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Hydrology and Earth System Sciences
Discussions

Interactive comment on "A simple topography-driven and calibration-free runoff generation module" *by* Hongkai Gao et al.

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We thank Anonymous Referee 2 for the very constructive and detailed comments. Here are our replies.

Overestimation of the saturated area. The overestimation of the saturated area is most likely caused by the different definition of saturated areas in field measurement and in hydrological models. The discussion and interpretation of the overestimation of the saturated area fraction in the BB basin are described in Line 604-614.

Model validation in BB basin. We will add the model performance in the validation period, and evaluate the models in BB.

Model performance on low flow. The performance gains on low flow (I_{KGL}) have

been investigated and shown in Figure RC2.

Calibration-free. We may politely insist that the HSC-MCT is a calibration-free runoff generation module. We agree that the threshold area for stream initiation is important while generating HAND maps. But the threshold area can be determined based on observation rather than calibration, although the threshold area varies in different climate, geology and landscape classes. The limitation of the fixed threshold area has been discussed in Line 601-604.

MCT method. MCT is an approach to estimate the S_{uMax} by measurable input. But since we fixed this parameter as S_{R20y} (the amount of root zone storage capacity, which ecosystems need to bridge droughts with 20 years return period), which may also vary in different ecosystems. Improving the MCT to allow more flexible estimation for different ecosystems will be promising to improve model performance, which is discussed in Line 595-599.

Computational cost. The discussion on the computational cost will be added in the revised manuscript.

More concerns:

1. The saturated area fraction simulated by HBV is presented in Figure 8b. But the HBV cannot explicitly generate the spatial discretization of saturation area.

2. Yes, the beta value of 0.98 is the averaged calibrated value of beta. Please note that the intention of the HSC module is to propose a new runoff generation module, which is, to some extent, supported by large-sample ecological field observation, and free of calibration, rather than fitting the CDF of HSC with other existing curves/modules. The purpose to show the TWI frequency of TOPMODEL is to demonstrate the curve that we used to estimate runoff in TOPMODEL. The HSC curve in Figure 7 is derived from the spatial distribution of HAND, therefore the HAND distribution curve is not shown in this figure.

3. Label a-b will be added in Figure 8, and the caption will be refined. The averaged relative soil moisture of root zone (S_u/S_{uMax}) at catchment scale is used to estimate the proportion of saturated area (A_s). In the manuscript, we demonstrated the estimated As rather than the soil moisture, because As is more directly linked with runoff generation simulation. Yes, TOPMODEL does perform better in the second and the fourth events, but generally HSC performs better than TOPMODEL (evaluated by R^2 and I_{KGE}).

4. This is a good suggestion. IKGE might be a better metric to evaluate model performance on saturated area fraction estimation. Evaluated by IKGE, HSC also performs better than the TOPMODEL, although both HSC and TOPMODEL do not perform well (-3.0 for HSC, and -3.4 for TOPMODEL). The reasons for the unsatisfactory results are discussed in Line 604-614.

5. We intended to present the procedures to derive the HSC curves for the MOPEX catchment, which are helpful for readers to understand how the HSC module works.

6. The results of I_{KGL} will be presented.

Minor concerns:

1. We may politely insist that the HSC-MCT module is calibration-free and performs equally well or better as a calibrated model. There are two reasons. Firstly, as we clarified in the above, HSC is directly derived from the HAND distribution in a DEM, without any calibration. Secondly, HSC-MCT performs comparably well with HBV. Since the median IKGE value of HSC-MCT is 0.65, which is a better performance compared to HBV (0.61). And the averaged IKGE value of HSC-MCT is 0.59, which is comparable to 0.62 (HBV). So it is fair to say the model performance of the calibration-free HSC-MCT and HBV are comparable.

2. This will be rephrased.

3. We will refine introduction.

4. This will be rephrased.

5. More detailed about the calculation of HAND can be found in Rennó et al., 2008; Gharari et al., 2011.

6. Please refer to Vrugt et al., 2003.

7. Yes, we will add more details on the climatic and hydrological data in the BB catchment.

8. The saturation maps are not interpolated. They are generated directly by field mapping, and a global positioning system (GPS) was used to delineate the boundary of saturation areas (Ali et al., 2014).

9. We will revise it as suggested.

10. We will revise it as suggested.

11. This will be refined.

12. The reasons for the cases where HSC/HSC-MCT produced lower performance will be discussed.

13. The discussion will be revised.

14. This will be revised.

15. This will be revised.

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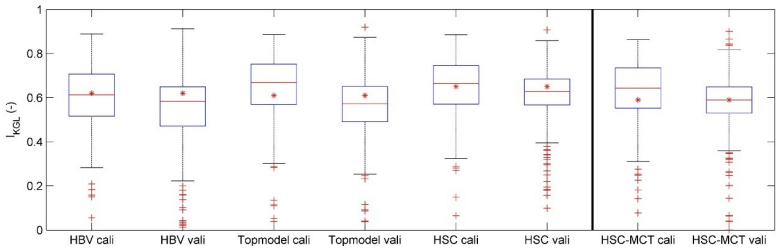

Fig. 1. Figure RC2. Model performance on low flow (IKGL).