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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Exploration of virtual catchments approach for runoff predictions of ungauged catchments" *by* Jun Zhang et al.

Anonymous Referee #2

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The authors have provided an interesting use of virtual catchments to explore the sensitivity of the unit hydrograph to several geomorphological features. The project is well-conceived and provides an interesting tool for continued analysis. I would like to see the authors strengthen their statistical presentation, address a one concern in the logic of their argument and more-fully describe the potential for ungauged applications.

Firstly, I'd like the authors to consider the statistical significance of their results. Several power functions are fit to different curves. Each time, the fitted coefficients are contrasted with the coefficients implied by the Flood Estimation Handbook. The authors fail to provide any hypothesis test on the strength of their evidence. For example, in line 161, the coefficient is fitted as -0.29, contrasting with the implied -0.35. While the original value (-0.35) probably contains some degree of uncertainty, the fitted value

(-0.29) is certainly uncertain. Depending on how these regressions were fit (I'm assuming ordinary least squares, though this should appear in the methods section), it is possible to execute a hypothesis test to determine if the resulting fitted value is significantly different from the expected value from the Flood Estimation Handbook. (This raises a minor point, again on line 161, where "significant" is used in a qualitative sense. Given the statistical meaning of the word in this context, I'd suggest avoiding value judgements or finding a synonym.)

In addition to considering the significance of the results, I would ask the authors to consider their fitted equations a bit more closely. The authors fail to provide any assessment of goodness of fit to portray the accuracy of their estimates. Furthermore, do these regressions meet the assumptions of their approach? If we are talking about ordinary least-squares fitting, then we need to understand the performance of the residuals before we can begin to trust coefficient estimates. For example, consider figure 5: The residuals of the 10mm/h storm appear highly non-Normal. They display uncaptured, systematic curvature. This certainly raises concerns about the validity of the coefficients. While I understand that the intent is to contrast with the equation from the Flood Estimation Handbook, this limitation should be acknowledged and the implications thereof discussed.

Moving on, I would like the authors to provide some further consideration of the logic of their argument that virtual catchments allow us to assess underlying conditions across diverse physical conditions. It seems to me that the use of a hydrologic model forced through a set of virtual catchments is a stronger reflection of the underlying model rather than reality. Of course, with a well-performing model, this point is moot: The model approaches reality, and, therefore, the behavior of the forced model is the behavior of reality. However, I think it should be acknowledged that, without a thorough assessment of all aspects of model performance, we can never be certain that they curves we identify (as in Figure 5 and elsewhere) are a reflection of underlying physical properties (reality) rather than a product of the model's conceptualization of reality.

While this may not discredit the authors' findings, I think it is an important limitation to discuss.

Additionally, I would like the authors to consider expanding the discussion of ungauged applications. The authors claim that the use of virtual catchments allows models to be applied in ungauged regions, avoiding the need to transfer parameters of the unit hydrograph. However, the authors then proceed, in their first step, to calibrate their model the site of interest. The fact that a model must first be calibrated to a particular site makes ungauged application particularly difficult. Now, it may be that the authors are instead arguing that a model calibrated to an arbitrary catchment can then be forced with virtual catchments similar to the ungauged region of interest, but this is not immediately clear from the discussion. Furthermore, it seems somewhat ill-advised to take a model calibrated to one setting and force it with artificial settings. The mere fact that calibration is required implies that the underlying model is not a perfect representation of reality: why, therefore, would we expect it to behave across a range of virtual catchments when re-calibration would be required across a diverse range of observed catchments? Again, I am not seeking to discredit the authors' argument, but am merely hoping my concerns might foster more discussion in the manuscript.

Before closing, let me mention some minor concerns: I would like to see the authors provide a bit more description in their section on methodology. For one, it would be good to describe how the authors plan to apply the concept of virtual catchments. For the uninitiated, it is not clear what is meant by a virtual catchment until it is described in the results section. Additionally, the authors acknowledge the limitations of the Nash-Sutcliffe model efficiency in section 3.1, but I would ask them to explore other metrics like the efficiency of the logarithms or square roots, or still other metrics. As the performance of the underlying model is essential, as I argued above, I think it worthwhile to further demonstrate the accuracy and precision of the model. Finally, the authors should provide the methodology that was used to estimate the curves throughout the results section.

Finally, I sincerely thank the authors for their work and their well-written manuscript. It was easy to read, which made it easy to consider its technical merit. I look forward to their considered response and hope to have ignited some useful thought and discussion. If you would like any clarification on my comments, I strongly encourage you to reach out to me.

Possible typographical errors: (not exhaustive, just ones I noticed)

Line 62: "...especially in because small catchments ..." seems to have an extra word.

Line 118: "patterns" should not be plural

Line 177: I think you mean "fluctuation"

Line 185: You refer to similar trends, but you should probably note that these are similar in sign only. Similarly, you refer to "vast" differences. That is subjective, especially without any formal consideration of significance.

Line 232: Should "The analysis between Qp and L..." be "The analysis between Qp and [Tp]..."? That would seem to match the figure and heading.

Line 236: You refer to significance here, but it appears to have no statistical support. A synonym might be more appropriate.

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