

Review of “Seasonal to decadal evolution of firn properties and impacts on hydrology of the Juneau Icefield”

Summary:

This paper uses repeat firn cores collected at four sites on the Juneau Ice Field, together with climate reanalysis and numerical firn modeling to investigate changing firn properties on the JIF and their impacts on runoff from the accumulation zone. Given the dearth of data on firn structure and firn hydrology on Alaskan glaciers, this paper provides a valuable first look at these questions.

Major Comments:

[1] The research questions articulated in lines 105-107 are much broader than this study can answer, given the limited number of study sites. I would suggest that the authors tighten these questions to the scope of the study. Perhaps something along the lines of:

(1) How have firn properties changed on seasonal to decadal time scales at 4 sites in the Juneau Ice Field wet snow zone?

(2) How have these firn property changes affected runoff at these sites?

Alternatively, the introduction and discussion would need to make a stronger case for why the inferences from these four sites can be extrapolated to Alaskan glacier hydrology more generally.

[2] Structurally it might be helpful to present the results in the same order you present the data collection (cores -> reanalysis -> model).

[3] The paper could be strengthened by using multiple climate reanalysis or regional climate hindcasts in the climate analysis (Sections 2.2 and 3.1). Some discussion of how these reanalysis products have been validated for Alaska and their limitations would also be appropriate. If reported trends are consistent across multiple reanalysis products, this would make a stronger case for the results of this paper. If only one reanalysis product is used, I would encourage the authors to very clearly justify why that particular product was selected.

[4] For all analyses where you report rates of change, please give the p value and confidence intervals on the slope from linear regression results so the reader can evaluate how robust the relationship is.

[5] Line 237 – 244: How are these absolute changes in the date of melt onset being reported? Is this the date in 1980 vs. the date in 2019? I assume that the change is not perfectly monotonic from year to year, so it is important to explain how these differences are calculated. If you want to report absolute change rather than a rate of change from a linear regression, comparing decadal averages might be most appropriate. I have the same questions/concerns about the discussion on the length of the melt season, the number of annual melt days, and the timing of runoff.

[6] The paper would be strengthened with some quantitative comparison between the CFM model results and the field data, as well as with a discussion of model performance and limitations. The CFM results are really central to the conclusions about changing refreeze and runoff proportions, so it would be good to justify to the reader that the model setup captures at least the general observations of density, etc.

[7] The discussion of the GPR data seems underdeveloped. Where exactly was the data collected (a map inset on Figure 1 might be helpful)? Can the data be shown in comparison to the cores it was collected near in a figure? The results discuss apparent changes in attenuation/reflectivity over time, but in the discussion the GPR data is mostly referenced to suggest that some ice layer horizons may be continuous, but then that observation is almost largely discounted. Are the “unstacked radar profiles” mentioned in the discussion from this same data set? If so, that comparison should probably be mentioned in the methods. Overall, it is not totally clear to me what the GPR data adds to the interpretation or conclusions.

Minor Comments:

Line 27: if you choose to define firn, do so the first time it is mentioned on line 24.

Lines 75 – 81: might want to include a short discussion of the role of microstructure and thermal properties since the topic sentence for the paragraph includes these topics.

Line 97: spell out “ELA” the first time you use it

Line 97: can you quantify “significant mass loss”?

Line 122: “These include different climatic regimes and their history of previous repeat mass balance and snow density measurements (McNeil et al., 2020).” I don’t really understand what the second half of this sentence is trying to convey and how it is related to the first half of the sentence.

Lines 124-126: It would be helpful to have these statistics in Table 1 if you’re going to discuss them here (could be from past publications or measurements if you want to save your measurements for later in the paper).

Line 127: It would be helpful to provide some information on how far apart in time and space the repeat cores were collected at each site.

Line 150: For the reader who is not intimately familiar with the Ochwat et al. (2021) paper, it would be helpful to briefly comment on the source of all these numbers. Without context they seem very subjective, so if there is a quick (1-2 sentence) way to justify them, I think that would be valuable.

Line 155: Might be helpful to include (potentially in an appendix or supplement) a table of exactly what measurements were made at each site and on each core on which dates.

Equation 4: this is kind of nitpicky, but k is more commonly used for relative *permeability* (e.g. the flow parameter) and ϵ for relative *permittivity* (the electrical property). You are clear about the definition, so you don't have to change it, but I do think it could be clearer at first glance to use ϵ since in this context you could totally be interested in calculating relative permeability.

Section 2.3: not totally clear from the text, but I assume that you are just running CFM at the 3 core sites in the accumulation zone? Please clarify in text.

Equation 5: change ρ_j to ρ_j

Line 229: broken reference link to appendix figure.

Figure 2: font size is really hard to read at 100% zoom – can you increase?

Line 309: Should this be a reference to Figure 5?

Lines 316 – 322: I don't totally understand the difference between “annual refreeze in the firn” and the “percent liquid water that is introduced into the firn that is refrozen”.

Lines 342 – 349: Need to be very clear in this section what is modeled results and what is measurements.

Line 389: even greater spatial variability than what? What is the point of comparison?

Lines 460-468: it would be at least worth mentioning that the next step from this idealized calculation would be to run CFM across the entire Taku Glacier accumulation zone. Also, can you contextualize these numbers with total runoff from Taku? How does the amount of runoff from the firn/accumulation zone compare to runoff from the ablation zone?