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Detailed Responses to Reviewer 2's Comments

Anne Martin, Élyse Fournier and Jonathan Jalbert

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First, we would like to thank the three reviewers for their thorough review and relevant comments and suggestions. Based on their feedback and recommendations, we notably adjusted the structure of the paper and added numerous clarifications. The modifications in the revised version of the manuscript are highlighted in blue. Below are detailed responses to all of Reviewer 2's comments.

The paper under consideration presents a statistical approach using the Pearson Type I distribution to estimate the upper bound of historical rainfall, incorporating uncertainty bounds. The authors aim to quantify uncertainty and address subjectivity inherent in the various stages of the World Meteorological Organization (WMO)-recommended Probable Maximum Precipitation (PMP) estimation methods. However, the WMO-recommended moisture maximization method focuses on maximizing highly efficient storms based on the physical mechanisms of those storms. From a statistical perspective, precipitation's tendency to exhibit a heavy-tailed distribution poses challenges in defining an upper bound, and this study similarly encounters this issue.

Major concerns

1. Previous studies demonstrated that precipitation naturally often exhibits a heavy-tailed distribution (shape parameter greater than 0) that brings rare storms over global scale, the proposed method struggled to estimate upper bound of those places by majority of parameter estimation methods. In this study, the method of moments partially quantifies the range with limited data, but the range is unrealistically large, for example, the range estimated for St-Hubert station varies between 165 to 9006.

   It is also the case here that precipitation is heavy-tailed and unbounded, as shown through the classical extreme value analysis in Section 6.3. In this paper, we proposed a statistical model for the PMP with a finite upper bound based on the moisture maximization logic. However, since this model does not fit the data well and is highly sensitive to it, as shown by the non-parametric bootstrap confidence intervals, it suggests that the PMP definition based on the moisture maximization logic may not be appropriate. We therefore recommend using extreme value theory instead.

2. A simulation study is conducted with distribution assumed convex density and found more than 40,000 sample size (in arid/semi-arid region that equivalent to more than 1000 years wet days) is required to stabilize the estimate. Given this, it is surprising that the authors did not attempt to expand the sample size for the two stations by incorporating numerical model ensemble precipitation products. Doing so could have supported their findings.

   This is a good suggestion to augment the actual precipitation data with simulated precipitation from a climate model or a weather generator. It is indeed something we could consider if we were to use this proposed model to estimate the PMP, although this is not our final recommendation in this paper. However, such data augmentation should be carefully implemented to avoid overconfidence. For instance, if 40,000 daily precipitation data points generated from a weather generator are used to estimate the model, do these 40,000 data points contain 400 times more information than a recorded series of size 100? At this point, this is beyond the scope of the present paper, but it could be an interesting avenue for future investigation. Elements of this discussion has been added in the Discussion of the revised version.

3. This study compares their estimated upper limit with moisture maximization based PMP value. The PMP values using moisture maximization were found to be 282 mm for Montréal and 436 mm for St-Hubert, whereas the observed 24-hour maximum precipitation for these stations was 81.9 mm and 106.5 mm, respectively. Thus, the maximization ratio will be 3.44 and 4.09. The reason behind the exceptionally high maximization ratio may be due to the selection of storms and/or estimation of storm associated precipitable water. This study includes low magnitude storms (0.9 quantile might give more than 500 samples but previous studies mostly consider the highest 50 or less storms) and did not separate those storms that could lead to higher maximization ratio. Previous studies mostly limit the maximization ratio 2.0 (that only for orographic storms). Imposing a similar limit could provide some physically possible value around 200mm that aligns with 10,000-year return level (POT based) and PMP value would not much different within 26 km distance. Since the moisture maximization method provides an unrealistically high PMP value, comparing with this value to validate the method is questionable. It is recommended to use multiple study sites and consider those sites where maximization ratio lies below 2.0 and compare within those sites.

   PMP estimates using the moisture maximization method in Section 2.2 are based on the top 10% of storms, as suggested by Clavet-Gaumont *et al.* (2017). The reference has been added in the revised version. A sensitivity analysis was performed, and regardless of the quantile used for storm selection (10%, 1%, or 0.1%), the PMP result remained unchanged. This is because the event of September 20, 1989, with 63.8 mm at the Montreal station, is maximized regardless of the storm threshold. The same applies to the St-Hubert station, where the precipitation of 73.4 mm on July 5, 1958, is maximized. The maximization ratios are 4.4 and 4.9, respectively. Since precipitable water was not directly observed, it was estimated using the dew point, which may indeed affect the quality of the PMP estimates.

The approach you suggested to improve PMP estimates using the usual moisture maximization method would be appropriate if that were the goal of the paper. However, we applied the simple moisture maximization method with the usual formulas at these stations primarily to highlight, to some extent, the flaws of the methodology and the need for great care in obtaining sensible PMP estimates. While the approach you recommend, choosing sites where the maximization ratio is below 2.0, may work for those specific sites, it would not be directly replicable to other locations. Therefore, although the elements you propose to improve the PMP estimates have been added to the manuscript, we believe this is beyond the scope of the present paper, as our focus is on the developed model for statistical PMP estimation.

4. National Academies of Sciences, Engineering, and Medicine (2024) recommends for risk-informed extreme value analysis methods that account for low exceedance probabilities and provide robust uncertainty and nonstationary quantification. It remains unclear how the proposed method offers advantages over or resolves issues better than these recommended approaches.

   In this paper, we provide additional support for using extreme value theory, as recommended by the National Academies of Sciences, Engineering, and Medicine (2024). The newly proposed statistical approach for PMP estimation does not perform well, as it requires an extensive amount of data and is highly sensitive to the data. In the revised version of the manuscript, we emphasized more clearly that we align with the conclusions of the National Academies of Sciences, Engineering, and Medicine.

5. The choice of Pearson Type I distribution over other distributions is missing.

   We have added more details in Section 3.1 explaining why the Pearson Type I distribution is the natural choice for the moisture maximization logic.

Minor comment:

- Line 304: The placeholder “Figure??” needs Figure number.

  Thank you for pointing that out. It is now corrected.

- Additionally, there is inconsistent notation in Equation 4 compared to Equation 1.

  Yes indeed, thank you.

- The term ”EP” and “EPmax” should be clearly defined to maintain consistency and avoid confusion.

  This is a translation mistake from our part. Thank you for pointing that out. It is now corrected.