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ACCOUNTING FOR HYDROLOGIC MODEL ERRORS IN ENSEMBLE STREAMFLOW PREDICTION

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1. INTRODUCTION

Hydrologic forecasts depend on several essential elements: an estimate of the current state of the hydrologic processes, knowledge of precipitation that has already occurred, a forecast of future meteorological variables, a selection of hydrologic model, and a model calibration. The combined effect of uncertainties (or errors) about these elements is contained in the hydrologic model output. Therefore, hydrologic forecasts must be given in probabilistic terms to convey the degree of uncertainty regarding estimates.

Ensemble Streamflow Prediction (ESP) is a portion of the National Weather Service River Forecast System that provides an ensemble of streamflow forecasts, and transforms the ensemble further into a probabilistic prediction of streamflow, or any streamflow-related variable. When the ESP is run in historical simulation mode, forecast errors do not contribute to streamflow forecast uncertainty. Hydrologic errors, which encompass all other types of errors, have the effect that the climatology of model outputs is not the same as the climatology of the observations being estimated.

2. ACCOUNTING FOR HYDROLOGIC ERRORS

The goal of this research is to adjust ESP streamflow forecasts to account for hydrologic errors (forecast errors are dealt with separately), such that the adjusted forecasts preserve original monthly statistical climatological characteristics of streamflow. Three different adjustments ("error models") are formulated: they are described in the text that follows.

2.1 Error Model 0

The adjustment is performed directly on daily streamflow forecasts through empirical cumulative distribution functions of observed and historical simulated data for a given month. A schematic of the error model 0 is given in Figure 1. The model does not require calibration (except to sort observed and simulated values for each month). Probability of exceedence is estimated for each forecasted streamflow value from the cumulative distribution function of historical simulated data. Each forecast value is then replaced with the observed value having the same exceedence probability. By construction, the error model 0 preserves monthly climatological distribution functions, but no attempt is made to reconstruct climatological streamflow correlation structure.

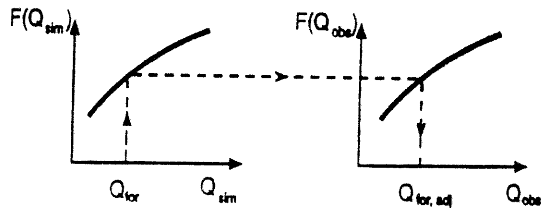

Figure 1. Schematic of error model 0

2.2 Error Model 1

The adjustment on model outputs is performed through transformed standardized normal space (so-called "z-space"; see schematic of error model 1 in Figure 2). Error model 1 attempts to preserves monthly climatological statistics, including correlation structure of streamflow. This is done based on the assumption that there is a persistence of errors in transformed space.

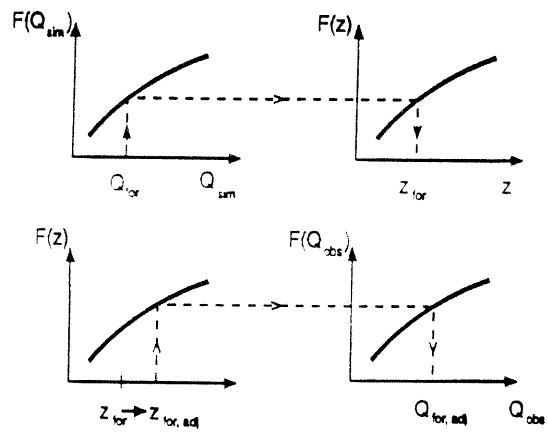

Figure 2. Schematic of error models 1 and 2

A model has two modes: deterministic and stochastic. In the deterministic mode, error at day (t) is assumed to be a function of an error at the previous day (t-1):

$$e(t) = \phi e(t-1) \qquad (1)$$

where e(t) is a normally distributed random number $e(t) \sim N(0, (\phi' \sigma_e)^2)$ that represents the error in z-space at time t; ϕ and σ_e are model parameters that have to be calibrated for each month separately.

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