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Editorial

Advanced Hydrologic Modeling in Watershed Scale

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Hydrologic modeling in the watershed scale is a key topic in the field of hydrology. The hydrological model is an important tool to understand the impact of climate change and human activities on rainfall–runoff processes, and especially on water resources for humans in a changing environment. In traditional hydrological modeling, the precipitation data of in situ rainfall gauges are adopted to force hydrological modeling, and the simulated discharge is used to validate the hydrological model by comparing it with the observed discharge at the hydrological station. In the last two decades, with the development of satellite remote sensing and artificial intelligence, many new datasets and methods have been introduced into hydrological modeling. Multi-source fusion precipitation products (such as GPM (Global Precipitation Mission), MSWEP (Multi-Source Weighted-Ensemble Precipitation), CMFD (China Meteorological Forcing Dataset), and atmospheric assimilation datasets (such as CMADS (China Meteorological Assimilation Driving Datasets)) better display spatial distribution than ground rainfall data and have the potential for a better performance in hydrological modeling on middle and large spatial scales. Additionally, data on evaporation, soil moisture, and water level at the channel from remote sensing may be applied to validate the simulated evaporation, soil moisture, and discharge. Even water storage change can be evaluated by GRACE (Gravity Recovery and Climate Experiment) data. Deep learning models and agent-based models may be used in the process representation and parameter estimation. The interaction of hydrological processes to ecological processes and social processes has also attracted attention in recent years.

When the Special Issue opened, we planned to invite original research articles that contribute to new progress in the hydrological modeling in the watershed scale under global changes. Among the topics of interest for this Special Issue are:

- Application of new datasets and methods in hydrological modeling;
- New process representation in hydrological modeling;
- Progress of parameter estimation;
- Interaction of hydrological processes to ecological processes and social processes and their co-evolution processes;
- Coupled modeling of surface water and groundwater;
- Flood and drought based on hydrological modeling;
- Flux observation in the validation of hydrological modeling;
- Isotopic tracing in the validation of hydrological modeling;
- Role of macropore flow or preferential flow in the hydrological process;
- Sediment and other mass transport in the hydrological process.

Before the deadline for manuscript submissions for this Special Issue, we received many manuscripts on the hydrological modeling in the watershed scale. Finally, ten articles are published in the Special Issue.

In the simulation of hydrological processes, SWAT model was applied in 5 case studies, which are in the Bayin River basin of China [1], the Fengle watershed in the middle–lower Yangtze Plain of China [2], the Tangbai River Basin crossing Henan province and Hubei

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province of China [3], 12 hydrological sites in the Illinois River watershed of U.S [4], and the Wei River Basin on the Loess Plateau in China [5].

In the Bayin River basin of China, the study aimed to accurately simulate the impact of vegetation change on hydrological processes in an arid endorheic river watershed undergoing revegetation, and LU-SWAT-MODFLOW model was developed by integrating dynamic hydrological response units with a coupled SWAT-MODFLOW model [1].

In the Fengle watershed in the middle–lower Yangtze Plain of China, the study assessed the performance of two well-known gridded meteorological datasets, CFSR (Climate Forecast System Reanalysis) and CMADS (China Meteorological Assimilation Driving Datasets), and three satellite-based precipitation datasets, TRMM (Tropical Rainfall Measuring Mission), CMORPH (Climate Prediction Center morphing technique), and CHIRPS (Climate Hazards Group InfraRed Precipitation with Station data), in driving the SWAT model for streamflow simulation [2].

In the Tangbai River Basin of China, the river basin has been exposed to high doses of fertilizers for a long time and the study simulates hydrologic and nutrient cycling using the SWAT model with limited data available [3].

At 12 hydrological sites in the Illinois River watershed of the U.S, it developed a new hybrid SWAT-WSVR model that integrated the SWAT model with a Support Vector Regression (SVR) calibration method coupled with discrete wavelet transforms (DWT) to better support modeling watersheds with limited data availability [4].

In the Wei River Basin on the Loess Plateau in China, based on the measured data at the ground stations, the temporal and spatial evolution of the ecohydrological and meteorological factors were analyzed, and the SWAT model was used to identify the relationship between the model parameters and the factors, such as precipitation, potential evapotranspiration, NDVI, and the other environmental characterization factors of the river basin [5].

At the same time, the runoff are simulated by other models or methods, such as the Hydrological Engineering Center–Hydrological Modeling System (HEC-HMS) [6], a two-stage annual precipitation partitioning method [7], Xin An Jiang model [8], and the GR3 model [9].

The HEC-HMS was used to simulate snowmelt runoff in the Kırkgöze–Çipak Basin that has a complex topography where altitude differences range from 1823 m to 3140 m above the sea level in eastern Turkey [6].

Using a two-stage annual precipitation partitioning method, the study quantified the impact of climate change and human activities on the annual total stream flow, surface runoff, and base flow in the Weihe River Basin (WRB), wherein the surface runoff and base flow are separated from the measured total flow by using a one-parameter digital filter method for which the common filter parameter value is 0.925 [7].

With the calibrated Xin An Jiang model, the study increased the insight into the difference between the calibrated objective functions by evaluating eight objectives in three different classes (single objectives: KGE(log(Q)) and KGE(1/Q); multi objectives: KGE(Q)+KGE(log(Q)), KGE(Q)+KGE(1/Q), KGE(Qsort)+KGE(log(Qsort)) and KGE(Qsort)+KGE(1/Qsort); split objectives: split KGE(Q) and split (KGE(Q)+KGE(1/Q))) in Bahe, a semi-arid basin in China [8].

The GR3 model, a rainfall–runoff model, was combined with the background of inter-basin water transfer to simulate the hydrological process of Huangtaiqiao basin in Jinan city, Shandong Province, China for 18 consecutive years with a 1 h time step [9].

In the groundwater recharge case, the study utilized an integrated approach based on remote sensing (RS) and GIS using the influence factor (IF) technique to delineate potential groundwater recharge zones in Islamabad, Pakistan [10].

Based on the hydrological modeling, these studies promoted the understanding of the impact of vegetation change on hydrological processes, the performance of meteorological datasets and precipitation datasets, hydrologic and nutrient cycling, a new hybrid SWAT-WSVR model, the relationship between the SWAT model parameters and the factors, simulation of snowmelt runoff, the impact of climate change and human activities on the annual total stream flow and base flow, the difference between the calibrated objective functions, simulation of the hydrological process with the background of inter-basin water transfer, and potential groundwater recharge zones.

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References

1. Jin, X.; Jin, Y.; Mao, X.; Zhai, J.; Fu, D. Modelling the Impact of Vegetation Change on Hydrological Processes in Bayin River Basin, Northwest China. *Water* **2021**, *13*, 2787. [CrossRef]
2. Liu, J.; Zhang, Y.; Yang, L.; Li, Y. Hydrological Modeling in the Chaohu Lake Basin of China—Driven by Open-Access Gridded Meteorological and Remote Sensing Precipitation Products. *Water* **2022**, *14*, 1406. [CrossRef]
3. Wan, W.; Zheng, H.; Liu, Y.; Zhao, J.; Fan, Y.; Fan, H. Ecological Compensation Mechanism in a Trans-Provincial River Basin: A Hydrological/Water-Quality Modeling-Based Analysis. *Water* **2022**, *14*, 2542. [CrossRef]
4. Yuan, L.; Forshay, K.J. Evaluating Monthly Flow Prediction Based on SWAT and Support Vector Regression Coupled with Discrete Wavelet Transform. *Water* **2022**, *14*, 2649. [CrossRef]
5. Wu, H.; Liu, D.; Hao, M.; Li, R.; Yang, Q.; Ming, G.; Liu, H. Identification of Time-Varying Parameters of Distributed Hydrological Model in Wei River Basin on Loess Plateau in the Changing Environment. *Water* **2022**, *14*, 4021. [CrossRef]
6. Şengül, S.; İspirli, M.N. Predicting Snowmelt Runoff at the Source of the Mountainous Euphrates River Basin in Turkey for Water Supply and Flood Control Issues Using HEC-HMS Modeling. *Water* **2022**, *14*, 284. [CrossRef]
7. Mu, Z.; Liu, G.; Lin, S.; Fan, J.; Qin, T.; Li, Y.; Cheng, Y.; Zhou, B. Base Flow Variation and Attribution Analysis Based on the Budyko Theory in the Weihe River Basin. *Water* **2022**, *14*, 334. [CrossRef]
8. Yang, X.; Yu, C.; Li, X.; Luo, J.; Xie, J.; Zhou, B. Comparison of the Calibrated Objective Functions for Low Flow Simulation in a Semi-Arid Catchment. *Water* **2022**, *14*, 2591. [CrossRef]
9. Yang, J.; Xu, C.; Ni, X.; Zhang, X. Study on Urban Rainfall–Runoff Model under the Background of Inter-Basin Water Transfer. *Water* **2022**, *14*, 2660. [CrossRef]
10. Maqsoom, A.; Aslam, B.; Khalid, N.; Ullah, F.; Anysz, H.; Almaliki, A.H.; Almaliki, A.A.; Hussein, E.E. Delineating Groundwater Recharge Potential through Remote Sensing and Geographical Information Systems. *Water* **2022**, *14*, 1824. [CrossRef]