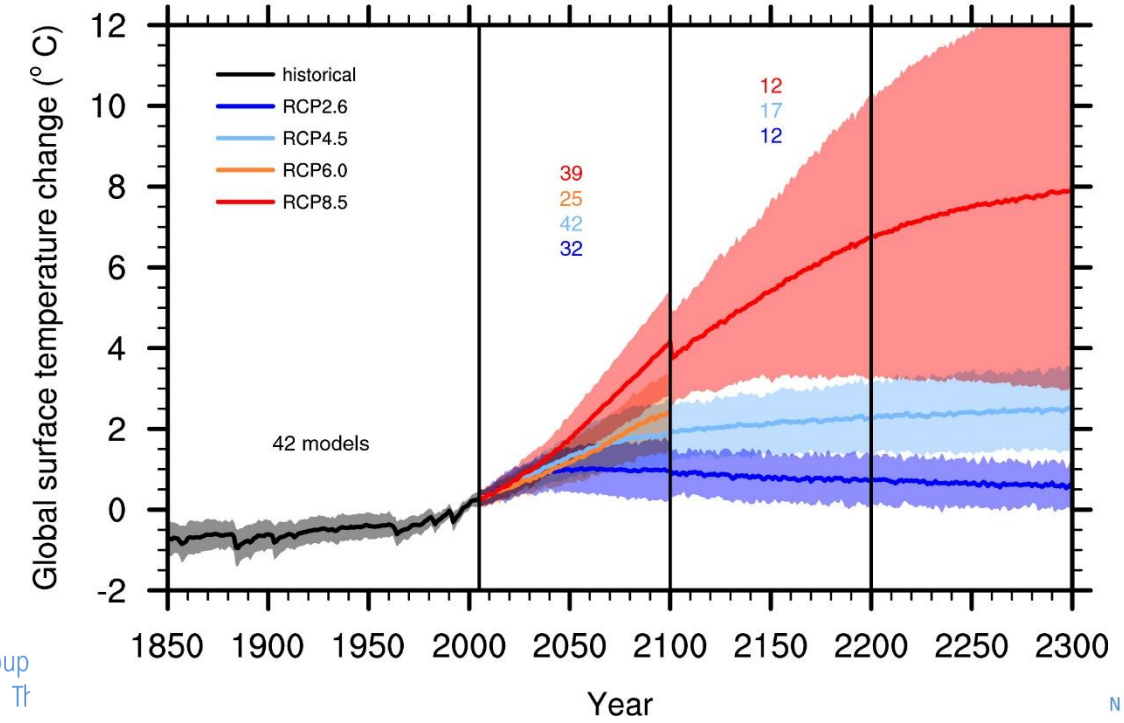


Fig. 12.5

Summary

- Cumulative emissions of CO_2 largely determine global mean surface warming by the late 21st century and beyond. Most aspects of climate change will persist for many centuries even if emissions of CO_2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO_2.
- Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. Halting global-mean temperature rise at any level requires near zero carbon emissions at some point in the future.
- Every ton of CO_2 causes about the same amount of warming, no matter when and where it is emitted.
- Cost optimal pathways for low targets show peak emissions in the next decade. Delay will commit future generations to stronger reductions, with implications on cost, technology, etc.
- The long term goal can be defined as a threshold, or as an eventual target after overshooting. Targets other than temperature are possible.

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Further Information

www.climatechange2013.org

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WMO UNEP