

Summary

This work presents a new method to obtain Antarctic surface melt using only near-surface air temperature and is parameterized for different regions of Antarctica. Overall, the work presented is of high quality and will improve our understanding of AIS surface melt. However, I think the presentation of the methods, results and contribution of this work needs to be modified throughout the paper to clarify how this work fits into previous studies and contributes to ongoing efforts to better understand AIS surface melt. Many of the paragraphs are a bit confusing and difficult to read because unnecessary information is present. I feel confident that once the writing is clarified and condensed a bit that this work will be a great contribution! Nice job on the figures as they are all very clear.

Major revisions

I think the main thing that is missing for me is a quantified justification for calculating parameters for your PDD in each region or basin. What do you gain from the by-region parameterization of your PDD model? How much better does your model do in each basin/ice-shelf region compared to observations than if you just chose one value for the whole AIS?

Many of the sentences throughout the paper use “this” or “it” without specifying what “this” or “it” is referring to. For example, in Line 164: “It shows that most of the cells in Antarctic...”

You mention that topography can introduce spatial variability in PDD parameterization. In this work, you parameterize a PDD model for each basin, but what about topographic variability within each basin? I am left wondering how variable the optimal PDD model parameters are within each basin/region?

I think more emphasis needs to be put on why your PDD model is useful throughout the paper (esp. in the intro and discussions sections). This work provides a new method but not really any new information about AIS melt that cannot be obtained from RACMO or satellite observations. To that end, I think the final sentence in the introduction is a bit misleading because really you just compare output from your PDD model with observations and regional climate model output of surface melt. I would suggest focusing on the novelty of the method and potential applications for it, instead of the fact that you use your model to estimate AIS surface melt from 1979-2022 (because this can be and has been done already with satellite observations and RCMs instead).

Minor revisions

I find the abstract a bit vague. There is too much emphasis on introductory material (lines 1-12) while only one sentence touches on the results (lines 16,17) and this sentence does not make sense within the rest of the abstract (e.g. what epoch?). I think this sentence does not do a good job of summarizing your results in the abstract and I am left wondering what to take away from the paper.

Lines 24-28: You talk about future projects of Antarctic surface melt but what about current Antarctic melt? I think it will help to add a sentence or two that covers the current state of knowledge of AIS melt (i.e. Stokes 2021, Arthur 2022, Corr 2022).

Line 28 – Explain how AIS melt impacts ice sheet mass balance.

Lines 29 – 47: Much of these paragraphs is unnecessary. I think that these paragraphs draw focus away from the main topic of this paper (which is not hydrofracture and ice-shelf collapse as it may seem by reading these two paragraphs). I think this can be summarized in a few sentences related to why surface melt is important in Antarctica.

Line 48: “surface melt has most likely been accelerated by the rapid increase of atmospheric temperatures...”. I do not believe that this statement is correct as I don’t think that AIS surface melt has accelerated. Alison Banwell recently reported results at the Cryosphere 2022 conference in Reykjavik showing a statistically significant *decrease* in surface melt across the AIS (will be published soon). Also, the observational trends reported in Figures 5 and 6 disagree with this statement.

One thing that I think is missing from the introduction – Why are PDD models helpful? What do they add? I think perhaps some of the info from the abstract on PDD models would be better in the introduction.

Line 59 – “The PDD model calculates...” All PDD models or just one in particular?

Line 60 – “... based on the temperature-melt relationship”. Earlier (line 57) you mention that PDD models also use the precipitation field. Is this just some PDD models? Or are you talking about the ice sheet models that use precipitation fields to determine SMB?

Lines 65-67 – “Wake and Marshall (2015)...” I find this sentence to be a bit distracting and confusing. I think you could just simplify to: “Wake and Marshall (2015) suggest that Antarctic surface melt can be estimated solely from monthly temperature”.

Line 69 – What do you mean by “universal usage”?

Line 71 – “Topographic influences” such as what?

Line 79 – “... ice shelf region...”. Refer to Figure 1.

Lines 81 – Specify that you take *melt volume* from RAMCO.

Line 92 – Specify that you use hourly 2-m air temperature ERA5 data in the text (also on line 174).

Line 95 – ERA5 performs better *at what* than those other models?

Line 109 – “around 6 am and 6 pm” – How close to 6 am and 6 pm? Does the acquisition time vary each day?

Line 110 – “This dataset is being continually updated...” Consider moving this sentence to your Data Availability statement.

Line 115 – “We therefore omit those periods from our analysis” – Which analysis in particular? These periods are not omitted from the trend analysis in section 4.2. I would probably suggest to omit these no-data periods from the trend analysis as well (for both satellite and PDD model trends).

Line 116 – For readability, change “More recently, there is a newly developed...” to “We also use a more recently developed...”.

Lines 119-120 – It is not necessary to specify that this product has a “twice finer spatial resolution than satellite SMMR and SSM/I product” since you mention the resolution of both products.

Line 123 – Consider changing the section heading to “**Regional climate model melt output**”. Additionally, I believe that much of this section is unnecessary. You are just using the melt output from RACMO not doing any of the SEB calculations, correct? Therefore I think this section should focus on describing the RACMO product used instead of explaining SEB modeling as this description is a bit confusing because you do not actually do this in the paper.

Line 147 – Specify that the 27 drainage basins you use are *grounded* ice. I would also specify that you consider “all ice shelves”, “all grounded ice” and “all AIS ice (both floating and grounded)” as regions in this study as well.

Line 157 – “..., which are multiplied...”. What is this referring to?

Lines 161-170 – It is unclear to me why this paragraph (and Fig. 2) is necessary. Has this relationship between melt and temperature already been shown in other work (ie Trusel 2015)?

Line 173 – add “binary” before “melt/no-melt signal”

Line 180 – Do you use all ERA5 data or just the hours of 6am and 6pm? I am confused because Eq. 3 sets $MD^* = 1$ if at least one hour has $T - T_0 > 0$, but in the line below it sounds like you are only using those two hours (6am and 6pm)?

Line 184 – I believe this is the first time you use the “RMSE” acronym so you should define it here.

Line 187 – It might be helpful to introduce the concept of “mask matrices” for each region in Section 2.4.

Line 190 – I think it is a bit confusing how you use the word “region”. Here you say there are 38 regions which I understand to be the 27 drainage basins + ice shelf regions + all ice shelves + all grounded ice + all of Antarctica? This is not entirely clear in all places in the text because the word “region” is also used to describe the ice shelf regions. Maybe consider changing to “area of interest” when talking about the 38 “regions of interest”.

Lines 192 – 194 – The text in parenthesis can be deleted because it clutters up the sentence and is mentioned in the data section.

Section 3.2.2 – Perhaps provide an introductory sentence to define the DDF and explain why it is necessary. (I know this is in the intro but might be useful to mention briefly again here)

Section 3.3 – What exactly are you testing here? I find this section to be very confusing!

Line 213 - “45” This number has no context in this sentence. 45 what?

Line 224 – change “AIS and ice shelves” to “*whole* AIS and *all* ice shelves”.

Figure 3 (and 4) – Your y-label is “RMSE per computing cell”. Is this correct or should it be the regional RMSE?”

Line 225 – “Lower ability” – what exactly do you mean by this?

Lines 226 – 230 – I believe that these sentences can be more succinct and that the part describing the Jakobs et al 2020 study is largely unnecessary and confusing (ie what is “unrecognizability”. I think you could shorten this to something like: “In Fig. 3a-a the RMSE at $T_0=0$ °C is larger than at $T_0=-1.8$ °C (our optimal threshold temperature). This finding indicates that using $T_0=0$ °C as a melt threshold may miss events, a finding consistent with other work (Jakobs et al 2020).

Lines 230 – 234 – What exactly are you trying to say with this sentence? Overall, I think this paragraph can be made much shorter. You are just explaining why you round the DDFs right? I would consider mentioning that you choose to round the DDFs at the beginning of the paragraph (right now it is a bit lost at the end of a long paragraph), and then using the rest of the paragraph to explain why you do this.

Line 253 – “the optimal DDF better estimates...” Which DDF? DDF = 2.8 mm... or the one that is calculated for each basin?

Line 259-260 – “This may lead to a single...” I am confused why you mention this because in your work you do not use a singly parameterization for all drainage basins (Table 2).

Section 4.2 – In this section the analysis of melt days and melt volume are intermixed throughout. I would consider separating these two analyses because they use completely different products (satellite obs. Vs RACMO). This section is also really just further *evaluation* of how your PDD model captures trends/variability in surface melt. You aren’t really providing any new information here about AIS melt variability and trends (that cannot be obtained from already existing products). Hence, I think it might be useful to re-frame the results from this section as model evaluation.

Figure 5 & 6 – I think it would be helpful to also provide difference maps between the observations/RACMO output and the PDD results.

Figure 6d – How do you get melt volume in areas with no annual melt days in Fig. 5d (e.g. parts of the Ronne-Filchner and Ross ice shelves)?

Line 299 – *Why* do you think that the PDD model does not capture some of the trends seen in the observations?

Line 304 – 306 – “It is worth noting that on the marine edge...”. Make the distinction between melt days trend and melt volume trend in this sentence as these are really two different things.

Figure 7 – Is this figure necessary in the main text? It is simply ERA5 output so why is it important?

Line 308 – “West Ice Shelf (part of the ice shelves in Wilkes Land)”. By this do you mean to say that West ice shelf is located in Wilkes Land?

Lines 315 – 318 – What do you mean by “temporal stability” and what sort of “time series analysis” do you perform? What do you mean by “We gather all 27 drainage basins for the next stage of analysis”?

Figure 8 (and in-text analysis) – I mentioned this before but I would consider only performing the trend analysis from 1992-2022 so you do not include any of the years with missing satellite data.

In this section (4.2) you mention “residuals” many times. What are the residuals? What do you mean by this? I was a bit confused what you meant every time I read the word “residuals” which I think limited my understanding of the last part of section 4.2.

Section 4.3 – While RACMO and satellite observations are perhaps closer to the truth than a PDD model there are biases that exist in these products too. Are there studies that mention these biases that you could also discuss in this section?

Line 391 – “same surface melt distributions” – what do you mean by this?

Technical corrections

Line 6 – “Past, present or future contexts”: replace “or” with “and”

Line 60 – Change “it is” in “Although *it is* empirical...” to “PDD models are”. Doing this will clarify what “it” is referring to throughout that sentence.

Line 103 – change “(once in two days before 1988)” to “(once *every* two days before 1988)”

Line 104 – change “melt and no-melt” to “melt *or* no-melt”

Line 144 – change “we use” to “products used”

Line 151 – change “requires” to “require”

Line 184 – Change “in” to “for”

Line 225 – Change “at the point which T_0 equals $0C$ ” to “where $T_0 = 0C$ ”

Line 288 – “That the PDD model...”. Beginning this sentence differently will help the sentence read better.