The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2021-362

Anonymous Referee #1

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-RC1, 2022

General Comments

The authors use their simulation code "Advanced Terrestrial Simulator" to simulate different scenarios switching certain processes (expansion of water during freezing, cryosuction, advective heat transport) on or off and investigate the extent of the changes to the simulation results. The authors draw conclusions on the relevance of the processes and try to address the question, if they can be safely ignored to simplify the model and save computation time. The scenarios make sense and try to give a representative sample. The paper is well written and the different scenarios are comprehensibly described. The figures are a bit small and overloaded, thus it is sometimes hard to see all the simulation results compressed into one figure.

In my opinion the key question is, if the content of the paper is of sufficient general interest and is really giving new insight. The title of the paper suggests that the results are generally relevant for "field-scale permafrost hydrology models". However, they will to some extent be influenced by the concrete modelling approach, discretization scheme, linear solver (the authors mention that the AMG-preconditioner they use is not well suited for advective transport)... Thus it is more a kind of sensibility analysis of the results produced by their code in different scenarios. The authors tend to not carefully distinguish between small differences in the model results produced by their code (assuming that the representation of the different processes in their code is correct) and a low relevance of the process in reality (or at least in modelling reality). However, this is not at all the same.

What is also missing is an analysis of the discretisation error associated with the different grids and the time step used (if the grids are too coarse, the results are not really realiable). Thus I think the paper can be published, but it is not an essential step forward.

Specific comments

Title: I would suggest to make the title a bit less general, e.g. "Evaluation the sensitivity of prediction results to process simplifications for the advanced terrestrial simulator". It is not clear, that the results obtained here, are really generalizable to other codes. Especially, as the change of the model results relative to the safed computation time is of interest.

line 191: The soil-freezing characteristic curve is usually used as a material property of a certain soil. Thus I find this term here rather confusing

figure 1: Too much information is packaged into too small figures here. It is very hard to see for example the rain precipitation at sage, because it is in the background of the other sites. Maybe you could make one set of plots pere site in a 3x3 matrix?

table 2: the van Genuchten-Mualem model can produce unphysical results for n values much smaler than 2 (which is true for all parameter sets here)

3.2 mesh design: why 78 cells? Have some tests be done, that this is a sufficient resolution to obtain grid convergence?

line 333-344: how was this column initialization transferred to the hillslope? Does this not produce an instable initial value for the hillslope?

line 374-376: might this averaging of local data not smooth the effect of neglecting processes? If you have only a local effect at one or two points, this could be greatly reduced by the averaging

figure 4 and 5: The figures are again rather small

figure 6, line 414: The concept of a "decrease percentage" is rather hard to understand (especially if it gets negative). Would it not be easier to understand, if you use the relative runtime? Which than would be either smaller than one (thus faster) or larger?

section 4.2: there is no information about the effect of neglecting cryosuction on the runtime. However, isn't that the main point of the paper (how much precision do you

sacrifice for which acceleration?)

figure 13: I am not sure, how much this figure really helps in understanding. you need to read the text very carefully to only understand, what is represented here (not talking about what it means)

conclusions: as stated above: the results found here do not have to be representative for all "permafrost models" Thus conclusions like "Excluding soil cryosuction in permafrost models can..." or "Assuming equal ice-liquid densitiy will not result..." are a bit ambitious or even dangerous

line 494: "factitiously" is a very rare word. how about "artificially"?