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

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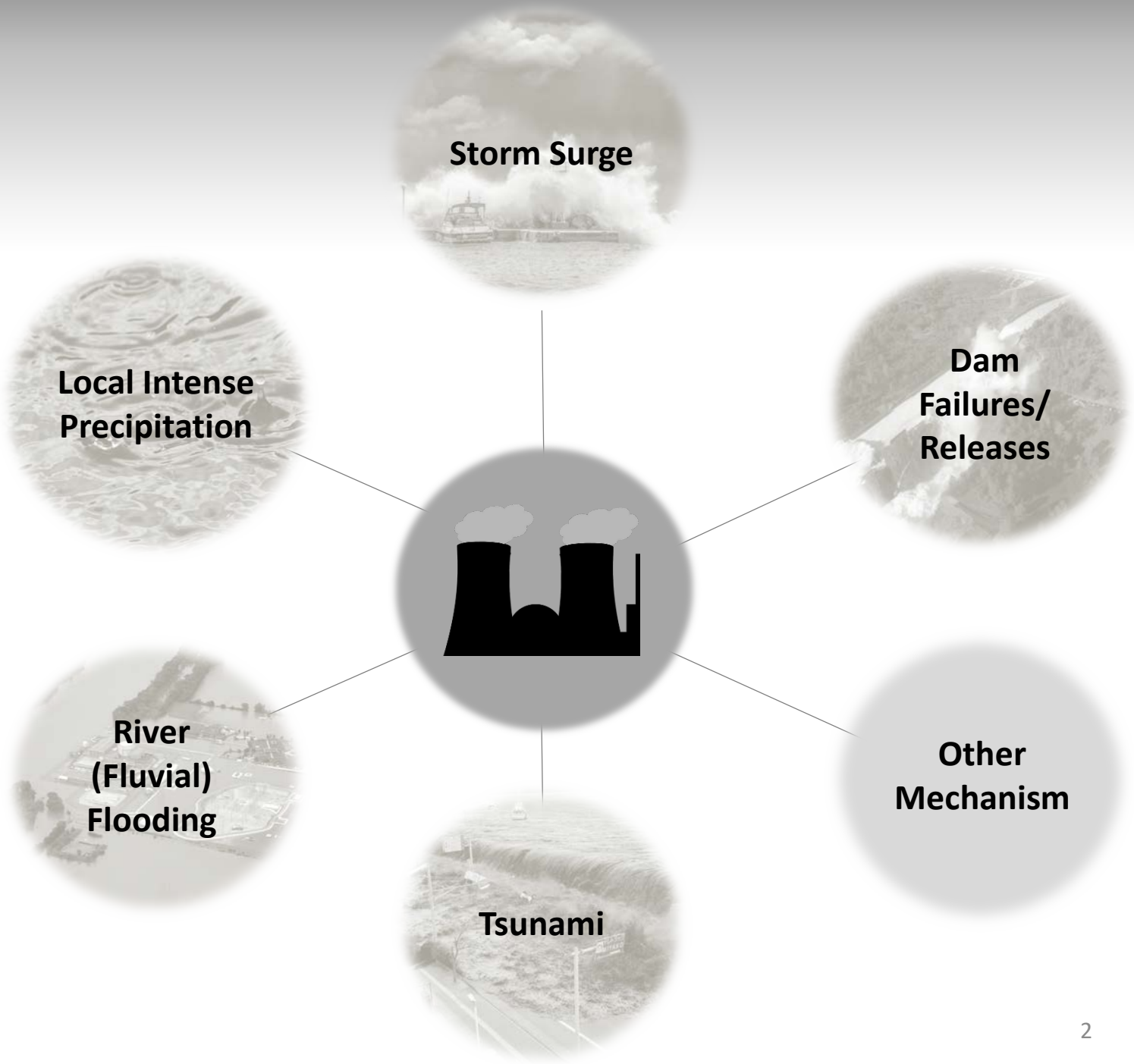
Project Context



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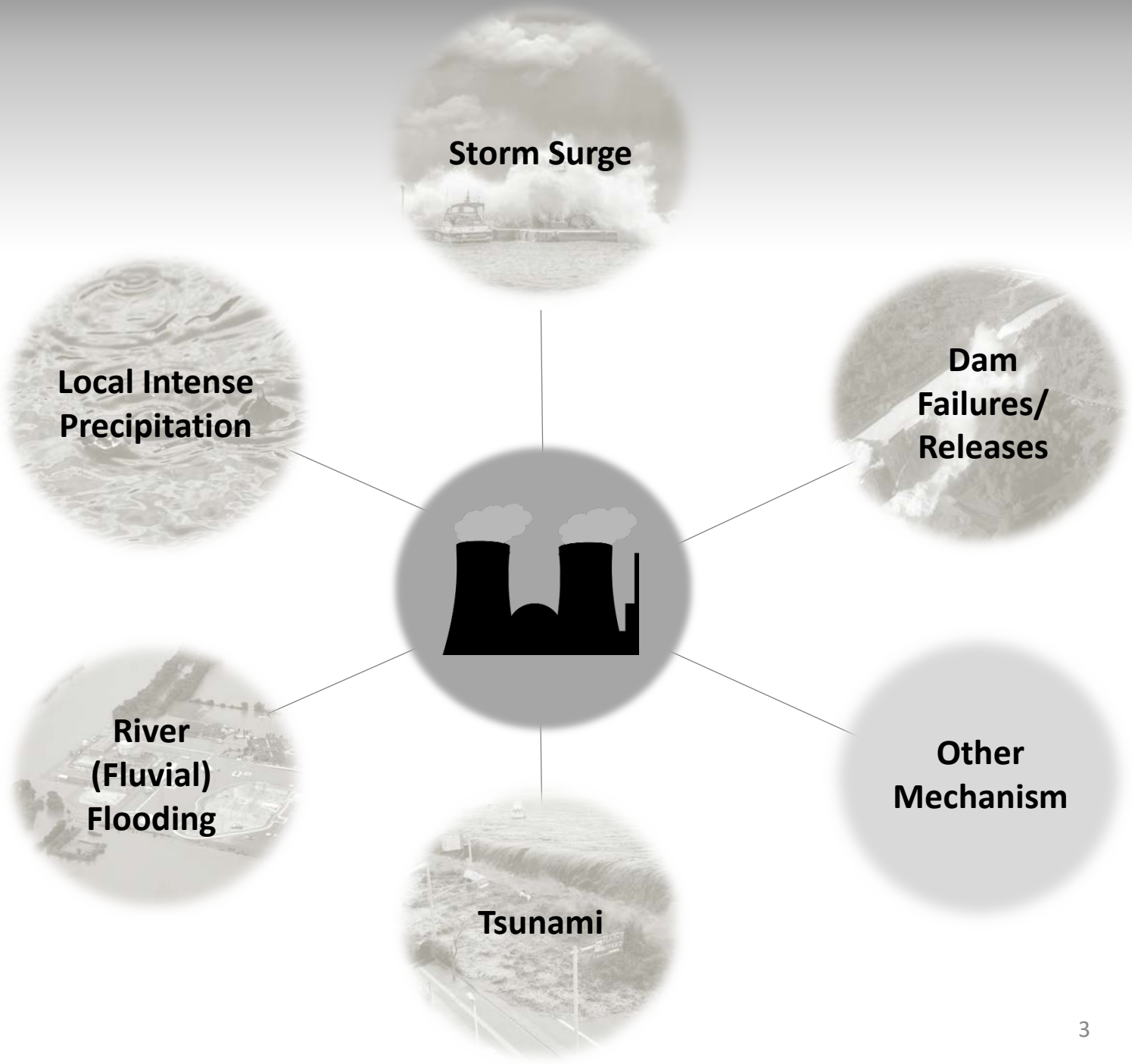

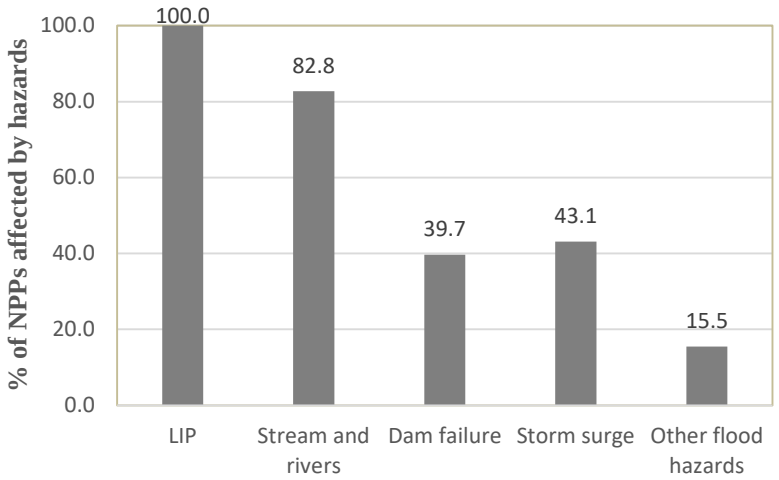

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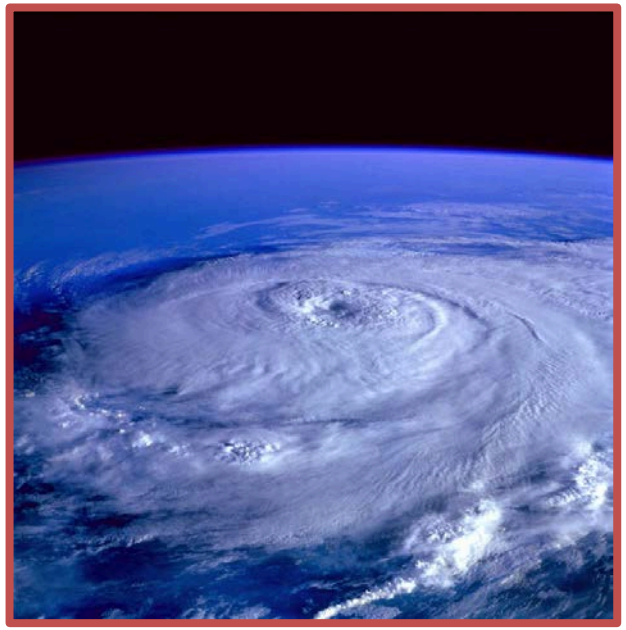

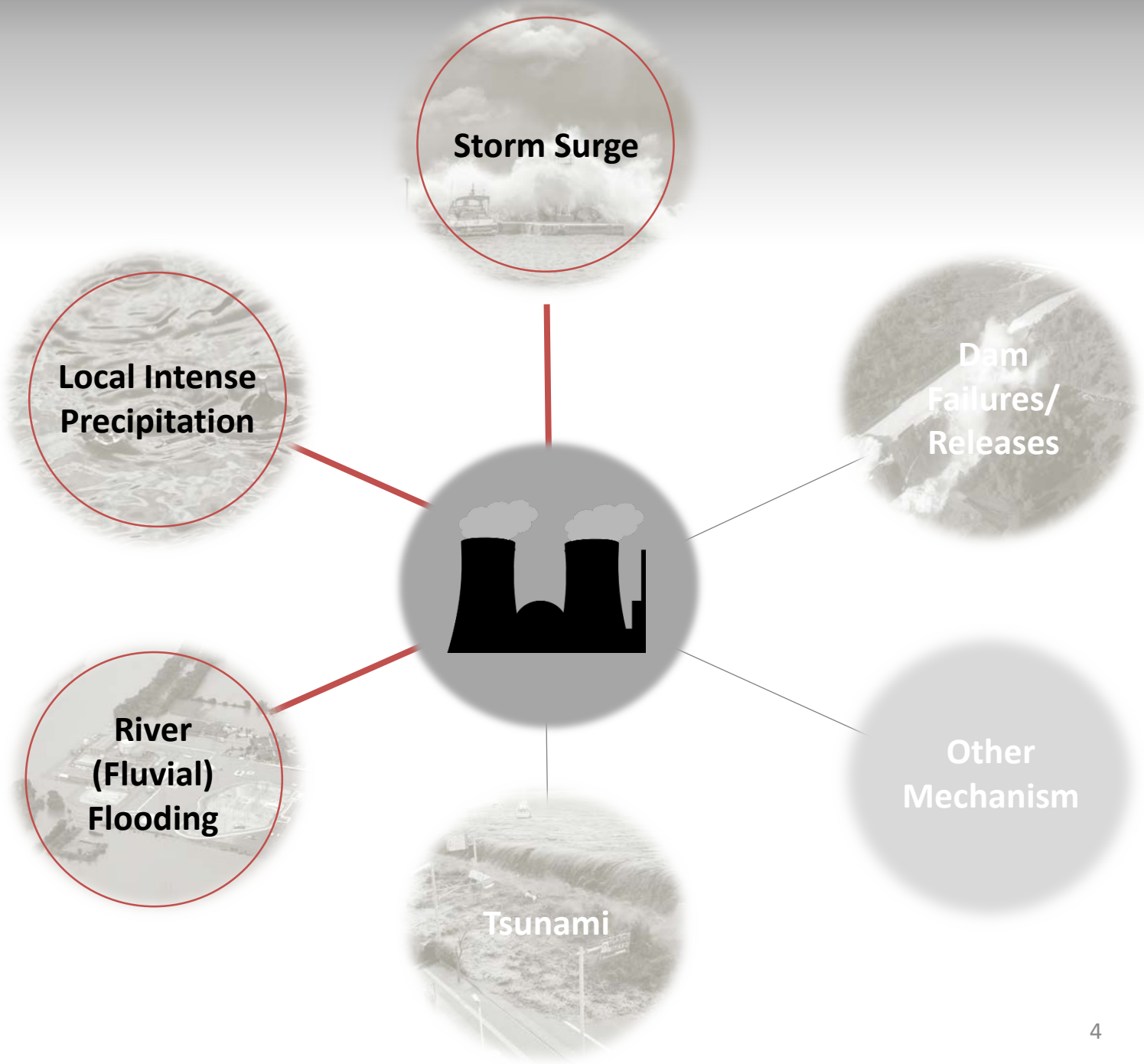

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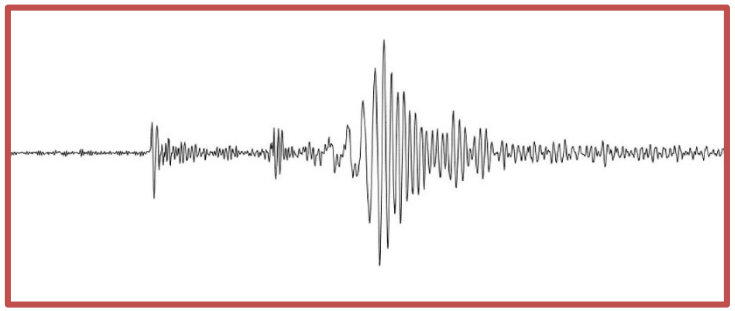

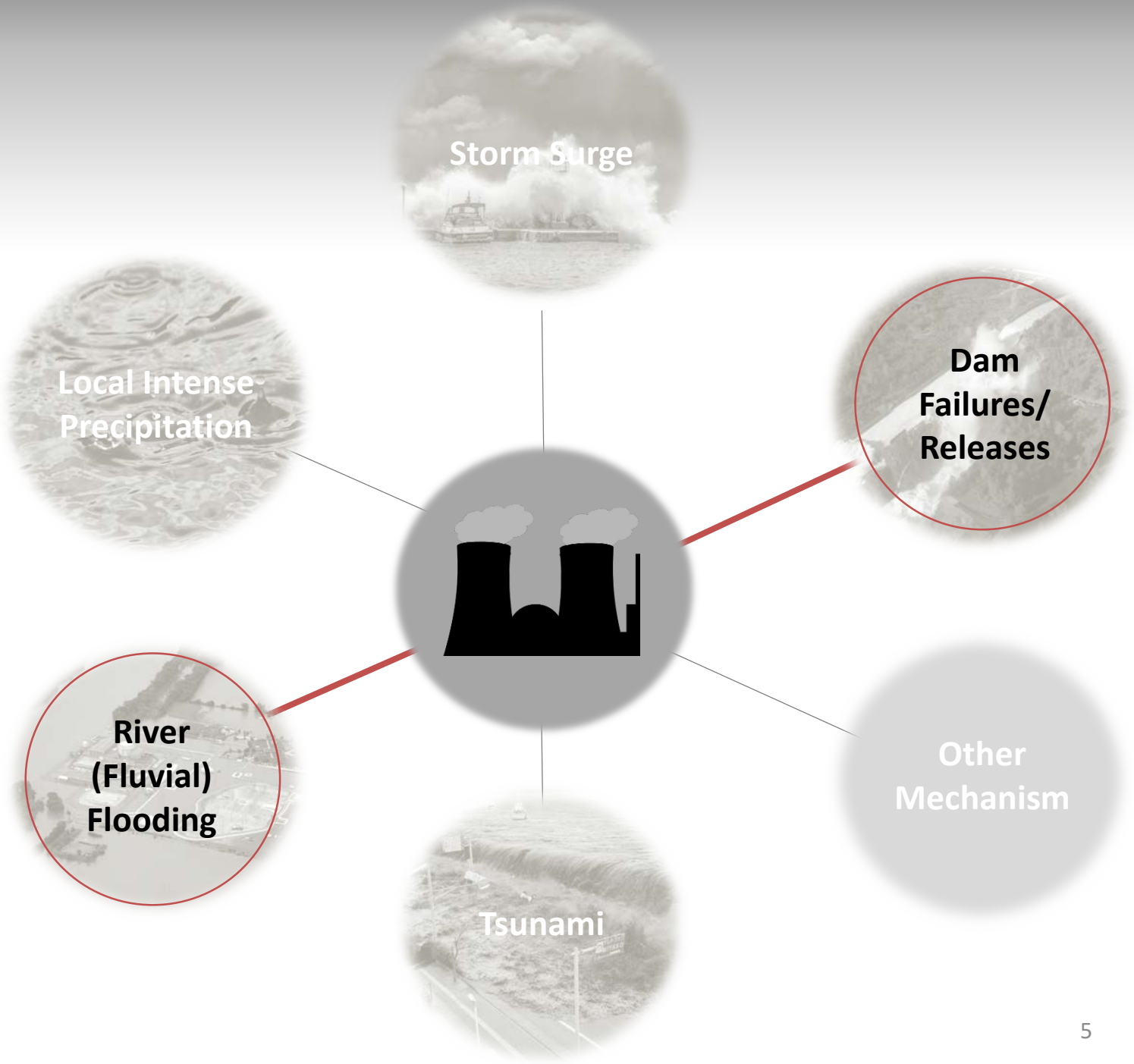

Project Overview

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 multi-mechanism floods (MMFs)

Project Overview

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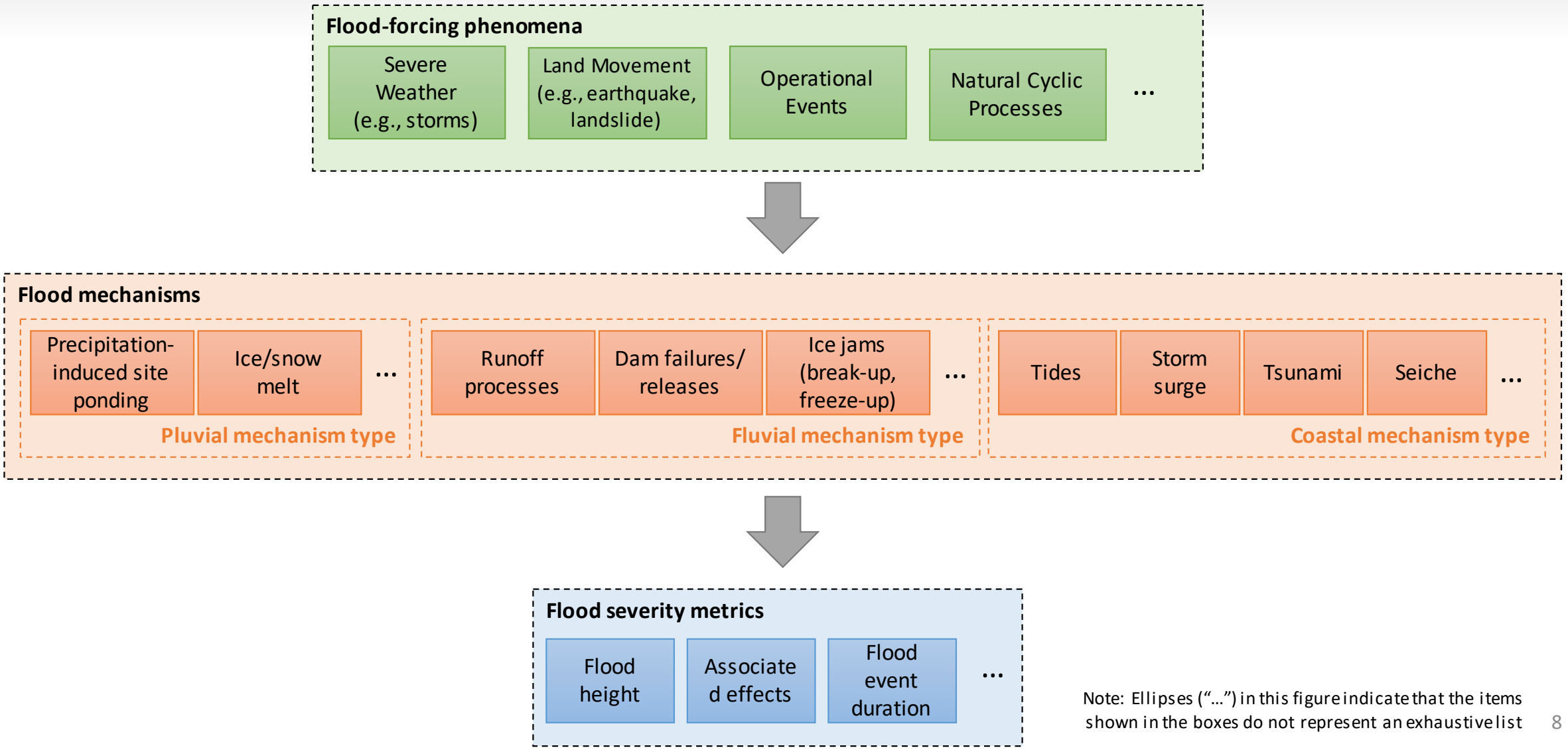
Task	Description	Status
1	Survey of current concepts and methods in MMF hazards	Complete
2	Critical assessment of selected methods and approaches for quantifying probabilistic MMF hazard risk	Complete [Under Review]
3	Development of example case studies to illustrate best practices for quantifying probabilistic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

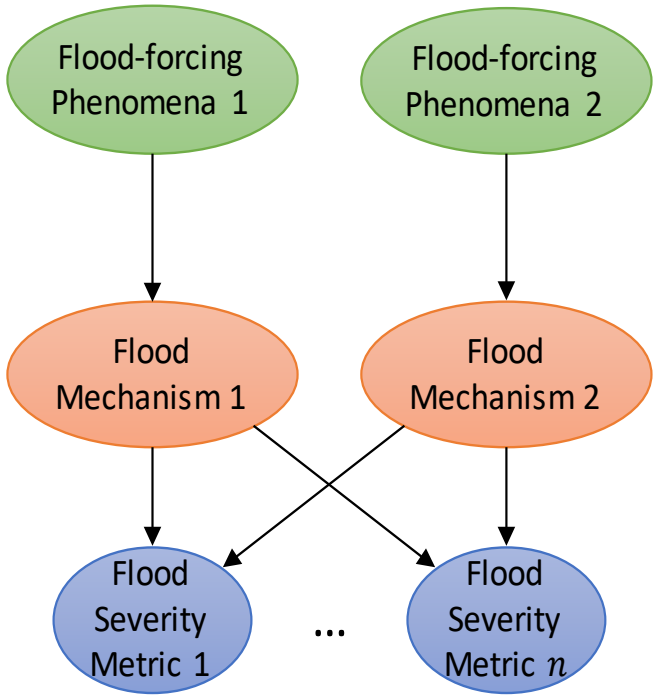
Terminology Hierarchy



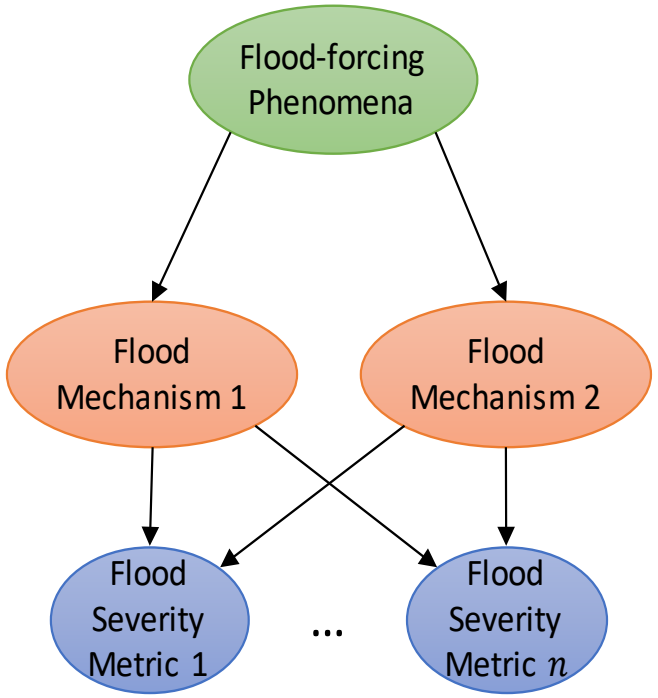
Note: Ellipses ("...") in this figure indicate that the items shown in the boxes do not represent an exhaustive list

Categories of Flood Mechanism Combinations

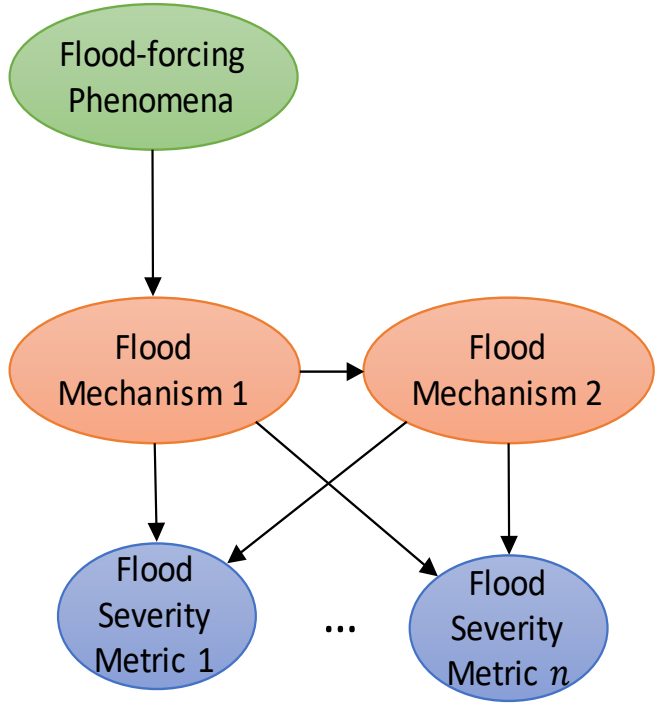
Note: The ellipses ("…") in this figure indicate that nodes are (could be) present but are not explicitly shown.



(a) Coincident Mechanisms

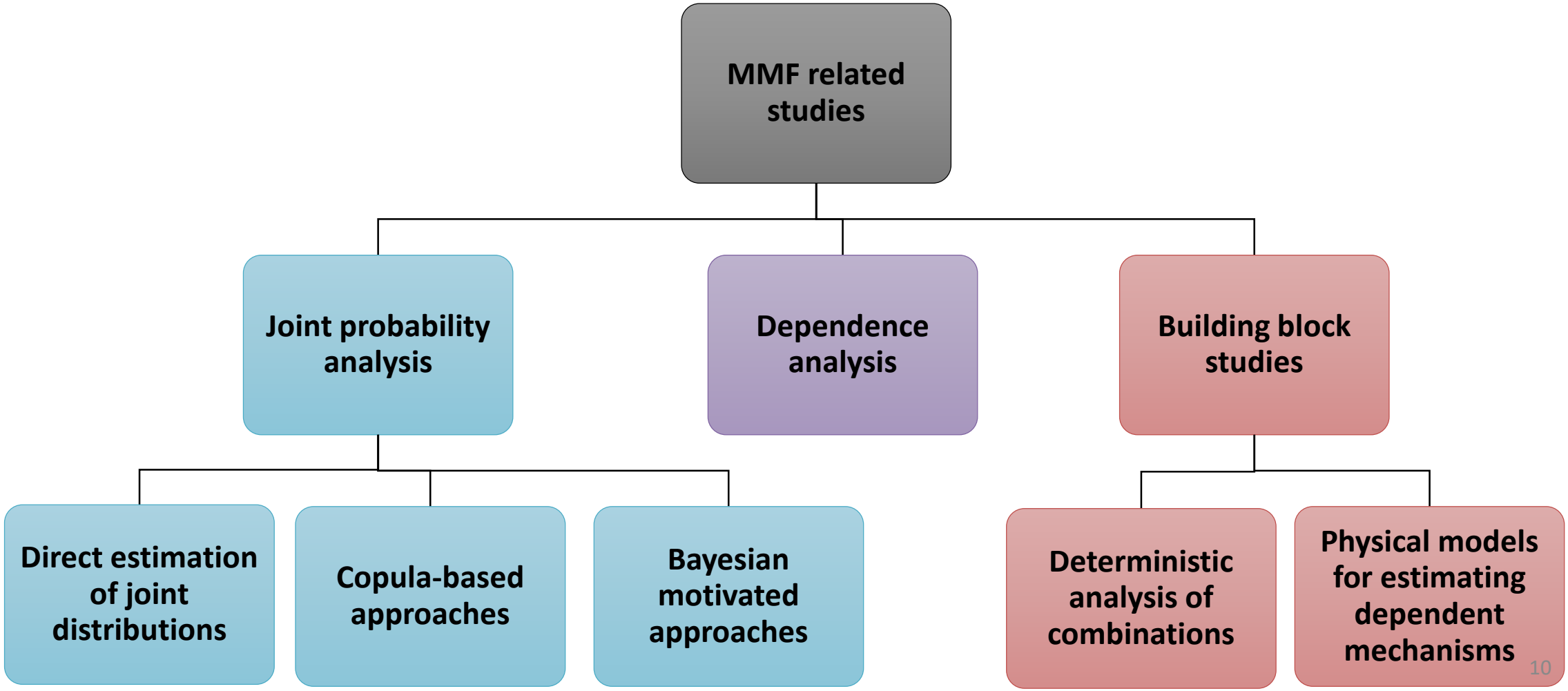


(b) Concurrent Correlated Mechanisms



(c) Induced Correlated Mechanisms

Summary of Existing Resources



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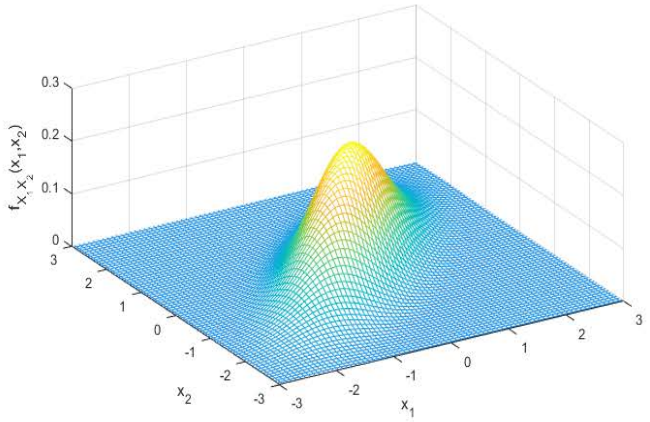

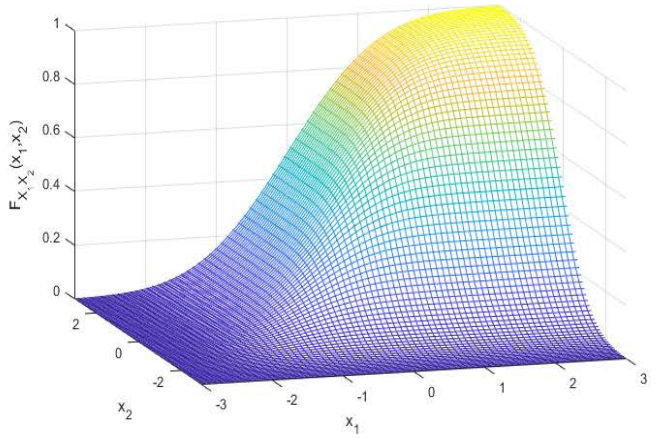

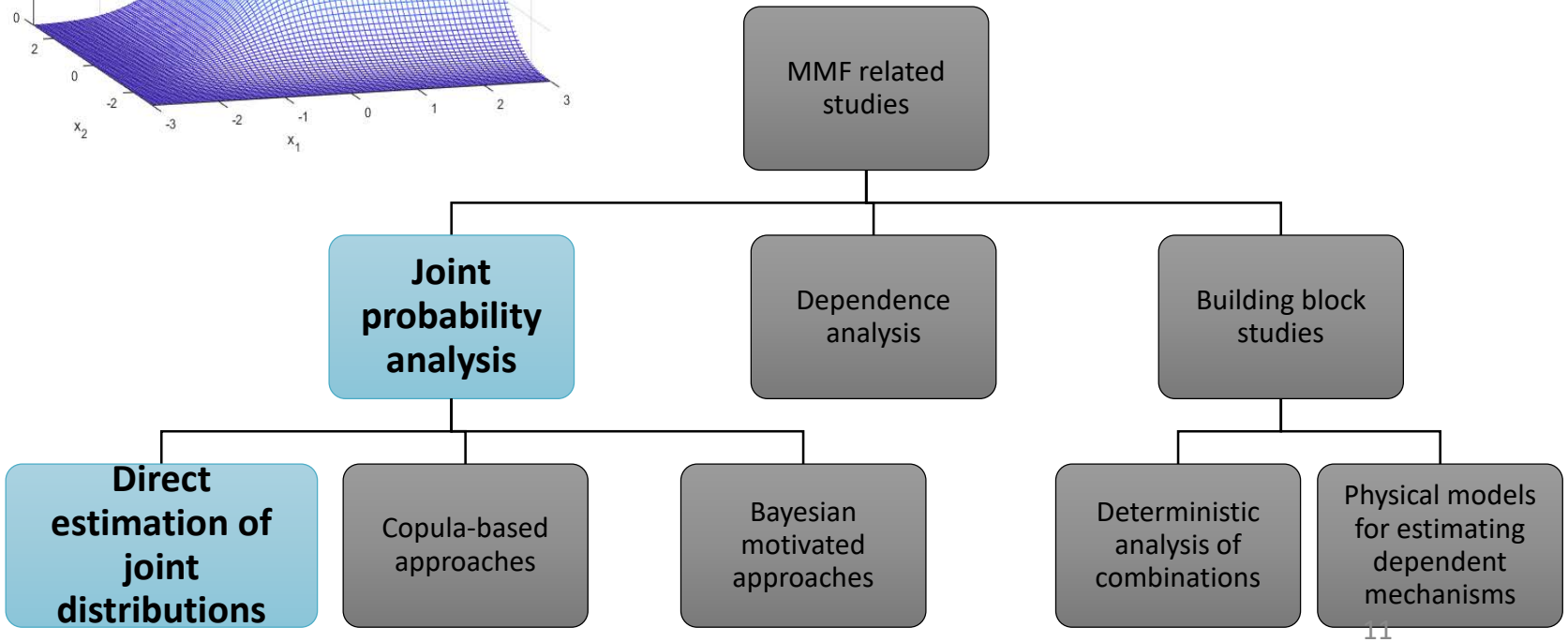

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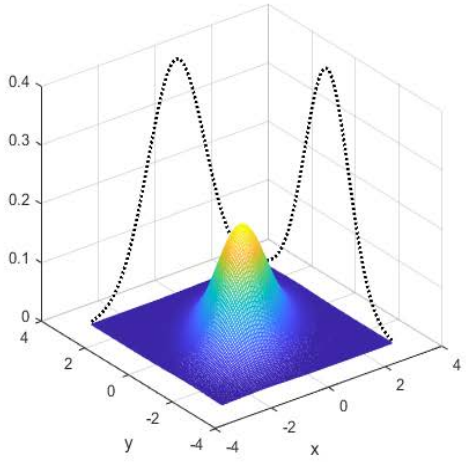

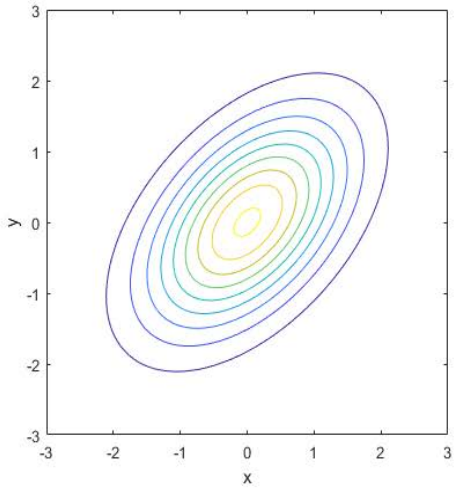

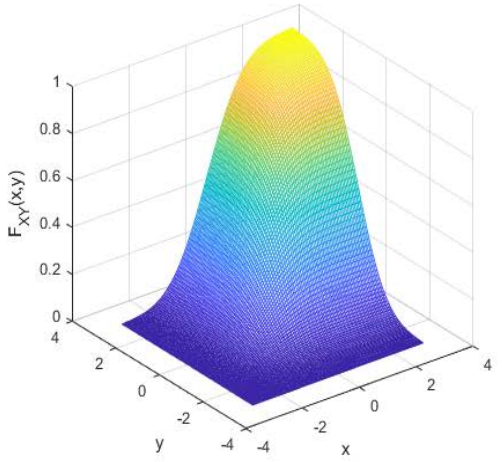

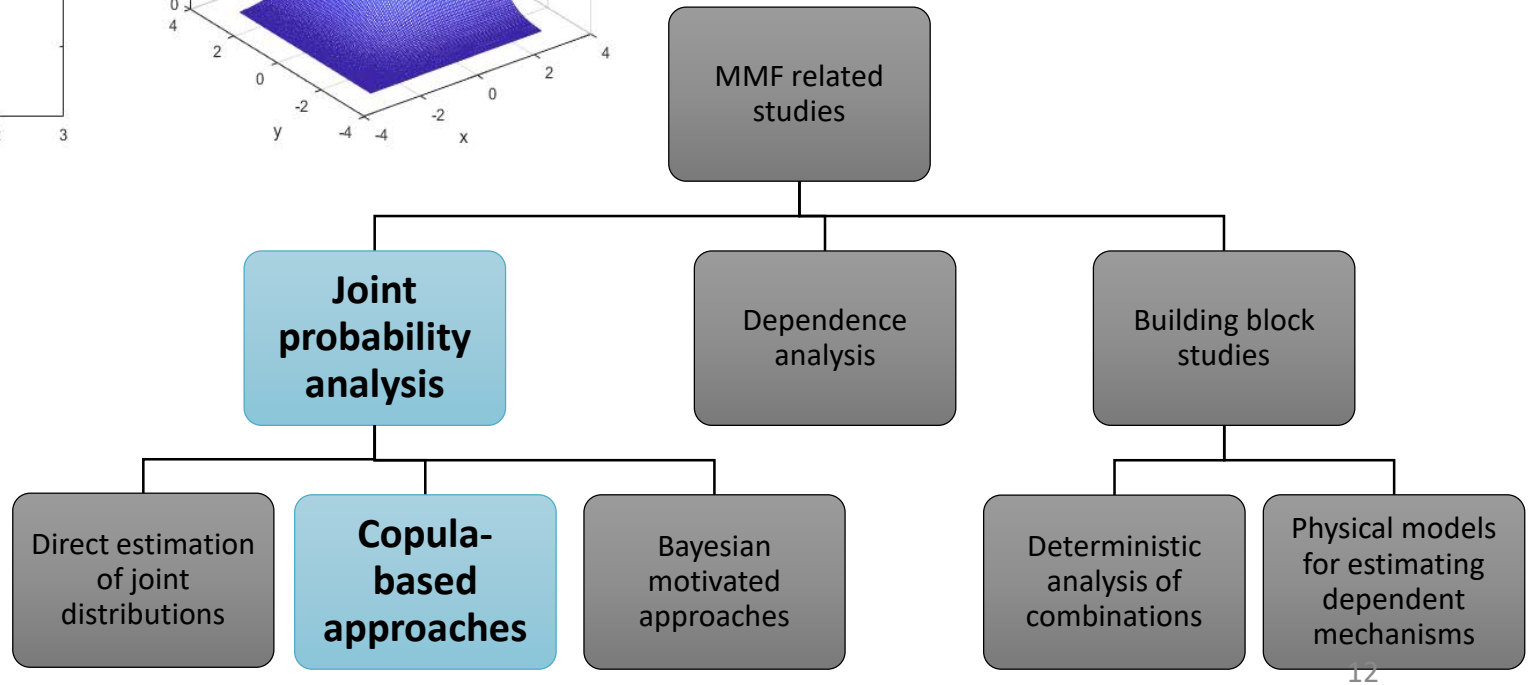

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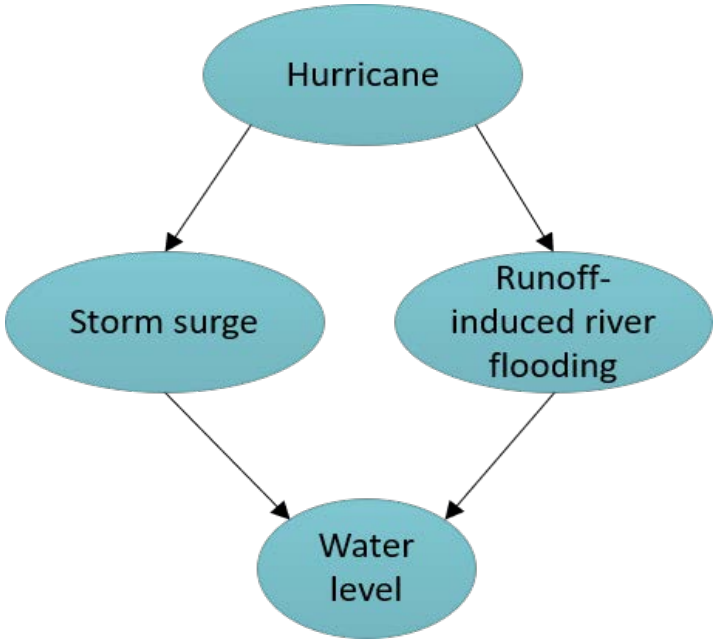
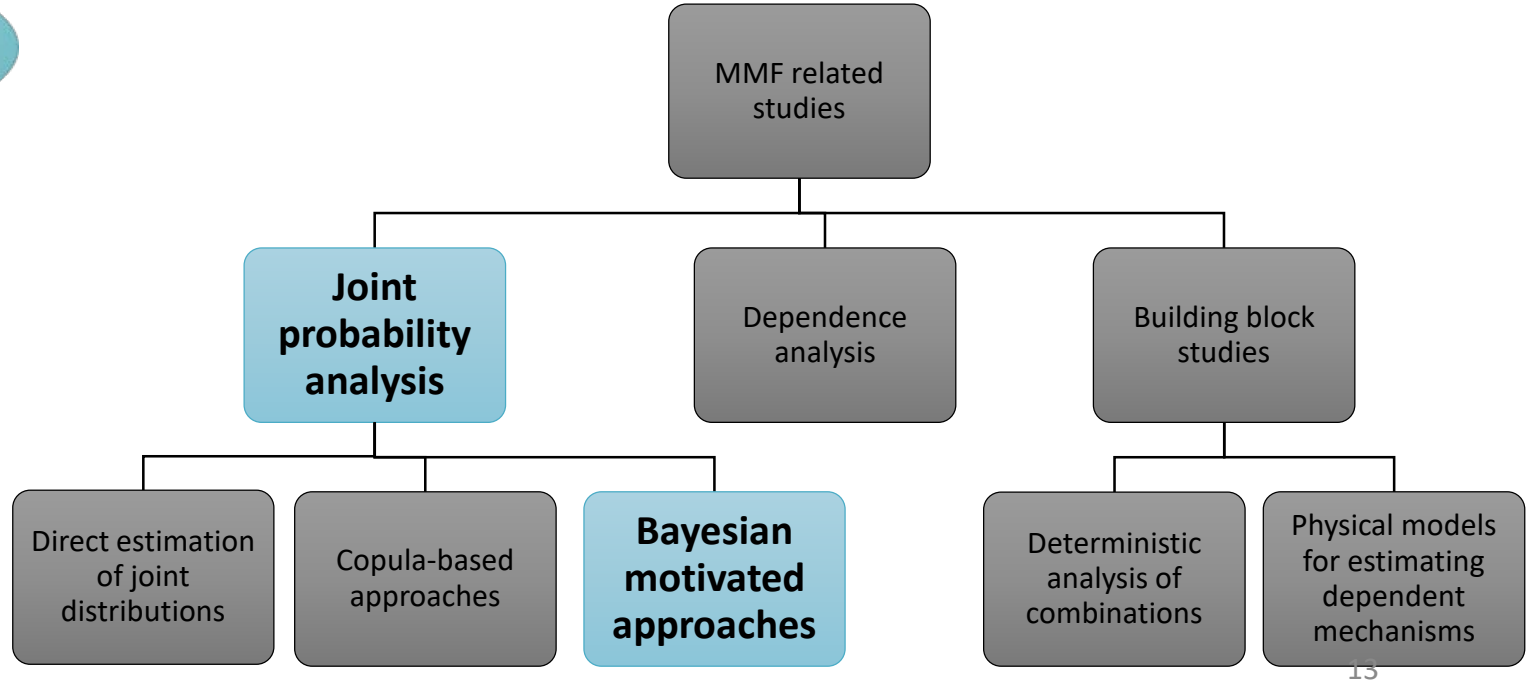


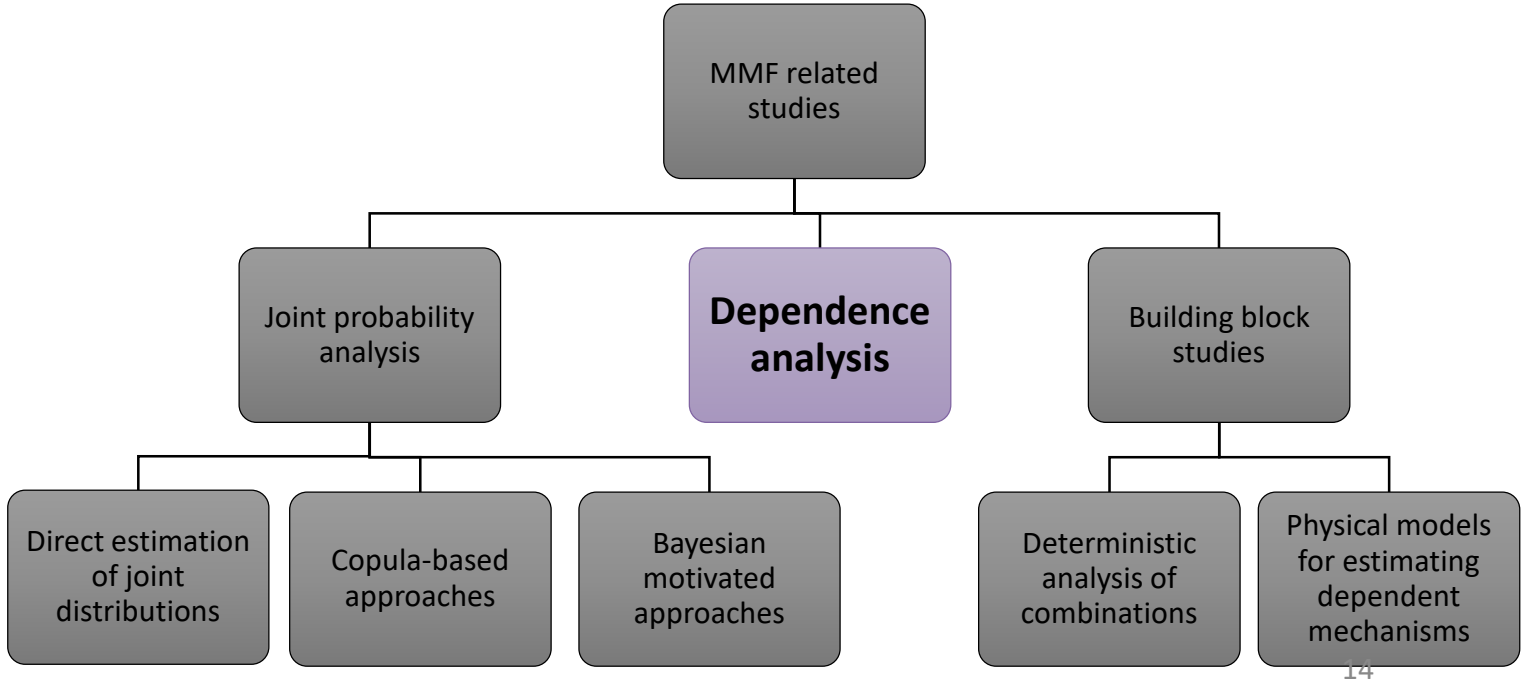


Summary of Existing Resources

Correlation Measures
$(\rho, \tau, \dots)$

Variables

Timing



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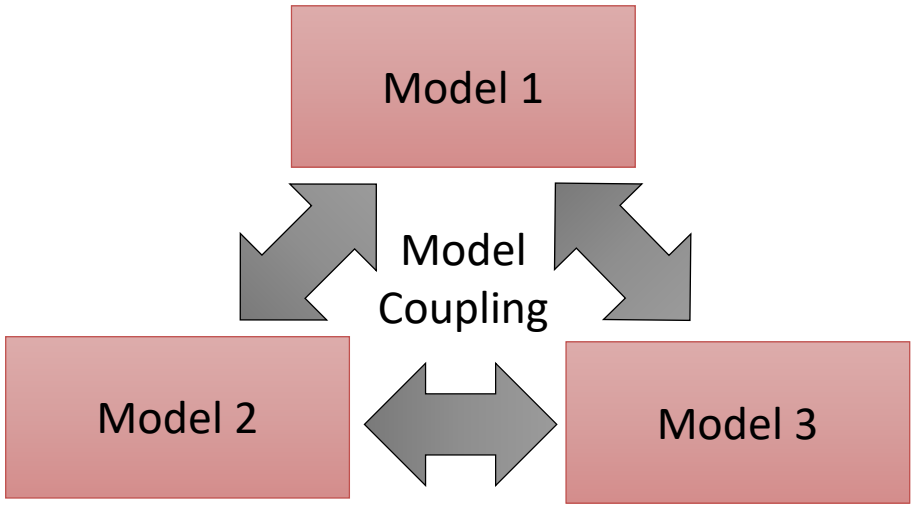

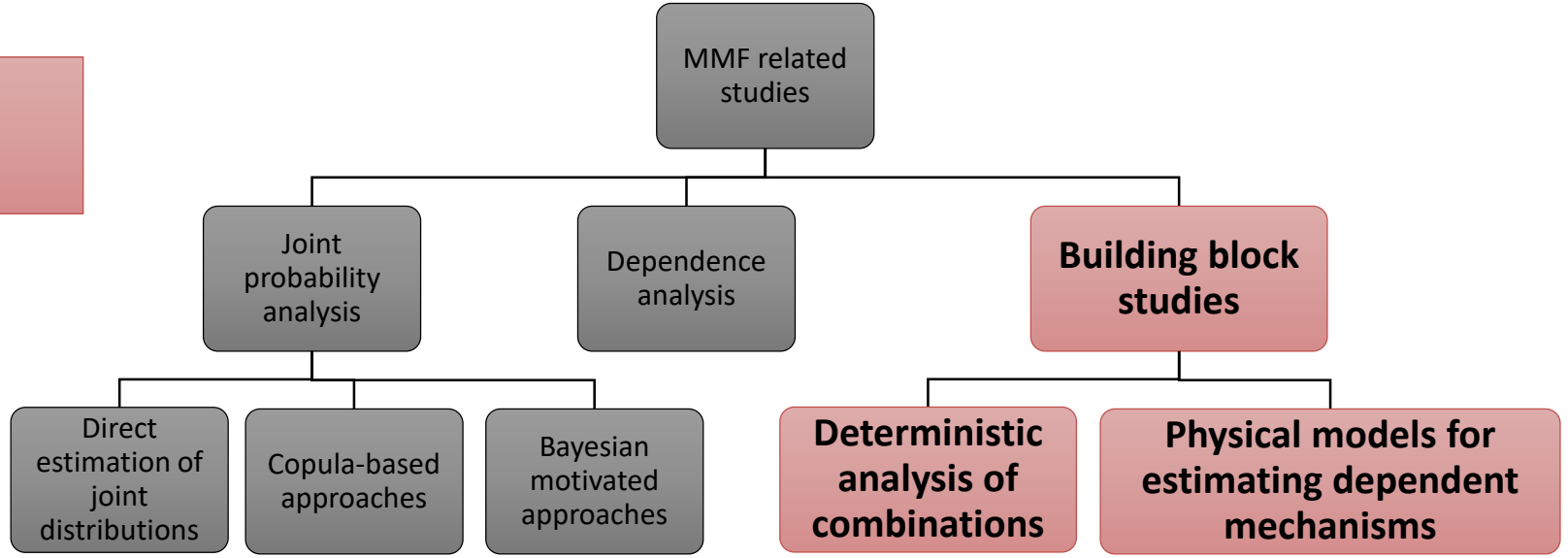

Scope of Existing Studies

Coastal MMFs	Storm surge combined with precipitation and/or river flow
	Surge, waves, and water levels
	Tides and tsunamis (process interactions)
Non-coastal MMFs	Combined river discharges at river confluences (copula based flood frequency analysis)
	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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Provide technical background for the development of flood hazard curves for multi-mechanism floods (MMFs)

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Next Steps

Case Study 1: Inland Flooding

Flood-Forcing Phenomena: Severe Weather	**Flood Mechanisms:** Snowmelt-Driven Flooding	**Flood Severity Metric:** Flow (Discharge)

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 copula-derived joint distributions in PFHA
- Strengths and limitations of the copula-based MMF assessment approach

Next Steps

Case Study 2: Coastal Flooding

Flood-Forcing Phenomena: Hurricane	**Flood Mechanisms:** Surge and Precipitation/Flow	**Flood Severity Metric:** Water Level

Overall Approach: Bayesian

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

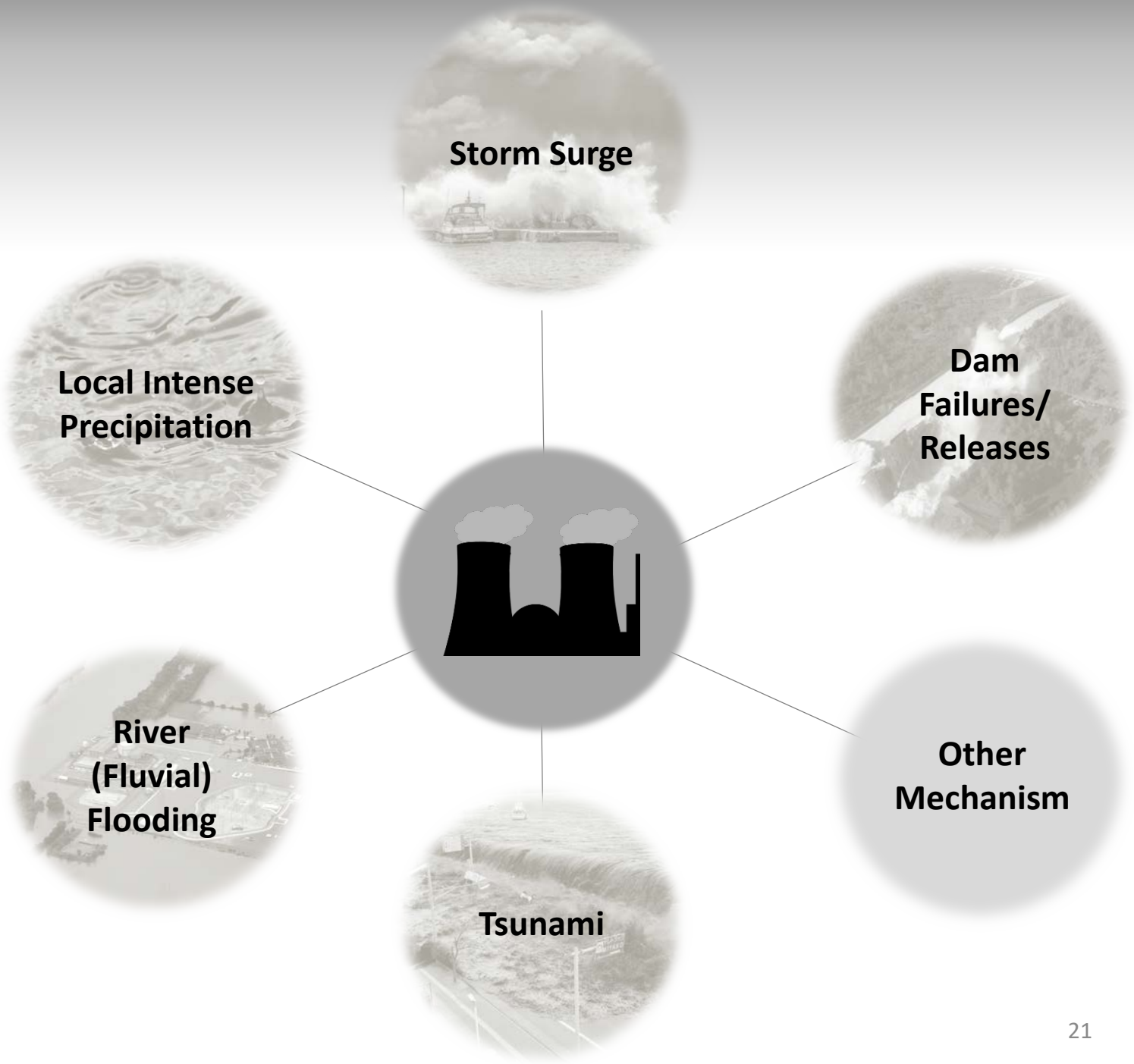
Key Models: Statistical, Surrogate

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?


Storm Surge
Local Intense Precipitation
Dam Failures/ Releases
River (Fluvial) Flooding
Other Mechanism
Tsunami