We would like to thank Anonymous Referee #3 (AR3) for their constructive and positive comments. Below, we will respond to the comments made by AR3: the comments from AR3 in black, our response in blue.

This work firstly introduced a multi-layer FSM into the SSiB3 to represent the freezing-thawing process and the heat and water transfer in a multi-layer frozen soil (SSiB3-FSM). To overcome the difficulties in achieving stable numerical solutions for frozen soil, a new semi-implicit scheme and a physics-based freezing-thawing scheme were applied to solve the governing equations. With that, the performance of the SSiB3-FSM model, as well as the effects of frozen soil process on the soil temperature profile and soil memory and maximum frozen soil depth, were investigated over the using observation and models simulations over the Tibetan Plateau and North China region. The study allows for a better understanding that frozen soil processes are of great importance in controlling surface water and energy balances during the cold season and in cold regions. Furthermore, it also allows for accurate freeze-thaw cycle simulation and frozen soil predictions.

How to solve the highly nonlinear equations in multi-layer frozen soil are the difficulties in land surface model and the climate models. The study has a great potential to provide guidance for future development of frozen soil model in land surface model and climate models. Few published papers focus on the effects of frozen soil processes on soil temperature, soil memory and maximum frozen depth in the TP and NC. This study provides useful information.

The analyses in the paper are well organized and the results are reasonable. The presentation of this article is generally clear. Based on my evaluation for the merit of this paper, I suggest publication of this paper with some revisions.

R: Thank you very much for your helpful comments and suggestions for the improvements of the manuscript. We have responded to the following comments or questions and modified the manuscript accordingly.

1. In abstract, line 20. Consider clarifying how they are investigated. Observations are mentioned below, please state which observations were used for the comparison.

   R: The observation data used to validate the models are mentioned in the abstract. See line

20-21.

2. At the end of the abstract, please consider adding an additional sentence to describe the impact of your findings for future research or practical applications.

   R: We modified the abstract by adding description of the study results at the end of the abstract. See line 30-31.

3. At line 185, “It can effectively produce stable solutions for long-term integrations with the heat and mass balances.” It’s too general. Please provide relevant data or citations to support these statements.

   R: We rewrote this sentence. See line 188-191.

4. At line 272, it is not clear why this is not just Section 4.1.2. Consider revising to use the section headings instead of a numbered list. Otherwise, write a sentence to introduce the list first. The same problems are at line 306 and 308.

   R: Agreed. We have revised them.

5. At line 347-349, “To more clearly display these relationships, the soil temperature phase lag time, defined as the point at which the cross-correlation with the first soil layer equals 1, with depth is shown in Fig. 7b and Fig. 8b.” Please check that this is what was meant here. Please revise to clarify.

   R: This sentence clarified how we defined the soil temperature phase lag time based on Figure 7a and 8a. We revised this sentence and see line 356-359.

6. Why do you plot Figure 11 with the simulated soil temperature instead of observed data?

   R: The observed soil temperature data is monthly data, but the simulated soil temperature data is daily. In order to clearly exhibit the temporal characteristics of soil temperature profile, we used the simulated daily data to plot the climatology of annual soil temperature variation with soil depth over TP and NC. The observed climatology of simulated daily soil temperature (Left) over the TP (14 sites averaged) and (Right) NC (16 sites averaged) for 1981–2005 has also been shown as following. It has shown the similar characteristics with Figure 11.

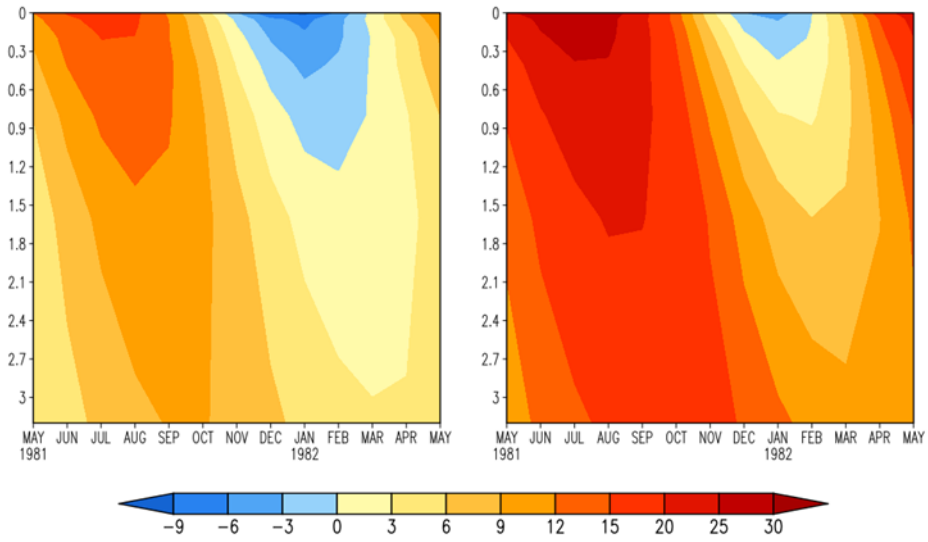

Figure. The climatology of observed monthly soil temperature (Left) over TP (14 sites averaged) and (Right) North China (16 sites averaged) for the period of 1981-2005. (Unit: ℃)

7. There might be errors in Figure 2. Please check at the last step of Fig.2 $\theta_{l,j}^{k}$ should be $\theta_{l,j}^{k+1}$ or not.

   R: Agreed. We have corrected it.

8. Please check it is “1.5cm” or “15cm” at line 412.

   R: Yes. It should be 1.5 cm. We have revised it.