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Hydrology and Earth System Sciences Discussions

Interactive comment on "Exploring the physical controls of regional patterns of flow duration curves – Part 2: Role of seasonality and associated process controls" *by* S. Ye et al.

Anonymous Referee #4

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HYDROLOGY AND EARTH SYSTEM SCIENCE DISCUSSIONS

Review of Manuscript # hessd-9-7035-2012

Exploring the physical controls of regional patterns of flow duration curves – Part 2: Role of seasonality and associated process controls

Authors: Ye, Yaeger, Coopersmith, Cheng, Sivapalan

1) Overview

Utilizing a top-down approach, this study aims at exploring the dominant processes

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Interactive Discussion
Discussion Paper

that control the variations of runoff regime behavior over the continental United States. The MOPEX dataset containing over 50 years of daily climatic and flow data from 197 catchments located in a range of climatic and physiographic settings in the continental United States was used. The authors start with a simple two-bucket model (representing fast flow and slow flow processes) and systematically increase the complexity through addition of new processes on the basis of model performance assessment in relation to observed runoff regime curves. Using the complete model, a sensitivity analyses was performed to explore the dominant processes and the required minimum model complexity based on a performance metric (Aikake information criterion). The authors conclude that systematic regional trends exist in dominant processes across Continental U.S. The identified dominant processes were: fast and slow runoff components, snowmelt, subsurface-influenced fast flow, interception loss and seasonal phenology. Only at the end of the manuscript, the authors did somehow a weak attempt to link process understanding explored through the regime curve to the flow duration curve.

2) General Comments:

I think the manuscript is interesting for the HESS readership and makes a good contribution in the subject area of top-down approach to process understanding. The authors performed a detailed modeling study with a diverse dataset to investigate the dominant controls and required model complexity to reproduce the regime curve in over 150 catchments in the U.S. I read the manuscript with a great interest. Due to a lot of work that was performed, the manuscript is very lengthy. I think it should be, and can be, shortened. Below, I provided a few suggestions in this regard. My main concern about the manuscript is that no quantitative results were provided about the model calibration and performance assessment steps. These should be included in the manuscript as summary plots together with appropriate discussions. Only then the reader will have an understanding about satisfactory model and the required processes. I also think that the title of the manuscript should be changed. Current title puts more emphasis on

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FDC rather than the regime curve; almost 95% of the manuscript is about reproducing regime curve. The manuscript should be revised based on the comments provided in this section and sections listed below before it could be accepted for publication.

Main Comments:

1) The main goal of this paper is to understand the process controls underpinning the runoff regime behavior of some 197 watersheds in the continental U.S through a model-based top-down approach. Therefore the title of the manuscript does not reflect the content of the manuscript and should be modified. The current title misleads the reader as if the manuscript is devoted to investigation of the physical controls of the flow duration curve. Also, flow duration curve provides magnitude frequency of flow within a specified period and does not contain any time information. Therefore the use of "role of seasonality" and "flow duration curve" in the title is also misleading.

2) A clear definition of the runoff regime curve should be provided in Section 1 or Section 2.1. The definitions provided state that "mean seasonal variation of within-year runoff variability". Does this mean the authors take the 50-year average of runoff for each day of the year? Clearly state in the manuscript. If daily values are used than the authors should make a distinction between "runoff" and "streamflow" because the latter includes the channel routing. I believe MOPEX dataset contains the streamflow observations.

3) What is the advantage of using a Bayesian method for parameter estimation with assumptions of normally distributed regime curves and fast and slow flows? Why not use a more straightforward calibration algorithm such as "Dynamically dimensioned search" or "Shuffled Complex Evolution"? If uncertainty bounds were provided Bayesian method would be more understandable.

4) Page 7056, Line 11: Explain how the MSE threshold of 0.53 was selected to classify satisfactory/unsatisfactory models. Is this value selected to choose 75% of the watersheds based on fast and slow runoff components? Explain in detail and justify, as this

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is an important value.

5) Table 1. Instead of reporting the mean values of the parameters, their distribution should be provided, which gives more information about the catchment groups. Box-whisker plot is a good way to show distributions together with the means.

6) Page 7042, Lines 7-9 vs. Page 7049, Lines 5-8: In Page 7042, authors state that base model is calibrated first and than new processes are added. Not clear whether model is calibrated again after each process is added. In Page 7049, the authors state that full model (including all process improvements) was calibrated first than components were removed while fixing the parameter values to the calibrated parameter values of the full model.

7) Model calibration and model performance assessment are critical steps in identifying dominant processes and minimum model complexity. The link between the model and the hydrologic processes can be established only when the calibrated parameters are physically tied to the watershed processes. I think both calibration results and performance assessment results should be provided in a quantitative manner in this manuscript. How the MSE values varied across regions? What were the improvements in AIC criterion between model improvements? A summary of the quantitative values of these measures should be provided in a figure or two and discussed in the manuscript.

8) Figure 3: Figure 4 contains all the information provided by Figure 3. Figure 3 should be removed and the base model should be highlighted in Figure 4.

9) Section 2.2 and Section 3 should be merged and condensed to reduce the manuscript length.

10) Figure 13: Figure 13a is not necessary and can be removed to shorten the manuscript. All the information contained in Fig 13a is already provided by Fig 13b.

Minor Comments:

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Page 7039, Line 21-22: State which “vegetation type” data is used and the number of classes.

Figure 1: Explain AI in the figure caption. Describe whether “calendar year” or “water year” is used. If water year is used describe the period.

Figure 1 & 2: Describe how mm/day runoff was calculated.

Page 7041, Line 13: Explain clearly how the FDC was constructed in this study.

Page 7042, Line 10: Explain “critical assessment” of model performance. How does it differ from classical model performance assessment?

Page 7043, Line 10-20: Refer to model schematic figures (Figs 3 and 4) where appropriate.

Page 7044, Line 19-20: Clarify this sentence together with the implications for modeling. Also define “Mean residence time” parameter in relation to parameters already explained.

Sections 2.2.1 – 2.2.5: In all these modification steps do the authors perform model calibration and performance assessment steps? These steps should be clearly explained before going through the modification steps. Even after reading “Section 2.3.1 Model calibration” it is not clear to me whether parameter calibration is performed after each modification listed in these sections.

Page 7050, Line 25:Replace “prediction” with “performance” since the study deals with reproducing historical flows but not forecasting future flows.

Page 7050, Line 26: Explicitly state how many of the 197 catchments were removed from the dataset?

Page 7051, Line 6-10: Explain each term in Equation 16 clearly. There is no “SQobs” variable. And what is “Qmean”. Is it “Qobsmean”.

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Page 7051, Line 8: SQsim is estimated from Eqn. 17? Please explain.

Equation 17: MSE: Mean squared error. There is no “Mean” term in the equation.

Page 7051, Line 17: Define “satisfactory”.

Page 7052, Line 1: Replace “used perform” with “used to perform”.

Page 7052, Line 6: The use of “discharge”. “Runoff” has been used until now. Please be consistent through the manuscript.

Page 7052, Line 9: Remove “use”.

Figure 5. Caption: Replace “CA” with “Northern CA”.

Page 7054, Line 4: Replace “subsurface-induced” with “subsurface influenced”.

Page 7054, Line 13: Replace “an further enhanced one” with “a further enhanced”.

Page 7055, Line 1: Explain “GSI”, was not explained before.

Page 7056, Line 13: State the number of catchments that were satisfactory/unsatisfactory.

Page 7056, Line 19: Explain “satisfactory”.

Page 7058, Line 17: Replace “decrease AIC” with “decrease in AIC”

Page 7058, Line 17: Replace “less 3% ” with “less than 3%” or with “3% less”.

Page 7058, Line 22: 197 catchments: I thought a number of catchments have been eliminated earlier in the analysis.

Page 7059, Line 1: Replace “. snowmelt” with “. Snowmelt”.

Page 7059, Line 22: Replace “. snowmelt” with “. Snowmelt”.

Page 7062, Line 5: Less than 150 catchments: As mentioned earlier, provide the exact numbers. Earlier stated 197 catchments (see also above).

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Page 7062, Line 20: Difficult to see the catchments in Southern California in Figs 11 & 12.

Page 7062, Line 24-25: “phenology decreases” Is the arrow for phenology in Figure 13 pointing the right direction? In addition, I suggest using elongated triangles instead of arrows. Triangle narrows toward reduced process direction.

Figure 13: Figure 13b: There seems to be a problem with the “base model” regime curve plots.

Page 7064, Line 13: It seems from Fig. 14 that in none of the catchments full model captures the extreme flows. Therefore no need to mention NY, GA, FL, TX and ID. Alternatively, mention all regions.

Page 7064, Line 27: Yes, timing information is lost in FDCs however, information on extreme values and frequencies becomes rich. Whereas in regime curve extremes are averaged out. Therefore both FDC and regime curve contain different and complementary information.

Page 7065, Line 20: Replace “. snowmelt” with “. Snowmelt”.

Page 7066, Line 10: Close the parenthesis.

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