

Review of “Contributions of supraglacial lakes to the Greenland Ice Sheet melting”

Cotronei et al. (2026)

In this manuscript, the authors describe a simple model to investigate the impact of ponded surface meltwater on Greenland ice sheet surface topography and elevation change. In general, such an exercise is interesting and does have important implications for the inclusion of ponded meltwater in Global Climate Models, which largely neglect meltwater processes. However, I have several major and minor concerns with the modelling approach, all of which impact the robustness and applicability of the results.

Major Concern #1 – I understand the justification of having a simple model for these exercises. However, some model simplifications here deviate too far from reality. For instance, not considering refreezing is a huge limitation. In reality, many surface lakes refreeze or become buried (20-60% depending on location and year; Dunmire et al., 2025). It is therefore hugely unrealistic to assume that all meltwater produced is transported off the ice sheet via seepage. Lake refreezing limits the processes of lake-bed deepening and elevation lowering. The impact of ponded meltwater on these processes (e.g., L262-265) is a key result of this manuscript; however, without considering refreezing, I fear this result is unrealistic and a bit meaningless.

In addition to the neglect of refreezing, the accumulation rate is far too low (~33% regional climate model estimates), which I believe further amplifies elevation changes in perhaps an unrealistic manner.

Another consideration that is neglected is the impact of a diurnal cycle. The decision to not include diurnal temperature dynamics should be discussed.

In general, many model details are either missing or discussed in illogical places. For instance, what is the timestep over which the model is run? Many variables and parameters in the equations are either not defined or are defined much later in tables. For ease of reading, it would be helpful to define parameters as they appear in the text, instead of listing the values in a table which is not referenced until much later.

My last major comment is that, in general, many of the sentences are difficult to read. There are numerous long, convoluted sentences that I had to read multiple times to understand. I would suggest shortening and simplifying sentences where possible.

Minor Comments

L8: “Only the lowest emission scenarios prevent...” This sentence is quite extreme and I’m not sure that it is substantiated by the results of this manuscript, considering that this model is very simplified and missing key processes.

L17: “Assuming that ice ablation occurs at a rate...” Is there a simpler way to write this sentence? It is very convoluted and I had to read several times to understand what it was saying.

L30 – What is meant by “Mechanical processes”

L30 – “In this study...” Perhaps this would be best at the end of the introduction. It feels a bit abrupt to go from background information (L13-30), to what was done in this study (L30-35), then back to background information (L35-60). I would recommend consolidating the background information.

L34 – “and all Greenland more than global means” Not sure what is meant by this.

L40 – “Eventually supraglacial lakes typically drain through moulins and fractures in the ice sheet”. This is not necessarily true. In fact, a large portion of the water (20-60%) refreezes or remains buried in buried lakes depending on the year and ice sheet region. While many lakes drain, literature does not suggest that this is the most “typical” fate of supraglacial lakes.

L45 – the mention of sea ice here is very abrupt. Either remove the comparison to meltwater on sea ice, or I suggest finding a better transition here.

L49-51- This concept of the positive melt-albedo feedback has been explained several times in the introduction section. I recommend consolidating these explanations and then later referring to this process as the “melt-albedo feedback”, as it is commonly referred to.

L70 – “We assume that these are the main variables that need to be taken into account”. I would re-frame this to something like “We assume that these are the main *state* variables...”. Originally, I was very concerned to not see precipitation considered here, but then I found it was included later on. I would consider rephrasing here to avoid similar confusion.

Figure 2 confuses me. Why is the water level below the snow? Personally, I don't take a whole lot away from this figure.

Could there be a figure depicting some of the equations? For instance, you could show how the melt rate (Eq. 2), or albedo (Eq.3) vary as a function of water depth (W). This would be more helpful than either Figure 1 or 2.

It seems from Equation 4, that as soon as the temperature drops below freezing, seepage begins to occur? Is this true?

Equation 5 – what is x ? What is θ ?

L154 – “basin by basin” is confusing, because you are not considering the GrIS drainage basins. Maybe rephrase to “lake basin”? Also, it should be mentioned earlier that only a 40km cross-section of the Greenland ice sheet is considered here.

Algorithm 1 – maybe move this to the appendix? It's not easy to read and not intuitive to figure out what happens here. Another suggestion would be to make a graphical schematic for water flow in your model.

L159 – “specifically the one located immediately to its right.” It is unclear to me what is meant by this, and I have a hard time visualizing. As suggested above, a schematic could be helpful.

L205 – Is just the ice thickness considered in the linear relationship between elevation and temperature? Not the ice+snow elevation?

L207 – 8 °C drop in temperature per kilometer – please motivate this value in the manuscript.

L217 – How long is the spin-up period?

L220 – I'm confused about the decision to initialize with no snow. Likely, you now have a situation with a too-shallow snow layer (especially considering the low accumulation rate), which leads to the snow melting out too early, contributing to increased ponding, and an amplified, potentially unrealistic feedback.

L241 – “We integrate the model described above over 200 years with an additional 10-year spin-up” What is meant by this? You run the model for 200 years?

Table 1 – It would be good to integrate some of these values within the text as well.

Figure 3 – Change the legend to “Ponded water” and “no ponded water. (same for Figure 4). The second simulation has melt water, it just cannot pond, correct? Also, the tick labels are very small in this figure and difficult to read.

Section 4 – Sensitivity analysis of the model: The sensitivity analysis should first be introduced in the methods section.

L270 – “Each parameter” – which parameters?

Figure 4 – Since panels A) and C) depict the same experiment with ponded water, they should probably be placed next to each other.

Figure 6 – It is interesting here that with the accumulation rate doubled, you essentially prevent any elevation change. It is especially interesting considering the accumulation rate used is already less than half regional climate model estimates.

L307 – Do you bias correct the GCMs for the historical period? Both CESM2 and NorESM have temperature biases compared with ERA5 for the historical period and these biases should be considered.

In the introduction, a large motivation for this work is to help in the parameterization of supraglacial lakes in global climate models. However, this is not brought up again in the discussion or the conclusions. From this study, do the authors have suggestions as to how to adapt GCMs to include supraglacial lakes?

The way that equations are referenced is not consistent. For example, “second equation in Eq. 1” (L96) and “first Eq. of Eqs. 4” (L125).

Technical corrections

L35 – remove possible

L57 – “adapted from a climate model” → “adapted *for* a climate model”

L69 – Remove “According to our aim”

L246 – Replace “circa” with “approximately”