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September Southwest Climate Outlook

Precipitation & Temperature: August precipitation totals were above average across most of Arizona and New Mexico (Fig. 1a), buoyed by a surge of monsoon storms that started in late July and extended through the first week of August, and a surge of moisture linked to Tropical Storm Javier in mid-August. August temperatures were mostly average to below average in Arizona and New Mexico (Fig. 1b), a decline that did not alter the overall seasonal pattern of very warm temperatures observed during the summer months (Fig. 2). September precipitation to date (Sept 1 – Sept 14) ranges from well above average in southeastern Arizona and portions of New Mexico, tied mostly to heavy rains during Hurricane Newton, to well below average in other areas of the region that did not record as much activity during this time (Fig. 3). Water year precipitation to date (Oct 1, 2015 – present) is below average in much of the Southwest, particularly in Southern California, most of southern Arizona, and western New Mexico (Fig. 4).

Monsoon: With two weeks remaining in the 2016 monsoon (June 15 – Sept 30), seasonal precipitation totals to date are generally below average in much of Arizona, except for clusters in the southeastern corner of the state. During the same time frame, precipitation totals are average to above average in most of New Mexico. These totals gloss over the spatial and temporal variability of the monsoon, but they do provide a rough measure of the monsoon's performance in terms of intra-regional comparisons and in comparison to prior years. Tropical storm activity (primarily Javier and Newton in 2016) provided a boost to seasonal monsoon totals (for more detailed discussion, see Monsoon Tracker).

Drought & Water Supply: Long-term drought persists across the Southwest (Fig. 5). The Sept. 15 U.S. Drought Monitor designated all of Arizona and much of western and central New Mexico as experiencing some form of drought. The northwest and southeast portions of Arizona, along with most of the designated areas in New Mexico, were classified as abnormally dry (D0), while much of southwestern and northeastern Arizona were designated as experiencing moderate drought (D1). The far southwestern corner of Arizona was designated as experiencing severe drought (D2), reflecting the persistent multi-year drought conditions in central and Southern California.

La Niña & Drought: Sea-surface temperature anomalies and atmospheric patterns all generally indicate ENSO-neutral conditions. Previous forecasts pointed towards the formation of a weak La Niña. In the last month, model consensus has shifted toward an increased probability of an ENSO-neutral winter, with a declining (but still present) chance of a weak La Niña event (see La Niña Tracker). An ENSO-neutral winter would be less likely to lead to the drier-than-average conditions associated with La Niña, but given the wide range of observed precipitation totals over ENSO-neutral winters (see Fig. 6 on page 4), this shift does not necessarily lead to increased certainty in the seasonal precipitation forecasts.

Precipitation and Temperature Forecasts: The Sept. 15 NOAA Climate Prediction Center's seasonal outlook for October calls for equal chances of above- or below-average precipitation for most of the Southwest (Fig. 6 top) and increased chances of above-average temperatures across the western U.S. and the Southwest in particular (Fig. 6 bottom). The three-month outlook for September through November calls for increased chances of above-average temperatures across the U.S., including the Southwest, while calling for equal chances of average, above-average, or below-average precipitation.

Tweet Sept SW Climate Outlook CLICK TO TWEET

SEP2016 @CLIMAS_UA SW Climate Outlook - Climate Summary, La Niña Outlook, Monsoon Tracker, Reservoir Volumes http://bit.ly/2cRTTcL

Online Resources

Figure 1
National Center for Environmental Information
https://www.ncdc.noaa.gov

Figure 2
West Wide Drought Tracker
http://www.wrcc.dri.edu/wwdt

Figure 3
High Plains Regional Climate Center
http://www.hprcc.unl.edu/

Figure 4
West Wide Drought Tracker
http://www.wrcc.dri.edu/wwdt

Figure 5
U.S. Drought Monitor
http://droughtmonitor.unl.edu/

Figure 6
NWS Climate Prediction Center
http://www.cpc.ncep.noaa.gov/

CLIMAS YouTube Channel

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www.youtube.com/user/UACLIMAS/

Podcasts

Visit our website or iTunes to subscribe to our podcast feed.

www.climas.arizona.edu/media/podcasts

September Southwest Climate Outlook

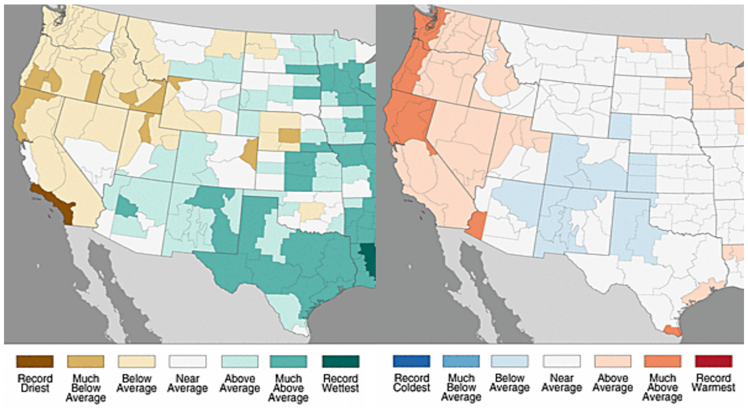


Figure 1: Aug 2016 Precipitation (a) & Temperature Ranks (b)

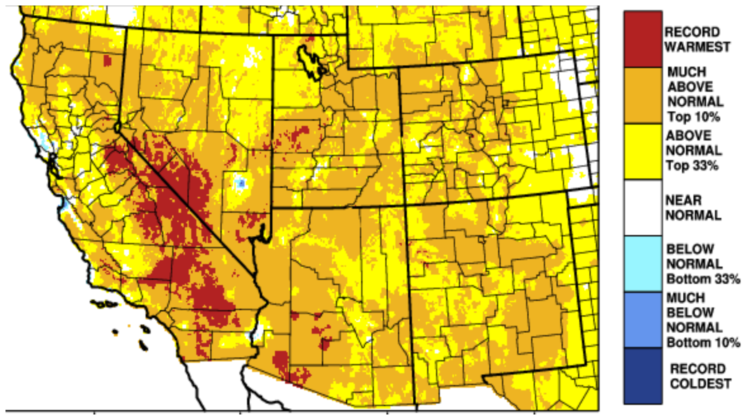


Figure 2: Mean Temperature Percentile June-August 2016

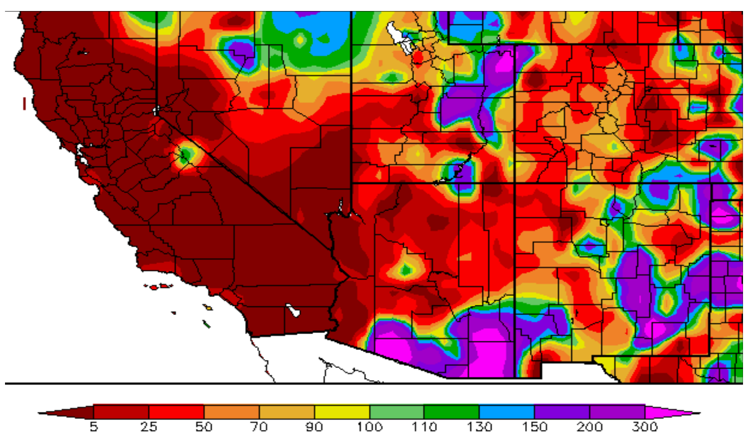


Figure 3: Percent of Normal Precipitation Sep 1 - Sep 14 2016

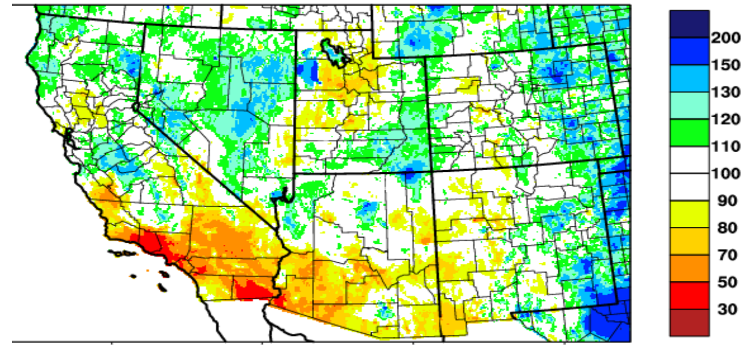


Figure 4: Percent of Normal Precipitation Oct 1 2015 - Aug 31 2016

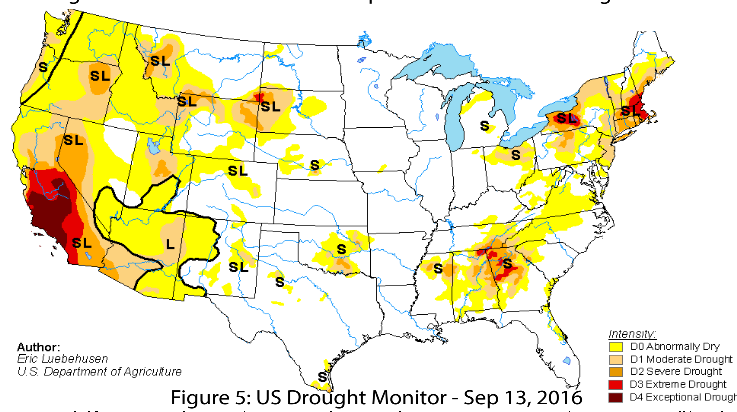


Figure 5: US Drought Monitor - Sep 13, 2016

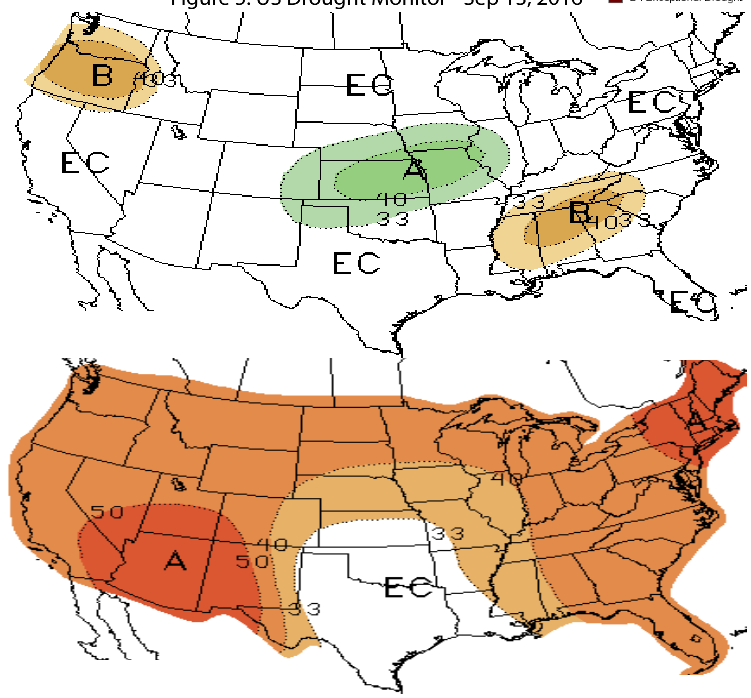


Figure 6: One-Month Precipitation & Temperature Outlook-Sep 15, 2016

Online Resources

Figure 1
Australian Bureau of Meteorology
http://www.bom.gov.au/climate/enso/index.shtml

Figure 2
NOAA - National Climatic Data Center
http://www.ncdc.noaa.gov/teleconnections/enso/

Figure 3
International Research Institute for Climate and Society
http://iri.columbia.edu/our-expertise/climate/forecasts/enso/

Figure 4
NOAA - Climate Prediction Center
http://www.cpc.ncep.noaa.gov/

El Niño

Information on this page is also found on the CLIMAS website:

www.climas.arizona.edu/sw-climate/el-niño-southern-oscillation

El Niño Southern Oscillation - La Niña

Oceanic and atmospheric indicators of the El Niño-Southern Oscillation (ENSO) remain in the range of neutral conditions (Figs. 1-2). In the last month, seasonal forecasts and models further reduced their certainty of a weak La Niña event forming in late 2016 or early 2017. The current projections find ENSO-neutral conditions to be the most likely outcome for this fall and winter, although the chance of a weak La Niña event cannot be ruled out. As past outlooks have noted, there was ongoing uncertainty regarding the prospects for La Niña, especially as it appeared to be having difficulty organizing, with limited coordination between ocean and atmosphere.

A closer look at the various forecasts and seasonal outlooks provides insight into the range of expectations for this La Niña event. On September 8, the NOAA Climate Prediction Center (CPC) highlighted ENSO-neutral conditions in both the ocean and atmosphere, and given the persistent neutral conditions, it shifted its forecast from slightly favoring La Niña to a 55–60 percent chance of ENSO-neutral conditions during fall and winter 2016-17. On September 9, the Japanese Meteorological Agency identified La Niña conditions as being in place, and projected a 70 percent chance that they would remain through winter 2017. On September 13, the Australian Bureau of Meteorology maintained its La Niña watch, but noted the lack of connection between ocean and atmosphere and the generally neutral conditions. The agency identified a limited chance of a "late and weak La Niña" emerging at some point, and highlighted that the borderline weak La Niña conditions may lead to weather patterns more in line with La Niña even if the event is not designated as such. On September 14, the International Research Institute for Climate and Society (IRI) and CPC forecasts described oceanic and atmospheric conditions that were borderline La Niña, but that models indicated a likely retreat into ENSO-netural status during winter 2016-2017 (Fig. 3). The North American multi-model ensemble characterizes the current model spread and highlights the variability looking forward to 2017. In the last month, the ensemble mean returns to neutral conditions over fall and winter 2016-17, whereas previously it had remained close to weak La Niña during this timeframe (Fig. 4).

(continued on next page)

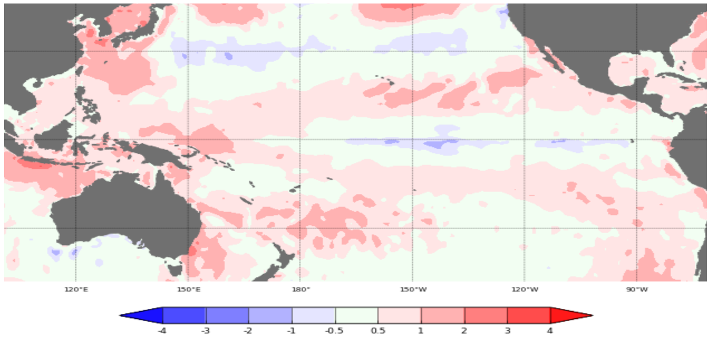


Figure 1: August 2016 Sea Surface Temperature (SST) Anomalies

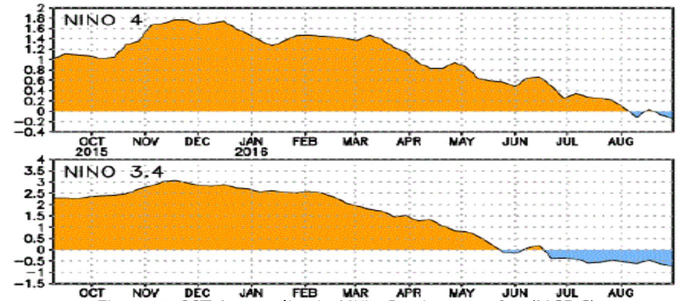


Figure 2: SST Anomalies in Niño Regions 3.4 & 4 (NCDC)

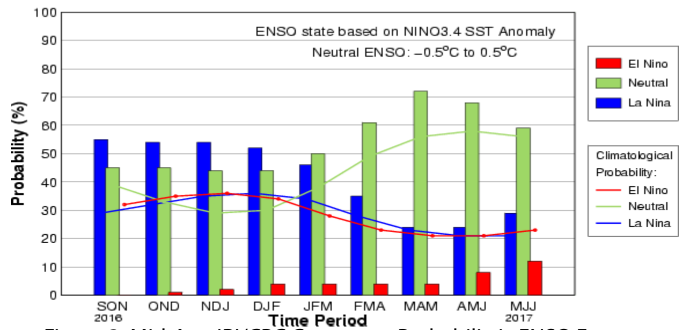


Figure 3: Mid-Aug IRI/CPC Consensus Probabilistic ENSO Forecast

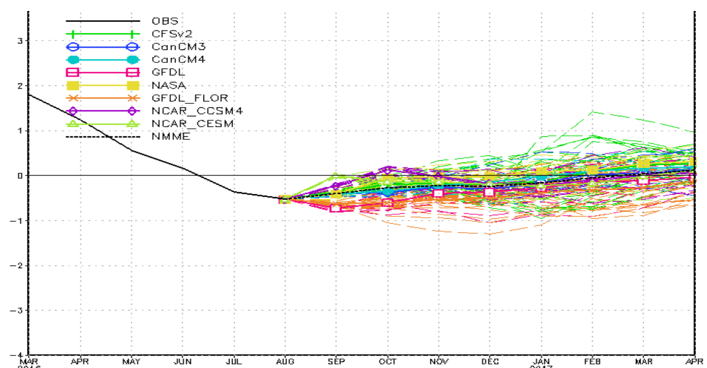


Figure 4: North American Multi-Model Ensemble Forecast for Niño 3.4

Online Resources

Figures 5a-5b
NOAA - Climate Prediction Center
http://www.cpc.ncep.noaa.gov/

Figure 6
Climate Science Applications Program
http://cals.arizona.edu/climate

El Niño

Information on this page is also found on the CLIMAS website:

www.climas.arizona.edu/sw-climate/el-niño-southern-oscillation

El Niño Southern Oscillation - La Niña - continued

The Southwest remains in a holding pattern regarding La Niña, even while the current forecast suggests it is now increasingly likely the region will experience an ENSO-neutral winter. Forecasters were likely already integrating the influence of La Niña into long-term precipitation forecasts and seasonal outlooks (Figs. 5a-5b), and it will be interesting to see if and how these forecasts change given the current ENSO-neutral forecast.

It is important to note that while a weak La Niña event would be more likely than not to bring drier-than-average conditions to the Southwest over the cool season, there is no basis to think that ENSO-neutral conditions will bring increased moisture over the winter, as the range of precipitation values for ENSO-neutral cool seasons ranges from very wet to very dry (Fig. 6). This is particularly the case if oceanic and atmospheric conditions are borderline weak La Niña yet they exert some influence on seasonal weather patterns even if not officially designated as a La Niña event.

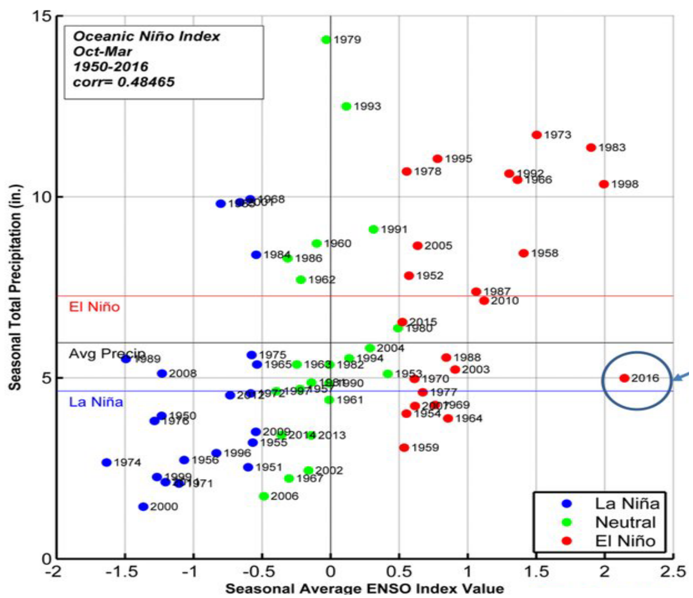


Figure 6: Arizona Climate Division 7 - ENSO vs. Precipitation

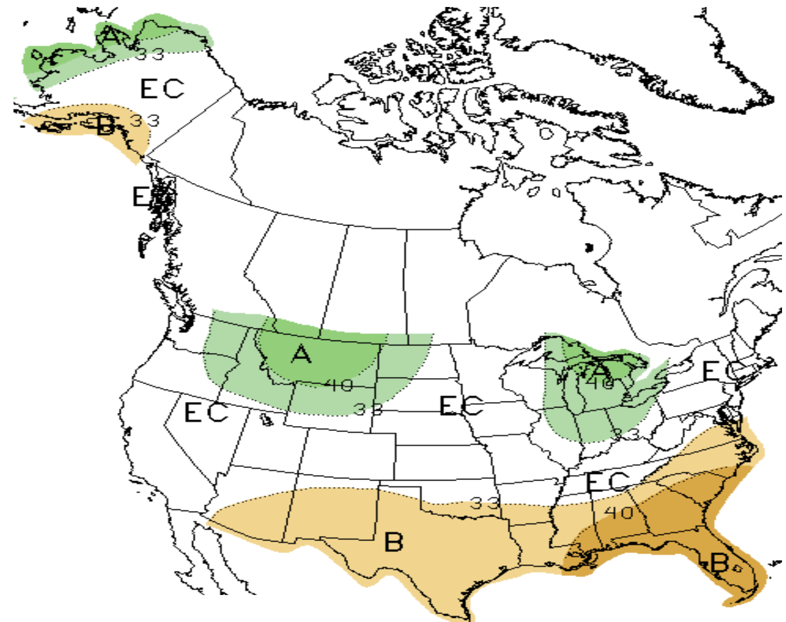


Figure 5a: Three-Month Precipitation Outlook Dec 2016 - Feb 2017

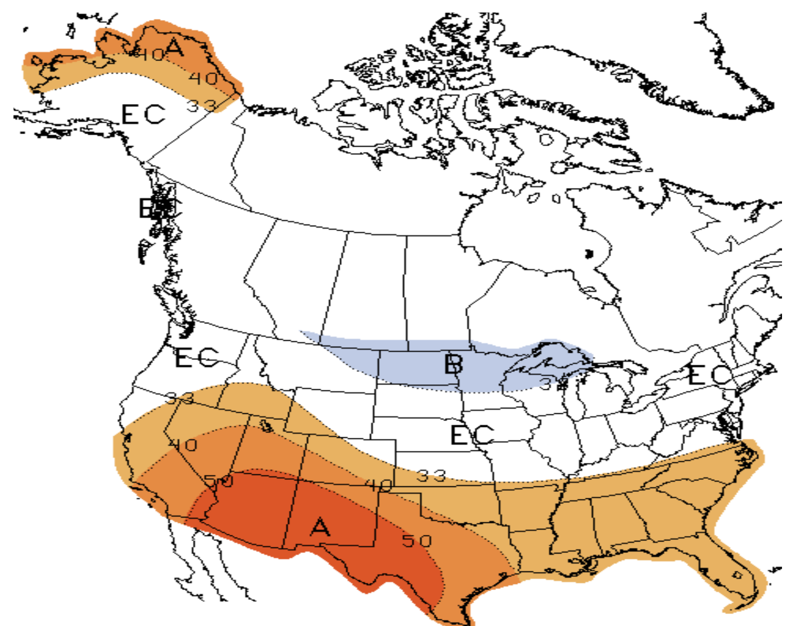


Figure 5b: Three-Month Temperature Outlook Dec 2016 - Feb 2017

Online Resources

Figure 1
Earth Systems Research Lab
http://www.esrl.noaa.gov

SW Monsoon

For more information, visit:

www.climas.arizona.edu/sw-climate/monsoon

Southwestern Monsoon

The monsoon in the Southwest U.S. officially starts June 15 and ends September 30. The National Weather Service began using these dates in 2008 to identify a discrete monsoon period as opposed to relying on varying assessments using dew point temperature and onset of precipitation events. Prior to 2008, the historical start date of the monsoon was based on observed conditions (primarily elevated dew point), which varied across the region in a way that reflected the generally westward migration of the monsoon onset (Fig. 1). Firm start and end dates may not perfectly align with regional variability (especially if monsoon conditions are not present at the calendar start to the monsoon), but standardized dates do provide a more consistent time frame to compare year to year and emphasize the spatial and temporal variability of the monsoon within and across years.

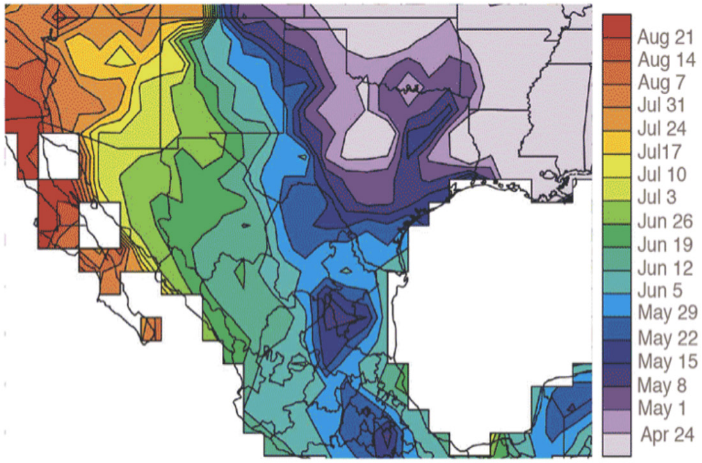


Figure 1: Historical Monsoon Onset Date

The southwestern monsoon is characterized by spatial and temporal variability. Storm events are interspersed with breaks of limited activity as migrating high pressure systems and available moisture dictates where in the Southwest rain might fall. This results in highly variable precipitation totals on a daily or weekly timescale. Regional climatology gives some indication as to the expected cumulative total precipitation any location might expect but says less about how those precipitation totals will be achieved. Any given year of monsoon activity is difficult to categorize on a week-to-week basis, and simple score-carding using seasonal precipitation to date will be skewed by recent runs of heavy rain or extended breaks in the monsoon. Totals should even out over the course of the season and vary around the long-term average, but outliers and extremes are always possible.

Monsoon Recap

The Southwest saw the first strong burst of widespread monsoon activity near the end of June. Most of the first half of July was characterized by a distinct break in monsoon activity, as atmospheric circulation patterns and lack of available moisture limited opportunities for widespread storms to develop, especially at lower elevations. By mid-to-late July, there were increasingly favorable conditions for storms to develop and spread, culminating in an extended period of widespread activity during late July and early August. Tropical Storm Javier helped jumpstart activity again in mid-August, providing a brief extension to storm activity via a surge of moisture from the Gulf of California. The remainder of August and early September saw a decline in widespread monsoon activity, even while numerous areas did see intermittent precipitation, particularly at higher elevations. On September 7, Hurricane Newton generated significant precipitation activity in a swath across southwestern Arizona and extending into central New Mexico, although observed values were less intense and widespread than initially forecast. Recently, the monsoon has been in active decline, with activity shifting to the northwest and regional activity looking more and more like fall across much of the region, although eastern New Mexico has seen an uptick in activity based primarily on surges of moisture from the Gulf of Mexico.

In what remains of the monsoon, limited opportunity exists for moisture and atmospheric circulation patterns to develop into widespread events, although intermittent convective activity could always develop across the region. Eastern Pacific tropical storm activity has the potential to contribute directly via rainfall events or at least to supply additional moisture to the region that could fuel storm activity, but this period of activity extends well beyond the bounds of the official monsoon (and also highlights the ongoing debate as to whether tropical storm events should “count” when discussing the performance of the monsoon).

Online Resources

Figures 2-5a
Climate Science Applications Program
http://cals.arizona.edu/climate

SW Monsoon

For More Information, visit:

www.climas.arizona.edu/sw-climate/monsoon

Based on cumulative totals since the official start of the monsoon, most of Arizona recorded average to below-average precipitation, even while clusters of the state have recorded above-average rainfall (Figs. 2a-3a). The percent of days with rain highlights the spatial variability of the monsoon and emphasizes the clustering of storms in the southeastern corner of the state (Fig. 4a). Precipitation plots from specific stations further highlight this variability, with Douglas, Flagstaff, and Tucson stations all showing that their seasonal average for monsoon precipitation had been surpassed by early September (Figs. 5a-c), while other stations such as Tacna 3 NE in the southwest corner of Arizona have only recorded a few events and are well below their seasonal total (Fig. 5d).

Cumulative precipitation totals since the start of the monsoon show New Mexico has caught up in the last month. Much of the state has now recorded average to above-average precipitation, although some areas still are below average (Figs. 3a-3b). Relatively widespread, uniform precipitation is indicated by the observation that most of the stations across the state recorded rain on at least 30 percent of days in which rain was recorded anywhere, and a slightly smaller yet still significant region recorded rain on 50 percent of such days (Fig. 4b). Station plots also demonstrate the lagging precipitation in select locations such as Albuquerque (Fig. 5e), while others such as El Paso, Texas, and the Animas 3ESE station recorded above-average precipitation (Figs. 5f-5g).

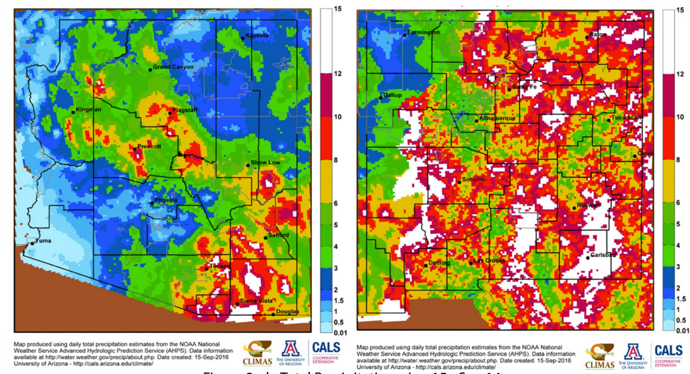


Figure 3a-b: Total Precipitation - Jun 15 - Sep 14

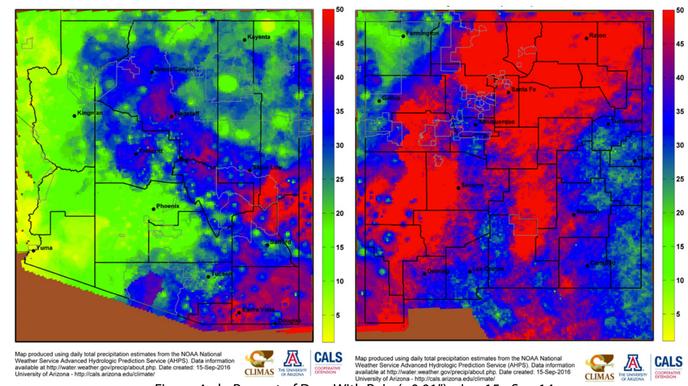


Figure 4a-b: Percent of Days With Rain (>0.01") - Jun 15 - Sep 14

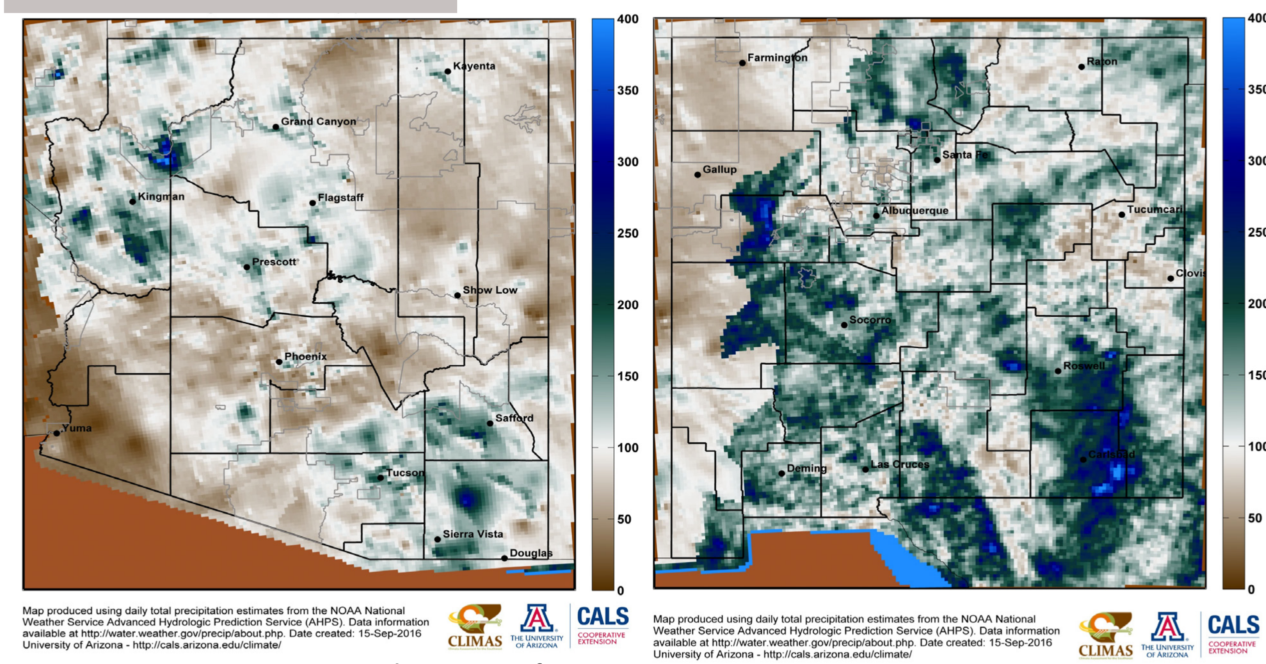


Figure 2a-b: Percent of Average Precipitation - Jun 15 - Sep 14

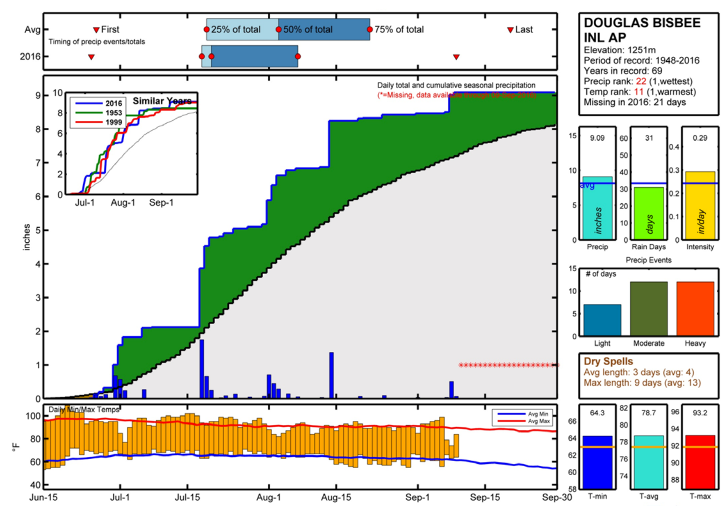


Figure 5a: 2016 Monsoon Precipitation to-Date - Douglas, AZ

Online Resources

Figures 5b-5g
Climate Science Applications Program
http://cals.arizona.edu/climate

SW Monsoon

Season Technical Summaries:

Technical summary plots were created for several stations across the region with high-quality long-term records. Email Mike Crimmins (crimmins@email.arizona.edu) to inquire about plots for additional stations or if you have any questions or suggestions on the plots.

For More Information, visit:

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

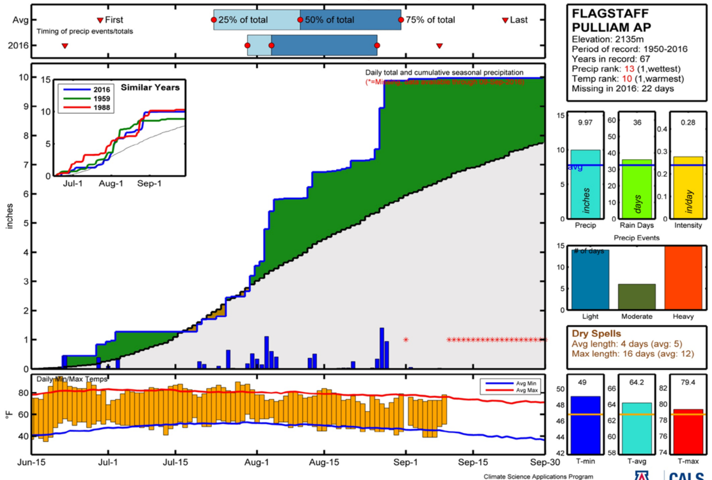


Figure 5b: 2016 Monsoon Precipitation to-Date - Flagstaff

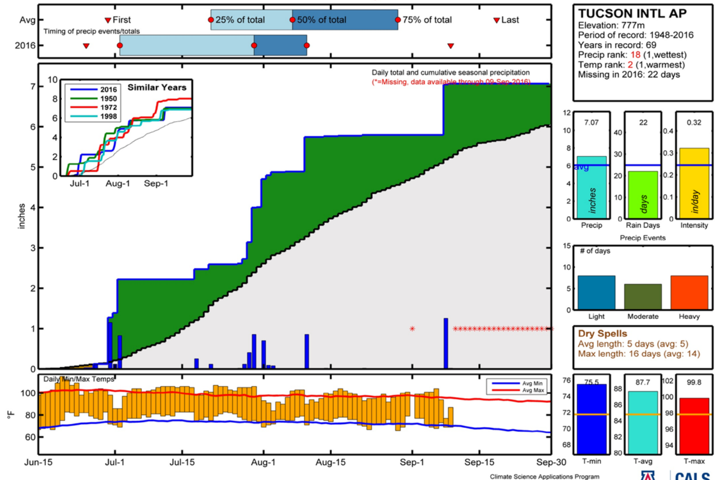


Figure 5c: 2016 Monsoon Precipitation to-Date - Tucson

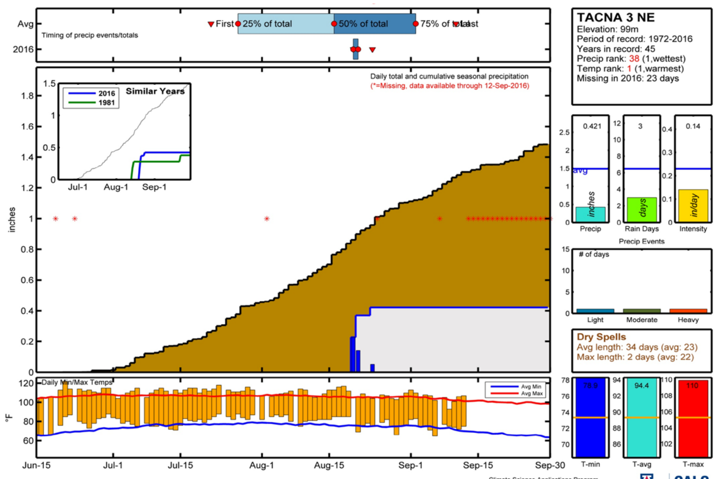


Figure 5d: 2016 Monsoon Precipitation to-Date - Tacna

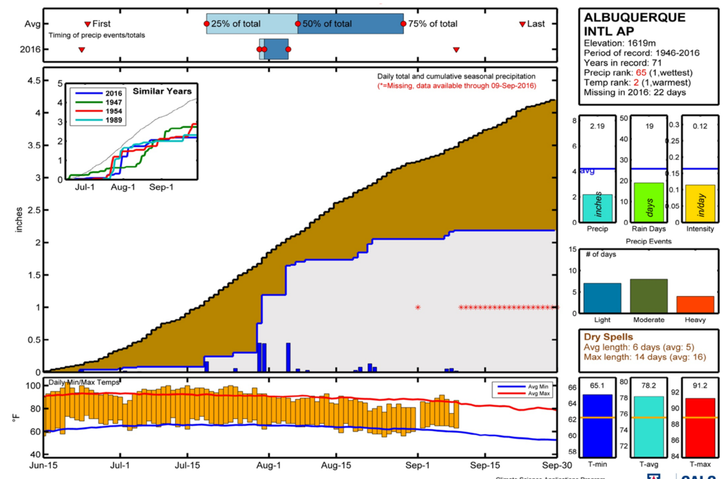


Figure 5e: 2016 Monsoon Precipitation to-Date - Albuquerque

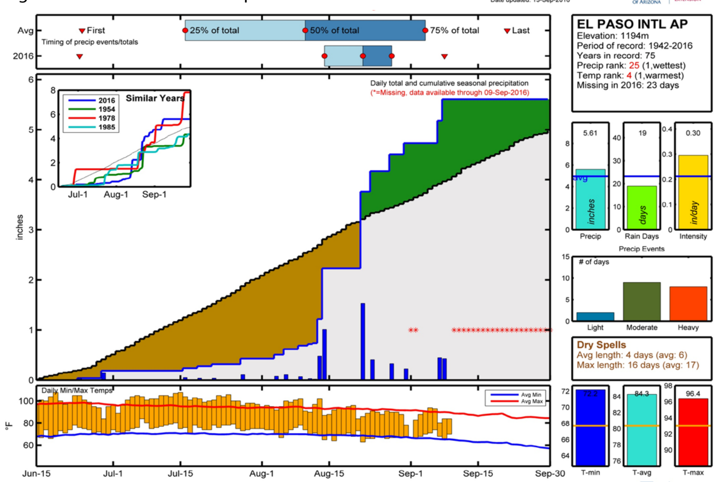


Figure 5f: 2016 Monsoon Precipitation to-Date - El Paso

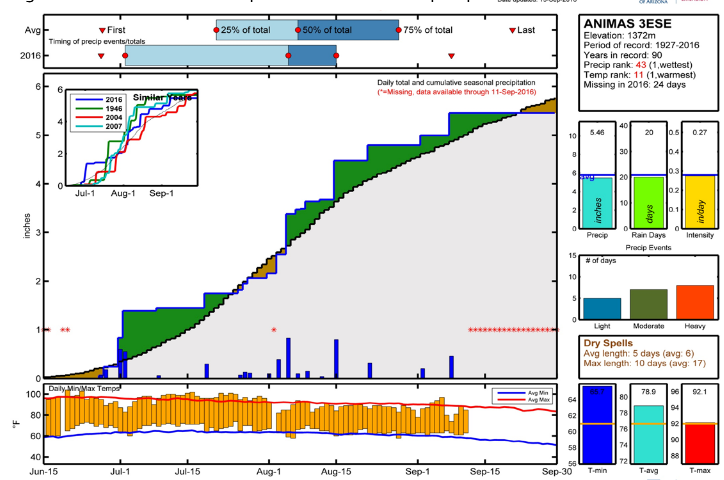


Figure 5g: 2016 Monsoon Precipitation to-Date - Animas 3ESE

Online Resources

Portions of the information provided in this figure can be accessed at the Natural Resources Conservation Service

Arizona: http://1.usa.gov/19e2BdJ

New Mexico: http://www.wcc.nrcs.usda.gov/cgibin/resv_rpt.pl?state=new_mexico

We updated our 'max storage' values for numerous NM reservoirs based on conservation storage vs. maximum flood capacity. This altered the percent capacity calculations, even while 'current storage' numbers are unchanged.

Contact Ben McMahan with any questions or comments about these or any other suggested revisions.

Notes

The map gives a representation of current storage for reservoirs in Arizona and New Mexico. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage (blue fill) as a percent of total capacity. Note that while the size of each cup varies with the size of the reservoir, these are representational and not to scale. Each cup also represents last year's storage (dotted line) and the 1981–2010 reservoir average (red line).

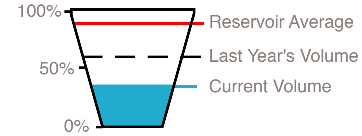
The table details more exactly the current capacity (listed as a percent of maximum storage). Current and maximum storage are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons). On average, 1 acre-foot of water is enough to meet the demands of four people for a year. The last column of the table lists an increase or decrease in storage since last month. A line indicates no change.

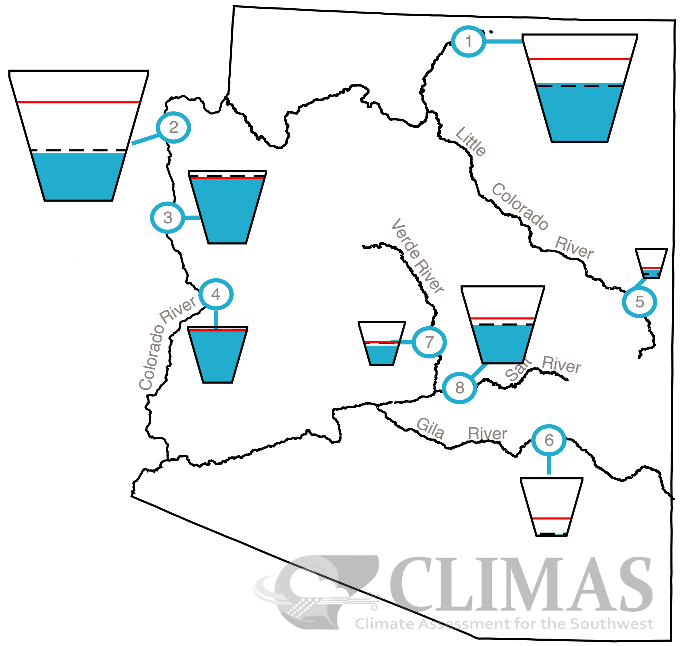
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

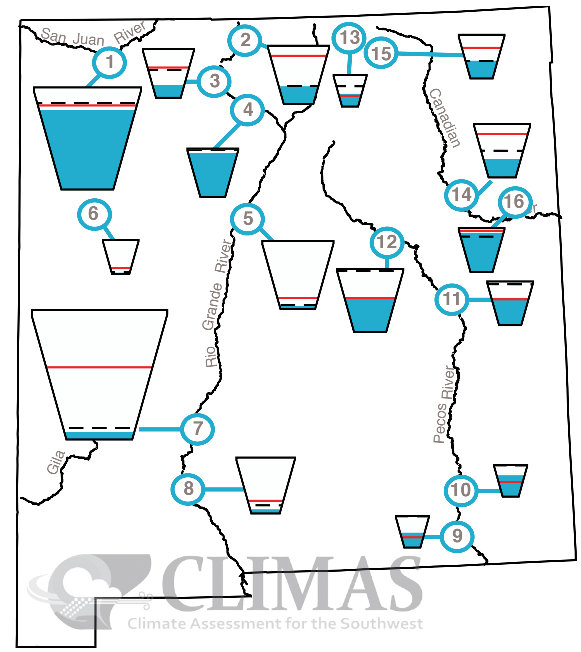
Reservoir Volumes

DATA THROUGH AUG 31, 2016

Data Source: National Water and Climate Center, Natural Resources Conservation Service







Reservoir	Capacity	Current Storage*	Max Storage*	One-Month Change in Storage*
1. Lake Powell	54%	13,083.8	24,322.0	-491.7
2. Lake Mead	37%	9,616.0	26,159.0	194.0
3. Lake Mohave	92%	1,674.0	1,810.0	-47.0
4. Lake Havasu	96%	591.7	619.0	-10.7
5. Lyman	26%	7.9	30.0	-0.7
6. San Carlos	1%	12.9	875.0	-3.8
7. Verde River System	45%	128.9	287.4	8.0
8. Salt River System	49%	983.4	2,025.8	-35.8

*KAF: thousands of acre-feet

Reservoir	Capacity	Current Storage*	Max Storage*	One-Month Change in Storage*
1. Navajo	79%	1,337.2	1,696.0	-27.1
2. Heron	30%	120.6	400.0	-13.7
3. El Vado	26%	50.2	190.3	-22.8
4. Abiquiu	65%	122.2	186.8**	8.7
5. Cochiti	90%	45.2	50.0**	-0.4
6. Bluewater	4%	1.7	38.5	-0.1
7. Elephant Butte	6%	132.3	2,195.0	-57.4
8. Caballo	7%	21.6	332.0	-7.1
9. Lake Avalon	47%	2.1	4.5**	0.4
10. Brantley	67%	28.2	42.2**	6.8
11. Sumner	62%	22.3	102.0**	-1.0
12. Santa Rosa	53%	55.8	105.9**	-27.0
13. Costilla	41%	6.6	16.0	-2.4
14. Conchas	33%	85.7	254.2	-11.3
15. Eagle Nest	40%	31.9	79.0	-0.9
16. Ute Reservoir	89%	178	200	-3.0