RECLAMATION

Managing Water in the West

Approaches For Integrating Climate Change Into Water Resources Planning

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NAU WREP workshop on Water Management and Climate Change

High Country Conference Center, 8 June 2011, Flagstaff, AZ

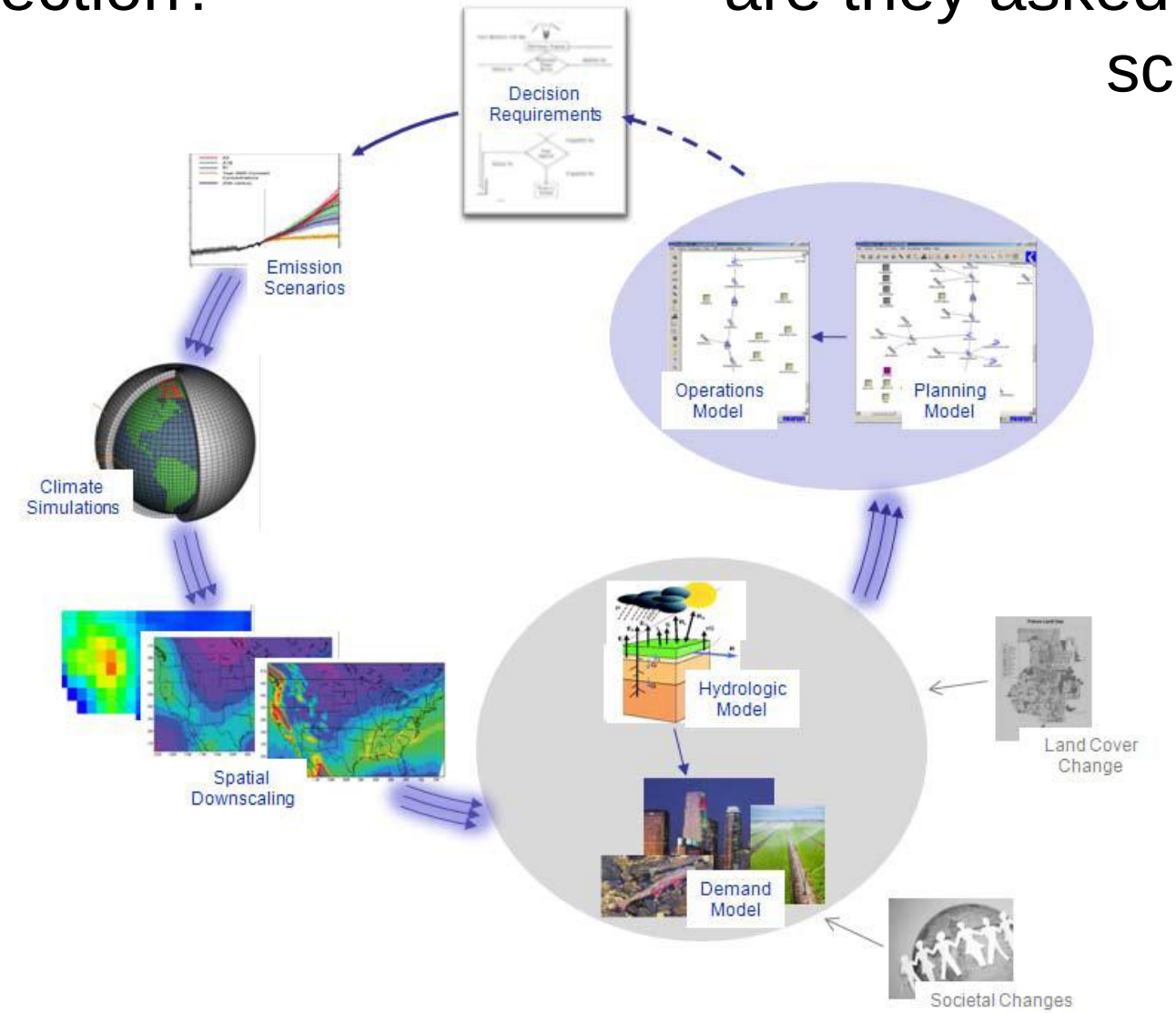
U.S. Department of the Interior
Bureau of Reclamation

Bottom Line Up Front

- We have numerous approaches for using climate change information in water resources studies.
- Most “information generation” frames are science-centric rather than decision-centric… both views have utility in selecting frames for local studies.
- Approaches may consider paleo; involves some type of past/projected blend of climate information.

Which actors affect method selection?

… and what questions are they asked during scoping?

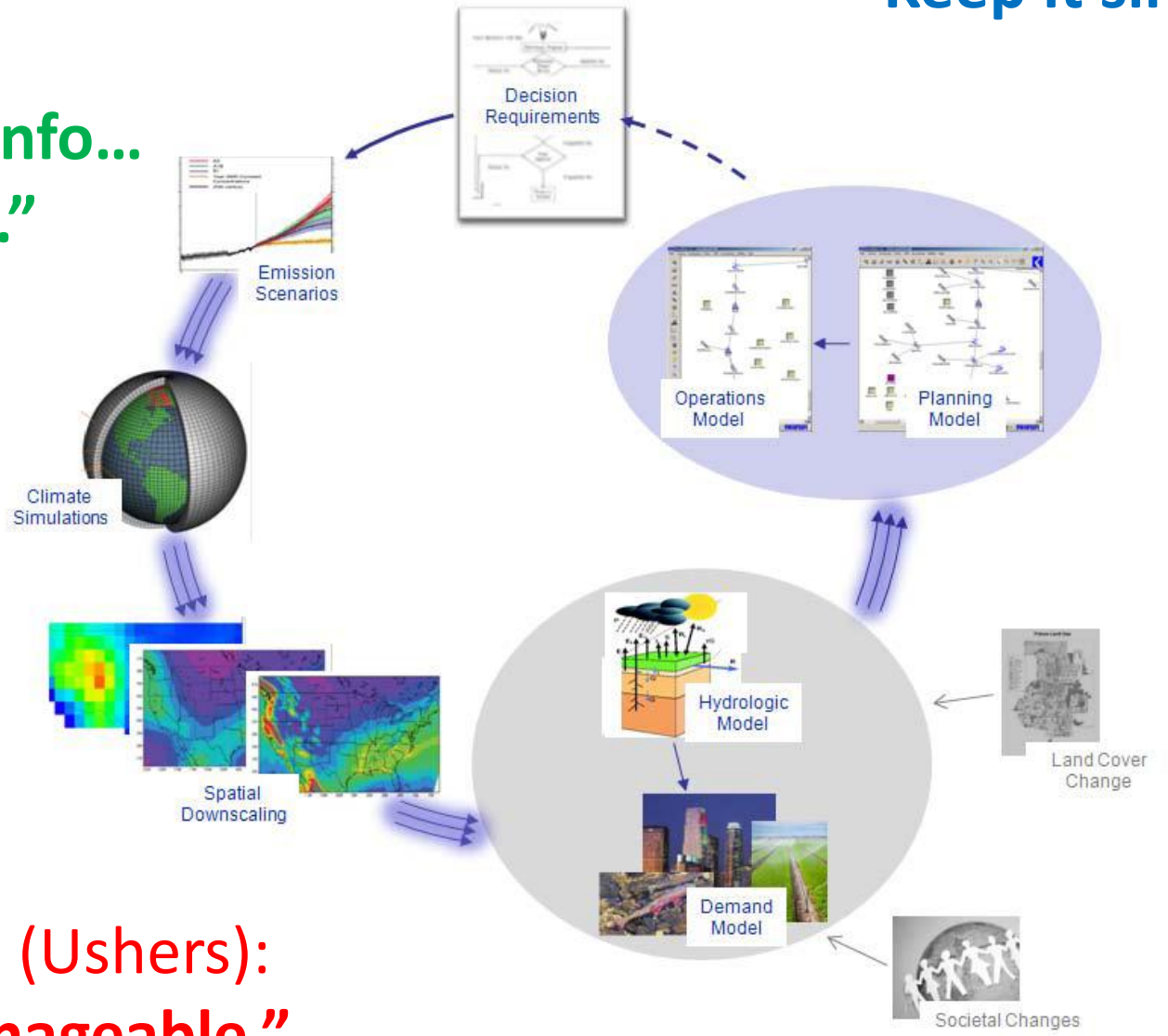


II. Climate Information Providers:

"Here's the info… use it wisely."

I. Decision-Makers:

"Keep it simple."



III. Technical Practitioners (Ushers):

"Keep it Manageable."

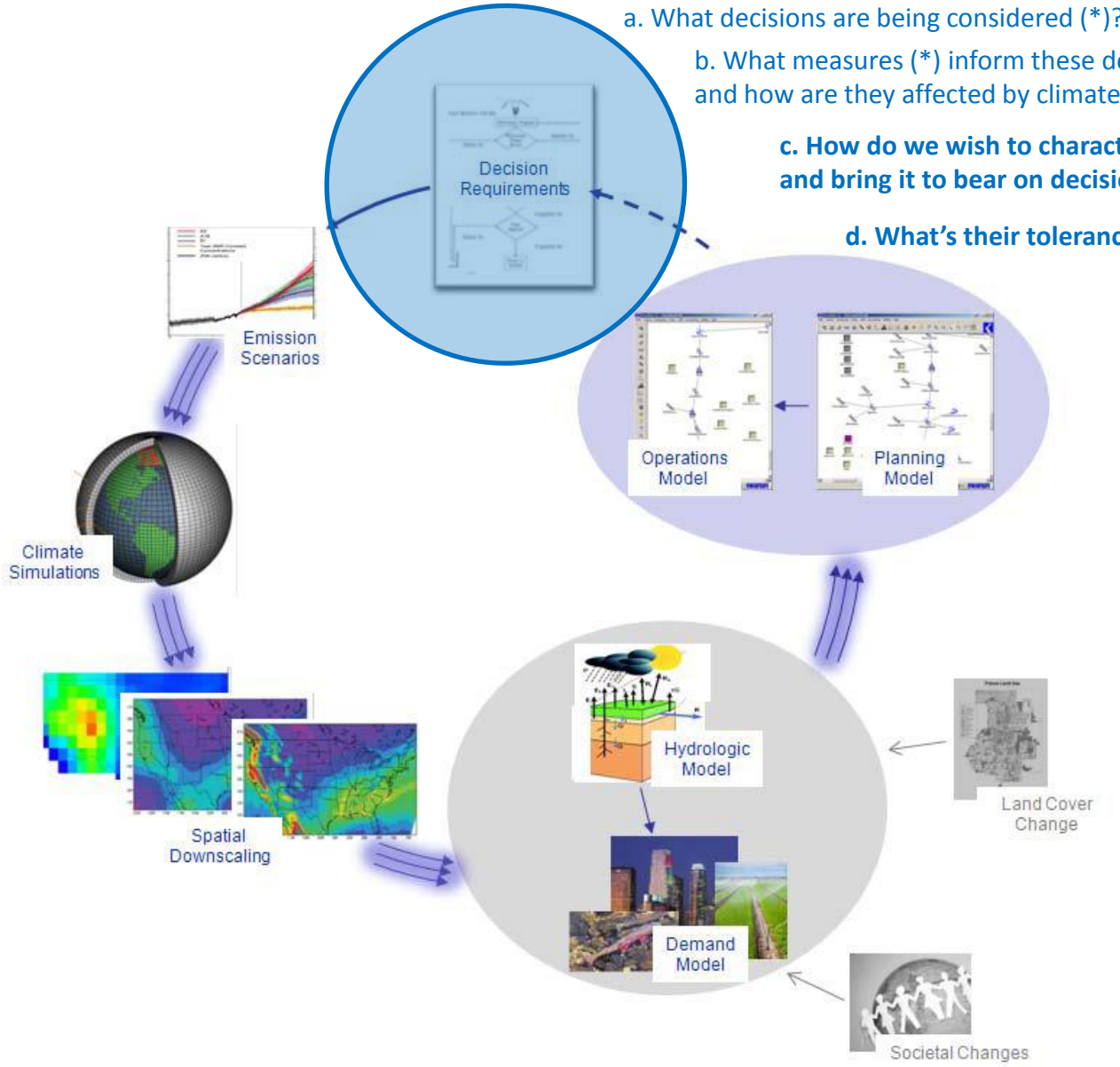
I. Questions for the Decision-Makers:

a. What decisions are being considered (*)?

b. What measures (*) inform these decisions, and how are they affected by climate?

c. How do we wish to characterize uncertainty and bring it to bear on decisions?

d. What's their tolerance for complexity?



(*) Positions and scales in space and time may be different for decisions, measures and climate influences.

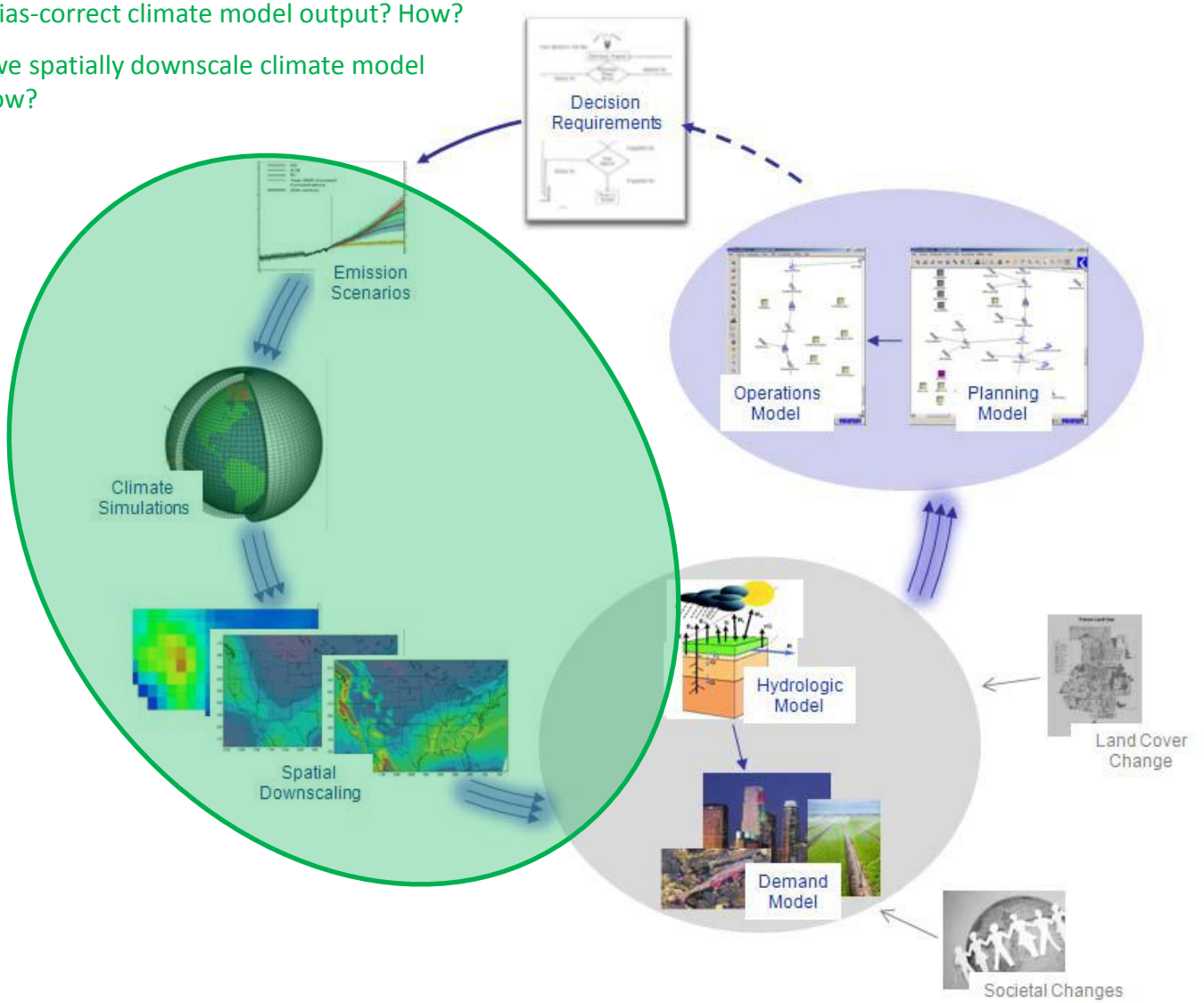
a. What future climate projections should we consider?

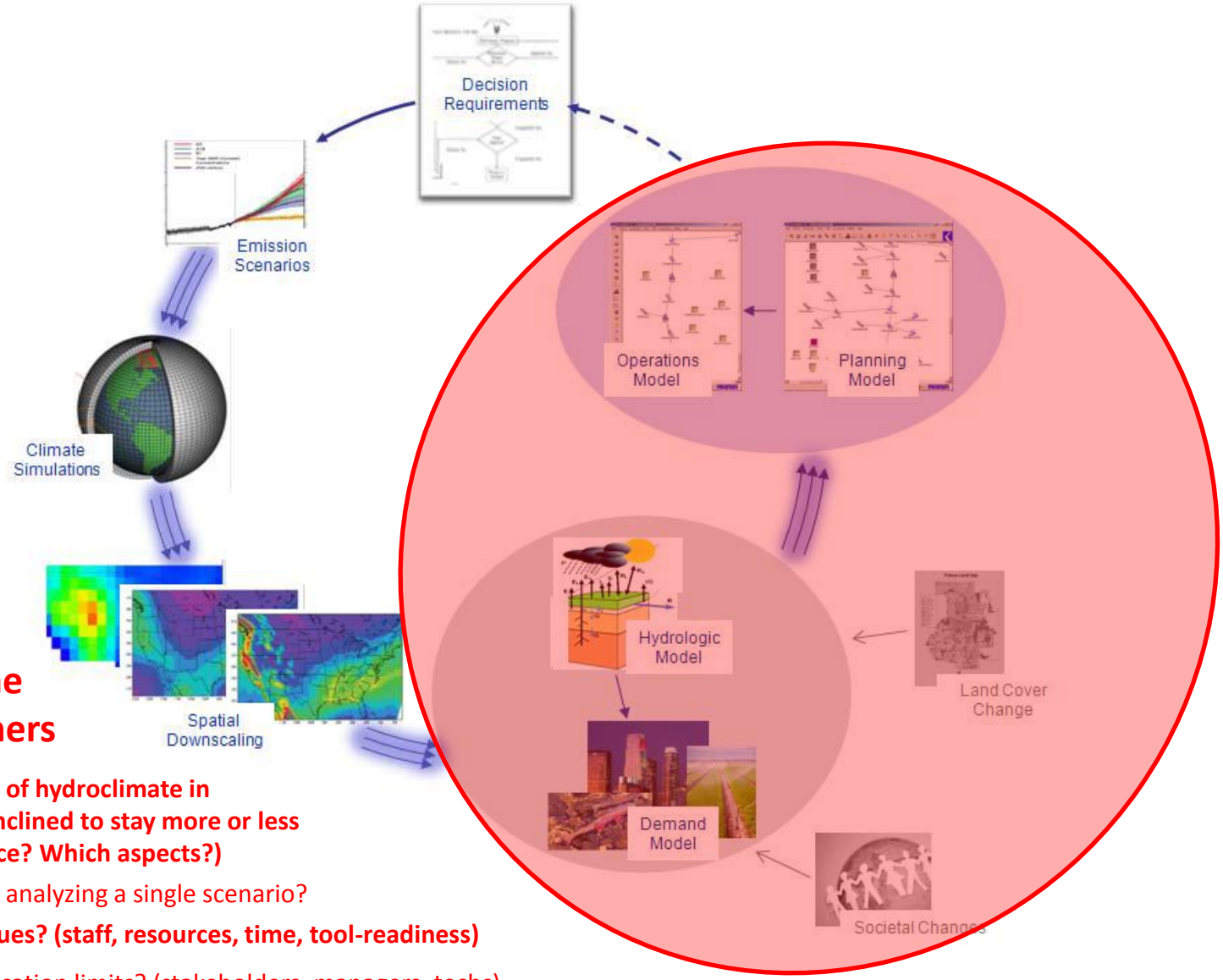
b. How should we regard outputs from these projections? (In the context of observations? Is regard affected by model or emissions choice?)

c. Should we bias-correct climate model output? How?

d. Should we spatially downscale climate model output? How?

II. Questions for the Climate Information Providers





III. Questions for the Technical Practitioners

a. What's the paradigm view of hydroclimate in planning? (i.e. Is the group inclined to stay more or less rooted in historical experience? Which aspects?)

b. What are the realities of analyzing a single scenario?

c. Are there capacity issues? (staff, resources, time, tool-readiness)

d. Are there communication limits? (stakeholders, managers, techs)

I. Emergent Approaches for "information generation"

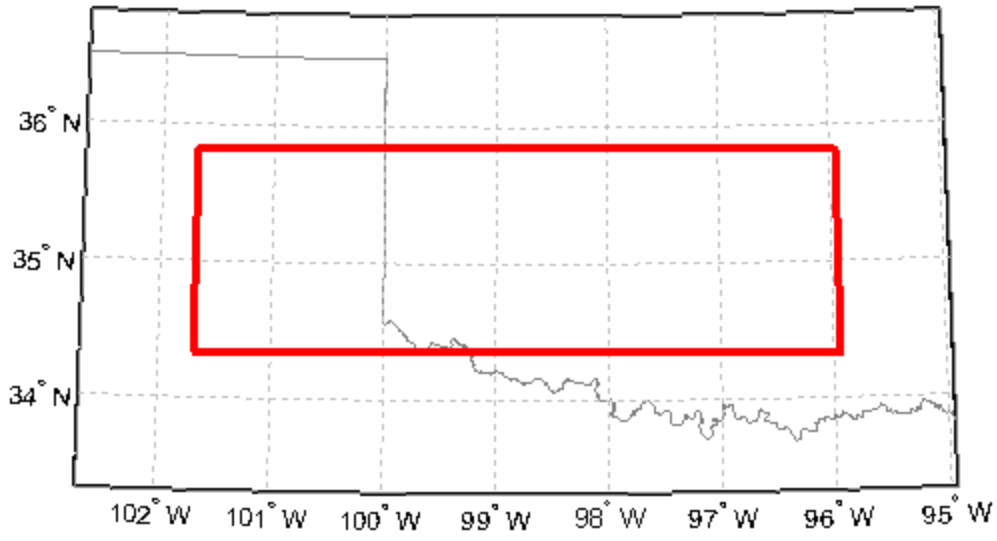
Two Method Classes have emerged…

- Period-Change
  - prevalent among hydrologic impacts studies
  - "perturbed historical" at some milestone future

- Transient
  - time-evolving view, from past to future
  - prevalent in the climate science community ("climate projections")

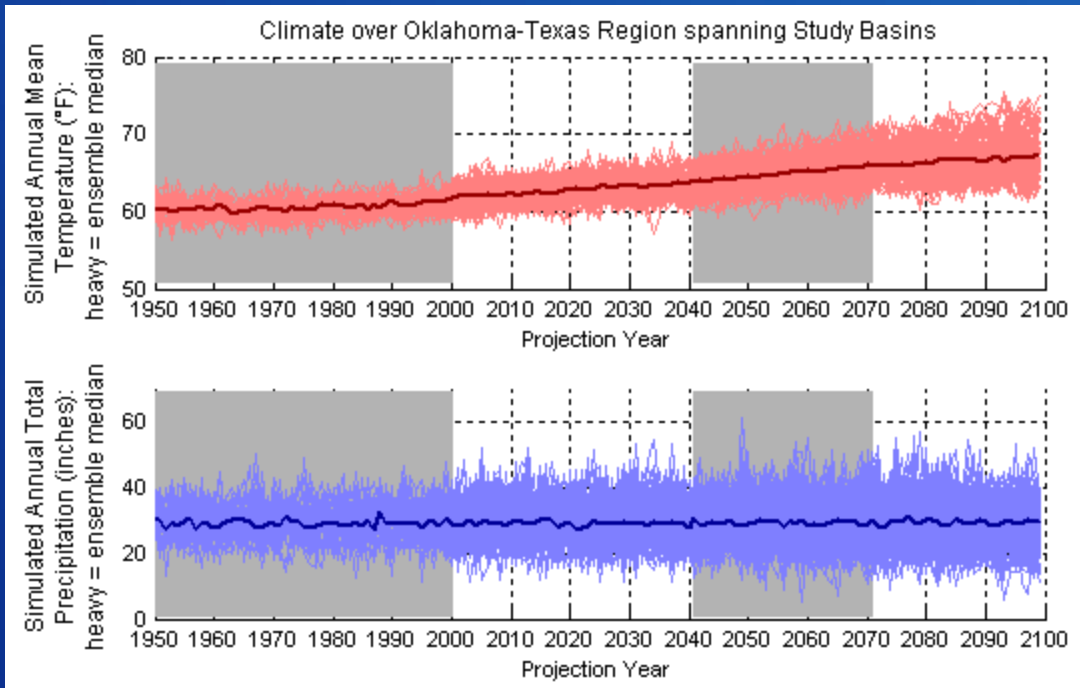
Period-Change: Overview

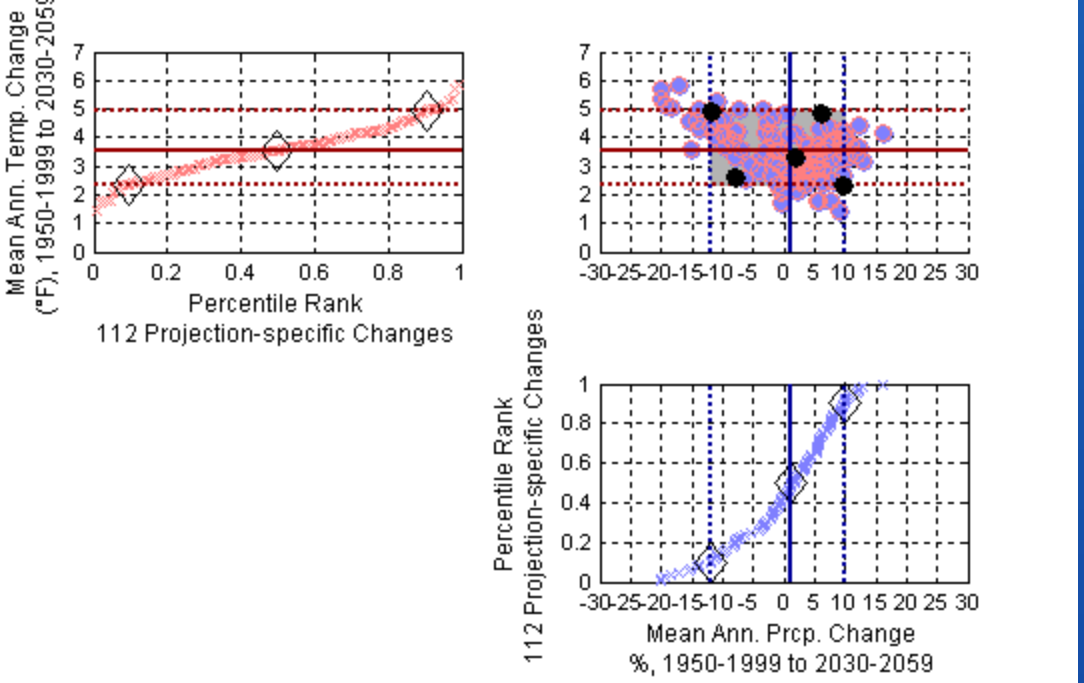
- Historical climate variability sequence is retained (space and time)
- “Climate Change” Scenarios are defined for perturbing historical, where a change is diagnosed from a historical period to a future period
- Studies typically feature an Historical scenario and multiple climate change scenarios in order to reveal impacts uncertainty
- Several methods are available to define scenarios, differing by:
  - time (e.g., change in means, change in distributions)
  - space (e.g., change in regional condition, or change in spatilly disaggregated conditions), and
  - amount of information (e.g., single climate projection, or many projections)



Defining climate change scenarios… start with a study region

Get climate projections over the region… choose “change” periods

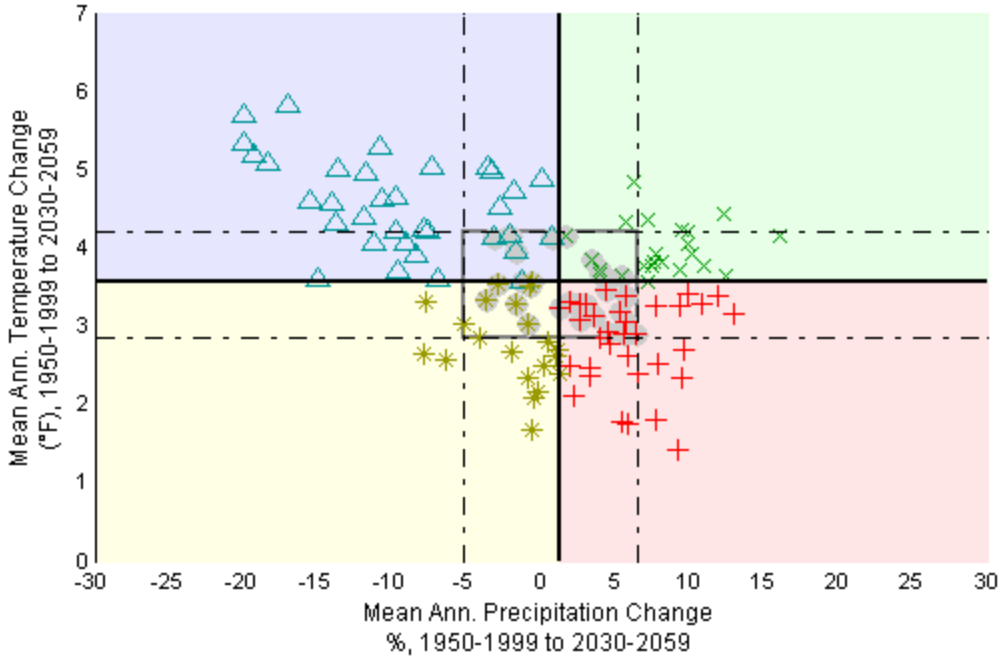




Define change scenarios to reflect range of possiblity…

Projection-specific approach: individual projections inform change definitions (e.g., black dot choices)

Ensemble-informed approach: projections are grouped and their information is pooled in the process of defining scenarios



Period-Change: Pros and Cons

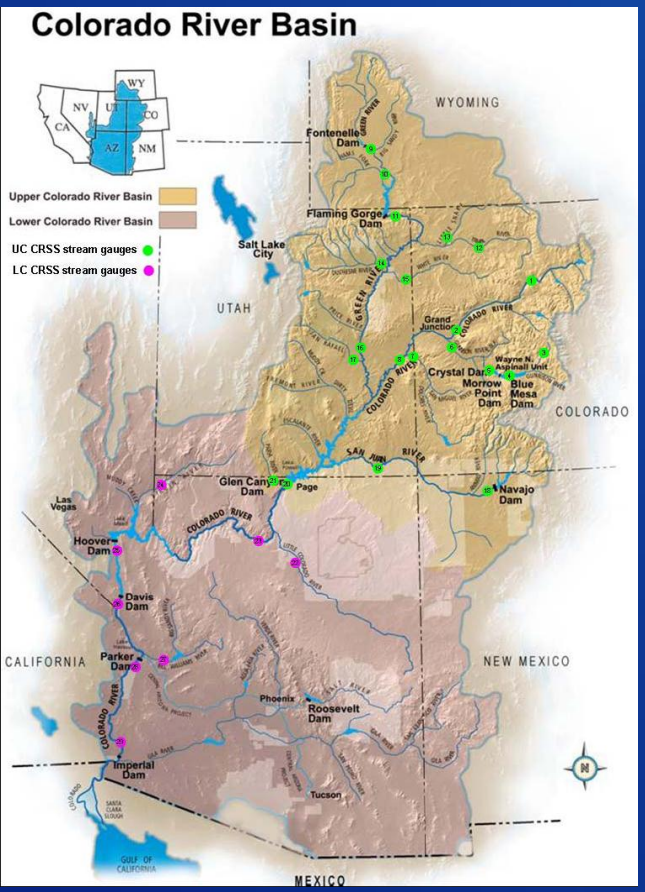
- Pros:
  - Retains familiar historical variability patterns
  - Simple frame for exploring system sensitivity
  - Permits “cautious” sampling of temporal aspects from climate projections (e.g., can be simple like change in annual mean, or complex like change in monthly distribution)

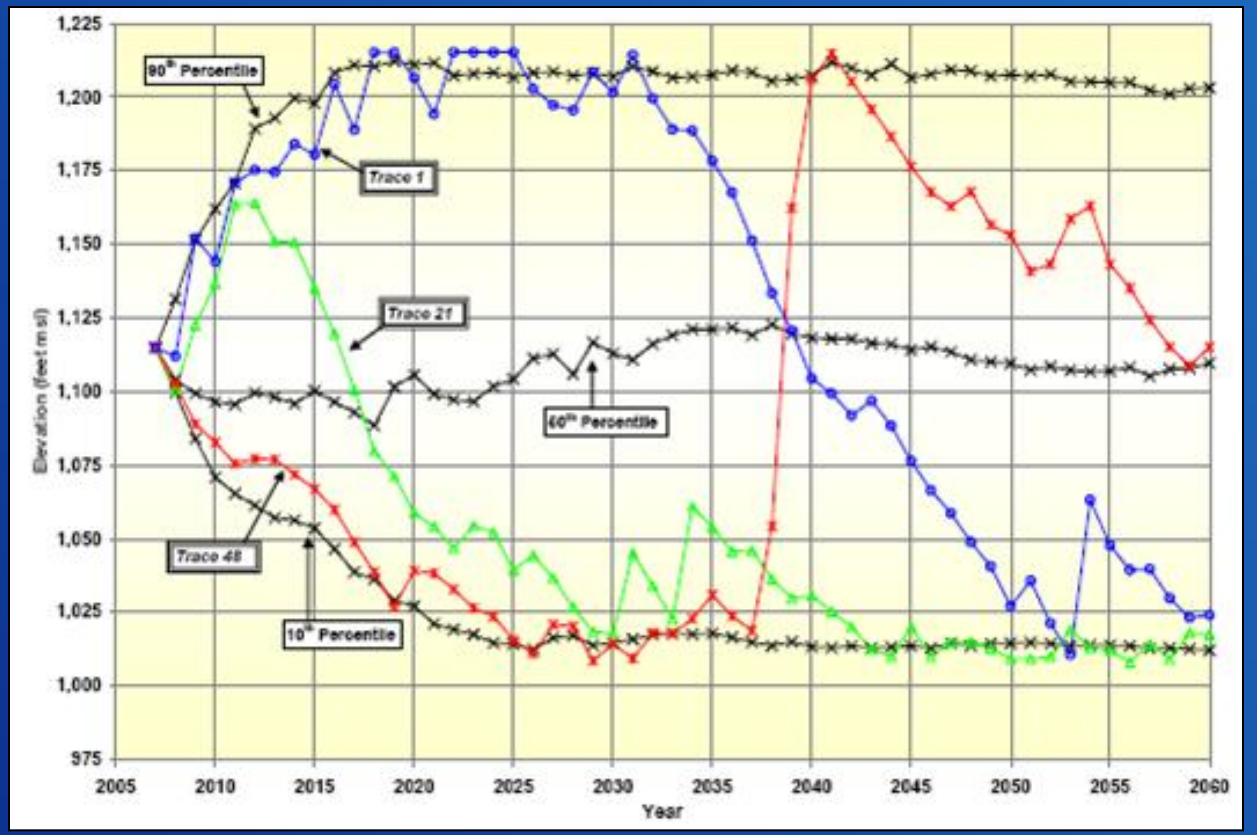
- Cons:
  - Less ideal for adaptation planning; climate change *timing* matters
  - Diagnosing period “Climate Change” is not obvious (more of a problem for ΔP than for ΔT)
  - Using single-projections to inform scenarios may yield month-to-month or geographic “surprises”

Transient: Overview

- Historical climate variability sequence not retained (but distribution may be retained through climate projection bias-correction…)
- "Climate" Projections are selected to define an evolving envelope of climate possibility, representing simulated past to projected future
  - Monthly or daily time series projections typically used
- Climate Projections may be developed using various methods, e.g.:
  - Time series outputs from a GCM simulation (or a GCM-RCM simulation)
  - … bias-corrected and spatially downscaled translations of these outputs
  - … stochastically resampled (resequenced) versions of these outputs, reflecting a different frequencies reference (observations, paleoproxies)
- Studies need to feature a large ensemble of climate projections to adequately portray an envelope of climate possibility through time

Communication and analytical tools need to feature "projection" paradigm. Some groups are ready for this, others are not...





Lake Mead End-of-December storage under the No-Action Alternative: 90th, 50th, and 10th percentile values

(Reclamation 2007, Figure 4.2-2)

Reclamation 2007

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Transient: Pros and Cons

- Pros:
  - Avoids challenges of “Climate Change” diagnosis
    - Not discussed, but a key issue is “multi-decadal varaibility” in projections
  - Supports “master planning” for CC adaptation
    - schedule of adapations through time, including project triggers

- Cons:
  - Projection historical sequences differ from experience
  - Requires “aggressive” sampling of temporal information from climate projections (frequencies vary by member, and may be questionable)
  - Information is more complex
    - Requires use of many projections, challenging analytical capacities, and requiring probabilistic discussion of results, evolving through time… requires learning phase

II. What about the process of decision-making?

Most info. generation approaches have been science-centric.

Science Application

1. What do we think we know about future climate? (science synthesis, survey of past and projected climate information)

2. Which climate information do we feel comfortable relating to our decisions?

3. Select an information frame that relates credible future climate aspects to decisions

Decision-Making

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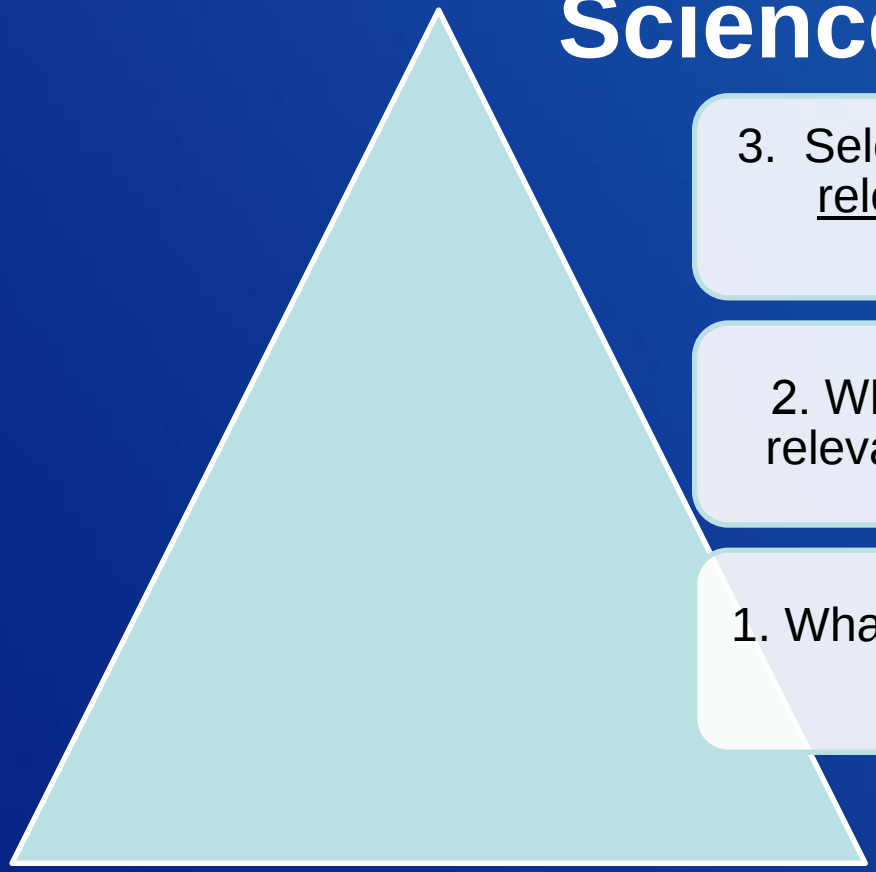
Would we select the same approach using a decision-centric view?



Science Application

3. Select an information frame to relates relevant future climate aspects to decisions..

2. What's hydroclimate conditions are relevant to these decisions? (***Scales!***)

1. What are the various decisions that we are considering?

Decision-Making

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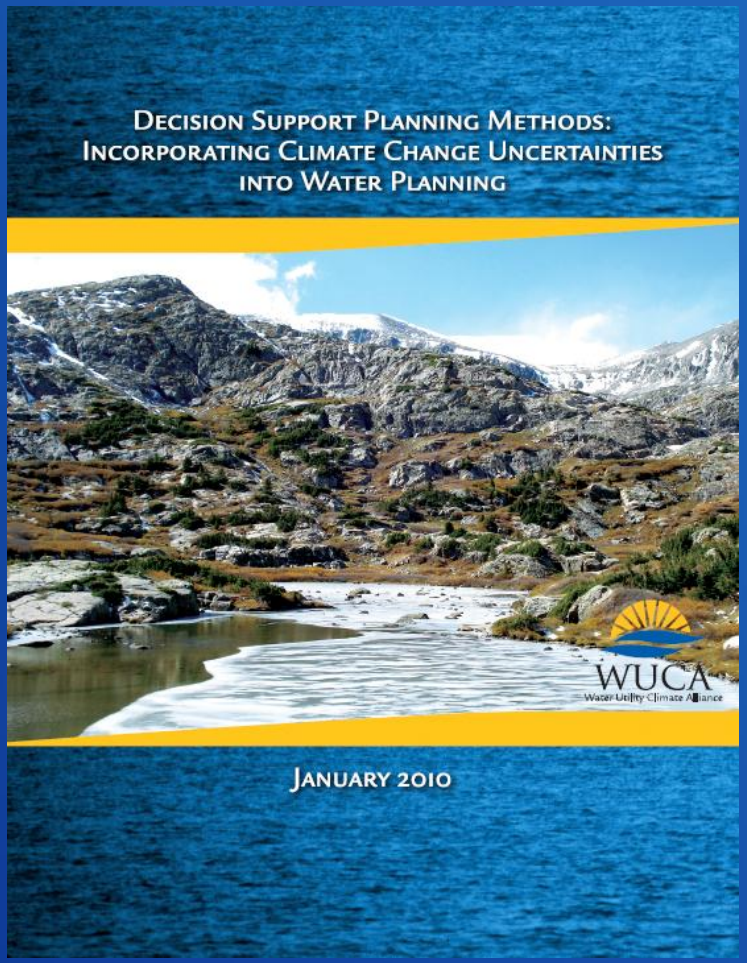
A decision-centric view may be more closely tied to “decision-making methods”

- WUCA 2010 – Review of planning & decision-making frameworks
  - Scenario Planning
  - Decision Analysis
  - Robust Decision Making
  - Real Options
  - Others…

- Pros/cons of these methods for supporting climate change adaptation?



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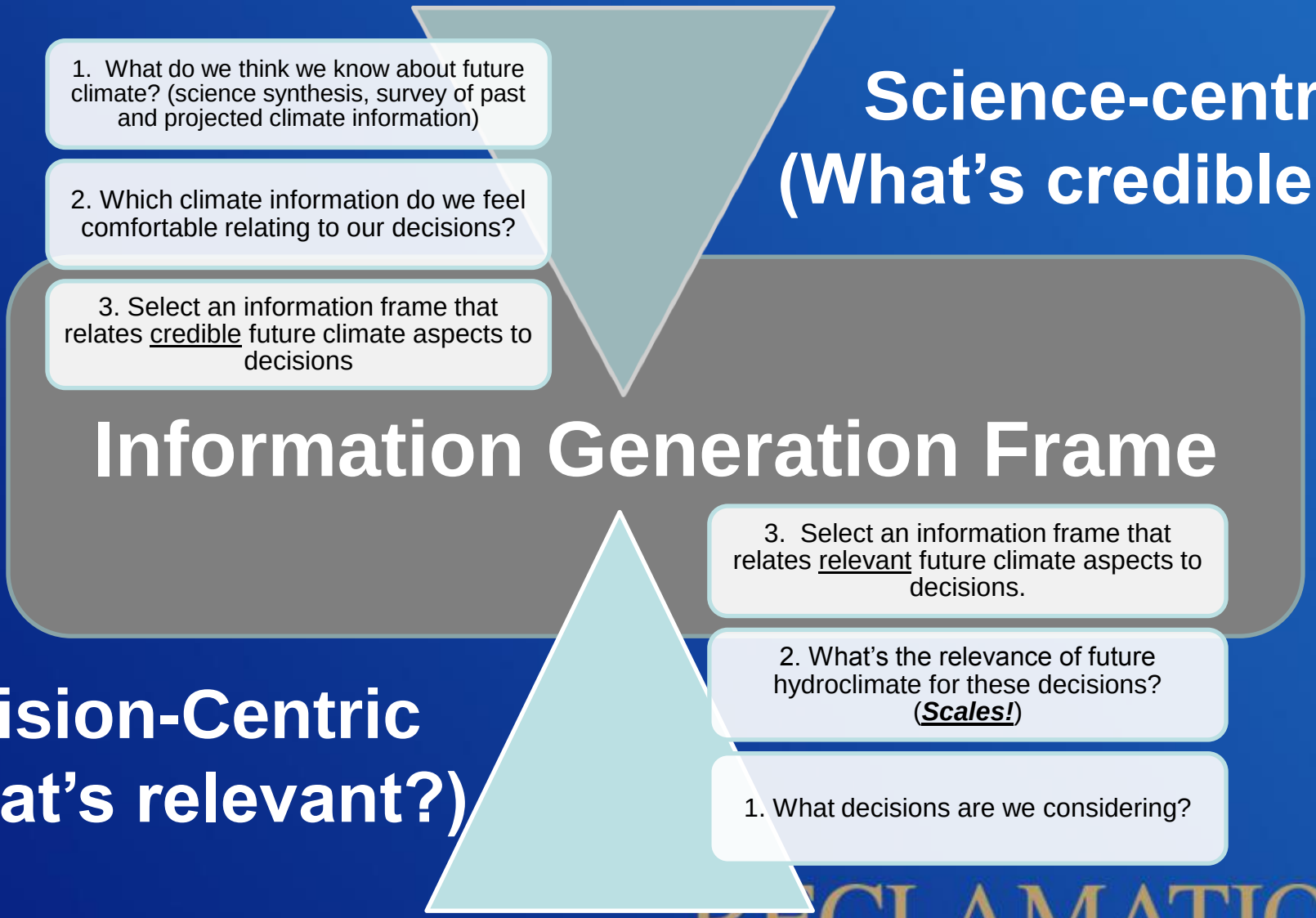
How can we best use both views?



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Climate Change and Water Working Group (CCAWWG) – 2010-2011 Activity:

Portfolio of Approaches Workshop, working toward developing guidance

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III. What about Paleoclimate?

We've discussed defining future climate in an observed/projected context…

I. Choose Climate Context

Instrumental Records: observed weather (T and P) and runoff (Q)

Global Climate Projections: Representing various GCMs, forcings → bias-correction, spatial downscaling

Runoff Magnitudes

watershed simulation

Regional T and P

II. Relate to Planning Assumptions

Runoff

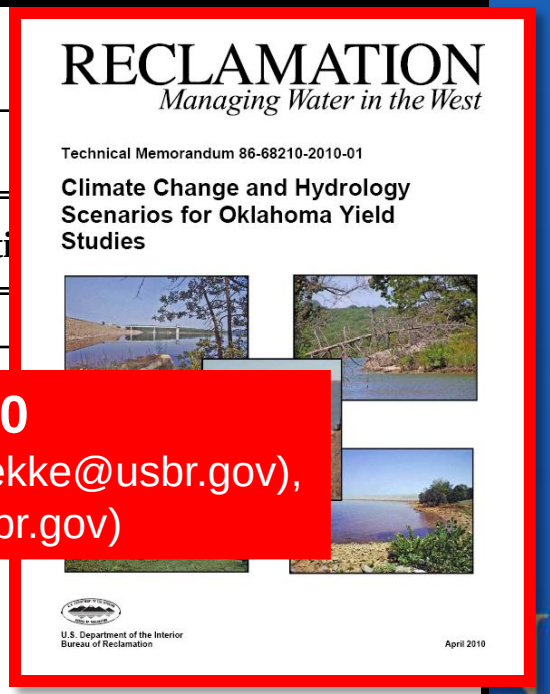
Supply Variability

Demand Variability

Operati

III. Conduct Planning Evaluations

System Analysis, Evaluate Study Questions
(related to Resource Management Objectives)



Reclamation 2010
Info: Levi Brekke (lbrekke@usbr.gov), Tom Pruitt (tpruitt@usbr.gov)

… other studies define future climate possibilities in a paleo/observed context.

I. Choose Climate Context

Paleoclimate Proxies: reconstructed runoff (Q)

Instrumental Records: observed weather (T and P) and runoff (Q)

Runoff Magnitudes

Yeartype Spells

statistical modeling

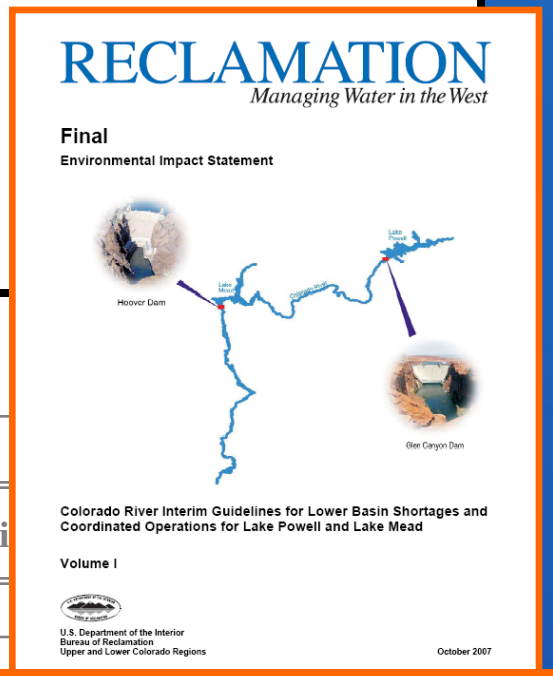
II. Relate to Planning Assumptions

Runoff

Supply Variability

Demand Variability

Operati

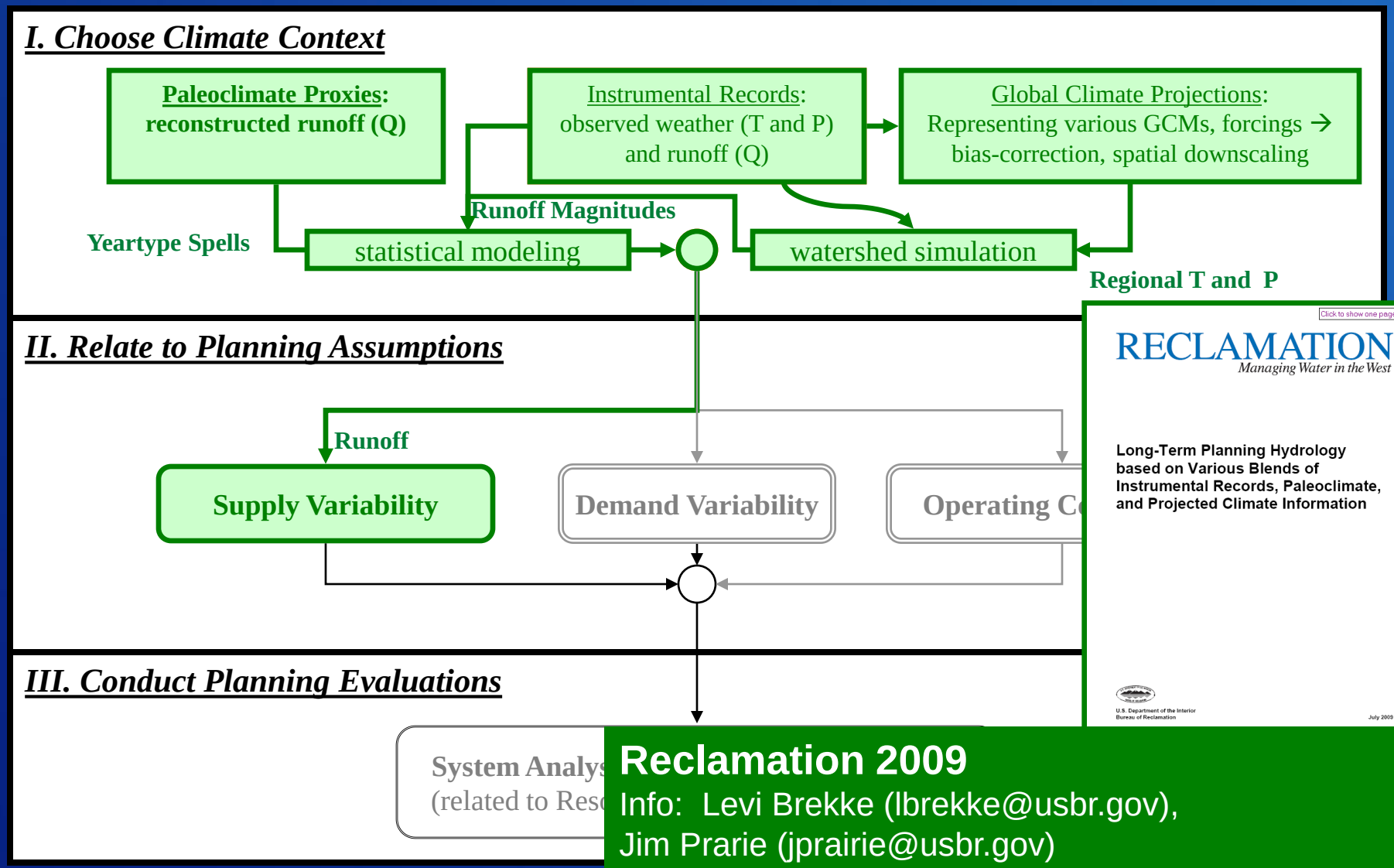


Reclamation 2007
http://www.usbr.gov/lc/region/programs/strategies.html

III. Conduct Planning Evaluations

System Analysis, Evaluate Study Questions
(related to Resource Management Objectives)

It's possible to blend these two approaches. (Reclamation 2009, CRWAS 2011, others)



Reclamation 2009

Info: Levi Brekke (lbrekke@usbr.gov), Jim Prarie (jprairie@usbr.gov)

Summary

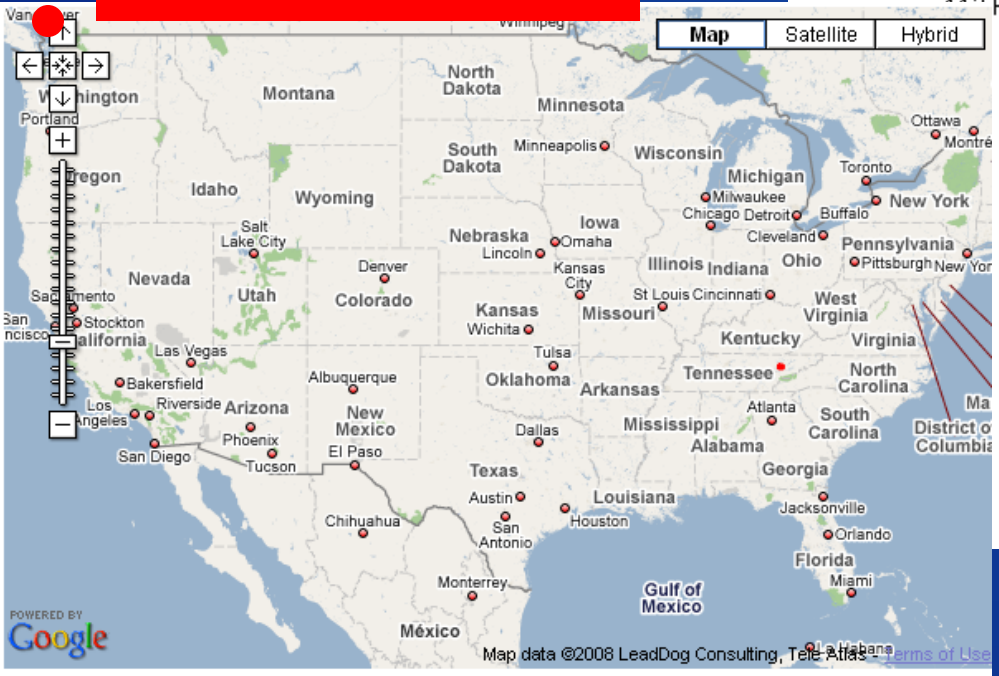
Questions? Levi Brekke, lbrekke@usbr.gov

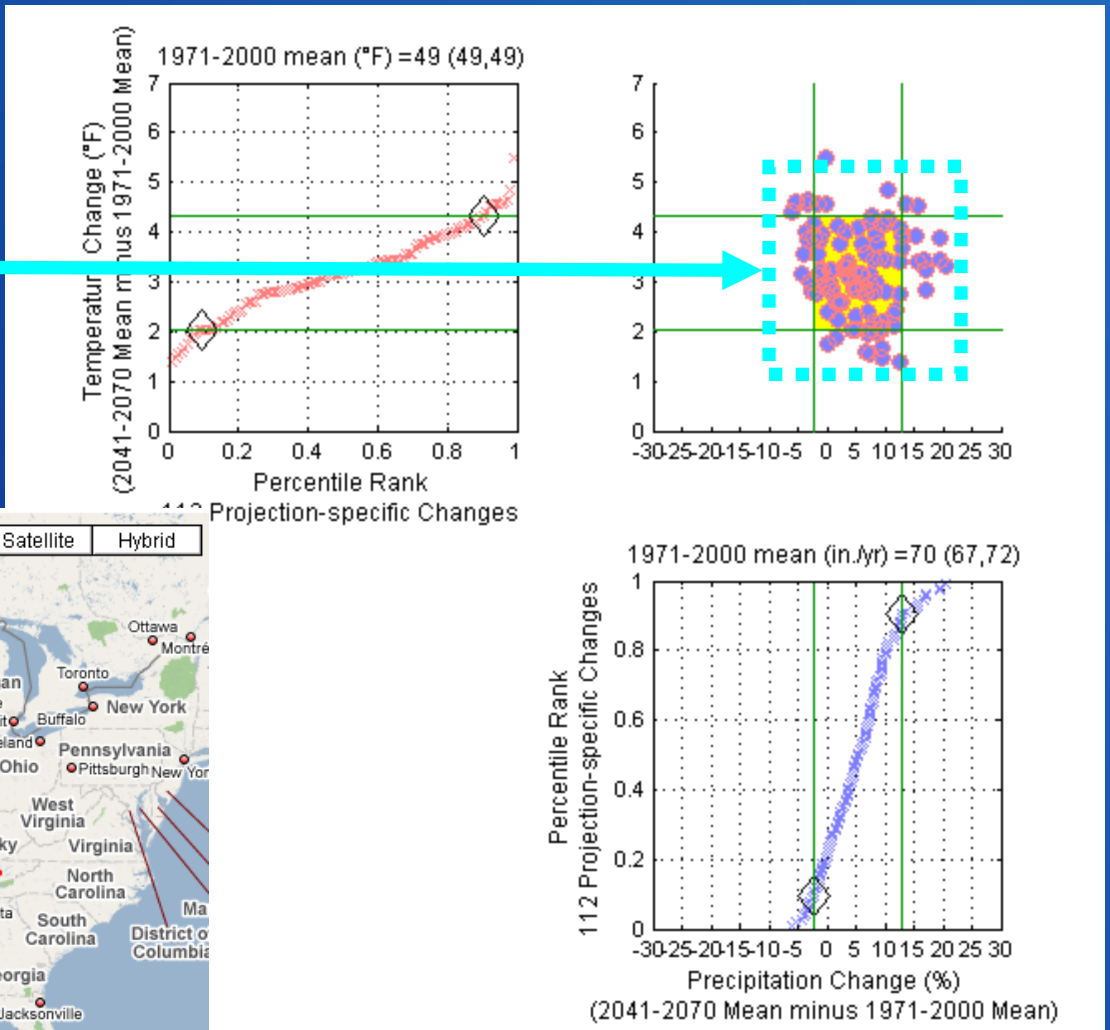
- We have numerous approaches for using climate change information in water resources studies.
- Most “information generation” frames are science-centric rather than decision-centric… both views have utility in selecting frames for local studies.
- Approaches may consider paleo; involves some type of past/projected blend of climate information.

Extras

Why Ensemble-Informed? One concern is stems from interpreting period-Prcp changes…

Question: Are these possibilities "*climate change only*" or "*blend of climate change and sampled multi-decadal variability*"? How much of the precipitation-change spread is due to "drifting" projections – credible "drifts"?





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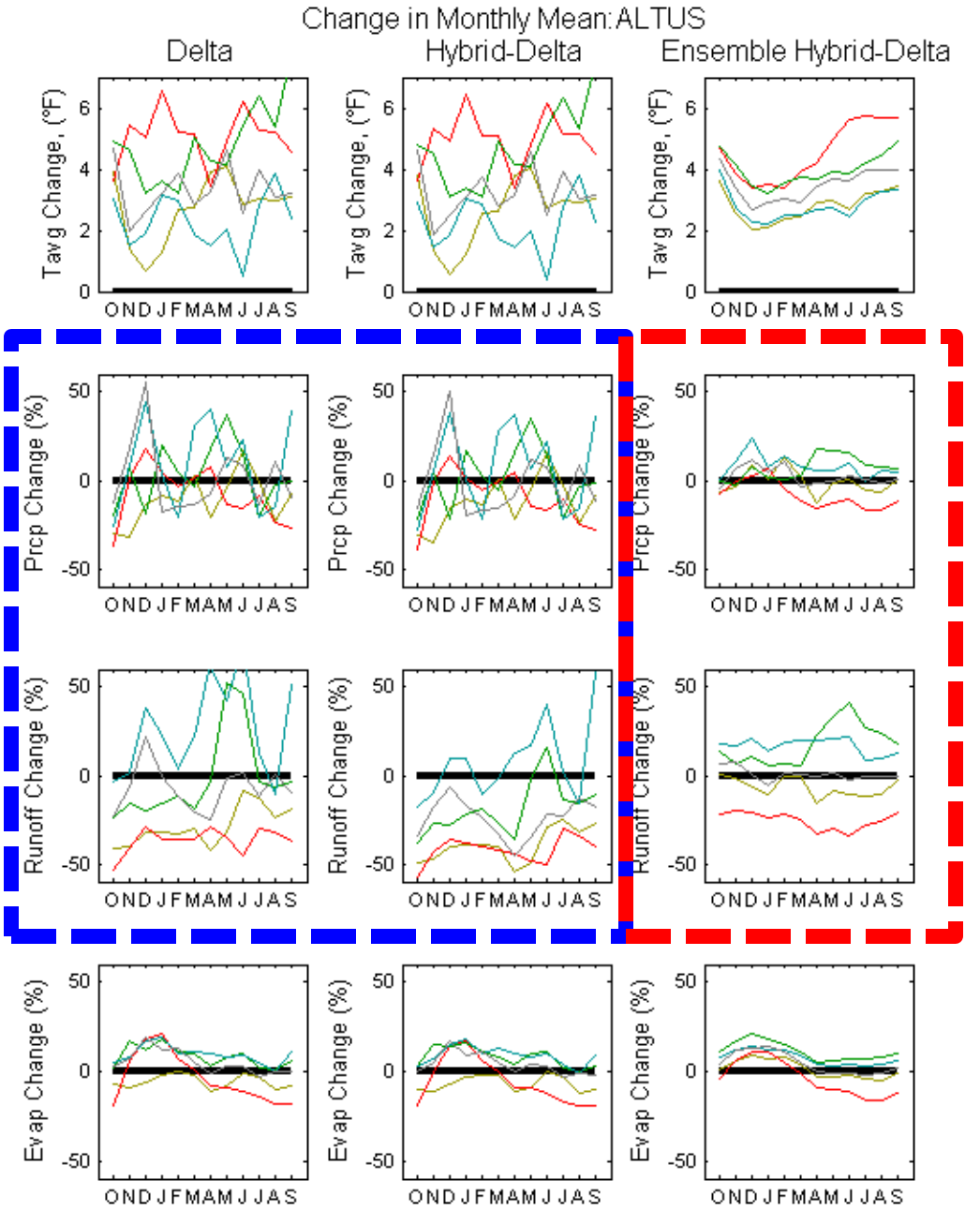
… another from portrayal of month-to-month impacts

Two projection-specific methods

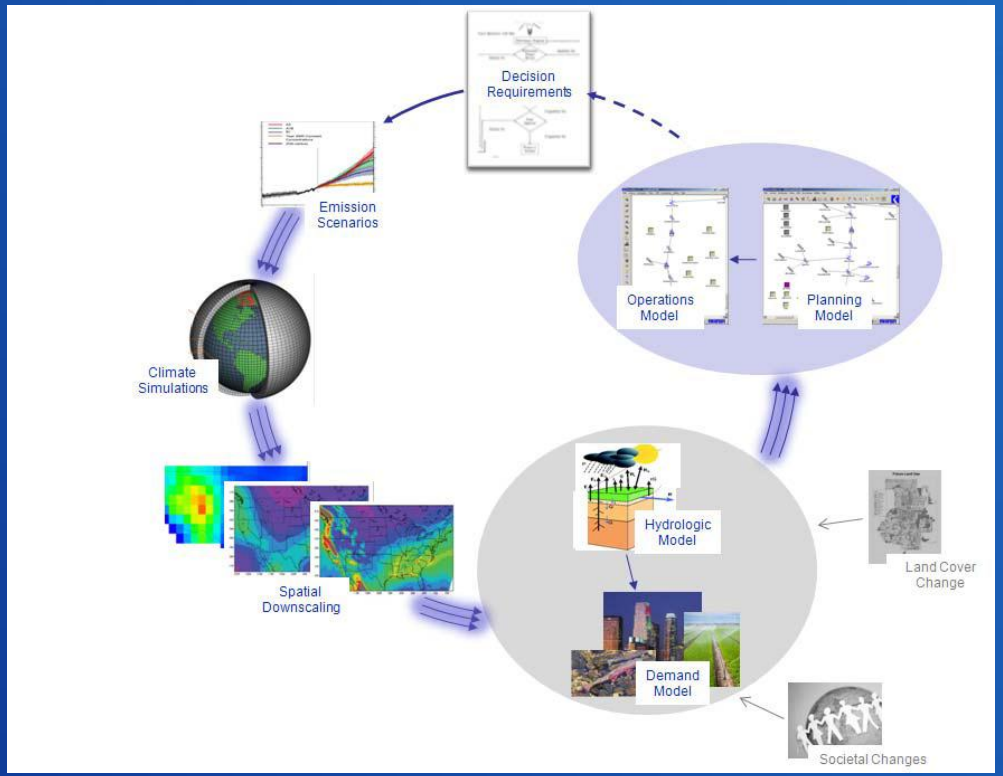
One ensemble-informed method

… projection-specific can lead to serial monthly impacts that seem questionable



About the Approaches Workshop

- **Goals:**
  - **develop a set of best practices for assessing the strengths and limits of the various approaches …**
  - **Set up the development of guidelines that are flexible enough to apply to current state-of-the-science information as well as future climate science developments**



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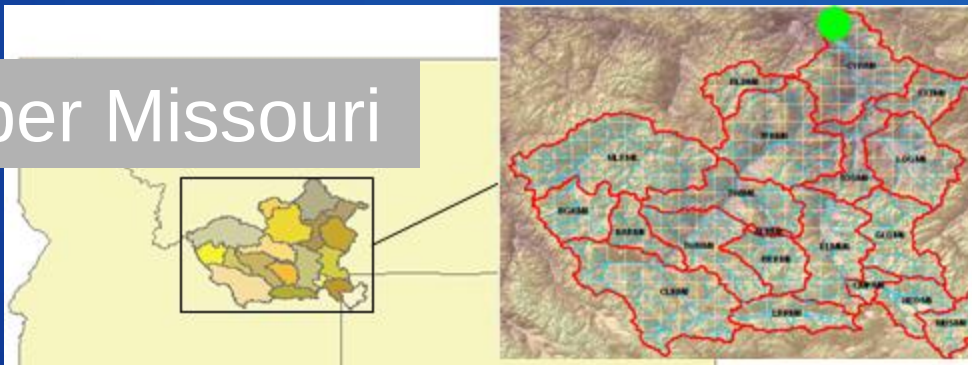
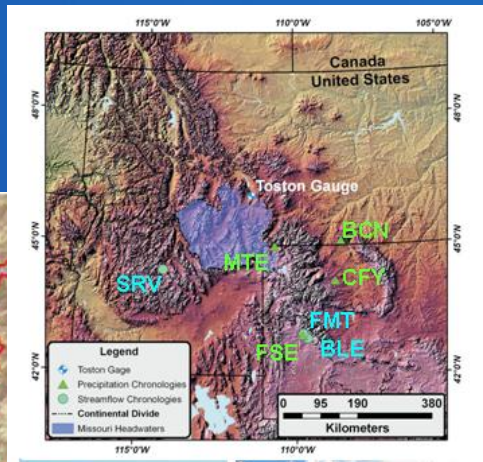
Case Study Basins

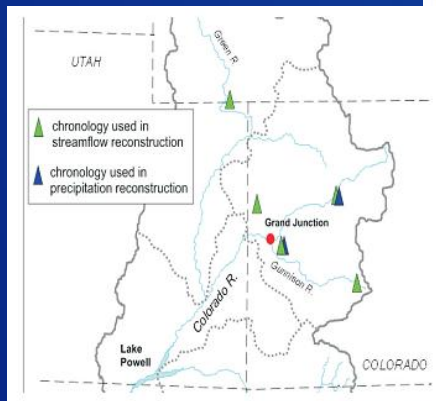
Upper Missouri

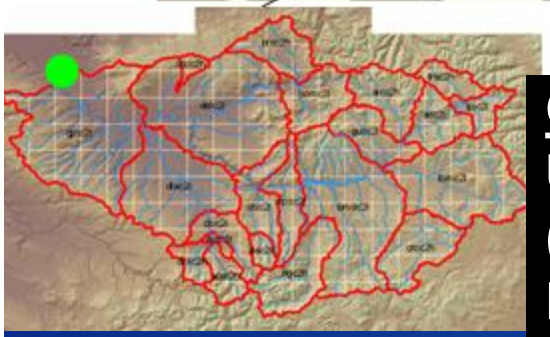


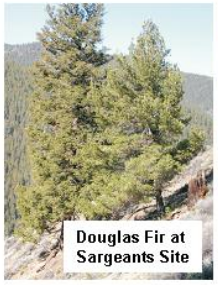


Representative Trees

Gunnison



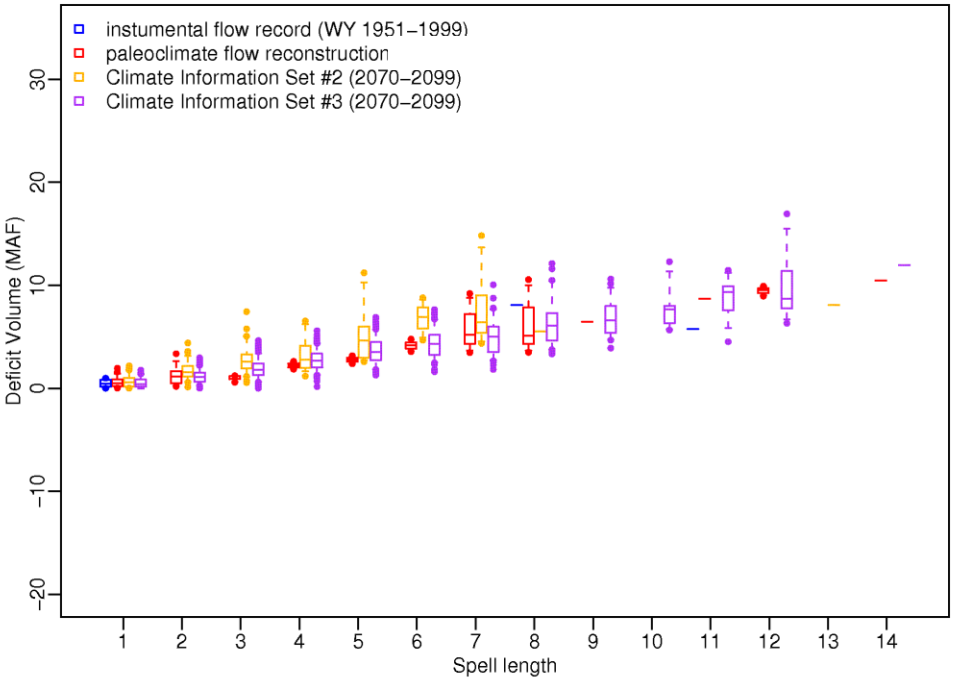


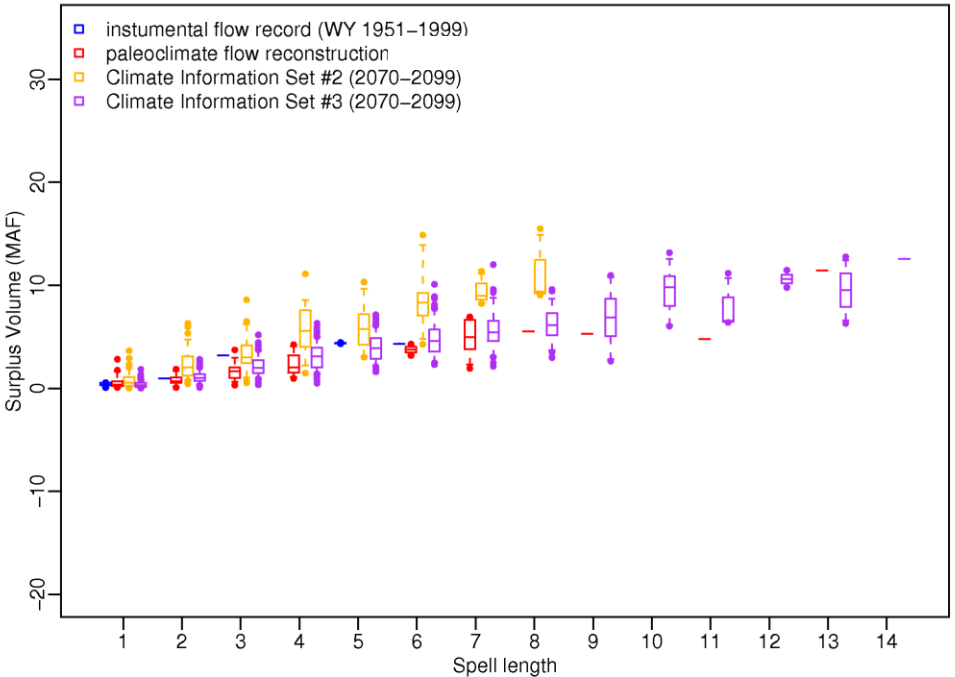


Colloaborators:
Univ AZ; Univ CO; NOAA RISAs (CLIMAS, WWA); State of WY; NWS CBRFC & MBRFC; USACE Omaha District; Reclamation RDO, UC & MAO

Drought & Surplus: Missouri

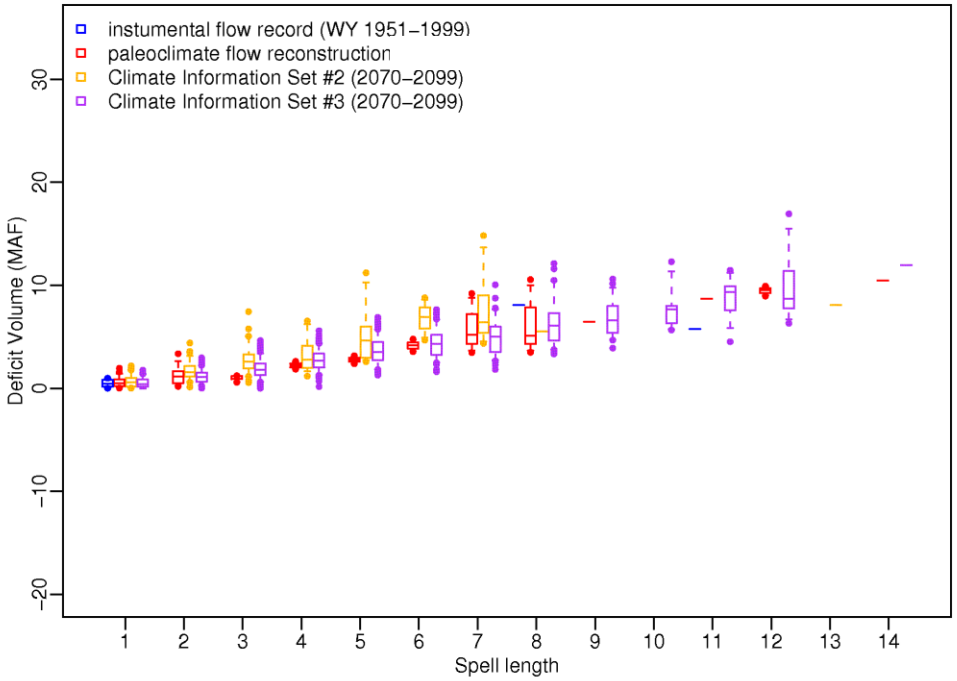
- Four information sets:
  - NULL (1951-1999), 1 seq.
  - Recon (1569-1997), 1 seq.
  - ALT 2 (2070-2099), seq. ens.
  - ALT 3 (2070-2099), seq. ens.
- Define Spells:
  - Classify years as “deficit” or “surplus” relative to period-median annual, specific to information set (and for ALTs 2 and 3, specific to each sequence)
  - Spell length is on x-axis (years)
- Compute Accumulation by Spell:
  - Volumes (y-axis)
  - Distributed across instances for each spell length (boxplots) and information set (color coding)

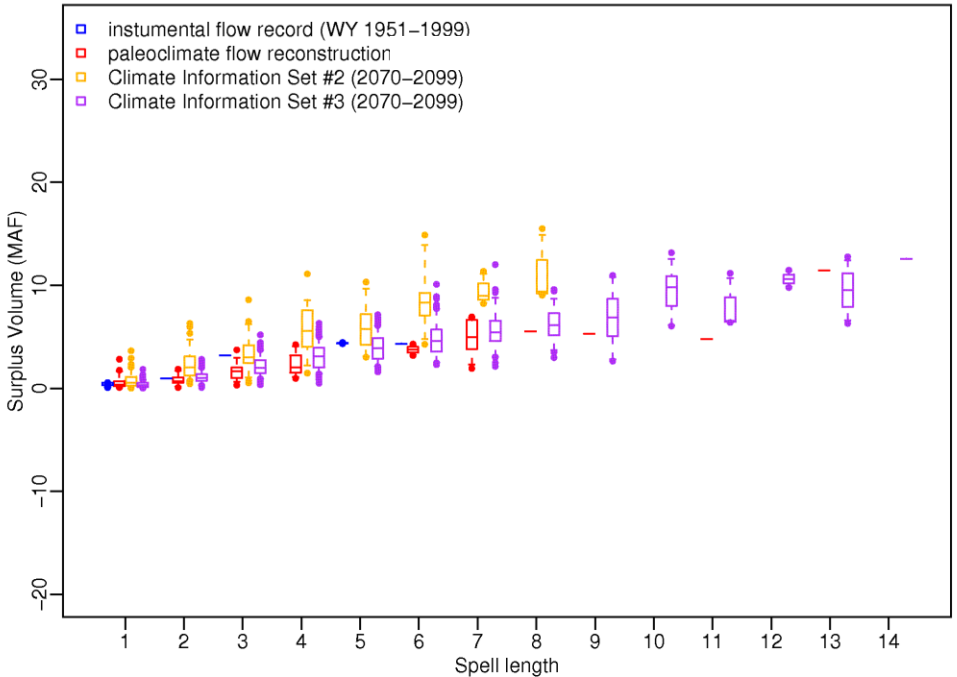




Drought & Surplus: Missouri

- ***REACTIONS***
  - NULL: Very few Deficit and Surplus cases in a single 49-year sequence (e.g., for deficits, there's one 8-year case, one 11-year case, and the rest being "1-year" cases)
  - RECON: More cases of Deficit and Surplus spells relative to the NULL, greater counts of longer spells (i.e. greater "persistence" than NULL)
  - ALT 3: Deficit and Surplus trends with spell duration are similar to Recon (focus on boxplot medians)... expected given stochastic design
  - ALT 2: Deficits and Surpluses trend more intensely with spell duration relative to ALT 3





Drought & Surplus: Gunnison

- ***REACTIONS***
  - NULL: Similar to Missouri (e.g., no deficit spells > 4 years in duration)
  - RECON: Similar to Missouri… there's a richer number of deficit and surplus cases, and a greater presence of longer-term cases
  - ALT 3: Similar to Missouri, Deficit and Surplus trends with spell duration are similar to the trends from the Recon information…
  - ALT 2: Unlike Missouri, Deficits trends with spell duration were found to be *comparable* to those of ALT 3; though, surplus trends with duration were more intense in ALT2