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Interactive comment on "Comparison of physically- and economically-based CO_2-equivalences for methane" *by* O. Boucher

Anonymous Referee #2

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This manuscript does a good job comparing some aspects of global warming potentials, global temperature change potentials, and the author's implementation of the global damage potential. Overall, it is clearly written and interesting. I generally like the logical flow and what the author is trying to accomplish. I particularly liked the presentation of the sensitivities of the GDP to various assumptions. Although my background is not in economics, I also found the discussion relating the economics of CO2 and CH4 emissions reductions with the policy equivalence metric interesting and thought provoking.

I believe that this manuscript can be a useful addition to the literature. However, I do have some concerns that I believe must be addressed before publication. In addition to the specific issues listed below, one of my biggest general concerns involves the

calculation of uncertainties. This is an important part of the work, but I do not feel that the uncertainties on the individual terms are suitably justified. Perhaps the most important one involves the discount rate. This is a highly contentious issue, and the uncertainty range has been assumed to be a rather narrow 1-3% per year. As I state below, I strongly believe the lower end of this should be reduced. For example, there has been some work that suggests that large climate change could lead to large areas of the tropics being uninhabitable to mammals. Even though that level of climate change is not expected in the near term, how does one discount away such an effect? Another uncertainty that I do not feel has been thoroughly probed is the damage function. This is highly uncertain, even the functional form, and will be dependent on the climate change impact of interest. Varying the exponent in a single functional form is likely not sufficient. I believe the inadequacies of the assumed parameter uncertainties make the resulting statistics (standard deviation, confidence ranges) of the GDP values far too conservative. It may even affect the mean.

Specific comments (page, line number):

2 23 Clarify "some degree of visibility"

4 14 seeks

6 2-4 This is an interesting question. It seems that if you raise it, you should provide some thoughts on an answer. Unless I just missed it, you have not.

8 2-3 It would be helpful to have references for the uncertainty ranges adopted included in the table. There needs to be justification for all of the uncertainty ranges. If nothing exists in the literature you should provide reasons for why you settled on these particular values, and perhaps some indication of how much confidence you have in the uncertainties adopted.

8 13-14 Make it clear you are only talking about the pulse response function here, not the RF.

8 21-22 You are probably making this assumption because you do not have future CO2 concentrations in your model. You should tell the reader here that you will address the impact of this assumption later in the text.

10 5 You could use a polynomial fit to demonstrate the sensitivity of the results to the functional form assumption. Since this function is so poorly constrained, and one of your purposes is to examine uncertainties, it is not sufficient to just choose one form and perturb the exponent in a rather narrow range.

10 15 I assume you mean “unacceptable”. If so, provide more explanation here.

10 23 This range of discount rates does not seem to encompass enough range. While 3% may be fine for an upper range, 1% is not low enough for the bottom end. A choice of 1% implies that every 70 years you discount damages by half. Thus, processes that happen on long time scales (e.g., sea level rise) are prescribed to be nearly irrelevant. I agree that there is much debate on the discount issue, but if you do not choose a lower rate to show the sensitivity to this factor, a large number of readers will find your results irrelevant. The fact that your range is the same as Hammitt is not suitable justification.

11 5-6 However, it has been shown that an effective discounting is consistent with a GWP time horizon choice, admittedly a discount rate that changes with GHG lifetime. You point this out in the conclusions, but it might be worth mentioning here as well.

11 8-10 This discussion could be clarified by reminding the reader that the “linear” cost function is consistent with the GWP.

Section 3.3 I very much like the way you have explored the sensitivity, first one parameter at a time, and then with a Monte Carlo approach.

13 24-26 This is indeed a noteworthy finding. Not surprising, but informative nonetheless.

Table 2. More explanation is needed regarding the Monte Carlo runs for GWP and GTP. Why are there no max and min values when you do show a probability distribution?

15 9-11 Provide a physical explanation for why there are such outliers. I assume that several parameters just happen to fall at the correct extreme (e.g., parameters 3, 10, 11, and 12) and it happens very rarely. Also, consider expanding the Figure 4 x-axis to include all values (i.e. out to 64).

15 19 Can you go further on the next page to support this statement? For example, it appears to me that you could show that the sustained emissions approach would yield a different metric depending on the discount rate, emission time, length of sustained period, etc. Because of this, it is more convenient to deal with pulse emissions as you have suggested.

16 11 You could clarify the justification for this equation. First, make it clear that the X and Y values are marginal cost reductions. Then you can point out that the marginal costs of reduction generally increase with increasing reduction, so that the “investor” will continue to make additional cuts until this equation is satisfied.

16 11-17 I think of the relationship between equations (10) and (11) a bit differently. You could write an equation that is analogous to (10) for CH4. Then, ratioing the two equations would yield equation (11). Your justification for equation (11) did not appear to be as obvious.

16 14 There is no discount rate in Eq (1). I assume you mean in Eq (3). But I still do not understand this statement. If the discount rates are not the same, it appears that the RHS of equation (11) would be different from the RHS of equation (13), making it impossible to compare the costs of emission reductions to the metric.

17 13-14 It seems to be stronger and still correct to say that generally, the CH4/CO2 equivalence should not be constant over time.

17 13-19 Another implication is that the equivalence depends on the future concentration scenario.

17 19-21 Please provide more discussion about this point. For example, a metric could

be used (in place of the GDP) that leads to a constant CH4/CO2 equivalence over time. Also, couldn't a metric be used in place of the GDP that would lead to sustained emissions metric making as much sense as a pulsed emissions metric on the right hand side of eq (13). I admit I may be missing the point here. If so, please further clarify your statement.

18 5-6 I am not completely convinced that you have bounded these values. See my earlier comments on the cost function and on discounting, and on uncertainties in general.

18 11-12 I suggest rewording this. It sounds like you want an ad hoc way to raise the CH4/CO2 equivalence. Past literature has shown that for certain situations, an increase is consistent with policy goals; it is not just something imposed.

18 12-13 Because of the importance of the damage function to your results, I would like some additional discussion of it. How well can it be bounded, for example. What is the justification for it being convex rather than linear? Please provide discussion and additional references.

18 18 They are both cumulative.

19 3-6 This makes it sound like you expect the GTP to agree with your GDP, and that the GTP is somehow inferior because it doesn't. By comparing an integrated quantity with a point-in-time quantity, you are really comparing apples with oranges. I suggest rephrasing and making it clear what the comparison really means.

19 15 I am not certain what you mean by "across sectors".

19 14-15 Also different impacts (e.g., precipitation vs. sea level) may be characterized by very different damage functions regionally and globally.

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