

## Review comments on

*“Precipitation Ensembles conforming to Natural Variations derived from Regional Climate Model using a New Bias Correction Scheme”*, **Kim et al.**

The authors present an improvement of the bias correction method for daily rainfall. This improvement is based on the correction of quantiles i.e. quantile matching between model output and observation. In the original method one usually transforms the Gamma parameters obtained from the model run in such a way that they match the parameters uniquely determined from the set of observations. The improvement lies in the fact that the variability of the parameters of the observations is taken into account. This is achieved by shifting and scaling the Gamma parameters of the model data in a way that maps them onto the ranges of observed parameters. These ranges are obtained by bootstrap sampling the observations, and so generating an ensemble of parameter sets. The result, when correcting an ensemble of model runs, is that the Gamma parameters for this ensemble show the same cloud as those for the generated ensemble of bootstrapped observations.

The paper by itself is well-written and the concepts conveyed in a clear manner and can be easily understood. However, I am missing the practical framework of the proposed method. I would structure the paper (any paper on bias-correction methods) as follows:

- Find an application: of the biascorrected data, e.g. rainfall-runoff simulation.
- Discuss the characteristics relevant to this application (e.g. variability of catchment precipitation at a certain timescale) and their bias.
- Explain why the proposed bias-correction method should properly correct these characteristics properly.
- Discuss what variability of the *ensemble* should be preserved.
- Demonstrate the skills of the method for just the abovementioned features using the catchment example.
- Discuss the shortcomings of the method, if any.
- Speculate on the effects of these shortcomings on the practical application.

The reason is that I am sceptical about generic one-suit-fits-all bias-correction methods for rainfall data. There are so many aspects of rainfall series; they can not be all corrected simultaneously. The way of correcting should therefore depend on what properties are relevant the application. For instance, one has a multi-model ensemble, the members of which are known to be systematically

biased in certain characteristics (i.e. mean rainfall) in the same way in their scenario runs as in their current-climate run and one wants to obtain an ‘unbiased’ ensemble of scenario runs to drive hydrological simulations, which are sensitive to the variability of n-day rainfall. The method raises some questions. Why is the spread of the parameter set also corrected? (I mean  $\sigma_{xo}/\sigma_x$  in eqns 4 and 5)? In doing so, the variability in the observation parameter sets is imposed onto the simulated parameter sets. The variability of the latter is lost in this action, thereby the added value of an ensemble of simulations. I would only apply the shifting to remove systematic bias in the parameters and accept the spread from the simulation.

More specific,

**pg 10264, line 1:** “..distribution mapping was the best...” Why and in what way? (references) What is the criterium? In the next line: “..correcting the model output towards the corresponding observation is still a controversial issue... Of all mentioned methods this is most true for distribution mapping. It is not even preserving the model’s distribution shape. With this method the corrected rainfall becomes the most similar to observed rainfall.

**pg 10264, line 8:** “.. uncertainty associated with the observation sampling uncertainty ...”. But what about the *model* uncertainty? How do you preserve that?

**pg 10264, line 13:** “boundary condition” = “external forcings”

**pg 10264, line 24:** In PPE’s, would you rather correct ensemble members individually or as an ensemble (since it is the same model)? In the latter case, the argument of disregarding the ensemble spread does not hold.

**pg 10269, line 14:** “..each member is corrected by a *different* transfer function.... Why is that? I think this is not common practice, the parameter uncertainty gives you the spread you are looking for. The bias-correction is only a remedy for a systematic deviation, a tendency of the model.

**pg 10270, line 16:** The transfer function is expressed in equation (2), but not all reader will realize that. Please refer to that equation. You could be a little more elaborate on Step 4.

**pg 10273-10274:** The discussion conclusion is maybe the most interesting part: (Just note, RCM runs for downscaling give more accurate results on a local scale, but their circulation derives from the GCMs. Often, circulation bias is the origin of rainfall bias. So downscaling doesn’t help there, no matter how detailed the RCM, if it is driven by a biased GCM.). You say that the spread of the ensemble should be preserved, but your method scales the ensemble’s variability of the distributional parameters to those of the resampled observations (generated ensemble supposed to resemble natural variability, which can also be debated, because this variability also contains ‘non-stationarity’). In that case, the original variability of the ensemble is lost. Then it is mentioned (or suggested?) that only a single transfer function is used for the ensemble, which I understand is common practice. After that I am lost: the spread is not matched by that of the *observations* .. therefore..fails to reproduce to preserve the spread of the *ensemble*. I think these are two entirely different spreads, the

former refers to the natural variability, the latter to the sensitivity of the model to uncertainty in the perturbed parameters. If a single transfer function for the complete ensemble, only correcting for a systematic shift in the parameters, then the ensemble of transformed parameters still has the same spread as before. Then why is the benefit of the ensemble negated by this transformation? Finally, I fail to understand why the transfer functions should be built under the assumption that the corrected members must originate from within the bounds of the natural variability of the observation.

A slightly different aspect potentially interesting to the reader is that not only the ensemble has its spread, but also the observation used to correct to.

## **Conclusion**

The paper gets the reader to think about the need to preserve certain aspects of variability, offering an alternative that is explained clearly, but tries to be just a little too generic. Major revision would make this paper significantly more useful.