Hydrol. Earth Syst. Sci. Discuss., 9, C1603–C1605, 2012
www.hydrol-earth-syst-sci-discuss.net/9/C1603/2012/

Hydrology and Earth System Sciences Discussions

Interactive comment on "How extreme is extreme? An assessment of daily rainfall distribution tails" *by* S. M. Papalexiou et al.

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Received and published: 21 May 2012

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The paper tackles a relevant problem in statistical hydrology and design engineering, pertaining to the definition of the shape of the upper tail of the probability distribution of extreme rainfall events. The paper is well written and the obtained results derive from the analysis of an impressive quantity of data (more than 15000 records are analyzed), which strongly enhances the quality of the manuscript. I therefore recommend publication of the manuscript in HESS, pending some revisions aimed at better supporting the conclusions of the paper.

The main conclusion of the paper is that "The analysis shows that heavier-tailed distributions are in better agreement with the observed rainfall extremes than the more often used lighter tailed distributions" (page 5758, line 15). In my opinion this conclusion demands further supporting evidence, for two main reasons:

1) The Authors compare four probabilistic models, two with an heavy right tail (pareto and weibull) and two with exponentially decaying tails (lognormal and gamma). For each model, parameters are estimated based on the available sample, and a modified mean squared error (page 5763, eq. 3) is calculated to measure the distance between the hypothetical and empirical distribution function. The considered variable in the adopted error function (eq. 3) is the exceedance probability, which might be sensible in a verification problem (e.g., determining the return period of a thunderstorm), but has some limitations in a design framework. In case of a design rainfall application, probably the best variable to be consider to judge the quality of a probabilistic model is rainfall itself; in fact, in design applications one fixes the probability level, and finds the design rainfall: as a consequence, discrepancies between data and models should be evaluated on the rainfall axis. I therefore believe the Authors should also consider in their analyses another (more standard) form of the error function, based on the squared differences between the empirical rainfall values, x_i, and the corresponding design values $x*_i$ (one for each distribution), where $x*_i$ is found as the quantile corresponding to the probability level given by equation (2). The conclusions drawn about the better performances of the heavy-tailed distributions may be completely changed (or strongly supported) by using this other error function.

2) The Authors use in their comparison four models, each one with two parameters: using models with the same number of parameters is essential when comparing the performances of different models, because more parameterized models would be improperly favored by their higher adaptability in a comparison with more parsimonious models. A similar effect applies also when models have the same number of parameters, but different structure: one model can be improperly favored toward the others,

except in very special cases (e.g., when all models belong to the position-scale family, or when the likelihood function is used to compare the model as in the Akaike Information Criterion or with the chi-squared test). Evidence for this effect is found, for example, in the fact that the acceptance limits for goodness-of-fit tests may be rather different in applications to testing different two-parameter distributions (with unknown parameters). A lower acceptance limit implies that the distribution of the test statistic (or, analogously, of the MSE norm as used in this paper) is shifted toward lower values under the null hypothesis (i.e., when the parent and hypothetical distribution are the same); this in turn implies that a distribution may tend to be favored toward another in a direct comparison, because, for example, the distribution has a greater adaptability due to the specific analytical form of the relation between the random variable and probability. One may be tempted to conclude that this more adaptable distribution is better than the others, but unfortunately a greater adaptability (lower estimation bias) frequently entails more difficulty in parameter estimation (larger estimation variance). To summarize: the finding that heavy-tailed distributions have better performances may be an artifact related to the fact that heavy-tailed distributions have a power-law parameter, while exponentially decaying distributions have not. The presence of the power-law parameter may provide greater flexibility to the models, but on the other hand it may entail an increase in the estimation variance, which is also very important to be considered in design applications. To better support a claim about the superiority of the heavy-tailed distributions for use in engineering practice (last paragraph of the manuscript), this bias-variance tradeoff should be further explored in my opinion.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 5757, 2012.