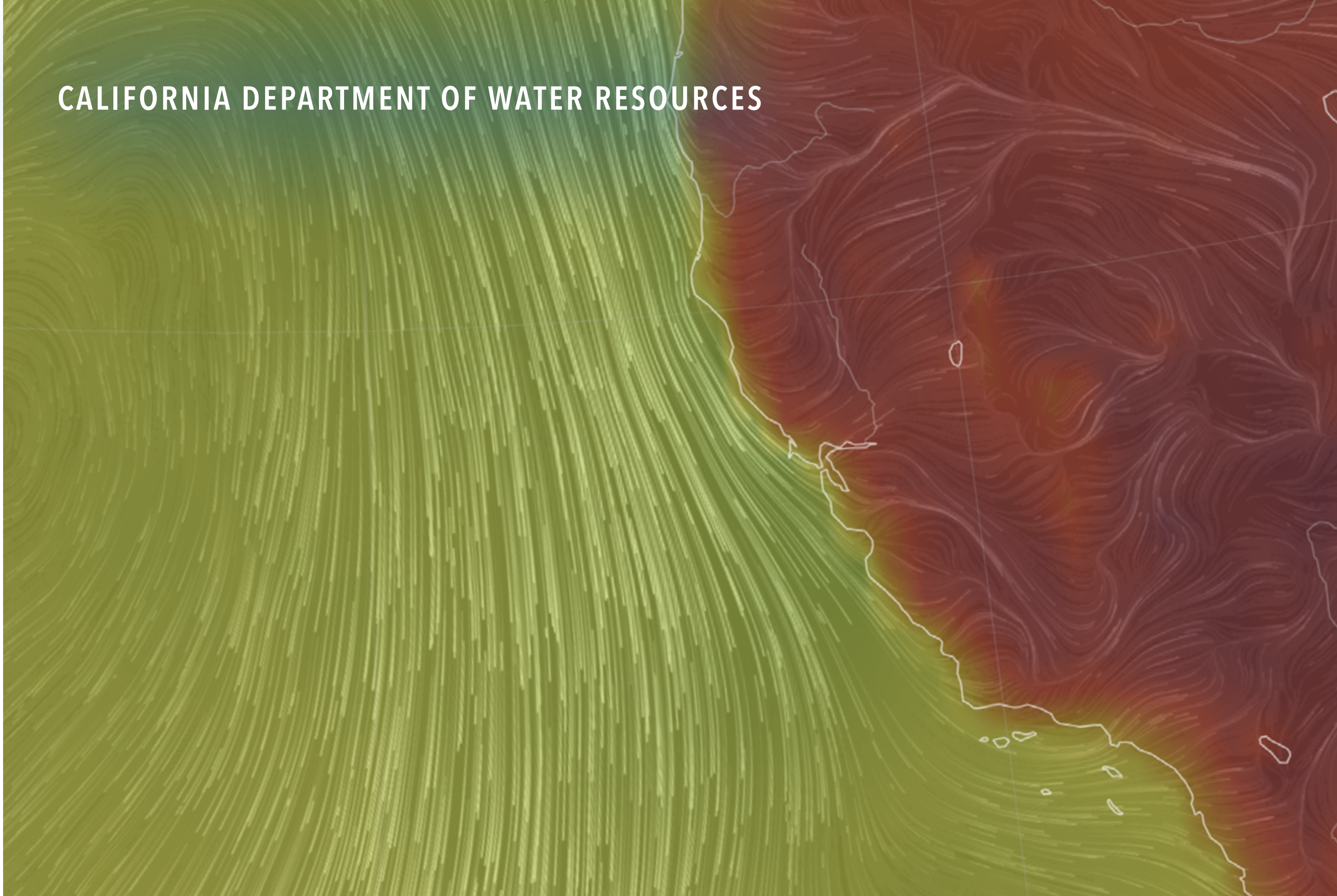
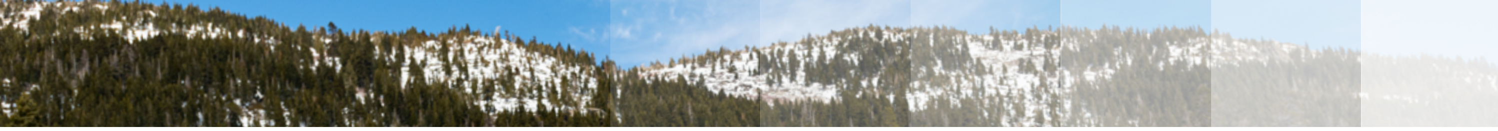
CALIFORNIA DEPARTMENT OF WATER RESOURCES



HYDROCLIMATE REPORT
Water Year 2020

Office of the State Climatologist

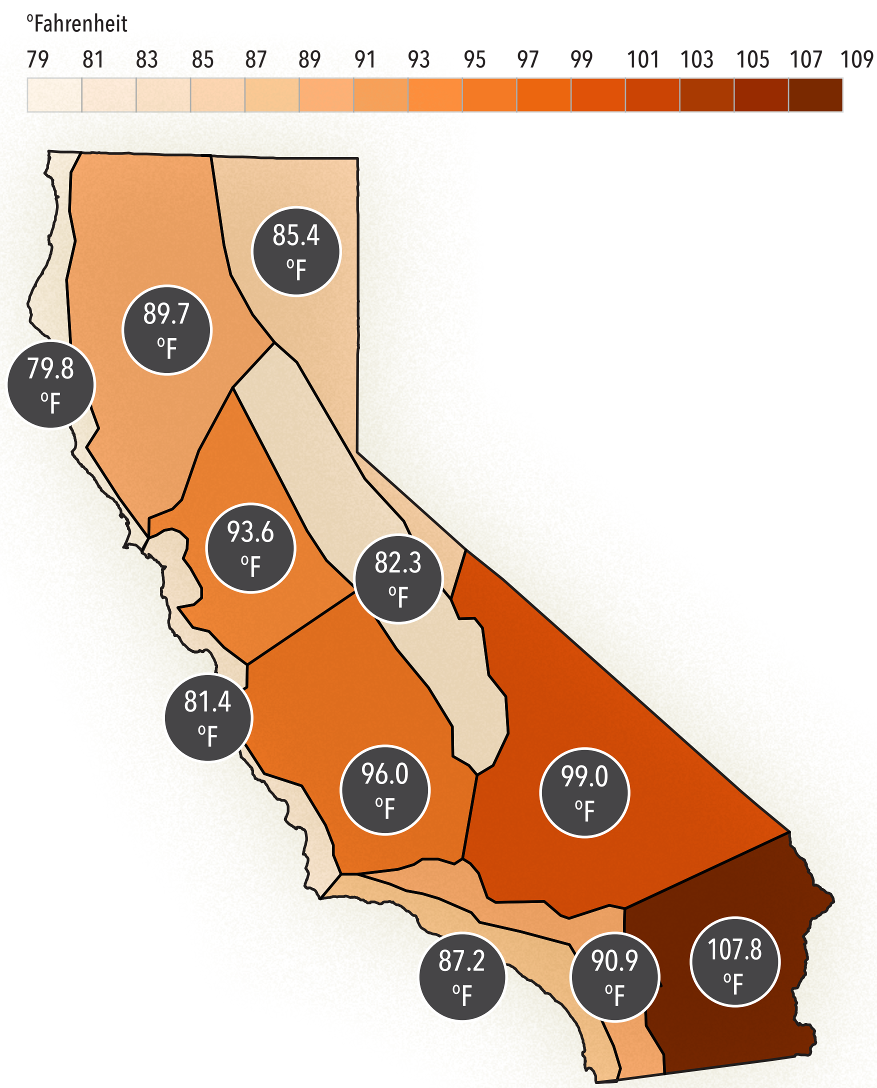


Executive Summary

Water Year (WY) 2020 continued to demonstrate the climate change narrative of greater variability and more extremes. In both precipitation and temperature, there were new extremes with a very dry February and very hot end to the water year. Late fall precipitation onset continued with the first significant storm of the year arriving in late November. The WY ended with 67 percent of average precipitation statewide and 62 percent of average in the Northern Sierra. For runoff, the Sacramento Basin had 66 percent of average April-July streamflow while the San Joaquin Basin had 58 percent of average. Peak statewide snowpack was 62 percent of average reaching that point in early April with a late season storm providing some offset to the winter's dryness. February was one of the big stories of WY 2020 with record low precipitation. In a year of extremes, August and September also contributed record warmth for the month including a 130-degree Fahrenheit reading at Death Valley on August 16, 2020. This observation, if verified by the World Meteorological Organization, would be one of the hottest daily temperature maximums recorded on Earth. Several cities set new records for days above 90 degrees as well.

August also provided multiple decaying tropical systems from the eastern tropical Pacific that made landfall north of the Golden Gate. These systems would spawn a lightning storm with over 12,000 strikes setting off over 700 wildfires. These wildfires would grow to be among the largest in the state's history, including the August Complex in the Mendocino National Forrest which is the State's first fire to consume more than 1,000,000 acres. Amidst a global pandemic, water year 2020 provided many new extremes posing new challenges for the state to find ways to adapt.

California Climatological Regions, Temperatures for August 2020



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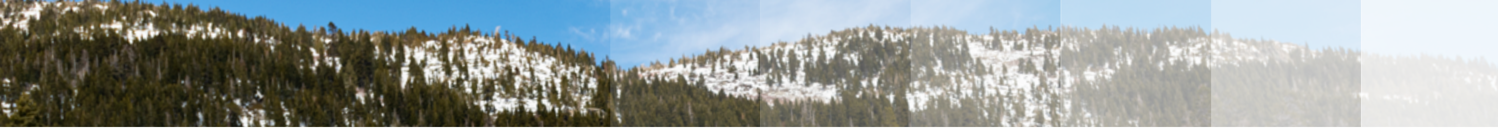
The State Climatologist Office would like to thank Peter Coombe, Elissa Lynn, Benjamin Hatchett, Kevin He, Jamie Anderson and the California Nevada Applications Program for their contributions to the annual Hydroclimate Reports.

In dedication to James D. Goodridge

The 2020 Water Year Hydroclimate Report is dedicated to James D. Goodridge. James "Jim" passed away during the 2020 Water Year at the age of 92. Jim was a good friend, colleague, and mentor for many DWR employees over the years. Jim started his career in meteorology on November 18, 1950, when he reported to work for the U.S. Weather Bureau where he collected data from weather observers reporting over the phone. Jim recalled on that day, the road into Yosemite Valley was washed out and made an exciting first day on the job. Throughout his career he brought enthusiasm for working with data and the people of California as the State Climatologist, civil engineer, and retired annuitant until 2018. With the DWR Hydroclimate Reports, it is hoped that the passion and interest Jim had for historical weather and climate data will be continued and his many contributions will continue to provide knowledge and context for future generations across the water community.

Front and back cover earth images courtesy of earth.nullschool.net. Cover: surface winds, September 30, 2020, 17:00 local time; back cover: Wind and Particulate Matter, same date, time.



Introduction

Welcome to the Hydroclimate Report for WY 2020 - an annual report highlighting weather and climate events of the water year as the world continues to warm. The report updates a collection of hydroclimate indicators important to the Department of Water Resources for tracking a changing climate. The indicators will include metrics for precipitation, temperature, snowpack, runoff, and sea level rise.

In the years ahead, continuing work on atmospheric rivers will yield additional metrics to help characterize these how these events that are central to California's water supply and flood events are impacted by a warming world. Characterizing the strength of the atmospheric river by the amount of wind and water vapor being transported, known as integrated vapor transport, plus associated freezing elevations during the events are two characteristics currently being investigated.

By tracking the change through a collection of indicators on an annual basis, it is hoped that transitions past important thresholds can be better anticipated enabling the continued refinement of adaptation strategies for water resources management.

For water year 2020, the report builds upon an indicator that incorporates the measurements of freezing elevation during precipitating events. This metric is key to determining how much runoff results from a given storm. It is anticipated that in the years ahead, the freezing elevation during precipitating events will include higher values for longer periods of time as a manifestation of more rain and less snow. The data comes from a collection of snow level radars installed in 2007 that are positioned in the foothills of the Sierra Nevada. Other signposts of change are also being investigated including a metric to characterize dry periods or the lack of sufficient atmospheric rivers to make an average or above water year.

Water year 2020 illustrated variability at a sub-seasonal time scale with additional examples of extremes including February's record dryness and August and Septembers' record heat. This year's annual Hydroclimate Report will be organized in the following fashion. After the introduction, the collection of indicators is presented. After the indicators, an overview of weather and climate events of the past year is presented highlighting unusual or new extreme events that have occurred. The report showcases potential additions to the collection of indicators in future years.

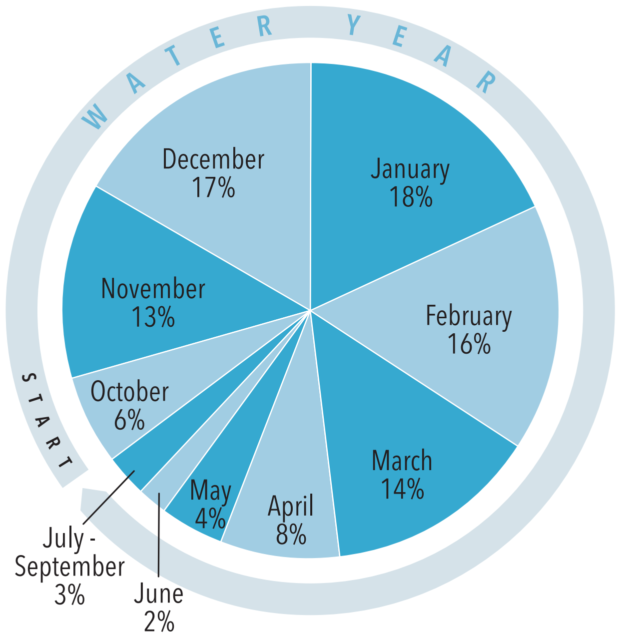
Key Hydroclimate Indicators

Indicators	Spatial Resolution	Temporal Resolution	Period of Record	Data Source
Temperature (Air)	WRCC Climate Regions	Monthly Mean	1895-present	WRCC
Temperature (Air)	NOAA Climate Divisions	Annual Calendar Year	1895-present	NOAA
Precipitation	WRCC Climate Regions	Monthly	1895-present	WRCC
Precipitation	Northern Sierra 8-Station	Annual Cumulative	1921-present	DWR
Precipitation	San Joaquin 5-Station	Annual Cumulative	1913-present	DWR
Atmospheric Rivers	Statewide	Annual Cumulative	2016-present	Scripps
Water Year Type / Streamflow (Unimpaired)	Sacramento River Basin	April-July	1906-present	DWR
Water Year Type / Streamflow (Unimpaired)	San Joaquin River Basin	April-July	1901-present	DWR
Snowpack (Snow Water Equivalent)	Statewide	April 1st	1950-present	Cooperative Snow Survey
Snowpack (Snow Water Equivalent)	Northern Sierra	April 1st	1950-present	Cooperative Snow Survey
Snowpack (Snow Water Equivalent)	Southern Sierra	April 1st	1950-present	Cooperative Snow Survey
Rain/Snow (Percent As Rain)	Selected Sierra Watersheds	Annual Cumulative	1949-2018	WRCC/PRISM
Snow-Level Radar	Colfax / Blue Canyon	November-April	2010-present	NOAA
Sea Level	Crescent City Tide Gauge	Monthly Mean	1933-present	NOAA
Sea Level	San Francisco Tide Gauge	Monthly Mean	1855-present	NOAA
Sea Level	San Diego Tide Gauge	Monthly Mean	1906-present	NOAA

What Is A Water Year?

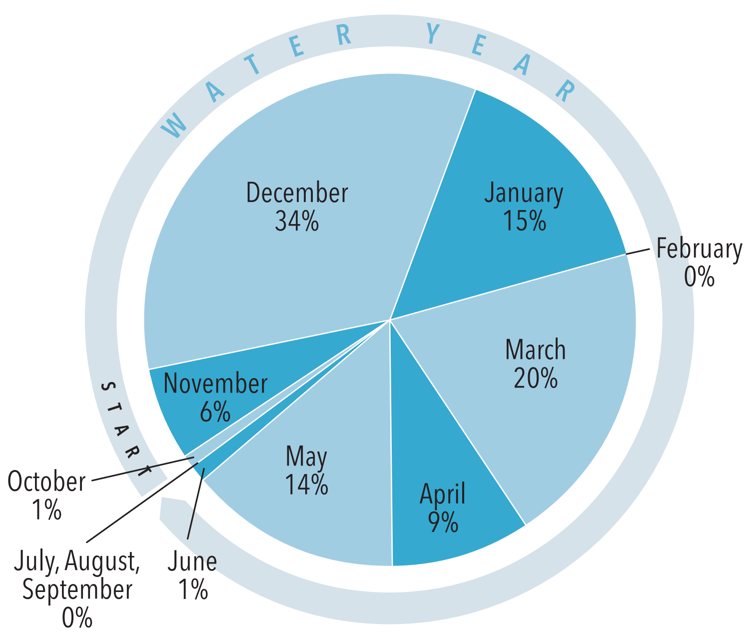
Northern Sierra 8-Station Precipitation Index (see map page 11 for locations)

Long Term Water Year Average by Month



The chart above depicts typical precipitation by month and percent of total that California receives throughout each WY. Precipitation generally arrives at the start of the WY in October and continues to increase through the winter months. The months of December, January, and February provide half of our expected annual precipitation. This is also the main development period of California's snowpack.

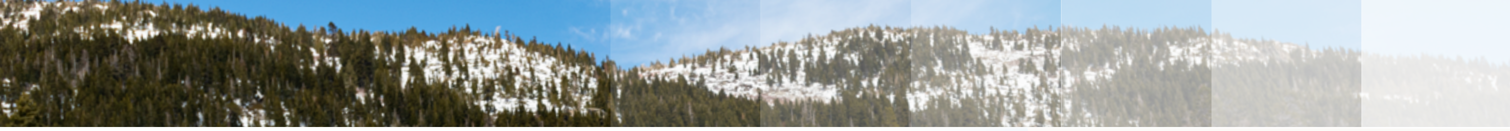
Water Year 2020 by Month



This chart represents monthly precipitation as percent of the total 2020 WY precipitation.

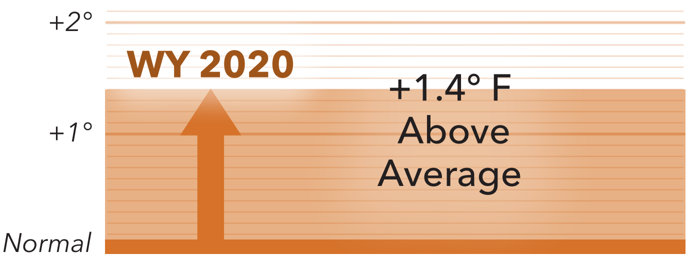
Hydrologic data such as precipitation and streamflow data are key indicators for the Hydroclimate Report. These data are typically represented as being within the water year (WY). A water year (also discharge year or flow year) is a term commonly used in hydrology to describe a time period of 12 months during which precipitation totals are measured. Its beginning differs from the calendar year because precipitation in California starts to arrive at the start of the wet season in October and continues to the end of the dry season the following September. On a calendar year time scale, the October to December precipitation would not be accounted for, including snowpack that doesn't melt and run off until the following spring and summer. DWR defines a water year in California to include the period from Oct 1 to Sept 30. The 2020 water year covers the period from October 1, 2019 to September 30, 2020.

A comparison of the pie charts on the left between the long-term average and WY 2020, shows almost 54 percent of the total WY precipitation occurred in January and March. On average, the months of January, February, and March of account for 48% of the average total annual precipitation. February was very dry, only receiving 0.02 inches of precipitation, the lowest since the start of the Northern Sierra 8-station index in 1921. The total WY rainfall at 31.7 inches was considerably less than the long-term average at 51.8 inches. The WY ended with a dry September with no precipitation being recordved in the Northern 8-Station area.



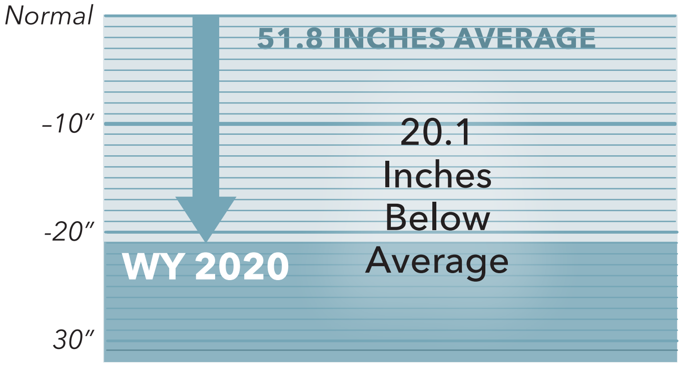
California Hydroclimate Water Year 2020 "At A Glance"

Temperature (Statewide)* *Page 8*



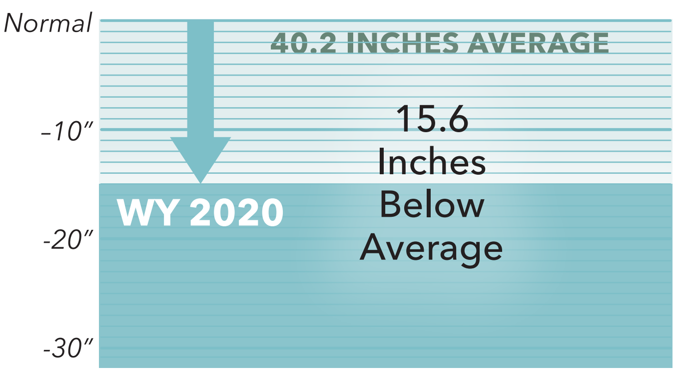
*Normal average air temperature represents 1981-2010 base period.

Precipitation (Northern Sierra)* *Page 11*



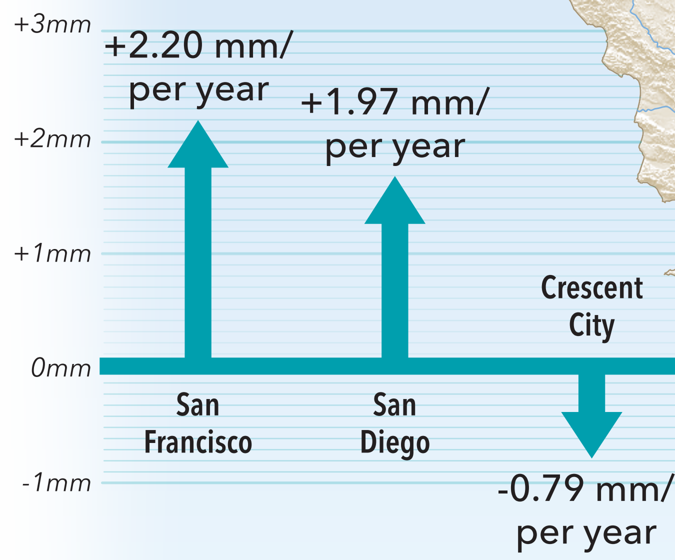
*Normal average precipitation represents 1966-2015 base period.

Precipitation (Southern Sierra)* *Page 11*



*Normal average precipitation represents 1966-2015 base period.

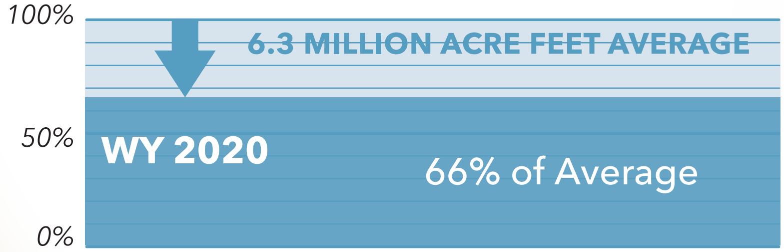
Sea level (100 year trend) *Page 22*



Indicators in Context

The DWR Hydroclimate Report is updated each WY to reflect key indicators that can be used to access long-term trends and is focused on reporting characteristics of a changing climate on California's water resources. Also, of importance in generating data trends are annual values that represent each WY, which spans from October 1st through September 30th. At a Glance focuses on the measured values for the reporting WY using several key indicators that are discussed in further detail throughout the report. A select group of key indicators are visually represented to depict the 2020 WY values departure from the long-term average or base period. Precipitation and snowpack are depicted in the graphic and are related the below average streamflow for the April-July period for both Sacramento and San Joaquin watersheds. Also, the statewide temperature was above average for the 2020 WY compared to the 1981-2010 base period. Sea level trends are depicted with their locations shown geographically on the California coast.

Streamflow, April-July (Sacramento River)* *Page 21*

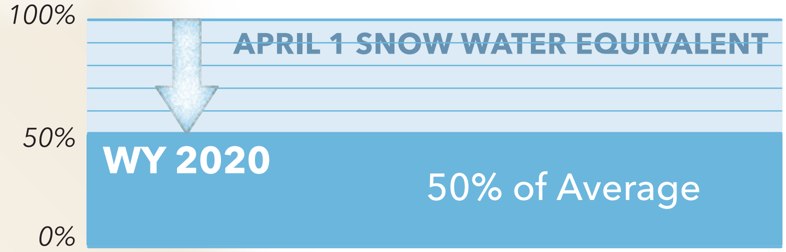


**Normal average streamflow represents 1966-2015 base period.*

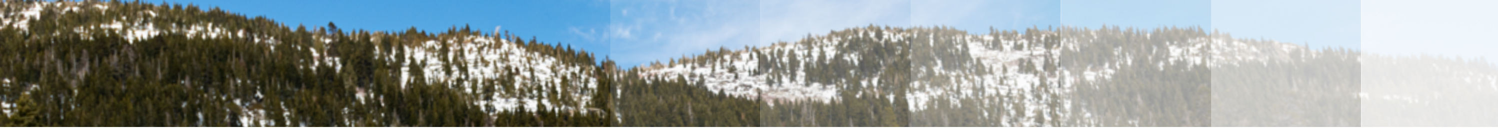
Streamflow, April-July (San Joaquin River)* *Page 21*

**Normal average streamflow represents 1966-2015 base period.*

Snowpack (Statewide)* *Page 14*



**Normal average snowpack represents 1966-2015 base period.*



Annual Air Temperatures

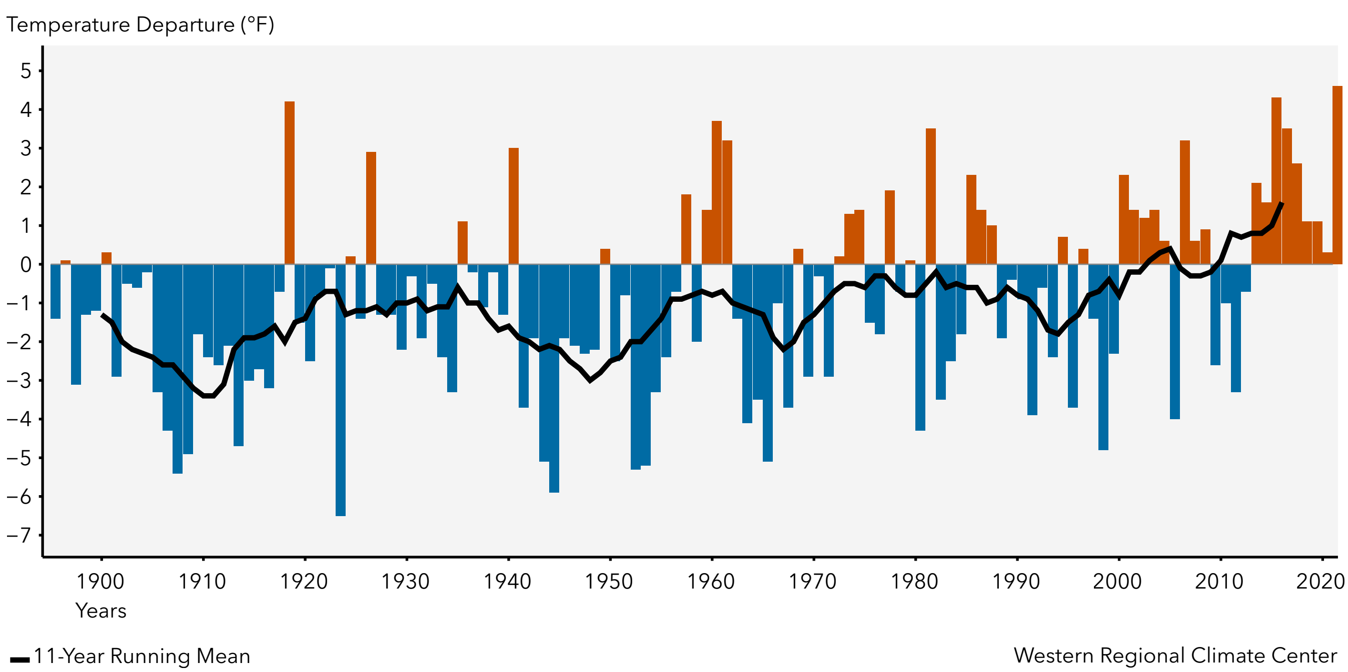
According to the Intergovernmental Panel on Climate Change (IPCC), the warming of the climate system is unequivocal. Many of the observed changes since the 1950s are unprecedented over decades to millennia. The atmosphere and ocean have warmed since the pre-industrial period (1850–1900). The observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature. From 1850–1900 to 2006–2015 mean land surface air temperature has increased by 2.8°F while global mean surface temperature increased by 1.6°F. (IPCC, 2019).

California's temperature record reflects global temperature trends. The upward trend in the globally averaged temperature shows that more areas are warming than cooling. According to NOAA's 2020 Annual Climate Report, the combined land and ocean temperature has increased at an average rate of 0.13°F per decade since 1880; however, the average rate of increase since 1981, 0.32°F, has been more than twice that rate.

According to the Western Region Climate Center (WRCC), California has experienced an increase of in mean temperature in the past century. The warmest year on record has been 2015 where temperatures were above 3.1°F from average. WY 2020 was 1.4°F above average, at 59.2°F, when compared to a 1981-2010 base period average temperature. Statewide average temperatures were ranked at 117 making WY 2020 the 8th warmest out of 125 years of record dating back to 1895. (WRCC, 2021).

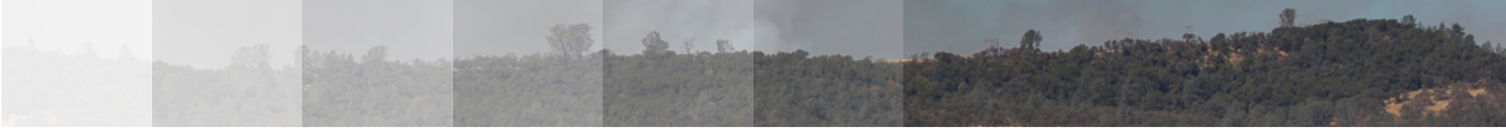
The NOAA Climate Divisional Dataset is a long-term temporally and spatially complete dataset used to generate historical climate analyses (1895-2020) for the contiguous United States. This data set is based on a calendar year instead of the hydrologic WY. There are 344 climate divisions in the US and this report's focus is on two climate divisions within California: Climate Division 2 (Sacramento Drainage) and Climate Division 6 (South Coast Drainage). For each climate division, monthly station temperature and precipitation values are

California statewide air temperature departures from 1981-2010 averages October through September



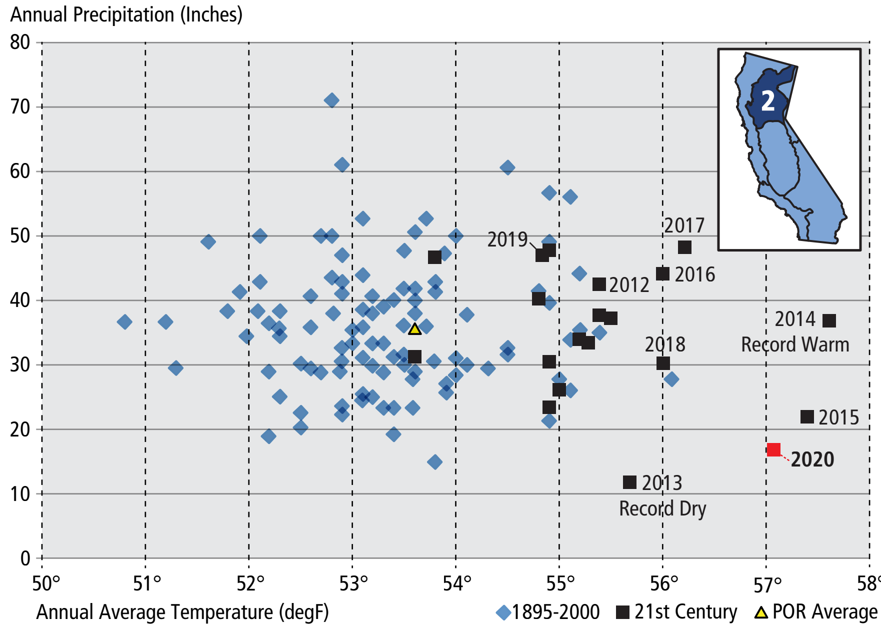
Summary Statistics

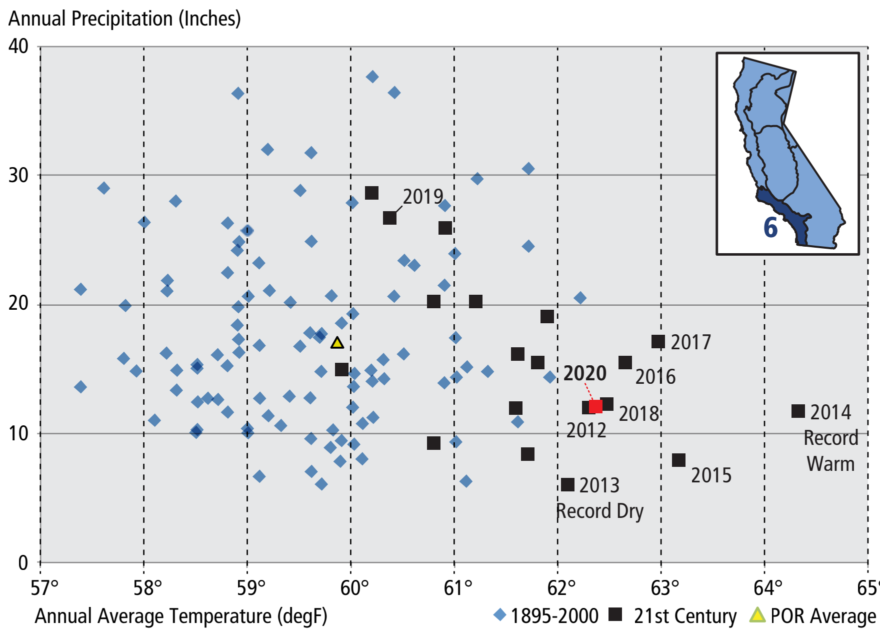
1981-2010 Averages	Extremes	Most Recent Year
Mean: 57.8°F	Warmest: 60.9°F (+ 3.1 °F from Average), 2015	October 2019-September 2020 | 59.2°F (+ 1.4 °F) | Rank: 117 of 125
Median: 57.9°F	Coldest: 54.5°F (- 3.3 °F from Average), 1917	(1 = Record Coldest, 125 = Record Warmest)



computed from daily observations. Plots of annual precipitation versus annual average temperature are shown, using the annual average values from 1895-2020. Within Climate Division 2 (Sacramento Drainage), the long-term record depicts a dramatic shift in annual average temperature. The data points from the 21st century are shown as boxes indicating an overall shift in climate compared to the historical record. The past several years are depicted as outliers, being some of the warmest years on record. Data from Climate Division 6 (South Coast Drainage) depicts even more annual precipitation variation from 5 to 40 inches per calendar year. The past 20 years since the turn of the century are also extremely warm and dry, indicating a shift in climate compared to the 20th century.

NOAA California Climate Divisions: #2 Sacramento Drainage; #6 South Coast Drainage

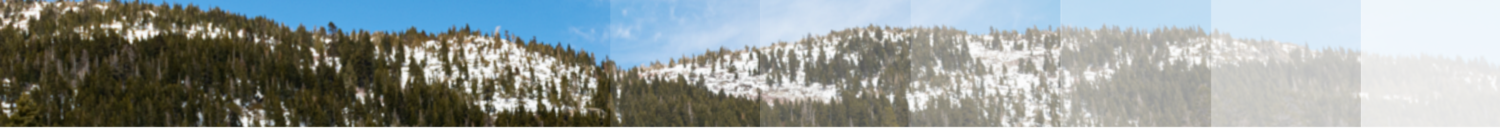




The Sacramento and South Coast Drainage Climate Division data plots show 2014 and 2015 as the warmest years on record. 2020 annual average temperature plots are depicted for the Sacramento Climate Division (57.0°F) and for the South Coast (62.4°F). The combination of warmer temperatures and lower rainfall in the 21st Century are outliers on the scatterplot graphs.

NOAA Climate Division Calendar Year Data

- Spatial resolution: NOAA California Climate Divisions
- Temporal resolution: Annual Mean



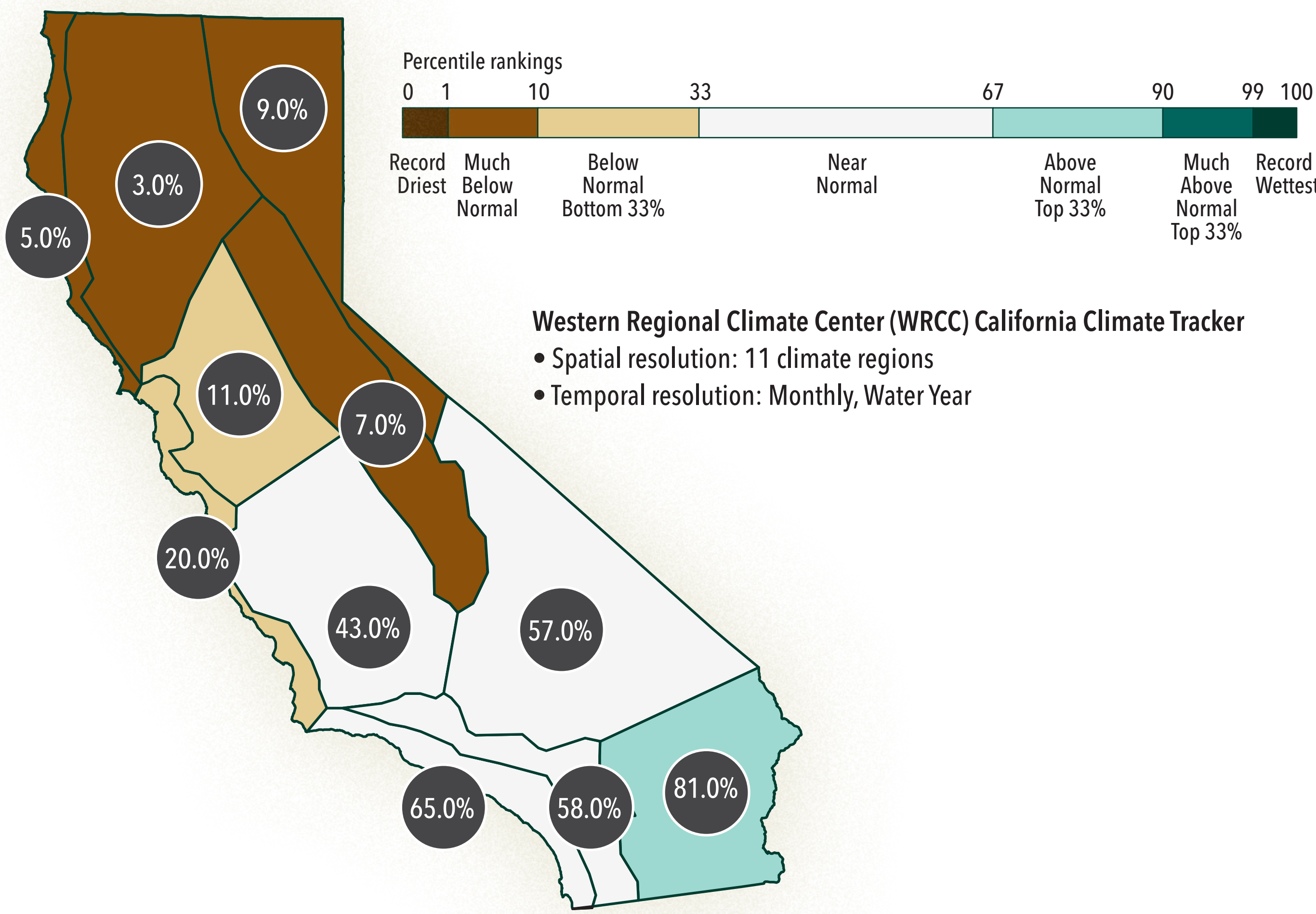
Annual Precipitation

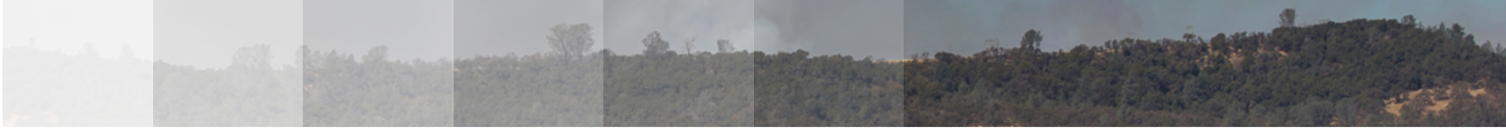
Annual precipitation data from California shows significant year-to-year variation. This inter-annual variability makes trend analysis difficult for this indicator. An analysis of precipitation records since the 1890's shows no statistically significant trend in precipitation throughout California. Although the overall precipitation trend is generally flat over the past 120 years, the precipitation record indicates significant decadal variability giving rise to dry and wet periods. A decadal fluctuation signal has become apparent in northern California where winter precipitation varies with a period of 14 to 15 years. This decadal signal has increased in intensity over the twentieth century resulting in more distinct dry and wet periods (Ault and St. George 2010). There is no known physical process driving this observed precipitation variability and remains an area for future research.

WY 2020 Precipitation

Statewide precipitation trends were analyzed by the WRCC using a data set that includes precipitation values across California. A total of 195 stations across the state are included in this analysis. Cooperative Observer Network (COOP), station data along with the Parameter-elevation Regressions on Independent Slopes Model (PRISM) database are considered in this analysis dating back to January of 1895. PRISM analyses depict above normal precipitation for the southern regions and below normal to much below in the northern regions in the state.

California Climate Regions Precipitation Rankings, Water Year 2020

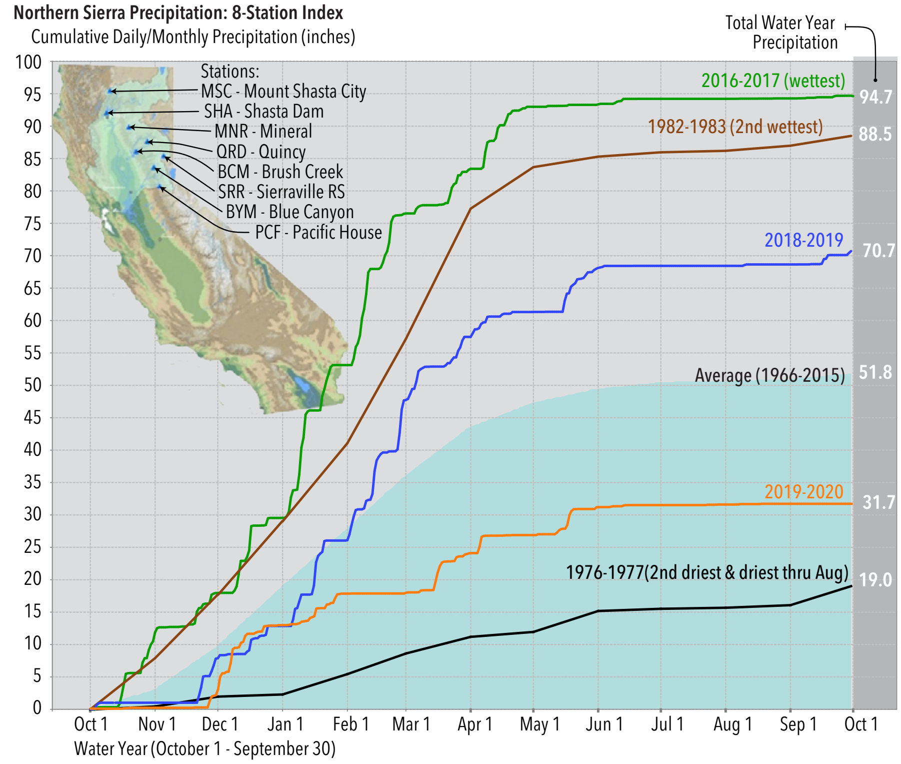




DWR Aggregate Precipitation Station Indices

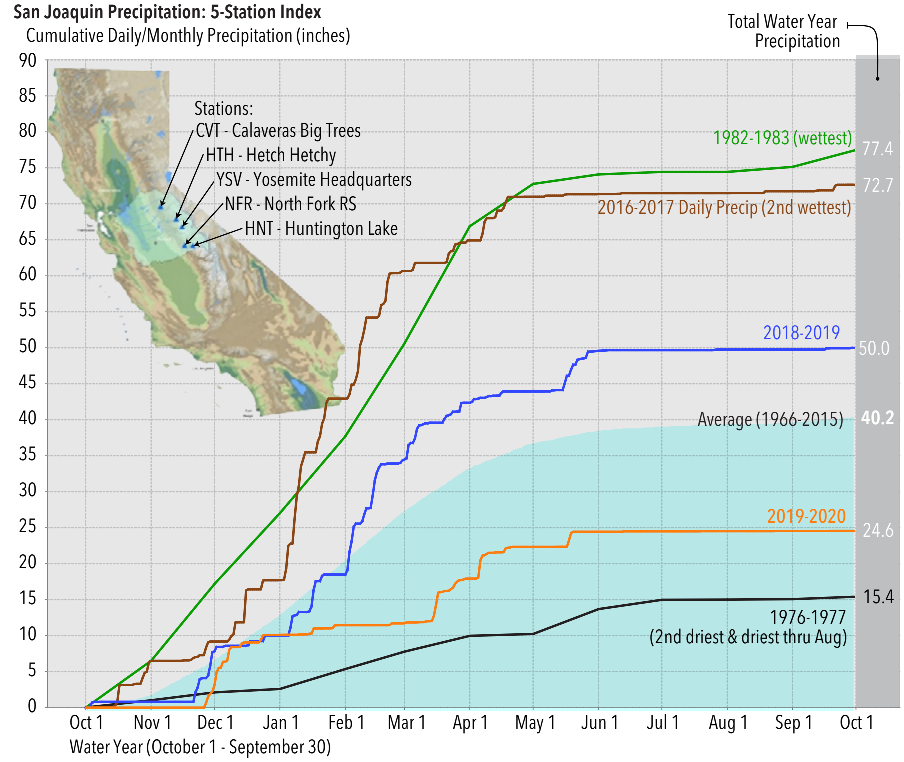
Regional precipitation trends are tracked by DWR at key locations critical to water supply in the state. These precipitation station indices are located in the Northern and Southern Sierra and correspond well to the WY type on the Sacramento and San Joaquin River systems.

Northern Sierra Precipitation: 8-Station Index

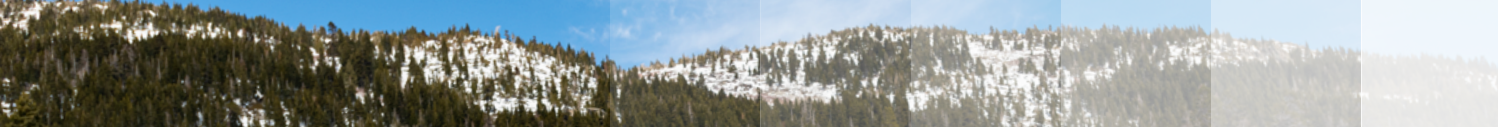


For WY 2020, the Northern Sierra Precipitation 8-Station Index shows total WY precipitation at 31.7 inches, well below the long-term average of 51.8 inches. Accumulated precipitation in for the WY was 20.1 inches below average, and 39 percent below normal. The year was characterized by almost no precipitation in February and very dry summer months.

San Joaquin Precipitation: 5-Station Index



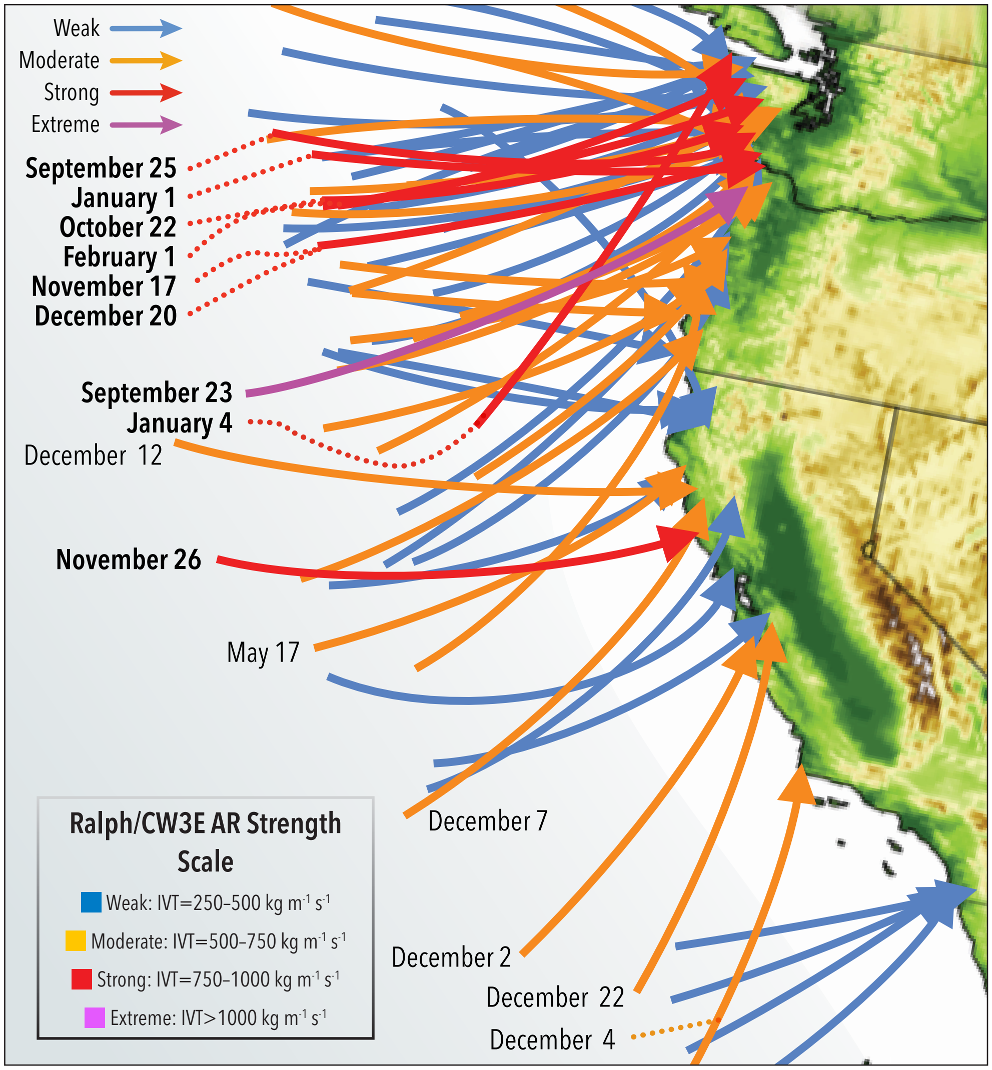
The San Joaquin Precipitation 5-Station Index, which is representative of the Southern Sierra, typically receives less precipitation than the Northern Sierra. WY 2020 had a total WY precipitation of 24.6 inches, which was below the average of 40.2 inches for the Southern Sierra. Cumulative precipitation for WY 2020 was 39 percent below normal.



Atmospheric Rivers

A limited number of precipitation producing storms move over California every Water Year. Attention has recently turned to storms associated with atmospheric rivers (ARs) due to their impact on water supply and flooding. ARs are long (approximately 1000 miles), narrow (less than 100 miles wide) bands of intense water vapor concentrated in the lower atmosphere that can be entrained into the leading edge of winter storms that make landfall over California and the west coast of the United States. Typically, only a few strong AR storms impact California during the winter months, and on average, AR storms provide 30 to 50 percent of California's annual precipitation and 40 percent of Sierra snowpack. With warmer air, and changing ocean conditions, AR episodes have the potential to increase in duration and intensity yielding increases in precipitation from the largest storms (Dettinger, 2016).

Distribution of all landfalling Atmospheric Rivers on the U.S. west coast during WY 2020



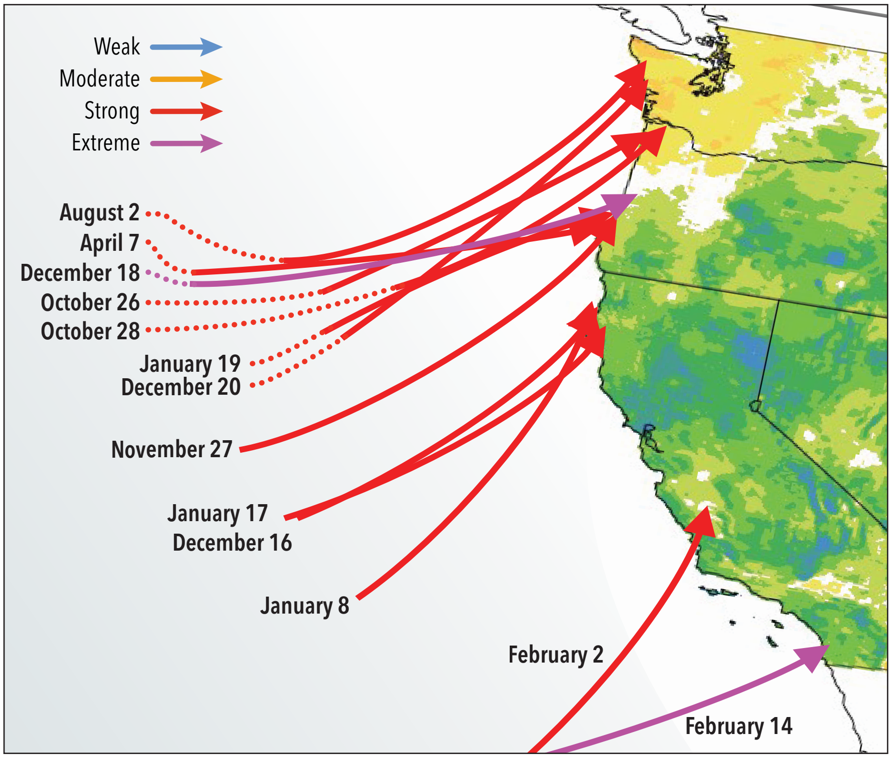
Graphic: Center For Western Weather and Water Extremes (CW3E) Scripps Institution of Oceanography. Produced by C. Hecht and F. M. Ralph

Atmospheric River strength by month and WY 2020 totals.

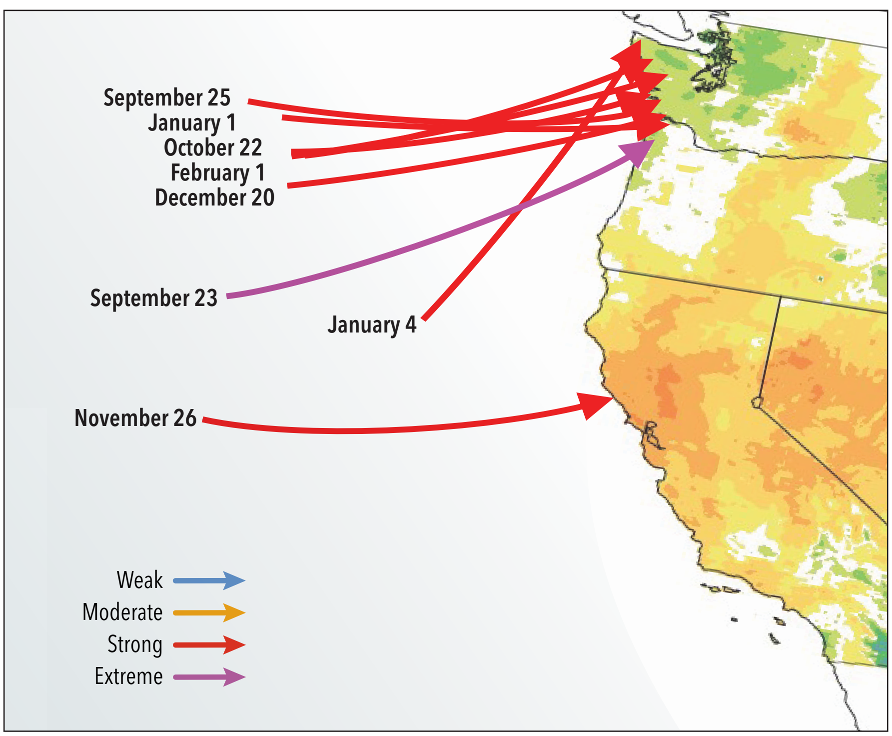
AR Strength	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	WY Total
Weak	2	3	0	4	2	7	4	4	3	2	0	0	31
Moderate	2	1	5	6	1	0	3	1	2	0	3	1	25
Strong	1	2	1	2	1	0	0	0	0	0	0	1	8
Extreme	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	5	6	6	12	4	7	7	5	5	2	3	3	65

Table: Center For Western Weather and Water Extremes (CW3E) Scripps Institution of Oceanography

Distribution of 13 Strong and Extreme Atmospheric Rivers on the U.S. west coast during WY 2019



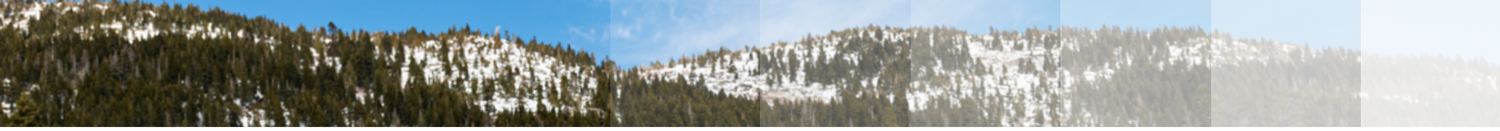
Distribution of 9 Strong and Extreme Atmospheric Rivers on the U.S. west coast during WY 2020



Recent research into the characteristics of ARs at the Center for Western Weather and Water Extremes (CW3E) has yielded a categorization, the Ralph/CW3E AR Strength Scale, based on the amount of integrated vapor transport (IVT). IVT is a combination of the amount of water vapor in the atmosphere above a given point and the horizontal winds that move the water vapor. IVT has shown early promise for AR characterization as well as predictability in weather forecast models (Lavers et al., 2016). The Ralph/CW3E AR Strength Scale includes four categories: weak, moderate, strong, and extreme. The categories are evenly divided in increments of 250 flux units of IVT with extreme being stronger than 1000 flux units.

The figure shows a characterization of the 65 ARs that made landfall along the US West Coast in WY 2020 as well as the location of maximum intensity of the AR when it hit the coast. Of the 65 landfalling ARs, 39 impacted the Northern California region and 14 impacted the Central and Southern California.

One key takeaway from Water Year 2020 was the lack of strong or greater magnitude ARs over California. For example, during WY 2019, the U.S. West Coast experienced a total of 13 strong or greater ARs compared to 9 during WY 2020. The 9 strong or greater magnitude ARs that made landfall during WY 2020 were primarily strongest over the Pacific Northwest. Only one AR brought strong or greater AR conditions to California in WY 2020, compared to six during WY 2019. This difference in AR strength and distribution resulted in water year precipitation accumulations of 20–70% of normal in water year 2020.

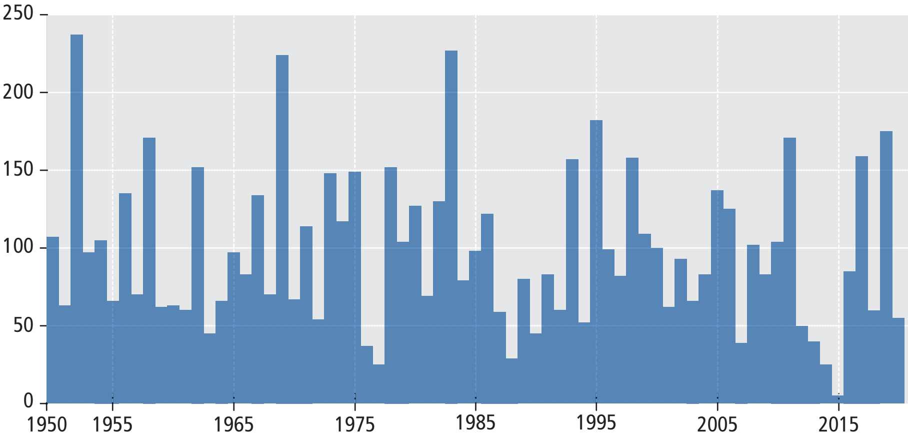


Snowpack

Snowpack is an essential water supply feature in California and historically provides approximately 15 million acre-feet of water accounting for one-third of the State's annual water supply. Numerous studies have reported declines in Western US snowpack in recent years and have been attributed to warming temperatures associated with climate change.

The California Cooperative Snow Surveys program has been actively collecting data since the 1930's from Northern and Southern Sierra locations. A consistent long-term historical record lends this data set to making a good indicator of snowpack in California. The California Environmental Protection Agency (EPA) Indicators of Climate Change in California (2018) report uses a subset of the snowpack monitoring locations; 13 stations from Northern Sierra and 13 stations from Southern Sierra which were identified by Scripps Institution of Oceanography researchers for their completeness and ability to represent their respective regions.The Hydroclimate Report will continue to track statewide snowpack trends and the Northern and Southern Sierra 13 station indicators with updated graphs each WY. Values presented are the April 1st Snow Water Equivalent (SWE), or snow-water content, as this is historically the date when the maximum snow accumulation has occurred at monitoring locations throughout the Sierra.

Statewide snow water equivalent (April 1)
Percent of average



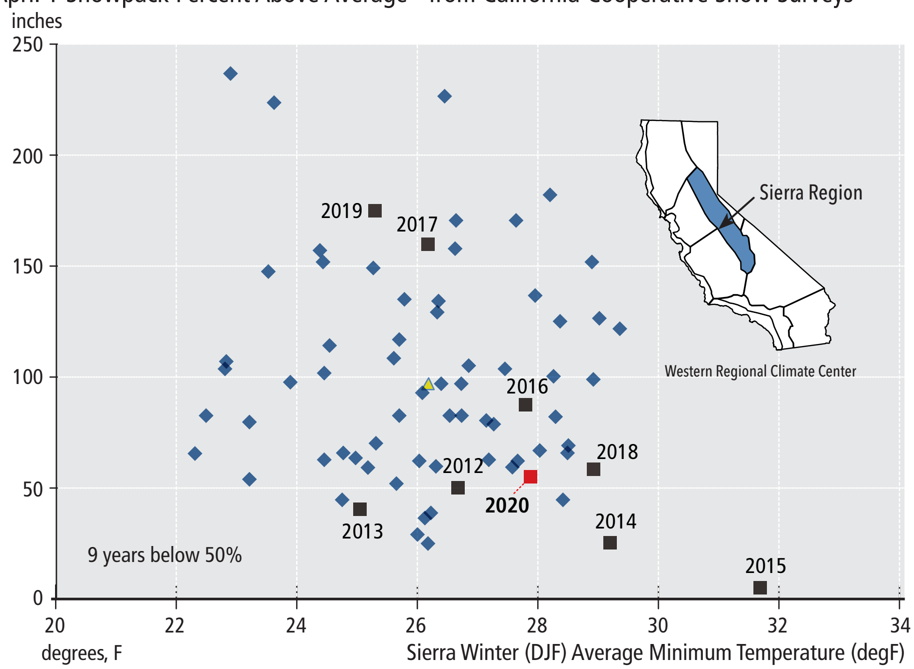
WY 2020 statewide snowpack water content was 55 percent of the long-term average. April 1st snowpack was significantly lower in comparison to WY 2019 where statewide snowpack water content was 175 percent of the long-term average. The lack of atmospheric river storms and extremely low precipitation in February played a role in bringing snowpack content lower than the long-term average. The decline in snowpack reduced water supply outlook in California and the long-term trend for this indicator has been on the decline since 1950.

California Cooperative Snow Surveys - Snowpack

- Spatial resolution: statewide, Northern Sierra, Southern Sierra
- Temporal resolution: Monthly Winter Season, April 1st SWE

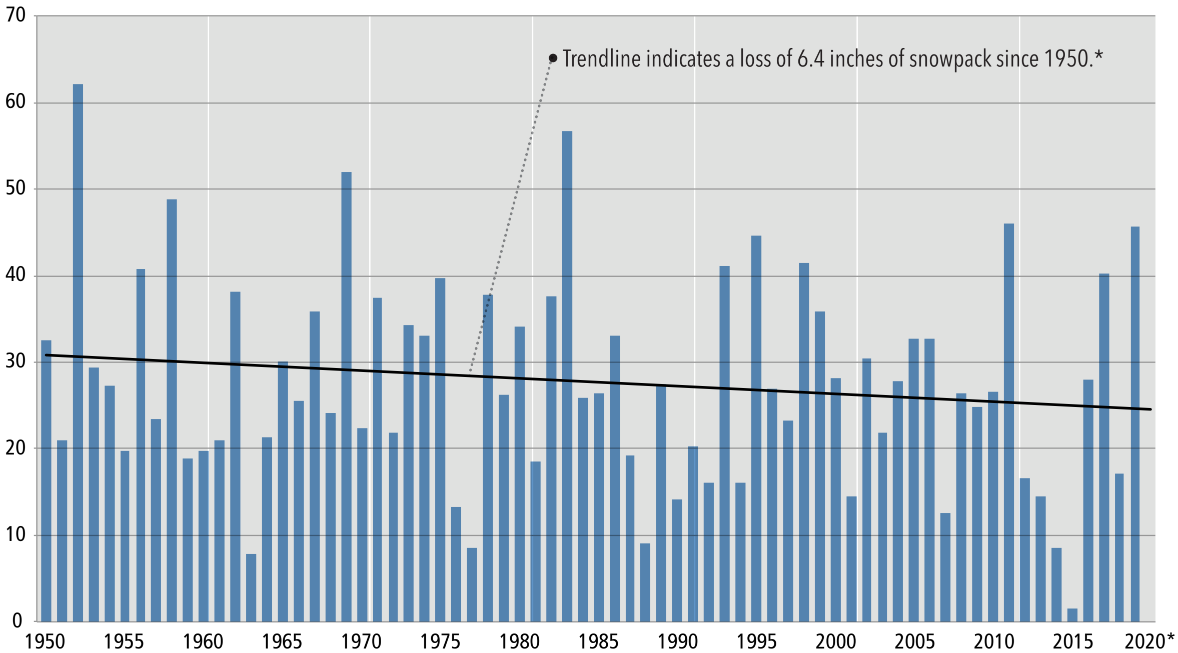
Sierra snowpack vs Winter Temperature, 1950-2020

April 1 Snowpack Percent Above Average - from California Cooperative Snow Surveys



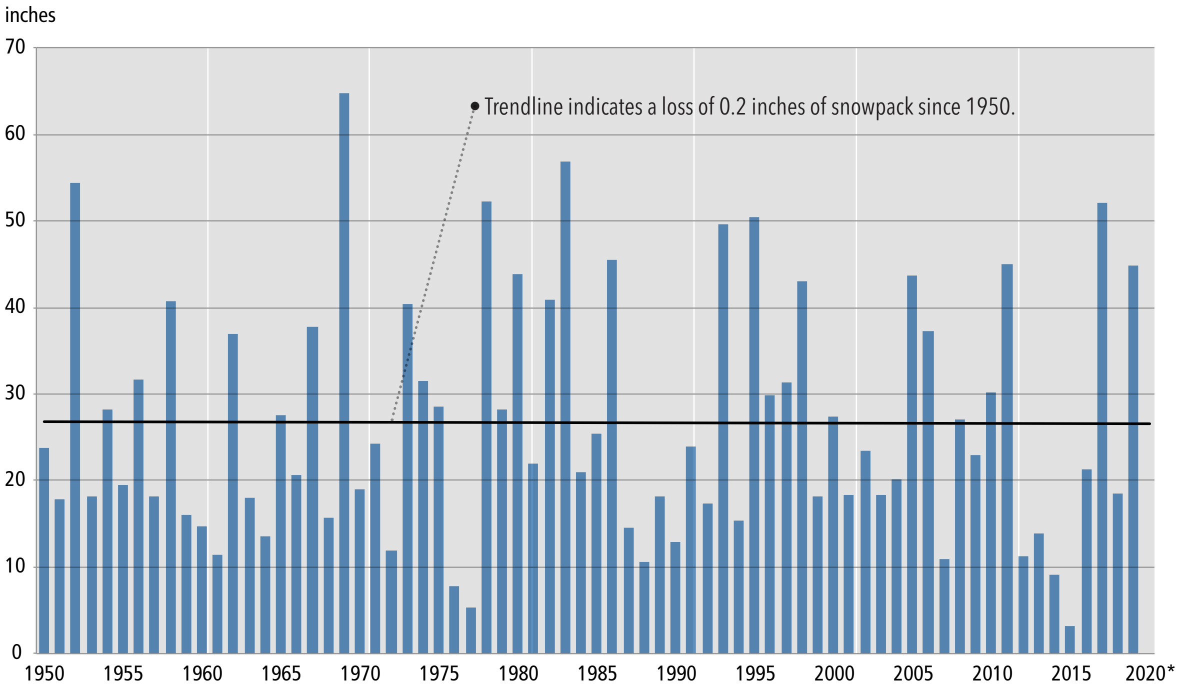
A scatterplot of April 1st snowpack vs. Sierra minimum air temperatures shows the past seven years labeled as boxes.

April 1 Snow-Water Content, 13 Northern Sierra Nevada Snow Courses

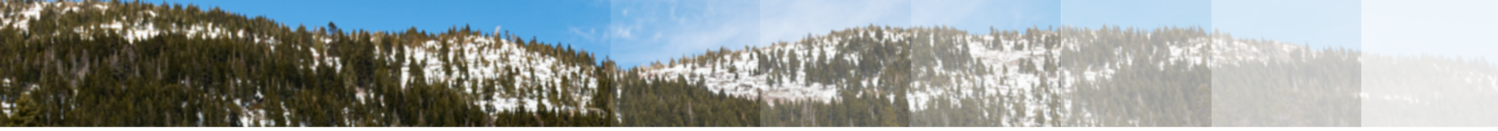


These figures demonstrate the trends in April 1st snowpack for 13 Northern and 13 Southern Sierra Nevada courses representative of their regions. Due to the work and travel restrictions due to the COVID-19 pandemic, a significant percentage of the snowcourses in the network were not sampled in WY 2020. Without enough sampling points to complete the dataset, WY 2020 will not be included in the figures and trends. The figures will be updated in WY 2021 if pandemic work restrictions are lifted and a sufficient amount of data is collected. Up to WY 2019, the Northern Sierra trend indicates a loss of 6.4 inches since 1950 where the Southern Sierra trend indicated a loss of 0.2 inches.

April 1 Snow-Water Content, 13 Southern Sierra Nevada Snow Courses



*WY 2020 is not included in the figure(s) and trend(s). Due to the work and travel restrictions related to the COVID-19 Pandemic many snowcourses were not measured, leading to a data gap for WY 2020. Figures and trends will be updated in future reports when a sufficient amount of snowcourses have been sampled.

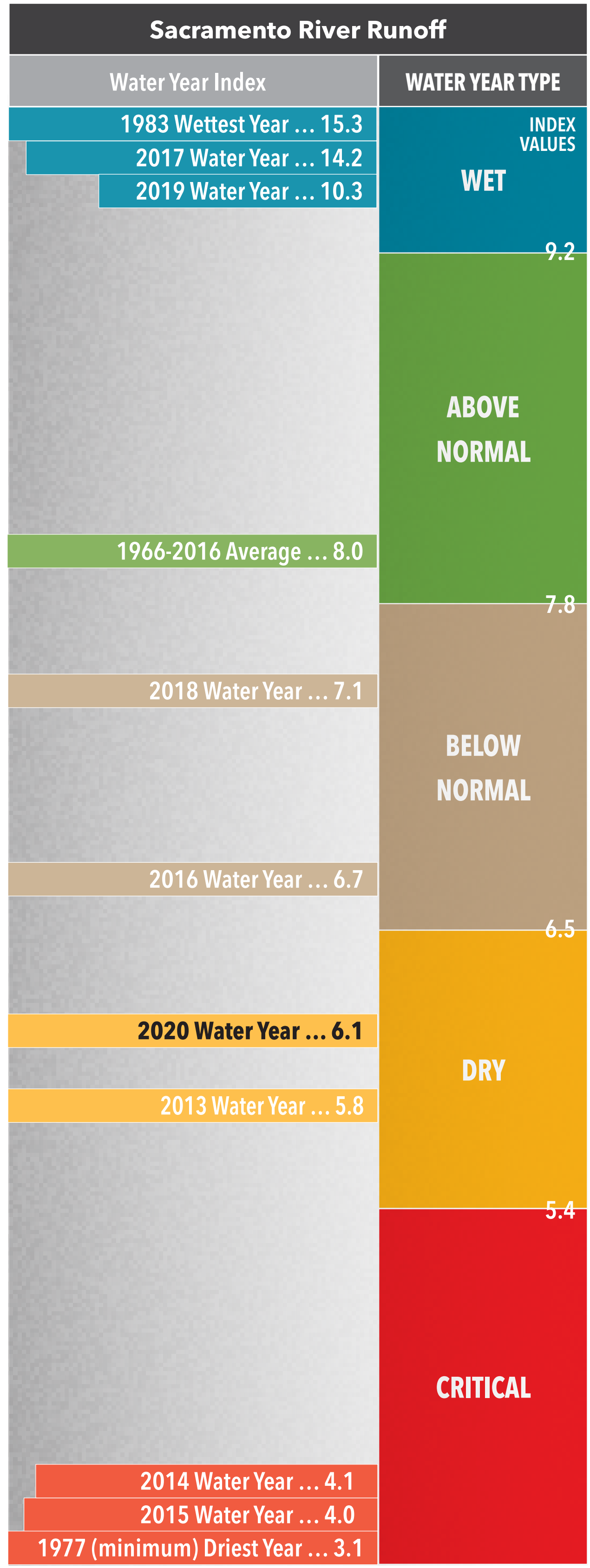


Water Year Type

California's water supply is influenced by geographic and seasonal variability which are subject to inter-annual climatic variability with year to year changes in precipitation and runoff. Runoff from the Sacramento and San Joaquin River basins provides much of the State's surface water supply and are classified using a WY type index system. Each WY, both river basins are classified as one of five WY types; a "wet" year classification, two "normal" classifications (above and below normal), and two "dry" classifications (dry and critical). Since the Sacramento River basin is rain-dominated and the San Joaquin River basin is snow-dominated, each basin has a separate method for determining water year types for that basin (CSWRCB, 1999). This WY classification system provides a means to assess the amount of water available from the basins and can be used as an indicator of water supply trends. These WY type classifications and "indices" were developed by DWR for the State Water Resources Control Board (SWRCB) for the Sacramento and San Joaquin River hydrologic basins as part of SWRCB's Bay-Delta regulatory activities and are important for water planning and management through each WY (see appendix for more detail).

The WY classification system for the Sacramento and San Joaquin River basins was designed based on historical hydrology and the assumption that the climate does not change over time (stationarity). With climate

Conditions during the final snow survey of the 2020 season at Phillips Station in the Sierra Nevada Mountains. The survey was held approximately 90 miles east of Sacramento off Highway 50 in El Dorado County. Photo taken April 30, 2020.

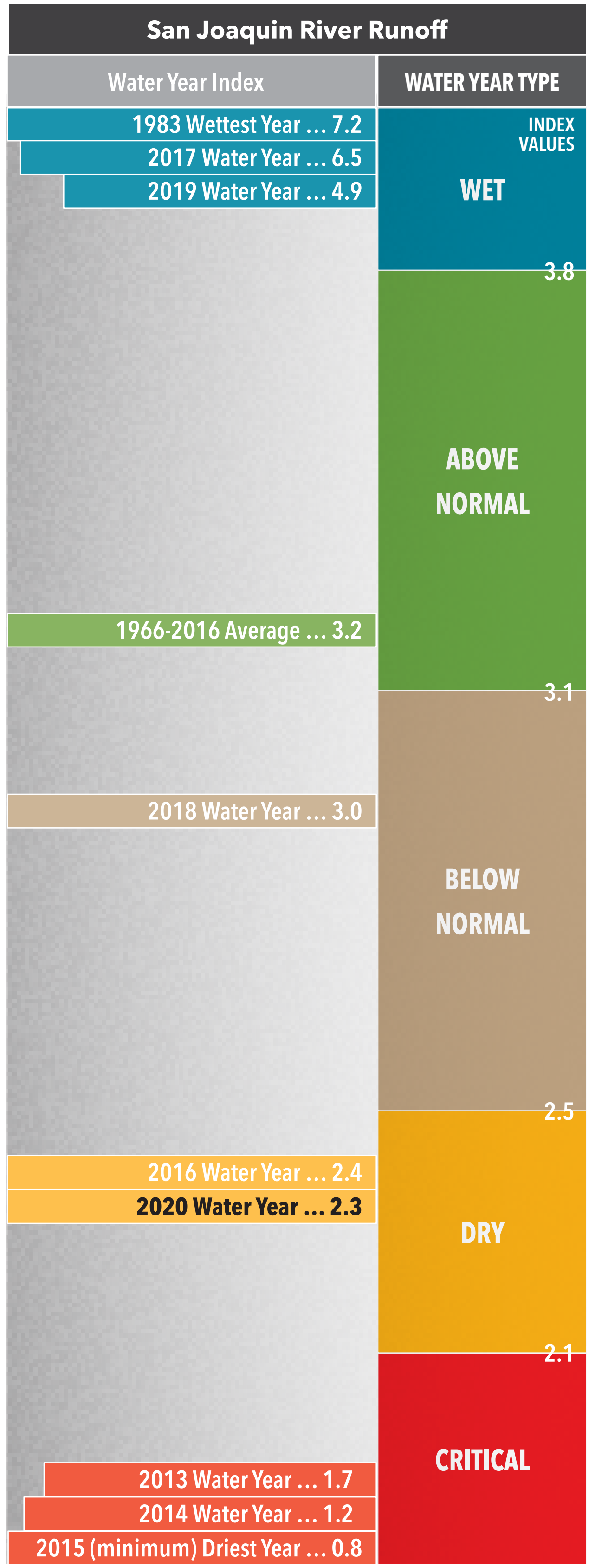


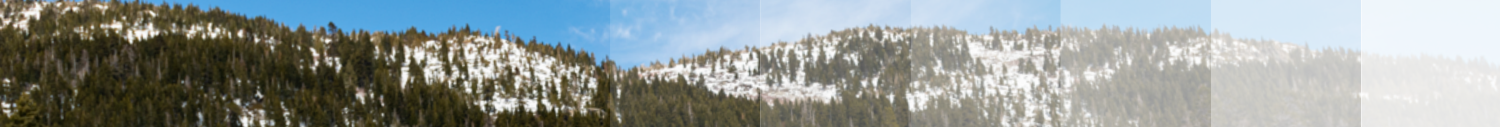
The Sacramento Valley 40-30-30 Index based on flow in million-acre feet for WY 2020 was 54 percent of average with an index value of 6.1 classified as a "dry" WY type.

change and changing hydroclimatic conditions there is debate whether this stationary approach to the WY indices will be adequate to inform water management decisions in the future. A modelling study by Null and Viers (2013) analyzed the context of climate change with the current WY classification system and found a significant shift in the indices due to warmer air temperatures and earlier snowmelt runoff resulting in changes to streamflow timing. These shifts in temperature and runoff indicate that the climate is changing over time (non-stationarity). A recent study by He et al. (2021) also used the current WY classification system with future runoff projections. Generally, projections show increases in October to March runoff. For the rain-dominated Sacramento River basin, the projected April to July runoff decreases, whereas for the snow-dominated San Joaquin Basin, the change in April to July runoff depended on the climate model used. These runoff changes result in changes in the projected water year types. The study highlights non-stationarity and long-term uncertainties in the results with runoff being more sensitive to the greenhouse gas emissions scenario used and water year types being more sensitive to the climate model used. Climate-adaptive water year typing methods could be explored in the future, which would take into account uncertainty in future climate and the hydro-climatic non-stationarity that has already been observed in the historical record.

In October, 2020, the San Joaquin River Gorge was regularly found full of smoke from multiple fires. Photo by Somer Shaw, BLM.

The San Joaquin Valley 60-20-20 Index based on flow in million-acre feet for WY 2020 was 52 percent of average with an index value of 2.3 classified as a "dry" WY type.





Rain/Snow Trends

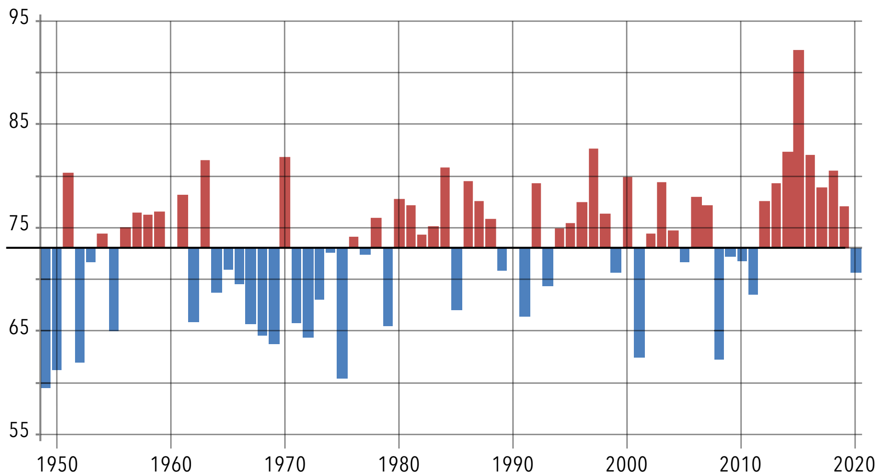
Mountains are natural reservoirs of water in California. Water is stored in the snowpack that accumulates during the cool season and is released during the warm season as snow melts. Historically, the middle and upper elevations of California's mountains receive the majority of cool season precipitation as snow. Because of California's dependence on snow-derived water supplies and susceptibility to flooding from snow melt events, it is an ideal location to examine changes in historical precipitation phase partitioning (meaning the fraction of precipitation that falls as rain vs. snow). Lynn et al. (2020) developed a methodology to study historical rain/snow trends at spatial scales relevant to broader management goals and with finer scale details across elevational and climatic gradients. This year's Hydroclimate Report incorporates new analyses of rain/snow trends, building upon the content shown in both the 2018 and 2019 Reports, however some indicators in this section use data sets only through 2018.

The bar chart shows the historical trend of percentages of rain and snow for all Zones A-D, from 1949- 2020. The mean shows the period average of rain making up 73 percent of total precipitation. Years that have a higher percentage of rain than the mean are more common and occur more successively in the recent years. The data shows substantial interannual variability due to climate signals that occur on annual indicator scales. Although not depicted, these trends are more evident in the northern parts of the state than central and southern portions, which are higher in elevation. For WY 2020, the percent of precipitation that fell as rain was below the long term and recent period means.

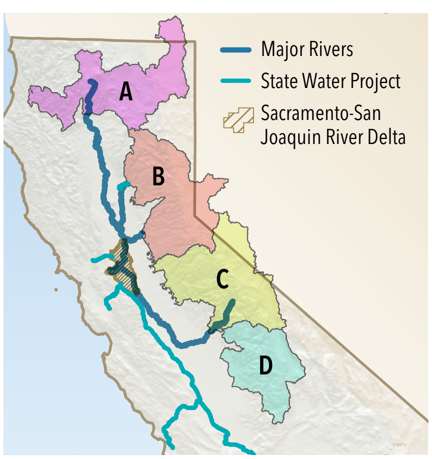
WY percentage of rain for the analysis period WY 1949-2020 for All Zones A-D

Mean for 1st half of record: 71; mean for 2nd half of record: 75; mean for entire dataset: 73; mean for 2020: 71; mean for the last decade:79

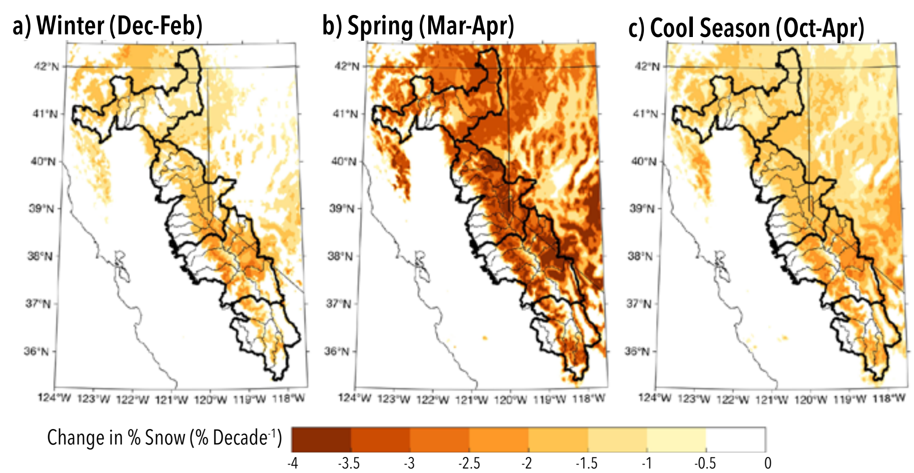
Years with red bars have a higher percentage of rain than the mean, and years with blue bars have a lower percentage of rain than the mean.



The figure below shows the analysis zones for rain/snow trends. Zone B includes Oroville reservoir, DWR's primary storage reservoir for the State Water Project.



Estimated changes in percent snow per decade for (a) winter (Dec-Feb), (b) spring (Mar-Apr), and (c) for the full cool season (Oct-Apr). Thick contours denote analysis zones A-D. Thin black contours denote United States Geological Survey HUC-8 watersheds. Only grid points with statistically significant trends are shown. This trend analysis indicates a greater fraction of precipitation across California's historically snow-dominated mountain regions, with spring showing the strongest trends (-2% to -4% per decade), followed by winter (-1% to -2% per decade). The largest decreases were found at mid elevations near the climatological freezing level.



This year's value may have been influenced by the timing of the precipitation over the course of the season and the lack of strong atmospheric rivers that can bring warmer tropic moisture where higher snow levels and more rain is expected.

The most notable, or largest magnitude, and widespread changes have occurred in spring at elevations near and below the climatological freezing level, see figure (below). The spring season signal of increasing precipitation as rain, especially in the middle elevation zones and southern upper elevation zones of California is consistent with declines in peak snowpack, changes in plant phenology, and earlier timing of runoff identified by earlier research. The transition from snow to rain at lower and middle elevations during the primary accumulation seasons has reduced the amount of water stored as spring snowpack and results in more precipitation falling as rain during storms, especially in regions with large watershed areas in lower elevations, increasing midwinter inflow into reservoirs.

Snowpack declines are projected to continue into the 21st century and be further exacerbated during droughts and extreme wet years. Additional analysis (DWR 2020) indicates that the highest elevation regions in the Sierra Nevada have not experienced significant declines in precipitation falling as snow, to date, during winter and spring. With continued warming and increased freezing levels, however, these areas will likely undergo declines in fraction of snow of the total precipitation volume. Many current multipurpose reservoir management paradigms require the maintenance of a flood pool, which is reservoir storage space allocated to attenuate periods of heavy inflow and reduce flood hazard during cool season storms. Water captured during the flood is later released to maintain the flood pool storage capabilities during the next possible event. Flood pool releases mean this water cannot be stored for later beneficial use and must be managed as a hazard rather than a resource. Work is in progress to develop adaptation strategies such as forecast-informed or dynamic reservoir operations and managed aquifer recharge to address this growing water management challenge.

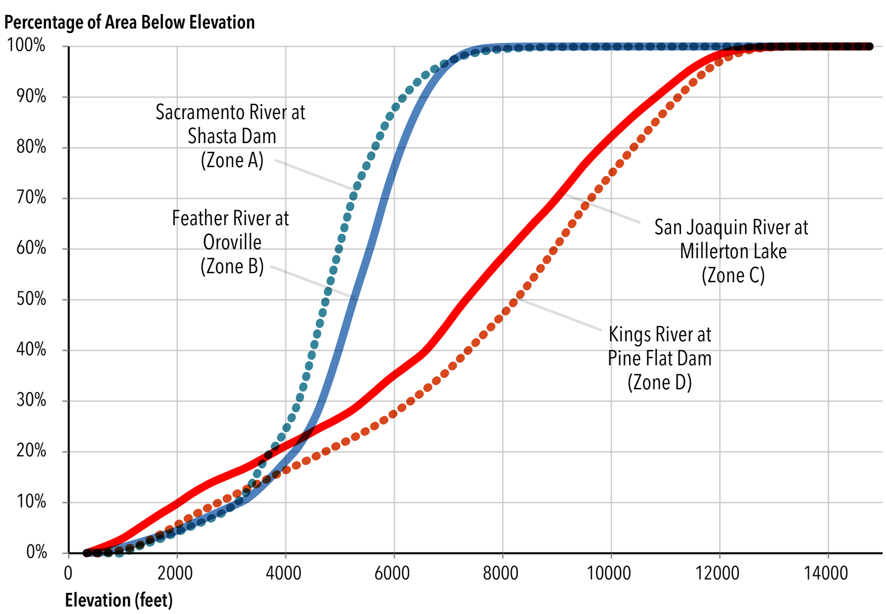
Decadal Trends In Percent Snow in 4000-6000 ft Vulnerable Elevation Band (1949-2018)

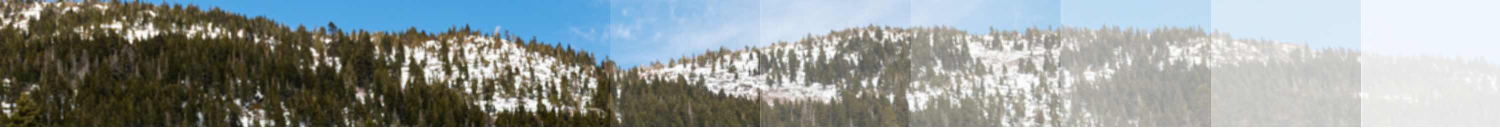
Analysis completed for publication ended with WY 2018. Future Hydroclimate Reports will include most recent years' data.

	Analysis Zones			
Season	**Southern Cascades (Zone A)**	**Northern Sierra Nevada (Zone B)**	**Central Sierra Nevada (Zone C)**	**Southern Sierra Nevada (Zone D)**
Fall (Oct-Nov)	-0.3	-0.4	-0.4	-0.4
Winter (Dec-Feb)	-1.4	-1.5	-1.6	-0.9
Spring (Mar-Apr)	-3.1	-3.2	-3.0	-2.7
Cool Season (Oct-Apr)	-1.7	-1.8	-1.8	-1.5

Looking more specifically at seasonal and geographic vulnerability in the critical reservoir-operation elevation band of 4,000-6,000 feet, this table indicates the maximum impact is occurring in the spring (March-April) in all regions, and is most pronounced in the Northern Sierra Nevada (Zone B).

The figure below shows the percentage of area below a defined elevation for major watersheds representing the Sacramento River at Shasta Dam (Zone A), Feather River at Oroville (Zone B), San Joaquin River at Millerton Lake (Zone C) and Kings River at Pine Flat Dam (Zone D). In the major watersheds of the Sacramento River Basin, most of the watershed area (over 90 percent) is below 7,000 ft elevation. In contrast, most major watersheds in the San Joaquin River Basin have over half of the watershed area above 7,000 ft elevation. This is reflected in the decadal trends of percent snow where the overall lower elevation Northern Sierra Watersheds are more vulnerable to warming temperatures where loss of snowpack and timing of snowmelt and runoff will affect flood management and water supply storage in reservoirs.



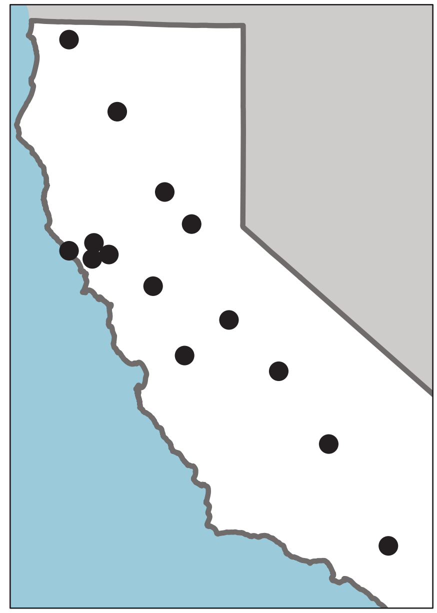


Snow-Level Radar

Snow-Level Radar is an indicator that provides information about snow level, or the elevation at which snow turns to rain, in the atmosphere. Snow-Level Radar is a result of research from the NOAA Hydrometeorology Testbed (HMT) Legacy project between the Earth Systems Research Laboratory and CA DWR. These ground-based snow level observing radars are positioned in a north-south transect of California, to provide high resolution observations during storms and information on extreme precipitation events and long-term climate observations.

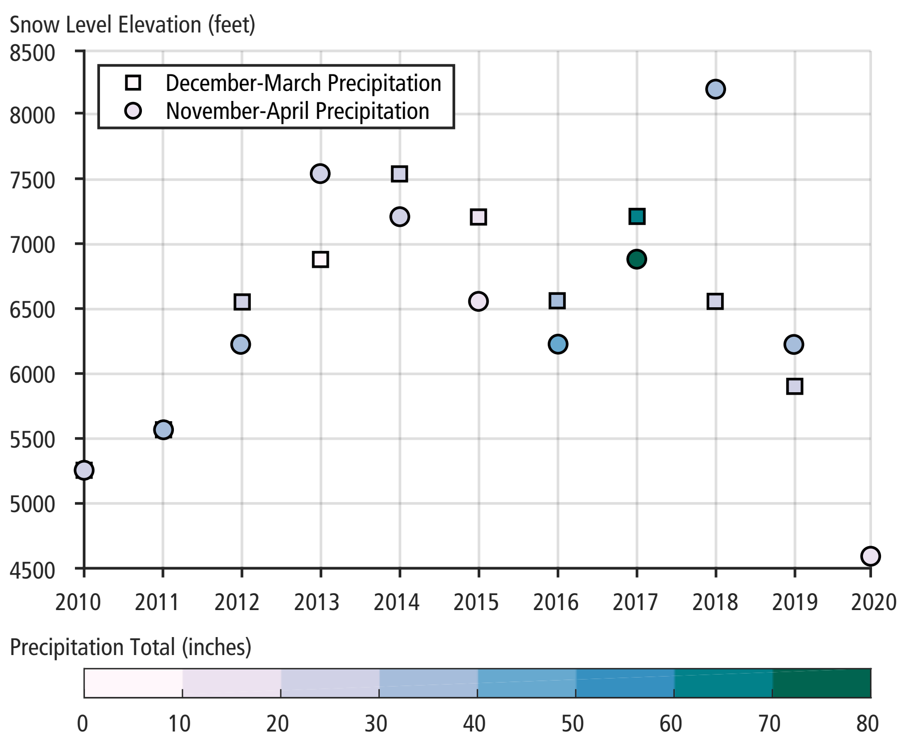
This indicator provides data to address research questions about how a warming climate affects the snow level during storms. Variations in snow level control the amount snow accumulating in the water supply watersheds of the Sierra Nevada and southern Cascades. Changes in the fraction of precipitation falling as snow can have significant impacts to water management objectives for flood management and water supply forecasting.

A recent study that employed snow-level sensing radar measurements identified a statistically significant trend in higher winter snow levels in the northern Sierra Nevada between 2008-2017 (Hatchett et al., 2017). However, due to the short duration of the snow level dataset, continued collection of observations is needed to determine if the upward snow level trend continues. As more data is collected and research becomes available, this indicator will continue to be tracked in upcoming Hydroclimate Reports.



Snow-Level Radar observing station locations in California

Snow level elevations at which 50% of total precipitation fell at or below during two time periods for the Highway 80 corridor using hourly Colfax snow levels and Blue Canyon precipitation. The first period, December-March (squares), is when the majority of snowpack accumulation occurs. The full cool season (November-April; circles), during which winter storms occur, is also shown. WY 2020 demostrated the lowest snow level elevations in the record since WY 2010, however with overall low storm precipitation totals this correlates with the statewide April 1 SWE being at 50 percent below normal for the 2020 WY. Dot/square colors correspond to total precipitation for the respective time periods, shown in the colorbar at the bottom.



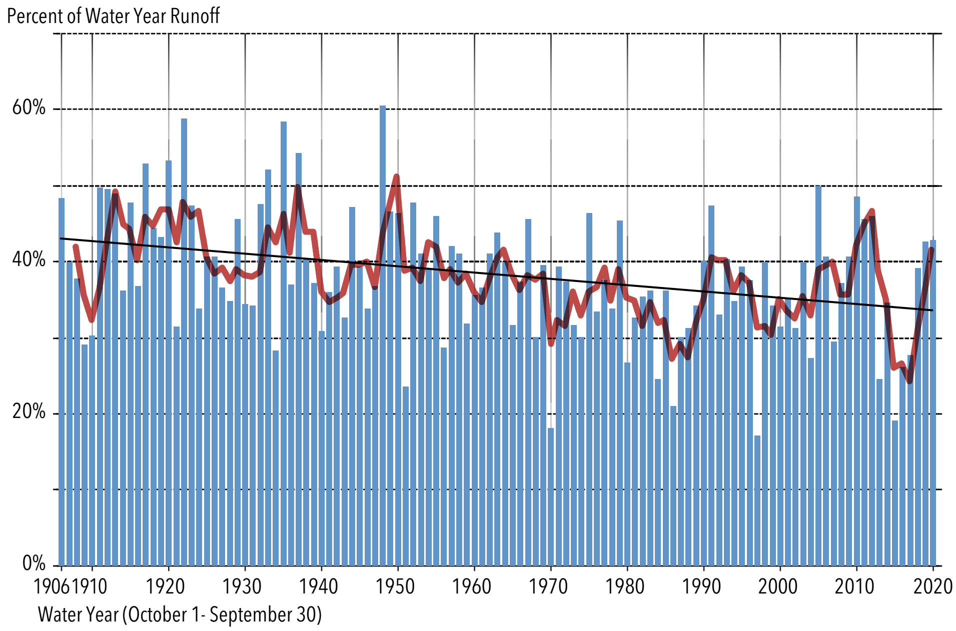
Unimpaired Streamflow: Sacramento and San Joaquin River Systems

With increasing temperatures and corresponding loss of snowpack, how can a comparison be made representing spring snowmelt? Since the main watersheds in California have been altered by water development projects such as dams and diversions, historical natural hydrology flows would be difficult to compare. To overcome this, natural or "unimpaired" flows are calculated to indicate flow change in each WY from 1906 in the Sacramento River and 1901 in the San Joaquin River systems.

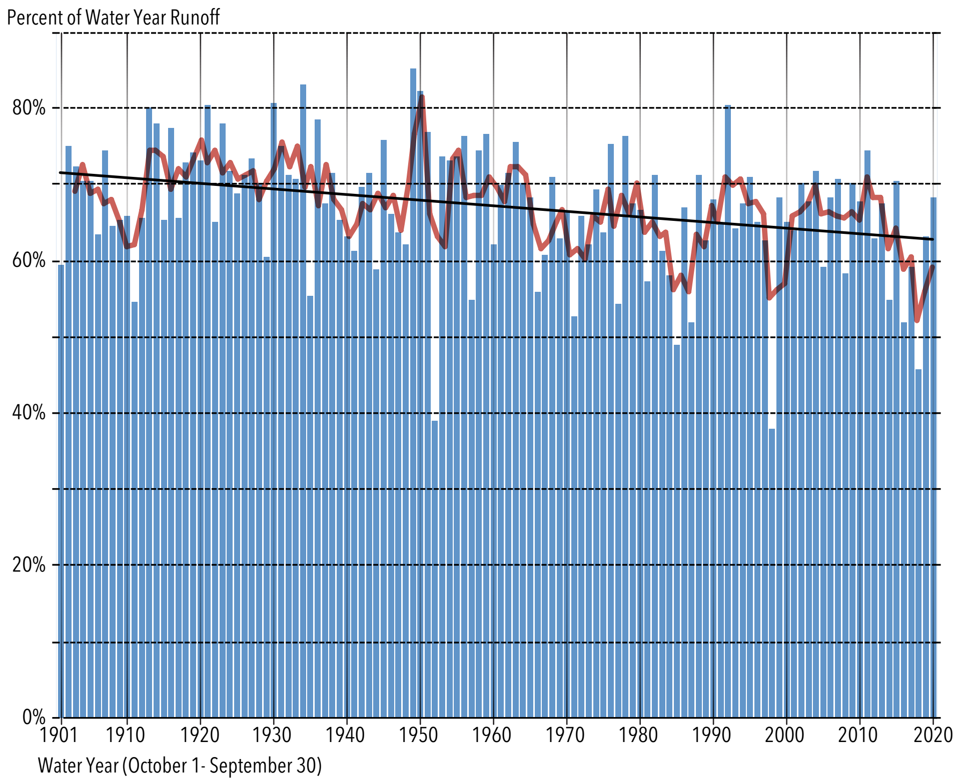
A method to quantify loss of snowpack and corresponding flow during the spring months was developed by DWR Chief Hydrologist Maury Roos in 1987. Instead of comparing seasonal snowmelt amounts, unimpaired flow occurring during the April through July snowmelt season is analyzed. Through this analysis, a distinct trend in flow loss is apparent. Currently, over the past 100 years data indicate a 8 percentage point decline per century on the Sacramento and a 9 percentage point decline per century on the San Joaquin River systems.

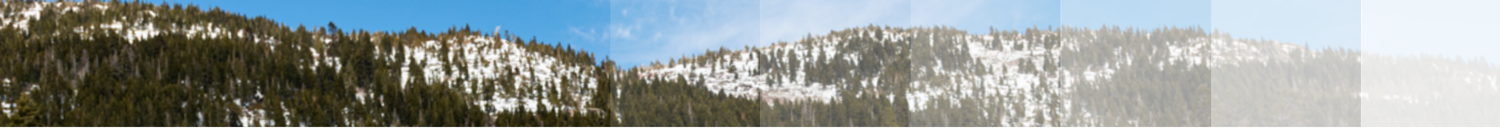
With below average precipitation and snowpack, WY 2020 April through July streamflow was 66 percent of average at 4.1 million-acre feet in the Sacramento River and 58 percent of average at 2.1 million-acre feet in the San Joaquin River. The percent of WY runoff during the April to July snowmelt period shows a declining trend for both the Sacramento and San Joaquin River systems.

Sacramento River Runoff, April - July Runoff in percent of Water Year Runoff
▬ Linear Regression (least squares) line showing historical trend ▬ 3-year running average



San Joaquin River Runoff, April - July Runoff in Percent of Water Year Runoff
▬ Linear Regression (least squares) line showing historical trend ▬ 3-year running average





Sea Level

Sea level is tracked along the California coast by the National Oceanic and Atmospheric Administration (NOAA) at 12 active tide gauges, which range in their periods of record from 39 years (Point Arena) to 162 years (San Francisco). Mean sea level at three key coastal tide gauges Crescent City, San Francisco Golden Gate, and San Diego are used as an indicator of change over time and to capture the broad scale geographic extent of the California coastline. For WY 2019, the La Jolla tide gauge in previous Hydroclimate Reports was substituted for the San Diego tide gauge as NOAA trend analysis for La Jolla was discontinued.

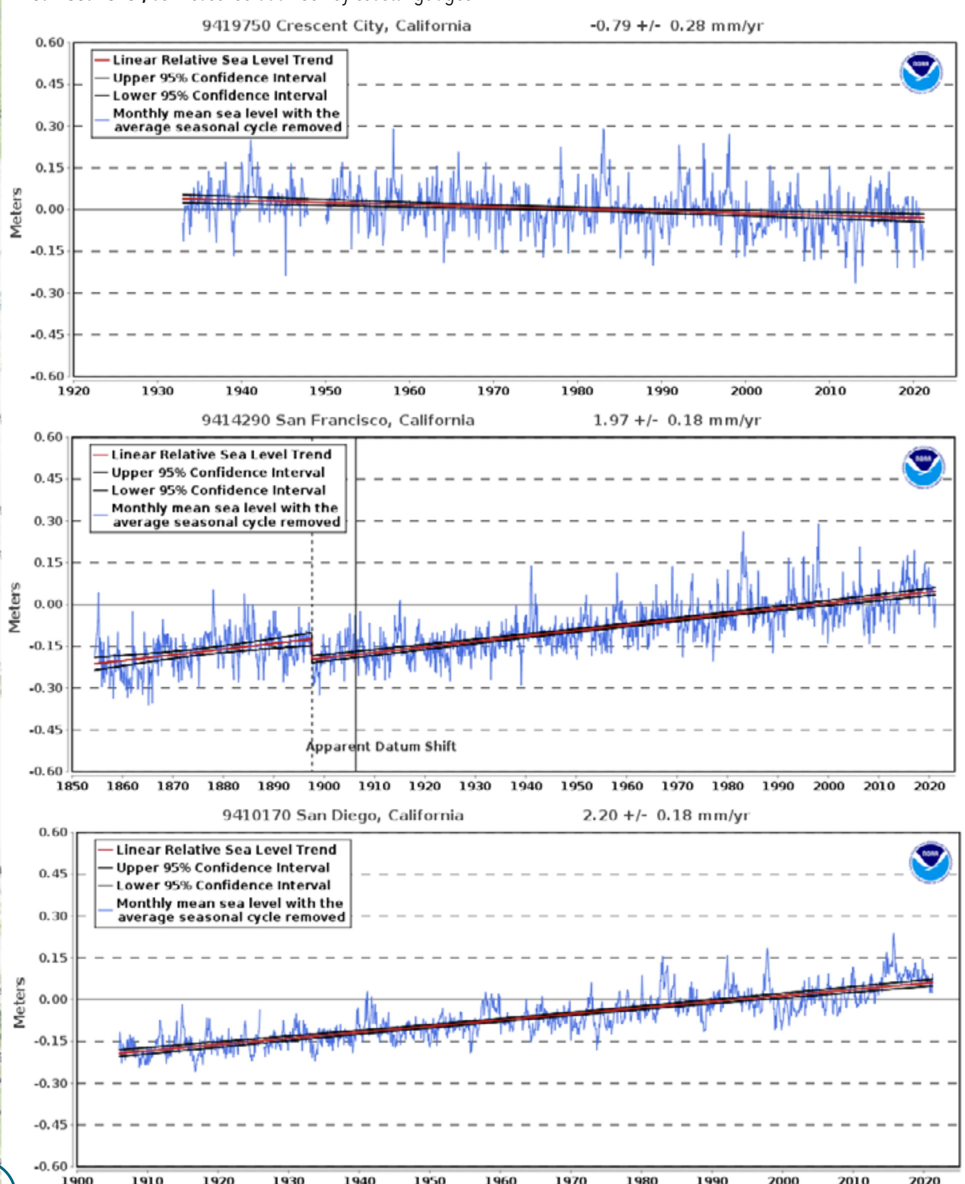
Local sea level for the shoreline of Southern and Central California (San Diego to Point Reyes) recorded at NOAA tide gauges range from less than 4 inches to just over 8 inches per century at the San Diego tide gauge.

Sea level at the Golden Gate tide gauge in San Francisco has shown a 7 inch per century increase, similar to average global measurements.

A general pattern of uplift shown at the Crescent City tide gauge, which has recorded relative sea level change averaging a decrease of 3 inches per century in sea level, or a drop in sea level relative to the coast, demonstrating that the coastline at this location is rising faster than sea level. At Cape Mendocino along the north central coast, a major tectonic boundary marked by the San Andreas Fault transition to the Cascadia Subduction Zone, which continues up the Pacific Coast to the state of Washington. From Cape Mendocino north for the next 120 miles to the Oregon border, the shoreline is being pushed upward due to subduction of the Gorda Plate beneath northern California.

Coastal uplift at the Crescent City tide gauge is subject to major periodic interruptions as geologic evidence indicates that the Cascadia Subduction Zone generates earthquakes of magnitude 8 or larger that can cause sudden subsidence along the coasts of northern California, Oregon and Washington. History shows a series of these events, which occur every 500 years on average, suggesting that sea-level rise along the California coast north of Cape Mendocino will change virtually instantaneously when the next large earthquake occurs.

Mean sea level, as measured at three key coastal guages



Notable Climate Events and Weather Extremes

Following a mid-winter dry period, a skier enjoys March snowfall in the Lake Tahoe area. Photo by Nina Oakley, Scripps Institution of Oceanography, March 2020.

WY 2020 demonstrated multiple extremes within a water year and continued the narrative of more heat and more variability. October started dry, tying for the 10th driest October statewide with records dating back to 1895. The dryness continued into November with the first significant storm arriving Thanksgiving week. This strong atmospheric river initially made landfall north of the Golden Gate, but created significant rainfall all the way to San Diego with localized flooding along the coast and some notable flood impacts in the southeast desert regions.

December ended up with slightly above average precipitation for the State with above average temperatures. Snowpack was slightly below average at the end of the month with the statewide value at 92% of average for the date.

Conditions shifted in January with precipitation falling off to about half of average in the north and drier in the south. The snowpack accumulation fell off leading to the percent of average decreasing to 68% of average at the end of the month. Temperatures continued to be slightly above average. The dry weather continued into February in sharp contrast to the previous year. Record dryness was recorded in many locations in the northern half of California while southern California was near or at record dryness for the combined January/February period. For the Sacramento Basin, it was a record dry month with only 10% of the previous record's amount of precipitation (0.4 inches in 1964 versus 0.04 inches in 2020). Statewide snowpack numbers fell to 44% of average. With a two of the three high precipitation months being dry, water year 2020 ended up as the third driest winter in the Russian River watershed, which only a year before was experiencing near record flooding.

March did not prove to be miraculous in bailing out a dry winter. In fact, precipitation continued to be below average, but was greater than the two previous months combined in many locations. This enabled the April 1 statewide snowpack to rise to 54% of average. April 1 is considered to be the average date of the peak of the seasonal snowpack. However, an early April storm added to the snowpack leading to a peak snowpack date of April 9 with 64% of an April 1 snowpack. Even so, April's precipitation again fell below average for the monthly accumulation.

May provided a change to the pattern of dry months. A wet 10-day period in the middle of the month resulted in the Northern Sierra 8-Station Index recording almost 200% of average precipitation for the month. Statewide the month was 130% of average and the 31st wettest May in the California Climate Tracker's period of record dating back to 1896.

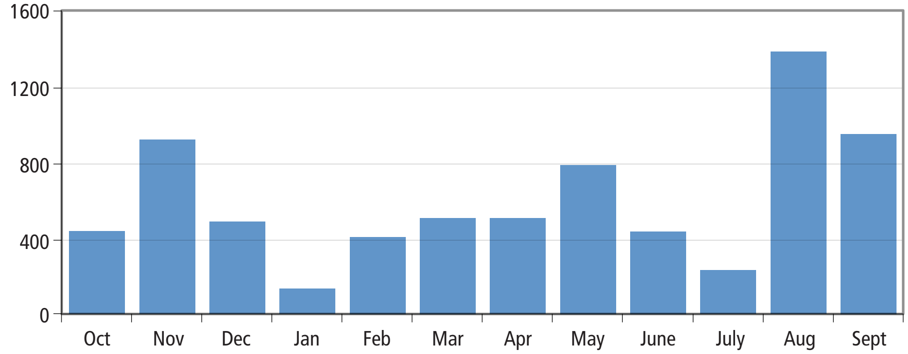
Temperatures were above average for both April and May.

With the onset of summer, precipitation dropped off while temperatures increased. While June and July were above average for temperature, the heat really kicked in in August and September to close out the water year. Both August and September set new monthly records for statewide average temperature and minimum temperature. For maximum temperature, August 2020 came in second to 1967. For September, the maximum temperature ranked sixth warmest. In August, Death Valley recorded a temperature of 130 degrees Fahrenheit on the 16th. The value is being verified by the World Meteorological Organization as it could be one of the warmest temperatures ever recorded on Earth.

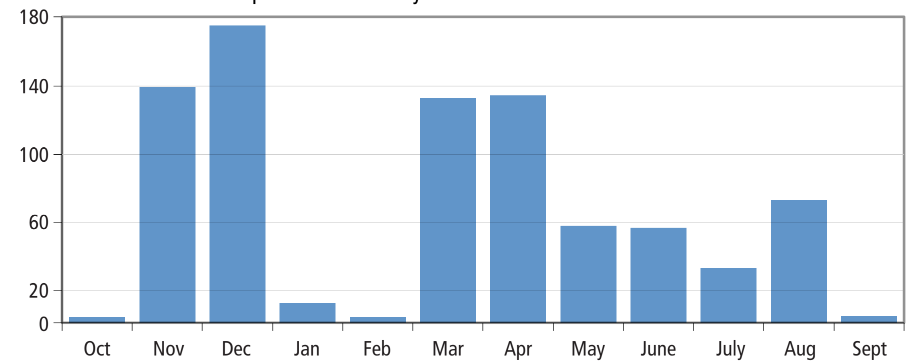
Record heat was not the only extreme in August. A series of decaying eastern Pacific hurricanes made landfall north of the Golden Gate and sparked an extreme lightning event that started over 700 fires. This would lead to a record setting year for fires in California with over 4 million acres burned.

Five of the State's largest six fires in history were ignited in August and September including the largest single fire (the Creek Fire) and the largest fire complex (the August Complex). On the whole, water year 2020 provided many more manifestations of climate change impacts.

Number of Statewide Temperature Records by Month for Water Year 2020



Number of Statewide Precipitation Records by Month for Water Year 2020

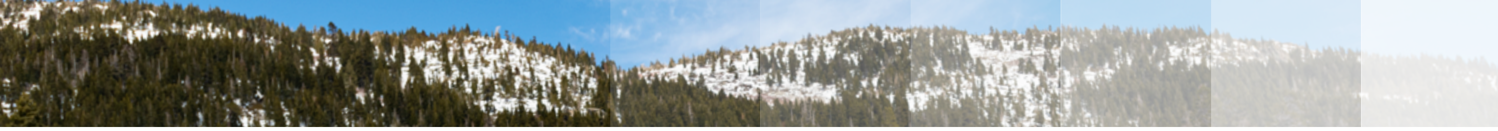


Dryness Metric Indicator

Observational changes in California hydroclimate includes a compression of the wet season and a movement to greater extremes. A study by Luković et al. (2021) has shown over the past six decades winter precipitation in California has been increasing, while both fall and spring precipitation have been decreasing. If these trends continue, adaptation would be needed for the changing characteristics of drought and aridity. To that end, an indicator or collection of indicators is needed that can characterize the contraction of the seasonal precipitation cycle and provide insight into the development of an adaptation pathway.

Time series that can be generated relative to precipitation include; fall precipitation onset date, spring precipitation end date, and various durations of dry spells. In addition, the temperature anomaly associated with the dry days can facilitate understanding of the increasing role temperature is playing within the natural variability of our precipitation season. In arid and semi-arid regions of the state, increasing durations of dry spells can lead to decreased runoff efficiency of the precipitation that does fall. A metric that has been used to describe this is the runoff ratio in which an estimate of the natural flow is divided by the precipitation. These metrics can be assessed at the watershed scale to account for the great spatial variability that exists in California's climate. Look for the further exploration and development of dryness indicators in future Hydroclimate Reports.

Morning mammatus clouds in Sacramento, California, looking south. These clouds occur in turbulence under thunderstorms, which are extremely rare in the summer, rarer still at 7am. The pattern was caused by the remnants of Tropical Storm Fausto and a period of record-breaking heat. The resulting thunderstorms went on to trigger over 11,000 lightning strikes and 650 wildfires across Northern California where fires burned approximately 2 million acres. Photo by Elissa Lynn, DWR, August 16, 2020.



Glossary

- **Anomaly:** The difference of a value over a specified period from the long-term average value (e.g. 1949-2005) over the same period.
- **Average Maximum Temperature:** The average of all daily maximum temperatures over a given time period.
- **Average Mean Temperature:** The mean value of the average maximum temperature and the average minimum temperature over a given time period.
- **Average Minimum Temperature:** The average of all daily minimum temperatures over a given time period.
- **Calendar Year (to date):** The interval between January and December (or to present month), inclusive.
- **Climate:** The average weather or the statistical description in terms of the mean and variability of relevant quantities over a period of time, ranging from months to thousands or millions of years.
- **Climate change:** A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties (often by using statistical tests), and that persists for an extended period, typically decades or longer.
- **Climate model:** A numerical representation of the climate system based on the physical, chemical, and biological properties of its components, their interactions and feedback processes, and accounting for all or some of its known properties.
- **Climate variability:** Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events.
- **COOP station:** Cooperative Observer Network (COOP), managed by the National Weather Service, consists of up to 12,000 weather stations across the United States that report daily measurements of precipitation and/or temperature.
- **Inhomogeneities:** Variations in data that are not attributed to climate variations. Non-climatic influences on the dataset can include abrupt changes due to changes in instrumentation or station location, as well as gradual changes due to growth of nearby vegetation or urban centers.
- **Linear Trend:** A simple method that fits a line (linear trend) to observations of a given variable over some time period. Beside each linear trend given on this set of pages is a 95% confidence interval that provides a measure as to how likely a trend is significant. For example, a trend of +2°F/100 years with an uncertainty interval of + or - 1°F/100 years says that with 95% confidence there is a positive linear trend, with a range between +1° and +3°F/100 years. On the other hand, a linear trend of + 2°F/100 years with an uncertainty interval of +/- 5°F/100 years does not provide conclusive evidence of a linear trend, as the range is between -3° to + 7°F/100 years. Confidence Intervals are calculated according to Santer et al 2000.
- **PRISM:** Parameter-elevation Relationships on Independent Slopes Model. A model that incorporates point measurements and topographic database to create a high resolution gridded climate database. More information on PRISM is available from Oregon Climate Service.
- **Percentile Ranking:** The ranking of a variable (e.g., temperature) over a given time period versus comparable time periods overall years of record, normalized to a 0 (coldest) to 100 (warmest) scale.
- **Precipitation:** The accumulation of water (in liquid form) that is deposited to the surface over a given time period.
- **Streamflow:** The amount of water flowing in a river.
- **Water Year (to date):** The interval between October and September (or to present month). For example the WY 2007 refers to the interval between October 2006 and September 2007.

Appendix

TEMPERATURE AND PRECIPITATION

WRCC California Climate Tracker

https://wrcc.dri.edu/Climate/Tracker/CA/

Monthly station data, taken from cooperative observers (COOP), along with gridded data from the PRISM database, are used to assess climate across the state. The primary variables that are considered in this process are monthly average mean temperatures and monthly precipitation totals. COOP stations across the state that reported over 75% of observations over the time period 1949-2005, and continued to report in 2006. A total of 195 stations across the state are included in this analysis. We consider COOP station data along with the PRISM database dating back to January of 1895. Temperature data from the COOP stations have been adjusted for inhomogeneities, a procedure used to "correct" for non-climate shifts in temperature. No effort is made to adjust for urbanization or land-use changes. Inhomogeneity detection includes the entire period of record; however the dataset contains larger uncertainties prior to 1918 due to the limited number of stations reporting statewide.

NOAA U.S. Climate Divisional Dataset

https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php

For many years the Climate Divisional Dataset was the only long-term temporally and spatially complete dataset from which to generate historical climate analyses (1895-2013) for the contiguous United States (CONUS). It was originally developed for climate-division, statewide, regional, national, and population-weighted monitoring of drought, temperature, precipitation, and heating/cooling degree day values. Since the dataset was at the divisional spatial scale, it naturally lent itself to agricultural and hydrological applications.

There are 344 climate divisions in the CONUS. For each climate division, monthly station temperature and precipitation values are computed from the daily observations. The divisional values are weighted by area to compute statewide values and the statewide values are weighted by area to compute regional values. (Karl and Koss, 1984).

Precipitation: DWR 8 Station and 5 Station Indices

Department of Water Resources hydrologists use two mountain precipitation indexes to track daily accumulation of rain and snow during the winter rainy season for the major Central Valley basins. The first is the Northern Sierra 8 station average, a group of 8 precipitation stations extending from Mount Shasta in the north to near Lake Tahoe in the south, which corresponds quite well to the WY runoff of the Sacramento River system (the Sacramento four river index). A southern group of 5 Sierra stations comprise the 5 station index which correspond fairly well to WY runoff for the San Joaquin River (the San Joaquin four river index).

The 8 station precipitation index includes: Mt Shasta City, Shasta Dam, Mineral, Quincy, Brush Creek, Sierraville, Blue Canyon, Pacific House.

https://cdec.water.ca.gov/reportapp/javareports?name=PLOT_ESI.pdf

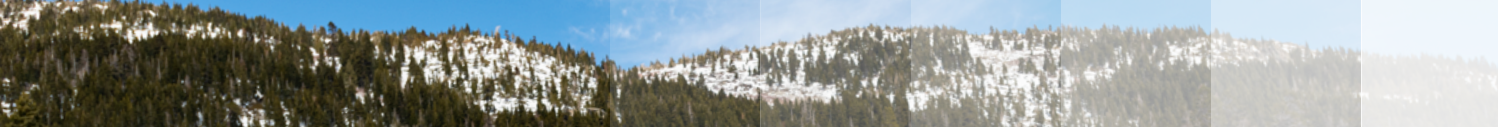
The 5 station precipitation index includes: Calaveras Big Trees, Hetch Hetchy, Yosemite, North Fork RS, Huntington Lake

https://cdec.water.ca.gov/reportapp/javareports?name=PLOT_FSI.pdf

ATMOSPHERIC RIVERS

https://cw3e.ucsd.edu/

The Center for Western Weather and Water Extremes, Scripps Institution of Oceanography, UCSD has developed a method in order to characterize atmospheric river (AR) events that make landfall along the US west coast. ARs are Identified using 6 hourly GFS Analysis derived integrated water vapor data. Arrows are drawn on the map where integrated vapor transport (IVT) within identified ARs was strongest over the US West Coast (arrows do not identify all locations each AR impacted). Given the spatial scale of a landfalling AR, the landfall latitude is an approximation. Intensity is determined for each AR using the Ralph/CW3E AR strength scale using IVT.



SNOWPACK

Bulletin 120 and Water Supply Index forecasts

Water Supply Index (WSI) and Bulletin 120 (B120) forecasts are posted at:

WSI: http://cdec.water.ca.gov/cgi-progs/iodir/wsi

B120: http://cdec.water.ca.gov/snow/current/snow/index.html

Recent Changes in the Sierra Snowpack of California (Roos and Fabbiani-Leon, 2017)

https://westernsnowconference.org/files/PDFs/2017Roos.pdf

During the 2012 Western Snow Conference, Roos and Sahota described contrasting trends for Sierrra snowpack. For a northern Sierra group of snow courses, a decline in April 1 measured water content was noted; however, for another group of southern Sierra courses, a small increasing trend in water content was noted. In both north and south, there was a decreasing trend in the volume of April through July runoff (mostly snowmelt) compared to total WY runoff. Now, after the drought, and a 2017 data update, the southern Sierra snowpack also shows a decreasing trend, although not as much as in the north.

Water Year Type: Unimpaired Flow (Runoff)

http://cdec.water.ca.gov/cgi-progs/iodir/WSIHIST

Unimpaired runoff represents the natural water production of a river basin, unaltered by upstream diversions, storage, export of water to or import of water from other basins. Sacramento River Runoff is the sum (in maf) of Sacramento River at Bend Bridge, Feather River inflow to Lake Oroville, Yuba River at Smartville, and American River inflow to Folsom Lake. The WY sum is also known as the Sacramento River Index, and was previously referred to as the "4 River Index" or "4 Basin Index". It was previously used to determine year type classifications under State Water Resources Control Board (SWRCB) Decision 1485.

Sacramento Valley Water Year Index = 0.4 * Current Apr-Jul Runoff Forecast (in maf) + 0.3 * Current Oct-Mar Runoff in (maf) + 0.3 * Previous Water Year's Index(if the Previous Water Year's Index exceeds 10.0, then 10.0 is used). This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the Sacramento Valley WY type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination is based on the May 1 50% exceedence forecast.

Sacramento Valley Water Year Hydrologic Classification:

Year Type:	Water Year Index:
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8, and less than 9.2
Below Normal	Greater than 6.5, and equal to or less than 7.8
Dry	Greater than 5.4, and equal to or less than 6.5
Critical	Equal to or less than 5.4

San Joaquin River Runoff is the sum of Stanislaus River inflow to New Melones Lake, Tuolumne River inflow to New Don Pedro Reservoir, Merced River inflow to Lake McClure, and San Joaquin River inflow to Millerton Lake (in maf). San Joaquin Valley Water Year Index = 0.6 * Current Apr-Jul Runoff Forecast (in maf) + 0.2 * Current Oct-Mar Runoff in (maf) + 0.2 * Previous Water Year's Index(if the Previous Water Year's Index exceeds 4.5, then 4.5 is used). This index, originally specified in the 1995 SWRCB Water Quality Control Plan, is used to determine the San Joaquin Valley WY type as implemented in SWRCB D-1641. Year types are set by first of month forecasts beginning in February. Final determination for San Joaquin River flow objectives is based on the May 1 75% exceedence forecast.

San Joaquin Valley Water Year Hydrologic Classification:

Year Type:	Water Year Index:
Wet	Equal to or greater than 3.8
Above Normal	Greater than 3.1, and less than 3.8
Below Normal	Greater than 2.5, and equal to or less than 3.1
Dry	Greater than 2.1, and equal to or less than 2.5
Critical	Equal to or less than 2.1

Eight River Index = Sacramento River Runoff + San Joaquin River Runoff. This Index is used from December through May to set flow objectives as implemented in SWRCB Decision 1641.

The current WY indices based on forecast runoff are posted at:

http://cdec.water.ca.gov/water_supply.html

And published in DWR Bulletin 120:

http://cdec.water.ca.gov/snow/bulletin120

These indices have been used operationally since 1995, and are defined in SWRCB

Decision 1641: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/decision_1641/

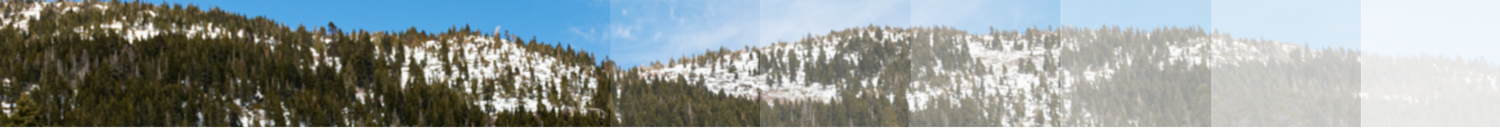
This report is updated each fall once the data is available.

SEA LEVEL TRENDS

https://tidesandcurrents.noaa.gov/sltrends/

The Center for Operational Oceanographic Products and Services has been measuring sea level for over 150 years, with tide stations of the National Water Level Observation Network operating on all U.S. coasts. Changes in Mean Sea Level (MSL), either a sea level rise or sea level fall, have been computed at 142 long-term water level stations using a minimum span of 30 years of observations at each location. These measurements have been averaged by month to remove the effect of higher frequency phenomena in order to compute an accurate linear sea level trend. The trend analysis has also been extended to 240 global tide stations using data from the Permanent Service for Mean Sea Level (PSMSL). This work is funded in partnership with the NOAA OAR Climate Observation Division.

The mean sea level (MSL) trends measured by tide gauges that are presented on this web site are local relative MSL trends as opposed to the global sea level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is some long-term vertical land motion occurring at that location, the relative MSL trend measured there is a combination of the global sea level rate and the local vertical land motion. The global sea level trend has been recorded by satellite altimeters since 1992 and the latest calculation of the trend can be obtained from NOAA's Laboratory for Satellite Altimetry, along with maps of the regional variation in the trend. The University of Colorado's Sea Level Research Group compares global sea level rates calculated by different research organizations and provides detailed explanations about the issues involved.



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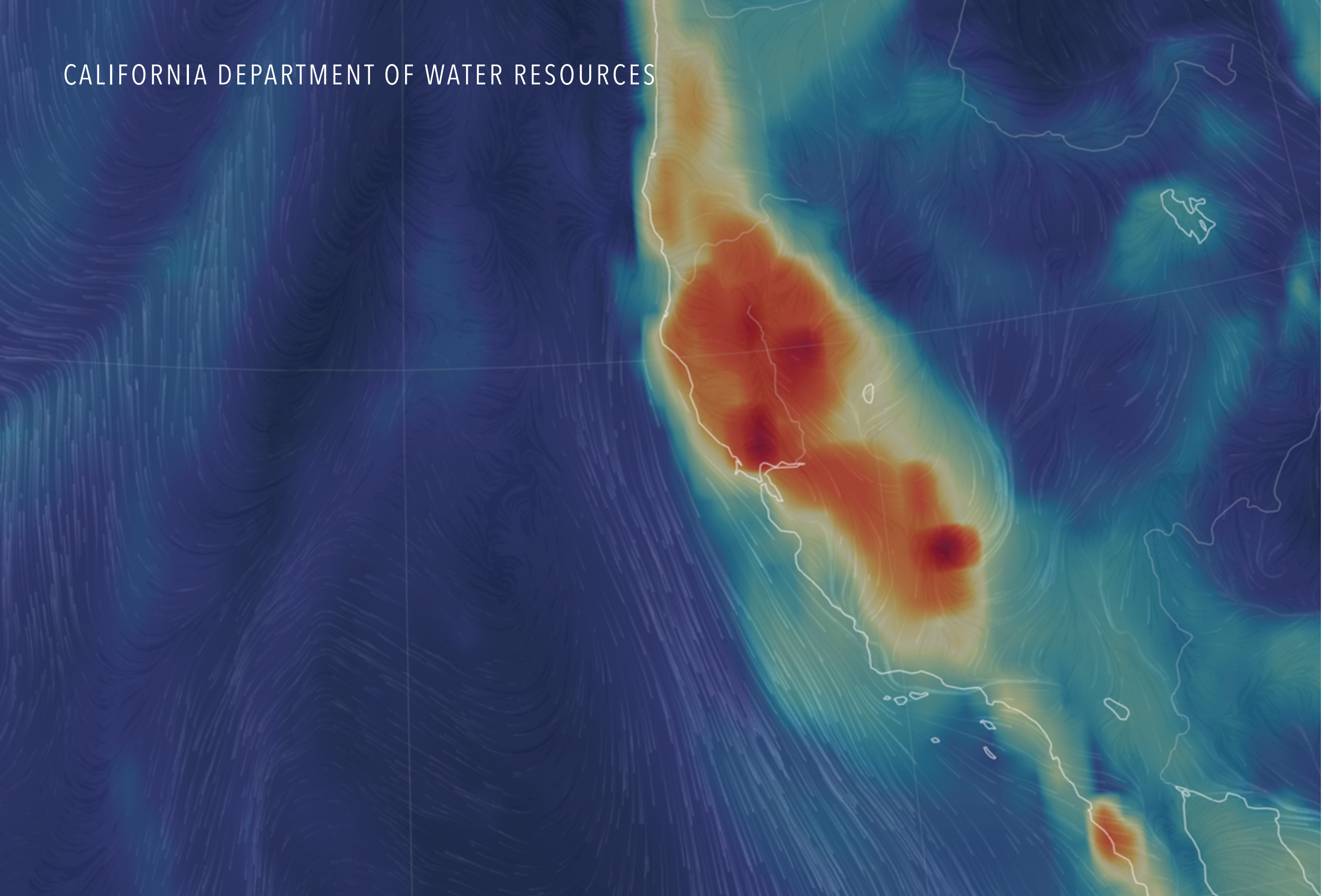
Ava Cooper, a Field Researcher from the Center for Western Weather and Water Extremes, installs a new surface meteorology station on Catalina Island off the coast of Southern California. Photo by Carly Ellis, Center for Western Weather and Water Extremes, July 20, 2020.

CALIFORNIA DEPARTMENT OF WATER RESOURCES



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Released August 2021

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