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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Comparison of uncertainty in multi-parameter and multi-model ensemble hydrologic analysis of climate change" *by* Younggu Her et al.

Anonymous Referee #2

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In this manuscript, the authors quantify the uncertainty in multi-parameter and multi-model ensemble hydrologic analysis of climate change using 61 Ohio River watersheds. The authors show from their results that the relative contribution of uncertainty in multi-GCM ensembles can be an order of magnitude larger than that of multi-parameter ensembles when predicting direct run-off. Evaluating groundwater and soil moisture, multi-parameter ensembles show to be the largest driver of uncertainties. The authors demonstrate within their study a "novel" framework for uncertainty-analysis which could be applied in other catchments.

All in all, the paper addresses relevant scientific questions within the scope of HESS. Although I do not think the approach for evaluating uncertainties they suggest is very

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novel, some substantial conclusions can be drawn from the research, which might be of interest for the water resources research community. I would therefore support the manuscript for publication but with substantial revisions taking into account the following general and technical comments/suggestions:

General comments: 1. In this study the authors used ABCD, a mathematical model rather than a process-based model. I wonder whether using a process-based hydrological model wouldn't solve already large part of the equifinality problem mentioned by the authors. Looking into the physical boundary values for each of the sub-parameters, the physical processes themselves, and calibrating/validating the sub-hydrological results should already for a large part solve this equifinality issue, resulting in only one or perhaps a few sets of parameters that describe the overall hydrological system best.

2. The authors mention that in the ABCD model soil water content is proportional to the evapotranspiration opportunity and that this exponentially increases with the potential evapotranspiration rate: from a physical point of view, shouldn't this be the other way around? Potential evapotranspiration being driven/(or limited) by the availability of soil moisture?

3. Does a simpler model (page 3 – line 10) have less uncertainty because they have less parameters incorporated? Or is the uncertainty less visible? Or: Does a more complex model lead per definition to higher uncertainty?

4. I doubt whether you can consider the different GCMs to be independent, since quite a few of them a highly related to each other. Could you elaborate how to deal with this?

5. The actual discussion part is relatively small. I would suggest the authors to elaborate a bit more on the impacts of their findings. But also to discuss any uncertainties/limitations of their conducted research.

6. From the text it did not became clear to me how the statistical downscaling of the GCM climate projections was done. Please elaborate a bit more on that.

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7. Overall, the study is quite wordy and different definitions are being used throughout the text. Try to be consistent in the use of definitions and remove redundant text.

8. Too many figures are included in the manuscript and most of the figures are too difficult to grasp. Try to simplify and diminish the number of figures shown.

Technical comments:

- P3-L3: “Many different models”: Out of many the authors name only three models, why not mention the others widely used: e.g. WaterGAP, PCR-GLOBWB, H08, LPJmL, etc?

- P4-L2: “22. . . 35 GCMs”: How were 35 GCMs derived from the initial 22 ones? What was the selection procedure applied here?

- P4-L16: “locations”: What do you mean here?

- P5-L27: what is meant with the long-term monthly hydrologic response?

- P5-L28: WW is an often used indicator for water withdrawals. Better use WA here.

- P7-L11: “maximum and minimum values”: please specify where these values refer to

- P7-L23 (formula): where do the subscripts mentioned in the formula come from? Cannot find their meaning in the text.

- P8-L19: “03232500”: Doesn’t this watershed have a name?

- P9-L5-6: I do not understand how to interpret these values: are these the average projected increase rates across all hydrologic components?

- P9-L7-8: “indicating. . .runoff hydrographs”: What could be a reason for this observation? In most models you see that precipitation changes are buffered towards runoff estimates.

- P9-L11-13: “Implying. . .PP”: Where does this water go to then? Increased ET? Higher soil moisture? Or less low-period flows?

- P9-L28: “multi-model(multi-GCM): just give it one name: multi-GCM.

- P10-L9: I do not fully understand the idea behind the overall parameter posterior distribution. What is the added value to aggregate the results over all the watersheds?

- P10-L24: “Unit of depth”: Not clear what is meant with this

- P11-L5: “relatively constant .. than in summer”: sounds like a contradiction

- P11-L26: Not clear to me whether a threshold of 97.5% is relatively loose or conservative.

- P11-L29: In the ABCD model soil moisture and groundwater are ‘rest-products’, isn’t it straightforward then that the impact of model-parameterization is larger than the impact of uncertainty in GCM-input?

- P11-L30: How can ET be directly be determined by direct runoff? Shouldn’t this be the other way around: uncertainty in QQ being driven by uncertainty in ET?

- P12-L10: So would you say that, in the Ohio River basin, precipitation is a larger determinant for water availability than Temperature?

- P12-L13-14: “This finding. . .climate change”: This is an observation that hold for this basin specifically. Does it also hold for other types of catchments, e.g. the temperature dominated ones?

- P12-L19-20: “and the thresholds. . .climate change”: Incomplete sentence

- P13-L1-3: “A total of. . . explored”: Fuzzy sentence, please rephrase.

- P13-L3-4: “Uncertainty associated. . .amount of precipitation”: I don’t understand this statement. Please clarify.

- P13-L7: How about the regional scale climate projections?

- Fig1: Is it necessary to present the area size in terms of log10?

- Fig5: These sub-figures are very difficult to compare. Would it be possible to make 2 figures (one for precip and one for temp) showing the ltm-hydrographs (12 months) for the different scenarios: * current conditions * near future under rcp4.5 and rcp8.5 * far future under rcp4.5 and rcp8.5

- Fig 6: see comment figure 5.

- Fig 7: Does it really make sense to show a multi-GCM, multi-parameter, multi-watershed projection?

- Fig 9: Are these values for all watersheds?

- Fig 12: Could you explain why for GW and PET the sign changes when the threshold increases? In lower thresholds multi-parameter uncertainty shows to be more important, whilst in high thresholds multi-GCM is a more important determinant for the uncertainty in outcomes.

- Fig 13: Legend of this figure is difficult to interpret. Perhaps give a figurative example to clarify.

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