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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "The influence of antecedent conditions on flood risk in sub-Saharan Africa" *by* Konstantinos Bischiniotis et al.

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GENERAL COMMENT: The authors investigate the influence of high-intensity rain events and antecedent moisture conditions on flood probability in a large target area, including almost the entire African continent. Based on a data set of reported floods (provided by Munich RE), the short-term (event-precipitation) and long-term conditions (SPEI) before each event are systematically compared. The results indicate, that most of the reported floods are related to high precipitation events during the last seven days. Further the authors argue, that rather moist conditions on seasonal scale lead to enhanced flood risk, most likely due to filled up storage systems. While the research

target is timely and the manuscript is well structured and easy to follow, I have some serious concerns about the statistical methods and the interpretation of the result. Particularly the conclusions remain very vague! Thus I recommend to extend the statistical analysis and to better test, whether the conclusions are robust and really supported by the underlying data sets. In the following I will summarize my major concerns. Since I expect the text to change significantly, I will not go into detail at this stage of the review process.

RESPONSE: We thank the reviewer for his/her comments, and we are pleased that he/she finds the topic timely and the paper easy to follow. Based on the comments and suggestions, we suggest a thorough revision of the original manuscript. The revised version of the paper includes an extended statistical analysis to support our conclusions. At the end of this response, we present the additional new figures proposed to be included in the revised manuscript and we look forward to other comments. Below, we address the comments point-by-point. Please note that the figures are in a pdf file in the supplement.

COMMENT 1: Introduction and data sets: The presentation of previous research in the field of flood forecasting in Africa is very short. No information is given on the timing of floods in different sub-basins of this vast target area and on the general climatic conditions. This information would be highly valuable in order to interpret (and scrutinize) the results of the statistical analysis. (E.g. It could be interesting to identify some differences between Eastern and Western Africa, which seem to behave differently in terms of the SPEI-flood relationship.) Likewise the introduction of the data sets is insufficient. I would expect a detailed description of the advantages and drawbacks of the data – especially the daily precipitation values on a coarse grid are extremely uncertain, since they do not cover local scale convective events, which frequently trigger high-intensity rain. The Munich Re data are introduced in two sentences only – again I think it would make sense to better discuss its origin and shortcomings!

RESPONSE 1: We would like to thank Reviewer#1 for his/her comments and recommendations. In the revised version, we include the Köppen climatological map (Level 1) to give more information regarding the general climatic conditions of each flooded location (Figure 1). Moreover, we compare the 3 main climatological areas (see Figure 2) in terms of their SPEIs. Although some differences in terms of SPEI-flood relationship are observed, these are not statistically significant.

Furthermore, we do agree that the datasets lack a rigorous description. Therefore, in the revised manuscript we discuss:

a) The uncertainty in disaster datasets, and the reasons for the discrepancies between them (e.g. different entry criteria, time period covered) b) An extended description of the sources of NatCatSERVICE database. c) The possible explanations of the upward trend in reported floods over time. d) The difference between the hydrological definition of a flood compared to the definition that it is used by flood loss reporting, and discuss how this difference can be associated with missed events. e) The uncertainty of hydrological variables in the reanalysis dataset due to the lack of ground-based precipitation records in our area of interest. f) The sensitivity of the reanalysis product to the resolution choice. g) The uncertainty in hydrological variables in tropical regions and in southern Africa h) The large uncertainty in of the daily precipitation reanalysis dataset in capturing local-scale high intensity precipitation events.

COMMENT 2: Statistical Methods: The majority of the methods used is purely descriptive and does not allow to draw verified conclusions. One example is Fig. 9., which shows the mean seasonal SPEI values before reported floods. The authors argue, that floods, which are not preceded by high-intensity rains (0-33%-interval) have larger SPEI-values during antecedent seasons. However, all of the lines are very close to each other. A test for statistical significance (t-test or similar) would be necessary to support this statement. Further a presentation with boxplots would be more suitable, since it does not only show the mean, but also the range (and overlap) of the different classes.

RESPONSE 2: We agree with Reviewer #1 that the methods used in the original manuscript are rather descriptive. To accommodate the comments of Reviewer #2, we performed in preparation of the revised manuscript a statistical comparison between Flood and No-Flood events, presented by means of boxplots (see Figures 3, 4). These figures show the SPEI values of all flood and no-flood events on different time scales (0, 1, 3 and 6 months prior to the recorded flood). For each 'flooded cell' the no-flood cases that are taken into account refer to the particular flood onset month of the no-flood years. Due to the very high number of no-flood events, the median value is close to 0 at all time-scales. The SPEI0-SPEI6 values of floods are significantly higher, which is underpinned by the results of a z-test (p=0,05). More specifically, the median value of SPEI0, exhibits a value close to 1. This indicates that, as expected, the wetness in the end of these months was high, demonstrating that SPEI0 could be used as a flood monitoring tool. On the (overlapping) seasonal time scales we see a positive relationship between reported floods and SPEI, which reduces while moving from SPEI1 to SPEI6 (0.5 to 0.1).

Regarding the different weather-scale intervals (i.e. 7-day precipitation terciles): their median SPEI values of the different 7-day precipitation terciles exhibit any statistical significance differences and therefore in the original manuscript, we used descriptive results. In the revised version, we have removed this Figure (Figure 8 in the original manuscript (SPEI per precipitation class). Instead, we compare the maximum 7-day precipitation during no-flood events in the 31-year record with the 7-day precipitation that preceded the flood events. For each flood, we standardized the 31 values (1 for the Flood (F) and the 30 for No Floods (NF), with a mean of 0 and standard deviation of 1 (see Figure 5). This figure presents in boxplots the standardized 7-day precipitation (PRE7) of Flood (F) and No-Floods (NF) events. The results of the z-test showed that preceding PRE7 of floods did not exhibit any significant difference with that of no-floods (p> 0,1). This shows that although PRE7 that preceded the flood is high, it does not fully justify the flood generation: There probably were also similar magnitude events, in the same locations and during the same months that floods were reported, that did not lead to a (reported) flood.

Being aware of the dataset limitations (e.g. incapacity of reanalysis datasets to capture convective rainfall events, likely inaccurate onset date, etc.), the message that we want to convey is that since we observe a relation between seasonal SPEI and flooding and that relation does not need a relation via weather-scale precipitation, implies that there probably is another factor that affects flooding on a seasonal scale prior to flood generation. This factor is assumed to be the soil saturation due to limited water storage capacity. These factors have been addressed in the revised version of the paper.

COMMENT 3: Dependency of SPEI and 7-day precipitation. An increased SPEI value before flood events might have different reasons. One would be the limited capacity of the storage. A second one could be the persistence of the climate. That would explain, why the 66-99% interval in Fig. 9 shows the highest SPEI for all seasons. In order to draw robust conclusions, it would be necessary to disengage those processes. In Fig. 10, the frequency of flood under different SPEI combinations is shown. The analysis of further combinations (e.g. SPEI0 - normal and SPEI3 - moist) could support the conclusions of the manuscript. Again, a test of statistical significance is highly recommended. Would it further be possible to show a point-cloud of seasonal SPEI against 7-dayprecipitaion for all flood events? A clear negative relationship (higher SPEI values lead to flooding although 7-day precipitation is not extreme), would also support the conclusion.

RESPONSE 3: As also mentioned in the response of Comment 2, we observed small but non-significant differences of the SPEI values between the precipitation classes. Therefore, we have removed this section from the analysis. In order to evaluate the persistence of the climate, we use the Pearson coefficient (R) between SPEI0 and PRE7 with seasonal SPEIs (Table 1). The results show that there is no significant correlation, which implies that there is no apparent climate persistence. This lack of correlation implies that the positive seasonal SPEIs (as shown in Figures 3, 4), did not affect the conditions during the flood onset month, but they played a role in flood

generation.

Moreover, in the revised version, we compare the frequency of floods and no-floods under different SPEI combinations. Since our sample size is not large, the combination of different categories of SPEI (e.g. SPEI0-normal & SPEI3-high) gives us a small number of events for each one of them. Therefore, we have used exceedance thresholds (e.g. SPEI0>0 & SPEI3>2). Based on the frequency of flood and no-flood events, we quantify the elevated probability of having a flood event compared to a no-flood under each combination (Figure 7). Using higher thresholds, the seasonal SPEIs behave differently. However, only few floods exceeded these thresholds (i.e. less than 10) and consequently, we can't draw any firm conclusions. For lower thresholds, we observe significantly elevated probabilities of having a flood. For example, when SPEI0>0 and SPEI1>1, it is 4 times more likely to have a flood event than can be expected assuming a random flood generation process.

COMMENT 4: The authors highlight, that a forecast based on the findings is possible and that uncertainties could be reduced. I have the feeling that this is very optimistic. Would It be possible to establish a very simple tool for each of the FPU-units (e.g. based on a SPEI threshold value) and quantify the probability of hits and false alarms?

RESPONSE 4: We agree that establishing a forecast-based financing system based on the finding of this research is quite a challenge. We have formulated our recommendations more cautiously. Our conclusions now include a message that forecast based financing could be based on some results of our research, and that there are seasonal flood signals, which might support more effective forecast-based risk mitigation solutions.

Regarding the FPU-units, we have decided to leave them out of this paper, as their sample size is small. Instead, we have identified statistically significant differences in larger areas, with different climatological characteristics . Regarding the very simple tool that Reviewer #1 mentions, we include a graph that shows the elevated probability, which is calculated by the frequency of floods and no-floods that exceed several thresholds (see R.3 and Figure 6, 7).

COMMENT 5) Conclusions and discussion: The conclusions and the discussion section include many statements, which are not proven by the data or by literature (E.g. second paragraph, page 15, but also others). I recommend to carefully check, and to focus on findings which are really supported by the data.

RESPONSE 5: In the revised manuscript, we now make statements that they are based on statistical analysis and have supported our conclusions with extended literature research.

Minor remarks

COMMENT 6: Section 2.1 and 2.2 could have more meaningful subtitles.

RESPONSE.6: We agree and have changed these titles.

COMMENT 7: p.5l.5: "The weather scale and SPEI periods do not overlap and the SPEI period lasts until the date of the weather scale period." This is not possible, since the SPEI is defined on a monthly time scale? Does the SPEI period end with the month before the flood event?

RESPONSE 7: We understand that in this part clarification is needed. SPEI is indeed defined on a monthly time-scale, but the seasonal SPEI period (SPEI1 , SPEI3, SPEI6) ends on the month before the month that the 7-day period is calculated. For example, if a flood is reported on January 1st, the 7-day period ends on December 23rd and the SPEI periods ends in November. In the revised text we have explained this more clearly.

COMMENT 8: Fig. 2: I am confused about the hydrograph. Is this a schematic figure or is it somehow based on discharge time series? If I understand the figure correctly, discharge already increases seasons in advance. Usually the start of a flood event is defined as the first significant increase of discharge (which would be 5 months in

advance in Fig. 2).

RESPONSE 8: Indeed, this graph might be confusing. Its is mainly to provide the reader a better understanding of the different time periods. The continuously increasing high discharge during the antecedent months does not represent reality. We have replaced it with a new one, where the discharge has a significant increase close to flood onset date.

COMMENT 9: p6.l14: Floods are grouped into wet and dry seasons? How exactly is this relevant for the statistical analysis?

RESPONSE 9: We agree with Reviewer #1 that the grouping the floods in wet and dry seasons does not provide any extra data for the statistical analysis. So, it is removed from the revised manuscript.

Additional References

In the revised document, we aim to include the following references;

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Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/nhess-2017-58/nhess-2017-58-AC1-supplement.pdf

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