

Factors Affecting Uncertainty of Future Water Supply & Quality

VA AWWA

**Drinking Water Quality & Research Committee Seminar
University of Richmond**

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Virginia Water Resources Research Center

20 March 2019

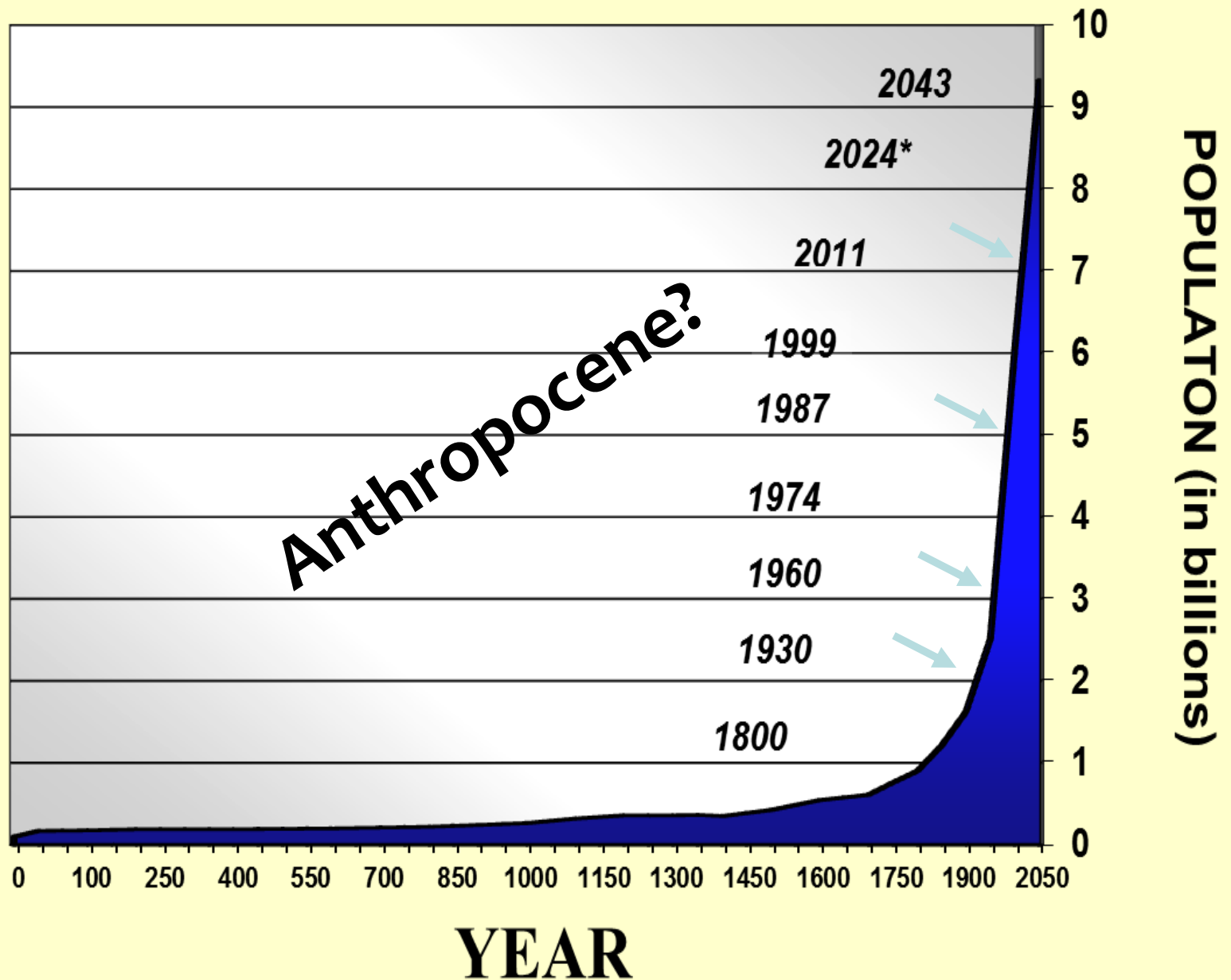


This Morning's Outline

- I. The Anthropocene context**
- II. Why uncertainty?**
- III. Sources of uncertainty**
- IV. Challenges for water planning & decisions**



Human Population 1 AD - 2050 AD



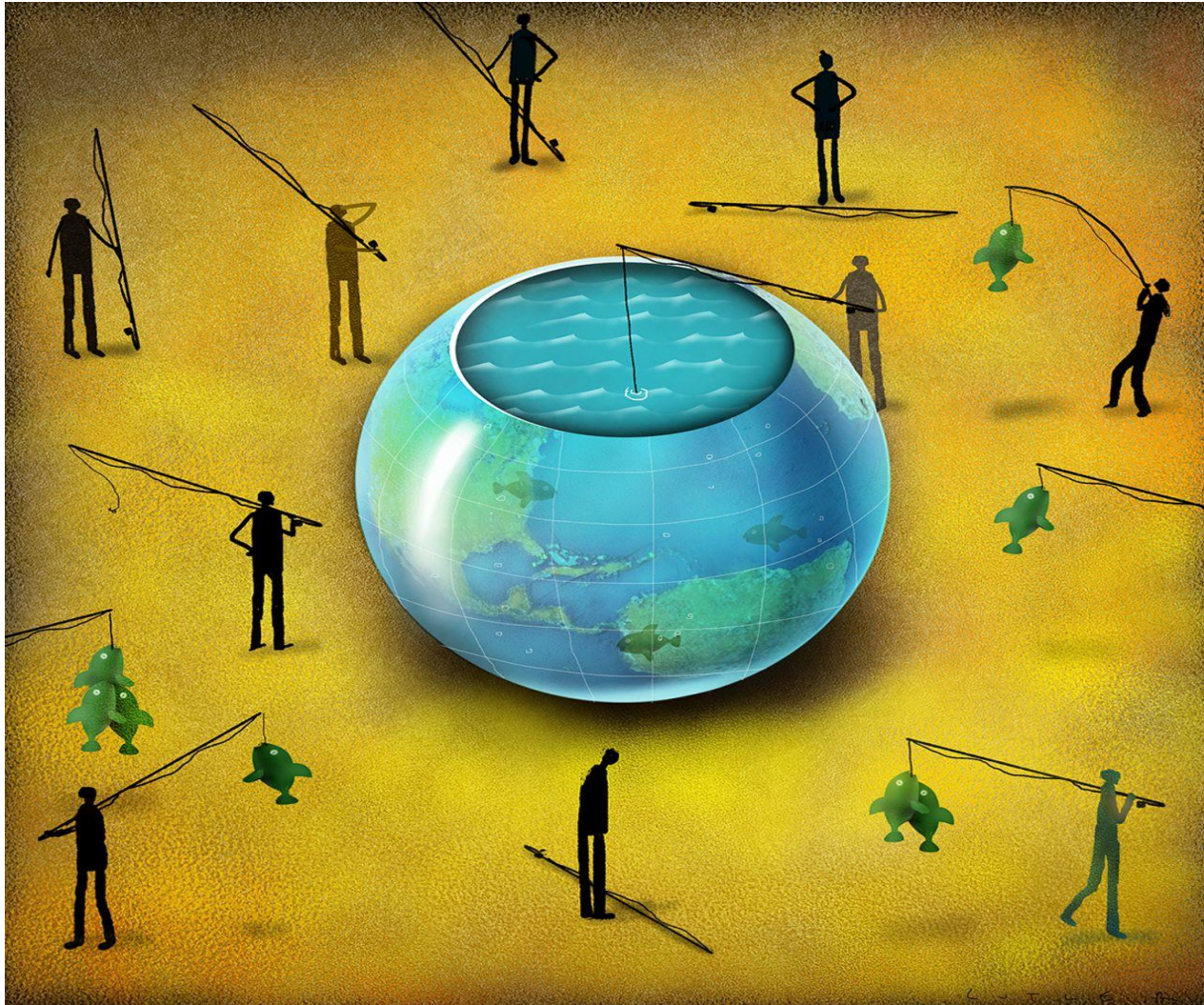
*Projected

Using Resources Without Heeding Long-term Consequences



Battersby PNAS 2017

Leads to Depletion that Harms All



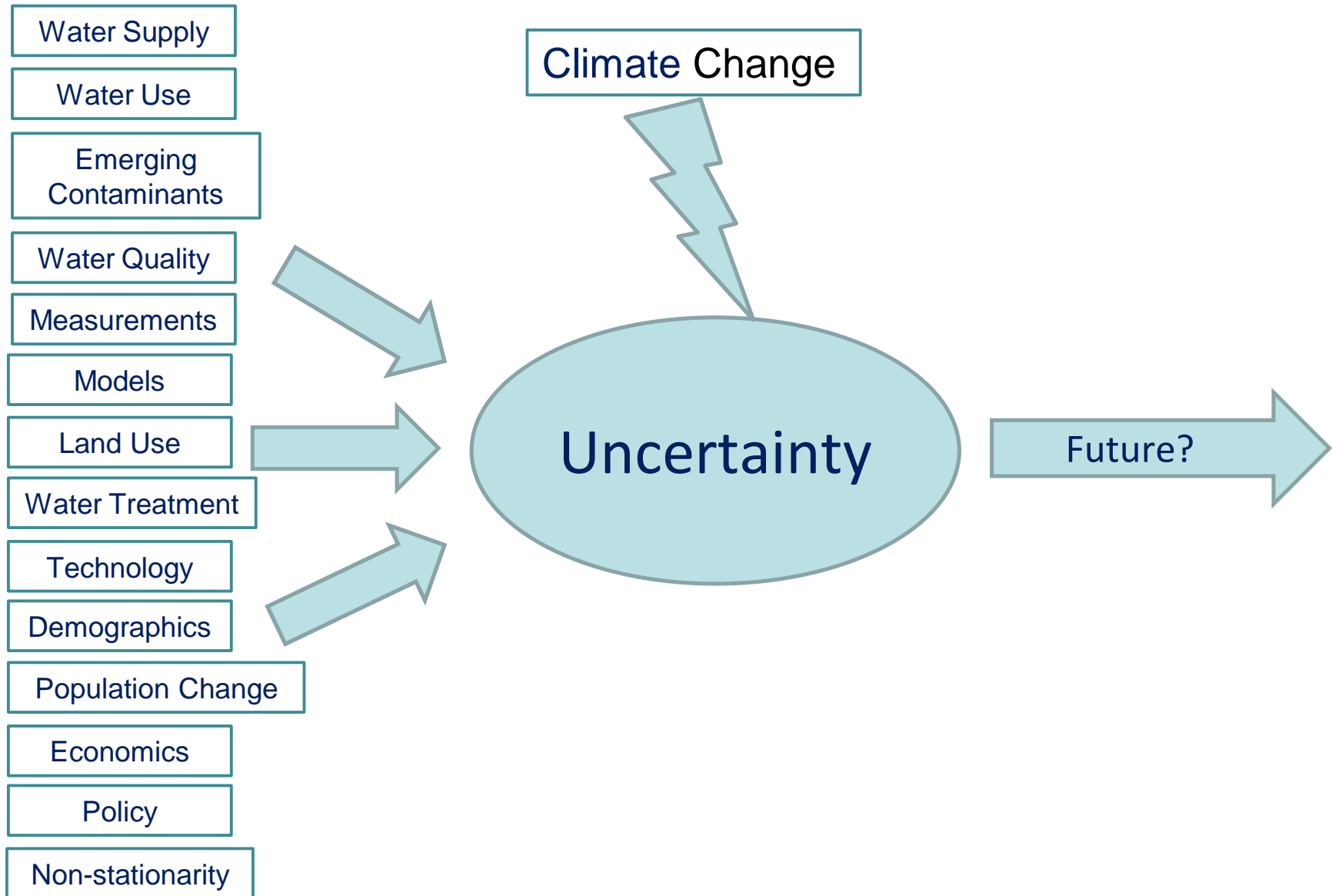
Battersby PNAS 2017

Risk versus Uncertainty

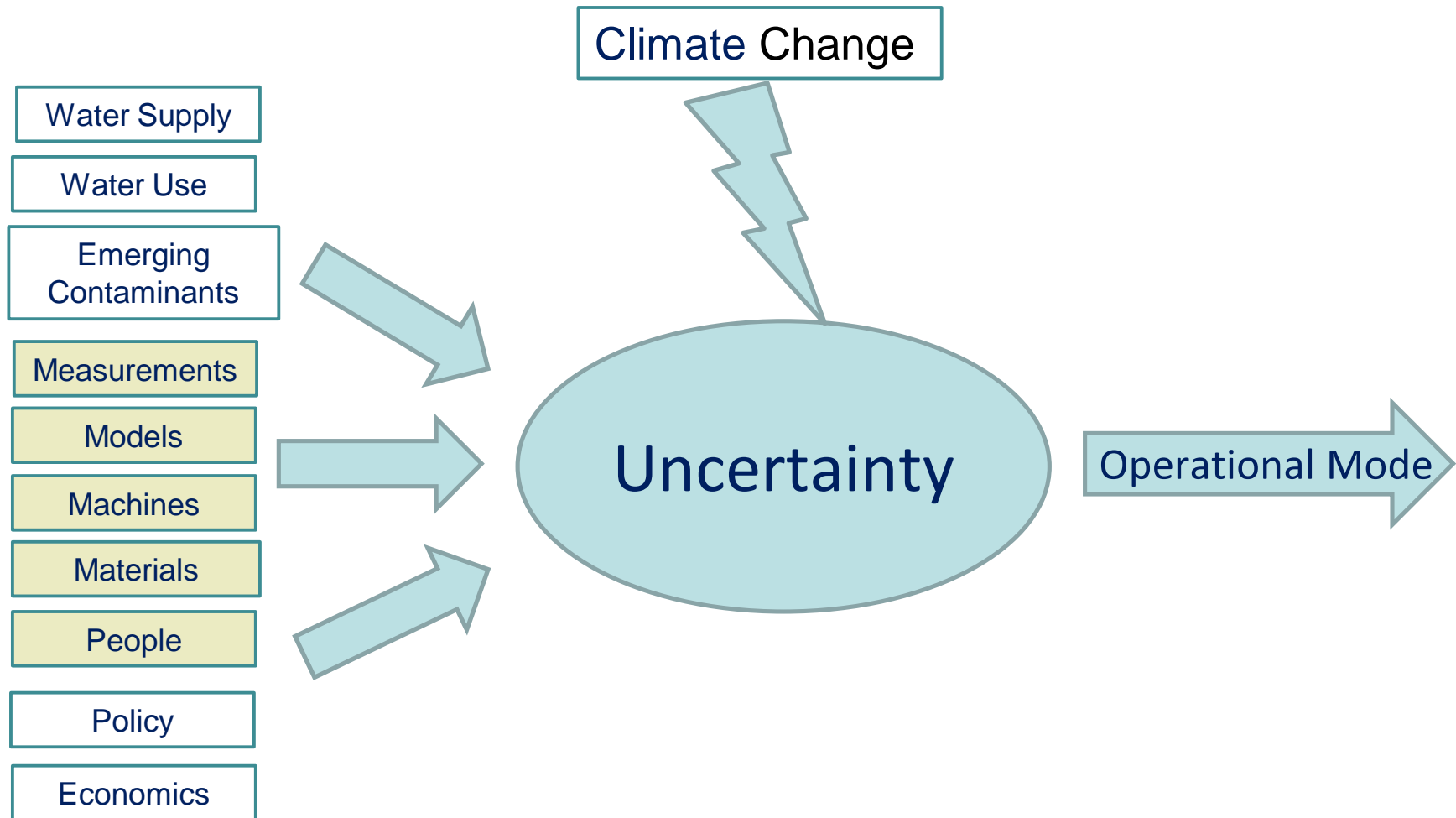
- ❑ Often used interchangeably
- ❑ Have different implications for environmental assessment & decision-making
- ❑ Risk includes both probability of occurrence & consequences associated with event
- ❑ Risk component – probability distribution setting likelihood of event occurring
- ❑ Uncertainty – probability distributions of possible outcomes unknown
- ❑ Uncertainty implies use of precautions



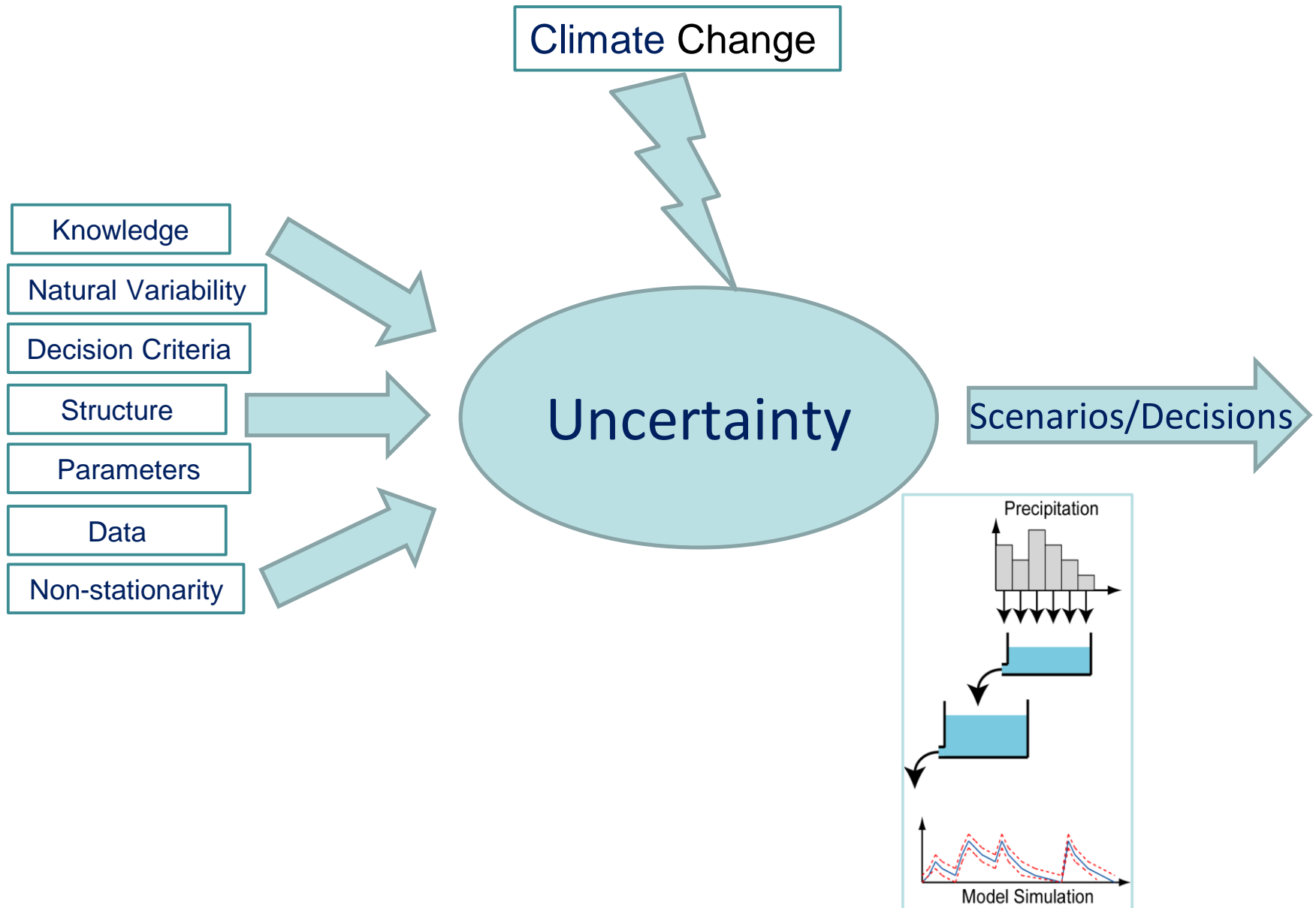
Sources of Uncertainty



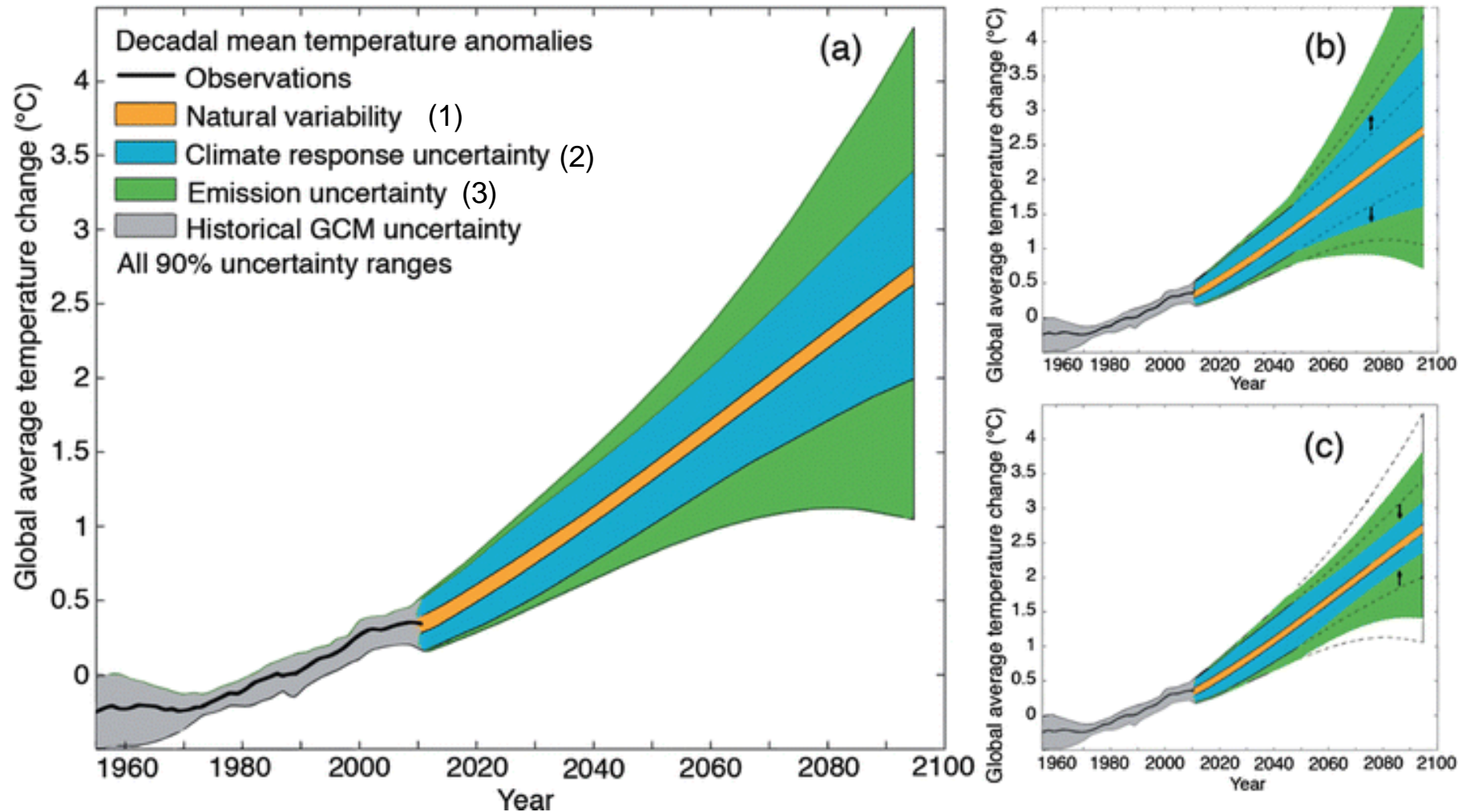
Sources of Uncertainty – Water Treatment



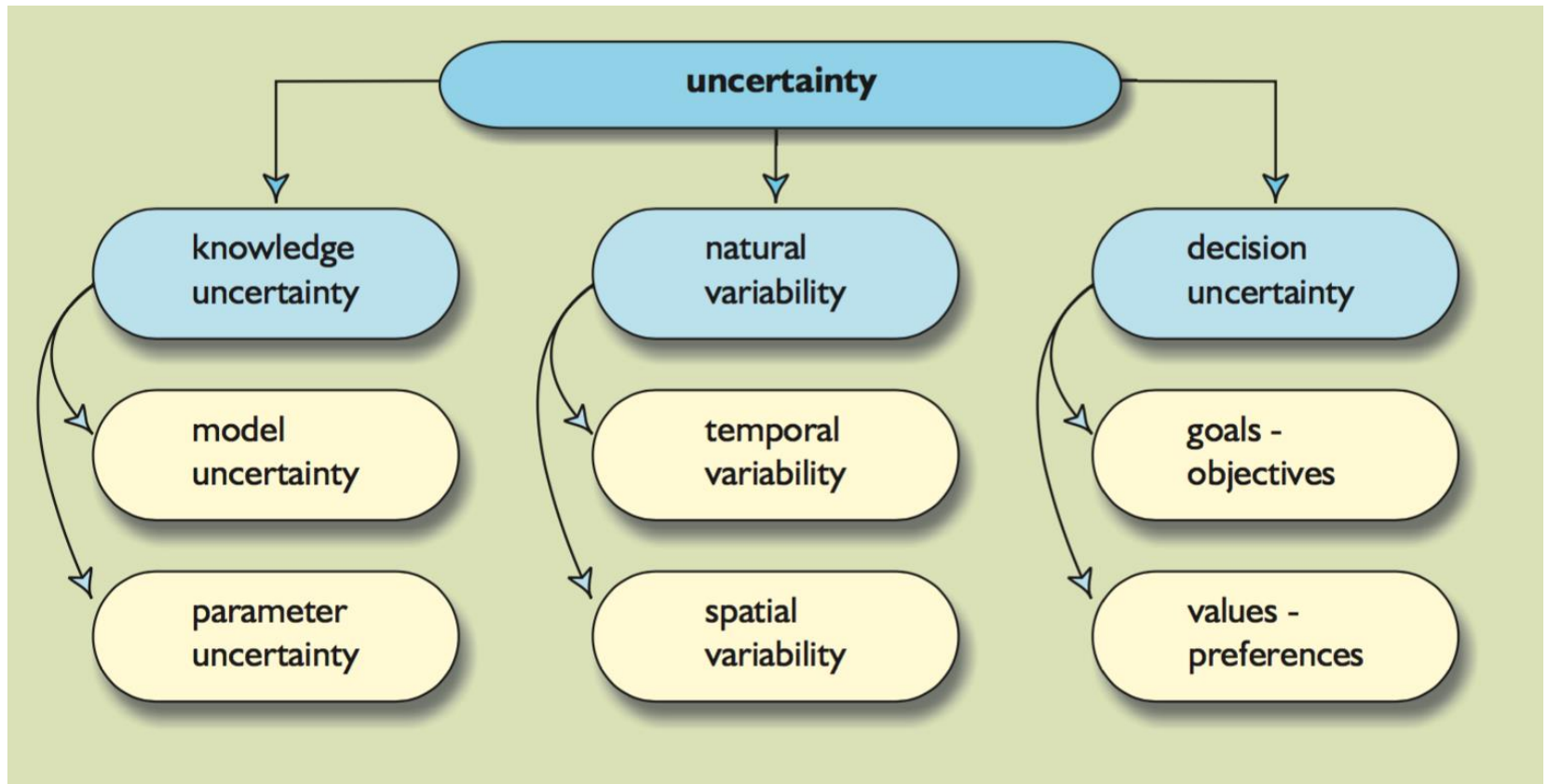
Sources of Uncertainty - Models



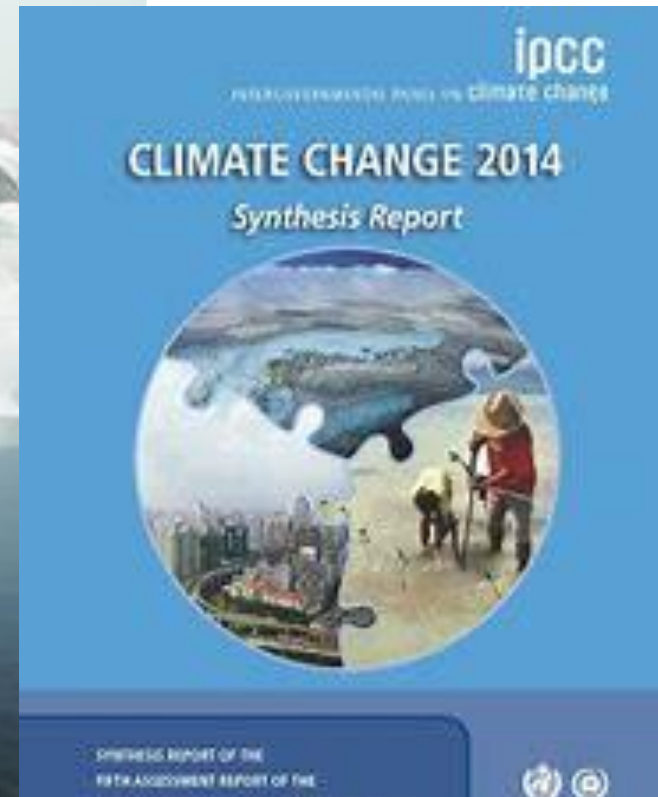
Types of Uncertainties in IPCC Models



Uncertainty



Climate Change is Water Change

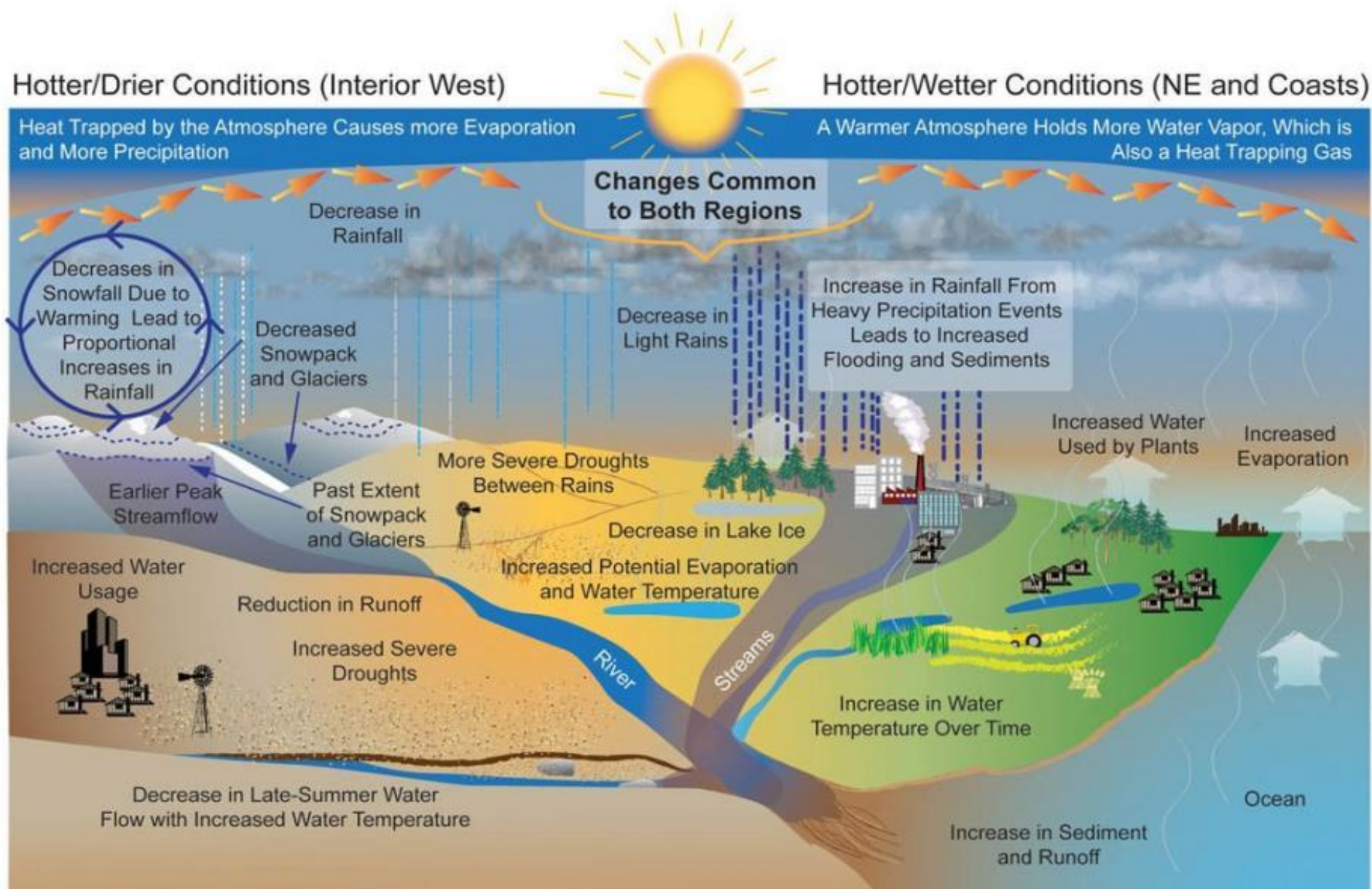


Climate Change is Precipitation Change

- ❑ Quantity
- ❑ Variability
- ❑ Timing
- ❑ Form
- ❑ Intensity

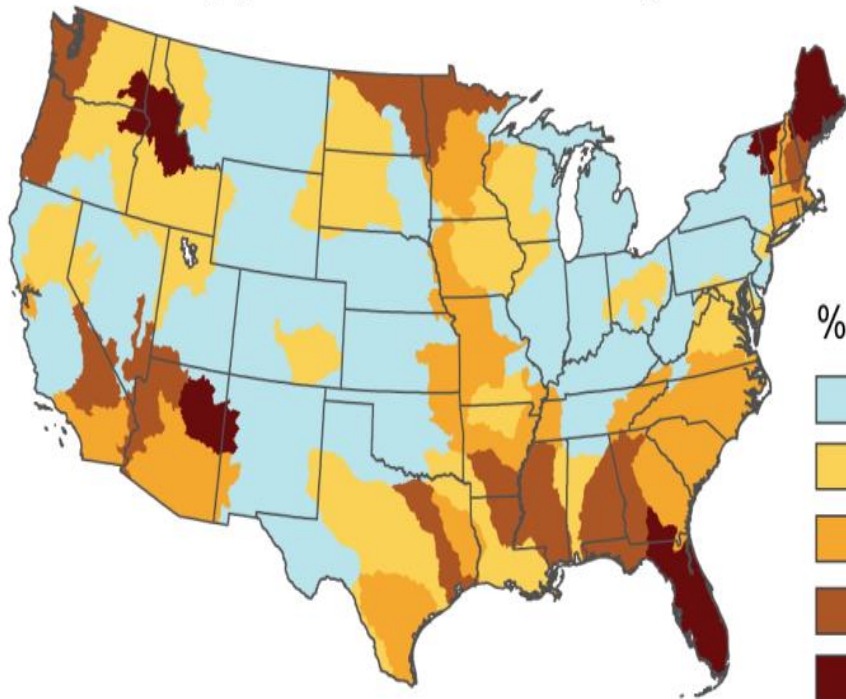


Projected Changes in Water Cycle

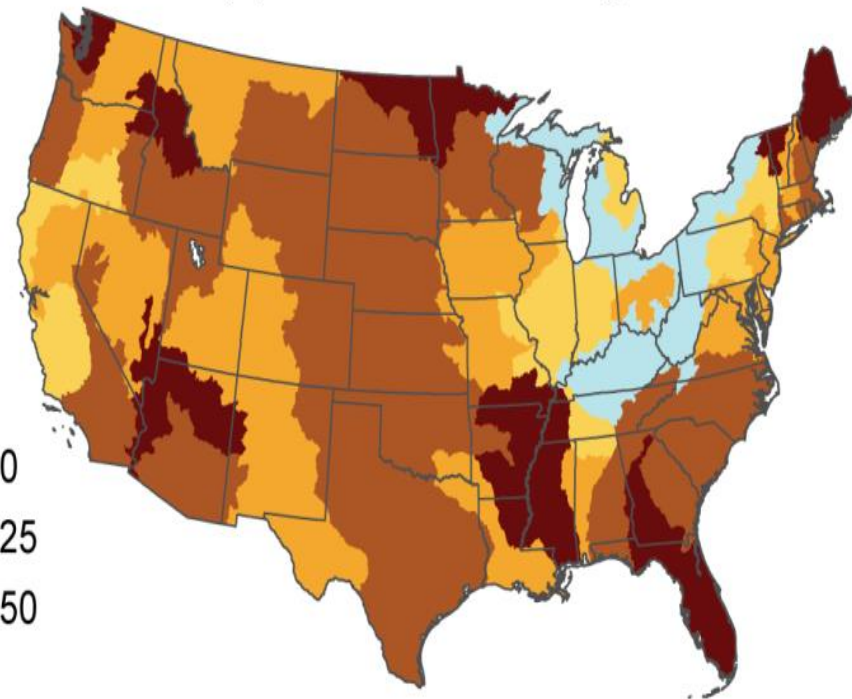


Water Withdrawals Projected to Increase – 2050 (IPCC)

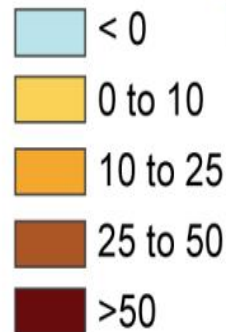
(a) Without Climate Change



(b) With Climate Change



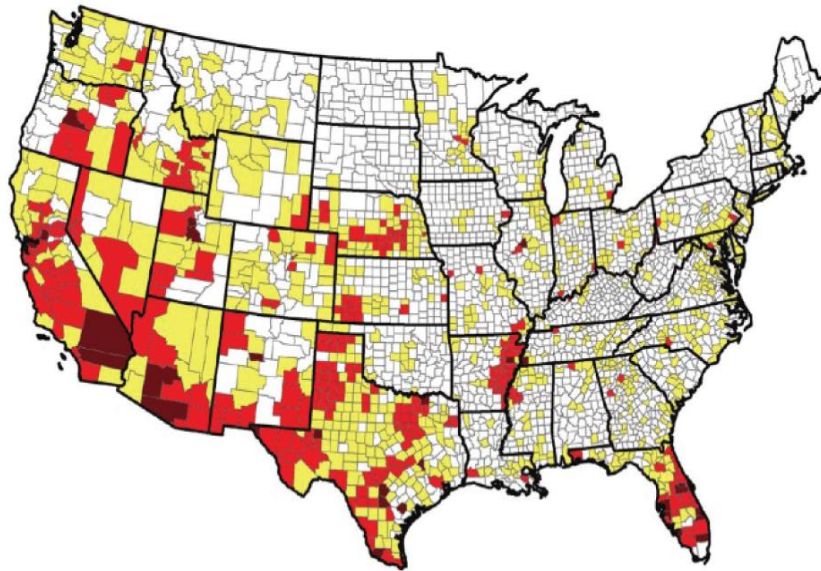
% change



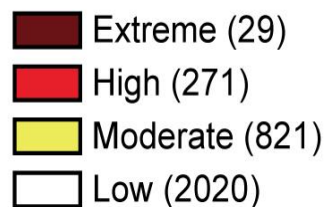
Water Supplies Projected to Decline

(IPCC)

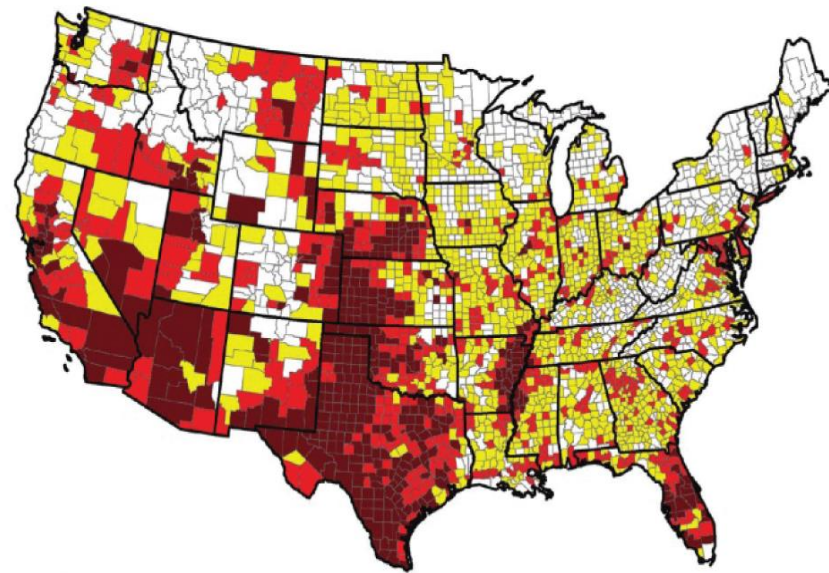
No Climate Change Effects



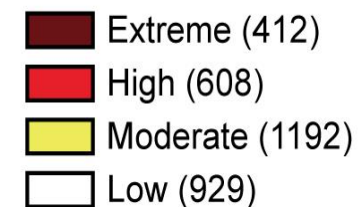
Water Supply Sustainability Risk Index (2050)



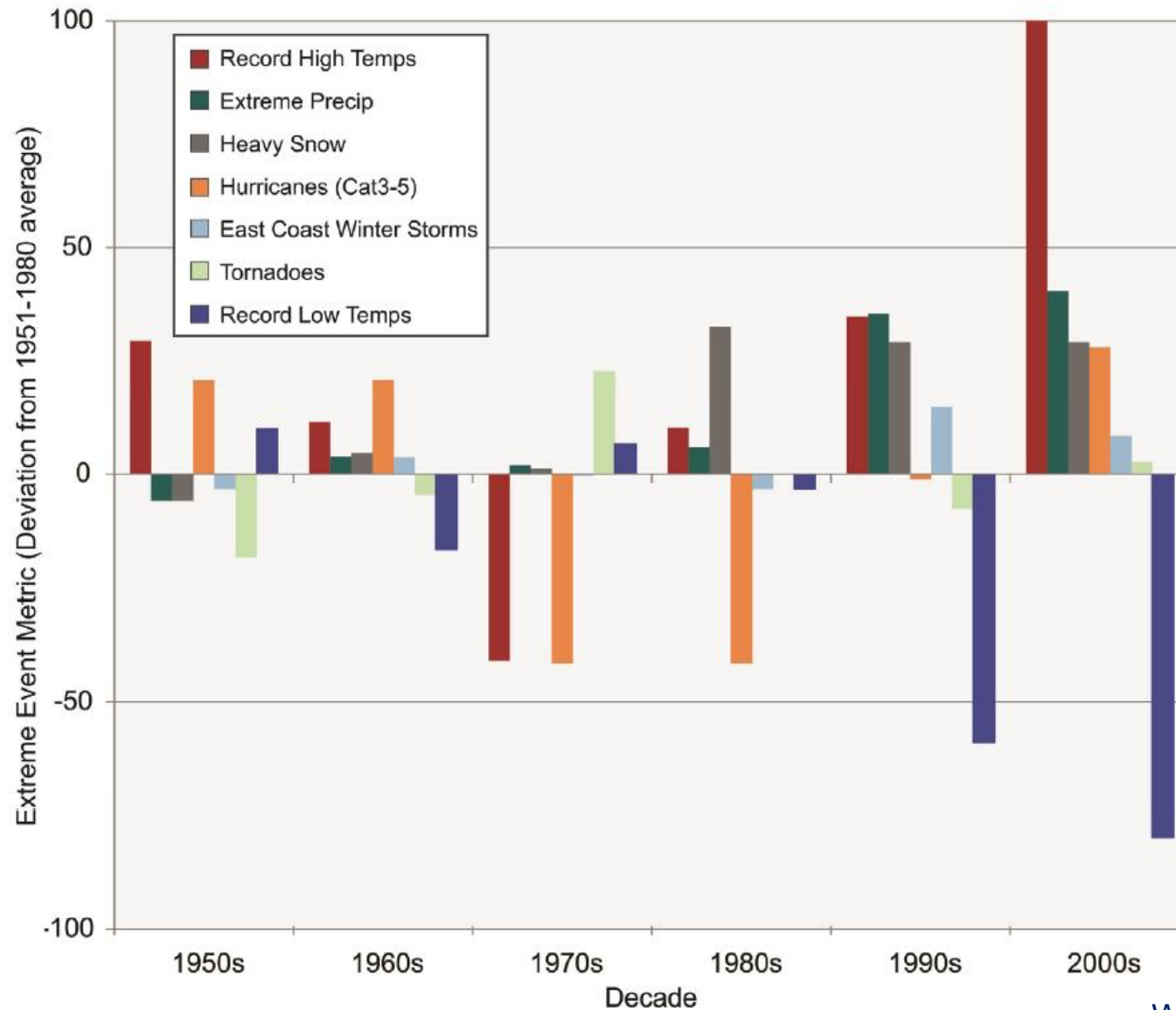
Climate Change Effects



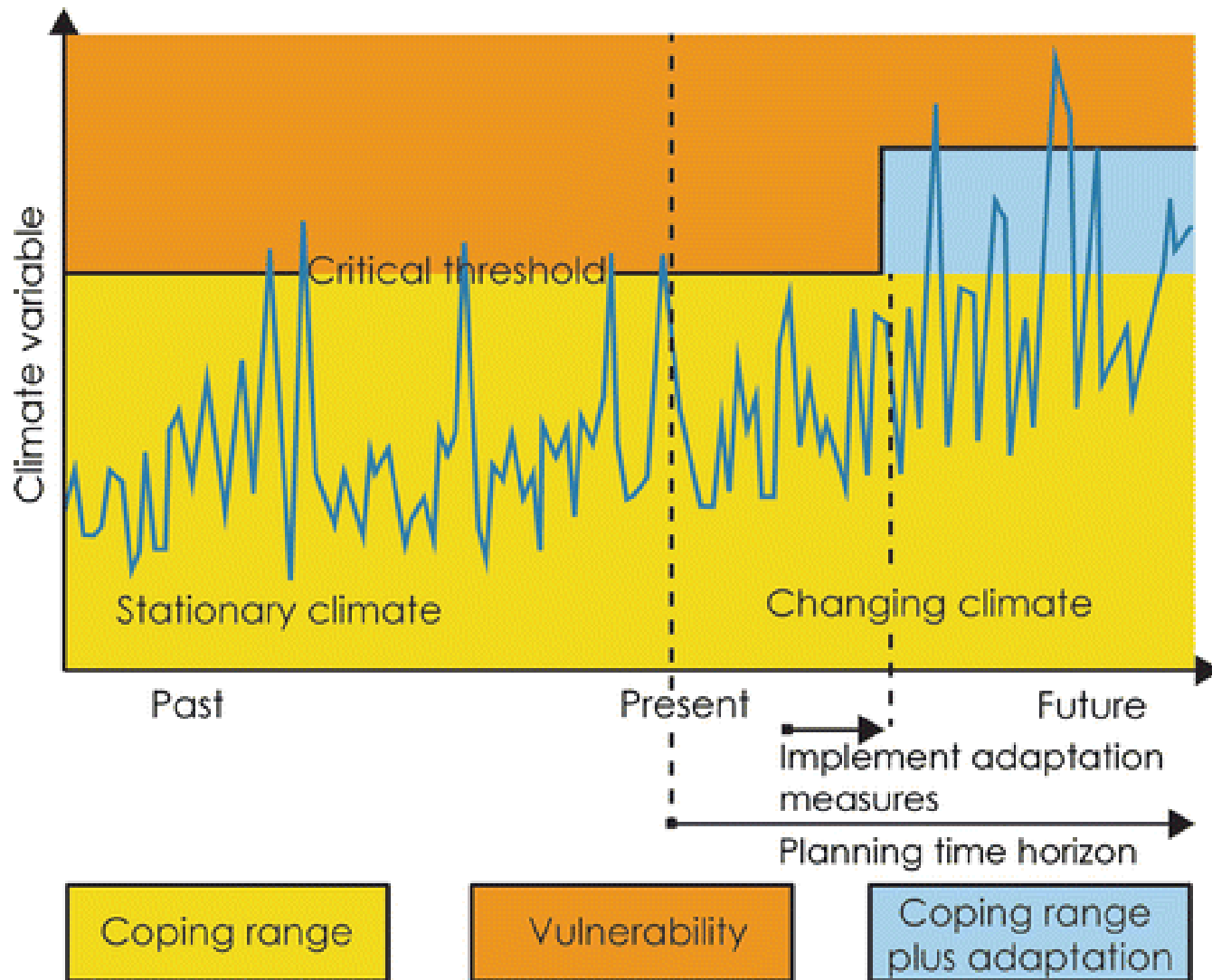
Water Supply Sustainability Risk Index (2050)



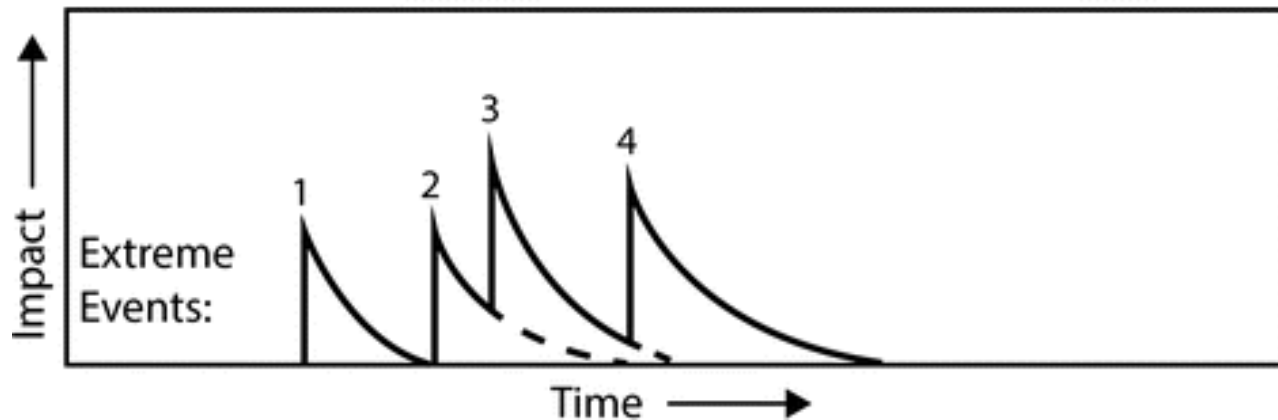
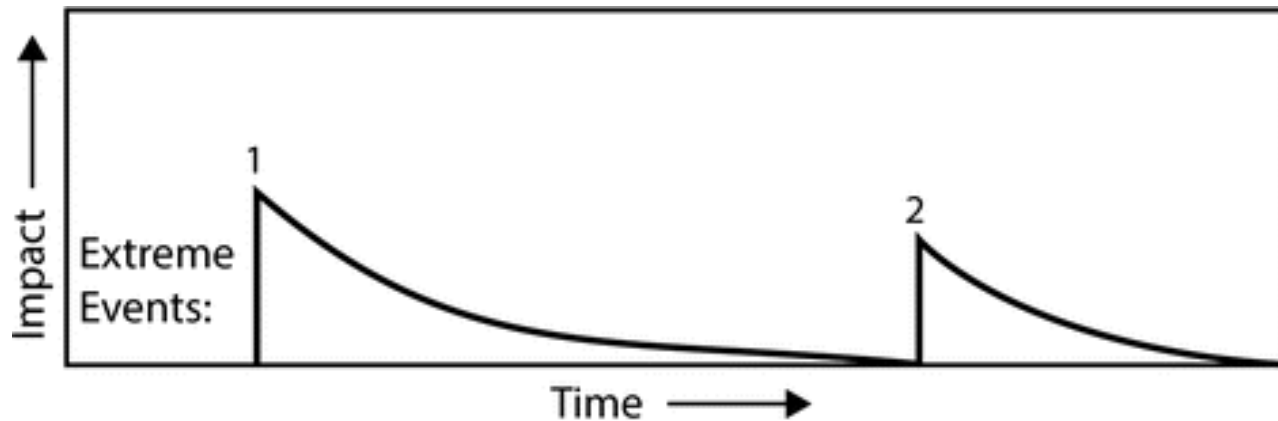
Extreme Weather Metrics for Recent Decades



Extreme Conditions vs Ability to Cope



Extreme Events Increase Impact with Increasing Frequency & Intensity



Homes flood as Missouri River breaches levees

Hundreds of miles of levees were affected, and the deaths of three people have now been blamed on the flooding.

By Heather Hollingsworth
Associated Press

KANSAS CITY, Mo. — Hundreds of homes flooded in several Midwestern states after rivers breached at least a dozen levees following heavy rain and snowmelt in the region, authorities said Monday while warning that the flooding was expected to linger.

About 200 miles of levees were compromised — either breached or overtopped — in four states, the U.S. Army Corps of Engineers said. Even in places where the water level peaked in those states — Nebraska, Iowa, Missouri and Kansas — the current was fast and the water so high that damage continued to pile up. The flooding was

blamed for at least three deaths.

"The levees are busted and we aren't even into the wet season when the rivers run high," said Tom Bullock, the emergency management director for Missouri's Holt County.

He said many homes in a mostly rural area of Holt County were inundated with 6 to 7 feet of water from the swollen Missouri River.

"The water isn't going to be gone, and the levees aren't going to be fixed this year," said Bullock, whose own home was now on an island surrounded by floodwater.

One couple was rescued by helicopter after water from three breached levees swept across 40,000 acres, he said. Another nine breaches were con-

firmed in Nebraska and Iowa counties south of the Platte River, the Corps said.

The Missouri River already crested upstream of Omaha, Nebraska, though hundreds of people remained out of their homes and water continued to pour through busted levees. Flooding was so bad around Fremont, Nebraska, that just one lane of U.S. 30 was uncovered outside the city of 26,000. State law enforcement limited traffic on that road to pre-approved trucks carrying gas, food, water and other essential supplies.

The flooding started after a massive late-winter storm hit the Midwest last week. The high water was blamed in the deaths of three people from Nebraska.

Two men in Nebraska have been missing since Thursday. One was last seen on top of his flooded car; the other was swept away after a dam collapsed.



The Missouri River floods across and closes K-7 highway near White Cloud, Kan., on Monday.

Mozambique's president says over 1,000 feared dead after cyclone



Pentagon lists possible cuts to pay for wall

The Pentagon document listed hundreds of projects worth about \$12.9 billion, though not all would be cut.

By Alan Fram and Lolita C. Baldor
Associated Press

WASHINGTON — The Pentagon sent a 20-page list of military construction projects to Congress on Monday that might be slashed to pay for President Donald Trump's wall along the Mexican border. Democrats expressed hope that by knowing which local projects could be targeted, lawmakers would be likelier to over-

Components of Water Quality

Physical – temperature, turbidity



Chemical – pH, nutrients, pesticides



Biological – bacteria, algae



Harmful Algal Blooms

- ❑ Sunlight + slow-moving water + excess nutrients
- ❑ Also called red tides, blue-green algae, cyanobacteria
- ❑ Can produce toxins
- ❑ Expanding drinking-water supply problem nationwide
- ❑ Increases water treatment costs

NOTICE

An algae bloom has made this area potentially unsafe for water contact. Avoid direct contact with visible surface scum.



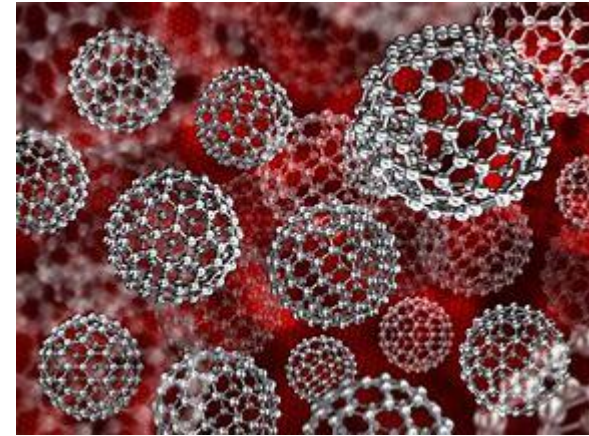
Salinization

- ❑ Increase in concentration of dissolved salts
- ❑ Agricultural irrigation
- ❑ Road de-icing
- ❑ Urban runoff
- ❑ Increases cost of water treatment
- ❑ Mining
- ❑ Damages infrastructure



Emerging Contaminants

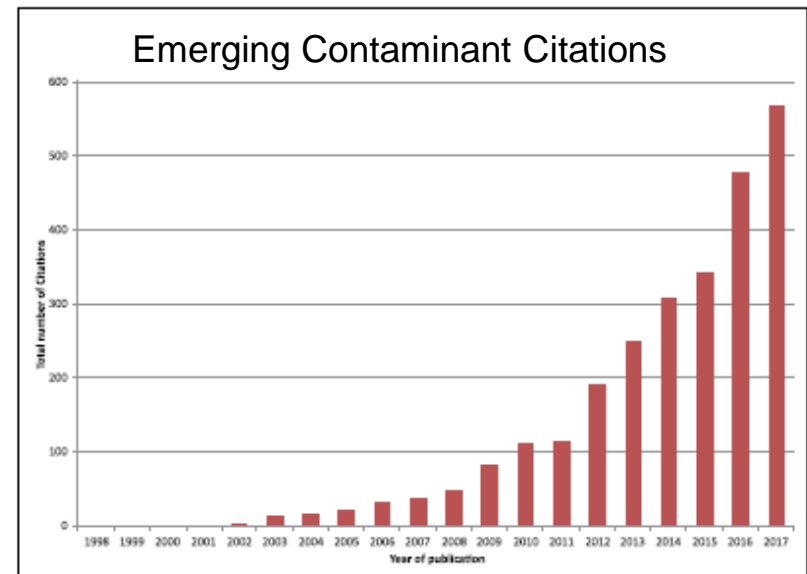
- ❑ Engineered nanoparticles
- ❑ Personal-care products
- ❑ Pharmaceuticals
- ❑ Endocrine-disrupting compounds
- ❑ Microplastics in tap water, well water, bottled water, beer
- ❑ Water treatment? Fate?



nanoparticles



microplastics



Purified Wastewater

- ❑ Technologies in use
- ❑ Groundwater replenishment in Orange Co, CA
- ❑ Occoquan Reservoir, VA
- ❑ Legislative hurdles
- ❑ Psychological hurdles



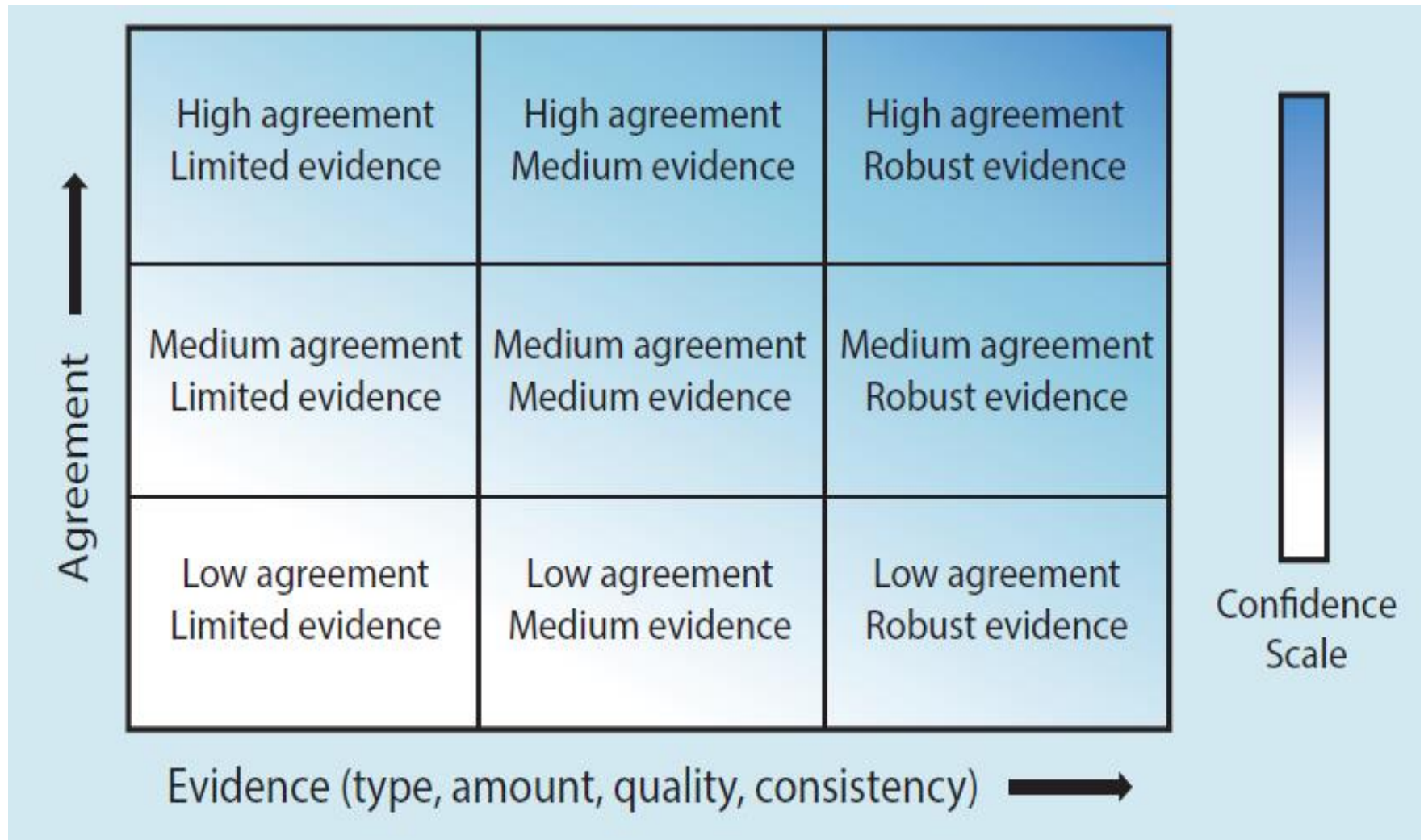
Aging Water Infrastructure

- ❑ Water-treatment systems
- ❑ Water-delivery systems
- ❑ Sewer systems
- ❑ Dams and reservoirs
- ❑ Hazardous-waste storage facilities



Decision Process: Evidence + Agreement

Proactive >>> Reactive



System-of-Systems Context for Proactive, Adaptive Water Management



Thank you!

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