

This paper presents a two-dimensional model to capture the spatial heterogeneity of subglacial sediment transport and erosion. Overall, I believe the model is useful for the understanding of subglacial sediment transport. The results and analyses are also insightful to understand how spatial heterogeneity affects subglacial transport.

However, the paper may need to improve the way of describing the modeling framework and explaining the results. For modeling descriptions, first, this paper shows a 2D model, however, the governing equations do not clearly show how the “2D” is represented in the model descriptions. Figures 3 and 9 show the 2D geometry of the studied area are complex geometries. However, it is not clear how these complex geometries are represented by mesh, and how such a mesh is incorporated into the governing equations. These details will be necessary for us to understand how the 2D is represented and variables defined on these 2D geometries are modeled. For the river routing model, Equation 16 shows the algorithm for calculating ϕ_o , however, the paper does not describe the governing equation for the river routing. It is not clear what governing equation and process are solved here. In addition, the model has a lot of parameters and variables that need to be solved. From the model description, it is not clear what variables are solved. Finally, the model used many equations that do not give sufficient descriptions of why you choose these equations, e.g., equations 2-4, 8, 9, 12, 16, 17, 21. I suggest the authors improve Section 2 to better describe these model equations.

For the results interpretations, I find it hard to link the conclusions or claims to the figures. In the current version, the conclusions usually come out first and then the claim is referred to a Figure. The linkage between the results and the message the figures describe are missing and is left for the potential audience to have the best guess. For example, on line 228-229, the paper states “Simulations show that over seasonal timescales, sediment discharge increases at the onset of melt and decreases shortly thereafter, prior to the maximum amount of water discharge that occurs each melt season (Figure 4).” However, Figure 4 has two subfigures and 5 lines. It is not straightforward to align the message of Figure 4 to the claim made here. This issue occurs in most of the explanations of the results. For example, at the lines 230 (linkage to Figure 6), 243 (linkage to Figure 4c); line 247 (link to Figure 6); line 265 (link to Figure 3a); line 393 (link to Figure 10a). The paper also has a few issues with missing figure titles such as Figure 4,5 and insufficient descriptions for each data, line, and color of a lot of subfigures (Figure 4a: sloping blue line). The figures use a lot of double y-axes. It is better to clearly define what each axis mean in the caption or inside the figure, not just by using different color of lines and leaving the potential readers to identify which one is which one. I suggest the authors pay more attention to the details of the figure legends, captions, and subtitles, trying to make sure each figure tells the message on its own.

More details of the comments are listed as follows for reference:

Line 4: add “are” after sediment

Line 41: move “to” to “explore”

Line 69: change “subglacial the” to “the subglacial”

Line 111: is there a reference for selecting 0.5 m^2 as the limit?

Line 122: is “w” the same as “wc” shown in equation 3?

Equation 16: where does this equation come from? Do you have a governing equation for this equation? What is the difference between the two ϕ_o ?

Line 184: how to determine the $w_{\{rj\}}$?

Equation 17: What is the difference between ϕ_o , ϕ^* , and Φ^* ? How does this equation relate to Equation 6?

Line 191: what is "mn"?

Equation 18: what is the governing equation of this equation?

Equation 19: is Q_s in the right-hand side the same as Q_w defined in equation 18?

Equation 21: why do you choose Equation 21 to represent temperature?

Line 228/Figure 4 caption: From Figure 4, I can see that the sediment discharge is highest at years 19-26, why are you saying the highest discharge is in years 14-17?

Figure 4b: the y-labels are the same for the two lines.

Figure 4a: it seems the water discharge starts to increase at year 10, but the captions say from year 12. Could you explain?

Figure 4: subfigure title a, b are missing.

Line 230: Figure 6 includes 6 subfigures. Which subfigure should I see to support the claim you made here?

Line 234-239: The descriptions in this paragraph are not well supported by the model results. These descriptions are more like conclusions but are not results. It is hard to link these claims to the results.

Line 242: Figure 5 shows the results are distributed values, which means these variables vary with coordinates x and y . However, I didn't see an equation in the method section describing x and y . What equations are solved to obtain these distributed values?

Line 243: Figure 4c is missing.

Line 247: Which subfigure in Figure 6 am I supposed to observe to understand the claim here? What is the meaning of early melt season? Do you mean the time at year 8.3? This needs accurate descriptions.

Line 250: It will be useful to draw a line in Figure 4 to show which time is spring.

Line 251-252: This claim cannot be observed in Figure 4b. I can observe that the highest sediment discharge occurs at years around 11.5 and 16.5. The sediment discharges in this time period do not show a decreasing trend. Where does this claim come from?

Line 253: Need to show where is winter time in Figure 4b.

Line 266-271: In the paragraph at line 260, Figure 6a, b has been referenced, however, the difference between different subfigures is defined in the paragraph at line 270. This makes it hard to understand the paragraph above. The order of these two paragraphs needs to switch.

Line 291: As you randomly select parameters, does this mean you are performing a sensitivity study? Why do you need to randomly select these parameters?

Line 300: As the parameters affect the model results, it is necessary to show the final parameters that give the lowest absolute error.

Line 304: From Figure 7, It seems the relative error between the model and observation is very large for most years except for the time between 2015-2016. Why do you only say it has trouble during 2012-2013?

Line 313: How is this claim supported by the results?

Line 314: The absolute error corresponding to B and H_0 vary a lot. How does this support the claim of "minimal influence" of these parameters?

Line 329: In Figure 7e, the units for B is Mpa m/s. How does variable B in Figure B related to the "B" here? It seems the B has a velocity unit here, different from that in Figure 7e.

Line 330: How does this slide speed are calculated? From the model?

Line 339: How do you calculate this value $2 \text{ m}^3/\text{s}$?

Line 341: I guess sediment discharge should be Q_s ?

Figure captions: most of the current figure captions include certain explanations of the results. These explanations make the captions very long and not easy to understand. I suggest only including the descriptions for the line title, legends, and meaning in the captions, but leave the explanations of the results in the main text. Please try to make the captions short but can sufficiently tell the meaning of each line.