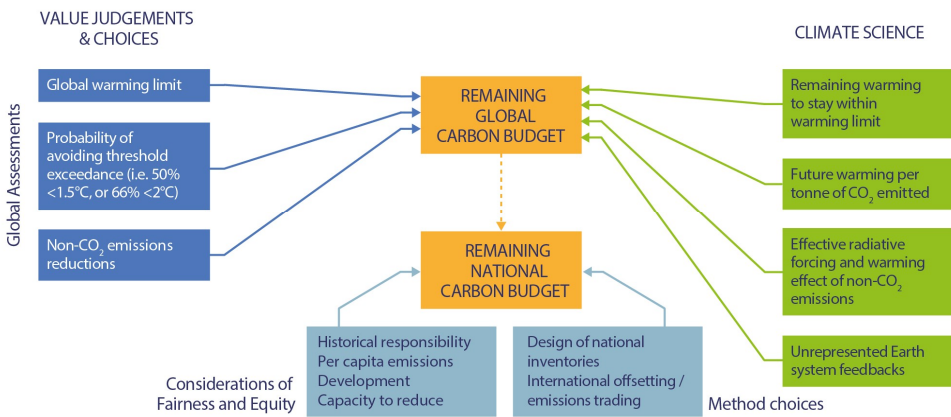


# Advances in estimating and tracking the remaining carbon budget

13<sup>th</sup> meeting of the UNFCCC research dialogue 1-2 June 2021 – presenter: Joeri Rogelj (Imperial College London/IIASA)

**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 CO<sub>2</sub> emissions (Matthews *et al* 2021) as well as the amount of warming projected to occur once global CO<sub>2</sub> 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 (CONSTRIN 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**).

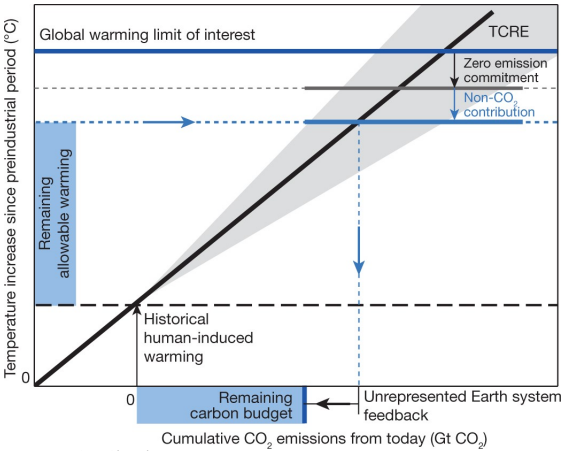
## D – Value judgments, choices & science interact to calculate the remaining carbon budget at global and national scale



Source: CONSTRIN ZERO IN report (2019)

**Key scientific publications:** Rogelj, J., Forster, P.M., Krieger, E., Smith, C.J., Séférian, R., 2019. Estimating and tracking the remaining carbon budget for stringent climate targets. *Nature* 571, 335–342. <https://doi.org/10.1038/s41586-019-1368-z>; MacDougall, A.H., Frölicher, T.L., Jones, C.D., Rogelj, J., Matthews, H.D., Zickfeld, K., Arora, V.K., Barrett, N.J., Brovkin, V., Burger, F.A., Eby, M., Eliseev, A.V., Hajima, T., Holden, P.B., Jeltsch-Thömmes, A., Koven, C., Mengis, N., Menviel, L., Michou, M., Mokhov, I.I., Oka, A., Schwing, J., Séférian, R., Shaffer, G., Sokolov, A., Tachiiri, K., Tjiputra, J., Wiltshire, A., Ziehn, T., 2020. Is there warming in the pipeline? A multi-model analysis of the Zero Emissions Commitment from CO<sub>2</sub>. *Biogeosciences* 17, 2987–3016. <https://doi.org/10.5194/bg-17-2987-2020>; Matthews, H.D., Tokarska, K.B., Nicholls, Z.R.J., Rogelj, J., Canadell, J.G., Friedlingstein, P., Frölicher, T.L., Forster, P.M., Gillett, N.P., Ilyina, T., Jackson, R.B., Jones, C.D., Koven, C., Knutti, R., MacDougall, A.H., Meinshausen, M., Mengis, N., Séférian, R., Zickfeld, K., 2020. Opportunities and challenges in using remaining carbon budgets to guide climate policy. *Nature Geoscience* 13, 769–779. <https://doi.org/10.1038/s41561-020-00663-3>; Matthews, H., Tokarska, K.B., Rogelj, J., Smith, C.J., MacDougall, A.H., Hausteiner, K., Mengis, N., Sippel, S., Forster, P.M., Knutti, R., 2021. An integrated approach to quantifying uncertainties in the remaining carbon budget. *Communications Earth & Environment* 2, 1–11. <https://doi.org/10.1038/s43247-020-00064-9>; CONSTRIN, 2019. ZERO IN ON the remaining carbon budget and decadal warming rates, The CONSTRIN Project Annual Report. CONSTRIN Consortium. <https://constrain-eu.org/>

## A – A new framework for estimating the remaining carbon budget



Source: Rogelj *et al* (2019)

**Five key components that can be assessed & tracked independently**

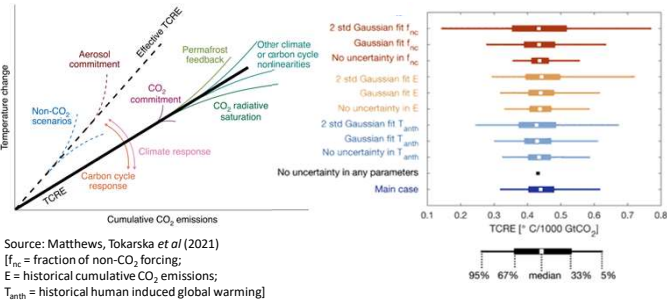
- 1. Historical warming**  
Starting point determining how close one is already to the global warming limit of interest, expressed in human-induced warming since preindustrial
- 2. TCRE - Transient climate response to cumulative emissions of CO<sub>2</sub>**  
Ratio of global warming per unit of cumulative CO<sub>2</sub> emissions
- 3. Zero CO<sub>2</sub> emissions commitment (ZEC)**  
Amount of warming projected to occur once global CO<sub>2</sub> emissions are brought down to zero
- 4. Future non-CO<sub>2</sub> warming**  
Projected additional warming from all non-CO<sub>2</sub> 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 CO<sub>2</sub> emission commitment (ZEC) and a study improving our understanding of the uncertainties surrounding the transient climate response to cumulative emissions of CO<sub>2</sub> (TCRE) have been published.

Model	ZEC <sub>25</sub> (°C)	ZEC <sub>50</sub> (°C)	ZEC <sub>90</sub> (°C)
Mean	-0.01	-0.07	-0.12
Median	-0.01	-0.05	-0.08
Standard deviation	0.15	0.19	0.23

Source: MacDougall *et al* (2020)



Source: Matthews, Tokarska *et al* (2021)

[f<sub>TCRE</sub> = fraction of non-CO<sub>2</sub> forcing;  
E = historical cumulative CO<sub>2</sub> emissions;  
T<sub>anh</sub> = historical human induced global warming]

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

Updates in historical CO<sub>2</sub> 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 CONSTRIN 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.

Probability of staying below	Remaining Carbon Budget (from start of 2021)	
	1.5°C	2.0°C
50%	355 Gt CO <sub>2</sub>	1,275 Gt CO <sub>2</sub>
66%	195 Gt CO <sub>2</sub>	945 Gt CO <sub>2</sub>

Source: CONSTRIN ZERO IN report (2020)



**CONSTRIN**

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