A NEW HYDROLOGIC ROUTING MODEL WITH APPLICATIONS FOR GEORGIA RIVERS

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Abstract. In this paper, a new hydrologic river routing model is developed to identify storage-outflow relationships for different reaches of a river. The model is then incorporated into a Bayesian forecasting framework (BFF) to generate ensemble forecasts of river flows that incorporate hydrologic and model uncertainties.

The routing model assumes that a river reach can be viewed as a cascade of conceptual reservoirs, each of which receives water from the upstream and releases water to the downstream according to a release rule. Additionally, these release rules are assumed to follow monotonically increasing storage-outflow relationships. Without any assumption on the mathematical structures of the rules, a Linear Quadratic Regulator (LQR) is used to identify the storage-outflow relationships.

The routing model was tested on the Equatorial Lakes in East Africa because this system is a series of cascading reservoirs and because actual observations of the storage-outflow relationships are readily available. Given the initial storage of each lake, the model was able to find storage-outflow relationships that closely approximate the observed data, as depicted in Figure 1.

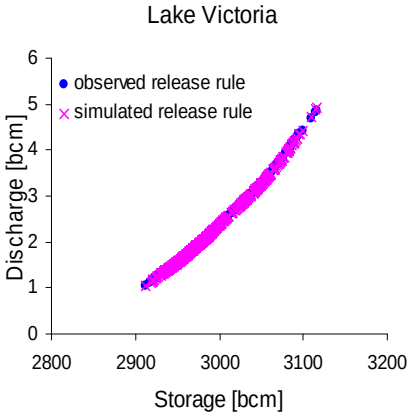

Figure 1a.

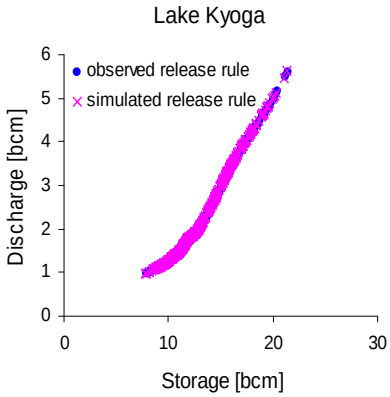

Figure 1b.

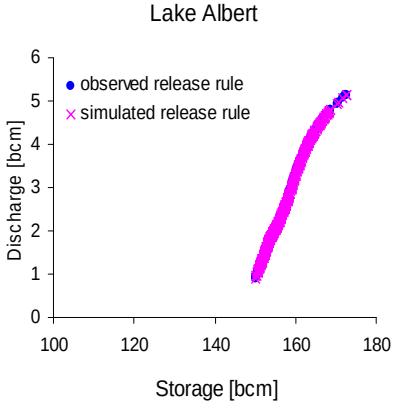

Figure 1c.

Figure 1: Storage-Outflow Relationships of the Great Equatorial Lakes

The storage-outflow relationships were then used to generate ensemble forecasts of river flows. Under this forecasting scheme, a historical analog method is used to select an ensemble of system inflows. Each inflow trace is then simulated with the previously estimated storage-outflow relationships to generate ensembles of river flows. In order to improve forecast performance, a Bayesian forecasting framework (BFF) was developed and used to generate updated river flow ensembles. The distributions

of the river flow forecasts at the outlet of the lake system before and after the application of the BFF are shown in Figure 2. It can be seen that the variances of the BFF distributions (blue-colored box plots) are smaller than those of the pre-BFF distributions (gray-colored box plots), while the actual river flows that materialized (red dots) still fall within the forecasted ranges. The BFF derived forecasts therefore provide more concise forecasts without significant loss of reliability.

The new routing model will be tested under various flow and terrain conditions for various rivers in Georgia. Comparisons with existing methods, such as Muskingum, Muskingum-Cunge, method of characteristics, and explicit/implicit routing schemes will be carried out to test model accuracy and efficiency.

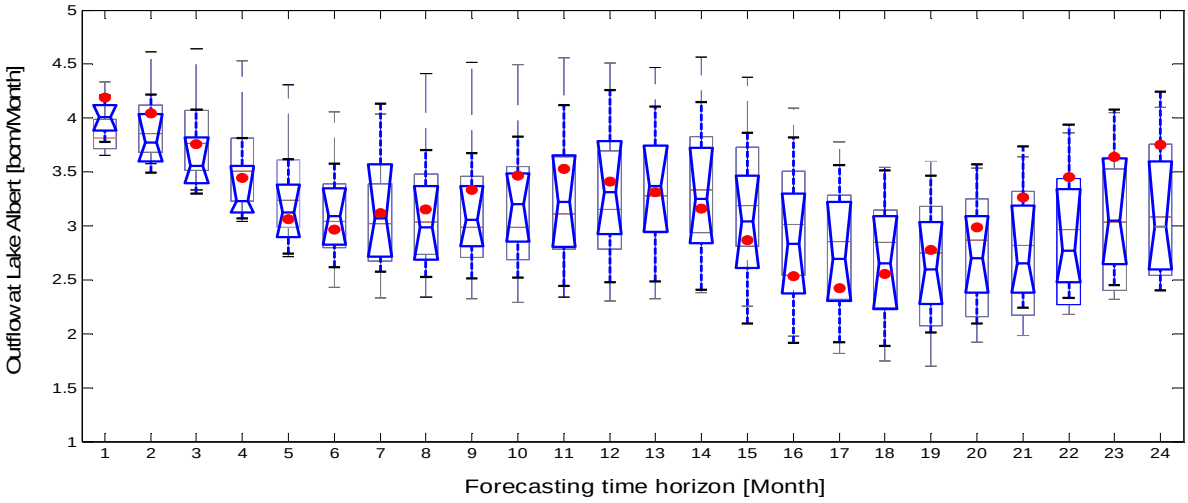

Figure 2: Boxplots of the forecasts from (a) the new routing model and (b) BFF