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Interactive comment

Interactive comment on "The application of new distribution in determining extreme hydrologic events such as floods" *by* Łukasz Gruss et al.

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Dear Referee,

Thank you for your comment. We do appreciate your constructive suggestions.

Reply to general comments:

Referee: In my opinion the title should be reconsidered because the pioneer work is that of Nascimento et al. 2016 and was tested using hydrological data. So this distribution is not new as indicated in the title. Reply: Nascimento et al. (2016) investigated new distributions on the data which were monthly maxima of water levels for the Gurgueia River and the maximum precipitation in 1931-2008 for the Barcelos Station in the north of Portugal. The latter are meteorological data. Nascimento et al. (2016) did not

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investigate the new distributions using data such as the maximum annual flows or daily flows. It should be noted that in flood frequency analysis flows are the most often used data. Flows were used by various researchers quoted in our article, including Abida and Ellouze (2008), Alila and Mtiraoui (2002), Bačová-Mitková and Onderka (2010), Beskow et al. (2015), Bezak et al. (2014), Cassalho et al. (2018), Escalante-Sandoval (2007), Gharib et al. (2017), Gruss et al. (2019), Gvoždíková and Müller (2017), Haktanir (1991), Holicky and Sykora (2010), Hosking et al. (1985), Kidson and Richards (2005), Kundzewicz et al. (1999), Kundzewicz et al. (2005), Lang et al. (1999), Langbein (1949), Madsen et al. (1997), Mamman et al. (2017), Rahman et al. (2015), Stojković et al. (2017), Szulczewski and Jakubowski (2018), Yadav (1998). This kind of research was carried out by Nascimento et al. (2016) for other parameters only partially. Therefore, we cannot agree with Referee's suggestion that the title should be changed. We are the first to test the new distribution using hydrological data which are flows. Therefore, we propose to maintain the current title of our article: "The application of new distribution in determining extreme hydrologic events such as floods".

Referee: The introduction is too large and does not focus on the problem: application of the 4 parameter distribution using two sampling methods. The new in this paper is the use of mixed (extended) distributions. Unfortunately, the goal or the idea behind mixing is not outlined. For example, it is the case when the origin of maximum floods can be different from year (event) to year (event). So the physical meaning behind mixing is not noticed in the beginning of the paper (as in line 85). However this is the spirit of the work of Szulczewski and Jakubowski, 2018). Extended distributions would be a key word, because it was presented in this manner in the principal reference used (Nascimento et al. 2016). A section on model comparison is missed. Because authors compare 3 parameter distributions to 4 parameter, specific criteria should be adopted such as BIC and AIC. Reply: In our opinion, our introduction does not differ substantially from standard introductions in other articles of this kind. It contains key elements that introduce our research, such as: - The importance of using maximum observed flows to calculate the exceedance probability. The introduction also justifies the selection of water gauge stations for hydrological analysis. - Presentation of the applied Flood Frequency Analysis (FFA) methods such as the Annual Maximum (AM) and the Peaks Over Threshold (POT) and the distributions studied in the world, along with the methods of estimating distribution parameters. - Moreover, the problem of genetic heterogeneity as well as statistical heterogeneity that each researcher encounters when using long observation series to analyze the distributions was discussed. - The introduction justifies the selection of 3-parameter distributions for our research. - The results of the research on mixed distributions were presented, as well as the research on new distributions carried out by Nascimento et al. (2016). We cannot agree with the Referee that the novelty of the article is the study of mixed distributions (as claimed by the Referee). For us, the comparison the new GGEV distribution and the 3-parameter distributions is new. Similarly, the aim of our study, stated by us in the article, is different from that mentioned by the Referee. Please note that the new GGEV distribution has 4 parameters. The first three of them appear in the GEV distribution: location, scale and shape, while the fourth parameter is an additional shape parameter. As a result, these 4 parameters shape the values determined by the GGEV distribution. On the other hand, the mixed distribution consisting of two distributions, e.g. the mixture of gamma and GEV presented by Szulczewski and Jakubowski (2018), include all the parameters from these two mixture components. In this case, 6 parameters. In our opinion, the GGEV distribution studied by us is preferred than a mixed distribution consisting of two or more distributions, because the estimation of its parameters is easier. According to Otiniano et al. (2019), extensions such as the dual gamma GEV distribution (GGEV), the exponentiated GEV distribution (EGEV), the transmuted GEV (TGEV) distribution and the q-GEV could constitute a new distribution class. In what regards the Referee's comment on adding a chapter on the comparison of models using the AIC and BIC criteria, we have to say that this would mean a significant expansion of this already extensive article. But at the same time we would like to point out that our goal was to find out which distributions, in which method (AM or POT) and with which method of estimation are best fitted to empirical data. It was not our goal to compare the distributions with each other. We used the following tests: the Chi-squared ($\chi 2$), the Kolmogorov-Smirnov (K-S) and the Mean Absolute Relative Error (MARE). Our choice was not accidental because we discussed our results with other authors, including Beskow et al. (2015), Cassalho et al. (2018), Escalante-Sandoval (2007), Haktanir (1991), Mamman et al. (2017), Szulczewski and Jakubowski (2018), Zhang (2007). Our methods were the same or similar to those used by these authors. In our opinion, the comparison of models using the AIC and BIC tests could be presented in a separate, follow-up article.

Our answers to specific remarks:

Referee: Abstract line 13 : it is not clear that authors discussed the parameter accuracy, later in this paper. Reply: We thank the Referee for pointing this out. We mentioned this issue in the abstract, but we should also indicate it in the introduction at the end of line 144. We hinted that in order to use a mixed distribution, many parameters should be estimated. For example, six parameters can be difficult to estimate. We mentioned that this was a disadvantage of mixed distributions, in which the mixture components are two or more distributions. Szulczewski and Jakubowski (2018) discuss the difficulties in estimating the parameters of such mixed distributions as follows: "In the case of the MIX distribution, it is much more difficult to work with the doubled number of parameters in trying to fit the mixture distribution." Also, Vaidyanathan and Lakshmi (2016) report it as follows: "However, computing time taken by the proposed method to obtain estimates is more owing to the fact that it searches the parameter space separately for each component."

Referee: Line 82 Pearson type III is 3 parameters. Its special case with 2 parameters is Gamma. Should be reformulated Reply: We would like to thank the Author of the comment for pointing this out. There is an error in line 83: instead of Pearson type III (2P3) we actually meant log-Pearson type III (LP3). In fact, we only quoted HolickÃ¡ and SÃ¡kora (2010) to have studied these distributions. Their conclusions show that distributions such as log-Pearson III Type and Log-Normal are appropriate for the observation series used.

Referee: Line 129 the term genetic is not clear here. Why this word? Authors may speak of flood generating processes. Reply: We thank the Referee for drawing our attention to the formulation of the problem of genetic heterogeneity. In this paragraph, we wanted to emphasize the problem of the emergence of genetic heterogeneity as well as statistical heterogeneity encountered by the researcher when using long observational series to analyze the distributions.

Referee: Line145 The 3 new distributions (The Dual Gamma Generalized Extreme Value Distribu-tion (GGEV), the Exponentiated Generalized Extreme Value Distribution (EGEV)) were presented in a certain context (See Nascimento et al. 2016 "In recent years, several common distributions have been generalized via exponentiation. Let G(x) be the cdf of any continuous baseline distribution..." and Eq. 4. This context should be recalled here. Otherwise the reader who does not know the work of Nascimento et al. and other similar works about extended distributions will not understand to general motivation of these "new" distributions Reply: We indicated that Nascimento et al. (2016) investigated 3 new distributions. However, they showed that the GGEV distribution gave the best results. Therefore, we decided to test it. In the methodology, we showed the formula for the probability density function.

Referee: Lines 153 to 161 should be reformulated in order to define the objectives and the next sections of the paper Reply: We propose to keep these lines as they are. In our opinion, goals have been defined and hypotheses have been set.

Referee: Line 160 why this hypothesis of the"best"? Authors may just say that they study the adequacy of GGEV Reply: When comparing the distributions with each other, authors such as Beskow et al. (2015), Cassalho et al. (2018), Haktanir (1991), Mamman et al. (2017), Szulczewski and Jakubowski (2018) used various tests of best fit. As the tests of the best fit, we also used the Chi-squared ($\chi 2$), the Kolmogorov-Smirnov (K-S) and the Mean Absolute Relative Error (MARE). This allowed us to verify our hypothesis that the GGEV distribution is the best-fitted distribution for the samples in the Upper Odra basin.

Referee: Line 169 what do authors mean by profil? water level? Reply: It is not water level. We mean the cross section of the river where the gauge station is located. The Referee is right. We should simplify it to: "The analyzed water gauge is located at km 18.43 of its course".

Referee: Line 172 is below meaning downstream? Reply: That's exactly what we meant. Thank you for pointing this out. We will rephrase it to: "One of the gauge stations (Turawa profile) is downstream of this reservoir".

Referee: Line 173upstream is more adequate than below Reply: We agree with the Referee. We will rephrase it to: "Another water gauge (Staniszcze Wielkie profile) is located upstream of the reservoir, and the distance from it to the reservoir is about 13.9 km".

Referee: Line 200 homogeneity tests Reply: Thank you for pointing this out. We agree with Referee.

Referee: Line 225 GEV and Pareto are linked if one considers the POT model. This should be noticed somewhere because authors selected GEV (exponentiated GEVs) while using POT. In general with POT we use Pareto. Reply: Thank you very much for this suggestion. We will consider this possibility in the introduction.

Referee: Line 255 why kurtosis while 3 parameters to fit? In general the smallest orders are used for distribution moments Reply: We agree with Referee. We should remove kurtosis in this sentence.

Referee: Line 259 Gamma is not listed line 246. This sentence should be removed line Reply: Line 259 should read 3P3 instead of gamma.

Referee: Line: 271 confidence level for what? Do authors study the parameters confidence intervals? Reply: This is the confidence level of the interval. We should add it.

Referee: Line 300 “One of the goals of this article was to propose a new GGEV distribution model in the AM and POT method” this is not fully documented. Reply: In our opinion, this is documented. We showed the results of the AM and POT methods as well as the distributions that were used in both methods.

Referee: Line 303 what is the reference of MARE test of adequacy? Reply: The MARE has been approximated in the methodology in lines 309-311. We refer to the methodology presented by Szulczewski and Jakubowski (2018).

Referee: Line 309 it is not clear how MARE is an index. Is it MAREor an index based on MARE? Reply: Using the MARE, we referred to the methods proposed by Szulczewski and Jakubowski (2018). We did this test in order to compare our results with theirs as they refer to the samples from the same basin. Szulczewski and Jakubowski (2008) mention that MARE is an index: "the MARE measure of fit, an index which is very close to the engineering intuition."

Referee: Line 314 A section on model comparison is missed. Because authors compare 3 parameter distributions to 4 parameter, specific criteria should be adopted such as BIC and AIC . Reply: We presented our standpoint on these issues in Reply to comment 2 of the general comments.

Referee: Line 318 are they significantly different from zero? If not, it is not a trend Reply: In our opinion, this was presented in the results.

Referee: Line 330 in POME application, to what extend are finding related to the level of the selected threshold? This could be more discussed. Reply: The SNHT test was performed in line with the methods proposed by Bezak (2014) and Rutkowska (2015). The discussion will be expanded.

Referee: Line 383 to compare fitting results of distributions involving a different number of parameters Ibelieve that AIC or BIC criteria are more appropriate. while this is

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currently found in theliterature, I do not believe on can rank distributions based on K-S results. K-S result isjust accepting or rejecting. The value by itself has not a real meaning. One can rankdistributions based of the performance of quantile estimation or parameter estimation(variance of standard error). Reply: The K-S test is recommended by Haktanir (1991), Mamman et al. (2017) and Zhang (2007). Additionally, the K-S test was also used by Beskow et al. (2015). We have been using it for several years among other tests in distribution studies. In addition, it is a test recommended by the Association of Polish Hydrologists. Moreover, Yilmaz and Çelik (2011) reported that: "An attractive feature of this test is that the distribution of the K-S test statistic itself does not depend on the underlying cumulative distribution function being tested. Another advantage is that it is an exact test (the chi-square goodness-of-fit test depends on an adequate sample size for the approximations to be valid)". Our standpoint on the issue of presenting a comparison between models using the AIC and BIC criteria is given in the reply to comment 2 of the general comments.

Referee: Line 410 empirical density (Kernel) should be reportedin Reply: Figures 5-7 show the theoretical distribution curves and, for comparison, the empirical distribution curves (Quantile function). In our opinion, this is sufficient. Below these curves, we have shown the probability density functions for different shape parameter values.

Referee: Figure 6 and figure 7 line 414 what is the reference to say that GEV distribution has a heavy tail? It is the case of Pareto, not for GEV as I know. May authors check according to El Adlouni et al. 2008 works (On the Tails of Extreme Event Distributionsin Hydrology. June 2008 Journal of Hydrology 355(1):16-33)? Reply: We must agree with the Referee. The wording was wrong. In this paper, we compared the tails of the two distributions shown in Figures 5-7. The description applies to figures 5-7. We wanted to show that the tail of the GGEV distribution is heavier than that of the LN3.

Referee: Line 430 "This indicates that the K-S test is stronger than theχ2 430 test." this is not clear. Why is it stronger? Is thre a physical reason for rejection? Reply: Maybe the wording used was wrong. Both the literature and our results show that the K-S test is more powerful than $\chi 2$. This is also the conclusion that emerges from our results.

Referee: Line 436 point 5 . this is known from the beginning.It cannot be a conclusion Reply: We agree with the Referee. we will delete this conclusion.

Referee: Table 1 "Water gauge location Â ÌĞz. what does it mean?geographic coordinates should be given source of Table 1 of what? Reply: Figures 1 and 2 complement the table. The table and the figures have a source. If it is necessary to enter the coordinates of water gauge stations, we will provide them. The parameters in Table 1 are used in hydrology. The water gauge location is given as the kilometer of the river course.

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