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Estimation of catchment transit time in Fuji River Basin by using an improved lumped model

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As an important parameter that reflects the characteristics of catchments, the catchment transit time (CTT) has been given much more widely attentions especially in recent years. The CTT is defined as the time water spends travelling through a catchment to the stream network [1], and it describes how catchments retain and release water and solutes and thus control geochemical and biogeochemical cycling and contamination persistence [2]. Conventional approaches for estimating CTT require specific hydrological characteristics such as transit time distribution (TTD) functions. The objectives of the present study are to develop a new approach for estimating CTT without prior information on such TTD functions and to apply it to the Fuji River basin in the Central Japan Alps Region.

In this study, an improved Tank model [3] was used to compute mean CTT and TTD functions simultaneously. It involved water fluxes and isotope mass balance. Water storage capacity in the catchment, which strongly affects CTT, is reflected in isotope mass balance more sensitively than in water fluxes. A model calibrated with observed discharge and isotope data is used for virtual age tracer computation to estimate CTT. This model does not only consider the hydrological data and physical process of the research area but also reflects the actual TTD with considering the geological condition, land use and the other catchment-hydrological conditions. For the calibration of the model, we used river discharge record obtained by the Ministry of Land, Infrastructure and Transportation, and are collecting isotope data of precipitation and river waters monthly or semi-weekly. Five sub-catchments (SC1~SC5) in the Fuji River basin was selected to test the model with five layers: the surface layer, upper-soil layer, lower-soil layer, groundwater aquifer layer and bedrock layer (Layer 1- Layer 5). The evaluation of the model output was assessed using Nash-Sutcliffe efficiency (NSE), root mean square error-observations standard deviation ratio (RSR), and percent bias (PBIAS) [4].

Using long time-series of discharge records for calibration, the simulated discharge basically satisfied requirements of reproducing water fluxes and their balance, while improvements in parameter estimations relating to isotope mass balance is necessary. The results of each sub-catchment demonstrated that the mean CTT of SC4 (1873 days = 5.13 years) is the longest among the other sub-catchments. However, the mean CTT of SC5 was estimated to be 316 days as the smallest one. The time of 6.78 years are required to renew 99.9% of the water volume in the SC5. The other sub-catchments need more than ten years to get 99.9% water volume refreshed. The estimated TTD functions demonstrate their dependence on precipitation amount and area of the catchment.

Reference:

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