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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Empirical atmospheric thresholds for debris flows and flash floods in the Southern French Alps" *by* T. Turkington et al.

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Dear Editor,

We would like to express our thanks to the two valuable reviews by the referees. They have both provided useful comments to improve the quality and scientific relevance of this paper.

After this segment we have commented on each of the reviews in more detail. Taking into consideration these reviews, we have altered the text to improve the quality of the manuscript. This can be seen in the attached pdf file with all changes have been highlighted in yellow or with a strike-through. While reviewing the report ourselves, some additional minor grammatical errors were also corrected.

Kind regards on behalf of all authors,

Thea Turkington

Referee 1

During the revision of the paper we included further information about CAPE (page 9), and tried to made clearer the assumptions we made, and synthesize more the results and discussion to make it easier for the reader. We agree that the paper was a bit lengthy, and from your suggestion we have attempted to streamline the results and discussion, reducing these sections by approximately one page. We would also like to address some of your more detailed comments below.

1. The selection of atmospheric indicators

"Selection of indexes CAPE and specific humidity look right (?). The first one represents the level of instability, the second one the presence of precipitable water in atmosphere. But, are these two indexes exhaustive to evaluate precipitation intensity? High values of CAPE or tCAPE not always mean rain or intense rainfall, also if associated to high specific humidity. More, while single convective phenomena normally have a duration less than 3 hours, a tCAPE based on dt greater than 3 hours may be not adequate.."

We agree with the referee that more than two parameters are important to define rainfall and amount. CAPE and high specific humidity at 700hPa are indeed not the only requirements for intense convection. The use of more parameters, especially in the case of short range weather forecasting could be highly beneficial. However, for this paper we decided to only use two parameters, following what we used for rain gauges (e.g. one day and four day totals), as well as to prevent over fitting due to the limited number of flash events. As the paper is meant to present a methodology to link atmospheric fields to flash events, using two parameters keeps the methodology and visualization of the results simple. The use of only two parameters is a limitation of the

threshold, and could be one reason for false positives when using the meteorological indexes. A sentence has been added in the methodology section to address this (page 13, lines 22-26). Also, an extra reference has been added addressing this point (page 13, line 24): Hewitson and Crane (2006).

Furthermore, as the reviewer highlighted short term convective events may not be captured (those lasting less than 3 hours) by ERA-interim due to both the temporal and spatial resolution. Along with instances when convection is confined to a shallow layer of the atmosphere, these explanations could have led to misclassification of flash events. They may also explain the low threshold value of CAPE. Using a NWP model with a finer spatial resolution may be beneficial, although it would be expected that the NWP would not always resolve correctly the precise location of the convection - so some uncertainty about where the convection would be would remain. We have added a short extension related to this on (page 23, line 9).

2. Location of the rain gauges

"About rainfall results, looking to fig. 1, the position of the rain gauges, compared to the "affected torrents", is inadequate. Only rain gauges 1 and 5 are close to the "affected torrents" and probability, while they are located at a distance less than 10 km they are strongly correlated. Finally, the affected region is about one half of 512 kmq with only one significative rain gauge. So far we have about one rain gauge for 256 kmq. Evaluation of flash flood in this contest is very hard if we consider that core of intense cumulonimbus precipitation is few tens of kmq."

This was actually what prompted us to try and use atmospheric indicators in the first instance - so yes we agree with you. Due to the localized nature of the convection, it can be difficult in mountainous regions to capture the 'true' rainfall with rain gauges. We think that this methodology has potential to help in other areas that have a similar problem. However, in areas were the rain gauge cover is adequate; the weather stations may perform better. We have added a small section to address this (page 18).

" Some doubts about the number of analyzed events. In my opinion, 43 events are insufficient for a significative inference, considering that events are categorized in 4 classes. "

We completely agree that more events would improve the significance and reliability of the results. This is especially true for what we classified as the 'synoptic' where there were only 19 events. However, in the case of the synoptic events, the thresholds did not hold up in the validation time step demonstrating that we were unable to find atmospheric thresholds for these events (if one even exists). For the 44 flash events in group CC, the threshold still performs better than the rain gauges. Of the convective events not used to develop the threshold, 18 of the 24 convective events were above the threshold. Grouping all the flash events together (63), the atmospheric threshold still performs better than the weather station, although by a smaller margin. This is not communicated clearly enough in the paper though, so have added a paragraph to address this (page23).

3. The use of satellite imagery

"[t]o evaluate past rainfalls for ungauged sites, infrared (MSG) and microwave satellite data probably may give more accurate results"

Thank you as well for your suggestion about using satellite data. As you point out, it may still be an improvement over the rain gauges. We did not use satellite data due to the spatial resolution and accuracy of these proxy measurements. Therefore, we decided not to include satellite data into this study, but this could be part of future work.

Referee 2

During the revision we have tried to clarify the points you raised, especially with regards to the framing of the mathematical elements of the paper in Section three (see point 1). We added more detail in the explanation of the mathematical, trying to highlight the equations in terms of how we used them in the research. We also corrected the

continuity and grammatical mistakes that you found. We would also like to reply to your other comments in more detail below:

1. Clarity of Section 3.2 and 3.3

"[S]ection 3.2 and 3.3 would benefit from a little editing for clarity, i.e. with the use of the SI in relation to the meteorological variables, and with regards to the application of Bayes theorem. At first reading it is not entirely clear how these were applied to the datasets used in the paper. I think that the authors should be more prescriptive of how these were applied to the datasets used in this paper"

We agree with the reviewer that it may confuse the reader how precisely the mathematical elements were applied in the paper. Therefore, we have modified the text on page 12, lines6-8, 22, 25 and page 13, lines 13-14 to clarify the relevance of the SI value to the research. This was also undertaken for Bayes' theorem in Section 3.3 (page 14, lines 2-3).

2. Number of samples

"In agreement with the other reviewer a concern is the limited number of available events from which this analysis was conducted. I feel that the paper would benefit from a comment on the limitations that the small sample size imposes."

As with the previous referee's comments, we agree that the limitations of using this number of samples could be more clearly conveyed. We have added an extra portion to the general discussion about the limitation of the number of flash events, especially those classified as synoptic (page 23). As both reviewers have stressed this point, we have also added this point to the conclusions (page 25).

3. Minor corrections/suggestions

"As the paper deals with scales at which thresholds are derived through the application of models (p.3, lines 19-25) and I feel that this could be appropriately mentioned in the abstract for context, e.g.: The method is tested in the Ubaye Valley in the southern

French Alps (548 km2), which is known to have localized convection triggered debris flows and flash floods"

We have added the catchment size to the abstract (page 2, line 15).

"P.10, line 13 - (large scale atmosphere) was defined on P.6, line 3, but first appeared earlier on P.5, line 19."

Thank you for spotting this mistake. We have removed it from page 10, line 13 and page 6, line 3. The definition has been moved to page 6, line 1.

"P.11, line 23 - Each day in the calibration period 1989-2004 is assigned a label as an event day (a day where one or more flash events were recorded), and non-event days (where no flash event was recorded)."

The missing bracket has been added to page 12, line 3.

"P.15, lines 10-13 - needs consistency: The earliest local convective event reported in a year occurred on the 1 June (number 5 in Table 3) and the latest on the 23 November (number 13 in Table 3). The synoptic events occurred over a wider range of months, between March (number 9 in Table 3) and November (number 1 in Table 3). OR The earliest local convective event reported in a year occurred on the 1 June and the latest on the 23 November (numbers 5 and 13 in Table 3). The synoptic events occurred over a wider range of months, between March and November (numbers 9 and 1 in Table 3)."

The text has been changed to be more consistent on page 15, lines 22 and page 16 line 2.

"P.15, line 15 - (Fig. 5, middle and bottom) for consistency?"

The extra text was added to make the reference more explicit (page 17, line 7).

Please also note the supplement to this comment:

http://www.nat-hazards-earth-syst-sci-discuss.net/2/C464/2014/nhessd-2-C464-2014-supplement.pdf

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