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Interactive comment on "Reviews and syntheses: Four Decades of Modeling Methane Cycling in Terrestrial Ecosystems" *by* X. Xu et al.

Anonymous Referee #5

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The manuscript by Xu et al. reviews the past four decades of modeling methane emissions from terrestrial ecosystems. The authors provide a timeline and structure for assessing both the level of detail in terms of the processes represented and also in terms of how the processes are represented. Overall, the authors do a very nice job of comprehensively summarizing the current state of art in methane modeling and tracing the history of model development over the past four decades.

My main comments are : 1. The authors categorize the representation of processes into empirical to mechanistic approaches. This is rather subjective and it would be very helpful for the reader to have a section (1-2 paragraphs) describing how the authors define these terms. For example, even some of the mechanistic representation of processes rely on empirical response functions, and are thus only semi-mechanistic. In an ideal setting, what would be the definition of a purely mechanistic modeling approach?

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2. Some of the descriptions of the processes are fairly vague. For example, even the description of methanogenesis is abbreviated to just mentioning "acetoclastic and hydrogenotrophic methanogenesis". Given that the authors are trying to emphasize a more mechanistic modeling approach, increasing the level of detail for each process would be helpful.

3. The discussion on substrate is particularly useful because most methane models do not consider this explicitly. Given the rise of atmospheric CO_2, addressing how substrate has changed due to CO_2 interactions, and what this means for modeling approaches and methane emissions is necessary to be mentioned.

4. Lastly, in the discussion for data needs, the list and ideas for integration within models is also very helpful. However, some discussion of the benchmark targets that the modeling community should aim for, and how to handle the uncertainties in benchmarks, would be very useful.