Mean and Extreme Climate Change Impact on State Water Project

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For California’s Fourth Climate Change Assessment

Study Goals

- Assess **mid-century** impacts on SWP & CVP of
  - Rising temperatures
  - Shifting precipitation patterns
  - Sea level rise

- Use state of the art water resources planning models

- Climate change impacts assessed for

  **Model Inputs**
  - Rim inflows
  - Sea level rise
  - Water demands
  - River indexes
  - Others

  **Model Outputs**
  - Delta exports
  - Delta outflow
  - Carryover storage
  - System reliability
  - X2
Main Features of the Approach

- 20 CMIP5 (Climate Model Intercomparison Project Phase 5) Projections selected by DWR’s CCTAG (Climate Change Technical Advisory Group)
- LOCA (Localized Constructed Analog) downscaling
- Streamflow Generation by the VIC model (Variable Infiltration Capacity)
- Variable Perturbation Ratio
- Variable Sea Level Rise
- Water Demand under Climate Change
- New DWR’s Water Planning Model: CalSim 3.0

**Emissions Scenarios:** RCP4.5 and RCP 8.5

10 Global Climate Models

*Projections of temperature and precipitation*

**Bias Correction and Downscaling:** LOCA

**Hydrologic Process Model:** VIC

*Projections of streamflow*

**Water Planning Model:** CalSim 3.0

*SWP and CVP Impacts*
Why Perturbation Ratio Method?

Concerns

- Errors in streamflow simulation from surface hydrological models even after calibration & bias correction
- Current Global Climate Models do not reproduce observed interannual variability of streamflow

Solution: Perturbation Ratio

- Avoid using simulated flow directly and is also able to partially correct errors in simulated flow
- Still keep observed interannual variability

Monthly Inflow to Lake Oroville from WY 1995

- Inflow (TAF)
- Dates from 01 Oct 1994 to 01 Sep 1995

Graph showing the comparison between simulated and observed inflows with peaks in March 1995.
Mid-Century Precipitation and Temperature Change

- Wetter in the North
- Drier in the South
- Warming statewide
- Greatest warming inland
Rim Inflow under Climate Change

- 9 out of 20 scenarios project wetting trend for mid-century
- Total Sacramento Valley rim inflow increases by 4.4% (887 TAF)
- Most of streamflow increase occurs during winter high flows
- Peak month of rim inflow shifts to February from March

Impacts assessed at mid-century (centered around 2060)
Sea Level Rise is temperature dependent

Each climate projection was assigned either 0.5, 1.0 or 1.5 ft of sea level rise based on mid-century surface air temperatures at San Francisco Bay.

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<th>CCTAG CMIP5 GCM Projection</th>
<th>Temperature Change (°C)</th>
<th>Sea Level Rise (ft)</th>
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Climate Change Water Demand

Sacramento Valley Applied Water Demand increases by 6.5% (527 TAF)

Impacts assessed at mid-century (centered around 2060)
Mean Impact on South of Delta Export

- Decrease by 10% (521 TAF) in 2060
- Range -44% to +21%
- 16 of 20 scenarios project export reductions
- 9 of 20 scenarios project wetting trend, but only 4 of 20 project export increases

Impacts assessed at mid-century (centered around 2060)
Mean Impact on North of Delta Carryover Storage

- Decrease by 24% (1527 TAF)
- Range from -62% to +7%
- Decrease by ½ during drought episodes
- Little change during flood episodes
- 18 of 20 scenarios project carryover storage reduction
- 9 of 20 scenarios project wetting trend but only 2 of 20 scenarios project carryover storage increase

Impacts assessed at mid-century (centered around 2060)
Mean Impact on Delta Outflow

Net Delta Outflow increases significantly in the winter and early spring and decreases in late spring and summer.
Driest Climate Model Projection in Mid-Century: ACCESS 1.0/ RCP8.5

(a) Precipitation Change

(b) Temperature Change
Extreme Impact on South of Delta Export

During future severe drought episodes for the driest climate projection, Delta export would reduce to half of the exports in historical severe drought episodes.
Causal Analysis on South of Delta Export Impact

- Four climate change factors
- Through a series of sensitivity experiments, impacts of these four factors on CVP/SWP could be separated (Wang et al, 2011)
- **Seasonal Patterns Shifts** of rim flow causes 42% reduction of the three export reduction terms (i.e. $269/(269+229+150)$)
- **Sea level rise** causes 35% reduction

![Diagram showing the effects of four climate change factors on Delta export reduction. The factors and their relative contributions are indicated by bars: Seasonal Pattern Shifts (-269), Sea Level Rise (-229), and Applied Water Demand Change (-150). The chart also shows Annual Inflow Change (127).](chart.png)
Conclusions: Mid-Century Climate Change Impacts

- At mid-century
  - South of Delta export ↓ 10%
  - Carryover storage ↓ 24% decrease

- Mid-century under current operating conditions, increases in winter rim inflows to the Sacramento River basin, become net Delta outflow to the Pacific ocean, not increased Delta exports or carryover storage

- For the driest projection, Delta exports decrease by 44%.

- In the future severe drought episodes, Delta exports would reduce to half of exports from historical severe droughts

- From sensitivity analysis, early snow melting and higher ratio of rain in the precipitation exerts the greatest climate change impact on SWP/CVP; sea level rise is the second.