



Climate Monitoring in the Mediterranean Coast Network 2017 – Channel Islands National Park

Natural Resource Report NPS/MEDN/NRR—2018/1839



ON THE COVER

Pinnipeds on Point Bennett, San Miguel Island

Photo credit: S. Ostermann-Kelm

Climate Monitoring in the Mediterranean Coast Network – Channel Islands National Park

Natural Resource Report NPS/MEDN/NRR—2018/1839

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December 2018

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. 2018. Climate monitoring in the Mediterranean Coast Network 2017 – Channel Islands National Park. Natural Resource Report NPS/MEDN/NRR—2018/1839. National Park Service, Fort Collins, Colorado.

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Abstract

This report details the climate (temperature, precipitation, and drought) of Channel Islands National Park (NP) during 2017. Gridded maps are used to present broad-brush conditions across the region for each month. This regional presentation is compared to detailed data from Remote Automated Weather Stations (RAWS) and manual, ranger-managed weather stations. Prior to analysis, a set of data quality control checks were performed by the author in accordance with a National Park Service protocol (Rocky Mountain Climate Working Group 2010). 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.

NOAA - National Oceanic and Atmospheric Administration

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

RAWS – Remote Automated Weather Station

US Drought Monitor - A broad brush assessment of drought conditions. See <http://drought.unl.edu/dm/monitor.html>

Tmax / Tmin – daily Maximum / Minimum Temperatures. Monthly Tmax and Tmin are averages of daily Tmax and Tmin, respectively.

Introduction

Channel Islands National Park is comprised of five islands 20 to 61 kilometers from mainland Southern California, including San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara. Remote, rugged and geographically diverse, each island experiences unique weather and climate conditions, in part, because the park islands span a major transition in climate that begins at the California coastline where the cool waters of the northern Humboldt Current mix with the warmer California Current from the south (Redmond and McCurdy 2005).

This report summarizes all the climate data for Channel Islands NP that were complete enough to support monthly and annual summaries for calendar year 2017 at the time of writing. Only a subset of the weather stations located in Channel Islands NP were used because instrumental failure and incomplete data entry led to a large number of missing values in the time series from some of the weather stations, making them intractable to analysis. Climatic events in this report 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.

Channel Islands National Park began monitoring weather in the mid-1980s, although weather records extend back into the early 1900's for some islands. The program consists of four Remote Automated Weather Stations (RAWS), one on each island except San Miguel, supplemented by daily observations made at six sites by island staff when stationed on the islands (Ranger Station data). The RAWS data are downloaded via satellite and archived by the Western Regional Climate Center (WRCC) at the Desert Research Institute in Reno, Nevada. WRCC also archives the Ranger Station data for the Park. The weather data used in this report are available from the WRCC or from the NPS sponsored web interface located at www.ClimateAnalyzer.org. RAWS parameters measured include precipitation, air temperature, relative humidity, wind speed and direction, solar radiation, fuel moisture, fuel temperature, and barometric pressure.

Redmond and McCurdy (2005) discuss an approach to weather and climate monitoring among the Channel Islands in the context of broader climate monitoring and modeling nationwide. Their rationale and specific design considerations form the basis for the Channel Islands National Park weather and climate monitoring program, including the choices of parameters to measure, RAWS and manual weather station siting, considerations for data handling and display, and operating procedures for site maintenance.

Each island except San Miguel has one park owned and maintained RAWS, supplemented by weather instruments manually operated by island staff. Collectively, the stations provide data on weather from both the marine layer and terrestrial climate regimes of the islands (McEachern et al. 2008). In addition to the Park, a number of agencies and organizations including the National Interagency Fire Center (NIFC), the U.S. Navy, the County of Santa Barbara, California State University, Northridge (CSUN), the University of California, Santa Barbara, and the Santa Barbara Amateur Radio Club have invested in island weather stations. Collectively, these stations address the

needs of Park resource management, Park operations, fire planning and management, Navy operations, mariner safety and specific research needs.

Those interested in additional climate-related information for Channel Island NP 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 (<http://www.wrcc.dri.edu/>)

Drought Monitor (<http://drought.unl.edu/dm/monitor.html>)

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

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

Methods

Selection of Datasets

In order to place Channel Islands NP 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 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; <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 robust products in a wide variety of studies (Daly et al. 2008).

Ranger-managed, manual weather stations, often referred to as “ranger” stations, were included because they have long, established records that can be meaningfully compared to the RAWS stations. Both RAWS and “Ranger weather stations” are owned and maintained by Channel Islands National Park. Data from the “Ranger stations” are archived by the National Oceanic and Atmospheric Administration (NOAA) and are available from the Western Regional Climate Center or from the NPS sponsored web interface located at www.ClimateAnalyzer.org. 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.

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.

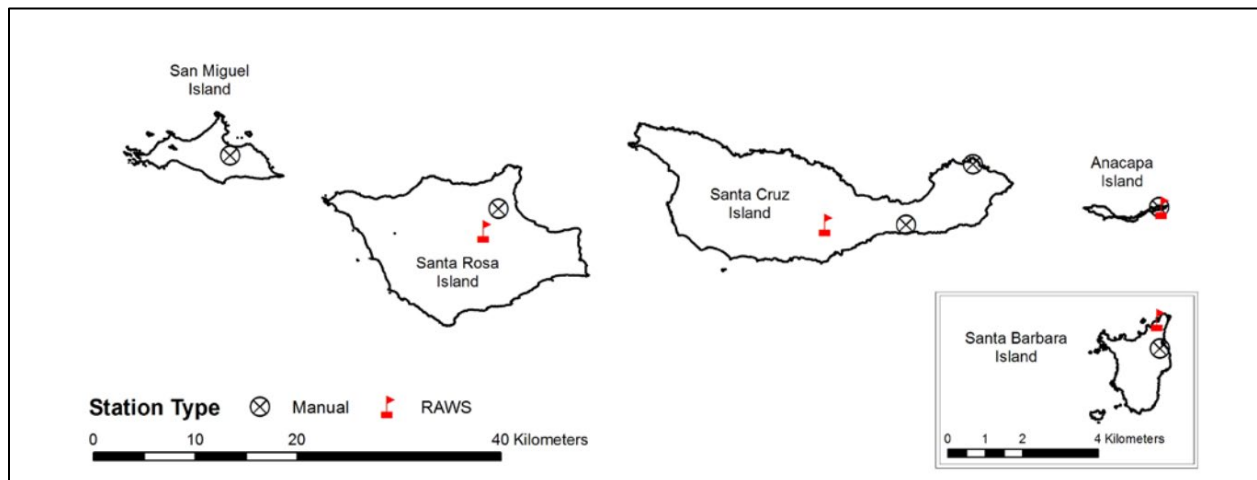


Figure 1. Map showing key climate stations used in this report. There are additional weather stations in Channel Islands NP, but data from those stations was not complete enough for 2017 to merit inclusion.

Quality Control of Ranger-Managed (Manual) Weather Stations

All of the “Ranger stations” used in this report are operated and maintained by Channel Islands NP. These stations are sometimes referred to as “Cooperative Observer” stations because in most cases their measurements are recorded by humans and entered into the Western Regional Climate Center website where the data is then aggregated and error checked by NOAA.

Data from these weather stations undergo quality control and error-checking by NOAA, 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 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 Ranger (manual) weather stations were also compared to corresponding estimates from the PRISM datasets and to the original datasheets used by weather station staff. When possible, data missing in the electronic records were recovered from the original datasheets and hand entered by the authors of this report. 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 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.

Quality Control of RAWS Data

All of the RAWS stations used in this report are maintained by Channel Islands NP. The park swaps RAWS sensors annually as part of the National Interagency Fire Center Weather Program. The Program maintains a parts depot in Boise, ID which exchanges clean, recalibrated sensors with sensors from the field. A detailed record of station maintenance is found in Appendix 2. Occasionally sensors fail during the year resulting in a data gap for that parameter. When this occurs, a replacement sensor is ordered from the parts depot in Boise, ID and the faulty sensor is replaced as quickly as possible.

Because RAWS 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 6 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, which were ascribed to

instrumental error and considered missing; and the missing data criteria just described for Ranger stations were used to calculate monthly statistics.

All the data used in the preparation of this report (including original and quality checked files) are available electronically from www.ClimateAnalyzer.org. Readers can download the data used in this report and make custom climate graphs and tables of their own by visiting www.ClimateAnalyzer.org

Results

Temperature, Precipitation, and Drought Status During Calendar Year 2017

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 (Figures 3 – 5) and compare them to the weather station data presented in Figures 6a and 6b and Tables 1 – 2.

Broader Picture – The Ongoing Drought Became More Severe

The region entered into drought conditions in April 2012 (Tercek 2013) and became progressively drier throughout 2013 and 2014. By the end of 2014, the islands were classified as “D4 - Exceptional Drought” by the US Drought Monitor, which is the most severe classification on this scale, and it retained this classification until the end of 2016 (Figure 2). Finally, in January, the drought began to slacken, eventually moving to the D1 rating by the end of the year (Figure 2).

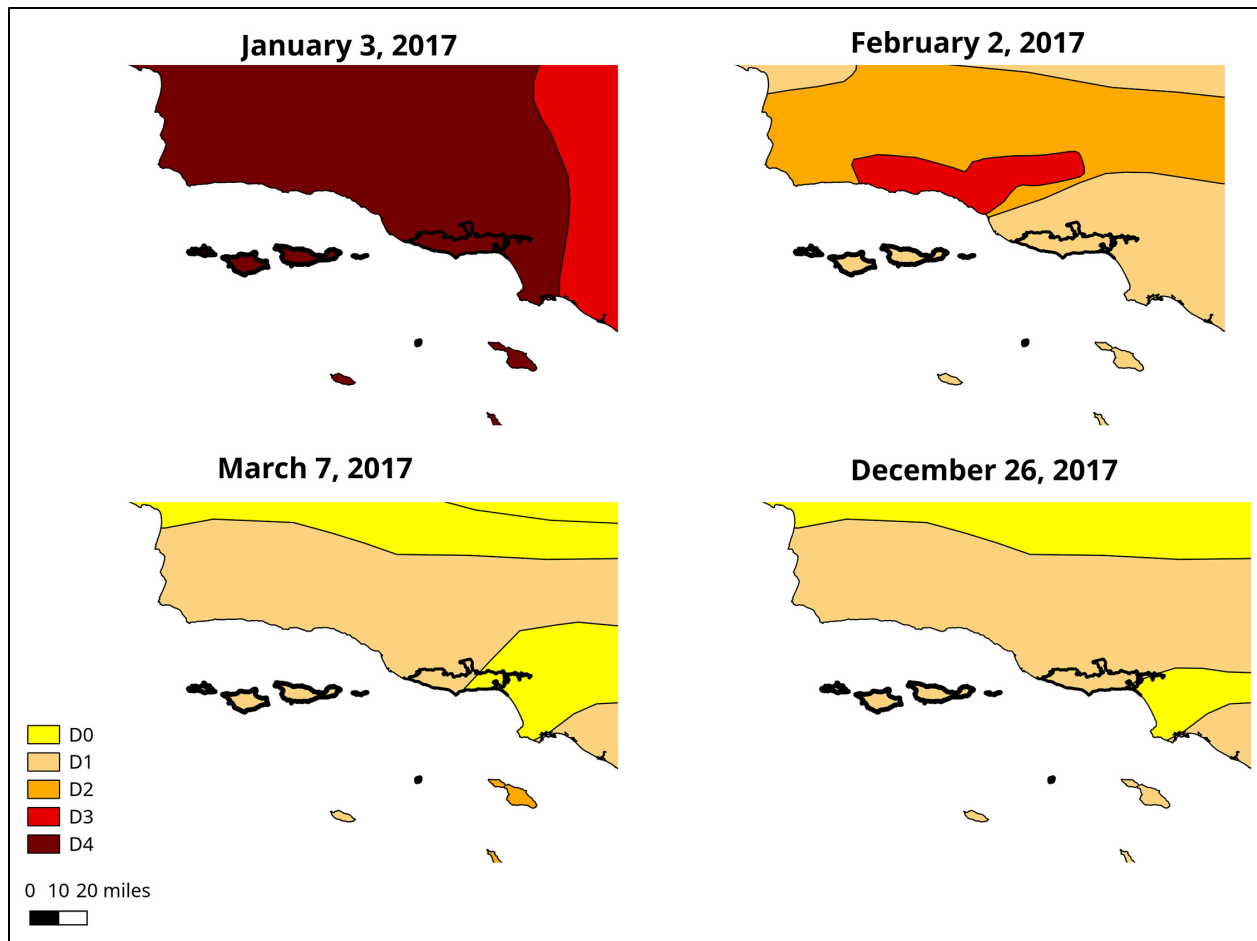


Figure 2. U.S. Drought Monitor maps for Channel Island National Park during calendar year 2017. Drought classifications range from “abnormally dry” (D0) to “exceptional drought” (D4). White areas = Pacific Ocean. For more information visit: www.drought.unl.edu/dm/monitor.html

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:

<http://www.pmel.noaa.gov/tao/elnino/el-nino-story.html>

ENSO started 2017 in a transition between El Nino and La Nina, switching fully into La Nina by Autumn. Normally, La Nina conditions produce drier conditions in southern California while El Nino produces wetter conditions. Rain falling early in the year did slightly ameliorate the drought in southern California. For long-term El Nino patterns, consult NOAA here:

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Precipitation During 2017

There are no weather stations with established 30-year averages within Channel Islands National Park, so we rely instead on PRISM maps (Figures 3 – 5) when comparing 2017 to the past. (See the Introduction for more information on how 30-year averages are calculated by NOAA).

January and February had above average precipitation throughout the region, while the other months were near to below average (Figure 3). Precipitation during the summer months (May – December) 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. Monthly total precipitation in inches during 2017 in Channel Islands National Park are shown in Table 1.

Temperature During 2017

According to PRISM, January and February were cooler than average, while the remaining months of the year were warmer than average. October – December were > 6 degrees above the 1981 – 2010 average throughout most of the islands (Figures 4 – 5). Monthly average daily maximum temperatures and average daily minimum temperatures during 2017 are shown in Tables 2a and 2b.

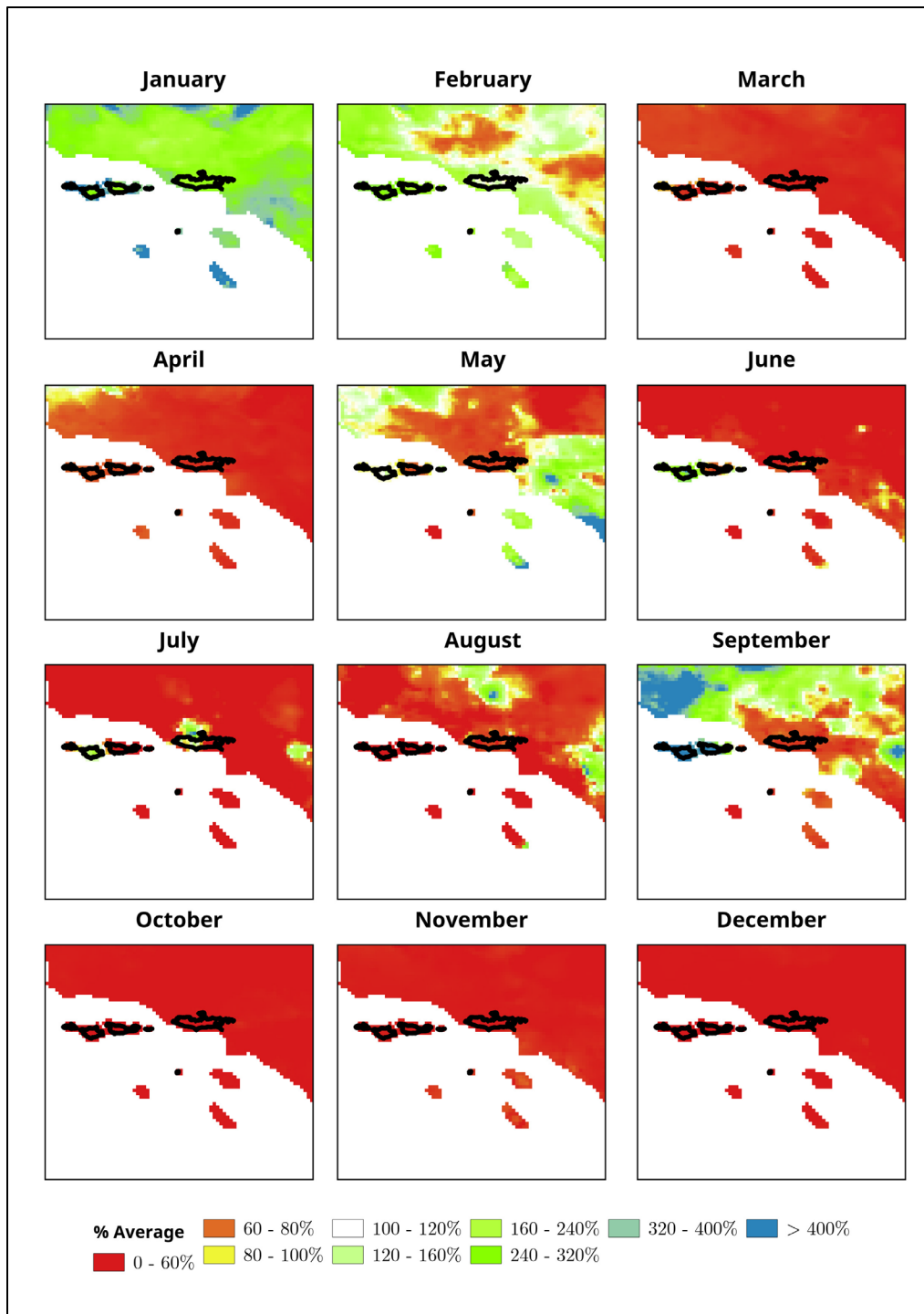


Figure 3. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing 2017 monthly precipitation as a percentage of 1981 – 2010 averages. White areas = Pacific Ocean. For more information, see <http://www.prism.oregonstate.edu/>.

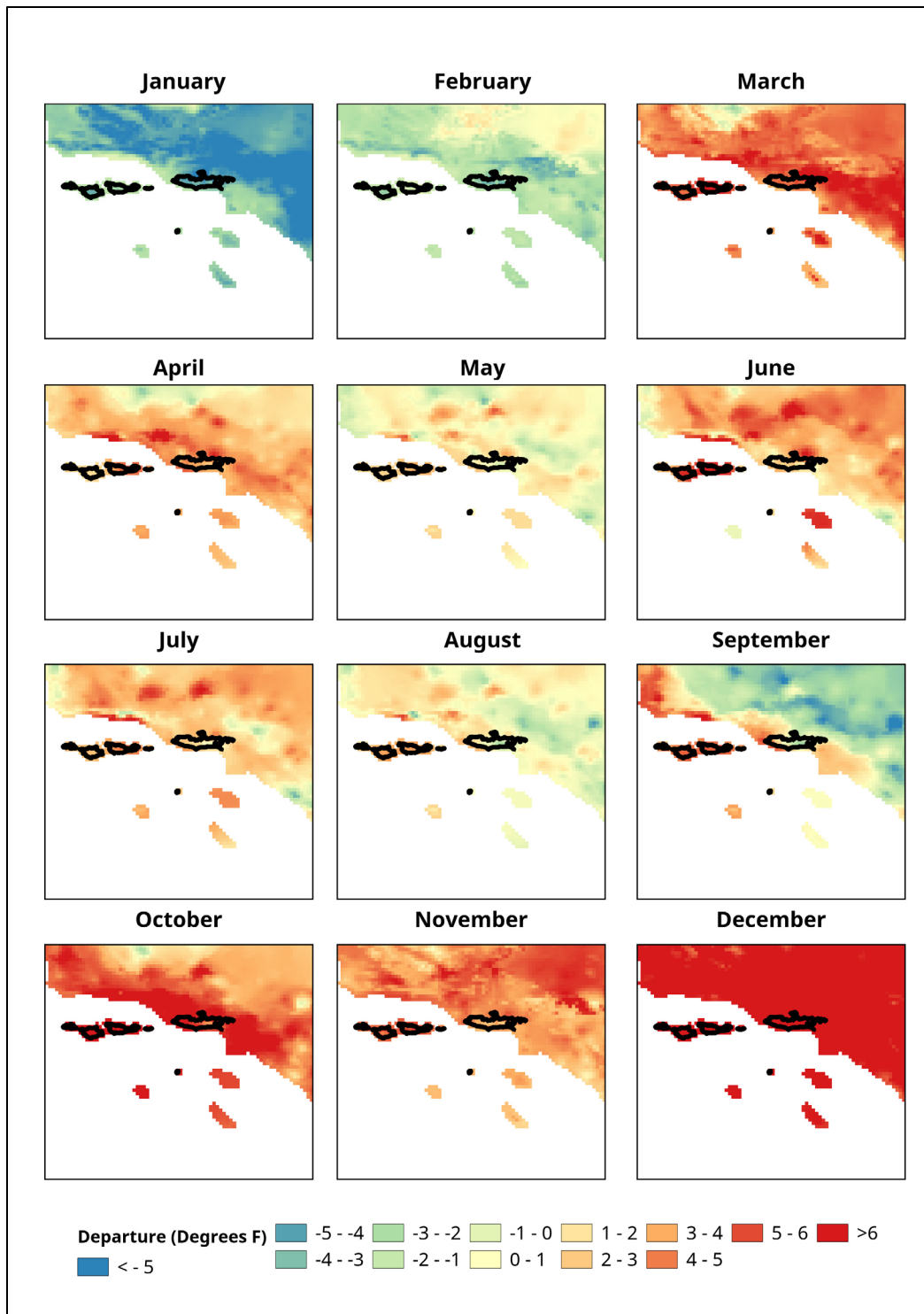


Figure 4. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing 2017 monthly average daily maximum temperature (Tmax) departure from 1981 – 2010 averages in degrees Fahrenheit. White areas = Pacific Ocean. For more information, see <http://www.prism.oregonstate.edu/>.

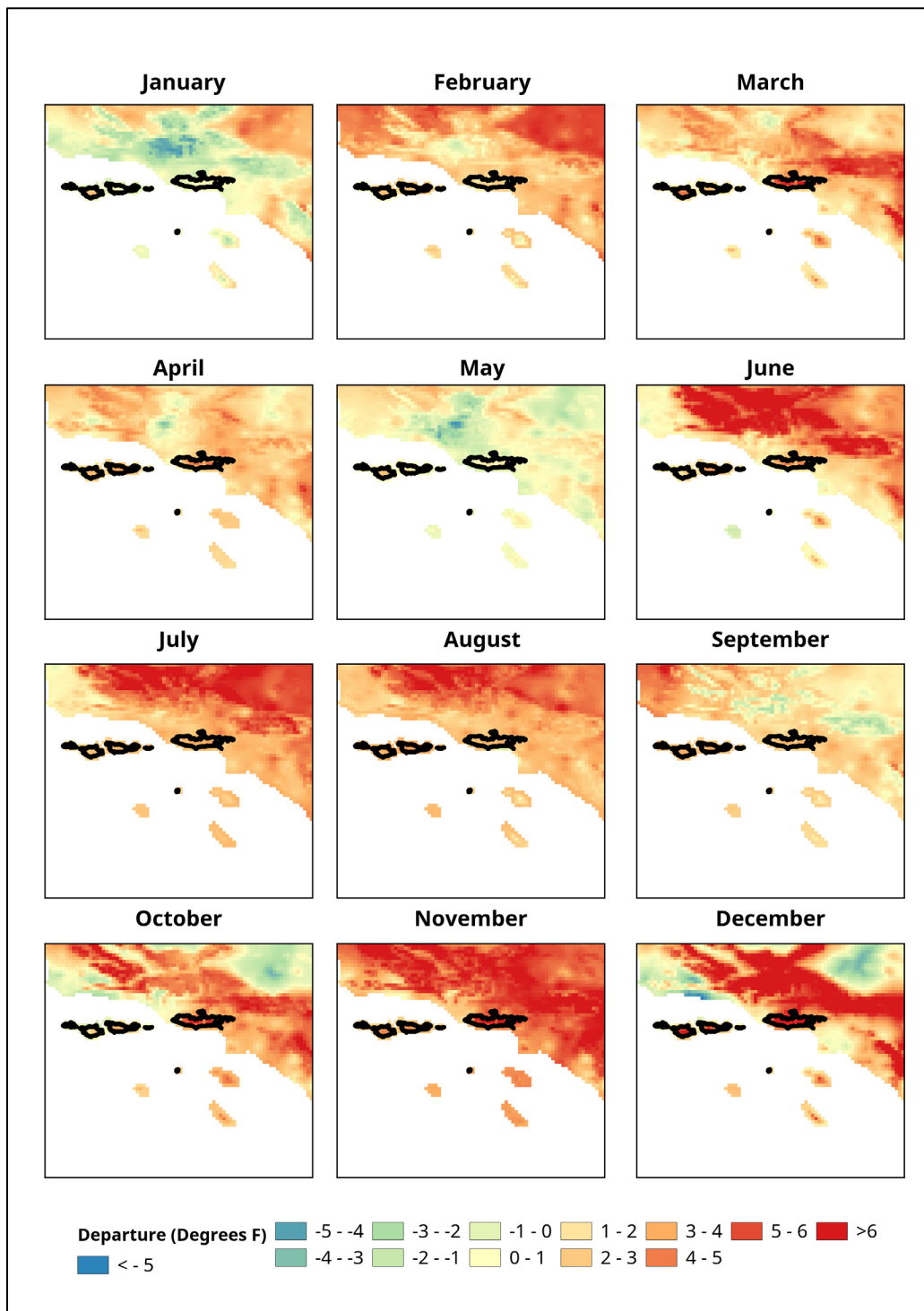


Figure 5. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing 2017 monthly average daily minimum temperature (Tmin) departure from 1981 – 2010 averages in degrees Fahrenheit. White areas = Pacific Ocean. For more information, see <http://www.prism.oregonstate.edu/>.

Table 1. Monthly total precipitation in inches during 2017 in Channel Islands National Park. N/A = insufficient data for an accurate calculation.

Month	Anacapa Island RAWS 2017	Santa Rosa Island RAWS 2017	Santa Barbara Island RAWS 2017	Santa Cruz Island RAWS 2017	Santa Rosa Island Manual 2017	Santa Cruz Island Manual 2017	Santa Barbara Island Manual 2017
January	5.26	5.29	4.24	9.29	N/A	N/A	N/A
February	4.98	5.39	3.82	7.79	N/A	8.11	4.11
March	0.38	0.89	0.48	2.64	N/A	2.78	2.7
April	0.26	0.35	0.07	0.54	N/A	0.47	N/A
May	0.05	0.46	0.1	0.14	N/A	N/A	N/A
June	0	0.17	0	0.01	N/A	N/A	N/A
July	0	0.06	N/A	0	N/A	N/A	N/A
August	0	0.17	N/A	0	N/A	0.04	N/A
September	0.08	N/A	N/A	0.4	N/A	0.56	N/A
October	0.02	N/A	0	0	N/A	N/A	N/A
November	0.01	0.11	0.01	0.01	N/A	N/A	N/A
December	0.05	0	0	0	N/A	0	N/A
YR	11.09	N/A	N/A	20.82	N/A	N/A	N/A

Table 2a. Monthly average daily maximum temperatures (Tmax) during 2017 in degrees Fahrenheit. N/A = insufficient data for an accurate calculation.

Month	Anacapa Island RAWS 2017 Tmax (F)	Santa Rosa Island RAWS 2017 Tmax (F)	Santa Barbara Island RAWS 2017 Tmax (F)	Santa Cruz Island RAWS 2017 Tmax (F)	Santa Rosa Island Manual 2017 Tmax (F)	Santa Cruz Island Manual 2017 Tmax (F)	Santa Barbara Island Manual 2017 Tmax (F)
January	59.7	57.2	59.6	62.8	N/A	N/A	N/A
February	58.3	55.9	58.2	63.3	N/A	63.5	57.6
March	62.4	64.0	61.1	72.7	N/A	66.8	67.5
April	64.7	61.5	62.4	73.7	N/A	68.3	N/A
May	64.5	62.3	61.7	73.5	N/A	67.7	N/A
June	67.2	64.2	63.7	80.2	N/A	71.6	N/A
July	70.8	72.0	N/A	83.0	N/A	75.3	N/A
August	71.9	70.9	N/A	83.4	N/A	75.1	N/A
September	73.5	N/A	N/A	82.7	N/A	79.4	N/A
October	73.1	N/A	71.8	82.5	N/A	80.3	N/A
November	67.7	68.4	66.0	75.1	N/A	73.2	N/A
December	66.1	68.3	65.4	73.1	N/A	71.0	N/A
YR	66.7	N/A	N/A	75.6	N/A	N/A	N/A

Table 2b. Monthly average daily maximum temperatures (Tmax) and average daily minimum temperatures (Tmin) during 2017 in degrees Fahrenheit. N/A = insufficient data for an accurate calculation.

Month	Anacapa Island RAWS 2017 Tmin (F)	Santa Rosa Island RAWS 2017 Tmin (F)	Santa Barbara Island RAWS 2017 Tmin (F)	Santa Cruz Island RAWS 2017 Tmin (F)	Santa Rosa Island Manual 2017 Tmin (F)	Santa Cruz Island Manual 2017 Tmin (F)	Santa Barbara Island Manual 2017 Tmin (F)
January	52.8	48.2	54.6	44.9	N/A	N/A	N/A
February	52.9	48.5	53.9	47.9	N/A	50.6	53.8
March	53.9	50.5	55.3	47.9	N/A	49.9	54.2
April	54.6	49.1	56.0	50.4	N/A	52.1	N/A
May	54.5	50.1	55.7	50.0	N/A	52.7	N/A
June	58.1	51.2	57.9	54.8	N/A	56.4	N/A
July	61.2	55.5	N/A	58.0	N/A	59.2	N/A
August	63.1	57.7	N/A	59.3	N/A	60.5	N/A
September	63.7	N/A	N/A	58.1	N/A	60.3	N/A
October	62.6	N/A	64.1	55.2	N/A	60.7	N/A
November	59.5	55.9	61.1	51.8	N/A	56.5	N/A
December	56.9	54.9	59.0	47.6	N/A	49.2	N/A
YR	57.9	N/A	N/A	52.2	N/A	N/A	N/A

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).

The Channel Islands RAWS have not been in operation long enough to calculate a “normal” growing season length. The manual stations had insufficient data for growing season calculations during 2017 (Figures 6a and 6b). Summary calculations for 2017 appear in Table 3.

Table 3. Accumulated Growing Degree Days (AGDD) and days above or below critical temperature thresholds during 2017 at RAWS in Channel Islands National Park. (-) = insufficient data for an accurate calculation.

Station Name	Station ID	AGDD40	AGDD50	# days >= 80 F	# days >= 90 F	# days <= 32F
Anacapa Island	RAWS	8094	4464	11	1	0
Santa Rosa Island	RAWS	N/A	N/A	N/A	N/A	N/A
Santa Barbara Island	RAWS	N/A	N/A	N/A	N/A	N/A
Santa Cruz Island	RAWS	8681	5062	130	27	0

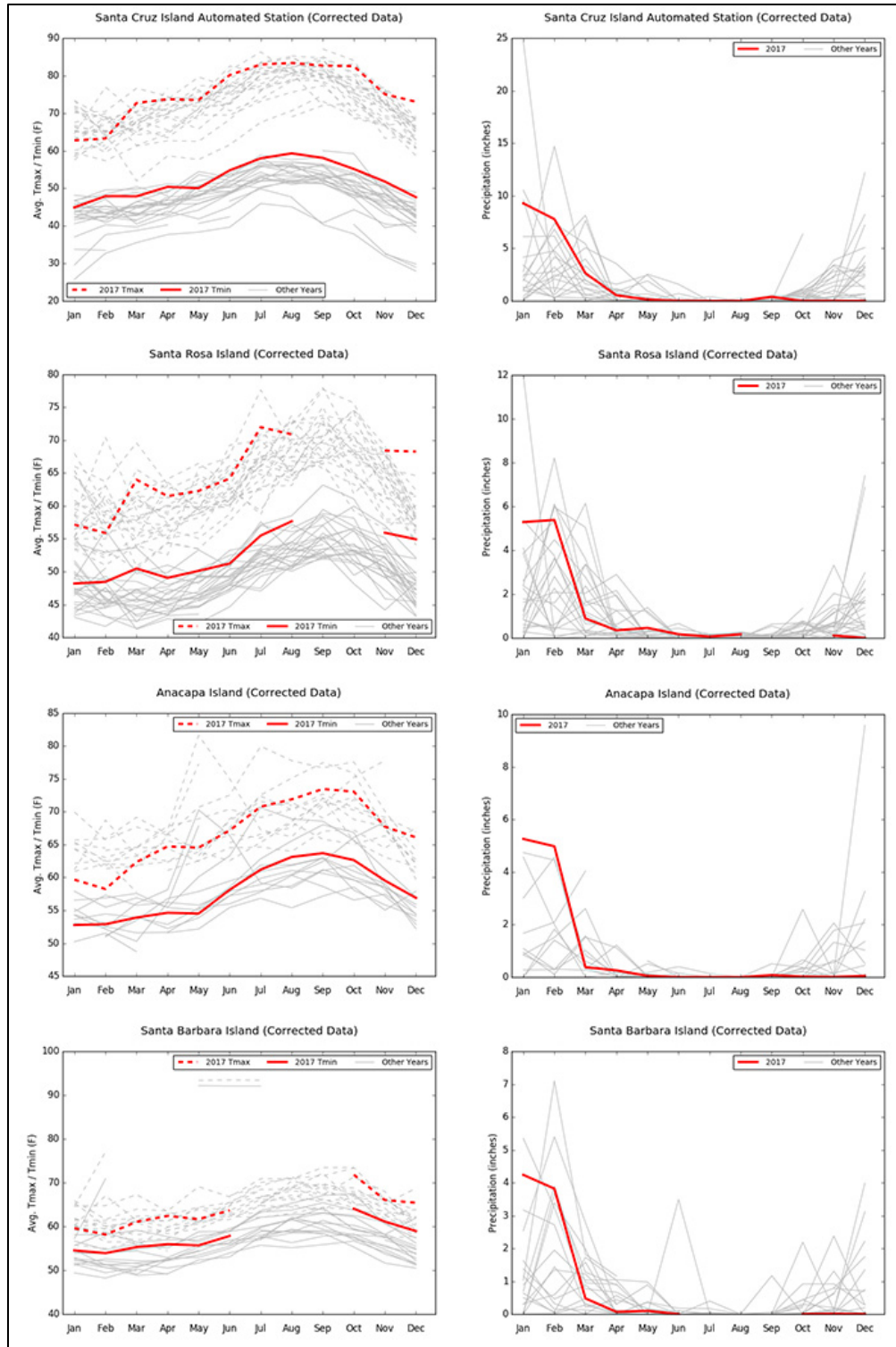


Figure 6a. Monthly precipitation (right) and temperature (left) data collected by RAWS in Channel Islands National Park. Red = 2017 measurements. Gray = other years.

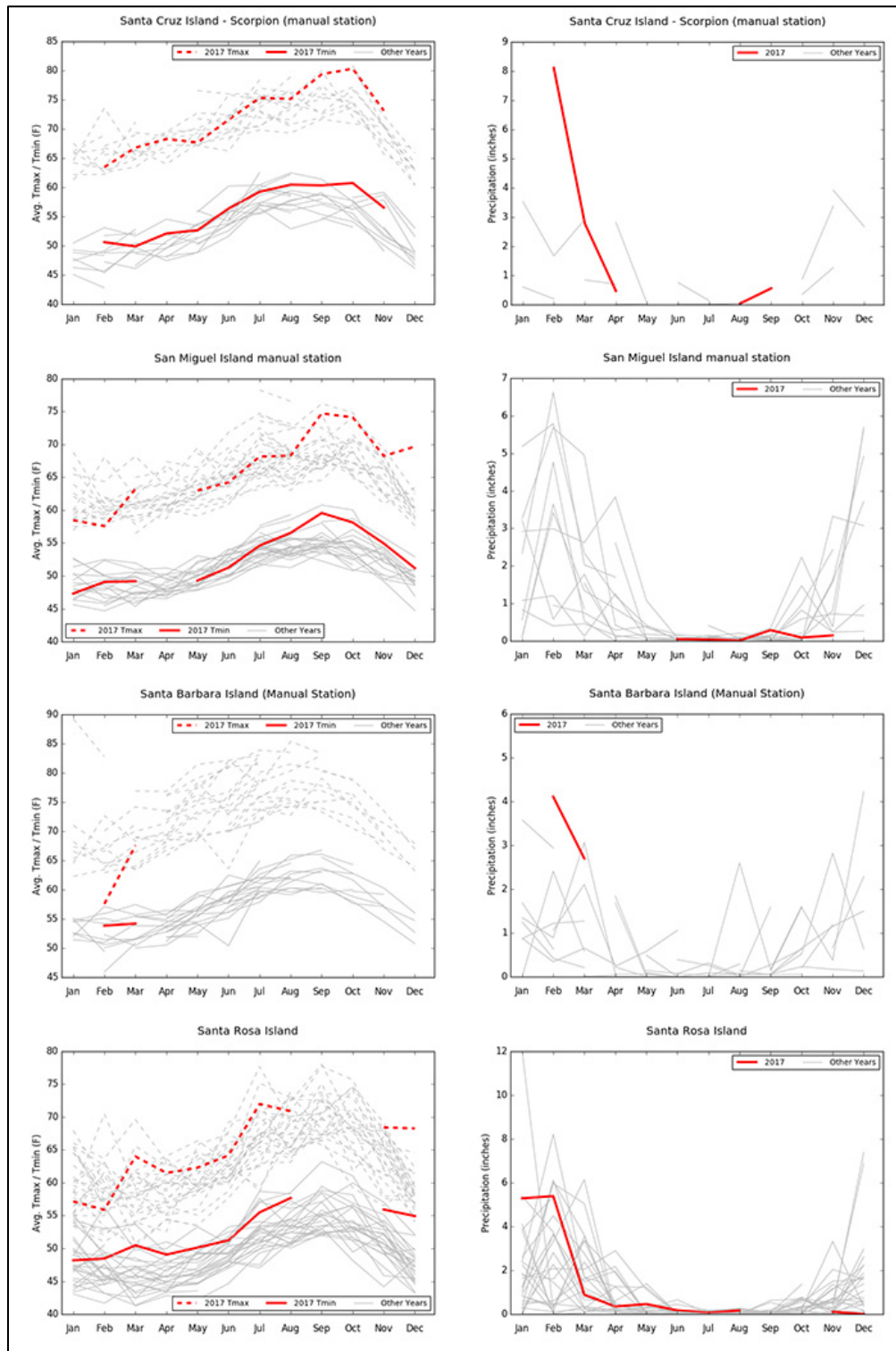


Figure 6b. Monthly precipitation and temperature data collected by manual “ranger” weather stations in Channel Islands National Park. Red = 2017 measurements. Gray = other years.

Conclusions

- The region entered into drought conditions in April 2012 (Tercek 2013) and became progressively drier throughout 2013 and 2014. By the end of 2014, the islands were classified as “D4 - Exceptional Drought” by the US Drought Monitor, which is the most severe classification on this scale, and it retained this classification until the end of 2016 (Figure 2). Finally, in January, the drought began to slacken in winter and spring 2017, eventually moving to the D1 rating by the end of the year (Figure 2).
- ENSO started 2017 in a transition between El Nino and La Nina, switching fully into La Nina by Autumn. Normally, La Nina conditions produce drier conditions in southern California while El Nino produces wetter conditions. Rain falling early in the year did slightly ameliorate the drought in southern California. For long-term El Nino patterns, consult NOAA here: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml
- January and February had above average precipitation throughout the region, while the other months were near to below average (Figure 3).
- According to PRISM, January and February were cooler than average, while the remaining months of the year were warmer than average. October – December were > 6 degrees above the 1981 – 2010 average throughout most of the islands (Figures 4 – 5).

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Appendix A

Table A1. Climate stations used in this report. Detailed histories, period of record, and 30-year averages can be accessed from the links provided.

Name	Stn type	Metadata
Santa Cruz Island (NPS)	RAWS	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCSCI
Anacapa Island (NPS)	RAWS	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCANA
Santa Barbara Island (NPS)	RAWS	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCSBB
Santa Rosa Island (NPS)	RAWS	http://www.wrcc.dri.edu/cgi-bin/rawMAIN.pl?caCSRI
Santa Cruz Island - Scorpion	Manual	http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7802+sca
Santa Rosa Island	Manual	http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7804+sca
Santa Barbara Island	Manual	http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7801+sca
San Miguel Island	Manual	http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7803+sca

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 159/149950, December 2018

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

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