Building a drought monitoring toolbox for AZ: Experimental Tools and Programs

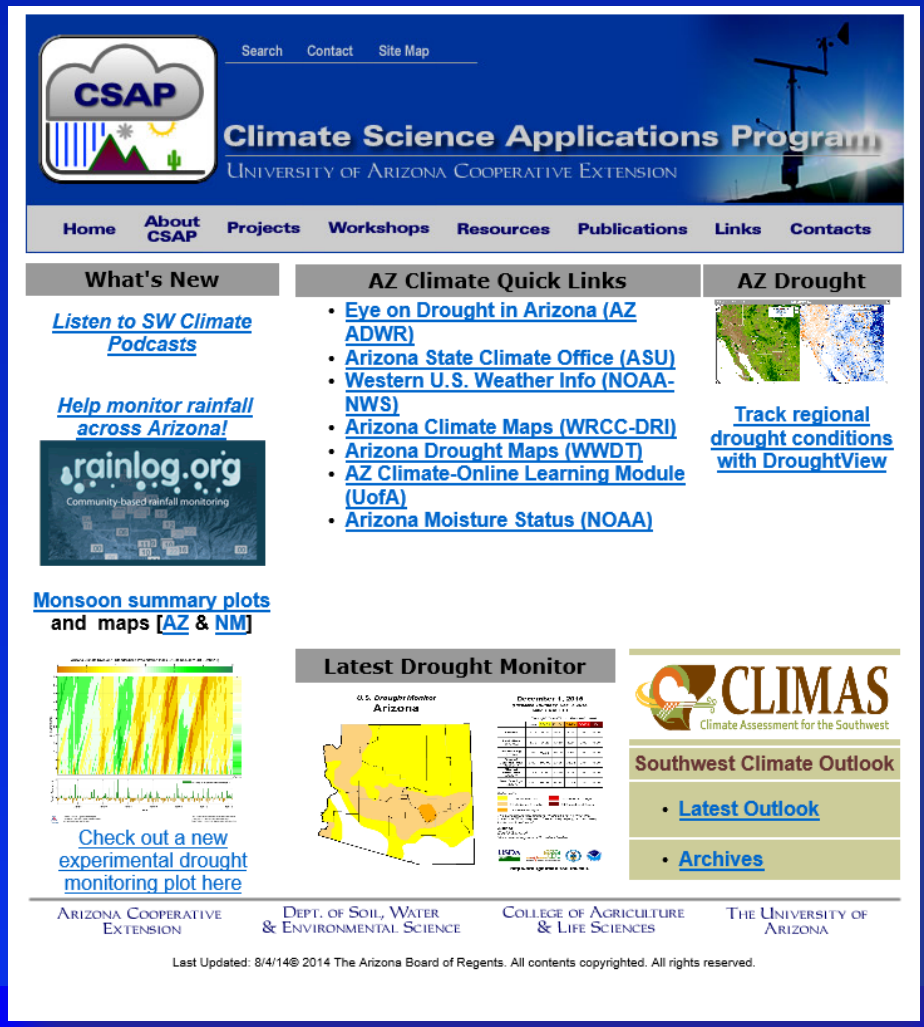
Mike Crimmins
Assoc. Professor/Extension Specialist
Dept. of Soil, Water, & Environmental Science
The University of Arizona

Presentation Overview

- Tracking drought across Arizona is hard: seasonality, topography, multiple timescales
- Tools need to be flexible and able to capture different scales of variability
- No ‘silver bullet’ tool or product
- Consulting multiple drought information products good practice…but which ones?

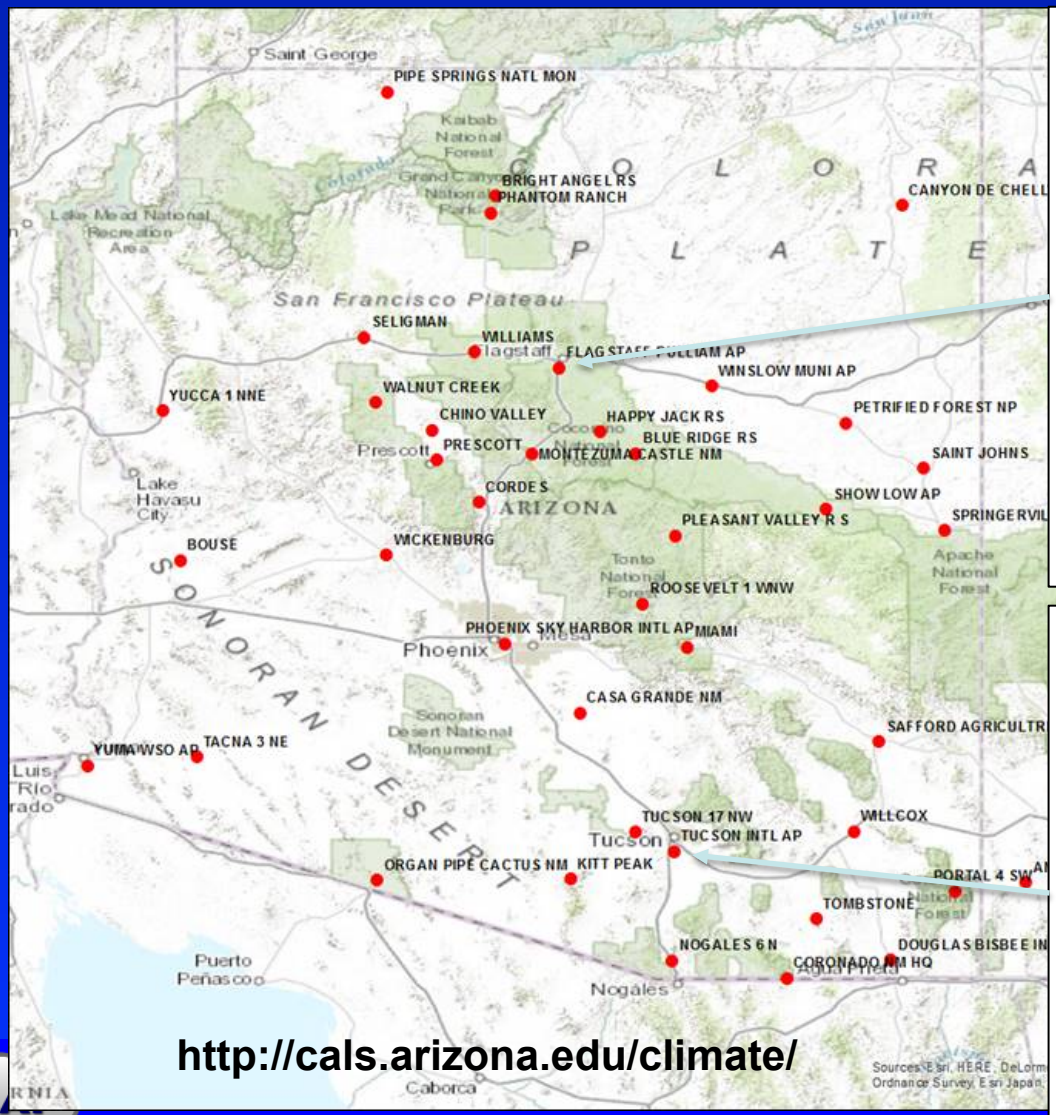
Climate Science Applications Program

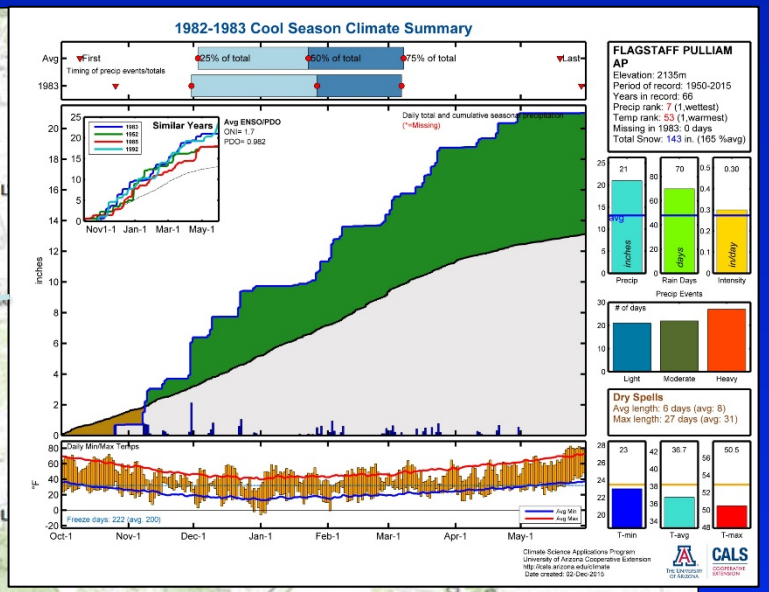
- Deliver relevant climate information to agricultural and resource management communities
- Conduct applied research on SW US climate
- Make climate science useful and useable through extension programming
- Connect CLIMAS and broader UofA climate science community to Extension

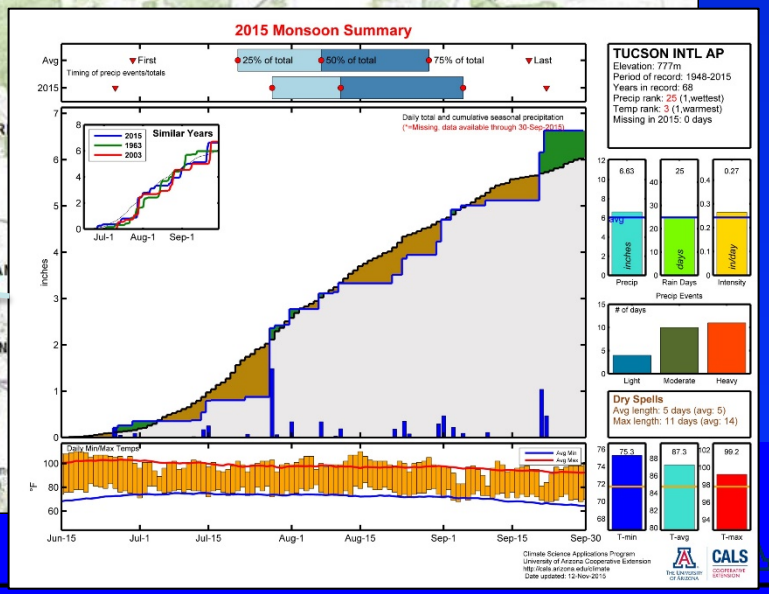


http://cals.arizona.edu/climate/

Station level seasonal climate summaries

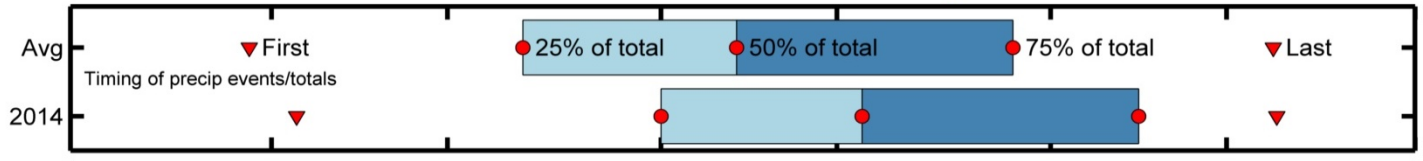


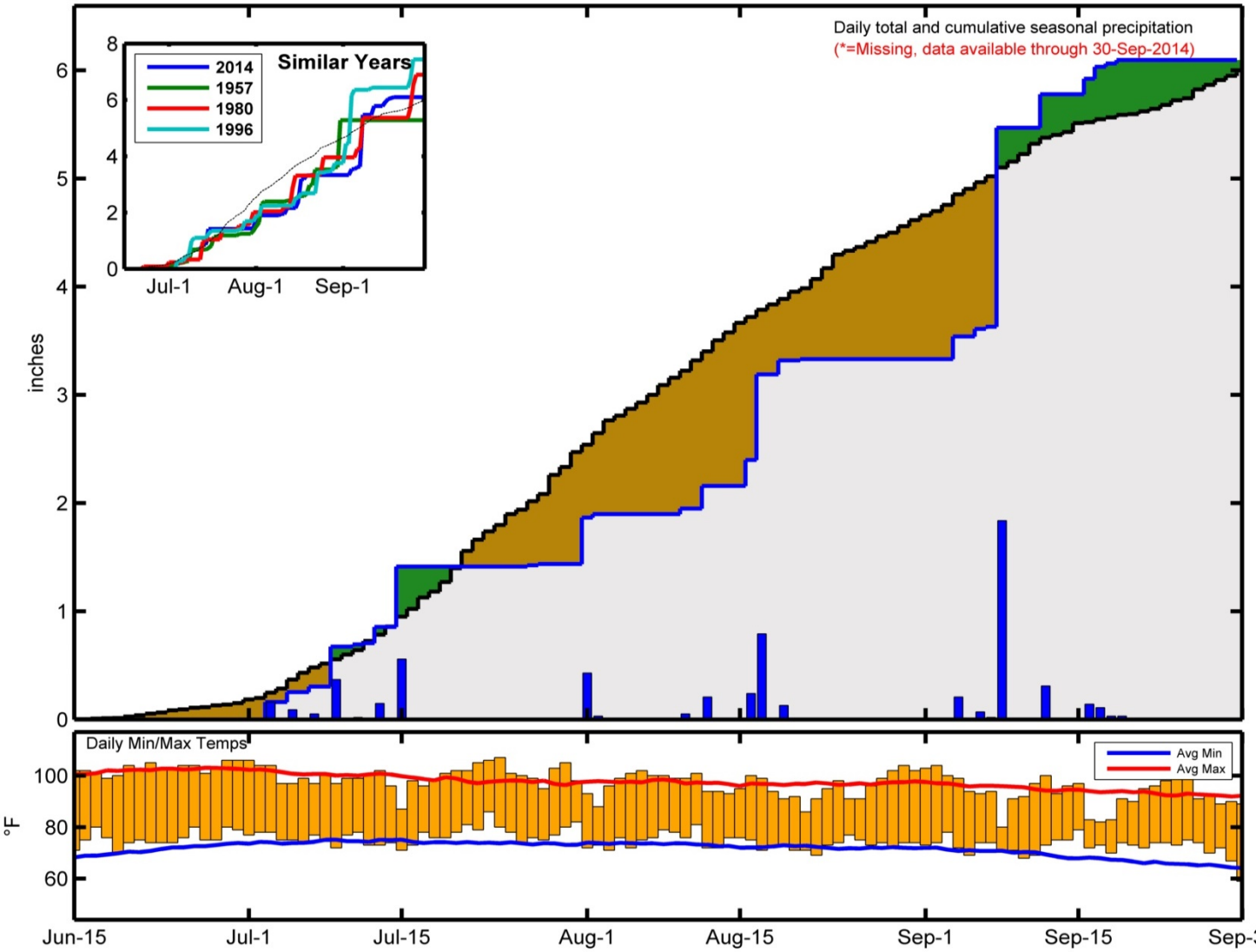




http://cals.arizona.edu/climate/

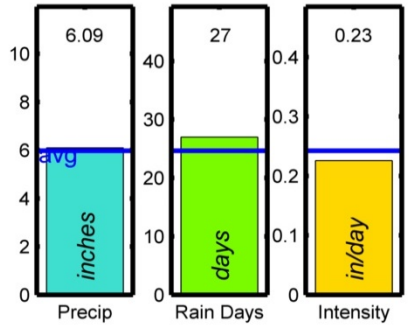
2014 Monsoon Summary

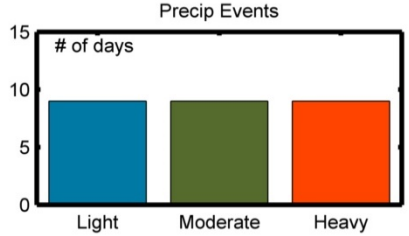




TUCSON INTL AP

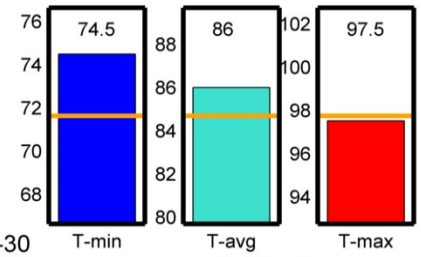
Elevation: 777m
Period of record: 1946-2014
Years in record: 69
Precip rank: 31 (1,wettest)
Temp rank: 12 (1,warmest)
Missing in 2014: 0 days





Dry Spells

Avg length: 4 days (avg: 5)
Max length: 13 days (avg: 14)

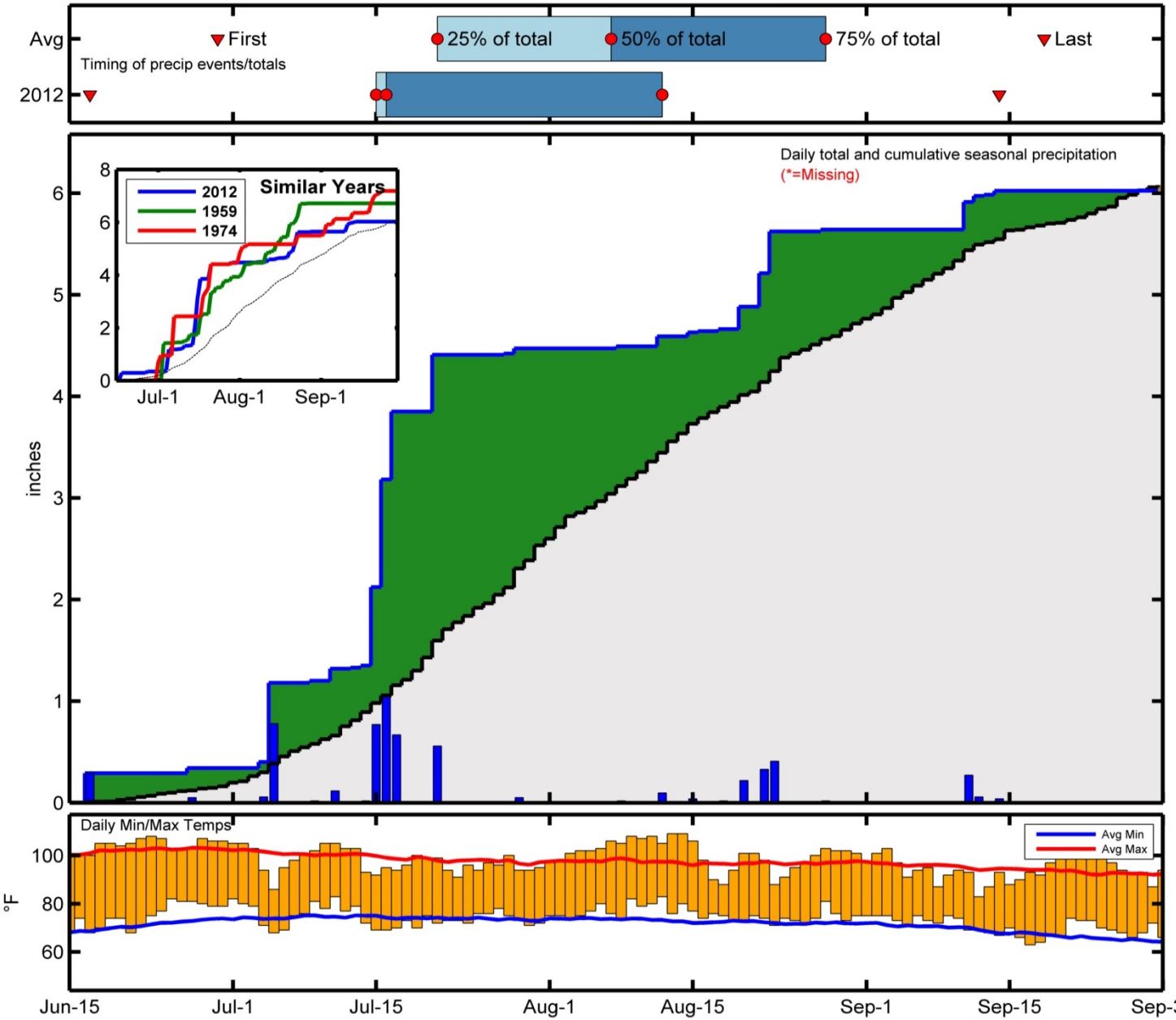


Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate
Date updated: 18-Nov-2014

THE UNIVERSITY OF ARIZONA | CALS COOPERATIVE EXTENSION

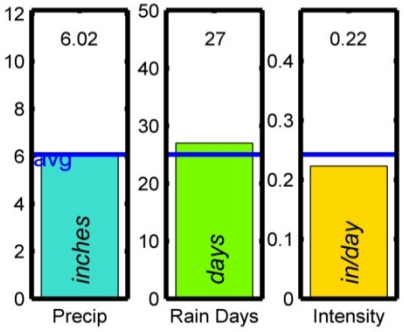
http://cals.arizona.edu/climate/misc/monsoon/monsoon_summaries.html

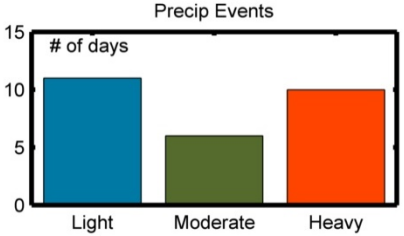
2012 Monsoon Summary



TUCSON INTL AP

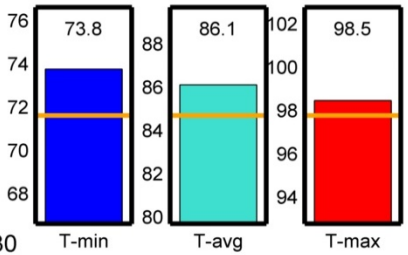
Elevation: 777m
Period of record: 1950-2013
Years in record: 64
Precip rank: 31 (1,wettest)
Temp rank: 10 (1,warmest)
Missing in 2012: 0 days





Dry Spells

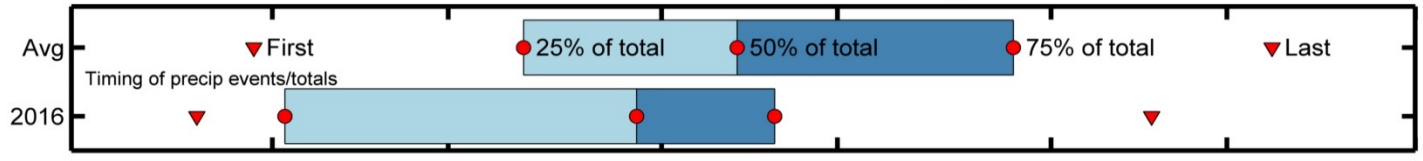
Avg length: 4 days (avg: 5)
Max length: 13 days (avg: 14)

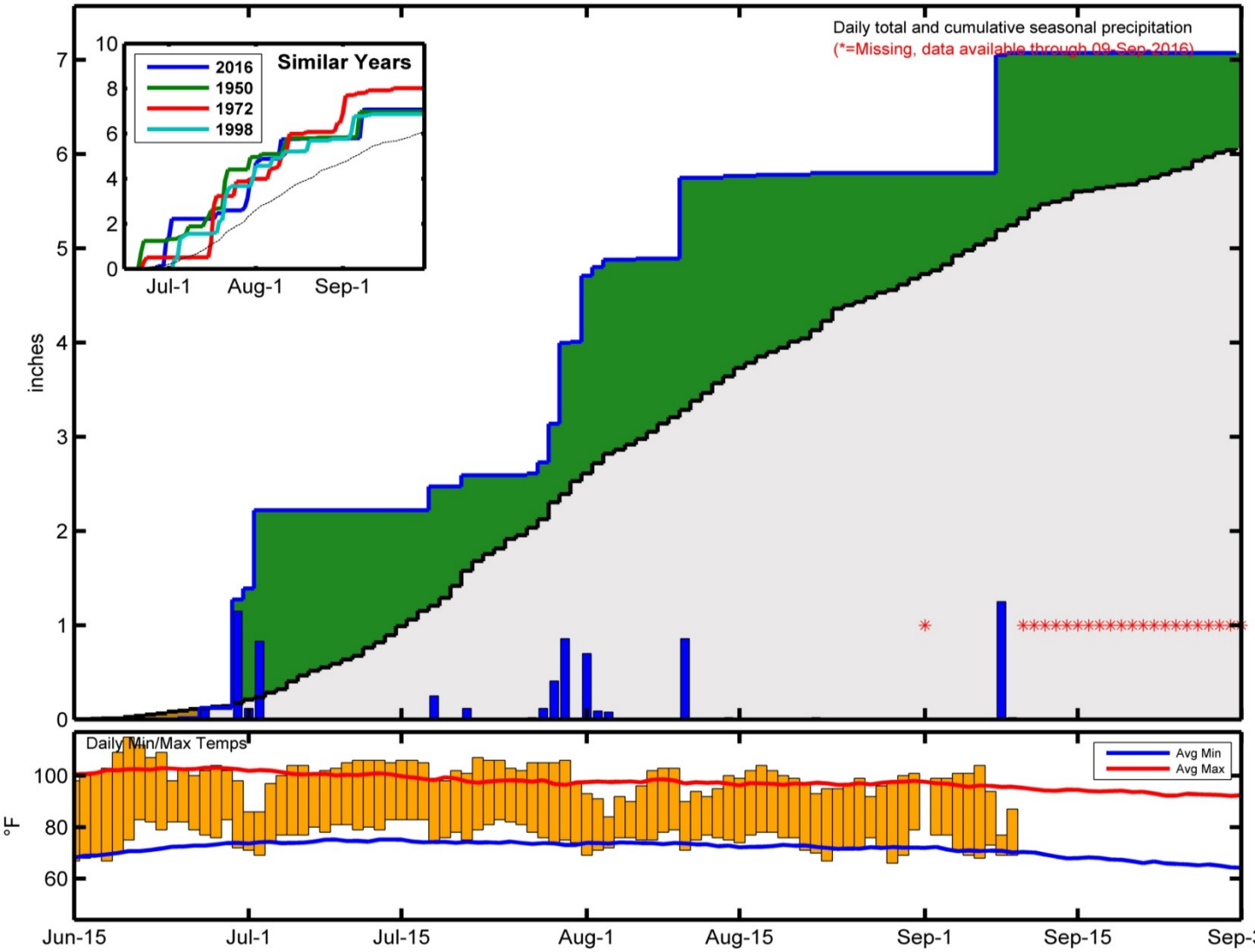


Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate
Date created: 03-Oct-2013

THE UNIVERSITY OF ARIZONA | CALS COOPERATIVE EXTENSION

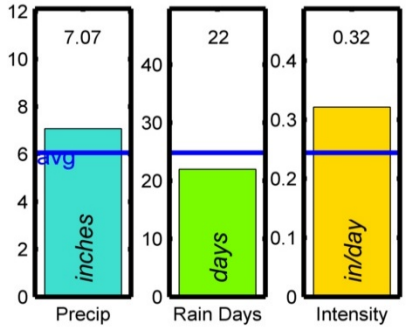
2016 Monsoon Summary

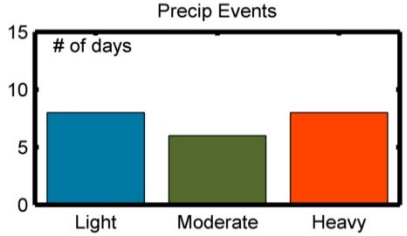




TUCSON INTL AP

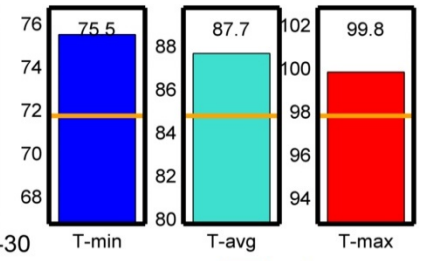
Elevation: 777m
Period of record: 1948-2016
Years in record: 69
Precip rank: 18 (1,wettest)
Temp rank: 2 (1,warmest)
Missing in 2016: 22 days





Dry Spells

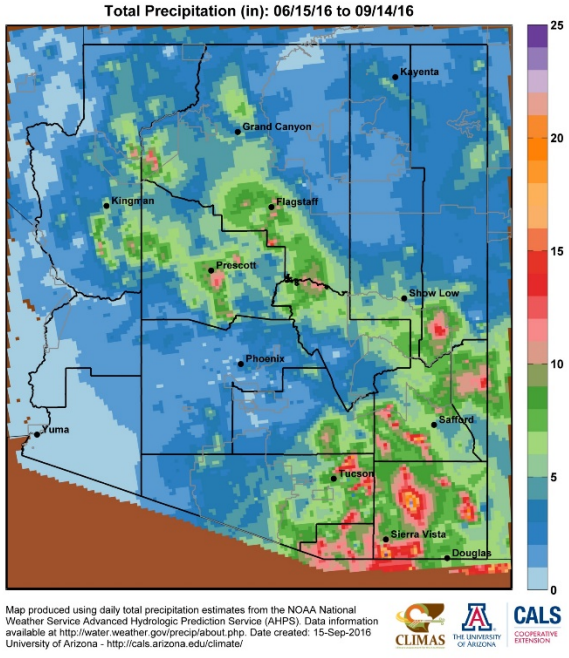
Avg length: 5 days (avg: 5)
Max length: 16 days (avg: 14)

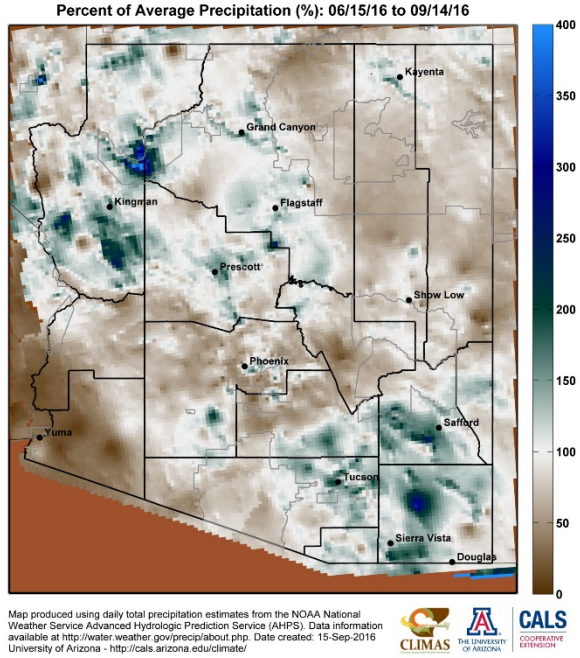


Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate
Date updated: 13-Sep-2016

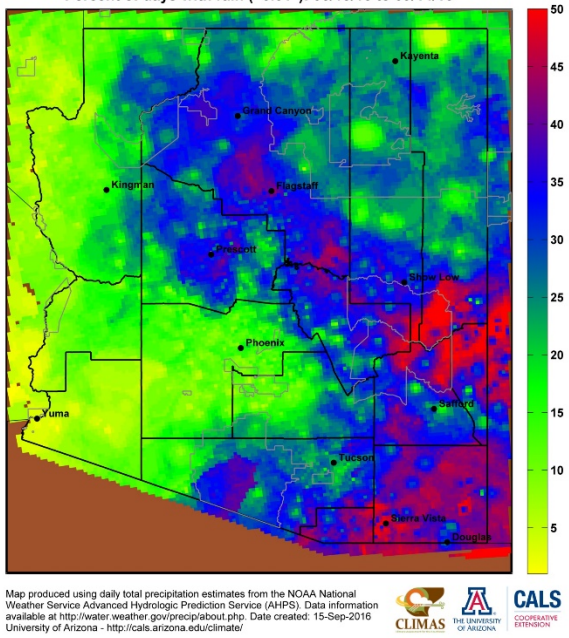
THE UNIVERSITY OF ARIZONA | CALS COOPERATIVE EXTENSION

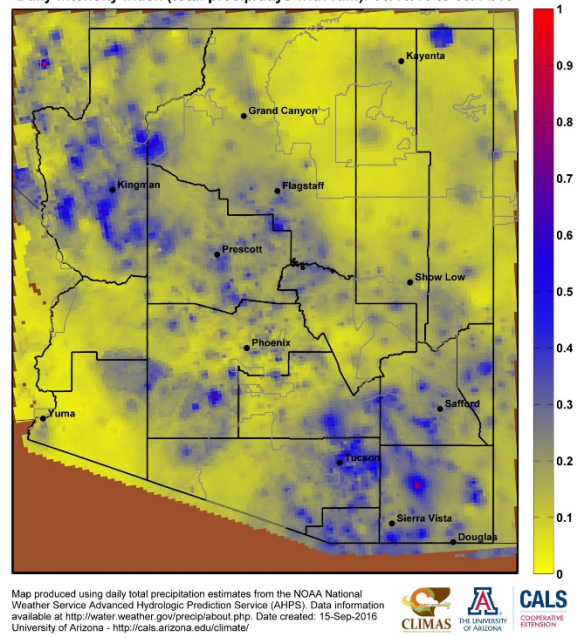
Monsoon Season Precip Monitoring Maps





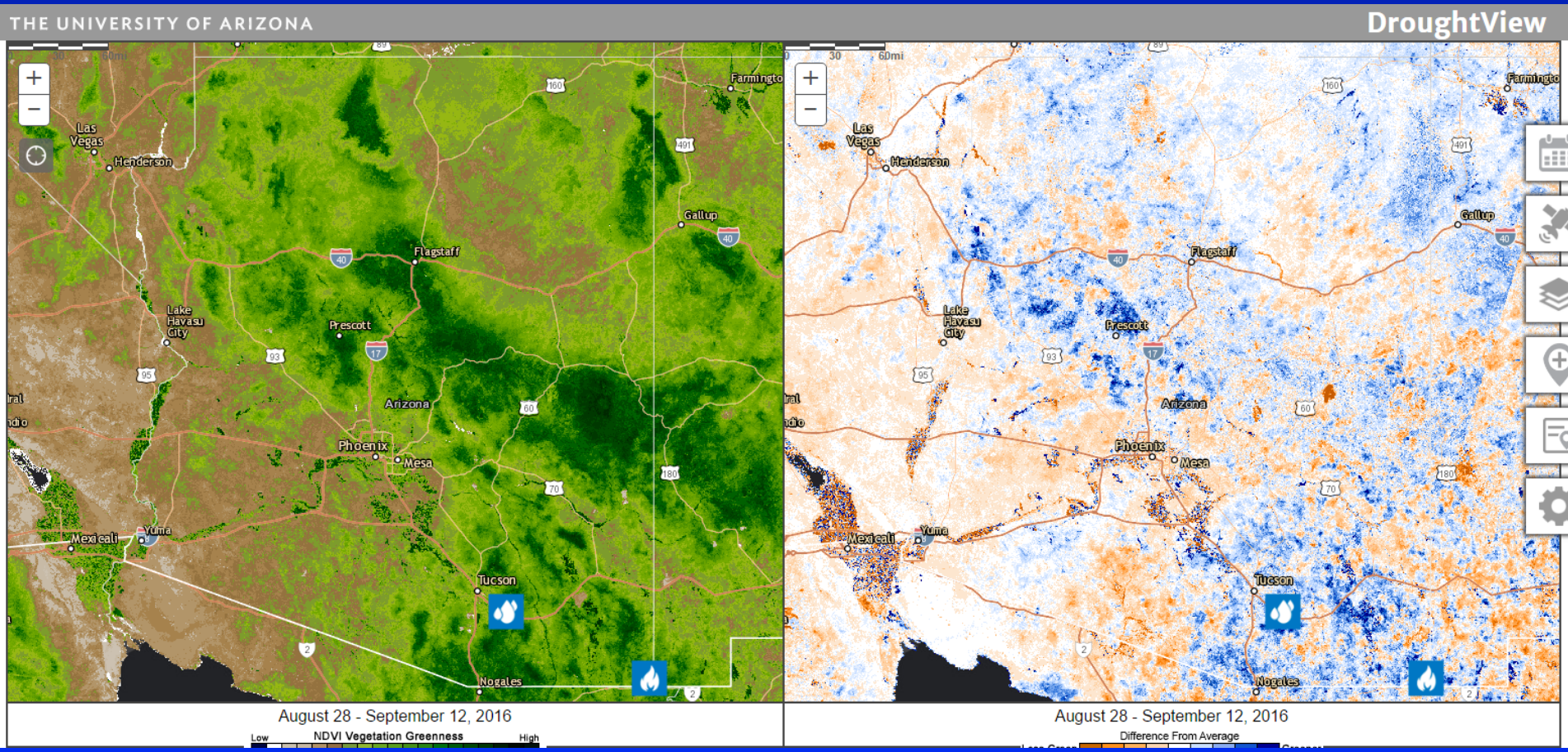
http://cals.arizona.edu/climate/





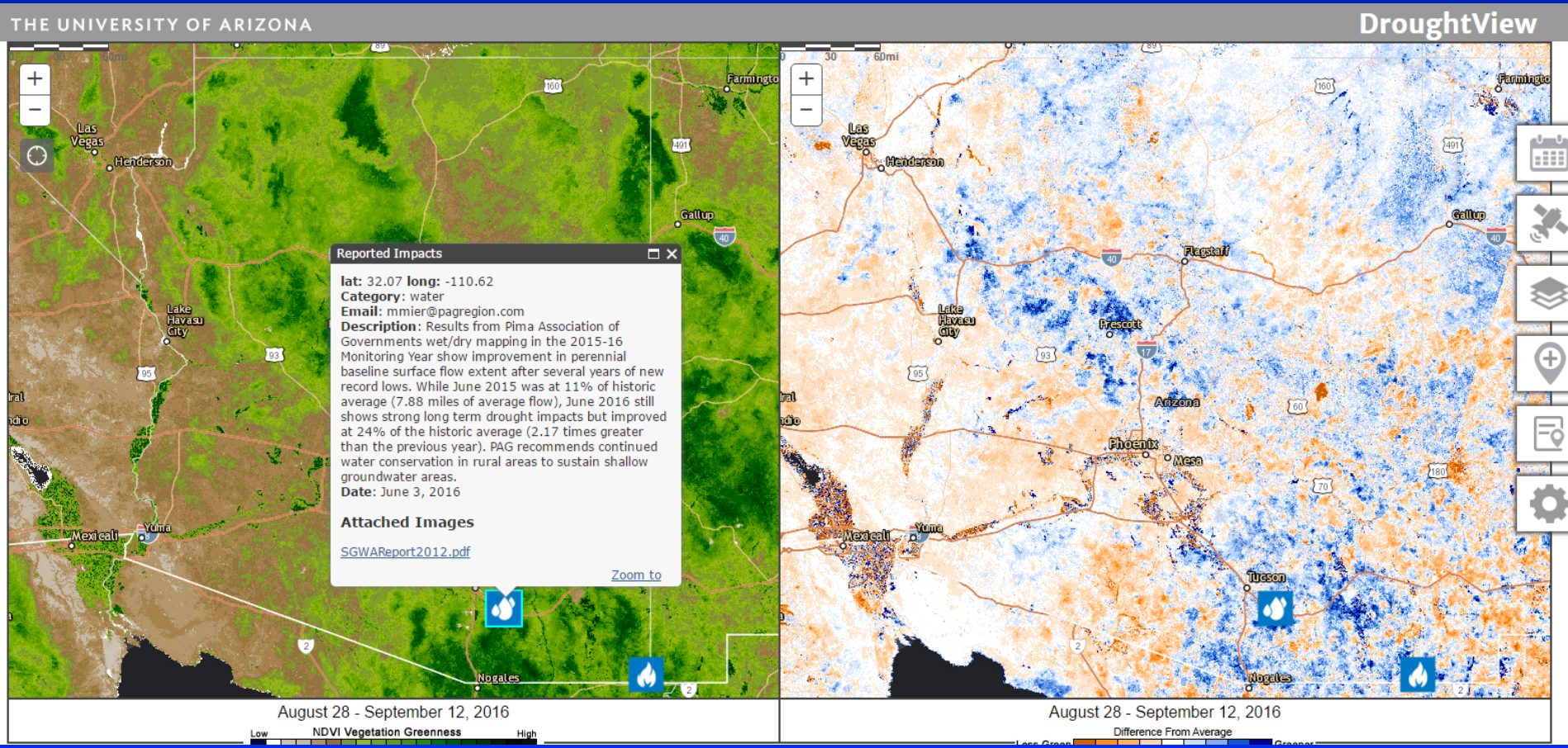
CSAP
Climate Science Applications Program

DroughtView: Remote sensing (vegetation 'greenness') visualization tool

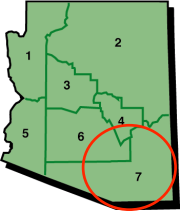


http://droughtview.arizona.edu/

DroughtView: Remote sensing (vegetation 'greenness') visualization tool



http://droughtview.arizona.edu/



Arizona Climate Division 7, Standardized Precipitation Index - (1-60 mos, Jan1981 - Aug2016)

-3 -2 -1 0 1 2 3

DRY Average WET

Long-term Drought

Short-term Drought

SPI Length(mos)

60 55 50 45 40 35 30 25 20 15 10 5

Aug16

Monthly Precipitation Anomaly (in.)

Precip Anom(in.)

4 2 0

Jan85 Jan90 Jan95 Jan00 Jan05 Jan10 Jan15

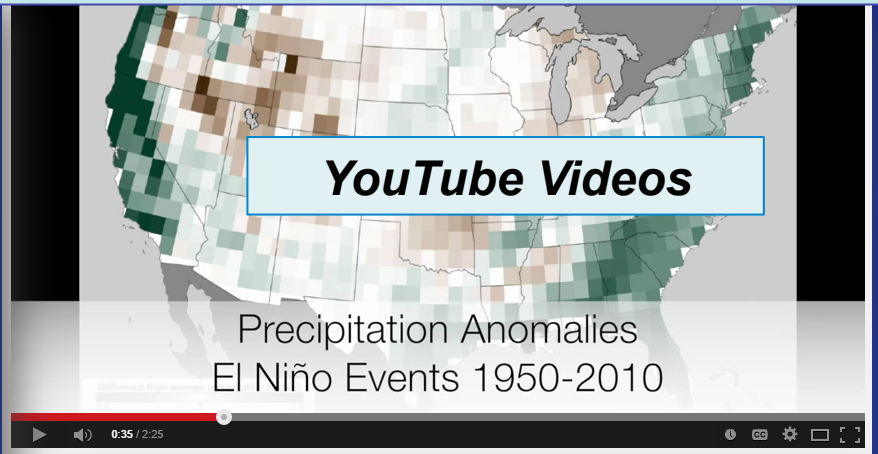
Year

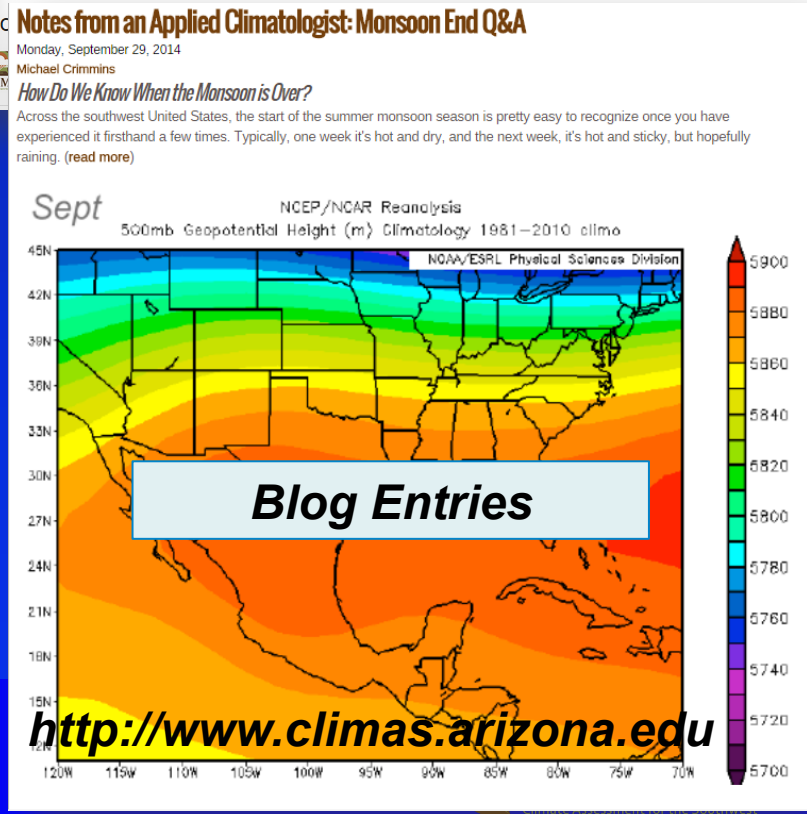
Climate Science Applications Program
University of Arizona Cooperative Extension
http://cals.arizona.edu/climate

http://cals.arizona.edu/climate/misc/spi/spi_contour.html

Data source: NOAA National Climatic Data Center
ftp://ftp.ncdc.noaa.gov/pub/data/cirs/climdiv
Base Period= 1900-2016 Date created: 12-Sep-2016

Climate information outreach…





http://www.climas.arizona.edu

Where Do Seasonal Climate Predictions Belong in the Drought Management Toolbox?

By Michael A. Crimmins and Mitchel P. McClaran

On the Ground

- Seasonal climate predictions, based largely on the status of the El Niño-Southern Oscillation, are one such tool but need to be used with prudence, understanding when and where they perform the best.
- Advance planning and preparation for drought includes finding the right place for uncertain climate predictions in management decision making, as well as working to reduce overall exposure to drought risks.

Keywords: drought, seasonal climate prediction, forecasts, El Niño-Southern Oscillation.

Rangelands 38(4):169–176
doi: 10.1016/j.rala.2016.06.004

Drought is a menacing natural hazard to ranchers and rangeland managers alike. Its impact on forage production and water resources have been studied for decades, with many tools to manage and anticipate its impacts emerging from this work. Seasonal climate predictions provide an additional tool to prepare for drought. Those predictions have been improving in recent decades, especially for winter precipitation predictions because of connections with sea surface temperature and pressure anomalies that manifest during El Niño-Southern Oscillation events. However, their limited predictive power in the summer growing season for most regions and coarse spatial resolution have limited their adoption by ranchers and rangeland managers. Therefore, rather than a panacea, seasonal climate predictions are better viewed as only one of many tools to increase preparation for future drought.

What Are Seasonal Climate Predictions?

Seasonal climate predictions sit at the intersection of weather forecasts that cover the timescale of hours to about 2 weeks and long-term climate projections, which typically extend beyond 1 year and out to a century.[1] Prediction of weather and climate at any timescale is challenging, but this intermediate seasonal timescale of beyond several weeks to about a year brings its own set of challenges. Seasonal climate predictions are structured to examine slowly evolving components of the climate system and then suggest how they may affect the expected average climate for the next month or coming seasons. These slowly varying components of climate include things like sea surface temperatures in the large ocean basins, sea ice and snow cover at higher latitudes, and soil moisture levels over large continental areas.

The El Niño Southern Oscillation

One of the most reliable climate phenomena used in seasonal climate predictions is tracking and attempting to forecast the state of the El Niño-Southern Oscillation (ENSO). ENSO is a somewhat regular (on the order of 2–7 years) shift in sea surface temperatures along the equator of the Pacific Ocean basin. Normally, temperatures are cooler in the eastern Pacific and warmer in the western Pacific due to easterly winds causing upwelling of cool water in the east and the movement of warmer surface water to the west. In some years, stronger than average easterly winds will intensify this pattern of cool east-warm west sea surface temperatures, which is termed a La Niña event. During El Niño events, these easterly winds weaken, causing warm water to slosh back to the central and eastern Pacific with warmer than average sea surface temperatures in these regions.

The location and extent of warm sea surface temperatures is critical in determining where anomalous tropical convection occurs and, in turn, its impact on global circulation patterns. Across the continental United States, the impact of ENSO is strongest during the winter season when the storm track driven by the position of the jet stream is typically disrupted

evaluated and integrated into this product based on tools past performance and expert judgement.[3] The National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA-CPC) issues a suite of seasonal climate outlooks the third Thursday of each month for the coming month and overlapping 3-month periods to cover a year from the current date. The outlooks include precipitation and temperature information represented in probabilities of observing the seasonal mean (or "normal" for the most recent 30-year normal period) for temperature or total for precipitation falling in one of three categories (terciles). These terciles (thirds of the full distribution) represent above (67th–100th percentile), normal (34th–66th percentiles), and below (1st–33rd percentiles) normal conditions based on the historical data for that location.

The outlooks are typically depicted as maps of probability anomalies for each of these three categories. For example, green colors show the shift in odds toward wetter than median conditions, and brown shows a shift in the odds toward drier conditions. Median is used as the measure of central tendency for precipitation rather than average because of the nature of typical precipitation distributions, which often consist of many small values and only a few large values. White colors on the map indicate equal chances of observing total precipitation or average temperature over this season in any one of the three categories, effectively communicating that there is not enough information to shift the odds in any direction and make a useful forecast.

The 3-month precipitation outlook made in October of 2015 shown in Fig. 2 has a very large shift in odds toward wetter than median conditions across much of the southern states and drier than median conditions across the northern states for the upcoming December to February season. Looking at Arizona in particular, the 50% probability anomaly indicates that there is a 50% chance of seeing above-normal (upper third of the historical distribution) total December to February precipitation, a 33% chance of observing normal (middle third of distribution) precipitation, and only a 16% chance of observing below-normal precipitation over this period. The exact opposite forecast is being made for Montana with a 50% chance of below-median precipitation (bottom third of local distribution) and implicitly a 16% chance of above-median precipitation. In between the dry signal to the north and wet signal to the south is the dreaded equal chances depiction, which indicates that total precipitation between December to February is equally likely to be wetter, drier, or simply near median values.

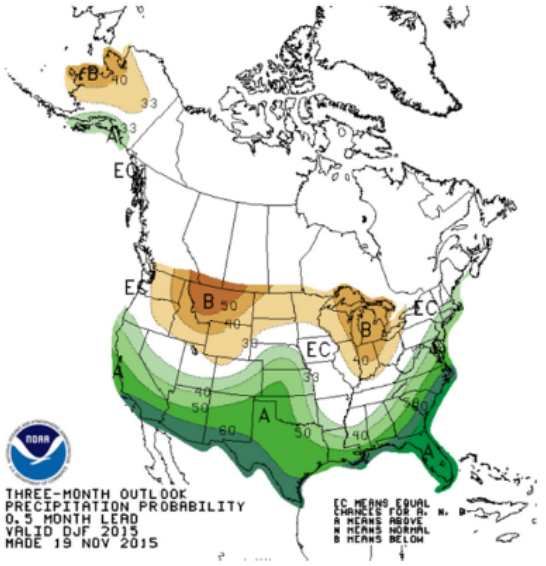
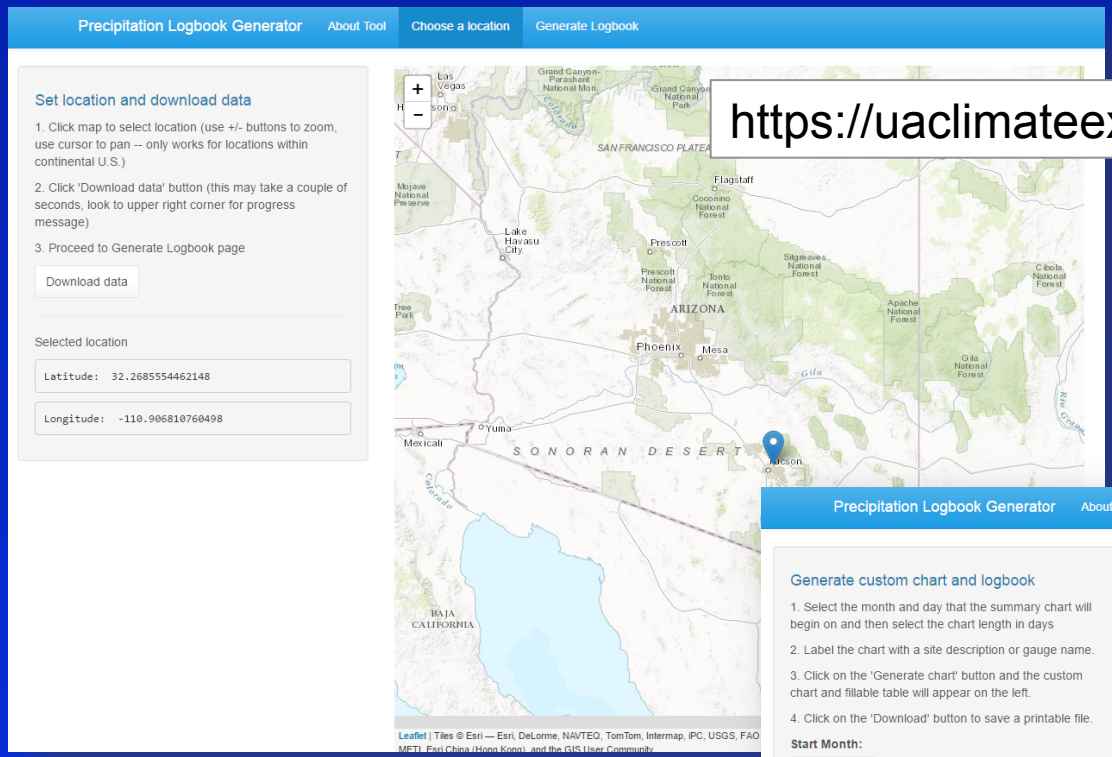


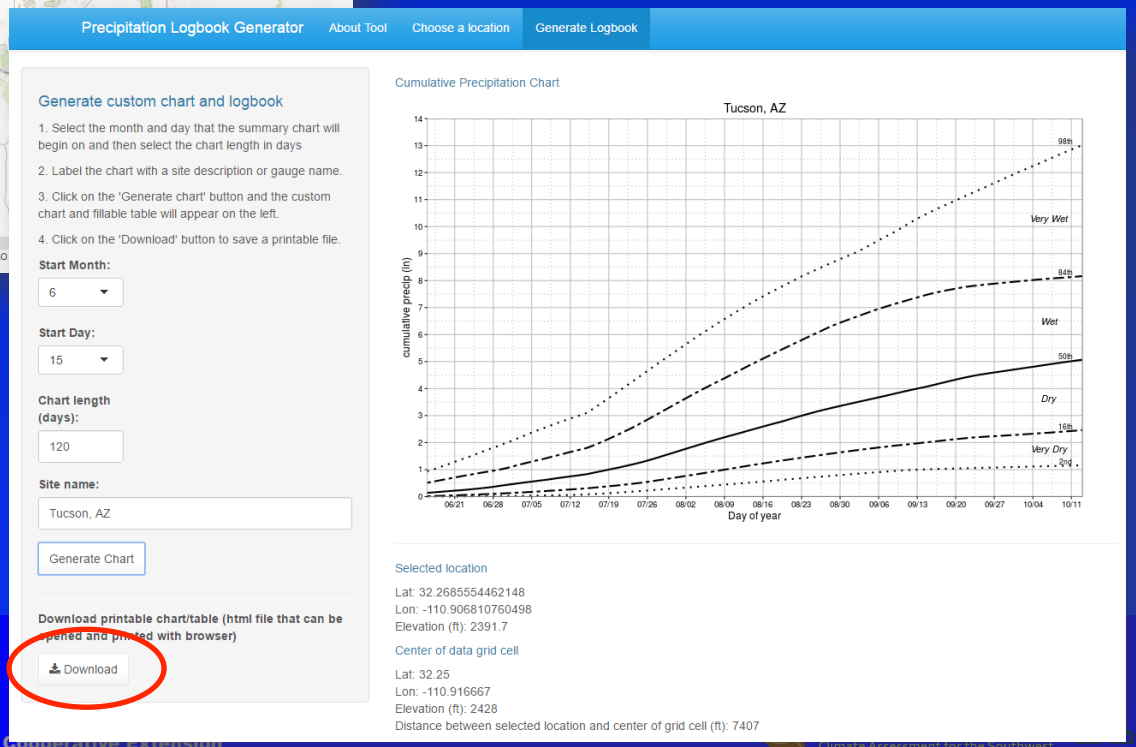
Figure 2. Three-month precipitation outlook made in October 2015 for the December-January-February period (NOAA-CPC).

Developing new precipitation monitoring strategies for ranchers and range managers

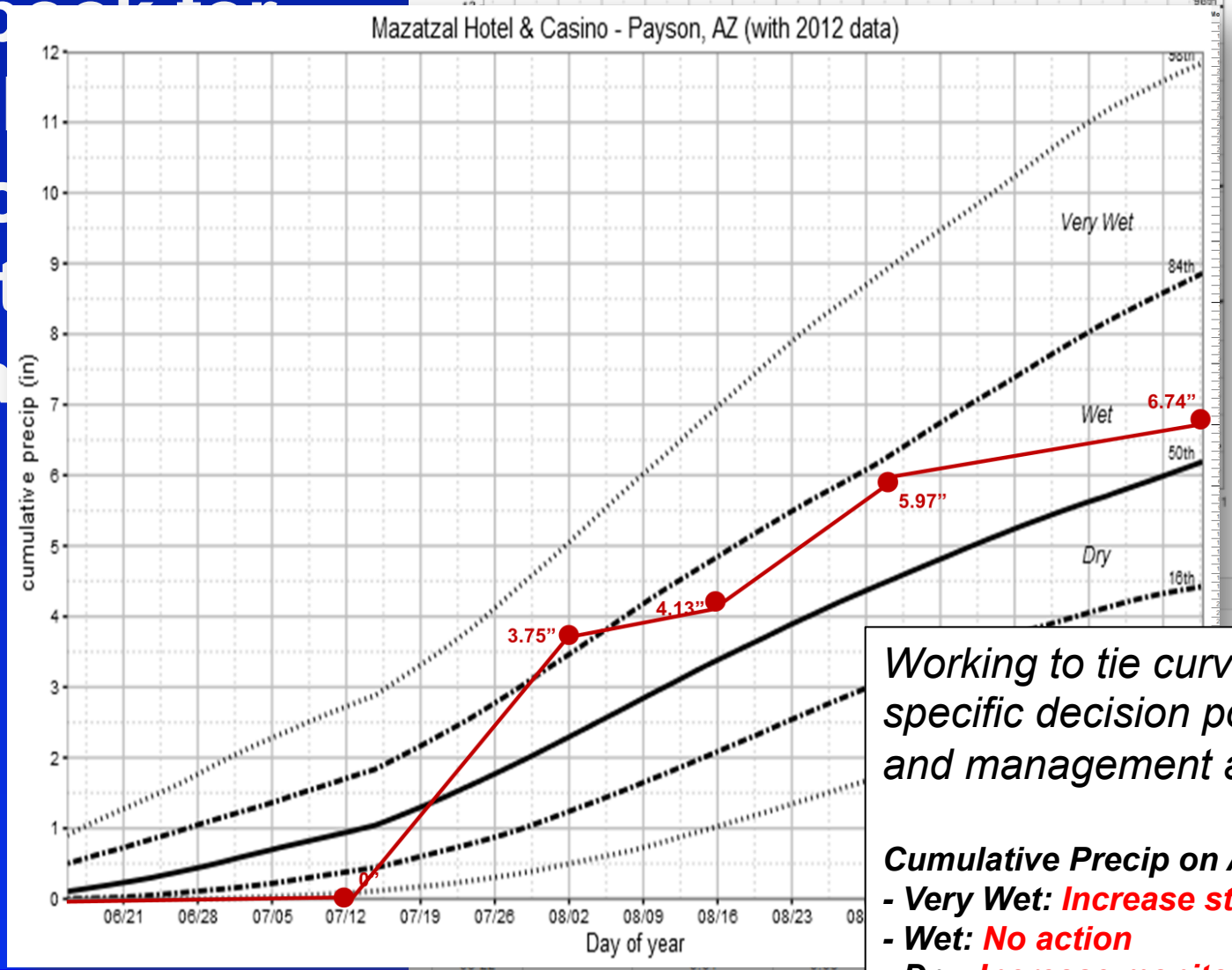
Precipitation Logbook Generator

https://uaclimateextension.shinyapps.io/precipChart/





Printable logb… for trac… prec… dept… loca…



Precipitation Logbook

Tucson, AZ

06-23	0.01	0.07
06-24	0.01	0.08
06-25	0.01	0.09
06-26	0.01	0.09
06-27	0.02	0.10

Working to tie curves to specific decision points and management actions

Cumulative Precip on Aug 3rd
- ***Very Wet:*** ***Increase stocking***
- ***Wet:*** ***No action***
- ***Dry:*** ***Increase monitoring***
- ***Very Dry:*** ***supplement feed/ water; relocate cattle***

Thanks!

crimmins@email.arizona.edu

http://cals.arizona.edu/climate