CONSTRAIN

CONSTRAINING UNCERTAINTY OF MULTI-DECADAL CLIMATE PROJECTIONS

Call for inputs from Parties and Observer States, UN Agencies and other international organisations and non-Party Stakeholders and observer organisations, to the first Global Stocktake (CMA4):

Submission by CONSTRAIN (Constraining Uncertainty of Multi-Decadal Climate Projections) to the first Global Stocktake (European Union Horizon 2020 Research and Innovation Programme Grant Agreement No 820829)

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1. CONSTRAIN is a Horizon 2020 consortium of 14 leading European research institutions investigating how several human and natural factors will affect the climate in coming decades, and translating the outcomes into policy-relevant information. The improved insights into both the climate system and the latest climate model results can help us to better understand and plan for what lies ahead, including on the timescales of the Nationally Determined Contributions (NDCs).

2. CONSTRAIN's work is highly relevant to the 2023 UNFCCC Global Stocktake (GST). Our submission largely focuses on the GST's thematic area of mitigation, providing background and context regarding greenhouse gas emissions and mitigation efforts (Decision 19/CMA.1, paragraph 36b). It also speaks to cross-cutting issues including methodologies for taking stock of the implementation of the Paris Agreement, and knowledge gaps regarding the information necessary to support a robust global stocktake.

3. Eight CONSTRAIN scientists were Lead or Coordinating Lead Authors of Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report(AR6) Working Group I (WGI), whose report set out the latest knowledge on the physical science basis of climate change, including near-term temperature rise. 47 peer-reviewed CONSTRAIN publications were referenced within the report itself, representing 70% of CONSTRAIN's research output at the time. CONSTRAIN research is also feeding into the IPCC AR6 WGIII report on the mitigation of climate change, due in spring 2022, particularly through the development and application of climate emulators (simple climate models).

4. This submission draws on CONSTRAIN's three annual ZERO IN Reports, which are provided alongside this document. The reports set out information on scientific topics that are fundamental to the Paris Agreement, as well as background and context on new developments at the science-policy interface. This includes new insights into the complex processes represented in climate models and what they mean for temperature change and other climate impacts over the coming decades. A fourth ZERO IN Report will be published in late 2022.

Understanding where we are with respect to the Paris Agreement Long-Term Temperature Goal (LTTG)

5. Planning and implementing pathways that aim to avoid dangerous climate change means knowing where we stand in terms of the Paris Agreement Long-Term Temperature Goal (LTTG). The LTTG aims to hold global average temperature rise to well below 2°C above pre-industrial levels, and pursue efforts to limit this to 1.5°C. The Paris Agreement reflects global, human-made long-term (20-30 year) temperature change that excludes short-term natural variability in the climate system. As a result, it is important to stress that reaching or exceeding 1.5°C warming in a single year, month or location, as a result of year-to-year variability, does not mean that the LTTG has been breached, as long as human-made warming still falls below 1.5°C.

6. A world that had warmed by a long-term global average of 1.5°C would see temperatures exceed that threshold in half of those years, and stay below it in the other half. This means that determining when human-made warming will have reached or exceeded 1.5°C will only be possible with hindsight. However, the more global annual temperatures approach, reach or exceed 1.5°C warming in the near future, the closer we will be to the LTTG.

7. Measuring where we are now with respect to the LTTG meanwhile involves maintaining the direct link between the Paris Agreement and the IPCC Fifth Assessment Report (AR5), which represented the best available science at the time. This includes looking forward from a modern reference period (1986-2005), and so advances in establishing how temperatures changed before this time will not affect our trajectory towards the 1.5°C limit, or the climate policy decisions that are based on it.

8. Irrespective of advances in climate science bringing new findings on how the world has and will change, what we do know is that global warming is continuing - by the end of 2021, the world had experienced approximately 1.2°C of anthropogenic warming[1] - so there is only a small window remaining to avoid the most dangerous climate impacts.

Near-term warming, warming rates and greenhouse gas emissions

9. The IPCC AR6 WGI best estimate is that, even with strong emissions cuts, global average temperatures will reach 1.5°C above pre-industrial levels in the mid-2030s. Under the WGI report's very low emissions scenario (SSP1-1.9), by the mid-2030s, warming will reach 1.5°C for a few decades, but drops back below it by the end of the century. All other scenarios lead to further warming above 1.5°C.

10. However, as well as the total amount of warming we experience, the *rate* of global temperature increase over the next few decades is of key importance: higher warming rates would reduce the timescales available for effective adaptation, in particular for the most climate-vulnerable countries.

11. The rate of near-term temperature change varies significantly across the five WGI illustrative emissions scenarios, with warming clearly decelerating in scenarios with rapidly declining greenhouse gas emissions. However, although CO_2-driven warming in the lowest emissions scenario is half that of the highest over the next few decades, overall warming from CO_2

[1] https://www.globalwarmingindex.org/

continues to increase in all five scenarios. This illustrates how cumulative CO_2 emissions will continue to cause warming until they reach net zero.

12. The main reason for a slowdown in anthropogenic warming in the two lowest emissions scenarios in coming decades is actually a decrease in forcing by non-CO_2 greenhouse gases such as CH_4. This highlights the opportunity to slow down near-term warming through strong action on non-CO_2 emissions. However, the slow-down is somewhat offset by weakened aerosol cooling, which would contribute to warming over the next 20 years.

13. Differences in the rates of near-term warming across the five illustrative scenarios nonetheless illustrate how strong mitigation could reduce the rate of human-induced near-term 2020-2040 warming, underscoring the benefits of near-term emission reductions including up to 2030, the timescale of the current NDCs.

What does a 1.5°C pathway look like?

14. In terms of global emission pathways consistent with Paris Agreement goals, the IPCC has assessed a variety of "1.5°C pathways", each of which come with about a 50% chance of limiting warming to 1.5°C. In some of these pathways, temperatures stay below 1.5°C, whereas in others they temporarily exceed ("overshoot") 1.5°C before declining again[2].

15. Among the five scenarios assessed in the WGI report, SSP1-1.9 is closest to a 1.5°C pathway. But SSP1-1.9 is just one of many pathways that we could follow in reality. For example, the COVID-19 pandemic only briefly reduced emissions, and therefore had a negligible effect on the climate, but presents the opportunity to set the world on a "green recovery pathway". By reducing greenhouse gas emissions by 50% by 2030 and reaching net zero emissions by 2050, such a pathway would give a good chance of staying within 1.5°C and also cut near-term warming rates by up to half.

16. There is no single "right" pathway to limiting warming to 1.5°C; instead there are many pathways that could lead us there, some delivering more benefits for sustainable development goals than others. However, regardless of the exact pathway we follow, it will require global CO_2 emissions to peak in the immediate future, then rapidly decline to net zero around mid-century. But we are still only talking about a 50% chance of staying within 1.5°C warming, and different temperature responses (i.e. greater warming or even cooling) cannot be entirely ruled out.

Uncertainties in the climate system affect our chances of staying within 1.5°C warming

17. If and when we will actually reach 1.5°C depends largely on which emissions pathway we now follow. But exactly how the climate system responds to those emissions will also play a role and there are still uncertainties when it comes to how global temperatures will respond to rising greenhouse gas emissions. These include the effects on temperatures of both aerosols and carbon release from thawing permafrost.

18. Variations in the complex climate processes represented in climate models can lead to differences in projected warming even if the same emissions pathway is followed, affecting the chances of staying within a given temperature limit. This highlights how the temperature projections provided by climate models, whether following aggregated NDCs or any other

[2] For further information see the CONSTRAIN briefing note What exactly is a 1.5°C pathway.

pathways, encompass a range of possible outcomes and should not be reduced to a single number.

Methodologies for taking stock of the implementation of the Paris Agreement: Remaining global carbon budgets

19. The remaining global carbon budget (the amount of CO_2 the world can emit while staying below a certain temperature limit) is a useful means of assessing whether global climate policies and ambitions, including the Paris Agreement, are on track. Using a methodology compatible with the IPCC AR6 WGI report, and for a 50% chance of staying within 1.5°C warming, CONSTRAIN estimates a remaining carbon budget of 420 $GtCO_2$ from the start of 2022.

20. Remaining carbon budgets are rooted in the scientific principle that global warming increases in an almost linear way with the total amount of CO_2 we emit, but several other factors also influence the remaining carbon budget. Calculating the budget involves making choices about the relevant temperature limit as well as as well as how certain we want to be of staying below that limit (e.g. a 50% or 66% chance).

21. Other factors include how much "headroom" to leave in the budget to account for the effects of non-CO_2 greenhouse gas emissions; how to account for the effects of climate feedbacks such as permafrost thaw or changes in ocean processes; how global temperatures will respond to future emissions; and how much warming has occurred to date. The remaining global carbon budget should, therefore, always be discussed with an awareness of the choices and scientific judgements that go into producing a final number.

Knowledge gaps

22. There are several scientific temporal and spatial knowledge gaps that, if addressed, would contribute to improving climate model projections on NDC timescales. These include questions around radiative forcing (the energy imbalance imposed on the climate system by either external natural factors or by human activities), and the roles that clouds and the oceans play in the climate system. Narrowing these knowledge gaps will improve the outputs of climate models and consequently the evidence base available to inform timely policy decisions on adaptation and mitigation. These knowledge gaps are being addressed through international research collaborations such as CONSTRAIN.

23. A further knowledge gap exists regarding the translation of new science into policy-relevant information. CONSTRAIN is developing knowledge translation tools targeted at improving the flow of climate science into policy and decision making, as well as promoting wider understanding. The main tools developed to date are the three ZERO IN Reports, which, underpinned by CONSTRAIN research, summarise the latest understanding on key climate science processes and concepts. These efforts to investigate and clarify some of the complex scientific concepts that underpin the Paris Agreement, as well as further explain those set out in IPCC reports, have been widely welcomed by stakeholders, helping them to understand the state of the climate system and to better follow developments in UNFCCC processes.

Notes

CONSTRAIN is a consortium of 14 European partners investigating how several human and natural factors will affect the climate in the coming decades, feeding them into climate models to reduce uncertainties in, and create improved climate projections for, the next 20-50 years, on regional as well as global scales.

CONSTRAIN is also translating this new scientific understanding into an improved evidence base, aimed at providing up-to-date scientific evidence for international climate policy, and supporting decisions on climate mitigation and adaptation. Three CONSTRAIN ZERO IN reports are currently available, focusing on the remaining carbon budget and decadal warming rates; a new generation of climate models, COVID-19 and the Paris Agreement; and near-term warming and the chances of staying within 1.5°C.

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