

Evaluation of long-term variability of rainfall-runoff properties in forested alpine catchment

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The water conservation function of forest, so-called "Green Dam" in Japan, is recognized as one of the important forest's functions. However it is often miss-understood by general public such as "sponge theory". Water balance in forested catchment is not clear because of its complexity by many hydro processes. The authors investigate the long-term variability of rainfall-runoff properties by forest growth and climate changes in the Gamansawa catchment (3 km²), Nakatsudawa, Gifu, Japan. The study area has long-term hydrological data acquired by Gifu prefecture and Forestry Agency, Japan from 1984 to 2007. Main forest types are cypress(67%), cedar(4%), broad-leaves forest(20%) and so on. The long-term tendency of forest variation is investigated by satellite image analysis with Landsat/MSS, TM and Terra/ASTER images acquired from 1984 to 2010. The mean NDVI over the study area are increasing. Therefore the forest should be growing in the research period. The authors investigate the trend of event based discharge rates f (=total direct discharge at the event / total rainfall at the event). The hydrological data is divided to many rainfall events and event based discharge rates are evaluated. The event based discharge rates are on a slightly decreasing trend with $df/dt = -0.006 [y^{-1}]$. Moreover the long-term hydrological data is divided to four periods and apply to the 4-layer tank model in order to evaluate the variation of hydrological properties in the study area. We assumed that the long-term variation in forest property is mostly surface soil layer such as soil layer thickness and lateral permeability. Vertical permeability depends on bed rock cracks should not so much increase. Based on this assumption, the model parameter of the bottom hole, which is related to infiltration to aquifer, is fixed. The model parameters of the second and lower tanks are also fixed. And the variability of the model parameters of side holes of the first tank, which are related to direct discharge, is investigated. We obtained the results as the model parameters of the side holes have the tendency of decrease as 0.9 to 0.7[d⁻¹], during the research period. Next, using these model parameters, the test rainfall events are simulated and the following results were obtained. 1) The peak discharge volume is decreased. 2) The event based discharge rates f are decreased as 0.6 to 0.5. This trend is the almost same as the mentioned event based discharge rates with long-term hydrological data analysis. These results suggest the flood mitigation function is increased during this period. On the other hand, although the model parameter of the bottom hole is fixed, total infiltration volume to lower tanks and base flow are increased. This result suggests that water conservation to aquifer also increase without increasing of vertical permeability such as bed cracks. It can be explained as follows. Consider a simple tank has one side hole and one bottom hole. The discharge from the side hole q [mm/d] is defined as $q = ah$, where h [mm] is the storage depth of the tank, a [d⁻¹] is the side hole size. The infiltration from the bottom hole i [mm/d] is defined as $i = bh$, where b [d⁻¹] is the bottom hole size. The time variation of h is defined as $dh/dt = q - i$. We obtain the total infiltration volume I as $I = bC/(a+b)$, where C is a constant of integration. By the above equation, when a is decreased with fixed b , total infiltration is increased. Therefore, it is suggested that increasing of water conservation can be explained with lateral permeability depend on forest growth. Moreover, we simulated two cases about evapotranspiration. First case is considered evapotranspiration with Hammon equation, and second is not considered. Hammon equation estimates probability evapotranspiration based on air temperature and daylight time. The results with two cases are the almost same. It is suggested that influence of climate changes have less effect than other factors.

Keywords: water conservation function, climate change, percolation, tank model