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Interactive comment on "A simplified permafrost-carbon model for long-term climate studies with the CLIMBER-2 coupled earth system model" *by* K. A. Crichton et al.

Anonymous Referee #2

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General Comments:

This is a valuable approach, as simplified models of permafrost carbon processes are required for simulations on interglacial timescales. The presentation is generally good, though more details on the rationale for making some of the specific choices of simplifications required for this type of modeling approach would help the reader to better understand tha applicability of the approach.

My main issue with this paper is that I have a hard time understanding how the model treats the huge differences in permafrost properties that are required given the enormous grid cell size, and whether this treatment makes sense. There are a large number

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of tunable parameters required in creating such a simple scheme, and while I recognize the importance of this approach, it would be informative to give some more detail on the sensitivity of the results to the values of these parameters.

More description is needed of the subgrid vs. re-mixing model, with a general introduction to the corresponding ideas behind each of these here. I think I understand it to be that either the C is kept separate between the permafrost-affected and permafrost-unaffected fractions of a gridcell, but more description of the assumptions made by each approach is required. Given the large gridcell size of CLIMBER, this would seem to be a critical question and more detail may be needed of the relative merits of each of these approaches before just assuming that one of them is more appropriate for all cases.

In any of the subgrid approaches, I don't see any mention of the model taking into account horizontal gradients in properties such as the temperature or frost index, nor how permafrost properties such as the frost index actually vary nonlinearly as functions of climate. Given the highly nonlinear behaviour of permafrost in general and permafrost carbon in particular, I would want to understand better how the gridcell-mean quantities vary relative to the diagnosed gridcell fractions. For example, if the climate were interpolated to a higher resolution (say the 2-degree resolution typical of GCMs), would the permafrost area change significantly? How about the permafrost C?

Specific Comments:

What is the CLIMBER timestep? I think that this may be an equally important concern as the spatial resolution question for determining whether to use a heat-diffusion approach versus the permafrost index approach used here.

I'm not sure I understand what the role of term b in equation 3 is, nor the domain over which this function is applied.

What is the physical meaning of the "slow" C pool here, which according to figure 12

does not equilibrate even on the glacial-interglacial timescale?

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