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Comment from reviewer on egusphere-2022-243

Anonymous Referee #1

Referee comment on "Predictability of rainfall induced-landslides: The case study of Western Himalayan Region" by Swadhi Ritumbara Das and Poulomi Ganguli, EGUsphere, https://doi.org/10.5194/egusphere-2022-243-RC1, 2022

The work aims at defining the triggering conditions, expressed by rainfall thresholds, of rainfall-induced landslides in the Western Himalayan Region, using landslide data from a global catalog and rainfall data from six stations, and gridded data. The work is clear and well-presented. The literature review is not complete. The results are presented and discussed by means of some figures that could be improved. Overall, in my opinion, the work has some serious flaws both in the data and in the methodology. These flaws affect considerably the results. I think the main flaws of the manuscript lie in: 1) the rainfall data, which are not complete and reliable, despite the efforts of the authors; 2) the method used for selecting landslide-triggering and non-triggering events, which is highly questionable and far from having a physical justification; 2) the method used for calculating the rainfall thresholds, which is particular and do not result in proper thresholds (the curves are best-fit curves); 4) the obtained results, which need some clarifications. Moreover, it seems that the Authors do not know well the current literature on rainfall thresholds: this issue spoils the discussion of the results. Finally, the structure of the paper needs a revision. There is not a clear distinction among method, results and discussion. Some methodological points are reported in the result and discussion section. Overall, the manuscript is a good attempt to study the critical conditions that lead to the initiation of landslides in a Himalayan region. Unfortunately, it has severe methodological issues which do not allow its acceptance in the present form. In the following, I report a list of comments and suggestions that could be useful for addressing these issues and improving the quality of the work. In my opinion, the manuscript does not meet the standards for being considered for publication. It can be reconsidered after major revisions.

List of comments and suggestions.

Line 19: I would not say "long-term climatology"
L31-31: these numbers deserve a reference
L49: the paper Gariano & Guzzetti 2016 does not deal with probabilistic approaches in

rainfall thresholds
L51: It is worth mentioning also the frequentist method (Brunetti et al. 2010), which seems to be the most adopted method worldwide, with applications also in the Himalyan Area: e.g. 1) https://link.springer.com/article/10.1007/s10064-018-1415-2 ; 2) https://www.mdpi.com/2076-3263/9/7/302 ; 3) https://www.mdpi.com/2073-4441/11/8/1616/htm ; 4) https://link.springer.com/article/10.1007/s11069-020-04407-9
L54-55: please add references
L56-57: I do not understand what you mean with this sentence.
L68: I think you missed two papers that deserve to be read before writing an article dealing with rainfall thresholds in the Himalayas: 1) https://link.springer.com/article/10.1007/s10346-018-0966-4 ; 2) https://www.mdpi.com/2076-3417/10/7/2466
L92: don't you think that only six stations are few for making reliable analyses?
L92-93: I would mention here that these are Indian states. For an immediate understanding.
L95: actually, only one station covers the period 1970-2017. for all the others, the measurement range starts from 1985. It's a difference of 15 years, so it is worth mentioning it. Moreover, the stations Joshimath and Katra have very few data, so I would remove them from the analyses. At the end, only Dehrandun and Banihal have a sufficient amount of data.
L98: for which locations are the gridded daily rainfall obtained? the same of the stations or for the entire areas of the considered states? and for which period? please specify
L100-101: I would add some details on the landslide inventory. how many landslides? what information includes? what's the temporal range? what the temporal and spatial accuracy... and so on.
L104: how many gaps are present in each rainfall series? you could add this information in table 1, by adding e.g. the percentage of missing data in the time span of each station.
L144: this paragraph is not clear at all. it starts talking about triggering rainfall events that cause landslides, it continues talking about weighted average rainfall and it ends talking about thresholds not better specified. I can't follow what the authors want to describe. It is very unclear to me how the triggering rainfall events were reconstructed and how they are linked to the landslides that are supposed to have triggered. I would suggest a rewording of the section.
L146: If I have understood well, you considered a rainfall event a series of rainfall measurements equal or greater than 1mm, regardless of the duration. I suppose that you obtained several events with very short durations. If it's so, how did you handle this issue?
L155-156: this sentence is not clear to me.
L167: don't you think that a distance of 50 km between the landslides and the rainfall is too much for associate a rainfall event to a landslide? and to say that those rainfall events have triggered those landslides? I think so. not to mention a distance of 100 km! In particular in a mountain environment where rainfall is affected by a high spatial variability (see e.g. https://www.sciencedirect.com/science/article/abs/pii/S0022169415007696)
It would be interesting to know what's the mean distance between stations and landslides considered in this study. Most of the studies regarding relationships between rainfall and landslides - particularly rainfall thresholds - do not consider distance longer than 15-20 km. I think this is a great flaw of the article.
L167: However, how many events were associated to each station? please add this information
L169: this can be reasonable if the landslides are deep-seated; in case of shallow landslides it seems a very long period. Do you have information on the depth of the landslides?
L172: considering the triggering rain event as the one that “produces the maximum rain intensity at most 30 days before the landslide” is highly questionable. so, if you have a rainfall event with the maximum intensity occurred from 25 to 23 day before the landslide

and then you have another event that occurred immediately before the landslide (with a lower intensity), you consider the first one? this has not physical justification.
L179-180: usually the exponent of an ID threshold is negative because the intensity becomes lower with higher duration, as you can see from several papers dealing with it. Your result is strange.
L182-182: there are some recent examples in the rainfall threshold literature that advise against using mean intensity and duration when calculating thresholds, because the two variables are dependent on each other, as you explained here. Conversely, in the case of thresholds defined using cumulated rainfall and duration (ED), the two variables are not dependent on each other. For this reason, it is preferable to define ED thresholds, in which the two variables measure independent quantities (see e.g. https://doi.org/10.1007/s11069-019-03830-x)
L188-190: I would suggest adding some details on the methods used for regionalization.
L194: How we can see that the region 1 is related to Banihal from figure 3?
L203-204: "The seasonal rainfall variability across the gauged sites shows the occurrence of peak rainfall during the monsoon season for most of the locations except Banihal". This is a very high difference, in particular comparing to the Katra station which is located 50 km far from Banihal and with an elevation difference of about 800 m. This deserves a better explanation.
However, looking at table 1, I see a lot of differences in the annual and seasonal average rainfall. Katra station has very few data so I would not include it in the analyses, because it could affect too much negatively the comparison.
L204: I'm not sure that you have described in the text how you have built this graph shown in Figure 4. Perhaps a clarification would be useful.
L212: Actually, I don't see this strong synchronicity. Perhaps it would be better to calculate an index for justify this link, as e.g. the Kendal rank correlation coefficient (https://doi.org/10.1093/biomet/30.1-2.81) or the Pearson or the Nash-Sutcliffe (1970) coefficient.
L218: actually, you didn't identify these landslide events. You used a global catalog.
L220: If you could not identify any landslides in the period 1988-2006, I would not use rainfall data before 2007 I the aim of the work is to study the "predictability of rainfall-induced landslides" as stated in the title.
L222: I would not say around 2010-2013. Actually, the events are clustered IN 2010 and 2013.
L232: Figure 7 is not very clear. I would suggest removing the landslides and the donut charts from panel b, for allowing comparison among (a) and (b). The donut charts could be moved in figure 6 (perhaps in a new panel with the map with the landslide types). Figure 6 is related to landslides, while figure 7 is related to rainfall. So please avoid confusion.
L235: Again about figure 7, the six stations are localized all in the southern part of the states. So I think it's a bit difficult to extrapolate the rainfall maps for all the norther, mountainous parts. unless you used gridded data for the whole area. but this is not specified in the data section.
L240: you write about an increase but you don't have landslide data for the previous period.
L241: how these landslide sizes were determined? what do small, medium, large, and very large mean?
L244-245: what were the results of this Wilcoxon rank-sum test?
L257: you write "little to no improvement". Actually, it seems there's a downgrade e.g. for Mandi station.
L259: "sparse temporal coverage" indeed, too few measurements
L263-264: again, this is highly questionable. Very often, it is not the event with the higher intensity that could be responsible for landslide initiation.
L267-278: "whereas the other associated events with modest to low intensity are considered non-triggering events". This should be better justified.
L269-270: Something strange in Figure 9, in my opinion. How can you have a triggering

event without a landslide (e.g. 2007 or 2016 in panel a) or after (e.g. 2015) a landslide? How can you have more triggering events that landslides in a period (e.g. 2007 in panel b)? Again, usually the triggering events are the ones that can be linked to the landslides, so most often are the ones immediately before the landslides.
L275-276: this sentence is not clear.
L277: this overlap among triggering and non-triggering events can be due to the fact that the selection of the triggering events was made - in my opinion - in a wrong way.
L279: this intensity value is a bit strange. Do you think that such a low intensity is able to trigger a landslide in the area? probably your data would need a postprocessing and analysis (allowing the elimination of very low values) before being use in threshold calculation.
L281: 1.2mm – very low.
L282: is not the number of landslide events that decrease... is the number of rainfall conditions associated (or not) to landslide initiation.
L282-283: "This implies landslides are triggered by short-duration high intensity rainfall". I would not make this general and strong statement.
L284-285: It seems that you have not mentioned how many triggering events were associated to each station. This is crucial for threshold calculation.
L287-288: That's fine. However, such curves are not thresholds. They are best-fit curves of the point distribution. Please read some papers dealing with threshold calculation and define proper thresholds. You can find information in these literature reviews: 1) https://doi.org/10.1007/s00703-007-0262-7 ; 2) https://doi.org/10.1007/s10346-007-0112-1 ; 3) https://link.springer.com/article/10.1007/s10346-018-0966-4 .
L289: these values of the intercept are very low, even more if considering that the thresholds are not thresholds but actually best-fit curves. By making some calculations using eq. 3, one can obtain very low values of intensity as threshold values. probably some low events should be removed from the analysis before calculating the thresholds. however, I still think that the problem lies in the method for the definition of landslide-triggering rainfall events.
L316: only one station have this 51-year operational period.

Table 1. I would use only one decimal place when referring to rainfall, unless you know there is this high measurement accuracy.
Figure 1. The quality of this figure could be improved. As an example, the map with the indication of the three states within the Indian continent should be placed as an inset of the other map. The North arrow and the scalebar could be placed within the map with the indication of the rain gauges.
Figure 3b. I would add the name of the sites in the plot, for a better understanding.
Figure 5. I would suggest coloring in blue the bars of monthly precipitation to be in agreement with the scale label.
I don't see the need for adding the smoothing. Please add justification. However, in the legend a "W" is missing.
Figure 6. The North arrow and the scalebar could be placed within the map. The little map with the indication of the three Indian states could be removed as it is already shown in figure 1. However, this map is not clearly visible. I would remove the DEM in background. The legend could be placed inside the map.
Figure 7. The pie chart (monsoon vs. non-monsoon) should be described also in the caption. This figure 7a is not very clear. I would suggest removing the landslides and the donut charts from panel b, for allowing comparison among (a) and (b). The donut charts could be moved in figure 6 (perhaps in a new panel with the map with the landslide types). Figure 6 is related to landslides, while figure 7 is related to rainfall. So please avoid confusion. Finally, please describe the acronym AAR in the caption.
Figure 10. I would leave only the names of the stations and remove the codes. Moreover,

how we can understand which events are triggering and which non-triggering in these graphs? A legend and a description in the caption are needed.