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Comment on 'Unintentional unfairness when applying new greenhouse gas emissions metrics at country level.'

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Abstract
Here, we provide a comment in response to a recently published paper 'Unintentional unfairness when applying new greenhouse gas emissions metrics at country level' by Rogelj and Schleussner (2019). We note a number of errors in their critique of the use of GWP* to relate cumulative and short-lived climate pollutants, argue that their logic is flawed, their ethical considerations are narrow and their conclusions not justified by the results presented.

1. Overview

Rogelj and Schleussner (2019) (RS19) make a number of errors in their critique of the use of GWP* to relate cumulative and short-lived climate pollutants. They focus on GWP* (Allen et al., 2016, 2018, Cain et al., 2019), but their fundamental critique would apply to the use of any flow-based metric, including forcing-equivalent emissions (Wigley, 1998; Jenkins et al., 2018), GTP_S (Shine et al., 2005), mixed metrics (Lauder et al., 2012), or CGTP (Collins et al., 2019). We document specific errors below, but our principal objection is more fundamental: it is not up to scientists to determine what is fair based on their own interpretation of the interests of others. The goals of climate science are accuracy and transparency. Ethical questions such as the degree to which historical contributions to current warming determine mitigation responsibilities require non-science considerations, accounting for a range of perspectives.

Improved accuracy and transparency can co-exist with unfairness, but they cannot cause unfairness, while inaccurate and opaque accounting rules can lead directly to unfair outcomes. To demonstrate this point, we rearrange equation 1 in Cain et al. (2019) thus:

$$E^*(t) = E_{LLCP}(t) + 4E_{SLCP}(t) - 3.75E_{SLCP}(t-20),$$

where E*(t) is CO2-warming-equivalent emissions in year t, $E_{LLCP}(t)$ and $E_{SLCP}(t)$ are emissions of long-lived and short-lived climate pollutants (LLCPs and SLCPs respectively, with SLCPs having lifetimes of up to a few decades) in year t, both in conventional GWP100 CO2e units, while $E_{SLCP}(t-20)$ is CO2e emissions of SLCPs in the year 20 years prior to t. RS19 acknowledge that cumulative CO2-warming-equivalent emissions calculated in this way give a relatively accurate indication of impact on global mean surface temperature (GMST). In contrast, simply adding $E_{LLCP}(t)$ and $E_{SLCP}(t)$ to give a single aggregate CO2e emission would overstate the GMST impact of a constant source of methane such as a long-established rice farm by a factor of about four (because $E_{SLCP}(t-20) = E_{SLCP}(t)$, so the actual

contribution to warming-equivalent emissions is $0.25E_{SLCP}$), while similarly understating the impact of a new methane source, such as a proposed fracking operation (for which $E_{SLCP}(t-20)=0$).

Whether or not such outcomes are considered fair is a matter for policy, and is best determined by the informed judgement of the communities involved. But it seems to us that one important form of unfairness is to overstate the impact of the rice farm relative to the fracking operation via the use of an inaccurate accounting rule. To inform policies in pursuit of a global temperature goal, it is helpful for the equivalence metrics used to compare different greenhouse gases to reflect their respective impacts on global temperature, an argument also made by others (Tanaka & O'Neill, 2018, Fuglestvedt et al., 2018).

Better reflecting the actual warming contributions made by emissions portfolios cannot cause unfairness. Inappropriately using accounting rules for purposes for which they were not designed can. Ultimately, arguments about how "fair" approaches to equivalence are depend on how well-matched the metric is with the variable(s) over which the emissions are being compared. In the following section, we provide supporting arguments and identify further inaccuracies, flawed assumptions and errors in RS19, which lead them to make incorrect assertions about and criticisms of GWP*. We also discuss variable and context-specific ethical standards, grandfathering and unresolved metric debates within UNFCCC.

2. Errors in RS19

The abstract incorrectly states that 'The use of GWP* would put most developing countries at a disadvantage compared to developed countries, because when using GWP* countries with high historical emissions of short-lived GHGs are exempted from accounting for avoidable future warming'. The use of a metric does not dictate policy decisions such as the treatment of historical contributions, whether climate policy should utilise a single- or multi-basket structure, or the appropriate mix of emissions reductions of different gases in a country's climate plan. Moreover, it is a value judgment to consider failure to reduce methane emissions as "avoidable", but not failure to implement active CO2 removal, which would have the same impact on global temperature. Which is more feasible depends on the policy context. There is nothing inherent in the metric that dictates the outcome.

RS19 correctly state that "the GHG metric which determines how different GHGs are accounted for in pathways … is not explicitly specified [in the Paris Agreement". They then state that "it can be inferred [to be GWP100] based on information and reports that fed into the development of the Paris Agreement", citing evidence from the IPCC's AR5, and a 2016 UNFCCC document. It cannot be asserted that the members of the Paris Agreement – the sole authority for its interpretation – construed its meaning as contingent on or flowing from any particular metric. That GWP100 has been used as the default metric to date should not be taken to imply it is therefore the metric of choice, especially in the context of SLCP emissions in a climate agreement with a temperature-based target (which the Paris Agreement's precursor the Kyoto Protocol did not have).

Similarly, while it true that the UNFCCC uses GWP100 as "a common accounting metric", UNFCCC documentation does not endorse its general use within the Paris Agreement. At COP24, in December 2018, an explicit decision was taken to adopt the GWP100 values from AR5[1] in the context of reporting national emissions and removals (rather than for setting targets). This decision noted that parties "may in addition also use other metrics (e.g. global temperature potential)". Even in the case of GWP100, there is ambiguity; AR5 presents two sets of tables for metrics (including and excluding climate-carbon feedbacks). The UNFCCC's Subsidiary Body for Scientific and Technological Advice (SBSTA) has repeatedly been unable to reach agreement on metric choice. At the time of writing, an agenda item[2] for COP25 (December 2019) "Common metrics to calculate the carbon dioxide equivalence of greenhouse gases" notes that its June 2019 meeting, "was not able to conclude its considerations on this matter"; earlier SBSTA meetings[3] explicitly noted "the limitations in the use of GWPs based on the 100-year time horizon in evaluating the contribution to climate change of emissions of GHGs with short lifetimes".

RS19 state that "applying novel metrics to a pre-defined policy context is problematic if no appropriate measures are taken to ensure internal consistency with the earlier use of other metrics in policy". This statement is itself problematic. If a novel metric is more consistent with a particular policy context, then it is less, rather than more, problematic to use it; this is especially the case where the policy context has changed markedly between the Kyoto Protocol and the Paris Agreement. This argument of RS19 also sidesteps the issue that the GWP100 values are themselves varying. The methane GWP100 used in the Kyoto Protocol has a value of 21, based on IPCC's SAR, as does documentation on the UNFCCC website[4]. The AR5 value, including climate-carbon feedback (which "likely provides a better estimate" (Myhre et al., 2013) than excluding it) is 34. A 60% spread in possible values hardly ensures internal consistency and yet UNFCCC do not seem to perceive this as problematic.

Despite the arbitrary nature of many aspects of GWP100 noted above, which the authors do not discuss, they do note that their results 'show that national emission estimates that use *GWP** are very sensitive to arbitrary choices'. In fact, every different metric or metric value will give a different national emissions estimate, and therefore any choice of metric could be deemed arbitrary. This arbitrariness and ambiguity can be avoided by treating each greenhouse gas separately, as recommended by Denison at el., (2019).

A fundamentally flawed assumption underlies RS19's use of the term 'grandfathering', as they make no clear distinction between grandfathering emissions and grandfathering warming. They state that "when applying Eq. 2 at the level of a specific country this is equivalent to implementing a 'grandfathering' principle because GWP* takes a country's historic emissions level as its starting point. The grandfathering principle is often regarded as being inequitable and hence strongly criticised'. In the three references then cited, two

[1] https://unfccc.int/sites/default/files/resource/cma2018_3_add2_new_advance.pdf#page=25 (Annex II, part D)

[2] https://unfccc.int/sites/default/files/resource/SBSTA2019_03E.pdf

[3] https://unfccc.int/resource/docs/2011/sbsta/eng/02.pdf

[4] https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials

do not distinguish SLCPs from long lived emissions. The third, Peters et al., (2015) did not estimate contributions of non-CO2 gases, and notes that because of the limitations to GWP100, a better route to dividing up remaining non-CO2 budgets would be to "share the 'remaining' temperature to reach 2 °C". This concept has motivated the development of using GWP* to calculate CO2-warming equivalent (CO2-we) emissions. Using CO2-we emissions provides a solution to problems related to grandfathering consistent with the arguments laid out in Peters et al., (2015).

The distinction between methane and CO2, because of their different lifetimes, is at the core of the reason why standard methods to calculate CO2e fail under ambitious mitigation scenarios. GWP* and CO2-we attempt to reconcile these differences by bringing short lived pollutants like methane onto the same warming footing as CO2. In this sense, the problem of 'grandfathering' emissions demonstrated using GWP* is an equal problem for historical CO2 emissions. This is because historical emissions of CO2 remain in the atmosphere today, i.e. the warming from past CO2 emissions is allowed to continue; countries are not expected to remove that CO2 from the atmosphere. It is not evident why different ethical standards should be applied to methane and CO2 (namely that countries should undo past warming caused by their methane emissions, but not that caused by their CO2 emissions). RS19 do not discuss this issue, which should be at the heart of a discussion of grandfathering and equity.

Further, the use of GWP* does not even imply that RS19's 'grandfathering' approach should be used, or that the correct target for every country is net zero CO2-we calculated using GWP* for all GHG emissions. To refer to 'the grandfathering approach of the original GWP*' is incongruous, as the original GWP* was not applied to any specific policy. To imply that the metric itself implies the grandfathering of emissions is incorrect. As they have themselves demonstrated, there are many ways to apply GWP*, all of which are consistent with the Allen et al 2018 definition (although the equation is incorrectly applied in RS19's 'zero reference' case). The 'limitations' RS19 note and the 'unintended consequences' are specific to the policy framework in which RS19 presuppose GWP* to be embedded. It is not a limitation of the metric itself.

In the first section, RS19 directly and inaccurately assert that Cain (2019) misunderstands well established climate science by 'suggesting that reducing methane emissions would result in global cooling'. Cain (2019) does not use the phrase 'global cooling', and is clear about the role of methane reductions on climate, consistent with established climate science such as in Solomon et al., (2010). If methane emissions decline globally, the result is a negative contribution to the rate of change in temperature. This is accurately described as cooling, even if overall global mean surface temperature is still above preindustrial levels, or if other emissions are generating a larger magnitude of warming at the same time. For example, if temperatures peak at 2C above the preindustrial baseline and decline to 1.5C, then cooling occurs after the peak.

In the discussion, RS19 incorrectly state that choice of time interval Δt used to determine rates of change of emissions $\Delta \mathrm{E}/\Delta t$ strongly alters results. This is not true of cumulative warming-equivalent emissions, nor is it true of annual emissions when these are changing smoothly over time, as in most policy scenarios, and from which the GWP* concept was

derived. RS19 instead discuss the impacts of setting a zero methane emissions baseline to report annual CO2-we emissions; a use of GWP* which they are the first to introduce, and hence could have also further elaborated to highlight the implications of different Δt values. In any case, altering Δt does not alter the total amount of cumulative CO2-we emissions, just how they are spread across a number of years. By altering Δt from 20 years to 1 year without making the commensurate change to $\Delta \mathrm{E}$, they describe a completely different emissions pathway with different warming implications, which therefore should and does correspond to a different level of warming-equivalent emissions in year t, although no change in cumulative warming-equivalent emissions over a 20-year period. This suggests RS19 have made an error in the rate of change contribution in the GWP* equation, and it is unclear from the manuscript whether the equation was correctly applied to the emissions data to create figure 3.

Finally, we note that conventional GWP100 is also unnecessary to address some of the equity discussions raised. RS19 imply that reporting annual methane emissions per capita using GWP100 can facilitate equitable policy design by highlighting how a number of developed countries are responsible for a disproportionate share of contemporary methane emissions (as shown in table 2). This point could and should be made just as (if not more) clearly by simply reporting the direct methane emissions per capita. Scaling by GWP100 to express this in terms of CO2e serves no purpose except to mislead by suggesting these emissions have an equivalent effect to the reported amount of CO2, which – as stated above and acknowledged by RS19 – they do not.

The discussion of negative emissions is a worthwhile topic, requiring attention if GWP* were to be applied in a policy context. This highlights the need for a comprehensive policy framework to be employed that drives action towards efficient achievement of the Paris Agreement goals. There is no in principle reason why GWP* should not – if correctly applied – reflect temperature contributions under negative emissions scenarios, though we have not developed it for this eventuality. This could be a topic for further work.

3. Summary

Many of the claims of "unintentional unfairness" that RS19 claim arise from innovations in metrics apply not only to GWP*, but to any metrics which successfully mimic the warming effects of a flow of gases, such as CGTP (Collins et al 2019). There is no ethical reason to think that warming from one source ought to be treated differently from warming from another source; doing so is arbitrary. Finally, it can easily be shown that there are important conditions under which the approach favoured by RS19 might be considered more unfair than equal weighting of warming-equivalent emissions.

Consider a world with two countries, Alpha and Bravo. They have jointly signed up to a 1.5°C limit. Alpha's warming (amounting to 1.5°C) comes entirely from CO2, and Bravo's (0.1°C) comes entirely from rice-paddy methane. To meet their joint commitment, warming must be reduced by 0.1°C. On the logic of RS19, this responsibility falls entirely on Bravo; because, they argue, it would be wrong for them to "grandfather" that atmospheric space. We disagree completely.

In our view, the warming from Alpha and the warming from Bravo ought to be discussed and negotiated over together, applying the same principles of justice to both. In a climate change regime complex with the explicit, over-arching aim of limiting warming, the principles of justice ought to be applied to warming, and to emissions as they imply warming, rather than to emissions as characterised for ad hoc, path dependent reasons that are based on an accounting system which cannot satisfactorily represent the warming implications of time-series of gases under mitigation scenarios.

In summary, if it is morally compulsory for countries to reverse their historical contributions to warming from methane emission rates, as RS19 state, then it is equally compulsory for countries to remove their past warming from emissions of CO2. To argue otherwise is to apply principles of distributional justice selectively (Frame, 2019). GWP* allows the cooling that would arise from either removing a tonne of CO2 from the atmosphere or from reducing methane emissions to be accurately equated. It, and related approaches such as CGTP (Collins et al., 2019), is more accurate at linking greenhouse gas emissions with warming impacts than any comparison based on pulse emissions metrics. This point has been made several times in the literature and is not controversial. Unfortunately, RS19 have presented a confused and often inaccurate application of GWP* which draws conclusions that cannot be justified from the results presented and arise from a narrow and partial treatment of the ethical dimensions of mitigation.

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