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Comment on hess-2020-657

Anonymous Referee #2

Referee comment on "Interaction of soil water and groundwater during the freezing–thawing cycle: field observations and numerical modeling" by Hong-Yu Xie et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2020-657-RC2, 2021

The work presented by Xie et al. (2021) investigated the interaction of soil water and groundwater mainly via the lateral groundwater flow and freezing or thawing induced water migration during the freezing-thawing cycle in a semi-arid region with shallow groundwater. They conducted field observations and numerical experiments and further analyzed the water budget components. The role of lateral groundwater flow and the freezing-thawing process was demonstrated important in the tested area. I found this work is interesting while there are some concerns about the current version of the manuscript necessary to be addressed from my perspective. First, the existence of freezing-induced water gain and lateral groundwater flow is mostly postulated from the observations and not directly measured. This renders that you have to demonstrate the reliability and uncertainties of your observations (e.g., liquid water content, the occurrence of thawed water infiltration, frost depth, …). Second, as most of the analysis part is based on the SHAW model simulations. I think the authors should put a bit more words on the SHAW model setup (e.g., bottom boundary condition settings, how groundwater is considered), model performance, and uncertainty (e.g., simulation of freezing/thawing dates, statistical performance). Thus, I suggest more dedicated efforts should be made before its publication in the HESS journal.

My specific comments are as follows:

Abstract:

Line 22-23: I notice that in your figures (Figure 4) the unit of soil water content is

cm3/cm3, please keep consistent.

1 Introduction:

Line 44: "… and further decrease the hydraulic conductivity of frozen soils" please explain or clarify.

Line 99-103: these sentence does not belong here, I think it should better be in the Introduction part.

2 Method

Please clearly present the soil texture (fraction of sand, clay, silt, organic matter) information.

Are the 5TM sensors calibrated on this site? What about the measuring accuracy of 5TM sensors regarding the soil moisture and temperature?

Line 112-114: From my understanding, Figure 1 cannot directly tell us that the increase of groundwater table depth is due to the freezing-induced water migration. Please carefully rephrase this sentence.

2.3 Model inputs

Line 174: "… soil column is set to be 155 cm." I can understand that you want to use the measured soil temperature (150 cm) as the bottom boundary condition. While for the other numerical scenarios, you use 200cm for the soil column. I think either you keep all the numerical scenarios as 200cm, or you should explain a little bit the potential uncertainties regarding the results.

Line 176: Please explain in more detail about the lateral groundwater flow in SHAW. And how did you calibrate the lateral groundwater flow as 1.03mm/d?

Line 187: For the bottom boundary conditions, I have a sense that the setting of the bottom boundary condition can affect the simulations. Please explain why you set the bottom as the no-flux boundary condition. Is it the more realistic condition for that site or for the better simulations?

Line 204: For presenting the different simulation scenarios (A, B, C, D), I would suggest that you include them as a table, listing the main difference among all the simulation scenarios (or numerical experiments).

Table 2: I think the row with “Calibrated parameters” should be below the row with “Initial parameters”.

3 Results and discussion

Figure 4: the scale of soil temperature should be finer (e.g., [-5, 10] oC) for Figure 4d, e, f.

In addition, I think there also be freezing or thawing periods for 90cm. Please zoom in and clarify.

Line 248: please explain how to define the "occurrence of thawed water infiltration".

Figure 5: I suggest that the statistical performance should be added here to demonstrate the capability of the SHAW model in simulating soil moisture and temperature.

Section 3.2: please also add some text describe how the model captures the observed freezing or thawing dates.

Figure 6: for better comparison, please present the observed frost depth and water table depth for all four subplots.

In addition, how is the frost depth measured?

Table 3: please clarify the frozen zone and how you calculate TWC.

Section 3.3: as you present two subplots in Figure 8, it is better to say what you want to say about the comparison here.

The effect of snow can be clearly identified (Figure 8), the role or the amount of snowfall should be stated from the water budget closure perspective.

4 Conclusions

I suggest adding some text describing that how well the SHAW model can capture the observed soil moisture, temperature, frost depth, and groundwater table depth.

Line 380: "a model is built…" should better be "a series of numerical experiments were set up to …" or something similar.