Hydrologic Effects of Climate Changes in a Forest Watershed

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EXTENDED ABSTRACT

The emissions of greenhouse gases and aerosols due to human activities continue to alter the atmosphere and affect the climate (IPCC, 2001). Recently there is a growing demand for information about the effects of climate changes under the global warming. In this study hydrologic simulation model was used to evaluate the hydrologic response to future climate changes on a small forested watershed. The input daily weather series were synthesized by stochastic weather generator whose parameters were derived from observed weather series and then modified in accordance with climate change scenario.

BROOK90 (Federer, 2002) is selected in this study to assess the impact of climate change on watershed hydrology. BROOK90 is a deterministic, lumped-parameter model that simulates the land phase of the rainfall-evaporation-streamflow part of the hydrologic cycle in small, forest watersheds. The model estimates interception and transpiration from a single layer plant canopy, soil and snow evaporation, snow accumulation and melt, soil water movement through multiple soil layers, stormflow by source area or pipe flow mechanisms, delayed flow from soil drainage and a first-order groundwater storage at a daily time-step.

BROOK90 was calibrated and validated against the streamflow data measured at a small forest watershed in Korea. The deviation in streamflow volume (Dv) was -1.7% for the calibration period, and Dv-value for the validation period was 4.6%. The correlation coefficient (r) and model efficiency (E) on monthly basis were 0.922, 0.847, respectively, for the calibration period, while the r- and E-value for the validation period were 0.941, 0.871, respectively. The simulated results showed that BROOK90 was able to reproduce hydrologic behaviour with higher correlation during the simulation period.

With the calibrated hydrologic model, we evaluate the impacts of future climate scenarios, which represent the assumption concerning the greenhouse gas emission and climate sensitivity in Korea. Climate change scenarios were generated using dynamic and empirical approaches. Future climate changes were modelled by nesting Regional Climate Model (RCM) and weather generation technique. According to the warming scenario proposed by the Korea Meteorological Administration, the increase in mean temperature to 2100 is estimated to be about 6.6^{o}C. And, the precipitation amount will increase by 10.5% around 2100 year in comparison with the present one.

Stochastic weather generator, WGEN (Richardson and Wright, 1984), was used to generate daily precipitation and temperature data through the 50 years (2051-2100) based on the projected climate change. The parameters of WGEN were also adjusted to account for climate change. Modeled scenario reflects the future climate change during the period of 2051-2100 by adopting the RCM results.

As a result of temperature rise in the future scenario, annual evapotranspiration slightly increased by 6.8%. Increase in precipitation due to climate change enhanced annual streamflow volume by more than 15%. The seasonal variations of streamflows at the present and the future were presented in Figure 1.

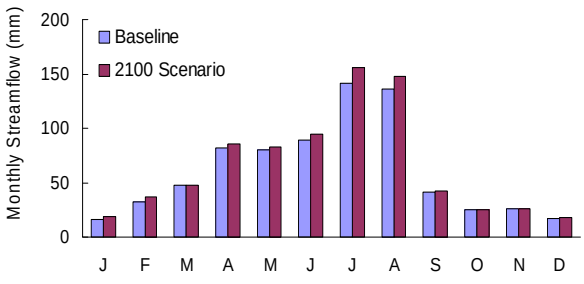

Figure 1. Simulated streamflow volume at the present and the future scenario