Advances in estimating and tracking the remaining carbon budget

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SUMMARY – Carbon budgets have been used over the past decade to inform emission cuts in line with limiting warming to internationally agreed temperature limits. Here, we look at some of the latest developments since the publication of the IPCC Special Report on Global Warming of 1.5°C that help us quantify, understand and track the size of the remaining carbon budget. As part of the IPCC Special Report on Global Warming of 1.5°C, a consolidated framework was developed for estimating and tracking the remaining carbon budget (section A; Rogelj et al. 2019). The five components of this framework can now be individually assessed and tracked. Recent advances have provided new insights (see section B) in how much warming to expect per unit of CO₂ emissions (Matthews et al 2021) as well as the amount of warming projected to occur once global CO₂ emissions have reached net zero levels (MacDougall et al 2020). Finally, these advancements can be integrated in updated estimates of the remaining carbon budget (section C). Finally, recent publications (CONSTRAIN 2019, 2020; Matthews et al 2020) once more clarify how value judgments play a role both in quantifying the remaining global carbon budget and particularly translating this budget to the national or sub-national scale (section D).

A – A new framework for estimating the remaining carbon budget

Five key components that can be assessed & tracked independently

1. Historical warming
   Starting point determining how close one is already to the global warming limit of interest, expressed in human-induced warming since preindustrial

2. TCRE - Transient climate response to cumulative emissions of CO₂
   Ratio of global warming per unit of cumulative CO₂ emissions

3. Zero CO₂ emissions commitment (ZEC)
   Amount of warming projected to occur once global CO₂ emissions are brought down to zero

4. Future non-CO₂ warming
   Projected additional warming from all non-CO₂ climate forcers

5. Earth system feedbacks otherwise not covered
   Effects on emissions and warming of Earth system components such as permafrost, wetlands, etc

B – Advancements in understanding of key components

Several studies have presented advances in our understanding of some of the key factors that determine estimates of the remaining carbon budget. Specifically, a new quantification of the zero CO₂ emission commitment (ZEC) and a study improving our understanding of the uncertainties surrounding the transient climate response to cumulative emissions of CO₂ (TCRE) have been published.

C – Up-to-date estimates of the remaining carbon budget

Updates in historical CO₂ emissions and the five key components highlighted in section A can be integrated to estimate up-to-date quantifications of the remaining carbon budget. The ZERO-IN Reports of the CONSTRAIN research consortium provide an annual update of remaining carbon budgets based on the latest available science. The next report will include an update based on IPCC AR6 WG1.

D – Value judgments, choices & science interact to calculate the remaining carbon budget at global and national scale

Key scientific publications:

Contact: j.rogelj@imperial.ac.uk