# Performance evaluation of stream flow prediction of eco-hydrological model calibrated with remotely sensed Leaf Area Index

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# Highlights

* Daily stream flow predicted through LAI-based calibration is evaluated.
* Compared performance with observed flow-based calibration and regionalization approach.
* This study is expected to help predict stream flows in ungauged basins.

# Introduction

Adequate monitoring of urban areas is important to manage urban water resources. Likewise, it is also necessary that understanding of hydrological processes in the natural basin that locate around the urban areas and affect the urban hydrological processes. Unfortunately, most headwater basins where the source of the urban stream begins have not yet been measured. Therefore, new model calibration strategies and evaluation methods are needed to predict stream flows of ungauged basins and further understand hydrological phenomena. Increased availability of satellite observations provides an opportunity to secure the predictive performance of hydrological models in ungauged basins. The evaporation process in a basin is one of the main parts that describes the water cycle process. Information about vegetation is also important to understand indirectly the evaporation process. This study investigates the potential of an eco-hydrological model calibrated using only remotely sensed vegetative information to predict stream flows in ungauged basins.

# Methodology

**Study area and data set**

Modelling experiments were conducted for basins in Korea. Four upper basins of dams (Namgang, Hapcheon, Imha, and Andong) with observed dam inflow data for use in performance evaluation were selected (Figure 1). In this study, dam inflow data observed at outlets of each basin and remotely sensed leaf area index (LAI) data from 2010 to 2020 were used. Note that, the LAI data used in this study is the Level-4 moderate resolution imaging spectroradiometer (MODIS) global LAI product (MOD15A2H) provided by Land Processes Distributed Active Archive Centre (LP DAAC). To acquire spatially integrated LAI time series, the area-weighted average values of pixels encompassed and/or intersected in each basin were used.



**Figure 1.** Location of selected basins.

**Model calibration**

This study used an eco-hydrological model that combines vegetation dynamics with a lumped hydrological model proposed by Choi et al. (2021). The model calibration schemes consist of (1) a model calibration scheme using observed dam inflow data (scheme F), (2) a model calibration scheme using remotely sensed vegetative information (scheme L), and (3) a regionalization approach traditionally used in an ungauged basin (scheme R). Calibration was performed for 2016-2020 using the Shuffled Complex Evolution Metropolis (SCEM) algorithm, and validation was performed for 2011-2020. Note that 2015 and 2010 were applied as warm-up periods, respectively.

**Performance evaluation**

Coefficient of determination (R2), Nash-Sutcliffe model efficiency coefficient (NSE) and Kling-Gupta efficiency (KGE) were used to analyze the accuracy of simulated stream flow. And uncertainties were examined using the mean coefficient of variation (MCV). In addition, Flow Duration Curves (FDCs) were plotted using simulated flows for the verification period and analyzed for each exceedance probability segment.

# Results and discussion

**Daily stream flows**

Figure 2 represents the average values of each metric estimated for the four basins. A standard calibration method, scheme F, demonstrates the best performance among the three schemes. For scheme L, the averaged values of metrics (R2, NSE, KGE) are 0.67, 0.62, and 0.79, respectively. R2 and NSE(KGE) of 0.5(0.6) or higher can be considered satisfactory simulation results (Ritter and Muñoz-Carpena, 2013; Patil and Stieglitz, 2015). The regionalization approach (scheme R) using calibrated parameter directly for a nearby basin also still shows good performance.



**Figure 2.** Averaged performance metrics for calibration schemes.

**Flow Duration Curves**

In high-flow parts (less than exceedance probability 0.4), scheme F and scheme R produced a curve that is relatively similar to the shape of the observed FDC (see Figure 3). It is likely that the reproducibility of the high-flows segment is high because calibration using observed flow data is sensitive to high-flows. On the other hand, scheme L shows results relatively close to the observed FDC of low-flows segments (more than exceedance probability 0.4). Soil moisture, baseflow, and evapotranspiration play a major role in dry season. As vegetative information is used for calibration, it is determined that it reflects the hydrological process such as soil moisture and evapotranspiration relatively well.

Conclusions and future work  
Both scheme L and scheme R may be useful calibration schemes to predict stream flows in ungauged basins without observed flow data. However, the regionalization approaches should be careful because a practitioner’s judgement is likely to have a significant impact on outcome of models. Therefore, if further validation is made on a wider variety of cases, it is expected that reasonable stream flows predictions for ungauged basins will be possible through a calibration scheme using satellite vegetation information. It would also be a good future work to identify the flow predictability using a variety of satellite observation information.



**Figure 3.** Flow duration curves (FDCs) for Namgang dam basin separated by exceedance probability intervals. Note that black solid lines are observed FDCs, solid lines with dots are simulated FDCs by schemes, and shaded sections are 95 PPU of simulated FDCs.

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