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Effects of Mixed Distribution Statistical Flood Frequency Models on Dam Safety Assessments: A Case Study of the Pueblo Dam

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Statistical flood frequency analysis, coupled with hydrograph scaling, is commonly used for dam safety assessment. The results are highly sensitive to statistical model choice. Past studies typically use a single distribution model, often the Log Pearson Type III or Generalized Extreme Value distributions. Floods, however, may result from multiple physical processes such as snowmelt or intense rainstorms. These differing processes can result in a mixed distribution of annual peak flows. Engineering design choices based on a single-distribution statistical model may hence be vulnerable to the effects of structural model error. Here we analyze observations from Pueblo, Colorado, where summer snowmelt and intense summer rainfall are key drivers of annual peak flows. This has potential implications for the annual probability of overtopping induced failure of the Pueblo Dam. We bypass the temporal separation problem by building on previous work of fitting mixed distributions directly to mixed distribution annual peak flows. We first use hydrograph scaling and a flood routing model to determine the design flood. We then analyze annual peak flows, historical floods, and paleo records through both single and mixed distribution statistical models to estimate return periods of the design flood. We address three questions: (1) How sensitive are the flood frequency results to the statistical model choice? (2) Which statistical model fits the data best? (3) How does this model structural uncertainty impact flood risk assessments?