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June Southwest Climate Outlook

Precipitation and Temperature: The Southwest was characterized by below-average precipitation in May, ranging locally from record driest to near average (Fig. 1a). Temperatures were above average to much-above average across most of the Southwest, with small pockets of record-warm conditions in the northwest corner of New Mexico and along the eastern edge of the state (Fig. 1b). The March through May period exhibited similar patterns of mostly drier-than-average to record-dry precipitation (Fig. 2a) and much-above-average to record-warm temperatures (Fig. 2b). Water-year precipitation to date (Oct 2017 – May 2018) highlights how dry most of the region has been at a longer timescale, with below-normal to record-dry conditions across Arizona and above-normal to record-dry conditions in New Mexico (Fig. 3). **Monsoon & Tropical Activity:** The Pacific tropical storm season got off to a strong start with Aletta and Bud, the former as an early start to the season in May, and the latter bringing well-above-normal June precipitation to parts of the Southwest (see Monsoon/TS tracker on pp. 4-6).

Snowpack & Streamflow Forecast: Snow was all but gone from the Southwest by June, and snow water equivalent (SWE) for the Upper Colorado River Basin remain below average, with only the upper Great Basin and Pacific Northwest having any semblance of above-normal snowpack. Warm and dry conditions continue to affect streamflow and runoff timing – a pattern that extends to the Upper Colorado River Basin, where streamflow forecasts are all well-below average.

Drought: Drought-designated areas continued to expand from last month. In the June 21 U.S. Drought Monitor, Arizona and New Mexico saw further increases in the extent and intensity of drought (Fig. 4). These designations reflect short-term precipitation deficits, above-normal temperatures at monthly and seasonal timescales, and longer-term drought that tracks the cumulative effect of extended periods of warmer- and drier-than-normal conditions. The surge of tropical storm activity (Bud) in mid-June brought a welcome reprieve from ongoing dry conditions, but the next realistic hope for drought relief is the summer monsoon. The extent of its impact will depend on when it starts and how much (and how regularly) precipitation actually falls.

Wildfire: The National Significant Wildland Fire Potential Outlook for June identified above-normal wildland fire risk across the Southwest except for eastern New Mexico and far northwestern Arizona, while the outlook for July calls for the fire risk to return to normal (Fig. 5a-b) in anticipation of monsoon moisture abating the risk. Southeastern Arizona and portions of New Mexico received precipitation linked to the remnants of Tropical Storm Bud, but regional patterns are not indicative of an early start to widespread monsoon activity (see Monsoon Tracker on pp. 4-6). A late start to the monsoon could extend the fire-risk window, especially if long periods of dry lightning—a major ignition risk in June and July—precede precipitation. The region has been relatively fortunate in 2018, with less lightning-caused fire activity than might have been expected (Fig. 6), given the exceptionally warm and dry conditions over the winter and above-normal fine-fuel loading and continuity.

El Niño Tracker: Neutral conditions are present in oceanic and atmospheric indicators, and longer-term outlooks indicate increasing chances of an El Niño event in 2018. Both the timing and the probability of an El Niño event are still uncertain, but most forecasts highlighted an increased chance of El Niño forming compared to last month, with now nearly twice the chance compared to ENSO neutral conditions. Notably, there is nearly zero chance of a La Niña event in 2018.

Precipitation and Temperature Forecast: The three-month outlook for June through August calls for increased chances of above-normal precipitation in Arizona and western New Mexico, with equal chances in central and eastern New Mexico (Fig. 7, top). The outlook calls for increased chances of above-average temperatures for the entire Southwest (Fig. 7, bottom).

Tweet June 2018 SW Climate Outlook

CLICK TO TWEET

JUN2018 @CLIMAS_UA SW Climate Outlook, ENSO Tracker, Hurricane Bud, Monsoon Tracker, AZ & NM Reservoir volumes https://bit.ly/2MNXRFt #SWclimate #AZWX #NMWX #SWCO

June 2018 SW Climate Outlook

Online Resources

Figures 1-2
National Centers for Environmental Information
ncei.noaa.gov

Figure 3
Western Regional Climate Center
wrcc.dri.edu

Figure 4
Climate Assessment for the SW
climas.arizona.edu

Figure 5
U.S. Drought Monitor
droughtmonitor.unl.edu

Figure 6
National Interagency Fire Center
nifc.gov

Figure 7
NOAA - Climate Prediction Center
cpc.ncep.noaa.gov

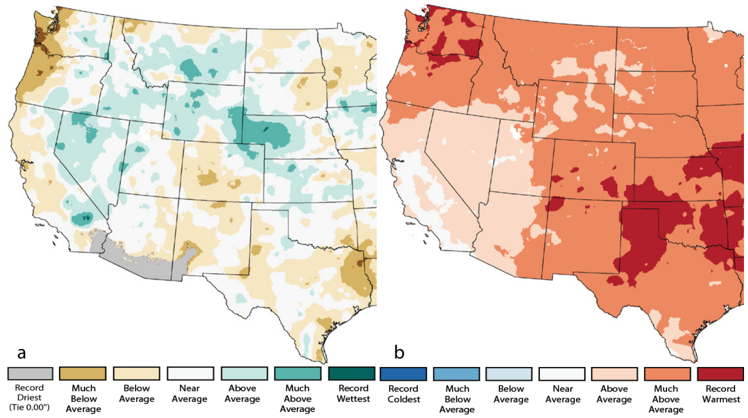


Figure 1: May 2018 Precipitation (a) & Temperature Ranks (b)

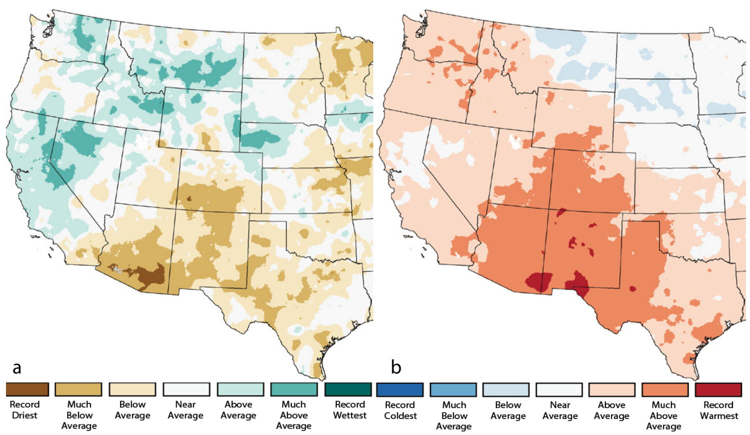


Figure 2: Mar-May 2018 Precipitation (a) & Temperature Ranks (b)

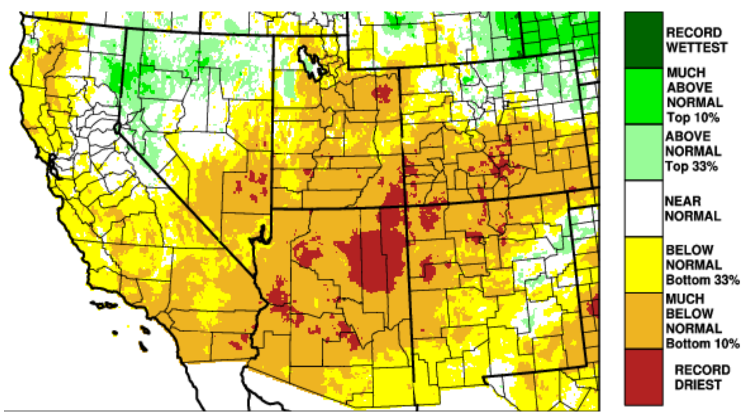


Figure 3: Oct 2017 - May 2018 Precipitation Rankings

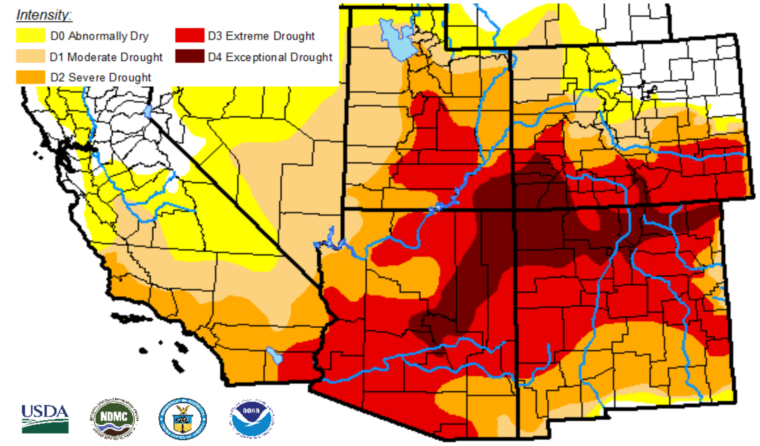


Figure 4: US Drought Monitor - June 19, 2018

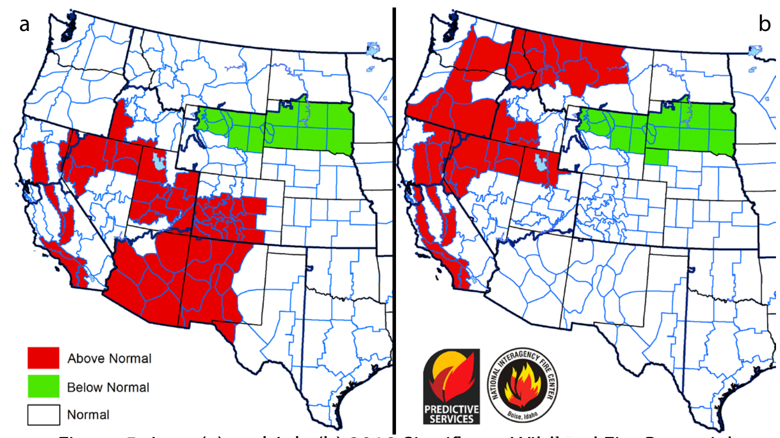


Figure 5: June (a) and July (b) 2018 Significant Wildland Fire Potential

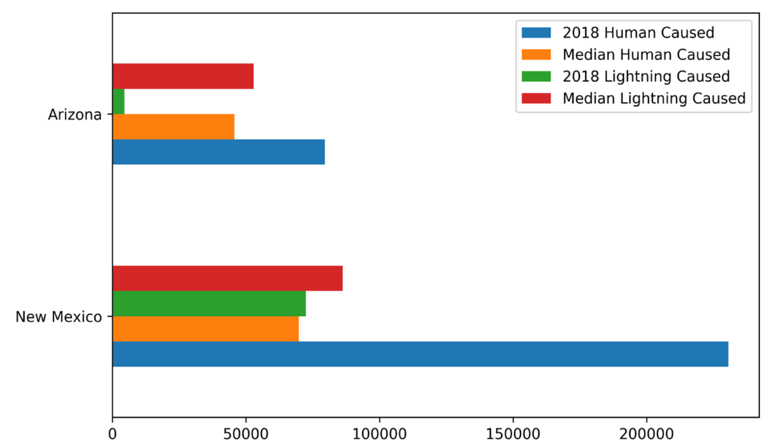


Figure 6: 2018 Widlfires (to date) vs. Median - Human and Lightning Caused Acres Burned

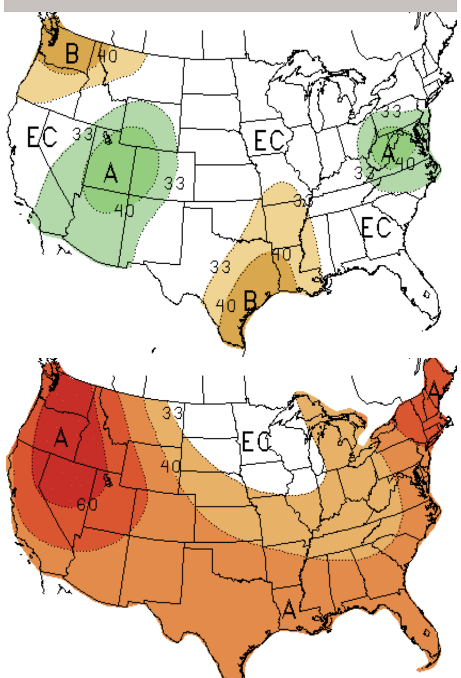


Figure 7: Three-Month Outlook - Precipitation (top) & Temperature (bottom) - Jun 21, 2018

Online Resources

Figure 1
Australian Bureau of Meteorology
bom.gov.au/climate/enso

Figure 2
NOAA - Climate Prediction Center
cpc.ncep.noaa.gov

Figure 3
International Research Institute for Climate and Society
iri.columbia.edu

Figure 4
NOAA - Climate Prediction Center
cpc.ncep.noaa.gov

climate.gov - Spring Predictability Barrier
https://bit.ly/1Xipsx7

El Niño / La Niña

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

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

ENSO Tracker

Oceanic and atmospheric conditions remained ENSO-neutral over the last month (Figs. 1-2), and most ENSO forecasts and outlooks reflect these conditions. On June 5, the Australian Bureau of Meteorology maintained its ENSO Outlook at "inactive," with neutral conditions likely to persist through summer. However, the agency noted that models forecast warming conditions in surface temperatures in the tropical Pacific Ocean—a precursor to the emergence of an El Niño event. On June 11, the Japanese Meteorological Agency (JMA) saw an end to lingering La Niña conditions in spring 2018, a 70-percent chance of ENSO-neutral conditions over summer, and a 50-percent chance of either El Niño or neutral conditions this fall. On June 14, the NOAA Climate Prediction Center (CPC) issued an El Niño watch even while short-term conditions were expected to remain ENSO-neutral. CPC indicates a 50-percent chance of an El Niño event developing this fall and a 65-percent chance of El Niño conditions this winter. Similarly, but with earlier timing, the International Research Institute's (IRI) June 19 ENSO Quick Look calls for a 50-percent chance of an El Niño event this summer and a 65-percent chance of El Niño over the fall. IRI predicts the event to be weak initially but to potentially reach moderate strength during the fall and winter. The North American Multi-Model Ensemble (NMME) returned to ENSO-neutral conditions, and despite uncertainty over the latter half of 2018, also is increasingly suggestive of a weak to moderate El Niño event by the end of 2018 (Fig. 3).

Summary: As recently as last month, ENSO-neutral conditions were seen as a near-certainty over summer. Forecasters are increasingly bullish on the likelihood of an El Niño event by the end of 2018, and more recent outlooks have increased the chances of an earlier start. A closer look at how these forecasts compare to climatology captures how these seasonal forecasts compare to long-term patterns. The most recent IRI plots indicate a roughly 65-percent chance of El Niño (Fig. 4, red bars), which is approximately 30 percent higher than climatology (red line), while the roughly five-percent chance of La Niña (blue bars) is about 30 percent below climatology (blue line). This illustrates that 1) an El Niño event is increasingly possible by the end of 2018, but it is far from certain; 2) a La Niña event is all but impossible; and 3) the chance of ENSO-neutral conditions is roughly equivalent to climatology. It is still relatively early, but current indications are now favoring the formation of an El Niño in 2018.

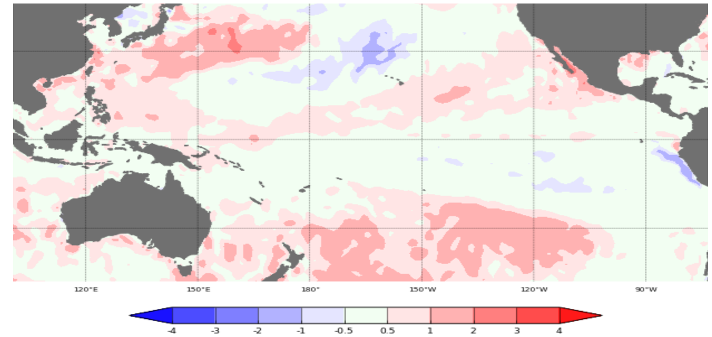


Figure 1: May 2018 Sea Surface Temperature (SST) Anomalies

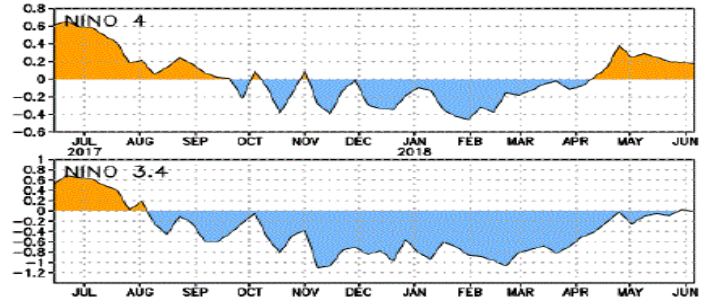


Figure 2: SST Anomalies in Niño Regions 3.4 & 4 (NCDC)

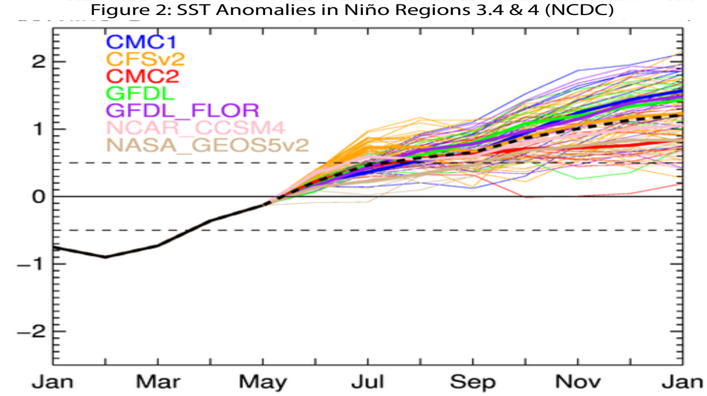


Figure 3: North American Multi-Model Ensemble Forecast for Niño 3.4

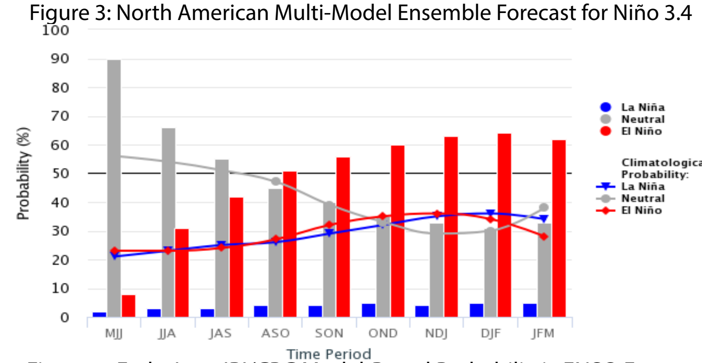


Figure 4: Early-June IRI/CPC Model-Based Probabilistic ENSO Forecast

Online Resources

Figure 1
International Research Institute for Climate and Society
journals.ametsoc.org/doi/abs/10.1175/2007JCLI1762.1

Figures 2a-2b
Monsoon Definition & Progression National Weather Service - Tucson
wrh.noaa.gov/twc/monsoon/monsoon.php

Figure 3
CLIMAS: Climate Assessment for the Southwest
climas.arizona.edu

NWS Tucson has an excellent extended explanation of seasonal atmospheric dynamics that drive monsoon progression.
wrh.noaa.gov/twc/monsoon/monsoon_info.php

Monsoon Tracker & Hurricane Bud

Was our mid-June precipitation the monsoon? In 2008, the National Weather Service (NWS) changed the definition of the start of the Southwest monsoon from a variable date based on locally measured conditions to a fixed date of June 15 (and a fixed end date of Sept 30). This allowed for a clear delineation of the period of monsoon activity (108 days) and focused NWS's messaging strategy as it pertains to the expected hazards during that period, which include extreme heat, strong winds, dust storms, flash flooding, lightning, and wildfires (see monsoon safety awareness hub at NWS Tucson).

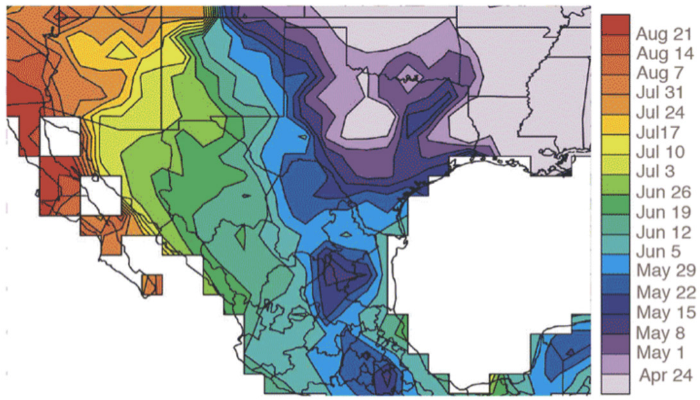


Figure 1: Historical Monsoon Onset Date

Prior to 2008, the flexible start date reflected the seasonal progression of the monsoon, with a considerable temporal gradient across the region (Fig. 1).

This gradient is linked to seasonal atmospheric patterns and the establishment of the "monsoon ridge" in the Southwest (Figs. 3a-b, also see sidebar for link to NWS pages). The heating of the complex topography of the western U.S. with the increasing sun angle and contrast with the cooler water of the adjacent Pacific Ocean lead to the establishment of this upper-level ridge of high pressure over the Southwest U.S. (also known as Four Corners High). The flow around this upper-level ridge shifts from a dry southwesterly fetch in May to a moisture-rich southerly-southeasterly fetch in late June/early July (see figures, right).

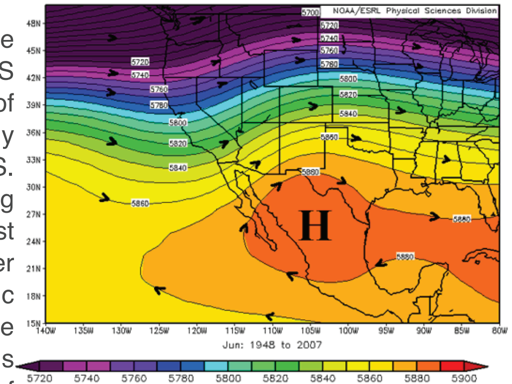


Figure 2a: NCEP/NCAR Mean 500mb Geopotential Height - Jul (1948-2007)

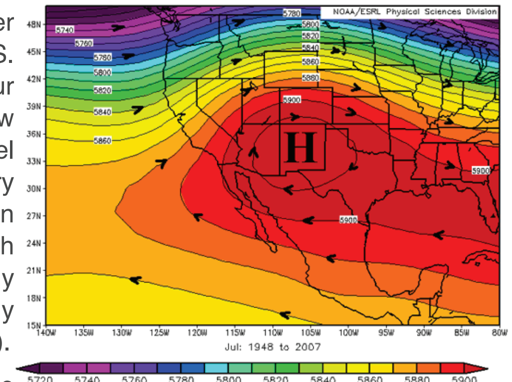


Figure 2b: NCEP/NCAR Mean 500mb Geopotential Height - Jul (1948-2007)

In Southern Arizona, the monsoon start date was based on the average daily dewpoint temperature. Phoenix and Tucson NWS offices used the criteria of three consecutive days of daily average dewpoint temperature above a threshold (55 degrees in Phoenix, 54 degrees in Tucson) to define the start date of the monsoon. As shown in Figure 3 the dewpoint temperature criterion produced start dates ranging from mid-June to late July over the period of record (1949-2016).

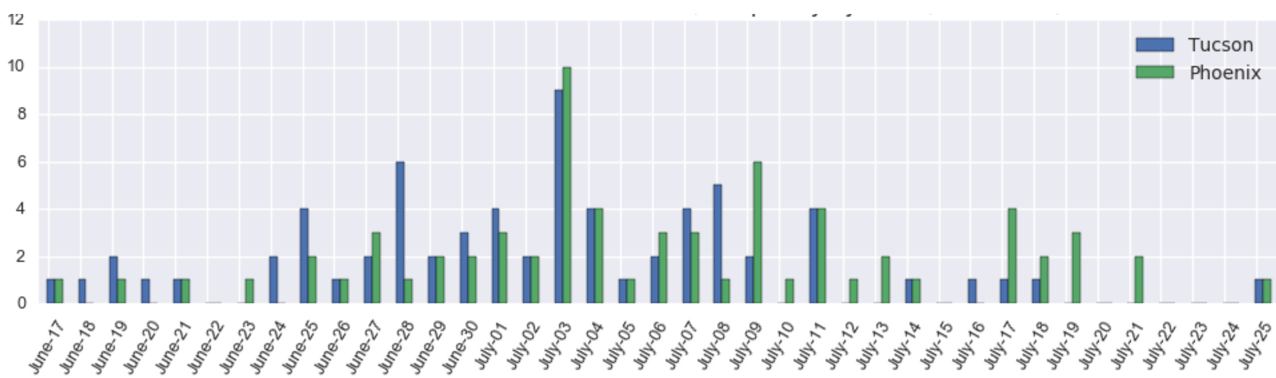


Figure 3: Monsoon Onset (as defined by dewpoint thresholds) in Tucson and Phoenix, Frequency by Date (1949-2016)

Online Resources

Figure 4
CLIMAS: Climate Assessment for the Southwest
climas.arizona.edu

Data: National Weather Service

Figure 5
National Weather Service Tucson
wrh.noaa.gov/twc/monsoon/monsoon.php

Figure 6
National Hurricane Center
nhc.noaa.gov

Monsoon Tracker & Hurricane Bud (cont)

Notably, by this metric, the earliest start date on record was June 17, but early July is far more common. In any case, June precipitation is relatively rare in southern Arizona (Fig. 4), thus the recent incursion of moisture from Tropical Storm Bud was a welcome change to our typical mid-June dry heat. Arriving in southern Arizona precisely on June 15 – the now official start of the monsoon – Bud raised the question: Did this moisture qualify as "monsoon"?

The moisture from Tropical Storm Bud was key to the widespread event, but the rain also was dependent on a low-pressure system that happened to be nearby. Bud was caught between a trough of low pressure off the coast of California and the subtropical ridge which was displaced well to the east over the Gulf of Mexico. The flow pattern over this event resembled a "transition" pattern typically seen at the end of the monsoon season (Fig. 5), when the mid-latitude jet stream becomes more active and the monsoon ridge starts to retreat south. Together these features helped guide the storm into southern Arizona.

The approaching trough of low pressure was also critical to cooling upper-level air temperatures, increasing the instability of the very moist airmass at the surface, and providing wind shear to help organize any storms that formed. This kind of assist is possible at the beginning of the monsoon in June but is much more common in late summer when we are transitioning *out* of the monsoon. It rarely occurs in the middle of the monsoon because of the dominance of the subtropical ridge pattern that limits how close mid-latitude storms can get to the Southwest.

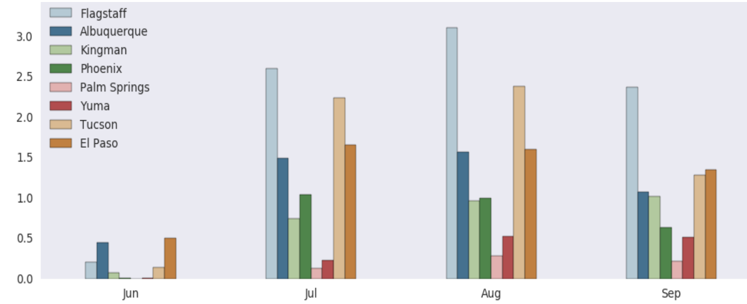


Figure 4: Average Monthly Monsoon Precipitation in the Southwest

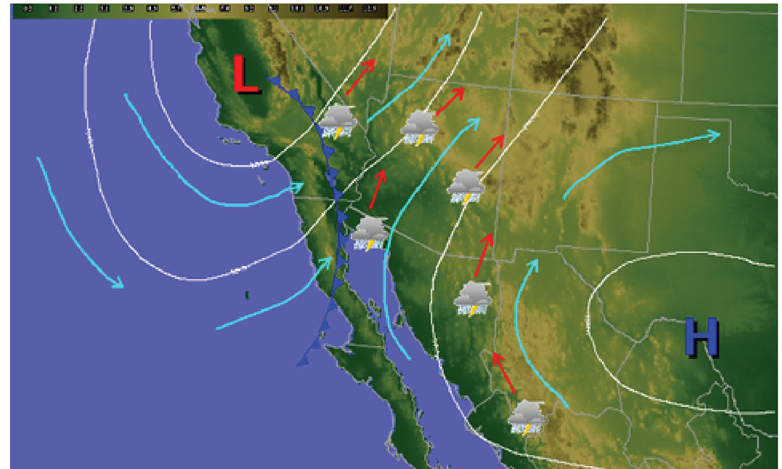


Figure 5: Type IV Monsoon Transitional Pattern (source: NWS Tucson)

Ultimately, the storm was less dependent on the exact track that Bud took in mid-June (Fig. 6), and more dependent on the coalescence of larger atmospheric patterns that came together to bring welcome – if unexpected – precipitation to the Southwest. On the following page, find examples of different data visualizations of this regional variability.

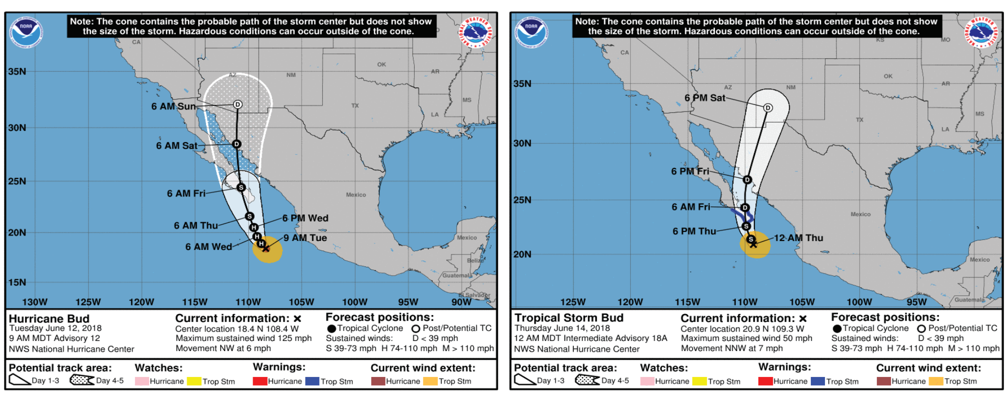


Figure 6: Hurricane/TS Bud - National Hurricane Center Advisory Maps for June 12 (left) and June 14 (right)

Online Resources

Figure 7
UA Climate Science Application Program
cals.arizona.edu/climate

Figure 8
Rainlog Citizen Science Monitoring Program
rainlog.org

Figure 9
CLIMAS: Climate Assessment for the Southwest
climas.arizona.edu

Data: rcc-acis.org

Monsoon Tracker & Hurricane Bud (cont)

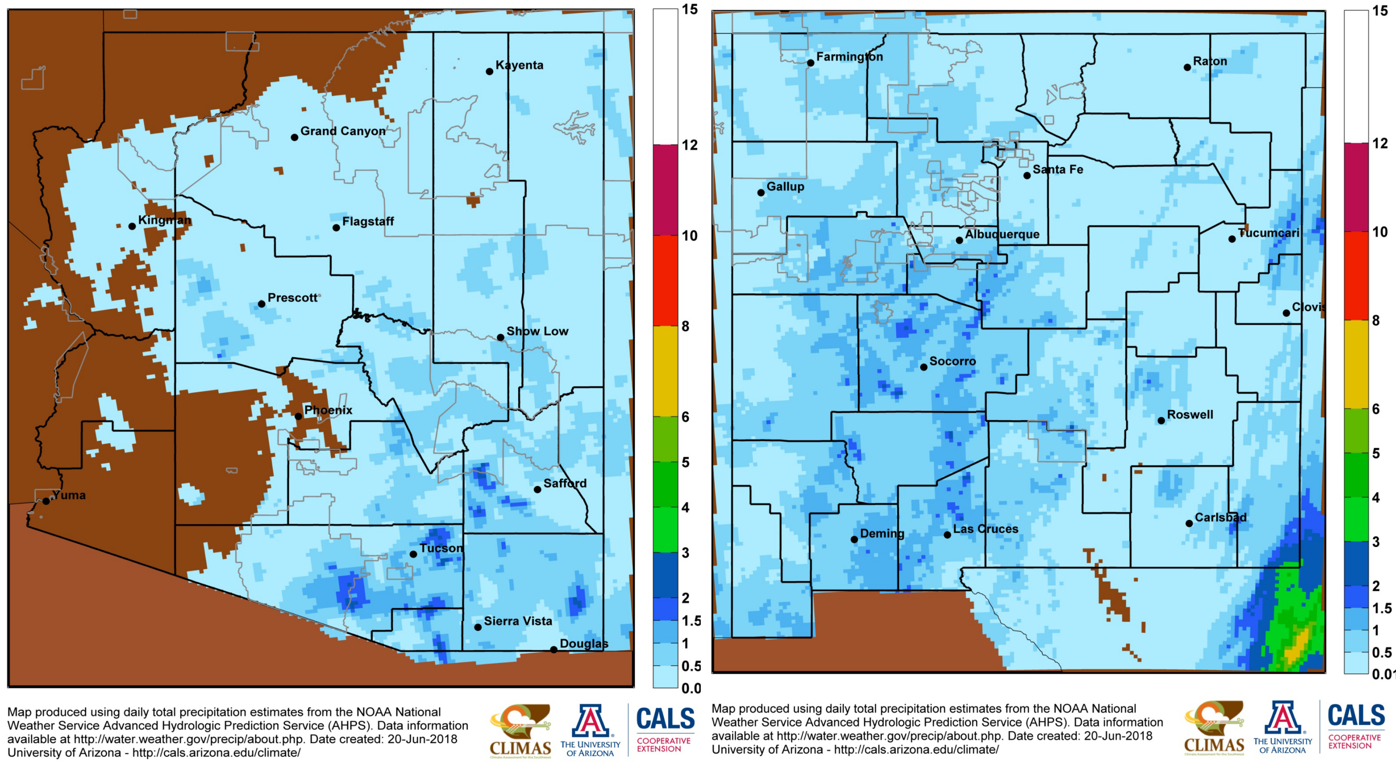


Figure 7a-b: Total Precipitation - Jun 15 - Jun 19, 2018

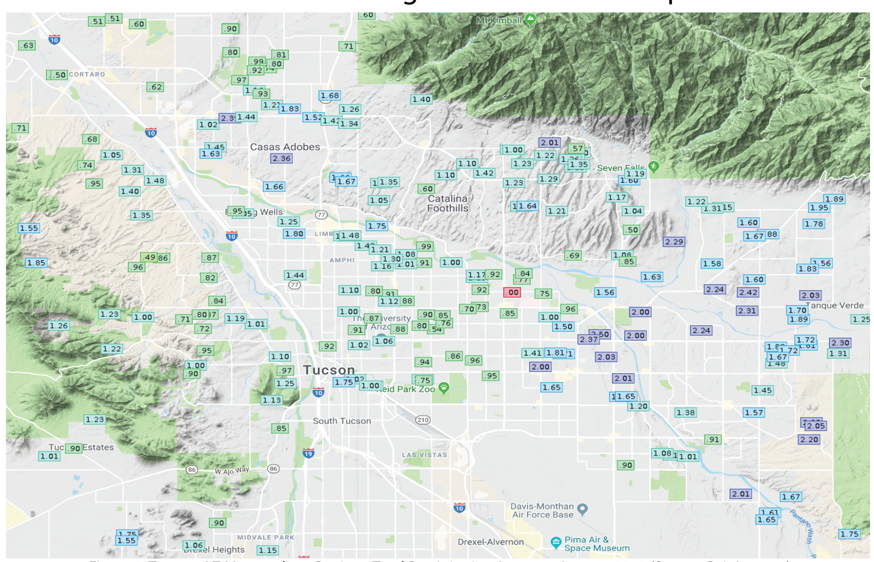


Figure 8: Tucson, AZ Metropolitan Region - Total Precipitation June 15 - June 17 2018 (Source: RainLog.org)

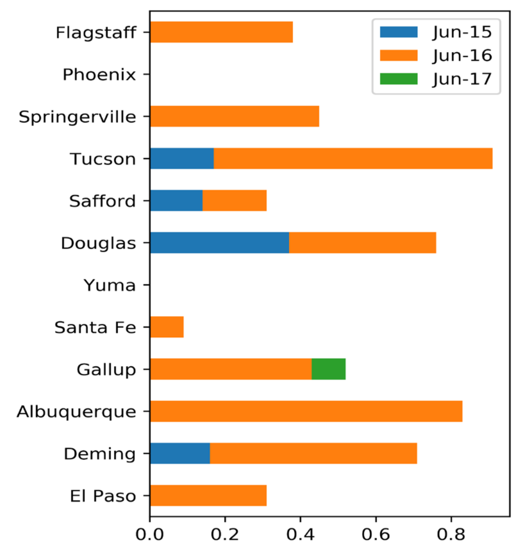


Figure 9: SW Regional Storm Totals - Jun 15 - 17, 2018

Online Resources

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

www.wcc.nrcs.usda.gov/BOR/basin.html

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).

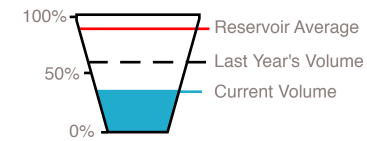
The table details more exactly the current capacity (listed as a percent of maximum storage). Current and maximum storage are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons).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

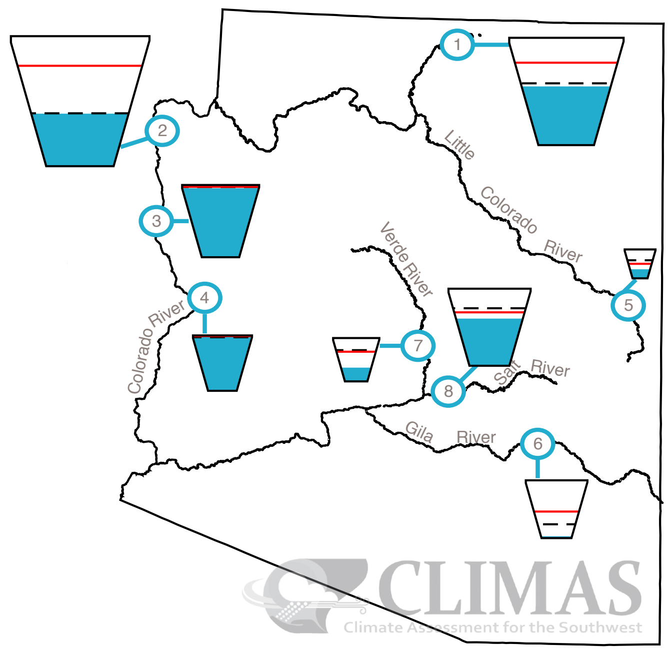
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

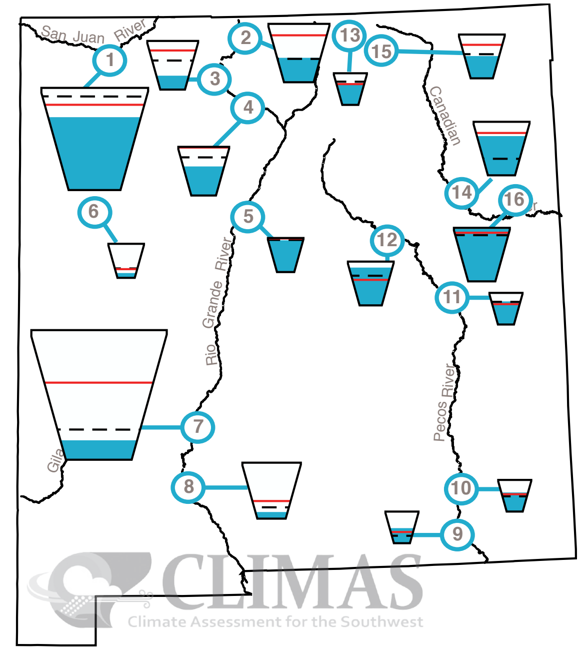
Reservoir Volumes

DATA THROUGH MAY 31, 2018

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







* in KAF = thousands of acre-feet

Reservoir	Capacity	Current Storage*	Max Storage*	One-Month Change in Storage*
1. Lake Powell	53%	12,885.9	24,322.0	-216.9
2. Lake Mead	38%	10,011.0	26,159.0	-376.0
3. Lake Mohave	94%	1,703.0	1,810.0	26.0
4. Lake Havasu	96%	591.3	619.0	25.7
5. Lyman	29%	8.7	30.0	-1.5
6. San Carlos	1%	12.7	875.0	-20.3
7. Verde River System	30%	85.1	287.4	-3.5
8. Salt River System	59%	1,190.7	2,025.8	-58.1

*KAF: thousands of acre-feet

Reservoir	Capacity	Current Storage*	Max Storage*	One-Month Change in Storage*
1. Navajo	72%	1,223.2	1,696.0	0.8
2. Heron	42%	166.6	400.0	14,3
3. El Vado	28%	53.8	190.3	-28.0
4. Abiquiu	59%	110.1	186.8	-7.9
5. Cochiti	93%	46.4	50.0	-0.9
6. Bluewater	14%	5.3	38.5	-0.4
7. Elephant Butte	15%	337.9	2,195.0	-56.4
8. Caballo	12%	38.7	332.0	-7.4
9. Lake Avalon	47%	2.1	4.5	-0.5
10. Brantley	60%	25.2	42.2	-5.0
11. Sumner	73%	26.4	35.9	-1.8
12. Santa Rosa	86%	91.1	105.9	-0.5
13. Costilla	65%	10.3	16.0	-2.1
14. Conchas	73%	186.1	254.2	-14.3
15. Eagle Nest	51%	40.5	79.0	-1.8
16. Ute Reservoir	97%	194	200	-2.0

Online Resources

Figure 1
Climate Program Office
cpo.noaa.gov

RISA Program Homepage
http://cpo.noaa.gov/Meet-the-Divisions/Climate-and-Societal-Interactions/RISA

UA Institute of the Environment
environment.arizona.edu

New Mexico Climate Center
weather.nmsu.edu

CLIMAS Research & Activities

CLIMAS Research
climas.arizona.edu/research

CLIMAS Outreach
climas.arizona.edu/outreach

Climate Services
climas.arizona.edu/climate-services

CLIMAS
Climate Assessment for the Southwest
A NOAA RISA TEAM

What is CLIMAS?

The Climate Assessment for the Southwest (CLIMAS) program was established in 1998 as part of the National Oceanic and Atmospheric Administration's Regional Integrated Sciences and Assessments program. CLIMAS—housed at the University of Arizona's (UA) Institute of the Environment—is a collaboration between UA and New Mexico State University.

The CLIMAS team is made up of experts from a variety of social, physical, and natural sciences who work with partners across the Southwest to develop sustainable answers to regional climate challenges.

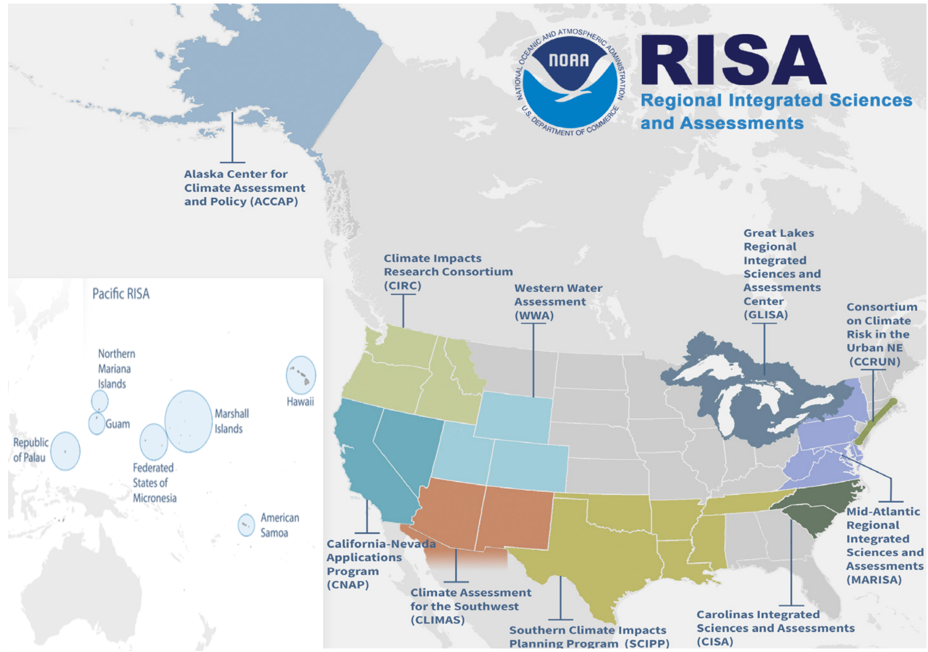


Figure 1: NOAA Regional Integrated Sciences and Assessments Regions

What does CLIMAS do?

The CLIMAS team and its partners work to improve the ability of the region's social and ecological systems to respond to and thrive in a variable and changing climate. The program promotes collaborative research involving scientists, decision makers, resource managers and users, educators, and others who need more and better information about climate and its impacts. Current CLIMAS work falls into six closely related areas: 1) decision-relevant questions about the physical climate of the region; 2) planning for regional water sustainability in the face of persistent drought and warming; 3) the effects of climate on human health; 4) economic trade-offs and opportunities that arise from the impacts of climate on water security in a warming and drying Southwest; 5) building adaptive capacity in socially vulnerable populations; and 6) regional climate service options to support communities working to adapt to climate change.

June 2018 SW Climate Podcast - Dealing with Drought, Monsoon Outlooks, and the Magical Monsoon Mystery Tour

In the June 2018 episode of the CLIMAS Southwest Climate Podcast, Mike Crimmins and Zack Guido dive into their favorite season. The monsoon is on the horizon, creating considerable excitement. First, they recap temperature and precipitation in the region, and talk about how they are related to the fire season so far. They turn to the monsoon outlooks and forecasts, with a close look at what these forecasts are saying, as well as how much certainty we have (or don't have) in monsoon seasonal forecasts. Zack then makes his case for the miracle monsoon – a mash up of different months of monsoons past – for what his ideal monsoon would look like (think fantasy football for monsoon monthly totals). They wrap up with a look at the seasonal forecasts – and focus on how ENSO is linked to expectations for tropical storms, the monsoon forecast, and seasonal outlooks, even if the signal is relatively weak this time of year.

https://bit.ly/2sG6ZTM