

## ***Interactive comment on* “Brief communication: Supraglacial debris-cover changes in the Caucasus Mountains” by Levan G. Tielidze et al.**

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### General comments

This contribution presents satellite imagery derived changes in supraglacial debris cover in the Caucasus Mountains between 1986, 2000, and 2014, based on Landsat and Spot imagery. The paper presents interesting data although I find some of the methodology unclear. The analysis of the data could be extended to support, or refute, some of the inferences in the discussion, which is sometimes rather speculative. When addressing these issues, the paper should be a relevant contribution, but may be better published as a standard format paper, instead of a brief communication?

### Main comments

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The description of the methods takes up a considerable fraction of the entire paper, but there still is some information missing. I had the biggest difficulties to understand how the GPR data was used. Hardly any information is given about it, but it appears to be relevant for “correcting” the debris covered area on the Elbrus Massif. If the GPR data was used in this study, I think the authors should provide much more information about the data and the results. At present, I’ve only seen one figure in the supplementary material (Figure S6). How reliable are the GPR measurements? Is there room for interpretation or was it all straight forward? I don’t question the observations; I would just like to see more of the data the authors collected.

Overall, I found the discussion quite confusing. It starts with a chapter on possible reasons for the observed SDC increase, but this chapter also addresses the question of spatial differences in SDC, without any temporal aspect. The authors mention many potential reasons for either spatial differences or temporal changes (and I think many of them are truly meaningful), but they remain speculative. I see potential to address some of these reasons with the current data, but that would require additional analysis. For example, the authors suggest that rock avalanches after 2000 may be one of the reasons why SDC increased more during the period 2000-2014 and they provide examples in the supplementary material. Wouldn’t it be possible to quantify these in order to assess their relevance? From the supplementary figure, it wasn’t clear to me if all of the rock avalanches were deposited in the ablation zone. If not, some of them may be gone again when buried under snow and ice in a few years. The authors also suggest that topographic differences between northern and southern slopes are responsible for spatial differences in debris cover. Instead of opposing just the two regions, wouldn’t it make sense to analyze the glaciers and their topographic setting for testing this idea? If true, there should be a correlation between the topographic reason and the observed difference. There exist other inferences or statements (“Little Ice Age moraine can affect the SDC increase on the glacier tongue, as debris often falls from lateral moraines onto the glacier surface”; “in the eastern Greater Caucasus, a large percentage of the debris cover is a result of the lithology”) that should be better backed up by observa-

tions, for example, from the spatial distribution of debris cover and its increase on the glacier surfaces.

The comparison with previous estimates of debris cover in the Caucasus Mountains is useful and worth reporting. However, when comparing results with the values reported in our recent paper (Scherler et al., 2018), it should be explicitly stated that the scope of our study was a different one. We attempted an automatized global assessment, knowing and discussing the issues of erroneous glacier outlines in the RGI and we explicitly stated that we did not correct any outlines in the RGI. In other words, we did not pretend to get the debris cover correct, if the RGI outlines are not correct. This is an important point that should be acknowledged to avoid making a straw man argument! It is also not clear to me how the data of Figure 2 was put together. Were only those glaciers compared that were analyzed in both studies? And what about the circular glaciers? Overall, I find Figure 2 not relevant. More relevant would be the comparison of the clean ice-debris cover boundary between our and this study, as in our automatized mapping, we were relying on a single threshold value for the entire Earth.

### Specific comments

P1L24: “Thereby”: I don’t see the causal connection to the foregone sentence P1L26-28: It would be good if you could provide an explanation, or your favorite explanation, why this is the case.

P2L2: “supraglacial debris thickness” P2L8: “Europe”: Nothing important, but I’m wondering if all of the Caucasus Mountains and thus all of the glaciers and their area are part of Europe? P2L10: Delete “similarly” P2L15: How does it contradict earlier studies? Please specify. P2L25: What determined your selection of glaciers? Does this mean there exist glaciers that you did not consider? Please clarify. P2L29: “a largest” -> “the largest” P2L39: “Additionally, . . .” -> Please specify how you included what kind of GPR results in which way. Also give references if it is published. If it is not published,

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I think you need to provide much more information on the GPR data.

P3L1: ASTER GDEM asks for a certain way of acknowledgement that is missing.  
P3L5: What threshold value did you use to distinguish between ice and debris? P3L13:  
“SDC is” -> “SDC are” P3L14: Delete “Relatively” P3L16: Again, it is unclear how you  
used GPR data (see comment above). Figure 1: I think this figure should be larger –  
but maybe that’s just due to the formatting of the PDF. P3L22: “sections” -> “regions”  
P3L23: “Elbrus Massif”

P4L9: Delete “however” & “critical to” -> “critical for” P4L10: “performed” -> “used”  
& Why is method 2 giving you a more realistic uncertainty estimate? P4L19: How  
is the geomorphology complicated? P4L31: “debris cover” -> “SDC” & comma after  
“increased”

P5L8: “Debris cover migrated up-glacier” -> I haven’t seen any data on the spatial  
distribution of the SDC. If you have, it would be worth showing it.

P5L10-P6L11: This chapter sounds more like results. Also see the main comments  
above.

P6L14: Regarding the GPR results, see main comments above. P6L25: Not clear how  
the cited studies and this one are broadly consistent. In that there is an increase? It  
appears difficult to compare a regional study with individual glacier studies. Perhaps  
compare results from this studies with previous ones by limiting to those glaciers that  
are in common? P6L31: “141% increment”? P6L36-P7L3: See main comments above.

P7L10: SCD -> SDC P7L15: “periglacial debris cover”: this term comes surprising and  
it’s unclear how this conclusion came about. Also, why is the monitoring “vital”? P7L16:  
Delete “a”

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-259>, 2019.

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