Motivation for Improving Seasonal Precipitation Forecasting

Jeanine Jones, California Department of Water Resources

1. Drought

2. Climate Change

Priority Need – Seasonal Precipitation Forecasts for Water Supply

- *Although it would be desirable to develop additional skill in forecasting the weather a month hence, what is needed for operation & management of a complex water supply project is a long-term projection, at least a year in advance, with a high degree of reliability.* (CDWR, 1978, review of 1976-77 Drought)
- *The Panel recommends that DWR identify & seek funding for research in the areas of long-range weather forecasting…Improved long-range weather forecasting would be invaluable in operating federal, State, and local water projects…*(Governor's Advisory Drought Planning Panel, 2000)
- *Top findings include: Improve seasonal prediction. Numerous stakeholders commented on the need for a seasonal prediction capability focused on cool season mountain precipitation, both in California and in the Colorado River Basin.* (NOAA, California Drought 2014 Service Assessment)
- *Skillful sub-seasonal to seasonal (S2S) precipitation forecasting would be extremely useful in informing drought preparedness and response*. CDWR, 2020, California's Most Significant Droughts)

JANUARY 2020

California's Most Significant Droughts:

Comparing Historical and Recent Conditions

State of California | California Department of Water Resources

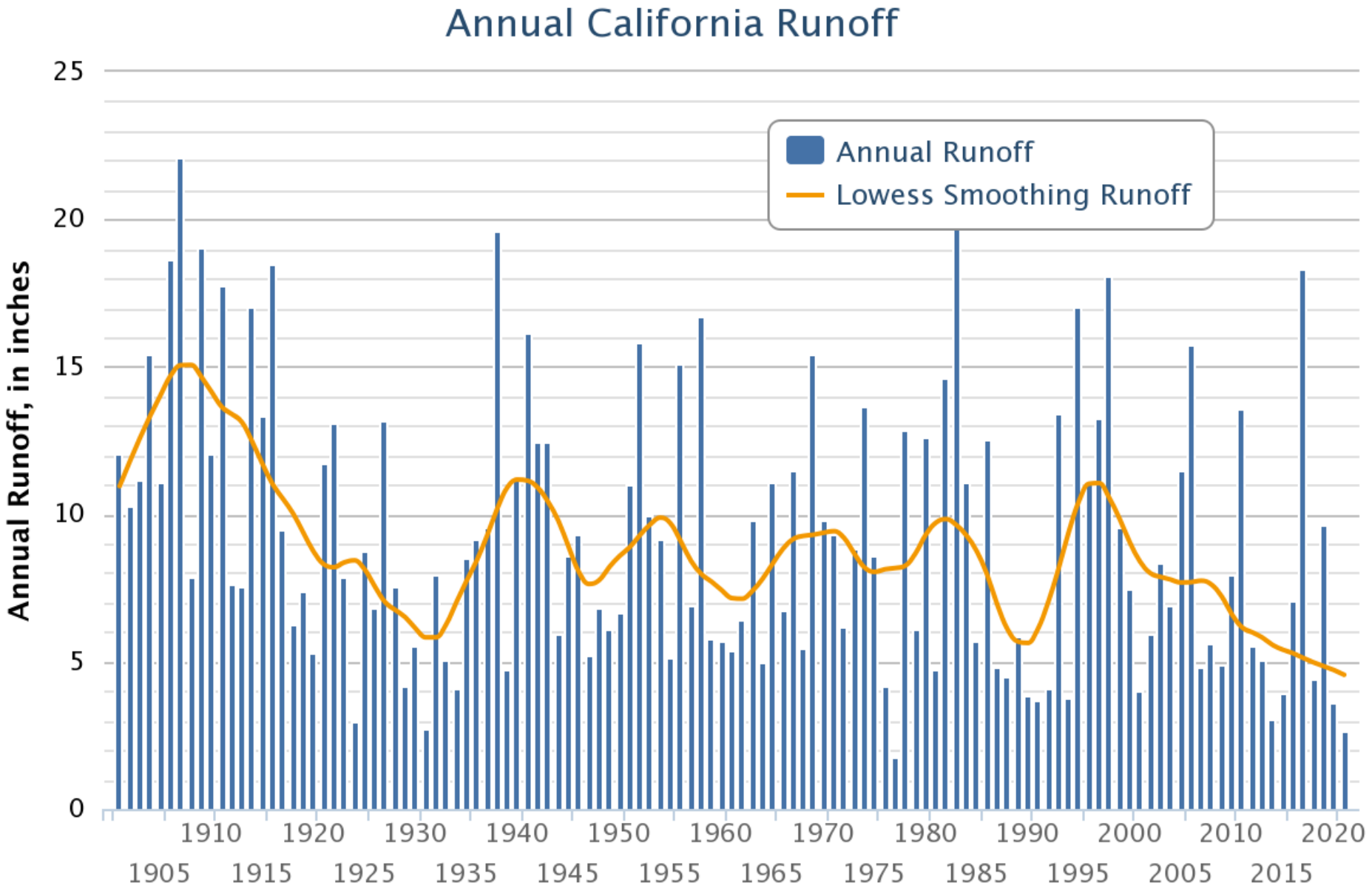
Report to the Legislature on the 2012-2016 Drought

As Required by Chapter 340 of 2016

March 2021

State of California | California Natural Resources Agency

USGS Calculated Statewide Runoff



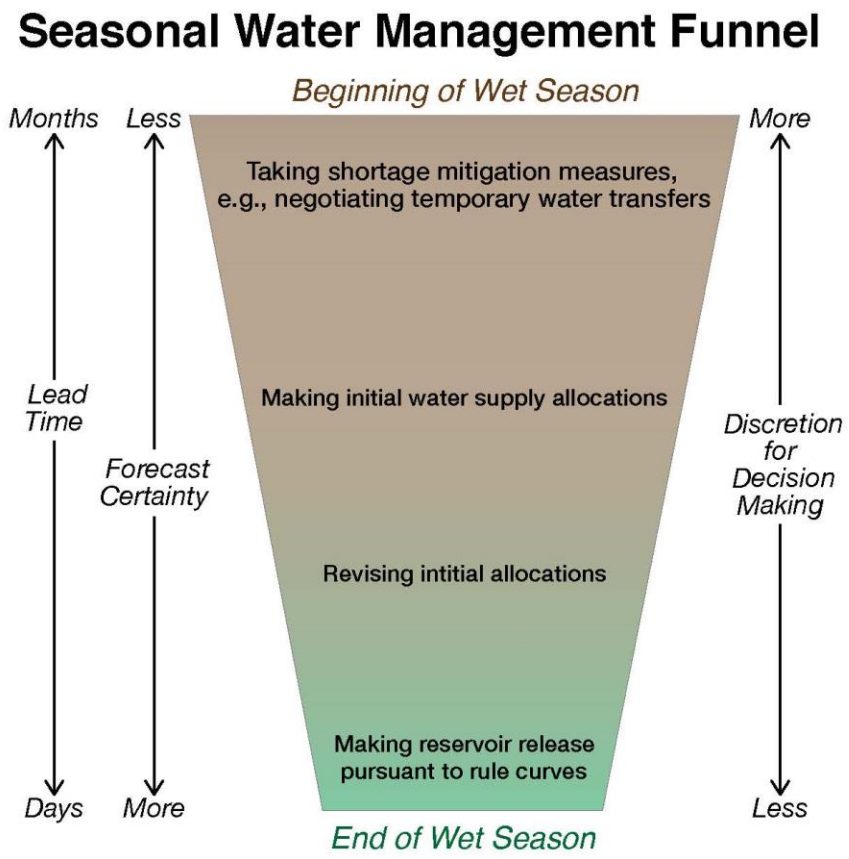
California's 20th & 21st Century Statewide Droughts (consecutive dry years)

- 1918-20
- 1922-24
- 1929-34
- 1947-50
- 1959-61
- 1976-77
- 1987-92
- 2007-09
- 2012-2016
- 2020- ??

California's Progress Since 2007-09 Drought on Key Drought Challenges

- Statewide coverage of groundwater level data in major aquifers ?
  - CASGEM legislation in 2009, SGMA legislation in 2014
- Small water systems ?
  - Multiple legislative provisions for mandatory system consolidation beginning in 2016, long-term resilience funding legislation in 2019 ($130M annually for 10 years), drought response grants in 2021 ($200M for small systems)
- Seasonal precipitation forecasting X
  - No improvement (precipitation forecasting is a federal, not a state, activity)

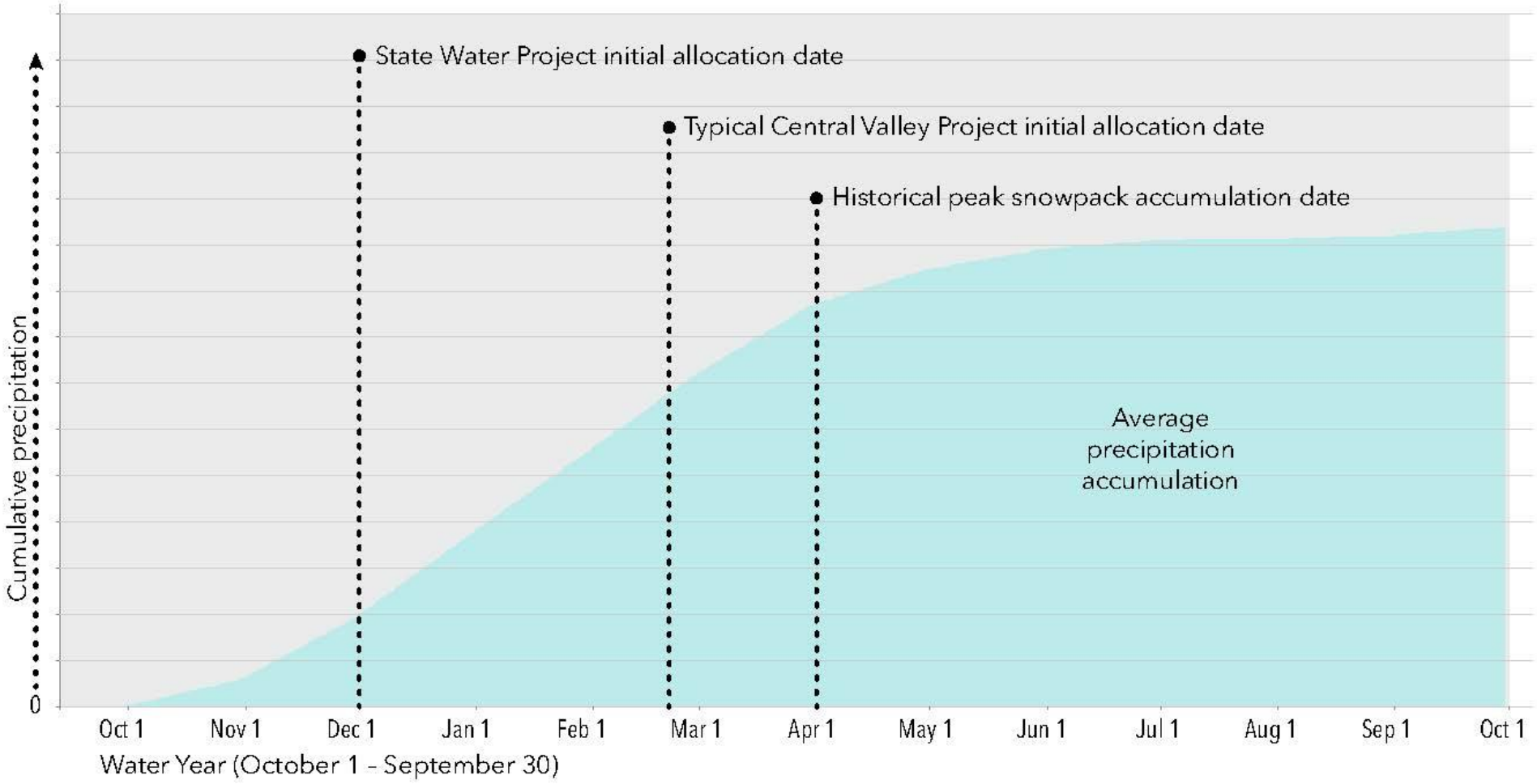
Lead Time for Drought Preparedness & Response



Drought Preparedness & Response

- It's all about lead time – the longer the better
- Precipitation (or snowpack, where applicable) provides the longest lead times
- Snowmelt runoff (streamflow) forecasts provide value for other purposes, but their lead time is too short for drought preparedness

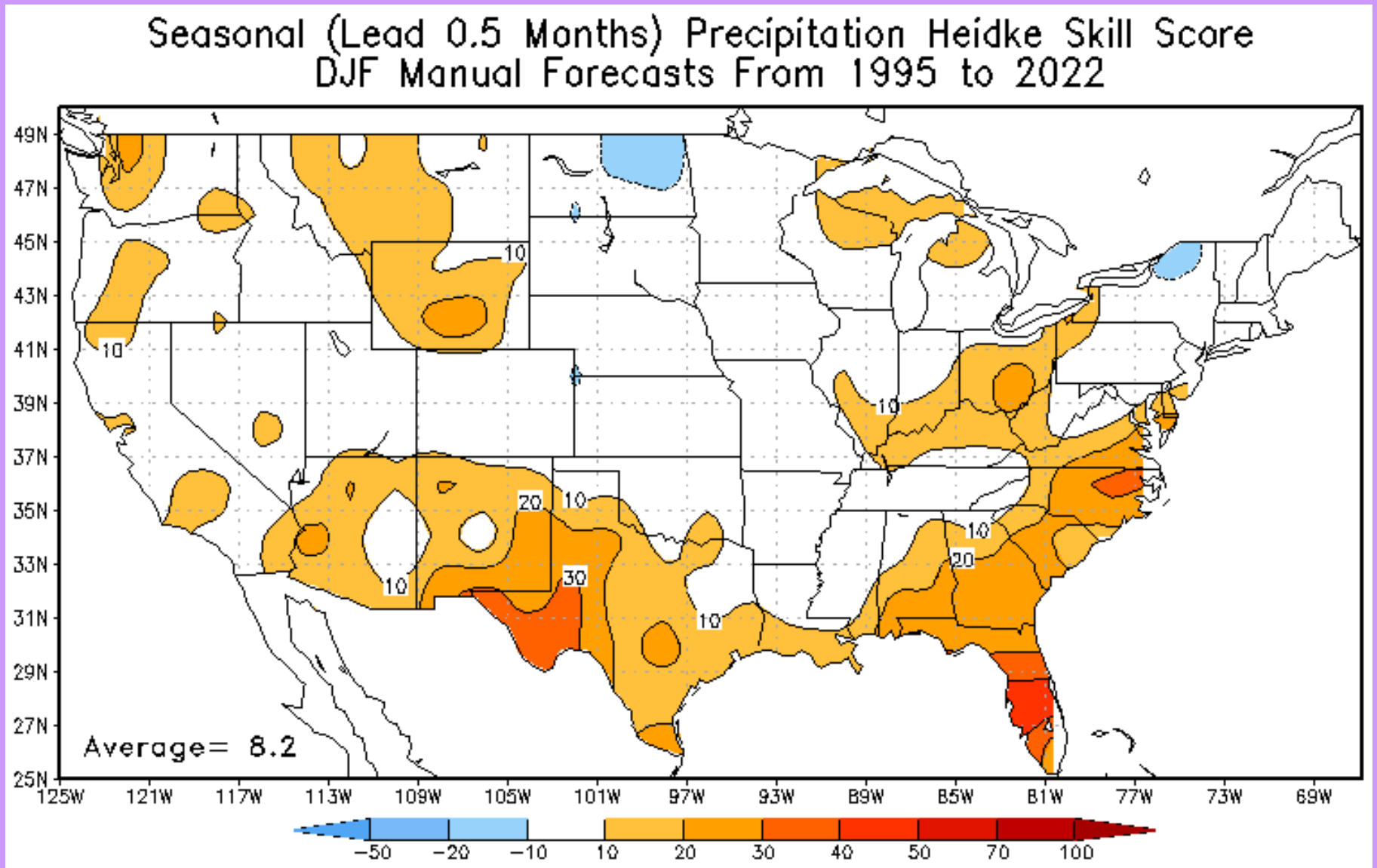
Short Lead Time for Making Decisions During California's Wet Season



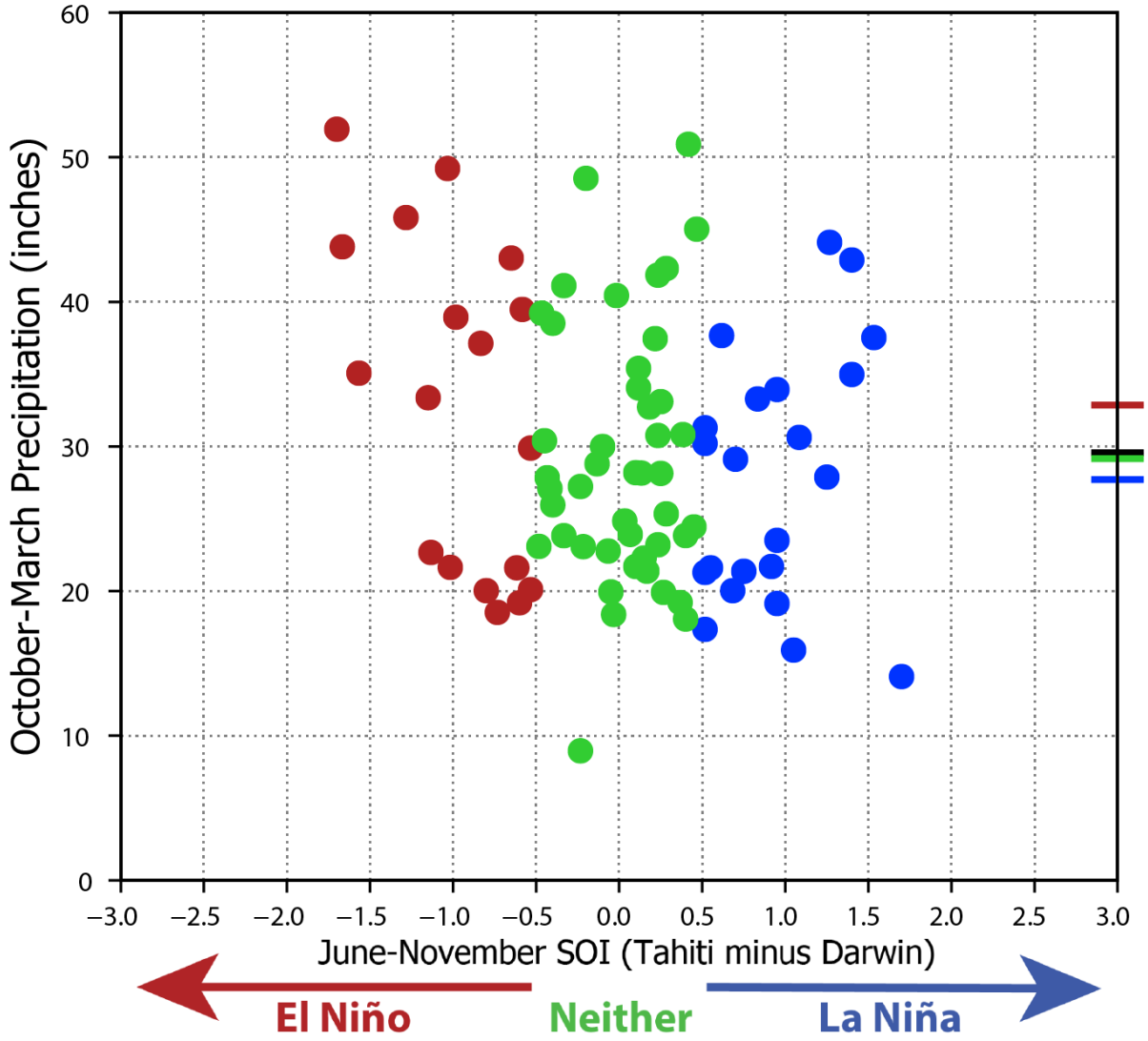
Why Lead Times?

- Manage impact risk and financial exposure risk
- Budgeting & resource allocation (e.g. water conservation projects)
- Project financing (local water agencies)
- Contract negotiation and execution
- Environmental permitting & regulatory approvals
- Construction activities
- Supporting individual water users' decision-making (e.g. agricultural producers make planting decisions in winter to begin field preparation by February)

Historical Skill of NOAA Seasonal Outlooks – No Value for Water Management

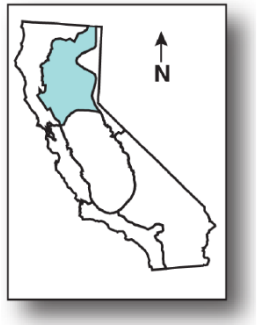


CA Division 2 October-March Precipitation
(versus Southern Oscillation Index for prior year June-November)



Years 1933/1934 - 2017/2018
r^2 = 0.04
Correlation = -0.20

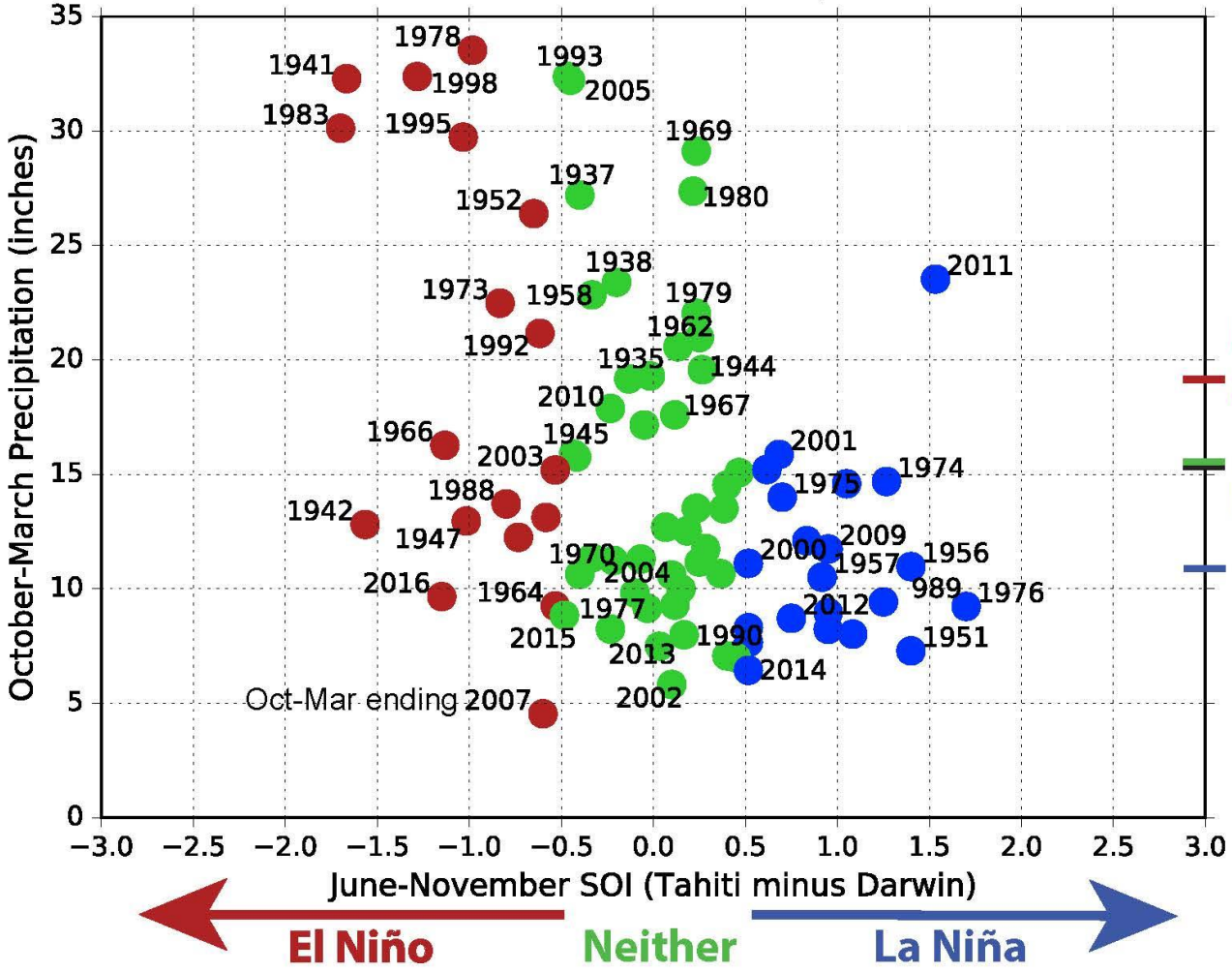
Mean = 32.86 in
Mean all = 29.57 in
Mean = 29.16 in
Mean = 27.71 in



Western Regional Climate Center

CA Division 6 October-March Precipitation

(versus Southern Oscillation Index for prior June-November)



Years 1933/1934-2015/2016

$r^2 = 0.19$

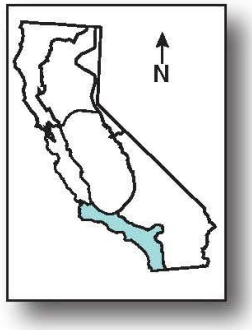
Correlation = -0.44

Mean = 19.32 in

Mean = 15.30 in

Mean all = 15.15 in

Mean = 11.27 in



Western Regional Climate Center

There is Life Beyond ENSO

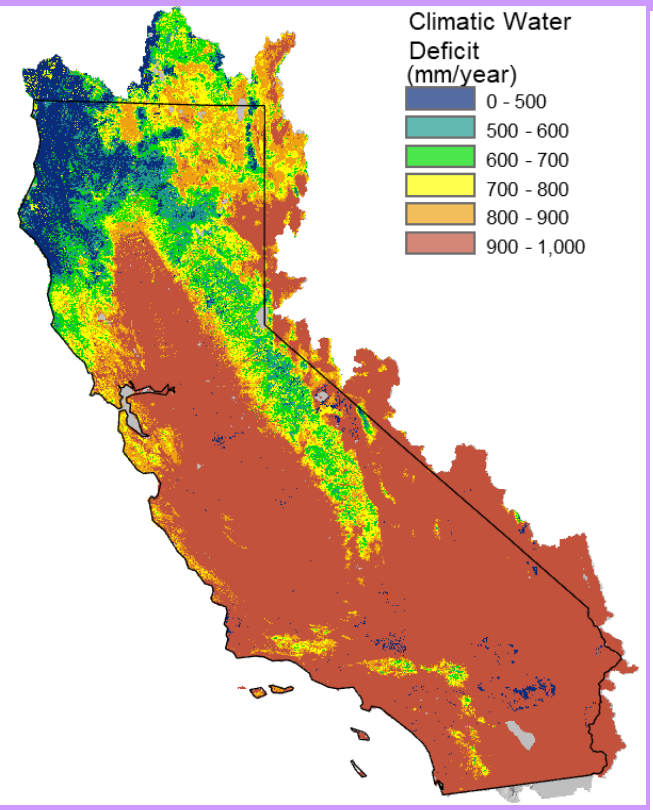
- An interesting finding of our study is that subseasonal variability represents a source of noise (i.e., limited predictability) for the seasonal time scale. This is because when prescribed in the model, subseasonal variability, mostly the MJO, weakens the El Niño–Southern Oscillation (ENSO) teleconnection with SWUS precipitation. Such knowledge may benefit S2S and seasonal prediction
- Potential Predictability of Southwest U.S. Rainfall: Role of Tropical and High-Latitude Variability
- Y. Peings, Y. Lim, and G. Magnusdottir
- https://doi.org/10.1175/JCLI-D-21-0775.1

But Things Are Heating Up

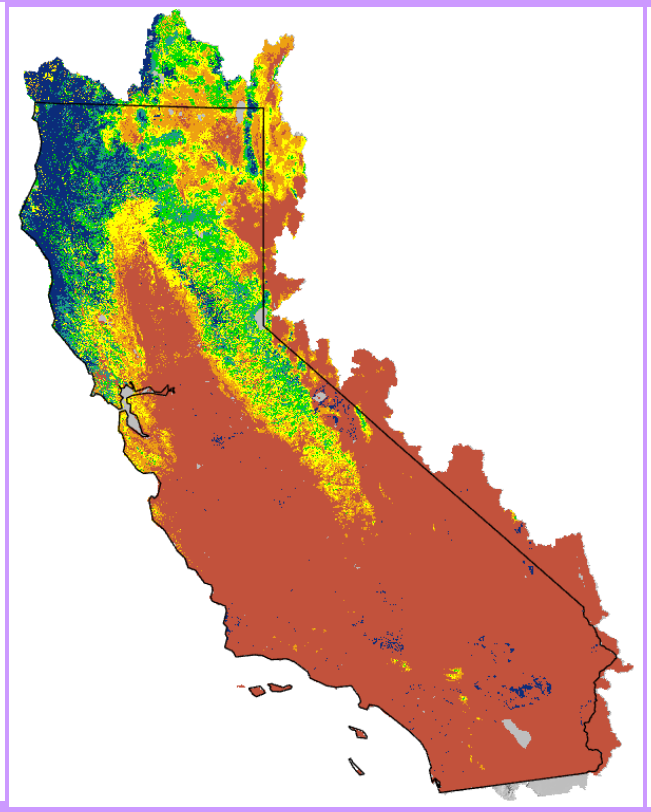
These Aren’t Our Grandparents’ Droughts

Climatic Water Deficit, USGS Basin Model

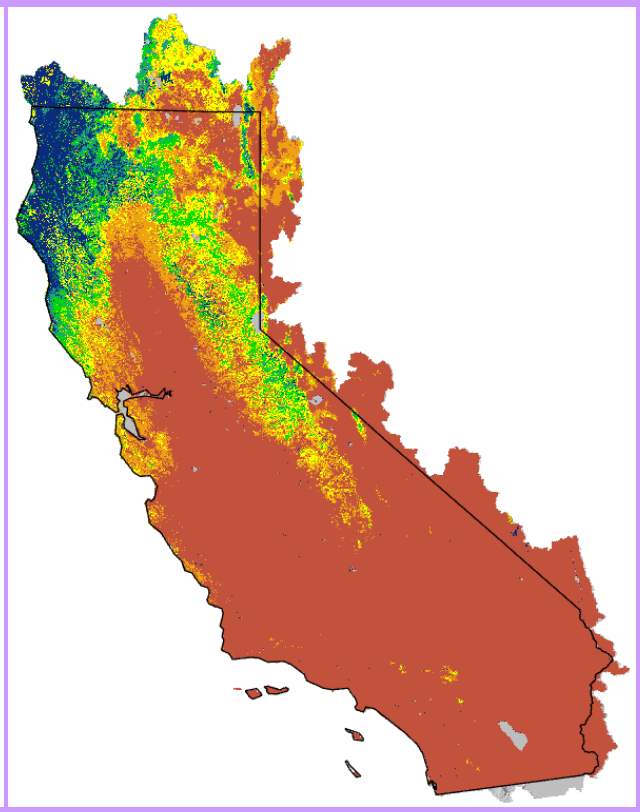
1977
a year with no water



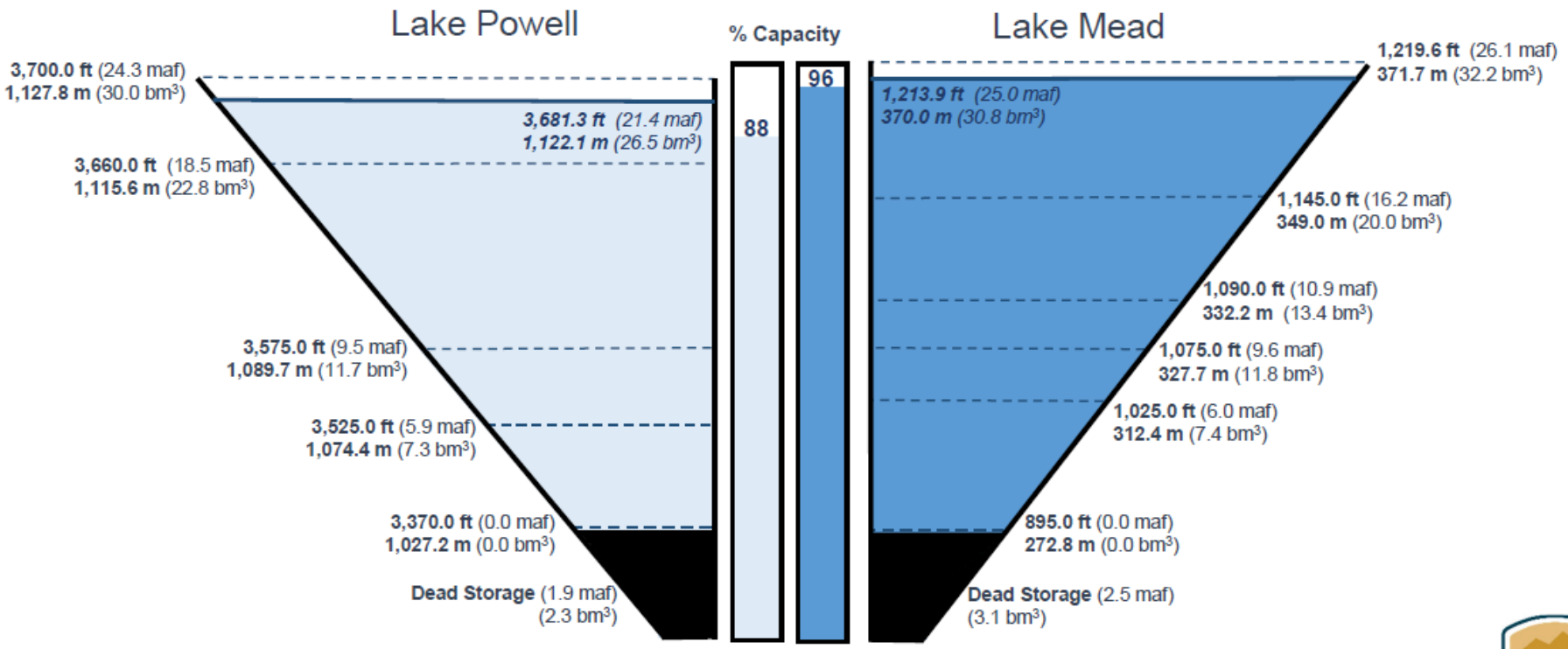
2014
a hot year with no water



2021
a hotter year with no water

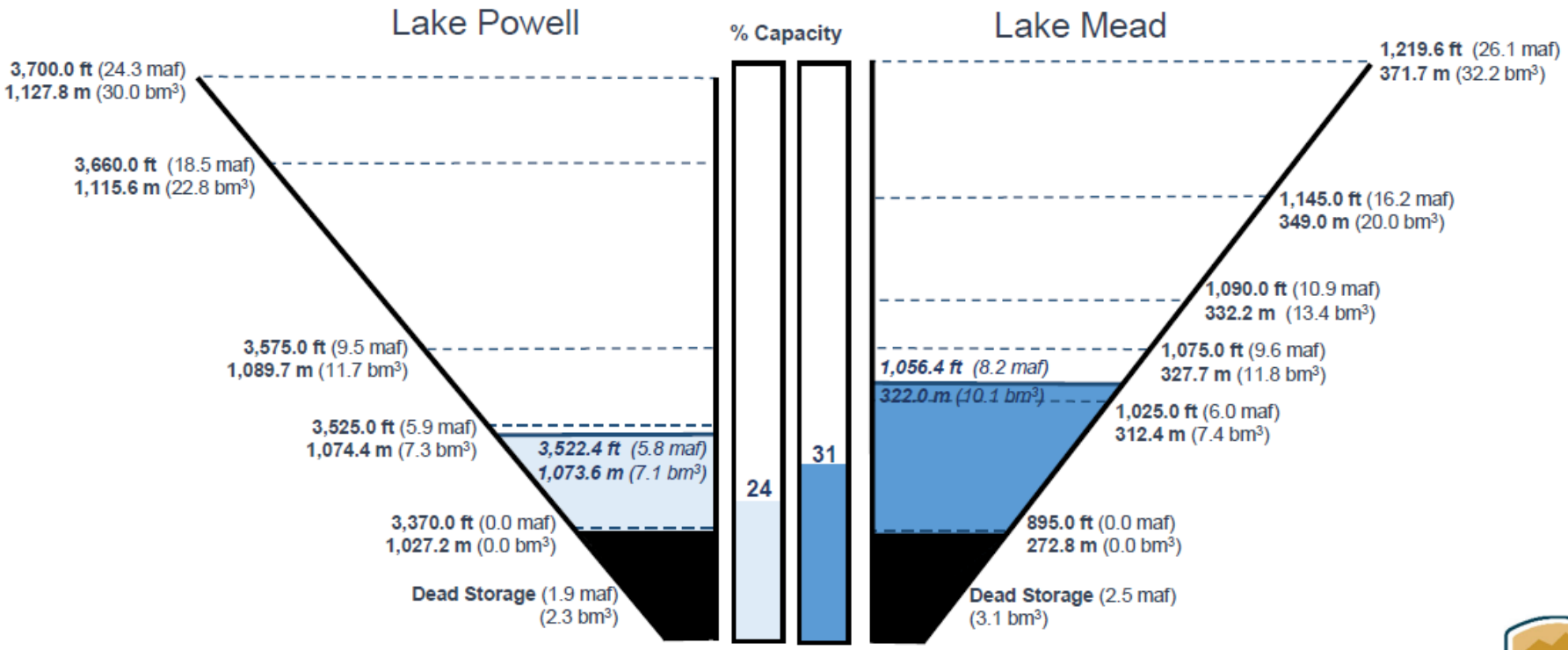


Entering Current Drought
December 1999



Notes
- *Units: feet (ft); meter (m); million acre-feet (maf); billion cubic meters (bm³)*
- *Water stored in Dead Storage cannot be released or withdrawn from the reservoir and, therefore, is not available for use.*
- *Schematic is for illustrative purposes only and is not to scale.*

Current
April 25, 2022



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California's Present Drought

- Zero allocation to most CVP ag contractors in WY 2021 and 2022, CVP M&I health & safety allocation in WY 2022, 5% SWP allocation
- Pending 2022 large-scale urban water use restrictions in Southern California due to infrastructure limitations
- First Lower Colorado River Basin shortage pursuant to the Interim Guidelines
- Record low Lake Oroville elevation in 2021, Hyatt PP unable to generate
- 70% statewide snowpack in WY 2021, yet runoff comparable to 2014-2015
- Groundwater impacts similar to San Joaquin Valley in 2012-16 now seen in parts of Sacramento Valley

Things Are Changing

Old

- Multi-year drought normal in reconstructed paleo & historical records
- Severely reduced CVP & SWP allocations
- Groundwater overdraft & land subsidence
- Impacts in San Joaquin Valley

New

- Droughts occur in warming climate, exacerbates impacts
- First Lower Colorado River Basin shortage declared, SWP & CVP health & safety allocations
- Early stages of SGMA implementation
- Impacts in Sac Valley

Catastrophic Wildfire Risk

- 1991 Oakland Hills fire (25 lives lost)
- October – November 2003 Southern California wildfires (22 lives lost)
- October 2007 Southern California wildfires (1 million people evacuated)
- 2017 Tubbs Fire, 2018 Camp Fire, 2021 Dixie Fire (urban water distribution system destruction)
- All but 2 of the state's 20 largest & 20 most damaging fires have occurred from 2000 onward

And Wildfire Damage to Water Infrastructure

Lessons Learned from Recent Droughts

- Act sooner when dry conditions emerge
- Recognize that increased temperatures are creating new or intensified impacts (e.g. wildfire)
- Transition from thinking of drought as an occasional emergency to thinking in terms of creating resiliency in a more arid climate
- Improve seasonal precipitation forecasting!

CDWR Approach to S2S Forecasting

- Begun in response to California's 2007-09 drought
- Worked through Western States Water Council to support inclusion of S2S title in the Weather Research & Forecasting Innovation Act of 2017
- As state funding available, CDWR funded applied research: NASA, NOAA, academia (examples covered in workshop agenda)

TITLE II of PL 115-25: SUBSEASONAL AND SEASONAL FORECASTING INNOVATION

- (c) FUNCTIONS.—The Under Secretary, acting through the Director of the National Weather Service and the heads of such other programs of the National Oceanic and Atmospheric Administration as the Under Secretary considers appropriate, shall— ‘‘(1) collect and utilize information in order to make usable, reliable, and timely foundational forecasts of subseasonal and seasonal temperature and precipitation; ‘‘(2) leverage existing research and models from the weather enterprise to improve the forecasts under paragraph (1)

NOAA 2020 Report to Congress

Regional Pilot Projects to Accelerate S2S Predictive Skill Improvement

- **Winter S2S Precipitation Forecasts for Water Management in the Western U.S.**
- The dominant fraction of the annual mean precipitation along the west coast of the United States and in the mountain regions west of the Mississippi River occurs from October through April. In many regions, this precipitation falls as snow, and the mountains act as a natural reservoir. Key science challenges to improving these forecasts include: inadequate model resolution (horizontal and vertical) to resolve the mountainous terrain, which influences the intensity of precipitation and the relative fraction of precipitation that falls as rain versus snow; improved fidelity in modeling of the atmospheric boundary layer in mountainous regions; and an inability to predict periods of blocked versus unblocked flow over the eastern North Pacific Ocean and western U.S.

Seeking Appropriations for the Pilot Project

- Proposed Committee Report Language
- Of the $XX million for the U.S. Weather Research Program, the Committee directs that $15 million go toward implementation of the pilot project for winter S2S precipitation forecasts for water management in the western U.S recommended in NOAA's report to Congress pursuant to Section 201 of the Weather Research and Forecasting Innovation Act of 2017 (P.L. 115-25). The pilot project should be carried out in coordination with the NWS Climate Prediction Center, Earth System Prediction and Innovation Center, and Environmental Modeling Center. The pilot should be modeled after NOAA's Hurricane Forecasting Improvement project, with a focus on measurable objectives for operational forecast improvement and should include forecasts of seasonal mountain snowpack accumulation as well as total seasonal precipitation.

It's Not About Planning for a 6-Year Drought Anymore

- 21st century hydroclimate is rapidly evolving from 20th century norms
- Institutional changes needed (e.g. land use planning)
- Fewer band-aids, more adaptation needed
- Adaptation takes time
  - Near-term, FIRO, groundwater recharge, & improving forecasting
  - Longer-term, modify infrastructure for diminished snowpack

Closing Thoughts

- Aridification driven by warming temperatures is already occurring
- This is happening much more quickly than are improvements in seasonal precipitation forecasting
- It’s past time to begin improving the forecasts

Improving Sub-Seasonal to Seasonal Precipitation Forecasting for Water Management

WESTERN STATES WATER COUNCIL