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Comment

## ***Interactive comment on “Short-term velocity variations of three rock glaciers and their relationship with meteorological conditions” by V. Wirz et al.***

### **Anonymous Referee #3**

Received and published: 26 September 2015

#### General

The data on surface velocities presented in this paper is quite valuable because short-term variation in rock-glacier movement has been still rarely monitored, especially through a season with snow cover. In addition, the statistical approach is new for discussing meteorological conditions which potentially drive episodic acceleration and deceleration (short velocity peaks) of rock glaciers.

However, the focus of this paper is vague. Although six different points and three different years showed various magnitudes and patterns of the motions, the authors only found meteorological conditions driving rapid spring-summer acceleration (including

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short velocity peaks) and gradual winter deceleration. Thus, the findings of this study in the abstract is mostly identical to that of Ikeda et al. (2008), which also (already) showed continuous records of deformation with high temporal resolution over five years of a fast-moving rock glacier. The authors stressed that the three-year records with high temporal resolution are unique in themselves among the studies on rock glacier deformation. Such originality is questionable, because the methodological difference between this study and Ikeda et al. (2008) seems to be not critical to obtain the main conclusions. Furthermore, the latter study discussed rheology of the frozen sediment, horizontal varieties of the annual surface movements, and internal structure and temperatures, all of which are not considered in this study.

The instrumentation of this study for obtaining velocities and temperatures on the surface is more sophisticated than that of Ikeda et al. (2008). Thus, it could be possible to show different focus leading to some conclusions different from the previous studies including Wirz et al. (2015) as well as Ikeda et al. (2008). If the authors cannot deeply discuss the factors responsible for the spatial differences in velocity of the six points and for the inter-annual differences in the three years as the submitted manuscript, in my opinion, one solution would be to make a paper mostly focusing on the short velocity peaks at the two points using statistical approaches. In the submitted manuscript, there is only weak links between the results from statistical analyses and processes discussed subsequently. Thus, overall construction would be better to be revised.

#### Minor remarks

p. 462, ll. 22-25

"Measurements made in a borehole at the Furggwanghorn rock glacier ... from October 2010 to May 2011 form the longest published time-series of displacement measurements with daily resolution, known to the authors (Buchli et al.,2013)."

Add information on the inclinometer measurement done by Ikeda et al. (2008).

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p. 463, ll. 22-23

"An overview of previous studies on intra-annual variability of rock glacier movements is given in Table A1."

Add information of Muragl rock glacier (Arenson et al., 2002) and Büz rock glacier (Ikeda et al., 2008) in Table A1.

p. 466, l. 22

What is DEM2? Do not use domestic abbreviations for worldwide readers.

p. 468, ll. 13-14

"An additional weather station was mounted in summer 2013 above the rock glacier Breithorn, but this data is not used in this study as it covered less than one year."

Delete this sentence.

p. 470, l. 12

Revise the chapter title, because the previous chapter also includes some methods.

p. 471, ll. 13-14

The first sentence needs a reference.

p. 472, l. 16

What is "logical values"?

pp. 477-478

The number of velocity peaks is focused first and the strength of velocity peaks second in this paper. Reconsider which is more responsible for the total deformation, and if the strength is more critical, change the order of descriptions.

p. 478, l. 18

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"but such was not available for the whole period"

It is difficult to understand this part.

pp. 479-480

Why was only the occurrence of the peaks statistically analyzed? It would be much better to check the relationships between meteorological parameters and the strength of the peaks.

p. 480, l. 19

What does "position" indicate in this analysis?

p. 481, ll. 8-27

If authors want to verify the SNR-t and  $t_p$  values, the section 3.1 should be revised. In addition, show the section of "Sensitivity tests" at the beginning of the result chapter, then declare that SNR-t = 40 and  $t_p = 6$  are adopted in this study.

p. 482, l. 13

"an additional years's worth of data"

Not years's but year.

p. 483, ll. 5-16

The authors guess if the temporal resolution of velocity measurements was high, most rock glaciers would show asymmetric annual velocity fluctuation and short velocity peaks. However, symmetric seasonal fluctuation of velocities without any short peaks cannot be ruled out. Because irregular fluctuations probably results from water infiltration in a permafrost body, (temperature-dependending) regular fluctuation of the movement is anticipated for rock glaciers containing an impermeable permafrost body.

I personally hope to consider possibility of phase shift in rock-glacier motion from sinusoidal slow phase controlled by ground temperatures to asymmetric fast phase induced

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by long-lasting water infiltration during snowmelt, both of which depends on so-called permafrost creep. Then, some rock glaciers have reached collapsing phase when water can infiltrate more drastically (and frequently). The extremely fast motion of the last phase should be treated as shear of a continuously fractured plane (or planes) rather than creep of a so-called shear horizon (actually not a horizon but a zone; the description in Fig. 1 is a wrong example). If the authors tested this phase-shift hypothesis, the paper would have markedly high originality! Thus, I think that the different patterns of motion among the six points and the three years are worth to discuss from rheological viewpoints in the near future. To do that, the first author should learn more about rheology in glaciology and landslide science.

p. 486, ll. 20-23

"Indeed, the few existing studies on the hydrology of rock glaciers all have shown that water is transmitted through the rock glacier within few hours (Krainer and Mostler, 2002; Ikeda et al., 2008; Buchli et al., 2013)."

This sentence suggests that it has been confirmed that water vertically passes through a creeping permafrost body within a few hours. Is this true? The authors seem to misunderstand something in the previous studies.

p. 501

"As potential important time we used during the peak, ... "

Add "days" between "used" and "during."

p. 503

It is curious that R2b and R7c have same number of days of snow-free, snow and zc.

It would be better to add the maximums, minimums, means and mediums of strength of peak (diffp) for snow-free, snow and zc, respectively.

p. 504

What is pos55?

p. 508

The photographs are too small to see topography on the rock glaciers.

p. 509

The color differences between R7a and R7c and between R2a and R2b are not clear.

How did the authors detect single snow-cover duration for six different sites?

Where is the “small figure” indicated in the last sentence?

p.501

The figure is too small.

p. 502

It is very difficult to check the synchrony of many parameters represented by dots in this figure.

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