Tools & Technology We Have Now That We Did Not Have in 2002: Forecasting Tools One to Three Years Out

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Forecasting Tools Development

- Updated Optimal Climate Normals (Temperature & Precipitation Trends)
- Improved Understanding of Drought and Ocean Conditions
- ENSO Plume Model Forecasts
- Improved Understanding of Drought and Land Conditions
- Reliability Conditioned on Decadal Variability
- National MultiModel Ensemble (NMME)
- Land-Data Assimilation System (LDAS)
- NOAA Drought Outlook
- Experimental Climate Divisions and Regional Drought Forecasts

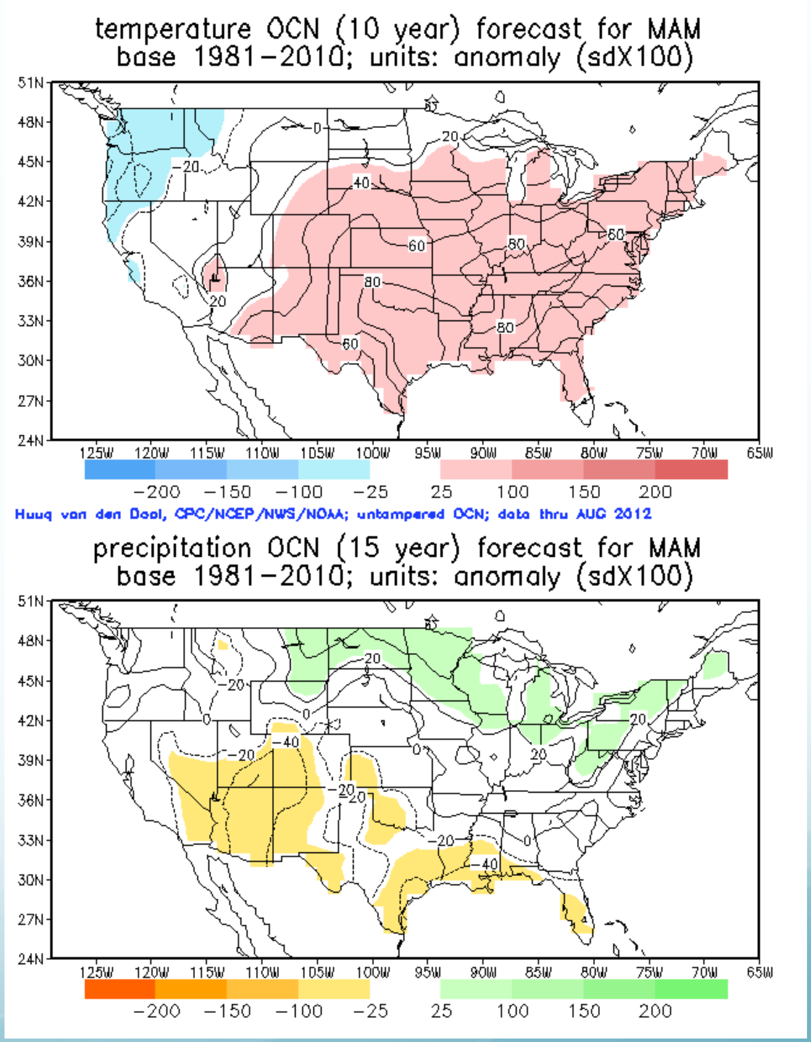
Updated Optimal Climate Normals (OCN)
Temperature and Precipitation Trends

Year-to-year persistence of the observed average anomalies for a given season emphasizing long-term trends and multi-year regime effects

For temperature, the OCN is the average of the last 10 years minus the 1981-2010 climatology for each season.

For precipitation, the OCN is the average of the last 15 years minus the 1981-2010 climatology for each season.

OCN March, April, May

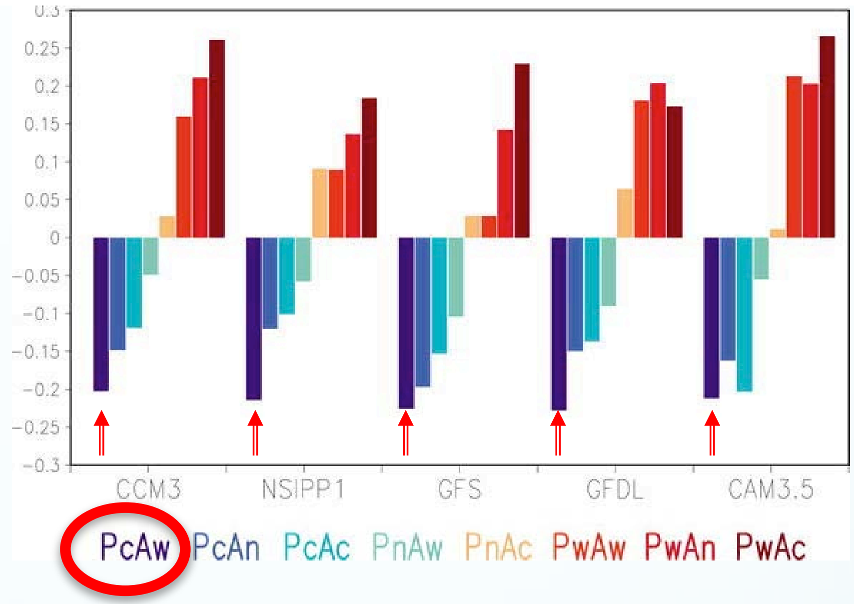


Huang et al. (1996)

Improved Understanding of Links Between Drought and Ocean Conditions

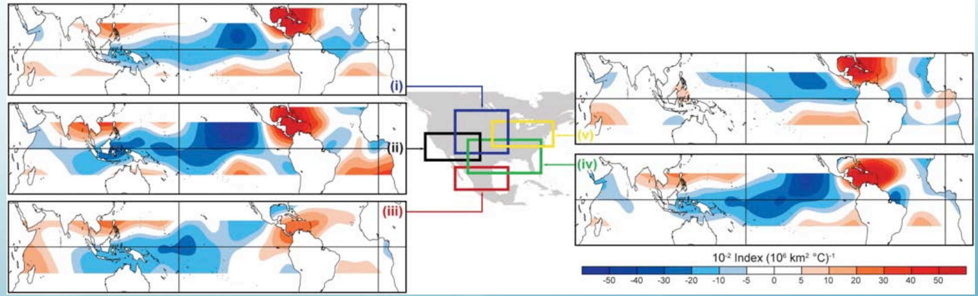
- Climate model based studies found that precipitation responses to the Pacific ENSO-like forcing pattern, with a cold Pacific leading to reduced precipitation and a warm Pacific leading to enhanced precipitation over most of the USA
- Atlantic AMO-like pattern is less robust; however is general agreement among the models that the largest precipitation response over the USA tends to occur when the two oceans have anomalies of opposite signs
- Better understanding and modeling of the ocean's role in significant past droughts

Continental USA mean annual precipitation responses



Schubert et al., 2009

Regionally averaged PDSI sensitivity to tropical SSTs



Shin et al., 2010

Improved Understanding of Links Between Drought and Land Surface Conditions

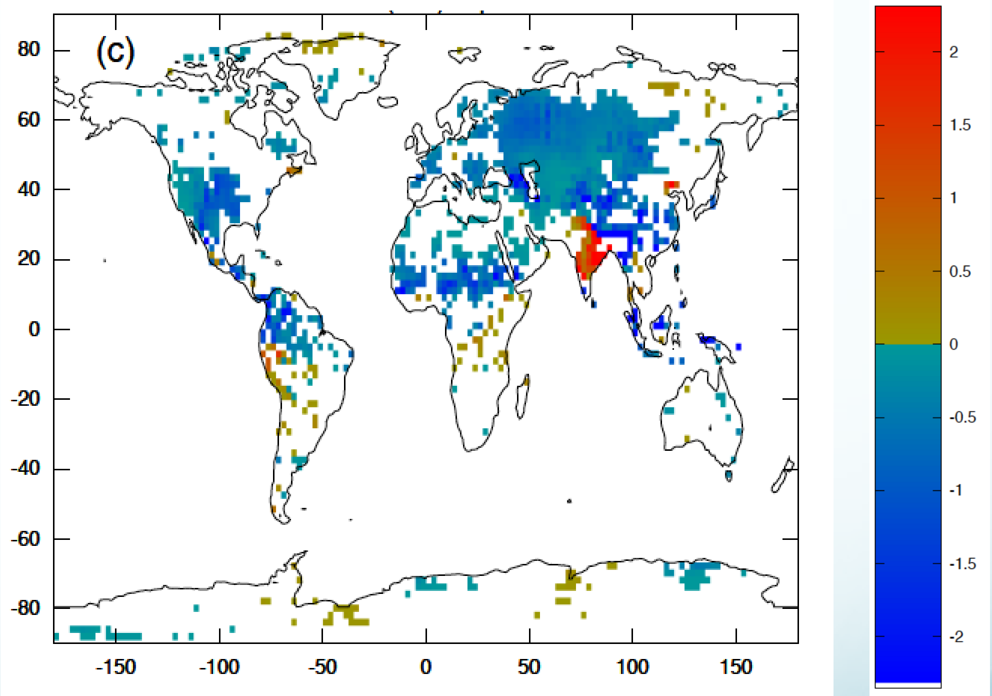
Soil moisture feedbacks modulate variability in temperature, precipitation, and cloudiness under warm conditions.

The lower threshold for the length scale of the dry anomalies required to affect the boundary layer is approximately 150 km or 18,000 km^2

Surface-convection feedback tends to perpetuate drought at this length scale through the suppression of convective storms and associated rainfall.

Brimelow et al., 2011

Change in summer seasonal precipitation (mm/day) induced by soil moisture feedback



Krakauer et al., 2010

IRI ENSO Plume Model Forecasts
Eastern Equatorial Sea Surface Temperatures

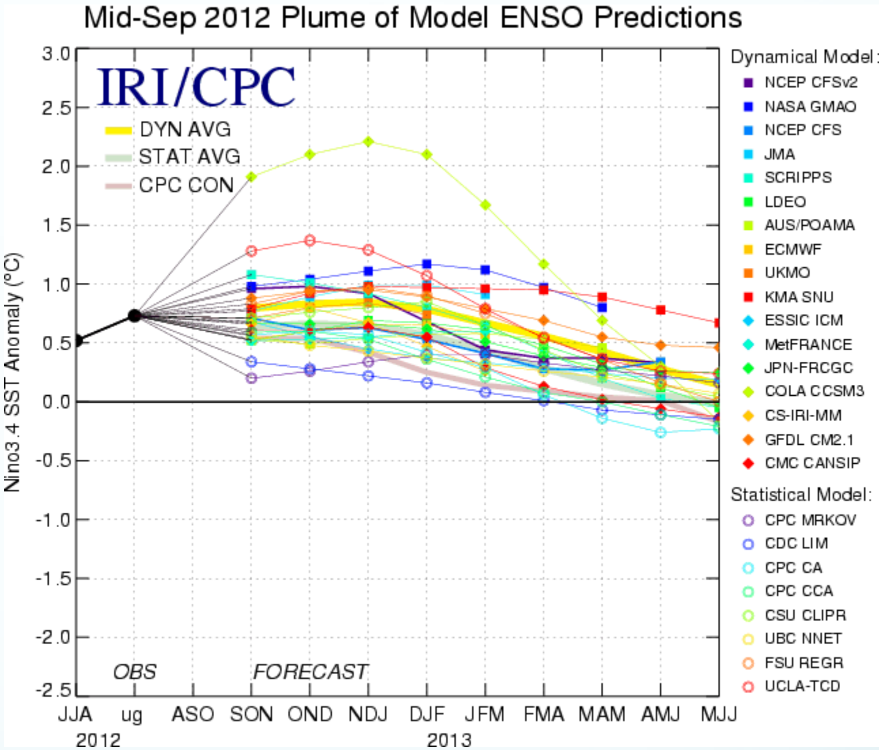
Dynamical and statistical models forecasts for SST in the Nino 3.4 region for nine overlapping 3-month periods.

Expected skill among models is not equal and generally decreases as lead time increases.

Forecast skill also is dependent on time of the year – better between June and December than between February and May.

Differences among the forecasts of the models reflect both differences in model design, and actual uncertainty in the forecast of the possible future SST scenario.

There has been increase from 9 dynamical models in 2002 to 17 dynamical models in 2012.



Low predictability in the past decade has masked a gradual improvement of ENSO predictions, with skill of dynamical models now exceeding that of statistical models. (Barnston et al., 2012)

IRI.Columbia.Edu/climate/ENSO/currentinfo/SST_table.html

Reliability Conditioned on Decadal Variability

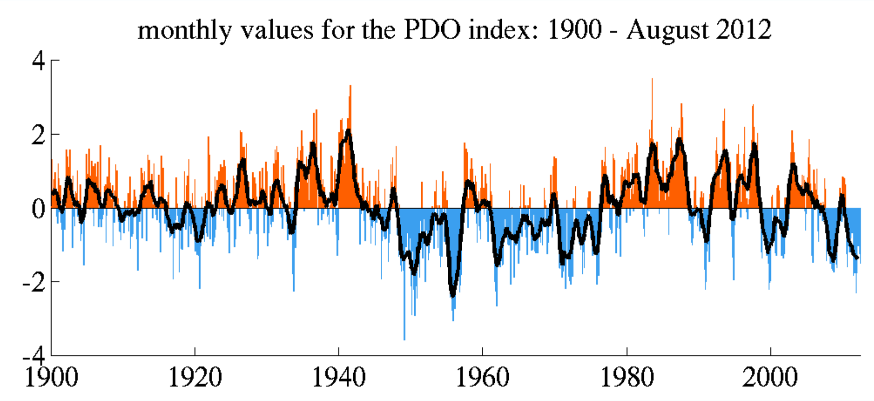
North Pacific Oscillation (NPO) modulates ENSO teleconnections affecting North America

El Niño (La Niña) signals are strong and stable during the high (low) NPO phase

Signals tend to be weak, spatially incoherent, and unstable during the El Niño–low NPO and La Niña–high NPO

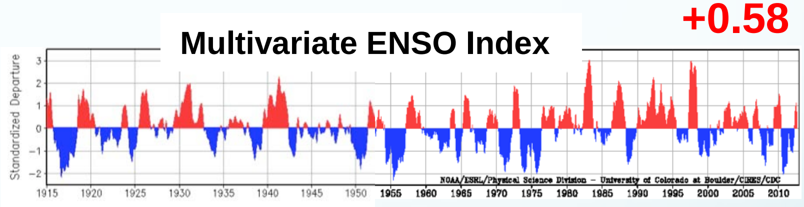
High (low) NPO epochs to be conducive to El Niño (La Niña) related predictability

Confidence in any North American ENSO-based climate forecast that resembles canonical El Niño or La Niña patterns should be conditioned on NPO phase



-1.93

+0.58

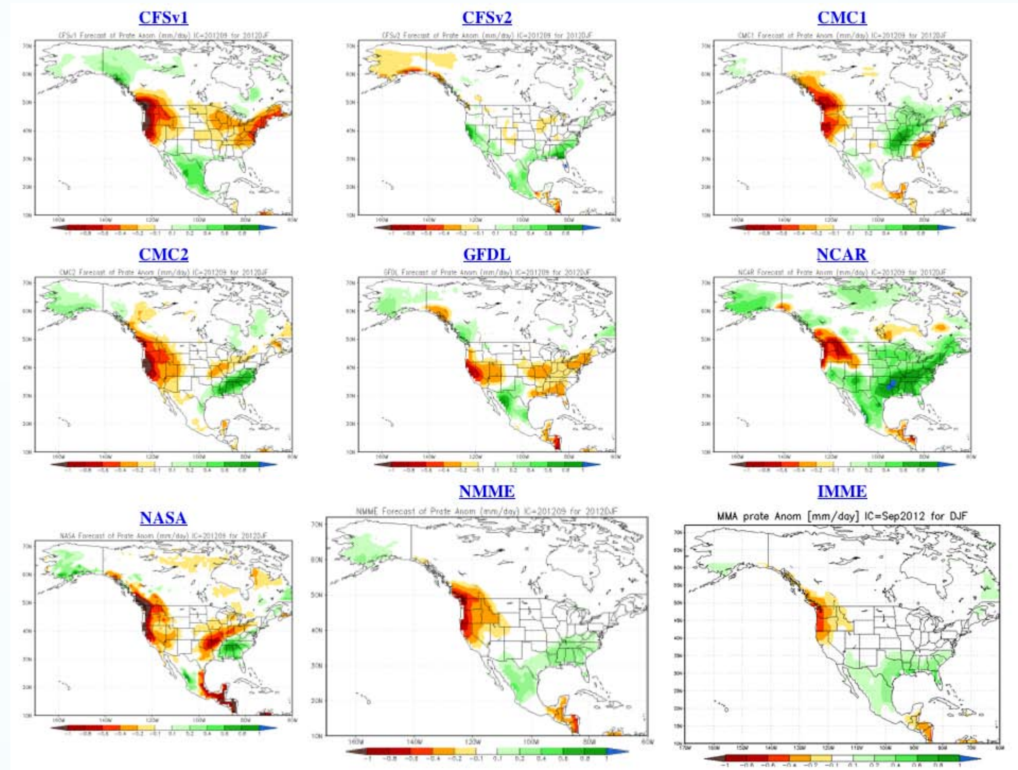


Gershunov and Barnett (1998)

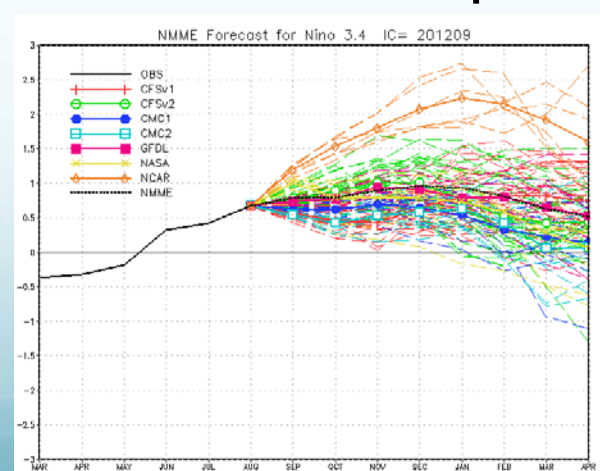
National MultiModel Ensemble (NMME)

An experimental multi-model seasonal forecasting system consisting of coupled models from US modeling centers including NOAA/NCEP, NOAA/GFDL, IRI, NCAR, NASA, and Canada's CMC

The multi-model ensemble approach has proven extremely effective at quantifying prediction uncertainty due to uncertainty in model formulation, and has proven to produce better prediction quality (on average) than any single model ensemble



Winter Season Precipitation Anomaly (mm/day)



NMME Nino 3.4 Plume

North American Land Data Assimilation System (NLDAS)

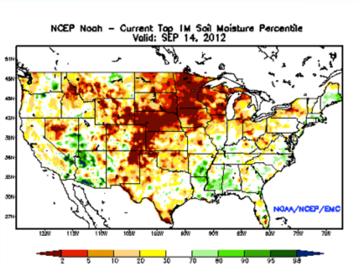
The NLDAS is a multi-institution collaborative project :
NOAA's National Centers for Environmental Prediction (NCEP),
NASA's Goddard Space Flight Center (GSFC),
NOAA's Office of Hydrologic Development (OHD),
Princeton University,
and University of Washington.

The NLDAS uses four land surface models:
Noah, Mosaic, SAC and VIC.

Four models are run in near real-time at the NCEP's Environmental Modeling Center to provide output products to support the US National Integrated Drought Information System (NIDIS) and US Drought Monitor.

Using the NLDAS Ensemble Mean Soil Moisture as a Drought Indicator

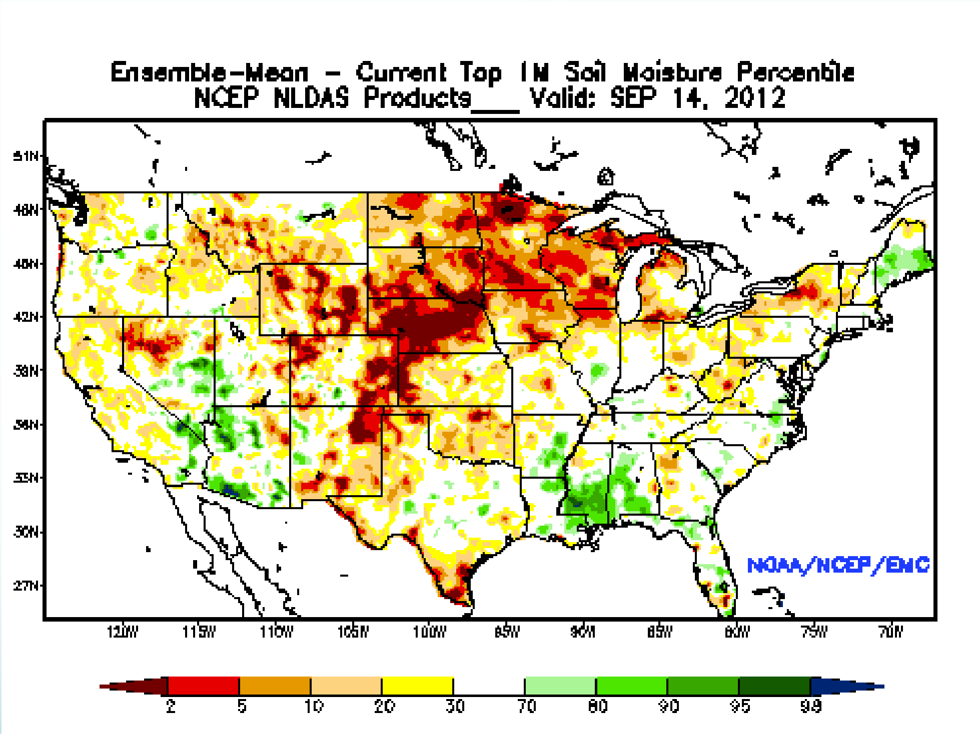
Shallow layers of soil moisture can be used as <u>agricultural</u> drought indicators. Model runoff as <u>hydro</u> indicators.

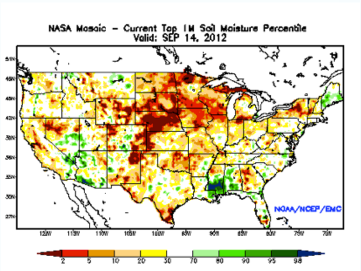


NCEP Noah

OHD SAC

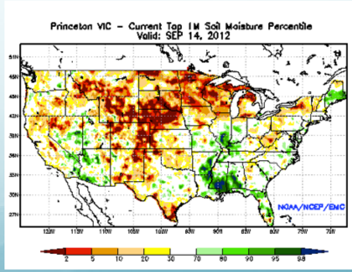
Ensemble Mean





NASA Mosaic

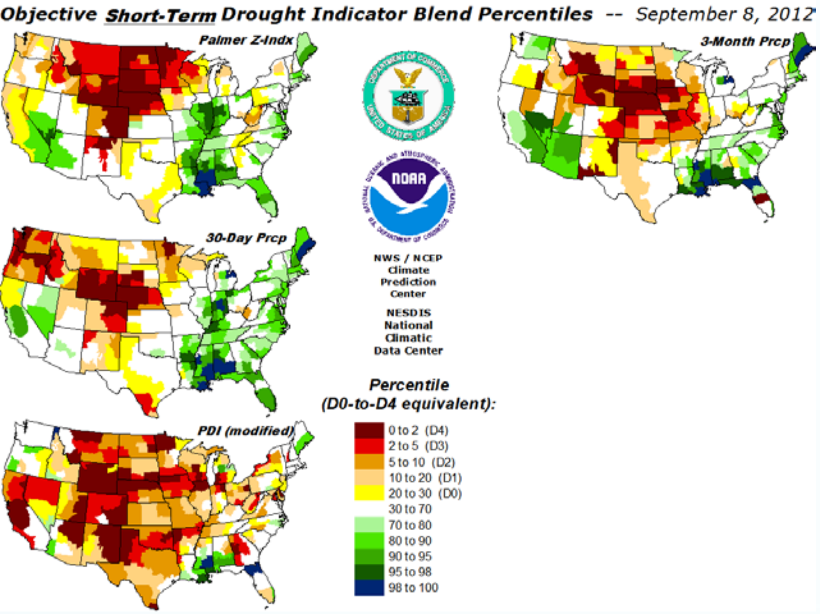
Princeton VIC

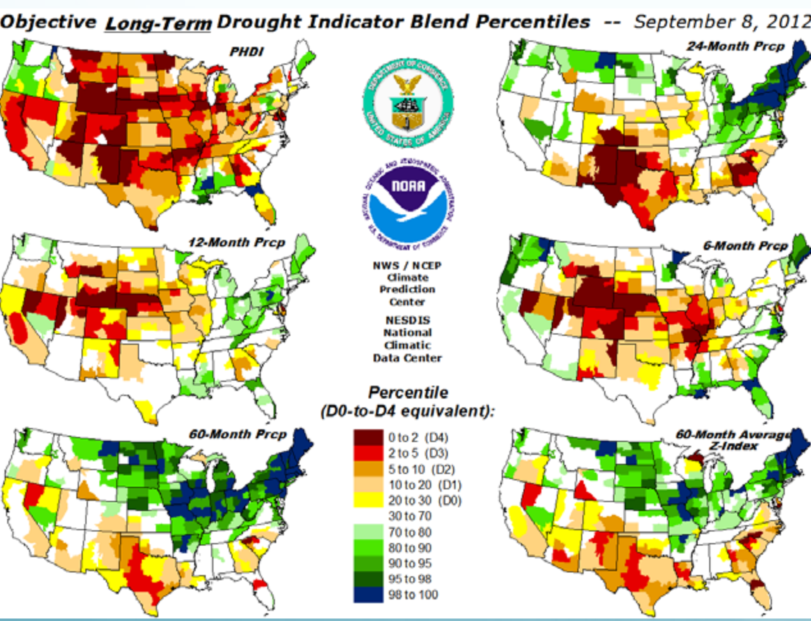


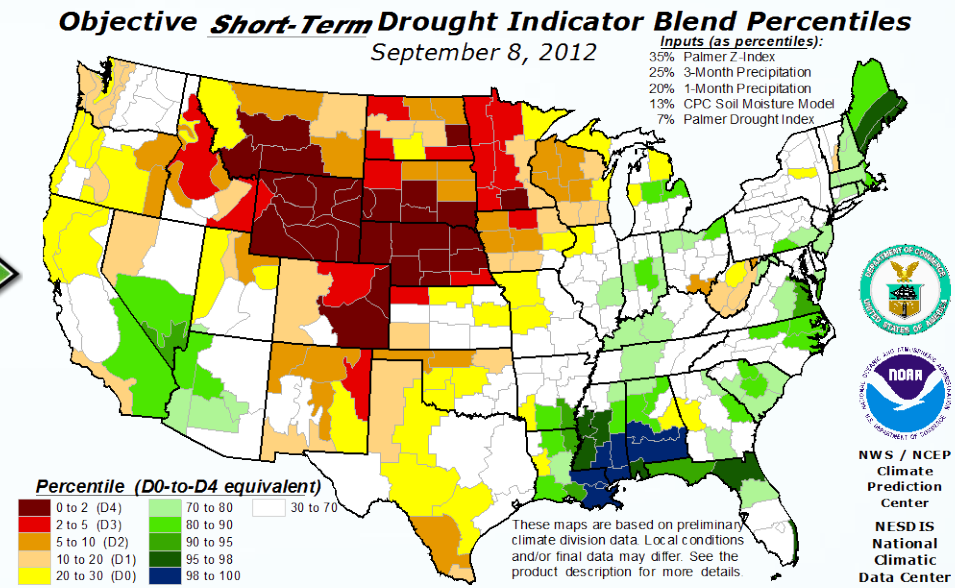
Percentile soil moisture levels correspond to U.S. Drought Monitor levels D0 to D4

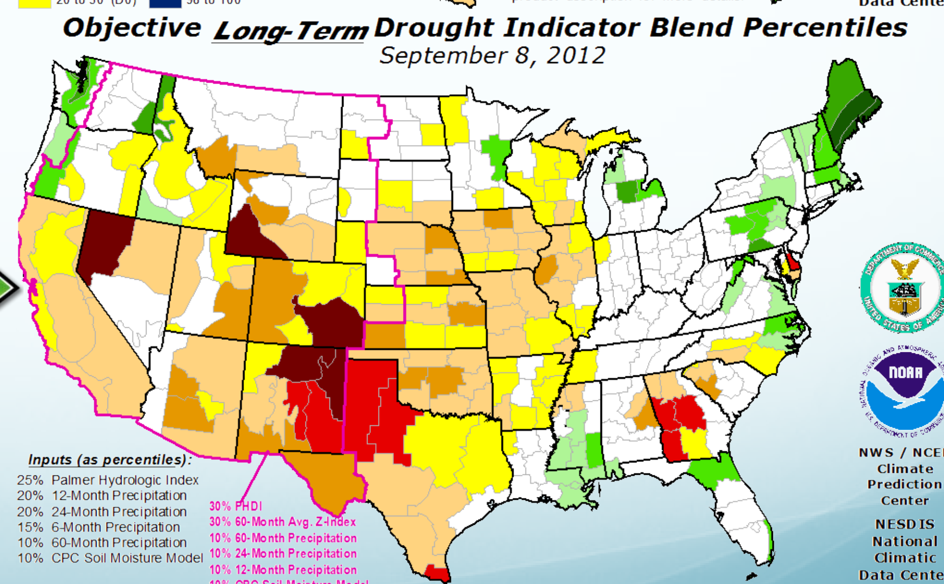
www.emc.ncep.noaa.gov/mmb/nldas/drought/

NOAA Drought Outlook Inputs



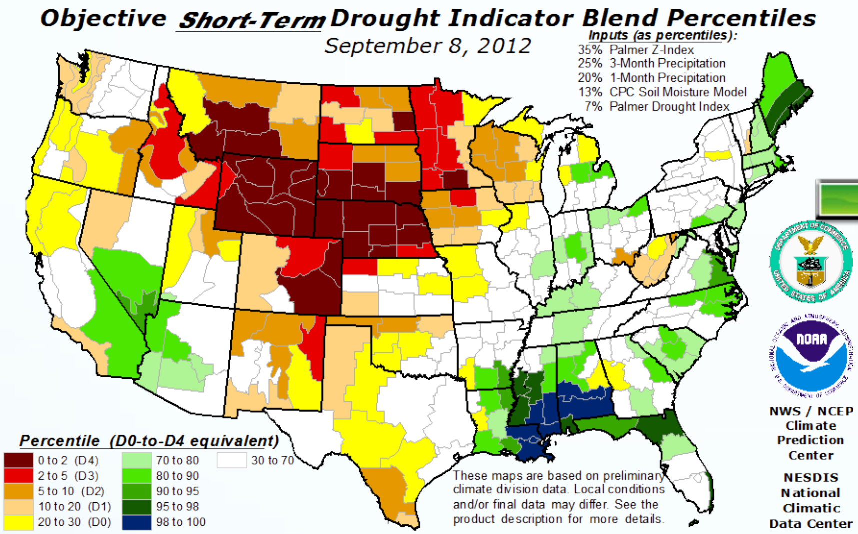


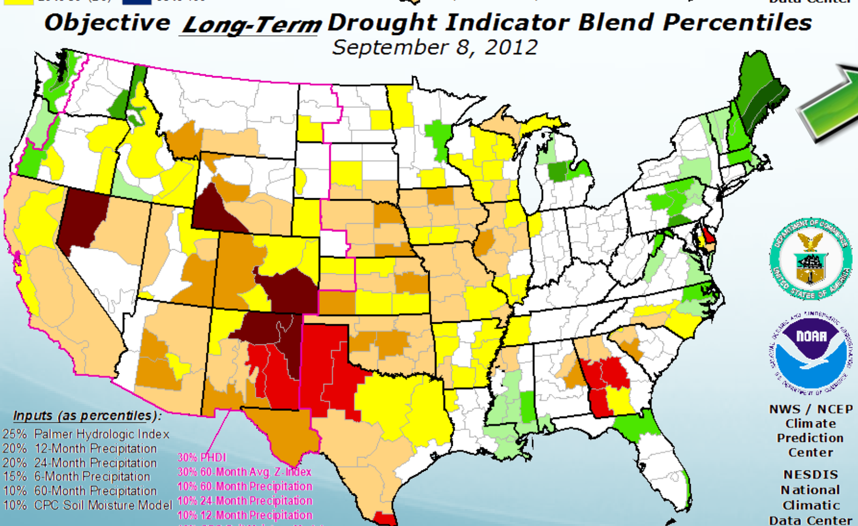




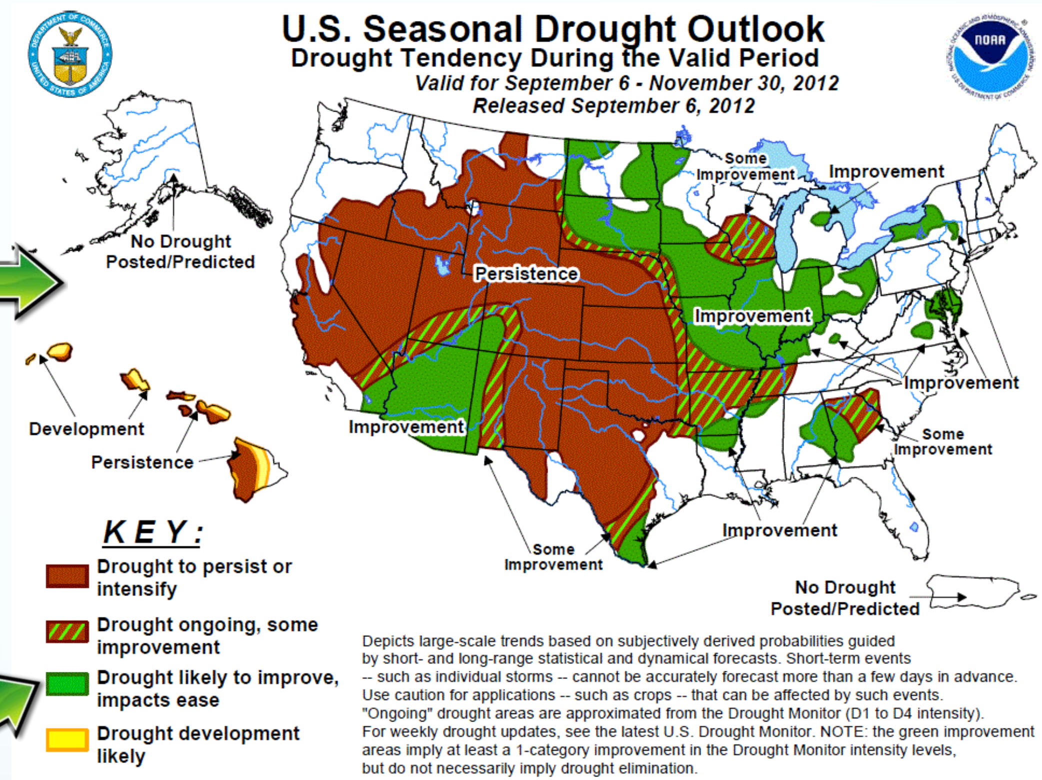
The short-term map (top) approximates impacts that respond to precipitation over the course of several days to a few months, such as agriculture, topsoil moisture, unregulated streamflows, and most aspects of wildfire danger. The long-term map (bottom) approximates impacts that respond to precipitation over the course of several months to a few years, such as reservoir content, groundwater depth and lake levels. HOWEVER, the relationship between indicators and impacts can vary significantly with location and season. THIS IS PARTICULARLY TRUE OF WATER SUPPLIES, which are additionally affected by source, and management practices.

Bi-Weekly NOAA Drought Outlook
Seasonal Assessment and Discussion



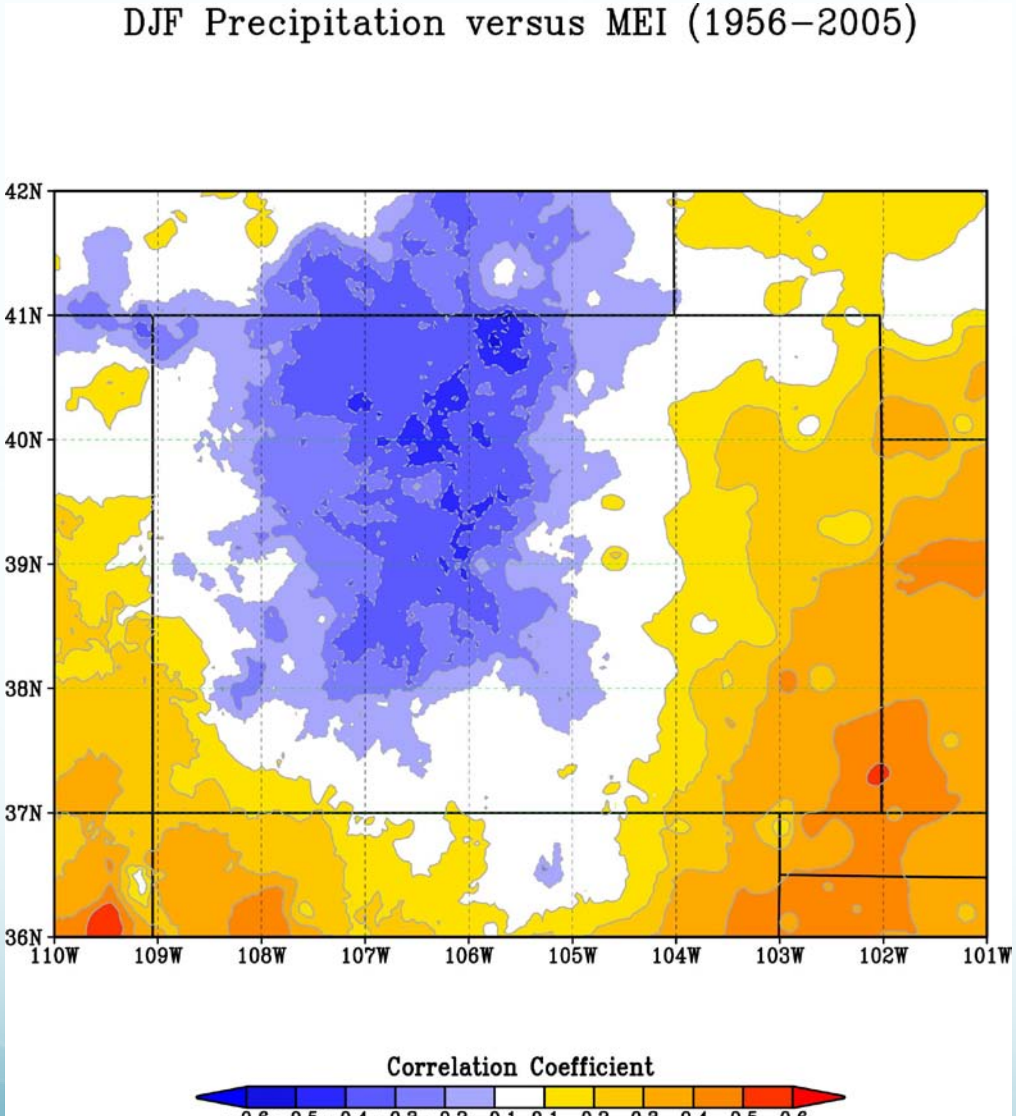


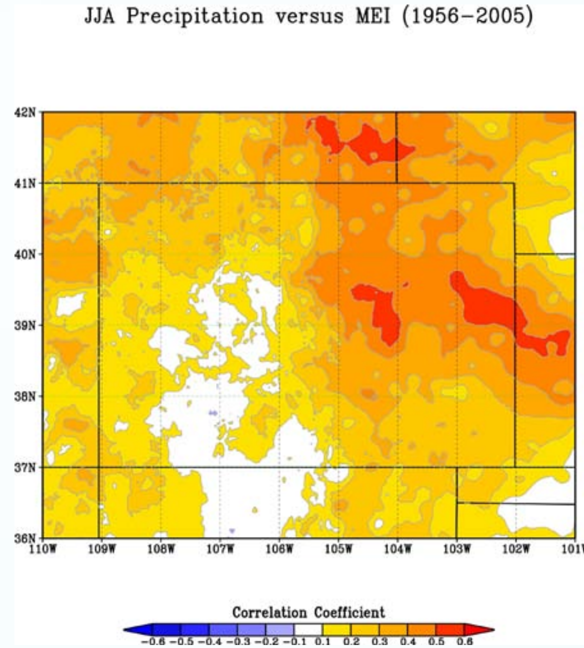
The short-term map (top) approximates impacts that respond to precipitation over the course of several days to a few months, such as agriculture, topsoil moisture, unregulated streamflows, and most aspects of wildfire danger. The long-term map (bottom) approximates impacts that respond to precipitation over the course of a few years, such as reservoir content, groundwater depth and lake levels. HOWEVER, the relationship between indicators and impacts can vary significantly with location and season. THIS IS PARTICULARLY TRUE OF WATER SUPPLIES, which are additionally affected by source, and management practices.



Tools include official CPC one month and seasonal temperature and precipitation outlooks, various medium- and short-range forecasts and models such as the 6-10 day and 8-14 day forecasts, the most recent 384-hour GFS total precipitation amounts, the soil moisture tools based on the Constructed Analog on Soil (CAS) moisture, the Climate Forecast System (CFS), the four-month Palmer drought termination and amelioration probabilities, climatology, initial conditions, and NLDAS

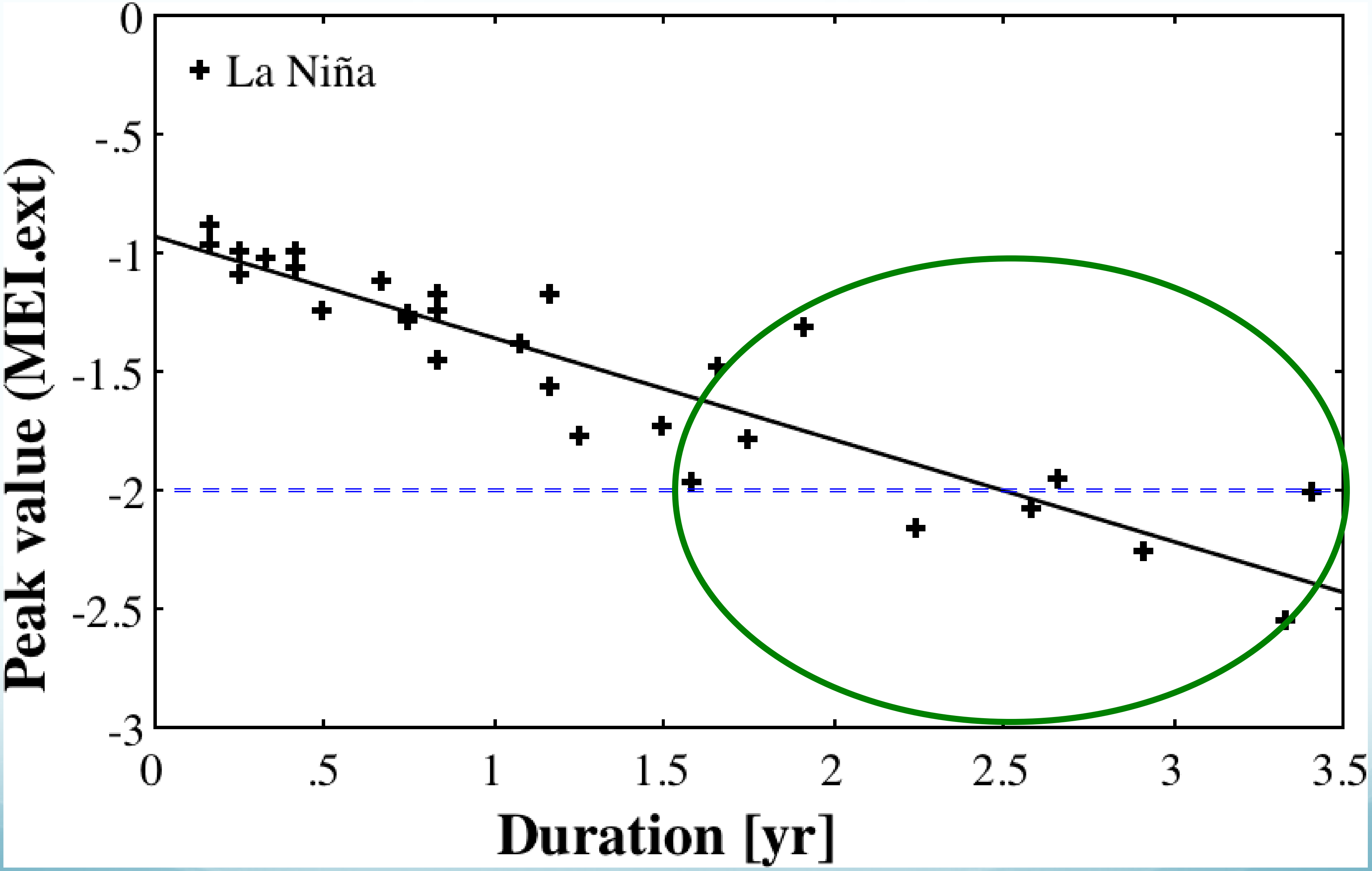
ENSO footprint in Colorado





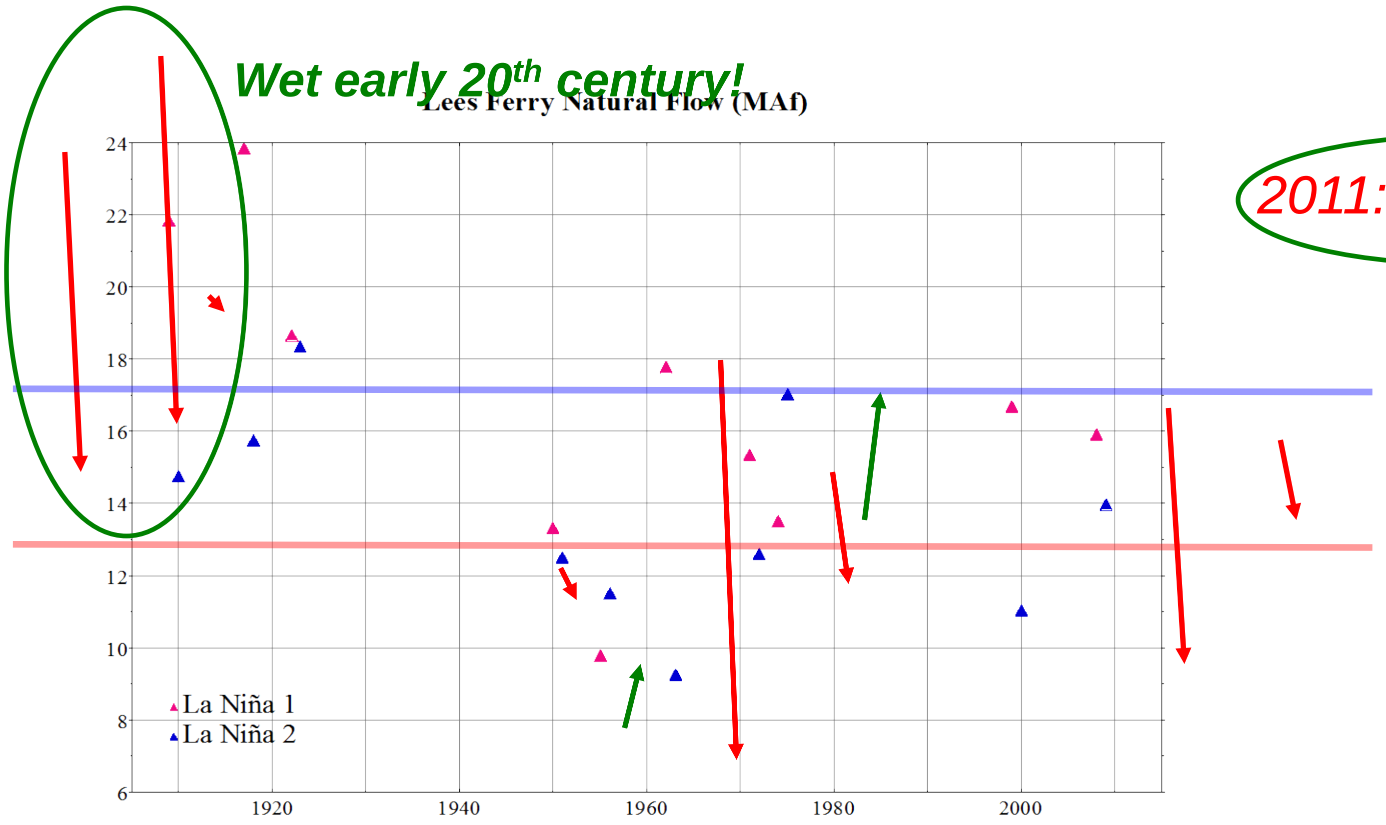
While most of CO tends to be wetter during El Niño than La Niña (top right map for summer), things get more complicated during winter (left): our mountains are often WET with La Niña rather than El Niño, reversing the typical ENSO footprint during the rest of the year.

Sometimes, ENSO can be predicted > 1yr!



http://www.esrl.noaa.gov/psd/enso/mei.ext/

'Double-dip' Las Niñas



2011: 20.49MAf(e)

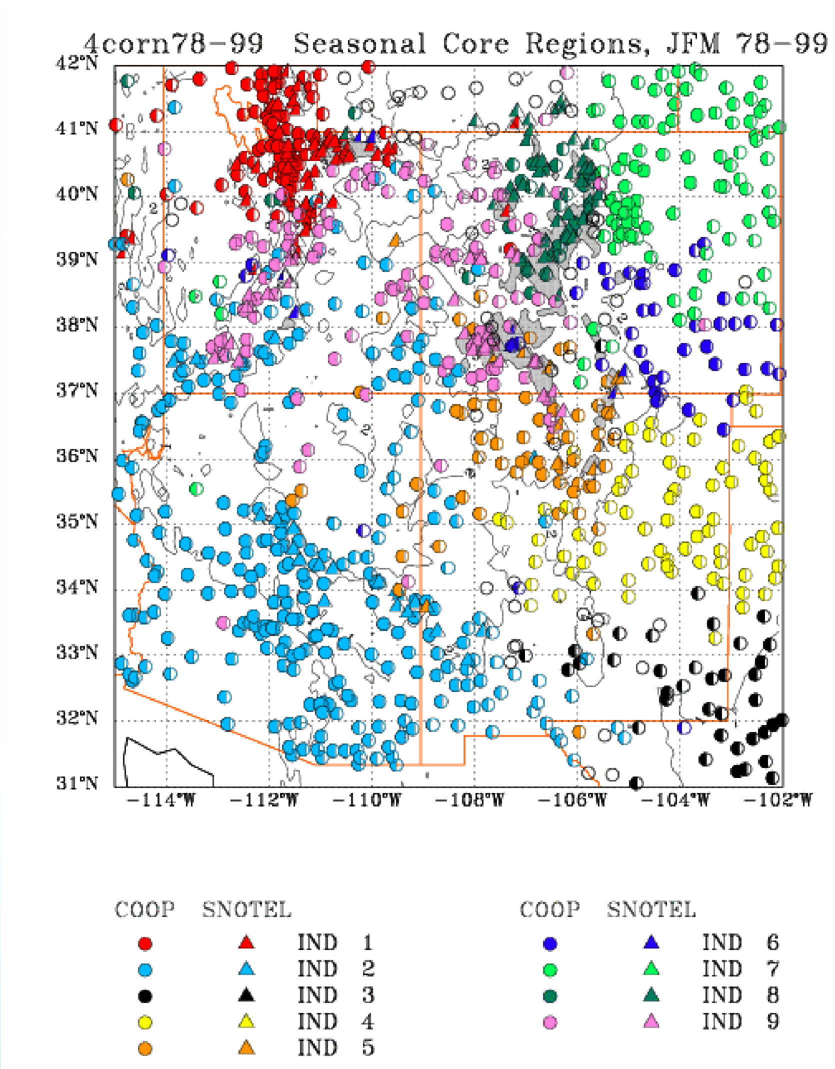
Mean flow for Year 1: 16.7 MAf (Δ= +1.7MAf

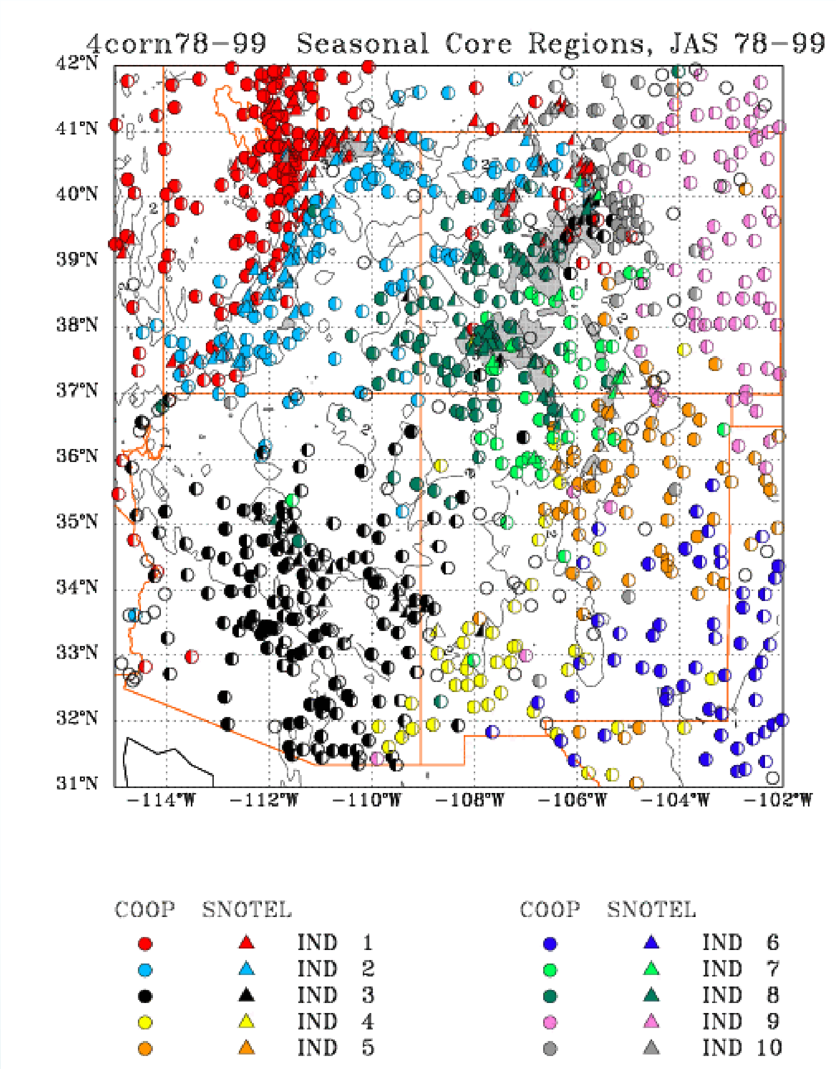
Mean flow for Year 2 13.7 MAf (Δ= -1.3MAf)

Data courtesy of James Prairie (Bur. Rec.)

Before 2010, a drop in runoff has been typical (8 of 10 cases) for 2nd La Niña year runoff for the Colorado River. This reduction tends to be biggest for cases that start out wet – so, the decline in 2012 runoff vs. 2011 is not unexpected!

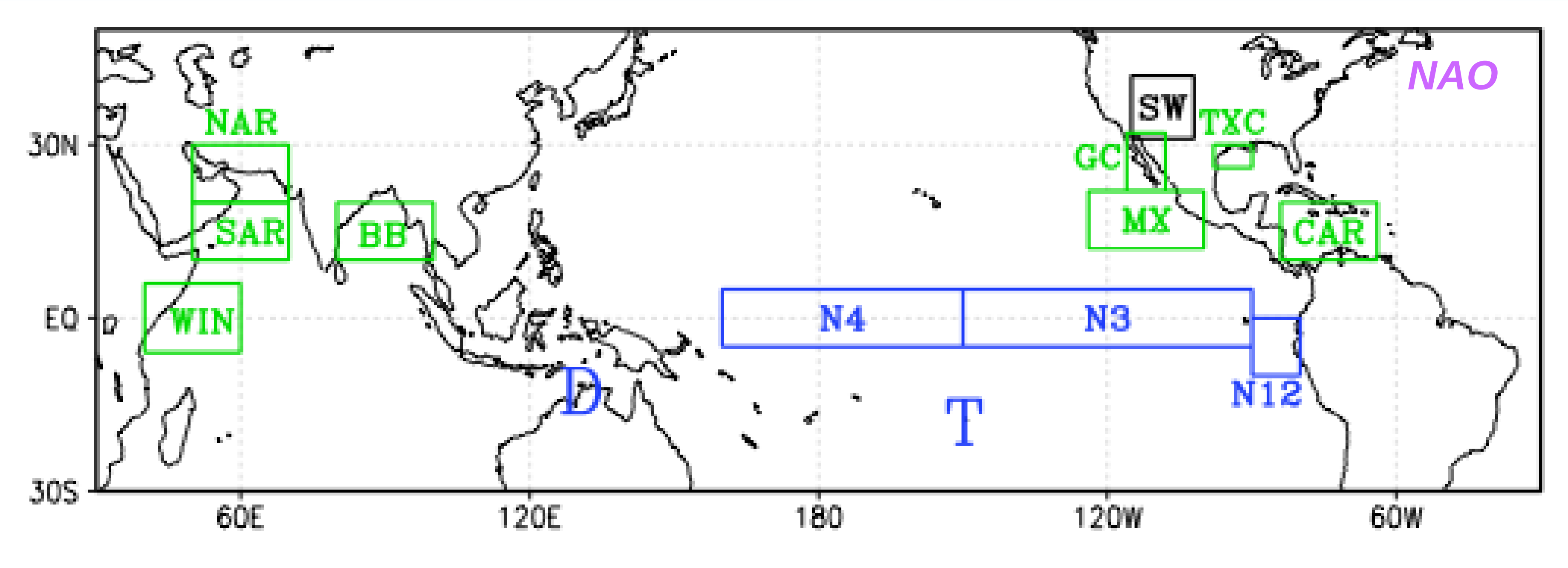
Interior Southwest 1st generation 'climate divisions'





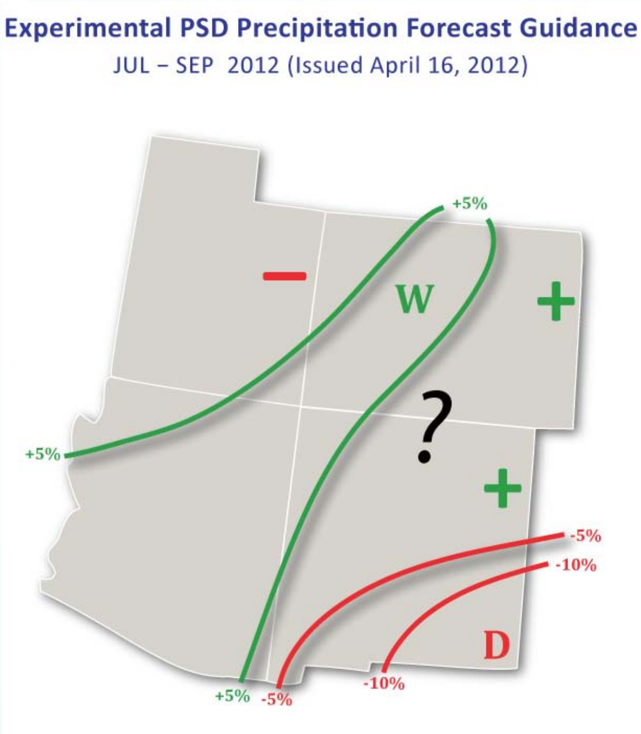
Climate tends to show similar anomalies at a time where the coloring is the same. Fractional fill-in for each station symbol is proportional to locally explained variance by "core region" time series. This formed the basis for a decade of seasonal forecasting.

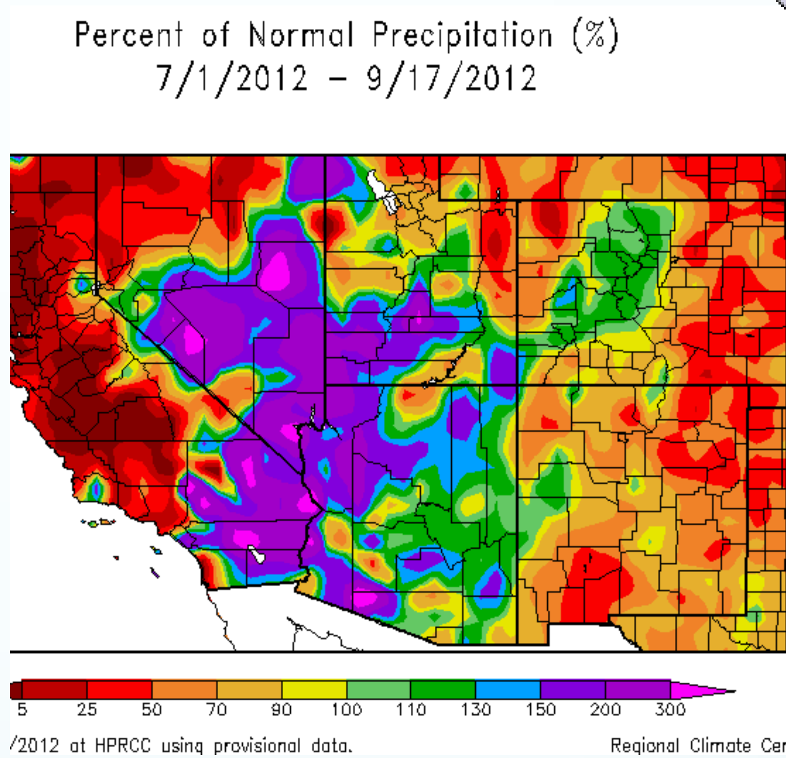
Useful predictor regions for this region (SW)



Aside from ‘flavors of ENSO’ (east-west differences in SST anomalies, onset and demise timing), the Indian Ocean stands out with four important SST regions (**N**orthern and **S**outhern **AR**abian Sea, **B**ay of **B**engal, and equatorial **W**est **IN**dian Ocean). Near-U.S. SST (**G**ulf of **C**alifornia, West Coast of **M**e**X**ico, **CAR**ibbean and near-**T**e**X**as **C**oast) may achieve skill by influencing regional moisture transports. The ***NAO*** plays a frequent role as well, presumably via its impact on Atlantic SST.

Statistical Forecast for July-September 2012





April's forecast for July-September 2012 (left) was optimistic from AZ into CO, and pessimistic for eastern UT and southern NM. ***As of mid-September, the monsoon delivered above-normal precipitation from AZ into the north-central mountains of CO, while it was dry to the northwest and southeast of that enhanced moisture tongue. This is about as good as it gets for summer moisture forecasts. Possible culprit for lack of precipitation in CO and NM: smoke from wildfires that lingered through the summer!***