Manuskript: Long-term monitoring (1953–2019) of geomorphologically active sections on LIA lateral moraines under changing meteorological conditions, Moritz Altmann, Madlene Pfeiffer, Florian Haas, Jakob Rom, Fabian Fleischer, Tobias Heckmann, Livia Piermattei, Michael Wimmer, Lukas Braun, Manuel Stark, Sarah Betz-Nutz, and Michael Becht
Submitted on 27 Dec 2022
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RC2: 'Comment on egusphere-2022-1512', Anonymous Referee #2, 22 Jun 2023

Reviewer: This study analyzes the complex long-term geo-morphological dynamics (about 60 years) that took place in in five glacier forelands within the Eastern European Alps, by means of a data-analysis approach. Specifically, the main challenge of the work, if I understood correctly, is to derive a procedure based on acquisition of aerial imagery, DEMs, LiDAR scenes, laser scanner images, etc., to monitor the sediment yield and the volume production over a time horizon of 6 decades. Analyses of the meteorological drivers are also added.

The work is within the scope of the journal, and may provide an important contribution to the specific field of geomorphological active gully systems on Little Ice Age, although other similar efforts were published by the same authors for the same area (see Altmann et al., 2020 or Betz-Nutz et al., 2023).

I argue the choice of the title 'under changing meteorological conditions' for the reasons I will explain in the following. Additionally, I found the reading particularly tough and, to my opinion, the clarity of the presentation can be improved.

Please read in the following my general and specific observations.

General observations:

- My main concerns regard the analyses of the meteorological drivers. (i) WRF simulation data are normally used to make forecasts. I don't' see the need to use such data here, unless justified.

  Authors: WRF has been successfully employed in simulations of past climate over different areas of the Earth. Some examples of studies using WRF to simulate the past climare are: Collier et al. (2015), Collier and Immerzeel (2015), Pieri et al. (2015), Pontoppidan et al. (2016), Collier et al. (2017), Warscher et al. (2019), Collier and Mölg (2020), Wang et al. (2020).

  Collier, E., and Immerzeel, W. W.: High-resolution modeling of atmospheric dynamics in the Nepalese Himalaya. Journal of Geophysical Research: Atmospheres, 120(19), 9882-9896, DOI:10.1002/2015JD023266 , 2015.

  Collier, E., Maussion, F., Nicholson, L., Mölg, T., Immerzeel, W. W., and Bush, A. B. G.: Impact of debris cover on glacier ablation and atmosphere–glacier feedbacks in the Karakoram, The Cryosphere, 9, 1617-1632, https://doi.org/10.5194/tc-9-1617-2015 , 2015.

  Collier, E., Mölg, T., and Sauter, T.: Recent atmospheric variability at Kibo summit, Kilimanjaro, and its relation to climate mode activity, J. Climate, 31, 3875–3891, https://doi.org/10.1175/JCLI-D-17-0551.1 , 2018.

Collier, E., and Mölg, T.: BAYWRF: a high-resolution present-day climatological atmospheric dataset for Bavaria, Earth Syst. Sci. Data, 12, 3097–3112, https://doi.org/10.5194/essd-12-3097-2020, 2020.

Pieri, A. B., von Hardenberg, J., Parodi, A., and Provenzale, A.: Sensitivity of precipitation statistics to resolution, microphysics, and convective parameterization: A case study with the high-resolution WRF climate model over Europe, Journal of Hydrometeorology, 16(4), 1857-1872, 2015.

Pontoppidan, M., Reuder, J., Mayer, S., & Kolstad, E. W.: Downscaling an intense precipitation event in complex terrain: the importance of high grid resolution. Tellus A: Dynamic Meteorology and Oceanography, 1271561, https://doi.org/10.1080/16000870.2016.1271561 , 2017.

Wang, X., Tolksdorf, V.,Otto, M., and Scherer, D.: WRF-based dynamical downscaling of ERA5 reanalysis data for High Mountain Asia: Towards a new version of the High Asia Refined analysis, Int. J. Climatol., 41, 743–762, DOI: 10.1002/joc.6686, 2020.

Warscher, M., Wagner, S., Marke, T., Laux, P., Smiatek, G., Strasser, U., and Kunstmann, H.: A 5 km Resolution Regional Climate Simulation for Central Europe: Performance in High Mountain Areas and Seasonal, Regional and Elevation-Dependent Variations, Atmosphere (Basel), 10, 682–715, https://doi.org/10.3390/atmos10110682 , 2019.

Reviewer: In fact, the use of the two climate products (from reanalysis and from WRF) for two different time horizon can be dangerous, because they are affected by different uncertainties and different bias errors, which are normally adjusted by means of bias correction method, and that can affect the retro-respective assessment.

Authors: To solve this problem, we will drop the ERA5 dataset and thus end the meteorological analysis for 2015. This means that meteorological data is missing until 2017/2019 (Analysis of geomorphological activity), but it is only one data source. We believe that the few years are expendable.

Reviewer: I would have used ground observations, given also the very small areas of interests. Please explain the choice and identify eventual meteorological stations.

Authors: In Kaunertal we have three weather stations (Gepatsch Alm station: Data since 2009, Weißsee station: Data since 2006). The aim was to go back to the 1950s, so there are no ground observations.

Reviewer: (ii) In fact, an additional concern regards the spatial resolution of the climate model products, that are characterized by a large resolution. Which is the overlap with the areas of interest? Provide a figure and discuss.

Authors: The required figures are shown below. The black squares represent the resolution of the simulated climate data. Climate data were extracted once per glacier foreland, whereby these were taken from the centre of the corresponding test sites. Due to the fact that test sites were grouped together, some individual test sites are located in a different grid. Therefore, an altitude correction was made for each site where climate data were extracted.

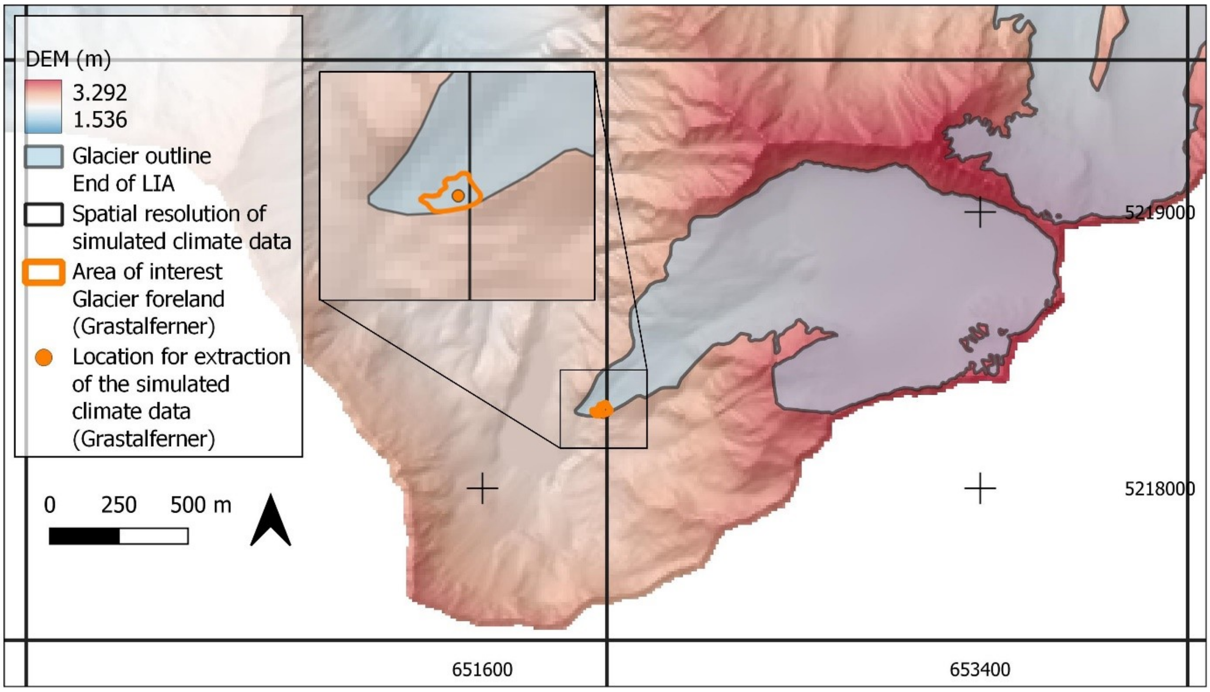

Fig. 1: Spatial resolution (2x2 km) of the simulated climate data and location of the extraction of the simulated climate data in the glacier foreland of the Grastalferner (Grastal Glacier).

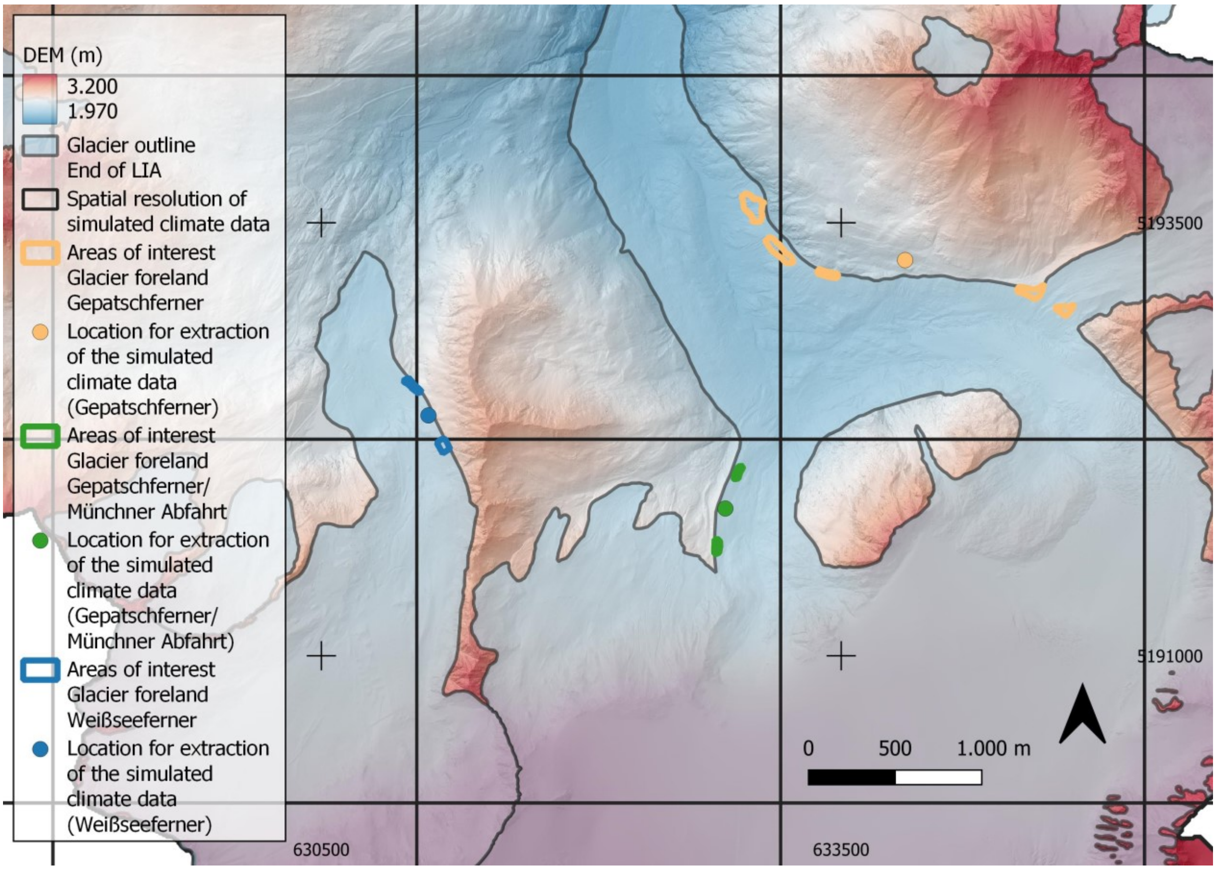

Fig. 2: Spatial resolution (2x2 km) of the simulated climate data and location of the extraction of the simulated climate data in the glacier foreland of the Gepatschferner (Gepatsch Glacier), Gepatschferner/Münchner Abfahrt and Weißseeferner (Weißsee Glacier).

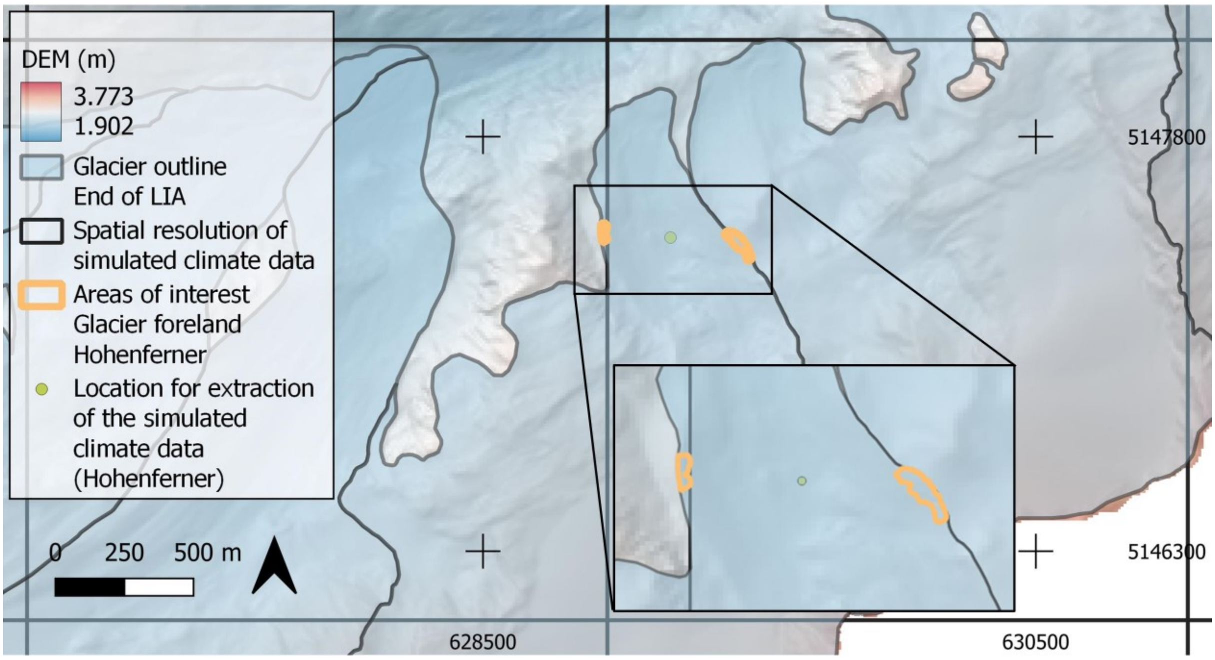

Fig. 3: Spatial resolution (2x2 km) of the simulated climate data and location of the extraction of the simulated climate data in the glacier foreland of the Hohenferner (Hohen Glacier).

- Reviewer: There is no real analysis of the link between morphodynamics processes and climate drivers; the study provides a screening of the meteorological series, that is fine. Therefore, the statement of analyses 'under climate changes conditions' is to strong, in my opinion. Again, there are no analyses of impacts of climate forcing on the physical processes but only a retrospective assessment.

  Authors: The title is changed accordingly: Long-term monitoring (1953-2019) of geomorphologically active sections of Little Ice Age lateral moraines in the context of changing climatic conditions.

- Reviewer: Also, the literature about the changes in precipitation is wide. Please, have a look to Libertino et al., 2019, Caporali et al.,2021. Within this context, how trends are assessed? Why the choice of those precipitation classes? An example of classification is given by Alpert et al., 2002.

  Authors: As the topographic data, i.e. the available DEMs, resulted in epochs of different lengths, the mean number of events per epoch was calculated and compared accordingly. The choice of these precipitation classes allows a comparison of higher and lower intensities. In contrast to Alpert et al. (2002), we chose an interval of equal size depending on the size of the precipitation classes. This was possible because, in contrast to Alpert et al. (2002), there are generally clearly lower precipitation intensities.

  Reviewer: Uncertainty assessment: the section describes mainly data statistics.

  Authors: The caption is changed to: Statistical analysis of the uncertainty assessment: (a) Size of the AoI, (b) Size of the stabe areas next to the AoI, (c) Max. values (stable areas), (d) Min. values (stable areas), (e) Standard deviation (stable areas), (f) RMSE (stable areas) and (g) Arithmetic mean.

- Reviewer: Clearly, all the conclusion derived for the meteorological drivers are affected by the modeling uncertainties of the used data. I suggest to smooth the title.

  Authors: The title is changed as already described above: Long-term monitoring (1953-2019) of geomorphologically active sections of Little Ice Age lateral moraines in the context of changing climatic conditions.

Reviewer: Observations and technical suggestions to improve the manuscript:

- Please, at the end of the introduction, state very clearly which are the scope and the research questions of the work, avoiding to refer to previous works (L126-127).
- Authors: The suggestion for improvement is accepted and will be changed.
- Reviewer: Since different methods based on data are implemented, I strongly suggest to include a flow chart to clearly describe the entire work flow.
- Authors: The suggestion for improvement is accepted and will be changed.
- Reviewer: Include a list of acronyms (they are impressively a lot!!)
- Authors: The request for change will be followed up. It is proposed not to draw up a list but to leave the most important acronyms and to write out the less important or less established acronyms.
- Reviewer: Sometimes figures and tables captions are not explicative. Please, explain the content of the figure/table in a concise manner.
- Authors: The request for change will be followed up.
- Reviewer: Figure 1: include letters (or number) to refer to the specific subplot figures. At first sight the figure results confusing (AOIs not clearly localized).
- Authors: The request for change will be followed up.
- Reviewer: Figure 2, 4, 5: detail captions
- Authors: The request for change will be followed up.
- Reviewer: Figure 6: try to synthesize the results by plotting the slope and intercepts for all the AOIs.
- Authors: These are already in Appendix A.
- Reviewer: Regression is a very simple tool that correlates dependent and independent variables. Please, state clear the problem in L252 to L256! Also lines from L257 to L262 are a bit confusing, I suggest to include a figure (a scheme) to describe the analyzed variables.
- Authors: Figure 5 already explains the variables, so it can be referred to additionally. L254 to L257 can be removed, as this is the original description of the SCA model. Finally, only the SCA approach according to Neugirg et al. (2015; 2016) is shown in the manuscript, which was used in the present study.
- Reviewer: L348: provide a reference. Often, other definitions are used.
- Authors: Since the precipitation data were available in a one-hour resolution, they were separated accordingly in the case of no recorded precipitation in the minimum resolution.
- Reviewer: L102: you may have a look to the contribution Noto et al., 2017 for the literature review.
- Authors: The reference suggestion has been read and will be added.
- Reviewer: L124: define AOI
- Authors: AoI will be defined.
- Reviewer: L194: define HAI

- Authors: HAI will be defined.
- Reviewer: I found some content of the section 5.3.1 (including figure 15) more opportune for the introduction; this concept was not clearly introduced.
- Authors: As the concept introduced is based on the results of this study, it is not yet explained in the introduction, but can be found in the discussion chapter.

- Alpert, P., Ben-Gai, T., Baharad, A., Benjamini, Y., Yekutieli, D., Colacino, M., Diodato, L., Ramis, C., Homar, V., Romero, R., Michaelides, S., and Manes, A.: The paradoxical increase of Mediterranean extreme daily rainfall in spite of decrease in total values, Geophys. Res. Lett., 29, 1–31, doi:10.1029/2001GL013554, 2002.
- Altmann, M., Piermattei, L., Haas, F., Heckmann, T., Fleischer, F., Rom, J., Betz-Nutz, S., Knoflach, B., Müller, S., Ramskogler, K., Pfeiffer, M., Hofmeister, F., Ressl, C., and Becht, M.: Long-Term Changes of morphodynamics on Little Ice Age Lateral Moraines and the Resulting Sediment Transfer into Mountain Streams in the Upper Kauner Valley, Austria, Water, 12, 3375, https://doi.org/10.3390/w12123375, 2020.
- Betz-Nutz, S., Heckmann, T., Haas, F., and Becht, M. 2023. Development of the morphodynamics on LIA lateral moraines in ten glacier forefields of the Eastern Alps since the 1950s, Earth Surf. Dynam. https://doi.org/10.5194/esurf -11-203-2023
- Caporali E, Lompi M, Pacetti T, Chiarello V, and Fatichi S (2021) A review of studies on observed precipitation trends in Italy. Int. J. Climatol., 41, E1–25, TS7. https://doi.org/10.1002/joc.6741.
- Libertino A, Ganora D, Claps P (2019). Evidence for increasing rainfall extremes remains elusive at large spatial scales: The case of Italy. Geophysical Research Letters, 46: 7437– 7446. https://doi.org/10.1029/2019GL083371.
- Noto, L.V., Bastola, S., Dialynas, Y.G., Arnone, E., Bras, R.L., 2017. Integration of fuzzy logic and image analysis for the detection of gullies in the Calhoun Critical Zone Observatory using airborne LiDAR data. ISPRS J. Photogrammetry Remote Sens. 126, 209–2.