Earth Syst. Dynam. Discuss.,
doi:10.5194/esd-2016-55-SC1, 2016

Earth System Dynamics Discussions

Interactive comment on "Accounting for the climate-carbon feedback in emission metrics" *by* Thomas Gasser et al.

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Received and published: 5 December 2016

This paper is a well-written, carefully constructed, and valuable contribution to the metrics literature. This paper improves upon the existing approach of incorporating climate-carbon feedbacks into GWP calculations and will constitute a very useful resource for subsequent assessments that will update these climate metrics. However, we strongly recommend the authors reconsider their recommendation to use the version of the GWP calculated with the climate-carbon feedback as the primary metric.

As noted in the manuscript, AR4 inconsistently calculated GWP's by including climate-carbon feedbacks for CO2 perturbations but not for non-CO2 perturbations. This inconsistency was noted in AR5 which presented climate metrics both with and without climate-carbon feedbacks for the non-CO2 perturbations (based on Arora et al., 2013

and Collins et al., 2013), and we agree with the authors that this inconsistency should be resolved. The use of a climate-carbon feedback that more realistically incorporates an eventual relaxation back to a prior equilibrium for a pulse of climate change, as is presented in this paper, is an improvement to the calculation of a GWP that includes climate-carbon feedbacks. However, one option that was overlooked in AR5, and is presented as a secondary option in this paper, is to remove the climate-carbon feedbacks from both the CO2 and non-CO2 perturbations. We argue that for reasons of simplicity and transparency, that removing the climate-carbon feedback entirely is preferable for calculating GWPs for the use of policymakers.

GWPs have found favor among the metrics community for two primary reasons: ease of computation and simplicity/transparency. Including climate-carbon feedbacks may partially negate both of these benefits of the metric. Without climate-carbon feedbacks, one can calculate the absolute GWP for any given gas (with a known lifetime and radiative forcing) in a simple two-step process. Relative GWP then requires only the use of a previously-calculated 4-exponential function for CO2. However, the calculation of an absolute GWP with climate-carbon feedbacks is apparently a 10 step process (see Figure 4). Including the climate-carbon feedbacks is also shown in this paper to require additional assumptions beyond gas lifetime and radiative efficiency (the only two parameters necessary for the calculation of a traditional GWP). Requiring this choice reduces both the simplicity and transparency inherent in the GWP. Inclusion of climate-carbon feedbacks makes the value of the GWP dependent on attributes of the model chosen – its climate sensitivity, its rate of ocean uptake of heat, and how the carbon cycle changes in response to warming. This kind of additional complexity has been noted as a drawback of the GTP in comparison to the GWP. Incidentally, as the last equation on page 6 shows, the GTP is now effectively a necessary step in calculating the GWP using the methodology in this paper. This approach also requires additional, somewhat arbitrary choices: for example, the authors chose a climate change step of +0.2°C to be approximately consistent with the peak warming of a 100 GtC pulse of CO2 and the approach of Joos et al. (2013), though Figure 3 shows that for step sizes

smaller than 1 degree, this choice does not appear to have a large impact.

Rows 5 and 6 of Table 2 demonstrate that there is little added value in terms of accuracy for the GWP when including the climate-carbon feedback (the 100 year GWP is particularly important as the metric in the most widespread use). The difference between the GWP calculated with and without climate-carbon feedbacks is less than 2% for any the 5 substances considered for any timeframe. This small improvement in accuracy of the 100 year GWP comes at the cost of complexity and lack of transparency as previously discussed. Moreover, despite the good work done by the authors in this paper, it is unclear to what extent use of a different model, parameters, or other choices could lead to changes in this small adjustment to the GWP.

The authors do note that "our results raise the question of whether the climate-carbon feedback should be included in emission metrics", and yet, they "recommend using the metrics shown in this fourth row of Table 2, since they are the most consistent, robust and up-to-date metrics available" (and even raise questions about what other feedbacks should be included, such as climate-wetlands feedbacks). We would strongly recommend that the authors reconsider this recommendation. The authors should continue to present the most up-to-date metrics based on their carbon-cycle models, but we believe that the authors should in fact endorse the use of the GWP without the climate-carbon feedback (in either the numerator or denominator). The authors show that including the climate-carbon feedback offers a slight improvement in accuracy, but in our opinion, that improvement in accuracy is far outweighed by the double drawbacks of increased difficulty of computation and loss of simplicity and transparency. Recommending the use of metrics without the feedback would mean highlighting the 3rd equation in Appendix C.1, as it would then be possible to calculate the GWP for any arbitrary non-CO2 gas given lifetime and radiative efficiency values. The authors could encourage other carbon-cycle modelers to similarly calculate carbon dioxide response functions without the inclusion of carbon-climate feedbacks such that a future IPCC assessment could draw from multiple studies to inform its GWP calculations.

We are, however, less opposed to the inclusion of climate-carbon feedbacks in the calculation of GTPs. Including the feedback in GTPs results in larger impacts than when considering the GWPs (almost 30% as the authors note, for the case of 20 year GTPs and either BC or SO2). Additionally, the additional computational cost, increase in complexity, and loss of transparency are much less powerful arguments when applied to the GTP in contrast to the GWP, since many of those drawbacks are inherent in GTP calculations in the first place.

Again, we commend the authors on an extremely interesting, robust, elegant, and useful analysis, but ask the authors to take our comments into account.

Thank you,

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The views expressed in this comment are those of the authors and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency or other government agency.

Additional technical comments:

We note as a relevant comparison, that Reisinger et al. (2011) calculated the effect on GWPs of using different RCPs to project future concentrations, and found that GWPs could change by 10 to 30% for N2O, -10 to 20% for CH4, and 2 to 36% for the halocarbons. However, the community has to date retained the assumption of constant background concentration, presumably in order to preserve simplicity and to avoid the necessity of choosing a single future emissions scenario (or combination of scenarios). The effect of this simplifying assumption is an order of magnitude larger than that resulting from the inclusion of climate-carbon feedbacks.

Page 1, line 14: “the IPCC presented tentative values”: The text of AR5 was not clear that the climate-carbon feedback values were to be considered “tentative”, nor does this match the way that the AR5 values have been perceived and used by the community.

Page 2, line 16: “The standard metrics provided in the fifth assessment report”: Similarly, the text of AR5 was not clear that the version of the metric that did not include climate-carbon feedbacks for non-CO2 gases (and was therefore “inconsistent”), should have been considered “the standard metric”.

Page 11, line 16: The phrasing of the following sentence could be improved: “which is itself the value chosen by Joos et al. (2013) – and therefore by the IPCC”: while the IPCC implicitly endorsed the approach of Joos et al., there was no explicit determination that 100 GtC or +0.2 degrees C is the optimal value to use. The IPCC can be limited by the literature available, and the choice of a given paper to support a parameter choice does not necessarily indicate endorsement of all the choices made within that paper. A preferable phrasing would be, “which is itself the value chosen by Joos et al (2013), which provided the carbon lifetime used by the IPCC” or something along those lines.

Page 11, line 18: the text refers to “Figure 5” as an illustration of the GTP calculation process, but should be corrected to refer to Figure 4.

Page 14, line 6: the authors do note that the inclusion of the feedback has less than a 10% impact on GWPs and GTPs, but the fact that the impact is less than 2% for other GWPs, even for short-lived species, for any time horizon, is an important distinction that is not sufficiently emphasized in the text. GTPs and GWPs are clearly impacted very differently here.

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