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Earth System Dynamics Discussions

Interactive comment on "Regional variation in the effectiveness of methane-based and land-based climate mitigation options" *by* Garry D. Hayman et al.

Anonymous Referee #1

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Review of esd-2020-24: Regional variation in the effectiveness of methane and land-based climate mitigation options

Summary

The authors present and apply a method for examining the contributions of methane and land-based mitigation to meeting 1.5 and 2 degree warming targets. They give a thorough description of their modeling framework and present the results of an ensemble analysis of individual and combined contributions of methane vs land mitigation to emissions reductions and how these reductions can allow for complementary fossil fuel emissions. They conclude that methane mitigation contributes 2-4 times more reduc-

tion potential than land-based mitigation, depending on the BECCS assumptions. They also show that there are regional differences in how effective BECCS is compared to afforestation/reforestation, and estimate that bioenergy crop productivity must be fairly high in some places (with low transport losses) for it to be an effective strategy. They also show that water usage for BECCS may impose limits to BECCS deployment in some regions.

Overall Response

This is an interesting and well-thought-out paper that examines key uncertainties in how to reach 1.5 and 2 degree targets. While I am not an expert in methane dynamics, the description of the framework is detailed enough to convey that the approach is reasonable for this analysis (assuming the methane references this is based on also have adequate methods). My main concern is the framing, and there is also some clarification of the experimental design that is needed. I elaborate on these two things here, with more detail below.

1) While I can appreciate the goal of presenting alternatives that allow for some fossil fuel emissions in these strict scenarios, this goal is not clearly articulated, and I am not sure that it is the most reasonable framing for this issue. Given that these are idealized scenarios and that there is considerable uncertainty on the adoption of mitigation policies, the actual extent of implementation of mitigation strategies, the assumptions and efficacy of mitigation strategies, and the modeling method, the estimated reduction levels here indicate that these approaches are more at the level of additional measures that would help ensure meeting particular targets under certain fossil fuel emission scenarios, rather than allow for more emissions to occur. Stating that doing these other mitigation actions allows for more fossil fuel emissions simply shifts responsibility away from the primary cause and increases the risk that these targets would not be met (the probability of exceedance is not particularly low to begin with). I suggest re-framing the study as additional mitigation potential or “insurance” mitigation potential. Barring a complete rework of the framing of the study away from allowing more

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Discussion paper

fossil fuel emissions and toward additional mitigation potential, there at least needs to be more discussion regarding the magnitude of these results in relation to the large uncertainties inherent in mitigation approaches, idealized scenarios, and modeling.

2) The description and figures and tables associated with the experimental design and its corresponding conditions are inconsistent and confusing.

Specific comments and suggestions

Abstract

lines 29-31: You should include that BECCS assumptions in general contribute to most of this range.

Introduction

You should include a description and examples of the expected emissions for 1.5 and 2 degree targets, which generally indicate that total (and fossil fuel) emissions need to drop to zero or negative to reach these goals. This provides a better context for why you are looking at how methane and land mitigation can alleviate the pressure to eliminate fossil fuel emissions completely.

Approach and Methodology

line 149: What is the first variable k?

line 172: It isn't clear how the global annual CH_4 concentration is used to linearly interpolate monthly ozone values.

lines 203-204? Why only the non-CO_2 components? If the models use different radiation schemes the CO_2 component could also contribute to this uncertainty. Unless the CO_2 radiative forcing is calculated the same way across the GCMs and in IMOGEN?

line 208: They "use" or "define" a framework?

line 207: "emissions"

lines 219-265: (section 2.3) This is very confusing and doesn't align with figure 3 or table 2. Table 2 is the most clear expression of the experimental design and should be used to organize this section and should be referenced up front. I suggest starting this section with a clear explanation of how many scenarios there are and each of the distinct components used to build them. Also, the nomenclature across the text, table 2, and figure 3 is inconsistent, adding to the confusion. It is also unclear how you reach different temperatures for control simulation, which appears to have a prescribed radiative forcing. I presume that the total radiative forcing is not prescribed, and that CO2 conc. and associated CH4 conc. feedbacks adjust to meet the prescribed temperature.

line 231: specify "...reduction in CH4 emissions..."

line 240: figures 4 and 3 should be switched

lines 267-281: Are you assuming that carbon stored in the atmosphere is just CO2?

line 296: Is there a better word than "productivity" here? Maybe "efficacy" or "mitigation potential"?

lines 328-353: this section 2.5 should be moved up and merged with section 2.3 (see previous comment) in order to clarify the experimental design.

Results and Discussion

line 367: and saturation effects?

lines 370-378: I would also like to see this put into the context of overall scenario uncertainty, as this is highly dependent upon human action. For example, the methane-related-mitigation AFFEB (over 85 years) is on the order of only about 6 years of late-century SSP5-8.5 emissions, which is a reference scenario. In the greater context, the potential methane mitigation effects represent more of a cushion or insurance approach to meeting idealized targets.

lines 379-383: This appears to be true, but this may be a coincidence as the dynamics appear to be quite different between separate and coupled mitigation. the figures do not show the correct breakdowns for the linear sum.

lines 389-415: section 3.2 Is this for the 1.5 degree scenario only?

lines 413-415: Clarify that this is the BECCS only amount (for only 1.5 degrees?), which is double the original amount. Also add the numbers for land mitigation potential shown in figure 7c-d, as these are apparently in the abstract (100 GtC) and are comparable to the numbers in the previous section. This also makes a better case for "strong sensitivity" to BECCS assumptions, although tripling productivity and reducing transport losses by 2/3 to get a doubling in reduction is hardly a "strong sensitivity."

line 430: larger than what? the land mitigation? You should also note the exceptions here, which are abundant: canada, mexico, south america, brazil, west africa, south africa, korea, japan

line 473: "...regions that produce..."

lines 481-482: This needs more explanation. It isn't clear from the figure that these three regions have water issues under this case, especially china. While two of them would use all water availability, one does not, and none appear to exceed availability.

line 469: Table 4 should include BECCS demand and percent of available used in the example cases. Then you would have a basis for the statement in lines 48-482.

Conclusion

line 499: This "strong sensitivity" is not clear from the paper. The results can more clearly explain how BECCS mitigation can double, although based on tripling of productivity and a 2/3 reduction in transport losses, which nearly doubles the land mitigation potential. This is tremendous increase in BECCS efficacy to get this result, so I am not sure that it is a "strong sensitivity." And you don't show what figure 11 looks like with the original beccs values, to see how much difference the beccs efficacy makes on land cover. Also note that this has a much smaller relative effect on the total AFFEB.

Tables and Figures

Figures 3 and 4 are out of order.

Figure 3 The legends and the caption and table 2 and the references in the text don't match, which makes the experimental design unclear. The CH_4 plots are c, e, g

Figure 6 Is the linear optimized the sum of ch4 and land based mitigation? Is so, then the bar breakdown is incorrect, as the coupling changes the land response.

Figure 7 again the linear sum does not look correct

Figures 12 and 13 I am confused about water withdrawal vs. irrigation demand. Isn't water withdrawn for irrigation? is this irrigation demand assumed to be additional water withdrawal?

Table 4 You should include BECCS demand and percent of available that would be used.

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