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Hydrology and Earth System Sciences
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Interactive comment on "Bias in downscaled rainfall characteristics" *by* N. J. Potter et al.

Anonymous Referee #3

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The paper is well written, and I agree that bias correction methods can and should be improved by correcting model bias with regards to temporal persistence. The authors have done a good job in their attempt to effectively remove modeled temporal bias at individual grid cells. That said, the authors need to provide better context with respect to the most recent advancements in bias correction methods. This was pointed out by the other reviewers as well, and they have provided some of the relevant literature that should be cited and discussed in your paper.

Some major points:

1. Yes, as the other reviewers have already stated, please place the application of bias correction in a broader context. Should we even bias correct rainfall or temperature data to force a hydrological model (Ehret et al., 2012, see Referee 2)? Ehret et al., (2012) argue that perhaps bias correction is simply applied to the end of the modeling

chain, and as a result, streamflow values themselves are bias corrected. Personally, I do not agree with this argumentation, because establishing an error correction function that estimates the bias of the hydrological model using observed forcings will not translate well to climate model forcings (which are themselves biased). The highly non-linear response of streamflow to biased modeled precipitation could prove problematic. In any event, you need to discuss some of these issues related to applying bias correction methods to climate model output.

Similarly, please add more discussion concerning the "inflation issue" or "non-stationarity" of quantile mapping. This is not a trivial component to methods such as the standard quantile mapping that assume a stationary error correction function. This is especially important when attempting to draw conclusions about future model projected changes to meteorological variables. What methods have been proposed to handle the inflation issue? (Cannon et al., 2015; Switanek et al., 2017; see Referee 2).

2. There are many approaches that can be taken to improve upon existing bias correction methods. The authors have tried to tackle an important one: that of rainfall persistence in time. The paper needs to discuss some of the other shortcomings of a method like quantile mapping, and why they chose to focus solely on improving temporal persistence. There are two other obvious deficiencies of traditional quantile mapping that will impact your results. The first is related to the inflation issue and the assumption of a stationary error correction function. This was highlighted above. However, even more closely related to your issue of temporal persistence, is that of spatial persistence. Your goal is to have precipitation events that are more realistic in their persistence in time (when compared to observations) to force a hydrological model. Too many wet days or too many dry days, statistically speaking, will be exacerbated when routed through non-linear streamflow response to precipitation, and this can ultimately lead to incorrect conclusions about how the hydrology is changing. Equally important with respect to streamflow output is spatial persistence (Bardossy and Pegram, 2012). Consider an example where average observed events cover 20 connecting grid cells, for a particu-

lar season, and a particular model, on average, cover 40 connecting grid cells. In this example, the model is putting down rain across a greater extent, and this will inflate the tail of the hydrological extreme events. I would argue that this effect has at least as strong of an impact on hydrologic response as temporal persistence. Bardossy and Pegram (2012) present a method to recorrelate model data so that the extent of events, on average, are comparable to observed event sizes. The authors need to either include some additional analysis concerning spatial persistence, or at the least, they need to discuss the contribution that this could have on streamflow output. I realize that you have compared the "spatial rainfall fields" from the models to that of "observed mean annual rainfall" (page 6, line 5). This is different than what I am pointing out. Averaging across days and seasons can hide differences between modeled and observed cross-correlations.

Some minor points:

Figure 3: It could be helpful for the reader to place Victoria geographically. Maybe you want to have a subplot in Figure 3 outlining Victoria in Australia.

Page 4, line 18: It seems that a combination of both CMIP3 and CMIP5 data have been used. Why use CMIP3 at all? CMIP5 has been around for quite some time now. This paper is not trying to show the improvement, or lack thereof, in model performance between CMIP3 and CMIP5.

Page 5, line 26: Figure 2 instead of "Figure"

References:

Bardossy, A., and Pegram, G., Multiscale spatial recorrelation of RCM precipitation to produce unbiased climate change scenarios over large areas and small, Water Resources Research, 48, W09502, 2012.

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