# Prediction of California's Most Significant Droughts

**Jeanine Jones, Department of Water Resources**

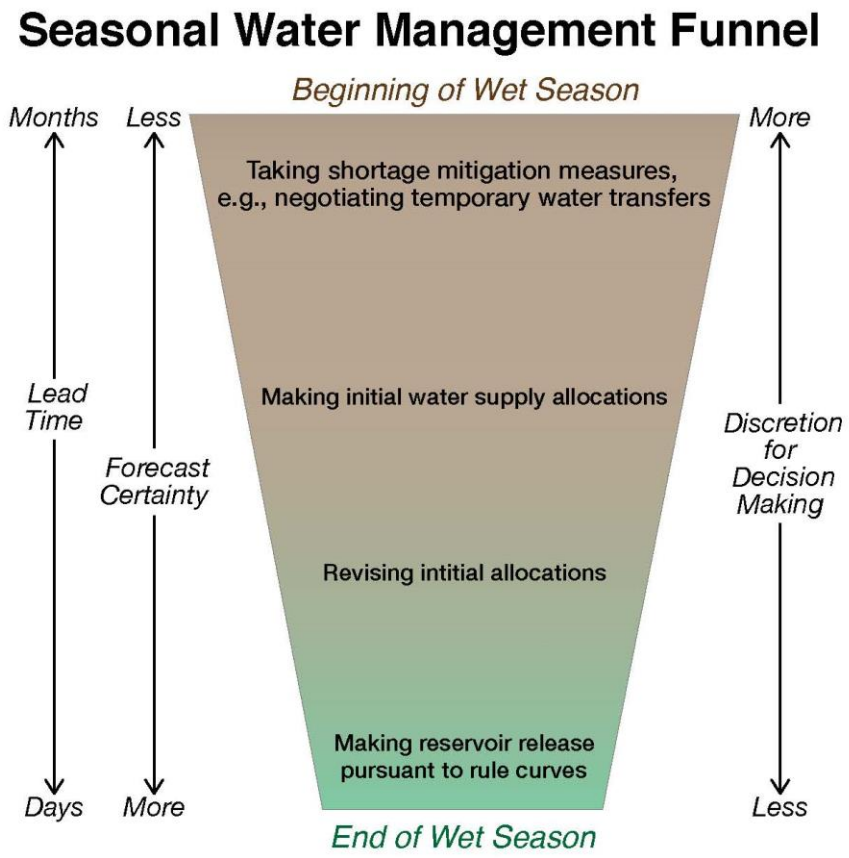
# Key Need – Skillful S2S Precipitation Forecasts to Support Water Management

- *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)

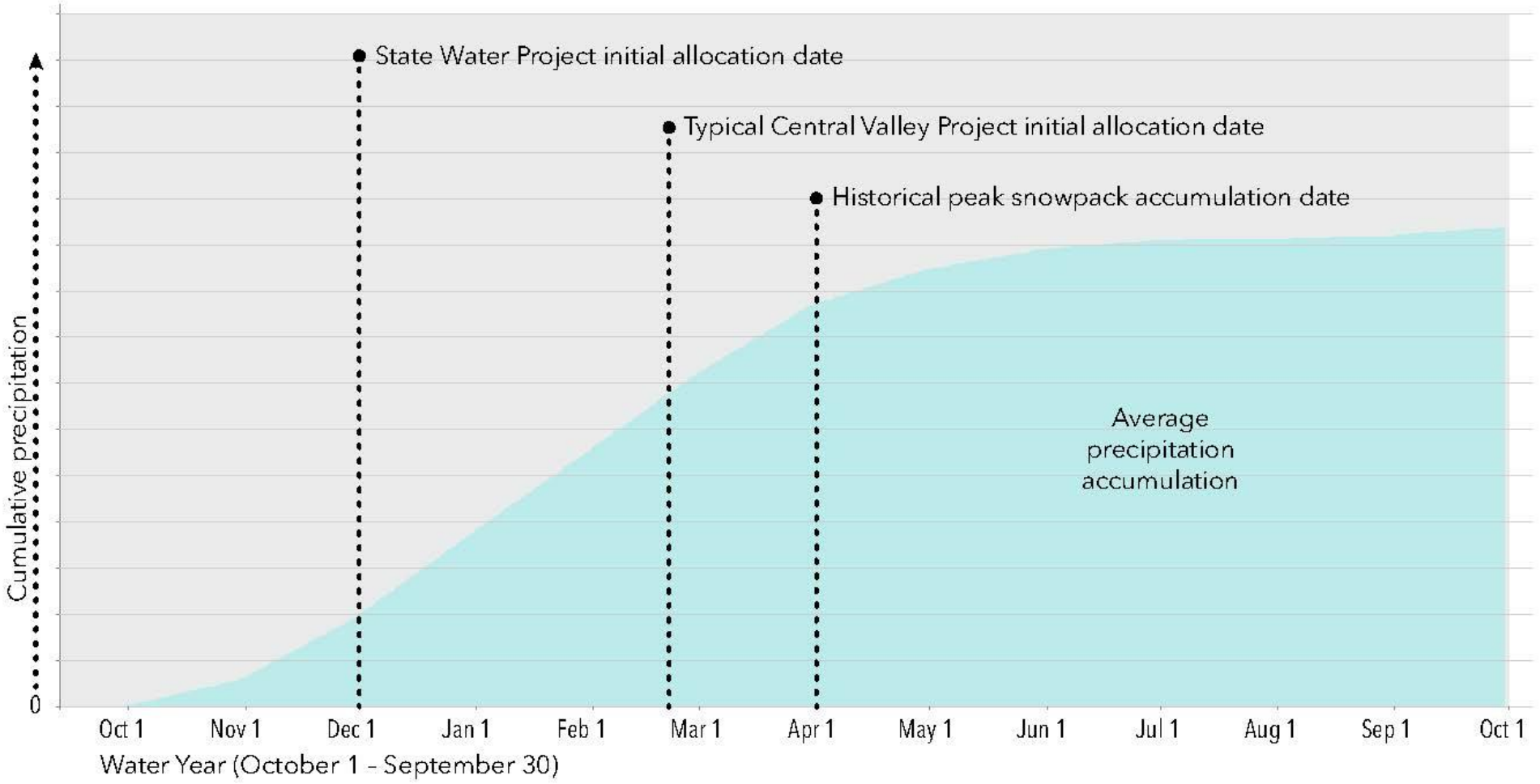
# Drought in California

- One dry year isn’t a drought
- Precipitation is key factor
- Runoff forecasts don’t provide lead time
- Drought duration is most important impact metric
- Lead time for response actions very important

# Lead Time for Drought Preparedness & Response



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



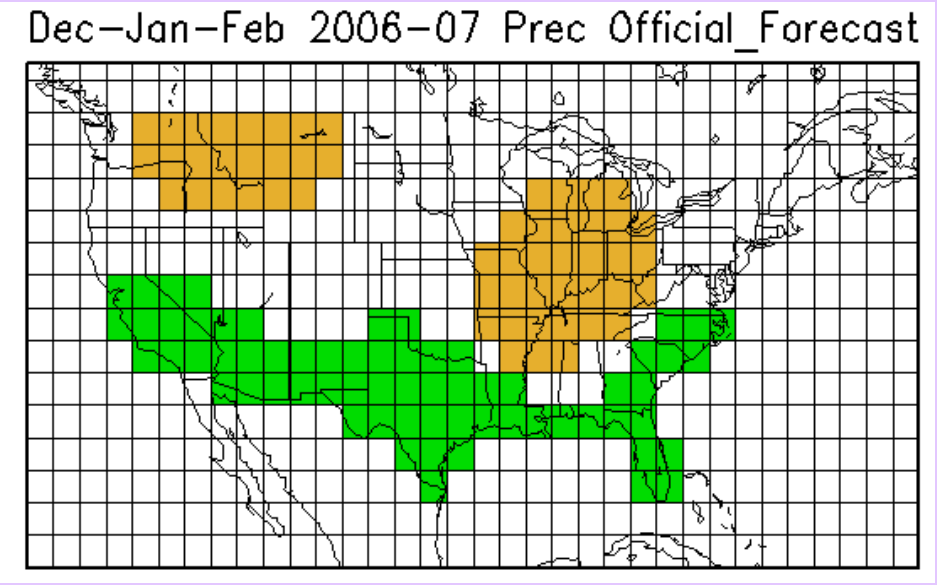
# Value of S2D Forecasts

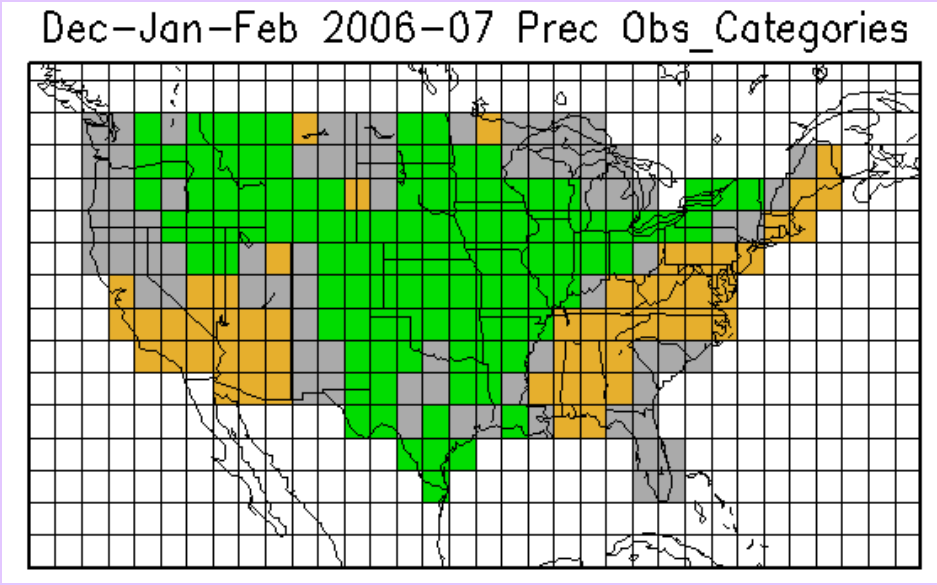
- Matches state budget cycle, decision time for resource allocation, lead time needed to spin up state relief programs
- State fiscal year: July 1st – June 30th
- Budget proposed in January, proposal revised in May, adopted in June
- In last drought, in-year amendments to enacted budgets for emergency drought relief in March: $687M in 2014, $1B in 2015

# California's 20th & 21st Century Statewide Droughts

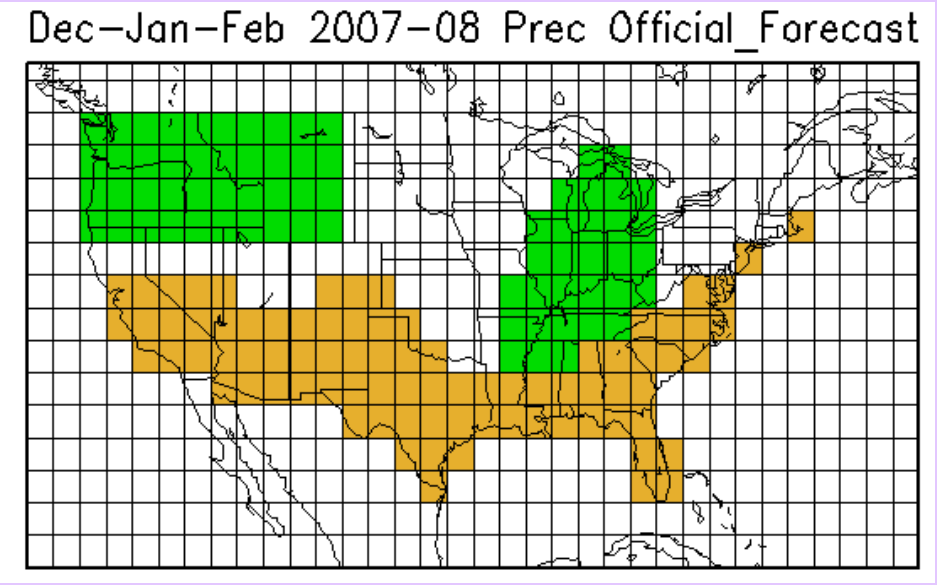
- 1918-20
- 1922-24
- 1929-34
- 1947-50
- 1959-61
- 1976-77
- 1987-92
- 2007-09
- 2012-16

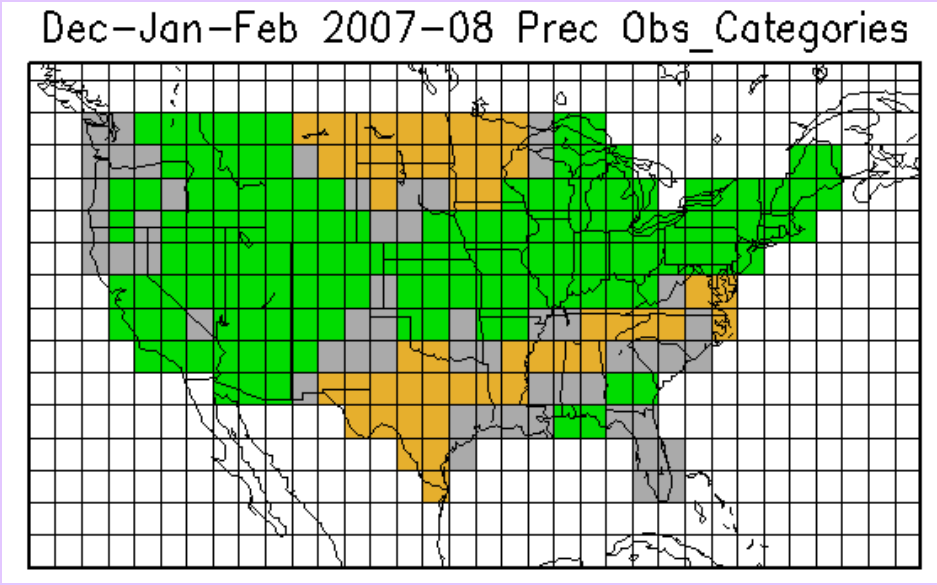
# Water Year 2007



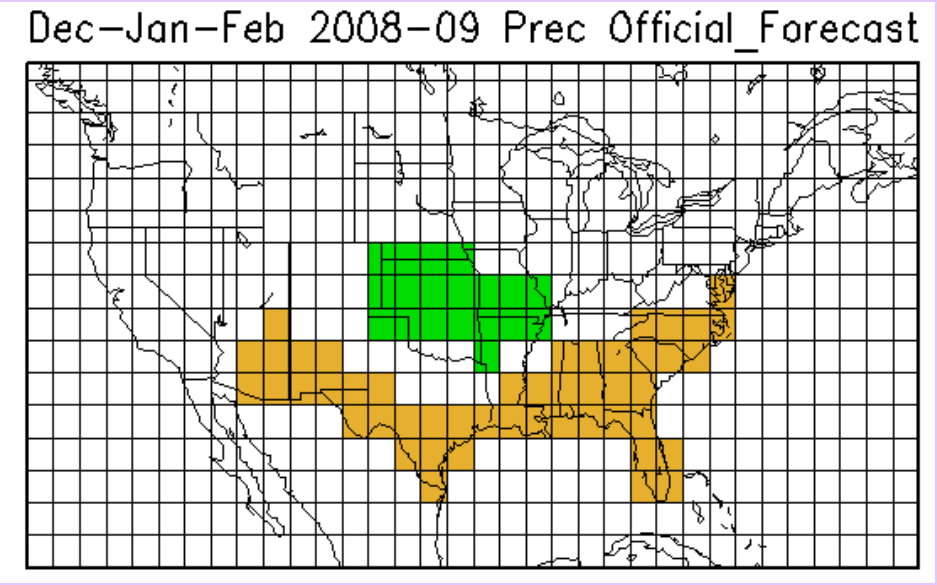



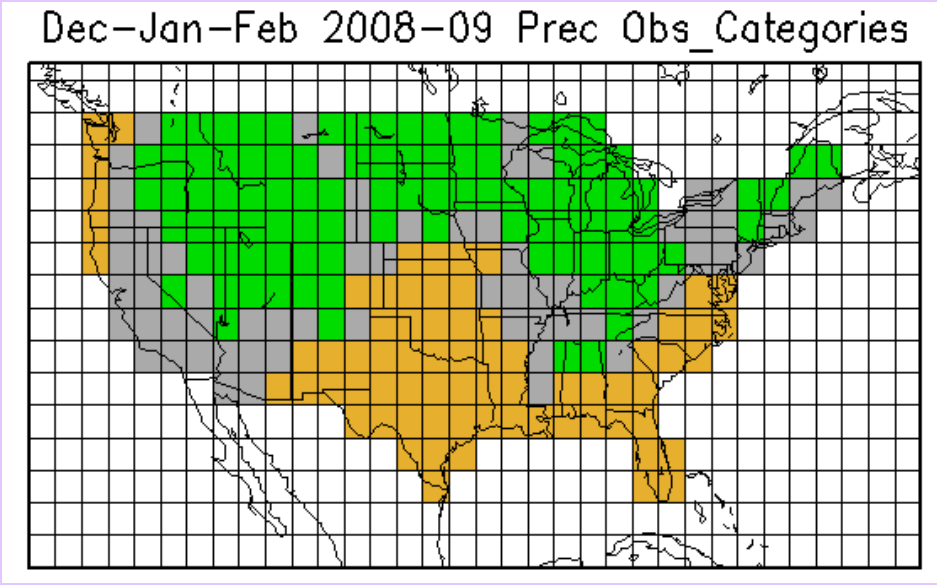
# Water Year 2008



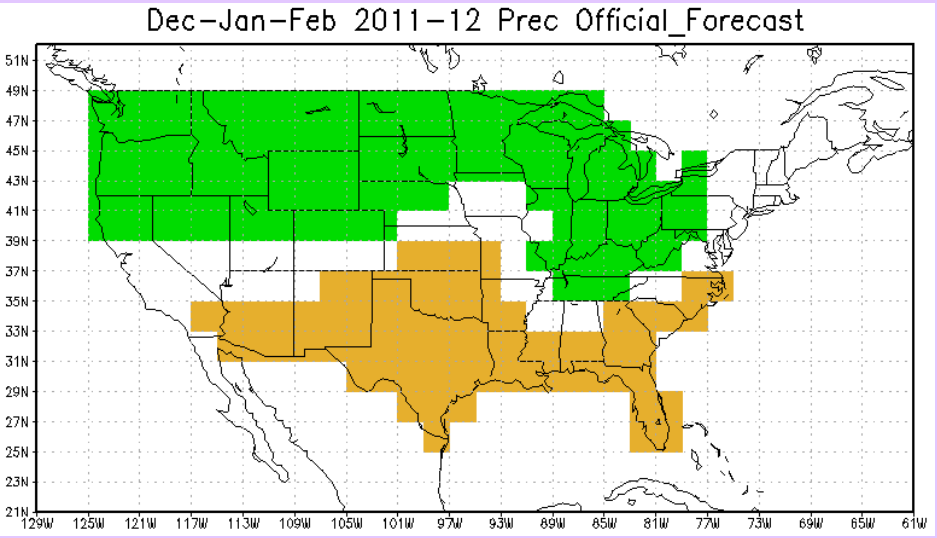



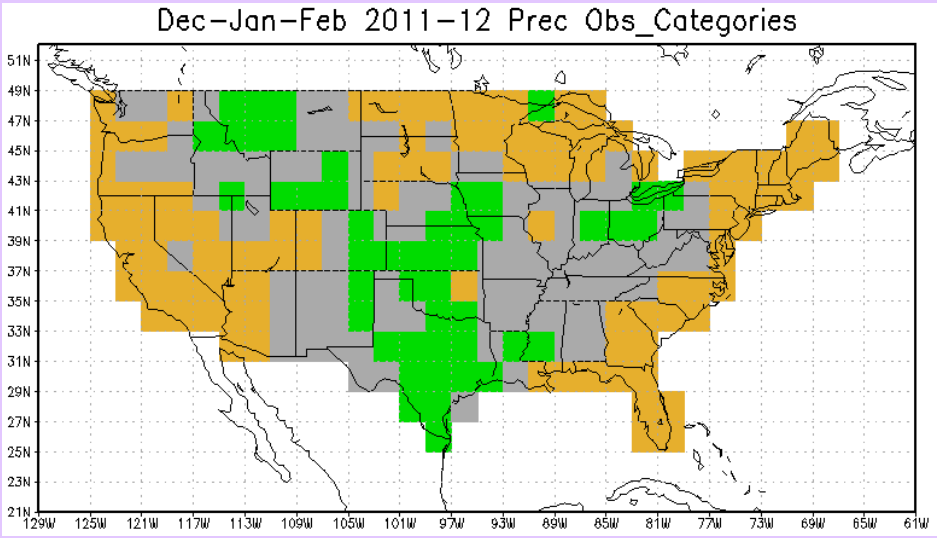
# Water Year 2009



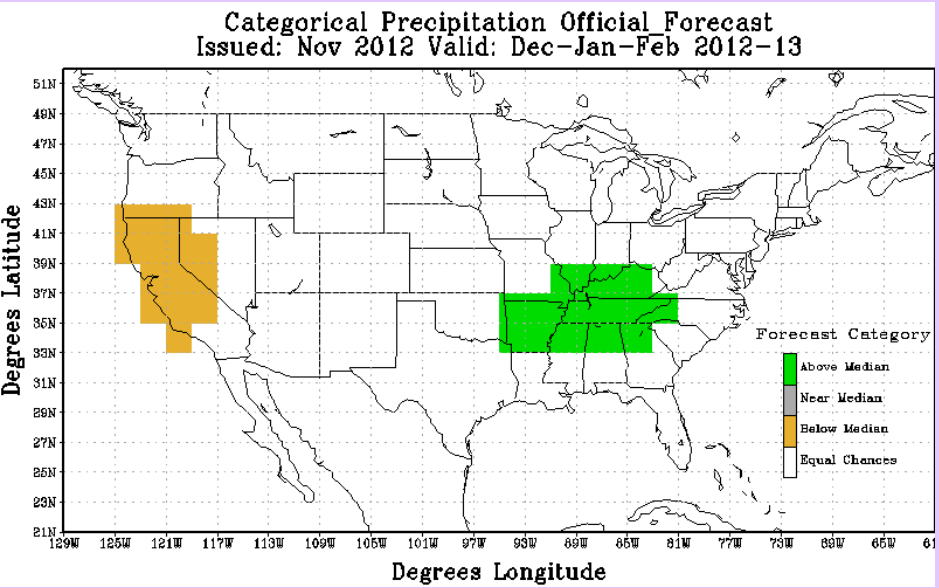



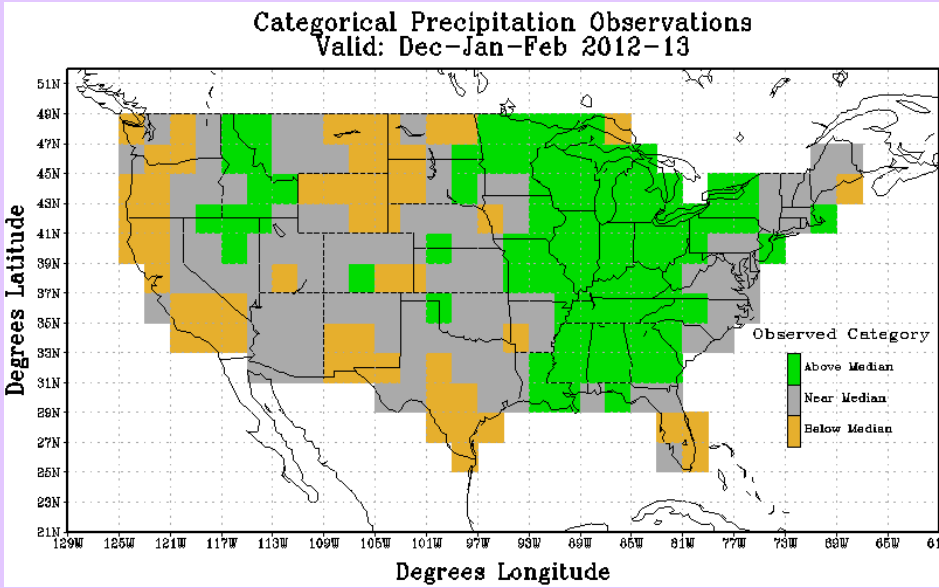
# Water Year 2012



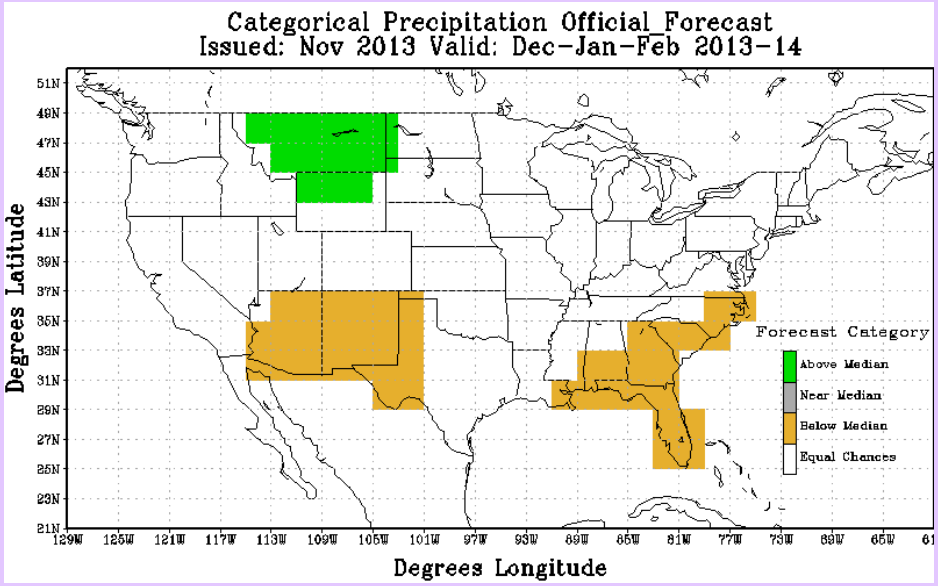



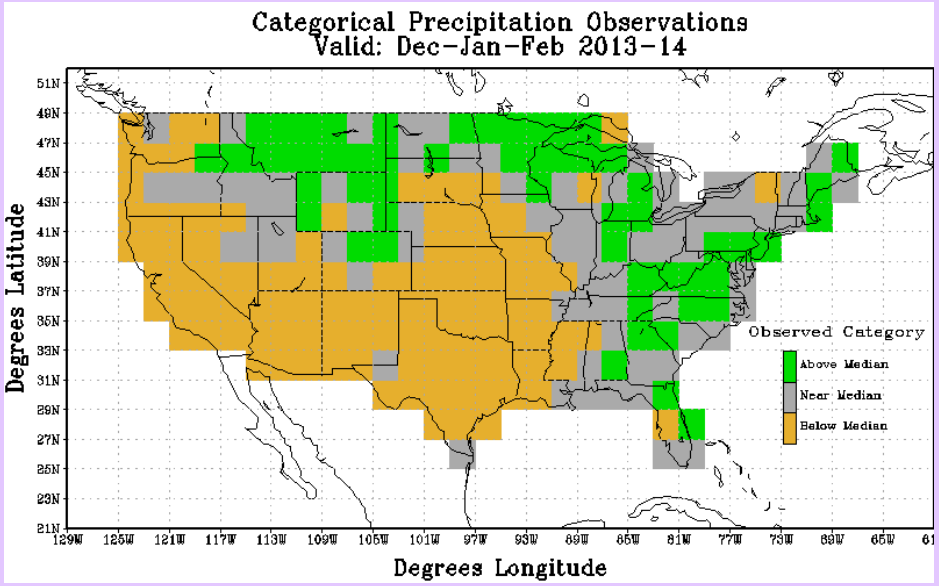
# Water Year 2013



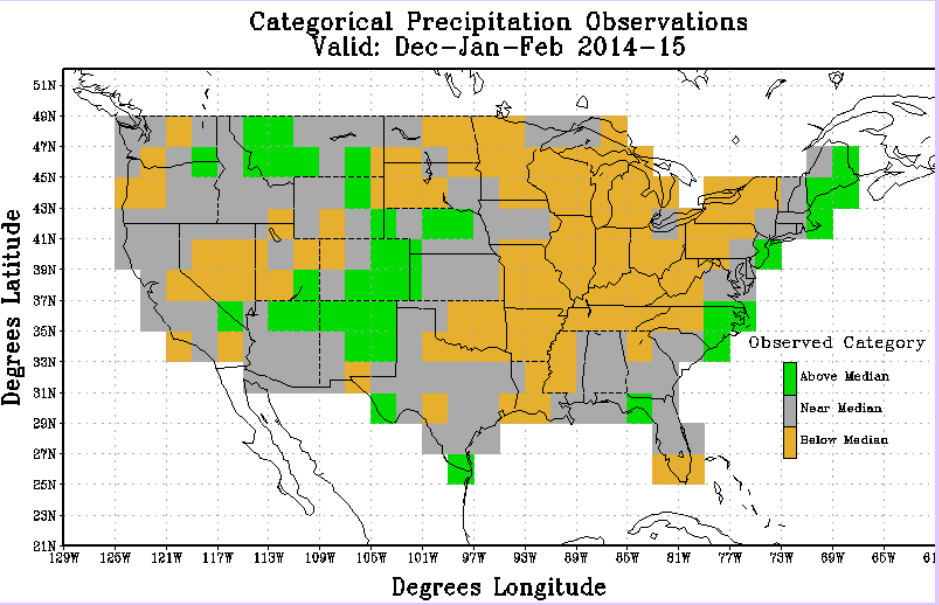



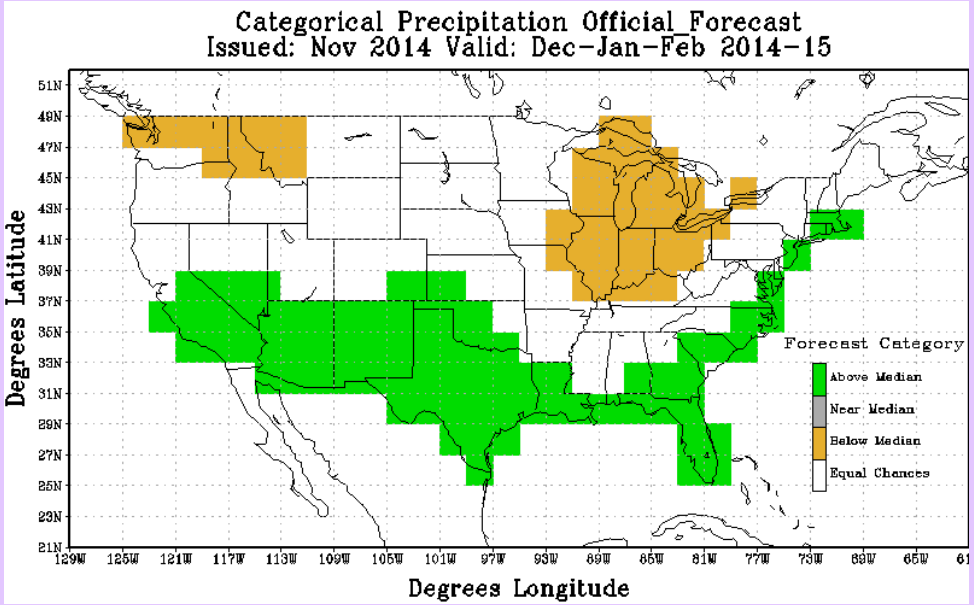
# Water Year 2014



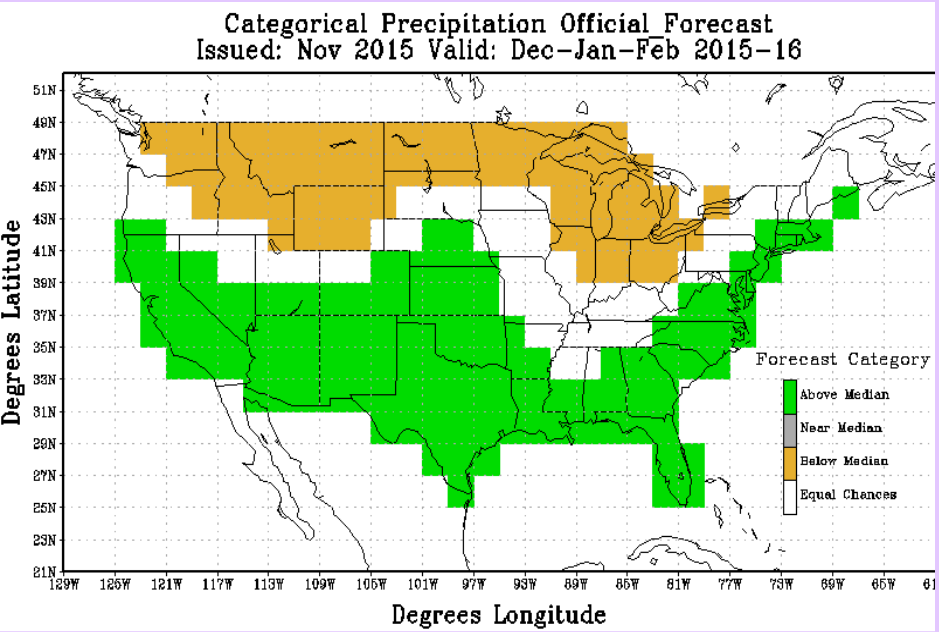



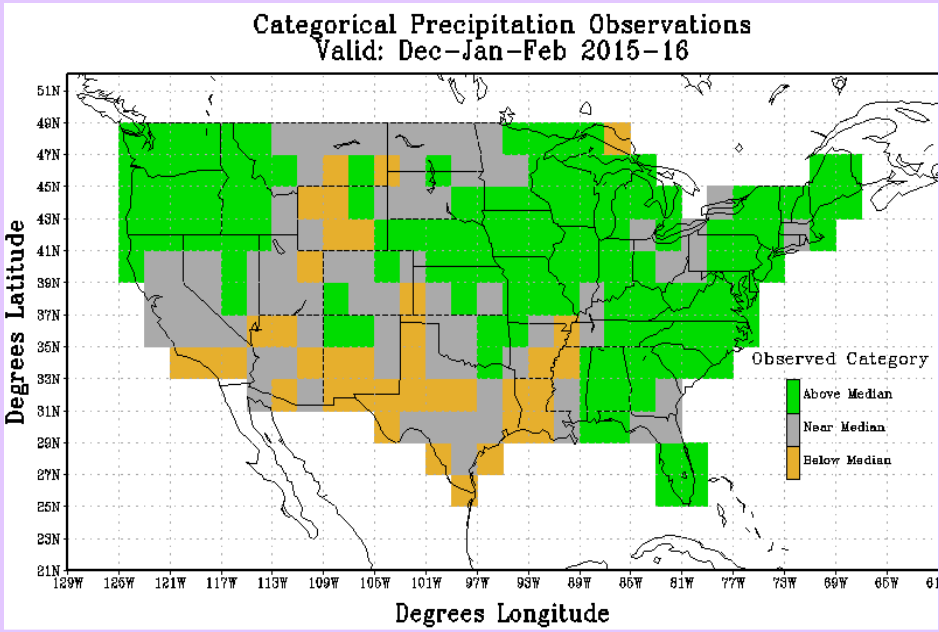
# Water Year 2015



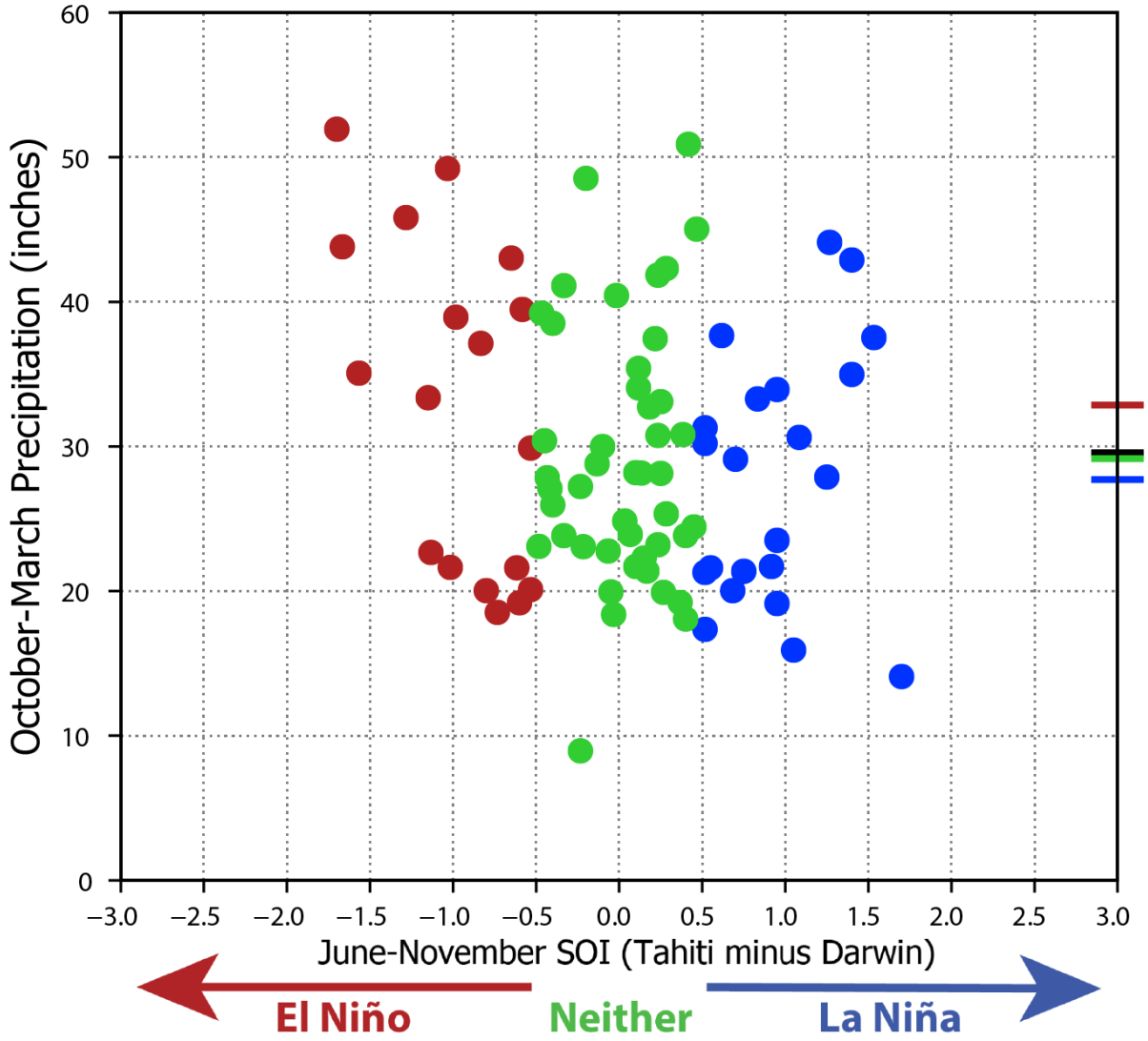
# Water Year 2016



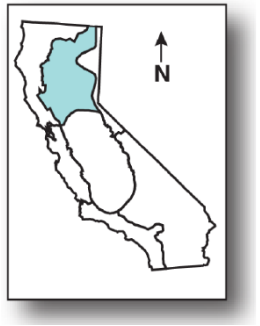

**Remember the Godzilla El Niño?**

# 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**

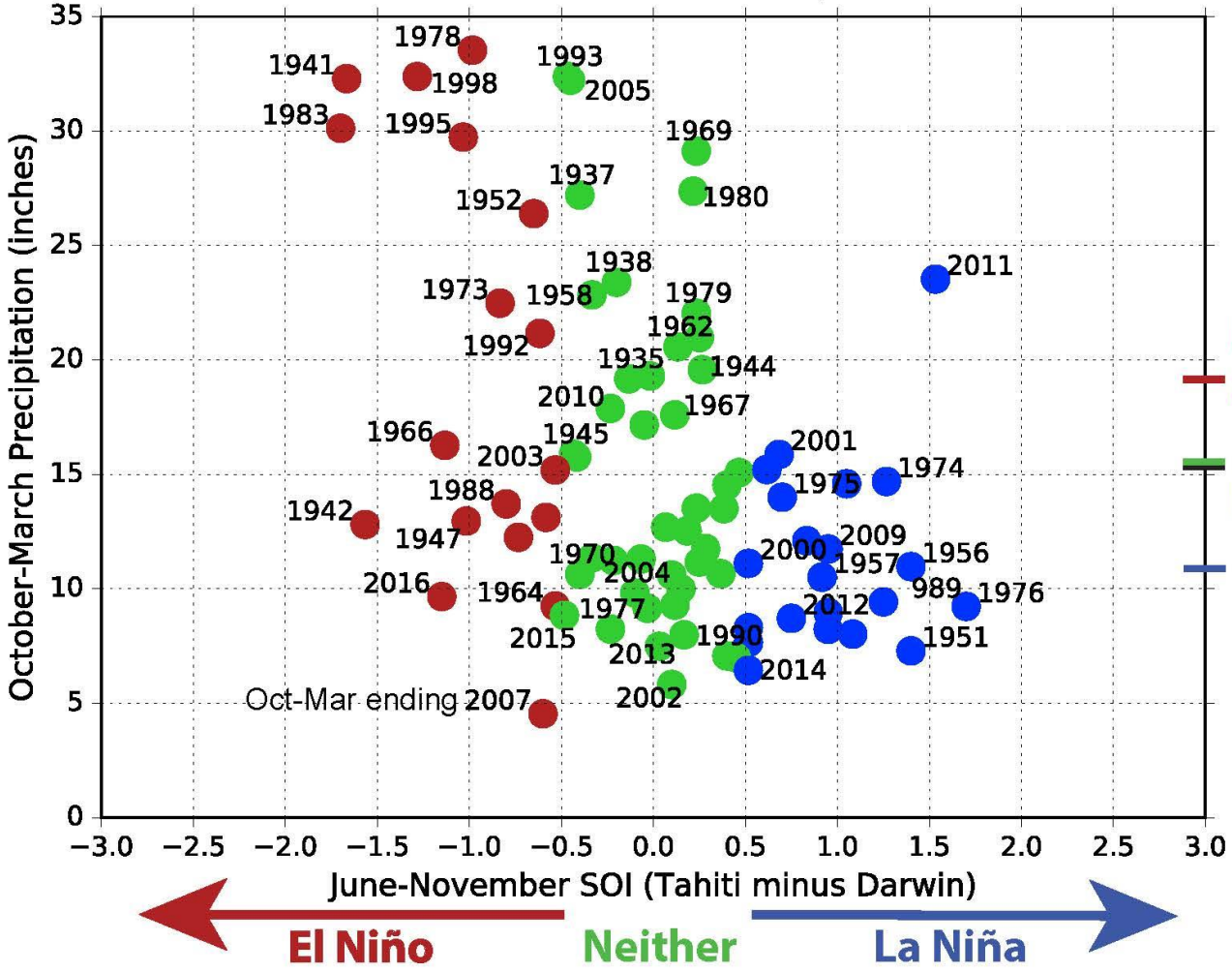
**Mean = 32.86 in**
**Mean all = 29.57 in**
**Mean = 29.16 in**
**Mean = 27.71 in**




Western Regional Climate Center

# CA Division 6 October-March Precipitation

## (versus Southern Oscillation Index for prior June-November)




**Years 1933/1934-2015/2016**

**$r^2 = 0.19$**

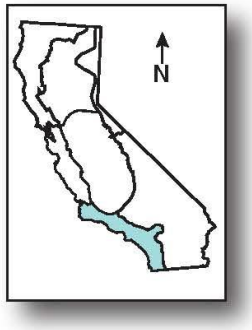
**Correlation = -0.44**

**Mean = 19.32 in**

**Mean = 15.30 in**

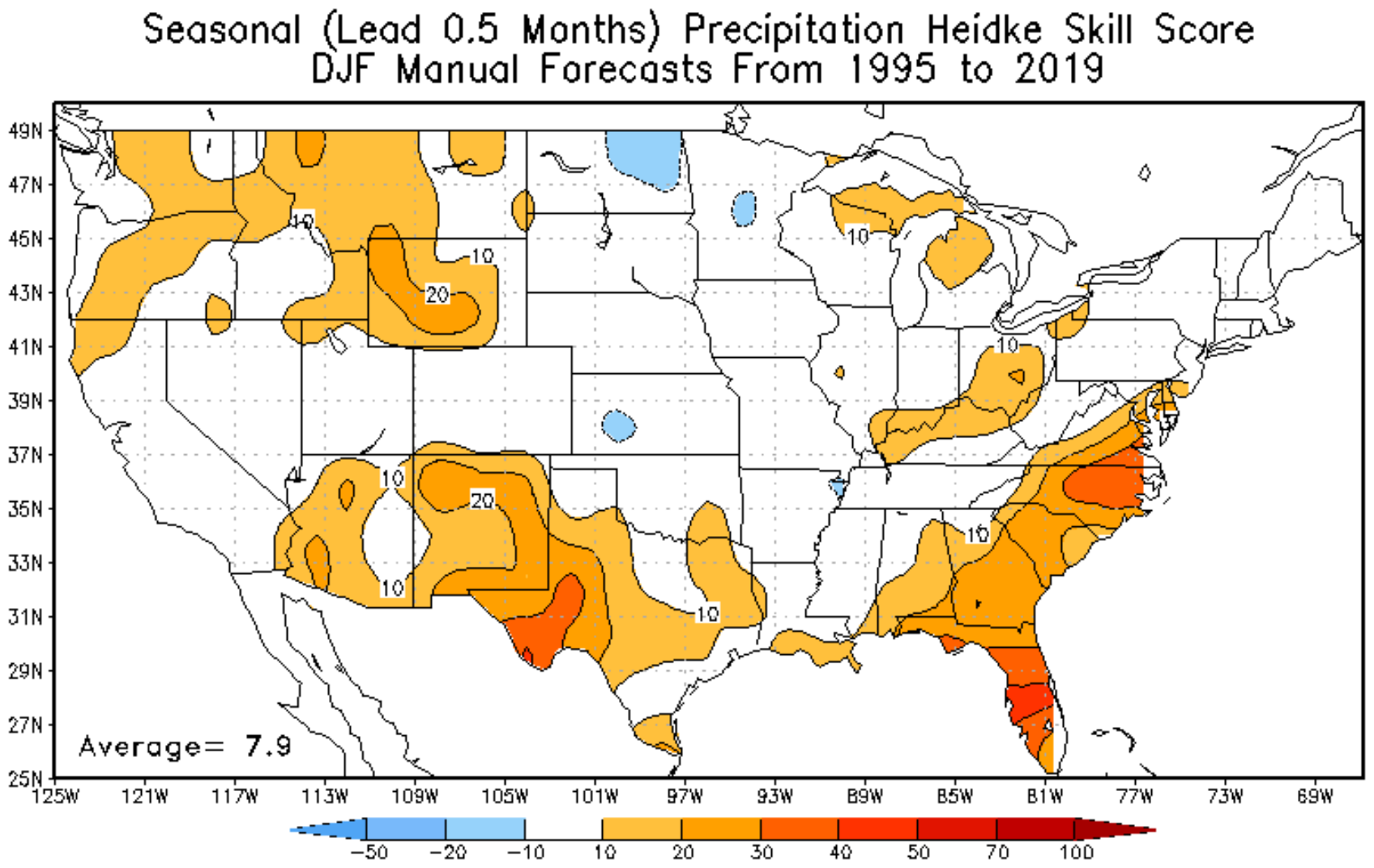
**Mean all = 15.15 in**

**Mean = 11.27 in**




Western Regional Climate Center

# Historical Skill of NOAA Outlooks



# CDWR Approach – Experimental Forecasts

- Began a decade ago, motivated by 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 funds applied research for experimental forecast products to explore approaches not used by NOAA, potential lower-hanging fruit
- Seeking products for transition to NOAA pilot

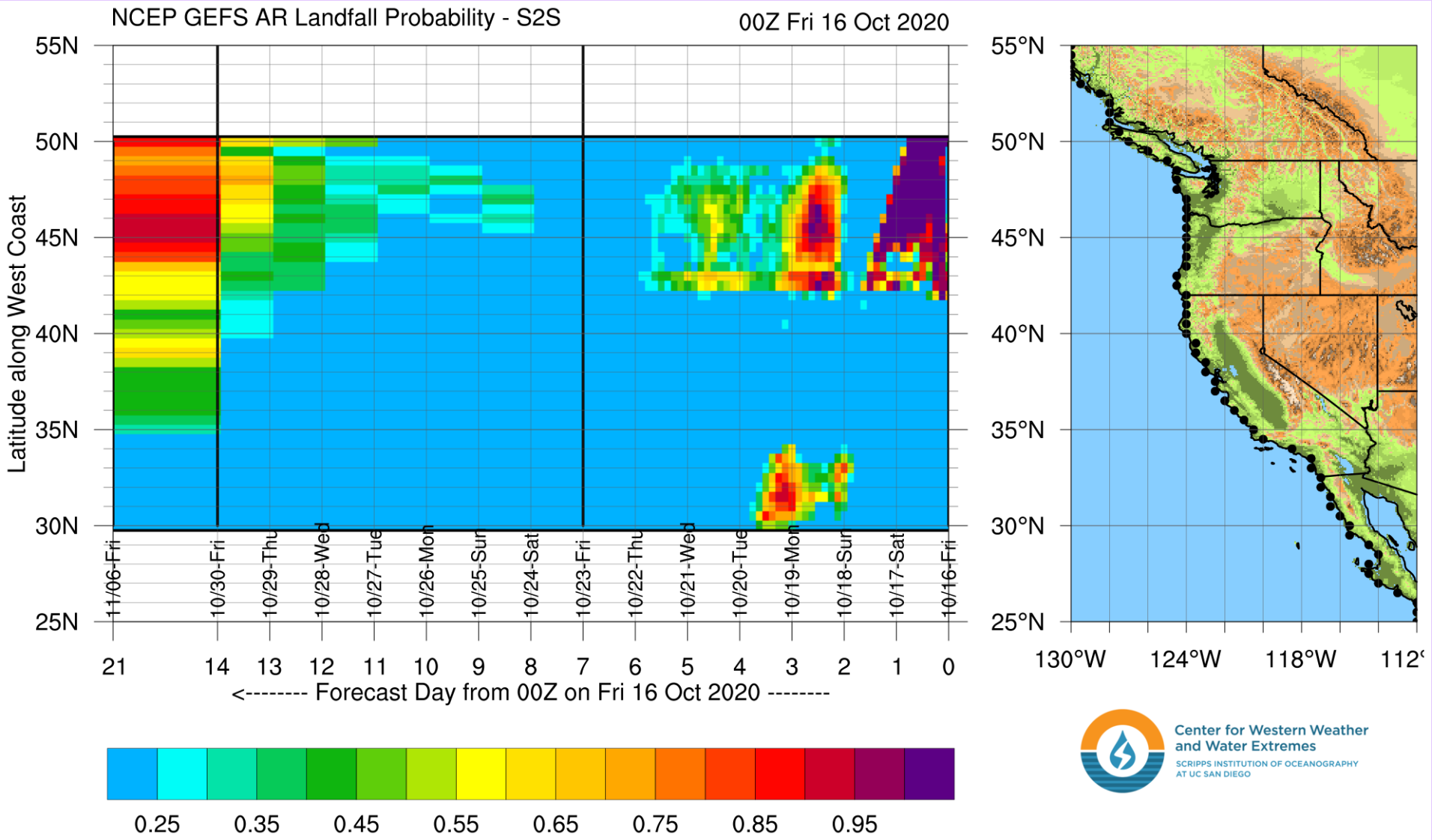
# TITLE II of PL 115-25: SUBSEASONAL AND SEASONAL FORECASTING INNOVATION

- (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)

# Example Sub-Seasonal Precipitation Forecasting DWR Funded

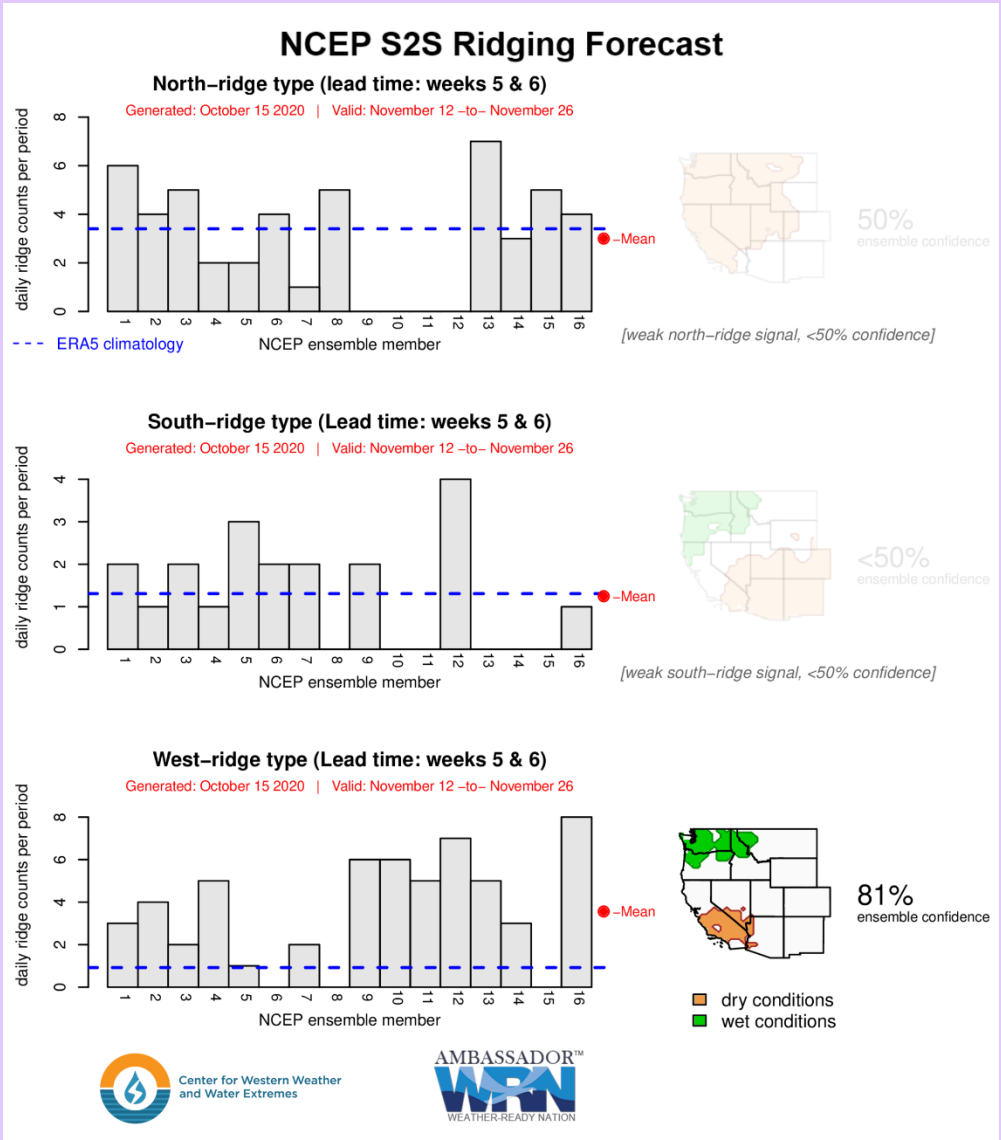
- Can atmospheric rivers (ARs) be detected/forecasted in global weather models? (Yes, development and application of automatic detection algorithm.)
- Can probability of AR occurrence be forecasted at sub-seasonal scale? (Yes, experimental week 3-4 forecasts, but minimal skill)
- Can atmospheric ridging be forecasted at sub-seasonal scale? (Yes, experimental forecasts being produced out to week 5-6, skill to be evaluated next year)

# Example Sub-seasonal Experimental AR Forecast Product

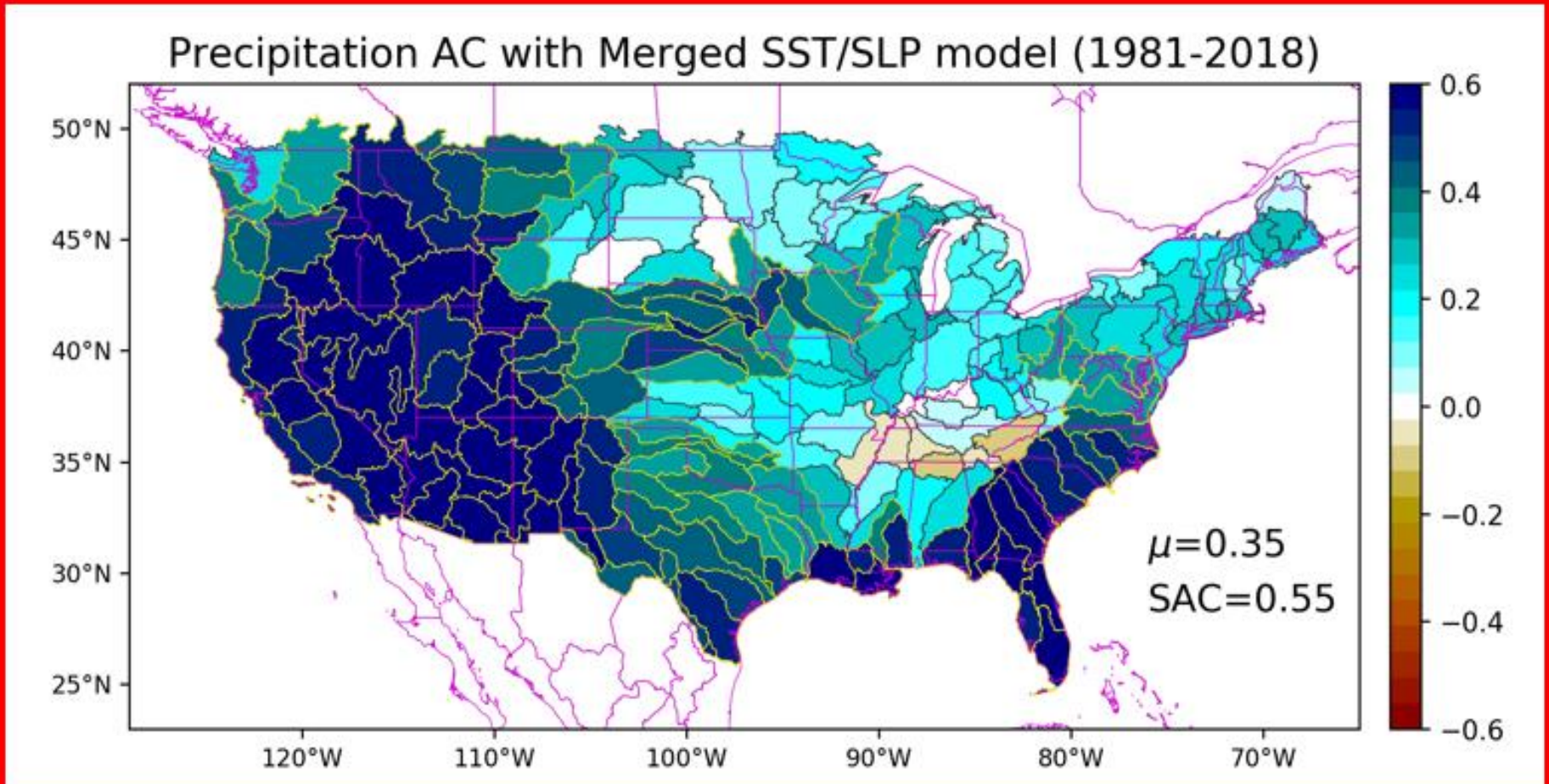



Center for Western Weather and Water Extremes
SCRIPPS INSTITUTION OF OCEANOGRAPHY AT UC SAN DIEGO

# Example Sub-Seasonal Atmospheric Ridging Forecast Product



# Example Seasonal Precipitation Experimental Forecasting Funded



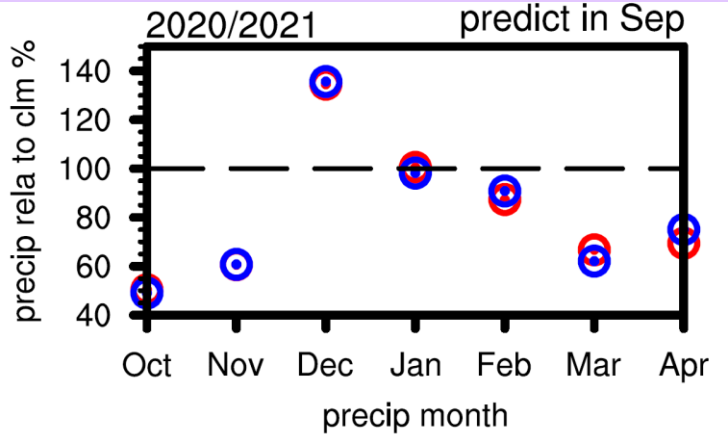

NOAA ESRL for DWR

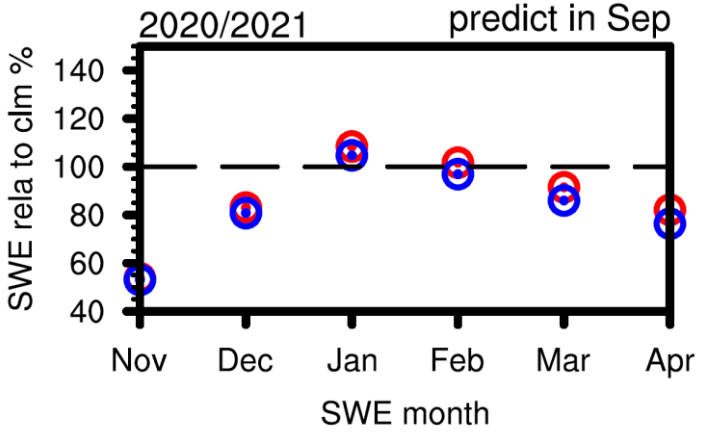
# Another Seasonal Example

## *Forecasts for the UCRB (made in early Sept)*

*Rainfall and SWE anomalies relative to their climatological values during Oct 2020-April 2021, based on August Observations, Preliminary experimental product prepared by UCLA for CDWR*

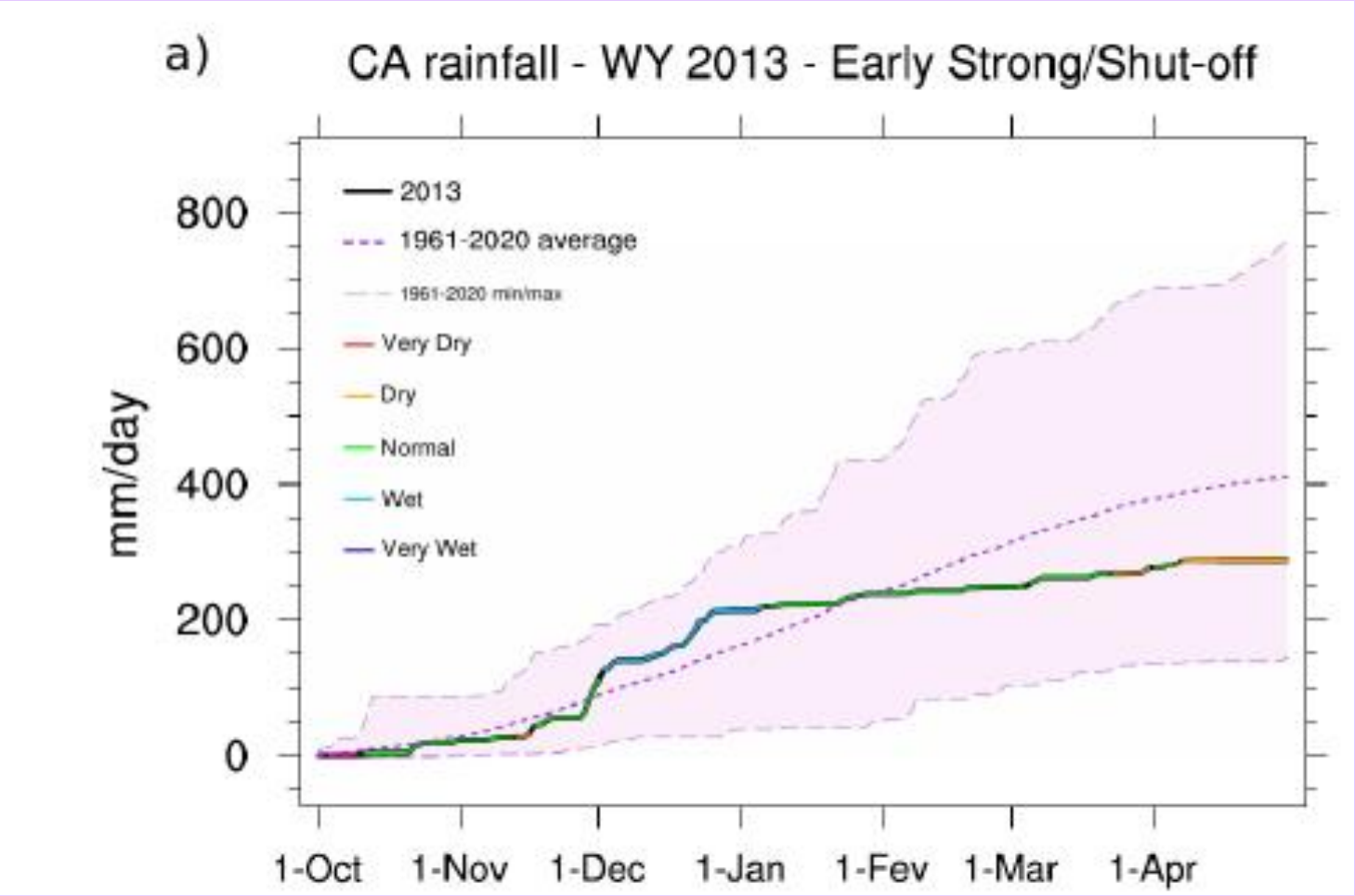
Red is neural network; Blue is stepwise linear regression




- **Generally lower rainfall and SWE than those of climatology from October 2020-April 2021, consistent with what we expect from warmer N. Pacific and La Nina.**
- **The result shown is based on the mean of the forecasts by the neural network and stepwise regression forecast models. The model and prediction skills were reported in the last report (attached in this email)**
- **The dashed horizontal lines indicates the climatological values of the precipitation in the left panel and of SWE in the right panel.**

# Climate Diagnostics – Transition Water Years

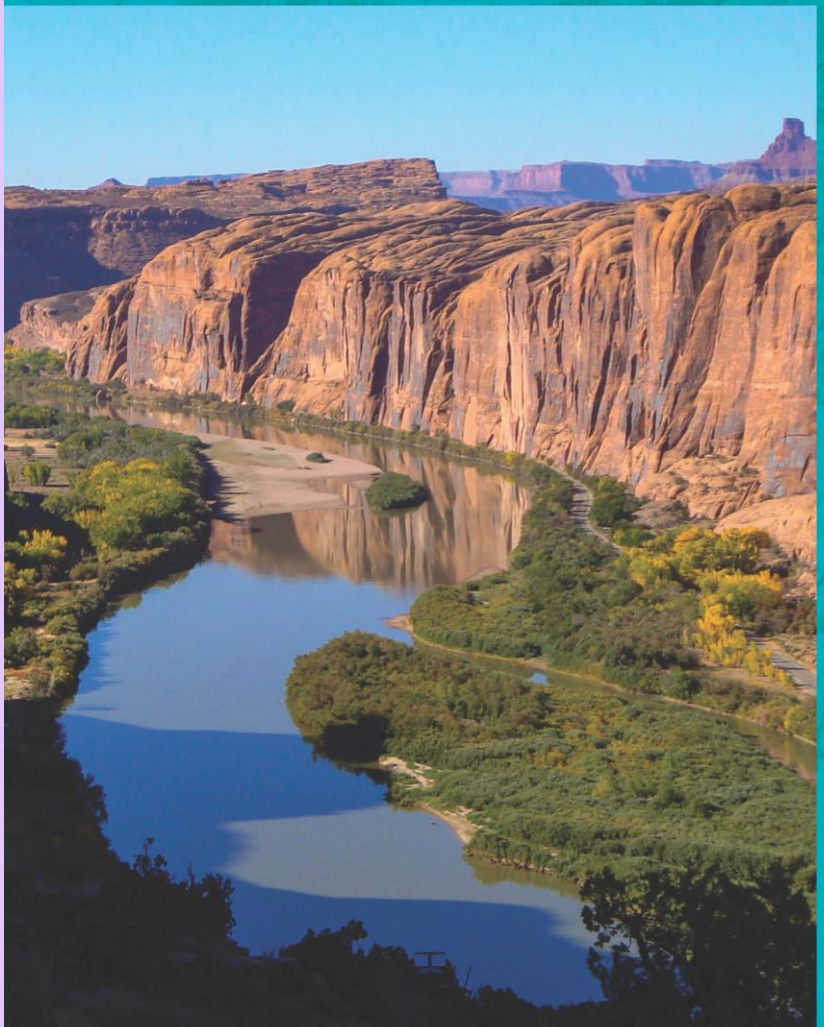



UC Irvine work in progress

# Forecasting Goals

- Now – begin exploring Year 2 forecasting opportunities
- 5 years – have suite of forecasting tools: year 2, beginning of wet season, mid-way through wet season
- 5 years – have a NOAA western winter seasonal pilot underway pursuant to PL 115-25
- 5-10 years – transition of forecasting tools to NOAA for operational use

# Improving Sub-Seasonal to Seasonal Precipitation Forecasting for Water Management



WESTERN STATES WATER COUNCIL