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October Southwest Climate Outlook

Precipitation and Temperature: September precipitation totals were near average across most of the climate divisions in Arizona and New Mexico (Fig. 1a), with one notable departure being the swath of above-average precipitation in the borderlands region linked to Tropical Storm Newton. September temperatures were average to below average in Arizona and average to above average in New Mexico (Fig. 1b). October precipitation to date has been below average across most of the region (Fig. 2), although October is one of the drier months in the Southwest, so dry conditions are not unexpected, and a single tropical storm or fall storm can skew the percent of normal. October temperatures have been 2 to 6 degrees above average for most of New Mexico and 0 to 4 degrees above average for most of Arizona (Fig. 3). This is in part connected to global trends that are likely to see 2016 as the warmest year on record (breaking the record set in 2015).

Monsoon 2016: Precipitation totals (June 15 – Sept 30) were generally below average across much of Arizona except for the southeastern and northwestern corners of the state (see Fig. 2a on p. 5). New Mexico saw more uniform coverage and average to above-average totals, especially in the southern half of the state (see Fig. 2b on p. 5). A number of weather stations in the borderlands region of the Southwest recorded well-above-average seasonal totals (e.g. Tucson, Safford, Douglas, Animas, El Paso, and Van Horn), while central areas (e.g. Albuquerque, Phoenix, Los Alamos) saw average or even below-average totals (see Southwestern Monsoon Recap on pp. 4-6 for more details).

Drought & Water Supply: Water year precipitation to date (Oct 1, 2015 – Sept 30, 2016) was below average in much of the Southwest, particularly in Southern California, most of southern Arizona, and western New Mexico, while northern Arizona and eastern New Mexico were average to above average (Fig. 4). Long-term drought conditions persist across the Southwest (Fig. 5). According to the US Drought Monitor, most of Arizona is designated as abnormally dry (D0) or experiencing moderate drought (D1), with the far southwestern corner of Arizona designated as experiencing severe drought (D2), reflecting the persistent multi-year drought conditions extending from central and southern California. In New Mexico, much of the northern half of the state, along with the US-Mexico border region, are designated as abnormally dry (D0). There is ongoing concern that continued western drought conditions may lead to water supply restrictions (for more information see reservoir storage on p. 7).

ENSO & La Niña: In a reversal from last month's forecasts, La Niña is back on the horizon for this winter. Current model consensus hovers around a 70-percent chance of a weak La Niña forming, but models and forecasts also indicate that this event could decline quickly in early 2017, which may limit its influence on weather in the Southwest. The relationship between the strength of La Niña and winter precipitation in the Southwest is relatively weak, and the Southwest is inherently dry (i.e. winter already sees relatively low precipitation totals in a normal year). Even so, the persistence and duration of La Niña conditions could increase the chance of a drier-than-average winter. This raises concern given the multi-year drought observed in the Southwest, and the possibility of water restrictions if Lake Mead drops below the 1075-foot elevation threshold.

Precipitation & Temperature Forecasts: The Oct 20 NOAA Climate Prediction Center's outlook for November calls for increased chances of below-average precipitation and increased chances of above-average temperature. The three-month outlook for November through January calls for increased chances of below-average precipitation (Fig. 6, top) and increased chances of above-average temperatures (Fig. 6, bottom).

Tweet Oct SW Climate Outlook CLICK TO TWEET

OCT2016 @CLIMAS_UA SW Climate Outlook - Climate Summary, La Niña Outlook, Monsoon Tracker, Reservoir Volumes http://bit.ly/2enZa0S

September Southwest Climate Outlook

Online Resources

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

Figures 2-3
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/

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www.youtube.com/user/UACLIMAS/

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www.climas.arizona.edu/media/podcasts

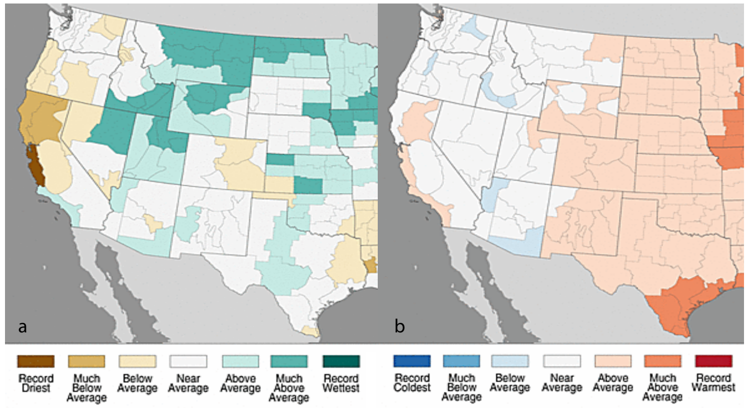


Figure 1: Sept 2016 Precipitation (a) & Temperature Ranks (b)

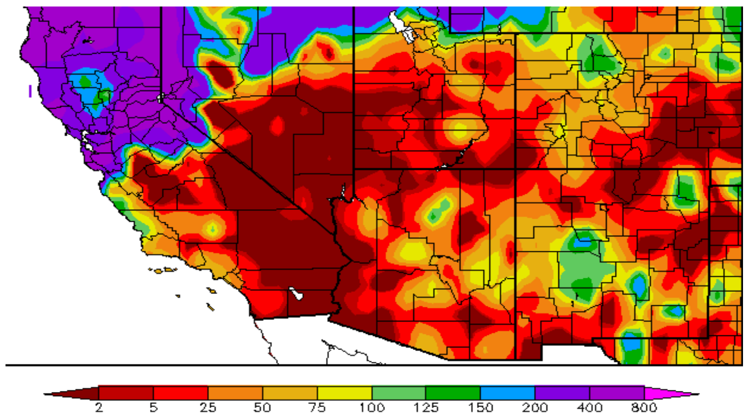


Figure 2: Percent of Normal Precipitation October 2016

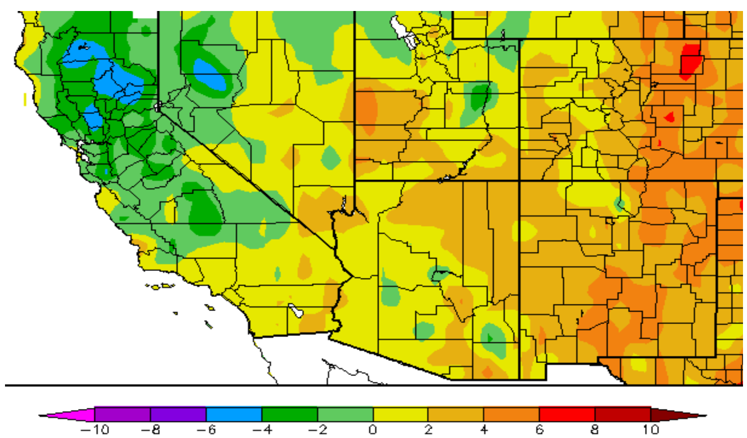


Figure 3: Departure from Normal Temperature October 2016

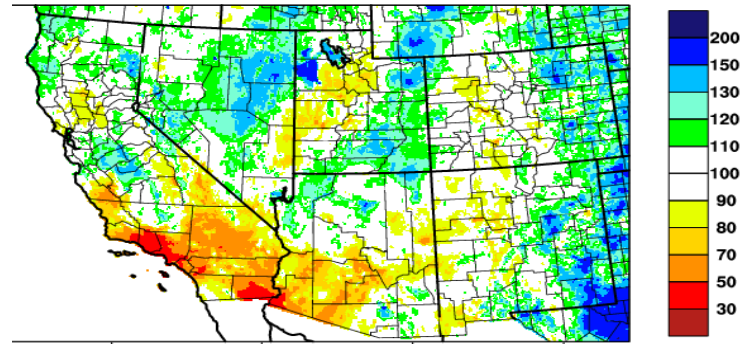


Figure 4: Percent of Normal Precipitation Oct 1 2015 - Sep 30 2016

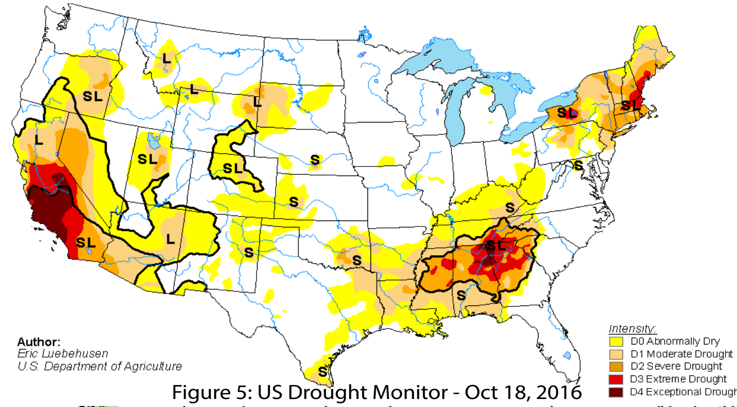


Figure 5: US Drought Monitor - Oct 18, 2016

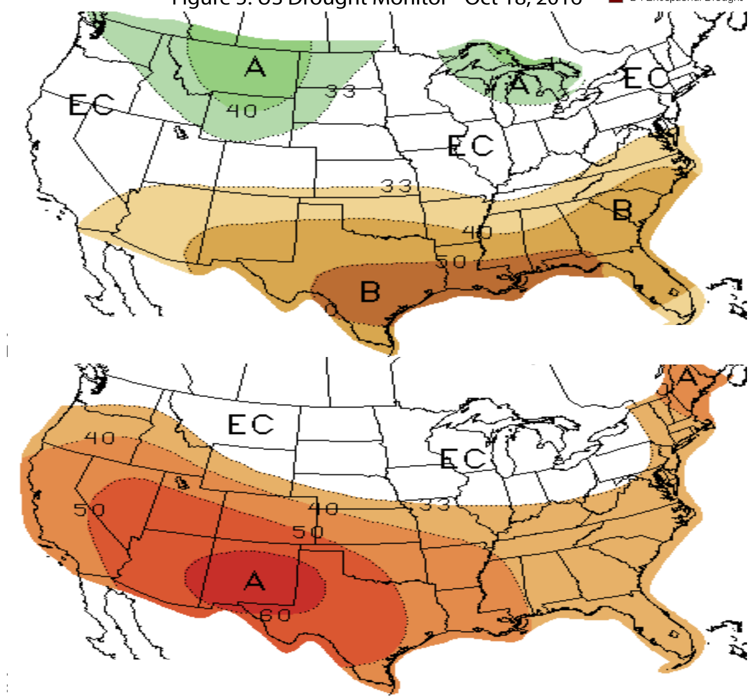


Figure 6: Three-Month Outlook - Precipitation (top) & Temperature (bottom) - Oct 20 2016

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

In the last month, oceanic and atmospheric indicators of the El Niño-Southern Oscillation (ENSO) have pushed forecasts back towards an increased likelihood of a La Niña event this winter (Figs. 1-2). Models are indicating an increased possibility of these conditions sustaining through winter 2017, leading to greater certainty regarding the formation of a weak La Niña event in late 2016 or early 2017. However, the chance of an ENSO-neutral winter cannot be entirely ruled out. Fluctuations in forecasts and models are likely due to the limited coordination between oceanic and atmospheric conditions described in previous outlooks, as well as generally borderline conditions between weak La Niña and ENSO-neutral.

A closer look at the various forecasts and seasonal outlooks provides insight into the range of expectations for this La Niña event. On October 11, the Japanese Meteorological Agency identified La Niña conditions in the equatorial Pacific, and projected a 60-percent chance that they would remain through winter 2017, down from 70 percent in September. Also on October 11, the Australian Bureau of Meteorology maintained its La Niña watch with a 50-percent chance of La Niña forming this winter, identifying numerous indicators that had shifted towards more La Niña-favorable conditions but noting that some uncertainty would remain until there was greater consensus in the models. On Oct 13, the NOAA Climate Prediction Center (CPC) pivoted to a more bullish La Niña forecast, with a 70-percent chance of La Niña developing in 2016 and a 55-percent chance of this event persisting through winter 2016-2017. On Oct 20, the International Research Institute for Climate and Society (IRI) and CPC forecasts described borderline weak La Niña conditions as present, but that may not even last through 2016, given poor atmospheric coupling and a general lack of trade winds typically seen in La Niña events. The North American multi-model ensemble characterizes the current model spread and highlights the variability looking forward to 2017. In the current run, the ensemble mean hovers around weak La Niña through 2016 before returning to neutral conditions in early 2017 (Fig. 4), whereas last month it showed a more rapid rebound to neutral conditions in 2016.

(continued on next page)

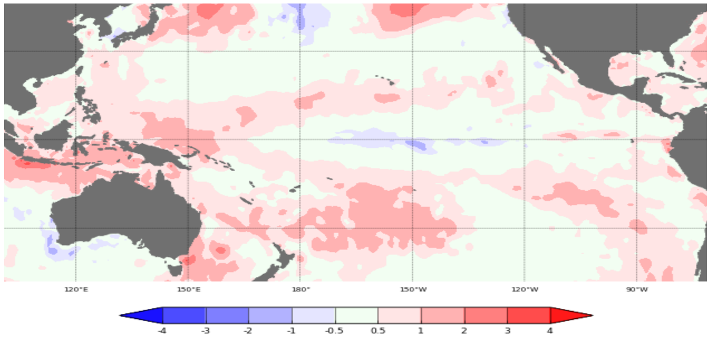


Figure 1: September 2016 Sea Surface Temperature (SST) Anomalies

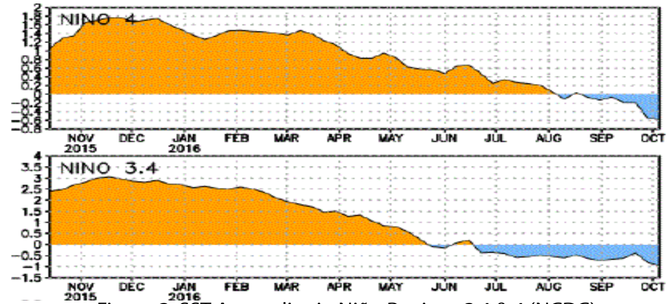


Figure 2: SST Anomalies in Niño Regions 3.4 & 4 (NCDC)

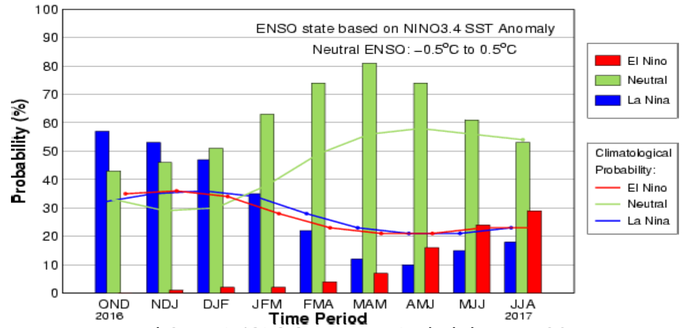


Figure 3: Mid-Sept IRI/CPC Consensus Probabilistic ENSO Forecast

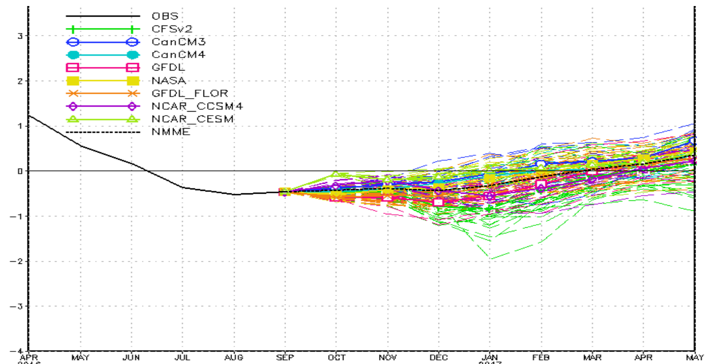


Figure 4: North American Multi-Model Ensemble Forecast for Niño 3.4

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

Collectively, these forecasts suggest that the Southwest is more likely than not to experience a weak La Niña event during winter 2016-2017, which could bring warmer- and drier-than-average conditions to the region over the cool season. The caveat is that most models show a relatively rapid decline in La Niña conditions by early 2017, which could mean a return of ENSO-neutral conditions before the peak of cool season precipitation in the Southwest (January-March), which might limit the La Niña influence on precipitation (Figs. 5a-b). On the other hand, even if the event wobbles back towards neutral, the oceanic and atmospheric conditions could still exert some influence on seasonal weather patterns. This uncertainty is difficult to plan around, but Southwestern winters are already characterized by a relatively dry climate (i.e. limited precipitation events over the cool season), and a La Niña event generally has the potential to shift that seasonal pattern to an even drier state (Fig. 6). There is greater variability in precipitation totals during ENSO-neutral years, making it harder to predict winter precipitation totals, but in general a wetter than average winter is unlikely if La Niña conditions persist.

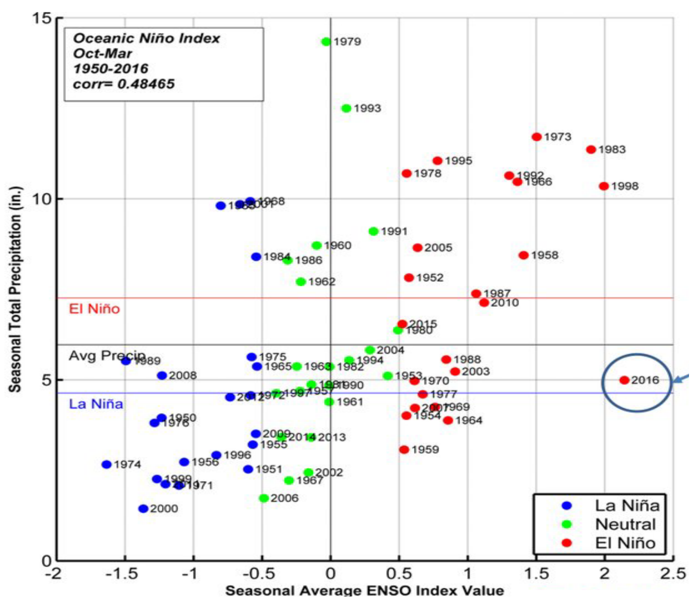


Figure 6: Arizona Climate Division 7 - ENSO vs. Precipitation

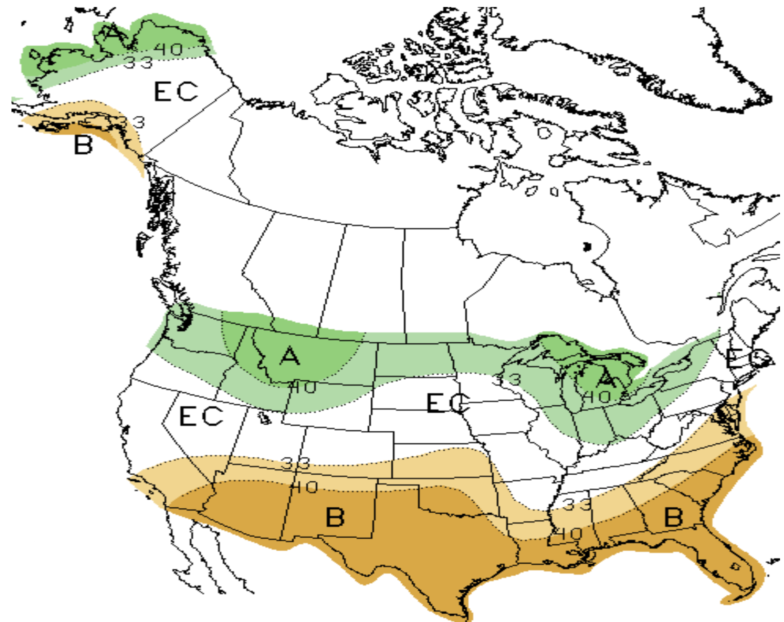


Figure 5a: Three-Month Precipitation Outlook Jan 2016 - Mar 2017

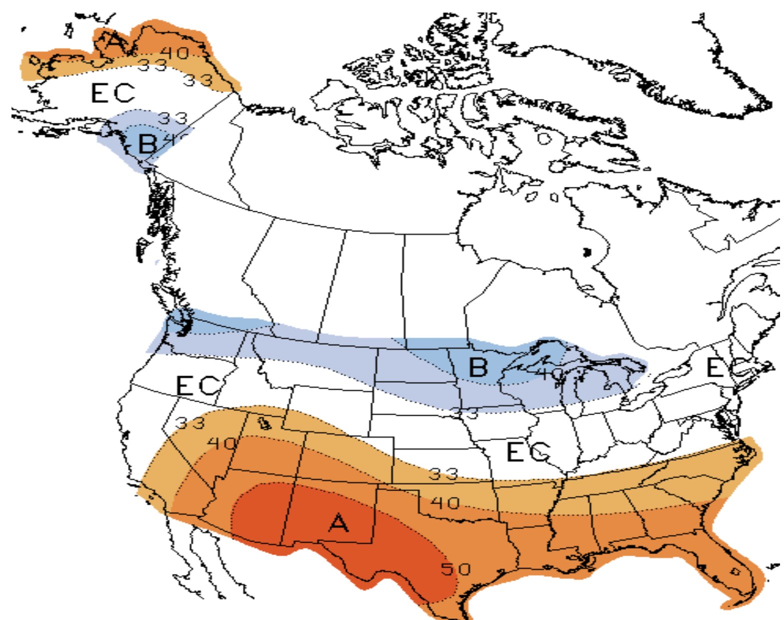


Figure 5b: Three-Month Temperature Outlook Jan 2016 - Mar 2017

Online Resources

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

Figure 2
Climate Science Applications Program
http://cals.arizona.edu/climate

SW Monsoon

In 2008, the National Weather Service identified the southwestern U.S. monsoon as a discrete period that starts June 15 and ends September 30. Prior to that, the start date of the monsoon was based on observed conditions, which varied across the region (Fig. 1).

Southwestern Monsoon Recap

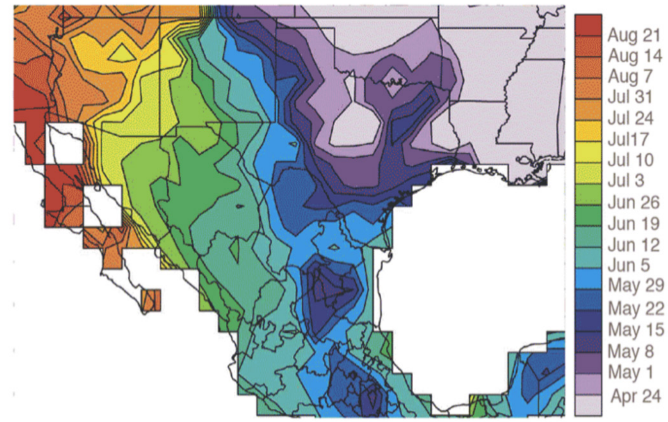


Figure 1: Historical Monsoon Onset Date

The Southwest saw the first strong burst of widespread monsoon activity near the end of June, followed by a break in monsoon activity over the first half of July 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, increasingly favorable conditions helped storms to form 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 September saw a decline in widespread monsoon activity, even while numerous areas did receive intermittent precipitation, particularly at higher elevations. On September 7, Hurricane Newton generated significant precipitation in a swath across southwestern Arizona and into central New Mexico. Finally, portions of southeastern Arizona and southwestern New Mexico saw a run of storms linked to a cutoff low in late September.

Based on cumulative totals for the official monsoon period, most of Arizona recorded average to below-average precipitation, even while clusters of the state recorded above-average rainfall (Figs. 2a and 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. 7a-c), while other stations such as Tacna 3 NE in the southwest corner of Arizona only recorded a few events and were well below their seasonal total (Fig. 7d).

Cumulative monsoon precipitation totals show that New Mexico caught up in the last month. Much of the state recorded average to above-average monsoon total precipitation, although some areas remained below average (Figs. 2b and 3b). Relatively widespread, uniform precipitation was 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 below-average precipitation in select locations such as Albuquerque and the Animas 3ESE station (Figs. 7e & 7g), while others such as El Paso, Texas, recorded above-average precipitation (Fig. 7f).

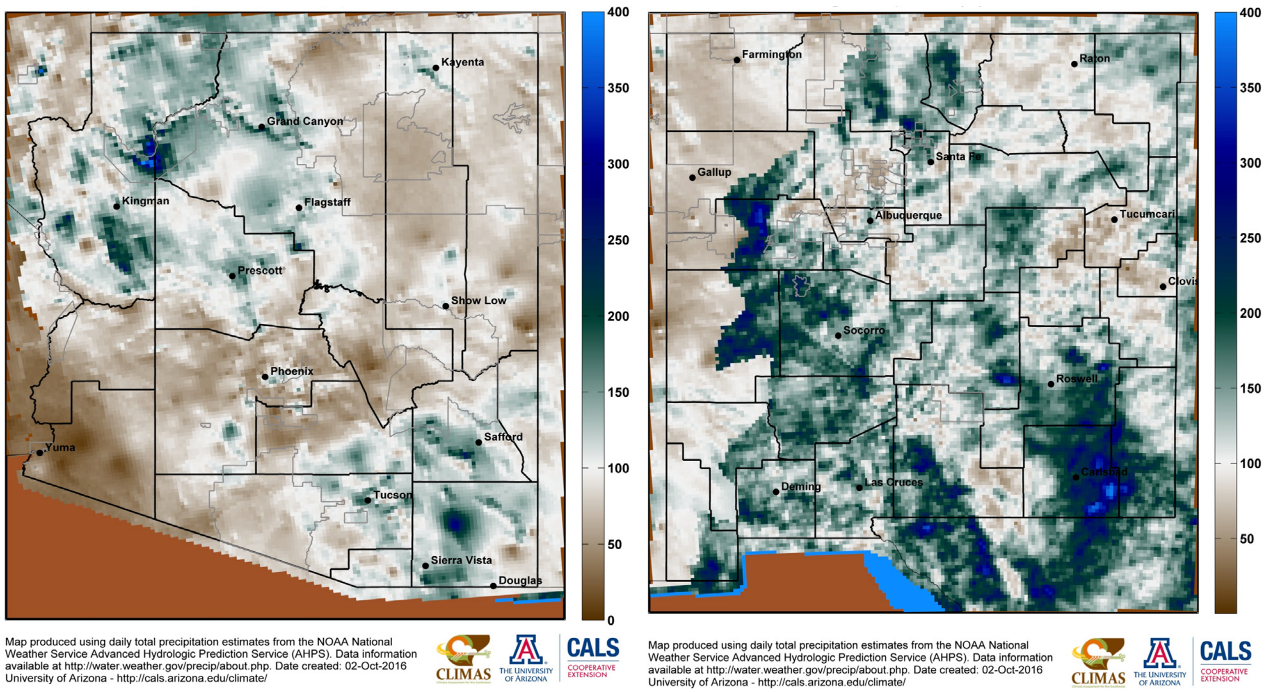


Figure 2a-b: Percent of Average Precipitation - Jun 15 - Sep 30

Online Resources

Figures 3-4
Climate Science Applications Program
http://cals.arizona.edu/climate

Figure 5
CLIMAS
www.climas.arizona.edu

Figures 6a-b
National Weather Service Tucson
http://www.wrh.noaa.gov/twc/

Figure 7a
Climate Science Applications Program
http://cals.arizona.edu/climate

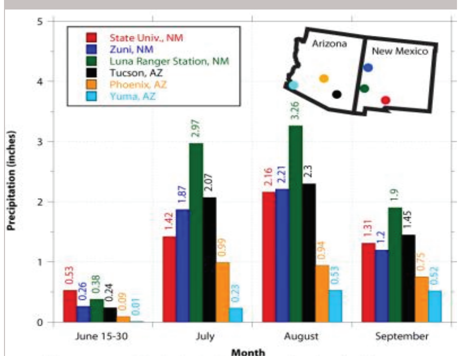


Figure 5: Monthly Monsoon Precipitation Totals

SW Monsoon

For More Information, visit:
www.climas.arizona.edu/sw-climate/monsoon

Monsoon Recap (cont.)

The official monsoon lasts for 108 days (June 15 – Sept 30), but the majority of storm activity occurs in July and August (Figure 5 below). As the season progresses, conditions become increasingly less favorable for monsoon storm formation, shifting from a typical monsoon circulation (e.g. Four Corners high) to a more fall-like pattern (Figs. 6a-6b). In 2016 there was a general consensus that the monsoon had basically shut down by mid-August. Around this time, however, eastern Pacific tropical storm activity ramped up (e.g. Javier, Newton), as typically occurs. Such activity is frequently attributed to the monsoon, as it contributes additional moisture to the region and can help fuel monsoon storm activity. Furthermore, the shifting circulation patterns can help recurve tropical storm activity back into the Southwest. The tropical storm season extends well beyond the bounds of the official monsoon, so it is a matter of timing and/or chance whether these storms contribute moisture before or after the September 30 monsoon cutoff. A few key events – Javier in August, Newton in early September, a cutoff low in late September – helped produce precipitation through the end of September. These storms may not be directly tied to the monsoon circulation patterns we see at the peak of the monsoon in July and August, but they do “count” in terms of seasonal totals and scoring the monsoon.

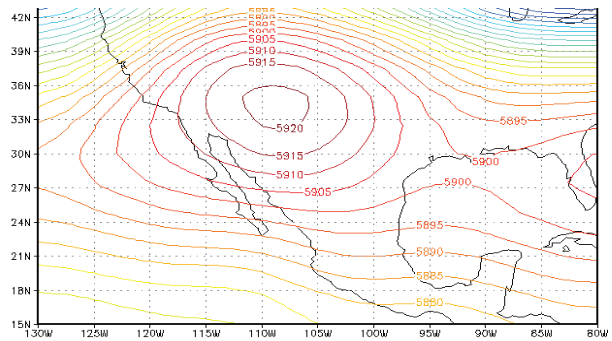


Figure 6a: 500mb Height, Aug 1 (Monsoon Peak)

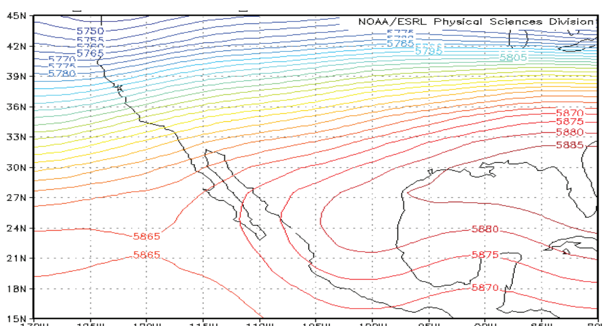


Figure 6b: 500mb Height, Sept 15 (Monsoon Decay)

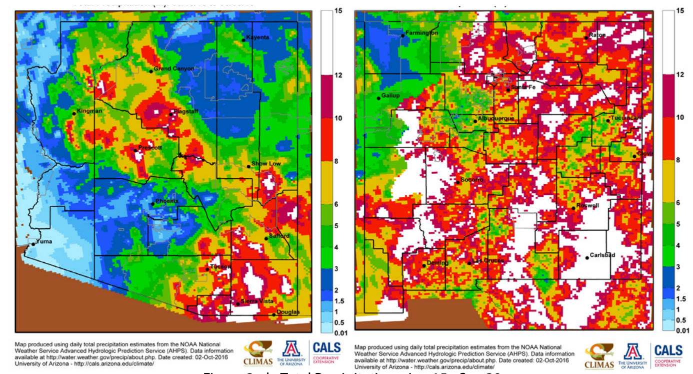


Figure 3a-b: Total Precipitation - Jun 15 - Sep 30

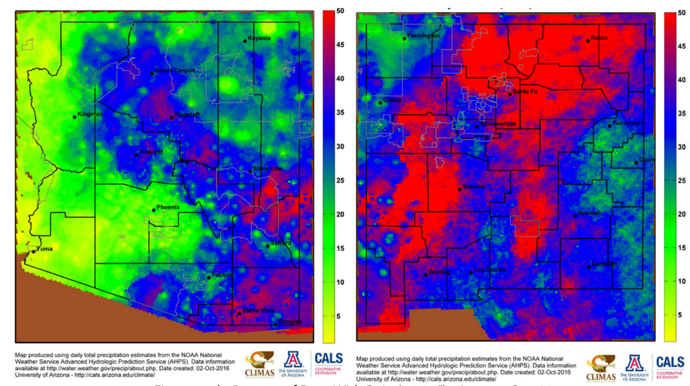
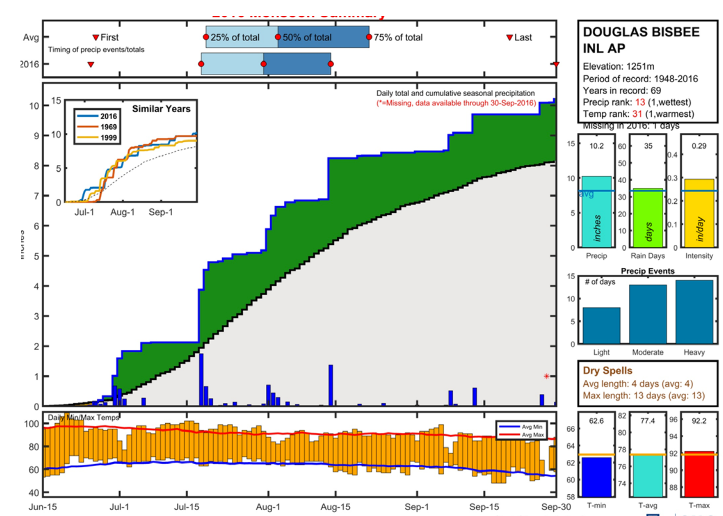


Figure 4a-b: Percent of Days With Rain (>0.01”) - Jun 15 - Sep 30



igure 7a: 2016 Monsoon Precipitation to-Date - Douglas, AZ

Online Resources

Figures 7b-7g
Climate Science Applications Program
http://cals.arizona.edu/climate

SW Monsoon

Season Technical Summaries

These 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

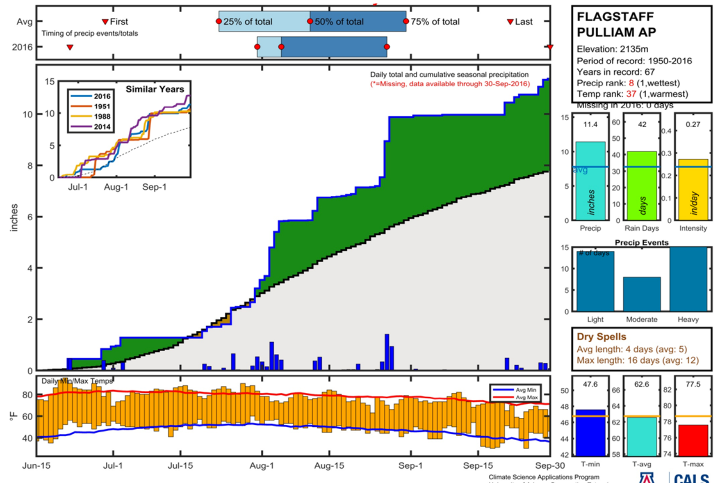


Figure 7b: 2016 Monsoon Precipitation to-Date - Flagstaff

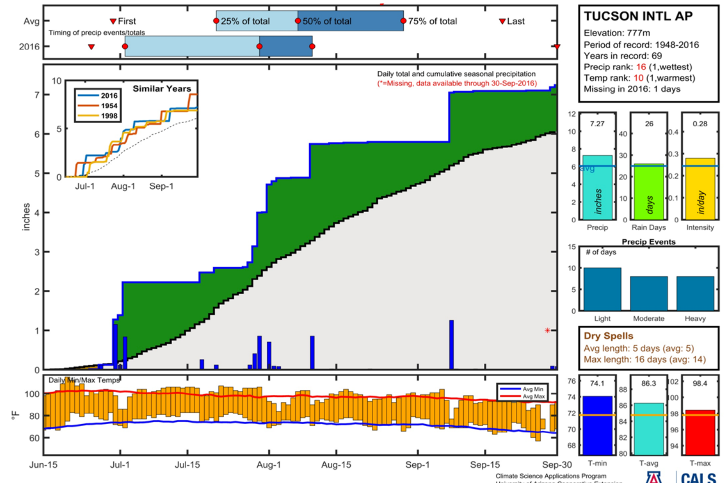


Figure 7c: 2016 Monsoon Precipitation to-Date - Tucson

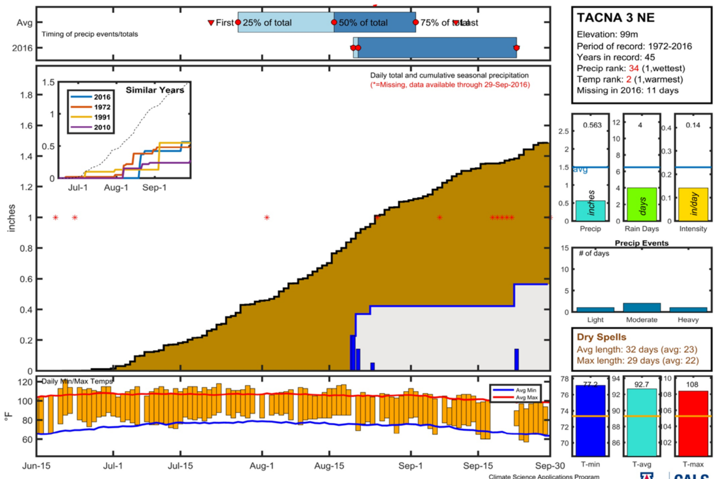


Figure 7d: 2016 Monsoon Precipitation to-Date - Tacna

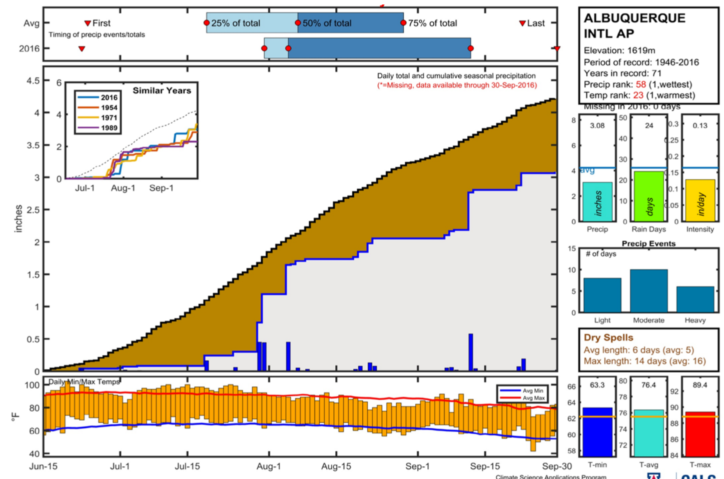


Figure 7e: 2016 Monsoon Precipitation to-Date - Albuquerque

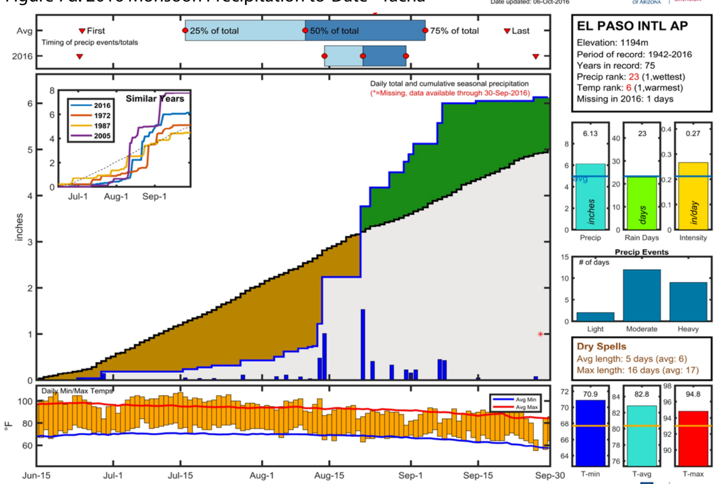


Figure 7f: 2016 Monsoon Precipitation to-Date - El Paso

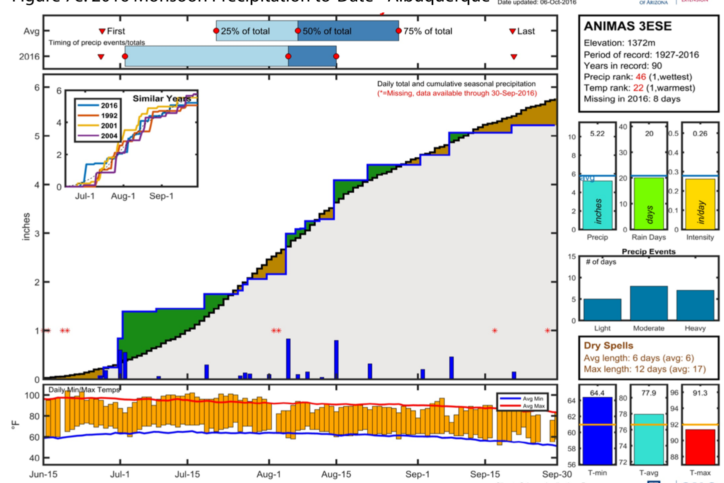


Figure 7g: 2016 Monsoon Precipitation to-Date - Animas 3ESE

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).

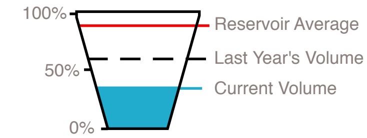
The table details more exactly the current capacity (listed as a percent of maximum storage). Current and maximum storage are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons). 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.

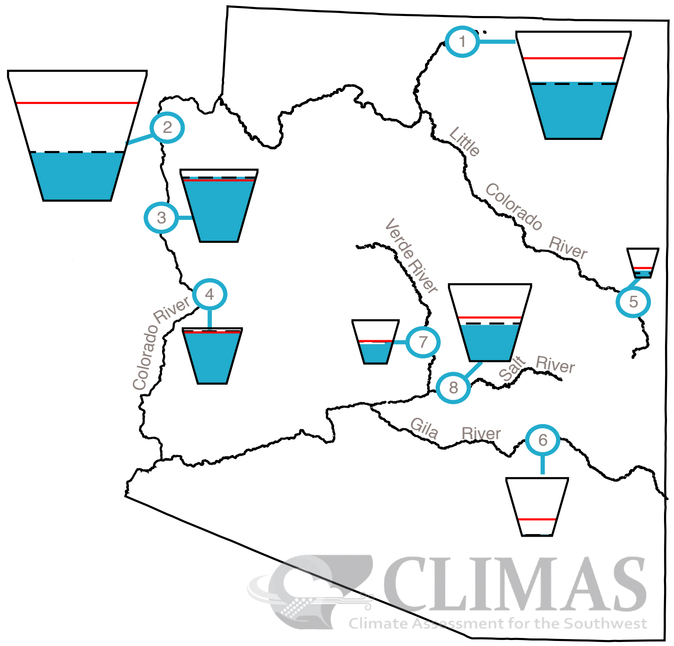
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

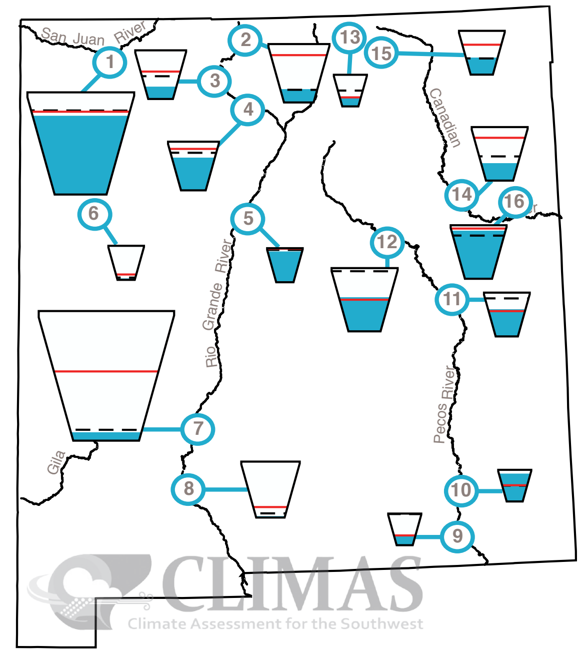
Reservoir Volumes

DATA THROUGH SEPT 30, 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	53%	12,822.1	24,322.0	-261.7
2. Lake Mead	37%	9,622.0	26,159.0	6.0
3. Lake Mohave	90%	1,624.0	1,810.0	-50.0
4. Lake Havasu	94%	581.5	619.0	-10.7
5. Lyman	23%	6.9	30.0	-1.0
6. San Carlos	2%	15.9	875.0	3.1
7. Verde River System	45%	129.9	287.4	1.0
8. Salt River System	46%	936.6	2,025.8	-46.8

*KAF: thousands of acre-feet

Reservoir	Capacity	Current Storage*	Max Storage*	One-Month Change in Storage*
1. Navajo	77%	1,309.8	1,696.0	-27.4
2. Heron	23%	92.7	400.0	-27.9
3. El Vado	25%	46.8	190.3	-3.4
4. Abiquiu	67%	124.9	186.8**	2.7
5. Cochiti	91%	45.4	50.0**	0.2
6. Bluewater	4%	1.6	38.5	-0.1
7. Elephant Butte	6%	132.1	2,195.0	-0.2
8. Caballo	2%	5.5	332.0	-16.1
9. Lake Avalon	29%	1.3	4.5**	-0.8
10. Brantley	88%	37.0	42.2**	8.8
11. Sumner	62%	22.4	102.0**	0.1
12. Santa Rosa	54%	56.9	105.9**	1.1
13. Costilla	26%	4.2	16.0	-2.4
14. Conchas	33%	82.4	254.2	-3.3
15. Eagle Nest	39%	30.9	79.0	-1.0
16. Ute Reservoir	89%	178	200	0.0

On the CLIMAS Website

CLIMAS Blog

Visit our blog for news, analysis and commentary related to SW climate.

http://www.climas.arizona.edu/blog

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Installations, Interviews, and Investment: my summer of gathering what's possible for the Navajo Nation's energy future

Stina Janssen

In spring 2014, I left my job in Seattle and went on a road trip to tour coal country from Appalachia to Arizona. I was searching for answers to restless questions: how, in the face of climate change, would the US transition its entrenched fossil fuel infrastructure to renewables? How could that transition re-center culture, community, and a sustainable economy? Through a 6-week volunteer stint at Black Mesa Water Coalition (BMWC), I began to see the outlines of answers in BMWC's work to develop community-based solar. I knew I wanted to stay connected to this important work and support it however I could.

Just a year later, I was back at Black Mesa Water Coalition as a student at the University of Arizona and a Climate and Society Graduate Fellow with CLIMAS (also funded by the Renewable Energy Network's Future Energy Leaders Summer Fellowship program). This time, I was working together with the small but mighty nonprofit to write a report about challenges, opportunities, and recommendations to develop solar power on the Navajo Nation

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Conservation and Development on the Loess Plateau

Joy Liu

Agriculture has always been a crucial part of the Chinese identity and cultural heritage. At the heart of China, where agriculture began to flourish, is the Loess Plateau, which has taken millions of years to be blown in by the wind, and known as 'cradle of Chinese civilization'. The Loess Plateau covers an area 2.5 times the size of UK, and is stripped away by the mighty Yellow River, a raging torrent which washes up to 1.6 billion tons of soil downstream every year (Williams 2010).

Researchers, practitioners, and policy makers in China and around the globe have been working on soil and water conservation on Loess Plateau since the dawn of 20th Century. From the eastern part of Loess Plateau, climate transitioned from semi-arid to arid to the inner west. Facing the encroaching desertification from the deserts to the northwest, and the massive urbanization projects within the region, rural farmers on the Loess Plateau are torn between conservation, mechanization, and economic development.

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