

The Cryosphere Discuss., author comment AC1  
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## Initial reply on RC1

Adina E. Racoviteanu et al.

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Author comment on "Surface composition of debris-covered glaciers across the Himalaya using linear spectral unmixing of Landsat 8 OLI imagery" by Adina E. Racoviteanu et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-372-AC1>, 2021

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Thank you for the thorough review, and for raising pertinent points related to the methodology used, its transferability and the validation of our results. As a first reply during the open discussion phase, we simply address the 5 main points raised, but note that the detailed minor comments will all be addressed in a revised manuscript and these are also valuable improvements to clarity of the writing and the representation of the existing literature.

We would like to clarify from the start that while using the Landsat archive has the benefit of allowing application over the past decades, these data have limitations. Hence, while we present an analysis of the possible controls on ponds and vegetation, we acknowledge that some of these controls may not be possible to extract with the current data. Given the limitations, our intent with this publication was to focus on demonstrating the method, and therefore we were cautious not to overinterpret our data.

With regards to the major comments, we wish to proceed as follows:

- **Choice of endmembers and validation:**

We appreciate and fully agree with this concern about the quality control of the surface types. We have checked for shifts in the Pleiades and Planet data with respect to Landsat, and have co-registered these images in COSI-Corr. This will be reported in the revised manuscript.

With regards to the choice of surface types, this was the most time-consuming part of the pre-processing, and it underwent multiple iterations. We clarify that we did not extract the spectral signatures from the Pleiades image but directly from Landsat using the pixel purity index routine in ENVI. Since this particular routine is proprietary to ENVI, we will explain it more detail in the revised manuscript. Were aware that these 'pure pixels' may still have a degree of mixture, and we will acknowledge this as a source of uncertainty in the revised manuscript. We mention here that for the pure pixels, we have selected homogenous surfaces based in the high-resolution data, which was co-registered as suggested by reviewer.

- **Focus regions:**

It is true that the distribution of the regions is not even. This is because we sampled known climatic regions, i.e., from west to east: a) the dry-arid monsoon transition zone; b) the central-eastern Himalaya and c) the heavily monsoon-influenced eastern extremity of the Himalaya. We will add one or two regions as suggested here. However, because these additional scenes will all be located in the central eastern Himalaya, we anticipate that differences in the composition might be due to interregional variability in lithology, for example, and may not help further inform the influence of the climatic gradient on the surface composition.

▪ **Generalization of the method to all of the Himalaya:**

We will validate the lake results at least one other sites of the Himalaya, depending on availability of Planet imagery close to the date of Landsat imagery. We do not have Pleiades imagery for the year 2015 from another site, so there might be a slightly higher uncertainty in the lake outlines we will derive from Planet (at 5 m), which will be discussed.

With regards to the transferability of the method: the idea here was to develop a single spectral signature in an area which includes a variety of lithology (i.e., Khumbu), to evaluate its performance over the entire range, and discuss the limitations of such an approach and ways to improve it in a subsequent study.

▪ **Controls on supraglacial ponds**

Yes, the 'slope' derivation here is the downglacier slope of the debris-covered section. For a revised manuscript, we will explore some further geomorphic analysis of the controls on pond incidence as suggested, such as looking at elevation bins. However, we note two limitations on the scope of the supraglacial pond control analysis we wish to present in this paper:

- as the surface composition, including the lake database, has not undergone manual corrections, we do not wish to over-interpret our results. Existing lake or debris cover databases, including the ones cited in this paper, typically undergo multiple iterations and improvement. A quality-controlled lake composition dataset, which would allow a full analysis of controls, would require a degree of randomised checking and potentially monaural adjustments, but this method can certainly form a starting point for such mapping. Here, our intent is to show the potential of the method to decompose the surface composition and notably the lake coverage.
- as noted by the reviewed lake extent is temporally variable and we offer only a snapshot, whereas a more complete analysis to deepen process-understanding would necessarily require investigations that go beyond the scope of the paper in our opinion, which we wish to focus on showcasing the potential of the method.

▪ **Use of the SAM method:**

We will remove this in the revised version of the manuscript. The SAM was an intermediary technique (hence its application over the entire image) - but we agree it is not relevant here.