

Review of ‘The importance of a surface organic layer in simulating permafrost thermal and carbon dynamics’ - Jafarov and Schaefer

October 23, 2015

1 Overview

Thank you for your improvements, especially in the ‘Methods’. It is now clear what model developments were implemented and how the initialisation was carried out.

Now I can see the overall picture, it is apparent that the emphasis of the paper needs changing. The emphasis currently is too much on the fact that including an organic layer improves thaw depth. This is not new, as seen by the references you provide to papers making this conclusion (eg. Lawrence and Slater, 2008). However, there is interesting science in this work, and it would be beneficial to change the emphasis of the paper to highlight this.

I suggest that the emphasis should be more on the carbon. The dynamic organic layer directly improves the distribution of carbon, as well as indirectly through the improved thaw depth. The changes to root depth also improve the distribution of soil carbon, as do the changes to initialisation of carbon. Thus, perhaps the main focus of the article could be the improved distribution of soil carbon, as all of the developments contribute to this.

As a motivation, it is well known that the carbon fluxes depend strongly on the amount of carbon that is present, and so beginning with the correct distribution is a prerequisite for considering the permafrost carbon feedback.

At present there is not a strong conclusion: the conclusion reads more like an extra piece of discussion. To make a stronger conclusion around the focus of soil carbon, you could say something along the lines of: “we improved the distribution of soil carbon by [quantity] and showed that the remaining differences are due to [factors].”

The abstract definitely requires some numbers, in particular indicating how much the soil carbon distribution has improved.

It would also be valuable to determine which of the model improvements has the greatest impact on carbon stocks and which is most important to include in land surface

models: in particular, take into account which aspects have not been widely considered in land surface models and make some recommendations for model developers.

The results and discussion do not form a clear narrative at present. I think they need to be re-written bearing in mind the slightly different focus and what your conclusion will be. Take the different threads of model improvement (thermal properties, carbon accumulation, and carbon initialisation), and draw these together to make a logical progression towards the conclusion, finishing the discussion with an evaluation of the improved distribution of soil carbon.

2 Detailed comments

Abstract: Need to include some numbers. Add some results at the end of the abstract, such as, “taken together, these developments improve the simulated present-day soil carbon distribution by [amount] compared to observations.” Don’t just say “Our results indicate” - actually state what the results are.

Introduction: You discuss the fact that the surface organic layer is important for thermal dynamics, and in turn the thermal dynamics impact the vulnerability of soil carbon. However, you should also emphasise that having the correct soil carbon stocks in the beginning of the simulation is important.

Last paragraph of introduction - Say more about the aim of the work rather than just stating what you did. For example: “In this work we aimed to improve the present-day soil carbon stocks in the SibCASA model, in order that simulations of future carbon release would not be biased by incorrect present day stocks. We took three different approaches to achieve this: firstly improving the thermal dynamics and ALT, secondly improving the carbon dynamics and build-up of carbon stocks in the soil, and finally initialising the older carbon with the observed distribution to get around the problem that carbon in different parts of the world originates from different climates and time periods.”

Methods: Sections 2.2 and 2.3 need a little reorganisation.

Lines 159-165 are out of place in the narrative (since that section is about the top organic layer). The following sentence should be in the previous section (2.1): “The current version of the model initializes the permafrost carbon by assigning carbon to the soil carbon pools below the maximum thaw depth. These frozen pools remained inactive until the layer thaws.” And the part about roots should be in the next section (2.3), but be aware that there is then some repetition in that section.

Why does the title of section 2.3 include ‘soil thermal factor’ - that does not seem to be in this section? Maybe it should be ‘soil freezing factor’?

I find Section 2.3 altogether a bit lengthy and still somewhat unclear. I take it the GPP also has a scaling due to soil moisture that is not defined in the text? So the constraint due to soil freezing is on top of the constraint due to availability of unfrozen

soil moisture. Do you have some more thorough justification for this?

There is a lack of clarity in the writing, mainly related to whether things happen in real life or in the model, for example in the following sentences: “Soil thaw always lags behind warming of the canopy. Photosynthesis is limited by water availability as well as canopy temperature and starts later in spring after the surface soil layers thaw out. Before the changes described below, leafout and new root growth occurred as many as 60 days before the start of photosynthesis.” - e.g. here it is not clear to me whether the first two sentences occur in reality, the model or both, whereas I can tell that the third sentence is about the model, although this is merely implicit. Please clarify ‘in reality’ or ‘in the model’ in all such cases where it might be unclear. Also please avoid repetition.

Regarding equations (6) and (8) (note, these need re-numbering) you should mark the indices ‘k’ to make it clear which quantities are given for each soil layer and which are for the whole column.

Results, Discussion, Conclusion: Could do with overall re-writing and re-structuring so I will not make many detailed comments at present.

I do not think Figure 4 adds to the scientific narrative. You have stated the result in the text (“an overall 9% reduction in GPP for the entire permafrost domain, nearly all of which occurred in spring.”), and this is sufficient for the paper.

Regarding the vertical distribution of carbon (Figure 5): as well as discussing why it still differs from reality, how about comparing it with the old model version to show the improvement? Can you also plot the profile without the dynamic organic layer?

The division of content between results/discussion/conclusion is not correct at present. Some discussion and conclusions appear in the results, and a lot of discussion appears in the conclusion. There is also some repetition. Please reorganise.

In my previous comments I asked for the discussion of the variations in ALT to be more rigorous. When I suggested correlations, I simply meant to give the value of the correlation coefficient to back up your claims of which factors are important for ALT: I don’t think that showing plots of one variable plotted against the other is particularly useful, so would suggest not to include Figure 9. Figure 8 is enough, and your discussion more like it was in the original manuscript, simply backed up by numbers as you go along to make it rigorous. The new discussion on this topic is a bit lengthy.

I hope these comments are useful. I realise that changing the emphasis of the paper requires some work, and that you may have a different idea about what to focus on, but I hope that you agree that the improvement in thaw depth due to organic layer is not so original compared with some of the other results (for example, most land surface models spin up carbon to equilibrium which does not deal with the old deposits as you have done here). Perhaps you would prefer a different emphasis from what I suggest, but either way I look forward to seeing a revised paper! Best wishes.