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Interactive comment on "On the asymptotic behavior of flood peak distributions – theoretical results" *by* E. Gaume

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1. This paper presents analytical results and numerical illustrations on the asymptotic properties of flood peak distributions obtained through the so-called derived flood frequency distribution approach. The analytical results are based on radically simplifying modelling hypotheses, i.e. that rainfall events are rectangular pulses with a given duration and a constant intensity having a specified probability distribution, and that the transformation of rainfall into runoff can be described by a randomly varying runoff coefficient. In the main part of the paper the distribution of rainfall intensity is assumed to be exponential, whereas in an appendix similar results are obtained assuming extreme value distribution of type II. The numerical illustrations are based on less radical assumptions and include temporal variation of rainfall and a rainfall-runoff model based on the Soil Conservation Service rainfall-runoff transformation. The paper concludes that (a) the asymptotic distribution of flood peak is of the same type as that of rainfall

intensity and (b) the distribution of the mean maximum rainfall intensity over a duration of the order of the concentration time of a watershed should be used as a guideline for any extrapolation of a flood peak distribution.

2. A large part of the paper is devoted to mathematical derivations in order to demonstrate that an exponential distribution of rainfall intensity will result in an exponential type distribution of flood peak. Undoubtedly, this is a useful result but I do not think that the derivations provided form a mathematical proof, even though they are thorough and careful. In my opinion, a simple yet more general proof can be given based on equation (1) (i.e., Y = C X where X is the rainfall intensity, Y is the flood peak and C the runoff coefficient). Assuming that X is distributed according to any distribution of exponential type (not necessarily the exponential distribution assumed in the paper) all its moments (i.e. for any order) will exist. Now, if C is bounded from above (i.e. by 1 as in section 2, which can be generalized for a time varying hyetograph), it will not be difficult to show that the moments of Y will be finite numbers, which means that the distribution of Y cannot be of hyper-exponential (power) type, or in other words, it will be of exponential type as well. A similar procedure can perhaps be followed to show that a hyper-exponential (power or type II) distribution of rainfall, whose moments beyond a certain rank r (depending on the shape parameter) become infinite, will result in a hyper-exponential distribution of flood peak. Again the multiplication of the quantity C bounded from both above and below cannot make finite the infinite moments of X for orders beyond r (except perhaps in the case that C is negatively correlated with X, which however does not have any physical meaning). Of course this comment is not a mathematical proof per se and is done in a constructive way for the case that the author wishes to explore it in more detail.

3. In the case that the theoretical part can be made more concrete, as indicated in the point 2 above, the numerical demonstrations could be focused not on the asymptotic behaviour of the flood peak distribution in its tails (as this will be obtained in a theoretical manner) but on medium range quantiles of the distribution.

4. The paper does not discuss the important issue of what the type of distribution of flood peak really is. It simply contains general statements such as "The debate on the estimation of extreme values in hydrology is still lively (Koutsoyiannis, 2004[a]; Klemes, 2000)" (p. 1847; this, however, may be misleading as I do not think that there is a debate between Koutsoyiannis and Klemes on this issue). Moreover, the emphasis is given to the exponential distribution both in the theoretical part of the paper as well as in the reference to the "Gradex" statistical extrapolation method (which I would not call a "theory" as does the author). According to the latter method, "the distribution of the daily rainfall amount is exponential" (p. 1846). Therefore, the author, although avoiding a clear position, indirectly points to the use of exponential type distributions for rainfall and consequently for flood peak. However, in the last years evidence has been accumulated that the distribution tails of rainfall are of hyper-exponential (rather than exponential) type (Chaouche, 2001; Chaouche et al., 2002; Coles et al., 2003; Sisson et al., 2003; Koutsoyiannis, 2004a, 2004b, 2005). Even earlier (e.g. Farquharson et al., 1992; Turcotte, 1994; also presented by Turcotte & Malamud, 2003), it was shown that floods seem to have heavier distribution tails than an exponential type distribution. The first conclusion of Gaume's paper might link the two lines of recent research findings concerning rainfall and flood. The importance of the distribution type could be indirectly inferred by the author's statement that the return period of an observed flood event is "some hundred million years if the EV I distribution is used" (p. 1848); this clearly suggests a severe underestimation of the rainfall amount or a severe overestimation of the return period. Thus, I think that the paper would benefit if this very important issue would be discussed in more detail based on the real world example studied (Clamoux river). The probability plots in the paper for this case seem to suggest a rather hyper-exponential distribution type.

5. Another interesting issue rises in the author's statement that "the only way to reduce the large uncertainties on estimated flood quantiles is to enlarge the studied series of data using the available information on historical floods as illustrated here and/or combining various data sets in a regional approach." This is indeed an important point,

also raised by National Research Council (1988; the author might wish to include the reference). I have a few remarks regarding this statement. Firstly, what is described cannot be "the only way" because two ways are already mentioned, the second being what has been called "substitution of space for time". Secondly, there is a third way, i.e. theoretical reasoning to infer the type of the distribution, as in Koutsoyiannis (2004a, 2005); Gaume's paper is another example emphasizing how useful theoretical reasoning may be in this respect. Thirdly, the illustration incorporating the analysis of information from historical floods is somewhat poor; certainly it can be improved by doing a more detailed analysis and comparison of distribution shapes and of uncertainty before and after the use of historical floods.

6. A minor comment: I think that an analytical solution can be found for the special case examined in p. 1840 and beyond (this can be in terms of the incomplete gamma function or the second exponential integral function). Also, I think that C cannot be independent from Y as written in the top of p. 1842.

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