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Integration of the generalized complementary relationship into a lumped hydrological model for improving water balance partitioning

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Abstract: Lumped hydrological models (LHMs) are useful tools to estimate catchment runoff (Q) owing to their low data requirements, high computational efficiency, and ease-of-use. However, most LHMs are purposely conceptualized for rainfall-runoff processes with over-simplified consideration of other water balance components, especially evapotranspiration (E). This produces an inappropriate water balance partitioning, i.e., the proportion from precipitation to Q and E. The generalized complementary relationship (GCR) has been developed as a reliable method for estimating regional E using only routine meteorological observations.

In this study, a lumped hydrological model (Xinanjiang model, XAJ) was integrated with the GCR (XAJ-GCR) to improve the water balance partitioning of LHMs. Three integration schemes and three calibration strategies (i.e., single objective only Q, single objective only E, and multi-objective both Q and E) were tested to investigate the performance of XAJ-GCR.

Long-term daily observations of Q and E in the Seolmacheon experimental watershed (8.54 km2) in South Korea were collected to test the capability of the XAJ-GCR model to capture hydrological dynamics. Results validate that the integration of GCR into LHMs is feasible and applicable for improving water balance partitioning. XAJ-GCR model obtained excellent results in simulating Q ($NSE_Q = 0.91 \pm 0.02$) and markedly improves simulating E with NSE_E from -0.35 ± 0.27 (mean ± standard deviation) to 0.56 ± 0.10.

This integration is strictly based on physical mechanisms, it can be useful for independent checks in a wide range of LHMs and other climatic zones. The findings of this study provide insights to improve water balance partitioning and increase the reliability of lumped hydrological models in water resource management and climate change impact studies.

REFERENCES

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