ENSO & California

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Skillful S2S Precipitation Forecasting

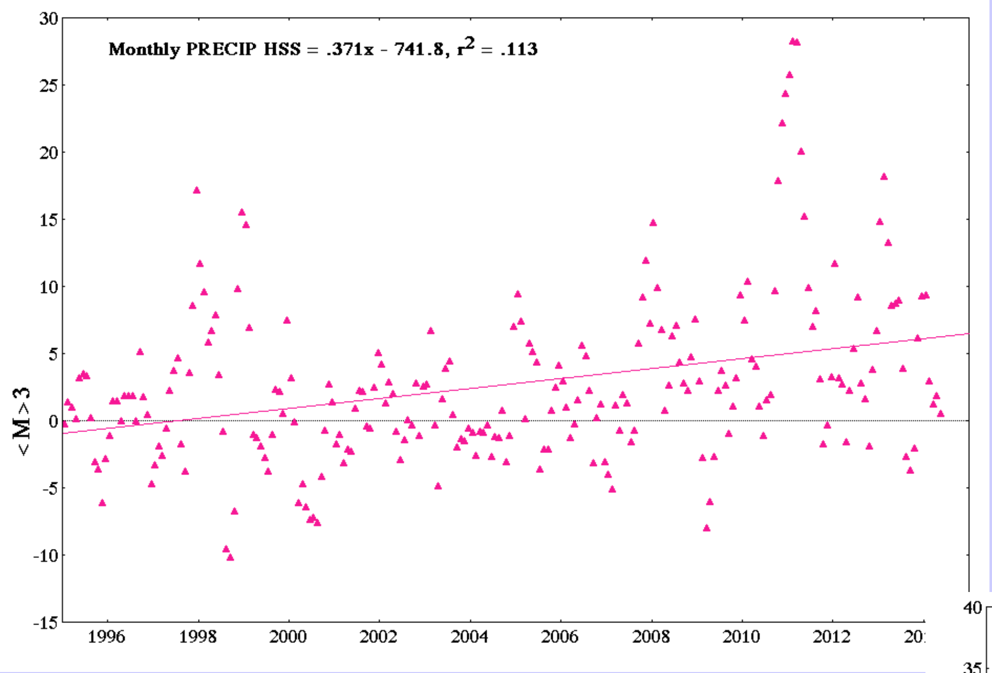
major information gap for drought preparedness and response

- Could we have an unusually wet late spring?
- This winter has been very dry through December, are dry conditions likely to persist the rest of the winter?
- Will this water year be dry? How long will dry conditions persist?

High-Priority Questions

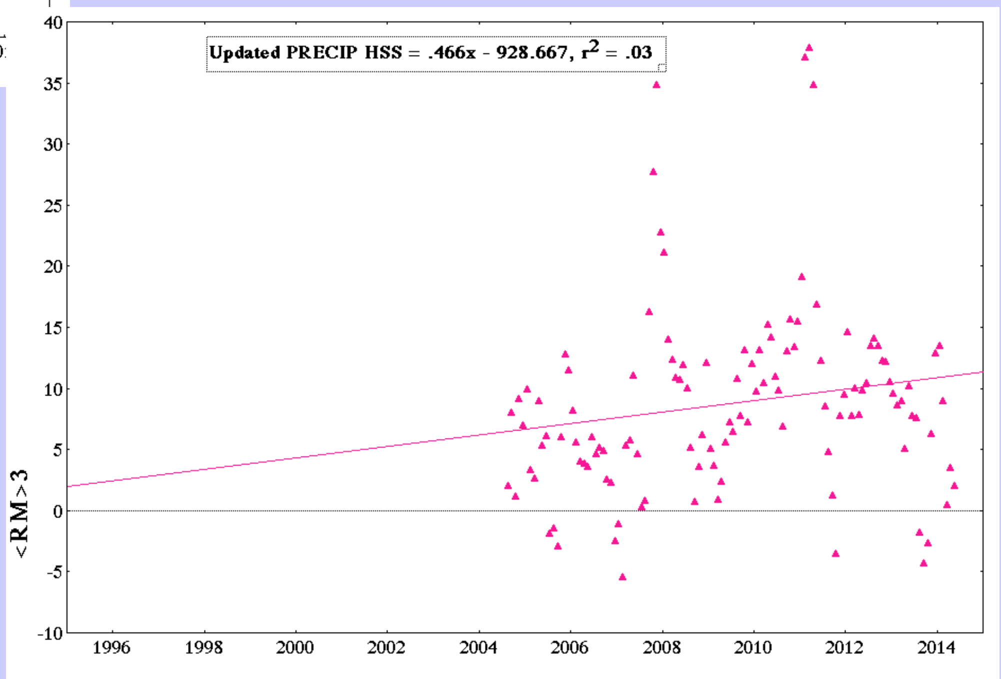
- It's November – will this water year be wet or dry? (for drought preparedness & response)
- It's mid-January – will the rest of the season be wet or dry? (informing reservoir operations generally)

CPC Forecast Skill – Monthly Precipitation



http://www.cpc.ncep.noaa.gov/products/predictions/long_range/tools/briefing/mon_veri.grid.php

CPC operational precipitation forecast skill (Heidke Skill scores) for monthly forecasts (top) and updated monthly forecasts (right). ***Skill has improved over time, but less so than for temperatures.***



Slide courtesy of Klaus Wolter

CPC’s sources for outlooks

- 1. ENSO
- 2. Trends (difference between 10yr temp mean or 15yr precip mean & 30yr climatology)
- 3. MJO
- 4. NAO
- 5. PDO
- 6. Soil moisture/snow cover
- 7. Statistical forecast tools
- 8. Dynamical forecast models (e.g. NCEP’s CFS)
- 9. Consolidation of trends & forecasts

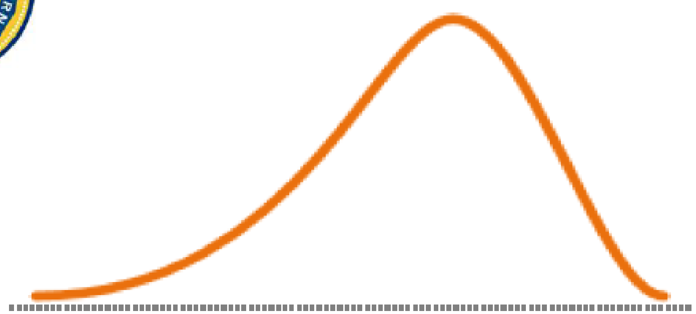
Will 2016 be Dry?

Where Do We Go From Here With Improving (Regional) Forecasting?

- After numerous CDWR science workshops…
  - Statistical forecasts (updating/improving)
  - Using the past to inform the future
    - Paleoclimate information (looking for decadal-scale signals, if any)
    - Analog years
  - Forecasts of opportunity
    - Predicting wet to predict dry (atmospheric river storms)

One Approach -- Analog Years & Statistical Modeling

Drought Prediction



$$f\,(Precip\,|\,?\,)$$

Using Bayesian network…

$$f(x|y,z,\ldots) \propto f(x,y,z,\ldots)$$

We apply *Copula functions* to determine the joint and conditional probabilities [f(x,y,z), f(x|y,z)]

- Large-scale climate signals
  - Southern Oscillation Index (SOI)
  - Pacific Decadal Oscillation (PDO)
  - Multivariate ENSO Index (MEI)
  - Arctic Oscillation (AO)
- Local-scale climate signals
  - Near-past condition (e.g. SPI)
- Combination of Large-/Local-scale signals
- What else?

Let's try

- SOI
- (SOI , PDO)
- (PDO , MEI)
- (SOI , SPI)
- (PDO, SOI, SPI)

Another Approach – Predicting Atmospheric River Storms

- Can we predict ARs or conditions favorable for their formation?
- Can we link AR formation to synoptic climate conditions?
- Can we predict the absence of ARs (bias toward dry conditions)?

Current CDWR-Funded Research

- Developing databases of AR storms/synoptic climate, object-oriented satellite precip database (2 projects, UCI & UCSD)
- Analog years database and statistical model (UCI)
- Paleoclimate reconstructions of Southern California streamflow/precip (in contract, U of AZ)
- AR/MJO predictions (in contract, JPL/UCLA)

Western Regional Climate Center

Will El Niño Make a Difference? Maybe Not

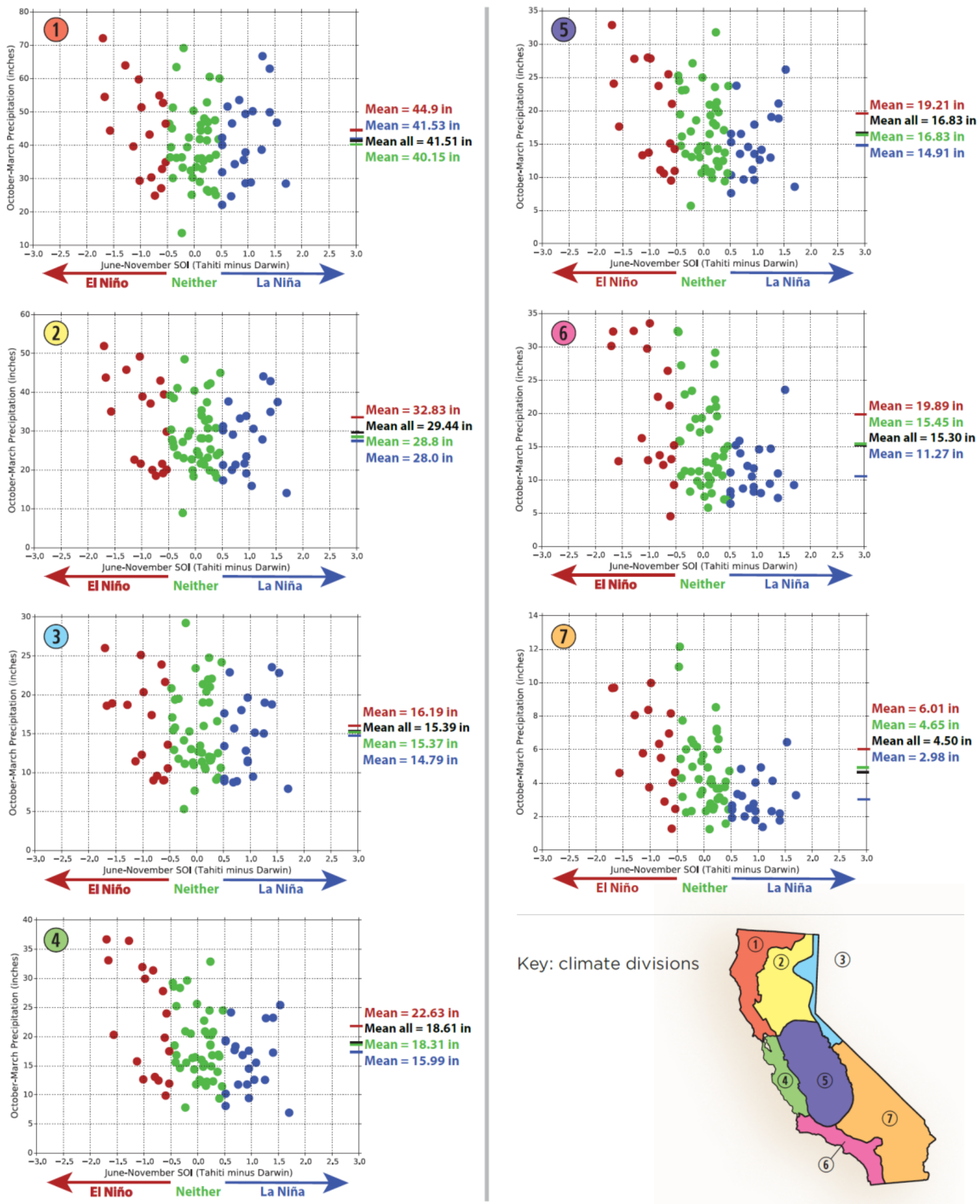
July 2015

- Making seasonal climate forecasts of precipitation—the ability to predict now if water year 2016 will be wet or dry (and how wet or dry)—is scientifically difficult, and the accuracy of such predictions is very low, much less accurate than that of a seven-day weather forecast. Scientists consider teleconnections (recurring and persistent, large-scale patterns of pressure and circulation anomalies over important regions of the globe that correlate with climate at a site of interest) when attempting to make seasonal climate forecasts.
- The El Niño-Southern Oscillation (ENSO) is one of the most studied climate phenomena, and one that can provide some predictive guidance in parts of the United States under certain conditions. ENSO is characterized by year-to-year fluctuations in sea surface temperatures along the equator in the Pacific Ocean between Peru and the International Date Line, and concomitant fluctuations in sea level air pressures between Tahiti and Darwin, Australia. The ENSO cycle is expressed as three states: neutral conditions, El Niño (warm ocean phase), and La Niña (cold ocean phase).
- The National Oceanic and Atmospheric Administration's Climate Prediction Center ENSO diagnostic discussion presently calls for a 90 percent chance of El Niño conditions in the fall and early winter. Forecaster consensus is for an event with a sea-surface temperature anomaly greater than 1.5 degrees Celsius which is the threshold for a strong event.

> "… a strong El Niño can result in a continuing drought year …"

- The graphics on the reverse show the relationship over an 80-year period between measured precipitation in each of California's climate divisions (see map key) and ENSO conditions, which are expressed as the Southern Oscillation Index, a measure of air pressure fluctuations between Tahiti and Darwin. The strongest El Niño and La Niña events plot on the far left and far right sides of the graphics, respectively.
- As illustrated on the reverse, there is almost no correlation between precipitation and El Niño conditions in Northern and Central California. ENSO's strongest signal in California is for Southern California to be drier than average in La Nina years.
- Since 1950 there have only been five events with an Ocean Niño Index value greater than 1.5 for the winter months of December through February (ONI value greater than 1.5 signals a strong El Niño). Those events occurred during the 1958, 1973, 1983, 1992, and 1998 water years. Looking at the Northern Sierra 8-station index (a precipitation index for the mountainous regions extending from east of Sacramento to above Shasta Dam) water year precipitation totals range from 36 inches (72% of average) in 1992 to 88.5 inches (177% of average) in 1983 while 1973's total was 51.6 inches (103% of average). Thus a strong El Niño can result in a continuing drought year like water year 1992, an average year like 1973, or a wet year like 1983.

Years 1933/34 through 2013/14 • October - March (winter) precipitation by Climate Division versus Southern Oscillation Index for immediately proceeding June - November



The bigger communications problem

U.S. cities running out of water

The nine cities with the worst drought conditions in the country are all located in California, which is now entering its fourth consecutive year of drought as demand for water is at an all-time high. The long-term drought has already had dire consequences for the state's agriculture sector, municipal water systems, the environment, and all other water consumers.

Based on data provided by the U.S. Drought Monitor, a collaboration between academic and government organizations, 24/7 Wall St. identified nine large U.S. urban areas that have been under persistent, serious drought conditions over the first six months of this year.

USA Today, 6/17/15

The U.S. Drought Monitor is produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the USDA and the National Oceanic and Atmospheric Administration (NOAA). 24/7 Wall St. identified the 10 urban areas with populations of 75,000 or more where the highest percentages of the area was under “exceptional” drought conditions in the first seven months of 2014. All data are as of the week ending July 15.

These are the cities running out of water.

10. Fresno, Calif.

> Exceptional drought coverage (2014): 75.1%

> Extreme drought coverage (2014): 100%

> Population: 654,628

Over the first seven months of this year, around 75% of Fresno was engulfed in exceptional drought, the 10th highest proportion among large urban areas. Such a drought can cause water emergencies brought on by shortages in reservoirs, streams and wells, as well as widespread agricultural failures. The remaining one-quarter of Fresno that was not in exceptional drought did not fare much better, as 100% of the city was in a state of extreme drought.