The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2017-31-AC1, 2017

The Cryosphere Discussions

Interactive comment on "Monitoring Tropical Debris Covered Glacier Dynamics from High Resolution Unmanned Aerial Vehicle Photogrammetry, Cordillera Blanca, Peru" *by* Oliver Wigmore and Bryan Mark

Oliver Wigmore and Bryan Mark

oliver.wigmore@colorado.edu

Received and published: 7 July 2017

The authors would like to thank Mauri Pelto who took the time to provide a detailed short comment response to this manuscript. Pelto's constructive comments and suggestions will greatly improve the quality and impact of the manuscript. Our responses can be found below a reiteration of the comments.

Wigmore and Mark (2017) provide a detailed review of the methodology employed using a UAV for repeated mapping of the debris tongue of Llaca Glacier, Peru. The

emphasis is on the methodology and I found this to be comprehensive and comprehendible. The level of detail provided by the UAV photogrammetry generated detailed maps of velocity and surface elevation change indicating the value of the approach. There is less emphasis on detailed review of the results. More attention should be given to the speed of supraglacial lake expansion and the volume of water they contain in Section 5.4, as this is both important but also another measure of the utility of the UAV.

Response: We will expand the discussion of our results and specifically address the likely role of supraglacial lakes, as these appear to be a critical driver of melt on the glacier tongue. We will provide an estimate of melt rate expansion between the two survey dates, however estimating their volume is not possible with our current dataset.

In Section 5.2 additional discussion of any ablation rates that could be derived in areas of low velocity such as the right panels in Figure 10 such as a zone mean would be useful.

Response: We originally derived zonal statistics by elevation band (10m intervals) across the glacier tongue (see figure below). These were removed in the final edit of the manuscript in the interest of space. However, with a reduction of the introduction and expansion of the results and discussion these could be included.

Below are specific comments, which are generally minor. 2-14: Differentiate Cordillera Blanca from Himalaya ie. The Himalayan glaciers are in a warmer/wetter environment.

Response: Agreed.

3-10: Is this paragraph needed? Full glacier mass balance is discussed, but this study is not completing full glacier mass balance.

Response: We will likely delete this paragraph when the introductory sections are consolidated per general response.

4-5: To improve the utility of one factor: : :..

Response: Agreed

4-30: Remove this sentence since you have sufficient references without and there are so many videographers uses of UAV's : : : "At higher elevations M. Willis (pers. com.) and S. Wernke (pers. com.) have had success using multirotor and fixed wing platforms for archaeological mapping in the Ecuadorian and Peruvian Andes respectively, at altitudes of up to 4000m: : :

Response: Agreed.

5-26: Reference a specific glacier such as Vallunaraju which shares a divide and terminates at _4750 m. Response: Agreed.

6-6: The lake cannot be classified as directly above Huarez which is over 12 km from the glacier. The drainage channel also enters the Rio Santa downstream of the main city of Huarez in the northern reaches of the city.

Response: Agreed, we will correct/reword appropriately.

10-11: How does the ice loss compare to net annual ablation in this area? If unknown report that.

Response: It may be difficult to find a value that is comparable as the area surveyed was only the glacier tongue – and it is debris covered. However, we will see if there is something appropriate to use and include in the discussion if possible.

10-20: Any temperature records from near this portion of the glacier during melt season?

Response: Yes, we have a T/RH sensor installed above the glacier tongue (South moraine).

10-28: Any observation on melt pond albedo or water temperature. The overall water temperature statement is not applicable if the surface pond is connected to surface streams that lead to rapid turnover.

Response: Pond albedo is lower than exposed ice cliffs. Unfortunately no water temperature measurements were made. In general the supraglacial melt ponds appear to receive inflow from surface streams, and melt from surrounding ice cliffs but have no visible surface outflow, thus turnover is not rapid.

10:28: You note the change in position of cliffs and melt rates of such features. What about the rate of melt pond expansion? This is commented upon and would be important to note.

Response: We will provide an estimate of rate expansion for the supraglacial ponds.

11-27: What about the impact of surface slope on the velocity gradient, there is close to twice the slope in the upper study area, as in the lower area of the study?

Response: We will include this.

11-32: There is sufficient melt for lubrication of any of the lower reaches of these glaciers during the melt season. In this case there is likely partial flotation of the lower section of the glacier, which is less lubrication than having a drainage system that is full and hence higher basal water pressure. 12-23: Likely lake volume range?

Response: For the upper lakes/ponds included in this survey the volume is unknown. Bathymetric surveys were completed for the lower main lake in 2004, with a max depth of 17m and total volume of 274,000m3.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2017-31, 2017.

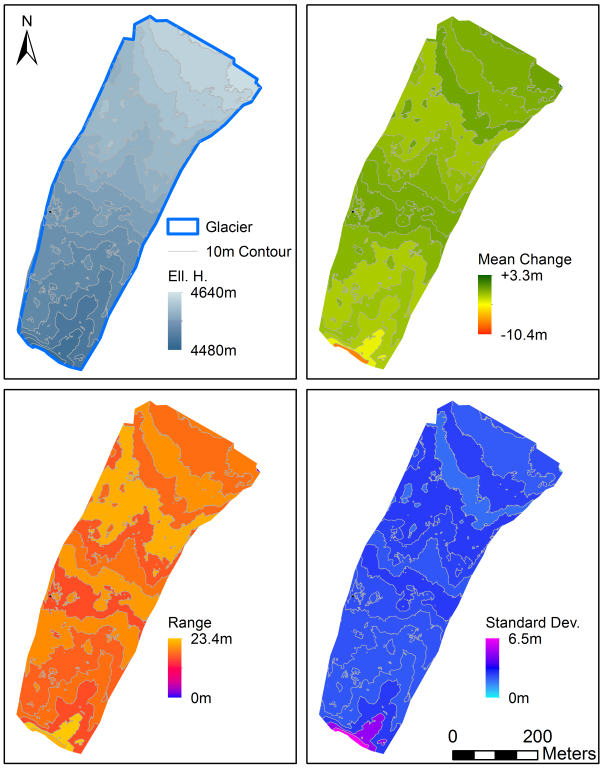

Fig. 1. Llaca elevation band stats