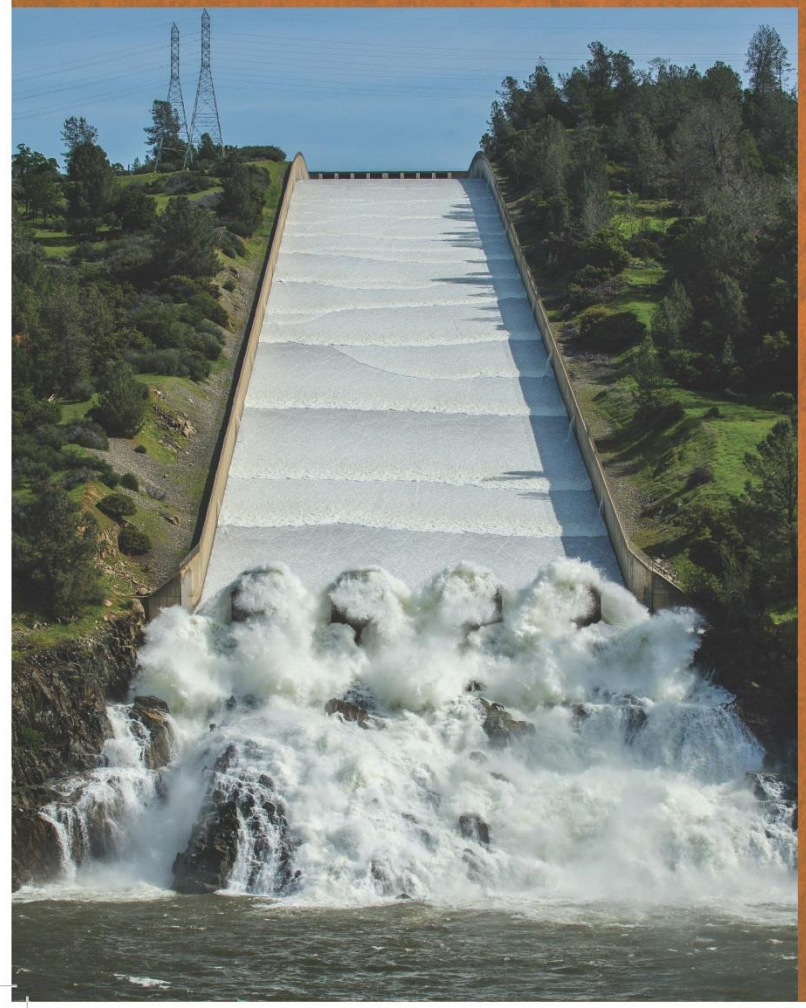
Improving Sub-Seasonal to Seasonal Precipitation Forecasting for Water Management

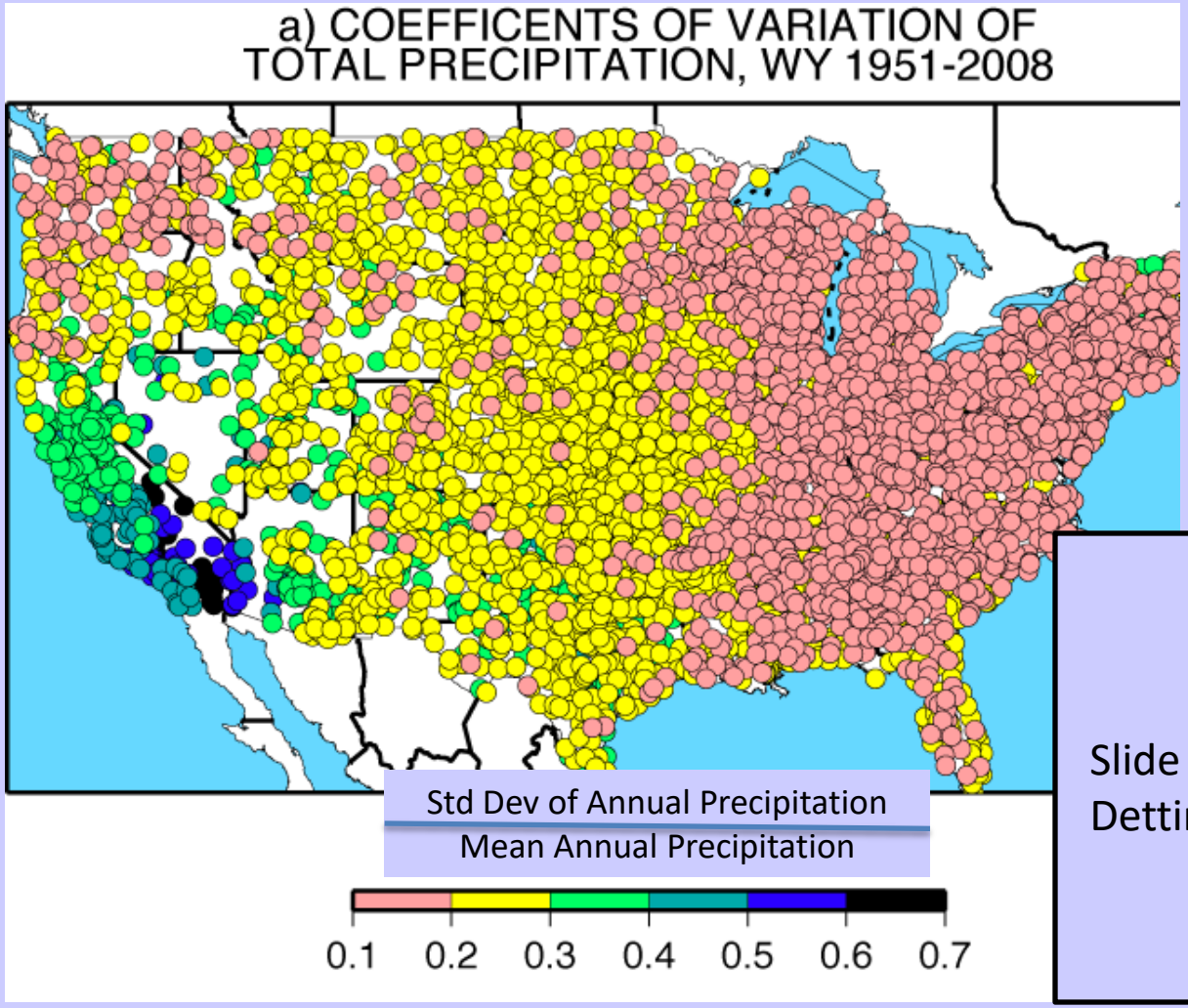


WESTERN STATES WATER COUNCIL

Sub-Seasonal to Seasonal (S2S) Precipitation Forecasting

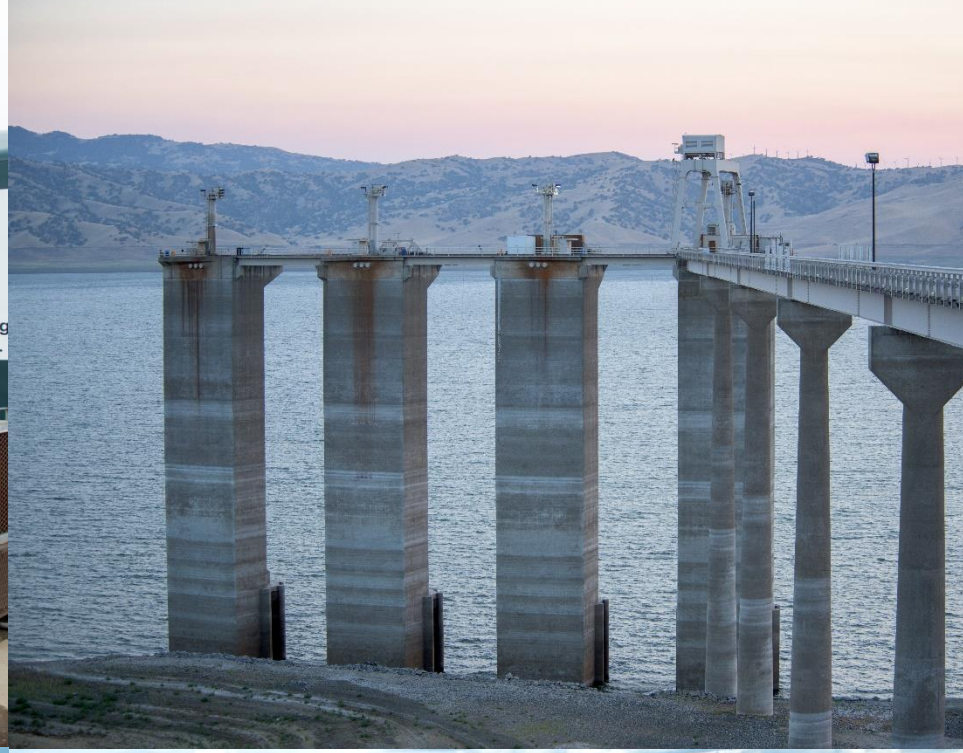
- Operational weather models – typically 2 weeks out (higher skill in first week)
- Sub-seasonal – 2 weeks to about 60 days
- Seasonal – up to 12 months

Variability of Western Precipitation

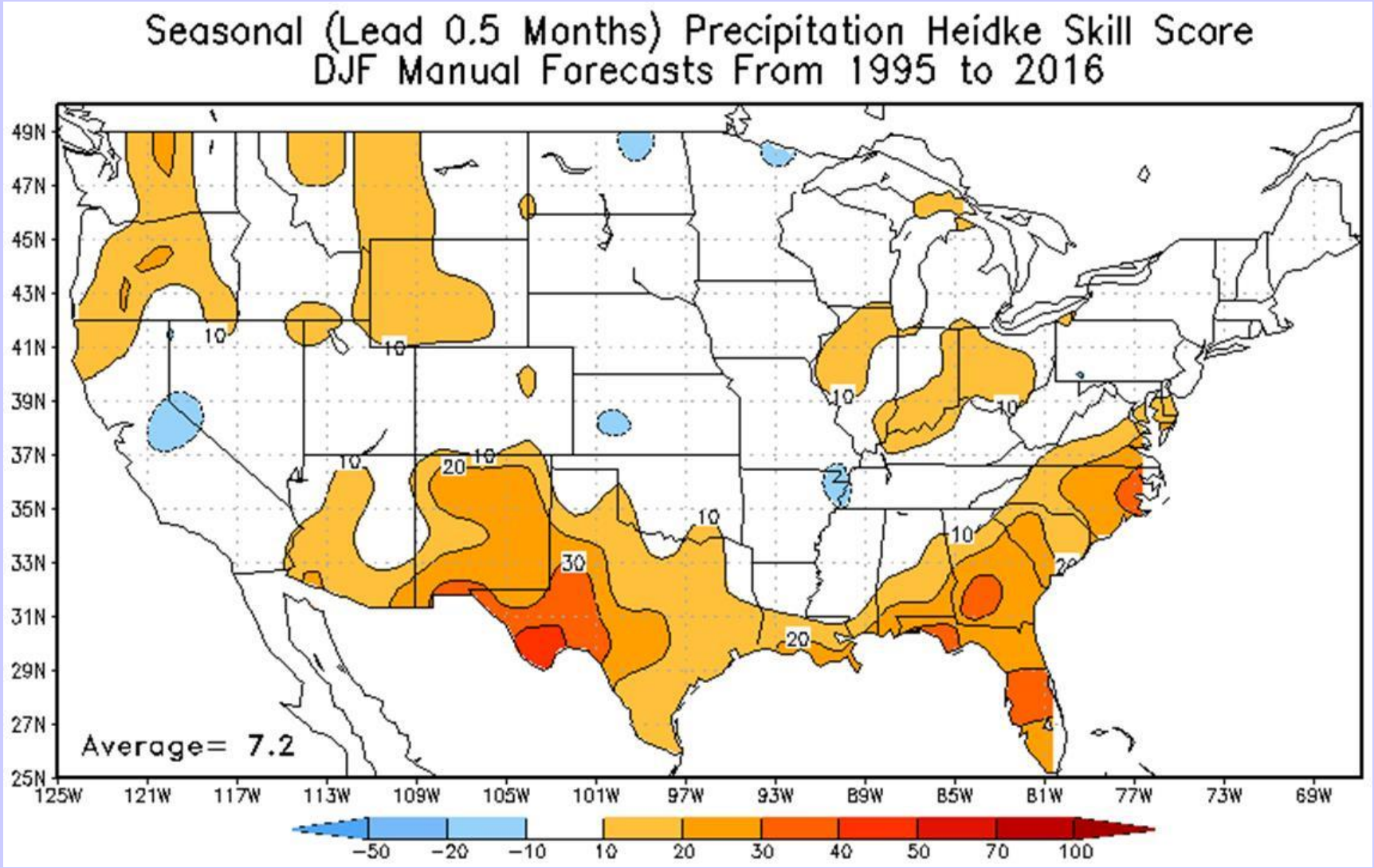


Slide courtesy of Mike Dettinger, USGS


Do not use this water for drinking
No utilice esta agua para beber.
FORD



The Problem – S2S Precip Forecasting Skill Inadequate for Water Management



NWS CPC figure

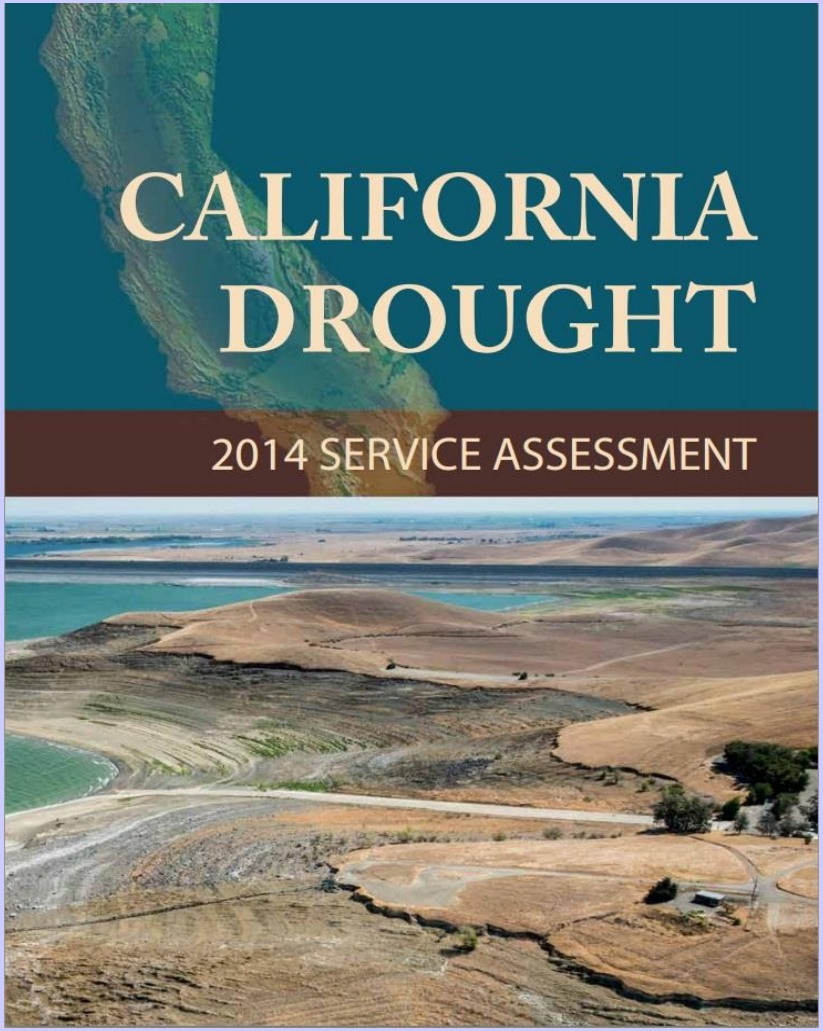
Excerpts from: *The 1976-1977 California Drought, A Review*. DWR, May 1978

There has been one serious problem in these forecasting techniques, and that is the lack of a proven system of long-range weather forecasting. The precipitation levels are never known until relatively late in each season, after the fact.

The procedure used by the NWS in these predictions is beyond the scope of this report, but is based upon predictions of airflow patterns in the atmosphere. The 30-day outlooks have been issued since 1947 but experience shows that success has been modest, with temperature forecasts enjoying more success than precipitation forecasts. Figure 28 is a com-

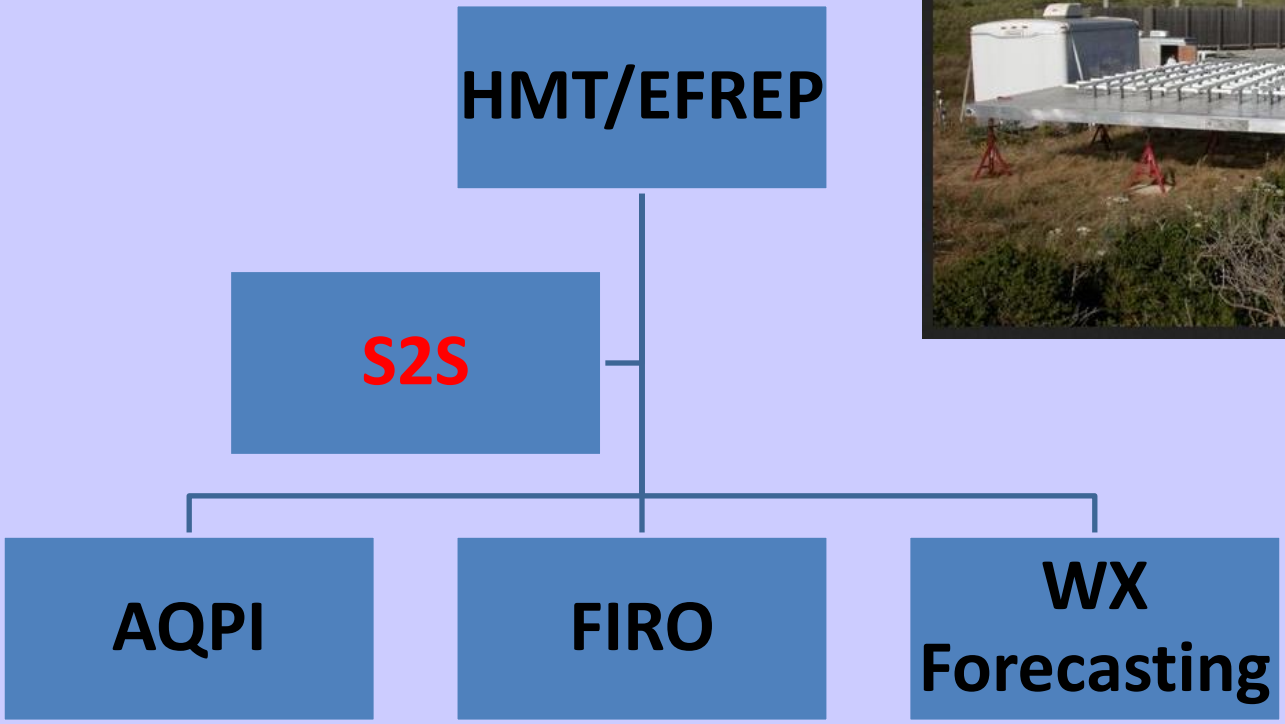
Although it would be desirable to develop additional skill in forecasting the weather a month hence, what is needed for operation and management of a complex water supply project is a long-term projection, at least a year in advance, with a high degree of reliability.

NOAA's California Drought Service Assessment



- **Goals:**
  - Understand drought impacted decisions
  - Assess NOAA's effectiveness in supporting those decisions
- **Methodology:**
  - 3 focus sectors (water resources, agriculture, fisheries)
  - 100+ interviews
  - 40+ reviewers
  - 400+ comments
- **Major Recommendations**:
  - Improve seasonal prediction for water resources
  - Develop full natural flow modeling and forecasting
  - Improve NOAA internal coordination

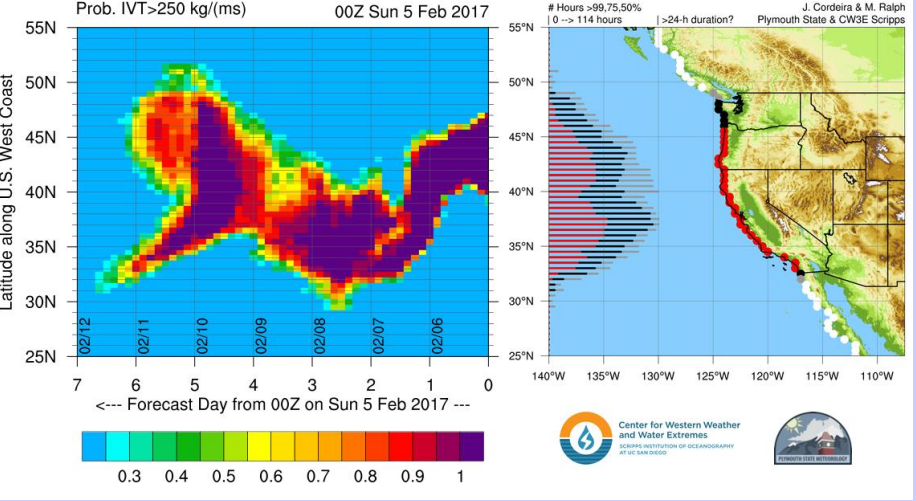
In the Beginning There Was HMT/EFREP…



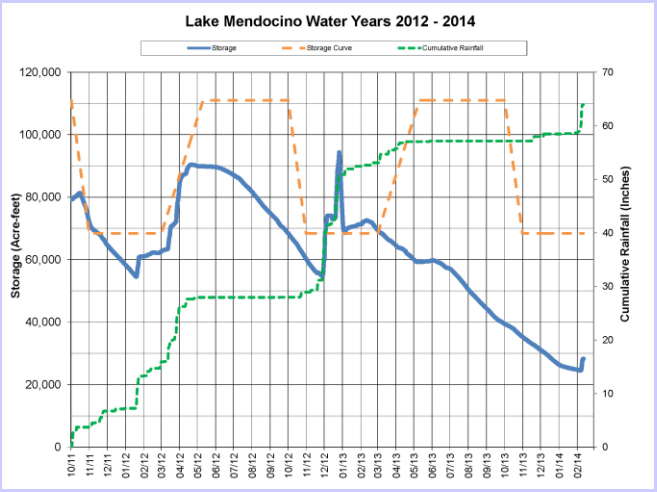
NOAA Hydrometeorology Testbed/DWR Enhanced Flood Response & Emergency Preparedness programs, a state-federal research observations partnership

State of California Investments in Observing & Understanding Atmospheric River Storms

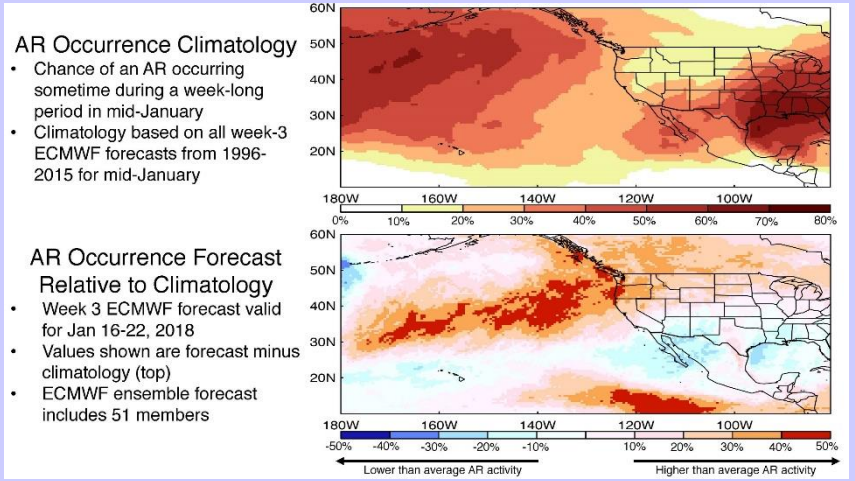
- NOAA HMT/DWR EFREP (state share) -- $15M
- DWR AQPI grant to Bay Area water agencies -- $19M
- Calwater I & II field observing campaigns -- $5M
- Other research with University of California system & NASA -- $3.5M



Weather Forecasts



Forecast-Informed Reservoir Operations (FIRO)

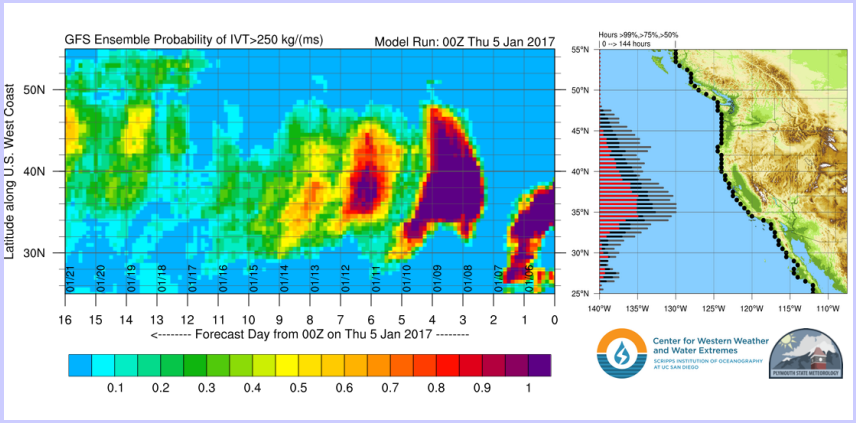


Experimental Sub-seasonal forecasts

Advanced Quantitative Precipitation Information (AQPI)

Example CDWR-Funded S2S Activities

Short-term (weather timescale) atmospheric river forecasting



CDWR contract with Scripps Institution of Oceanography

Sub-seasonal experimental atmospheric river outlooks

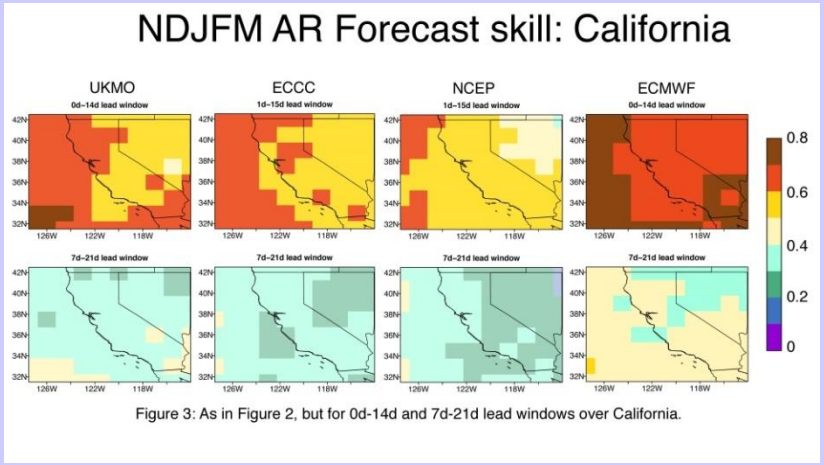
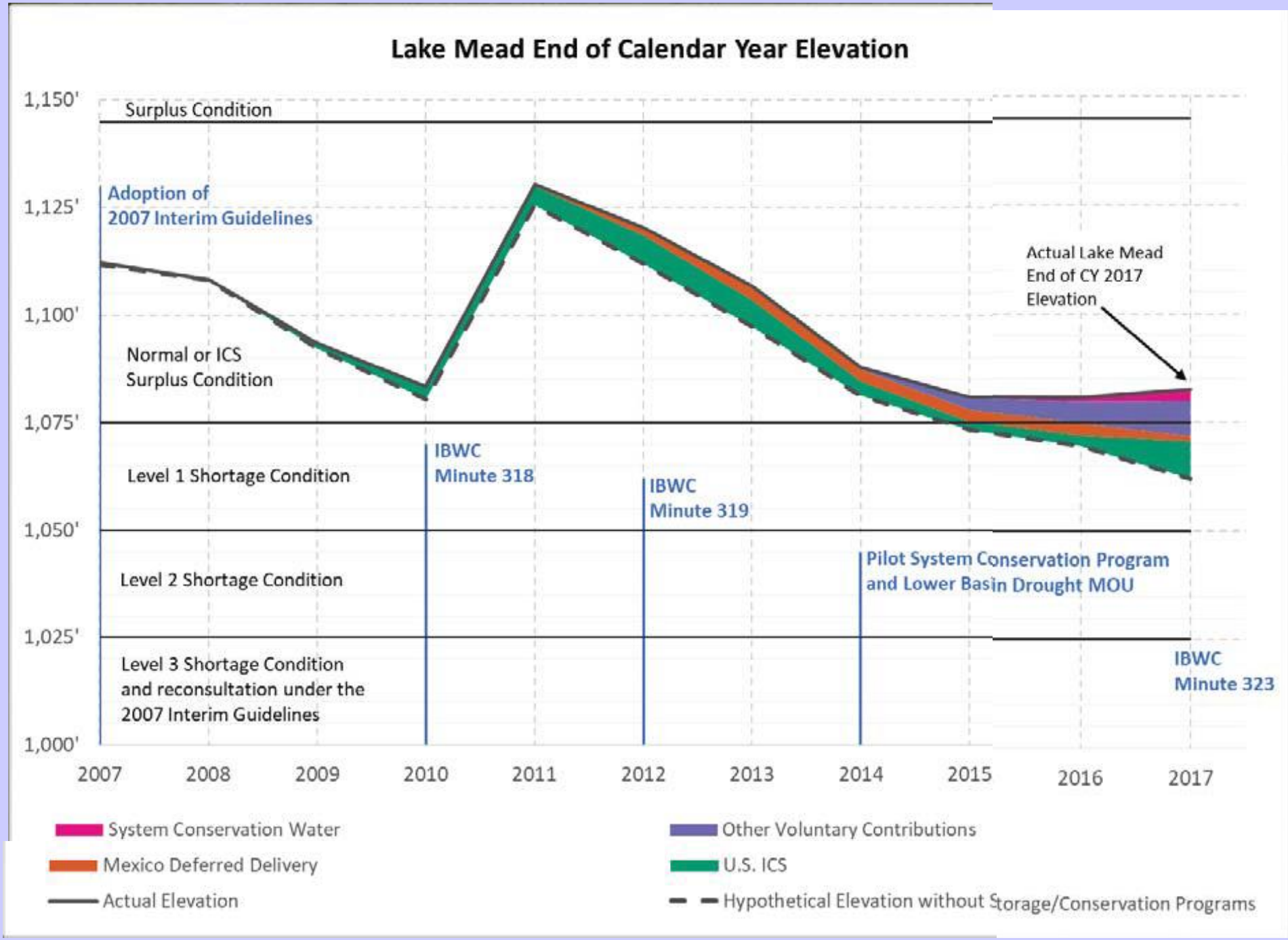


Figure 3: As in Figure 2, but for 0d-14d and 7d-21d lead windows over California.

CDWR contract with NASA JPL


Lake Mead End of Calendar Year Elevation
1,150'
1,125'
1,100'
1,075'
1,050'
1,025'
1,000'
Surplus Condition
Adoption of
2007 Interim Guidelines
Normal or ICS
Surplus Condition
Level 1 Shortage Condition
Level 2 Shortage Condition
Level 3 Shortage Condition
and reconsultation under the
2007 Interim Guidelines
IBWC
Minute 318
IBWC
Minute 319
Pilot System Conservation Program
and Lower Basin Drought MOU
IBWC
Minute 323
Actual Lake Mead
End of CY 2017
Elevation
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
System Conservation Water
Mexico Deferred Delivery
Actual Elevation
Other Voluntary Contributions
U.S. ICS
Hypothetical Elevation without Storage/Conservation Programs

Percent of Traces with Event or System Condition
Results from April 2018 MTOM/CRSS[1,2,3,4,5] (values in percent)

	Event or System Condition	2019	2020	2024	2022	2023
Upper Basin – Lake Powell	**Equalization Tier**	**2**	**15**	**17**	**20**	**24**
	Equalization – annual release > 8.23 maf	*2*	*15*	*17*	*20*	*22*
	Equalization – annual release = 8.23 maf	*0*	*0*	*0*	*0*	*2*
	Upper Elevation Balancing Tier	**96**	**51**	**53**	**52**	**45**
	Upper Elevation Balancing – annual release > 8.23 maf	*76*	*44*	*44*	*43*	*35*
	Upper Elevation Balancing – annual release = 8.23 maf	*19*	*6*	*8*	*9*	*9*
	Upper Elevation Balancing – annual release < 8.23 maf	*0*	*1*	*1*	*0*	*1*
	Mid-Elevation Release Tier	**3**	**34**	**21**	**16**	**18**
	Mid-Elevation Release – annual release = 8.23 maf	*0*	*0*	*0*	*1*	*2*
	Mid-Elevation Release – annual release = 7.48 maf	*3*	*34*	*21*	*15*	*16*
	Lower Elevation Balancing Tier	**0**	**<1**	**8**	**11**	**13**
Lower Basin – Lake Mead	**Shortage Condition – any amount (Mead ≤ 1,075 ft)**	**N**	**52**	**64**	**68**	**65**
	Shortage – 1st level (Mead ≤ 1,075 and ≥ 1,050)	*0*	*51*	*43*	*38*	*29*
	Shortage – 2nd level (Mead < 1,050 and ≥ 1,025)	*0*	*1*	*21*	*23*	*24*
	Shortage – 3rd level (Mead < 1,025)	*0*	*0*	*<1*	*6*	*12*
	Surplus Condition – any amount (Mead ≥ 1,145 ft)	**0**	**0**	**3**	**6**	**10**
	Surplus – Flood Control	*0*	*0*	*0*	*1*	*2*
	Normal or ICS Surplus Condition	**100**	**48**	**33**	**26**	**25**

[1] Reservoir initial conditions based on results from 35 simulations of December 31, 2018 conditions using the Mid-term Probabilistic Operations Model. MTOM uses the April 3, 2018 unregulated inflow forecast from the CBRFC.
[2] Each of the 35 initial conditions were coupled with 110 hydrologic inflow sequences based on resampling of the observed natural flow record from 1906-2015 for a total of 3,850 traces analyzed.
[3] Percentages shown may not sum to 100% due to rounding to the nearest percent.
[4] Percentages shown may not be representative of the full range of future possibilities that could occur with different modeling assumptions.
[5] The chance of a Lower Basin Shortage in calendar year 2019 is negligible.

RECLAMATION
Managing Water in the West

NEXT GENERATION EARTH SYSTEM PREDICTION

STRATEGIES FOR SUBSEASONAL TO SEASONAL FORECASTS

Committee on Developing a U.S. Research Agenda to Advance Subseasonal to Seasonal Forecasting

Board on Atmospheric Sciences and Climate
Ocean Studies Board

Division on Earth and Life Studies

This prepublication version of Next Generation Earth System Prediction: Strategies for Subseasonal to Seasonal Forecasts *has been provided to the public to facilitate timely access to the report. Although the substance of the report is final, editorial changes may be made throughout the text and citations will be checked prior to publication. The final report will be available through the National Academies Press in spring 2016.*

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

THE NATIONAL ACADEMIES PRESS
Washington, DC
www.nap.edu

H. R. 353

One Hundred Fifteenth Congress of the United States of America

AT THE FIRST SESSION

Begun and held at the City of Washington on Tuesday, the third day of January, two thousand and seventeen

An Act

To improve the National Oceanic and Atmospheric Administration's weather research through a focused program of investment on affordable and attainable advances in observational, computing, and modeling capabilities to support substantial improvement in weather forecasting and prediction of high impact weather events, to expand commercial opportunities for the provision of weather data, and for other purposes.

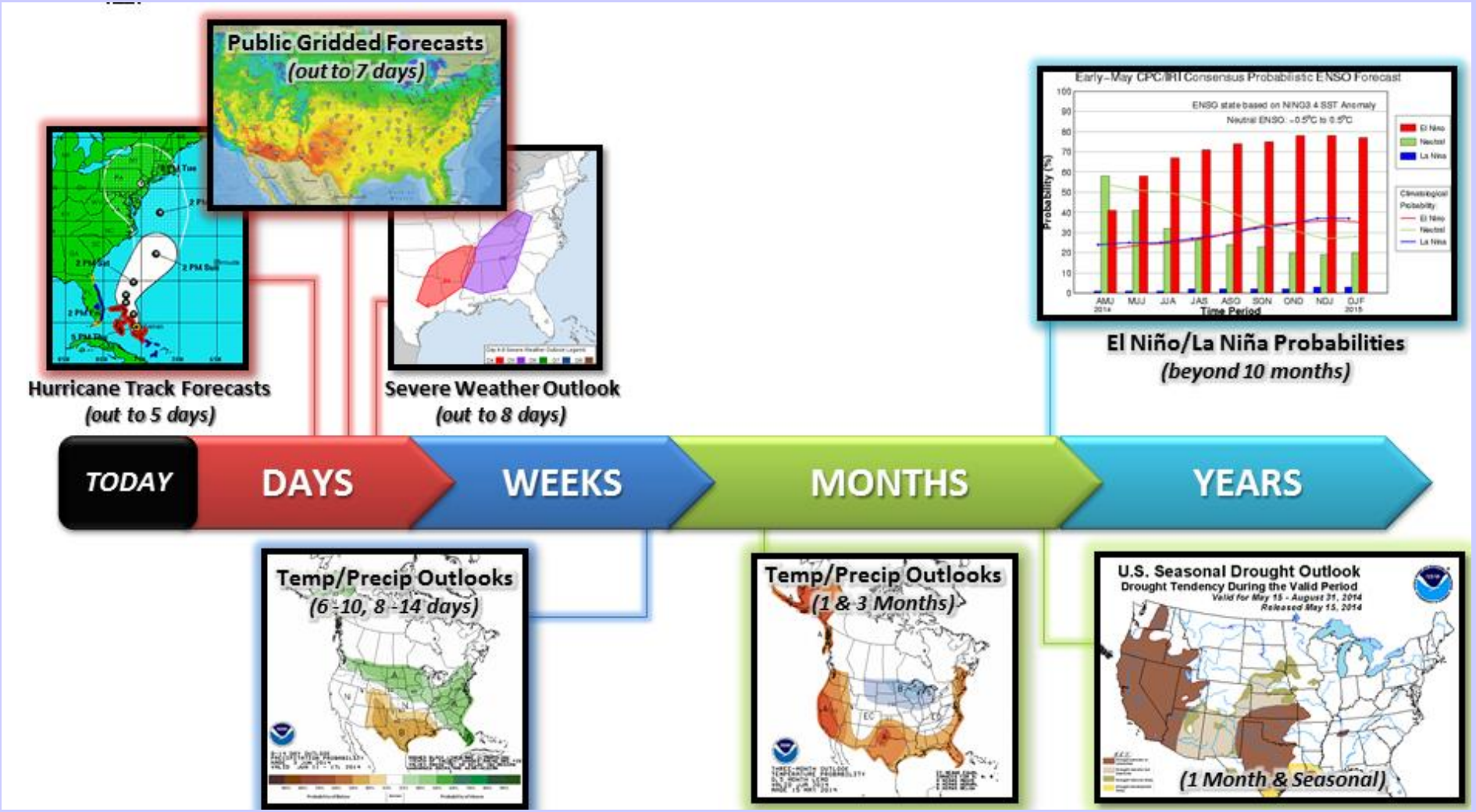
Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE; TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "Weather Research and Forecasting Innovation Act of 2017".

(b) TABLE OF CONTENTS.—The table of contents for this Act is as follows:

NOAA NWS Operational Products



Next Steps

- Increase visibility/awareness of need for improved forecast skill
- Emphasize priority for sustained S2S effort in NOAA budget, for National Weather Service and Office of Atmospheric Research
- Implement Weather Research & Forecasting Innovation Act of 2017
- Support forecast improvement pilot projects

Subseasonal-to-Seasonal (S2S) Precipitation Coalition

The Subseasonal-to-Seasonal (S2S) Precipitation Coalition is a broad-based, multi-state coalition of entities committed to advancing federal support for enhanced precipitation prediction in the Western United States.

After enduring several years of drought, Western states have experienced historic precipitation in recent months. In both extremes, improved forecasting will allow communities throughout the West to better prepare for wet and dry seasons alike.

Effective water management in the West is enhanced by sound, scientifically-based decisions made weeks to months ahead of time. While some of these key decisions hinge on expectations or predictions of precipitation, snow pack and general watershed conditions, precipitation forecasting beyond 5-7 days is highly uncertain.

Subseasonal-to-Seasonal "S2S" timescales span from lead times of two weeks to several months for precipitation forecasting.

The science community has identified a strategy for pursuing improvements to national precipitation forecasts from two weeks to several months in advance. The S2S Precipitation Coalition is informing policymakers of the importance of these water decisions and the need for forecast research and related science.

FOUNDING MEMBERS

Association of Metropolitan Water Agencies	www.amwa.net
Association of California Water Agencies	www.acwa.com
California Department of Water Resources	http://www.water.ca.gov
Colorado River District	www.coloradoriverdistrict.org
Orange County Water District	www.ocwd.com
Salt River Project	www.srpnet.com
Sonoma County Water Agency	www.scwa.ca.gov
Scripps Institution of Oceanography, UC San Diego	cw3e-web.ucsd.edu
Western States Water Council	www.westernstateswater.org

For additional information, please contact Jordan Smith at 202-298-1914 or jas@vnf.com.

September 2017