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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Technical note: On comparing greenhouse gas emission metrics" *by* Ian Enting and Nathan Clisby

Anonymous Referee #1

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General remarks:

1) I could not find the definitions of the manuscript type "technical note" on the ESD website (https://www.earth-system-dynamics.net/about/manuscript_types.html), so I cannot comment on the style of the submitted manuscript.

2) For the mathematically versed, Enting and Clisby provide some gourmet material, I am sure. I am myself not well versed in Laplace transforms, so I cannot comment on those technical aspects of the manuscript and would hope that the reviewer pool contains a knowledgeable person in that regard.

3) Aside from the mathematical beauty of the discussed equivalence metrics: IMHO, this branch of equivalence metrics has gone down a politically completely impractical

rabbit hole. Providing credits or debits to a country or actor under the implicit assumption that that country or actor will keep its emissions constant for all times, is as far away from political realities and practicalities as it can be. The reason is that the metric value of a few hundred or a few thousand (the value of lowering the level of CH4 emissions compared to a one-off emission of CO2) would make countries focus 100% on methane reductions (which would negate any need to do anything else, while methane emissions can be lowered) and as soon as methane emissions cannot be lowered, but increase, e.g. as agricultural production increases etc, the country would face such a heavy "penalty" that it cannot possibly offset that methane increase within a target period (e.g. under the Paris Agreement). Thus, the country would drop out of the international regime. In summary, these emission-rate focussed equivalence metrics like GWP*, while solving a scientific, mathematical problem nicely, would make any international effort of reducing a basket of GHGs politically impractical.

Detailed comments:

Line 64: Provide the reference for the assumed CH4 methane lifetime.

Line 66: Clarify whether the authors suggest adding "one additional CO2 contribution", i.e. increasing the metric value of CH4 by 1 or another value.

Line 73: The linearisation of CO2 forcing – by implying F = alpha * R (the airborne mass) is not necessarily in line with recent line-by-line codes (Etminan et al., 2016). While a valid linearisation for small deviations of emissions, please bring that to the reader's attention.

Line 87: Apologies, that I do not get this. More explanation of this line would be useful.

Line 123: Why should the parameter b be dependent of an annual growth rate – and what would be the advantage of it matching 100-year GWPs in an exponential growth scenario? Explain. . .

Line 137: it is unclear to me what the authors mean with "When metrics are used

for emissions trading, the behaviour at shorter timescales becomes important.". The timescale of interest for a metric is ideally roughly representative with the objective function that policy-makers would like to pursue: like minimising climate change over the next 100 years. Or to limit peak warming in 40 years from now etc. Emission trading only operationalises the emphasis that you would place on the mitigation of one GHG over another. Emission trading itself does not favour "shorter timescales" in terms of the metrics. The authors should explain / clarify what they mean.

Line 145: "in this type of context" is imprecise. The 100-year GWP does, as Figure 3 sort of suggests, pretty much exactly what it promises to do: Creating emission equivalence in terms of cumulative radiative forcing over the 100-year time horizon.

Line 151: The sentence "The increase after several centuries reflects. . . " is unclear. What does it refer to? Please clarify.

Line 174: It is unclear to me why the authors write that for GWP-H, with H being the time horizon, say H = 100yrs, "GWP . . . under-estimates the CH4 contribution from shorter timescales". Well, the GWP-100 is defined that the integral of radiative forcing should be the same from a unit CO2 and a unit CH4 emissions over a 100-year time horizon. So, by design, GWP will then under-estimate the CH4 contribution from timescales that are shorter than the cross-over point (0>x>100), and afterwards over-estimate the CH4 contribution. If CH4 "contribution" refers to the radiative forcing. Please either clarify, correct, or both ..

Line 159: The authors write "The goal of defining emission equivalence is to allow for emissions of different . . . so that a given radiative forcing target can be achieved for the least economic cost". Well, metrics have various explicit or implicit objective functions, but "radiative forcing targets" is not usually one. It is either cumulative radiative forcings (GWPs), which approximately the integrated warming over a certain period of time, or it is warming at a particular point in time (GTPs) etc.. Please clarify / rephrase.

Line 156: It is unclear what the authors want to say with the sentence "For a spe-

cific case, Lauder et al. (2013) suggested an approximate equivalence to changes in methane emissions balanced by an ongoing future CO2 uptake from growing trees". It is unclear whether the authors support that conclusion. In the light of the above discussion, with zero-CO2 emissions being 'equivalent' with non-changing CH4 emission rates (after a CH4 concentrations reach their new equilibrium), whether the Lauder et al. conclusion (as presented here) still holds. Please clarify.

Line 165: In the conclusion, I'd appreciate a bit of discussion from the authors on the general point I raise above, i.e. the practicality of rate-based emission metrics vs GWP-100 in a real-world context.

Figure 3: Maybe I misunderstand the scaling of the y-axes, but the dashed GWP line should not cross the solid CH4 line in year 100, but earlier. The GWP-equivalence is given if the cumulative radiative forcing over a 100-year time horizon is equal. Thus, the crossing of the dashed line should be such that the integral underneath the solid and the dashed (GWP) line is identical from year 50 to year 150. Please clarify or explain why I am wrong in thinking that.

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