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Geoscientific Model Development Discussions

Interactive comment on "A Hydrological Emulator for Global Applications" *by* Yaling Liu et al.

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In this study, the authors use a simple hydrological model "abcd" to emulate the behavior of more complex models (e.g. VIC). They modify the abcd model by including the baseflow index to better represent the partition of total runoff into direct runoff and baseflow. They present a lumped and a distributed version of the model, which are calibrated using the GA technique. They apply the model on global scale and compare the results against VIC simulations. Based on the results, they provide recommendations on the use of different versions of the model.

Although the model used is not new and the concept of simplified emulator is an established one, however, the global-scale application of the model and its assessment over multiple basins across globe make it an interesting study. A simple and computationally efficient emulator that can work well on global scale is useful for several applications.

I think the manuscript at its current stage needs some more work. Some additional analyses need to be added. Therefore, I suggest moderate revisions for the manuscript before it is accepted in GMD.

Following are my comments:

[1] How reliable are the VIC simulations? Calibration of VIC can significantly change its streamflow outputs. So what type of simulations are used in this case for the comparison purpose? How were the soil and vegetation parameters calibrated/selected? All these points need to be discussed in greater details.

[2] How did VIC perform in the extreme climate regions, for example, in snow-dominated catchments? This issue needs to be addressed properly. Maybe you can explore the following cases:

Case-1: If both emulator (E) and model (M) are matching the observations (O) well then that's great. There could be some sub-cases for this case:

(i) Both emulator and model match the observations well but from different directions (M – O – E). For example, they might have opposite (positive/negative) bias errors but the absolute values of the errors could be close.

(ii) The model is matching the observations well and the emulator is matching the model well, all in one direction (O – M – E).

(iii) The emulator is matching well both the model and the observations, but in different directions (M – E – O).

Case-2: If none of them are matching the observations well but their own outputs match each other, then too, I think an emulator is serving its purpose in a way (although not quite useful).

Case-3: If the emulator is matching the observations well but the model isn't then that's an interesting finding.

Case-4: If the model is matching the observations well but the emulator isn't then there is a problem. Therefore, this needs to be explored in greater depth.

[3] At seasonal time scales, the model performance is expected to be better. It would be crucial to also check the results on daily time scale. Maybe you can produce a set of time series plots, scatter plots, and spatial contour plots for daily level, as done for the seasonal case.

[4] Figure 3: Any idea why there are those biases in the lower streamflow values? Is there any location-specific pattern of these biases?

[5] Line 113: Which one's the other parameter you adopt the value of?

[6] Line 200: Did you try different weights on the two objectives?

[7] Line 290: In order to do a fair comparison, VIC and the two versions of the models should be run on the same computer, preferably with good configuration.

[8] Figure S1: I am not sure if you can say that all of them are comparing well. The discrepancies/mismatches should be clearly discussed in the manuscript. You are only showing the correlations here. What about the bias error?

[9] X-axis marks are missing for the first two subplots of Figure S1. Use same axis for the scatter plots in Figure 2.

[10] My comments about the manuscript:

Writing: The manuscript is very well written. I don't have any suggestions on this part.

Figures: Figures look good. Increase the legend in Figure 3.

Tables: Table 2 can go to the supplementary materials.

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