

**General comments:**

Anonymous Referee #1	Reply
<p>The paper presents a detailed analysis of the causes that may explain the high impact of intense Mediterranean rainfall events in the city of Genoa (Italy). The study presents a multi-disciplinary study addressing both the hazard (rainfall intensity) and vulnerability (evolution of urbanization and river courses other centuries) in the area.</p>	<p>Genoa is a very interesting case study at international level for the high geo-hydrological risk due to the contributory action of three factors: 1) high triggering probability of "self-regenerating storm cells" that can produce rainfall among the most intense in the Mediterranean area, 2 ) marked steepness of the slopes therefore outflows are rapid and unpredictable, 3) the deep and intense urbanization of the area.</p>
<p>The topic is of interest for the readers of NHESS, but, the objectives and main results of the study are not explain deeply enough for the readers to really understand the interest of the study and also how this particular case study can be of broader interest for the scientific community. In addition, in its present state, the paper also presents several structural weaknesses and that should be addressed before possible publication</p>	<p>Page 2452 lines 25-28 we have written: Among the important topics analyzed in this paper there are: (i) the meteorological characteristics of these events, (ii) the changes in the rate of daily precipitation, and (iii) the most significant periods of the urban land development determining important changes of the territory above all on the hydrographic network and in the fluvial spans.</p>
<p>First, the objectives of the study are not stated clearly enough. The authors say that they “examine the circumstances that led to an increased geo-hydrological risk in Genoa city and in its surroundings”. This statement is too vague: why are they doing this study? What are the hypotheses they want to examine, with which methodology?</p>	<p>Please, see above. In addition to that it's necessary to read the contents of Table 2 ("Main geo-hydrological events Involving Genoa city and neighboring areas from the 19th century to 1970"), the Table 4 ("Impacts from the main geo-hydrological events in Genoa city from 1970") and the Table 5 ("Other geo-hydrological processes in Genoa city and main events in Genoa metropolitan area from 1977"). These can explain the reason for which Genoa is an interesting international case study about the geo-hydrological risk: the great number of events and their frequency were studied from a meteo-hydrological point of view with the aim to highlight the geo-hydrological risk factors and their changes over time.</p>
<p>In addition, the paper is not well structured. For instance in section 2 there are already some results discussed (Table 3).</p>	<p>Table 3 is not a result, but it's an element. Table 3 shows the average monthly rainfall values in three areas of Genoa, on the East, in the center and on the West.</p>
<p>In section 3, the authors provide a review of previous work, but also apparently of their own work, which is not easy to distinguish from what has been done before.</p>	<p>The trends of rainfall, temperatures, rainy days and daily precipitation in Genoa were analyzed by several authors until 2000. Our work is directed to update the trend to 2014 (included), partially confirming the results already discussed in the literature.</p>
<p>They also give the historical data sources they have used, but do not explain how those sources were used later and why</p>	<p>Page 2456 lines 25-27 we have written that the vulnerability of the area has increased over time due to changes in land use, mainly due to urbanization, which is clearly visible when comparing old maps and recent.</p>
<p>The purpose of section 4 is not very clear to me: it is quite descriptive providing details on some of the events and trying to compare them. But what the authors want to show is not explained</p>	<p>Page 2459 lines 5-6 we have written: Considering only Genoa city, in the last 45 years, 10 important events took place: 6 of them caused very severe damage and casualties (Table 4). We have described these events: 1970, 1992, 1993, 2010, 2011 e 2014.</p>
<p>Why do they describe those events only and not all the events listed in the Table 1?</p>	<p>Please, see above. Table 1 refers to a list of serious geo-hydrological events in Italy in the last 20 years. The authors obviously want to focus their attention on the events that hit the Genoa city from the big 1970 event till today.</p>

<p>I would suggest that the authors organize their paper (sections 2 to 5) in a more classical way, with a “materials and methods” section and a “results” section. The paper has two distinct parts, dealing with rainfall hazard and land use evolution. It could be interesting to cross the results of both parts to deepen the analysis</p>	<p>Currently the manuscript is organized with the following sequence of sections: Introduction, Geographical settings of Genoa, Previous research in the study area and Methodological approach, Genoan geo-hydrological disasters from 1970 to present, Genoan urban development (divided into: Variation about the land-use, Modifications in the width of the riverbed, The progradation of the coastline to the sea, the riverbed diversion), Discussion and conclusion. And it’s possible to structure the paper in a more classic way, if this improves the readability of the manuscript combining n. 4 and 5 paragraphs according "materials" and "results".</p>
<p>Finally, I do not find that the conclusions are well supported by the results presented in the paper, in particular all the claims related to climate change impact and trends, which do not rely on solid statistical tests</p>	<p>Given that the topic of the manuscript is not a climatological analysis and that the trends highlighted in Figure 3 (relative to the increase in average annual temperature and the decrease in rainy days through the use of the Standardized Anomaly Index) seem representative, and have already been discussed in literature, perhaps till 2002, we can upgrade the significance tests, which have already been successfully applied in the papers mentioned in the references.</p>

### Specific comments

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<p>P2452, lines 7-10: I don’t believe that the increasing trend of high impact events is supported by the data presented in the paper. For such a claim, long time series should be analyzed and statistical tests should be used to assess if those trends are statistically significant or not.</p>	<p>All right! We will perform the significance test, although the trend highlighted in Figure 3, already accepted in literature, appear to be sufficiently representative for the objective of the paper</p>
<p>P2452, line 24: how do you define an unacceptable risk? The definition is subjective and depends on the people’s point of view that may change from one individual to the other.</p>	<p>See table 4. Since 1970 in Genoa city there were 6 geo-hydrological events that provoked the loss of 61 lives. This is not sufficient to define an unacceptable risk? According to Nielsen et al. (1994) should be already unacceptable only one fatality.</p>
<p>P2453, lines 27-28: why are you interested in this question? For which purpose will your results be used? Urban planning? Flood prevention?</p>	<p>Tables 2-4-5 refer to the geo-hydrological events that hit Genoa City and its Metropolitan area. From 1970 to today we have cataloged at least 20 episodes, then with return time of 2 years. If necessary we can better highlight the core of the paper, namely the issue of flood prevention and the consequent risk reduction</p>
<p>P2454, line 23: catchments more than 4 km<sup>2</sup> is somehow misleading. It gives the reader the feeling that catchments are very small in the area, whereas some are more than 150 km<sup>2</sup>. I suggest adding the range of catchment sizes in this category in the presentation.</p>	<p>OK, we divide the Genoa’s basins by class according the catchment surfaces</p>
<p>P2455, lines 1-9: here the authors give the names of the catchments, but it is difficult to locate them in the map: add the names in the map or use the letters you provide in Fig.1.</p>	<p>Okay, even if the detailed legend of Figure 1 provides all the information about the names of the basins and other items contained in the text</p>
<p>P2455, lines 15-17: these are already results, mixed with a general description of the study area. This is not very clear.</p>	<p>As explained before, the table 3 is not about the results! It simply shows the average monthly rainfall in three areas of Genoa.</p>

P2456: this section could be better organized with subsections describing for instance i) previous studies in the area; 2) meteorological data used in the study and the methods used to analyze them; 3) historical sources and how they were used in the study.	Okay, we can articulate this section in subsection as required
P.2457, lines 10-16: here you provide information about your own work, mixed with a review of previous works. With this respect, it would be useful to better highlight (also in the objectives and introduction) what is the added value of your study as compared to existing ones.	Okay, we'll clarify better which is our original contribution. The trends of rainfall, temperatures, rainy days and daily precipitation in Genoa have been analyzed by several authors, until 2000. Our job has been that to update the data to 2014 (included), the period in which many severe events have occurred.
P2457, lines 23-29: you speak about negative or positive trends, but you should analyze these trends using statistical tests to know if those trends are statistically significant or not.	The current trend analyzed through the Standardized Anomaly Index seem representative and verified until 2002 in the bibliography. IN spite of this, if you believe that it's necessary (since it is not the work of statistical climatology).. we will integrate our paper with the test such as Mann-Kendall
P2458: here you provide the different sources of historical information you have used, but you do not explain how you used this information. For instance, did you georeferenced the old maps and overlay with present maps? Did you only perform qualitative analysis? Etc	The figures 6-7-8-11 show clearly the use of historical maps for the evaluation of urban sprawl and the resulting observations on: variation about the land-use, modifications in the width of the riverbed, the progradation of the coastline to the sea, the riverbed diversion. The historical-cartographical comparison has considered land and urban planning changes around those points remained fixed over the years, such natural elements or historical buildings and monuments.
P2460, section 4: please clarify the objectives of this section which is very descriptive	Page 2459 lines 5-6 we have written: Considering only Genoa city, in the last 45 years, 10 important events took place: 6 of them caused very severe damage and casualties (Table 4). We described the 6 most serious events over the last 45 years: 1970, 1992, 1993, 2010, 2011 and 2014.
P2460, line 13-15: repetition with some elements already in the introduction	We don't see repetitions between what is reported in section 4 and in the introduction. Please specify.
P2461, lines 13-15: this sentence is very subjective and not supported by the data presented in the paper	Figure 4 shows the different rainfall intensity of the events recorded in the third millennium, which appear more focused on shorter periods, in particular in 3 and 6 hours.
P2461, lines 22-28: you speak about trends but this is not supported by statistical tests, providing information about whether the results are significant or not.	The current trend analyzed in Figure 4 (below) appear representative and already highlighted by other authors, but if necessary, we will perform statistical tests as suggested.
P2462, lines 5: "Figure 5 shows the trends..". I believe "trends" is probably not the right word to use. "Figure 5 provides the hyetograph and hydrograph.." would be sufficient.	Yes, ok.
P2466, line 9. I don't understand the use of the word "consequently". There is no relationship between the two sentences.	"Consequently" because most of the flooding occurred after a substantial urbanization of the area, as described in the previous lines 1-7 of P2466.
P2467, lines 1-6, 6-14. The results discussed here do not really appear in the paper. This is the same for the sentences in lines 20-25.	We can explain better, even if the figures quoted in P2467 seem to support our claims.
P2468, lines 10-15. It could be interesting to provide somewhere in the papers figures about the estimated concentration times in the various catchments. Would it be possible to also estimate those values for past conditions, for instance taking into account that water	It's possible to do hydraulic evaluations on the basins now, but they are less reliable for past events in scarcity of detailed hydrological information (especially for events of the XIX and first part of XX centuries).

pathways were larger?	
Tables 1 and 2 are interesting but they are not really exploited in the paper.	They have been cited in the introduction, together with the fig. 1, to give the immediate reference about the importance of the topic. Then, as already said, we focused on the events of the past 45 years, of whom we have data and information
Figure 1: is somehow too small. In addition, some information about catchments names is missing (see comment 5)	Ok, we try to enhance it.
Figure 3: Provide the units of the y-axis.	The Standardized Anomaly Index, exposed to P2457 lines 17-19 (with references) conveys the anomaly of the parameter examined compared to the average value of the reference period, thus being dimensionless. A positive index indicates an amount higher than the average, while a negative index is related to a deficit.
Figure 4 (bottom graph). Here you have a time series of about 50 years. So it would be possible to apply statistical tests for trend analysis (for instance Mann-Kendall test). Figure 12: Are you sure that you manage to identify all the events that occurred in the past?	Although the trends seem however obvious, here it is possible to apply statistical tests to the graph, in the absence of previous studies on this time series, as is instead carried out and reported in the literature for similar series recorded near Genoa University. For the figure 12: it lists all events occurred from the nineteenth century to today, thanks to a careful historical research. Flood and geo-hydrological events also known in previous centuries, since Roman times (line 11, 12 in introduction), but in this case the information is definitely incomplete and fragmented. For this reason we have not reported them, limiting our observations to the 50-year period from the nineteenth century.