

The authors present a range of different observational data related to rock glacier movement, ground surface temperatures, and geophysics from the Carpathian mountains. The work focuses on identifying areas of movement within previously inventoried rock glacier boundaries using PSInSAR. The results are complemented by additional GNSS displacement data from some sites, as well as temperature based investigations of permafrost occurrence and geophysical surveys from individual rock glaciers. The authors show the value of SAR-based displacement mapping for identifying slow movement, which aids activity categorization in rock glacier inventories. The manuscript provides a valuable overview of rock glacier movement in an interesting region with many relict and transitional rock glaciers, where it is of particular importance to work towards understanding ice content and ice content dependent response of movement to climatic forcings.

I find the manuscript to be generally well written. In some sections, the clarity of the text would benefit from restructuring and I had a few questions about methods and results while reading. Color choices in some of the figures could be improved. I am sure my comments and questions can be addressed and confident that this will make a good contribution for ESurf after some manageable revisions mostly pertaining to structure and clarifications in the text.

General comments:

Methods: In the section describing the PSInSAR analysis, it would be beneficial to more clearly distinguish between descriptions of the author's approach and EGMS. I feel that the text jumps between both, making it challenging to follow. The Terrasigna method appears to produce substantially improved coverage and this seems like a valuable output, so it would be good to be very clear here about the advantages of the method/product compared to alternatives. See also specific comments below.

Results: Some of the figures could be improved regarding colors and visual contrast, see below. I struggle to understand figure 5. This is only mentioned once in the text without much explanation. It would be beneficial to add a few sentences spelling out what is shown in the figure.

Discussion: I am unsure why the first part of the discussion (displacement over time) is not in the results section. Unless there is some particular reason for this choice I would suggest moving it to results and restructuring the discussion accordingly.

Language: Ensure consistent use of tenses throughout the manuscript.

Line by line:

Introduction

L 45 *increased rock 45 glacier velocities has been observed due to warmer climate*

→ have been

I suggest rephrasing as “..have been linked to warmer climate”. You might consider citing Kellerer-Pirklbauer et al 2024 ([10.1088/1748-9326/ad25a4](https://doi.org/10.1088/1748-9326/ad25a4)) or similar work.

L 62 *transitional rock glaciers behaviour* → rock glacier's behaviour

L85 *At 2000 to 2100 m elevations, the mean annual air temperature hovers around 0° C, with annual precipitations typically around 1000 mm*

This is an awkward sentence construction, consider rephrasing for clarity. I believe “precipitation” should be singular.

Fig 1

Panel a) consider adding the names of the cities to the “city” markers to help readers with orientation.

Panel b) what is the small red dot near rock glacier 6? Does this have any significance?

Panel c) add a scale bar. Consider marking the location of panel c in panel b, e.g. with a box showing the extent of the map as shown in c.

Methods

L121 can you specify what the “ecological criteria” were?

L122 *Rock glaciers are categorised into three types based on their activity status: active, transitional, or relict, as outlined by (RGIK, 2023)*

I am unsure whether this paragraph describes what you did or states what the RGIK recommends, or both. In the prior sentence you say kinematics were not used for the inventory since little data is available. However, this sentence reads like you did classify them based on kinematics/activity? Or was this done solely based on geomorphology and ecological criteria? Consider restructuring this part to clarify what you did and how you used your criteria to determine activity status.

L132 Please cite key references for the EGMS products, as listed for example here under “scientific papers”

https://land.copernicus.eu/en/products/european-ground-motion-service?tab=technical_summary

L132 *The algorithms employed in this work closely resemble those described in EGMS Algorithms, with a few notable differences described below*

Clarify what exactly the differences are. You describe what you did in the following paragraphs but do not specify how exactly that is different from EGMS. You are producing a product with improved coverage, so it would be beneficial to state clearly how that is achieved.

L135 *Figure 3b illustrates the coverage of Terrasigna’s PSInSAR analysis of the same area, derived in this study solely from one S1 path*

Does the term “Terrasigna’s PSInSAR analysis” refer to the analysis you carried out for this study? “Terrasigna” has not been introduced. I understand it is a company but I think this section could be clarified. You might consider something like: We carried out a PSInSAR analysis of the same area, derived solely from one S1 path. In the following, this is referred to as “Terrasigna PSInSAR”.

L139 and following: Similar to the above comment: I think this section could be clarified by restructuring it to more clearly identify your work.

Fig. 3: The legend is hard to read, try to improve image resolution. The yellow-ish colors are hard to distinguish from the true color background image, especially in panel a. Consider an alternative color scale.

L168 *Although permafrost in marginal conditions may occur as patches with a relatively small extent, the minimum size of an MA considered in this study was 300 m²*
Why did you choose this size threshold?

L169 *a one-meter resolution digital elevation model*
Data acquired in which year?

L182 *using a DEM with 10 m pixel spacing*
What is the source of this DEM? Acquisition date? Add citation if possible

Results

Fig 4: The green dots are hard to see on the green background. Consider a different color. The relict feature on the right side of the image has several yellow dots and one magenta dot but no MA. Did you apply some kind of minimum dot density to define a MA? Similarly, in the transitional feature in the middle of the image, there is a mix of green and magenta dots in the magenta MA. What was the decision process to classify the MA in the faster category?

Fig 5: This looks like there is a decreasing trend in displacement over time. I assume this is not the correct interpretation, but please clarify by modifying the figure, the caption, and/or adding an explanation in the text. How do the scatter plot and trend lines relate to the inset panel with the map? I assume the MA in the map were derived from the points in the scatter plot - do the MA represent the state of the rock glacier in a particular year? How is negative displacement supposed to be interpreted?

Fig 12: the symbol for “no permafrost” is hard to see, consider using a different color.

Fig 14: Explain the black ellipses in the lowest panel in the caption. Consider adding panel labels that can be referred to in the text. Consider changing the color map in the top two panels (see, for example: <https://hess.copernicus.org/articles/25/4549/2021/hess-25-4549-2021.html>). I find it hard to distinguish any variation in the lowest panel. Could the scale be changed to make differences more apparent? The highest values on the scale (0.50) do not seem to be reached and the annotation in the plot states max 0.2. Perhaps this would be easier to interpret if the maximum value of the scale was reduced.

Discussion

General comment: The first section and Fig 15 seem like results more than discussion. Is there some particular reason why Fig 15 is considered part of the discussion rather than a result? The linkage to climate drivers is suitable for the discussion but consider placing the analysis of movement over time in the results.

L 383: *"..exhibited consistent movement between 2016 and 2021 and two distinct types of velocity were identified.."*

Please define what you mean by "consistent movement" and explain how "distinct types" of velocity were determined.

Fig 15: what are the black lines? Explain in the caption. The text states that "two distinct types of velocity were identified" but does not clarify how.

L436: *Additionally, the PSInSAR analysis revealed that, in many instances, the fronts of the rock glaciers in the Retezat Mountains remain stable*

Is this evident in any of the figures? Is it possible to show an example?

L448 Interesting!

L455: consider adding some references to work related to convective cooling in coarse blocks. For example: <https://doi.org/10.5194/tc-18-2103-2024> <https://doi.org/10.5194/tc-11-1311-2017> or anything else you find pertinent.