RESPONSE TO REVIEWER

Review of Manuscript No.: hess-2021-352

Title: "Rainfall-runoff relationships at event scale in western Mediterranean ephemeral streams

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We are grateful to the Reviewer for his/her thoughtful and constructive feedback. In this Response to the Reviewer's file, we provide complete documentation of the changes that have been made in response to the reviewer's suggestions and comments. The original comments are shown in **bold text** and the author responses are shown indented in plain text. Quotations from the revised manuscript are shown in *italic text*. Line numbers in the author responses refer to locations in the revised manuscript.

Referee #2

The authors propose a study that analyze the transformation rainfall-runoff in semi-arid catchments of Southern Spain, where the ephemeral regime of rivers and the climatic stress may lead to hazardous floods or, on the contrary, to dramatic droughts. The study is quite novel and gives significant insight about precipitation depths and return intervals, which may determine water and sediment flows in the channels. The statistical analysis is fine and suitable for the study aims. The results are presented with clearness and synthesis. Although the study is of good quality, I have three suggestions that may improve the MS:

- several methodological sentences are reported in the results sections, and this may confuse the reader. I ask the authors to revise both parts.

Thank you for your suggestion. We moved the methodological descriptions in results section to methodology (see detailed lines and paragraphs at the end of this document).

- although literature about the flow regime in ephemeral channels is not abundant, some other cross-comparisons with similar studies may further valorize the study results

Thank you. We added several new references to improve the discussion in all the addressed aspects and to compare our work with similar research in nearby areas and in similar terms (L359-363).

"[…] For instance, Camarasa (2021) showed that runoff is more dependent on rainfall intensity in the Mediterranean area, and Gutiérrez-Jurado et al. (2019) demonstrated that soil type has the greatest influence on flow generation, as well as Bull et al. (2000) mentioned in a study of a watershed near to our study area. In addition, anthropic interventions such as irrigation, industrial uses, roads, or any water resources change at large scale, can modify rainfall-runoff dynamics, leading to increased consequences of flooding (Conesa-García et al., 2016; Betancourt-Suárez et al., 2021)."

Betancourt-Suárez, V., García-Botella, E., Ramón-Morte, A.: Flood mapping proposal in small watersheds: A case study of the rebollos and miranda ephemeral streams (cartagena, Spain). Water, 13(1), 102, https://doi.org/10.3390/w13010102, 2021.

Bull, L.J., Kirkby, M.J., Shannon, J., Hooke, J.M.: The impact of rainstorms on floods in ephemeral channels in southeast Spain. Catena, 38(3), 191-209, https://doi.org/10.1016/S0341-8162(99)00071-5, 2000.

Camarasa, A.: Flash-flooding of ephemeral streams in the context of climate change. Geog. Res. Lett., 47(1), 121-142, https://doi.org/10.18172/cig.4838, 2021.

Conesa-García, C., García-Lorenzo, R., Pérez-Cutillas, P.: Flood hazards at ford stream crossings on ephemeral channels (south-east coast of Spain). Hydrol. Process., 31(3), 731-749, https://doi.org/10.1002/hyp.11082, 2016.

Gutiérrez-Jurado, K.Y., Partington, D., Batelaan, O., Cook, P., Shanafield, M.: What Triggers Streamflow for Intermittent Rivers and Ephemeral Streams in Low-Gradient Catchments in Mediterranean Climates. Water Resour. Res., 55(11), 9926-9946, https://doi.org/10.1029/2019WR02504, 2019.

- some expectations about the future trends of rainfall-runoff transformation under the forecasted climate change scenarios (higher mean temperature and lower precipitation amounts) in the studied area may be reported on the authors' knowledge and experience.

Regarding future trends, we added a few lines relating the rainfall-runoff potential changes in both watersheds to the expected decrease in precipitation and increase in temperature, leading to a higher evapotranspiration. As stated in previous works, this scenario, depending on the emissions development, has high probabilities of produce changes in seasonality of flows, increasing risks of floods and droughts. Despite we do not explicitly address climate change scenarios in our study, we appreciate your comment and agree that it deserves to be mentioned (L373-376).

"However, a change in the seasonality of flows is expected under these changing conditions of precipitation, leading to potential alterations that could intensify wet and dry periods (Pumo et al., 2016). In Algeciras and Upper Mula watersheds, climate change scenarios also depict a decrease in water resources caused by the changing seasonality, due to an increased evapotranspiration situation (Martínez-Salvador, et al., 2021)."

Martínez-Salvador, A., Millares, A., Eekhout, J.P.C. and Conesa-García, C.: Assessment of Streamflow from EURO-CORDEX Regional Climate Simulations in Semi-Arid Catchments Using the SWAT Model. Sustainability, 13(13), 7120, https://doi.org/10.3390/su13137120, 2021.

Pumo, D., Caracciolo, D., Viola, F., Noto, L.V.: Climate change effects on the hydrological regime of small non-perennial river basins. Sci. Total Environ., 512(A), 76-92, https://doi.org/10.1016/j.scitotenv.2015.10.109, 2016.

Some other minor suggestions are reported in the commented MS in attachment.

Thank you, we addressed all your suggestions, point by point:

L44: Here, I suggest adding shortly the main results of these studies. Added a short summary of results of those studies (L44-46)

"These studies highlight that, in the current Spanish Mediterranean scenario of decrease of total amounts of precipitation but increase in intensity (Serrano-Notivoli et al., 2018), hydrological connectivity is more dependent on rain intensity."

Serrano-Notivoli, R., Beguería, S., Saz, M.A., de Luis, M.: Recent trends reveal decreasing intensity of daily precipitation in Spain. Int. J. Climatol., 38(11), 4211-4224, https://doi.org/10.1002/joc.5562, 2018.

L49: Could you express a research hypothesis? Thank you for the suggestion. Now, the research hypothesis is stated in a few lines, closing the introduction section. (L51-53)

"Based on the watershed physical and climatic characteristics, we hypothesise that rainfall-runoff relationships are based in the intensity and magnitude of singular events, strongly dependent on seasonality of precipitation."

L93: What do you mean for "reliable"? Please be more specific. Thank you. We agree that the term can be confusing and we have removed it without changing the meaning of the sentence.

L96: How do you ensure this reliability? We replaced *"reliable"* by *"average"*.

L113: Not clear why you summed the hourly maximums. We added an explanation to make clear the reason of summing hourly maximums. (L120)

"to be representative of the amount of precipitation corresponding to the hours of maximum rainfall"

L128: Or "return interval"? We computed the "return levels" for different "recurrence intervals" (or "return periods"). This paragraph was completely rewritten due to a change in the method of frequency analysis proposed by Referee #1.

To contextualize the different thresholds of the RE for different probabilities of generating flow in both watersheds, we estimated the return levels of the RE using the generalized Pareto distribution (GPD) for extreme events using the peak-over-threshold (POT) approach. POT is most suitable when complete time series (as RE) are available due to all values exceeding a certain threshold can serve as basis for model fitting (Coles, 2001). We used four different estimators to fit the POT data to a GPD (Maximum Likelihood Estimation (MLE); Unbiased Probability Weighted Moments (PWMU); Moments (MOM); and Likelihood Moment (LME)) to establish proper and wide

confidence levels in the estimate of maximum rainfall per RE. Thresholds for the asymptotic approximation by a GPD in both watersheds were manually selected through the graphical representation of Mean Residual Life, the Dispersion index and the scale and shape parameters (see Figure S1 and S2).

L159: Significantly? Modified as suggested.

Figure 4: Better "Study period". Modified as suggested.

L171: Please use a more technical term. Perhaps "quicker" or "higher"? The expression was changed by the term “faster”.

L201: "the majority" Modified as suggested.

L215-220: All this part is methodological and should be moved in that section. Thank you for your suggestion. Indeed, this part better fits in methodological section, and we moved it accordingly.

L233-234: I ask the authors to reconsider whether this part may be moved to the methodological section. Thank you. We moved this part to the methodological section.

Figure 8: Better to reduce the lables on y-axis. This figure completely changed to show the results based on a different method of frequency analysis calculation based on a suggestion from Referee #1. Now, labels in Y-axis are better readable.

L299-302: The location of this part may be also reconsidered. Thank you for your suggestion. Instead of moving this part of the text, which fits in the linear–non-linear comments of the discussion section, we rewrote it to promote a more fluid reading (L379-380).

“For this reason, we used a GAM approach, that takes advantage of non-linear relationships, which are highly representative of the great irregularity of precipitation in the Mediterranean area. This approach represents an advantage among the wide variety of methods that has been previously used to model these thresholds in ephemeral or low-yield streams such as multivariate regressions, machine learning approaches, etc. (e.g., Kaplan et al., 2020; Kampf et al., 2018; Shortridge et al., 2016). Furthermore, GAMs allow for avoiding stationarity assumptions in rainfall-runoff relationships (Tian et al., 2020) in comparison with the abovementioned methods.”

L308: Please reconsider the form of this sentence. Thank you. Based on the new explanations of the POT method now used for frequency analysis, this part of the text has been slightly changed. Now, the sentence is clearer and more informative (L396-398):

“Low return periods were shown for events generating new flow at 95% probability, but they dramatically increased when probabilities were increased until maximum (99.5% in Algeciras and 98.8% in Mula). However, the analysis has some limitations to consider.”