



PROJECT MANAGEMENT CENTER FOR EXCELLENCE

A.J. CLARK SCHOOL OF ENGINEERING
Civil & Environmental Engineering Department



UNCERTAINTY CHARACTERIZATION IN QUANTITATIVE MODELS

A. Komey, R. Patov, G. Baecher
2017 Project Management Symposium

PRESENTATION OUTLINE

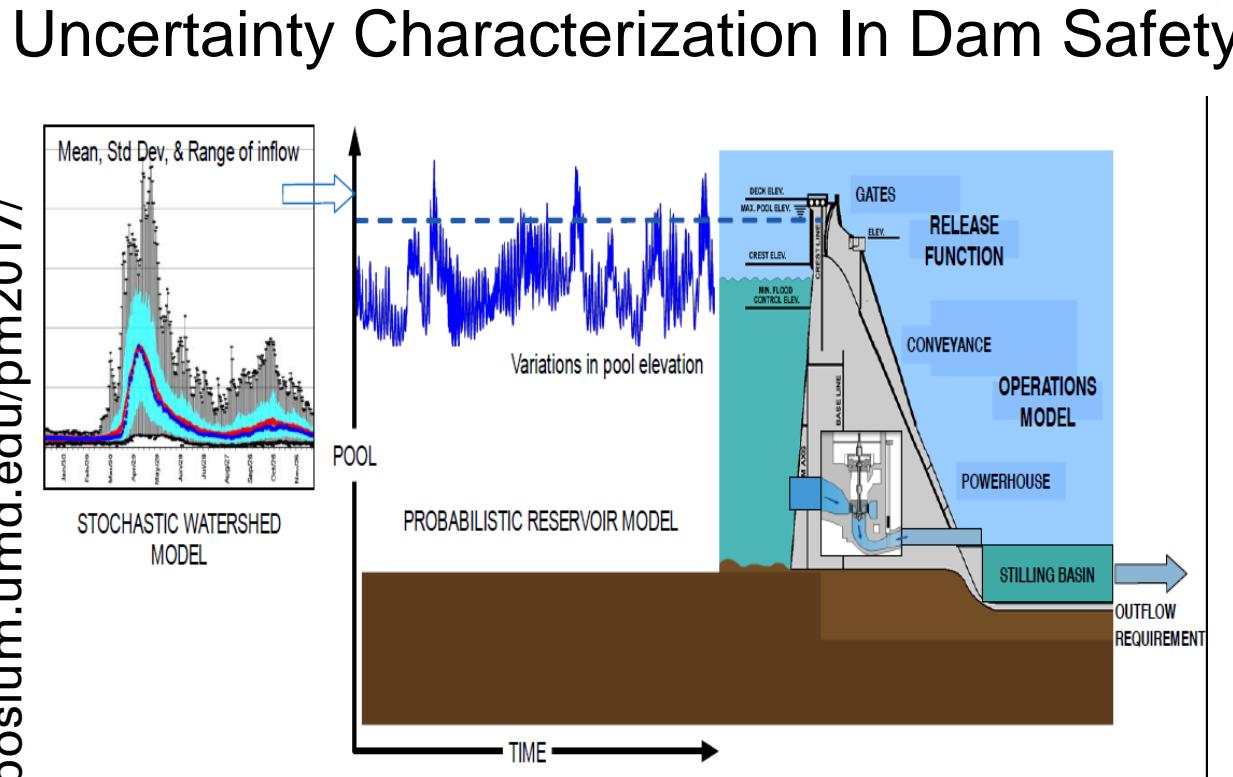
Background & Motivation

Concepts

Research Synthesis

Concluding Remarks

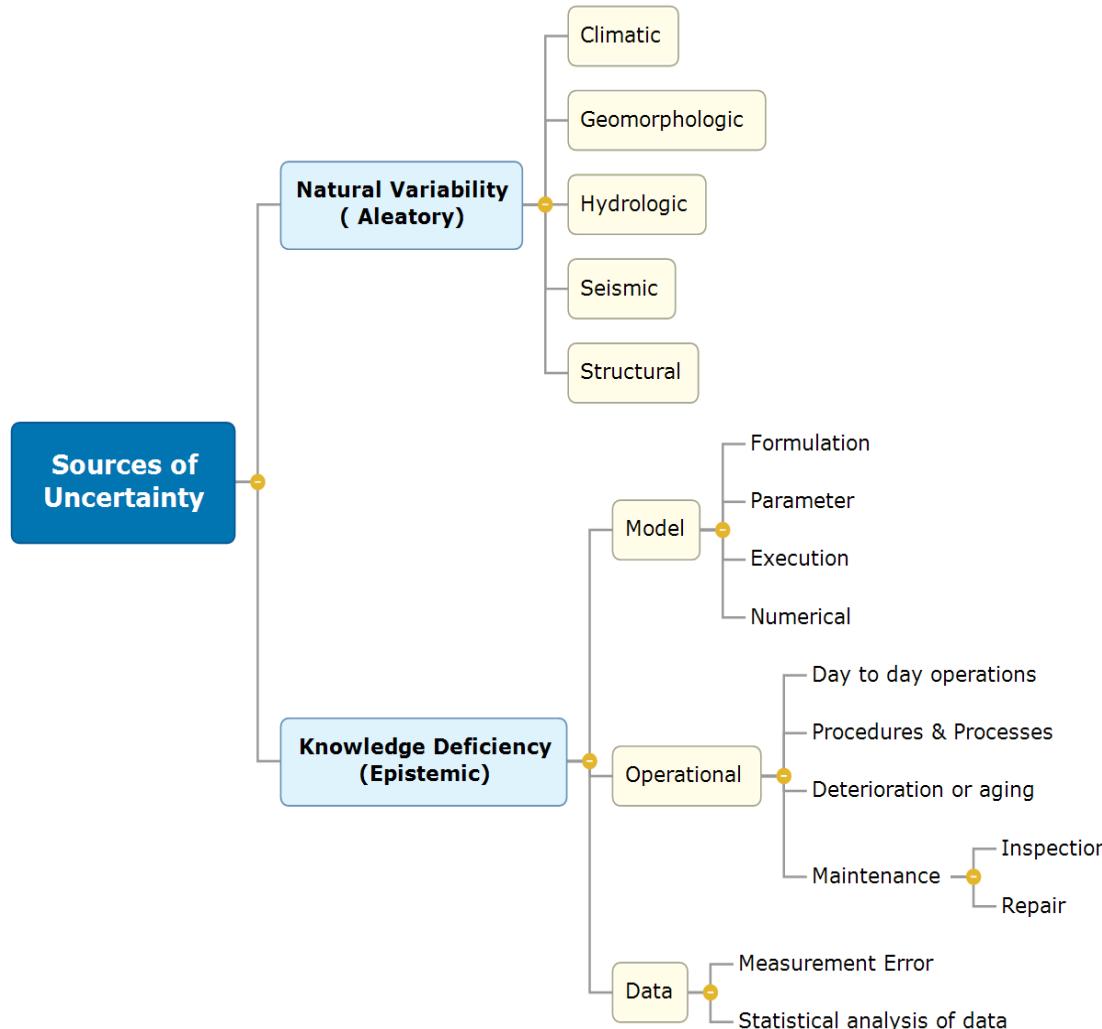




Modelling Framework

- Stochastic Simulation (Monte Carlo approach)
- Engineering modelling
- Component reliability analysis
- Systems reliability assessment
- Uncertainty characterization and propagation through Systems Model

Sources of Uncertainty



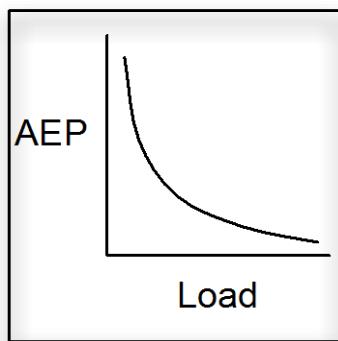


Categories of Uncertainty

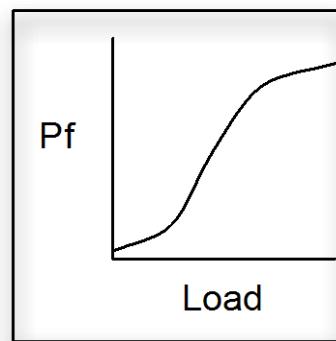
- (i) Input parameter uncertainty** (each model requires a, typically high dimensional, parametric specification)
- (ii) Boundary condition uncertainty** (uncertainty as to boundary conditions, initial conditions, and forcing functions),
- (iii) Structural Uncertainty** (the model only approximates the physical system)
- (iv) Observational Error** (Observational uncertainty arises due to errors in the measurement of natural systems, resulting discrepancies between the real system observations and the outputs produced by the simulator),
- (v) Scenario uncertainty** (scenario identified based on possible combinations of input data to provide insight into the consequences of each scenario).

General Modelling Protocol (Dam Safety Risk Analysis)

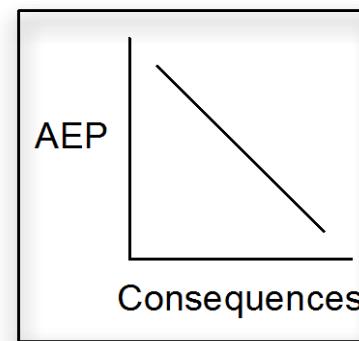
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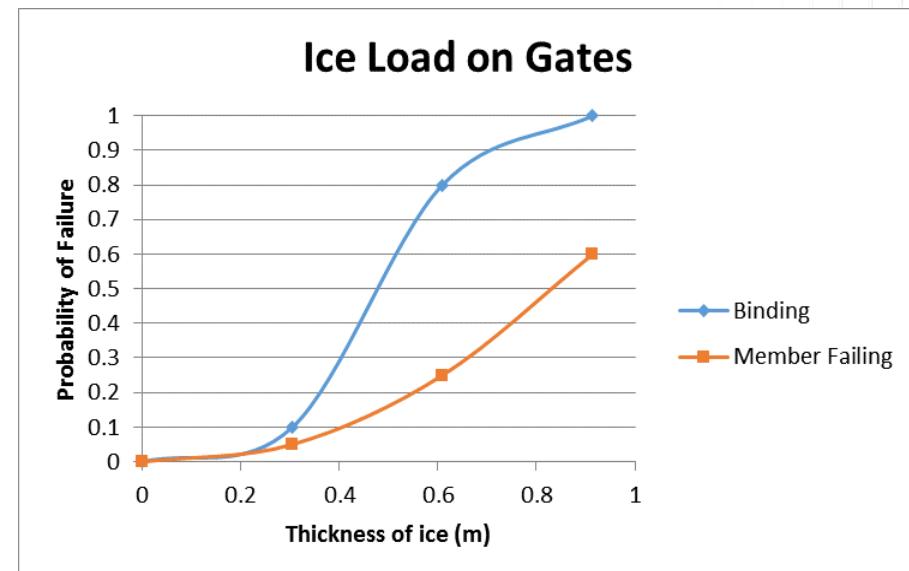
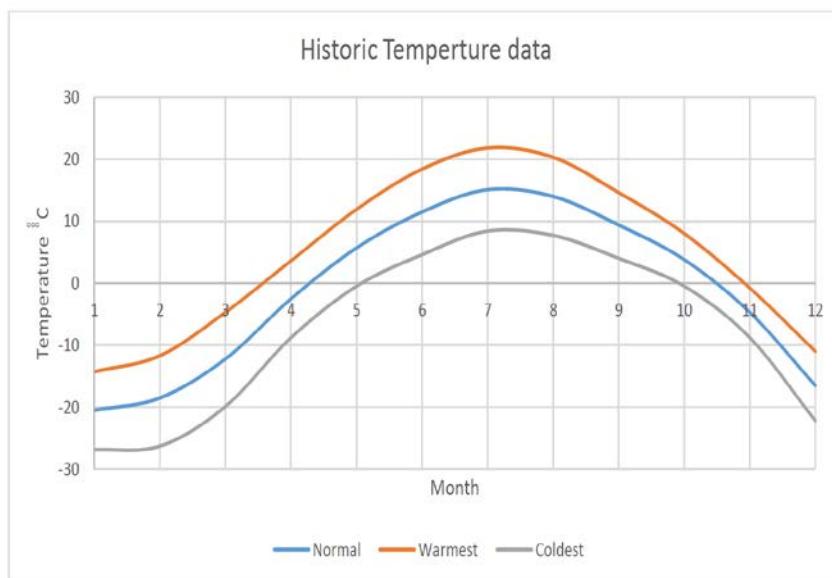
$P(\text{Failure}|\text{Load})$



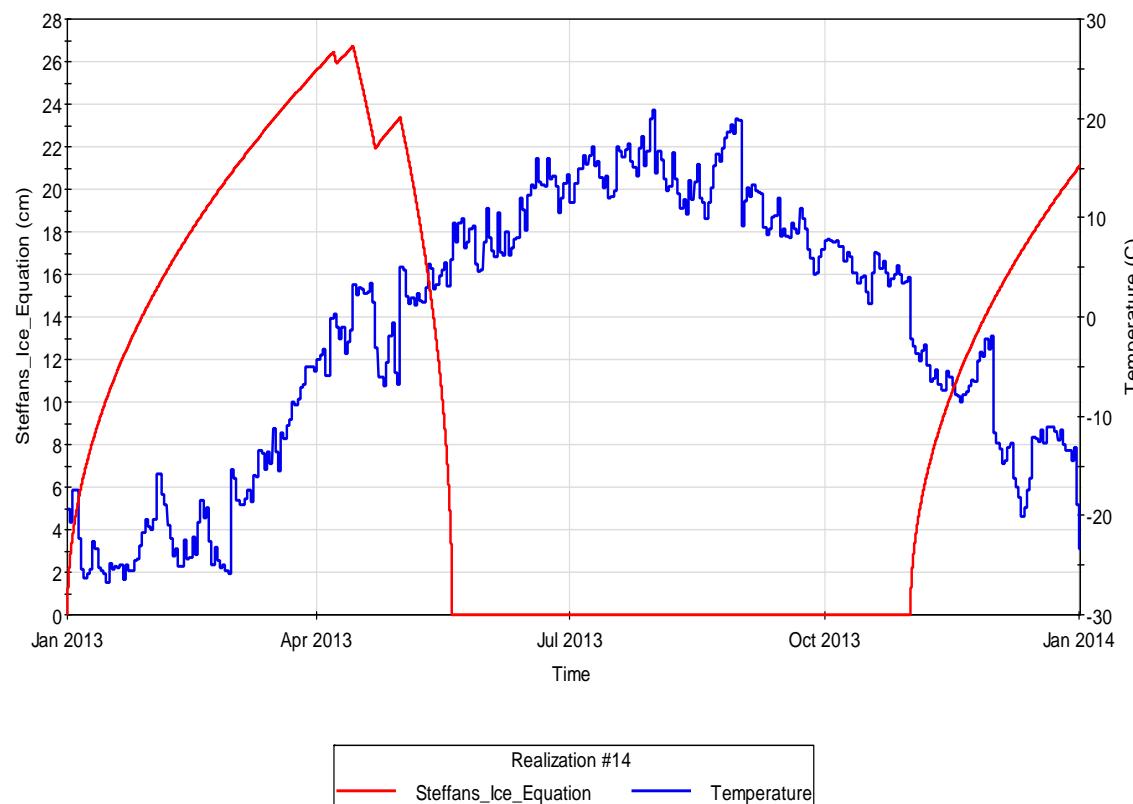
$P(\text{Consequences})$



INPUT PARAMETER UNCERTAINTY LMR COMPLEX EXAMPLE



Ice Build-up in Reservoirs



Stefan Equation
 $H=2.7\sqrt{\text{Freezing Degree Days [}^{\circ}\text{Cdays]}}$

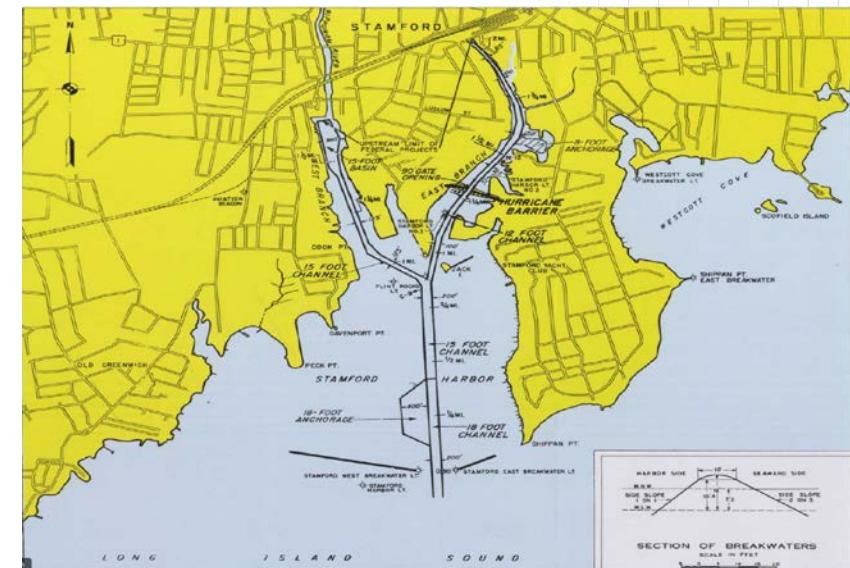
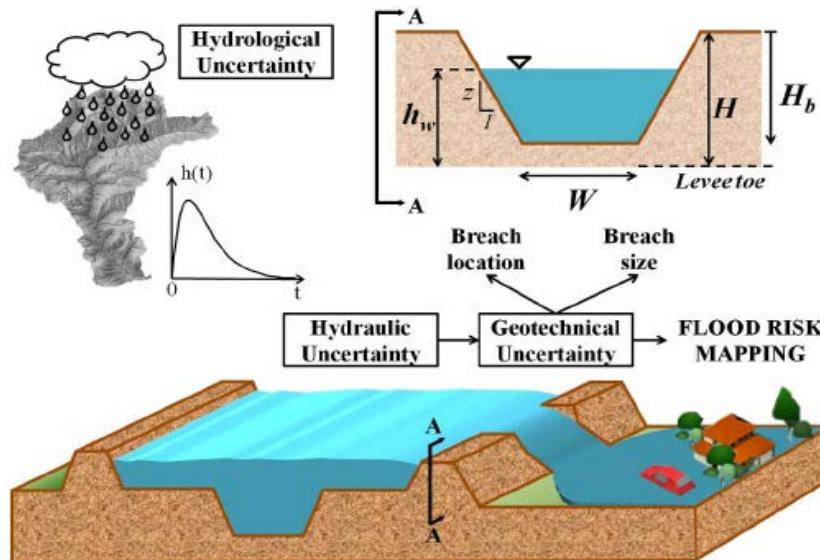


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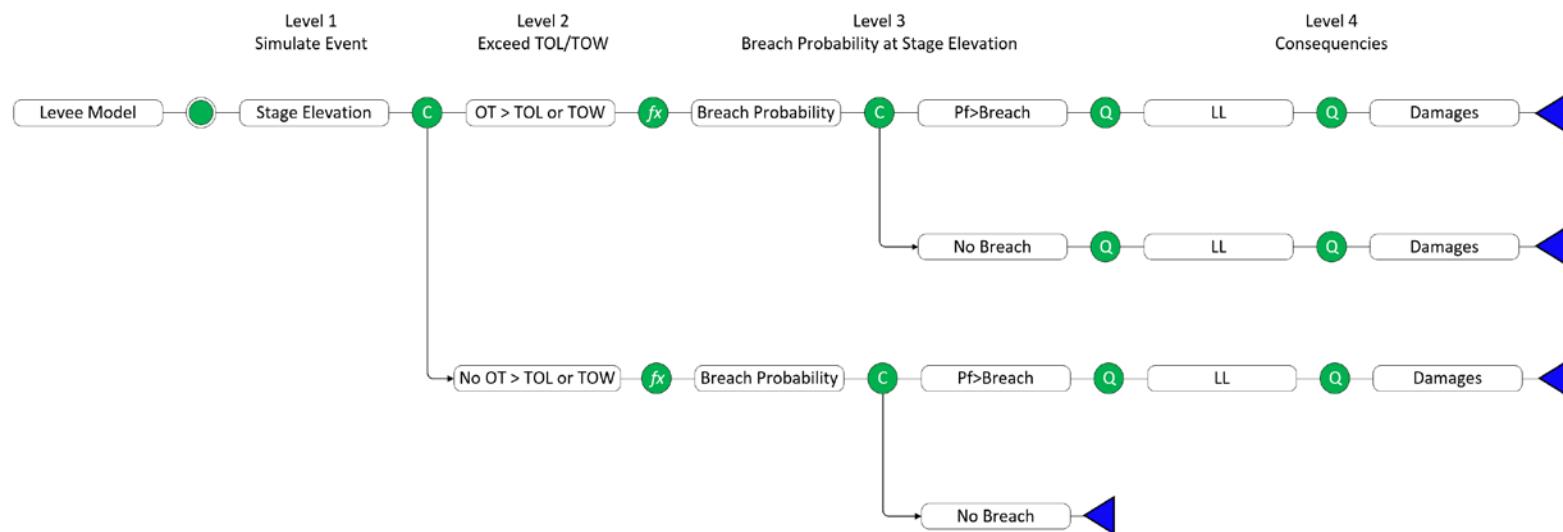
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STAMFORD HURRICANE PROTECTION BARRIER



- Constructed between 1965 and 1969.
 - Provides protection to about 600 acres, which includes principal manufacturing plants, a portion of the main commercial district, and residential sections.
 - The hurricane barrier (above) consists of three elements which protect the project area against tidal surge during hurricanes and severe weather.

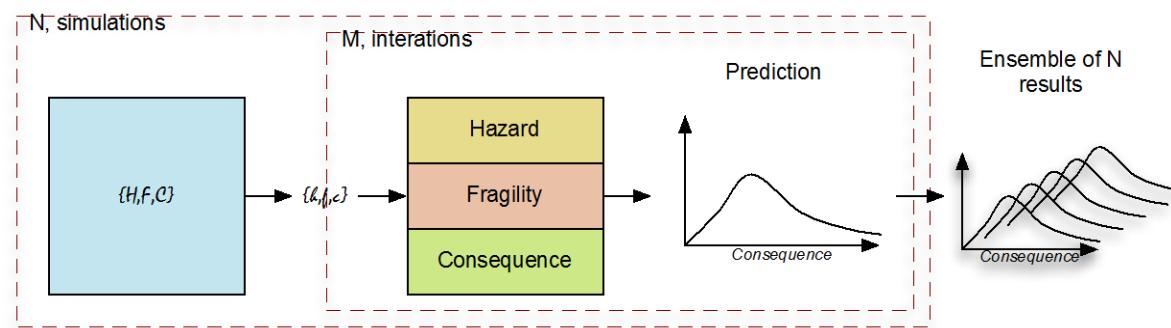
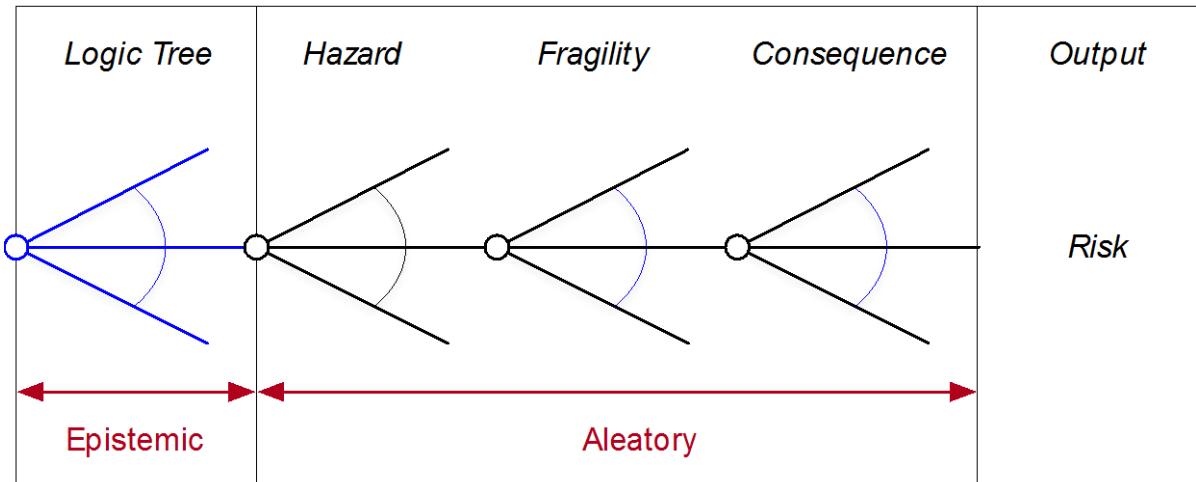
Model Structure



The key elements of this event tree are:

- Chance nodes: Stage elevations modeled as a continuous distribution.
- Conditional nodes: Overtopping if stage elevation exceeds a critical height.
- State variable nodes: Total probability of breach at simulated stage elevation.
- Discrete event nodes: Breach/No Breach; outcome simulated.

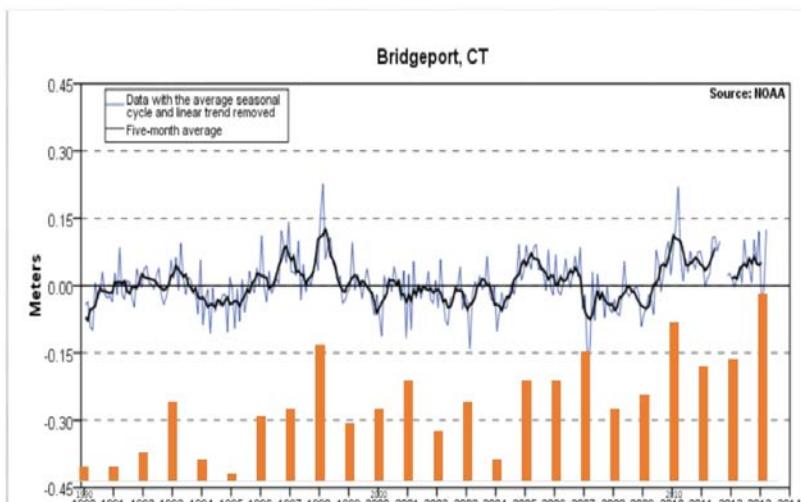
Logic tree approach to Uncertainty Propagation



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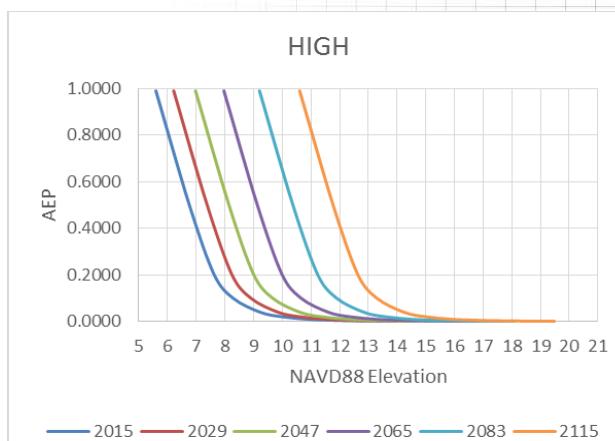
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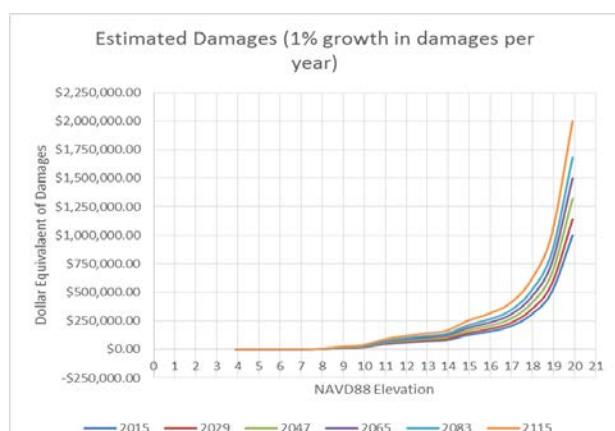


Historical peak stage elevations
annual trends

Model Inputs

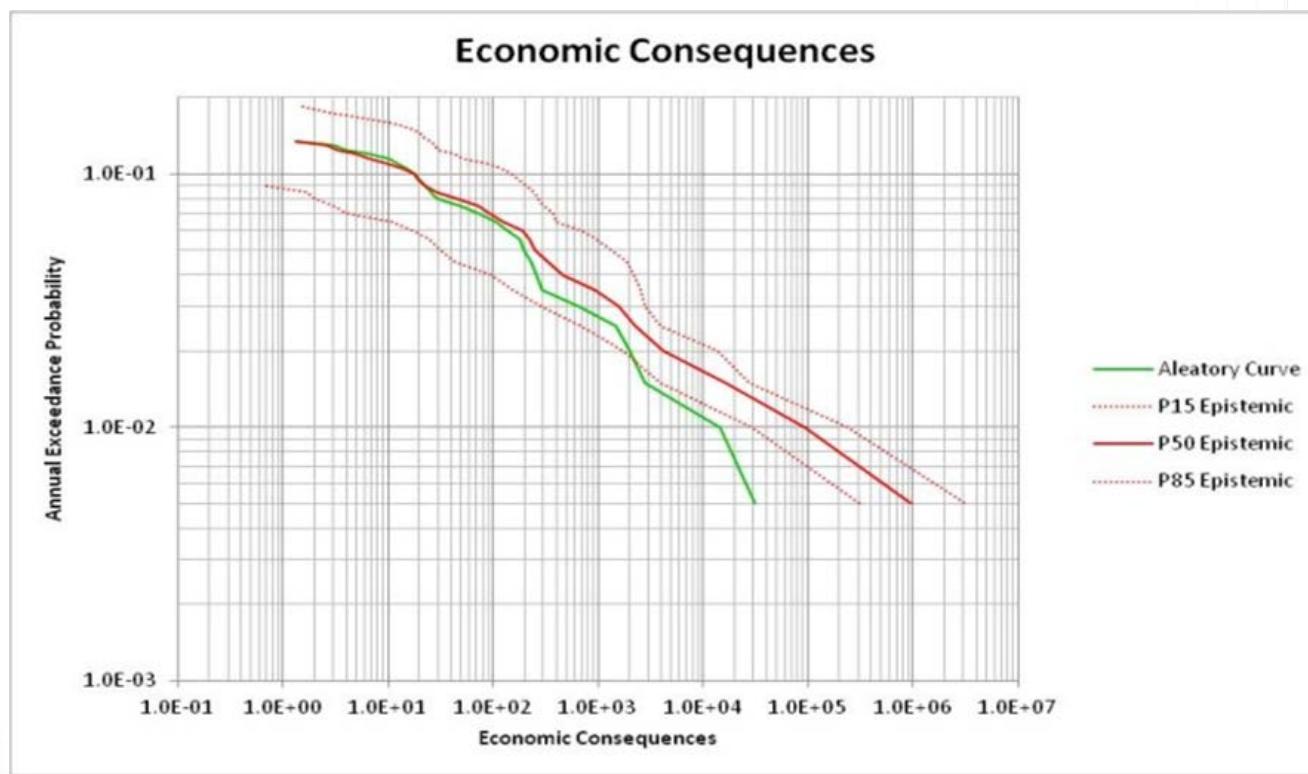


Hazard curves



Economic Consequences of Levee
System Breach

Output Aleatory and Epistemic Uncertainty Curves for Levee System





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Concluding Remarks

- To analyze the uncertainty about complex systems, it is important to have an overall framework to unify all of the sources of uncertainty.
- Within this framework, all of the scientific, technical, computational, statistical and foundational issues can be addressed.
- Such analysis poses serious challenges, but they are no harder than all of the other modelling, computational and observational challenges involved with analyzing complex systems.



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THE END

THANK YOU