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Interactive comment on "Glacier change and glacial lake outburst flood risk in the Bolivian Andes" *by* Simon J. Cook et al.

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We thank Wilfried Haeberli for his constructive comments on our manuscript, and are pleased that he views our work as welcome and interesting. We have made a number of changes to our manuscript in response to his comments, and respond to these below.

Hazard and risk aspects

A key criticism of our manuscript is that it employs a self-correlation between lake volumes and areas (Equations 2 and 3 in the original manuscript) to predict the volumes of Bolivian glacial lakes. These comments follow constructive interactive comments made by Wilfried Haeberli about Cook and Quincey (2015) (see http://www.earth-surf-dynam.net/3/559/2015/esurf-3-559-2015-discussion.html). In our original manuscript,

we sought to avoid total reliance on the widely used empirical volume-area relationship of Huggel et al. (2002) by supplementing this with a new empirical volume-area relationship derived from a more targeted and appropriate selection of lakes from the collation of data undertaken by Cook and Quincey (2015), i.e. those of a similar area to the lakes encountered in Bolivia, and restricted to moraine-dammed lakes only. Nonetheless, this did not avoid the use of a volume-area self-relationship, and the reviewer has questioned the validity of its use here. These concerns are valid.

To address this issue in the revised manuscript, we have taken the reviewer's advice by instead using the depth-area data collated by Cook and Quincey (2015) to predict mean depth for Bolivian glacial lakes. Depth can be multiplied by measured lake area to derive lake volume. We now explain this in the text where we present Equation 2, and the updated values are shown in Table 2. We have removed the V-A relationship of Huggel et al. (2002), and we have removed values from Table 2 and in the text that were derived from that relationship. The majority of these changes can now be found on P6 L5-25.

On the subject of peak discharges calculated using Equation 4 (now equation 3), the reviewer raises the point that we should emphasise that these represent worst-case values. We have now highlighted that throughout the manuscript wherever we discuss these values, and where we describe the methods used (i.e. where Equation 3 appears). E.g. P6 L24 and P8 L22-3.

The reviewer also raises the interesting point that the potential for glacial hazards to occur may not reduce as glaciers disappear. This is pertinent to the interactive comment on our manuscript by Mauri Pelto (doi:10.5194/tc-2016-140-SC1), who queried whether GLOFs represent an "emerging" threat in Bolivia. Certainly, we agree that glacial hazards, including GLOFs, could become a worsening threat to communities in Bolivia, but there are no long-term data available (at least to our knowledge) to examine any such trends. See P5 L3-5 for example (plus other edits in response to minor corrections below).

Minor corrections

1-24: changed to “contain” P1 L24

2-04: changed to “increasing atmospheric temperature” P2 L4.

2-26: we now cite these references P2 L26-7

4-15 and 5-first paragraph: We have noted on p5 L11 that the selection of this distance threshold is somewhat subjective. We have followed the precedent here of Wang et al. (2011, 2015). We made the suggested addition about permafrost thaw, and cited a new study by Rangecroft et al. (2016) that indicates almost complete permafrost disappearance in the Bolivian Andes by the 2080s (P5 L3-5).

5-9: We have added a statement about the importance of other factors in determining flood magnitude. P5 L13-14.

5-13/14: We now acknowledge that smaller lakes could still generate damaging floods. P5 L18.

5-23: We now acknowledge that floods could propagate further than 20km. P5 L28.

7-33: removed “increase” P8 L7

8-10/14: We have added a statement to emphasise that these discharges are worst case / unlikely. P6 L24 and P8 L22-3.

11-01: We were unsure what the reviewer was suggesting. Perhaps a way of decreasing word count. We have left this for now.

11-23: We now cite Linsbauer et al 2016. P12 L25.

11-28: full stop removed P12 L12

12-28/29: We felt that the conclusion section was perhaps the wrong place to discuss rock dam stability since this appears to be an issue in its own right. Instead, we elaborated on this issue on P5 L34 to P6 L2, and removed mention of rock-dammed lakes

in the conclusions. We have emphasised in the conclusions that these are worst-case scenario values of peak discharge.

Table 2: Yes. This was dealt with in an earlier point.

References

Cook, S. and Quincey, D.: Estimating the volume of Alpine glacial lakes, Earth Surface Dynamics, 3, 559, 2015.

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