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Interactive comment on "Identifying robust bias adjustment methods for extreme precipitation in a pseudo-reality setting" *by* Torben Schmith et al.

Timo Kelder

t.kelder@lboro.ac.uk

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Comment on 'Identifying robust bias adjustment methods for extreme precipitation in a pseudo-reality setting' T. Kelder, R. L. Wilby, T. Marjoribanks, L. Slater

Torben Schmith and co-authors address a complex, but important topic. Climate model corrections typically assume stationary biases between simulated and observed extreme precipitation but, in practice, such biases may well be nonstationary (i.e. distributions may shift significantly in the future). Robust evaluation of bias correction methods is hampered by the inability to analyse future model biases, since there are obviously no observations of the future. To address this issue, the authors use model simulations as a pseudo-reality of the present and future climate to evaluate the ro-

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bustness of various bias correction methods within these 'virtual' worlds.

The authors processed a large amount of data from the EURO-CORDEX ensemble and we commend them for this interesting research and their purposeful discussion of findings. The paper concludes by recommending a preferred bias correction method for climate projection. We offer a few suggestions and raise some issues for further elaboration by the authors.

1. Given that the analysis is based on an ensemble of climate model experiments, the logic should be explained for treating model-to-model biases in extreme precipitation as equivalent to model-to-observation biases. The paper acknowledges the limited ability of $\sim$10km resolution model simulations at representing convective processes. Hence, more explanation is needed for an unfamiliar reader on why model experiments can be used to draw conclusions about the best bias correction methods on hourly timescales, if one cannot trust the model simulations to realistically represent convective processes.

2. Related to #1, a few cautionary remarks could be made about some of the GCMs used to drive the CORDEX experiments (see: Liepert and Lo, 2013). The realism of the downscaled extreme precipitation depends on the realism of the boundary forcing. Use of an 'ensemble of opportunity' is not unusual, but some studies narrow the choice of candidate models (and hence uncertainty) based on physical realism tests (e.g. McSweeney et al., 2015; Rowell, 2019).

3. In the inter-model cross-validation setup, every model/pseudo-reality combination is used. This setup can be useful for assessing relationships between present and future bias correction factors (e.g. Fig. 9), but does not mimic climate projections, where the ensemble mean, and range are typically used. In the present setup, a future projection is treated as a deterministic prediction, rather than a probabilistic projection. Perhaps use of the climate 'pseudo-observed' run might be favoured over future predictions simply because there is less variability in the present climate? How sensitive are the

results to taking the mean of all ensemble members minus the 'pseudo-reality' member (e.g. Fig. 3 in Räty et al. 2014)? This has the added benefit of involving much fewer permutations (and hence calculations).

4. The range of the projection matters. For example, Fig. 4 shows that there are future scenarios that exceed the present climate range. Hence, the worst-case 10-year precipitation event from the 'pseudo-obs' range would not include plausible future 10-year events. Therefore, more qualification is needed in the Abstract and Conclusions to guard against this possibility and the potentially misleading assertion that "the superior approach is to simply deduce future return levels from observations". Overall, the headline findings of the research could be presented in more nuanced ways, especially within the Abstract.

5. The Abstract and Introduction assert that "Severe precipitation events are usually projected using Regional Climate Model (RCM) scenario simulations." We gently remind the authors that statistical downscaling is also widely used for projecting severe precipitation events and suggest that more inclusive wording be used.

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