Flexible Water Supply Infrastructure Planning Under Uncertainty
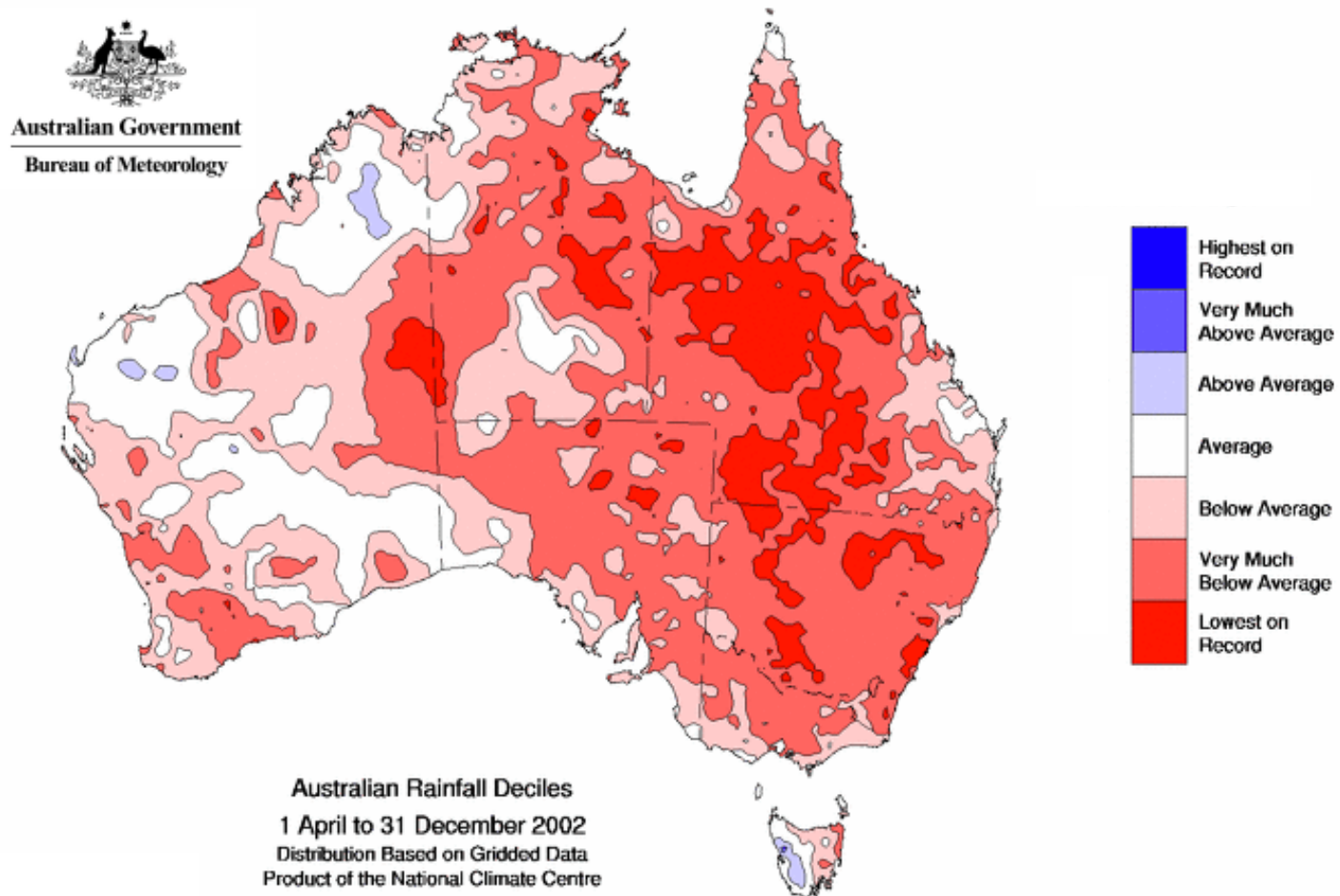
Sarah Fletcher

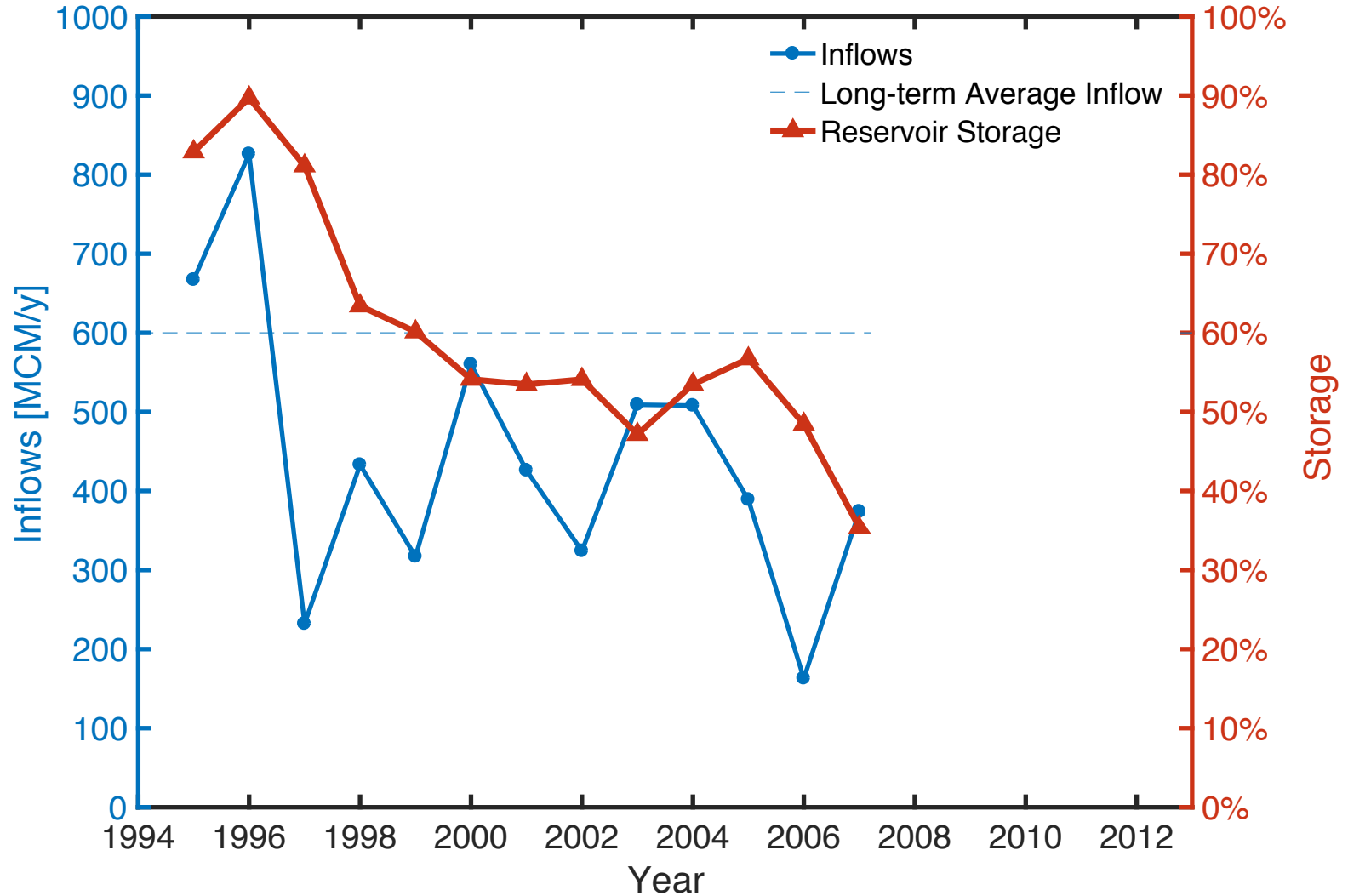PhD Candidate, Institute for Data, Systems, and Society, MIT

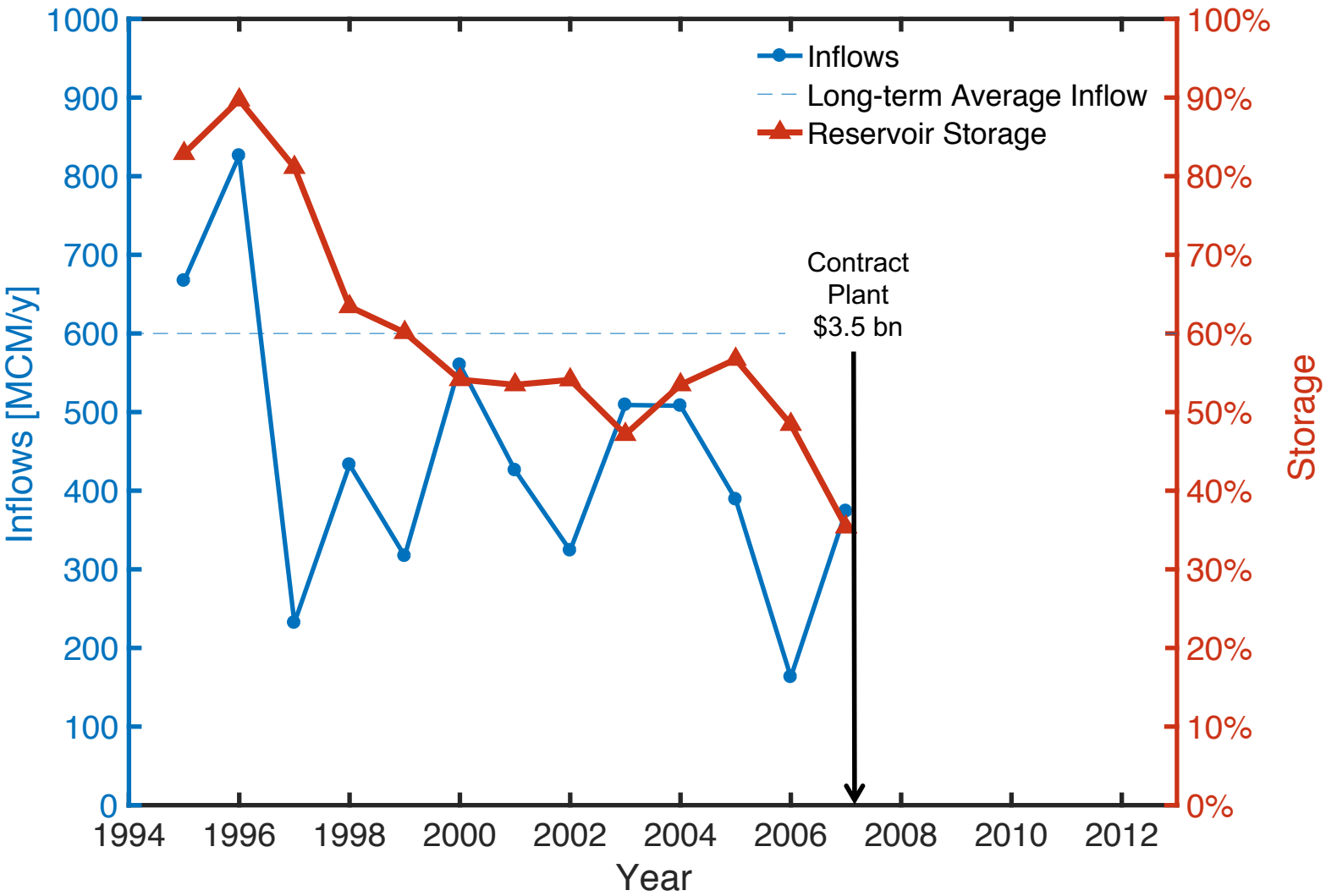Water Management for Future Climate Scenarios, J-WAFS

January 31, 2018

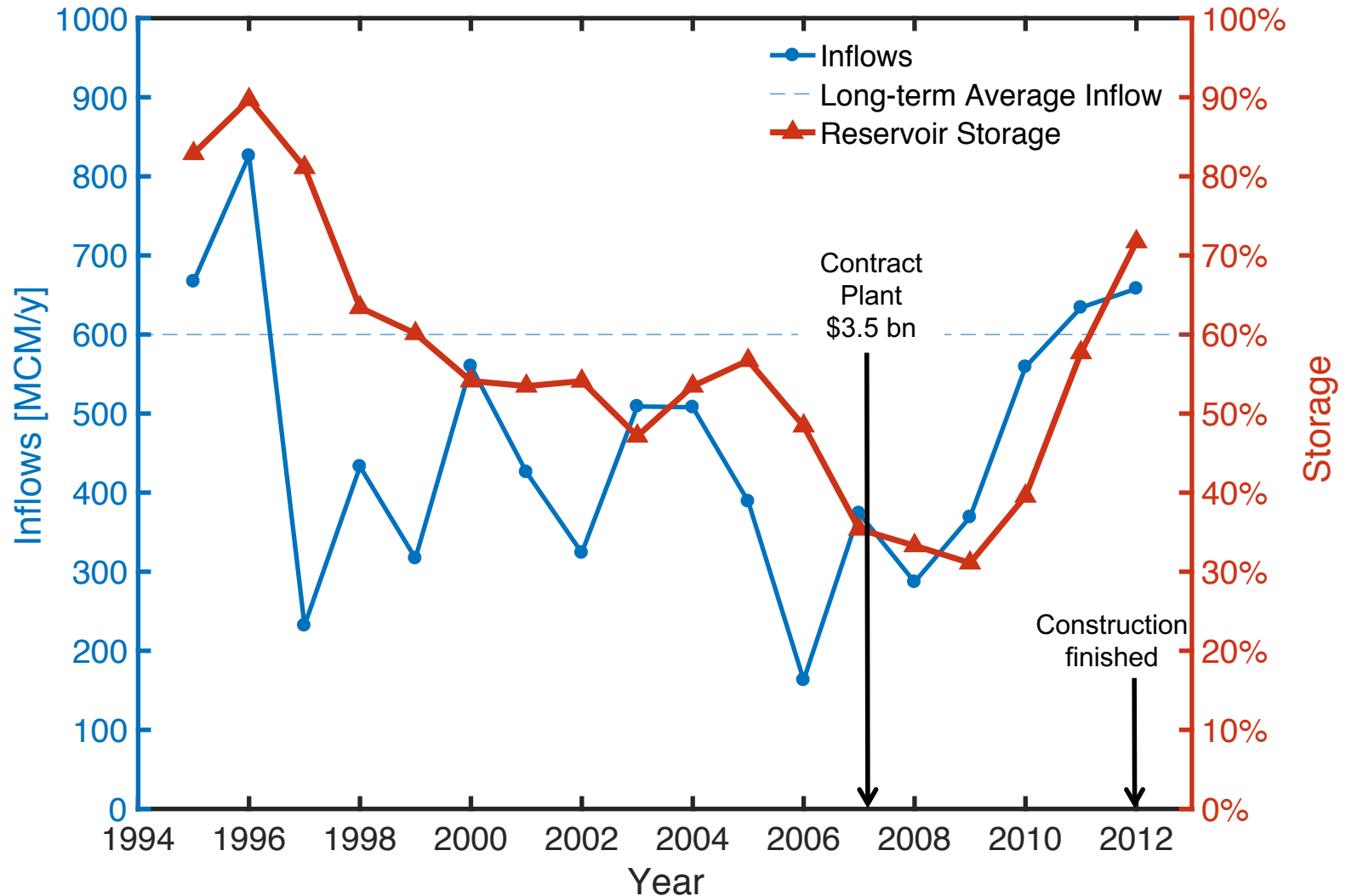# Millennium Drought: Australia faces driest decade (1997-2009) in recorded history

Australian Rainfall Deciles
1 April to 31 December 2002
Distribution Based on Gridded Data
Product of the National Climate Centre

Millennium Drought reduces water storage in Melbourne to 30%

"Fighting drought with innovation: Melbourne's Response to the Millennium Drought in Southeast Australia", WIREs Water 2015; Melbourne Water

3

Melbourne Water decides to build 150 mcm/y RO plant in 2007

Drought ends, storage to 65% when plant comes online

"Fighting drought with innovation: Melbourne's Response to the Millennium Drought in Southeast Australia", WIREs Water 2015; Melbourne Water

5

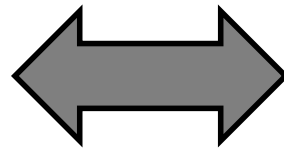# How can we plan water supply infrastructure for an uncertain future?

Challenges

- Large capital investments

- Long lifetimes

- Complex, changing systems

How can we plan water supply infrastructure for an uncertain future?
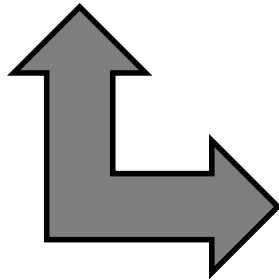
Uncertainties

- Supply variability
- Demand growth
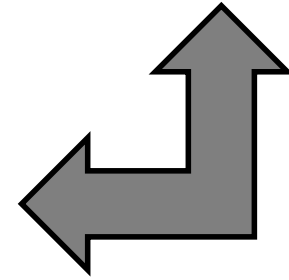- Climate change
- Extreme events

Characteristics

- Stochastic variability
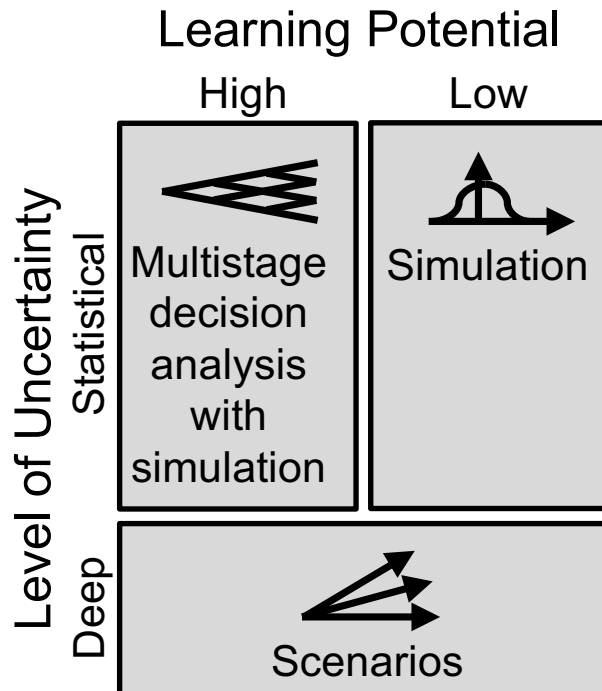- Lack of information
- External risks
- Quantifiable

Planning Paradigms

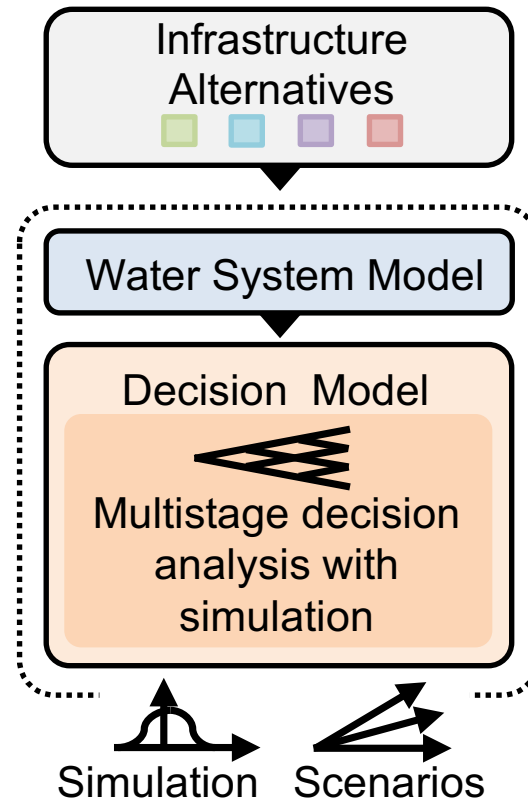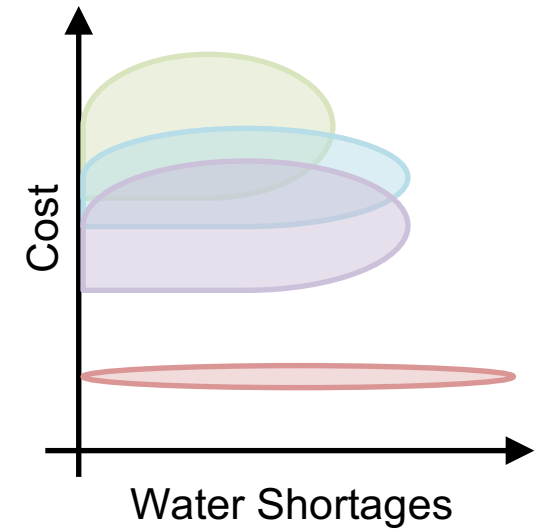- Resilience
- Robustness
- Adaptability

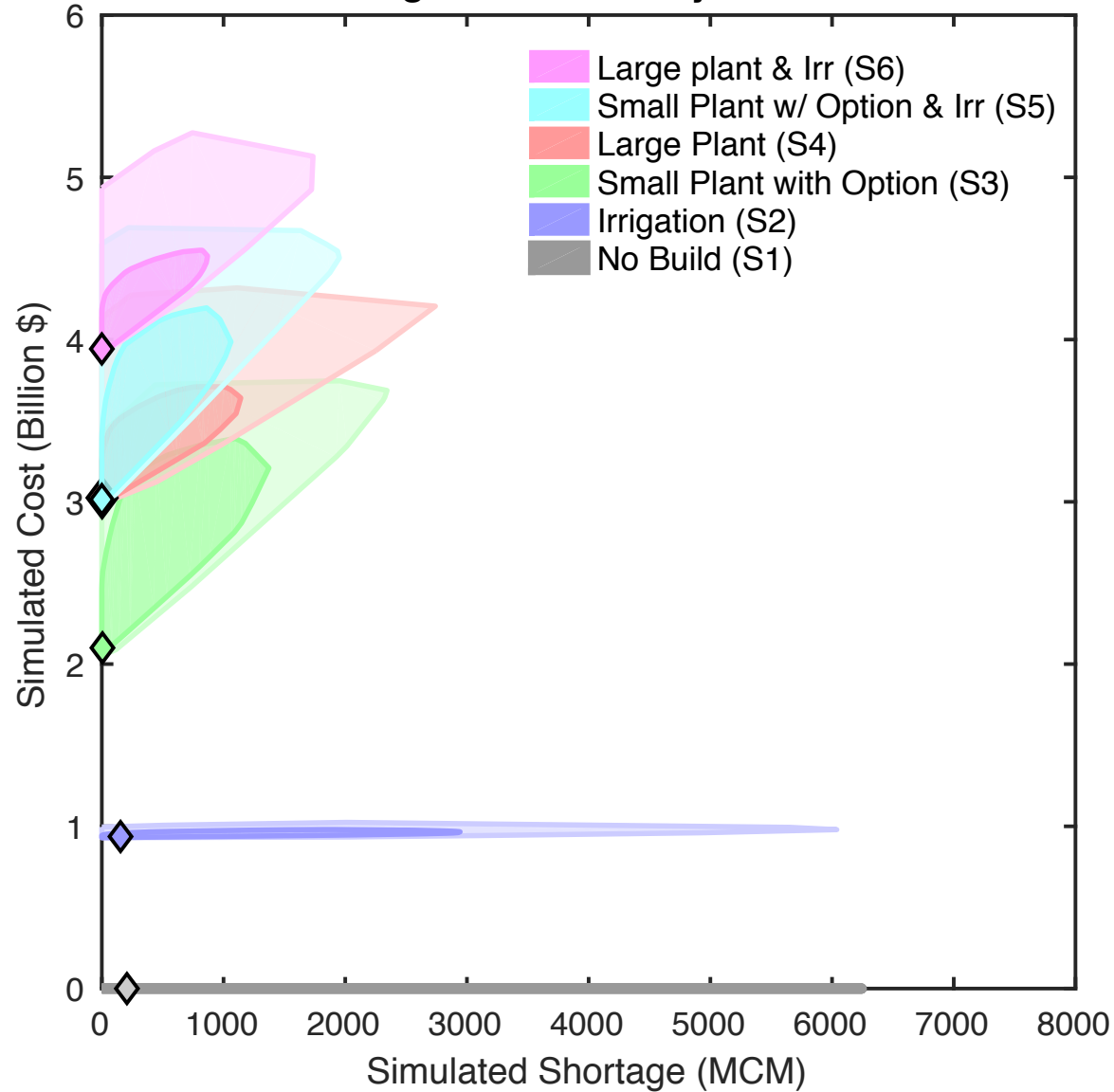# Modeling Framework

1. Uncertainty Categorization

Learning Potential

2. Modeling

3. Risk Profile

Back to Melbourne: Flexible infrastructure design

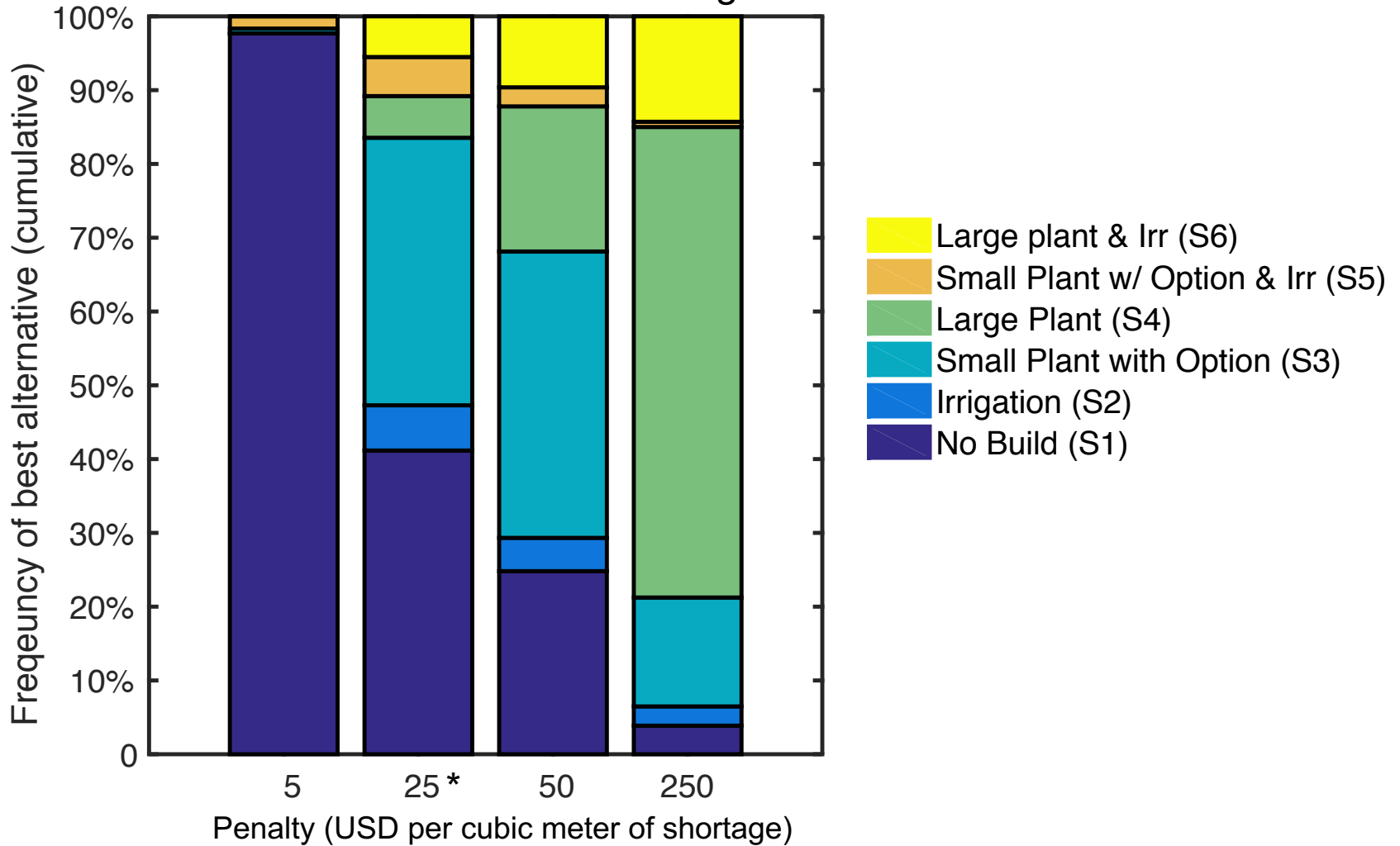|	Infrastructure	Capital Expenditure (M$)	Capacity (MCM/year)
S1	No Build	0	0
S2	Pipeline and irrigation upgrade	1,002	Variable: Max 100
S3	Small RO plant with expansion option	2,045 [+1,095]	Firm: 75 [+ 75]
S4	Large RO plant	2,900	Firm: 150
S5	Small RO plant with expansion option; Pipeline and irrigation upgrade	3047 [+1,095]	Firm: 75 [+ 75] Variable: Max 80
S6	Large RO plant; Pipeline and irrigation upgrade	3902	Firm: 150 Variable: Max 80

Cost and Water Shortage Distribution by Infrastructure Alternative

Legend:
- Large plant & Irr (S6)
- Small Plant w/ Option & Irr (S5)
- Large Plant (S4)
- Small Plant with Option (S3)
- Irrigation (S2)
- No Build (S1)

Y-axis: Simulated Cost (Billion $)
X-axis: Simulated Shortage (MCM)

Risk Ranking by Infrastructure Option
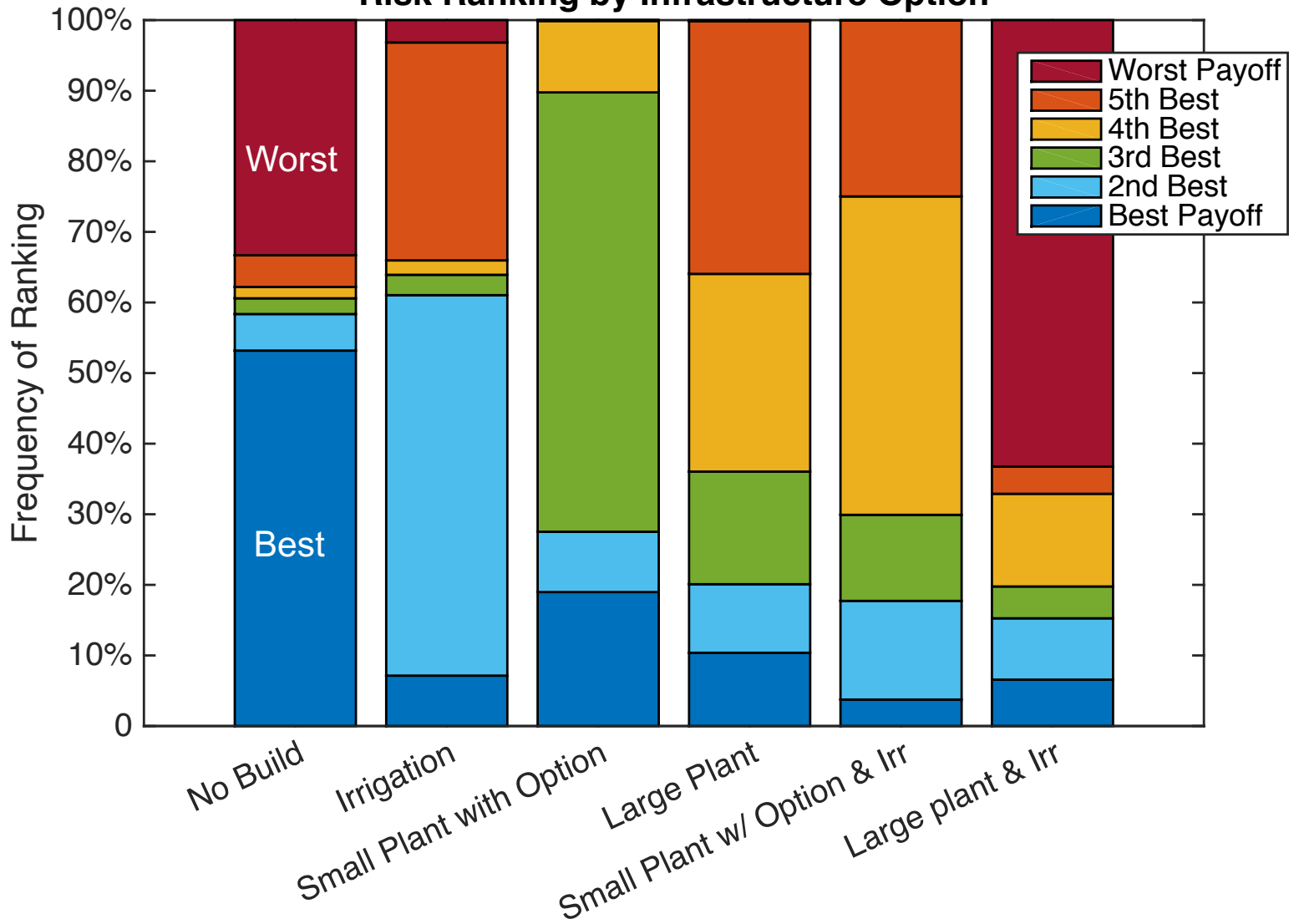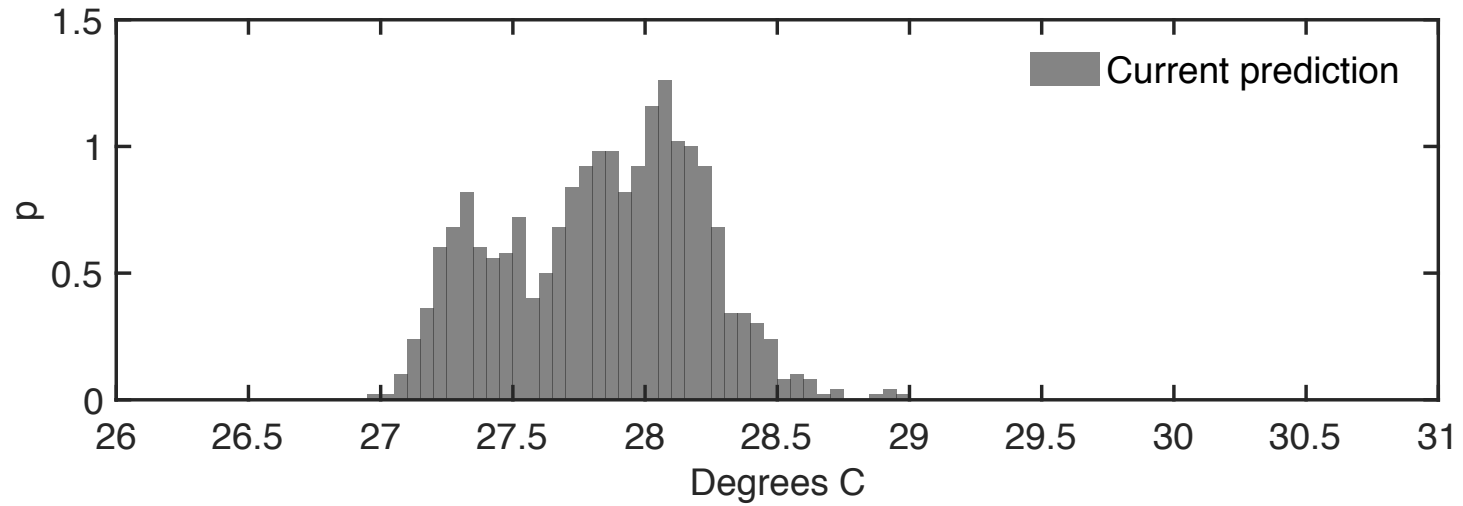
Societal Cost of Water Shortages

Climate change uncertainty in Mombasa, Kenya

- Planning a dam for domestic and agricultural water supply

- Substantial uncertainty in climate change – half models say going to get wetter, half say going to get drier
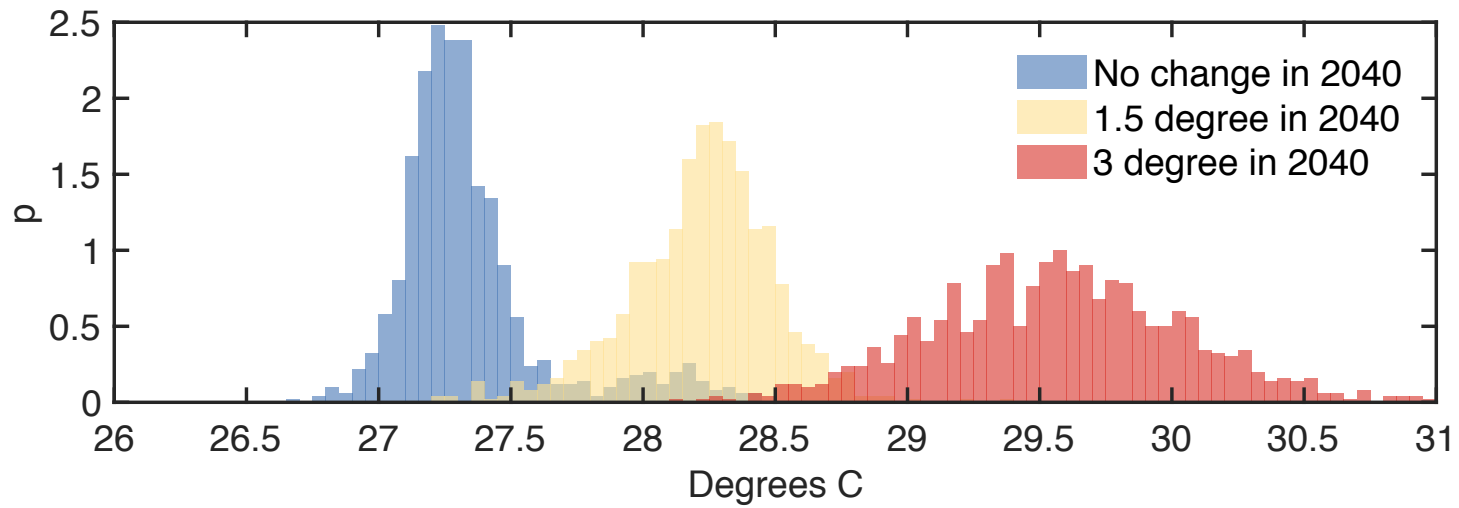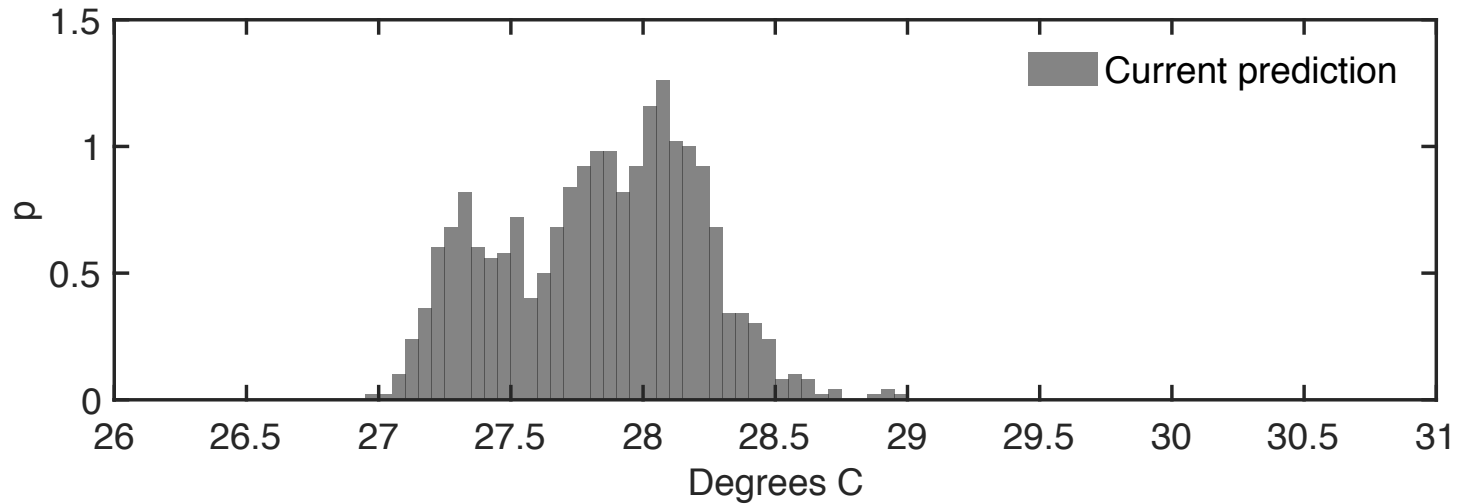
Disaggregating climate uncertainty: variability, model, scenario
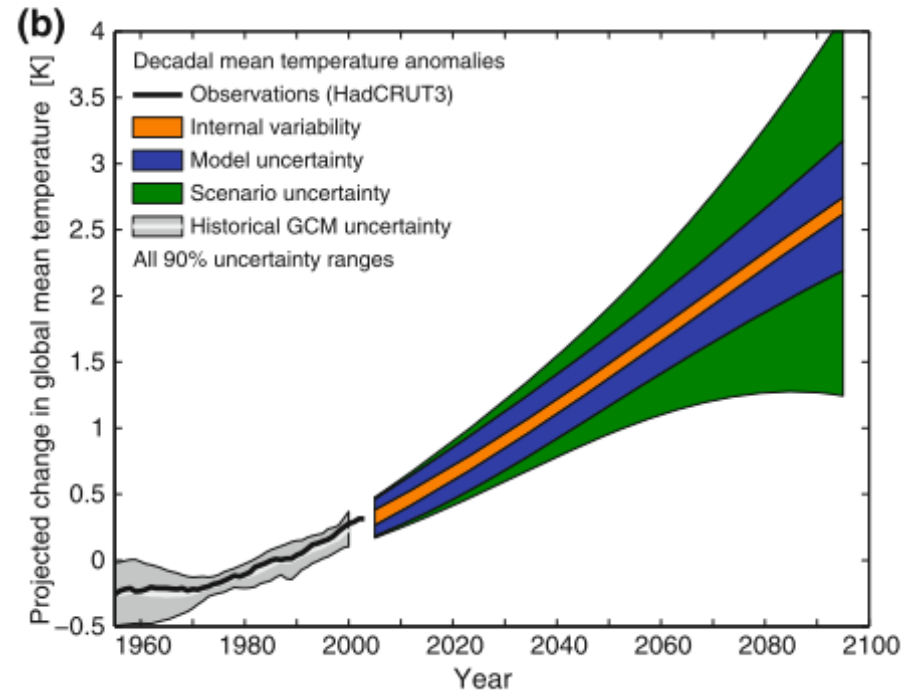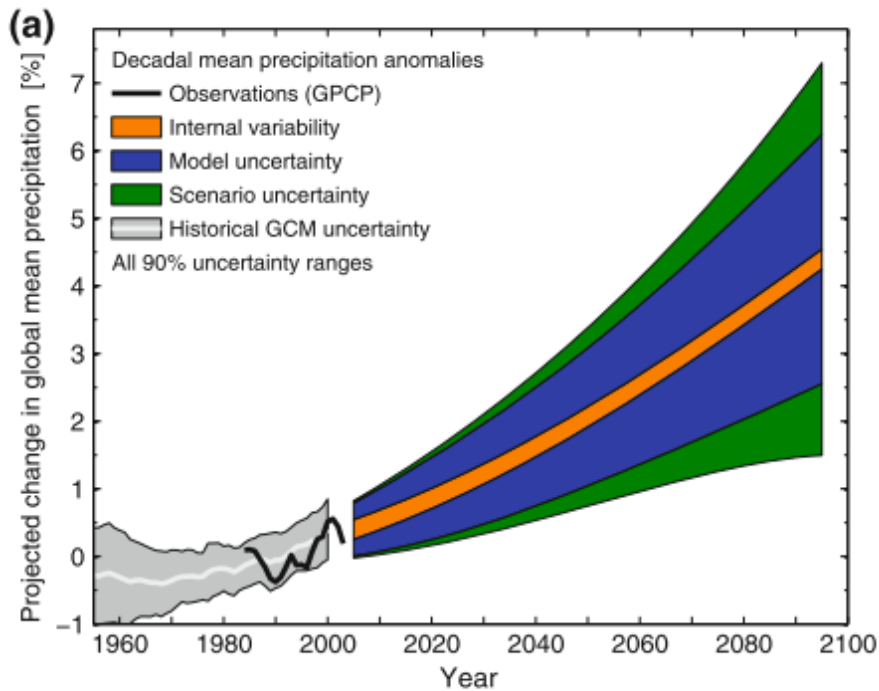
2100 Temperature Prediction for Mombasa, Kenya

2100 Temperature Prediction for Mombasa, Kenya

Takeaways

- Diverse uncertainties impact water systems uniquely

- Some uncertainties offer learning opportunities over time

- We need to account for uncertainty in future dynamically, so that we can proactively prepare to adapt today

- Flexibility can mitigate risk, especially for uncertainties with high learning potential

Thank You!