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Hydrology and Earth System Sciences Discussions

Interactive comment on "Effects of seasonality on the distribution of hydrological extremes" *by* P. Allamano et al.

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Referee 1 is gratefully acknowledged for his/her insightful comments. In the following are reported our responses (plain text) interspersed by his/her highlighted comments (in italic).

1) *While comparing the analytical model and the data analysis I got confused on the definition of the random variable that is analysed. While the model refers to depths of "rainfall events", for the case study the "daily totals" of precipitation depths (depths for a specified duration - rainfall intensity) are used. When doing the analysis of Section 4, it is assumed that every rainy day (over threshold) corresponds to one event. Wouldn't it be a problem if, for example, the maximum rainfall depths in the region of interest*

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Interactive Discussion

Discussion Paper

correspond to rainfall durations longer than 1 day? [. . .]

Referee 1 is indeed right when he/she states that in the current manuscript there is some confusion about the definition of the random variable. In fact, while in the abstract and introduction we refer to hydro-climatic extremes, from Section 2 onwards we start referring to rainfall events only. In the revised version of the manuscript, since the approach presented is amenable to be applied to all kinds of hydrological extremes, we will amend this confusion by generalising the text. Reference to the rainfall case will be made only in the case-study section were the application to the North-West of Italy is illustrated. For what concerns the rigorousness of applying the model to over-threshold daily totals of precipitation, we agree that rainfall events with durations longer than one day would distort the estimates of α (which would be underestimated if one considers one event per day) and λ (which in turn would be overestimated). However we believe that considering the daily scale for over-threshold precipitation is a good compromise when looking for intense rainstorms, considering also that extreme precipitations are almost uncorrelated in time. The use of this scale might also compensate the opposite effect of two (or more) possible storms occurring in the same day but accounted as one.

2) *The authors state that the reason behind the better performance of the AM method relative to the POT method probably lies in the greater flexibility of the Gumbel distribution compared to the exponential distribution (those distributions descend from the formulation of the simplified stochastic model of rainfall extremes). This is likely one reason but I would suggest another (more general) one. If the annual maxima happen almost always in the same season (and I guess this is the case for the stochastic model), the AM method works well no matter if seasonality is strong or not [. . .]*

We agree with Referee 1 that this is likely another reason that justifies the POT vs AM behaviour. His/her comment will be integrated in the revised manuscript text.

Minor comments:

- 4792-15: amended

- 4792-18: *what does the temporal shift delta represent? If the sinusoids are in phase, then the maximum rainfall depths happen when the storms are less frequent?* No, if the sinusoids are in phase the maximum rainfalls occur when the storms are more frequent. We will clarify this point in the text.

- 4793-21: we will add a sentence to specify the variable change.

- 4795-7: amended

- 4796-9: *why is it interesting to see how R_T varies with the parameters λ_0 and a_α?* we decided to show the variability of R_T with λ_0 since a large sensitivity of the return period ratio to this parameter was observed. In particular the ratio is observed to increase (and not to decrease) with the number of events per year. This effect can be of interest when the role of the threshold on the sample properties is evaluated.

- 4796-15: *is there an interpretation of the change of $R_T^{(POT)}$ with δ?* The reason behind the dependence of $R_T^{(POT)}$ on δ is to be found in the event generation mechanism. In fact, when the two regimes are in phase we have a very high probability of picking all the exceedances in the same season, with the consequence that they will be almost identically distributed and the return period ratio will be low. Conversely, when the two regimes are out of phase, we will have a very mixed distribution of the events deriving by the coexistence of one season characterized be few very intense events with another season with a lot of small events. In this case, the non-exponentiality of the distribution will be very marked, with consequent high R_T values. We will add an explanation for this effect in the discussion part.

- 4798-10: *it is interesting that for AM the maximum error happens when the number of storms per year is large rather than low, while for POT was the opposite. Is there an explanation for that?* The behaviour observed in Fig. 2 (of the manuscript), with the contour plot maximum occurring respectively for high λ_0 values, can be referred to the form of Eq. (10), where the design event dependence on λ_0 is formalized. From this equation, in fact, it can be inferred that the design event is greater when the number of events λ_0 is higher. Considering higher design event values corresponds to evaluating the differences between the base and the seasonal distribution more on the right tail, where the differences are more pronounced and cause the high R_T values. In the revised paper we will add a comment on this effect. The opposite behaviour is observed in Fig. 4 (of the manuscript) for the AM case, where the maximum R_T is found to occur in correspondence of very high values of a_α and low values of λ_0. In this case several mechanisms concur to the maximum formation, making the result less intuitive. However, since the return period ratios in this case are modest, we believe this point to be of minor importance with respect to the general paper message.

- 4799-1: see reply to comment (1)

- 4799-6: *what is the effect of the threshold chosen for the analysis? Would POT with higher threshold work better, approaching the AM performance?* Indeed POT obtained with higher thresholds would behave more similarly to the AM case. However, pushing up the threshold would not remove the cause (but just the symptom) of the "bad performance" of the POT which, in this case, resides in the fact that the events are not identically distributed.

- 4799-21: *delta is almost always 0 in the region, meaning that the maximum rainfall depths happen when the storms are less frequent?* In the region of study the two regimes are in phase, i.e. the maximum rainfall depths occur when the storms are more frequent. We will clarify this in the revised manuscript.

- 4801-12: *how would the R_T ratios look like if the quantiles were used instead of the return periods? Would the difference between POT and AM be so radical?* In Fig. 1 (of this comment) is shown, for the POT case, the behaviour of the quantile ratio, i.e. the ratio between the quantiles with the base and seasonal distribution for a given return period. The quantile ratio variability is graphed in the domain of λ_0 (x-axis) and

a_α (y-axis). The same assumptions that were made to draw Fig.2 (of the manuscript) still hold, i.e. T=100 yr, $\delta = \pi$, n=1 and $a_\alpha = 0.5$. The ratio is found to vary between 0.7 and 1, which corresponds to a systematic underestimation of the design event when seasonality is ignored. The differences from the AM case are therefore smaller if the quantile ratios are considered instead of the return period ratios. However the differences are still relevant and need to be considered.

- 4800-20: *another reason for the differences observed between POT and AM could be that, if the annual maxima happen almost always in the same season„ the AM method works well no matter if seasonality is strong or not. POT, instead, is affected by the fact that the "identically distributed" hypothesis is not satisfied.* This is exactly the question that, in our opinion, is worth to be discussed (see also the reply to comment 2). Is the AM method working well or the method is just blind towards non-identically distributed sample values? And, conversely, is the sensitivity of the POT approach to seasonality a disadvantage or rather an advantage of the method?

- 4801-23: *the underestimation of $\lambda_0^{(AM)}$ and overestimation of $\alpha_0^{(AM)}$ is because the AM analysis assumes the extremes to be identically distributed through the year?* The underestimation of $\lambda_0^{(AM)}$ is the consequence of the overestimation of $\alpha_0^{(AM)}$. This entails, as stated in the paper at lines 4802-2 to 5, that the model tends to keep the total amount of "over-threshold precipitation" constant, by compensating the decrease in the rates with an increase in the amounts.

- Fig. 1: we will introduce both notations for the sake of clarity

- Fig. 3: it will be amended

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 4789, 2011.

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Interactive Comment

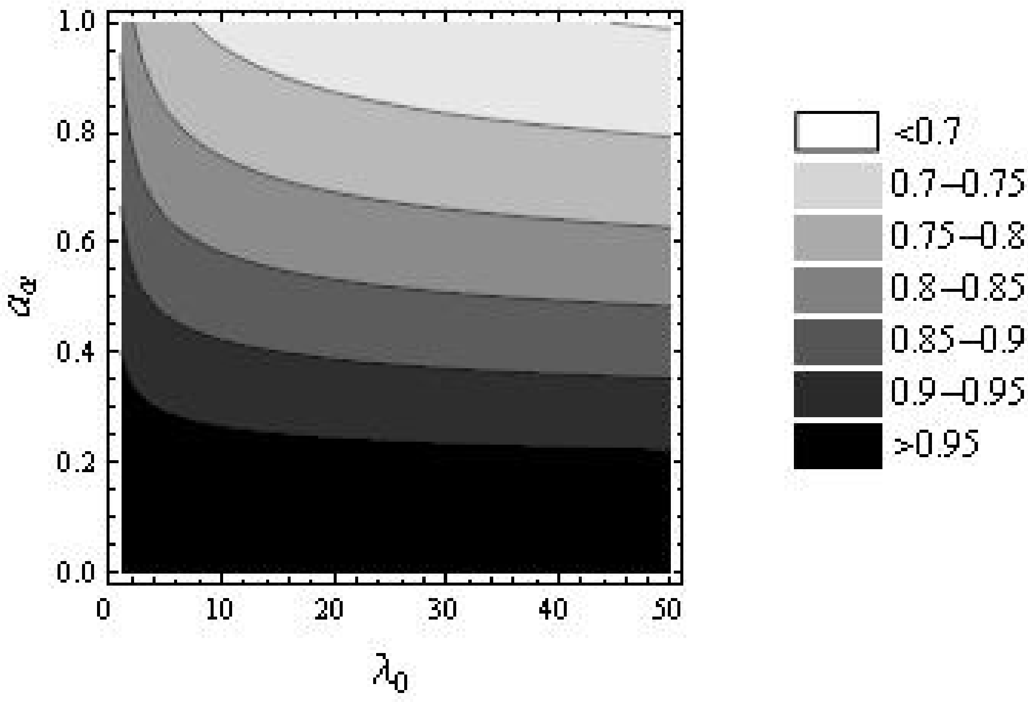

Fig. 1. Sensitivity of the quantile ratio, i.e. ratio between the quantiles with the base and seasonal distribution for a given return period, to variations of lambda_0 (x-axis) and a_{alpha} (y-axis)