Climate, Drought, and Change

Delta Science Program
August 25, 2014

Oroville Reservoir January 2009
Presentation Overview

• Current Drought Conditions
• Relation to 20\textsuperscript{th} Century Droughts
• Decadal Scale Variability
• Signs of Change

Folsom Reservoir January 2014
California’s topography affects our weather and climate.
Key Phenomena Affecting California Water Supply/Flooding:

Storm Track changes

MJO/Tropical Convection

Easterly Wave

Cyclogensis

Atmospheric River

Flooding & water supply

The size of the AR results from the alignment of key processes

The absence of AR activity important to drought
PSD Near Realtime Observations - Map

SurfaceMet Data
- Temperature (F)
- Integrated Water Vapor (cm)
- Snow Depth (in)
- Wind Speed & Direction (mph)
- Accumulated Precipitation (in)

Wind and Precipitation Radar Data
- Snow Level (kft msl)
- Integrated Water Vapor Flux (cm)(m/s)

Radar NEXRAD Data
- Radar Reflectivity Mosaic
- Radar 1 Hour Precip Mosaic

12/27/2013
California Snow Water Content - Percent of April 1 Average For: 08-May-2014

NORTH

CENTRAL

SOUTH

California Reservoir Storage, Percent of Normal, 1977 and 2010-14

Source: California Department of Water Resources

Credit: Brad Rippey, USDA
NOAA Climate Division 5 Calendar Year Data
1895-2013

Annual Precipitation (inches)

Annual Mean Temperature (degrees F)

1895-2000  21st Century  POR Average

1976  1947  2013
36 Month CA Statewide Precipitation Accumulation

- July 1 2011–June 30 2014 observed precipitation
- July 1 1974–June 30 1977 observed precipitation (previous driest 36-month period ending in June)
- July 1 1981–June 30 1984 observed precipitation (wettest 36-month period ending in June)

1974-1977: 46.65 in.
2011-2014: 45.19 in.

Average: 69.63 in.

Data Source: NOAA
Western Regional Climate Center
*WY2014 assumes no further precipitation this year
Other Rankings

- 8 Station Precipitation Index 8th driest water year
- 5 Station Precipitation Index 3rd driest water year
- 8 River Index 4th driest single year and 3rd driest 3-year
- California Climate Tracker warmest winter, second warmest water year to date for Sierra region
Multi-Year Sequencing

• 20th Century shows 2, 3, 4, and 6 year droughts

• Multi-decadal dry period 1910-1940 in observed record for 8 Station Index & Sacramento Basin Runoff

• Paleorecord shows multiple 10+ year droughts as well as 2 century-long dry periods (climate shifts)
DWR Paleohydrology Study

- Extend existing record for Sacramento, San Joaquin and Klamath Basins
- Conducted by University of Arizona Laboratory for Tree Ring Research (Dave Meko, Connie Woodhouse, and Ramzi Touchan)
- Data and report available at: http://water.ca.gov/waterconditions/waterconditions.cfm
Temporal Variability

San Luis Reservoir 2014, DWR Photo
Year to Year Precipitation Variability

California precipitation is uniquely variable

Higher values are higher variability
Decadal Scale Variability

- Los Angeles County
- Sonoma
- Mendocino
- 8 Station Index
- 5 Station Index
Northern Sierra 8 Station Index

Annual Average: 50 inches  
Maximum Year (1983): 88.5 inches  
Minimum Year (1924): 17.1 inches  
Period of Record 1921- Present

9 of 14 years of 21st Century below average
21\textsuperscript{st} Century Breakdown So Far – 8 Station Index

<table>
<thead>
<tr>
<th>Period of Record</th>
<th>1971-2000</th>
<th>21\textsuperscript{st} Century</th>
</tr>
</thead>
<tbody>
<tr>
<td>POR Average: 50 inches</td>
<td>1971-2000: 53 inches</td>
<td>21\textsuperscript{st} Century: 49 inches</td>
</tr>
</tbody>
</table>

Note WY2012 was 3\textsuperscript{rd} driest December (0.34”) and WY2014 was 4\textsuperscript{th} driest (0.80”)
Sacramento River Runoff Distributions (Thousand Acre-Feet)

POR Average: 17,823 taf
1971-2000: 18,827 taf
21st Century: 16,068 taf
San Joaquin 5-Station Index

Annual Average: 40 inches
Maximum Year (1983)  77.4 inches
Minimum Year (1924)  14.8 inches
Period of Record 1913 - Present

10 of 14 years of 21st Century below average
21st Century Breakdown So Far – 5 Station Index

POR Average: 40 inches
1971-2000: 42 inches
21st Century: 37 inches

Note WY2012 driest Dec (0”) and WY2014 10th driest (1.10”)

Period of Record - Blue
1971-2000 - Brown
21st Century - Green
San Joaquin River Runoff Distributions (Thousand Acre-Feet (taf))

- POR Average: 5873 taf
- 1971-2000: 6161 taf
- 21st Century: 5338 taf
Climate Change

Tenaya Lake
Climate Change Expectations

- Smaller Snowpack/More Rain Less Snow
- Earlier Snowmelt Onset
- More Variability
- More Extremes

Are we seeing these already?
California Climate Tracker - WRCC

California Statewide Precipitation Oct-Jul

YEAR
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

INCHES
0
10
20
30

Orange Line Denotes 11-year running mean

Linear Trend 1605-present  + 2.36 ± 3.09 in.  (+ 10 ± 13%) per 100 yr
Linear Trend 1949-present  - 1.55 ± 8.74 in.  (- 7 ± 39%) per 100 yr
Linear Trend 1975-present  - 5.61 ± 21.41 in.  (- 25 ± 96%) per 100 yr

Wettest Year
37.94 in. (17%) in 1983
Mean 22.12 in.

Driest Year
8.68 in. (46%) in 1924
STDEV 6.82 in.

Oct-Jul 2014 11.02 in. (49%) RANK 3 of 119

Precipitation Rankings Oct-Jul 2013-2014

Western Regional Climate Center
California Climate Tracker - WRCC

Maximum Temperature Rankings
Oct-Jul 2013-2014

Minimum Temperature Rankings
Oct-Jul 2013-2014
California Climate Tracker - WRCC
New Rain/Snow Metric for DWR

Credit: Aaron Cuthbertson, Elissa Lynn DWR
Kelly Redmond WRCC
Summarizing Thoughts

• Current drought along with 21\textsuperscript{st} century droughts have shown record setting characteristics and are warmer than 20\textsuperscript{th} century counterparts

• Atmospheric river events provide significant inputs into annual precipitation totals – fewer such events in drought years
Conclusions

• The expectation of increased variability means new extremes and extreme transitions with WY 2013 serving as an example.

• Planning for future droughts can take advantage of information in the historical record including paleo reconstructions. The trick will be to increase our understanding of causal mechanisms and watershed condition/response.
Questions?

Michael.L.Anderson@water.ca.gov