## Probabilistic Assessment of Flood Hazards Due to Combinations of Flooding Mechanisms: Study Progress and Next Steps

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### **Project Overview**

### **NRC Sponsored Project Title:**

Methods for Estimating Joint Probabilities of Coincident and Correlated Flooding Mechanisms for Nuclear Power Plant Flood Hazard Assessments

### **Project Objective:**

Provide technical background for the development of flood hazard curves for multimechanism floods (MMFs)

### **Project Overview**

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Task	Description	Status
1	Survey of current concepts and methods in MMF hazards	Complete
2	Critical assessment of selected methods and approaches for quantifying probabilistic MMF hazard risk	Complete [Under Review]
3	Development of example case studies to illustrate best practices for quantifying probabilistic MMF hazard risk	In-Progress

### Terminology Hierarchy



## Categories of Flood Mechanism Combinations

Note: The ellipses ("...") in this figure indicate that nodes are (could be) present but are not explicitly shown.



(a) Coincident Mechanisms

(b) Concurrent Correlated Mechanisms (c) Induced Correlated Mechanisms







ΙZ







## Scope of Existing Studies

	Storm surge combined with precipitation and/or river flow				
Coastal MMFs	Surge, waves, and water levels				
	Tides and tsunamis (process interactions)				
Non-coastal	Combined river discharges at river confluences (copula based flood frequency analysis)				
MMFs	Other hazards (e.g., rain on snow)				

## Key Insights from Existing Studies

#### Key characteristics

- Site-specific (but geographically diverse)
- Focus on (relatively) short return periods
- Diversity in phenomena considered and definition of flood severity metrics

#### **Diversity of modeling considerations**

- Return periods considered (typically "short")
- Data source and length of record (often "short")
- Statistical modeling approaches and choices Ex:
  - Direct estimation? Bayesian Approach? Copula?
  - Why type of copula is better?
  - How to address concurrence of extrema?
- Model validation approach

#### **Challenges and Gaps**

- Inconsistencies in terminology Same words ↔ Different concepts Same concepts ↔ Different words
- Scope and focus of studies (intended results)

Development of hazard curve (surface)

#### VS.

"building blocks"

- Lack of comprehensive frameworks
- Limited treatment of certain phenomena and mechanisms

### Next Steps

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### Next Steps



Overall Approach: Copula

Data Sources: Observed (streamflow) and Synthetic (hydrologic [VIC] model output)

Key Models: Statistical, Numerical/Hydrologic

#### **Anticipated Outcomes**

#### Demonstrate:

- General procedures to construct multivariate joint distributions using copulas
- Selection of suitable marginal distributions and copula functions
- Potential applications of copuladerived joint distributions in PFHA
- Strengths and limitations of the copula-based MMF assessment approach

### Next Steps



#### **Overall Approach: Bayesian**

Data Sources: Observed (tidal, streamflow, precipitation, hurricane track) and Synthetic (numerical model output)

#### Key Models: Statistical, Surrogate

#### **Anticipated Outcomes**

#### Demonstrate:

- General conceptual approach to construct multivariate joint distributions using Bayesian modeling approaches
- Development and use of requisite marginal and conditional distributions
- Quantification of joint distributions and development of hazard curves through forward inference
- Strengths and limitations of the Bayesian-motivated MMF assessment approach

# Questions?

