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Managing Water in the West

Water and Environmental Resources Adaptation Planning: Information Needs

Levi Brekke (Reclamation, Research & Development Office)

Workshop on Climate Change Impacts and Integrated Assessment (CCI/IA), Session 4:
Needs for Scenarios: Science, Assessments and Decisionmaking

Snowmass, CO, July 31, 2014



U.S. Department of the Interior
Bureau of Reclamation

Water and Environmental Resources Planning occurs in various forms (Reclamation examples shown)

Goal: prepare for future risks to water supplies and demands under climate change and other stressors

WaterSMART Basin Studies

- Assess future scenarios and vulnerability
- Appraisal level evaluation of many solutions
- Federal and non-Federal collaboration

Goal: inform recommendation to Congress whether to invest in a water resources development through authorized study (e.g., infrastructure, management criteria)

Feasibility Studies

- Includes prior appraisal studies, evaluates justification of proposed action and associated environmental impacts
- P&Gs apply

Goal: address ESA Section 7(a)1 (conservation of listed species), ESA Section 7(a)2 (consultation compliance to avoid jeopardy/adverse modification)

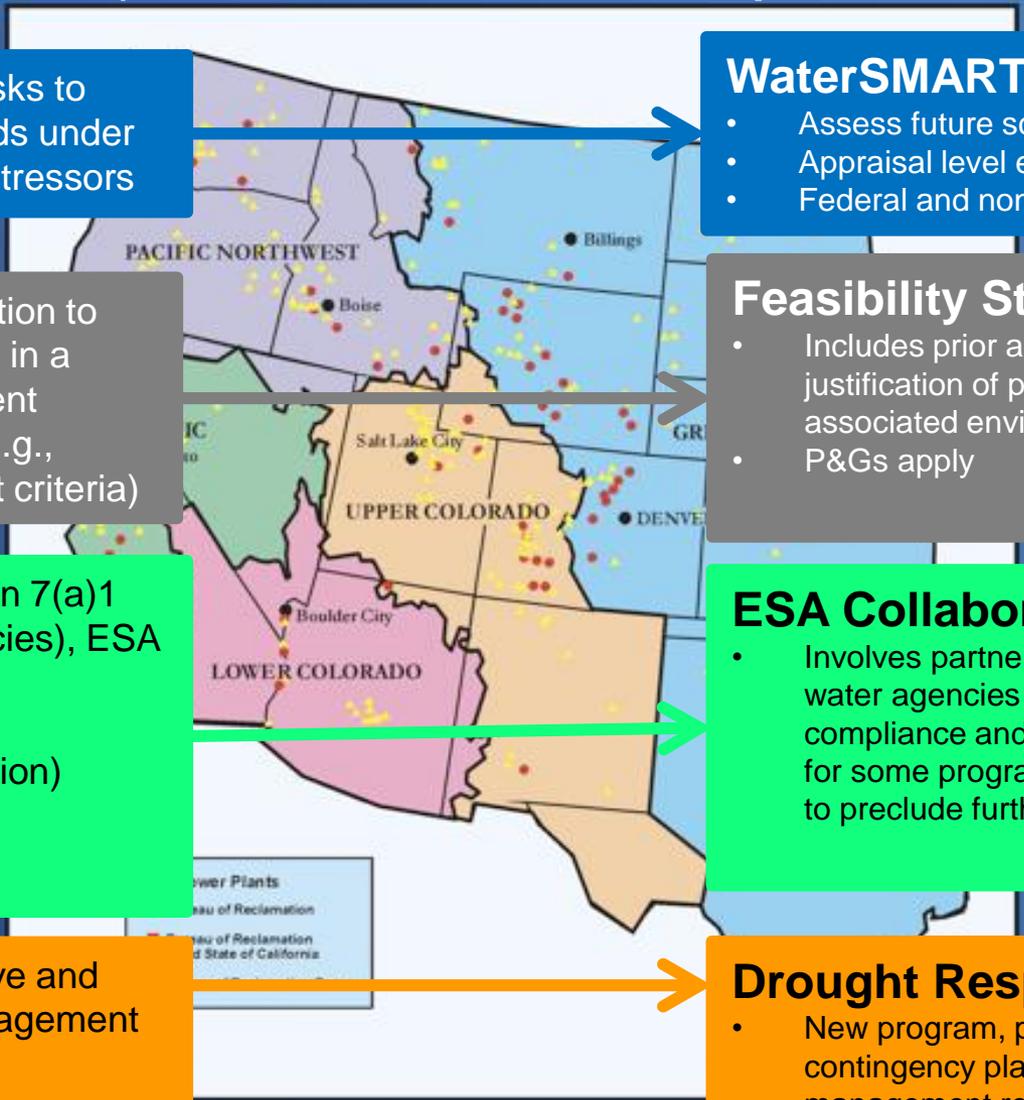
ESA Collaborative Programs

- Involves partnering with environmental and water agencies to identify and implement compliance and conservation strategies, and for some programs, engage basin partners to preclude further listings

Goal: facilitate collaborative and proactive drought risk management among basin partners

Drought Response Planning

- New program, promote development of contingency plans to complement management reactions during drought



Climate Context in Water and Environmental Resources Planning

(focus on built systems)

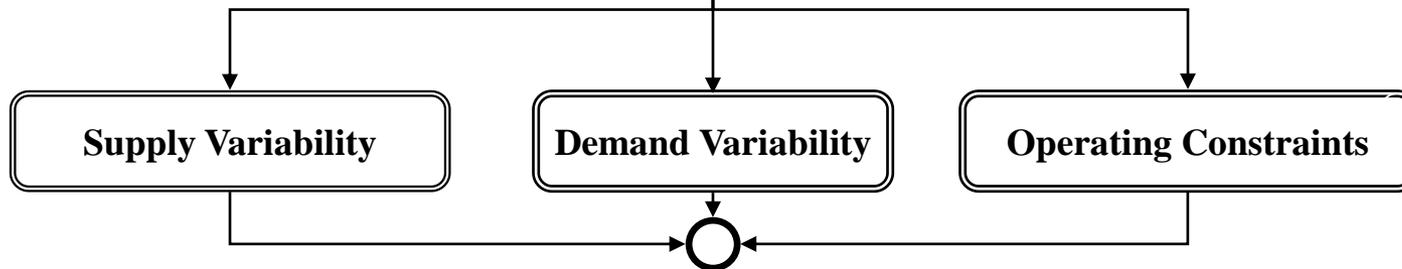
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Traditional climate context in water resources planning

I. Choose Climate Context

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

II. Relate to Planning Assumptions

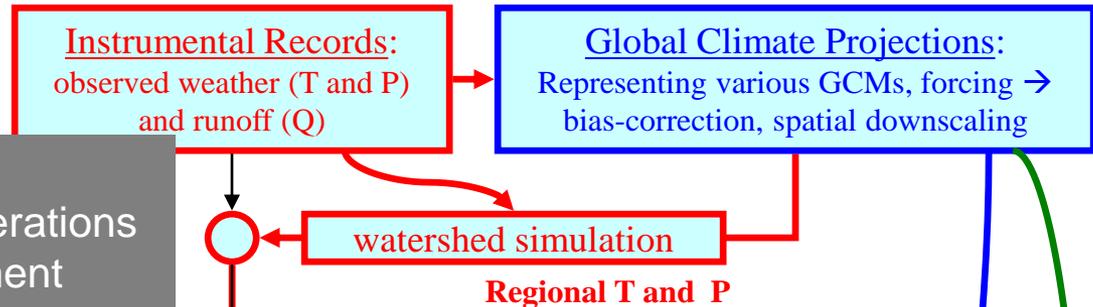


III. Conduct Planning Evaluations

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

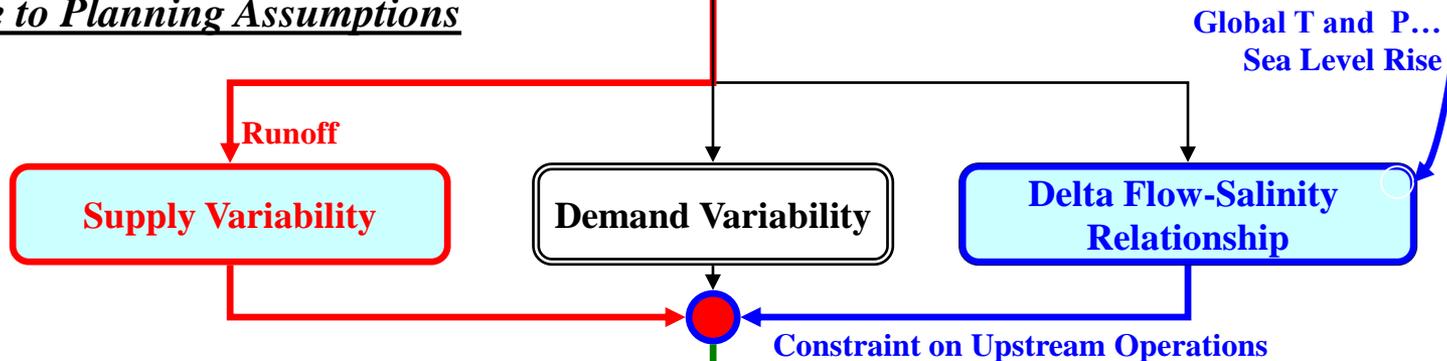
We've developed ways to blend climate change information into this context.

I. Choose Climate Context

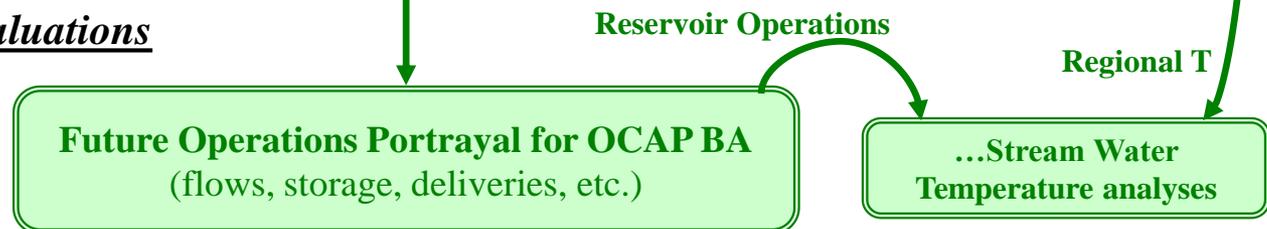


e.g., Reclamation 2008, Mid-Pacific Region's Central Valley Project – Operations Criteria and Plan, Biological Assessment

II. Relate to Planning Assumptions

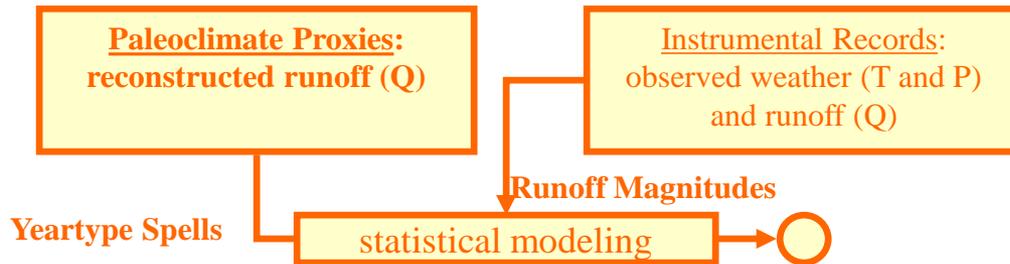


III. Conduct Planning Evaluations

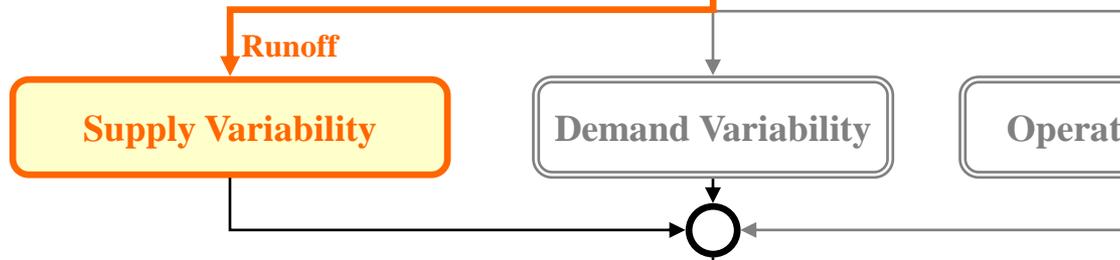


... future climate & hydrology assumptions can also be based on blend of observed and paleoclimate information.

I. Choose Climate Context



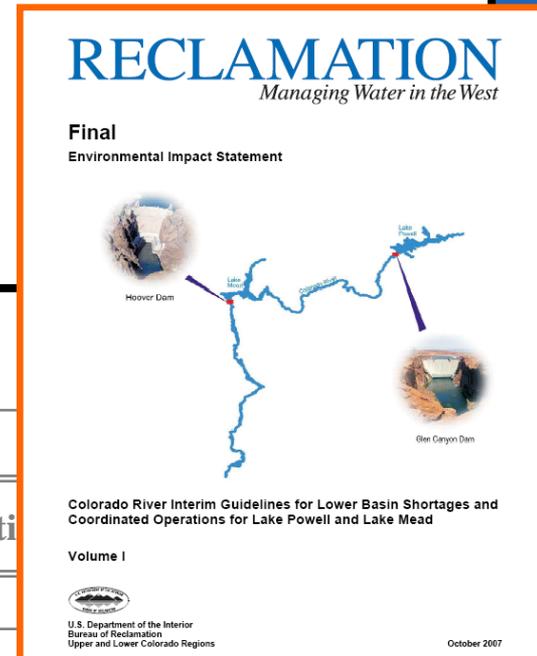
II. Relate to Planning Assumptions



<http://www.usbr.gov/lc/region/programs/strategies.html>

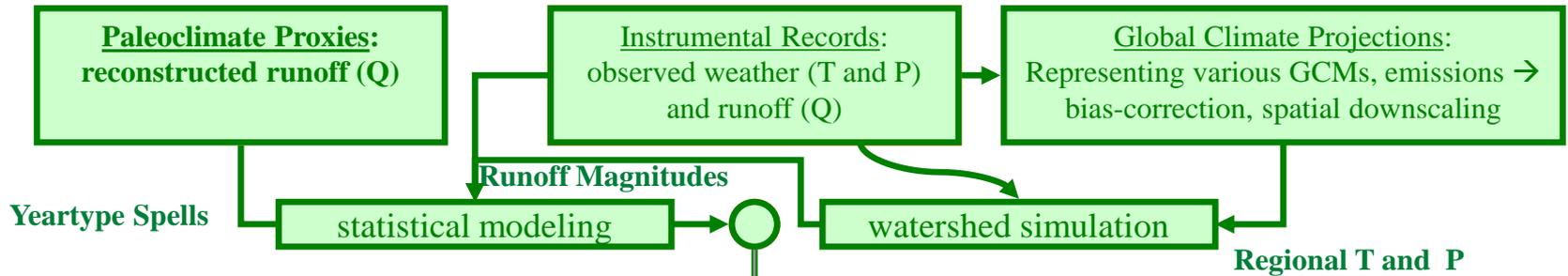
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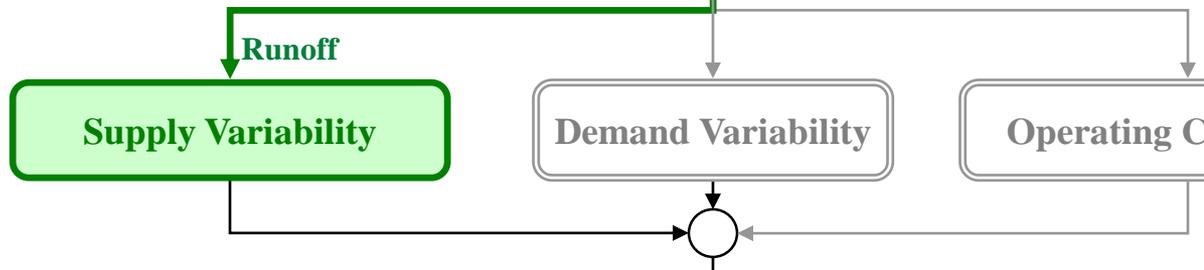


... we can also possible blend all three.
 (Reclamation 2009, CRWAS 2011, others)

I. Choose Climate Context

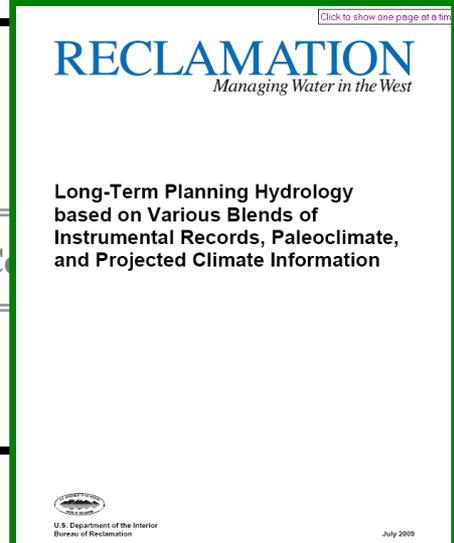


II. Relate to Planning Assumptions



III. Conduct Planning Evaluations

http://www.usbr.gov/research/docs/2009_Hydrology-DiffClimateBlends.pdf
 (related to Resource Management Objectives)



Where do we get future climate
information for planning?

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Information Resources (examples)

- Statistically Downscaled (*supports risk-based planning, lacks preferred efficacy*)
 - [LLNL-GDO \(Federal and Non-Federal collaboration\)](#)
 - [USGS CIDA Geodata Portal](#) (LLNL-GDO data + others)
 - [USGS/NASA NEX-DCP30 Project](#) (like LLNL-GDO data, but much finer resolution)
- Dynamically Downscaled (*better efficacy, lacks projections, less utility for risk-based planning*)
 - [NARCCAP](#) (CMIP3)
 - [CORDEX](#) (CMIP5) ← *better risk support? To be determined...*
- More resource options at:
 - <http://www.data.gov/climate/portals/>

Statistical resources seem to be used more by engineers and planners. Preference factors may be interest in large projection ensembles, ease of access

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LLNL-GDO archive's CMIP3-related datasets

http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html

CMIP3

- Climate, monthly (BCSD), 2007
 - 16 GCMs
 - up to 3 emissions per GCM, multiple runs
 - 112 projections
 - 1950-2099, NLDAS, 1/8°
- Hydrology (extend from BCSD), 2011
 - same attributes as BCSD CMIP3
 - only western U.S. coverage
 - Serve (a) monthly water balance variables, and (b) daily forcings and gridded runoff
- Climate, daily (BCCA), 2011
 - 9 GCMs
 - 3 emissions
 - 57 projections
 - {1961-2000, 2046-2065, 2081-2100}, NLDAS, 1/8°

RECLAMATION CLIMATE CENTRAL USGS
Santa Clara University SCRIPPS INSTITUTION OF OCEANOGRAPHY

Bias Corrected and Downscaled WCRP CMIP3 Climate and Hydrology Projections

This site is best viewed with Chrome (recommended) or Firefox. Some features are unavailable when using Internet Explorer. Requires JavaScript to be enabled.

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Summary

This archive contains fine spatial-resolution translations of:

- climate projections over the contiguous United States (U.S.) developed using two downscaling techniques (monthly BCSD Figure 1, and daily BCCA Figure 2), and
- hydrologic projections over the western U.S. (roughly the western U.S. Figure 3) corresponding to the monthly BCSD climate projections.

Archive content is based on global climate projections from the [World Climate Research Programme's \(WCRP's\) Coupled Model Intercomparison Project phase 3 \(CMIP3\)](#) multi-model dataset, which was referenced in the Intergovernmental Panel on Climate Change Fourth Assessment Report. Please see the "About" page for information on data development, including the methodology to perform climate model bias-correction and spatial downscaling.

Purpose

The archive is meant to provide planning analysts access to climate and hydrologic projections that are spatially downscaled to a "basin-relevant" resolution. Such access permits several types of analyses, including:

- assessment of local to regional climate projection uncertainty.
- assessment of climate change impacts on natural and social systems (e.g., watershed hydrology, ecosystems, water and energy demands).
- risk-based exploration of planning and policy responses framed by potential climate changes evident in these projections.

Archive History

November 2007: Archive additions include:

- 112 projections of monthly temperature and precipitation at 1/8d resolution over the contiguous U.S., developed using the "Bias-Correction Spatial Disaggregation" (BCSD) downscaling technique (see "About").

December 2010: Archive additions include:

- gridded meteorological observations (see "About") used to guide the BCSD application, and
- the intermediate datasets developed during BCSD application (i.e. 2d regridded global climate projections over the contiguous U.S. (2d Raw) and bias-corrected versions of these projections (2d BC)).

August 2011: Archive additions include:

- 63 projections of daily minimum temperature, maximum temperature and precipitation.

Figure 1. BCSD CMIP3 Monthly Climate Analysis example - Median projected change in average-annual precipitation (cm/year), 2041-70 versus 1971-2000.

Figure 2. BCCA CMIP3 Daily Climate Analysis example - Calendar-day, ensemble-mean change in 20-year diurnal temperature range for three percentiles of diurnal range: 10th, 50th and 90th for the period pairs shown.

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LLNL-GDO archive's CMIP5-related datasets

http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html

• CMIP5

- Climate, monthly (BCSD), 2013
 - 37 GCMs
 - up to 4 emissions per GCM, multiple runs
 - 234 projections
 - 1950-2099, NLDAS, 1/8°
- Climate, daily (BCCA), 2013
 - 21 GCM subset from BCSD CMIP5
 - up to 4 emissions per GCM, multiple runs
 - 134 projections
 - 1950-2099, NLDAS, 1/8°
- Hydrology (extend from BCSD), 2014
 - 31 GCM subset from BCSD CMIP5
 - up to 4 emissions per GCM, first run only
 - 99 projections
 - same other attributes as BCSD
 - CONUS + Canadian portions of Columbia and Missouri River Basins
 - Serve (a) monthly water balance variables, and (b) daily forcings and gridded runoff

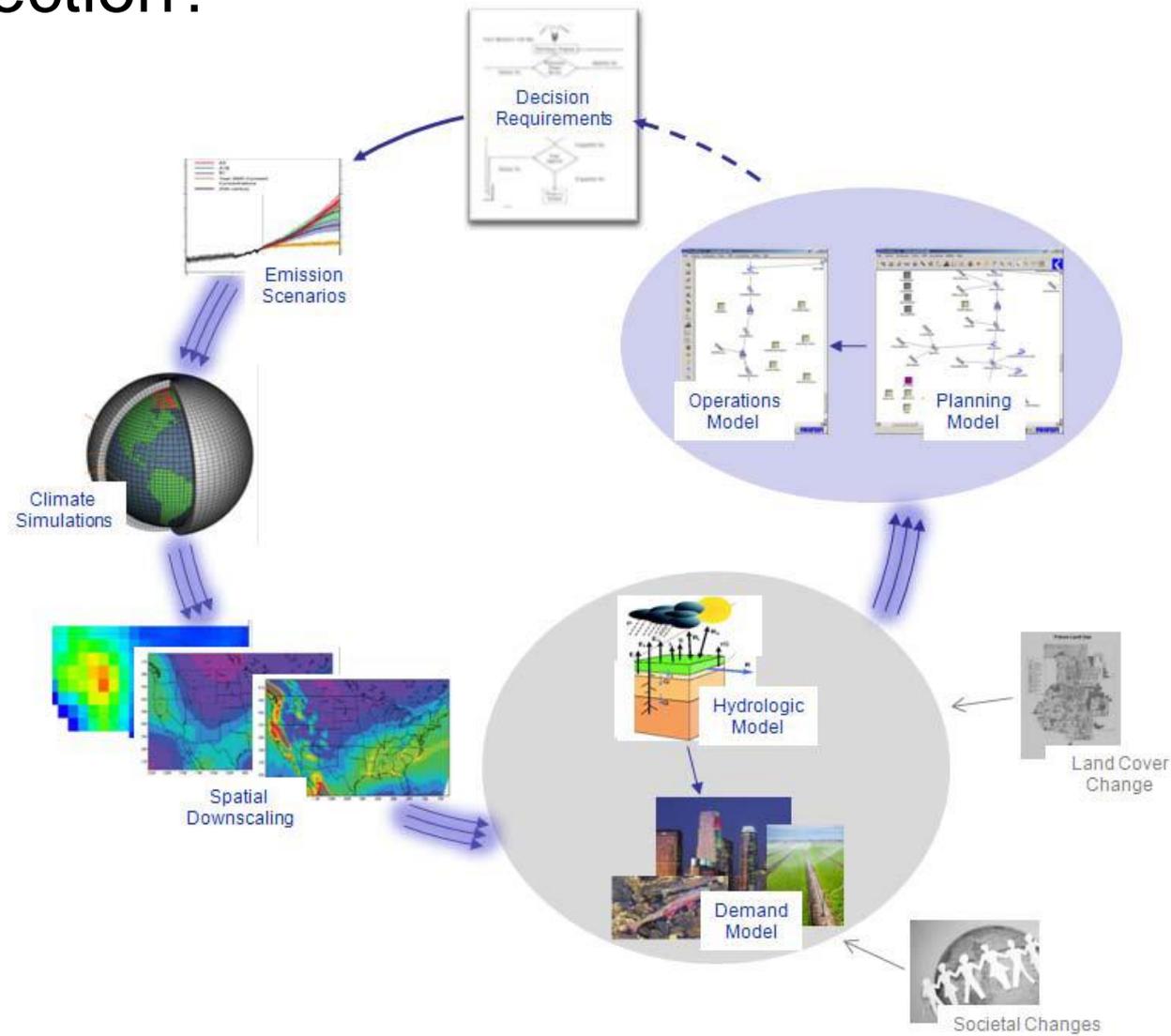
The screenshot shows the website interface for 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections'. At the top, there are logos for RECLAMATION, NCAR, USGS, Santa Clara University, CLIMATE CENTRAL, and SCRIPPS INSTITUTION OF OCEANOGRAPHY. The main title is 'Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections'. Below the title, there is a navigation menu with links: Welcome, About, Tutorials, Projections: Subset Request, Projections: Complete Archives, Feedback, and Links. The main content area includes a section for 'Downscaled CMIP5 climate and hydrology projections' documentation and release notes, a 'Summary' section, and a 'Purpose' section. The 'Summary' section describes the archive's content, including spatial resolution translations of climate projections over the contiguous United States (U.S.) developed using two downscaling techniques (monthly BCSD Figure 1, and daily BCCA Figure 2), CMIP3 hydrologic projections over the western U.S. (roughly the western U.S. Figure 3), and CMIP5 hydrology projections over the contiguous U.S. corresponding to monthly BCSD climate projections. The 'Purpose' section states that the archive is meant to provide access to climate and hydrologic projections at spatial and temporal scales relevant to some of the watershed and basin-scale decisions facing water and natural resource managers and planners dealing with climate change. To the right of the text, there is a figure titled 'Figure 1. Central Tendency Changes in Mean-Annual Precipitation over the contiguous U.S. from 1970-1999 to 2040-2069 for BCSD3, BCSD5, and Difference.' The figure consists of two maps of the contiguous United States showing precipitation changes. The top map is labeled 'Mean-Annual Precipitation Change, percent CMP3,1970-1999 to 2040-2069,50%tile' and the bottom map is labeled 'Mean-Annual Precipitation Change, percent CMP5,1970-1999 to 2040-2069,50%tile'. A color scale below the maps ranges from -20 (red) to 20 (blue), with 0 being white.

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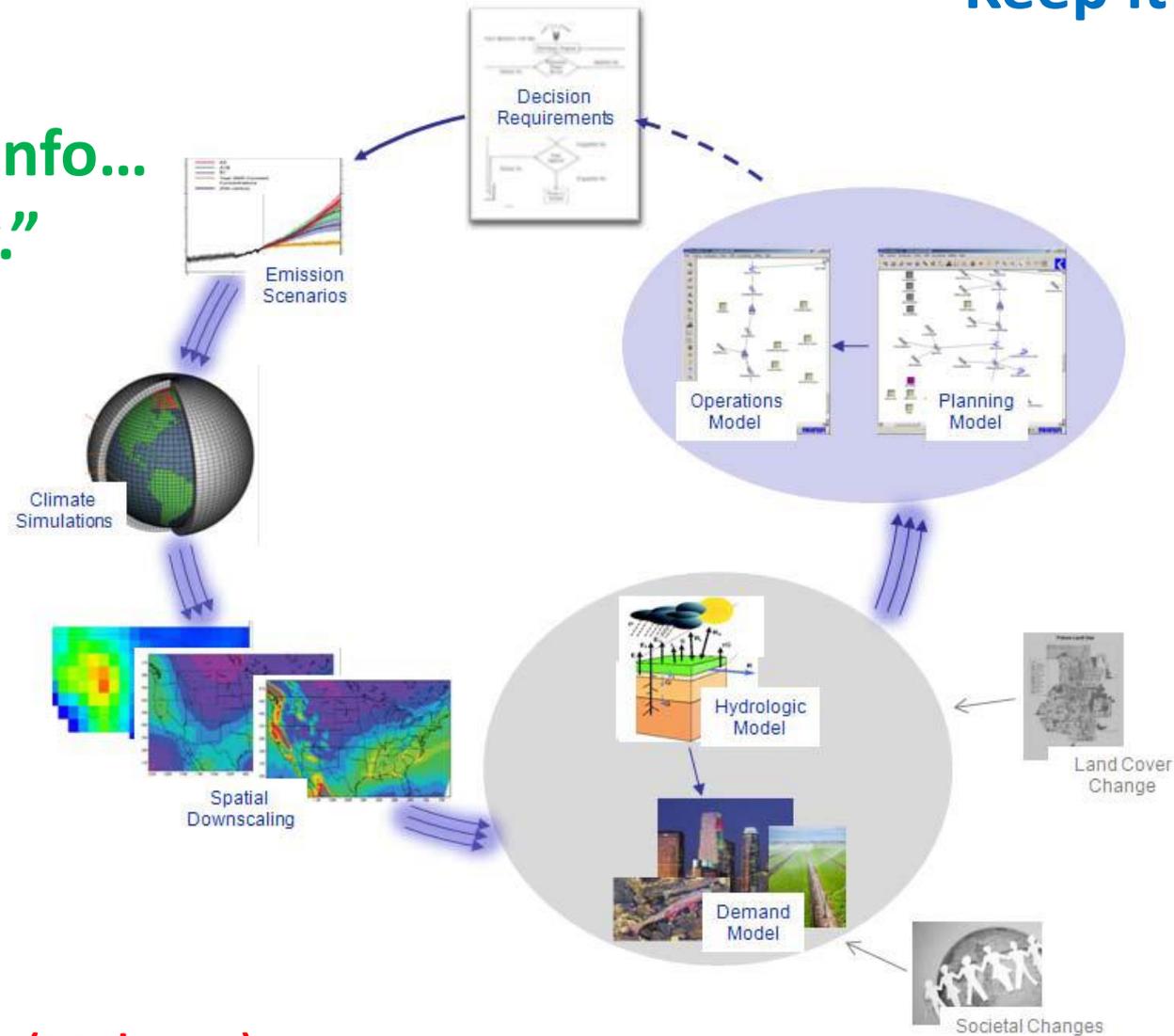
How do we use climate change
information in regional to local
planning?

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Which actors affect method selection?



II. Climate Information Providers:
“Here’s the info... use it wisely.”



I. Decision-Makers:
“Keep it simple.”

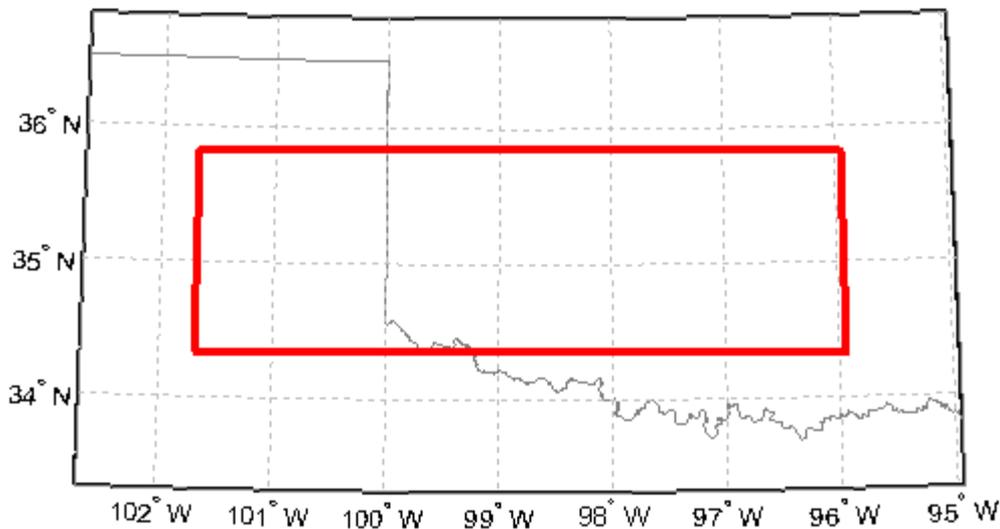
III. Technical Practitioners (Ushers):
“Keep it Manageable.”

Two Method Classes have emerged...

- Period-Change
 - prevalent among water impacts studies
 - “perturbed historical” at some milestone future
 - comparative studies: past, future
- Transient
 - prevalent in the climate science community (“climate projections”)
 - time-evolving view
 - continuous study, from past to future

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:
 - change metric (e.g., change in means, change in distributions)
 - space (e.g., change in regional condition, or change in spatially disaggregated conditions), and
 - number of projections informing a scenario (e.g., one, several, many)

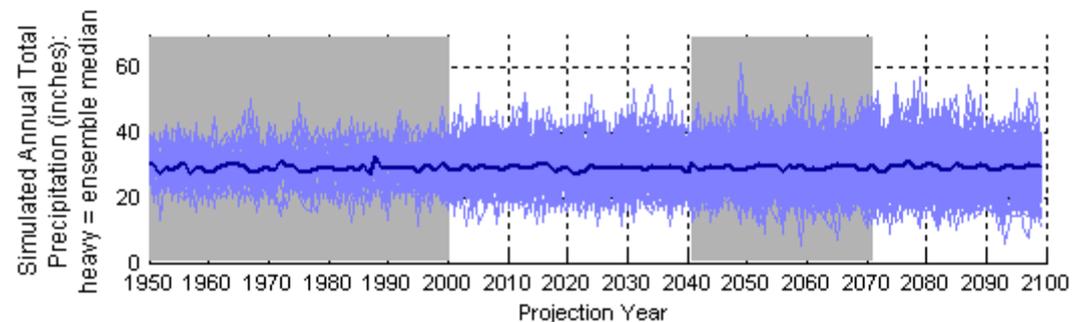
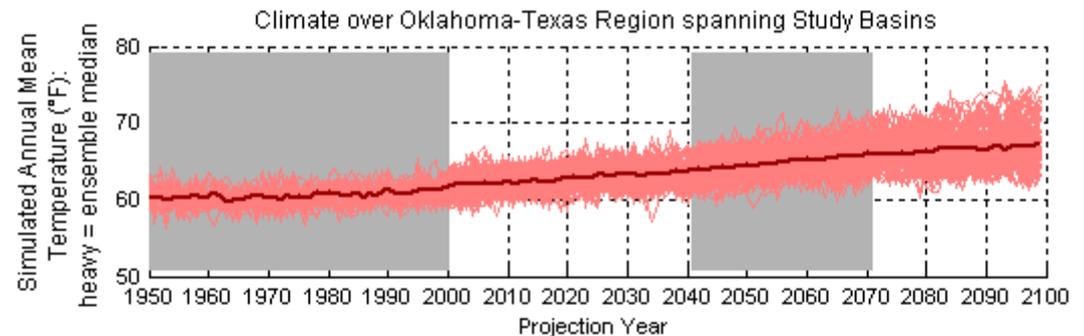


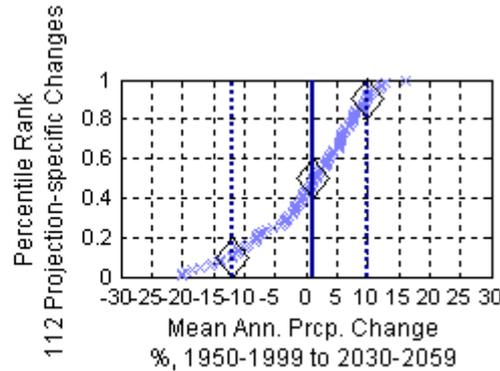
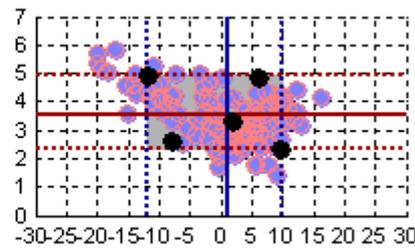
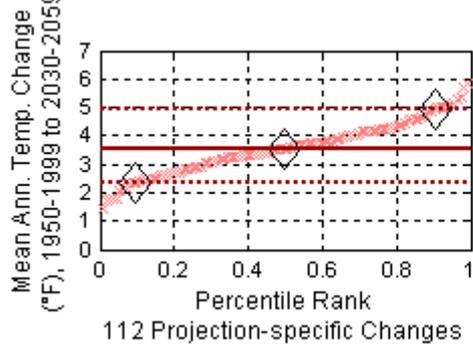
Let's say we wish to identify climate change scenarios for western Oklahoma...

1. Define climate change region

2. Get spatially averaged climate projections over the region.

3. Define "change" periods.





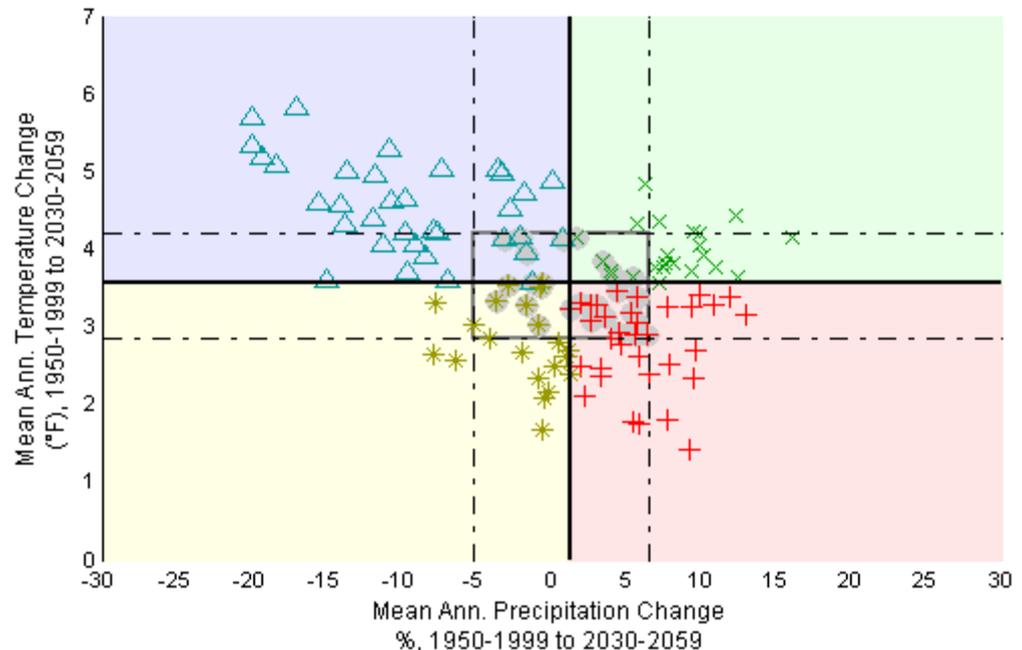
4. Compute change for each projection.

5. Select projection(s) to inform scenarios, represent central tendency and spread

6. Carry forward to impacts analysis

Projection-specific approach:
single projections inform corresponding scenarios

Ensemble-informed approach: multiple projections are grouped and collectively inform scenarios

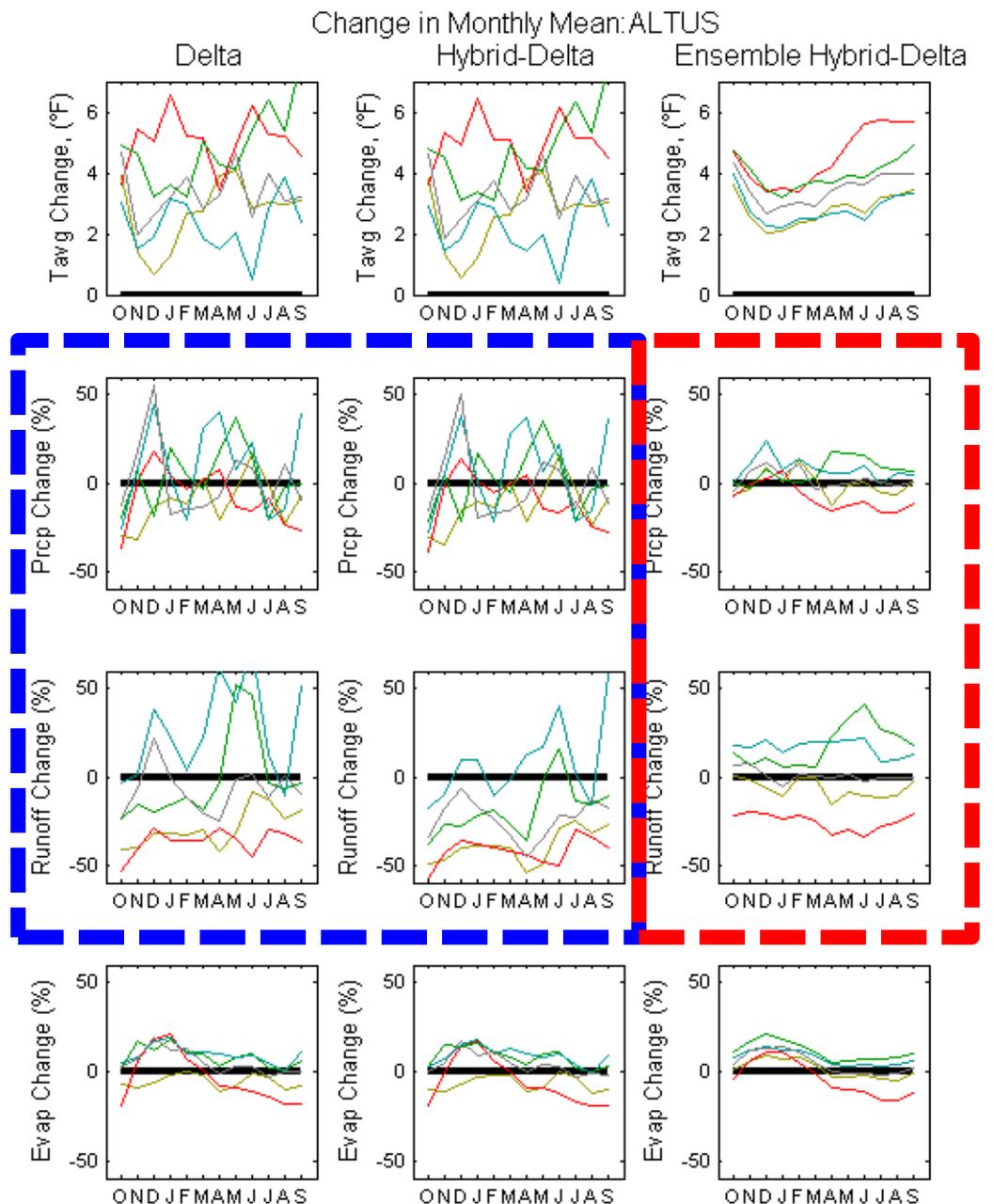


Difficulties with period-change approach:

- (1) projection-specific scenarios tend to have noisy month-to-month change factors → *motivates ensemble-informed approach if we want to emphasize consensus signal*
- (2) projected precipitation changes – are they signal or low-frequency variability? → *select projections away from tails*

projection-specific methods

ensemble-informed method



black = historical (VIC sim, MaurerEtAl2002 weather)

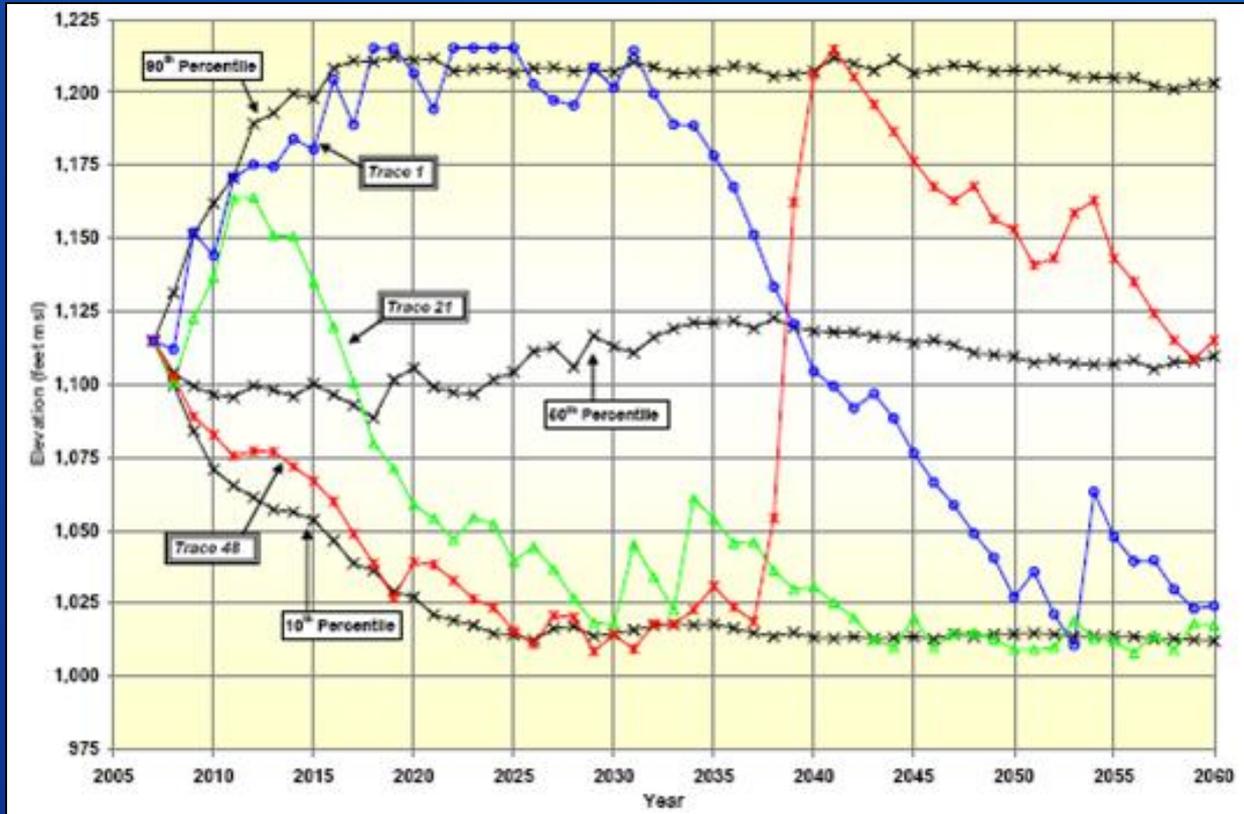
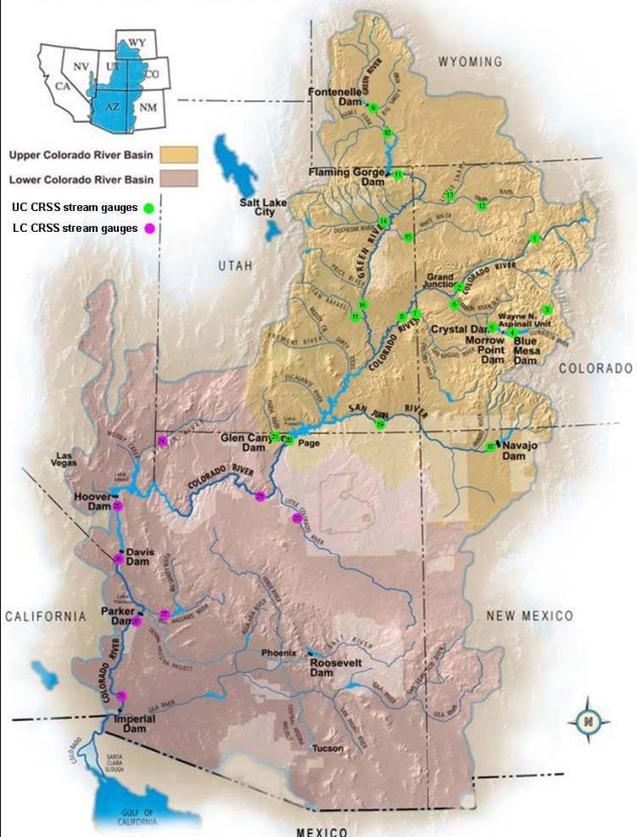
colors = climate change, 1950-1999 to 2030-2059 (gold, red, blue, green, gray = drier-less warming, drier-more warming, wetter-more warming, wetter-less warming, middle)

Transient: Overview

- Historical climate variability sequence is 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
- Studies need to feature a large ensemble of climate projections to adequately portray an envelope of climate possibility through time
- Projection ensembles of various forms may be used, e.g.:
 - Time series outputs from a GCM simulation (or a GCM-RCM simulation)
 - ... or spatially downscaled, bias-corrected versions
 - ... stochastically resampled (resequenced) versions of these outputs, reflecting a different frequencies reference (observations, paleoproxies)
 - used in WaterSMART Colorado River Basin Study, referenced by Lempert, 7/30/14

Difficulties: communication and analytical tools need to be compatible with “projection” paradigm. Some groups are ready for this, others are not...

Colorado River Basin



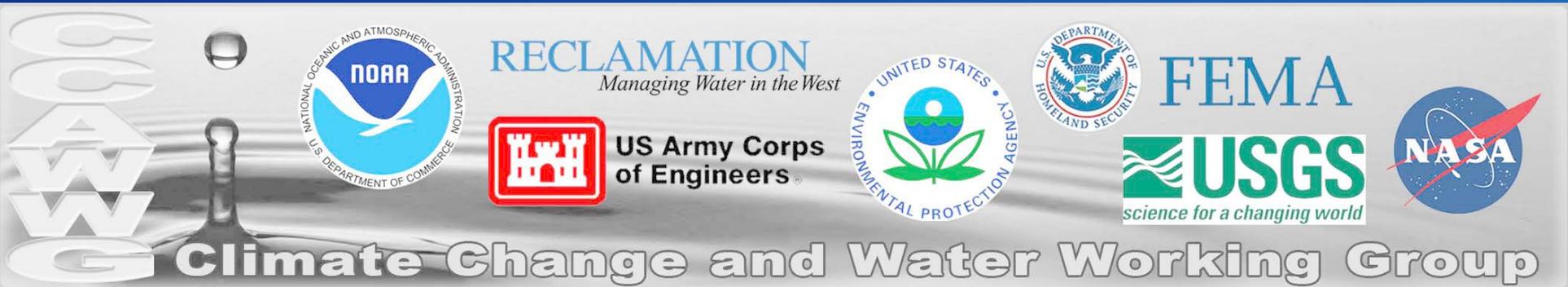
Lake Mead End-of-December storage under the No-Action Alternative: 90th, 50th, and 10th percentile values

(Reclamation 2007, Figure 4.2-2)

Application Challenges

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Since 2008, collaboration among Federal water science and management partners



- **Defining User Needs, Developing Research Strategy**
- **Fostering collaborative R&D**
- **Developing Climate Change Training Capacity**
- **Hosting Workshops on Emerging Topics (e.g., Nonstationarity, Portfolio of Assessment Approaches)**

www.ccawwg.us

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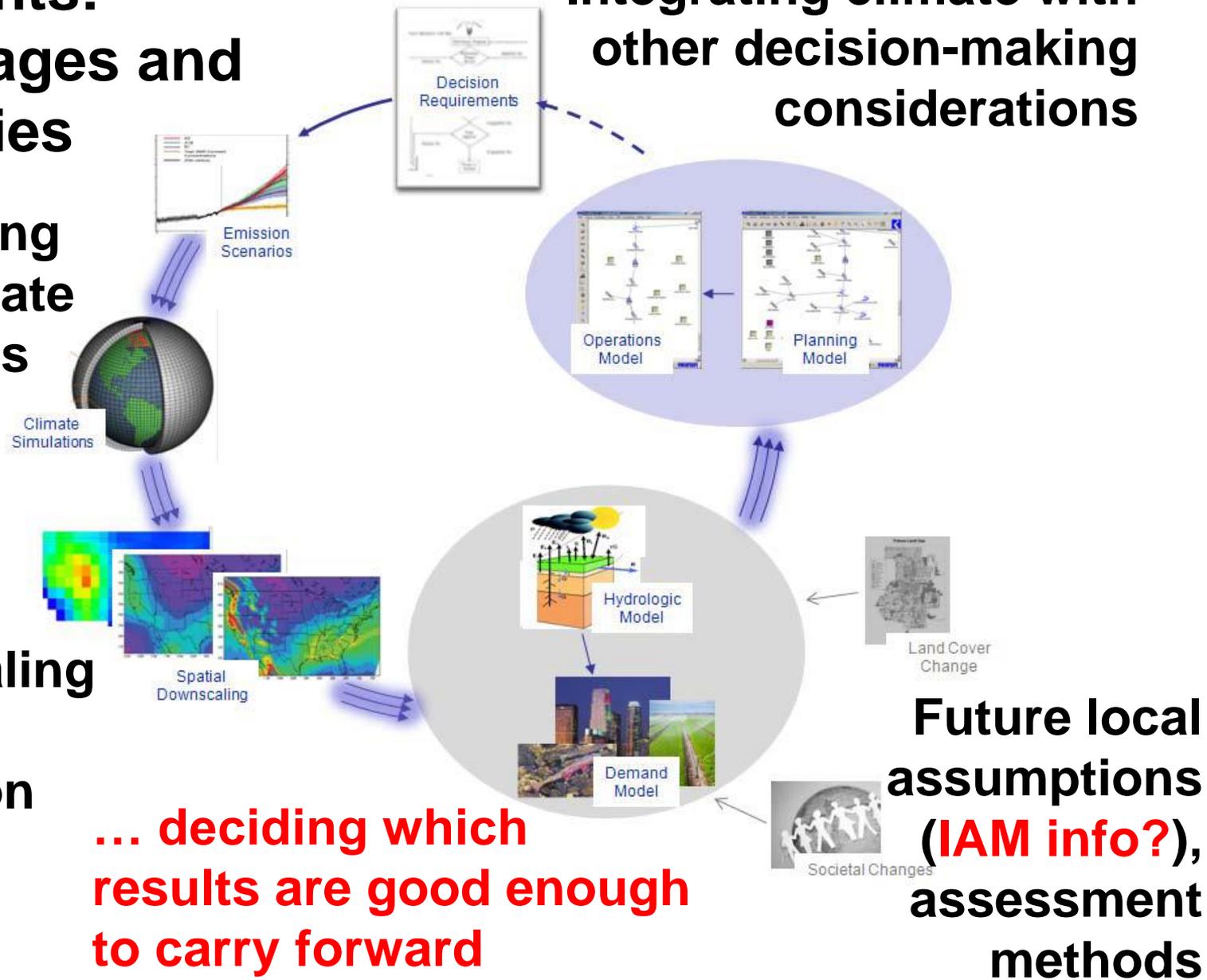
Climate Change Assessments: Method Stages and Uncertainties

Representing global climate possibilities

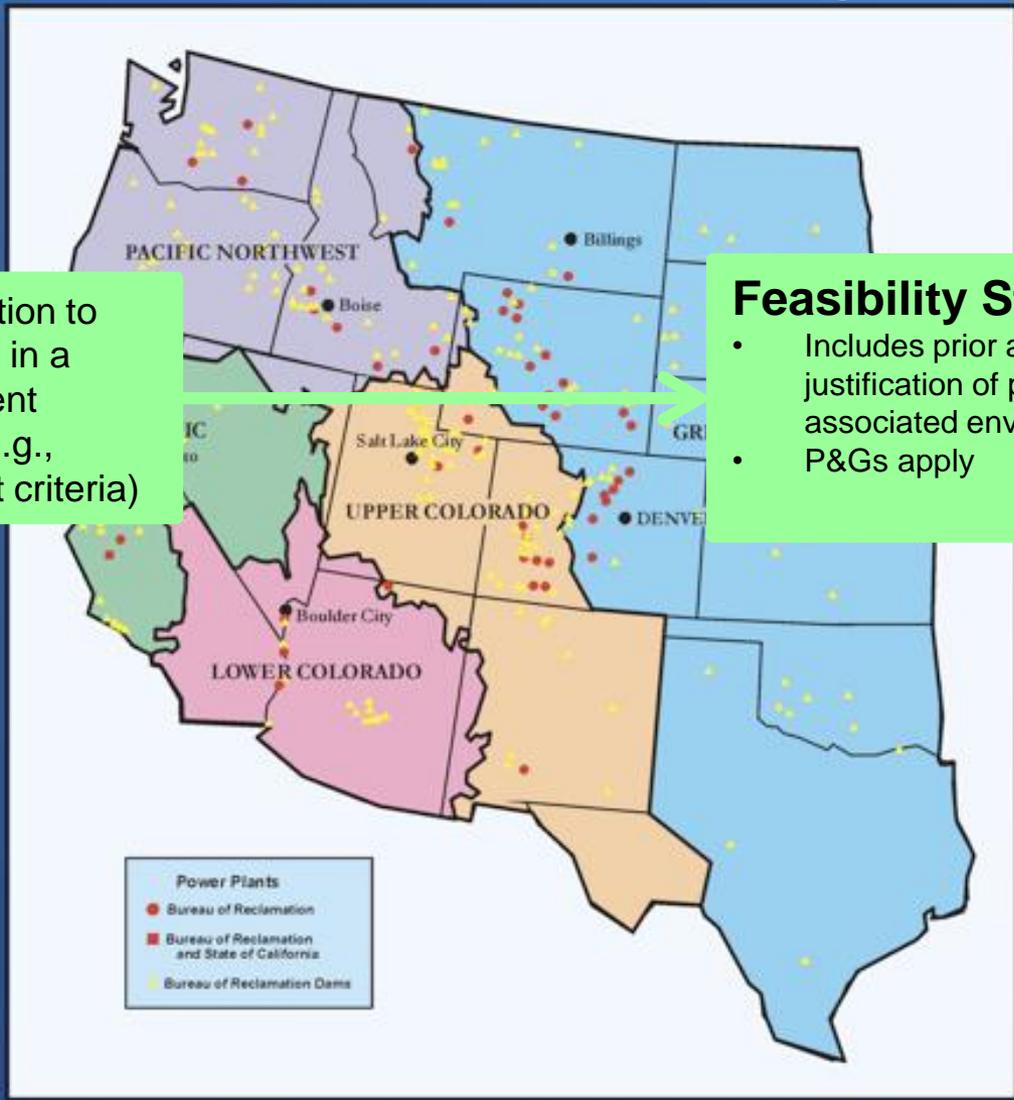
Spatial downscaling & bias-correction method

... deciding which results are good enough to carry forward

Integrating climate with other decision-making considerations



Vulnerability Assessments and Adaptation Planning vs. Feasibility Studies... the latter has unique challenges



Goal: inform recommendation to Congress whether to invest in a water resources development through authorized study (e.g., infrastructure, management criteria)

- ### Feasibility Studies
- Includes prior appraisal studies, evaluates justification of proposed action and associated environmental impacts
 - P&Gs apply

Reclamation Feas. Studies ~2006 to 2012

- Climate change recognized as important planning consideration
- Analysis of climate change was discretionary
- Typical Approach – (1) historical climate assumed in “default” no-action and action-alternatives evaluation; (2) parallel climate change sensitivity study conducted w/ Period-Change “scenarios”
- No clear tie between climate change and major decision

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Reclamation Feas. Studies post-2012:

- **Updated Feasibility Study D&S (CMP-09-02)**

Requires effects of climate change be considered in feasibility study no-action (i.e. without-plan future condition) and implicitly all action-alternatives

Game Changer:

Then:

Use of climate change was at the discretion of individual study teams

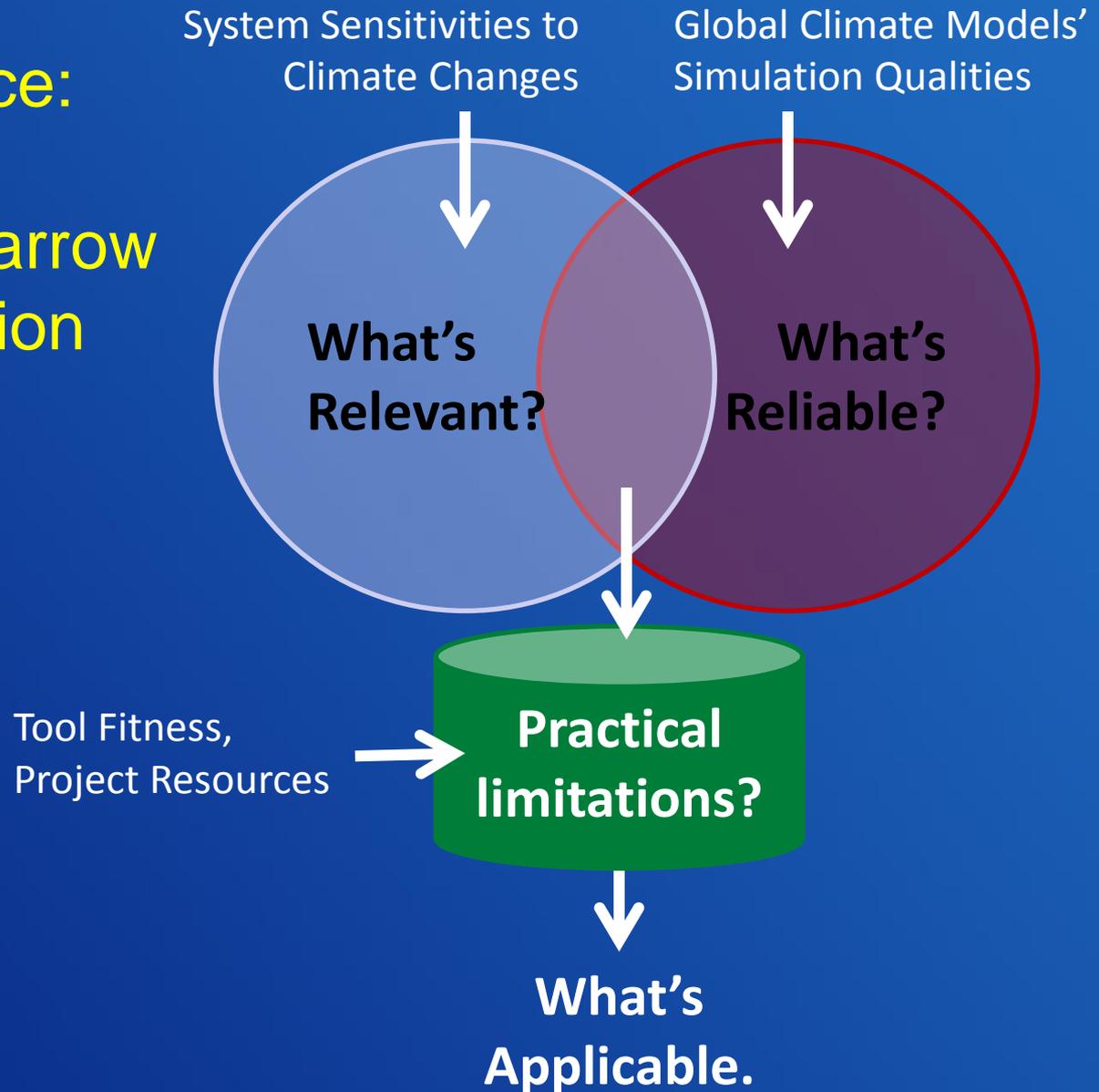
Now:

Consideration of climate change is required for all feasibility studies

- **Question: How do we do implement CMP-09-02?**
- **Need Guidance...**

Initial thoughts on developing guidance:

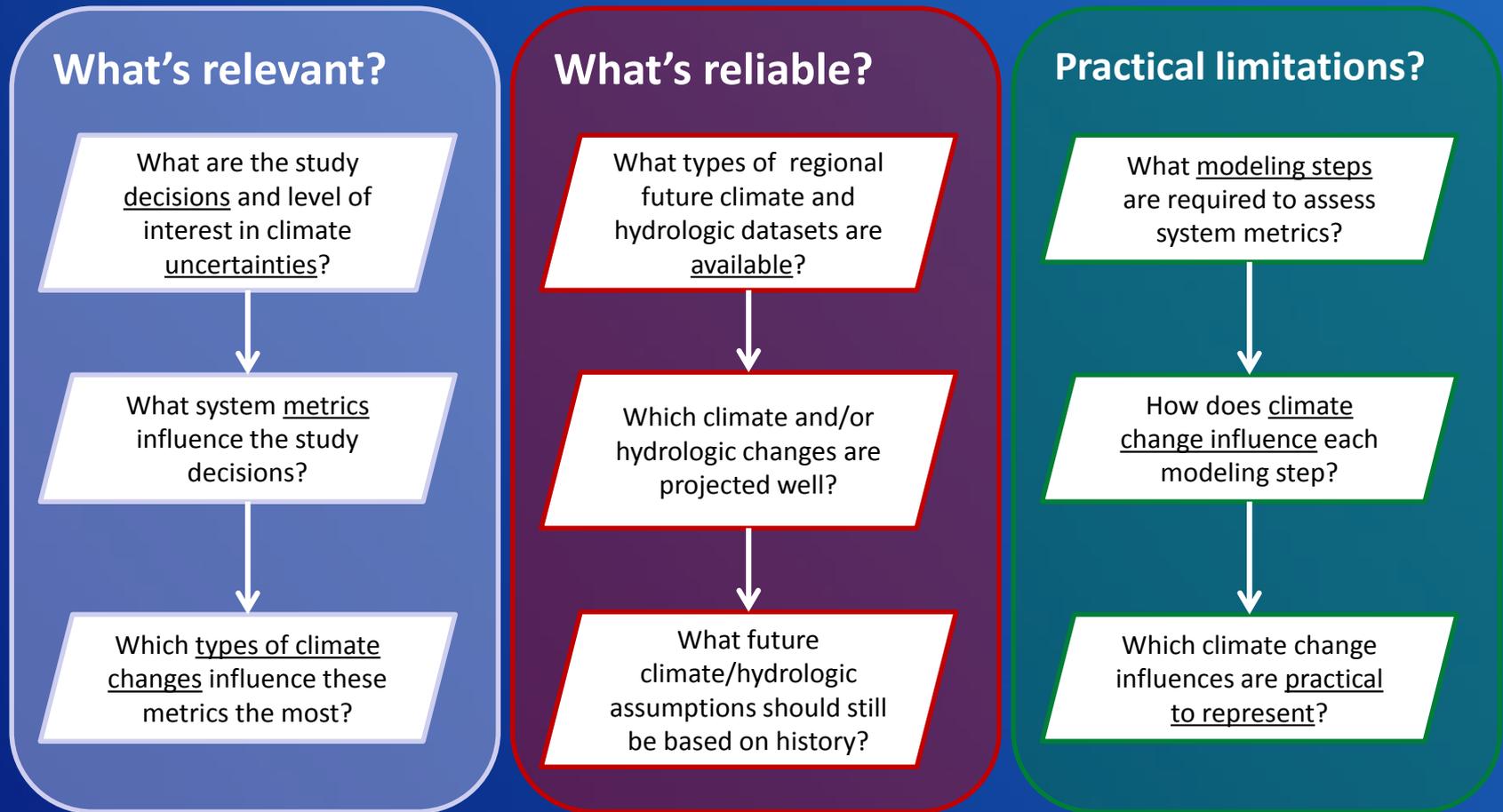
use relevance to narrow the reliability question



Draft, Guidance in development

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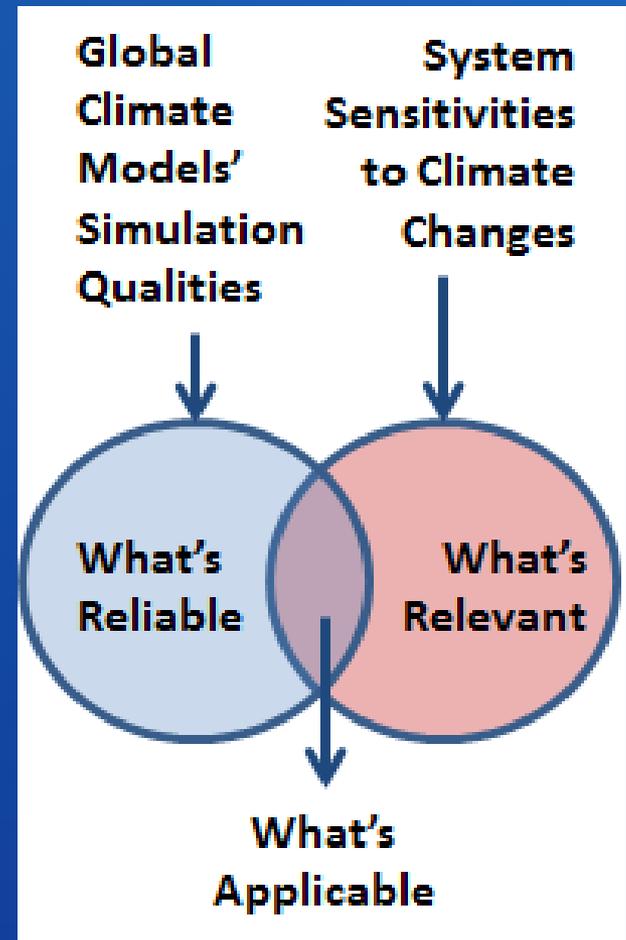
... encourage Scoping Teams to answer common questions; let answers be free to vary by study



Test Drive these Guidance Principles:

FY13-14 Project: Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning

- Sponsors:
 - Reclamation, USACE, NOAA/CIRES
- Goal
 - develop, pilot and evaluate a framework for evaluating information relevance & reliability to guide judgment of applicability
- Approach
 - Broadband quality evaluation of CMIP5 (*What's reliable?*); serve results on web
 - System sensitivity analyses to different types of climate changes (*What's relevant?*); compile results for relevant performance
 - Applicability Pilot (California Central Valley CVP-SWP reservoir systems, **mock scoping**, observe process, what do participants value, what works well, what doesn't...)



Summary

Questions? Levi Brekke,
lbrekke@usbr.gov

- There are many approaches to consider, where preferred approach depends on scoping actors' concerns.
- Any approach features future hydroclimate assumptions that reflect a blend of historical and projected hydroclimate information.
- Approach selection to inform investments may well consider relevancy, reliability and practicality perspectives.
- **IAM community may be well positioned to help local planners make future assumptions about future land cover and socioeconomics.**

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