Simulating hydrological responses with a physically based model in a mountainous watershed

Qin Xu\(^1\,2\,3\), Jianyun Zhang\(^1\,2\,3\), Liliang Ren\(^4\,5\), Xing Chen\(^4\,5\)

\(^1\)The State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, NHRI, Nanjing, Jiangsu, P. R. China, \(^2\)Research Center for Climate Change, MWR, Nanjing, Jiangsu, P. R. China, \(^3\)Hydrology and Water Resources Research Department, NHRI, Nanjing, Jiangsu, P. R. China, \(^4\)The State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Hohai University, Nanjing, Jiangsu, P. R. China, \(^5\)Hydrology and Water Resources College, Hohai University, Nanjing, Jiangsu, P. R. China

A physical and distributive approach was proposed by Reggiani et al. (1998) to describe the hydrological responses at the catchment scale. The rigorous balance equations for mass, momentum, energy and entropy are applied on the divided spatial domains which are called Representative Elementary Watershed (REW). Based on the 2nd law of thermodynamics, Reggiani et al. (1999) put forward several constitutive relations of hydrological processes. Associated with the above equations, the framework of a physically based distributive hydrological model was established. The crucial step for successfully applying this approach is to develop physically based closure relations for these terms and simplify the set of equations. In this paper, several closure relationships, expressing mass exchange fluxes as functions of relevant state variables in a physically reasonable way, were formulated in the upstream of Huangnizhuang watershed, which is a mountainous watershed located in the Huaihe River Basin of the east part of China. Therefore a hydrological model based on the above closure relationships and the original approach founded by Reggiani et al. was established for this watershed. The paper showed how a theoretical hydrological model based on the REW method was applied to prosecute the hydrological response simulation for a watershed. The established model was used to carry on the short-term (runoff simulation of storm event) and long-term (daily runoff forecasting) hydrological simulation in the studied watershed and the simulated results were analyzed. These results and analysis proved that this physically based distributive hydrological model can produce satisfied simulation results and describe the hydrological responses correctly. Finally, several aspects to improve the model demonstrated by the results and analysis were put forward which would be carried out in the future.

**Keyword:** REW, physically based model, closure relationships, Numerical solution, Huangnizhuang watershed