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The Cryosphere Discussions
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Interactive comment on "Attribution of Greenland's ablating ice surfaces on ice sheet albedo using unmanned aerial systems" *by* Jonathan C. Ryan et al.

Anonymous Referee #4

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This study investigates Greenland albedo, a very important variable in understanding recent ice sheet melt increases and mass balance. Specifically, this study examines how fractional area of six different surface types and albedo vary along a 25 km long transect in Southwest Greenland. The distribution of six surface types were determined by analyzing high-resolution data collected with an UAV. The importance of each surface type in explaining albedo was quantified by correlating the first and second principle component of albedo derived from MODIS with the fractional area of each surface type. This investigation showed that spatial variability of distributed impurities was the most important surface types controlling albedo.

To my knowledge, this is the very first paper to ever publish UAV derived albedo and

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surface type classification for the Greenland ice sheet. It is an important contribution to the literature about Greenland ice sheet albedo, and will most likely be followed by many other studies deploying UAV for this type of analysis. The text is easy to read. The discussion section is terrific and does a great job placing the findings in the context of existing literature. The presentation and analysis of this fascinating and rich dataset in the methods and result sections would benefit of a little bit of more work. Below follows some suggestion and comments for the authors to consider.

Main comments: ————————

1. The ground resolution of the orthomosaics is reported to 15 cm. yet, many cryoconite holes are smaller than that, and the size of these holes may change of the season. This is mentioned in the discussion, but should be brought up in the introduction as well so that the reader knows from the very start that this study is limited to areas with large cryoconite holes. Consider calling it "area with concentration of large cryoconite holes". See more thoughts about this in minor comments below.

2. The principle component analysis should be described in the methods section. Among other thing mention which days of MODIS data were used to calculate PCs (August 8th?), where the PC rotated or unrotaed?, what is the overlap of the UAV footprint and the MODIS footprint, and so on. Finally, it would be interesting to see PC1 and 2 in a figure (e.g. Fig. 6)

3. I recommend a discussion about the uncertainty analysis of MODIS imagery. In particular, the discussion should bring up the differences in footprints between MODIS (pixel) and AWS data (point). In addition to the AWS point comparison, consider comparing the MODIS albedo with the average UAV albedo within each MODIS pixel. This comparison would be very interesting, as the UAV will capture the spatial variability within each pixel that the AWS station does not.

4. The finding that surface meltwater influence 12% of MODIS albedo despite only covering 2% of the surface is noteworthy. This points to surface meltwater having a

disproportionate influence on albedo relative to its area. Consider expanding on the analysis of the surface type influence on albedo by factoring in the areal extent of each surface type.

5. Reorganize the figures so that they appear in chronical order. In the manuscript Fig.6 is mentioned before Fig 4. and Fig 5.

6. Check the fractional area calculation of the surface types. In figure 6, clean ice covers ∼50% of the area at the start of the transect, and distributed impurities covers ∼60%. This adds up to more than 100%.

Minor comments: ————————-

Page 1

Title: Confusing. . .rephrase. The sentence is difficult to understand.

Page 2

L15: “Lovénbreen , Svalbard” » “Lovénbreen, Svalbard”

Page 3

L7-8: Provide more details or references to the “data cluster normalization” method

L11: Add Apogee before SP-110 for consistency

Page 4

L16: add equal sign in R2=0.85

L12-L22: The final steps are difficult to understand. Explain why the “linear least squares regression between the reflectance of surfaces within the illumination-corrected images and albedo of surfaces measured using the CM3 pyranometer from the ground” is needed. In the previous text it was explained that the CM3 pyranometer was used to establish the error in the SP-110 pyranometer, but here another reason seems to be given. Please clarify.

Page 6

L3 – 8: Elaborate on the overlap of the MODIS and UAV footprint and the differences in spatial resolution. In figure 3 it looks like the aPYRA was resampled to MODIS pixels? If so, please mention this in the method section. Furthermore, a more comprehensive comparison of aPYRA and aMODIS would be extremely interesting in understanding MODIS sub-pixel variability (but perhaps beyond the scope of this paper).

L24: Rephrase this sentence. Clarify that 0.28 to 0.47 are albedo values. Furthermore, Figure 3 does not show that the variability in albedo is related to surface types. Please rewrite or include a measure of surface type area in Figure 3.

L26: Explain why this finding is “as would be expected”

Page 9

L5-9. This text about how the cryoconite hole distribution might influence the conclusions is a bit problematic since the distribution of small cryoconite holes is unknown. However, it is not a big problem for this study. Simply state at the very beginning of the paper that your study is limited to features larger than 15cm. You can call it “areas with concentrations of large cryoconite holes” to clarify that smaller cryoconite holes exist but are not part of your study. Similarly, rephrase your conclusion and write “spatial patterns of aMODIS does not seem to be governed by the distribution of clustered large cryoconite holes” or something along those lines.

Page 10

L18: Move the description of aCAMERA calculations to the methods sections.

Tables and Figures

Table 2: Mention the year in the table text

Table 3: Consider reformatting the table to make the fractional area items easier to read. For example list the various fractional area categories as sub columns to “frac-

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tional area", instead of a list for each figure.

Figure 4: Provide a legend for the histograms that are inset in panel A, B, and C. Also mention them in the figure caption

Figure 5. Explain the histograms (see comments to Fig. 4). Explain in the figure caption what the albedo mention in the box is about.

Figure 6: Clarify in the figure text if the data is from a specific day or based on averages.

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