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Comment on esurf-2022-24

Oliver Sass (Referee)

Referee comment on "Development of the morphodynamics on Little Ice Age lateral moraines in 10 glacier forefields of the Eastern Alps since the 1950s" by Sarah Betz-Nutz et al., Earth Surf. Dynam. Discuss., <https://doi.org/10.5194/esurf-2022-24-RC1>, 2022

The paper presents a highly impressive, huge dataset of paraglacial geomorphological processes at lateral moraines. The multitemporal DGM data derives from archival aerial images reaching back to the 1950s as well as from recent drone imagery (400-1600 images per section) and terrestrial laser scans. Ten glacier forefields were investigated, including 1-3 selected moraine sections in each one. For almost all of the sites, three points in time were available for orthophoto evaluation. On each moraine section between 15 and 79 ground control points were fixed and surveyed by dGPS. These numbers show that a unique dataset is presented that definitely warrants publication in Earth Surface Dynamics.

The data is well presented and the conclusions are very interesting for our understanding of paraglacial adjustment of moraine slopes, and of the validity of a space-for-time substitution approach. Thus I recommend acceptance with **minor revisions**.

Specific comments

L75-80: The aims could be pointed out a bit more precisely.

L190 ff (3.4): I don't know exactly how the 3D block thinning works, but it sounds questionable to just automatically delete points from the point cloud. I doubt that this procedure makes comparability and adjustment of the point clouds any better.

L206 ff (3.5): The section on error estimation should be extended by 1-2 explanatory sentences. That is a bit too little information.

L251: "the profile with the biggest height difference was determined" – why this? That doesn't become clear...

L257: I tried hard but I do not understand why "the area between the lines was divided by the width of the gullied moraine section". Maybe a small sketch would help.

L266: "For moraine sections which show so little erosion that no erosion area can be clearly defined, the entire moraine section is considered as erosion area." – I understand the idea behind it; nevertheless, this sounds a bit odd and you might bring a bias into the analysis. When you narrow down active sites to the actual active area, the process rates will inevitably increase. When you don't do the same for less active areas, their rates will be even lower than already. Consider to use the entire slope area in all cases, or give clear reasons why you don't.

L275: "multiplied by the cell size": Maybe I missed it, but I think the cell size has not been explained nor quantified at this point.

L310: "Both parameters are highest for the DoDs based on aerial images." Is this a problem of the method (likely), or could it be that the amount of surface change was in fact higher in the "aerial image" period?

L311 ff: Deviations of up to 76.5 cm are a bit much for "stable surfaces". I understand that this is an outlier; however, the deviations are just shown, and there is no explanation of how this affects the interpretation. Add a sentence on that.

L 348: "geomorphic activity beyond the subsidence is low" – Beyond the subsidence - probably yes. But the subsidence itself is, quantitatively, a very important process. It might be triggered by ice melt but this process has set the whole slope in motion and so it shouldn't be discarded as irrelevant dead ice melt. Maybe the entire section should be treated as 4.3.1: Geomorphic processes triggered by dead ice melt. Otherwise it appears to the reader that processes triggered by dead ice melt do not count towards morphodynamics. Later in the paper this becomes clearer, but here it is somewhat misleading.

L395 ff ("On the DoD 1973–2009...") - Start with pointing out that the prominent red area in Fig. 7b is glacier melt! (You know it, but the reader doesn't...)

L405: "ground moraine of an earlier glacier flowing eastward" – Odd statement - doesn't the current glacier also flow eastward? Better: "... from an earlier, larger glacier extent."

L417 (caption Fig. 7): - Indicate top and bottom (it is quite clear when you look at it a bit longer, but you could help the reader); - indicate the glacier extent (maybe with a blue dotted line); - mention the magenta-coloured polygon (bedrock outcrop in g and h) in the caption

L437 (caption Table 4): Headcut retreat in which time period?

L502: what does "colour map batlow10 from Crameri et al., 2020" mean? Does a colour chart have to be cited?

L518 (Fig. 10): I feel that the presentation of the data in this figure is a bit awkward. By summarising the data into just three groups, information is lost. Why not present a scatterplot with time on the x axis and erosion rate on the y axis, using different point signatures for deeply gullied and less deeply gullied sections?

L562: "at different distances from the LIA maximum" – The result is understandable but I feel that the term "distance from the LIA maximum" is misleading. This could as well be downvalley from the LIA moraines. I assume that "100% distance from the LIA maximum" means "at the current glacier margin"? If yes, write it, e.g. "at different position between recent glacier terminus and maximum LIA extent".

L584/585: "... show a decrease of the erosion rates" – No, of the slope angle! (or am I wrong?)

L590 (Fig. 14): Phew, it took me a while to understand what is depicted here. Is there a simpler way to express this?

Editorial comments

L83: better "down" instead of "up"

L87: delete "mainly the central Alps and the northern and southern Alps" as these sum up to the entire Eastern Alps

L105: at different distances

L132: delete first sentence (because it is meaningless)

L288 (Table 3): When the columns DoD1 and DoD2 are identical, it might be better to merge the respective cells.

L290: "For the investigation of possible factors influencing the morphodynamics on lateral moraines, besides the detailed analysis of the moraine sections, we conducted also an analysis including the entire defined glacier forefields." Re-arrange this complicated sentence: "We conducted an analysis including the entire defined glacier forefields in order to investigate possible factors influencing the morphodynamics on lateral moraines."

L291: "This analysis is based on the negative raster cells of the DoDs and parameters derived from the DEMs." delete – repetition

L294: "The most recent DEMs of the entire glacier forefields, so from the 2000s ..." Hard to understand, please reword

L295: "The resolution of all models is 1 m." This sentence seems to be out of place here, perhaps bring it earlier.

L389: Delete "gully" at the end of the line

L390: "For the gully formation since the 1950s, the moraine section APF3 in the forefield of the Alpeiner Ferner serves as an example" – rearrange to "The moraine section APF3 in the forefield of the Alpeiner Ferner serves as an example of gully formation since the 1950s"

L450: "time and again" instead of "again"

L453: show signs of stabilization