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A hazard-based risk analysis approach to understanding climate change impacts to water resource systems: application to the Upper Great Lakes

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Abstract

Water resources systems are designed to operate under a wide range of potential climate conditions. Traditionally, systems have been designed using stationarity-based methods. Stationarity is the assumption that the climate varies within an envelope of variability, implying that future variability will be similar to past variability. Due to anthropogenic climate change, the credibility of the stationarity-based assumptions has been reduced. In response, climate change assessments have been developed to quantify the potential impacts due to climatic change. While these methods quantify potential changes, they lack the probabilistic information that is needed for a risk-based approach to decision-analysis. This dissertation seeks to answer two crucial questions. First, what is the best way to evaluate water resource systems given uncertainty due to climate change? Second, what role should climate projections or scenarios play in water resources evaluation? A decision analytic approach is applied that begins by considering system decisions and proceeds to determine the information relevant to decision making. Climate based predictor variables are used to predict system hazards using a climate response function. The function is used with climate probability distributions to determine metrics of system robustness and risk. Climate projections and additional sources of climate information are used to develop conditional probability distributions for future climate conditions. The robustness and risk metrics are used to determine decision sensitivity to assumptions about future climate conditions. The methodology is applied within the context of the International Upper Great Lakes Study, which sought to determine a new regulation plan for the releases from Lake Superior that would perform better than the current regulation plan and be more robust to potential future climate change. The methodology clarifies the value of climate related assumptions and the value of GCM projections to the regulation plan decision. The approach presented in this dissertation represents a significant advancement in accounting for potential climate change in water resources decision making. The approach evaluates risk and robustness in a probabilistic context that is familiar to decision makers and evaluates the relevance of additional climate information to decisions.

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