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Interactive Comment

Interactive comment on "Empirical streamflow simulation for water resource management in data-scarce seasonal watersheds" *by* J. E. Shortridge et al.

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We thank the referee for their thorough review of the manuscript and thoughtful comments. Many of the issues that the referee raises (particularly the specific comments starting on page C5082) highlight areas where we can describe the work and related literature more clearly, and we will certainly address these in the manuscript's revision. However, we did want to address some of the more substantial comments so that the rationale for our modeling and evaluation process is made clear:

Referee comment: The description of the data-driven models (line 14, page 11091 – line 20, page 11092) is too synthetic and thus prevents the reader from understanding the experimental set-up (e.g., Table 2) as well as some of the results reported in Section 3. . .The experimental set-up is described only partially and some of the adopted techniques require more parameters than those listed in Table 2.

Response: To ensure that the work is clear and reproducible, we will expand Table 2 so that it includes all of the parameters used to fit the models (rather than just those that were optimized through cross validation) when the manuscript is revised.

Referee comment: I have some doubts regarding the second formulation (Equations 2-3). Streamflow anomalies are calculated by (a) subtracting the long-term average streamflow and (b) dividing this number by the long-term standard deviation. However, the streamflow process appears to be non-stationary. . . the changes in land use have an impact on the rainfall-runoff process, while the long-term average and standard deviation are calculated on the hypothesis of a stationary process. I think that the authors should elaborate on this point.

Response: The referee is correct that streamflow processes in the region are most likely non-stationary due to changes in land cover over decadal time scales as well as the influence of rising temperatures. However, these changing conditions are incorporated into the calculation of the streamflow anomaly value itself, since this value is a function of temperature, rainfall, and agricultural land cover. Thus, while the conversion from streamflow anomaly to raw streamflow value in CMS uses stationary measurements of long-term average and standard deviation, the calculation of the anomaly value itself does not rely on any assumption about stationary conditions.

Referee comment: I do not understand why they have not used an additional (and better) metric, such as KGE.

Response: The use of NSE was included because it is the most widely used error metric in modeling studies conducted in the region, and provided a rough point of comparison between these models and physical models that had been previously developed for the region. MAE was included as an error metric because it provides a simple and easily interpretable measure of error on the same scale as observed flow volumes. The use of alternative error metrics has been discussed extensively in the literature (for instance Pushpalatha et al., 2012; Mathevet et al., 2006; Criss and Winston, 2008). While model evaluation in terms of alternative or additional error metrics could provide interesting insights into what is contributing to predicitive capabilities of different model formulations, the objective of this paper is to look beyond predictive capability and instead compare model formulations in terms of error structure and uncertainty. Examination of the KGE performance metric (Gupta et al., 2009), for example, confirms that models outperform climatology in all watersheds, though the specific ranking of model performance does change in some cases.

Referee comment: Why does the climatology model perform so well? Given the results reported in Table 3, one might conclude that complex data-driven models are not needed since a simple climatological model can get excellent values of NSE and MAE.

Response: The climatology model does well because seasonality accounts for such a large portion of the variability in monthly flow, a phenomenon discussed by Legates and McCabe (1999) and Schaefli and Gupta (2007). However, this model does not account for any degree of interannual variability nor the possibility for non-stationary conditions caused by changing land cover and climate, and thus is unsuitable for streamflow simulation over the short term (eg., based on seasonal climate forecasts) or long term (due to land cover and climate change).

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