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Behind the scenes of runoff performance

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Hydrological models are valuable tools for short-term forecasting of river flows, long-term predictions for water resources management and to increase our understanding of the complex interactions of water storage and release processes at the catchment scale. Hydrological models provide relatively robust estimates of streamflow dynamics, as shown by the countless applications in many regions across the world. However, various model structures can lead to similar aggregated outputs, i.e. model equifinality. To provide reliable estimates, it is of critical importance that not only the aggregated response but also the internal behaviors are consistent with their real-world equivalents. In a previous international comparison study (de Boer-Euser et al., 2017), eight research groups followed the same protocol to calibrate their twelve models on streamflow for several catchments within the Meuse basin. In the current study, we hypothesize that these twelve process-based models with similar runoff performance have similar representations of internal states and fluxes. We test our hypothesis by comparing internal states and fluxes between models and we assess their plausibility using remotely-sensed products of actual evaporation, snow cover, soil moisture and total storage anomalies. Our results indicate that models with similar runoff performance represent internal states and fluxes differently. The dissimilarities in internal process representation imply that these models cannot all simultaneously be close to reality. Using remotely-sensed products, the plausibility of process representation could only be evaluated to some extent as many variables remain unknown, highlighting the need for more experimental research. The study further emphasizes the value of multi-model, multi-parameter studies to reveal to decision-makers the uncertainty inherent to the lack of evaluation data and the heterogeneous hydrological landscape.

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