

Reply to the comments of Lukas U. Arenson

Maike Offer and colleagues present an innovative and well-executed study of seasonal thermo-hydro-mechanical dynamics in permafrost rockwalls using automated ERT monitoring integrated with temperature, piezometric, and mechanical data. The results convincingly demonstrate the importance of hydrostatic and cryostatic pressures in controlling rock slope stability, providing valuable new field-based evidence in an area where observations are typically scarce. Overall, this is a novel, well-written, and scientifically robust contribution that clearly advances the understanding of coupled processes in permafrost rock slopes. The manuscript is well structured, figures are original, of high quality, and the interpretation is generally sound and well supported by the data. I particularly appreciated the integration of multiple datasets (ERT, anchor loads, piezometry, and temperature), which allows for a compelling process-based interpretation. I very much enjoyed reading the manuscript. Minor comments are mostly editorial and stylistic and are provided in the annotated version attached.

Line 16: preparing -> conditioning changed.

Line 23: include "rock mass" changed.

Line 41: "rock mass" It is important to clearly differentiate between rock and rock mass in general. changed.

Line 46: have "so far" → "to the author's knowledge" changed.

Line 50: delete "useful" changed.

Line 69: delete "here" changed.

Fig. 1: It is understood that there is only one PIV data point. It is a very important point, but it would be useful to highlight how representative the data may be in the context of a generally heterogeneous system.

From lines 272–276 we already pointed out that the piezometric measurement is point-scale data: *"It is important to note that the analysed measurements are subject to uncertainties due to their spatial context. The piezometric sensor provides point-scale information within a heterogeneous rock environment and only captures pressure levels in the rock discontinuities above its installation depth. Consequently, the actual hydrostatic pressures might exceed the observed values."*

We have now extended this statement to account for the representativeness of the hydrological dynamics of the rockwall by adding: *"However, the piezometric signal is considered representative of the hydrological dynamics of the rockwall, as its temporal evolution coincides with the resistivity decrease observed across the entire ERT profile (Fig. 3). This agreement between a localised pressure measurement and the profile-scale geophysical response indicates that the piezometer captures a system-wide forcing rather than a local anomaly."*

Line 120: Specific time of day, i.e. always at the same time or did this vary during the year?

The measurement time varied from day to day. The system had to be manually connected and disconnected by the staff at the summit station, so timing depended on factors like touristic traffic and weather conditions (thunderstorms). That said, all measurements were taken during the day between 8:00 AM and 4:00 PM. However, we did not see significant differences within this time window. We added the time information to the revised manuscript: *"Both Wenner and reciprocal measurements were repeated daily during daytime hours (8:00 AM–4:00 PM CET) over one year, starting in April 2024."*

Line 138: delete “and schistosity” → check sentence, i.e. where you want to have this information included. Or was the drilling also perpendicular to the schistosity of the rock structure? We removed “and schistosity” as suggested. Since the schistosity runs parallel to the slope (Line 94), drilling perpendicular to the slope also meant drilling perpendicular to the schistosity. However, this was not the decisive factor for the drilling direction.

Line 145: “The” → “A” changed.

Line 227: average daily temps? Or average of the recorded values? There may be a difference. The average was calculated from daily mean air temperatures. We have clarified this in the revised manuscript by replacing “average” with “mean daily air temperature”.

Line 235: average (highlighted) We changed it to “mean daily air temperature”.

Fig. 3: you could use this graph to add average temperatures, similar to the average anchor loads in b). In general, very good figure.

Thanks for the positive feedback on the figure. We considered adding average temperatures to Figure 3 but decided against it. Figure 3a already shows air temperature at 10-minute intervals, daily averages, and bedrock temperature. The figure also focuses specifically on the ERT measurement period (April 2024–2025), so bringing in multi-year averages would introduce a second time dimension that could confuse readers. On top of that, since Referee #2 suggested moving the average anchor loads to the appendix, keeping multi-year average temperatures in the main figure would now feel inconsistent. Lastly, the circle in Figure 3c serves as a legend that carries over to the subsequent figures, so it needs to be introduced here and should not be changed.

Line 250: average (highlighted) We changed it to “a mean daily value”.

Line 258: mean → no longer average daily? We changed it to “mean daily”.

Line 268: seasonal average (highlighted) We changed it to “a mean daily minimum”.

Line 288: “The mean anchor load was calculated for each defined seasonal phase...” changed.

Line 314-315: (-3° inclination with a total length of 25m) → already mentioned. Can be deleted changed.

Line 354: Has pore water been tested for salinity?

While pore water salinity was not measured directly, pore water conductivity was determined in Offer et al. (2025), which is the parameter directly controlling electrical resistivity. We have included these values in the revised manuscript to make this point more transparent: “Laboratory experiments by Offer et al. (2025), conducted on seven saturated core samples with a pore water conductivity of $0.058 \pm 0.002 \text{ S m}^{-1}$, comparable to local snowmelt water (0.014 S m^{-1}), captured the temperature–resistivity relation under both frozen and unfrozen conditions but did not replicate the influence of transient water flow in discontinuities observed in the field ERT measurements.”

Offer, M., Weber, S., Krautblatter, M., Hartmeyer, I., and Keuschnig, M.: Pressurised water flow in fractured permafrost rocks revealed by borehole temperature, electrical resistivity tomography, and piezometric pressure, *The Cryosphere*, 19, 485–506, <https://doi.org/10.5194/tc-19-485-2025>, 2025.

Line 388: minor comments related to units. Typically, use a space between the number and the unit as you have it here.

We went through all units in the written text and could not find a case where the spacing differed from the convention mentioned at line 388. If you can point to a specific example, we are happy to correct it.

Line 462: Reported as far as the authors know changed.

Line 516: phase III changed.

We thank Lukas U. Arenson for his careful reading and helpful comments, which helped improve the quality of the manuscript.