Review Del Vecchio et al. "Patterns and rates of soil movement and shallow failures across several small watersheds on the Seward Peninsula, Alaska" – ESurf"

The paper presents an impressive and novel study on how soil moves in the Arctic and how its movement is affected by a changing climate. To investigate this, a variety of techniques is applied, including DGPS, UAV and InSAR measurements and modeling. As many previous studies used statistical approaches, this is an original approach which substantially contributes to scientific progress by presenting important results on Artic soil movements and controlling factors on different scales.

While I did enjoy the detailed descriptions of field observations, including field photos, and the discussion of the findings in a wider context, the manuscript is overall quite long (> 9000 words excluding references). It discusses so many different results and aspects that it is hard to find the key messages in the text – which are very nicely stated in the conclusion. The addition of new methods and results in the discussion section does not help the structure and the discussion sometimes seems to drift a bit too far from the results that are actually presented. It would be great if the structure of the manuscript could be improved (clearly separate method, results and discussion) and the key findings better presented in a tightened discussion. Shortening the manuscript could help to better convey its key messages.

Some more general points that need to be improved are the geomorphological terminology (some terms need to be clarified), the methods description (some more details needed, e.g. InSAR analyses) and the discussion of more factors affecting slope movement.

Please find details below. I am looking forward to read a revised version of this nice and interesting paper!

Specific comments

Abstract

l. 25: What does topographically smooth mean? No landform? So not only no solifluction lobes but also no solifluction steps? Could this be a solifluction sheet? Please clarify, e.g. using the solifluction terminology in the IPA glossary (https://www.permafrost.org/wp-content/uploads/Glossary/Glossary_of_Permafrost_and_Related_Ground-Ice_Terms_1998.pdf).

l. 27: What is a comparable temperature landscape? Comparable in terms of which properties? Please clarify.

1. Background and study area

Is is a bit unclear which "background" is presented, maybe the title "study area" would be sufficient?

Please add a short overview of the different landforms and geomorphic processes (solifluction lobes, sheets, which type of other slope failures?) you investigated in your study area.

2. Methods

l. 110: “of what appeared to be solifluction lobes” – where they solifluction lobes or not? In the abstract, you talk about solifluction lobes, so I assume these were indeed solifluction lobes?

Can you maybe shortly outline in this section how the many different methods you used come together for your analysis? What exactly did you measure with which methods on which spatiotemporal scales and which results do you compare/integrate?

3.1 Differential GPS

The GPS setup remains partly unclear: How was ensured that the corners of the plastic rectangle don’t shift? This depends on the position of the rebar rods, which is not clear. How could the tops of the rebar rods be measured if they were hammered 50 cm below the ground surface?

GPS accuracy (1.8 cm) is already in the range of solifluction movement for several sites in the Arctic (see Matsuoka 2001, Table 1), this should shortly be mentioned, although luckily your slope is moving quicker.

2.2 Field mapping and UAS imagery

l. 127: Can you elaborate on which landforms (if any) you placed your targets? This would help to understand why they move more/differently than the lobe targets.

l. 139: How were the additional georeferenced UAS images collected? In a same way as in 2018 (flight + DGPS points) or differently? Please clarify.

l. 138: With which resolution did you measure permafrost depth using tile probes? E.g. probing every 10 m, every 100 m?

l. 144: Can you maybe add where you dug trenches in Fig. 2?

l. 144: Please justify why dense shrubs and trees indicate absence of permafrost using references.

2.3 InSAR

l. 167: What does “LOS” mean? Please clarify.

For me it remains somewhat unclear what you actually measured with InSAR. Does it mean you measured displacement only for the specific sites J1-J5? Those are rather far from Teller 47 and their geomorphology, permafrost conditions etc. remain unclear. So how are those

large scale displacement measurements comparable to the lobe scale displacements measured with DGPS?

Please provide information on InSAR accuracy, resolution of InSAR results and more information on InSAR processing in general (see e.g. Rouyet et al. 2021).

Rouyet, L., O. Karjalainen, P. Niittynen, J. Aalto, M. Luoto, T. R. Lauknes, Y. Larsen, and J. Hjort. 2021. Environmental Controls of InSAR-Based Periglacial Ground Dynamics in a Sub-Arctic Landscape. Journal of Geophysical Research: Earth Surface 126:e2021JF006175.

It remains unclear here how you want to find out the role of topography without using terrain data. You mention only later in the discussion that you also analyzed terrain data. This needs to be added here.

2.4 Infinite slope model of stability

Model setup: You used an overall soil thickness of 1 m, however, you found in your field survey that there are large permafrost free areas (Fig. 1a). Wouldn't it make sense to incorporate the spatial permafrost patterns you are aware of?

Movement rates from targets: It remains unclear how you derived the movement rates from the GPS targets on the lobes and for the UAV survey. Please add a short explanation.

3. Results

l. 208: Looking at Fig. 2c, it seems like the failure occurred on the lobe tread, not the lobe front/riser. Please clarify in the text and Fig. 2c (see later comment on Figure)

l. 213: This appears to already be an interpretation, which seems better suited for the discussion.

l. 257: Did you test statistically if there was a significant difference in movement between the lobes and the GCPs? If not please test or rephrase.

l. 267: What exactly is the "satellite watershed"? I cannot find it in Fig. 3A.

l. 281: "Figure" is missing before the references to the figures.

4. Discussion

5.1.1 Geomorphic controls

l. 308-311: This section belongs into the methods description. Please adjust.

l. 312-316: This section belongs to the results. Please adjust.

This discussion of the controls on your slope scale soil movements should be more comprehensive. You measured permafrost on the slope scale, so does this play a role? And does it maybe matter where on the slope/lobes you actually placed your targets? Previous studies showed that soil movement differs strongly within solifluction lobes and that parent slopes are usually moving more slowly than the solifluction landforms on them (e.g. Ballantyne, 2013, Eichel et al. 2020, Harris et al. 2008). Yet, you interestingly found a different pattern, with similar movement rates for lobes and parent slopes, which needs to be discussed. Finally, vegetation is also important factor for solifluction lobe development and movement (e.g. Benedict, 1976, Eichel et al. 2017, Price, 1974). Does vegetation differ between lobes and parent slope and could vegetation play a role for observed movement patterns?

Ballantyne, C. K. 2013. A 35-Year Record of Solifluction in a Maritime Periglacial Environment. Permafrost and Periglacial Processes 24:56–66.

Benedict, J. B. 1976. Frost creep and gelifluction features: A review. Quaternary Research 6:55–76.

Eichel, J., D. Draebing, T. Kattenborn, J. A. Senn, L. Klingbeil, M. Wieland, and E. Heinz. 2020. Unmanned aerial vehicle-based mapping of turf-banked solifluction lobe movement and its relation to material, geomorphometric, thermal and vegetation properties. Permafrost and Periglacial Processes 31:97–109.

Eichel, J., D. Draebing, L. Klingbeil, M. Wieland, C. Eling, S. Schmidtlein, H. Kuhlmann, and R. Dikau. 2017. Solifluction meets vegetation: the role of biogeomorphic feedbacks for turf-banked solifluction lobe development. Earth Surface Processes and Landforms 42:1623–1635.

Harris, C., M. Kern-Luetschg, F. Smith, and K. Isaksen. 2008. Solifluction processes in an area of seasonal ground freezing, Dovrefjell, Norway. Permafrost and Periglacial Processes 19:31–47.

Price, L. W. 1974. The Developmental Cycle of Solifluction Lobes*. Annals of the Association of American Geographers 64:430–438.

5.2 Patterns and styles of abrupt erosion and slope failures

l. 390: What exactly do you mean by “the tundra”- only above ground biomass or above and below ground (roots)? Please specify.

l. 396-399: This section belongs to the methods.

l. 398: Could you shortly explain what a “logarithmic bin” is? This would be very helpful for readers unfamiliar with that term to understand the results in Fig. 7.

l. 400-405: This section and related Fig. 7 and 8 belong to the results.

l. 445: What exactly do you mean with “shear strength of the tundra mat”- shear strength of the above ground or below ground biomass (roots)? Please specify. Can you maybe provide references on the shear strength of tundra soils?

5.3 Ground ice thaw

l. 465: “do” instead of “does”

l. 497: “Areas” seems double?

Figure 9: Please describe where you got data for this figure in the methods and and describe the figure in results, so you can discuss it here.

Figures

Figures in text are sometimes labeled 1a (like in the figures), sometimes 1A. Please adjust.

Figure 1:

- Different units for Easting and Northing? Please check if this is correct (also in other figures).
- In 1a red “1B” has a capital B, while label of the figure is (b)
- Unclear: is one square one lobe as indicated in the figure legend, or is a square a GPS survey target as indicated in the figure caption, with possibly multiple targets per lobe?
- Adding a field picture or orthophoto of the investigated lobes would be helpful
- Scale bars would be helpful.
- Can you maybe delineate the small watersheds you studied?
- Maybe add an additional Figure 1(c) where lobes are depicted and all GPS survey markers are shown? This cannot be seen in Figure 1(b)

Figure 2:

- Add scale bar and north arrows for orthophotos.
- Add location of b,c,d to a) as well.
- 2c: Please mark the lobe here for the reader.

Figure 3

- A,b: Please mark lobes and add scale bars.
- Please add “survey markers” to lobes and “UAV” to targets in the caption and the Fig 3c,d to clarify what is actually shown (points measured on lobes, not lobes tracked by themselves).

Figure 5:

- I cannot see any cyan slope failures in 5a. Please check. Maybe it helps to zoom more into study area?

Figure 7:

- Please correct “containting’ in b and f