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Overcoming the Cascading Issues of Data Scarcity and Uncertainty for Seasonal Hydropower Planning in East Africa

Akash Koppa, Mekonnen Gebremichael, and William W-G Yeh

University of California, Los Angeles, Civil and Environmental Engineering, Los Angeles, United States (akashkoppa@ucla.edu)

The classical stochastic programming with recourse for seasonal hydropower planning assumes that the first stage is deterministic i.e, the forecast for the first month is sufficiently accurate. When ensemble streamflow forecasts are used, the deterministic first month forecast is derived using weighted average of the ensemble members (for example, using Bayesian Model Averaging [BMA]). Therefore, the assumption of stochastic programming with recourse fails when streamflow data required for weighting ensemble forecasts is scarce or unavailable. This study addresses the problem of data scarcity by weighting the ensemble quantitative precipitation forecasts (QPFs) used for streamflow forecasting rather than the streamflow forecasts themselves. The 'ground truth' data for precipitation are global gridded rainfall datasets. As the global rainfall datasets (a mixture of remote sensing and gage-based datasets) exhibit large inter-dataset variability, data scarcity problem leads to the issue of data uncertainty. We address the data uncertainty problem by considering the first stage in stochastic programming formulation as stochastic.

Thus, the study addresses the following research questions: 1) What is the impact of weighting QPFs instead of streamflow forecasts on the hydropower production? 2) How does stochastic programming with first stage stochastic affect hydropower optimization compared to the classical formulation?

The study area is the Omo-Gibe basin in Ethiopia consisting of a cascade of three reservoirs (Gibe I, II and III). The time period chosen is 2005 for which hydropower production data is available. The planning horizon chosen is 9 months based on the availability of QPFs. Thirty Ensemble seasonal QPFs from NMME are used as forcing for Noah-MP hydrologic model to generate forecasts of reservoir inflows. The gridded rainfall 'ground truth' datasets are TRMM, CMORPH, CPC, GPCC, CRU, PERSIANN and CenTrends.

To address the research questions we compare hydropower production of the following four different formulations with observed power production to see if there is an improvement:
I) All stages are deterministic - derived by BMA of ensemble QPFs
II) Stochastic programming with recourse (First stage deterministic) - first stage derived by BMA of ensemble QPFs
III) Stochastic programming with recourse (First stage stochastic) - 30 scenario members in first stage are the thirty ensemble members
IV) Stochastic programming with recourse (First stage stochastic) - 7 scenario members in first stage are derived by BMA of QPFs using each of the seven rainfall datasets

Scenarios II, III and IV provide probabilistic forecasts of hydropower production taking into account uncertainty in QPFs. Preliminary results show that scenarios III and IV provide much wider range of hydropower values which is valuable in incorporating the uncertainty in validation datasets into hydropower planning.