The Cryosphere Discuss.,
doi:10.5194/tc-2016-229-RC1, 2016

The Cryosphere Discussions

Interactive comment on "Resolution capacity of geophysical monitoring regarding permafrost degradation induced by hydrological processes" *by* B. Mewes et al.

Anonymous Referee #1

Received and published: 21 November 2016

General Comment: This paper aims to analyse the resolution capacity of Electrical Resistivity Tomography (ERT) and Refraction Seismic Tomography (RST) to identify hydrological and periglacial processes in rock glacier. To address this objective, the authors use ERT and RST data from the Becs-de-Bosson rock glacier in the Swiss Alps measured in 2012 and 2013, create synthetic models to test the resolution capacity of ERT and RST as well as 4PM, a combined ERT-RST-approach developed by Hauck et al. (2011). Hydrological processes of rock glaciers are seldom investigated and poorly understood. There is a lack information how water flow influences active layer thaw or permafrost degradation in rock glaciers or affect rock glacier movement. Therefore, the objectives of this study are interesting for a wider readership and addresses a

Printer-friendly version

Discussion paper

relevant scientific question within the scope of journal The Cryosphere. However, this study provides no novel concepts, ideas or tools but partially new data. There are no substantial conclusions reached based on the presented results and assumptions of the used synthetic models have no empirical or knowledge basis and contradict partially physical laws. Consequently, the analysis of the resolution capacity completely fails. In addition, scientific methods and model assumptions are insufficiently outlined. The major problem of this study is, it uses data which was not derived to address this study's research question and research set up is not suited to give new insights on the important topic of hydrological processes in rock glaciers.

Detailed Comments:

1) The data set and model generation of ERT and RST The authors used an ERT data set derived from 71 electrodes with 4.5 m spacing which should result in a transect length of 315 m much longer than the transect length displayed in Figure 3a and 9a. There is no information which software was used to invert the data, I assume Res2DInv, and which inversion parameters (e.g. robust constraints, number of iterations, smoothing) was selected. Res2DInv enables to weight vertical or horizontal layers, latter approach is often used in assumed layered structures such as in rock glaciers. In addition, data processing of the seismic data remains unknown, there is no description how seismic traveltimes were derived and how these traveltimes were inverted into the tomography. I assume, the authors used the tomography module provided by ReflexW, however, inversion parameters and data quality (such as Root Mean Square Error) are required to follow the authors modelling approach and to evaluate the model quality. Hilbich (2010) used a layered starting model with a gradient increase of p-wave velocities. This way of modelling as well as potential horizontal weighting of resistivity data results in a layered model often used in rock glacier seismic modelling. If the authors used layered modelling approaches, then it is very difficult to resolve vertical structures in tomographies which is the main objective of this study. The authors aim to evaluate snow melt influence on active layer thawing, however, they have no

information on snow cover. They determined complete snow meltout using temperature data loggers and conclude that snow melt was completed one day to one month before the measurements took place. Due to the timing of the measurements, it is impossible to measure water infiltration or increased water levels. The authors write in their result section that “due to the coarse grained material and the slope of the rock glacier, seasonally or inter-annually melting ice would rather result in quick infiltration and run-off on top of the ice-layer” (page 12 l.22ff). If you know that water will infiltrate and run-off immediately in high-porosity rock glaciers why you build two synthetic models that assume vertical saturated areas or and saturated layers exist? The timing of the measurements induces that the authors can obtain the response of the active-layer and permafrost layer due to thermal and hydrologic processes that occurred before the measurement. To distinguish the effects of these processes is impossible without any further data on snow distribution, snow height, water content measurements or sedimentological insights on the rock glacier. Anyway, the author derived a baseline model (SYN1, Fig. 3b) based on the ERT and RST measurements in July 2013 (Fig. 3a).

2) Synthetic model generation and assumptions It is unclear where the synthetic models are located and which part of the ERT and RST us overlapping. The baseline model (SYN1) assumes the existence of a dry, coarse active layer with 8000 âĎęm and p-wave velocities between 500 and 1000 m/s in the lower section of the rock glacier and a wet, fine debris layer with 1500 âĎęm and 350 – 800 m/s. Unfortunately, there is no sedimentological evidence which can support the lateral differentiation of the debris. Furthermore, the authors distinguish ice-rich and ice-poor layers. The ice-poor layer possesses resistivities in the range of the active layer and is no evidence provided by the RST or other independent data that confirm that an ice-poor layer exists. In summary, the derived baseline model is poorly underpinned by data. Additional thermal and sedimentological data from e.g. boreholes should be used to construct a baseline model. Synthetic model 2 (SYN2) assumes the existence of a 1.5 m thick saturated layer in a depth between 3.5 and 5 m. There is no evidence in the data which supports this scenario. In addition, the authors admit in the result section that

the scenario is unrealistic, thus, “seasonally or inter-annually melting ice would rather result in quick infiltration and run-off on top of the ice-layer” (page 12 l.22ff). Synthetic model 3 (SYN3) assumes the existence of three 0.5 m wide water saturated vertical paths of preferential flow and a horizontal flow path below the ice core. Rock glaciers consist of debris and porosity is assumed to be around 40%. The large pores between the individual blocks act as macropores. There is no explanation what constraints the water and results in vertical infiltration paths. It remains completely unknown why the authors choose the location of this vertical preferential paths at 30 m, 55 m and 90 m transect lengths. Furthermore, it is impossible that water saturated areas of 0.5 m width exist surrounded by pores of the same porosity filled with air. Water could use these air-filled pores to run off. However, Figure 6b displays this physically impossible scenario. The remaining synthetic model (SYN4) describes active-layer thaw and is the only reasonable model that can be derived from the ERT and RST data.

3) 4PM model In the next step of this study, the synthetic models are applied in the 4-Phase model. The authors conclude that a suitable porosity model is of great importance for 4PM modelling, thus, porosity stays constant with time and small errors in the porosity model will impact the resulting model. However, it is not sufficiently explained what porosity model they chose and why. Figure 6a displays a two layered porosity scenario. The upper layer has a porosity of approximately 40 % and reach from the surface to 10 m depth. The lower layer range from 10 to 15 m and shows a porosity value of approximately 5 to 10 %. This porosity model contradicts the RST and ERT data in Fig. 3a as well the baseline model in Fig. 3 b. If there exist a difference between coarse debris in the lower part of the rock glacier and fine debris in the upper part, the porosity should reflect this sedimentological differences. The bedrock is described of quartzite and gneiss which are usually possess lower porosities than 5 to 10 % especially if they are covered by 10 m thick debris. A borehole could be used to determine once realistic values. The sensitivity of 4 PM modelling to porosity should be quantified.

In summary, the authors construct two unrealistic scenarios (SYN 2 and 3) and a non-confirmed baseline model (SYN1) combine it with a 4PM model of assumed porosities and show that vertical structures and saturated layers are well resolved in their synthetical models. Unfortunately, these features cannot be detected in any of the data-derived ERT and RST models. Therefore, the authors validate their unrealistic assumptions with their synthetic models. The whole research approach is model-driven and not research-driven. Resolution of vertical and lateral structure was the original aim of the study. This resolution depends on the geometry of electrodes and geophones. An investigation of resolution should use different geometries and compare the effect of these geometries. The used measurement set up, timing of measurements and the lack of additional geomorphological, sedimentological and snow cover data result that this study provides no novel information which should be published in The Cryosphere. The authors fail completely to achieve one of their aims. All conclusions are basic knowledge and published before in numerous papers.

See additional detailed comments in attached pdf.

Please also note the supplement to this comment:
http://www.the-cryosphere-discuss.net/tc-2016-229/tc-2016-229-RC1-supplement.pdf

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-229, 2016.