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Atmospheric rivers and reservoir control: Combining multiple sources of forecast information to design conjunctive management policies in California

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Forecasts and observations of hydrologic and climatic states have significant potential to improve water supply and flood control operations in multi-purpose reservoirs, which largely lack formal rules describing how to incorporate this dynamic information. This study develops reservoir control policies trained on a broad set of forecasts and observations that span short-term (1-3) and medium-range (1-15 day) timescales, including: an ensemble of synthetic short-term precipitation and temperature forecasts based on state-of-the-art dynamical hindcast products; hydrologic response, based on a rainfall-runoff model; and binary forecasts of regional storm occurrence to compensate for potential spatial bias. A simulation-optimization approach is used to train reservoir policies structured as trees, which are highly interpretable and provide insight into the value of information provided by different sources of observed and forecasted data. The approach is demonstrated on a case study of Folsom Reservoir in California, using a simulation model of reservoir operations combined with a simplified groundwater model to explore the potential for conjunctive use to improve the utility of forecasts. Results show that forecasts and current-state observations need only indicate the potential occurrence of a storm, rather than its intensity, to effectively inform management decisions in regions like California where wintertime, synoptic-scale atmospheric rivers dominate the flood regime. Further, increased conjunctive use capacity reduces the importance of forecast skill, because surface storage can be moved to groundwater during the flood season without sacrificing future water supply. Finally, the policy trees trained with this approach are validated against an out-of-sample hydrologic period to ensure their robustness. This analysis serves to better link hydroclimatic observations and predictions with water resources management decisions to improve the tradeoff between water supply and flood control objectives in large, multi-purpose reservoirs in California and other regions with similar flood hydroclimatology.