

The Cryosphere Discuss., author comment AC2
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Reply on RC2

Adina E. Racoviteanu et al.

Author comment on "Surface composition of debris-covered glaciers across the Himalaya using spectral unmixing and multi-sensor imagery" by Adina E. Racoviteanu et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-372-AC2>, 2021

Initial Response to reviewer 2

We thank the reviewer for the thorough review of our paper and detailed and valuable line by line comments, which will all be addressed in the revised version of the manuscript. With respect to the 3 important issues identified by the reviewer, we will address these as follows:

1. Structure of the manuscript

Thank you for these suggestions. Clearly it is important that we have the methodological description clear and consistent, as we wish to demonstrate the utility of the method with this paper. Therefore, we will rework the paper to present a more balanced level of detail of the various aspects of the methods applied and the associated strengths/limitations. We will also move the analyses presented in the discussion to the results as requested and other improvements to the structure suggested within the line by line comments will also be applied.

2. Validation outside the Khumbu region

We are happy to add another validation site or two outside the Khumbu region, as also pointed out by Reviewer 1. We have searched for Planet imagery outside the Khumbu for the same year and as close as possible to the same days as the Landsat scenes. We have searched the ESA data for this year and unfortunately there are no Pleiades, SPOT or WV scenes for this year for any sites. Planet Imagery is limited in the western part (Lahaul-Spiti), with no acquisitions around the date of the Landsat image in 2015. We will therefore proceed with validation in 1 – 2 additional sites where suitable scenes are available.

With respect to the comment about differences in lithological and morphological composition of the debris, we are fully aware of these differences. We are also aware that, because we could not capture the full variability in lithologies and geologies in the study region using Landsat data, there may be uncertainties. With respect to atmospheric differences that could affect image corrections, as described in the manuscript, we tested

the Dark Object Subtraction approach used in the ARCSI routine against ground data from two sources (CAMs and Aeronet), and the atmospheric profiles were then derived for each scene. We consider these to be the less important sources of errors but we will check again they are all addressed in our discussion of uncertainty. These uncertainties will be discussed more fully in the revised manuscript.

3. A more rigorous analysis is required with respect to the supraglacial ponds.

We thank the reviewer for these interesting ideas for further analysis. As we stated in the paper, given the limitations of the Landsat data, our intent with this publication was to focus on demonstrating the method, and therefore we were cautious not to overinterpret our data, as we believe that an in-depth process analysis would ideally be performed on a fully quality-controlled dataset, and potentially a multi-temporal one, given the known seasonal and interannual variability in lakes. That being said, additional analyses are of course possible using some of the readily available datasets mentioned by the Reviewer. Therefore, we will investigate including (a) glacier surface changes from Brun et al., (2019); (b) glacier velocity from Dehecq. et al., (2020) and (c) perhaps climate data as suggested (ERA5 or HAR).

With respect to the use of machine learning algorithms (i.e., RF), we consider this to be potentially promising, but beyond the scope of the current paper, which is already quite substantial in length. We prefer to recommend a full analysis with machine learning involving a quality-controlled dataset to remove any outliers or errors, which may be done in future versions of this dataset.

We welcome the reviewer's suggestion to aggregate the data rather than to present the data by glacier-by-glacier. We remain to be convinced that aggregating the data by elevation bands is meaningful, because of the large spread in altitudinal range of the debris-covered tongues in this area, and uncertainty about how absolute elevation relates to the downglacier position of supraglacial lakes which might be a more meaningful process-orientated metric. However, we will explore this option by performing the analysis to ascertain if it yields more meaningful relationships, as well as testing the 1° gridding approach to aggregating data as used in Dehecq et al. (2020). This latter option would provide consistency with the existing datasets mentioned. We hope to include a new Figure in the revised paper, which will contain some aspects of these data and provide a broader context for the changes detected in our study.