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Managing Water in the West

Climate Projections for Water Resources and Environmental Planning

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Acknowledgments:

Presentation reflects thoughts and contributions from Martyn Clark (NCAR) and Jeffrey Arnold (U.S. Army Corps of Engineers)

U.S. Department of the Interior
Bureau of Reclamation

Bottom Line Up Front

- The water management community has developed capabilities to use climate projections in long-term planning assessments.
- Through CCAWWG , Reclamation is collaborating with Federal water science and management partners to understand limits of these capabilities, define community needs, and identify research opportunities.
- CESM presents several unique research opportunities…

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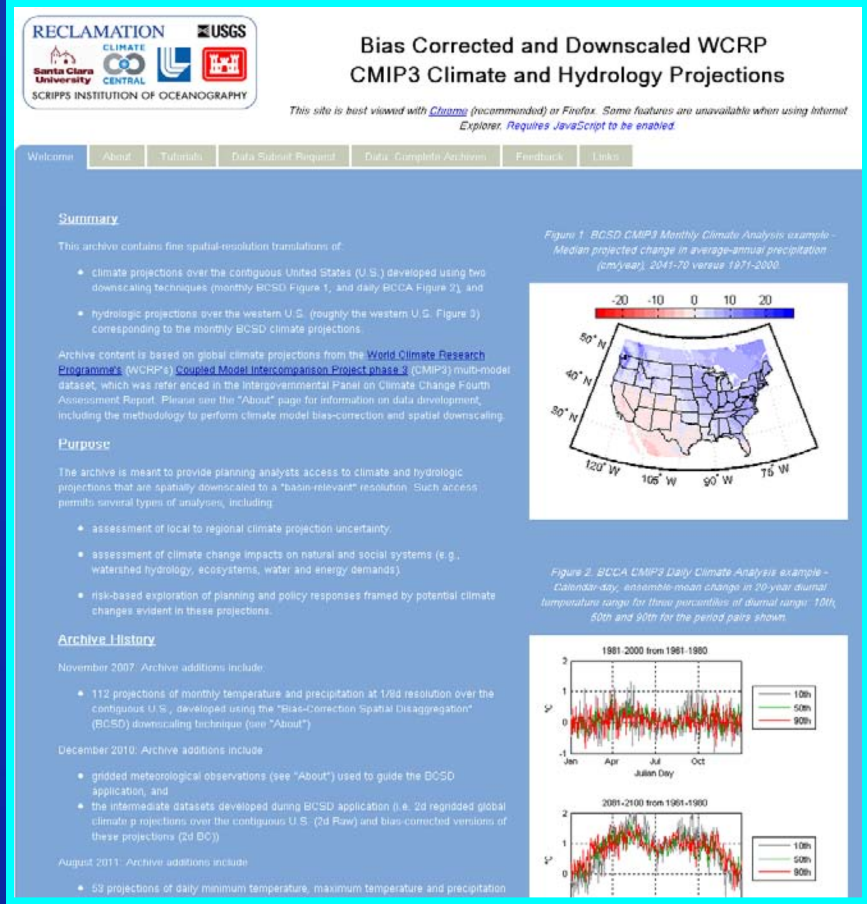
Early Activity: improve access to "many" downscaled climate (2007-present) and hydrology projections (2011-present)

http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/

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



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Early Applications (leveraging the previous "archive" as well as other downscaled information sources)

- Internal activity
  - Reclamation 2008 (ESA Biological Assessment, CA Central Valley Project)
  - Reclamation 2009 (NEPA EIS, CA San Joaquin River Restoration Program)
  - RMJOC 2010 (Columbia Basin; BPA, USACE, and Reclamation development of future climate & hydrology change scenarios)
  - Others…
- External Activity (tracked)
  - CO Front Range Climate Change Vulnerability Study (2008-2012)
  - Colorado River Water Availability Study (same)
  - California Climate Action Team studies (2006, 2009)
  - NOAA RISA assessments (CIG, WWA)
  - Others…

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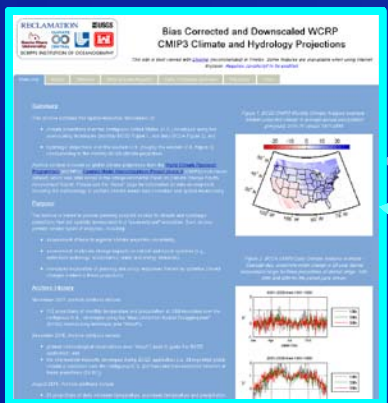
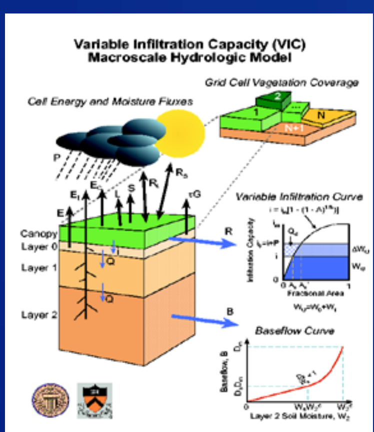
Recent Application: West-Wide Hydrology Projection & SECURE 9503 report (2011)

112 BSCD CMIP3 Climate Projections…

http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/dcpInterface.html



8 “big basin” VIC hydrology model-apps from Univ. of WA…



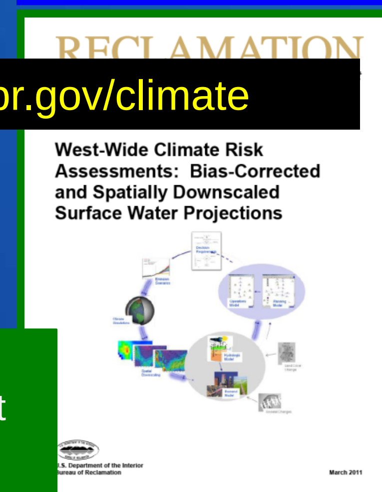
…112 Hydrologic Projections covering western U.S.…

Data-service, Reclamation and broader public use

Analyses of Period-changes in climate and hydrology

SECURE Report to Congress, 2011 focus on median changes; future reports have broader scope

http://www.usbr.gov/climate



Technical Report, data-development (TSC 86-68210, March 2011)

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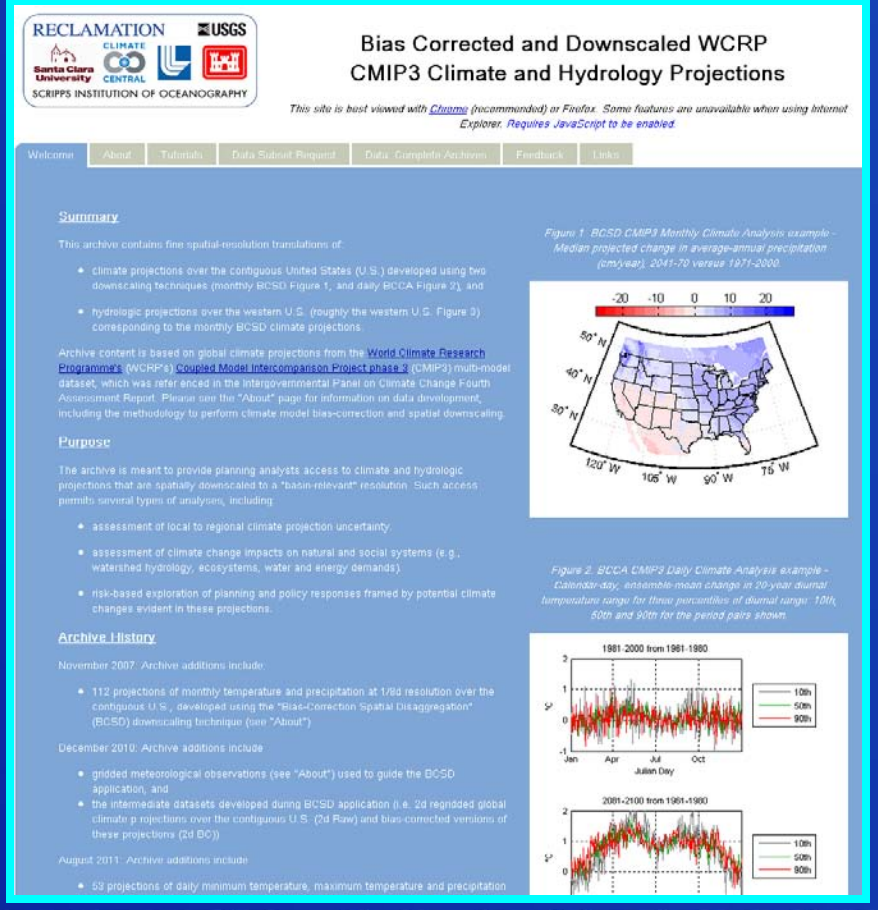
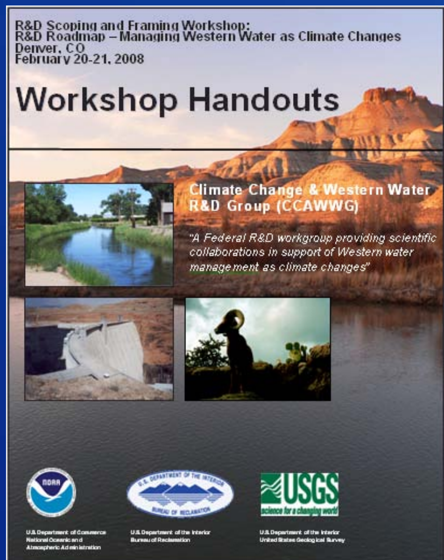
Downscaled CMIP5 Climate and Hydrology Projections (climate exp. ~Mar 2013)

http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/

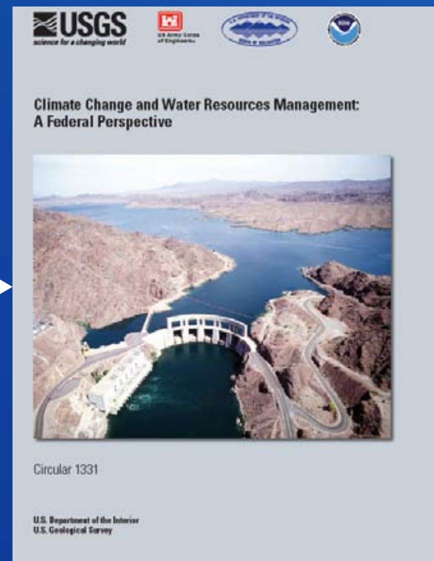
- CMIP5
  - Climate, monthly (BCSD)
    - 37 GCMs
    - 4 emissions
    - 234 projections
    - 1950-2099, NLDAS, 1/8º
  - Climate, daily (BCCA)
    - 21 GCMs
    - 4 emissions
    - 134 projections
    - 1950-2099, NLDAS, 1/8º
  - Hydrology (extend from BCSD)
    - same attributes, although driven by projected changes in diurnal temperature range and average temperature, not just the latter (as in prior effort)
    - CONUS + Canadian portions of Columbia and Missouri River Basins
    - Serve (a) monthly water balance variables, and (b) daily forcings and gridded runoff



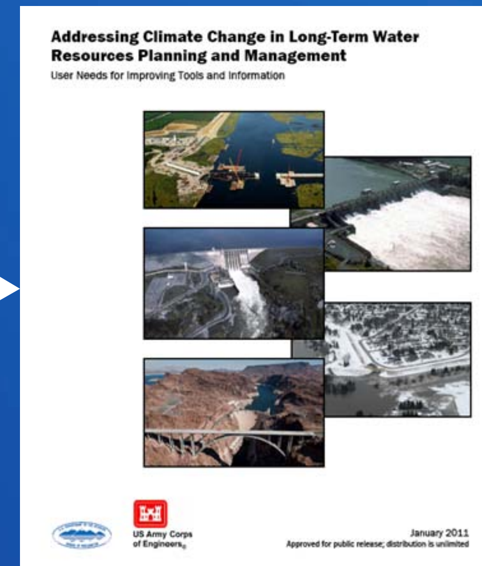
Defining User Needs…



C-CAWWG
February 2008
Workshop



USGS Circular
1331
January 2009



CCAWWG User
Needs Document
January 2011

http://www.ccawwg.us/

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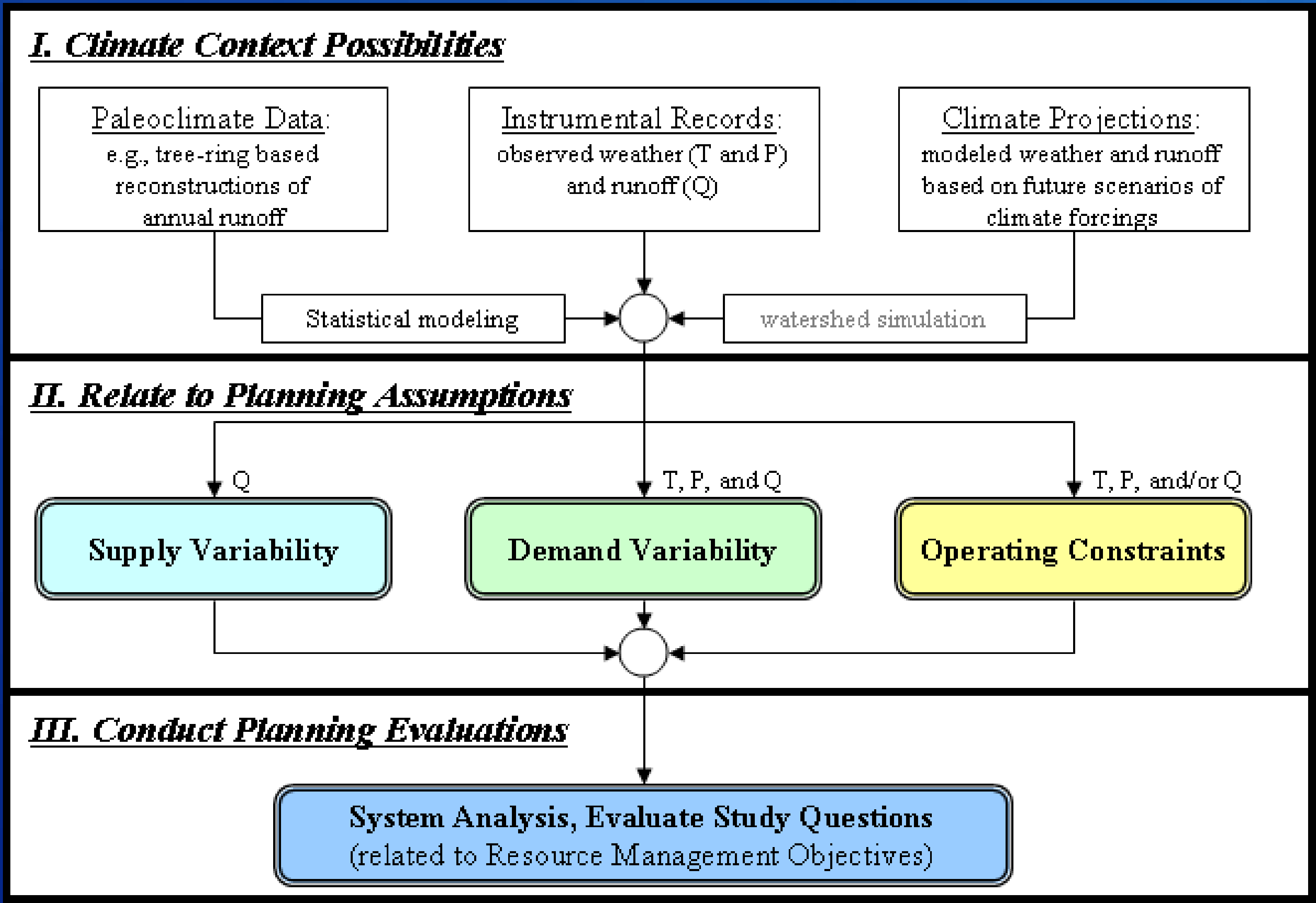
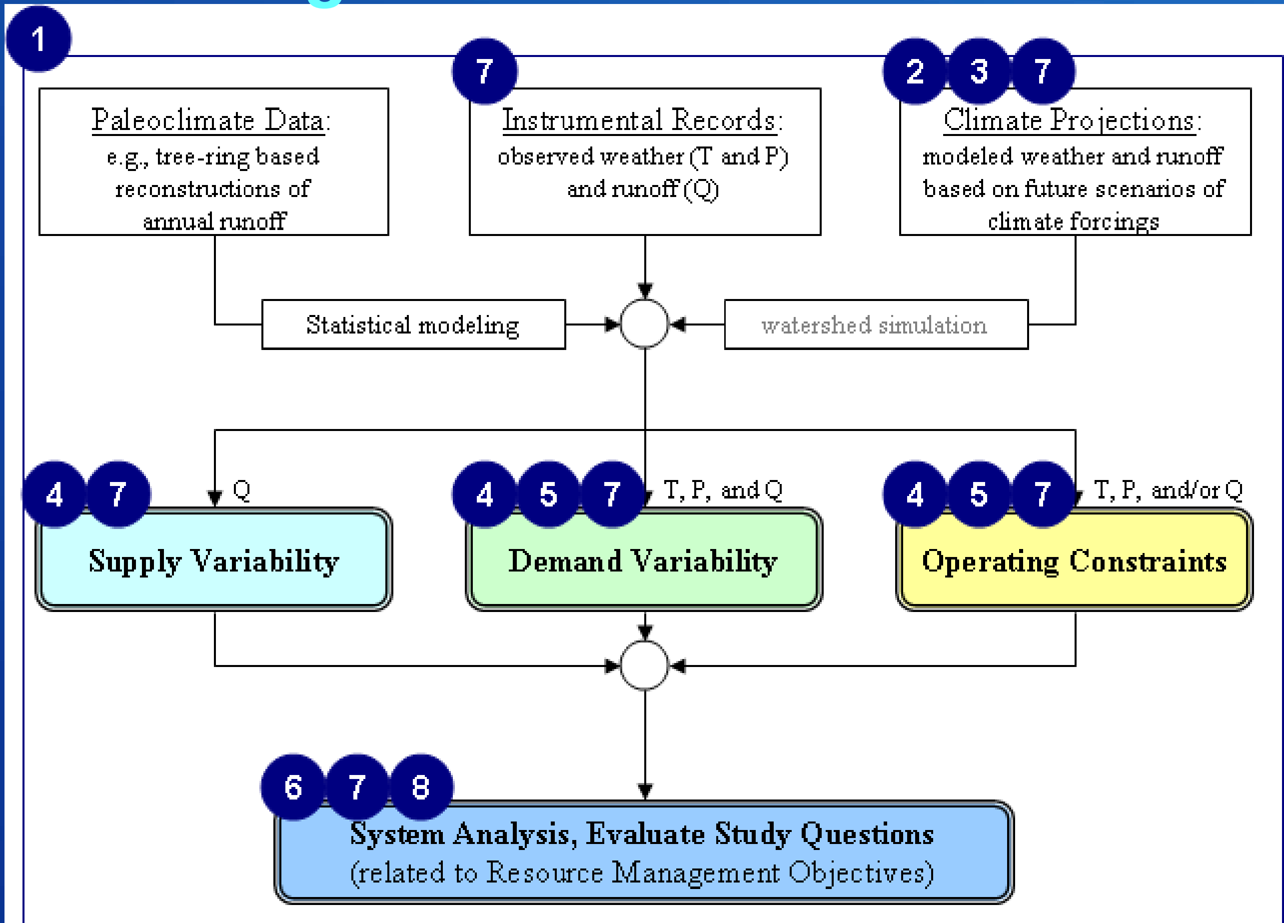
Role of Climate Information in Water Resource Management Studies



Eight Technical Steps for incorporating climate change into **Water Resource Management Studies**



1. Summarize Literature on Climate Change and Water Resources
2. Obtain Climate Projections Data
3. Decide which Projections to use and how to use in Planning Scenarios
4. Assess Natural Systems Response
5. Assess Social Systems Response
6. Evaluate Study Questions (regarding Resource Management Objectives)
7. Assess and Characterize Uncertainties
8. Communicate Uncertainties and relate to Decision-Making

Prioritization of Research relative to Technical Step (Gap Category)

Technical Step	Technical Step (Gap Category)	Average Priority Rankings [1]	
		Reclamation/ USACE	All Respondents
1	Summarize Relevant Literature	1.5	1.5
2	Obtaining Climate Change Information	2.5	2.4
3	Make Decisions About How To Use the Climate Change Information	3.0	2.7
4	Assess Natural Systems Response	3.0	1.9
5	Assess Socioeconomic and Institutional Response	2.5	2.3
6	Assess System Risks and Evaluate Alternatives	1.5	2.0
7	Assess and Characterize Uncertainties	2.0	2.6
8	Communicating Results and Uncertainties to Decisionmakers	3.0	3.0

[1] Averaged across gaps in a given Step
(1 = low, 2 = medium, and 3 = high)

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Summary of Gaps and Priorities (*Steps 2 through 4 highlighted…*)

Technical Planning Steps and Associated Gaps in Tools and Information	**Priority Ranking [1]** Reclamation/ USACE	All Respondents
Step 2 – Obtaining Climate Change Information		
2.01 Improved skill in simulating long-term global to regional climate.	High	High
2.02 Downscaled data at finer space and time resol	High	High
2.03 downscaled data and the down-scaling methodologies used to develop these data (including both statistical and dyna clima	High	High

2010 BCCA, 2011 WWCRA VIC-hydrology projections

2011-2013 NCAR Project #1 (Sensitivity of Impacts to Downscaling/Hydrology Methods)

[1] Color shading indicates priority rating on research to address gaps: low (yellow), medium (light orange), and high (dark orange).

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Summary of Gaps and Priorities (*Steps 2 through 4 highlighted…*)

Technical Planning Steps and Associated Gaps in Tools and Information	**Priority Ranking** [1] Reclamation/ USACE	**Priority Ranking** [1] All Respondents
Step 2 – Obtaining Climate Change Information		
2.04 Indication of conditions of where and when the stati… hold … dyna…	Medium	Medium
2.05 Synthesis of sea level projection information and guidance on consistent use in planning for all Reclamation and USACE coastal areas.	Low	Low

2011-2013 NCAR Project #1 (Sensitivity of Impacts to Downscaling/Hydrology Methods); NOAA NCPP (Dixon/Hayhoe)

[1] Color shading indicates priority rating on research to address gaps: low (yellow), medium (light orange), and high (dark orange).

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Summary of Gaps and Priorities (*Steps 2 through 4 highlighted…*)

Technical Planning Steps and Associated Gaps in Tools and Information	**Priority Ranking [1]**	
	Reclamation/ USACE	All Respondents
Step 3 – Make Decisions About How To Use the Climate Change Information		
3.01 Understanding on observed climate variability from daily to multidecadal time scales, which underpins interpretation of future variability in climate projections and its relation to planning assumptions.	High	High
3.02 Understanding how to interpret future variability in climate projections and relevance to operating constraints on shorter- to longer-term time scales (from daily to multidecadal).	High	High
3.03 … at all … plann…	Medium	Medium

2006-2007 USGS/CA-DWR/SCU project (Brekke et al. 2008); tracking literature (2008-present), lots of studies/frameworks based on CMIP3

[1] Color shading indicates priority rating on research to address gaps: low (yellow), medium (light orange), and high (dark orange).

Summary of Gaps and Priorities (*Steps 2 through 4 highlighted…*)

Technical Planning Steps and Associated Gaps in Tools and Information	Priority Ranking [1] Reclamation/ USACE	All Respondents
Step 4 – Assess Natural Systems Response Watershed Hydrology (WH), Ecosystems (E), Land Cover (LC), Water Quality (WQ), Consumptive Use on Irrigated Lands (CU), and Sedimentation and River Hydraulics (SRH)		
4.01 … wate… scop… — 2009-2011 Reclamation/USGS/NWS project on models' preferences; 2011-2013 NCAR Project #1; tracking literature	Low	Low
4.02 (WH) Understanding how climate change should impa… repre… — 2011-2013 NCAR Project #1; tracking literature	High	High
4.03 (WH) Method and basis for estimating extreme hydro… proba… — PACE Mahoney; 2012-2013 NOAA/CIRES project #1	High	High

[1] Color shading indicates priority rating on research to address gaps: low (yellow), medium (light orange), and high (dark orange).

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Summary of Gaps and Priorities (*Steps 2 through 4 highlighted…*)

Technical Planning Steps and Associated Gaps in Tools and Information	Priority Ranking [1]	
	Reclamation/ USACE	All Respondents
Step 4 – Assess Natural Systems Response Watershed Hydrology (WH), Ecosystems (E), Land Cover (LC), Water Quality (WQ), Consumptive Use on Irrigated Lands (CU), and Sedimentation and River Hydraulics (SRH)		
4.04 (WH) Guidance on strengths and weaknesses of available versions of spatially distributed hydrologic weather data that may be used for both watershed hydro[illegible] mode[illegible]	Medium	Medium
4.05 (WH) Understanding how climate change should impact groundwater recharge and groundwater interaction with surface water supplies.	Medium	Medium
4.06 (E) Understanding how climate change should impact inland and coastal anadromous fisheries.	Medium	Low

2011-2012 Reclamation/NWS (Elsner); 2011-2013 NCAR Project #1

[1] Color shading indicates priority rating on research to address gaps: low (yellow), medium (light orange), and high (dark orange).

CESM Opportunities

- Overarching question: How can SDWG scope CESM research to inform use of climate projections in long-term planning?
- Opportunities:
  1. Provide finer-resolution sneak preview
  2. Prep users for “hydroclimate” projections
  3. Foster offline use of CESM hydrology model

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1) Finer-Res. Sneak Preview

- Goal: provide sneak preview on what GCMs may be able to produce in the coming years
- Approach:
  - conduct CESM experiments across multiple resolutions ("current" to "future" higher resolution); leverage MPAS initiative
  - complement with nested RCM simulations
- Questions:
  - How does finer resolution CESM simulation affect the regional to local climate change "story"?
  - How are simulated regional/local climate changes different when using hi-res CESM vs. coarser-res CESM w/ nested RCM? … and with different RCMs?
  - How does CESM representations of hydrology differ from other land models?

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2) "Hydroclimate" Projections

- Goal: prepare user community for future where GCMs produce meaningful local hydroclimate projections (*eliminating need for downscaling*)
- Approach:
  - educate users on hydrology schemes in GCMs
  - conduct experiments to understand GCM structure and resolution controls on simulated local hydroclimate
- Questions:
  - At what resolutions are GCMs' projections of "local" hydroclimate meaningful? For which hydroclimate variables & statistics?
  - How are these findings sensitive to chosen land-surface hydrology scheme?

3) Offline Use of CESM LSM

- Goals: enhance user feedback to the broader CESM land-surface modeling efforts; facilitate users' migration to applying more process-based hydrology models
- Approach:
  - educate users on CESM's land-surface hydrology scheme (LSM)
  - scope research explore how to maximize utility of CESM LSM for water management applications:
    1. improve input datasets and associated estimates of uncertainty
    2. meld model application approaches found in "engineering hydrology" with those featured in the "land surface" modeling community
    3. include CESM LSM in multi-physics and process-diagnostic experiments designed to increase understanding on model application preferences
- Questions:
  - Ask Martyn ☺

Questions?