Climate Scenarios and Climate Sensitivity for the Bay Delta Conservation Plan

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Presentation Focus

• Key Research/Application Questions
  – Which climate projections should be selected for long-range water planning impact analyses when the entire ensemble cannot be simulated?
  – What balance of climate projection versus observed variability should be incorporated in planning?
  – How can climate change uncertainty be presented as scenarios of the future?

• Scenarios based on these research/application questions were developed for use in the Bay Delta Conservation Plan

• Summary of Projected Changes to System
Sacramento-San Joaquin Delta supports a vital ecosystem and serves as a major hub for water exports.

Recent export restrictions under biological opinions.

Delta smelt

Sacramento

Stockton

SWP Pumps
CVP Pumps
Bay Delta Conservation Plan (BDCP)

- Collaborative approach to restore the Sacramento-San Joaquin Delta’s ecosystem and protect water supplies
- Conservation measures being considered by the BDCP
  - tidal marsh restoration,
  - floodplain restoration,
  - alternative ways for conveying water for exports,
  - changes to operations of current facilities, and
  - control of toxic pollutants, invasive species, and other impairments to water quality
Integrated & Cascading Set of Analyses

- Process seeks permit for a 50-yr period
- Quantitative analysis being prepared for disclosure of impacts/effects at three points in time
- Approximately 2015, 2025, and 2060
Observed Climate
1950-1999 (Maurer et al 2002)

Temperature

Precipitation
Observed Statewide Temperature Trends
1896-2009

California Statewide Annual Mean Temperature

Annual
11-Year Running Mean

Water Year (October - September)
Observed Statewide Precipitation Trends
1896-2009

California Statewide Annual Precipitation

- Annual
- 11-Year Running Mean

Water Year (October - September)
Downscaled Climate Projections

- **112 downscaled climate projections**
  - PCMDI CMIP3 DCP archive
  - BCSD downscaling method
  - 16 GCMs included in IPCC AR4
  - SRES A2, A1b, and B1 scenarios to bracket range
  - Multiple realizations

<table>
<thead>
<tr>
<th>Modeling Group, Country</th>
<th>WCRP CMIP3 I.D.</th>
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<tr>
<td>Bjerknes Centre for Climate Research</td>
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<td>UKMO-HadCM3</td>
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Source: IPCC 2007
Multi-model Ensemble is Superior to Any Individual Model Projection

Statistical significance of model trend in JFM Tmin for western U.S. with increasing # of realizations

Change in model “skill score” with increasing # of realizations

Source: Pierce et al, 2009

Source: Gleckler et al, 2008
Climate Scenarios – Nearest-Neighbor Method

Relationship Between Changes in Mean Annual Temperature and Precipitation
Scenarios - 10 NN Method
Feather River Basin (Example)

Change over 2011-2040 period as compared to 1971-2000 base period

- Q1 (drier, less warming)
- Q2 (drier, more warming)
- Q3 (wetter, more warming)
- Q4 (wetter, less warming)
- Q5

- 112 GCMs
- Q1 (10NN)
- Q2 (10NN)
- Q3 (10NN)
- Q4 (10NN)

Temperature Change (C)
Precipitation Change (%)

T50
P50
T10
P10
T90
P90
T25
P25
T75
P75
Projected Changes in Annual Temperature and Precipitation (Q5 Scenario)
VIC Hydrologic Analysis

Climate interaction with the watershed characteristics matter immensely
Streamflow Routing and Climate Station Locations
Temperature Projections
Delta Location @ 2060
Precipitation Projections
Feather River location @ 2060

Monthly Precipitation (mm/day)

Observed, Q1, Q2, Q3, Q4, Q5
Projected Streamflow
Feather River at Oroville @ 2025
Projected Streamflow
Feather River at Oroville @ 2060
Projected Streamflow
Tuolumne River at New Don Pedro @ 2025
Projected Streamflow
Tuolumne River at New Don Pedro @ 2060
Navigating Sea Level Rise Uncertainty

Source: Rahmstorf 2007
Effect of Sea Level Rise on Salinity Intrusion

X2 is defined as the position of the 2 psu bottom salinity value, and is measured along the axis of the estuary in km from the Golden Gate.

Source: MacWilliams 2010
Putting it Together ... system responds to climate forcings at both the watershed-scale and ocean boundary

1. Emissions Scenario
2. Climate Simulations
3. Spatial Downscaling
4. Hydrologic Models
5. Operations Models
6. Bay-Delta Models

IPCC emission scenarios
IPCC AR4 simulations. Statistically downscaled.
Sea level change

CALSIM II hydrology and operations model
VIC hydrologic model
UNTRIM, RMA, DSM2 estuary models

Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003
Summary of Changes to the Delta System
(Difference at 2060 from No Action, No Climate Change reference)

No Action

Proposal Project

Shasta Carryover Storage (kaf)

Increase in No. of Events Activating Floodplain (more than 7 consec. days)
Summary of Changes to the Delta System
(Difference at 2060 from No Action, No Climate Change reference)

No Action

Proposed Project

Delta Exports (kaf/yr)

Spring Delta X2 (km)
Summary

• Long-range planning for programs such as the BDCP with cascading analyses and many alternatives require a manageable, yet informative set of climate scenarios for analysis
• Ensemble-informed climate scenarios have been developed for California for this long-range planning purpose
• Hydrologic and system responses to future climate change is substantial, but geographically/facility varied
Thank you!

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Sorting through Regional Climate Uncertainty

Relationship between Changes in Period-Mean Annual Precipitation and Temperature:
Folsom
(112 projections, evaluated at 2060 [2046-75] relative to 1971-2000)

- All projections indicate strong warming trend
- Precipitation trends are less conclusive, particularly in near-term