

Response to Reviewer 2 comments. My co-authors and I thank Dr. Warren for providing very helpful feedback. We have addressed each comment and indicate how we have done so in red below. Overall we believe that the manuscript has greatly improved with the help of this and the other reviewer's comments.

Interactive comment on “The seasonal evolution of albedo across glaciers and the surrounding landscape of the Taylor Valley, Antarctica” by Anna Bergstrom et al.

Stephen Warren (Referee)

sgw@uw.edu

Received and published: 6 November 2019

Major comment: Further analysis is required to take into account the slopes of the glacier surfaces. Although the authors did not state this explicitly, I think the radiometers at the ground stations were probably leveled horizontal, rather than parallel to the surface. If the ice surface is sloping to the south, then at midday it is receiving less incident solar flux than a horizontally-leveled upward-looking radiometer, and the measured albedo needs to be corrected for this slope. An example of the bias that can result, if the slope-correction is not made, was shown in Figure 9 of Grenfell et al. (1994) and related discussion. A similar correction must be made to the upward flux measured from the helicopter, using the sun azimuth and elevation for the times that the different glaciers were overflown. For flights under overcast cloud, no correction is needed, because both the upward and downward radiation are diffuse.

We appreciate the reviewer making this point. We have done extra analysis taking this concept in to account coupled with an additional literature review. The meteorological stations are all leveled and measuring albedo over a horizontal surface and therefore do not need correction. We applied the method outlined by Grenfell et al. (1994) to our airborne dataset of apparent albedo. This method works well for most locations over which we collected data. However certain areas, namely the lower elevations of Canada and Taylor glacier, are too topographically complex for this method to work well and produces physically unrealistic results. We tested corrections using both and mean and median slope with little difference between the results. We did an additional literature review to determine how this problem is addressed elsewhere and found that methods vary depending on if they were developed for station or satellite data and unfortunately neither scale is particularly suitable for this application. We discuss limitations of the simplified correction method and locations where it is particularly problematic in a new section we added to the manuscript titled “Error sources and albedo correction”

Some considerations for how to make albedo measurements from helicopter were discussed by Allison et al. (1993), which the authors might like to read.

Discussion of this paper is included in the error sources and estimation section that was added to the manuscript. We thank the reviewer for making us aware of this paper. It was very valuable in developing this section.

Minor comments: Some confusion results from the terminology. Going “up-valley” sounds like going to higher elevation, so I was at first puzzled to read that albedo increased with increasing elevation but also increased going down-valley. Maybe you could instead say “downTaylor” and “up-Taylor” to forestall this confusion.

We changed this language throughout and now use west, generally referring to the Hoare and Bonney basins closer to the polar plateau, and east, generally referring to the Fryxell basin and closer to the Ross Sea.

p 4 line 17. Explain why the radiometer was hanging so far (6 meters) below the helicopter. How was it maintained level?

The radiometer had to be in a box slung from the helicopter due to safety regulations of the helicopter contractor. We explored the possibility of mounting it directly to the helicopter, but this was not possible due to rules in place about what can be attached to the helicopter. The solution was to sling the instruments. They are maintained level by over 200 lbs of ballast in the box and a large fin attached to the back of box. There is minor swing of the box however, observations of the flights lead us to believe that it was maintained mostly level throughout the flight. We add language discussing how swing may contribute to error in new section titled “Error sources and albedo correction”

p 6 line 4-5. “Accumulation due to foehn events is removed.” Why?

This statement was made in error. Accumulation due to foehn events was removed in processing this dataset for other purposes but was not done here. Any accumulation of snow will affect albedo and wind-driven accumulation is left in the dataset presented in this study. This sentence has been removed

p 8 line 13. If the soil became damp or wet, this would explain the reduced albedo, as shown by Bøggild et al (2010, Figure 6) and explained by Bohren (1987).

We appreciate the reviewer bringing this to our attention and agree that soil wetting likely reduces albedo due to regular deliquescence of MDV soils. We have added language discussing this as a final paragraph in section 5.1

p 14 line 27. “arguably”. Is this word needed? Who argues against this claim?

Arguably has been removed and the sentence has been edited. It now reads:

Albedo is one of the most important parameters for glacial energy balance across all types of glaciers at all latitudes

Figure 1. In the inset, the Ross Sea is to the left of the star, but it's to the right of the main map, causing confusion. The inset should be rotated 180 degrees, so that north (at the star) is toward the top.

We have rotated the map and it is now in the same orientation as the main map.

Figure 2 is too small. I don't see the “polygons” (line 7); maybe they will be apparent when you expand the figure.

Figure 2 has been enlarged. The polygons should now be visible just inside the edge of the lakes and glaciers.

Figure 3g. The peak seems to be at 14:00. What time zone are you using? It would be better to use local sun-time for this plot.

We have adjusted this and the plot now uses local sun time.

In Figures 4 and 5, the data are classified first by year and second by surface type. Consider reversing this hierarchy, or maybe add two figures with the reversed hierarchy. The years are different from each other, but the surface types are more different from each other than the years are. So try merging all three years onto one graph to plot the seasonal cycle for soil, for example. This will also resolve the seasonal cycle better, with 14 points from November to January instead of only 4 or 5.

See response to comment below.

Figure 4 caption line 1. Change “percent” to “fractional”. Also on Figure 5.
This has been changed in both figures.

Figure 5. Most of the information in this figure (except for the snowfall events) seems to duplicate Figure 4. Readers looking back and forth between Figure 4 and Figure 5 will be frustrated trying to make sense of any differences.

We have changed both figures 4 and 5. Figure 4 now focuses on the range of corrected values across landscape types. All seasons are on the same figure and figures are separated by glaciers, lakes, and soils. Figure 5 is similar to what was in the original submitted manuscript, but a new panel has been added that is the same three figures separating individual, glaciers, lakes, and soils, across seasons but uses corrected albedo instead of apparent albedo. This new figure configuration allows us to discuss differences across each of these landscape components using both correct and apparent albedo. We believe that this improves discussion and illustrates the differences between apparent and corrected albedo (Figure 5) and how this changes across landscape types, while showing the overall seasonal patterns of albedo (Figure 4).

Syntax and spelling:

It is jarring to read “We” six times in the abstract. Some of these can be replaced. For example, you could say “The seasonal evolution is yet to be fully characterized”, “A camera, gps, and shortwave radiometer were hung from a helicopter . . .”, “These data are coupled with incoming radiation . . .”. Your sentence “We also observed that albedo followed a pattern . . .” can be shortened to “The albedo followed a pattern . . .”

These edits have been made as well as some additional edits to the abstract to improve clarity.
We believe the abstract is now more clear and readable.

page 3 line 31. “wind-transported material that frequently melts to form cryoconite holes”. It is the ice that melts, not the wind-transported material.

This has been edited to clarify that the material melts the ice below it.

page 5 line 3. “. . . did not meet usability standards or associated with . . .”

We added “were” between or and associated. The sentence now reads: Individual measurements were either discarded if they did not meet usability standards or were associated with a given landscape feature and the closest meteorological station

p 9 line 16. “on the that flight”

We removed the word “the”

p 9 line 31. Change “principals” to “principles”.

This change has been made

p 16 line 22. "This research a part of"

We added "is" to the sentence. It now reads: This research is a part of the McMurdo LTER, funded by the National Science Foundation grants 1115245 and 1637708.

p 17 line 4. Change Antarcitca to Antarctica.

This has been changed.

p 19 line 13. Change Stoeve to Stroeve.

This has been changed.

p 19 line 28. Change "Manag." to "Research"

This has been changed.

p 24 line 4-5 "shown are as". Maybe you mean "are shown as".

This sentence has been fixed to read "are shown as".