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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Improving hydrological projection performance under contrasting climatic conditions using spatial coherence through a hierarchical Bayesian regression framework" *by* Zhengke Pan et al.

Anonymous Referee #2

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General Comments

The study of Pan et al. tests a Hierarchical Bayesian framework to incorporate time and spatial variability in model parameters. Specifically, the method was tested for the GR4J-model in three Australian catchments. Four modelling scenarios were tested, and one base scenario was formulated. The study shows that including spatially and temporally variable parameters improves model performance and reduces uncertainty.

The article shows interesting work, which could be a nice contribution to the field.

Generally, the article needs some more explanations on the method, but there is also some incomplete reasoning. Hence, there are several issues I'd like to address.

Specific comments

Key of the article is the hierarchical framework, but the authors may want to work on the explanation of the method. It is especially not clear to me how the hyper-parameters are determined, and how the catchment-specific values follow from that. Are the hyper-parameters estimated in SCEM-UA? Or are these pre-defined? The gaussian distributions are defined by the authors as prior distributions, and that makes me assume that the model parameter theta is determined in SCEM-UA starting from this prior distribution, whereas the remaining model parameters are either kept fixed or sampled from a uniform distribution and independently for each catchment. Is that correct? Because if that is the case, the hyper-parameters (and hence the distribution) are determined in advance, so what are these based on? Besides, the choice of a gaussian distribution may seem a logical first guess, but it remains an arbitrary choice. So what is the reasoning behind this choice? In addition, the choice of the prior distribution may lead to some circular reasoning. When spatial coherence is used, the variation in performance goes down, but is this not just an artefact of the pre-defined gaussian distribution? In other words, if the prior distribution is set narrower, the resulting posterior distribution will probably be narrower as well. I believe it is therefore crucial to report also the prior ranges (or fixed values) for especially the (time-invariant) theta-parameter, but also all other model parameters.

I also wonder how valid it is to assume the catchments are similar. The authors state on p15.L314, that the catchments satisfy the homogeneity assumption. What is this assumption and how do they satisfy this assumption? A clear description of the catchments may be needed to defend that the catchments are the same. Just looking at the DEM and the annual values of rainfall and runoff (Table 2) give me the idea that the Big catchment (405264) behaves fundamentally different compared to the other two. This catchment also reached much higher performances in calibration (Fig.5 and 6) when

no spatial coherence is used, and also shows different results in the BIAS comparison (Figure 7).

Sometimes, the conclusions and statements of the authors do not seem to be strongly supported by the data as shown. The boxplots with performances (Figures 5, 6) show relatively similar performances, and, to be honest, a clear pattern is not very obvious. In addition, the authors tend to generalize in some cases findings that mainly apply to just two of the three catchments (see also my minor comments). I believe additional analyses may be needed to support the conclusions more, for example a statistical test to check if the distributions are significantly different. Or the addition of other, multiple performance measures, to assess the performance over multiple aspects (high flows, low flows etc.). Further, all beta-values plot around zero in Figure 8, basically pointing at the absence of a clear trend. Is this indeed true? It would be interesting to show the timeseries of the parameter. The absence of a trend may explain the similar performances for all scenarios, and especially also why the time-varying scenarios do not outperform the others clearly. Besides, when beta is around zero, there is no point of looking at omega, as this does not do much in that case.

Concluding, the authors may need to clarify more what they did and how they arrive at several conclusions. I hope the authors find my comments useful, and I look forward to a revised manuscript.

Technical corrections

P.7. section 2.1.1. Please elaborate on how the dry periods are defined.

P8. Section 2.1.2. Why add this paragraph when you only refer to section 2.5?

P10. L210 Do you mean Eq. 1?

P10.L210 ...expected to the same... → expected to be the same

P12. L50. Please define N and n

P12.L258. Which parameters are optimized in SCEM-UA?

P15.L326. Please explain how I can see this from Figure 4, except for the pre-defined red colour. Is this where the black line crosses the axis? Why are the first years not considered?

P16.L339-340. Are these references in the right place? You describe your own results, shouldn't you refer to one of the figures?

P17.L355-357. This is, as far as I can see, not true for all catchments. Catchments 225219 and 405264 have a higher median, but the variation is less for 225219.

P17.L362. As far as I can see, it has only the highest median value for catchment 225219.

P18.L375. The performances in the verification period seem higher to me? What do you mean calibrated performances were inferior?

P.18L375-377. This is not true for catchment 225219

P18.L379. The ranges seem not very different between scenarios 4 and 5, only slightly.

P18.L379-380. It's not very obvious that scenario 3 has a higher median performance for catchment 405264

P18.L382 This is not very obvious to me

P18.L394. Compared –> comparing

P20.L438. Is omega for scenario 4 not the lowest in all cases? Or do you mean the absolute values?

Figure 2. Please define all symbols and abbreviations in the figure.

Figure 5,6: I would suggest to plot the boxes for calibration and verification next to each other. It's easier to see whether there is an improvement or not. Please also add the units (also when a unitless number is presented)

Figure 7. Please make the labels and text bigger.

Figure 8, 9. Maybe use the same colors for the scenarios in both plots. What are the units of beta and omega?

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