



Cabrillo National Monument Climate Monitoring

2010 Annual Report

Natural Resource Report NPS/MEDN/NRR—2015/1058



ON THE COVER

Lighthouse at Cabrillo National Monument
Photograph by the National Park Service

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October 2015

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. 2015. Cabrillo National Monument climate monitoring: 2010 annual report. Natural Resource Report NPS/MEDN/NRR—2015/1058. National Park Service, Fort Collins, Colorado.

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Executive Summary

This report details the climate (temperature, precipitation, drought, streamflow, and wind conditions) of Cabrillo National Monument during 2010. Gridded GIS maps are used to present broad-brush conditions across the region for each month. This regional presentation is compared to detailed data in the National Weather Service Cooperative Observer (COOP) Network, and data from USGS stream gages. Prior to analysis, a set of data quality control checks were performed by the author in accordance with established National Park Service protocols (Rocky Mountain Climate Working Group 2010). Cabrillo NM began the year in a state of drought classified as “Moderate Drought (D1),” but this was mitigated by the beginning of March. Total annual precipitation was above the 1971 – 2000 averages across the region. Average daily maximum temperatures (Tmax) for the year were generally near or below the 1971 – 2000 averages. Average daily minimum temperatures (Tmin) for the year were generally near or slightly above average (Table 2). April and July had notably below average temperatures. Tmax in July was 6.4 degrees Fahrenheit below the 1971 – 2000 average at San Diego Lindbergh Field. In October and December, Tmin was generally above average (Figure 5) but Tmax was generally below average (Figure 4). The growing season, as measured by Accumulated Growing Degree Days (AGDD) was of near average length, based on averages calculated for the period of record at Chula Vista COOP station, near Cabrillo NM. There was significant spatial and month to month variability in the data that provided exceptions to these generalizations, so an examination of the regional maps (Figures 3-5) are key to understanding the climatic patterns for 2010. Section 3.1 contains a set of narratives that provide details for each season of the year. Bullet points within section 3.1 highlight key data for each month of the year.

Introduction

Background

This report details the climate (temperature, precipitation, drought, and streamflow) of Cabrillo National Monument (Cabrillo NM) during 2010. 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 2010 are also compared to a historical context, based primarily on a standard 30-year average or “normal” period (currently 1971–2000).

The content is divided into sections that discuss precipitation, temperature and drought; and streamflow. The section on temperature, precipitation and drought is further sub-divided into seasonal narratives that highlight key data and events. 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. Those interested in additional climate-related information for Cabrillo NM and the surrounding areas should seek:

- Western Regional Climate Center (<http://www.wrcc.dri.edu/>)
- Drought Monitor (<http://drought.unl.edu/dm/monitor.html>)
- NOAA (National Oceanic Atmospheric Administration) National Weather Service (<http://www.cpc.ncep.noaa.gov/>)
- USGS (U.S. Geological Survey) Water National Information System (<http://waterdata.usgs.gov/nwis>)

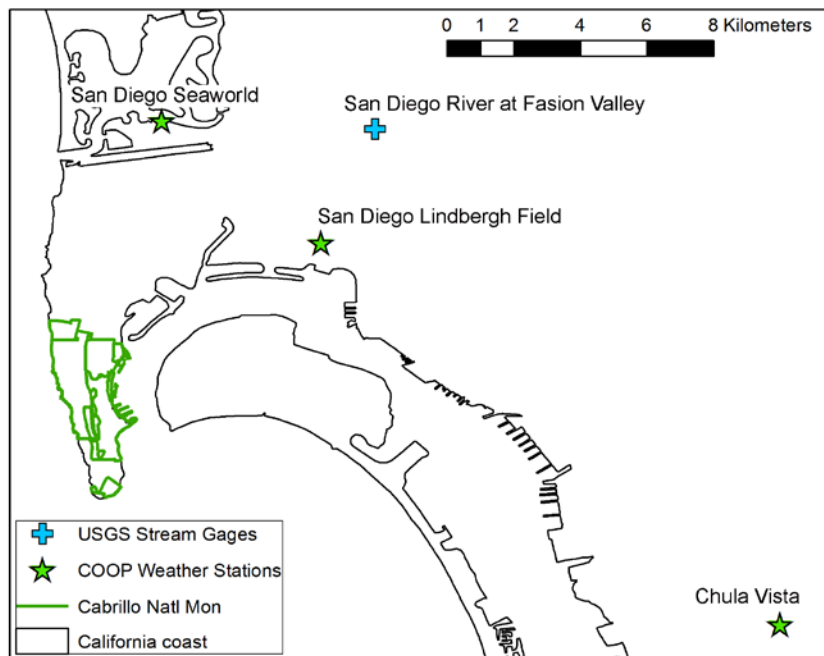


Figure 1. Map showing key climate stations and stream gauges near Cabrillo National Monument.

Approach and Methods

Selection of Datasets

In order to place Cabrillo NM within a regional context, grid-based estimates of precipitation and temperature were used to provide a broad overview of climatic conditions in the area. These estimates were generated via 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; <http://www.prism.oregonstate.edu/>), this approach has a long history of use in the western United States, and it has been shown to provide highly robust products in a wide variety of studies (Daly et al. 2008). 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 of interest. In the case of Cabrillo NM stations from the National Weather Service Cooperative Observer (COOP) network were chosen from nearby locations. COOP 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, COOP stations were not considered if they had not been in operation during the period 1971 – 2000 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.

As a way of presenting the integrated effects of temperature and precipitation, maps from the US Drought Monitor (<http://drought.unl.edu/dm/monitor.html>) were used to depict broad-brush conditions across the region. Even though the watercourses in the region are human-controlled and not directly tied to rainfall, USGS stream gage data (<http://waterdata.usgs.gov/nwis>) were used to contrast streamflow during the 2010 water year, which ran from October 2009 to September 2010, with average conditions during the period of record.

Quality Control of Coop Data

The agencies responsible for the initial data collection (e.g., National Weather Service) and the parties responsible for archiving these data (e.g., Western Regional Climate Center) performed basic quality control measures. Following guidelines from Kittel (2008) and Kittel et al. (2009), an additional series of quality checks were performed by the author of this report, involving graphing and visual inspection of the 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 COOP stations were also compared to corresponding estimates from the PRISM datasets and to the original datasheets (B-91 forms) used by weather station staff. When possible, data missing in the electronic records were recovered from the original datasheets and hand entered. 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.

Results

Temperature, Precipitation, and Drought during Calendar Year 2010

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.

January – April: General Patterns

Cabrillo NM began the year in a state of drought classified as “Moderate Drought (D1),” (Figure 2), but this drought was mitigated by the beginning of March (Figure 2). Precipitation across the region was well above the 1971 – 2000 average in January and slightly above average in February (Figure 3). Average daily maximum temperatures (Tmax) and average daily minimum temperatures (Tmin) were generally above average during January (Figures 4, 5). During February Tmax was near or below average and Tmin was generally above average. March was quite dry, with precipitation generally less than 25% the 1971 – 2000 averages and temperatures generally near or above average (Figures 3-5), but this was compensated by a cool, wet April (Figures 3-5), which maintained the region's drought free status (Figure 2).

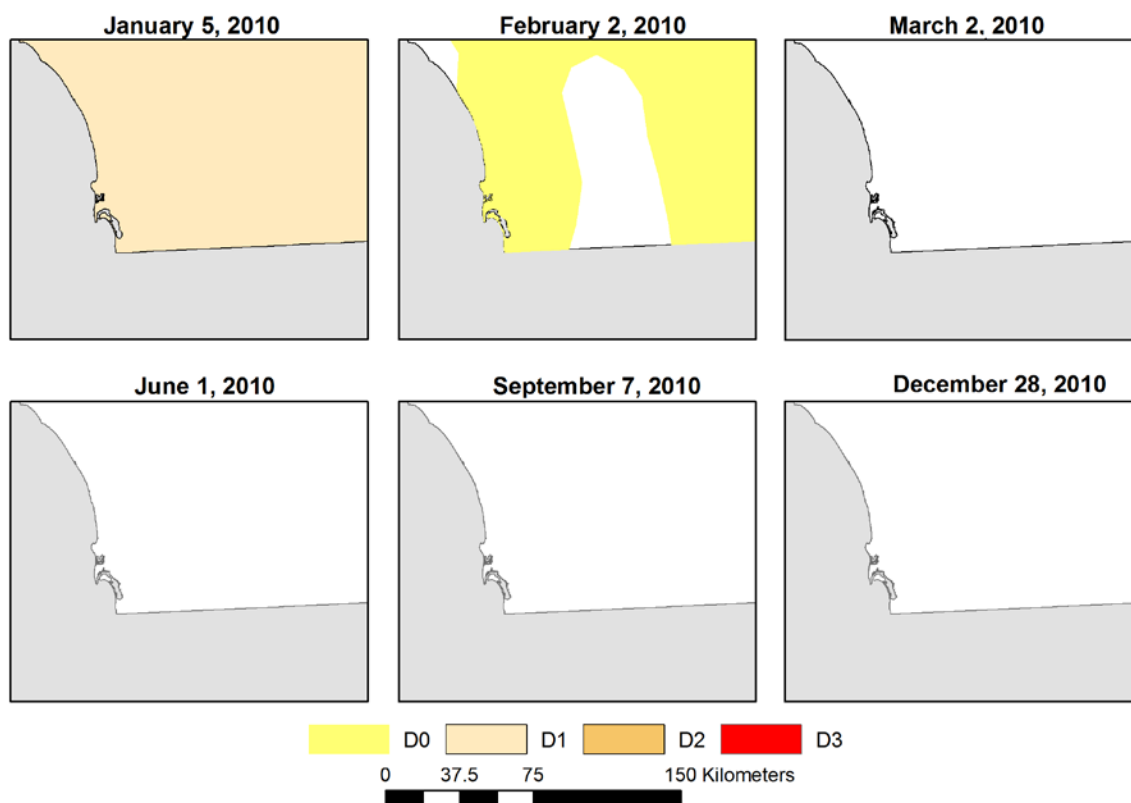


Figure 2. U.S. Drought Monitor maps for Cabrillo National Monument over the course of calendar year 2010. Drought classifications range from abnormally dry (D0) to exceptional drought (D4). White areas on the map indicate lack of drought status. For more information visit: www.drought.unl.edu/dm/monitor.html.

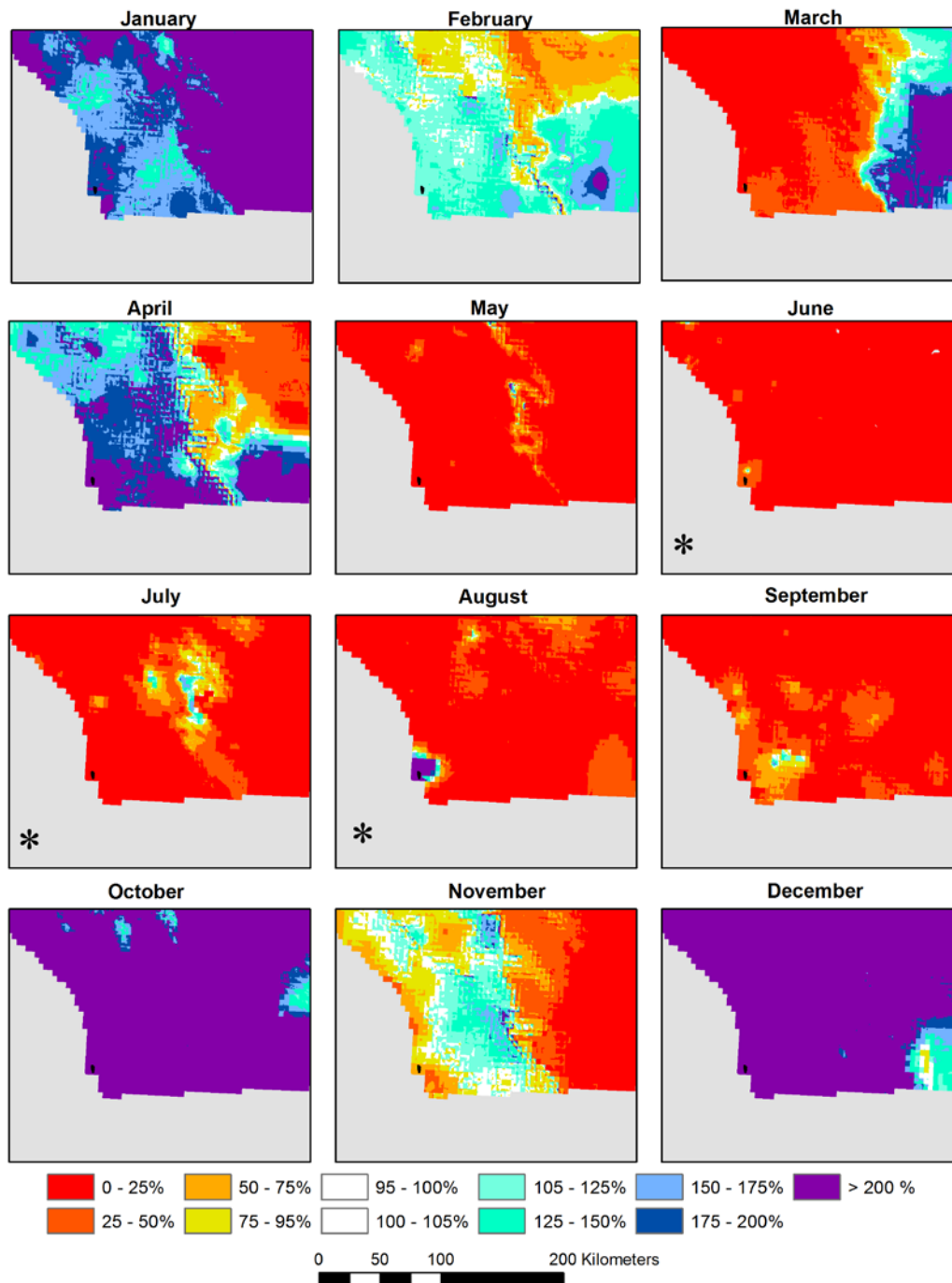


Figure 3. Maps showing percent of average precipitation versus 1971–2000 for each month in calendar year 2010. Colors show estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). Gray area = Pacific Ocean. Cabrillo National Monument is lower left on the coast in black. PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see <http://www.prism.oregonstate.edu/>. Asterisks indicate months that had very low average precipitation during 1971 – 2000. For example, the Chula Vista weather station had July average precipitation during 1971 – 2000 of 0.03 inches. For this reason, map colors indicating 0 – 25% average precipitation may represent very small absolute departure from average.

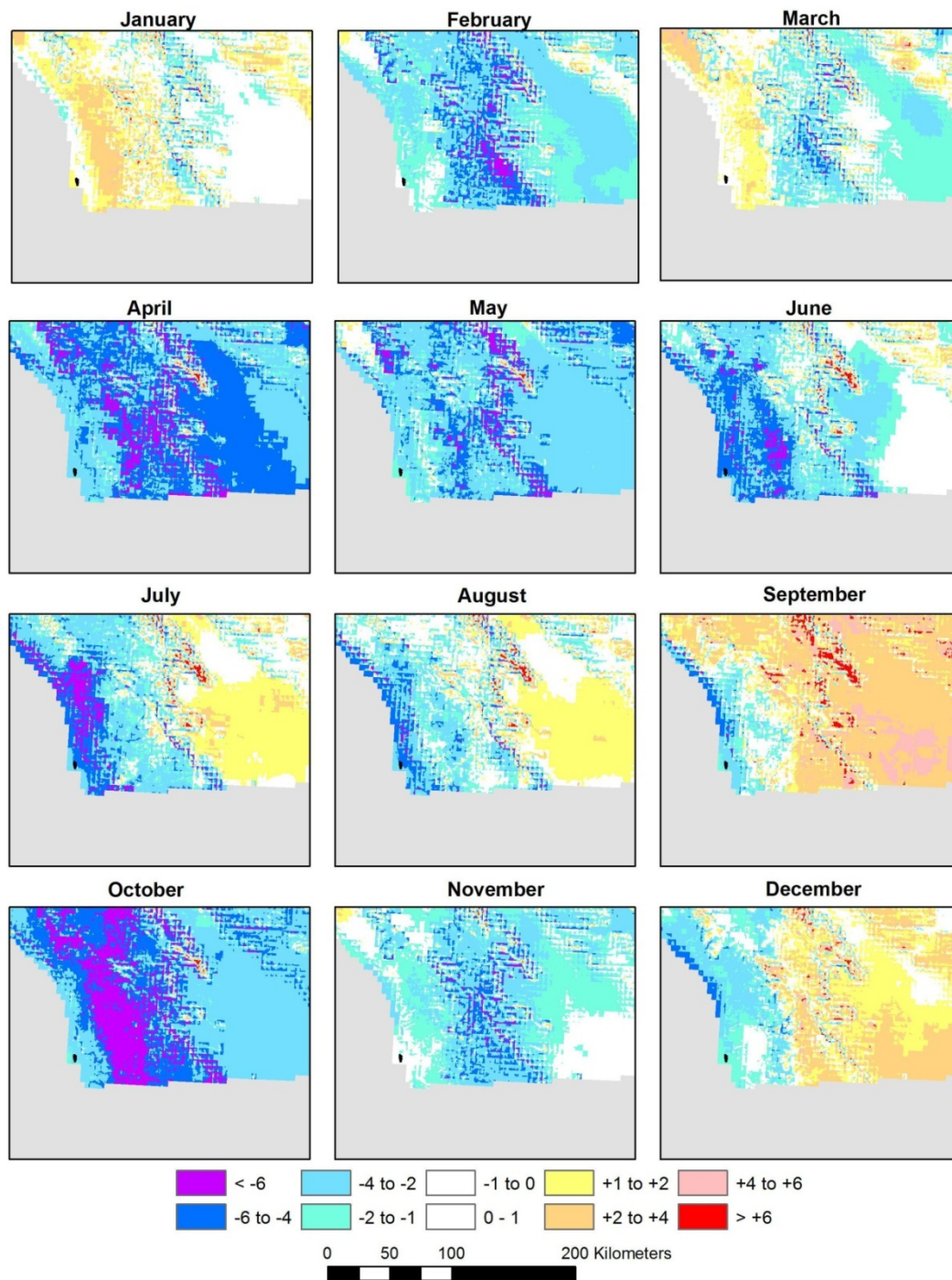


Figure 4. Maps showing departures from average maximum daily temperatures (Tmax) for each month in calendar year 2010 versus 1971–2000. Departure values are reported in degrees Fahrenheit. Gray area = Pacific Ocean. Cabrillo National Monument is lower left on the coast in black. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see <http://www.prism.oregonstate.edu/>.

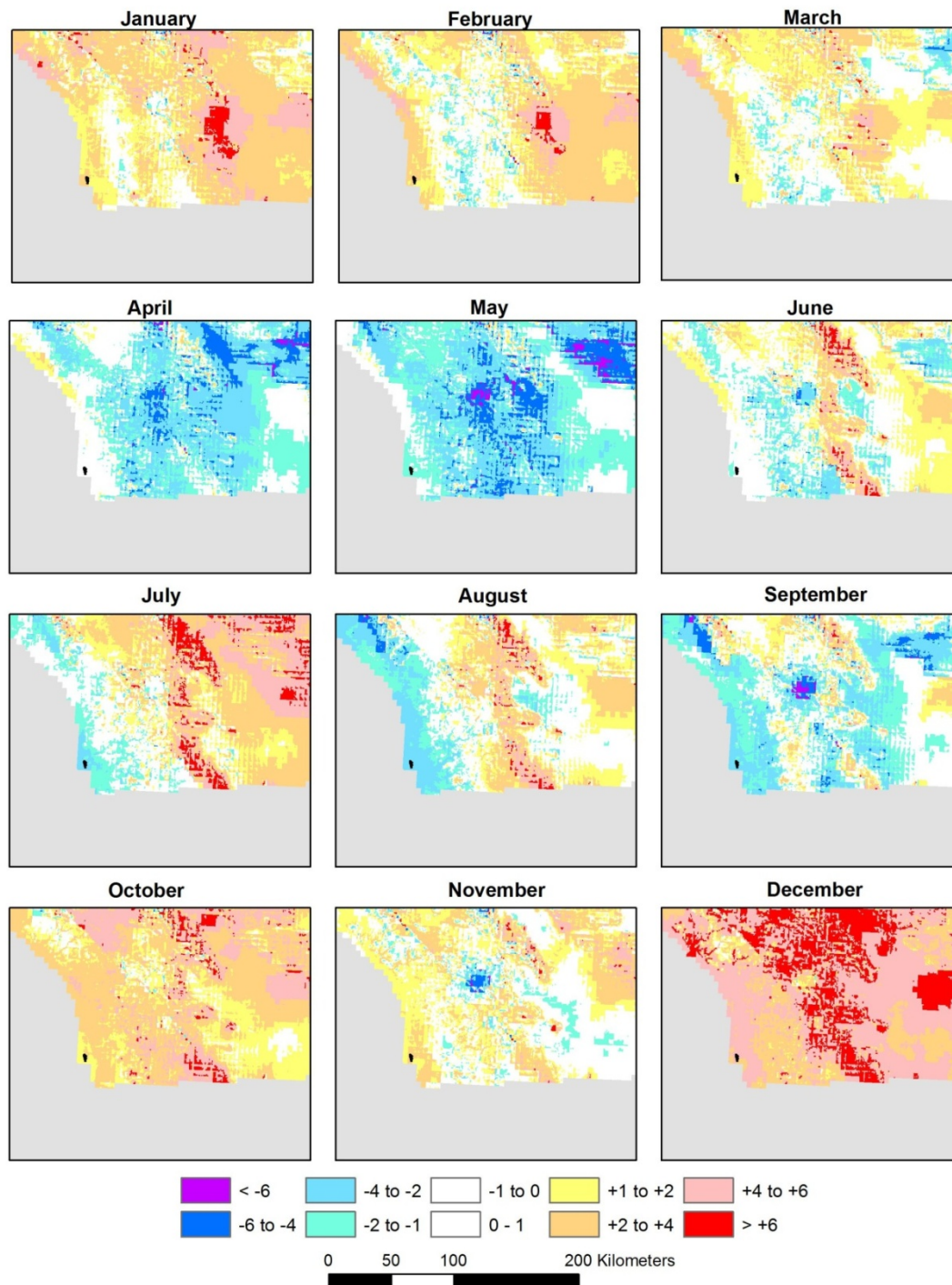


Figure 5. Maps showing departures from average minimum daily temperatures (Tmin) for each month in calendar year 2010 versus 1971–2000. Departure values are reported in degrees Fahrenheit. Gray area = Pacific Ocean. Cabrillo National Monument is lower left on the coast in black. Maps were created using estimates from the Parameter-elevation Regressions on Independent Slopes Model (PRISM). PRISM interpolates precipitation values between actual observation stations, and corrects these interpolated estimates for changes in topography across the region. For more information, see <http://www.prism.oregonstate.edu/>.

January – April: Details from Weather Station Data (Tables 1, 2; Figures 6-8):

- ⤴ January precipitation ranged from 148% - 204% the 1971 – 2000 average at San Diego Lindbergh Field and Chula Vista, respectively. Tmax ranged from 1.02 degrees Fahrenheit (F) below average (Chula Vista) to 0.68 (F) above (San Diego Lindbergh Field). Tmin was within 1 degree (F) of average.
- ⤴ February precipitation ranged from 112% average (San Diego Lindbergh Field) to 120% average (Chula Vista). February Tmax ranged from 1.41 (F) below average (San Diego Lindbergh Field) to 2.69 (F) below average (Chula Vista). Tmin was within 1 degree (F) of average.
- ⤴ March precipitation ranged from 30% average (San Diego Lindbergh Field) to 46% average (Chula Vista). March Tmax and Tmin were both within roughly one degree above or below average.
- ⤴ April precipitation was 225% average at Chula Vista and 237% average at San Diego Lindbergh Field. April Tmax was 3 – 5 degrees (F) below average. Tmin was roughly 1.93 degrees (F) below average at San Diego Lindbergh Field and very near average at Chula Vista.

Table 1. Total monthly precipitation in inches and percentage of 30-yr. averages.

Station Name	Station Type	Station ID	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual Total
Chula Vista	COOP	41758	4.06	2.39	0.95	1.55	0	0	0	0	0.17	2.06	0.45	4.92	16.55
		% of 30-yr avg.	204	120	46	225	0	0	0	0	85	528	41	417	166
San Diego Lindbergh Field	COOP	47740	3.38	2.28	0.68	1.78	0.01	0.02	0.02	0	0.03	2.18	0.88	5	16.26
		% of 30-yr avg.	148	112	30	237	5	22	67	0	14	495	82	382	151
San Diego Sea World	COOP	47741	4.92	2.35	(-)	(-)	(-)	0.03	0	0	0.09	2.61	(-)	(-)	(-)
		% of 30-yr avg.	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Station IDs are from National Weather Service Cooperative Observer stations. Monthly statistics are not reported if more than 3 days of data are missing.

(-) = Insufficient data for an accurate calculation.

Table 2. Average daily maximum temperatures (Tmax), average daily minimum temperatures (Tmin) during 2010, and departure from 1971 – 2000 averages.

Station Name	Station ID	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Chula Vista	41758													
Tmax (F)		67.48	66.11	68.42	65.03	66.16	67.27	70.26	72.9	73.9	69.84	69.1	65.71	68.52
Tmax Departure (+/- F)		-1.02	-2.69	0.02	-5.17	-4.14	-5.33	-5.84	-5.4	-4.8	-6.56	-3.1	-3.09	-3.48
Tmin (F)		46.52	48.57	50.48	52.77	55.74	59.5	61.94	62.81	60.83	59.16	51.6	49.16	54.92
Tmin Departure (+/- F)		0.42	0.87	0.48	-0.03	-1.36	-0.8	-2.06	-2.49	-2.87	1.46	1.8	3.66	-0.08
San Diego Lindbergh Field	47740													
Tmax (F)		66.48	64.89	67.32	65.63	66.71	67.37	69.39	72.84	74.33	72.65	70.3	65.61	68.63
Tmax Departure (+/- F)		0.68	-1.41	1.02	-3.07	-2.59	-4.83	-6.41	-4.66	-2.67	-1.35	0.4	-0.69	-2.17
Tmin (F)		49.97	51.64	53.16	54.47	57.58	60.23	62.29	63.16	63.3	63.23	54.33	51.9	57.11
Tmin Departure (+/- F)		0.27	0.14	-0.44	-1.93	-2.22	-2.37	-3.61	-4.24	-2.8	2.03	0.73	3	-0.99
San Diego Sea World	47741													
Tmax (F)		62.68	62.14	63.86	63.48	(-)	66.03	67.65	69.45	68.63	67.29	66.88	(-)	(-)
Tmax Departure (+/- F)		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)
Tmin (F)		47.23	50.14	50.48	52.28	(-)	59.4	61.39	61.87	60.37	58.94	51	(-)	(-)
Tmin Departure (+/- F)		(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)	(-)

Note: Station IDs are from National Weather Service Cooperative Observer stations. Monthly statistics are not reported if more than 5 days of data are missing.

(-) = insufficient data for an accurate calculation.

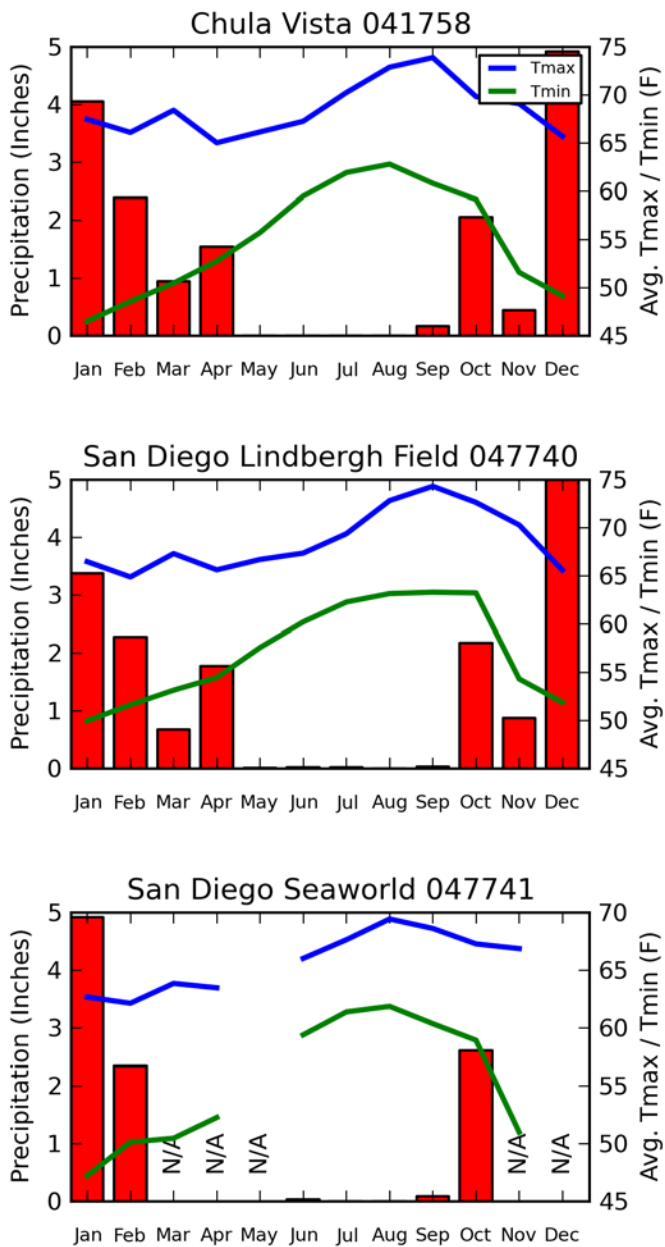


Figure 6. Total monthly precipitation, average daily maximum temperature (Tmax), and average daily minimum temperature (Tmin) during 2010 at key COOP stations near Cabrillo National Monument. N/A = Insufficient data for an accurate calculation.

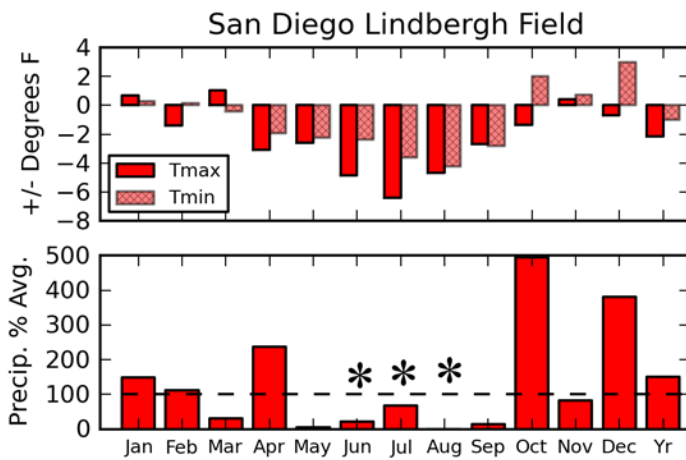
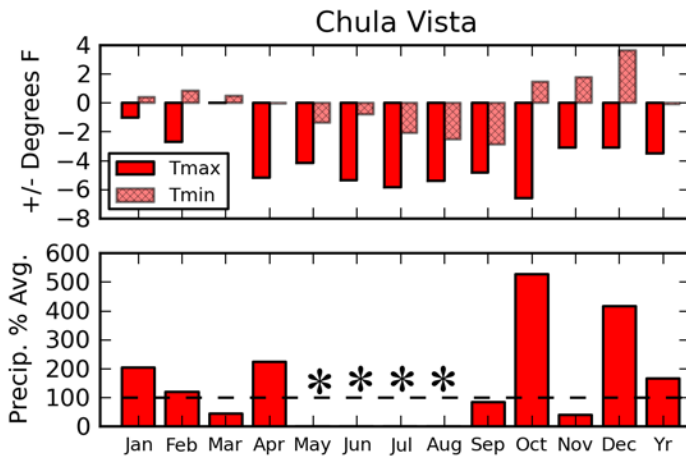


Figure 7. Departure of 2010 precipitation, average daily maximum temperature (Tmax), and average daily minimum temperature (Tmin) from 1971 – 2000 averages at key COOP stations near Cabrillo National Monument. Asterisks indicate months that had less than 0.2 inches average precipitation during 1971 - 2000. When interpreting months that have been marked with asterisks, it is important to bear in mind that 0% average precipitation may represent a small difference in absolute precipitation departure.

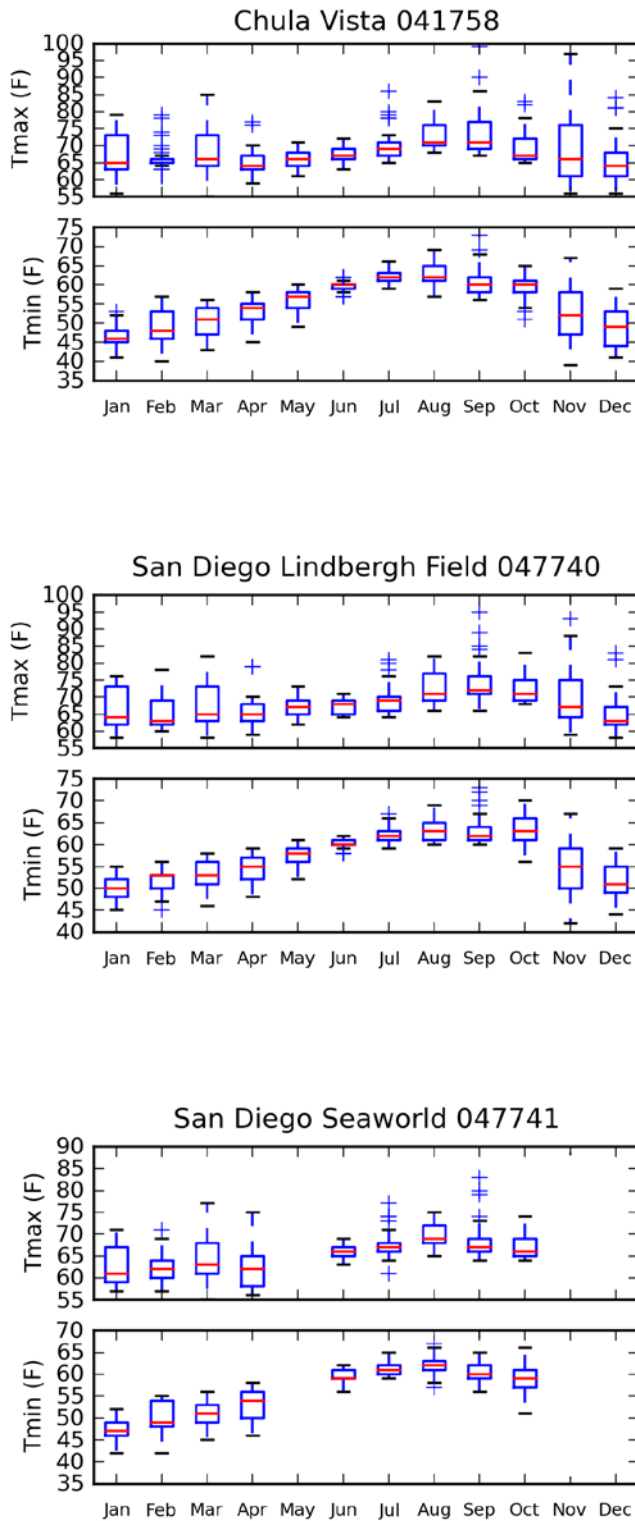


Figure 8. Boxplots of average maximum (Tmax) and average minimum (Tmin) daily temperatures at key climate stations near Cabrillo National Monument. Horizontal lines indicate the median value. Boxes indicate the 25th and 75th percentiles. Whiskers extend 1.5 times the interquartile Range (IQR). Crosses indicate values exceeding 1.5 times the IQR.

May – August: General Patterns

As characteristically low summer precipitation combined with generally below average temperatures (Figures 4, 5), May - August in and near Cabrillo NM continued the drought – free conditions that had begun in March (Figure 2). July, in particular, saw temperatures that were lower than average (Figures 4, 5). For example, San Diego Lindbergh field reported Tmax 6.4 degrees (F) below the 1971 – 2000 average and Tmin was 2 – 3.6 (F) below average.

COOP stations in the region typically experience less than 0.2 inches of precipitation during May, and even less during June – August. For example, June average precipitation for San Diego Lindbergh Field during 1971 – 2000 was 0.09 inches, and July average precipitation was 0.03 inches at both Chula Vista and San Diego Lindbergh Field. Because average (“normal”) precipitation is low during these months, care should be taken when interpreting statistics that quantify the amount (%) of normal precipitation that fell during the summer months. In the case of calendar-year 2010, PRISM maps (Figure 3) show that May – June were apparently quite dry, with precipitation often less than 25% average across the region. However, in terms of absolute difference (rather than % difference), this amounted to a small change from normal. For example, during June 2010, the San Diego Lindbergh Field Airport recorded 0.02 inches total precipitation. This was 22% of the 1971 – 2000 average, but only 0.07 inches less than normal. Since the absolute departure from average precipitation was not great, drought status was not affected (Figure 2).

May – August: Details from Weather Station Data (Tables 1, 2; Figures. 6 – 8):

- ⤴ May Tmax was 2.59 (F) below average (San Diego Lindbergh Field) to 4.14 (F) below average (Chula Vista). May Tmin was 1.36 (F) below average (Chula Vista) – 2.22 (F) below average (San Diego Lindbergh Field).
- ⤴ June Tmax was 4.8 (F) below average (San Diego Lindbergh Field) to 5.3 (F) below average (Chula Vista). June Tmin was 0.8 (F) below (Chula Vista) to 2.37 (F) below (San Diego Lindbergh Field).
- ⤴ July Tmax was 5.8 (F) below average (Chula Vista) to 6.4 (F) below average (San Diego Lindbergh Field). July Tmin was 2.06 (F) below average (Chula Vista) to 3.61 (F) below average (San Diego Lindbergh Field).
- ⤴ August Tmax was 4.6 (F) below average (San Diego Lindbergh Field) to 5.4 (F) below average (Chula Vista). Tmin ranged from 2.5 (F) below average (Chula Vista) to 4.2 (F) below average (San Diego Lindbergh Field).

September – December: General Patterns

Drought free conditions were maintained until the end of the year (Figure 2). Below average precipitation in September (Figure 3) was compensated by generally cooler than average September Tmax and Tmin. Even though November was generally drier than the 1971 – 2000 averages, it had near – average Tmax and only slightly above average Tmin. October and December both had precipitation at roughly 300% or more average (Figure 3). Average daily maximum temperatures (Tmax) were often below average during October and December (Figure 4), but average daily minimum temperatures (Tmin) were near or above average during these months (Figure 5).

September - December: Details from Weather Station Data (Tables 1, 2; Figures 6-8):

- ⤴ September precipitation ranged from 14% average at San Diego Lindbergh Field to 85% average at Chula Vista. The 1971 – 2000 average precipitation at these stations during September was 0.21 and 0.2 inches, respectively. At Chula Vista, this meant that September 2010 had 0.03 inches less precipitation than average. At San Diego Lindbergh Field, September 2010 had 0.17 inches less than average.
- ⤴ September Tmax was 2.67 (F) below average (San Diego Lindbergh Field) to 4.8 (F) below average (Chula Vista). September Tmin was 2.8 – 2.9 (F) below average at both stations.
- ⤴ October precipitation was 495% average (San Diego Lindbergh Field) to 528% average (Chula Vista). Much of this precipitation occurred during October 19, 2010. On this day, the Chula Vista weather station recorded 1.28 inches of precipitation. As a point of reference, the average monthly precipitation during October (during 1971 – 2000) was 0.39 inches. This rainstorm made headlines across southern California. See for example:
<http://www.signonsandiego.com/news/2010/oct/19/loud-lightning-startles-people-awake-alpine-ramona/>.
- ⤴ October Tmax was 1.35 (F) below (San Diego Lindbergh Field) to 6.56 (F) below average (Chula Vista). October Tmin was 0.73 (F) above average (San Diego Lindbergh Field) to 1.8 (F) above average (Chula Vista).
- ⤴ November precipitation was 41% average (Chula Vista) – 82% average (San Diego Lindbergh Field). November Tmax 0.4 (F) above (San Diego Lindbergh Field) to 3.1 (F) below (Chula Vista). November Tmin was 0.73 (F) above (San Diego Lindbergh Field) to 1.8 (F) above average (Chula Vista).
- ⤴ December precipitation was 382% - 417% average at San Diego Lindbergh Field and Chula Vista, respectively. December Tmax was 0.69 (F) below average (San Diego Lindbergh Field) to 3.09 (F) below average (Chula Vista). December Tmin was 3.0 (F) above average (San Diego Lindbergh Field) to 3.66(F) above average (Chula Vista).

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 AGDD 40, 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, AGDD 50 is calculated with a base temperature of 50 (F).

When viewed from the perspective of growing season length, calendar-year 2010 was near average. AGDD 40 and AGDD 50 were within 3 - 6% of the average calculated for the period of record at the Chula Vista COOP station (Table 3).

Table 3. First and last freeze and frost dates accumulated growing degree days and days above or below critical temperature thresholds.

Station Name	Station Type	Station ID	AGDD40	AGDD50	# days $\geq$ 80 F	# days $\geq$ 90 F	# days $\leq$ 32F
Chula Vista	COOP	41758	7937.5	4289	23	4	0
		Avg. 1918 – 2009	7674	4054	(-)	1.8	1
San Diego Lindbergh Field	COOP	47740	8356.5	4706.5	23	3	0
		Avg 1914 – 2009	(-)	(-)	(-)	(-)	(-)

(-) = 30-year average not available

Accumulated growing degree days (AGDD) are an index of growing season length. AGDD is calculated as the sum of the differences between daily mean temperature (Tmean) and a base temperature. For AGDD40, the formula is $\text{Sum}(\text{Daily Tmean} - 40\text{F})$. $\text{AGDD50} = \text{Sum}(\text{Daily TMean} - 50\text{F})$

Streamflow

Unlike other climate parameters in this report, streamflow is presented across a standard water year, which in this case runs from October 1, 2009 to September 30, 2010. This better matches the annual cycle of precipitation, which is minimal during summer months (see section 3.1). Since the rivers and creeks in and near Cabrillo NM are all influenced by human activity, including artificial dams, stream flow is as much a result of management priorities as annual climatic events. Nevertheless, it is noteworthy that the midpoint of annual discharge was about 4 weeks earlier than the historical average, occurring on January 22, 2010 (blue vertical dashed line, Figure 10) and it coincided with heavy rainfall during January 19 - 22, which made headline news across southern California (See for example <http://www.signonsandiego.com/news/2010/jan/21/california-braces-for-4th-day-of-rain-wind/>).

Conclusions

- ⤴ Cabrillo NM began the year in a state of drought classified as “Moderate Drought (D1),” (Figure 2), but this drought was mitigated by the beginning of March. The region remained drought free for the rest of the year (Figure 2).
- ⤴ Heavy precipitation in late-January 2010 contributed to higher flows in the San Diego River, which reached their mid-point of flow for the 2009 – 2010 water year roughly 4 weeks early (Figure 9).
- ⤴ Total precipitation measurements for the year were generally above average at the weather stations cited in this report (151% - 166% average, Table 2, Figures 3, 7). April, October, and December had precipitation that was well above the 1971 – 2000 averages for those months (Table 2, Figure 3). Summer precipitation was below average (Figure 3), but the region typically has low precipitation during May – August, so the region's drought status was not affected (Figure 2).
- ⤴ Average daily maximum temperatures (Tmax) for the year were generally near or below the 1971 – 2000 averages. Average daily minimum temperatures (Tmin) for the year were generally near average (Table 2). April and July had notably below average temperatures. Tmax in July was 6.4 degrees below the 1971 – 2000 average at San Diego Lindbergh Field. In October and December, Tmin was generally above average (Figure 5) but Tmax was generally below average (Figure 4).
- ⤴ The growing season, as measured by Accumulated Growing Degree Days (AGDD) was of near average length, based on averages calculated for the period of record at Chula Vista COOP station, near Cabrillo NM.

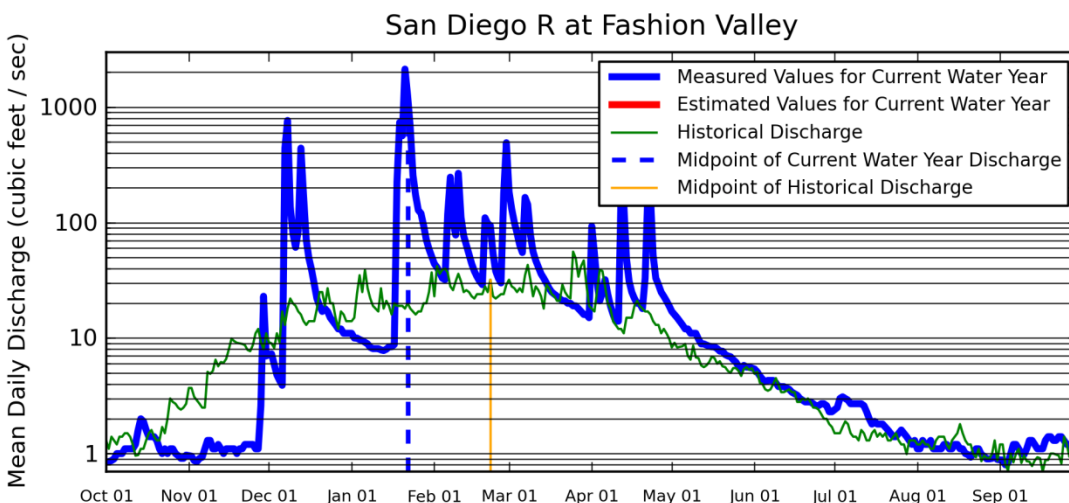


Figure 9. Streamflow near Cabrillo National Monument for the 2010 water year (October 2009 through September 2010) versus median daily flows. Historical median and stream flow pattern are based on the period 1983 – 2009. Data courtesy of the U.S. Geological Survey.

Literature Cited

- Daly, C., M. Halbleib, J. I. Smith, W. P. Gibson, M. K. Doggett, G. H. Taylor, J. Curtis, and P. P. Pasteris. 2008. Physiographically sensitive mapping of climatological temperature and precipitation across the conterminous United States. *International Journal of Climatology* 28(15):2031–2064.
- Kittel, T. 2008. The development and analysis of climate datasets for national park science and management: A guide to methods for making climate records useful and tools to explore critical questions. Report prepared for the National Park Service Inventory and Monitoring Program. University of Colorado, Institute of Arctic and Alpine Research, Boulder, Colorado.
- Kittel, T., S. Ostermann-Kelm, B. Frakes, M. Tercek, S. Gray, and C. Daly. 2009. A framework for climate analysis and reporting for Greater Yellowstone (GRYN) and Rocky Mountain (ROMN) networks: A report from the GRYN/ROMN climate data analysis workshop, Bozeman, Montana, 7–8 April 2009. Final draft. Prepared for the National Park Service, Greater Yellowstone Inventory and Monitoring Program, Bozeman, Montana.
- Rocky Mountain Climate Working Group. 2010. Rocky Mountain climate protocol: Climate monitoring in the Greater Yellowstone and Rocky Mountain inventory and monitoring networks, Version 1.0. Natural Resource Report NPS/IMRO/NRR—2010/222. National Park Service, Fort Collins, Colorado.

Appendix 1. Weather stations for Cabrillo National Monument

Table A-1. Stations selected for Cabrillo National Monument.

Station Name	Stn type	Stn ID	Period of record
Chula Vista	COOP	41758 ¹	1918 – present
San Diego WSO Airport AKA Lindbergh Field	COOP	47740 ²	1914 – present
San Diego Sea World	COOP	47741 ³	1988 – present
Stream Gages		ID	
San Diego R. at Mast R near nr Santee		11022480 ⁴	
San Diego R at Fashion Valley		11023000 ⁵	

Note: COOP = National Weather Service Cooperative Observer Network, SAO = Surface Air Observatory, CWOP = Citizen Weather Observation Program

¹ Metadata available at: <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca1758>

² Metadata available at: <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7740>

³ Metadata available at: <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7741>

⁴ Metadata available at:
http://waterdata.usgs.gov/nwis/dvstat/?format=sites_selection_links&search_site_no=11022480&agency_cd=USGS&referred_module=sw

⁵ Metadata available at:
http://waterdata.usgs.gov/nwis/dvstat/?format=sites_selection_links&search_site_no=11023000&agency_cd=USGS&referred_module=sw

Table A-2. Stations considered and rejected for Cabrillo National Monument.

Name	Stn type	Stn ID	Reason for rejection
Nester Telemark	COOP		Ended 1982
Imperial Beach Fire Dept	COOP		data unavailable
Point Bonita	COOP		Ended 1971
Natl City Fire Dept	COOP		Ended 2004
Cabrillo Nat Monument	COOP	41252	Ended 1968
Point Loma #2	COOP	47018	Data not available
Coronado Fire Dept	COOP	42040	Data not available
Imperial Beach Ream Field NAS	SAO		Data only available thru 2003
North Island NAS	CWOP		Real time data only

Note: COOP = National Weather Service Cooperative Observer Network, SAO = Surface Air Observatory, CWOP = Citizen Weather Observation Program

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NPS 342/130075, October 2015

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