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The Cryosphere Discussions

Interactive comment on "Surface motion of active rock glaciers in the Sierra Nevada, California, USA: inventory and a case study using InSAR" *by* Lin Liu et al.

O. Humlum (Referee)

ole.humlum@geo.uio.no

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It is always interesting to see a new technique applied in geomorphological research, and this work by Liu et al on rock glaciers is no exception from this. There may well be a great rock glacier research potential represented by the InSAR technique used on these fascinating landforms. So, I read the manuscript with high interest.

I am not myself an expert on InSAR, and therefore not able to evaluate the technical details described in the present manuscript. But I will instead take the approach of the interested geomorphologist.

Beginning with the conclusion, it is my overall impression is that there still are some

important issues which should be adressed, before a final manuscript version is prepared.

Let me then continue with a number of issues related to details which are not overly important, but nevertheless in my opinion need to be clarified, corrected or elaborated on.

As one example of this might be mentioned the geographical position provided in figure 4 of the main study locality, the Mount Gibbs rock glacier. The position given in the text for this particular rock glacier (page 348) takes you nicely to the correct place, but this position differs from that provided in figure 4, which takes you to an entirely different place. It might actually be useful for the reader if you clearly stated in the text that many of the rock glaciers in Sierra Nevada really come out nicely using Google Earth.

For another example the reader might be referred to page 345. In line three is stated that rock glaciers may sustain surface runoff in a warming climate. Presumably what you mean is that they are important for runoff in climates which are dry during the growing season, and this not being dependent upon climate warming or cooling?

A third example can be found on page 348. Here you write that 'The till flowing into (the?) lake origins from the ice glacier at the peak of Mount Gibbs'. What do you here mean by 'till'? In a geomorphological/sedimentological context 'till' is defined as sediment deposited by a normal (ice) glacier. Are you instead referring to melt water coming from the ice glacier at the head of the rock glacier, or what? Please clarify what is meant by this statement. Looking at the Mount Gibbs rock glacier on Goggle Earth I see no indications of till flowing into the lake (Kidney Lake) in front of the rock glacier.

At some places the meaning of the wording used seems unclear to me. As an example, on page 353(line four) I was left wondering what exactly was meant by the expression 'deeper in cirques' and also how this might affect flow rates'?

Then moving on to more important matters, on page 352 it is mentioned that your study

(database) considers 59 rock glaciers in total, but I was not able to find any information to how many of these are classified as inactive or active by previous studies (especially Millar and Westfall 2008)? This would be very useful for the reader to know, to compare with your findings.

Another important question which came up was this: how can you feel sure that you are recording the true rock glacier movement by your analysis, and not only (or partly) normal periglacial surface creep? In my opinion, this important question deserves to be discussed in the paper.

The movement pattern shown by figure 4 apparently makes much sense when interpreted as representing the true rock glacier movement, but it would have been even more convincing, had you also shown the periglacial surface creep rate (if any) recorded for the slopes around the rock glacier. On figure 4, the rock glacier is masked out, and movement only shown inside the rock glacier limits, so it is impossible for the reader to carry out this visual test.

A third critical remark relate to the rather short observation period your analysis is based on. Most observations are done between April 2007 and January 2008 (latest in May 2008), within one year only. Can we feel sure that the seasonal differences described in your manuscript represent persistent phenomenon, and are not only (by chance) due to the short observation period? Again, I tend to agree that your interpretation makes a lot of sense, but I would very much prefer to see it substantiated by an analysis based on observations made over a period of several years.

Finally, I would also like to see a more detailed comparison between field measurements/observations and your results based on a remote sensing technique. Let me give you one short example of how this might be achieved:

One of your conclusions is that rock glaciers in the southern Sierra Nevada move faster than rock glaciers in the central Sierra Nevada, but you also mention that there was no significant correlation between the movement rate and elevation or size of the rock

glaciers studied. Here it struck me that you might easily be able to carry the analysis one important step further. At least, looking at snow drift forms clearly visible in the Google Earth images I obtained the impression that your study region must be dominated by snow blow from the southwest? This visual impression (if correct) might represent a nice and easy way of testing the importance of snow drifting and snow avalanching for the activity (movement rate) of rock glaciers in the Sierra Nevada? At the Mount Gibbs rock glacier you even see (in Google Earth) nice traces of snow avalanches transporting snow and rock debris down onto the ice glacier at the head of the rock glacier.

The diagram shown along with these comments is based on your own supplementary data and shows the distribution pattern of your rock glacier sample and their associated flow rates as found by your analysis. To me it appears that there is a pronounced dominance of rock glaciers facing NE, that is, downwind in relation to the SW winds suggested by snow drift forms visible in Google Earth. In this way (presumably there are several others) I believe that your analysis in the 'Regional inventory' might be taken further by comparing with available field observations.

Summing up, I definitely feel inspired by reading this manuscript, and I enjoy seeing you applying a new observation technique (new to me at least) which presumably will be very important for many types of geomorphological research, including rock glacier research.

Therefore I certainly welcome this contribution to modern geomorphological research. However, at the same time I feel that several of the issues raised above deserve additional consideration, to demonstrate beyound doubt the importance of this new observation technique.

Interactive comment on The Cryosphere Discuss., 7, 343, 2013.

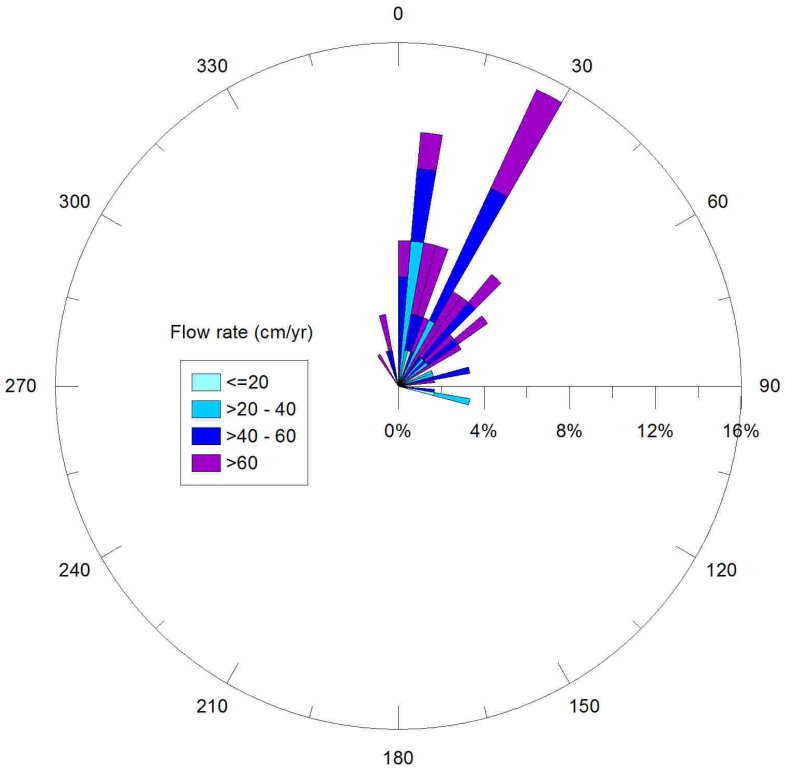

Fig. 1. Rock glacier flow rate vs aspect (360 degree scale)