hess-2015-53 Author's Response to Anonymous Referees #1 and #2

"Large-scale hydrological modelling by using modified PUB recommendations: the India-HYPE case" by I.G. Pechlivanidis and B. Arheimer

We would like to thank once again Referees #1 and #2 for their interest to our paper. Here, we clarify on the major concerns made by each Referee. In our final revision of the full paper we will address all comments.

RESPONSE TO MAJOR POINTS

Reviewer #1 made two main points: 1) Highlighting Hydrological Insights Gained, and 2) Large Sample Application. We have responded in our reply to the point about Highlighting Hydrological Insights Gained by mapping the flow signatures across the subcontinent. However, we did not yet explicitly respond to the Large Sample Application comment.

Regarding the Reviewer's point 2, we show that the use a single model structure was inappropriate in some places. Figure 11 shows how various physiographic catchment characteristics link to model performance. The figure shows that poor performance is linked to catchments with shallow soils and/or low precipitation. This is mentioned in Section 4.5 (lines 10-21). The geographical location of catchments with good/poor model performance is shown in Figure 12. The results are discussed in Section 4.6 (lines 8-31). The lessons learnt are the need to work on snow accumulation/melting and evapotranspiration components of the model code and/or parameters. We come back to this in Section 5.1 where we indicate needs for model refinements.

We believe that as the paper is rather long and complex, which result in that the reader might have problems digesting the detailed information provided. Rather than including more information, we suggest to remove details to better target the readers' focus on the main findings in the revised manuscript. We suggest removing details from Section 3 (Data and Methods) as most of this information can be found in the literature and it is not unique for this article. Instead the focus should be on setting up a multi-basin model using the PUB approach and lessons learnt from this modeling process. On this we agree with the reviewers. This will make the manuscript more pleasant and straightforward.

Reviewer#2 made two main points:
1) *"- The discussion on uncertainties and data errors, while exhaustive, is almost entire qualitative. With the very many methods for uncertainty analysis available, a more comprehensive uncertainty analysis would sure make a strong point."*

This is generally a good point and uncertainties should certainty be considering in modeling studies, but we disagree that our approach is "almost entirely qualitative". On the contrary:

- Figure 4 shows quantitatively uncertainty for various signatures during calibration and validation periods and "blind" catchments that were not used in calibration.
- Figure 5 shows quantitatively the uncertainties due to reservoir regulation.
- Figure 7 shows quantitatively the behavioural range from a Monte Carlo approach exemplified for one parameter.
- Figure 9 shows quantitatively the progress in model performance and consistency, and corresponding decrease in errors during the stepwise calibration.
- Figure 12 shows quantitatively the spatial model performance using different metrics across the subcontinent.

A comprehensive overall uncertainty analysis (of all the sources of uncertainty present at such a large scale) requires numerous model realisations which are practically very difficult (but we guess not impossible) for a such computationally heavy model. To implement such a methodology at 6000 subbasins in a distributed model is really not straightforward and would end-up in a new study. For this article, there are no intentions to proceed in such experiment, as this is not the objective of this study.

2) *"Lastly, the monsoon climate characteristics of the study region do not help. With such an extreme seasonality, and only monthly data available, the modelling challenge essentially boils down to a yearly water balance prediction, which is almost entirely dominated by uncertainties in the precipitation data and the evapotranspiration parameterisation. Under such conditions it is hard to do proper model diagnostics"*

The observed monthly data of discharge do capture seasonal variability of the systems (see Figure 1 below) and the model performance thus reflects the temporal dynamics and not only annual water balance. Note the scale for the Ganga River; it has an inter-annual amplitude in river discharge of 50 000 cumecs in the monthly records! Accordingly, we also assess the model capacity to simulate various flow signatures that represent flow dynamics; see the spatial patterns of flow signatures across India from response to Referee #1, which we suggest to include in the revised manuscript.

The size of the sub-catchments is on average 810 km2 and the catchment area of the discharge stations where model evaluation is performed is on average 75 493 km2 (as can be found in Table 2). Hence there is a dampening effect on river flow in the model and this also justifies the use of monthly values for model diagnostics when working at this scale.

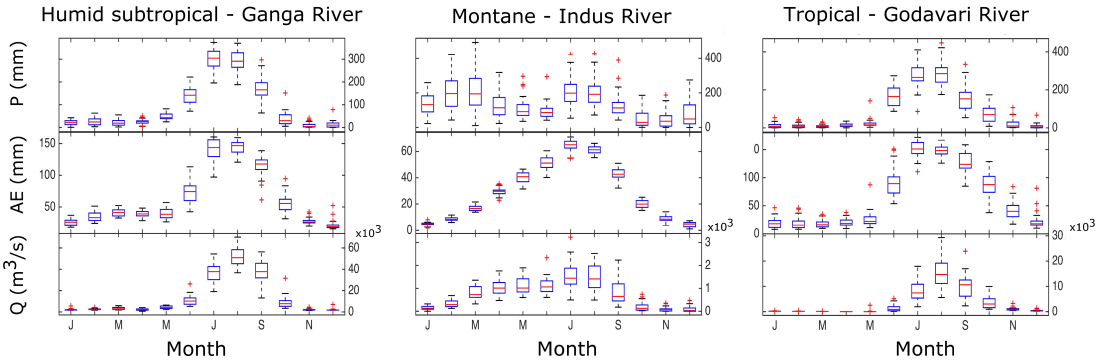

Figure 1. Annual cycles at three river systems of various climate in the Indian subcontinent (P – observed precipitation, AE – modeled actual evapotranspiration, Q – observed discharge).

If the editor agrees, we could insert this figure to show seasonality in observations in the paper.

When revising the manuscript into a new version, we will also approach the specific comments from both referees. We agree on most comments and make relevant adjustments in the text. For those that we do not agree we will give the Editor an explanation. Especially we will focus on shortening the paper. We still believe that the manuscript in the revised form is worthwhile publishing and the novelty is that we actually apply the catchment modelling approach to the continental scale. We believe that this is currently in the frontline of hydrological sciences, it has been requested in numerous opinion papers lately and we also see several efforts in this direction during the last years. This kind of efforts tries to bridge the gap between land-surface schemes, global hydrological models and the catchment modelling community, which could contribute to advance science by merging the best from each community. We will more clearly emphasise this ambition in the introduction to highlight the message we want to convey in large scale modelling.