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Discussions

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Interactive comment on "Improved ELMv1-ECA Simulations of Zero-Curtain Periods and Cold-season CH$_4$ and CO$_2$ Emissions at Alaskan Arctic Tundra Sites" *by* Jing Tao et al.

Anonymous Referee #2

Received and published: 21 December 2020

The manuscript by Tao et al. describes an improved capacity of the ELM land surface model to simulate the zero-curtain period and cold season greenhouse gas emissions. The paper is well-written and the changes made to the model are well-described. I don't see large shortcomings to this paper but, like the other reviewer, it would be nice to have a few more clarifications on why certain approaches were chosen and to place the results in a broader context.

First of all, the model is only tested on four sites in Alaska. Two are from the same area, while the other two are further inland. I'm not convinced that this climatic gradient is sufficient to capture the dynamics of the cold season across the Arctic, which is the

stated goal by the authors for their next paper. Especially since the model does not capture the soil temperature during the cold season at IVO. This may be due to the model setup (e.g. soil conditions or atmospheric forcing), but could also be due to an incorrect simulation of the insulation of the snow as suggested by the other reviewer. In any case, this does not add confidence that the model will perform well in, for example, central Siberia or in the sub-Arctic, where winter conditions are quite different from the north slope of Alaska. This regional bias needs to be considered in the text since it is essential to judge the performance of the model.

Second, the simulation of cold season greenhouse gas emissions is much improved but, again, with only a few sites used for validation this may be getting the right numbers for the wrong reasons, when the model has been specifically optimized for these sites. The addition of cracks and plant remnants to act as conduits to the atmosphere makes sense, but this is a rudimentary solution that does not enable the simulation of sudden bursts of CO_2 and CH_4 which have been observed across the Arctic during the cold season – including at Barrow (Mastepanov et al., 2008; Pirk et al., 2017; Raz-Yaseef et al., 2017). A discussion on why the model is not able to do this, and how this may lead to a systematic bias would be warranted.

Finally, the paper is incredibly detailed, which is generally welcome, but in this case there are simply too many figures and tables. The information presented in Figure 5 overlaps with Figure 3 and Table 4, for example. I suggest that some of these figures and tables are moved to the supplemental information, especially when they're only briefly discussed in the text.

Also, some of the figures are incredibly busy because several parameters are plotted together but this makes it confusing to me what I'm looking at without continuously checking the legend. The colors are hard to distinguish from each other, especially the yellow color when printed. It would also help if the observations are plotted with a clear black line or dashed vs continuous, for example, and that soil moisture and temperature are also plotted with different line types.

Minor comments:

Page 4, Line 110: were these gaps large? If gaps were only a few days this is fine, but it would be good to know if weeks or months of data needed to be gap-filled.

Page 6, line 176-177: no need to specify that the 'S' stands for supplemental. This is rather standard knowledge.

Page 13, line 405: it's unclear to me why there's an ensemble of grey dots for the NewPC_NewDecom_NewCH4 but not for the other dots? This is not well-described in the caption or the text.

Page 18, line 562: please elaborate on why the single static multiplicative function would not be appropriate.

References

Mastepanov, M., Sigsgaard, C., Dlugokencky, E. J., Houweling, S., Ström, L., Tamstorf, M. P. and Christensen, T. R.: Large tundra methane burst during onset of freezing, Nature, 456(7222), 628–630, doi:10.1038/nature07464, 2008. Pirk, N., Mastepanov, M., López-Blanco, E., Christensen, L. H., Christiansen, H. H., Hansen, B. U., Lund, M., Parmentier, F.-J. W., Skov, K. and Christensen, T. R.: Toward a statistical description of methane emissions from arctic wetlands, Ambio, 46(1), 70–80, doi:10.1007/s13280-016-0893-3, 2017. Raz-Yaseef, N., Torn, M. S., Wu, Y., Billesbach, D. P., Liljedahl, A. K., Kneafsey, T. J., Romanovsky, V. E., Cook, D. R. and Wullschleger, S. D.: Large CO2 and CH4 emissions from polygonal tundra during spring thaw in northern Alaska, Geophysical Research Letters, 44(1), 504–513, doi:10.1002/2016GL071220, 2017.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2020-262, 2020.