

Interactive comment on “Spectral Characterization, Radiative Forcing, and Pigment Content of Coastal Antarctic Snow Algae: Approaches to Spectrally Discriminate Red and Green Communities and Their Impact on Snowmelt” by Alia L. Khan et al.

Anonymous Referee #1

Received and published: 1 September 2020

General Comments:

This seems to be a good, descriptive story about two color morphs (red and green) of snow algae on Antarctic Peninsula islands; the role that each morph plays in radiative transfer to the snow there; and how the two can be distinguished using remote sensing products. The authors do an effective job of describing how they calculated radiative forcing due to algae and found it similar to another estimate a hemisphere away on

C1

a maritime glacier in Alaska (Ganey et al., 2017). This latter result may not be too surprising, considering that the latitudes (60 N and 62 S) have similar solar insolation and the algal reflectance spectra, too, look alike. The Antarctic context with two colors of snow algae that appear rather straightforward to separate using remote sensing is quite interesting. I wonder how much of the difference in Figure 4 is due to abundance and how much is due to actual pigment differences? I wonder how much of Figure 6 is a bit too speculative.

Overall, I look forward to seeing revisions.

Specific Comments:

Which leads to the following questions for the authors that this reviewer would appreciate in a revision.

1) Was there any measure of algal abundance? Cell counts for instance? Sort of interesting that green algal blooms absorbed so much more than the red ones. Is it due to algal abundance or pigments? For example, those curves in Figure 4 look like other papers' figures where what varies is the abundance of algae, rather than color. This could be addressed to satisfy the curiosity of some readers.

2) Would the authors be willing to discuss this caption from Figure 5 “C) Absorption normalized to chlorophyll plus phaeopigment biomass demonstrates that red algae (red line) communities absorb considerably more per mg of pigment compared to mixed (black line) or green (green line) algae patches” in the context of the Dial, Ganey, Skiles 2018 hypothesis that natural selection favors the red-colored pigment in red-colored snow algae to melt more snow, thereby freeing-up water and nutrients needed for life (in lines 315-317, perhaps).

3) Might it be worth reviewing some of the key differences between biotic and abiotic LAP as described in the opening paragraph of Ganey et al. 2017 to highlight the fact that living organisms act on the cryosphere in a fundamentally different way than

C2

mineral particles or black carbon do?

4) Line 38+: “This intense warming is likely increasing snowmelt availability, potentially impacting red and green snow algae blooms, which are sensitive to light (Rivas et al., 2016)” could include other citations including:

The original paper claiming that snow algae are sensitive to light and that pigments protect.

Bidigare R, Ondrusek ME, Kennicutt MC et al. Evidence a photoprotective for secondary carotenoids of snow algae. *J Phycol* 1993; 29:427–34.

A paper suggesting that perhaps photoprotective pigments have another role.

Gorton HL, Williams WE, Vogelmann TC. The light environment and cellular optics of the snow alga *Chlamydomonas nivalis* Bauer Wille. *J Photochem Photobiol* 2001; 73:611–20.

A theoretical and experimental paper that algal pigments are not just protective, but functional in melting snow and ice.

Dial RJ, Ganey GQ, Skiles SM. What color should glacier algae be? An ecological role for red carbon in the cryosphere. *FEMS Microbiology* 2018; 93.

5) Lines 325-329: Not clear if these are for Fig 6 C or something else. Fig 6 C needs a bit more fleshing out both in the methods and in the results. If I’m reading between the lines, this is using algae spectra from the late two-thousand-teens and measured PAR from the late nineteen-nineties to show a possible time course of radiative forcing due to various colors/mixtures of algae? And what about figure 6e? One year recently or an average of the Palmer data in the 1990s? These results seem speculative at best. Snow alga abundance is notoriously variable from year to year, so not sure assuming this constant balance of red vs green year after year is informative. Perhaps avoid what could be construed as over-interpretive modeling...or maybe I’m missing the point. What is/are the point/s?

C3

Technical Corrections:

Line 46, 51, 53, etc.: misplaced comma? misplaced parentheses? Using the “eg.” I’d think that abbreviation would be inside the parens...or is this a standard practice for the journal (doesn’t appear to be; suggest dropping all the “eg.” Followed by a citation?

Line 47: “influenced by inputs from penguin and seal excreta, which helps to fertilize local glacial, terrestrial, and aquatic ecosystems (Hodson, 2006).” Plural subject implies use of plural verb: “help” rather than singular form?

Line 61: Recent paper also pertinent: Onuma, Y., Takeuchi, N., Tanaka, S., Nagatsuka, N., Niwano, M. and Aoki, T., 2020. Physically based model of the contribution of red snow algal cells to temporal changes in albedo in northwest Greenland. *The Cryosphere*, 14(6), pp.2087-2101. Also might be worth pointing out some other qualitative differences between biotic and abiotic LAPs as mentioned in Ganey et al.

Lines 64-78 could be reduced to a simple statement that the taxonomy is unstable.

Line 82: algae is a plural word: “Snow algae were first mapped...” would be correct.

Line 85: Replace as “On the Greenland ice sheet”?

Line 94: “are clean (free of snow algae)” does this mean clean of all LAP? Or just algae? Maybe say more simply “are free of snow algae”?

Line 98: “several heritage approaches to estimate pigment concentration” what’s a “heritage approach”?

Line 105: “with slightly less frequent wildlife traffic.” Than what/where?

Methods: are all, some, or no sites glacial? Hard to infer except that the snowpacks are optically thick, but my impression is that none are glacial: correct? Although Figure 1 suggests the possibility of glacial edge?

The references need major revision to clean up and make useable to readers.

C4

Some examples of incomplete citations (there may be more):

Ganey, G. Q., Loso, M. G., Burgess, A. B. and Dial, R. J.: forcing on an Alaskan icefield, , (September), 490 doi:10.1038/NGEO3027, 2017

Mobley, C. D.: Estimation of the remote-sensing reflectance from above-surface measurements, 1999.

Painter, T. H., Duval, B., Thomas, W. H., Heintzelman, S., Dozier, J. and Mendez, M.: Detection and Quantification of Snow Algae with an Airborne Imaging Spectrometer Detection and Quantification of Snow Algae with an Airborne Imaging Spectrometer, , 67(11), doi:10.1128/AEM.67.11.5267, 2001.

Takeuchi, N., Dial, R., Kohshima, S., Segawa, T. and Uetake, J.: Spatial distribution and abundance of red snow algae on the Harding Icefield , Alaska derived from a satellite image, , 33, 1–6, doi:10.1029/2006GL027819, 2006.

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-170>, 2020.