The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC2
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Comment on tc-2021-362

Anonymous Referee #2

Referee comment on "Evaluating simplifications of subsurface process representations for field-scale permafrost hydrology models" by Bo Gao and Ethan T. Coon, The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-362-RC2, 2022

This paper presents a quantitative evaluation, using numerical modelling, of the effects of making certain assumptions regarding relevant physical processes in the context of a coupled groundwater flow - permafrost (freeze/thaw) system. Specifically, three assumptions are tested - assuming a uniform water-ice density, neglecting cryo-suction and neglecting advective heat transport.

The analysis is conducted on two system scales -a simplified 3D hillslope domain and a 1D column. The ATS simulator is used for all simulations. The modelling approach is valid and the conclusions are logical.

There are a few weaknesses in the paper outlined below.

- The paper does a good job of presenting the quantitative numerical comparison of these assumptions, in terms of errors, but insights are lacking on explaining the reason for these differences. All results are shown as time series and error plots. More insight is needed into the actual physical processes and system behaviour, not just on 'dry' figures or plots showing errors. i.e. to answer WHY these processes are or are not important under these conditions. For example, there are no results shown in space of the flow system or temperature field of their 3D domain (maybe these are in the SI ?). This would at least help interpret what is happening in space, where flow is going, temperature gradients etc.
- I did not find the comparison of computational efficiency very relevant (ex lines 508-520). The authors seem to suggest if the computational cost of including advective heat transport is high, then it can be neglected. Computational cost should have little or no bearing on whether or not to include a process - if a process is important & relevant, it needs to be included, regardless of the computational cost. Most codes are efficient enough to include advective het transport even at large scales.
- I found the results and conclusions were cast too strongly as being definitive in the

general context. These results are specific for the conditions assumed (geometry, flow system, etc.). For example, Line 502-503 states: 'Therefore, for most Arctic systems at this scale, it is reasonable to neglect advective heat transport.' Which is much too strong a statement and needs to be rewritten or deleted. There are many published cases showing that advective heat transport is indeed critical in many real-site cases, not just conceptual or simplified as in this case, where here it is cast as less relevant. I provide a few examples in the attached marked copy.

Specific comments:

- The paper refers a few times to 'a general Arctic system' (Line 27) or to '... a normal Arctic system' (Line 490) .... These should be replaced by, ex., 'a conceptual system'... or 'in these specific simplified cases'. There is no such thing as a 'general' or 'normal' Arctic system. Line 490 in particular reads like a general statement which is not true, you have to re-read it to finally understand it refers to these specific cases only. More acknowledgement is needed in general that these are specific results for these cases only, not generally-applicable conclusions.
- Line 111: The Nixon (1975) paper is much too old to use for justifying this statement that 'it is commonly recognized that heat conduction predominates ...'. This might have been the case in 1975, but not more recently in the past decade or so. So the entire viewpoint should be modified as well. i.e. that it has become recognized more recently that advection can be significant but is still often neglected ... Or perhaps that in some cases it is not known whether advection is important or not but it is neglected anyway …
- Line 156 - needs to be corrected to advection-dispersion (or advection-conduction). ('diffusion' is almost always used only in the context of mass transport). Same for Heading 2.3 (line 297).
- Table 6 – four significant digits is excessive here.
- See attached marked manuscript for all grammatical corrections and other comments.

Please also note the supplement to this comment:
https://tc.copernicus.org/preprints/tc-2021-362/tc-2021-362-RC2-supplement.pdf