Modeling and Optimizing Multi-Reservoir System for Savannah River Basin under Changing Climates

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Compared to a single reservoir and its management, characteristics of multi-reservoir systems are large-scale and complex, and basin wide water management decision-making has always been challenging. Most studies nationally have relied upon single-reservoir models to represent large-scale, multi-reservoir systems, but such abstraction might not be appropriate for the need to optimize hydropower systems on a finer time scale and examine physical behavior in response to climate trends and population growth. A growing body of research suggests proactive water resources' operational actions might have a higher success rate if improved climate predictability are being utilized. To address these issues and scientific questions, a multi-reservoir model is developed to not only capture complex interactions between storage and water demands, but also to quantify the impacts of hydroclimatical uncertainty and variability. Climate information based streamflow forecasts are statistically downscaled from Global Climate Model (GCM) data and uncertainties in precipitation changes are represented by ways of ensembles. The main objective of multi-purpose, multi-reservoir operation is to maximize the total systemwide profits from different releases and hydroelectricity generation. A technique for solving high-dimensional, non-linear problems, Particle Swarm Optimization is applied to determine the optimal releases, subject to a myriad of governing constraints and the operating constraints of meeting target storage and water contracts. The developed multi-reservoir model will be applied for the 3 reservoirs in the Savannah River Basin, a region with reasonable hydroclimate prediction skill and a critical river basin that supplies water and hydropower for South Carolina and Georgia. Efficacy and effectiveness of the developed multi-reservoir model will be compared to other existing representations such as aggregated and equivalent reservoir methods. With the need for efficient, basin-wide integrated reservoir management in handling increasing occurrence of droughts, this study contributes to the utility of improved climate forecasts in short-term reservoir management and in improving yield in hydropower generation. Further expansion of the project includes assessment of changes in temperatures and precipitation on basin-wide hydropower production on a decadal time scale and exploring adequate risk management actions and adaptation strategies under various climate scenarios.