Response to referee comments.

Referee comments in black and author responses are in blue.

Interactive comment on "Post processing rainfall forecasts from numerical weather prediction models for short term streamflow forecasting" by

D. E. Robertson et al. Anonymous Referee #1

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This paper describes an approach for post processing rainfall forecasts from NWP models. This approach combines a simplified version of the Bayesian joint probability modelling approach for calibrating the marginal distributions with the Schaake shuffle for modelling spatio-temporal correlations. Its effectiveness is demonstrated with forecasts from the ACCESS-R NWP model at rain gauge locations in the Ovens catchment in southern Australia. The method described in the paper is new, interesting and potentially useful also for other NWP systems and regions with possible limitations pointed out in the discussion. It is well written and, while not fully self-contained, comprehensible apart from a few paragraphs where some further clarification would be desirable. Apart from one more severe concern regarding the forecast verification I have only minor comments and suggestions which are detailed below. If these points are addressed appropriately, the paper is suitable for publication in 'Hydrology and Earth System Sciences'.

We thank the referee for his review and constructive comments on the manuscript.

(1) p. 6766, l. 25: "forecasts" instead of "forecast"

Corrected

(2) p. 6769, l. 21: sth is missing after "post processed probabilistic"

Corrected

(3) section 3.1: I find it a bit confusing that initially the model is written as a multiple predictor, multiple predictand problem where also the correlations between the different predictands are modelled through R, while later only single predictands are modelled in that way and correlations between different predictands are modelled indirectly via the Schaake shuffle. Please make this point a bit clearer.

We now present the bivariate formulation of the statistical model rather than the multivariate formulation which should resolve the confusion.

(4) p. 6774, l. 13: isn't it rather "cumulative marginal distribution"?

At this point we are introducing the concept of comparing the marginal distribution, which can be commulative probability or density (one determines the other). In the subsequent paragraph described that we undertake this comparison using only the cumulative marginal distribution.

(5) section 3.3.1: In my opinion the comparison with the raw ensemble is unfair. While it is true that the CRPS reduces to the MAE in the case of a point forecast, it is not appropriate to use

the CRPS to compare a probabilistic forecast with a point forecast. This results in an unfair comparison because it implicitly presumes that the deterministic NWP prediction was probabilistic with zero uncertainty (which is not true, it simply does not provide uncertainty information). A fair comparison should either involve only probabilistic forecasts and use the CRPS, or should involve only point forecasts and use the MAE. The latter can be achieved by taking the median of the probabilistic forecast as a point forecast.

Many papers compare ensemble and deterministic predictions arising from NWP and hydrological models. Several of these papers make a direct comparison between probabilistic and deterministic prediction using the CRPS/MAE as the score of choice (for example, Velázquez et al., 2009; Regonda et al., 2013; Boucher et al., 2011; Abaza et al., 2013; Laio and Tamea, 2007). Gneiting and Raftery (2007) argue from a statistical perspective that the scores are directly comparable.

A philosophical argument can be made that a deterministic NWP prediction contains uncertainty but simply does not provide uncertainty information. However, from the hydrological forecasting perspective adopted in the paper, the necessary pragmatic approach to using a deterministic numerical weather prediction is to treat it as having no uncertainty.

(6) section 3.3.4 and p. 6782, l. 7: the authors refer to "space time correlation structure" but I cannot quite see where the spatial aspect comes in. When the authors study cumulative totals, I understand that "cumulative" refers to lead time only. For space to play a role one I would expect that some accumulation over several observation sites is considered, but unless I have missed sth this is not what is being done here

The reviewer is correct that in this instance we do not examine the spatial correlations in the results section. However, totals can be taken to imply total across many stations or a single station.

The words "space time" have been removed in this section.

(7) section 4.2.4 and Fig. 10: I suggest that the reliability diagrams are enhanced with uncertainty information (confidence intervals) to give quantitative support for the statement that "there is considerable sampling uncertainty associated with the observed frequencies"

Confidence intervals have been added to figures 10 and 11

(8) Fig. 2.: I think the word "space" is missing after "transformed and untransformed"

Text modified to correct error

(9) Fig. 6: Please define "percentage bias" in the text

Definition is provided in section 3.3.2, italic typeface highlights definition.

Forecast bias is the average difference between the mean of the probabilistic forecast and corresponding observation. Biases in rainfall forecasts will potentially be amplified in streamflow forecasts and therefore it is important that rainfall forecast have minimal bias. *Forecast bias, as a percentage of the observed value,* is assessed for the raw NWP predictions and post processed forecasts for individual forecast periods and cumulative totals throughout the forecast period.

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