The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2020-87-RC2, 2020

The Cryosphere Discussions

Interactive comment on "Seasonal and Interannual Variability of Melt-Season Albedo at Haig Glacier, Canadian Rocky Mountains" *by* Shawn J. Marshall and Kristina Miller

Anonymous Referee #2

Received and published: 16 June 2020

Review of: Seasonal and Interannual Variability of Melt-Season Albedo at Haig Glacier, Canadian Rocky Mountains

Submitted to The Crysphere by Marshall and Miller.

Major Revisions required.

Albedo measurements from in-situ weather stations are used to identify melt season albedo dynamics for Haig Glacier. The results are used to comment on the conventional application of degree-day melt rates and on how albedo describes glacier mass balance.

These types of in-situ data driven papers are very important to the understanding of glacier dynamics and glacier mass balance, especially for mountain glaciers. The manuscript is well written with a logical presentation of material. I would suggest a minor re-organisation of the Introduction section to separate the literature review from specific mention of the study on Haig Glacier, as the sporadic reference to the study on Haig Glacier comes across as a bit disjointed. The final paragraph of the Introduction should be devoted to specific details regarding Haig Glacier. Specifically, how the study on Haig Glacier addresses the limitations related to glacier albedo and modelling.

Abstract:

The improvements related to the stochastic model on mass balance and the modification of the degree day model should be provided in more detail.

Line 11: Summer should be defined in the abstract (e.g., June 1 to August 31). Summer is defined on Line 104.

Body of text:

Line 28: It is true that albedo is involved in the control of surface energy balance, but it is the net radiation (short wave and long wave) that mostly controls melt. Net radiation was previously mentioned, but a better description of how net radiation is related to albedo and what the proportion of shortwave to longwave radiation is, would be very useful.

Line 29-30: Reference to Haig Glacier should probably come at the end of the introduction.

Line 48-51: This sentence seems to be a bit misplaced and should be moved to the end of the introduction as a bridge between the literature review and the methods section.

Line 64: Please define what a melt-albedo feedback is.

Line 69-71: Snow algae can be of many species (up to 4 or 5). Is there a reference for

this material, or is it an observation from Haig Glacier? If it is an observation it would find a better home in the Results section.

Line 76: A recent article in Remote Sensing of Environment might be of interest here: Williamson et al., 2020 - Comparing simple albedo scaling methods for estimating Arctic glacier mass balance.

Line 78-79: This material might be better suited in the final paragraph of the Introduction.

Line 82: Can you provide more detail on what the “simplified parameterizations” entails?

Line 111: Campbell does not make many instruments. The details for the instruments should be included (manufacturer and instrument), at the very least for the radiometric instruments, as different instruments are sensitive to different range of the EM spectrum.

Line 119-120: Data collection ongoing has previously been mentioned.

Line 124: If only one station is collecting data how was the lapse rate estimated? Please provide details.

Line 126: How much error is related to the estimation?

Line 132: Define “questionable data”.

Line 154: There is a recursive reflection from the bottom of optically thin clouds or from scattered clouds and a high albedo snow covered surface.

Line 165: Please define Jaycar QM1582. What is the spectral range of this instrument?

Line 221: “this” should be these.

Line 245: The introduction mentions two AWS. It is not clear which station these results refer to. I assume from the data period this is the on ice station (upper ablation zone).

Line 284: “jump” might not be the best descriptor here.

In Table 2 why is Em larger for August than July? Cloud cover – because Em is using only shortwave radiation?

Line 289: What type of regressions are these? Linear, least-square regressions, Pearson’s? Are the correlations statistically significant? If so, which ones?

Line 291: What does “correlated” mean in this instance?

Line 297: Define “fewer samples”.

Line 300: Define “melt out” or replace with better descriptor.

Line 309: Define “ripened and saturated”? Line 315: Some other citations that might be useful here, especially in the context of spatial variability of albedo. 1. B.W. Brock, I.C. Willis, M.J. Sharp. Measurements and parameterization of albedo variations at Haut Glacier d’Arolla Switz. J. Glaciol., 46 (2000), pp. 675-688 2. S.N. Williamson, L. Copland, D.S. Hik. The accuracy of satellite-derived albedo for northern alpine and glaciated land covers Polar Sci., 10 (2016), pp. 262-269

Line 323: Describe the film, thickness composition, etc. Is there liquid water in the surface matrix? If so, what effect does this have on albedo? O.k., I see this is addressed on Line 335. Line 325: Not clear where the values for Figure 5 are coming from, and provide how N=224 was derived. Line 343: Adding year to the dates will reduce confusion. Figure 6: Mean values should have standard error included on the figure. Line 376: “dropping” should be decreasing. Line 385: The values of $\sim$0.1 and 0.07 are close enough that instrument error might render these inseparable? Line 395: Can evidence be presented that Haig glacier was indeed downwind of the forest fire smoke? For example, can specific fire events be linked to specific albedo declines for 2017? Without this link the material presented here is speculation. Line 399: Which year? Line 400: Please present pertinent details for the data. The reader can’t evaluate the data from an unpublished source. Line 401: How is this “consistent”? Provide

details, references or rationale. Line 407: I assume that algae assimilate carbon that was on the glacier before, or during, its growth. If this is correct, then the algae are a carbon flux and not a source per se. Line 420: What does “reasonable” mean? Is this fit presented by the authors?

Line 428: What about heterogeneity of albedo? Albedo increases on a glacier as elevation is gained. What is the amount of variability in albedo for a surface that appears to be homogeneous?

Line 432: “brighten” should probably be changed to increases the albedo to that of fresh snow ($\sim$0.85), before declining to seasonal normal values (over a given time period on the order of days).

Line 446: What does “some” mean in this instance?

Line 453: “reasonable” should be described. What is the difference between the two? Line 455: What is the temperature control on snow fall events? Snow does fall when the surface temperature is > 0.

Line 458: What does “this year” mean?

Line 465: Why were five realizations chosen?

Line 468: I don’t remember seeing any run-off data?

Line 471: Please describe how this is a positive feedback. A warming atmosphere produces more rainfall events (instead of snow) at the glacier’s elevation. Rain further melts the glacier causing more rainfall events?

Line 525: Are there no observations of this behaviour on Haig Glacier?

Line 529: From which transect date?

Line 536: This paragraph is mostly results and should be presented in the Results section. It is a bit problematic that the authors are relying heavily on unpublished data

to interpret the albedo results. Are the unpublished results necessary?

Line 551: Upon what basis is this statement made? There is no observation station at lower station, yet the melt feedbacks are the strongest here. What exactly is the melt feedbacks and why is this plural?

Line 578: Shouldn’t start a new paragraph with “this”.

Line 582: Does water vapour pressure increase over the study period, or for that matter, any of the other environmental variables measured at the weather station?

Line 590: What are the “ways” that you suggest?

Figure 4: Including dates for the photos would be helpful.

Figure 7a: No snow pits appear on the figure. The figure leads me to believe there are additional temperature measurements available.

Figure 8: The modelled values seem to reach a maximum at $\sim$0.85. What is the reason for this? The observed data clearly achieves higher albedo values.

Figure 9: There are $\sim$seven points in the above the trend line (f$\sim$7; albedo$\sim$0.7) that if removed would greatly improve the correlation. Can the author identify the origin of these points (i.e., a specific year, or month)?

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