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Hydrology and Earth System Sciences Discussions

Interactive comment on "Multivariate design via Copulas" *by* G. Salvadori et al.

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The Authors thank Prof. Gräler for his comments.

1. Prof. Gräler writes (p. C3148): "In contrast to the univariate case, the area/volume uniting these 99.9% of all possible events can unfortunately be shaped in many ways."

   Yes, this is the critical point. Our approach is quite general, since we suggest to calculate the return period according to the probability measure of the critical region, irrespectively of its shape, as stated in Eq.s (5)-(7) and Definition 1.

2. Prof. Gräler writes (p. C3148): "However, the probability to exceed one or more of the margins is given by $1 - C_{QVL}(u_1, u_2, u_3) = 1 - t^* \approx 0.053481$, no matter

   which specific design event is used in the given example. Hence, a simulation of 1000 yearly maximum floods will yield about 53 floods that exceed one or two of the three margins. Depending on the sensitivity of the designed dam to either higher flood peaks, higher volumes or higher initial water levels, this approach may or may not give the right design event."

   The issue has already been discussed, e.g., in Salvadori (JSM, 2004) and Salvadori & De Michele (WRR, 2004), and also later papers. Here two cases were considered:

   - the OR case (at least one marginal exceeds a critical quantile);
   - the AND case (all the marginals exceed a critical quantile).

   Clearly, the critical regions change as a function of the design event chosen on the critical layer, whereas the approach outlined in the present HESS paper yields a unique critical region. As also suggested in other comments, which of the approaches should be chosen may depend upon the application, and we agree on this point.

3. Prof. Gräler writes (p. C3149): "However, it is highly questionable that a single point is able to sufficiently represent the properties of all critical points. Given the above commentary, I recommend to use a design ensemble along the critical layer induced by the Kendall distribution (as also suggested by Vandenberghe in an earlier comment). Such an ensemble will improve the representation of the critical layer."

   This interesting point has been discussed both during the S.T.A.H.Y. Short Course "Copula Function: Theory and Practice" held last July and the "Water Session" at the 58th World Statistics Congress of the International Statistical Institute held last August. The issue is not a simple one, and in the revised version of the paper we shall discuss it in details, as well as the related remarks/suggestions received.

4. Prof. Gräler writes (p. C3149): “The above discussion illustrates the importance of the right choice of a total ordering. In applied sciences, this order should be related to the applied meaning of a larger (more extreme) event in nature.”

   As mentioned above, our approach is quite general, since we can also consider as “extreme” the smaller event (and not just the larger one, as it is useful, e.g., in the case of droughts).

5. Prof. Gräler writes (p. C3149): “The authors present a sound and valuable alternative to define a rather natural total order in a multidimensional euclidean space. However, the selection of the right ordering in every application and i.e. the choice of a particular design event or a design ensemble will remain an active topic of research. An open and wider discussion of this issue in the last part of the presented paper would have been desirable.”

   We definitely agree with this comment, and the issue will be stressed and discussed in the revised version of the paper.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 5523, 2011.