A hierarchical Bayesian model for spatial scaling method: Application to streamflow in the Great Lakes basin

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Abstract

This study presents a regional, probabilistic framework for estimating streamflow via spatial scaling in the Great Lakes basin, which is the largest lake system in the world. The framework follows a two-fold strategy including (1) a quadratic-programming based optimization model *a priori* to explore the model structure, and (2) a time-varying hierarchical Bayesian model based on insights found in the optimization model.

The proposed model is developed to explore three innovations in hierarchical modeling for reconstructing historical streamflow at ungaged sites: (1) information of physical characteristics is utilized in spatial scaling, (2) a time-varying approach is introduced based on climate information, and (3) heteroscedasticity in residual errors is considered to improve streamflow predictive distributions. The proposed model is developed and calibrated in a hierarchical Bayesian framework to pool regional information across sites and enhance regionalization skill. The model is validated in a cross-validation framework along with four simpler nested formulations and the optimization model to confirm specific hypotheses embedded in the full model structure. The nested models assume a similar hierarchical Bayesian structure to our proposed model with their own set of simplifications and omissions. Results suggest that each of three innovations improve historical out-of-sample streamflow reconstructions although these improvements vary corrsponding to each innovation. Finally, we conclude with a discussion of possible model improvements considered by additional model structure and covariates.

Keywords: Spatial scaling, Rgionalization, Herarchical Bayesian modeling

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