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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.

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We thank Dr. Strozzi for his insightful and constructive comments. We have addressed all of them and made the suggested changes in the new version of our manuscript. Our point-by-point replies (in black) to his critical comments (in blue) are listed below.

This linked pdf file is our revised manuscript with all changes highlighted in yellow (http://www.the-cryosphere-discuss.net/7/C437/2013/tcd-7-C437-2013-supplement.pdf). Please note that the page/line numbers are different in the original discussion paper and our revised paper. And in our following replies, we refer to the line numbers in our revised paper.

It is worth mentioning at the beginning of page 346 that rock glaciers are optimum targets for InSAR, as there is no vegetation cover.

AUTHORS: We point out that active rock glaciers have sparse vegetation cover and thus minimize temporal decorrelation problem due to vegetation changes (lines 57-59).

For the discussion at the end of page 346, (Dr. Strozzi meant page 345) please be aware that at least for the European Alps there are GPS measurements over long time periods, see e.g. https://edit.ethz.ch/ggl.baug/publicationsEmbedded_cs/printDetail?id=116509&language=DE

AUTHORS: We cite this continuous GPS monitoring work (lines 43-45).

It is mentioned many times that a 'significant seasonal variation of surface speed' was observed, but this is verified only over a single season. The sentence should be therefore smoothed a little bit, even of the peak of velocity in the fall is in line with measurements in the Alps (see reference before).

AUTHORS: Limited by the available data, we are only able to produce time series results for the 2007-2008 season. Therefore, we tune down our statement and point out at several places including abstract and conclusions that the seasonal variation occurred in a single season (e.g. lines 11, 12, 275, 351-352, 421).

Regarding the discussion at the middle of page 346, how can you be sure that every signal of movement correspond to a rock glacier and not to another moving landform?

AUTHORS: We add a paragraph in the method section on InSAR inventory (lines 205-216, section 3.2) to describe our strategy to separate rock glaciers from other moving features in high mountains. Locations of soil solifluction and boulder streams

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are listed in the database of Millar and Westfall (2008), which is used to exclude these two types of periglacial features from our inventory. All other features (debris flows, landslide slumping, avalanches, rock fall/slides, or regular ice glaciers) typically move at speeds at least one order of magnitude higher than rock glaciers, and therefore lose coherence in our 46-day-long ALOS interferograms. These features also have distinct geomorphic characteristics and can be easily separated from rock glaciers by visually inspecting Google Earth images.

p.350, l.17. Because the tropospheric artifacts are "assumed" to be uniform within this small area.

AUTHORS: We clarify that we assume uniform tropospheric artifacts, which is reasonable within small rock glacier areas (line 174).

The discussion about the effect of dry snow cover at page 355 deserves more attention. It is correct to say that L-band radar waves can easily penetrate through thin and dry snow, but, as explained by Guneriussen et al. (InSAR for estimation of changes in snow water equivalent of dry snow. IEEE T. Geoscience and Remote Sensing 39(10):2101-2108, 2001) this has an effect on the interferometric phase. At L-band, 12 cm of SWE would correspond to a phase shift of 2PI, for a snow density of 200 kg/m3 this corresponds to a snow depth of 60 cm. Some information about the snow cover distribution over Sierra Nevada should be given. Of course, if the snow cover distribution over the relatively small size of a rock glacier is constant, no phase shift is observed.

AUTHORS: We agree that effect of snow cover on our InSAR measurements deserves more discussion. In our revised manuscript, we first provide background information on snow precipitation in California Sierra Nevada in regional overview (section 2.1, lines 87-88). Then in section 5.1 (lines 328-347), we discuss this issue in detail from two aspects: InSAR decorrelation and InSAR phase shifts (and cite Guneriuseen

et al., 2001). We point out that it is difficult to quantify these effects, due to the significant temporal changes of snow depth in our study area, a lack of ground-based observation, and weakness in snow models. We state that since we measure rock glacier motion w.r.t. a reference point right outside the rock glacier. It is reasonable to assume the phase shift due to snow is constant which is therefore effectively removed.

Please indicate flight and LOS directions on Figure 4.

AUTHORS: As suggested, we note the fight and LOS directions on the InSAR speed plot (now Fig. 5b).

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