Natural Hazards
and Earth System
Sciences

Discussions

Interactive comment on "Representative rainfall thresholds for flash floods in the Cali river watershed, Colombia" *by* A. D. Ávila et al.

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1   General assessment

This paper presents new rainfall thresholds for flash floods for the Cali River watershed in Colombia. It uses a relatively simple, straightforward method to link accumulated rainfall and antecedent rainfall, which has the potential to be used in early warning systems. However in terms of scientific contribution, the methodology is not particularly innovative, and more sophisticated analysis as previously been published. The authors do a good job of placing the research in the wider scientific context, although there is only limited discussion and assessment of research more directly related to the field.

Most of the figures are clear, and the text of an appropriate length. However, the text in some places is unclear or verbose, and rearranging or rewriting of the text in places could improve readability. In my opinion, while the paper fits within the scope of NHESS, further clarification of the methodology and discussion of the results is required.

I agree with the first referees comments, and have outlined some further specific and technical comments below.

2   Specific comments

2.1   Introduction

Some work is needed on the structure and content of the introduction. While the authors do place the research in the wider context (climate change, early warning systems), I feel that it is missing the current understanding, and challenges with regards to rainfall thresholds (the need for this work compared to what is already been accomplished in the scientific community). Furthermore, the examples of flash floods may be best restricted to either those in the catchment or similar catchments, or where the example provide further information about the problem or solutions relevant to the work in this paper. Here are some references that may be useful:

- Borga, M., Stoffel, M., Marchi, L., Marra, F. and Jakob, M., 2014. Hydrogeomorphic response to extreme rainfall in headwater systems: Flash floods and debris flows. Journal of Hydrology, 518, Part B(0): 194-205 doi:http://dx.doi.org/10.1016/j.jhydrol.2014.05.022.

- Diakakis, M., 2012. Rainfall thresholds for flood triggering. The case of

Marathonas in Greece. Natural Hazards, 60(3): 789-800 doi:10.1007/s11069-011-9904-7.

- Marra, F., Nikolopoulos, E.I., Creutin, J.D. and Borga, M., 2014. Radar rainfall estimation for the identification of debris-flow occurrence thresholds. Journal of Hydrology, 519, Part B(0): 1607-1619 doi:http://dx.doi.org/10.1016/j.jhydrol.2014.09.039.

- Nikolopoulos, E.I., Crema, S., Marchi, L., Marra, F., Guzzetti, F. and Borga, M., 2014. Impact of uncertainty in rainfall estimation on the identification of rainfall thresholds for debris flow occurrence. Geomorphology, 221(0): 286-297 doi:10.1016/j.geomorph.2014.06.015.

- Zehe, E. and Sivapalan, M., 2009. Threshold behaviour in hydrological systems as (human) geo-ecosystems: manifestations, controls, implications. Hydrol. Earth Syst. Sci., 13(7): 1273-1297 doi:10.5194/hess-13-1273-2009.

2.2 Methodology

1. I am particularly missing from this paper the justification for the methodology chosen. What are the advantages and disadvantages for the method you used? For this method, the boundary for the critical rainfall threshold appears to be very subjective – what determines a concentration of data points? Commonly used in rainfall thresholds for landslides (although as the first reviewer pointed out, different from flash floods), are intensity-duration thresholds, or using terms from this paper, the AR threshold varies depending on AAR. Why was this method not chosen? Furthermore, even though in the introduction you mention early warning systems, you do not take the logical step of looking at false alarm rates, missed events etc. that could be easily implemented with the method you presented.

2. There are places where clarification of methodology is required (see also the technical comments sections):

   - How did you arrive at the precipitation amounts: are they an average of all the stations? Maximum? This should be clearly indicated, and why this method was chosen.

   - Percentage of flash floods vs probability of flash flood confusion: In the methodology (4102 lines 3-4), you mention that the maximum threshold is the highest percentage of flash floods. In literature, the maximum threshold is often the threshold above which you have the maximum probability of landslide or flash flood. And from the paper you site, Glade et al. (2000), a maximum threshold is defined as the "the rainfall value above which landslides have always been recorded". It is also not clear how the percentage of flash floods is calculated (between thresholds?). As there is also confusion in the terminology in the results section, I recommend including an equation to clarify how the values in the figures and thresholds were calculated, and perhaps choosing a second measure for assessing the thresholds.

   - It is also not clear from the methodology why you have a maximum minimum threshold for AAR, and only maximum for AR in Figures 4-7.

3. Trend analysis: Besides moving the results into the results section, I have a few extra questions and suggestions. Why were not all the rain gauges used? Highlighting in Fig. 2 the location of the ones used in the trend analysis would also be beneficial. Why was only the period 1980–2012 considered, not the 1950–2012 period used in Fig. 3? Perhaps it was as the first reviewer commented, to be able to link the analysis and rainfall variations and the flash flood thresholds. If this is the case, it needs to be addressed.

2.3 Results and Conclusion

4. In the results section, page 4105, you state that most flash floods are linked to AAR 5 and 7 days (which is explained), while in the conclusion you state that AR (antecedent rainfall) of 5 and 7 days is the best. How was this second conclusion reached?

5. As it was not clear to me what the percentage value actually referred to (percentage of flash flood events above the threshold, below the threshold, between thresholds), it is difficult to comment on the results. However, the conclusion on page 4106 that 5 or 7 day rainfall totals are more appropriate than 1 day rainfall totals appears counter intuitive for flash floods (or again, perhaps this is my misunderstanding). Regardless, this conclusion needs to be discussed. Are 5 to 7 days better because you are dealing with daily rainfall data? Are they actually floods rather than flash floods (which in the definition used occur within 6 hours of the event that caused it)? Autocorrelation in your data? Or is this just due to the methodology chosen? This discussion would help support your results.

6. Clarification on the calculation of return periods for discharge: How were these calculated? What was the length of the time-series? Based on Table 2, there were 27 events with return periods equal to or greater than 3 years in a 33 year period. If an annual maximum approach was used (which still equates to 16 events, a high number for 33 years), it may be more appropriate to use a peak-over-threshold approach

2.4 General

7. Figures: Generally the Figures 1-3 and 8 are clear and readable. However, including relief or topography in Figure 2 would aid in the discussion of orographic rainfall etc. Figures 4-7 could be improved: Could you indicate which rainfall

days were associated with flash floods? Right now it is not clear what the ratio of event days to non-event days there are above the thresholds. In the text it was also mentioned that a semi-logarithmic or logarithmic scale was used to define the thresholds. To increase reproducibility, it would be beneficial to maintain the same scale as used to determine the thresholds in the figures. To increase readability, it may be better to use a white back ground (and black lines, as mentioned in the main body of the text). On the y-axis, the term accumulated rainfall is used, which is a different terminology as in the main body of text. The captions also need include references to the value in the top right corner.

8. Terms antecedent rainfall and accumulated antecedent rainfall: The terminology is confusing for me; based on the terminology used, the 1 day rainfall total on the day which the flash flood occurred would be labeled antecedent rainfall. Perhaps you could use short-term rainfall instead, to clearly separate the difference between AR and AAR.

9. ENSO – You talk about ENSO in the introduction, and then make no mention of it in the rest of the text. Which events (if any) occurred during La Nina or El Nino conditions? If this is not relevant to the work done, remove from the introduction.

3 Technical comments

4096 lines 18-19 Inappropriate reference

4097 lines 26-27: References not in correct order

4097 line 27: Reference Vincent, 2007 is inappropriate as it deals with adaptive capacity as opposed to human intervention in ecosystems

4098 lines 4-5 Only more recent references are needed

4099 line 10: "the region experiences high amount of precipitation in April and May" - unclear (possibly "higher precipitation amounts in April and May"?).

4100 line 24-26: 'Average precipitation exceeding 1500mm': Is this for all rain gauges? Previous sentence already mentions that annual precipitation totals are between 1300 and 2700mm.

4101 line 7: For what period is the data available?

4101 line 15: Elevation rather than "altitude"

4101 line 25: Unclear, are you referring to the Aristizábal study? To clarify, I would change the sentence to "The study by Aristizábal et al. (2011) was the first to . . .."

4102 line 10: What is the critical threshold? Minimum or maximum threshold, both?

4102 lines 19-20 Unclear with what you mean by "number of events". Do you mean "number of events above the maximum threshold", Perhaps it is better to write "The percentage of flash flood events above the maximum threshold is also given" (this should also be added to the caption in the Figures).

4103 lines 8-9 Again only the more recent references are needed, as all four references include the same author as either first or second author.

4103 line 11-12 Remove i.e. Can rewrite as ". . .greatest flow, as there is a one month delay (Fig. 3)".

4103: line 25: For clarification, change "this" to "the distribution of flash floods"

4103: line 25 onwards: I am not clear on how this links with the previous paragraph. From April till June, is the mean wind direction more westerly than other months (and how was this assessed)? Otherwise, the explanation here does not fit.

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4104 line 4: In the current figure, the line is white not black.

4104 line 5-6: What is meant by adjusted by the greatest concentration of points?

4104 line 6-7: This is unclear. What is the total number of flash floods within the threshold? Do you mean "between the thresholds" ?

4104 line 17 "One may note" is not necessary.

4104 line 28 As "Interestingly is to observe. . . " is not clear, I suggest changing to "The lowest percentage of flash floods for all threshold was from AAR = 20".

4105 line 13 AAR = 7 (not AR = 7).

4105 line 19 "The results above" not " The discussion above"

4105 line 21: Unclear what is meant by "appropriated results". This study also use similar periods for AAR.

4106 lines 6-9 You should discuss in the previous section where the AR periods between 5 and 7 days provide the most accurate thresholds.

4106 line 18 remove 'outstanding'

4106 line 13 ". . .the AR up to 90 days prior. . ." where in the paper is an AR up to 90 days considered?

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