

Interactive comment on “Incremental improvements of 2030 targets insufficient to achieve the Paris Agreement goals” by Andreas Geiges et al.

Anonymous Referee #1

Received and published: 22 December 2019

1. Summary and general comments

This paper examines GHG emissions out to 2030 as pledged in the NDCs of the Paris Climate Agreement and create scenarios for further reductions, then extends these emissions scenarios to 2100 with statistically analogous scenarios from an existing database. The paper translates these emissions scenarios to end-of-century global mean temperature anomalies (relative to preindustrial) using a simple climate model, MAGICC6, and examines the consequences of such temperature increases for sea level rise, maximum temperature days, and economic damages. Based on this analysis, the paper states that the global community needs to reduce emissions noticeably

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more than they have already committed to do with the existing NDCs if they wish to avoid climate catastrophe, as none of the scenarios presented herein provide end-of-century temperature below the Paris Climate Agreement goal of 1.5 degrees of warming.

Overall, this paper is very well-written in terms on language and accessibility, with very few typographical or grammatical errors as well as a relatively straightforward and clear writing style. The paper is informative without being overly technical, and does a great job of succinctly placing the more technical modeling results in the context of a range of real-world consequences.

However, there is one significant problem with the submitted manuscript that should be addressed prior to acceptance for publication. As detailed below, the MAGICC6 model tends to warm more quickly than the aggregate of CMIP5 atmosphere-ocean global climate models. Furthermore, the CMIP5 AOGCMs warm more quickly than observations. As a result, the paper as submitted provides an overly pessimistic view of the GHG emission reductions that will be need to meet the Paris Climate Agreement. Upon revision, this tendency for MAGICC6 to overestimate warming needs to be addressed.

2. Specific comments

The relationship between 2030 emissions and 2100 temperatures constitutes the core of this paper. The methods state that MAGICC6 is run with the climate sensitivity range of AR5, largely driven by CMIP5, and the carbon cycle range of C4MIP. However, MAGICC6 tends to exhibit a faster increase in global mean surface temperature (GMST) than AOGCMs when run with comparable values for climate sensitivity (Schwarber et al. 2019, ESD, doi: 10.5194/esd-10-729-2019 – particularly figure 4). Also, the CMIP5 AOGCMs tend to warm more rapidly than observed GMST (AR5 figure 11.25; Fyfe, Gillett, and Zweirs 2013, Nature Clim Change, doi:10.1038/nclimate1972; Millar et al. 2017, Nature Geoscience, doi:10.1038/ngeo3031). Projections of future GMST provided by observationally constrained models are similarly noticeably

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lower than those from free-running AOGCMs (Chylek et al. 2016, *Climate Dynamics*, doi:10.1007/s00382-016-3025-7; Salawitch et al. 2017, Springer International Publishing, doi:10.1007/978-3-319-46939-3).

While this paper is in line with IPCC's estimate of necessary reductions from the 1.5 degree special report, the report largely relies on just MAGICC6 and FAIR (another simple climate model) to make these emissions statements. FAIR is only marginally better than MAGICC6 at meeting the median CMIP5 temperature response, as shown in Schwarber et al. 2019. MAGICC6 has enough tunable parameters to produce results in-line with CMIP5 models (Hartin et al. 2015, *GMD*, doi:10.5194/gmd-8-939-2015; Meinhausen et al. 2011b, *ACP*,* doi:10.5194/acp-11-1457-2011) and, presumably, observed GMST. However, these scenarios are not explored, and represent a shortcoming in the submitted paper. As a result, the warming scenarios used in this paper likely have a noticeable hot bias.

*(Meinhausen et al. 2011b, *ACP*, the companion paper to the one cited; it shows comparisons of MAGICC6 being both in line with and warmer than AOGCM results under different presentations)

The consideration above would, of course, bring into question the core proclamation that none of the suggested NDC improvement scenarios meet the 1.5 degree goal. If the actual climate system does not warm as much under the ALL33 scenario (or any other scenario) as suggested by the MAGICC6 model runs, the likelihood of meeting the 1.5 degree goal would be much higher than suggested in the submitted paper. This criticism is not to suggest that the core message will change dramatically if the potential hot bias is accounted for – it could still very well be that the ALL33 scenario does not end below the 1.5 degree goal, or does end below 1.5 degrees but not strongly enough to say it would do so with sufficiently high confidence. However, for this paper to be considered for publication, more justification (and/or context) needs to be given for the amount of warming that results from each emissions scenario, with careful attention to how well MAGICC6 can simulate observed warming.

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On one hand, if this particular configuration of MAGICC6 does definitively have a hot bias (as indicated by papers cited above), its use could be justified by stating that application of a hot model means any emissions scenario that meets the 1.5 degree goal under this analysis should meet that temperature goal no matter what model (or ensemble of models) is considered. That is, intentional underestimation in an emission scenario's potential success has the policy benefit of higher confidence in that scenario overall. On the other hand, statements such as the penultimate sentence of the abstract (lines 15-17), the opening paragraph of section three (lines 156-159), or the "clear evidence" conclusion (line 257) should probably be made based on likely warming scenarios, not on warmer-than-average scenarios.

3. Technical/other comments

Line 112 – spacing

Lines 136 to 140 – sentences are a little hard to follow

Line 165 – verb confusion

Lines 173 to 176 – I don't follow this sentence at all

Line 180 – the unit "cm" is separate from its numbers on the previous line

Line 181 to 182 – the two parts of the sentence are ordered backwards from what a reader might normally expect

Table 2, NDC column, 2300 row – spacing

Lines 219 to 220 – the last phrase here feels awkwardly worded

Line 245 – unnecessary comma after first word; also "...each country's specific..." (possessive)

Line 249 – unnecessary capitalization ("Land use")

Overall – aside from the major reservation about warming bias in the chosen model,

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this is a very well-written and well-reasoned paper

Interactive comment on Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2019-54>, 2019.