Does the paper address relevant scientific modelling questions within the scope of GMD? Yes

Does the paper present a model, advances in modelling science, or a modelling protocol that is suitable for addressing relevant scientific questions within the scope of EGU? Yes

Does the paper present novel concepts, ideas, tools, or data? Partly

Does the paper represent a sufficiently substantial advance in modelling science? Partly

Are the methods and assumptions valid and clearly outlined? Partly

Are the results sufficient to support the interpretations and conclusions? Partly

Is the description sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)? In the case of model description papers, it should in theory be possible for an independent scientist to construct a model that, while not necessarily numerically identical, will produce scientifically equivalent results. Model development papers should be similarly reproducible. For MIP and benchmarking papers, it should be possible for the protocol to be precisely reproduced for an independent model. Descriptions of numerical advances should be precisely reproducible. No

Do the authors give proper credit to related work and clearly indicate their own new/original contribution? Yes

Does the title clearly reflect the contents of the paper? The model name and number should be included in papers that deal with only one model. No, see my suggestion

Does the abstract provide a concise and complete summary? Yes

Is the overall presentation well-structured and clear? Yes

Is the language fluent and precise? Yes

Are mathematical formulae, symbols, abbreviations, and units correctly defined and used? Yes

Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated? Yes

Are the number and quality of references appropriate? Yes

Is the amount and quality of supplementary material appropriate? For model description papers, authors are strongly encouraged to submit supplementary material containing the model code and a user manual. For development, technical, and benchmarking papers, the submission of code to perform calculations described in the text is strongly encouraged. NA general comments:

This paper addresses a very interesting topic. The land surface components of Earth System Models usually make two fundamental simplifications in the model used for computing subsurface temperatures: 1) the geothermal heat flow is not taken into account, 2) the models have an insufficient depth extent to compute the effects of typical climatic thermal perturbations in the subsurface, without being affected by the lower thermal boundary condition. The effects, of both simplifying assumptions are addressed in this paper, focusing specifically on permafrost evolution and the storage/release of carbon in vegetation and soil. The subject of the paper is not new, as the authors acknowledge on page 2, but the effects have thus far hardly been quantified.

However, the authors have not provided a full description of their permafrost/thermal model. Are phase transitions incorporated? Do they couple active layer thickness changes to the hydrology model? What is their definition of permafrost in terms of ice-water content? How are the blanketing and buffering effects of snow on the surface incorporated? Many such descriptions are missing.

In addition, the authors assume a constant regolith thickness of a few meters, without porosity-depth changes, and a granitic bedrock to occur worldwide. Also, they assume a spatially constant geothermal heat flow. Both assumptions are very crude approximation of reality, which will severely affect their modelling results. Information on the global variation in subsurface composition and geothermal heat flow is available in literature and databases. See Kitover et al. (2014, 2015) for inspiration.

I am not familiar with modeling carbon content changes. Thus I have little comments on those sections.

specific comments:

Title: change to a title better reflecting the contents of the manuscript

e.g.: Effects of geothermal heat flow and assumed model thickness on permafrost distribution and carbon pool changes

page 2:

using the word “reflect” for the thermal effect of a too shallow lower boundary condition can only apply to the effects of climate warming. However, models are also used to study implications of climatic cooling (in the past).

l. 22: 20 C/km is a bit low for a general, global geothermal gradient. 30 C/km is more in line with observations

page 4:

l.8: mention that the two parallel planes are the upper and lower surface

l. 16: assuming a constant diffusivity implies that you assume no porosity change with depth (which is unrealistic for the modeled depth interval), and that no phase change occurs (no melting or freezing). Both assumptions are crude simplifications.

page 7:

l. 4: yes, but porosity decreases exponentially with depth. Thus the thermal diffusivity should change with depth, and is not a constant as you assume.

l. 5: this is a crude assumption. Also composition in the upper 41 meters changes with depth, due to porosity change

l. 7: the assumption that all bedrock (below 41 meters) consists of granite is not realistic

l. 13: mention that you later on will modify the model by incorporating a geothermal heat flow at the base of the model

page 9:

l. 2: you should look better. Such database do exist. For inspiration, check the papers by Kitover et al. (2014, 2015).

l. 6: what is the ice/water content for your permafrost definition? Please note that some authors have advocated a thermal definition of permafrost (like your definition of active layer thickness), since some permafrost in fact lacks ice. Also, please not that some permafrost contains more ice than just the normal porosity (i.e. in the forms of cracks and lenses)

page 29:

l. 35: no, permafrost will also melt from below. The phase transition will affect heat balance and thermal properties of the frozen/unfrozen bedrock. But, the ice-content in bedrock pores and fractures will be low.

page 30:

l. 1-2: yes, but increasing the cell size will reduce the resolution of tracing the lower boundary of the permafrost

<u>technical corrections:</u>

page 1:

l.9.: "… under forcings of two…."

l.13.: use "20 mW/m2" instead of "0.02 W/2"

l.14: replace "frontier" by "interface"

page 2:

l. 29: remove one "the" (leading to decay of)

page 3:

l.25: replace " is" by "in"

page 5:

l. 2: Insert "Thus"

page 8:

l. 6 please use 50 m instead of 5000 mm

l. 6 what is the relation between the hydrology model (50 meters) and the thermal model (42.1) meters). How are these linked? In the lines above I get the impression that they are coupled for the upper 3.8 meters. But how about the rest?

page 9:

l. 15: of the top of the permafrost

page 15:

l. 9/10: what do you mean? It should affect the amount of heat being diffused

page 22:

l. 11/12: please explain why his happens

page 29:

l. 13: the virtual aquifer has a thickness of 50 meters, not 5

l. 26: ..as high as 50-80% with respect to…

l. 35: no, permafrost will also melt from below. The phase transition will affect heat balance and thermal properties of the frozen/unfrozen bedrock. But, the ice-content in bedrock pores and fractures will be low.

page 30:

l. 1-2: yes, but increasing the cell size will reduce the resolution of tracing the lower boundary of the permafrost