A FACT CHECK OF THE CLIMATE COUNCIL OF AUSTRALIA'S REPORT "AIM HIGH GO FAST"

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The Climate Council's new report "Aim High Go Fast" provides a very compelling and strong case for urgent rapid emission reductions, both globally, and for Australia domestically. The report itself provides compelling scientific case as to why Australians should be concerned that peak global warming is limited to 1.5°, including the destruction of the Great Barrier Reef above this warming level, and the risk of triggering feedbacks which would accelerate warming if warming exceeds the 1.5° level.

Almost paradoxically, the Climate Council has gone much further beyond the best available science and claims that *"multiple lines of evidence strongly suggest that we can no longer limit warming to 1.5°C without significant overshoot and subsequent drawdown, and that the global average temperature rise will exceed 1.5°C during the 2030s"*. This bold claim is in contradiction with a range of other recent high-level scientific reports including the UNEP Gap Reports and the recent IPCC Special Report on 1.5˚C (IPCC SR15).

The 1.5°C limit in the Paris agreement is now widely accepted as the ultimate goal for which policy is aiming, and in turn has led to the focus globally on achieving net zero emissions by mid-century at the latest. The 1.5°C limit replaced the earlier 2°C goal adopted internationally in 2010 after an intensive international scientific review from 2013-2015, and was included in the adoption of the Paris Agreement in 2015.

There are fundamental scientific issues with the arguments brought forward in the report, specifically in relation to the argument that is made that "*we can no longer limit warming to 1.5°C"*. These issues will be discussed in detail in the document below, but in summary it is clear that the evidence presented in the Climate Council of Australia's report itself does *not* support their claim that 1.5°C will be exceeded. Nor that *"significant overshoot and subsequent drawdown"* would be the consequence.

Here we present a point-by-point rebuttal of the most important scientific shortcomings and misrepresentations in the Climate Council report, by section. We have been attempting to draw these issues to the attention of the Climate Council for the past six months, to no avail.

Part 1: Observed and projected trajectory of the climate system

Claim: Accelerated warming based on recent five-year warming rate leads to 1.5°C exceedance

The report claims that the rate of warming is increasing, stating that:

> *"Averaged over the 2016-2020 period, global temperature was about 0.24°C higher than the average of the previous five-year period (2011-2015)" [section 2.1 page 10]*

This has little significance in assessing the timing of 1.5°C exceedance. Global mean temperature evolution on inter-annual time scales is dominated by natural variability, a fact well-established in physical climate science, which is why timeframes of at least 20 years are used to establish long-term

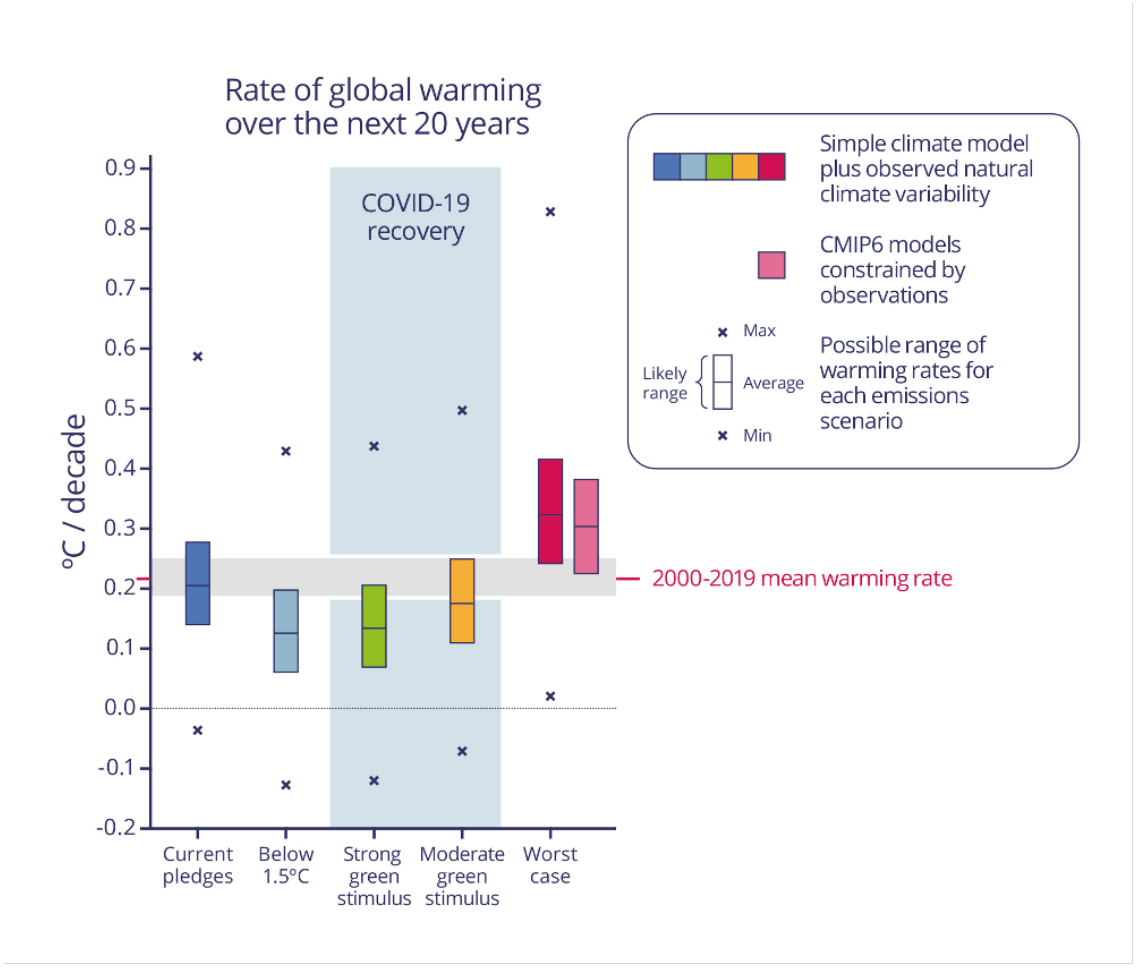
trends. Some may well remember the discussions around the so-called warming 'hiatus' that appeared to show that decadal warming has slowed down in the early 2000s. This turned out to be the effect of natural variability and incorrect.[1] Using a period of just five years to make strong claims about the acceleration of warming is equally as problematic.

It is important to highlight that the Paris Agreement temperature goal is about long-term anthropogenic warming. It is highly unphysical that the rate of anthropogenic warming should double without emissions doing so. A real-time estimate of the anthropogenic warming signal provided by the University of Oxford shows no such rapid acceleration. Conversely, it supports the assessment provided in the IPCC SR1.5 that on our current trajectory we are likely to reach 1.5°C between 2030 and 2050. Any claims that we are *likely* to reach 1.5°C within the next decade is unsubstantiated.

Claim: Projected temperature increase over the next 20 years does not depend on emissions scenarios [section 2.1 page 11]

This statement is false. The warming rate over the coming 20 years is already dependent on our emissions trajectory. If emissions were curbed in line with a 1.5°C pathway, the decadal warming rate over the next two decades would be around 0.13°C/decade in the best estimate, or about half the recent decadal warming trend.[2]

The COVID-19 related downturn in GHG emissions and plausible green recovery pathways would show a similarly strong effect on near-term warming rates.[3]



This figure shows that the emission pathway matters. McKenna *et al. Nat. Clim. Chang.* **11,** 126–131 (2021). https://doi.org/10.1038/s41558-020-00957-9

Claim: Accelerated sea level rise provides evidence for accelerated atmospheric warming [page 10]

Rising sea-levels are indeed a concern and so is an accelerated rate of sea-level rise. But to argue that rates of sea-level rise provide an argument that an atmospheric warming target is being exceeded is geophysically incorrect.

The report also cites accelerating sea level rise as a line of evidence of why the authors believe the increase in global mean temperature is accelerating.

The cause-and-effect relationship is the other way around. The sea-level rise signal lags atmospheric warming on timescales of decades to centuries. The observed trends in sea-level rise and ocean heat uptake are unfortunately what we must expect to accelerate even further, and continue long, after net zero emissions have been reached, even under scenarios where temperatures are already in decline.[4]

Claim: "All emission scenarios expect 1.5°C temperature rise to be breached in the early to mid 2030s." [page 13].

It should surprise no one that 1.5°C is exceeded in emission scenarios that are designed to exceed 1.5°C, as the authors have not included 1.5°C scenarios in their analysis.

The report provides estimates of when median warming for four RCP or SSP scenarios is exceeded. None of these scenarios is a 1.5°C scenario, the lowest scenario used is the RCP2.6 scenario, a below 2°C scenario.

The IPCC Special Report on Global Warming of 1.5°C included more than 50 emission scenarios that are *"as likely as not"* to keep warming to below 1.5°C, including nine with a probability of higher than 50%.[5] Other literature has shown how a green COVID-19 recovery scenario can bring the world on a trajectory to hold median warming to below 1.5°C.[6] The authors even admit this in a footnote, also citing the RCP1.9 scenario that is a 1.5°C scenario.[7]

The third-party analysis of the exceedance times for different CMIP6 scenarios is based on the full set of CMIP6 models, several of which have been shown to be unrealistically warm[8,9] and provide a range of up to 30 years for the 1.5°C exceedance time. Claiming it *will* be in the 2030s is thus not supported by this analysis.

Lastly, the authors cite a study that claims that the world is currently on a RCP8.5 trajectory. While historic emissions have been following this scenario most closely, there is a well-established understanding in the scientific literature that this view is incorrect, and that while the world is nowhere near doing enough to achieve the Paris Agreement goals, it is also very far away from building the fossil infrastructure implied by RCP8.5.[10] COVID-19 has strongly accelerated that trend.

Part 2: Committed (unavoidable) climate change

Claim: Locked-in warming should be assessed using a "constant concentration" approach [page 14] and means a further 0.6°C warming is locked in

The use of constant concentration is no longer considered legitimate in the scientific community for assessing committed warming in relation to net zero targets. Numerous recent publications and experiments indicate that the correct approach is to look at commitment following zero emissions being achieved.

The authors claim that *"There are two different model-based approaches to estimating the warming already locked in from past emissions: (i) zero emissions, and (ii) constant concentration."*

The argumentation then goes on to suggest there is a 'choice' to make between them. Physics is not a matter of choice. Concentrations will not stay constant once net zero emissions are reached. The authors rightly cite the state-of-the-art literature showing that there is *"no warming in the pipeline"* once net zero emissions are reached.[11]

The authors, however, then go on to suggest that 'constant concentrations' would be more appropriate, claiming that models estimating the zero-emissions commitment would not account for *"increasing carbon emissions from feedback processes within the Earth System".* This is incorrect. As the cited literature clearly shows, a wide range of carbon cycle feedbacks are included in state-of-the-art climate models,[11] some also including permafrost. Not all models do so, and important uncertainties remain. But there is no compelling evidence provided, that such effects would be of the pace and scale to justify their assertion that this would balance out declining concentrations after net zero.

A closer look into some of the references provides an illustration of questionable scientific practice. A study cited to support the claim that permafrost feedbacks are underestimated in 1.5°C scenarios (Turetsky et al. 2020) only looks at the RCP8.5 and RCP4.5 scenarios, both of which warm far above 1.5°C and up to 2300. The study finds much lower rates under RCP4.5,[12] which warms well over 2°C.

Lastly, the IPCC Special Report of 1.5˚C (IPCC SR15) includes established evidence that looks into the warming commitment, which clearly shows that warming of 1.5°C is not 'locked in'.[13] The authors fail to engage with any of this compelling evidence.

Part 3: Updated estimates of Climate Sensitivity [page 20]

Claim: "Thus, in light of the updated estimate of ECS, the IPCC SR1.5 carbon budgets are likely to overestimate the remaining allowable emissions for a given temperature target." [page 20]

The equilibrium climate sensitivity, which measures climate response over centuries, is much less relevant to assessing the consequences of emission pathways over the next decades than the transient climate response, and hence the use of equilibrium climate sensitivity as a line of evidence for exceedance of 1.5°C is not appropriate.

The cited paper by Sherwood and coworkers[14] is very a significant step forward in terms of our ability to constrain climate sensitivity. However, its main achievements were more a narrowing of the range, rather than changes, in the best estimates. The Sherwood paper mainly deals with Equilibrium Climate Sensitivity (ECS, long-term – centennial – warming after doubling atmospheric CO_2 concentrations), which is *not the key quantity for assessing near-term warming*. The IPCC AR5 has estimated a likely (66%) range between 1.5°C-4.5°C, the Sherwood paper significantly narrows this range to 2.6°C-4.1°C.

The more important factor for addressing near-term warming, and the question of 1.5°C exceedance is the *transient climate response* (TCR, warming at the time of CO_2 doubling in an idealised 1% per year increase scenario). While the Sherwood paper also provides a TCR estimate, it assigns much less certainty to the changes documented there. The Sherwood et al TCR estimate is also slightly higher than the central estimate for the IPCC AR5, but the authors conclude that "*our assessment of this quantity is very limited and should be treated with considerable caution*". Other analysis on emergent constraints on future warming projections indicate a TCR central estimate very similar to the IPCC AR5 estimate.[8]

The Sherwood paper also assesses central warming estimates for different RCPs. In the baseline case, the median estimate for RCP2.6 (a 2°C pathway) is exactly the same as the IPCC AR5 (compare Sherwood et al, 2020, Table 11). Uncertainties remain, of course, but to conclude that AR5 estimates are too low is not substantiated by this publication and it is premature to conclude with respect to implications for limiting warming to 1.5°C ahead of the IPCC AR6.

An even more recent publication has assessed the implications of more recent evidence on the Earth System response to emissions for carbon budgets.[15] It has reaffirmed the estimates based on the IPCC SR1.5. The claim by the authors that recent science has proven that the IPCC carbon budgets are likely an overestimate are thus not substantiated.

Part 4: Insights from past climates [page 21]

This section provides a snapshot of recent reports on the understanding of past climates and provides a very clear warning from the deep past of not rapidly reducing emissions to levels consistent with limiting warming to 1.5°C. However, none of the evidence provided links to the question of whether 1.5°C will be exceeded.

Part 5: Carbon budget analysis [page 23]

The carbon budget analysis provided includes several conceptual and simple arithmetic flaws, which together invalidate its conclusions in relation to the possibility of limiting warming to 1.5°C and carbon budgets are the wrong tool of choice in this analysis.

Calculation: Derivation of the remaining carbon budget

In their main analysis, on which the authors base their claims, the following points need to be clarified:

1) Non-CO_2 gases: the report removes 90 $GtCO_2$ to account for non-CO_2 greenhouse gases, citing the IPCC SR1.5 Table 2.2. It is not clear how this number is derived. Judging from the information provided in Annex A, it appears this is the authors' own assertion. The carbon budgets in Table 2.2 already account for non-CO_2 GHG emissions. It is thus not clear why they are being subtracted.

2) The authors then remove 245 Gt CO_2 based on Steffen et al. 2018. However, Steffen et al does not provide any numbers for 1.5°C, rather already very coarse and at times interpolated approximations based on individual studies for 2100.[16] The authors chose to linearly scale this to 1.5°C (compare Annex A), although there is no evidence that such a scaling is at all appropriate. Elsewhere, they argue with the non-linear nature of these tipping points, which does not quite match the argument of a linear 'interpolation'.

A recent study by leading experts on carbon budgets has provided *"an integrated approach to quantifying uncertainties in the remaining carbon budget"*[15] including from carbon cycles and permafrost. While important uncertainties remain, the authors estimate a remaining carbon budget of 440 $GtCO_2$ from 2020 onwards, with a range of 230–670 $GtCO_2$, (for a 67–33% chance of not exceeding the target), substantially higher than what the somewhat ad-hoc derivations the Climate Council delivers.

Conceptual: The use of appropriate probability levels to substantiate claims of exceedance

The report uses a 66% probability to assess the remaining 1.5°C carbon budget in its assessment. This is not just a political argument, but also a scientific one.

There is an important logical fallacy in the argumentation here. Certainly, if one wanted to argue that we can be sure to limit warming to below 1.5°C, higher probabilities of limiting warming to that level would be required. However, this is not the question at hand.

The authors claim that it is *"impossible"* [page 23] to limit warming to 1.5°C (without substantial drawdown) and they state this with absolute confidence. This reverses the burden of proof. To substantiate that argument, they would need to show with high probability that it is not possible to limit warming to 1.5°C. This would require demonstrating that warming is likely (66% chance) or even very likely (90% chance) to exceed 1.5°C. This is quite the opposite of what the Climate Council report does.

Conceptual: Application of carbon budgets for warming level exceedance

There seems to be an emerging consensus where world leading experts on the carbon cycle argue that it would be better to provide carbon budget ranges given the huge uncertainties in relation to them. Some of the leading experts - including the AR6 Lead Authors - systematically assessed these uncertainties in a January 2021 publication.[15] Their uncertainty estimate is +/- 50% of their central estimate.

It has been shown elsewhere that internal variability of the climate system limits the ability to estimate the remaining carbon budget by about 50 PgC.[17]

The analysis of the Climate Council presented in Box 2 (page 26/27) with different assumptions about non-CO_2 forcers illustrates both the profound uncertainties that remain, and that carbon budgets are the wrong tool of choice in this analysis.

In fact, emission pathway analysis is well established in climate science and there is comprehensive evidence provided in the IPCC SR1.5 on 1.5°C emission scenarios.

Conceptual: The claim for significant overshoot and subsequent drawdown

There is no analysis provided in the report on how 'significant' the overshoot would be or what the needs for drawdown would be. So there one can only speculate what they mean here and turn to the established scientific literature on the matter.

Emission reduction pathways that are aligned with the goals of the Paris Agreement to achieve net zero greenhouse gas emissions generally deploy some kind of carbon dioxide removal (CDR). Achieving net zero greenhouse gas emissions as implied by the goals of the Paris Agreement would lead to slowly declining temperatures.[18]

As outlined above, the point of whether or not CDR beyond achieving net zero greenhouse gases would be required strongly depends on geophysical uncertainties of the Earth System response. Only in cases where the climate response is significantly higher than our current best estimate (exceeding the 'as likely as not' 1.5°C range by the IPCC SR1.5) would large-scale CDR be required.

There are a number of mitigation pathways in the scientific literature that deploy large scale CDR in pathways linked to 1.5°C. Such a large-scale deployment of carbon removal has rightly been questioned with regard to the plausibility and sustainability of those pathways. However, the deployment of CDR in such pathways is, beyond model-specific assumptions, not linked to the probability to limit peak warming to 1.5°C, but rather the outcome of the scenario design,[19] end-of-century scenario postulations[20] and other value judgements[21] made in energy economic models underlying those pathways. There are pathways that achieve 1.5°C with very limited CDR established in the literature.[22]

The claim of a locked-in 'significant overshoot and subsequent drawdown' is thus neither supported by the evidence provided in the report nor the wider scientific literature.

Conceptual: Interpretation of the Paris Agreement long-term temperature goal

The view that there are two temperature limits, an upper and a lower, embedded in the Paris Agreement's long-term temperature goal (LTTG) is a misunderstanding. Specifically, the decoupling of the 1.5°C warming limit from the hold warming well below 2°C element of the Paris Agreement's temperature goal language to create the sense that there is an upper and lower limit to *"choose from"* in the Paris Agreement is incorrect.

The Paris Agreement's temperature goal and 1.5°C limit was the outcome of the UNFCCC Structured Expert Dialogue (SED) 2013-2015 involving IPCC and other scientific bodies. It found that the view that a warming of 2°C can be considered safe *"is inadequate"* and that *"limiting global warming to below 1.5°C would come with several advantages in terms of coming closer to a safer 'guardrail'".*[23]

Based on this assessment, the Paris Agreement LTTG not only references the 1.5°C, but it also modifies the previous *"hold warming below 2°C"* goal adopted in Cancun in 2010[24] to "*hold warming well below 2°C"*. While it is not clearly defined in terms of probability or absolute temperature, this clearly means a strengthening towards interpretations of the *"hold warming below 2°C"* language. The LTTG is linked to assessments of the risks and impacts of climate change based on the science available at the time, i.e. as reflected in the IPCC AR5 and metrics used therein.[25,26]

The Paris Agreement Article 2.1 contains only one long-term temperature goal and refers to one temperature limit:

"*Holding the increase in the global average temperature to* ***well below 2ºC*** *above pre-industrial levels and pursuing efforts to* ***limit the temperature increase to 1.5ºC*** *above pre-industrial levels,* ***recognising that this would significantly reduce the risks and impacts of climate change*****".**

The LTTG of the Paris Agreement constitutes one goal, while establishing 1.5°C global mean temperature rise above pre-industrial levels as the long-term warming limit.[27] The LTTG caters two interpretations: establishing a 1.5°C limit that should not be exceeded, or allowing for a temporarily exceedance (overshoot) of the 1.5°C limit, whilst requiring warming should always remain *"well below 2°C"*.[28] Under the latter interpretation, the LTTG requires the need to pursue (continuous) efforts towards 1.5°C, whilst holding warming well below 2°C, and hence the need to peak warming *"well below 2°C"* and reduce GMT again below 1.5°C in the case of a temporary overshoot.

The common scientific and policy interpretation of the former *"hold below"* 2°C goal from Cancun, which was replaced by the Paris LTTG following a UNFCCC review process, is that this is meant to hold warming below 2°C with a *likely* (66%) probability, which entailed peak mid-century warming of 1.7-1.8°C. Consequently the requirement of holding warming "*well below 2°C"* can only be understood as a need to be better than *"hold below 2°C"* with a likely probability, so that peak warming under well below 2°C pathways must be below 1.7°C.[29] The IPCC SR15 provides an assessment and mitigation benchmarks for pathways that are *"as likely as not"* (between 33% and 66% chance) to limit warming to 1.5°C. These pathways are subsumed in the 'low or no overshoot' pathway category. These 'low or no overshoot' pathways simultaneously provide a *"very likely"* (>=90%) chance to hold warming to *"well below 2°C".*[30] Emission pathways with such characteristics can thus be considered fully Paris Agreement compatible.

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