HydroPredict, Vienna, September 2012

Special Session 3: Choosing Models for Resilient Water Resources Management

Water Partnership Program (WPP)/TWIWA- The World Bank

Risk Informed Decision Making in a Changing Climate

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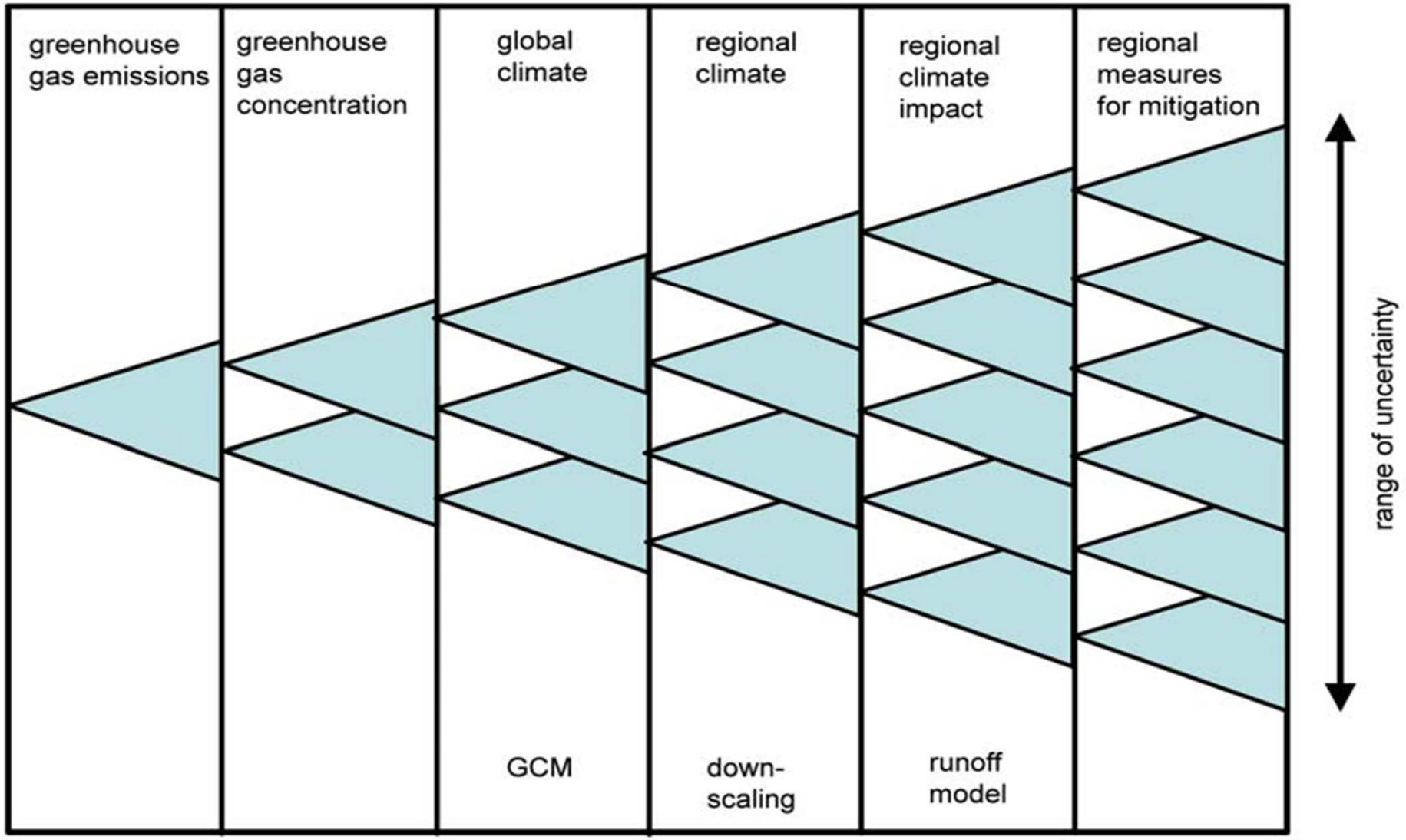
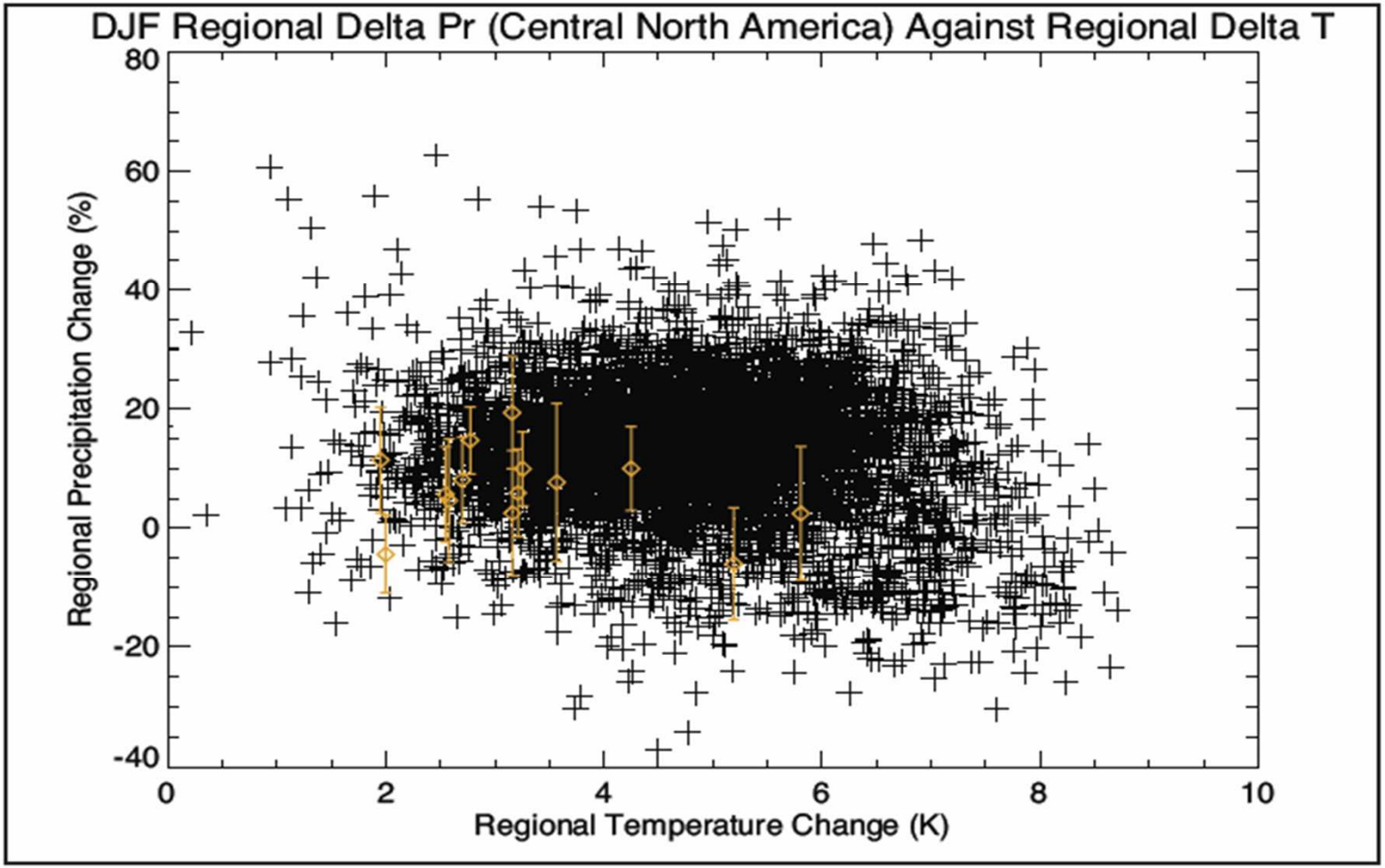
Outline

- Why a risk-informed decision making approach?
- Risk-informed decision making framework introduction
- Application to U.S. Army Corps of Engineers reservoir in Iowa, USA
- Next steps – Work with Alliance for Global Water Adaptation (AGWA)

Uncertainty in Climate Change Impact Analysis



Climate Model Uncertainty



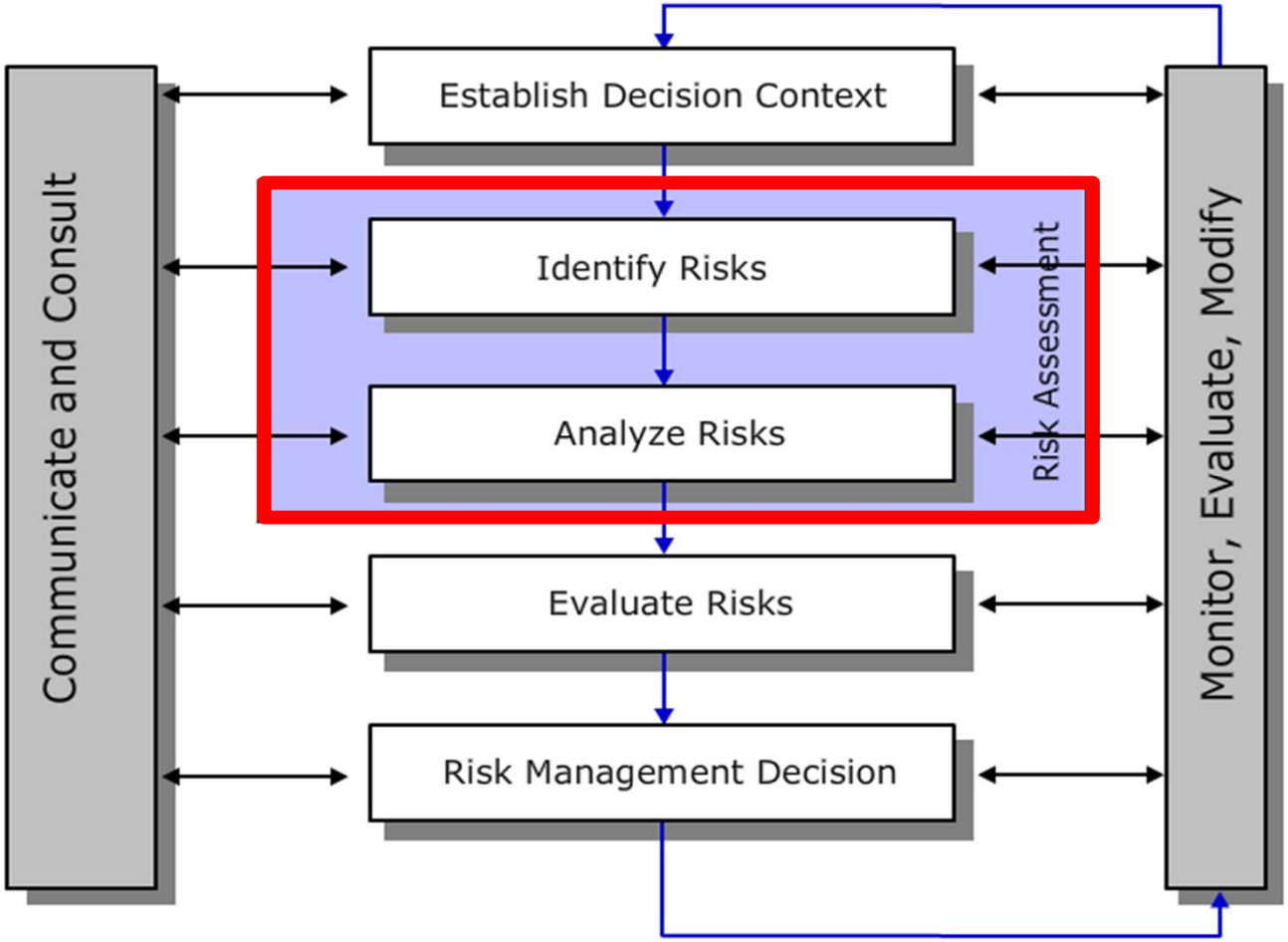
Probability Assessment

- Probability assessment has been based on observed record and assumption that the statistical properties of hydrologic variables in future time periods will be similar to past time periods.
- Climate change challenges this assumption.
- Use of climate model for future probabilities is likewise problematic.
- An ensemble of climate models is not a representative sample of future climate.

Problem Statement

- Future climate is uncertain: Recent past may not be representative of future climate, but climate projections are uncertain.
  - Probability distribution of future climate is uncertain making traditional cost benefit more doubtful.
  - Climate projections represent only a fraction of possible future climate.
- How do we make investment decisions given this uncertainty?

Risk Informed Decision Making Framework

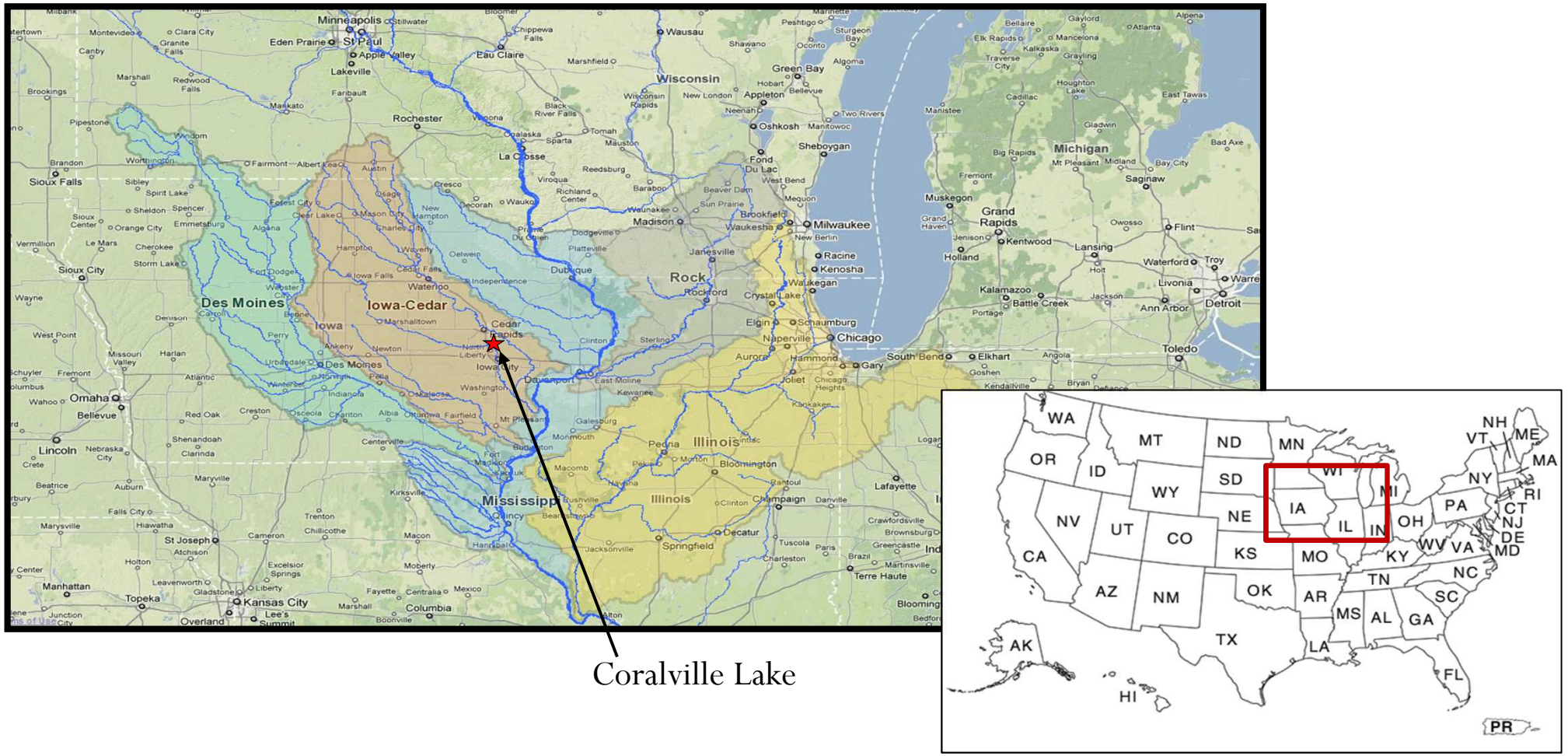


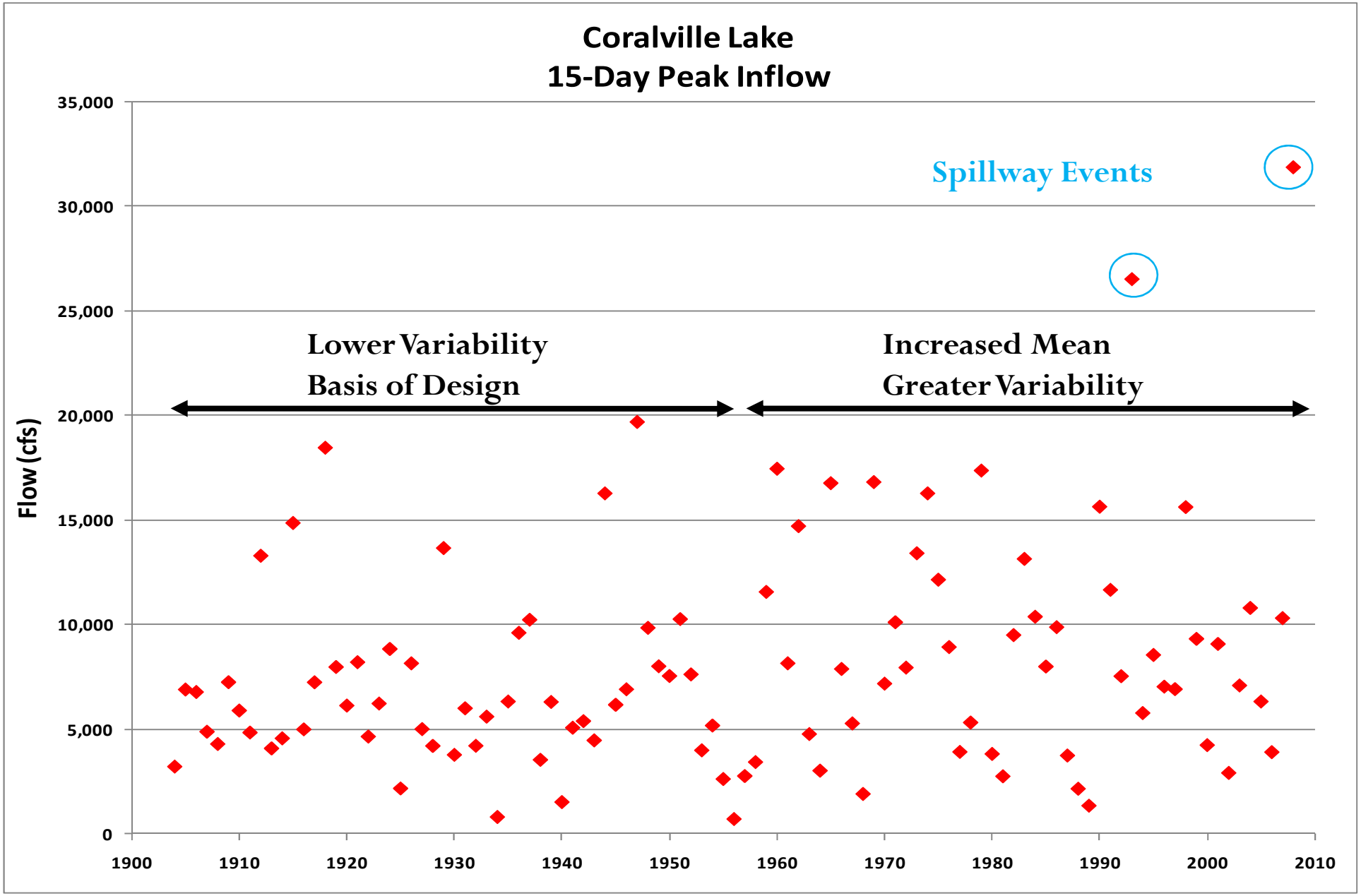
Identify Risk

- Identifying risks of loss or potential gain associated with decision context is beginning of what is commonly known as "risk assessment."
- Look for the Hazard or Opportunity
- Consequence Assessment
- Likelihood Assessment
- Risk Characterization

  Risk = (Consequence) and (Likelihood)

Example:
Coralville Flood Risk Management Analysis




Coralville Lake
15-Day Peak Inflow
Spillway Events
Lower Variability
Basis of Design
Increased Mean
Greater Variability
Flow (cfs)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Risk Assessment Part I: Identify Risks

- Identify critical zones through stakeholder involvement
- Conduct stress test of system under various climate states

Photo: Coralville Lake Dam – June 2008

Stress Tests

- **Goal**

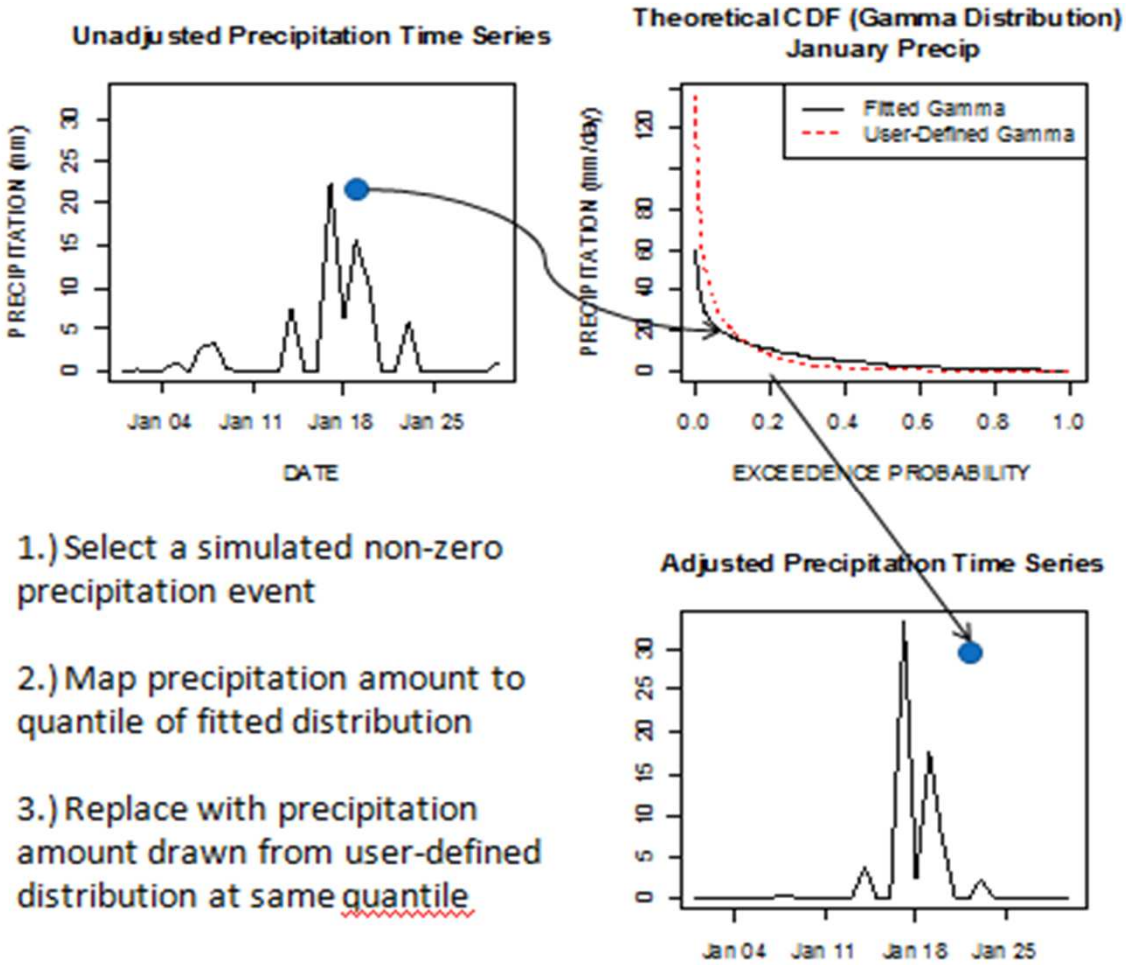
  To identify system breaking points under various climate states

- **Metrics Assessed**
  - Flood Management: Return Period, Expected Annual Damages
  - Water Supply: Firm Yield, Reliability, Cost

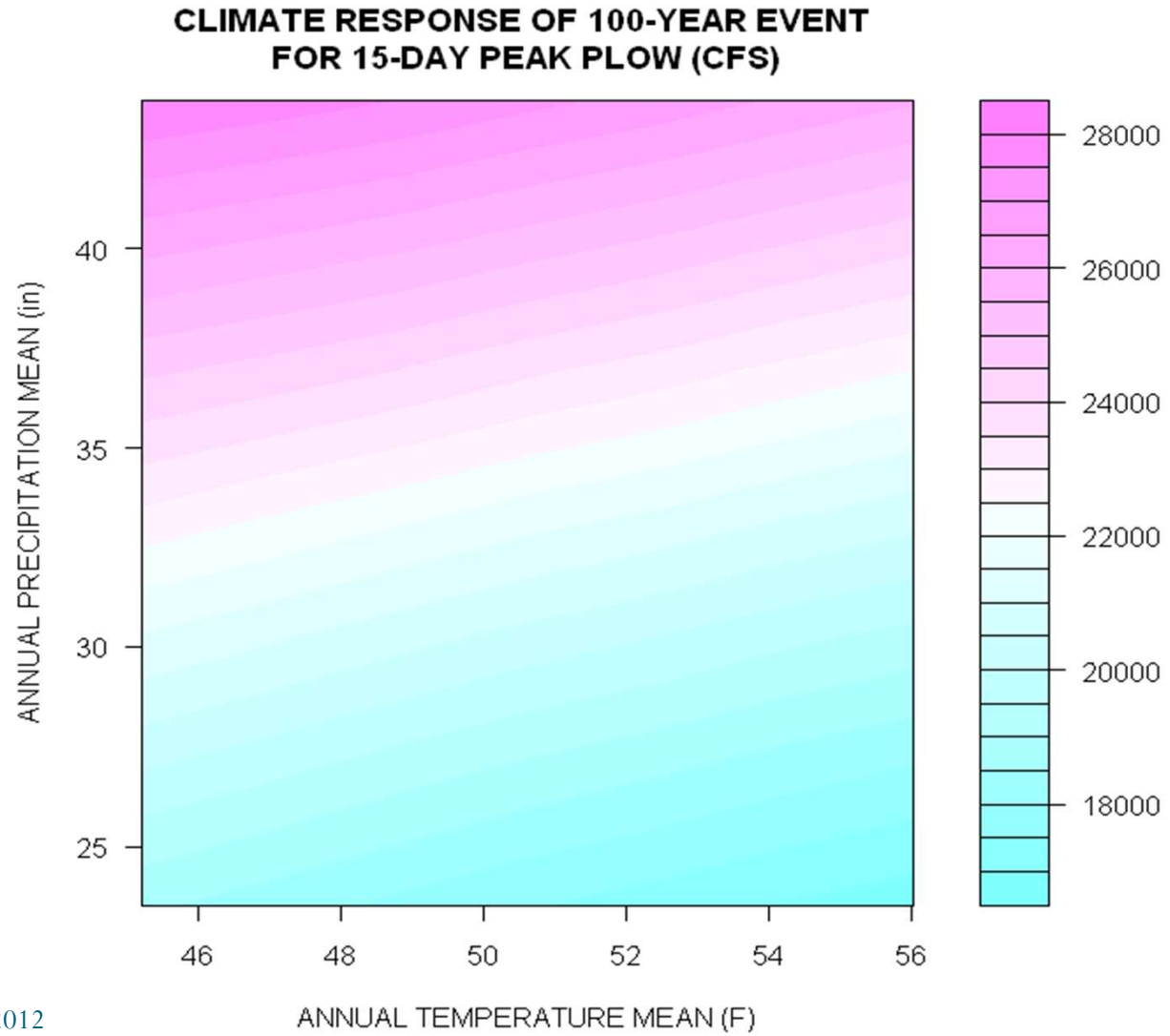
- **Approach**

  Use weather generator to stochastically model rainfall occurrence, amount, and other climate fields

Climate Stress Test: Prescribed Climate Changes



Stress Test:
100-yr Event for 15-Day Peak Flow



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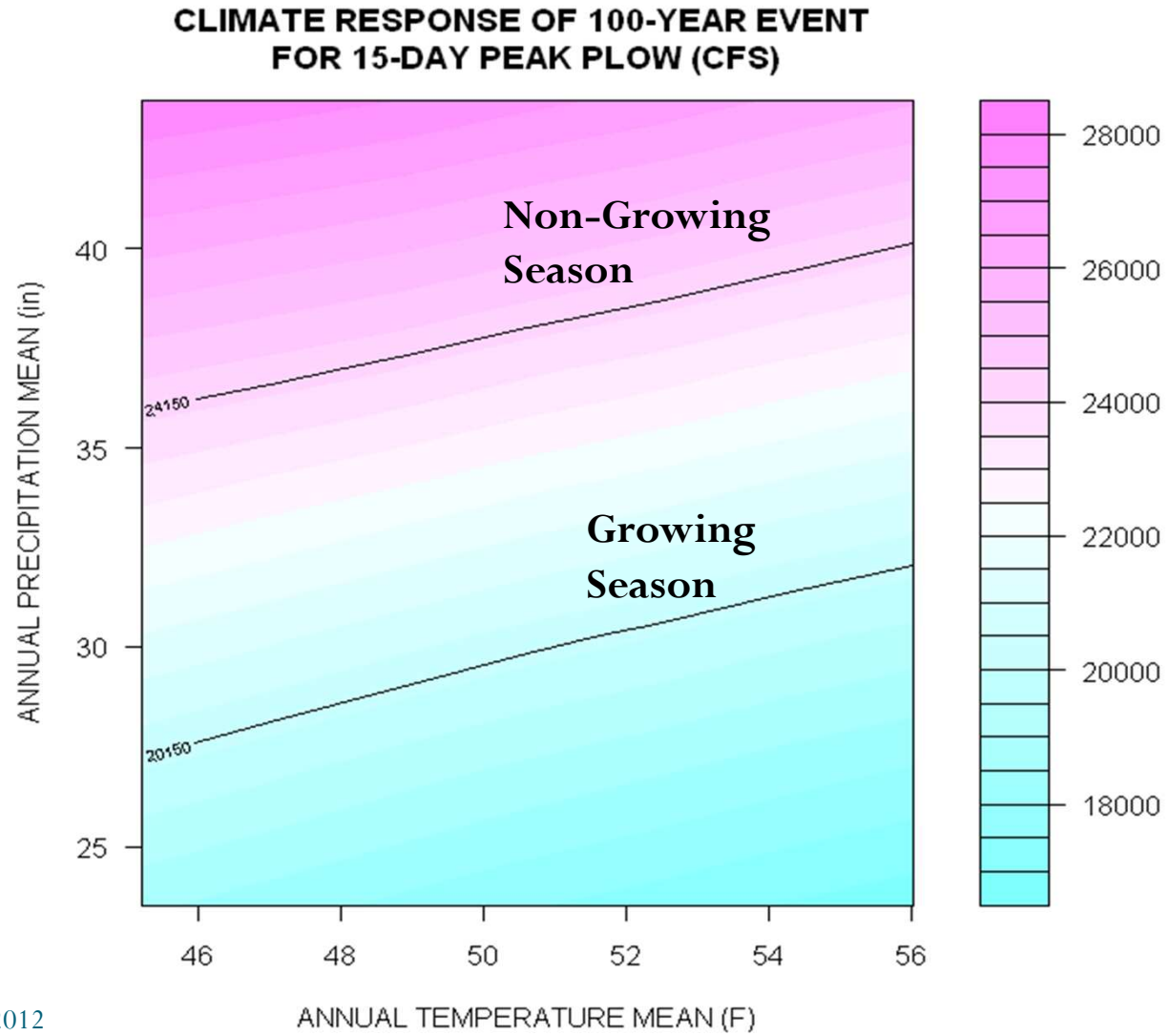
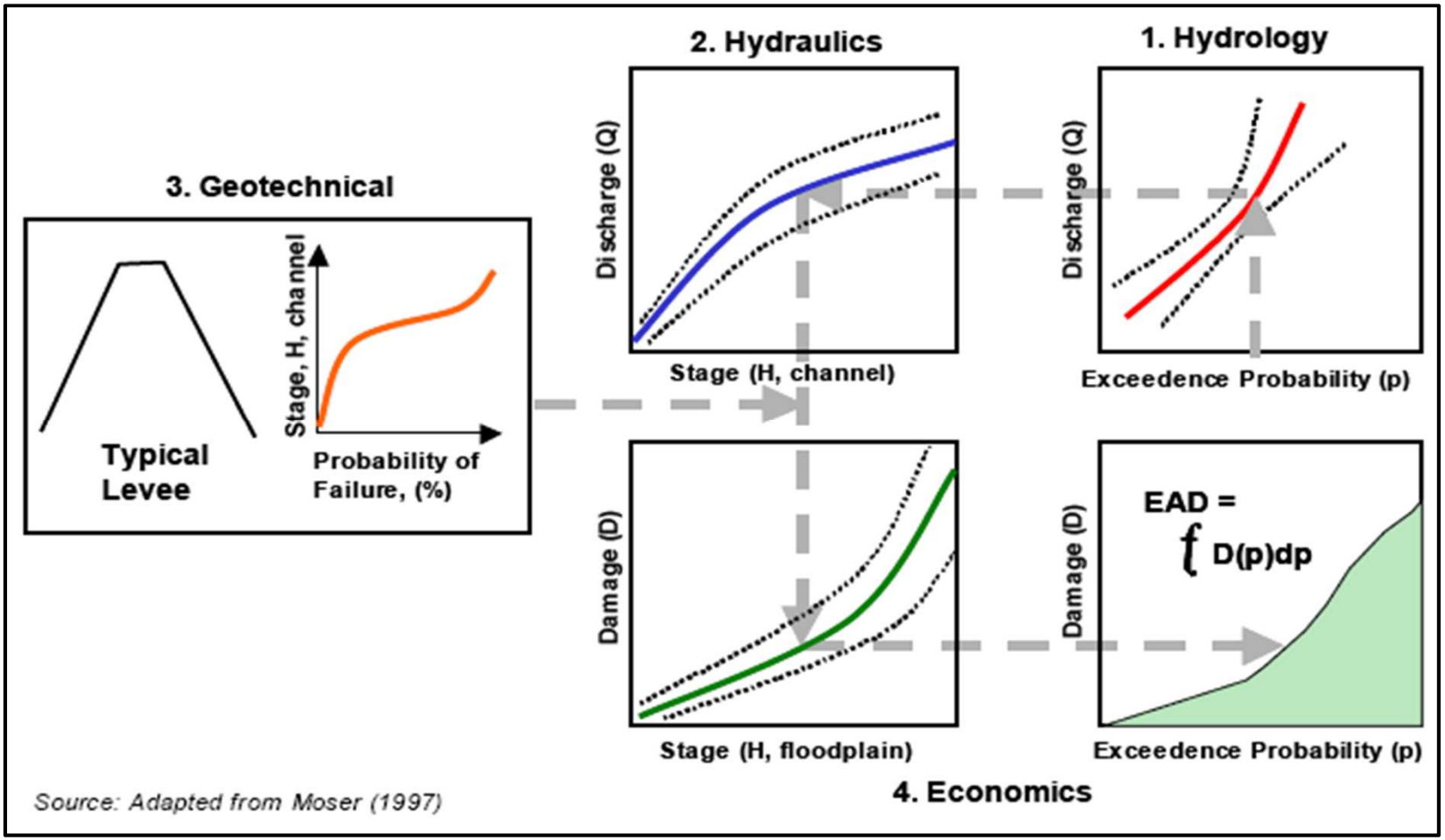


Stress Test:
Expected Annual Damages



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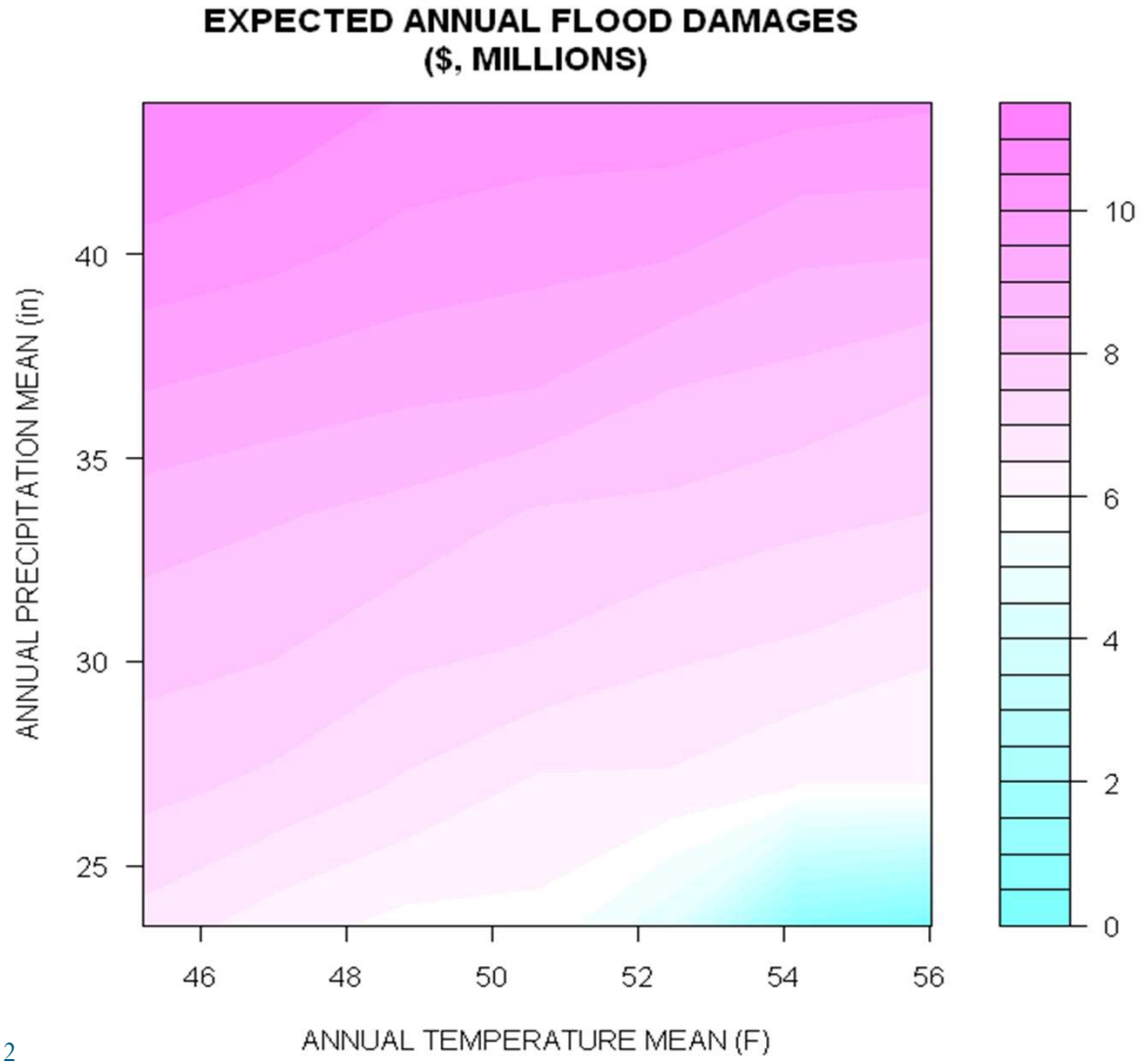

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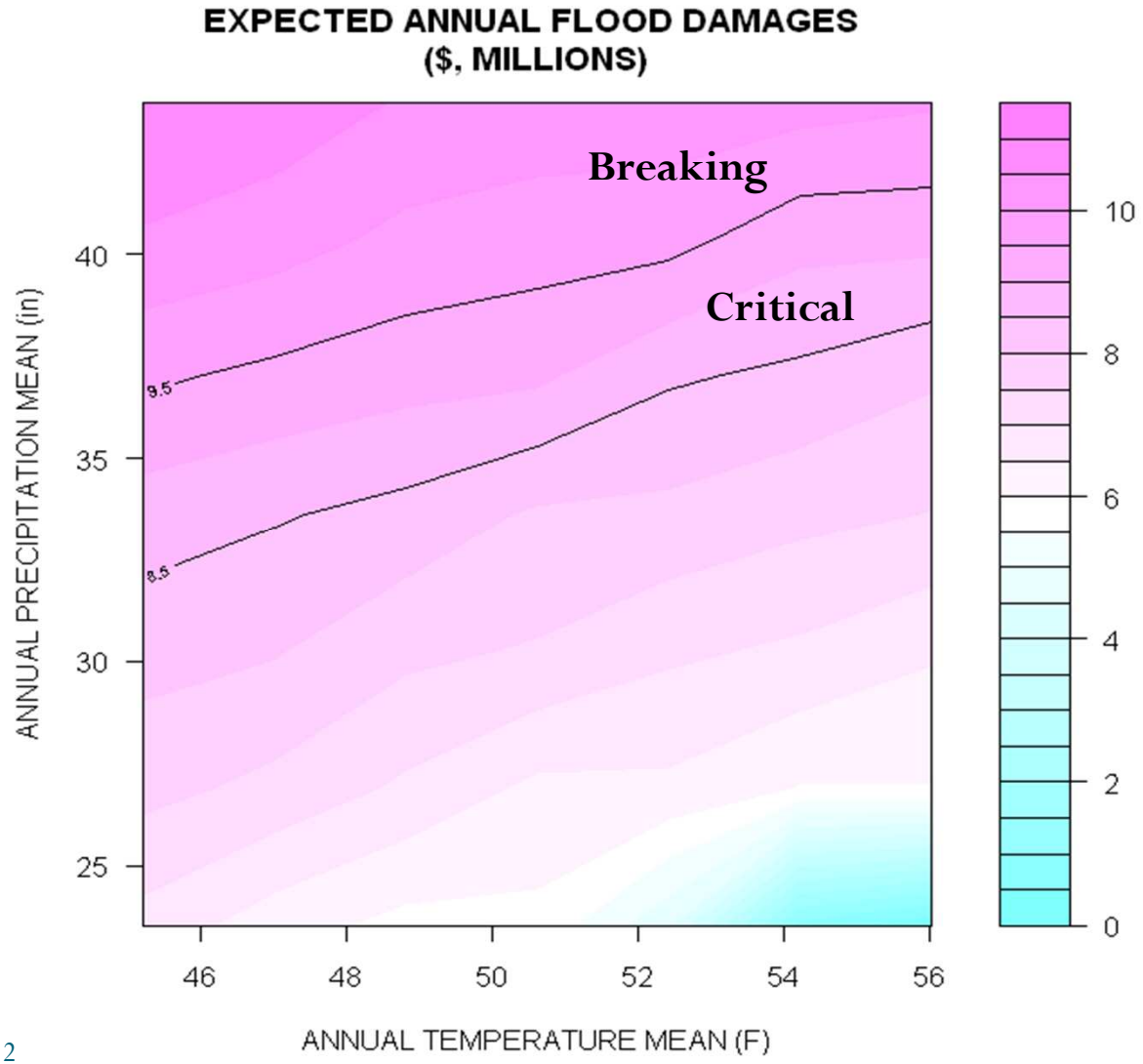
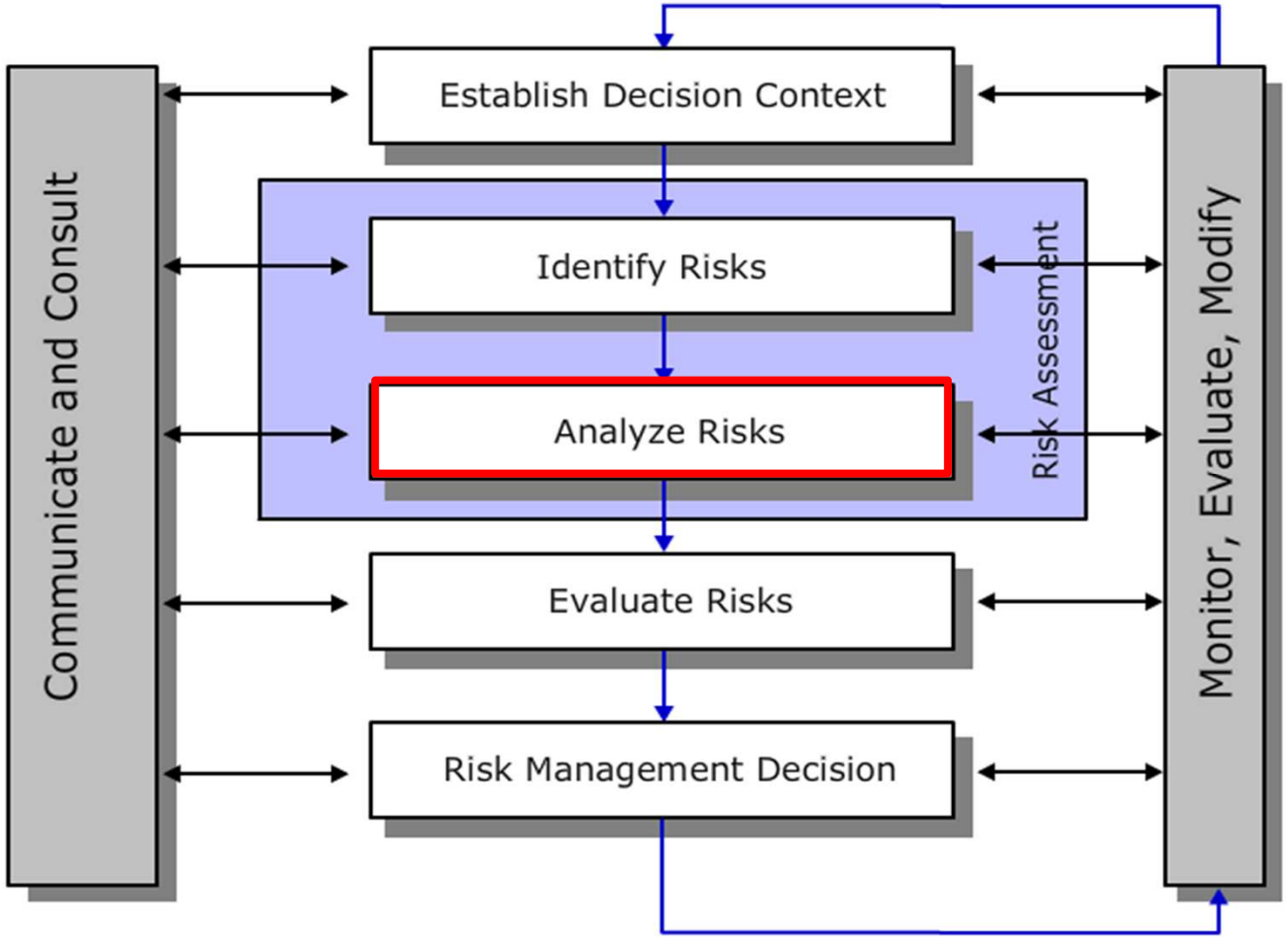
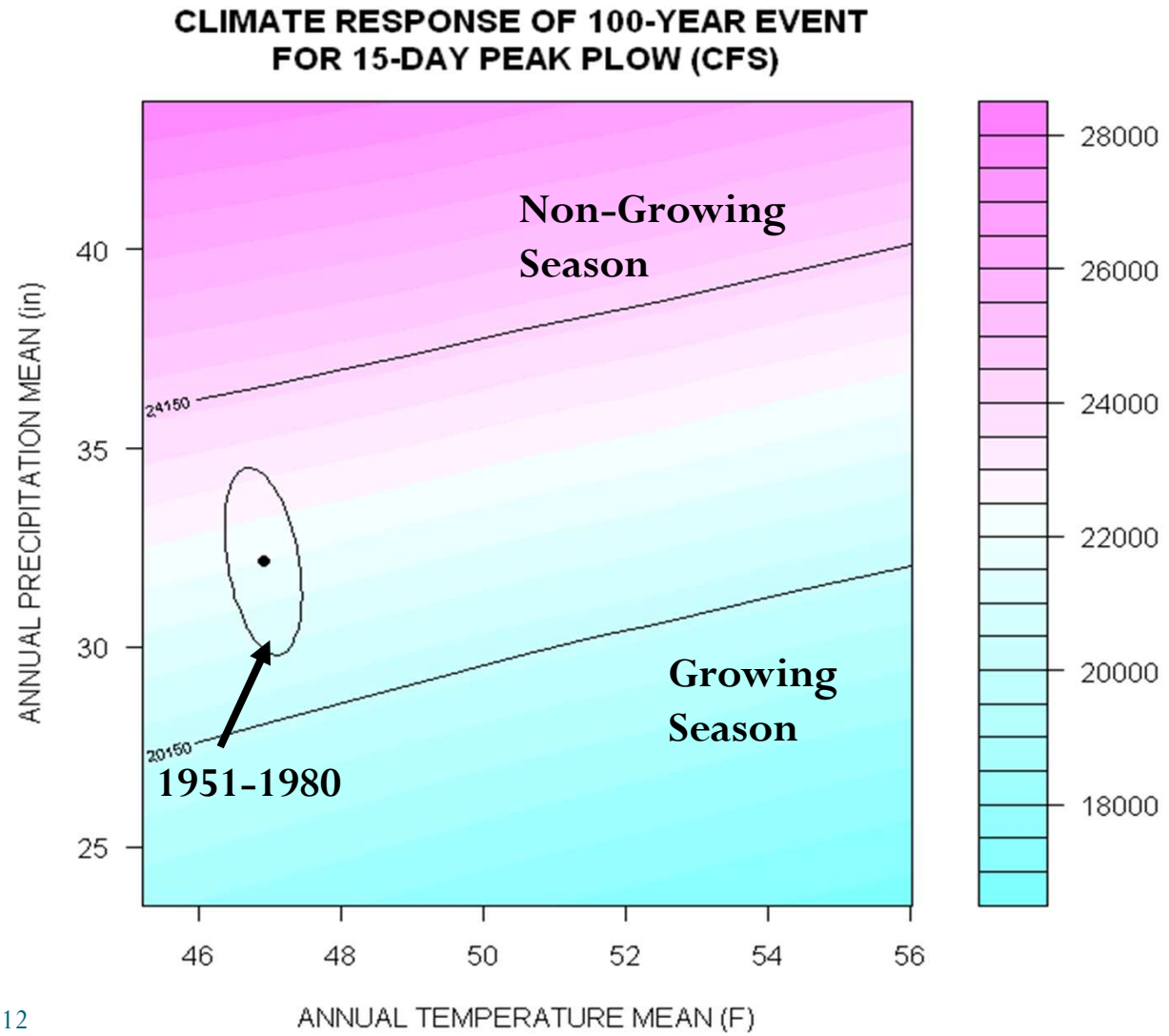


Risk Informed Decision Making Framework



Risk Assessment Part II: Analyze Risks



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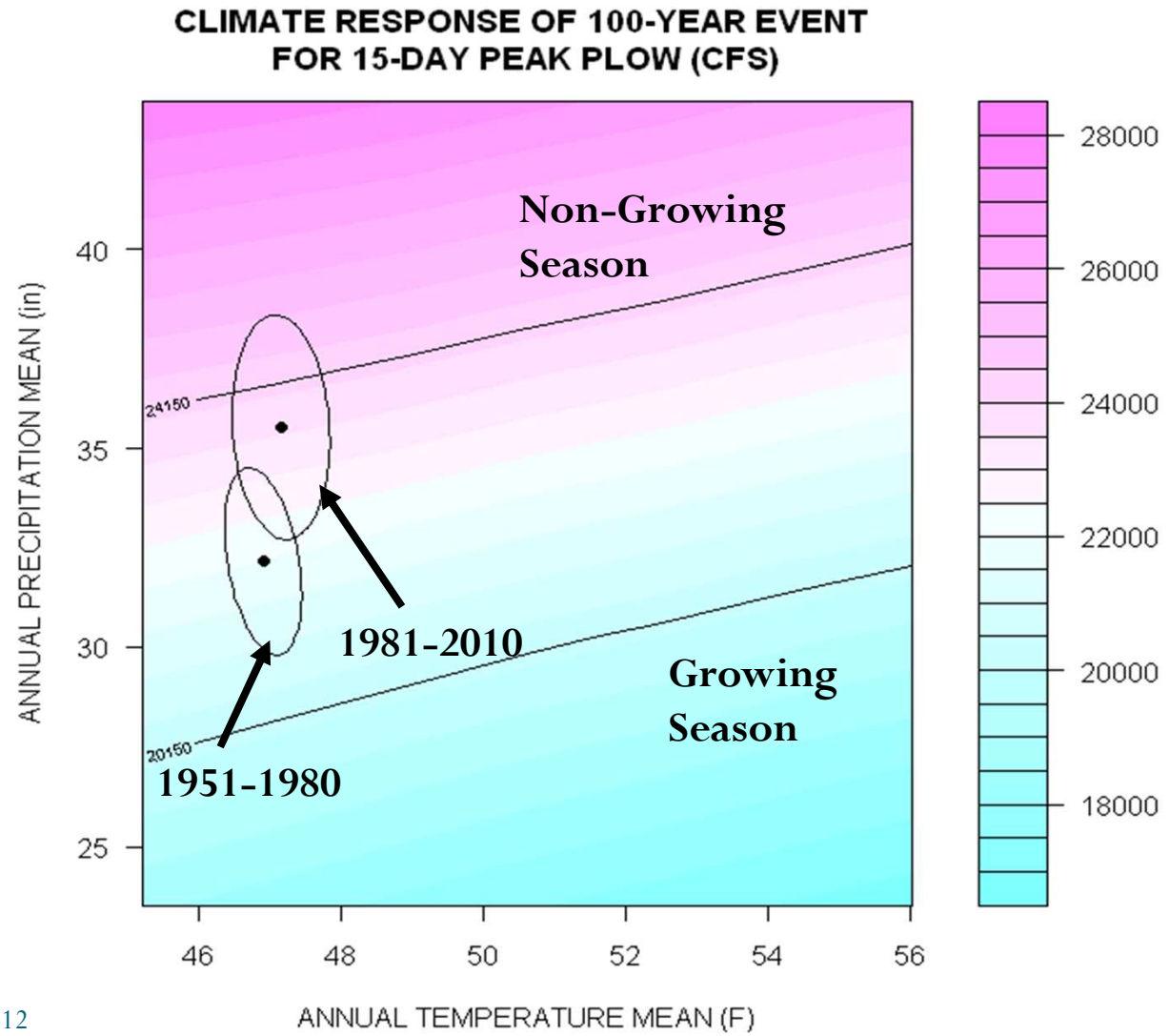

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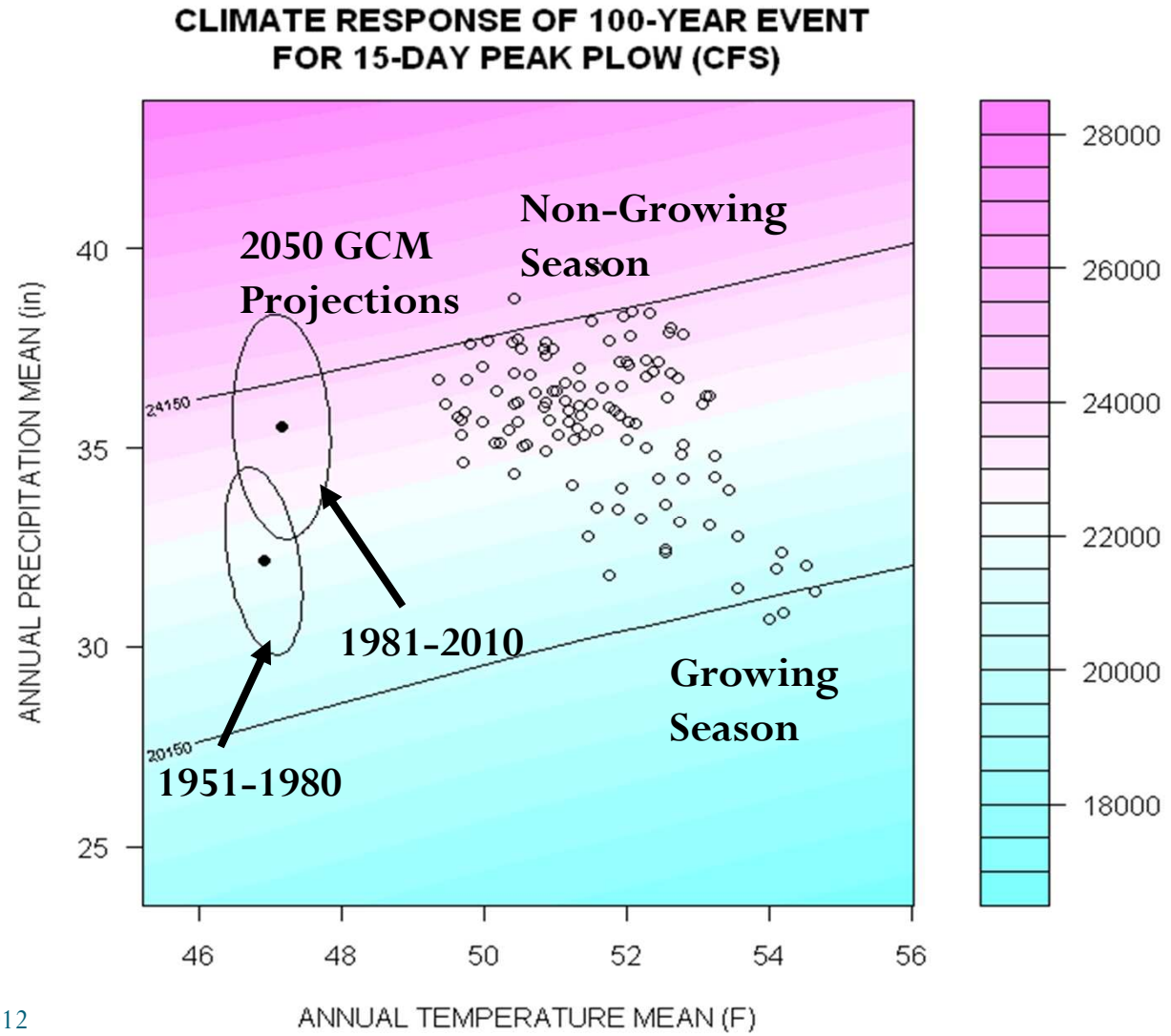

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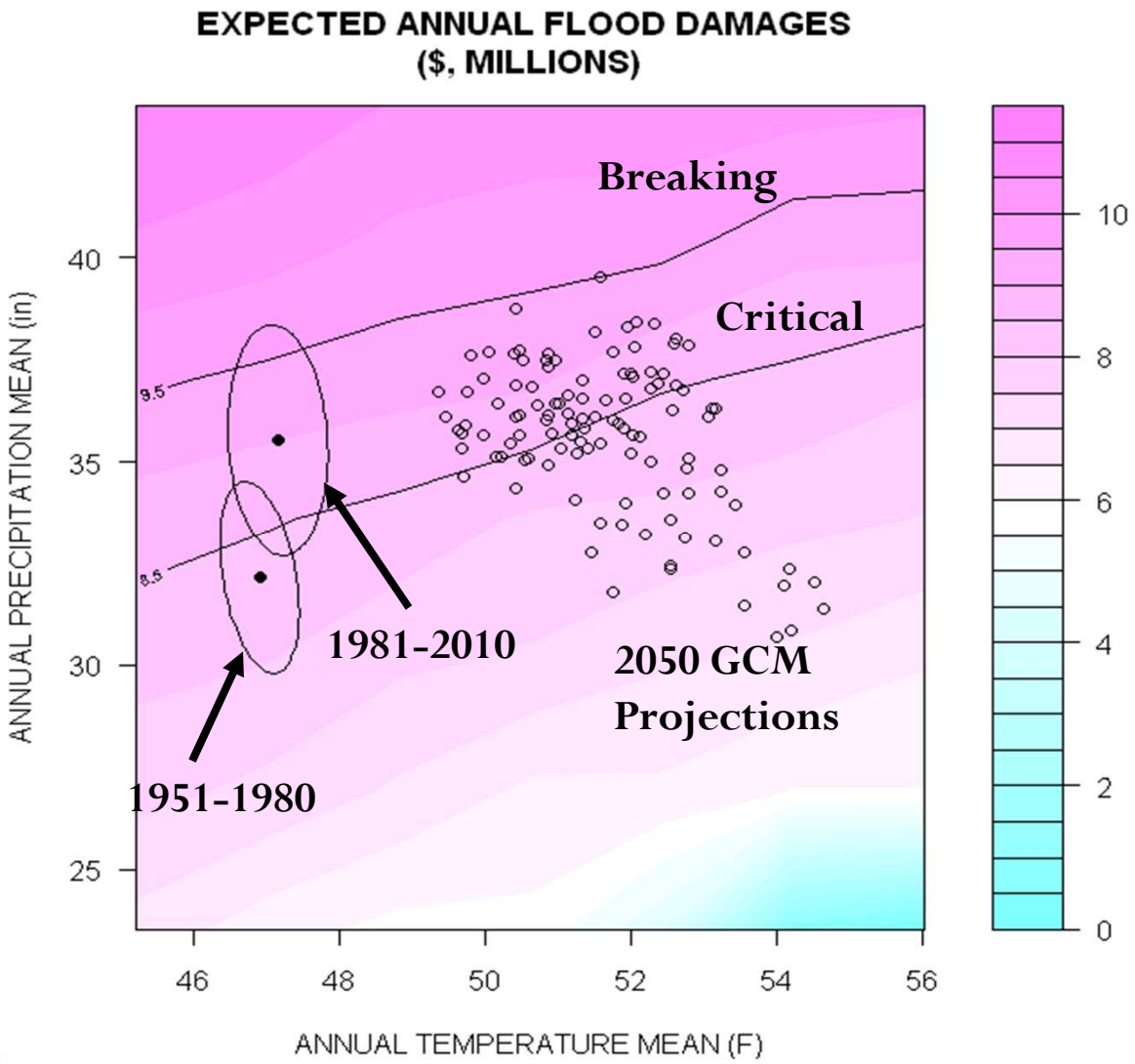

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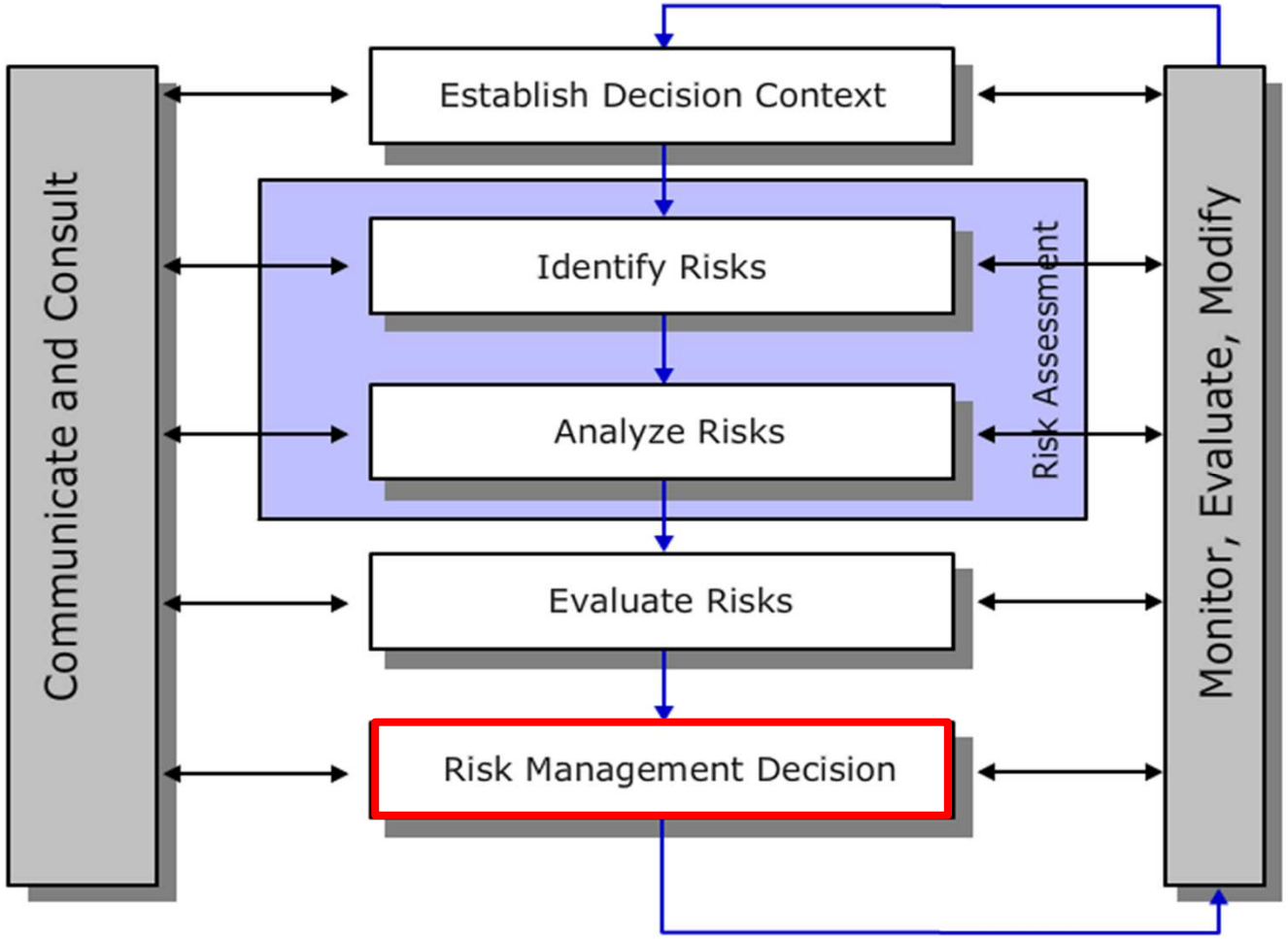

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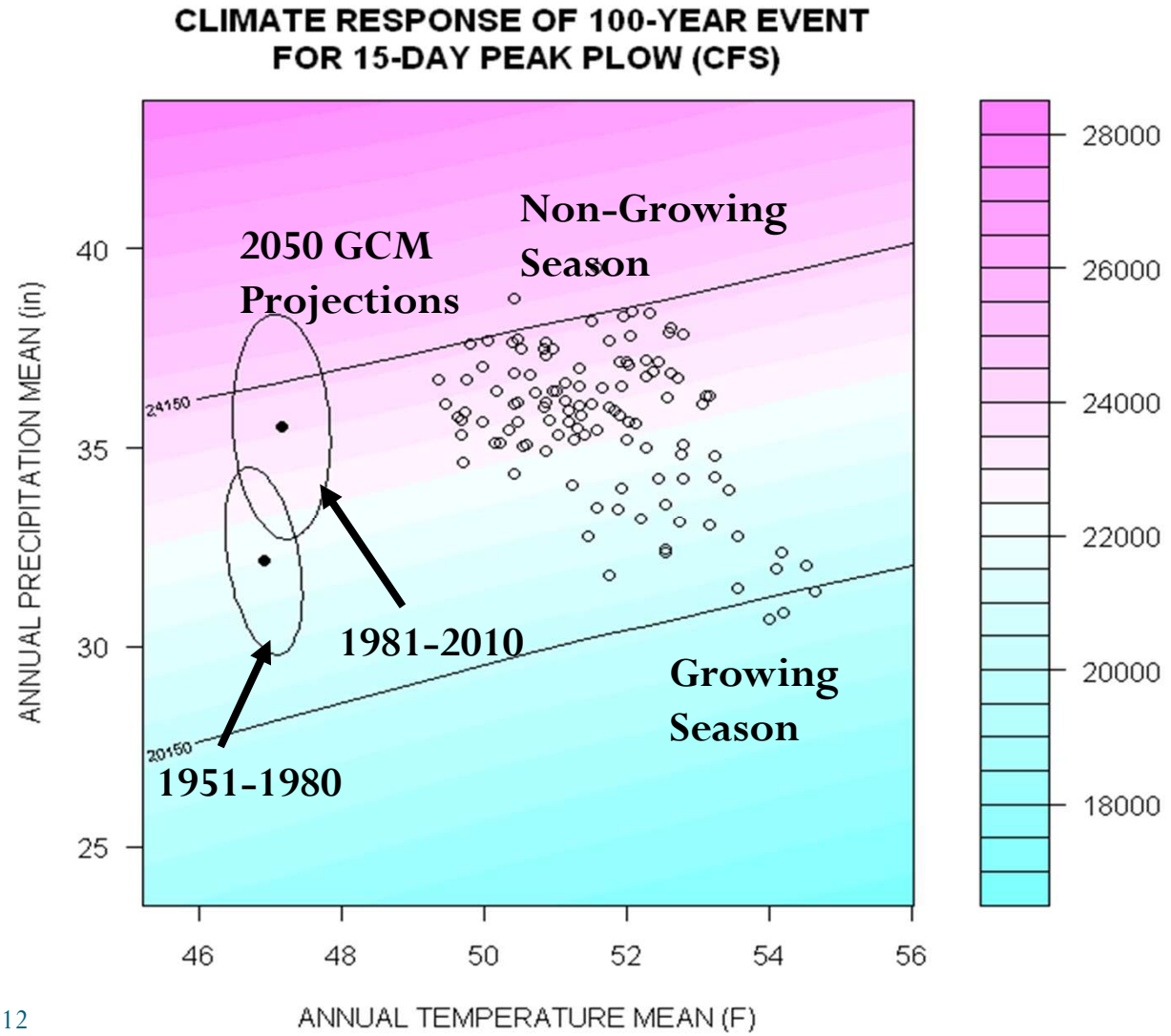


Decision Matrix

Confidence	Critical Zone: Low	Critical Zone: Med	Critical Zone: High
High		Observed data 1951-1981	
	TRADITIONAL COST-BENEFIT ANALYSIS		
Med		Observed data 1982-2010	
Low		GCM Projections	
	ADAPTIVE MANAGEMENT and ROBUST DECISION MAKING W/ HIGH UNCERTAINTY		

Decision Making Methods

- Low regrets alternatives that do well in different climates
- Incremental cost analysis and cost effectiveness of increased climate robustness
- Collaborative decision making and shared risk tolerance of future uncertainty

Future work

- **Methodology needs**
  - Different critical metrics
  - Additional climate variables
  - Seasonal models
  - Economic decision models
- **Collaborative**
  - Further collaboration w/ AGWA
  - Pilot studies
    - Water Supply pilot in Lake Oologah
    - Additional international pilot studies
      - Nicaragua
      - Bolivia

Thank you!

"Downscaling helps people do the wrong things more precisely."

Questions?

Photo: Coralville Lake Dam – June 2008

Weather Generator: Modeling Approach

1. Data-Driven, Semi-Parametric Weather Generator
   - Deals with spatial covariance problem

2. Wavelet Auto-Regressive Modeling (WARM)
   - Deals with long-term persistence problem

3. Quantile Mapping Adjustments
   - Allows us to model many types of climate changes

Comparison of Proposed Alternatives

Metric	Alternative 1		Alternative 2	
	Historic Data	GCM Projections	Historic Data	GCM Projections
EAD ($)				
Net Benefits ($)				
Robustness				
Climate Informed Robustness				

Additional Considerations

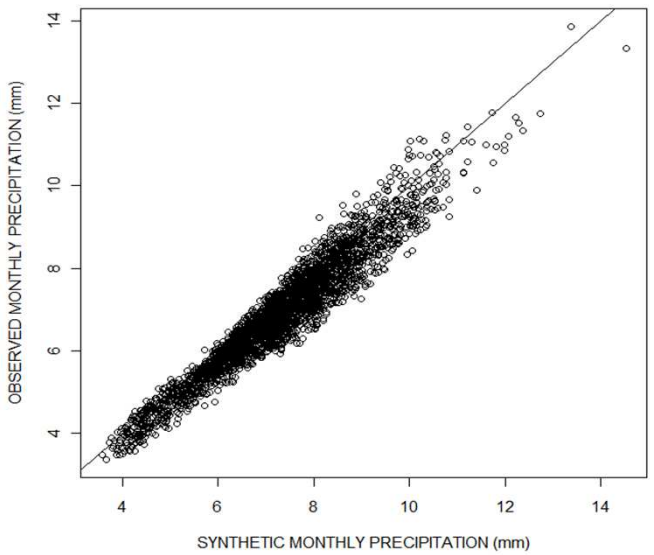
- Is this a one-time decision or a repeated decision?
- Are the risks under historic climate or climate change?
- Are climate projections credible?
  - Are they in agreement?
  - Do they suggest expected trends for region?

Evaluate Risks: Adaptive Management Approach

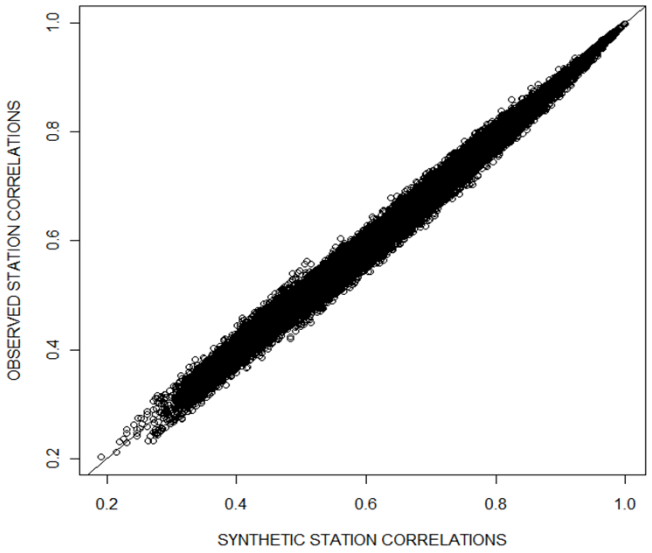
- Identify climate states each alternative is resilient to
- Build sequences of alternatives (i.e., Path A vs. Path B) to cover all 'plausible' climate states
- Explore the cost of choosing Path A when climate shifts towards Path B
- Assess the sensitivity of path selection to probabilities assigned to each climate state

PERFORMANCE

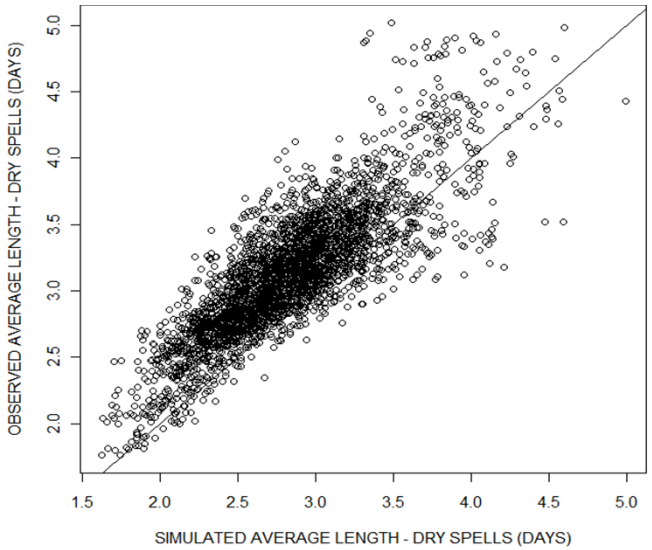
MEAN MONTHLY PRCP



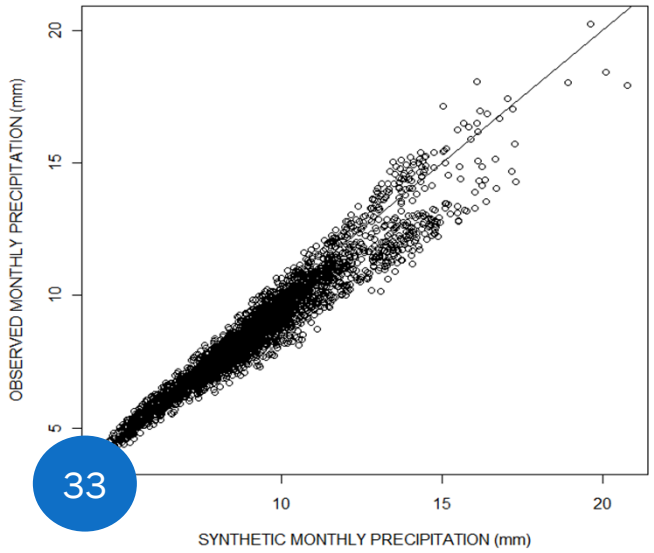
STATION CORRELATIONS (DAILY PRCP)



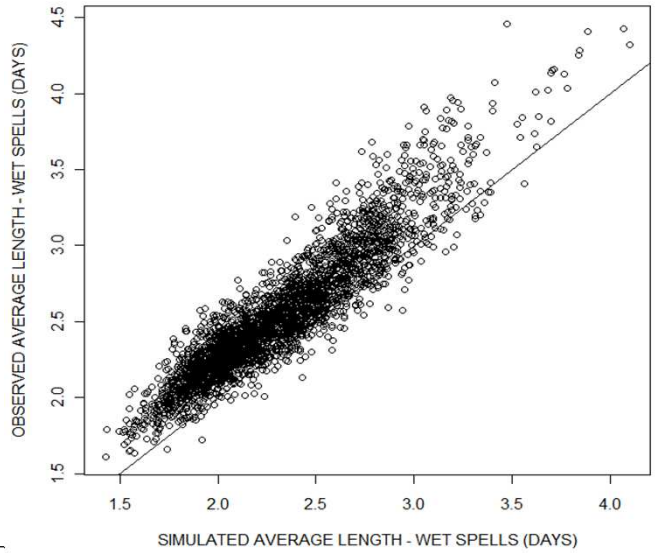
DRY SPELL LENGTH

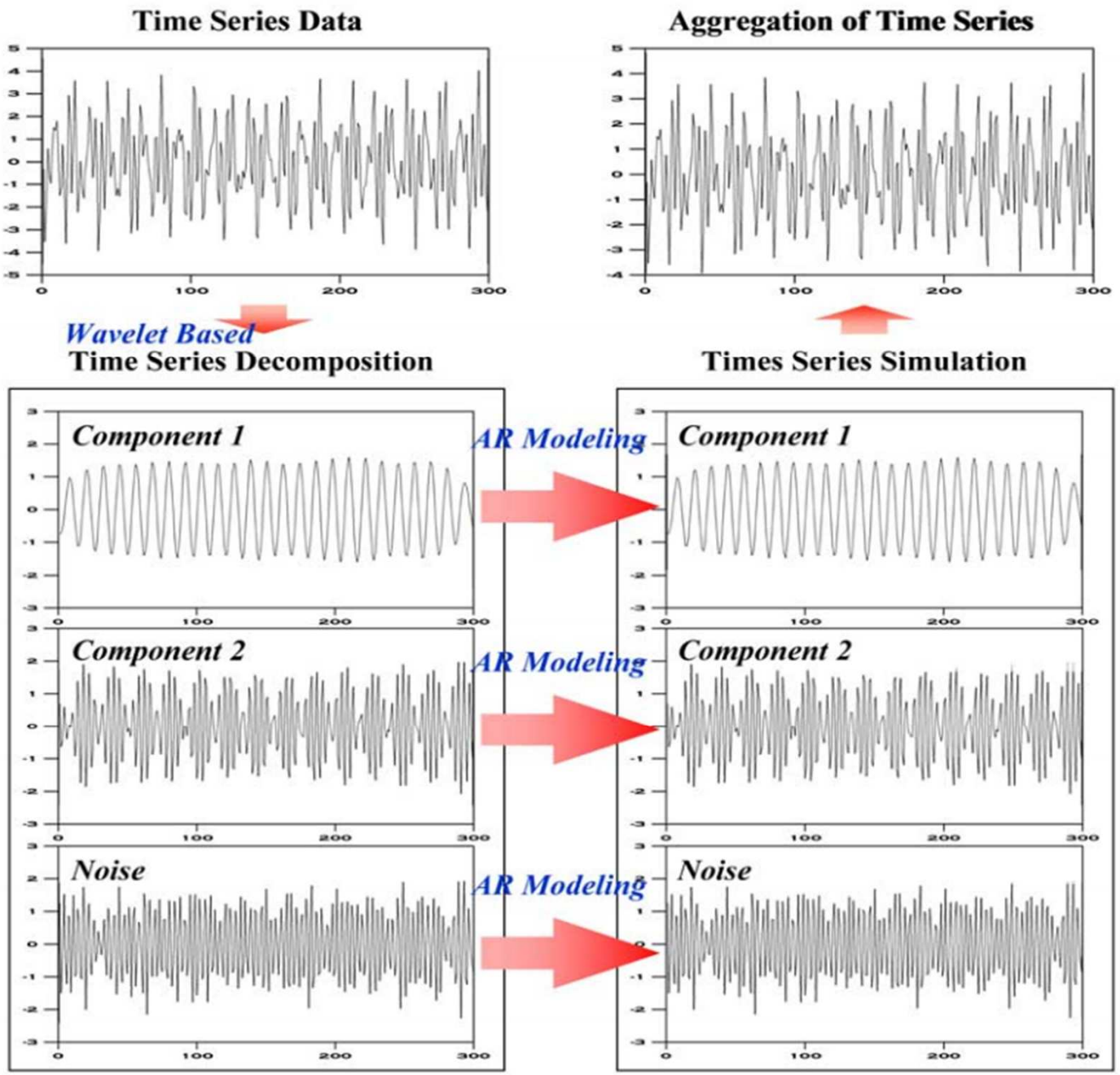


STDEV MONTHLY PRCP



WET SPELL LENGTH





K[illegible] al. 2007, Stochastic simulation for nonstationary time series using an autoregressive wavelet decomposition: Applications to rainfall and temperature