Coast to Cactus Weather Examiner

National Weather Service - San Diego

Volume 32 Number 2 weather.gov/sandiego April 2025

Inside this issue:

Research That Helps Understanding

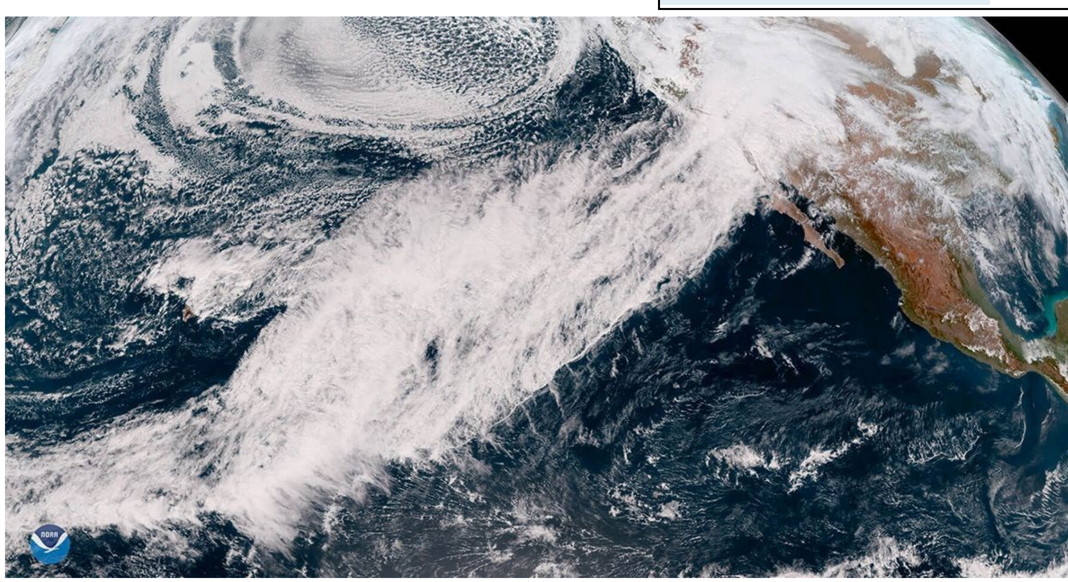
In recent months, researchers of weather and climate from Scripps Institution and UCLA have made some helpful discoveries with implications for weather forecasting in Southern California. Specifically, papers about how atmospheric rivers disrupt the ENSO canon of predictability for winter precipitation, and new methodology for improving risk estimates for extreme precipitation.

Atmospheric Rivers Explain Atypical El Niño and La Niña Years

These rivers in the sky don't play by El Niño or La Niña's rules - adapted from a UCSD story by Alex Fox.

El Niño and La Niña are climate phenomena that are generally associated with wetter and drier winter conditions in the Southwestern United States, respectively. In 2023, however, a La Niña year proved extremely wet in the Southwest instead of dry. New research from scientists at UC San Diego's Scripps Institution of Oceanography finds that atmospheric rivers explain the majority of atypical El Niño Southern Oscillation (ENSO) years, such as 2023. For example, during 2023's La Niña, California experienced a series of nine atmospheric rivers that added up to the state's 10th wettest year on record.

The study, published in the journal Climate Dynamics and supported by the California Department of Water Resources and the Southwest Climate Adaptation Science Center, shows that atmospheric rivers can overwhelm the influence of El Niño and La Niña on annual precipitation totals in the American West. This has important implications for water managers, who rely on

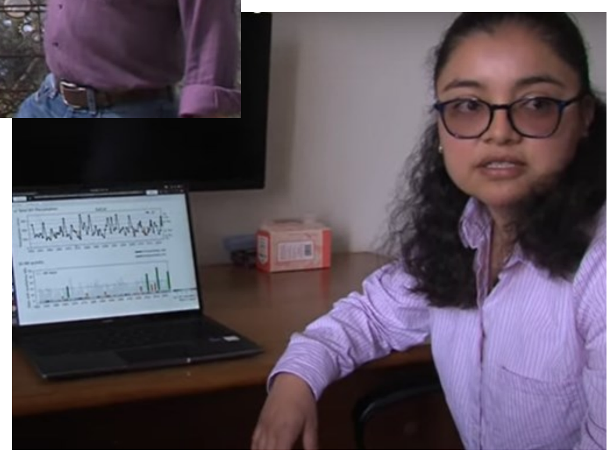


Research that Helps continued

seasonal forecasts based on El Niño and La Niña to inform key planning decisions around reservoirs and water allocation.

Despite El Niño and La Niña's pervasive influence on global climate, atmospheric rivers don't appear to follow their lead. "Atmospheric rivers don't dance to the tune of ENSO," said Alexander Gershunov, a climate scientist at Scripps and co-author of the study. While dancing to the beat of their own drum, atmospheric rivers are key in California's water supply, delivering on average up to 65% of the annual precipitation in Northern California and 40% in Southern California. Their contribution, however, varies greatly from year to year. For example, in Southern California, atmospheric rivers accounted for as low as 5% in 1977 and as high as 71% in 1956.

Alexander (Sasha) Gershunov (left), Rosa Luna-Niño (below) and other climate scientists authored the ENSO-AR study that was released in February 2025. (images KPBS)



"Atmospheric rivers are the precipitation wildcards in the Western U.S.," said Rosa Luna-Niño, a postdoctoral scholar at Scripps and lead author of the study. "One or two atmospheric rivers can turn it into a wet year, but a weak atmospheric river season can turn it into a dry year. This means we can't trust El Niño and La Niña completely to make accurate water year predictions."

Scientists expect these rivers in the sky will become increasingly important sources of annual precipitation in the Western U.S. under climate change, potentially making El Niño and La Niña years stray even further from their typical patterns.

NOAA declares an El Niño when waters in the central and eastern Pacific Ocean near the equator are anomalously warm over a three-month period. La Niña is the opposite, identified when there are colder than average water temperatures in the eastern equatorial Pacific. The temperature of this patch of the tropical Pacific Ocean is closely monitored because it has far reaching effects on atmospheric circulation and global climate. El Niño and La Niña typically last between nine and 12 months but can sometimes stretch to multiple years. The two phenomena are useful for long-range forecasting because they can be detected months before their effects are felt.

Atmospheric rivers are ribbons of water vapor in the sky that can deliver huge amounts of precipitation when they reach land. The landfall of a brewing atmospheric river can be predicted up to three weeks in advance (Scripps scientists at the Center for Western Weather and Water Extremes, or CW3E, are working to improve these forecasts), but the seasonal frequency of atmospheric rivers is nearly impossible to predict.

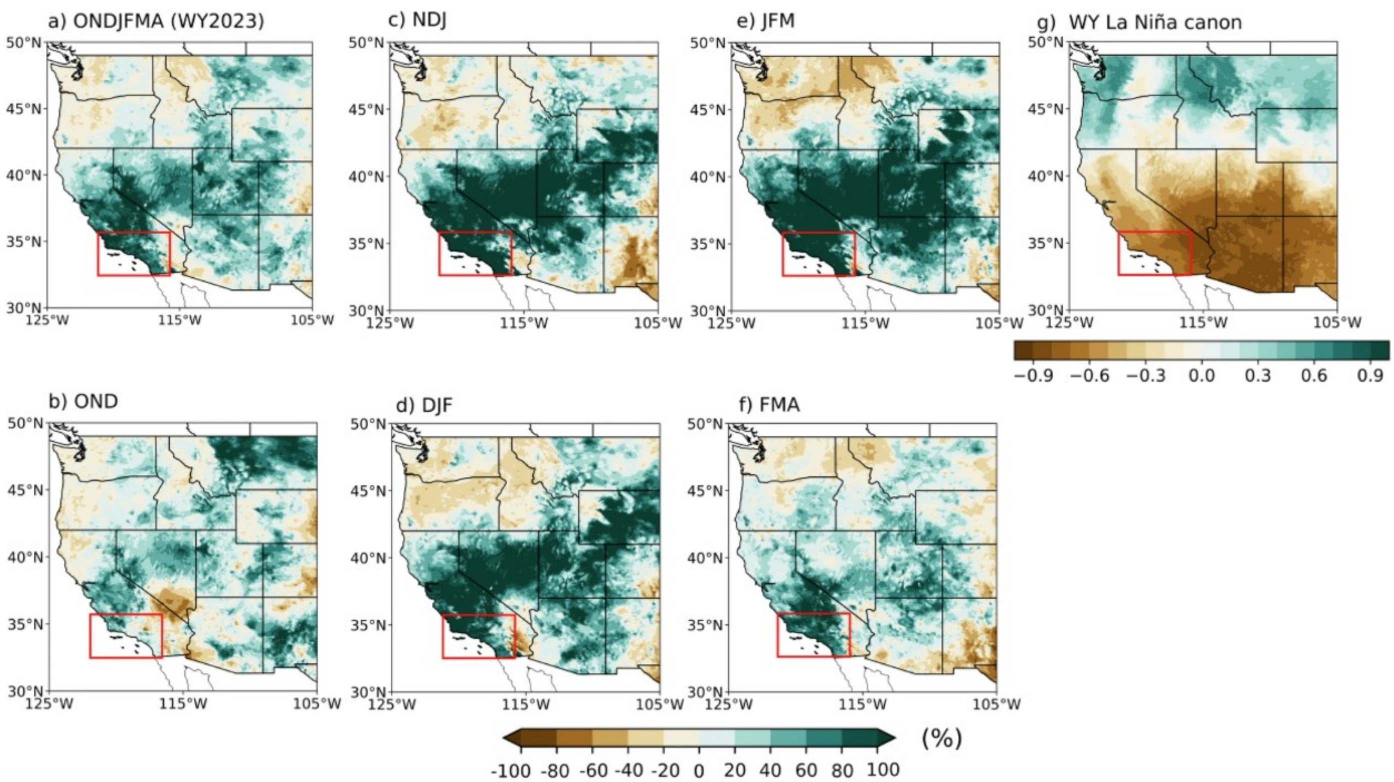
After 2023 brought record-setting rain and snowfall despite La Niña conditions in the Pacific, the study authors wanted to know if there were other years that went against the grain of what was expected based on ENSO. Further, they wanted to explore whether atmospheric river activity was higher or lower in those anomalous years. The team analyzed more than 70 years of weather data, comparing expected rainfall patterns based on ENSO with precipitation records.

The researchers separated rainfall into two categories — precipitation from atmospheric rivers and precipitation from other sources — to isolate the contributions of atmospheric rivers.

Research that Helps continued

The team's analysis revealed that roughly 32% of the ENSO years analyzed were what they termed "heretical," meaning they went against the canonical patterns of precipitation expected from El Niño and La Niña. Of those heretical years, anomalously high or low atmospheric river activity explained roughly 70% of them.

The results suggest that atmospheric rivers can override traditional El Niño/La Niña predictions. During these anomalous years, just a few powerful atmospheric rivers could transform an expected dry La Niña year into a wet one (1967, 2011, 2017 and 2023), or their absence could turn a predicted wet El Niño year into a dry spell (1964,1977, 1987, 2007, 2013 and 2015).



Precipitation anomalies during WY 2023 and La Niña canon. **a–f** Observed seasonal precipitation anomalies (%) based on the period 1952–2023, **g** Canonical precipitation anomalies during La Niña. The red box indicates the Southern California region

The findings suggest water managers in the Western U.S. cannot overly rely on El Niño or La Niña predictions for seasonal planning. Recently, CW3E at Scripps began including a disclaimer with one of its seasonal forecasts to clarify that while ENSO is the main driver of seasonal precipitation in the Western U.S., these forecasts account mostly for precipitation not associated with atmospheric rivers.

If climate change makes atmospheric rivers even more dominant contributors to yearly rainfall patterns in the future, as research suggests it will, ENSO could become even less useful for seasonal forecasting.

In the meantime, Luna-Niño said she and her co-authors are looking to merge the seasonal forecasts based on ENSO with the shorter term sub-seasonal forecasts that predict atmospheric rivers. "We need to keep improving our ability to predict atmospheric river landfalls, and the better we get at that the more we can use that information to help us interpret the seasonal forecast and vice versa," said Gershunov.

In addition to Luna-Niño and Gershunov of Scripps, F. Martin Ralph, Alexander Weyant, Kristen Guirguis, Michael DeFlorio and Daniel Cayan of Scripps as well as Park Williams of UCLA co-authored the study.

Improving Risk Estimates for Extreme Rain and Snow by Alex Fox, UCSD

A new study led by scientists from UC San Diego's Scripps Institution of Oceanography details an improved method for estimating the likelihood of extreme precipitation events in the western United States.

Flooding in lower Mission Valley, San Diego County, February 1980. Photograph courtesy of County of San Diego, Department of Sanitation and Flood Control.

The traditional approach estimates the frequency of severe rain and snow by analyzing meteorological records looking only at precipitation intensity over arbitrarily defined time periods, such as one hour or 24 hours. The new model — called Trivariate Event Distribution or TED — analyzes storm events by considering consecutive days of rainfall, maximum intensity and total rainfall. By considering these two additional variables, TED can offer risk assessments for extreme weather events that would not be considered extreme on the basis of maximum intensity alone. One such event occurred in February 1980, when Southern California experienced damaging floods as a result of sustained, moderate rainfall that in some places lasted more than a week.

In a test of the model's accuracy, the researchers found that TED provided a good statistical fit for the historical weather data for 87% of more than 4,000 weather stations across the western United States. The model's ability to provide a more holistic assessment of extreme rain and snow storm risk could inform infrastructure planning, insurance assessment and emergency preparedness.

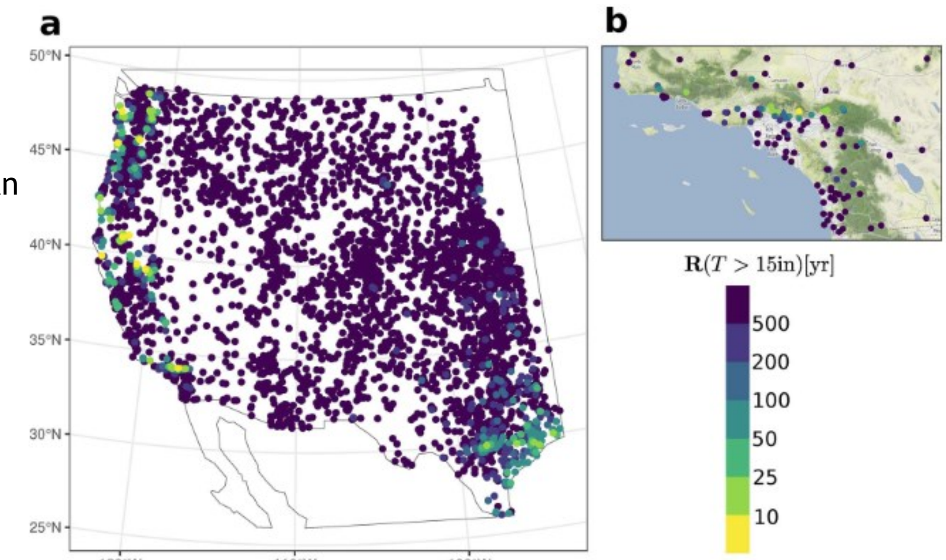


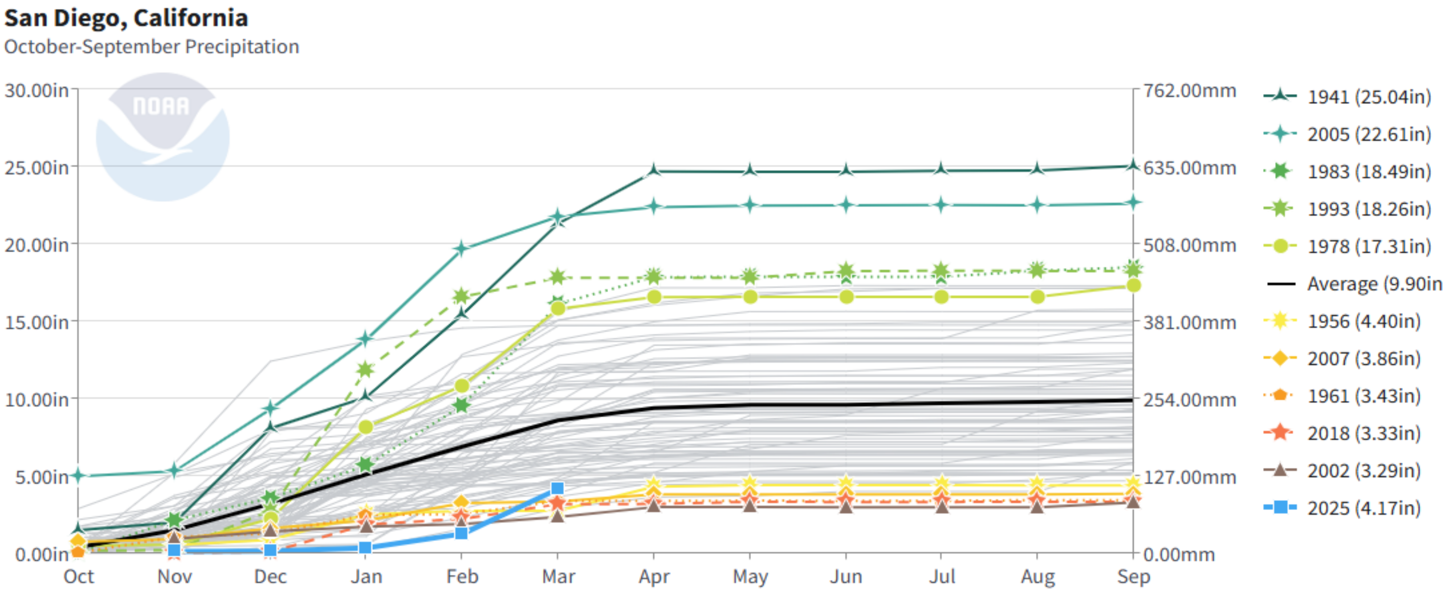
Fig. 5. (a) Estimated return periods for exceeding a 15 inch (381 mm) total accumulation in a single Event; (b) inset focuses on southern California, with the point for San Gabriel Canyon Pumphouse distinguished from the others by its triangular shape and large size.

The study, published Feb. 7, 2025 in the journal Scientific Reports, was led by Alexander Weyant and co-authored by Alexander Gershunov and Julie Kalansky of Scripps Oceanography. Other co-authors include mathematicians Anna Panorska and Tomasz Kozubowski at the University of Nevada, Reno. The research was funded by the California Department of Water Resources via the Atmospheric River Program.

Alexander Weyant (left) and Julie Kalansky (right), photos scripps.ucsd.edu

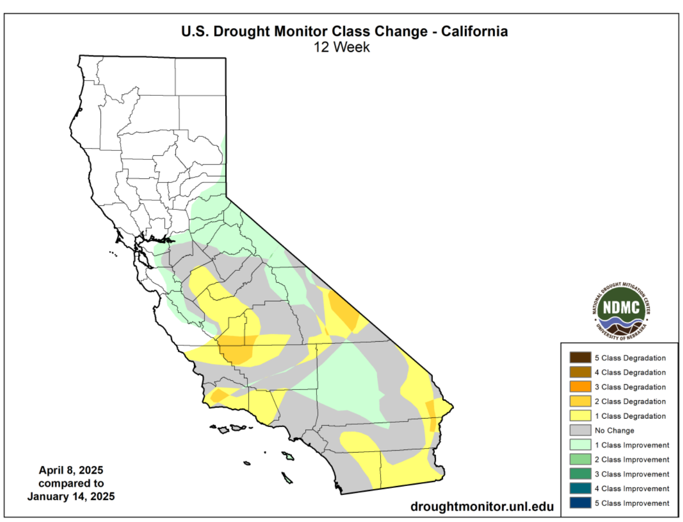
Drought Trends by Miguel Miller

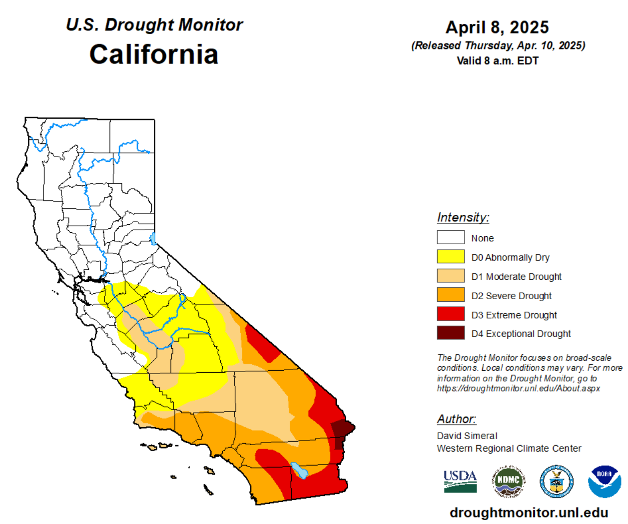
The record dry start to the winter wet season dug a rainfall deficit so deep that, by the end of February, nearly all hope was lost to make up the deficit before the wet season expired. March came and brought near to above normal rainfall to extreme southwest California. San Diego County harvested the most in March, as San Diego received double the average March rainfall. Riverside tallied about 150% of normal rainfall in March. But the beneficial March rain came nowhere close to making up the deficit.



Haywood precipitation plot for San Diego, showing the 2025 water year in blue. It was a record dry water year before March. Double the normal rainfall fell in March, lifting the water year to fourth driest in history. With the dry season quickly approaching, San Diego is unlikely to rise much further.

The outlook is bleak in the coming months, but rainfall in the last three months has provided some improvement to drought conditions (see trend image below), especially in San Bernardino County. However, the results are mixed, as other parts of Southern California showed some drought degradation in the last three months.

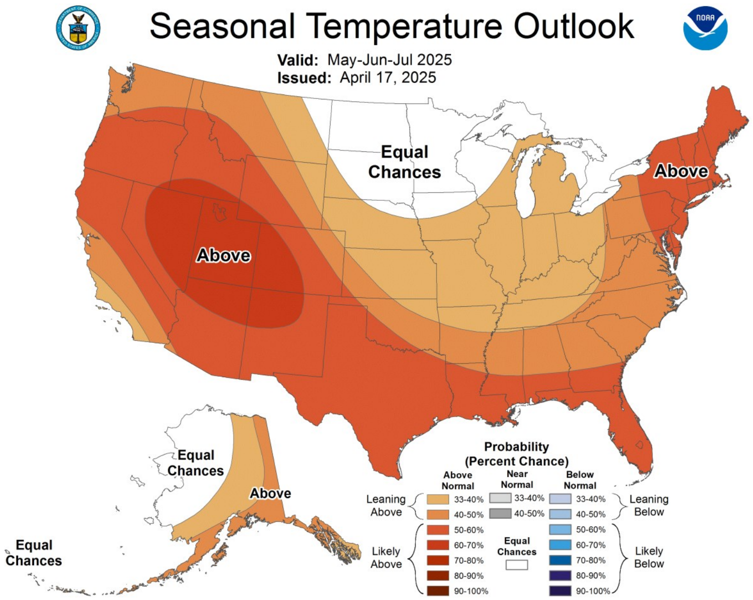




The change in drought conditions from 14 Jan to 8 Apr 2025, above left. Drought conditions as measured on 8 April 2025, above right. Maps from U.S. Drought Monitor.

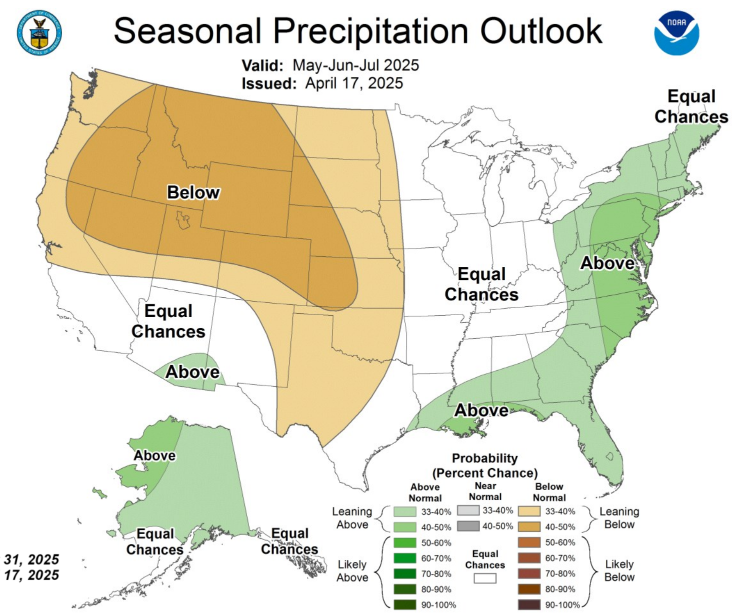
Seasonal Outlook

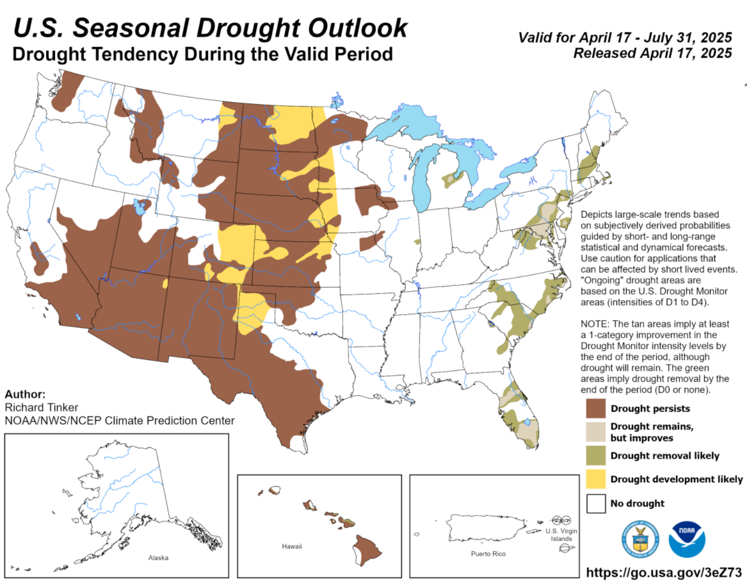
On 17 April, the Climate Prediction Center (CPC) released their three month outlooks for temperature, precipitation and drought.



The Temperature Outlook (left) shows the chances of a warmer-than-average **May-July** (orange and red) are quite high over nearly the entire country, particularly the interior West and New England.

Out of three possible precipitation outcomes—wetter than average, drier than average, or near average—the outlook for **May-July** (right) says that odds are leaning toward a drier than average period for the Northwest and plains. Odds tilt toward a wetter than average period across the Gulf and East Coasts, with a hint of a good start to the monsoon season in Arizona.





The Drought Outlook (left) **through July** indicates persisting and developing drought in the Southwest, the northern Rockies, Cascades and the Plains. Some drought improvement is expected through parts of the east coast and Florida.

Big Changes Coming to NWS Heat Alerts

On March 4, the National Weather Service (NWS) implemented updated names for its heat-related watch and warning products as part of the ongoing Hazard Simplification (Haz Simp) Project. This initiative is aimed at improving public understanding and utility of weather alerts by making them clearer and more intuitive. These changes are based on extensive public feedback, partner engagement, surveys, and social science research.

What's Changing?

Here's a quick look at the updates coming to heat-related watch and warning names and VTEC:
Excessive Heat Warning (EH.W) will be renamed to Extreme Heat Warning (XH.W)

Excessive Heat Watch (EH.A) will be renamed to Extreme Heat Watch (XH.A).

Heat Advisories will remain *unchanged*.

The new terminology is designed to better convey the severity of heat risks, ensuring that people take appropriate action when extreme heat events are forecast. It will also align language with recent changes to cold-related products using the Extreme Cold products suite and with federal partner language regarding dangerous and hazardous heat.

Why the Change?

The Haz Simp project has identified that users find the current Watch, Warning, and Advisory system confusing. By renaming these products, NWS aims to streamline communication and make it easier for individuals and organizations to understand and respond to heat-related hazards. The updated alerts will help communities better prepare for life-threatening conditions. For additional details, visit the NWS [Hazard Simplification webpage].

NWS San Diego Fosters Relationships with Partners

NWS San Diego discusses historic flash floods with San Diego Flood Control and City of San Diego

After January 22, 2024 saw historic flash flooding in San Diego that damaged 1000 homes and resulted in a FEMA disaster declaration, Public Works for San Diego County and the City of San Diego held a meeting to discuss the 1000-year flood event and improve future response. On the one-year anniversary of the flash flooding, San Diego County Flood Control meteorologists brought in additional public safety partners from the City of San Diego for a follow-up meeting.

Over the past year, all partners have been making an extra effort to enhance collaboration prior to and during heavy rain events. The NWS has worked closely with partners to help improve Impacted-based Decision Support Service (IDSS) during high-end rainfall events and provide and interpret necessary information such as rainfall rates.

NWS San Diego meets with San Diego County Flood Control and City public works. NWS photo.

As part of the discussions, NWS San Diego's hydrologic focal point Sam Zuber presented the latest information on Flood Inundation Mapping (FIM). NWS San Diego has also been developing and issuing specific rainfall rate forecasts for use in urban areas in support of swift-water rescue planning and mitigation efforts. This includes the use of probabilistic information and confidence levels for rainfall timing and intensity.

The outcomes from this meeting will result in improved communication for heavy rainfall events that impact the city of San Diego and also sets the stage for integration of full weather support at the Emergency Operations Center to better serve core partner needs.

NWS San Diego Tours the Seven Oaks Dam

Forecasters Sebastian Westerink, Alex Tardy and Sam Zuber tour the Seven Oaks Dam.

The largest watershed in southern California is the Santa Ana River drainage, which starts in the San Bernardino mountains and spills into the Pacific Ocean in Orange County. This region is known for extended dry periods and occasional massive precipitation events that can bring copious rainfall measured in feet in a single cycle, such as in December 2010, when an atmospheric river produced up to 27 inches of rain in the watershed.

On January 31, forecasters Sam Zuber and Sebastian Westerink, along with Warning Coordination Meteorologist Alex Tardy, were provided a familiarization tour of the Seven Oaks Dam and facilities on the Santa Ana River. The Dam was

NWS San Diego Fosters Relationships with Partners continued

constructed in collaboration with the U.S. Army Corp of Engineers in the 1990s, primarily for flood control, with a secondary purpose of water release into the Santa Ana River and Prado Dam as well as ground water recharge. The earth material dam has the 4th tallest intake tower in the U.S., at around 200 feet, and a dam embankment of 550 feet, making it the 12th tallest dam in the U.S. The dam operation is conducted by San Bernardino County Public Works, and much of the ongoing maintenance is funded by the Orange County Water District.

Familiarization of the Santa Ana watershed is critical to NWS San Diego hydrological operations, such as issuing downstream flood warnings and understanding the complex water supply system during normal or drought conditions.

Tour group photos at the front of Seven Oaks Dam structure (top) and inside the dam control tunnel (middle).

Water storage behind Seven Oaks Dam and field of debris from Tropical Cyclone Hilary (left).

The visit also gave the staff an opportunity to interact directly with core partners and managers in dam operations and public works, an important partnership for the area’s many weather impacts. Illustrating the significance of coordination on these complex impacts were the burned area surrounding the dam, a result of the 44,000-acre Line Fire, as well as the burned logs visible floating on the water behind the dam, which was a result of Tropical Cyclone Hilary’s rainfall flushing the El Dorado burn scar downstream in 2023. With this visit, NWS San Diego staff are better prepared to understand the needs of our core partners.

Quarterly Summary

January

The dry fall and winter continued in January. A high pressure ridge dominated, with occasional shortwaves moving too far north, or inside sliders that brought wind, but little or no precipitation.

However, one inside slider on 6-7 January had enough amplitude to bring showers to San Bernardino County. Wrightwood got 7 inches of the frozen kind of showers (snow), while a few inches were common around Big Bear Lake. Rainfall was greatest in the lower San Bernardino Mountains, where up to one half inch was observed (0.51 inch at Panorama Point).

San Diego Data - January

	Max	Min	Avg	Rain
Actual	67.3	45.3	56.3	0.21
Normal	66.4	50.3	58.4	1.98
Anomaly	0.9	-5.02	-2.1	-1.77
% of normal				11
Max	77	53		0.15
Min	60	39		

The tragedy that resulted from the Palisades Fire and the Eaton Fire in Los Angeles County made national and international news. (Alex Tardy screenshot)

Strong offshore flow on 7-10 January produced Santa Ana Winds, with gusts as high as 94 mph at Fremont Canyon. Numerous gusts reported from the foothills were 55-80 mph. Even some spots in the populated valleys were struck (Ontario reached 76 mph on the 9th). On the 7th, numerous wildfires erupted in Los Angeles County, including the Palisades and the Eaton fires, the two largest, most destructive, and deadly wildfires in county history (and this was January!). Many smaller fires broke out all across Southern California. Some were destructive and forced evacuations, but most were quickly contained. Many trees were downed and trucks were toppled in the northern Inland Empire in this multi-day wind storm. One fatality was reported in an overturned truck in Fontana.

Yet another offshore wind storm arrived on the 13th into the 15th. Top gusts in the foothills ranged from 45-65 mph, with Sill Hill taking top gust honors at 74 mph.

The weather pattern continued dry, with various troughs dropping south through the interior West, but not west enough to grab sufficient Pacific moisture to produce showers in Southern California.

The next strong Santa Ana Wind event hit the region on 20-21 January. Strongest wind gusts in the foothills achieved 65-90 mph. Exceptionally, Sill Hill recorded 102 mph, the second strongest gust ever measured in Southern California. Fortunately, fewer wildfires erupted during this event although there were some in populated areas. This event was not as long-lasting as the more destructive Santa Ana event earlier in January.

Yet another Santa Ana wind episode descended on the wind-fatigued region on the 23rd. Impressive wind gust reports filled the stat sheet again, with Sill Hill achieving the highest recorded gust of 97 mph. Many other foothill locations reported gusts of 65-88 mph, most common in San Diego County. More small wildfires erupted briefly through the 24th, even some in populated areas, but were quickly contained.

Finally, a legitimate winter storm brought rain and snow to the region on the 26th and 27th. This was a trough from the north that deepened and strengthened as it dropped

Quarterly Summary—continued

south into Southern California. Two-day storm totals reached 1.77 inches at Pine Hills (southwest of Julian), with over one inch recorded at many foothill gauges. Lower elevations got their first significant rain since spring of 2024. Amounts ranged from just over 1 inch in San Bernardino, Oceanside and Anaheim Hills, to less than 0.10 inch in the lower desert. Storm total snowfall reached 16 inches in the San Gabriels near Wrightwood, around one foot in the San Bernardinos, and several inches fell to elevations as low as 2,800 feet.

Higher pressure returned for dry and fair weather the last few days of the month.

The one significant storm of January on the 27th was a cold one, cold enough to bring about 2 inches of snow to Johnson Valley in the high desert. Photo by spotter Brett Trimper.

February

Dry weather continued through the first half of February. High pressure dominated, with several troughs occasionally passing by to the north of Southern California.

San Diego Data - February

	Max	Min	Avg	Rain
Actual	66.8	51.8	59.3	0.92
Normal	66.2	51.8	59.0	2.20
Anomaly	0.6	0.0	0.3	-1.28
% of normal				42
Max	82	58		0.63
Min	58	46		

A negative-tilt Pacific trough began to bring significant precipitation on the 13th and 14th, as if Mother Nature was showing the region some precipitation love on Valentine's Day. Impacts weren't as lovely, however, especially on Hwy 330 south of Running Springs on the Line Fire burn scar. A massive debris flow swallowed three vehicles and closed the road for repairs for 11 days. Smaller debris flows hit the Mt. Baldy area. Several swift-water rescues were made around Riverside (two men and two dogs in trees) and in southern Orange County. The greatest rain rates were 0.65 inch to 0.95 inch in one hour over the recent burn scars. 7 to 8 inches of rainfall pummeled the San Gabriel foothills over two days. Coastal and valley areas received 1 to 5 inches in general, but southern coastal San Diego County and the deserts got mostly less than 1 inch. Snowfall piled up to one foot at Mt. Baldy and Big Bear ski resorts, with several inches observed as low as 5,500 feet elevation. Except for those isolated negative impacts, this storm brought beneficial and much-needed precipitation to the thirsty, drought-intensifying region. Storm winds reached 60-80 mph in the front ranges of the mountains.

A big debris flow wiped out Hwy 330 south of Running Springs, on the Line Fire's burn scar on 13 February. (media photo).

Quarterly Summary—continued

Heaps Peak gusted to as high as 82 mph.

High pressure and quiet weather returned for the last half of the month. Just as before the mid-February storm, several troughs of low pressure occasionally and harmlessly passed by to the north of our region. Some offshore winds on the 20th were followed by a few days of dense fog along the coast on the 21st and 22nd. Another Santa Ana event on the 27th boosted temperatures as high as 90 degrees in the coastal valleys.

March

San Diego Data - March				
	Max	Min	Avg	Rain
Actual	65.1	52.3	58.7	2.91
Normal	67.0	54.5	60.7	1.46
Anomaly	-1.9	-2.2	-2.0	1.45
% of normal				199
Max	76	59		
Min	59	45		

March came in as a lion, with a storm arriving on the very first day. This was a compact closed low from the Pacific that brought initial precipitation on the evening of March 1st. A second, more robust Pacific system drove through the region on the 2nd and 3rd. A band of thunderstorms on the 2nd traversed the foothills of the San Gabriel and San Bernardino Mountains. Larson Ranch (San Gabriel foothills) harvested 1.50 inch of rain over the three days, while many foothills of San Diego County received over one half inch. Most of the populated lowlands received 0.20 to 0.50 inch, but parts of northern Orange County and the northern Inland Empire received less than 0.10 inch. 4 inches of snow fell at Yucaipa Ridge, Snow Summit and Mountain High, while lesser amounts accumulated to as low as 4,500 feet elevation.

A fleeting ridge for a couple days was a short break as the next storm system arrived on the 6th and continued through the 7th. Panorama Point just south of Crestline received 3.03 inches of rain from the storm. Many other foothill areas received more than 2 inches. A band of intense rainfall battered a stretch from La Jolla to Miramar with over 2 inches,

On 6-7 March, intense rains led to flash flooding and a debris flow in Trabuco Canyon on the Airport Fire burn scar (above, Orange County Public Works). A band of very heavy rain (over 1 inch in one hour) over La Jolla flooded streets that submerged several vehicles (right, media photo).

including a few gauges recording over 1 inch in one hour on the evening of the 6th. Flash flooding resulted. Heavy rain over the Airport Fire burn scar produced a flash flood and a debris flow in Trabuco Canyon. Other lowland areas received a storm total of roughly 0.50 to 2 inches. Snowfall amounted to as high as 15 inches at Snow Summit and Mt. Baldy Notch. Over one foot of snow fell at many locations in the San Bernardino Mountains as well as Palomar Mountain. Lesser amounts were recorded all over the mountains down to as low as 2,800 feet in the hills north of Aguanga.

Dry weather prevailed for the next several days.

A weakening trough moved through the region on 11 March, bringing San Diego County some rainfall. In a rare occurrence, San Diego joined Mt. Laguna and other mountain locations with the greatest amount of around 0.90 inch. Most lower elevations received 0.25 inch to 0.50 inch, except Orange County received less than 0.25 inch.

On 13 March, intense rains led to flash flooding and a debris flow in San Jacinto (above, where six people were rescued from the floodwaters (media photo). Meanwhile, small hail was observed in San Marcos (right, Craig Ellis).

A strong Pacific storm moved into Southern California on the 12th through the 14th. An atmospheric river enhanced the precipitation. Greatest amounts were in the foothills and mountains as usual, with Upper Silverado Canyon recording the most at 2.76 inches. About 0.75 inch to 2 inches was observed at lower elevations, with less than 0.75 inch in the deserts. Small hail was noted in San Marcos and Escondido. A flash flood struck San Jacinto, where just over 0.50 inch was measured in one hour on the morning of the 13th. Six people were rescued from their vehicles. Snowfall was prodigious in the San Gabriel and San Bernardino Mountains. Barton Flats got 34 inches storm total, while many other locations reported up to 28 inches. One foot of snow was reported at 4,900 feet in Oak Glen. Onshore winds were strongest in the foothills, mountains and deserts. Many locations had gusts over 50 mph, with Boucher Hill (front range of Palomar Mountain) clocking 69 mph.

Dry and warmer weather followed, except for a brief trough passage on the 18th that brought cooler and breezy weather. Dry zonal flow continued until a prominent ridge of high pressure amplified over California. This brought unseasonably warm weather for the first few days of Spring on the 24th through the 26th. Daily records for highest maximum and highest minimum temperatures were recorded in the valleys, mountains and deserts. The low deserts secured their first days of 100+ temperatures. Some valleys headed into the 90s while some mountains reached the 80s. The coast was very much tempered by a shallow marine layer and stubborn fog.

The next Pacific storm arrived on the last day of the month and continued into April 1st. Storm totals favored San Diego County where many locations in the mountains got over 0.50 inch. Less than 0.50 inch occurred in the coast and valleys. Only 0.10 inch or less was measured north of San Diego County.