



Climate Monitoring in the Mediterranean Coast Network 2020

Cabrillo National Monument

Natural Resource Report NPS/MEDN/NRR—2022/2459



ON THE COVER

Knobby Star (*Pisaster giganteus*) at Cabrillo National Monument
NPS photo

Climate Monitoring in the Mediterranean Coast Network 2020

Cabrillo National Monument

Natural Resource Report NPS/MEDN/NRR—2022/2459

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September 2022

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Tercek, M. T. 2022. Climate monitoring in the Mediterranean Coast Network 2020: Cabrillo National Monument. Natural Resource Report NPS/MEDN/NRR—2022/2459. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/2294406>

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Abstract

This report details the climate (temperature, precipitation, drought, and streamflow) of Cabrillo National Monument during 2020. Gridded GIS maps are used to present broad-brush conditions across the region for each month. This regional presentation is compared to detailed data from weather stations in the Global Historical Climatology Network (GHCN), automated meteorological stations, and data from USGS stream gages. Prior to analysis, a set of data quality control checks were performed by the author in accordance with an established National Park Service protocol. Readers can download the data used in this report and make custom climate graphs and tables of their own by visiting www.ClimateAnalyzer.org.

Acknowledgments

Funding for this report was provided by National Park Service Mediterranean Coast Network Inventory and Monitoring Program

Glossary

30-year average or “normal”: Official 30-year averages for each weather station are issued every 10 years by NOAA. Prior to 2011, the official reference period was 1971–2000.

B-91 Forms: Paper data sheets that are used to record climate data at weather stations

GHCN: Global Historical Climatology Network

NOAA: National Oceanic and Atmospheric Administration

PRISM: Parameter-elevation Regression on Independent Slopes Model. See <https://prism.oregonstate.edu/>

Tmax / Tmin: Mean daily maximum / minimum temperatures

US Drought Monitor: A broad brush assessment of drought conditions. See <https://droughtmonitor.unl.edu/>

Introduction

This report details the climate (temperature, precipitation, drought, streamflow) of Cabrillo National Monument during 2020. Climatic events are presented both from a local perspective, with data from individual weather stations, and from a regional perspective, with maps that depict broad-scale conditions across southern California during each month of the year. The climatic conditions of 2020 are also compared to a historical context, based on a 30-year average or “normal” period calculated over the years 1981–2010, and to historical data from weather stations that go back to 1939.

Typically, when a weather report states that a particular month was “warmer than average” or “cooler than normal,” the comparison is to a set of averages calculated over an agreed upon time period. These averages, which are known as “climatological normals,” are updated every 10 years by the National Oceanic and Atmospheric Administration (NOAA). From 1991–2000, meteorological measurements were compared to 1961–1990 averages; from 2001–2010 the reference period was 1971–2000; and starting in calendar year 2011, most weather data has been compared to 1981–2010 averages. NOAA further defines climatological normals as follows:

“In the strictest sense, a “normal” of a particular variable (e.g., temperature) is defined as the 30-year average. For example, the minimum temperature normal in January for a station in Chicago, Illinois, would be computed by taking the average of the 30 January values of monthly-averaged minimum temperatures from 1981 to 2010. Each of the 30 monthly values was in turn derived from averaging the daily observations of minimum temperature for the station. In practice, however, much more goes into NCDC's normals product than simple 30-year averages. Procedures are put in place to deal with missing and suspect data values. In addition, normals include quantities other than averages such as degree days, probabilities, standard deviations, etc. Normals are a large suite of data products that provide users with many tools to understand typical climate conditions for thousands of locations across the United States.”

Those interested in additional climate-related information for Cabrillo National Monument and the surrounding areas should seek:

The ClimateAnalyzer: www.ClimateAnalyzer.org. This web site allows you to create custom graphs and tables from both “official,” unedited data and from the corrected datasets used in this report. You can also download all the data from the weather stations in the area as spreadsheets.

Western Regional Climate Center (<https://wrcc.dri.edu/>)

Drought Monitor (<https://droughtmonitor.unl.edu/>)

National Oceanic Atmospheric Administration (NOAA) National Weather Service
(<https://www.cpc.ncep.noaa.gov/>)

U.S. Geological Survey (USGS) Water National Information System
(<https://waterdata.usgs.gov/nwis>)

Methods

Selection of Datasets

In order to place Cabrillo National Monument within a regional context, gridded-map-based estimates of precipitation and temperature were used to provide a broad overview of climatic conditions in the area. These estimates were generated with a statistical modeling technique that interpolates precipitation and temperature values between actual climate stations while also accounting for the effects of aspect and elevation. Known as the Parameter-elevation Regression on Independent Slopes Model (PRISM; <https://www.prism.oregonstate.edu/>), this approach has a long history of use in the western United States, and it has been shown to provide robust products in a wide variety of studies (Daly et al. 2008). In this report, PRISM data from calendar year 2020 are compared to 1981–2010 PRISM averages for each month by calculating the percent of normal precipitation (2020 precipitation divided by 1981–2010 precipitation, multiplied by 100) or the temperature departure (2020 temperature minus 1981–2010 average temperature) for each grid cell on the map of southern California.

Records from individual precipitation and temperature observing stations were included as a way to highlight intra-regional variability. The process of selecting specific stations included in this report is described in the Rocky Mountain Climate Protocol (Rocky Mountain Climate Working Group 2010). Generally, the selection criteria were:

- 1) Stations provide good spatial coverage within and near the parks / monuments of interest. In the case of Cabrillo National Monument, National Weather Service (NWS) stations were chosen from nearby locations. Data from these stations are available through the Global Historical Climatology Network (GHCN). GHCN stations have several advantages, including their relatively long period of record (Appendix 1), and the availability of established 30-year averages that can be used to quantify the difference between the current year and “normal” conditions.
- 2) Stations provide a sufficient length of record to provide historical context for current observations. For this report, GHCN stations were not considered if they had not been in operation during the period 1981–2010 at a minimum.
- 3) Instrumentation at individual stations is relatively consistent over the life of the record.
- 4) Instrumentation and siting standards used in selected networks are suitable for providing consistent, continuous, and long-duration records of climate and streamflow.

In addition to the GHCN stations, this report includes data from automated meteorological (MET) stations located at Pt. Loma, within Cabrillo National Monument. These stations have not been in operation long enough to have climatological normals / averages, and they sometimes suffer from equipment malfunctions that produce physically impossible values or missing data. Despite these flaws, however, these stations have the advantage of being located within Cabrillo National Monument itself, unlike more established stations in the region; and carefully screened data from these Met stations can accurately characterize current year temperature and precipitation.

As a way of presenting the integrated effects of temperature and precipitation, maps from the US Drought Monitor (<https://droughtmonitor.unl.edu/>) were used to depict broad-brush conditions across the region. Even though the watercourses in the region are human-controlled and therefore not directly tied to rainfall, USGS stream gage data (<https://waterdata.usgs.gov/nwis>) were used to contrast streamflow during the 2020 water year, which ran from October 2019 to September 2020, with average conditions during the period of record for the gage of interest (in this case 1982–2010).

The locations of weather stations cited in this report are shown in Figure 1. Metadata for these stations can be accessed from the internet links provided in Appendix 1.

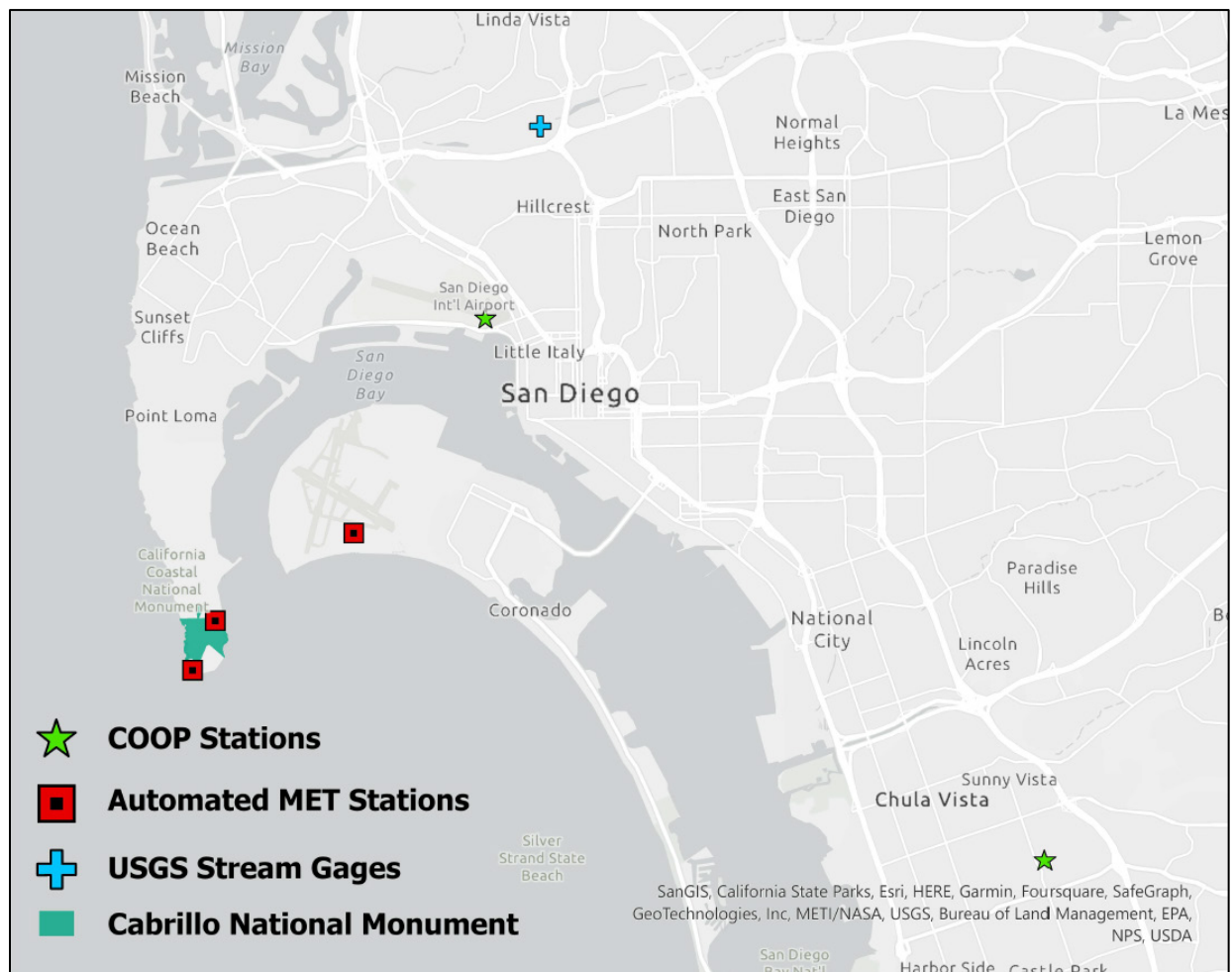


Figure 1. Map showing key climate stations and stream gauges in and near Cabrillo National Monument. Cooperative Observer (COOP) stations are accessed through the Global Historical Climatology Network (see text).

Quality Control of Global Historical Climatology Network Data

All of the GHCN stations used in this report are operated by the National Weather Service (NWS). These stations are sometimes referred to as “Cooperative Observer” (COOP) stations because in most

cases their measurements are manually recorded by human observers and submitted to NWS for aggregation and error checking.

Data from these weather stations undergo quality control and error-checking by NWS, and as part of this process many of the observations in the data files are assigned “flags” (letter or number codes) that indicate potential problems or other factors that should be taken into consideration when interpreting the data. Consequently, the author of this report has created software tools that assist in the interpretation of the data flags and diagnostic plotting of the data. Following guidelines from Kittel (2008), Kittel et al. (2009), and Rocky Mountain Climate Working Group (2010), the Qa/Qc employed by these software tools involved graphing and visual inspection of each time series, evaluation of the data quality flags that accompany each observation, comparison with historical observations and observations from surrounding sites, and logical consistency tests (e.g., confirming that minimum daily temperatures were lower than the daily maximum temperatures). Point observations provided by the GHCN stations were also compared to corresponding estimates from the PRISM datasets. If more than 3 days of precipitation data were missing for a particular month, a monthly total was not calculated, and the entire month was instead considered missing. Similarly, if more than 5 days of mean daily maximum temperature (Tmax) or mean daily minimum temperature (Tmin) were missing, monthly average temperatures were not calculated. The data handling was conservative, i.e., no data points were changed unless it was very clear that an erroneous value, for example a precipitation measurement with a missing decimal point that could be verified on the original station records, was found. Readers can download the data used in this report and make custom climate graphs and tables of their own by visiting www.ClimateAnalyzer.org.

Quality Control of Met Station Data

Because Met data are collected hourly, daily Tmax, Tmin, and precipitation values must be derived from the automated data stream. Furthermore, precipitation is recorded as a running total that must be translated into daily measurements. If any particular day in a record was missing more than six hours of measurements, the entire day was considered missing. In addition, if the temperature during any day varied by less than 2 degrees Fahrenheit, data for the entire day was considered invalid due to instrumental error and replaced with missing values. Once daily statistics had been calculated, diagnostic plots were used to screen for physically impossible measurements (e.g., 500 degrees Fahrenheit), which were ascribed to instrumental error and considered missing; and the missing data criteria just described for GHCN stations were used to calculate monthly statistics.

Results

Temperature, Precipitation, and Drought Status During Calendar Year 2020

The patterns described in this section are often stated as broad generalizations. In most cases there was significant variability across the region and exceptions to the patterns described here were common. In order to appreciate this variability, it is important to examine the PRISM maps and compare them to the weather station data presented in the figures and tables that follow.

Broader Picture – Drought Status

During 2019, the region briefly emerged from a multi-year drought, but 2020 saw a return to drought conditions, reaching D0 “Abnormally Dry” status by the end of the year (Figure 2).

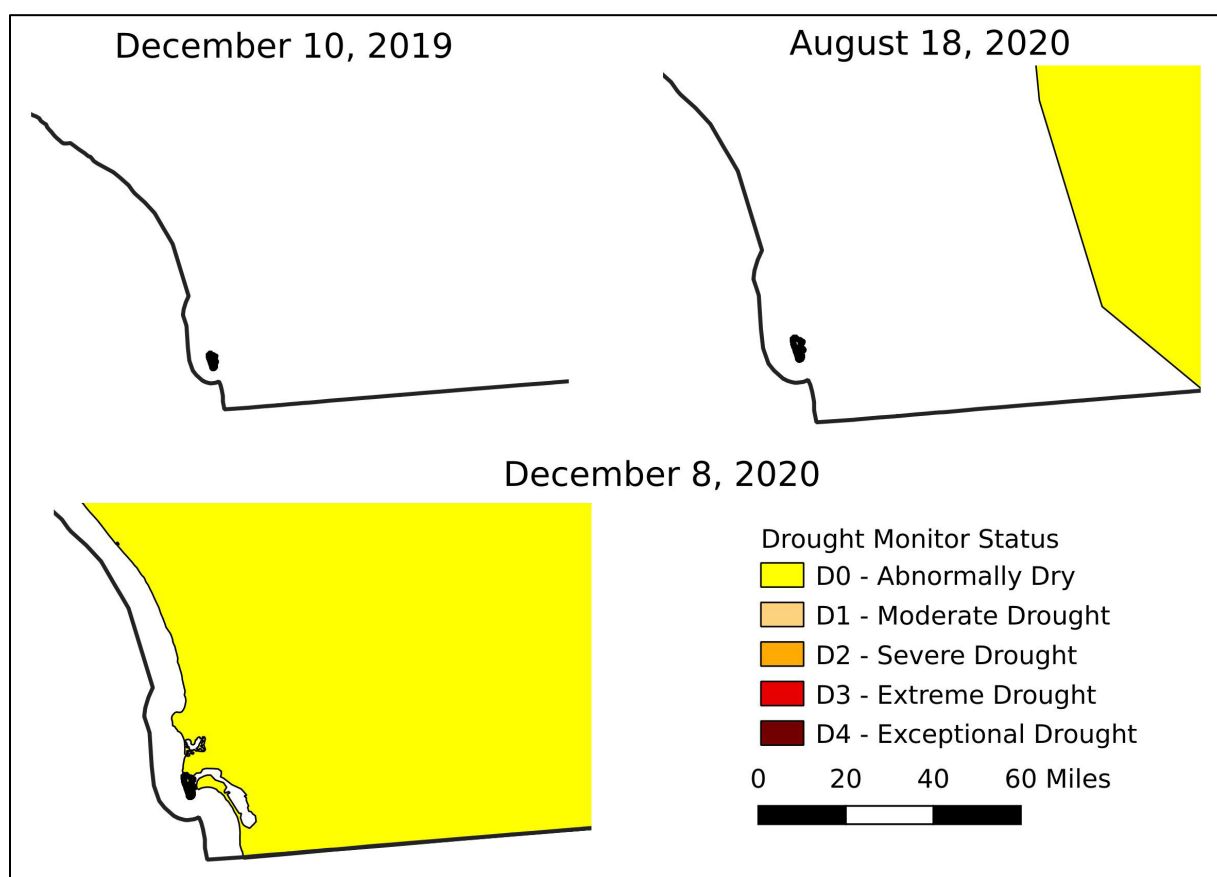


Figure 2. U.S. Drought Monitor maps for Cabrillo National Monument during 2020. Drought codes are D0–“Abnormally Dry,” D1–“Moderate Drought,” D2–“Severe Drought,” D3–“Extreme Drought,” D4–“Exceptional Drought.” Cabrillo NM is located on the coast, on the lower-left corner of each map (black polygon). The long, black line is the California state boundary. For more information visit: <https://droughtmonitor.unl.edu/>.

El Nino – La Nina Status

The El Nino–Southern Oscillation (ENSO) is an oscillation of the ocean-atmosphere climate system centered over the tropical Pacific Ocean that follows a rough cycle of approximately 2–7 years.

When ENSO is in its “El Nino phase,” sea surface temperatures in the central and eastern tropical Pacific are warmer than average, and this generally produces warmer, drier conditions in the northern continental United States and cooler, wetter conditions in the southern United States, particularly the southwest. In contrast, the opposite conditions prevail when ENSO is in its “La Nina phase.” More information on ENSO can be found on the NOAA web site located here:

https://www.pmel.noaa.gov/el_nino/what-is-el-nino.

Calendar year 2020 began with neutral conditions (near average sea surface temperatures) and during the course of the year transitioned to La Nina (colder than average sea surface temperatures).

For long-term El Nino patterns, consult NOAA here:

https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php.

Weather Station Temperature and Precipitation Data

Generally speaking, there are two components to drought: high temperatures, which increase evapotranspiration, and precipitation, or the lack thereof. Calendar year 2020 had below-average precipitation overall and annual temperatures that were slightly above average in San Diego and near-average in Chula Vista. As shown in Figure 3, the 2020 annual average daytime high at San Diego Lindbergh Field (73.2 degrees) was 3.5 degrees above the 1981–2010 average. Average daytime lows were 1.3 degrees above average. Total annual precipitation was 76% average in San Diego and 97% average in Chula Vista (Figure 3, 4; Tables 1, 2). In San Diego, March and April had above average precipitation (119–645% percent normal precipitation), while the remaining non-summer months had generally below-average precipitation. In San Diego, May, September and October were quite warm (average daily highs 5.5, 6 and 7 degrees above normal, respectively; Figure 3, 4; Tables 1, 2). Precipitation during the summer months (May–September) is so slight that calculations of percent average are misleading. An increase of only a few hundredths of an inch can mean the difference between an above vs. below average month during the summer.

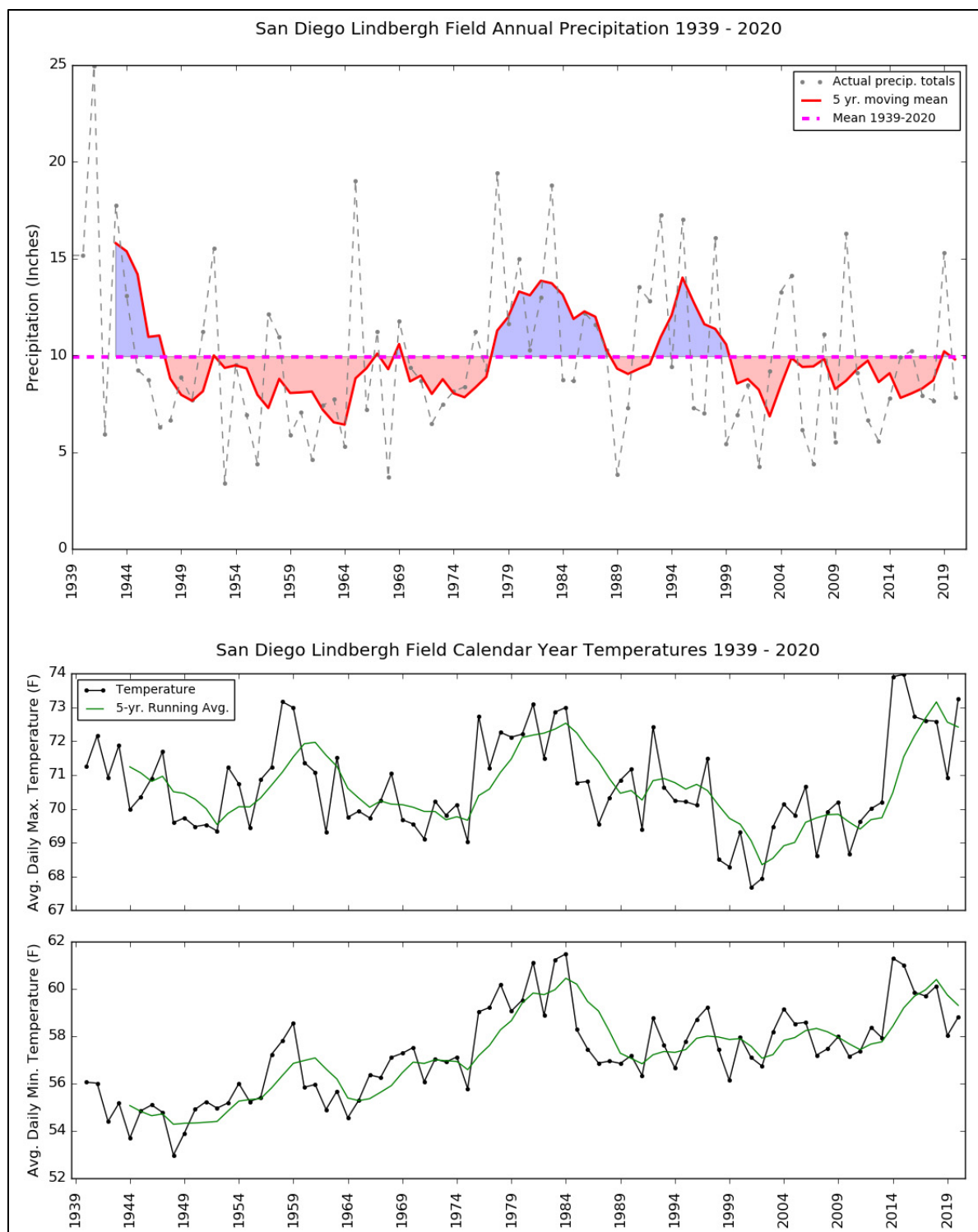


Figure 3. Climate conditions since 1939 at San Diego Lindbergh Field. Top: Total annual precipitation 1939–2020 (dots). Red-shaded areas = years when the running mean is below the 1939–2020 average (dashed red line). Blue-shaded areas = running mean above the 1939–2020 average. Bottom: Annual averages for daily maximum temperature and daily minimum temperature 1939–2020. Green line = 5 year running average of temperatures. Running averages include the current year and the previous 4 years.

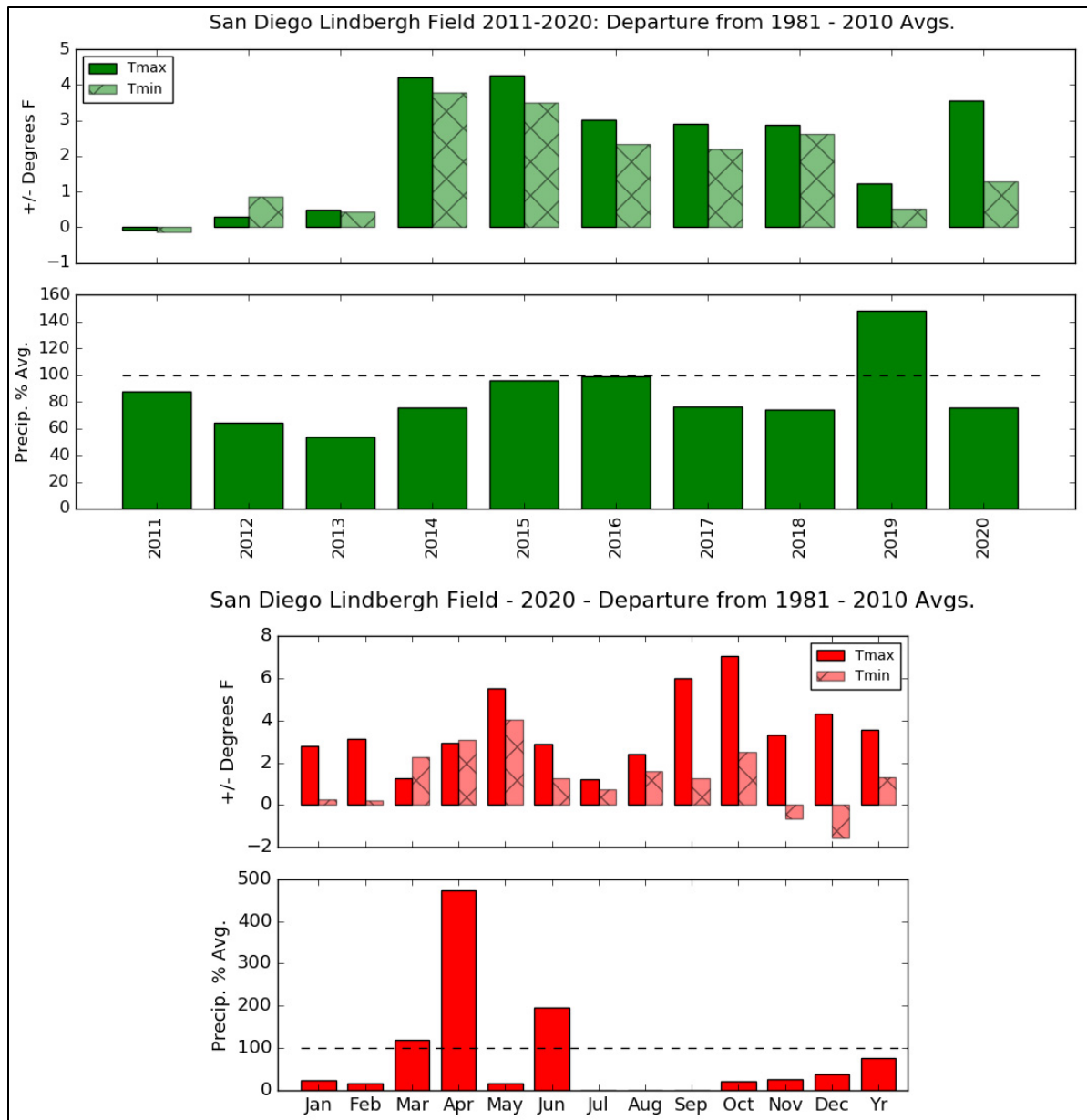


Figure 4. Departure from average climate conditions at San Diego Lindbergh Field. Top: Departure of 2011–2020 annual precipitation, Tmax, and Tmin from 1981–2010 averages. Bottom: Monthly departures of precipitation, Tmax, and Tmin from 1981–2010 averages during 2020. May–August often have less than 0.2 inches average precipitation so large percent departures, such as shown for May, are a small absolute difference.

Table 1. Total monthly precipitation in inches during 2020 and percent of 1981–2010 averages at key weather stations in and near Cabrillo National Monument. Precipitation is so low during summer months that departure calculations can be misleading. Summer average precipitation totals are in the range 0.02–0.05 inches, making even slight precipitation show a large percent increase.

Month	San Diego 2020 Precip (in)	San Diego (% Average)	Chula Vista 2020 Precip (in)	Chula Vista (% Average)
January	0.48	24%	0.38	20%
February	0.38	17%	0.27	12%
March	2.16	119%	2.78	165%
April	3.68	472%	4.45	645%
May	0.02	16%	0.08	87%
June	0.14	197%	0.22	315%
July	0.00	0%	0.00	0%
August	0.00	0%	0.00	0%
September	0.00	0%	0.00	0%
October	0.12	21%	0.04	7%
November	0.26	26%	0.47	51%
December	0.60	39%	0.80	56%
Year	7.84	76%	9.50	97%

Table 2. Average daily maximum temperatures (Tmax), average daily minimum temperatures (Tmin) during 2020 and departure from 1981–2010 averages expressed as +/- degrees Fahrenheit.

Metric	Month	San Diego 2018 (°F)	San Diego Departure (+/-°F)	Chula Vista 2018 (°F)	Chula Vista Departure (+/-°F)
Tmax	January	67.9	2.8	66.1	-2.4
	February	68.1	3.1	67.0	-1.1
	March	66.9	1.3	65.0	-3.1
	April	70.5	3.0	68.9	-0.5
	May	74.0	5.5	73.0	2.9
	June	73.7	2.9	73.2	1.2
	July	75.8	1.2	75.5	-0.4
	August	78.8	2.4	78.1	0.3
	September	81.9	6.0	82.3	4.3
	October	79.8	7.0	78.3	2.6
	November	72.3	3.3	71.0	-0.8
	December	69.0	4.3	67.6	0.3
	Year	73.2	3.5	72.2	0.3

Table 2 (continued). Average daily maximum temperatures (Tmax), average daily minimum temperatures (Tmin) during 2020 and departure from 1981–2010 averages expressed as +/- degrees Fahrenheit.

Metric	Month	San Diego 2018 (°F)	San Diego Departure (+/-°F)	Chula Vista 2018 (°F)	Chula Vista Departure (+/-°F)
Tmin	January	49.3	0.3	46.2	0.4
	February	50.9	0.2	47.6	0.1
	March	55.5	2.3	51.6	1.3
	April	59.0	3.1	55.4	2.4
	May	63.5	4.1	60.1	2.6
	June	63.3	1.3	61.7	1.1
	July	66.2	0.8	64.9	0.4
	August	68.3	1.6	67.8	2.2
	September	66.5	1.3	64.1	0.9
	October	63.1	2.5	60.6	2.7
	November	53.0	-0.6	49.9	-0.3
	December	46.8	-1.6	45.9	0.6
	Year	58.8	1.3	56.4	1.2

PRISM maps depicting spatial patterns in departure from 1981–2010 averages

The regional precipitation and temperature patterns seen in the PRISM maps (Figures 5–7) are similar to the patterns seen in the weather station data. March, April, and June had generally above-average precipitation throughout the region while the remaining non-summer months were generally below average. Average daily maximum temperatures were well above-average during September and October, while the other months were near average. Average daily minimum temperatures in the region were near or above average during most of the months in 2020, with particularly warm temperatures during April, May, September and October.

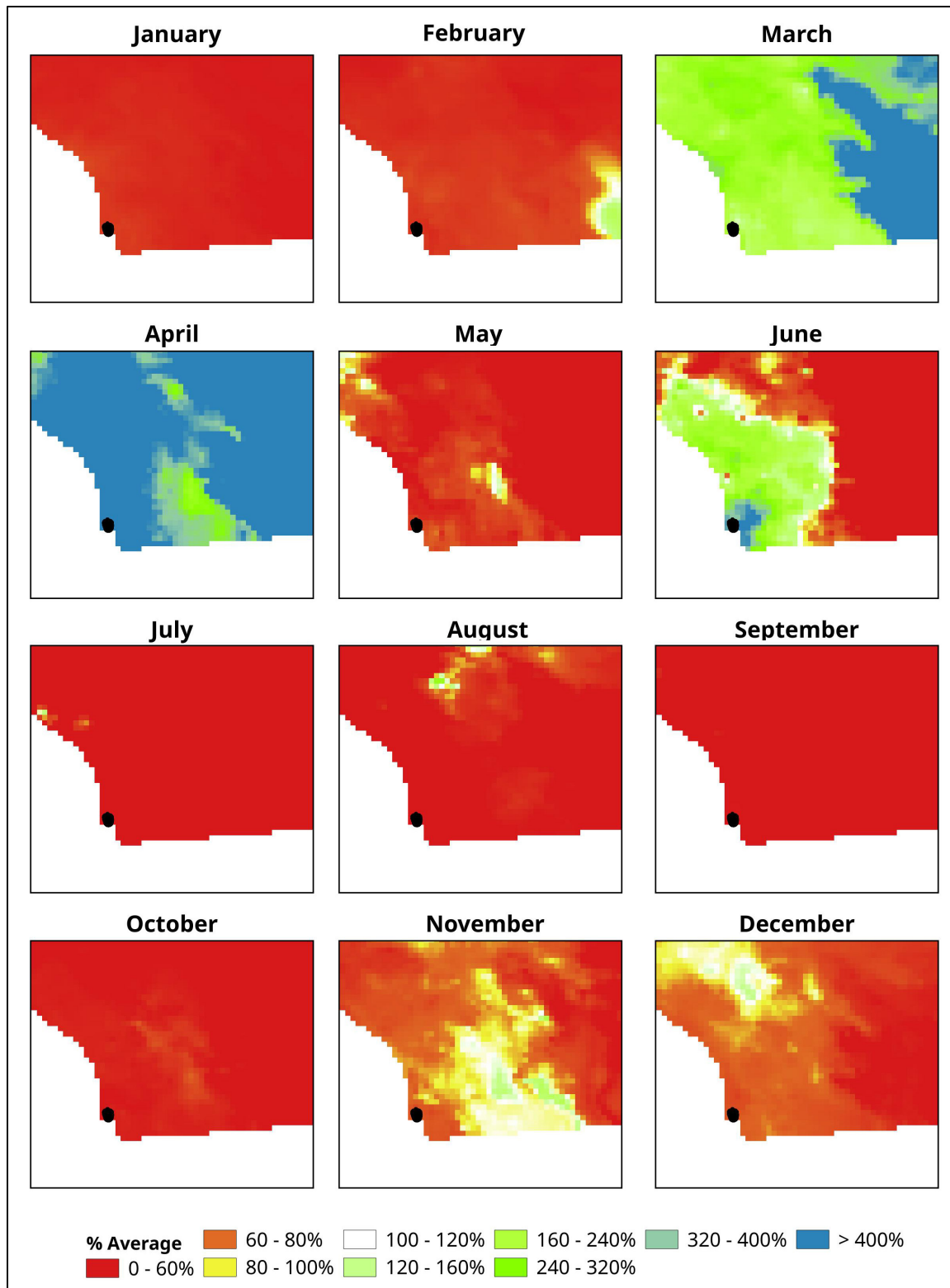


Figure 5. Maps showing percent of average precipitation relative to 1981–2010 for each month during 2020. Estimates are from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). White areas = Pacific Ocean. Cabrillo is located in the bottom left corner of each map. For more information, see <https://www.prism.oregonstate.edu/>.

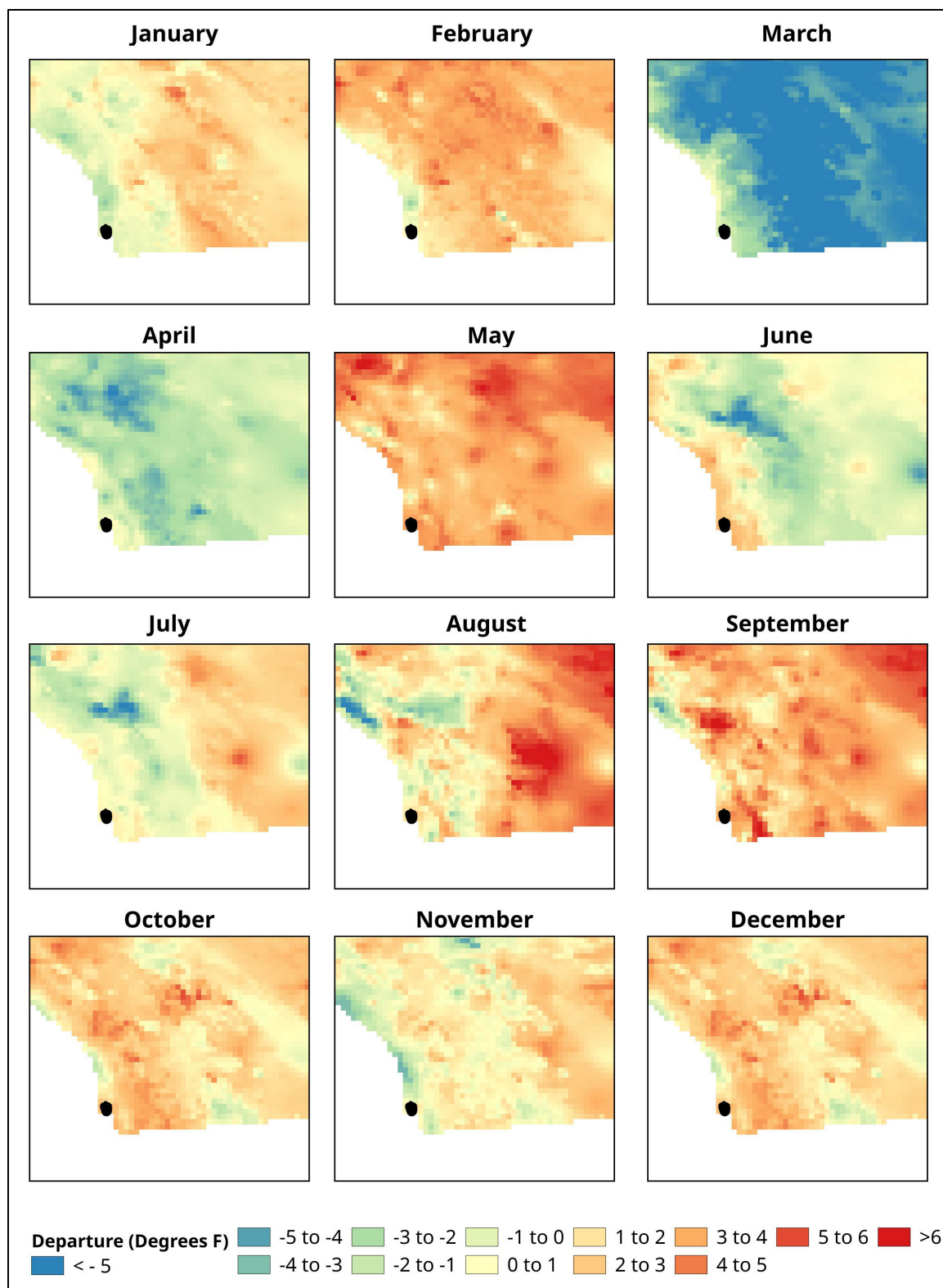


Figure 6. Maps showing departures from 1981–2010 average daily maximum temperatures (Tmax) in degrees Fahrenheit during 2020. Estimates are from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). White areas = Pacific Ocean. Cabrillo NM is on the coast, bottom left. For more information, see <https://www.prism.oregonstate.edu/>.

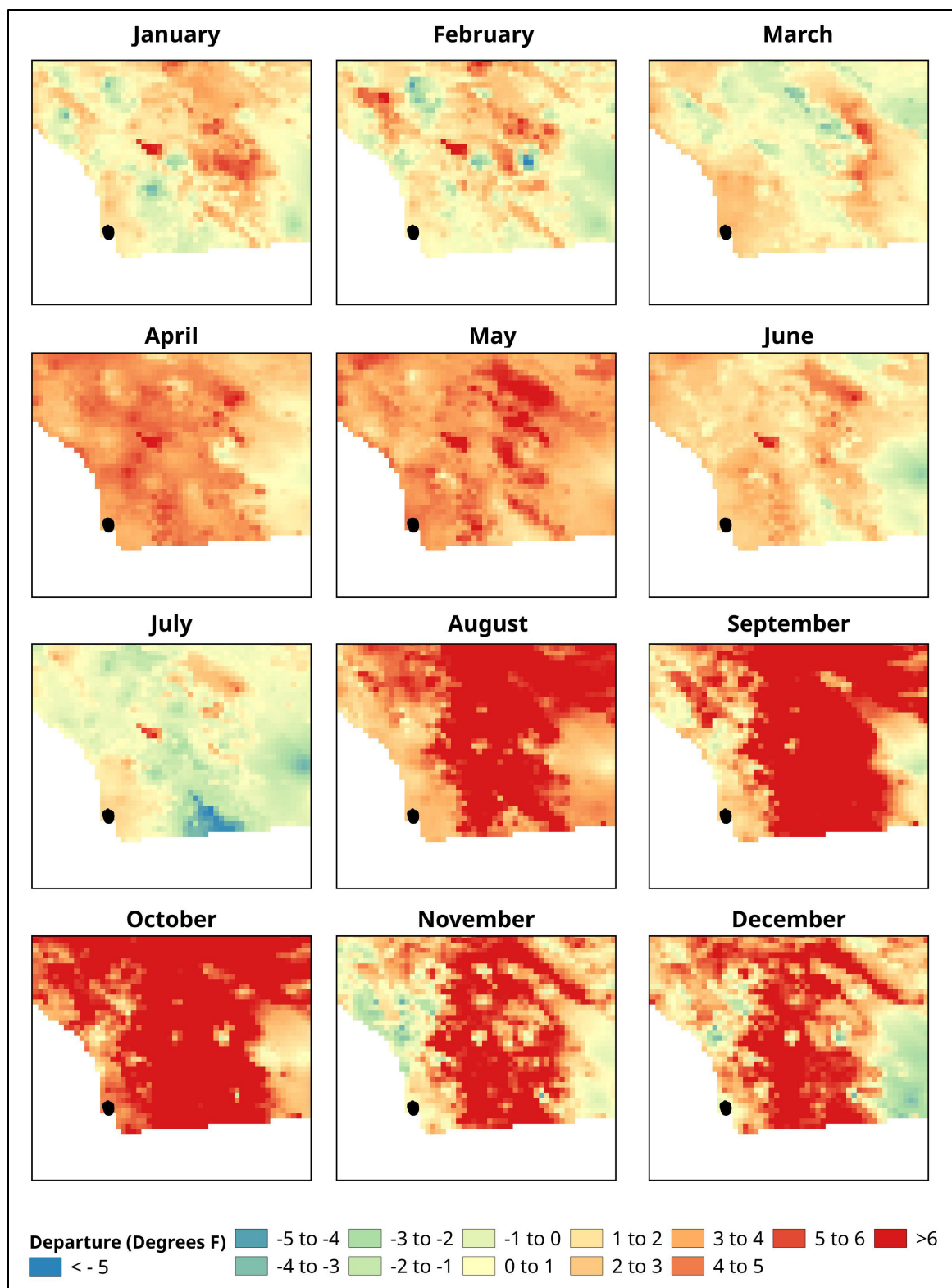


Figure 7. Maps showing departures from 1981–2010 average daily minimum temperatures (Tmin) in degrees Fahrenheit during 2020. Estimates are from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). White areas = Pacific Ocean. Cabrillo NM is on the coast, bottom left. For more information, see <https://www.prism.oregonstate.edu/>.

Streamflow

Since the rivers near Cabrillo National Monument are all heavily influenced by human activity, including artificial dams, streamflow is as much a result of management priorities as annual climatic events. Nevertheless, it is worth noting that streamflow in San Diego was near normal for the first half of 2020 and below average later in the year (Figure 8).

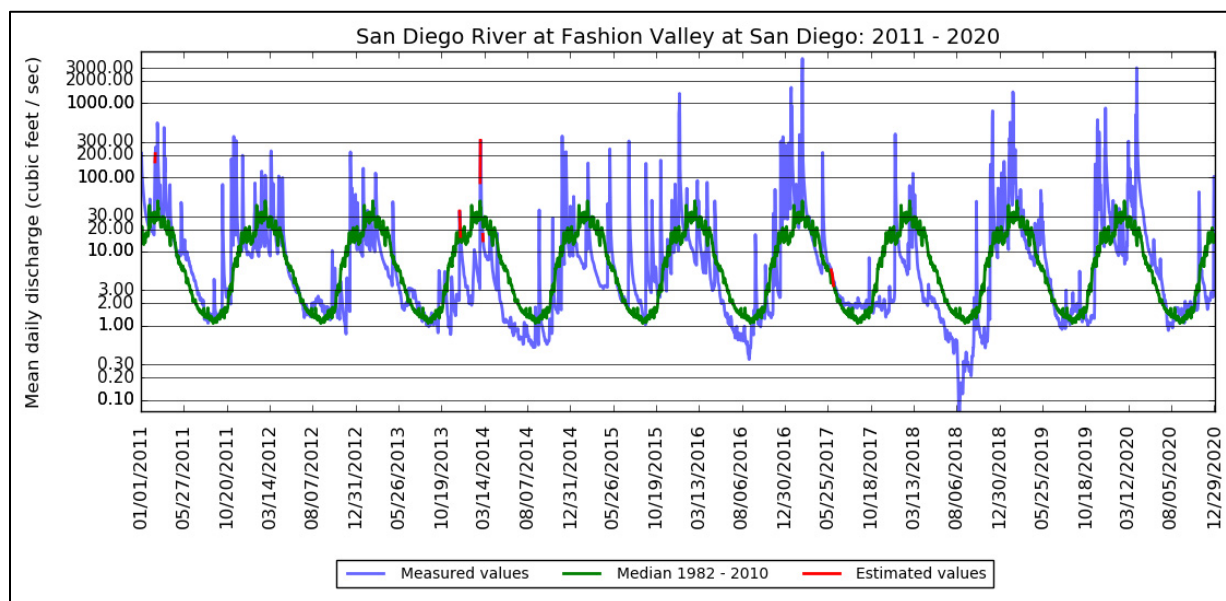


Figure 8. Stream discharge on the San Diego River near Cabrillo National Monument during 2011–2020.

Accumulated Growing Degree Days, an Index of Growing Season Length

Accumulated Growing Degree Days (AGDD) are often used as an index of growing season length. They are calculated as the sum of the differences between the average temperature for each day of the year and a base temperature. This base temperature is often chosen as the threshold below which plants are thought to be metabolically inactive. In the case of AGDD40, the base temperature is 40 degrees Fahrenheit. Consequently, 40 is subtracted from the mean temperature for each day, and these differences are added up for the entire year, giving a single number. Similarly, AGDD50 is calculated with a base temperature of 50 (F).

When viewed from the perspective of growing season length, calendar-year 2020 was near-to-above average (Table 3). At San Diego Lindbergh Field, AGDD 40 was 112% the 1981–2010 average and AGDD 50 was 121%. At Chula Vista, AGDD40 was 116% and AGDD50 was 130% the average.

Table 3. Accumulated Growing Degree Days (AGDD) and days above or below critical temperature thresholds during 2020.

Station Name	Time Period	AGDD40	AGDD50	# days ≥ 90 °F	# days ≤ 32 °F
San Diego Lindbergh Field	2020 Value	9522	5862	6	0
	1981–2010 Average	8478	4832	2.5	0
Chula Vista	2020 Value	8884	5227	9	0
	1981–2010 Average	7679	4059	1.9	0.9

Conclusions

- During 2019, the region briefly emerged from a multi-year drought, but 2020, saw a return to drought conditions, reaching D0 “Abnormally Dry” status by the end of the year, according to the US Drought Monitor.
- Calendar year 2020 began with neutral conditions (near average sea surface temperatures) and during the course of the year transitioned to La Nina (colder than average sea surface temperatures).
- Calendar year 2020 had above near-to-below-average precipitation overall and annual temperatures that were slightly above in San Diego and near average in Chula Vista. The 2020 annual average daytime high at San Diego Lindbergh Field (73.2 degrees) was 3.5 degrees above the 1981–2010 average. Average daytime lows were 1.3 degrees above average. Total annual precipitation was 76% average in San Diego and 97% average in Chula Vista.
- In San Diego, March and April had above average precipitation (119–645% percent normal precipitation), while the remaining non-summer months had generally below-average precipitation. In San Diego, May, September and October were quite warm (average daily highs 5.5, 6 and 7 degrees above normal, respectively).

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Appendix 1

Table A-1. Climate stations used in this report. Detailed histories, period of record, and 30-year averages can be accessed from the links provided.

Name	Station type ¹	Station ID	Metadata
Pt. Loma	MET	SDL13	https://mesowest.utah.edu/cgi-bin/droman/meso_base.cgi?stn=SDL13&unit=0&timetype=LOCAL
NPS Cabrillo	MET	HP017	https://mesowest.utah.edu/cgi-bin/droman/meso_base.cgi?stn=HP017&unit=0&timetype=LOCAL
Chula Vista	GHCN	41758	https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca1758
San Diego WSO Airport AKA Lindbergh Field	GHCN	47740	https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7740
San Diego Naval Air Station	MET	KNZY	http://www.climateanalyzer.org/raws/KNZY/
San Diego R at Fashion Valley	Stream Gage	11023000	https://waterdata.usgs.gov/nwis/dvstat/?format=sites_selection_links&search_site_no=11023000&agency_cd=USGS&referred_module=sw

¹Station Type: GHCN = Global Historical Climatology Network; MET = automated meteorological stations.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 342/186272, September 2022

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