

## ***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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Received and published: 18 July 2016

Cook et al: 2016 provide a detailed examination of glacier area change and glacier lakes in key glaciated regions of Bolivia. This is a valuable paper that advances both regional knowledge of glacier and glacier lake change, but also utilizes efficient and reliable techniques. The GLOF threat and the current trend in that threat may be overstated, given the current decline in ice-contact glacier lakes noted and the author's observation that few new lakes seem to be forming and the lakes will likely have reduced sizes. The impact on glacier runoff of the 43% glacier area loss is likely understated and should be better quantified, though still being a first order approximation.

Specific Comments: 2-27: The lack of attention is likely due to their not being any historic experience with GLOF suggesting the risk is not high in this region. Hoffman

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and Weggenmann (2012) point out that the Keara example here is the first known GLOF in the area.

4-1: The step wise approach for glacier area identification is a best practice approach.

4-27: If these lakes are not in contact with the glacier and the steep slope has not been recently deglaciated, than is GLOF is the correct term?

5-1: I assume this applies to only recently deglaciated steep slopes, if not just state.

5-28: Reword; Lakes confined within rock basins are less likely to experience breach incision.

6-3: Any examples of application of this formula in the Andes?

7-10: This is one of the key finding that all regions had a decline in ice contact lakes from 1986 to 2014, Figure 6a does not communicate this as well as a Table would.

7-17: A Table would provide a better display of lake number changes than Figure 6a or 6b, since these are not actual trends through the study period, a line chart display does not provide a clear picture of what is occurring. A table could also better quantify the total rock basin versus moraine dammed lakes.

8-10: Were the number of dangerous lakes determine at any other time than 2014? If so how many were there? How many of these 25 are ice-contact?

9-26: Can emphasize this point with some quantification. A 43% decline in glacier area suggests that total glacier runoff would have already declined substantially as runoff is product of glacier area and ablation rate. This will also affect timing as noted by below studies. “Despite a 15% increase in ablation rate, the 45% decline in glacier area led to a 38% decrease in glacier runoff in the Skykomish River basin” (Pelto, 2011). For specifics on the tropical Andes and seasonal impacts, Vuille et al. (2008) is useful. Some areas with losses of 20% of glaciated area have documented declines in glacier runoff and timing changes, that will be occurring here as well Stahl and Moore (2006),

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Dery et al. (2009) and Pelto (2011).

9-29: Is glacier water supply change felt keenly? This is a region without significant hydropower or fisheries; hence the impact would be on municipal and agriculture impacts. This is an impact with much wider potential importance than GLOF's and deserves further attention. Provide some information on annual precipitation in the region beyond the glaciers and some understanding of the relative water supply from glaciers to this area. A sentence or two defending the statement would prove valuable.

10-26: The decline in ice-contact lakes suggests the number of pro-glacial lakes will decline as glacier retreat continues in the near future. Is this true?

11-7 to 11-14: This discussion illustrates that GLOF risk should be declining as the authors note fewer new lake basins are being exposed or likely to be exposed and their size is reduced. This should be emphasized in abstract and conclusion.

12-5: Is there any chance in your view that remote sensing could be used to assess lake depth in combination with some ground truth? If so elaborate, if not leave alone.

12-25: Given the statements on 2-30 indicating a lack of previous damaging GLOF's and the decline in ice-contact lakes, I do not see how emerging can be used. If anything the data here suggests GLOF's risk will decline. It is certainly appropriate to emphasize the prior lack of quantification of the risk.

Figure 3: Is the Bolivia Peru Border in the Chaupi Orko Massif too far east?

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Pelto, M.: Skykomish River, Washington: Impact of ongoing glacier retreat on streamflow. *Hydrological Processes* 25(21): 3267–3371, 2011.

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Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-140, 2016.

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