Hydrol. Earth Syst. Sci. Discuss.,
doi:10.5194/hess-2016-507-AC2, 2017

Hydrology and Earth System Sciences
Discussions
Open Access
EGU

Interactive comment on "Simulations of water, heat, and solute transport in partially frozen soils" *by* Mousong Wu et al.

Mousong Wu et al.

mousong@kth.se

Received and published: 21 February 2017

REF 2 Comments General comments The manuscript sent by Wu et al. provides a study of simulating water and solute infiltration in partially frozen agricultural soil in northern China. Two winter periods were simulated. They used 1D subsurface, surface and atmosphere model (CoupModel) that is capable of simulating heat transfer, and soil water distribution in frozen and partially frozen soil. CoupModel is highly tested and quite well recognize model in cold snow dominated regions, and can be the most sophisticated model assesses water infiltration in partially frozen soils in cold regions. The author uses novel technique in calibrating the highly parameterized model. Even though Monte Carlo method is well used and has been (and should be) a standard process in every simulation exercise this paper provides some new information of sensitivity of parameters affecting simulated soil water content and temperature (heat

Printer-friendly version

Discussion paper

transfer) in frozen soils, new insight is also given to account solute in the model calibration, although it seems that CoupModel cannot provide a very good solute transport solvers (as author also clearly recognizes this) and there can be better tools available for that. This study also reveals that where the pitfalls are if solute transport is taken into account, and show that the results can be improved if solute transport is taken into account. There are some moderate/major issues that the authors need to take into account prior to publication.

Abstract Lines 24-25, the author mentions “novel techniques” but this study does not explore these techniques in depth, this needs to be removed from the abstract because it is not really the scope of the study.

Re: Thanks for the suggestion, we will remove it.

Introduction In recent literature there has been debate of using impedance factor, that CoupModel uses, in hydraulic conductivity function to account the blocking effect of ice (see Painter et al. 2016; Kuryluk and Watanabe 2013). The author could shortly improve introduction and discuss about this matter, because it has been raised up in the recent literature.

Re: We will re-write this part according to the recent literature suggested by the reviewer.

REF Kurylyk, B.L., and K. Watanabe (2013), The mathematical representation of freezing and thawing processes in variably-saturated, non-deformable soils, Adv. Water Resour., 60, 160-177 Painter, S. L., E. T. Coon, A. L. Atchley, M. Berndt, R. Garimella, J. D. Moulton, D. Svyatskiy, and C. J. Wilson (2016), Integrated surface/subsurface permafrost thermal hydrology: Model formulation and proof-of-concept simulations, Water Resour. Res., 52, 6062-6077, doi: 10.1002/2015WR018427. In lines 54-73, the author brings up a lot of literature about previous studies but do not mention the most important results of them. Maybe the most relevant studies with respect to this study should only bring up, and the most important results of them and how they are correlated or

Printer-friendly version

Discussion paper

not with this study. The author mentions very lightly (see line 71) the most common results: that soil condition and boundary conditions have an effect but this is way too general outcome of these previous studies. Line 93, AIS model should be mentioned in this list (see Painter et al. 2016, WRR paper) because they have freezing/thawing included in distributed hydrological modeling.

Re: We will read the references carefully and summarize the previous studies focusing on the findings instead of some general outcomes. And the more recent contribution to this subject will be added in the introduction.

Line 103, delete “the” before neglecting

Re: Will be deleted.

Line 104, delete “the” before neglecting

Re: Will be deleted.

Line 121, “,” delete empty space

Re: Will be deleted.

Material and Methods Line 187-191, why the observation interval was not denser and not the same as observations from the meteorological station?

Re: Observations for soil moisture and soil temperature was conducted in different parts of the field, which is several hundred meters away from the meteorological station. These field observations were done manually, so it was not possible to keep the same intervals as in meteorological station, which was automatically.

Line 193, delete “theory”, because it is not only CoupModel theory but theory in general (flow etc.), maybe the author could invent a new headline.

Re: Will be deleted.

Line 195, why groundwater level was chosen as a lower boundary condition and not

e.g. bedrock?

Re: In this study, we chose the lower boundary at 6 m depth. This was because groundwater level will not reach there. So water content at this depth could be seen as stable as at bedrock.

Line 196, “CoupModel could be . . .” what this “could” means? Maybe “could” should be deleted

Re: Will be deleted.

Line 199 and Line 203, check the meaning of kw

Re: kw is unsaturated hydraulic conductivity, we will make the expression consistent in L199 and L203.

L217, the CoupModel neglects diffusion, maybe the author could discuss about the effect of neglecting diffusion a little bit more in detail, the simulated results are not that good and maybe this is the major issue here.

Re: Thanks for good suggestions. We will add discussions on this diffusion in the model, actually it could be a source of uncertainty in the modeling of solute transport. We have realized this when we developed the model and analyzed the modeling results on solute, and also mentioned it. But it would be more detailed explored in the revision.

Line 222-223, is the lower boundary “groundwater” level or “drainage”, I think the choice of groundwater level, or drainage may affect the results. If drainage is used, then the drainage equation should be clearly shown. The author only mentions that this equation appears in the table S2.

Re: The lower boundary is drainage. The drainage equation here used is Hooghoudt equation. We did not list it in the main text. We will put it in the main text in the revision.

Line 232, T0?, please refer to equation

Re: T0 refers to Equation (5), we will add it in the revision.

Line 284, what the author mean that you focus on calibration and not validation? What do you mean by validation?

Re: Here, validation means using data outside of the calibration period (e.g. one year for two sites) to assess the model. Since we focused on the model performance in calibration with limited data, we did not discuss the model performance outside of the simulation period in this paper.

Results and Discussion Line 341 How “temperature gradients” affect the soil water and solute transport, please explain.

Re: Temperature gradient could drive water flow in soil profile, which could also cause dissolved solute transport. This will be explained in revision.

Line350, define NP

Re: NP means number of parameters show tight correlation to variables. Will be explained in main text.

Line 365-371, this is difficult to follow, if the reader is not aware of the equations, maybe the equation should be explained in the text, at least a proper references should be provided that reader immediately knows what equations should be looking at in the appendix.

Re: The reference of each parameter to the equations will be added here in main text to make it much clearer.

Line 377-380, what this means in practice? Be more specific.

Re: It means in choice of parameter ranges for these parameters related to evaporation and radiation processes, we should properly decide the prior distribution of parameters as well as their value ranges. This will be addressed more specifically in the main text.

Lines 381-384, what this means in practice? Be more specific.

Re: This means in calibration of model for Site NE, we need to choose proper representation of snow and frost processes with respect to model structure and parameters values. For Site IM, we need to choose proper equations for representing water transport and surface energy balance, as well as reasonable parameters related to these processes.

Line 388-394, the resolution (time interval) of observations seems to be very important, why not taking data hourly?

Re: Unfortunately, due to difficulties in sampling frozen soil and in recording TDR data in study sites, we have limited measurement intervals. We did all measurements manually, so this limited the observation intervals. We may not be able to change them in this study. But we can learn from the study that in the next step of experimental work, we will increase measurement intervals for soil water content during freezing/thawing season.

L400-403, can this be also an issue of the model, see lines 205-207?

Re: This could be both an issue of the model, because in the model some processes are not taken into account, e.g. surface ice cover in Site IM, lateral drainage in Site NE. These could cause uncertainty in modeling results.

Line 436-437, unclear, please reword

Re: Reword as 'Total water content at 5 cm depth shows relatively large uncertainties in both sites. For the whole simulation period, larger uncertainties were also detected when soil started freezing or was nearly totally thawing.'

Line 440-441, unclear, please reword

Re: Reword as 'These parameters will not be suitable for unfrozen conditions, when large water fluxes occur in soil.'

Line 458, “Simulated liquid water content. . .”? delete “in comparison with the measured”

Re: Will be deleted.

Line 466-467, please reword. The equations should be clearly shown or referred.

Re: Related equations will be referred here in revision.

Line 482, “validation”, calibration instead?

Re: Will use ‘calibration’.

Line 485 delete “work”

Re: Will be deleted.

Line 485 “surface water”? do you mean “soil water”?

Re: Has changed into ‘soil water’

Line 484-487 unclear, please reword

Re: Reword as ‘Since the study focusing on water and energy balance in upper 40 cm soil layer, we did not take water and heat transport in lower layers.’

Line 494, delete “work” after calibration

Re: Will be deleted.

Line 496, change “assumption of” to “assumption that”

Re: Will change as suggested.

Line 504-505 unclear, please reword

Re: Reword as ‘As is known that, during soil freezing period, water and solute fluxes are mainly upward.’

Line 517 carefully., delete ”.”

Re: Will be deleted.

Line 517-518, be specific that what type of data should be collected

Re: Reword as ‘. . . e.g. solute concentration, continuous liquid water content measurements would be of importance in calibration of model, . . .’

Line 555 “surface water”? do you mean “soil water”

Re: Changed into ‘soil water’

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., doi:10.5194/hess-2016-507, 2016.

Printer-friendly version

Discussion paper