Reviewer #1

Thank you for giving me the opportunity to review "Implementation of salt-induced freezing point depression function into CoupModel_v5 for improvement of modelling seasonally frozen soils" by Wu et al.

General comments

The consideration of salt concentrations on the freezing/thawing dynamics of agricultural soils is an important and interesting addition to the CoupModel. I appreciate the study and found it reasonably well written overall. The description of the model and the application of the model are good, however, the introduction lacks a proper literature review on hydrological models which simulate soil-surface water-groundwater flow under consideration of winter hydrological processes. This is an important aspect to discuss in the introduction, because it allows readers to better understand the novelty of the extended CoupModel approach. Rather than the CoupModel, which only considers a soil column, integrated flow models have the capability of considering entire agricultural fields or watersheds, including freezing/thawing of soils. However, while these integrated flow models (i.e., MIKE SHE, HSPF, SUTRA, HydroGeoSphere, or ParFlow) have many advantages, they are also limited in that they are less rigorous in their mathematical implementations of freezing/thawing processes. This needs to be highlighted in the introduction, with proper referencing of these existing but with regard to winter hydrological processes less rigorous approaches. I provided references to these four modelling codes in my detailed review below.

Response to general comments: We agreed with the reviewer. This is a good point. We have mentioned those models the reviewer has suggested and highlighted that the CoupModel has more rigorous mathematical implantations than those models.

Another problem of the study is the fact that results and discussion are combined into one section. This is not per se a problem, but as so many analyses were carried out, it is extremely cumbersome to find the more widely applicable information within your results and discussion section. A lot of information gets lost between the extremely site specific performance criteria, parameter sensitivities etc. This is a pity, because the analyses are all very interesting and the findings that derive from the site specific numbers are more widely applicable. Please split the results and discussion section in order to improve the impact of your article. Moreover, include many of the statements which are now placed at the end of each sub-section in the results and discussion in the conclusions instead. For example statements such as 'In the future development of the CoupModel, we recommend inclusion of a new scheme for water and energy balance on ice coverage.'. This sentence does not belong in the results section, it should form part of the conclusions.

Response to comment: We agreed with the reviewer and have split the section "Results and Discussion" into two separate sections.

I support the publication of this study in HESS but I suggest minor to moderate revisions as outlined below prior to acceptance for publication. I also strongly advice the authors to consider a professional English editing service, as there are still many small mistakes in the text. I highlight quite a few of those, but I could not pick out every missing 'the' and so on. For the article to be ready for publication in a high quality journal such as HESS I suggest improving the English with professional help.

Response to comment: Thanks for the suggestion on improving English. We have asked a professional English editing service to help us improve language of the manuscript.

Specific comments and technical corrections

Title: remove '_v5' from the title

Response to comment: We have changed the title as "Modelling seasonal freezing and thawing of agriculture soils in northern China: Implementing a salt-induced freezing point depression function in CoupModel".

Abstract: Line 14-15: Change to 'Salt in agricultural fields impacts soil freezing/thawing characteristics and, therefore, soil hydrologic processes' Line 21: Why 'Nevertheless'? I don't understand the logic of this sentence. This is not a contradiction to the previous sentence and doesn't require nevertheless. Line 23: 'However' is not needed Line 26: Change to 'provides' Line 27: Change to 'highlights'

Response to comment: We have added the suggested sentence. In Line 21 and 23, "Nevertheless" and "However" have been deleted. In Line: 27, we have changed these words as suggested.

Introduction: The introduction is well written overall and the objectives of the study are clearly stated. There is a lack of literature review for already existing models which are capable of simulating freezing/thawing of soils, and the differences between the new approach and these models is not properly discussed. I want to see a better discussion of existing models with proper referencing as well as a discussion on how CoupModel is different or 'better', as the authors claim. Below are some minor corrections as well as 4 other model examples which must be discussed. These are all minor changes, however.

Response to comment: We have mentioned those suggested models in Introduction and added a discussion on how CoupModel is different from them.

Line 31: Change to 'recognized for their importance' Line 46: Change to 'on the freezing rate of soil' Line 48: Change to 'in the two same agricultural fields as used in this study'

Response to comment: We have made the suggested changes.

Line 55-62: Some references to more advanced numerical models using soil freezing thawing must be included in this paragraph. You only cite simple hydrological models, but not the advanced, process-based flow simulators that are often used to simulate winter hydrological processes. Include at least the following four with proper referencing:

MIKE SHE: Graham, D. N., & Butts, M. B. (2005). Flexible, integrated watershed modelling with MIKE SHE. In V. P. Singh & D. K. Frevert (Eds.), Watershed Models (pp. 245–272). Boca Raton, FL, USA: Taylor and Francis.

HSPF: Bicknell, B. R., Imhoff, J. C., Kittle, J. L. J., Donigian, A. S. J., & Johanson, R. C. (1997). Hydrological Simulation Program-Fortran, User's manual for version 11. Retrieved from Athens, GA, USA.

HydroGeoSphere: Schilling, O. S., Park, Y.-J., Therrien, R., & Nagare, R. M. (2019). Integrated Surface and Subsurface Hydrological Modeling with Snowmelt and Pore Water Freeze-Thaw. Groundwater, 57(1), 63-74. doi:10.1111/gwat.12841

SUTRA: Voss, C. I., & Provost, A. (2010). SUTRA: A model for saturated-unsaturated variable density groundwater flow with solute or energy transport. Version 2.2. Retrieved from Reston, VA.

Response to comment: We have added the suggested models in Introduction and discussed them.

Line 63: Change to 'However, there are large uncertainties...' Line 64-65: Change to '...uncertainty analysis methods are often applied by combining ....' Line 66: Change to 'is one of the commonly applied methods for uncertainty analysis...' Line 69: Change to 'in simulations, a concept known as equifinality (Beven 2006)' Line 70: Remove the last sentence on line 70. If you did this in your study, then describe it in the methods section. In the introduction this information is not needed. Line 78: remove 'grown' Line 86-87: change to 'Thus, we extended CoupModel to consider impacts of...' Line 88-89: change to ' The main objective was to 1) extend CoupModel by considering effects of salt on the freezing point; 2) identify parameter sensitivity; 3) analyze the uncertainty in modeling soil hydrology in seasonally frozen agricultural soils.'

Response to comment: We have made the suggested changes.

2. Material and Methods Lines 97-99: You suggest that the typical clay type soils of Qianguo are low porosity. However, you give a bulk porosity of 0.46, which is massive!

Discuss this better or rethink your statements.

Response to comment: We have changed the sentences as "The soil profile at Site Qianguo is homogeneous, with porosity of 0.46, bulk density of 1.42 g cm^{-3} and soil texture characterized as clay loam (Table 1)".

Line 99-100: the water table fluctuates between 1.5 and 2m. Is that the variation in GW levels or is the variation 0.5m and the 1.5-2m is the depth at which the water table is normally situated? not clear.

Response to comment: "1.5 to 2.0 m" refers to the groundwater table depth below soil surface. We have clarified it in Line 99-100.

Line 102: change 'from' to 'form'

Response to comment: We have changed it in Line 102.

Figure 1: change the color of the blue dots in the figure to a brighter color, it's almost impossible to see them. The figure is overall very complicated. Can you please rearrange the subfigures in a better way?

Response to comment: Thanks for the suggestion. We have made the following modification for Fig 1. Firstly, we have changed the blue dots to the green dots to make them easier to read. Secondly, we divided this figure into three sub-figures and used a), b) and c) to make them easier for reading. The caption have been revised accordingly.

Line 109: Exact dates are provided for Yonglian, but not for Qianguo. Line 111-112: What is the soil type? Porosity is the same as in the first site. Again, is this the water table fluctuation in variation or the depth at which the water table normally is?

Response to comment: We have provided the dates for Qianguo, and the soil type as well. We have also explained the groundwater fluctuation referred to the groundwater table depth below soil surface.

Line 115-116: reference Figure 1, so that readers know that the selected study plots are illustrated in Figure 1

Response to comment: We have added Figure 1 as a reference to the text.

Table 1: Site: The abbreviations NE and IM have not yet been introduced

Response to comment: We have corrected the site name in Table 1, as Qianguo and Yonglian.

Line 127: what do you mean by 'the daily temperature data were collected? Did you measure just once a day? Is that value representative of the average daily temperature? Or did you record at a higher interval and then averaged to daily average temperatures?

Response to comment: Temperature is measured every day at noon. The reason for measuring the temperature once a day is that the limited resource doesn't allow us to install a data-logger in a remote field. We have clarified it in Line 127.

Line 149: delete '(by hearing the voice)' Line 153: Specify which meteorological stations, and provide the data alongside all other data. Or state where the data can be obtained. All data used for the study must be available or made available.

Response to comment: we have deleted '(by hearing the voice)' in Line 149. The meteorological stations are installed at each site in the field and run by local water management unit. The data are available upon request to the correspondence author. We have addressed it in Line 153.

3. CoupModel

Line 157: remove '_v5' and change the section title to 'Extension of the CoupModel'

Response to comment: We have changed the section title, in Line 157.

Line 158: change to 'The model domain covered the top 6m of the soil, with unit area considered' Line 163: change to 'in this study are' Section 3.1.: Change all to present tense. Line 166: change to 'CoupModel solves the coupled...'

Response to comment: We have changed the expression in Line 158, 163, 166, and changed all to present tense in model description.

Line 381: change to 'for analysis of water, energy'...

Response to comment: We have changed it in Line 381.

4. Results and Discussion Here you combine Results and Discussion into one single section. While some strictly dismiss this combination, where the circumstances allow it I don't mind combining both in one section. However, your Results and Discussion is very long with a lot of Figures, aspects, numbers etc. The discussion of the different important findings gets lost among the many numbers, performance criteria, sensitivities etc. Therefore, I suggest renaming this section 'Results' and adding a separate section 'Discussion' where you summarize the findings of the different analyses, i.e., where you state clearly and without using too many numbers which parameters were sensitive due to what reason etc.

Response to comment: Thanks for the suggestion. We have separated Results from Discussion. In Results, we mainly showed the results in modeling. In Discussion we have discussed parameter uncertainties, model performance, and simulation results uncertainties etc.

Line 410: change to' which is used to estimate' Figure 5: This is a very poorly described figure. It isn't at all clear which plot relates to which parameter. Which parameters are sensitive to what outcome?? Explain better!! The same is true for Figure 6 !! Line 447: change to 'Even though we have...'

Response to comment: We are sorry for the poorly described figures. We have improved the figures by using larger fonts for the important parameters in the sub-figures and to make the figures easier to read. Accordingly, we have revised the related section (Section 4.2).

5. Conclusions The conclusions lack precise statements for what is still needed. In the results and discussion section, things like 'In the future development of the CoupModel, we recommended inclusion of a new scheme for water and energy balance on ice coverage.' (lines 492-493). This information and all the other statements on what is still required must be provided in the conclusions. This comment is similar to my comment above: Because you combined results and discussion into one single section all this information gets lost! You carried out so many interesting analyses with your extended CoupModel that a combined results and discussion section is not appropriate. Please consider splitting results, discussion and conclusions so that the readers can more easily find the important findings and conclusions, rather than having to go through all the extremely site specific performance and sensitivity numbers! The specific numbers are have no widely applicable meaning, but the conclusions you draw from them do. Therefore, make them more visible to increase the impact of your paper.

Response to comment: Thanks for the suggestions on improving our paper. We have revised the Conclusion part by emphasizing the needs in the future.

Line 543: change to 'are coupled in agricultural fields'

Response to comment: We have changed it in Line 543.