

# ***Interactive comment on “Changes of the tropical glaciers throughout Peru between 2000 and 2016 – Mass balance and area fluctuations” by Thorsten Seehaus et al.***

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Received and published: 31 March 2019

In my opinion this is a solid study with important new results and there is no doubt that I would like to see this paper published, eventually. While I think that the methods are good state of the art there are a few issues in the results which irritate me and make me wonder whether there are some more basic problems with data collection and analysis which I detail further below. To start I'm impressed by the amount of work done by the authors on a generally high level of data analysis, well presented. It adds new insights on glacier changes (area, surface changes and mass balance) which were previously not known on this level of detail and spatial coverage. I also like the discussion section

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which is transparent, comprehensive and encompasses the (full) coverage of available literature. In this discussion section the authors critically analyze a number of differences (and similarities) between their results and those of other studies. I can follow this discussion and I think it is mostly appropriate but I'm wondering whether there are underlying errors or uncertainties in terms of data sampling or analysis that may have gone undiscovered. I list here a number of possible problem areas: The authors did not measure the full extent of the glaciers, and transparently report on it but the effect and possible uncertainties involved are not clear to me. The glacier area changes reported in Figure 9 and Table 2 contain numbers that raise some questions. An area loss of only about 5% from 1970 to 2000 is in contradiction to what is generally reported, indicating values of 15-20% (Salzmann et al. 2013, Silverio and Jaquet 2004, others, incl. unpublished data). The authors indicate some aspects about incomplete inventories, or sampling issues. I'm not sure whether this large discrepancy can be explained by the mentioned aspects but urgently needs to be clarified. I'm also irritated by the error indications related to glacier area changes reported in Table 2, of up to 30% which is much higher than what is commonly achieved in remote sensing based mapping studies (ca. up to 5%). This also needs to be clarified. I have seen many glacier mapping studies in the tropical Andes (published, or reviewed) which had errors because of inappropriately selected images with snow coverage which then resulted in erroneous glacier change results. I can't say whether this study is affected by a similar problem. In any case the authors should carefully review the literature they cite and whether some of these studies have such errors (at Coropuna for instance some published studies have such errors). I'm surprised by the drastic change of glacier and mass balance change of 2000-2013 vs 2013-2016. The authors list a number of plausible reasons, and I think the increased precipitation (accumulation) at high altitudes is a very important finding here. Nevertheless, important open questions remain. Fig. 9 indicates a change in the El Niño Index around the year 2013, changing from slightly negative to strongly positive. Reported mass balance and (high altitude) surface change can certainly be explained with this mechanism to some extent. But it

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is unclear (and not plausible) how precipitation changes would immediately translate into rather drastic changes in glacier area, even if the response of tropical glaciers through feedback processes including precipitation and albedo changes is more direct than in mid-latitude glaciers. The comparison of their results with ground based mass balance measurements (glaciological method) are very significant. The authors are right that there are problems with the mass balance measurements which in fact are very challenging on these glaciers. Nevertheless, the authors should investigate this issue in more depth. I would also recommend to look in more detail on locally available field data which co-author Alejo Cochachin disposes of. The measurement interval (2000-2013) could have an effect, and changes towards more negative glacier mass balances could have been started earlier than 2013. Also, just as an additional information, according to mass balance measurements we did in collaboration with the Peruvian colleagues indicate that mass balances (since 2010) are much more negative in the Cordillera Blanca than in the Cordillera Vilcanota. All these points, open questions and uncertainties leave me with considerable doubts whether there are (basic?) problems with data collection, processing and analysis. For me these are the fundamental points that absolutely need to be clarified before this study can be published. I encourage the authors to do a serious investigation about these issues such that we can have reasonable confidence that the reported results reflect the reality and are not distorted by any errors.

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2018-289>, 2019.

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