



Mediterranean Coast Network Climate of 2012 Annual Report

Channel Islands National Park

Natural Resource Data Series NPS/MEDN/NRDS—2014/697



ON THE COVER

Rock on the beach at Cabrillo National Monument
Photo by Ashea Mills

Mediterranean Coast Network Climate of 2012 Annual Report

Channel Islands National Park

Natural Resource Data Series NPS/MEDN/NRDS—2014/697

Michael T. Tercek, Ph.D.
Walking Shadow Ecology
PO Box 1085
Gardiner, Montana 59030

Paula Power
Channel Islands National Park
1901 Spinnaker Drive
Ventura, CA 93001

August 2014

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

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm/>). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Tercek, M.T. and P. Power. 2014. Mediterranean Coast Network climate of 2012 annual report: Channel Islands National Park. Natural Resource Data Series NPS/MEDN/NRDS—2014/697. National Park Service, Fort Collins, Colorado.

Contents

	Page
Figures.....	ii
Tables.....	ii
Executive Summary.....	iii
Acknowledgments.....	iii
Glossary	iv
Introduction.....	1
Approach and Methods	3
Selection of Datasets.....	3
Quality Control of Ranger-Managed (Manual) Weather Stations.....	4
Quality Control of RAWs Data.....	4
Analysis of Wind Data.....	5
Results.....	6
Temperature, Precipitation, and Drought Status During Calendar Year 2012	6
Broader Picture – The region became drier during the course of 2012.....	6
Drought Monitor	6
The Reconnaissance Drought Index	7
El Nino – La Nina Status	8
Precipitation During 2012.....	8
Temperature During 2012.....	9
Accumulated Growing Degree Days, an Index of Growing Season Length	11
Wind Speed and Direction.....	17
Conclusions.....	19
Literature Cited	20
Appendix 1.....	22
Appendix 2.....	23

Figures

	Page
Figure 1. Map showing RAWs and manual (“ranger stations”) climate stations used in this report	3
Figure 2. U.S. Drought Monitor maps for Channel Island National Park during calendar years 2012 - 2013	6
Figure 3. The Reconnaissance Drought Index (RDI) calculated for the Santa Rosa Island (top) and UCLA (bottom) weather stations	7
Figure 4a. Monthly precipitation and temperature data collected by RAWs in Channel Islands National Park. Red = 2012 measurements. Gray = other years.	12
Figure 4b. Monthly precipitation and temperature data collected by manual “ranger” weather weather stations in Channel Islands National Park. Red = 2012 measurements	13
Figure 5. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing monthly precipitation as a percentage of 1981 – 2010 averages	14
Figure 6. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing monthly average daily maximum temperature (Tmax) departure from 1981 – 2010 averages in degrees Fahrenheit	15
Figure 7. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing monthly average daily minimum temperature (Tmin) departure from 1981 – 2010 averages in degrees Fahrenheit	16
Figure 8. Wind roses for data from RAWs in Channel Islands National Park, contrasting calendar years 2011 and 2012 to the averages for 2005 – 2010	17
Figure 8. Continued.....	18

Tables

	Page
Table 1. Monthly total precipitation in inches during 2012 in Channel Islands National Park.	8
Table 2. Monthly average daily maximum temperatures (Tmax) and average daily minimum temperatures (Tmin) during 2012 in degrees Fahrenheit.	10
Table 3. Accumulated Growing Degree Days (AGDD) and days above or below critical temperature thresholds during 2012.	11

Executive Summary

This report details the climate (temperature, precipitation, drought, and wind conditions) of Channel Island National Park (NP) during 2012. 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 Remote Automated Weather Stations (RAWS) and manual, ranger-managed weather stations. Prior to analysis, the authors performed a set of data quality control checks in accordance with a National Park Service protocol (Rocky Mountain Climate Working Group 2010).

Key points summarizing calendar year 2012 are presented as bullets in the Conclusion section at the end of the report. 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 are key to understanding the climatic patterns for 2012. 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

The National Park Service Mediterranean Coast Network Inventory and Monitoring Program provided funding for this report .

Glossary

AGDD: Accumulated Growing Degree Days

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

Climate: Complete and entire ensemble of statistical descriptors of temporal and spatial properties comprising the behavior of the atmosphere. These descriptors include means, variances, frequency distributions, autocorrelations, spatial correlations and other patterns of association, temporal lags, and element-to-element relationships. The descriptors have a physical basis in flows and reservoirs of energy and mass. Climate and weather phenomena shade gradually into each other and are ultimately inseparable (Davey et al 2006).

Climate Normal, 30-year Average or “Normals”: A long-term average value of a meteorological parameter (i.e., temperature) measured at a specific station. For example, “temperatures are normal for this time of year” means that temperatures are at or near the average climatological value for a given period. Climate normals are usually taken from data averaged over a 30-year period (e.g., 1971-2000). 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.

Cooperative Observer (COOP) Stations: A station where measurements are typically recorded by human observers on paper data sheets that are submitted to NWS for aggregation and error checking. COOP stations can also be automated to collect data at regularly scheduled times.

CSUN: California State University, Northridge

ENSO: El Nino-Southern Oscillation

F: Fahrenheit

FAO: Food and Agriculture Organization

GHCN: Global Historical Climatology Network

Met: Automated meteorological weather station

NIFC: National Interagency Fire Center

NOAA: National Oceanic and Atmospheric Administration

NP: National Park

NRA: National Recreation Center

NWS: National Weather Service

P: Precipitation

PET: Potential Evapotranspiration

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

Qa/Qc: [The combination of quality assurance \(the set of processes used to measure and assure the quality of a product, and quality control \(the process of meeting products and services to user expectations\).](#)

RAWS – Remote Automated Weather Station

RDI: Reconnaissance Drought Index

Tmax / Tmin: Mean daily maximum and minimum temperatures.

UCLA: University of California, Los Angeles

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

Water Year: The Water Year (or Hydrologic Year) is most often defined as the period from October 1 to September 30 of the following year. It is called by the calendar year in which it ends. Thus, Water Year 2011 is the 12-month period beginning October 1, 2010 and ending September 30, 2011. The period is chosen so as to encompass a full cycle of precipitation accumulation.

Weather: Instantaneous state of the atmosphere at any given time, mainly with respect to its effects on biological activities. Distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere.

WRCC: Western Regional Climate Center

Introduction

Channel Islands National Park (CHIS) comprises five offshore 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 CHIS that were sufficiently complete at the time of writing to support monthly and annual summaries for calendar year 2012. Only a subset of the weather stations located in CHIS were used because instrument failure and incomplete data entry resulted in a large number of missing values in the time series from some of the weather stations. This made them unsuitable for 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.

CHIS 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) discussed 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 CHIS 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>)

Approach and Methods

Selection of Datasets

In order to place CHIS 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 in addition to the RAWS stations 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.

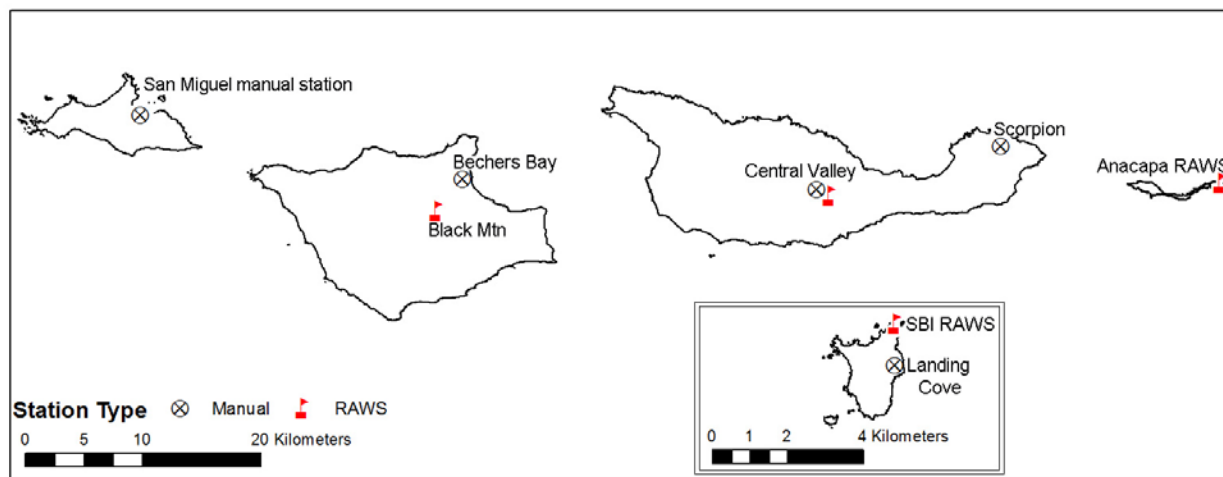


Figure 1. Map showing RAWS and manual (“ranger stations”) climate stations used in this report. There are additional weather stations in Channel Islands NP, but data from those stations was not complete enough for 2012 to merit inclusion.

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. Drought status was also assessed with the Reconnaissance Drought Index (RDI), which is the ratio of precipitation (P) to potential evapotranspiration (PET) divided by the average of this ratio for the time period selected minus one, or $((P/PET)/(\text{avg-P}/\text{avg-PET})-1)$ (Tsakiris and Vangelis 2005). Evapotranspiration, in turn, is calculated using the Penman-Montieth equation, with methods described by the Food and Agriculture Organization (FAO)

(Allen et al 1988). Negative values of the index indicate drier than average conditions, while positive values are wetter than average.

Quality Control of Ranger-Managed (Manual) Weather Stations

All of the “Ranger stations” used in this report are operated and maintained by CHIS. These stations are sometimes referred to as “Cooperative Observer” stations because in most cases human observers record their measurements on paper data sheets (NOAA Form B-91 and NOAA form 72-5A). The data are 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 authors of this report have created software tools that assist in the interpretation of the data flags and diagnostic plotting of the data. (This software, the Climate Data Summarizer, can be downloaded from www.YellowstoneEcology.com). 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. For example, no data points were changed unless it was very clear that an erroneous value was found and verified, like a precipitation measurement with a missing decimal point that could be verified on the original station records.

Quality Control of RAWS Data

All of the RAWS stations used in this report are maintained by CHIS. The Park swaps RAWS sensors annually as part of the National Interagency Fire Center Weather Program. The Program maintains a parts depot in Boise, Idaho 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, 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 instrument 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. These data files may be read and re-analyzed by the same software that was used to produce this report, available for download at www.YellowstoneEcology.com. Readers can download the data used in this report and make custom climate graphs and tables of their own by visiting www.ClimateAnalyzer.org

Analysis of Wind Data

Wind roses were used to present average conditions during 2012 and to contrast them with the period from 2005 – 2010. This period was chosen because it was common to all the RAWS stations in the park.

Results

Temperature, Precipitation, and Drought Status During Calendar Year 2012

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 7 – 9) and compare them to the weather station data presented in Figures 4 – 6 and Tables 1 – 2.

Broader Picture – The region became drier during the course of 2012.

Drought Monitor

After recovering from drought during 2010, the region remained drought-free for the entirety of calendar year 2011 (Tercek 2012). Drought-free conditions continued throughout the region until below average precipitation from January to March 2012 (data presented below) led to a return of drought in April 2012 (Figure 2). Above average precipitation during April provided slight relief, but the region remained in D0 – D1 drought status through April 2013 (Figure 2).

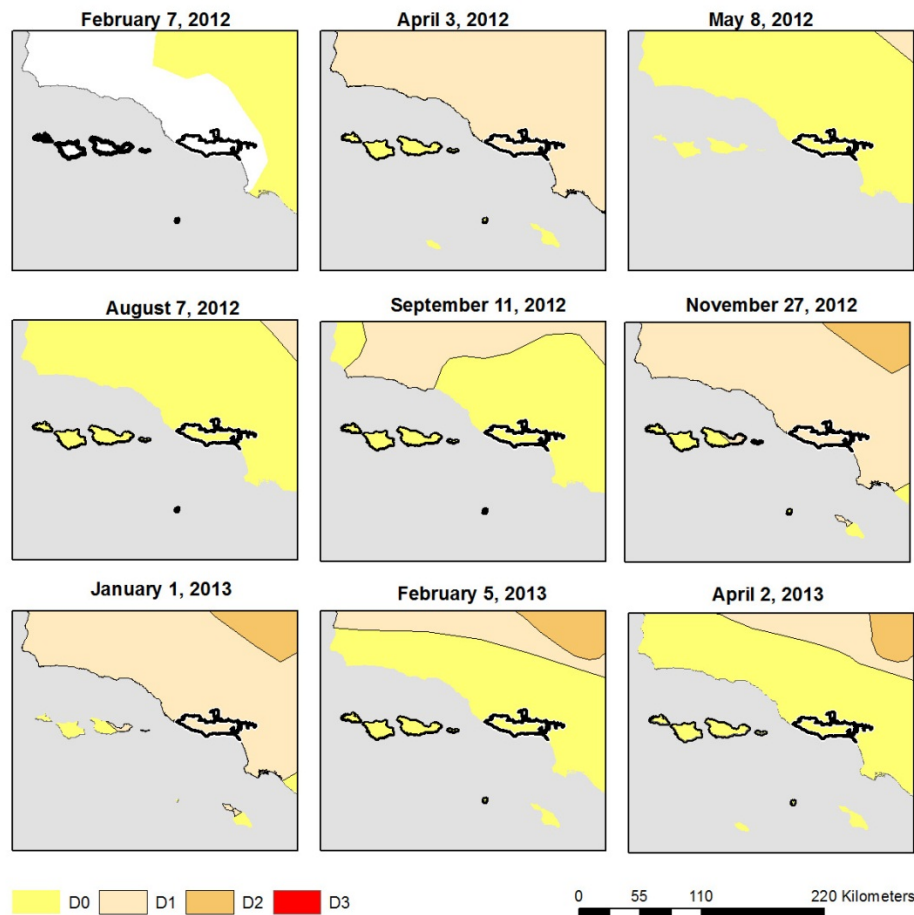


Figure 2. U.S. Drought Monitor maps for Channel Island National Park during calendar years 2012 - 2013. Drought classifications range from “abnormally dry” (D0) to “exceptional drought” (D4). Gray areas = Pacific Ocean. White areas = no drought. Rightmost black outline = Santa Monica Mountains NRA. Left black outlines = Channel Islands. For more information visit: www.drought.unl.edu/dm/monitor.html

The Reconnaissance Drought Index

Within Channel Islands National Park, only the Santa Rosa Island RAWS had data that was complete enough to calculate the Reconnaissance Drought Index (RDI). Despite the missing years, the patterns seen during 1990 – 2012 on Santa Rosa Island are similar to those found on the mainland at the UCLA weather station during 1945 – 2012 (Figure 3, though note the differences during 1996 – 1997 and 2002 – 2004), with the same water years scoring as above or below the long-term RDI baseline (positive or negative index values). For example, during the last 5 water years, 2009 – 2010 and 2010 – 2011 were wetter than average while 2007 – 2008, 2008 – 2009, and 2011 – 2012 were drier than average at both locations (Figure 3).

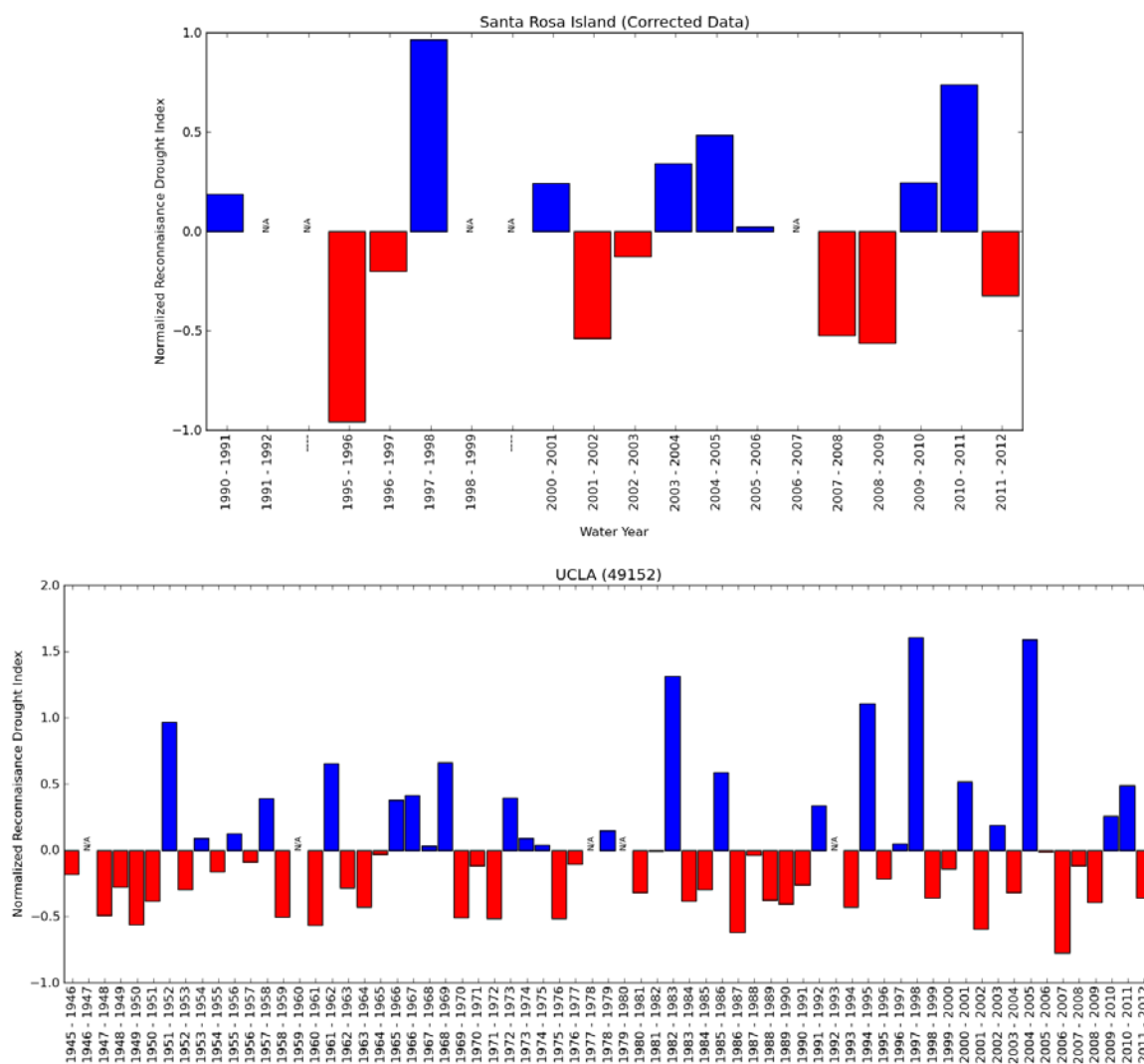


Figure 3. The Reconnaissance Drought Index (RDI) calculated for the Santa Rosa Island (top) and UCLA (bottom) weather stations. Negative index values indicate water years that were drier than the long-term. Positive values indicate wetter than average water years. Water years run from October – September of the following year. Because of the length of the record, calculations for the UCLA station are based on official National Weather Service data instead of data corrected as described in the methods section of this report.

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. 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>

During 2012, ENSO transitioned from La Nina to a neutral state between La Nina and El Nino. Normally, La Nina conditions produce drier conditions in southern California while El Nino produces wetter conditions. Given its transitional state, predicting the effects of ENSO on regional climate in the next 12 months is difficult. For long-term El Nino patterns, consult NOAA here:

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

Precipitation During 2012

The precipitation patterns seen in the PRISM maps (Figure 5) are similar to the patterns seen in the weather station data (Figure 4, Table 1). April had generally above average precipitation; December had generally near to slightly below average precipitation, while the other months of 2012 were generally well below average (Figures 4,5; Table 1). Note that precipitation during May – August is very low, and it is therefore easy to misinterpret calculations of “percent normal” for these months. For example, July average precipitation at UCLA is only 0.02 inches.

Table 1. Monthly total precipitation in inches during 2012 in Channel Islands National Park.

Station Name	Stn Type	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR
Anacapa Island	RAWS	0.95	0.11	1.52	1.12	0.02	(-)	(-)	0	0	0.04	1.33	1.03	(-)
Santa Rosa Island	RAWS	0.46	0.61	1.62	2.17	0.03	0.03	0.05	0.01	0.02	0.08	1.17	1.7	7.95
Santa Barbara Island	RAWS	0.29	1.35	1.22	0.31	0.89	0	0.05	0	0	0.44	0.79	0.7	6.04
Santa Cruz Island	RAWS	2.07	0.28	2.07	(-)	(-)	(-)	0	0	0.04	0.82	2.83	2.84	(-)
Santa Rosa Bechers Bay	Manual	(-)	0.71	1.21	2.31	0.02	0	0	0	0.05	0.03	1.85	(-)	(-)
Santa Cruz Scorpion	Manual	(-)	(-)	(-)	2.82	0.05	(-)	0.07	(-)	(-)	0.87	3.38	(-)	(-)
Santa Barbara Island	Manual	0.87	1.22	1.27	(-)	0.14	0.07	0.31	0.04	0.06	0.65	(-)	(-)	(-)
San Miguel Island	Manual	(-)	0.87	(-)	2.61	0.08	0.03	0.15	0.05	0.09	0.05	(-)	(-)	(-)

(-) = insufficient data for an accurate calculation

Temperature During 2012

Within Channel Islands National Park, only the Santa Rosa Island RAWS and the San Miguel manual station had enough data to calculate temperature averages for every month (Figure 4, Table 2). The remaining RAWS and manual stations provided averages for only some months of the year. Despite the limitations in the data from the local weather stations, the temperature patterns observed on the islands are clearly similar to those observed on the mainland (see Tercek 2013), and to those illustrated in the PRISM maps (Figures 6 – 7). Namely, January and August – October had average daily maximum (Tmax) and average daily minimum temperatures (Tmin) well above the 1981 – 2010 averages (note the contrast between the red line and the gray traces from previous years in Figure 4), with some locations more than 6 degrees (F) warmer than normal. In contrast, February – July were generally cooler than average and December had below average Tmax but near-average Tmin (Figures 4-7, Table 2).

Table 2. Monthly average daily maximum temperatures (Tmax) and average daily minimum temperatures (Tmin) during 2012 in degrees Fahrenheit.

Station Name	Parameter	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR
Anacapa Island	Tmax (F)	64.32	61.34	61.71	66.27	77.29	(-)	(-)	68.77	71.13	75.23	77.8	93.48	(-)
RAWS	Tmin (F)	54.26	52.14	50.29	56.17	67.87	(-)	(-)	60.32	62.43	66.1	68.47	86.81	(-)
Santa Rosa Island	Tmax (F)	64.58	59.38	57.77	60.1	59.61	60.93	62.77	72.68	72.57	70.55	65.33	55.68	63.5
RAWS	Tmin (F)	50	46.07	43.45	44.87	44.77	47	49.87	54.13	55.3	56.55	54	46.45	49.37
Santa Barbara Island	Tmax (F)	60.52	56.48	61.03	91.8	(-)	(-)	65.33	69.39	69.47	68.77	65.17	68.74	(-)
RAWS	Tmin (F)	52.9	50.66	53.87	89.67	(-)	(-)	57.53	61.81	63.03	62.23	58.17	61.97	(-)
Santa Cruz Island	Tmax (F)	71.94	67.93	65	(-)	(-)	(-)	(-)	85.26	84.7	80.32	71.27	62.81	(-)
RAWS	Tmin (F)	41.61	42.45	41.34	(-)	(-)	(-)	(-)	57	56.43	54.06	49.77	44.16	(-)
Santa Rosa Island	Tmax (F)	(-)	62.17	60.97	62.7	63.77	65.48	66.48	70.77	70.7	72.77	67.63	(-)	(-)
Bechers Bay Manual	Tmin (F)	(-)	46.86	46.9	48.5	48.39	50.26	52	53.52	53.93	57.13	53.66	(-)	(-)
Santa Cruz Scorpion	Tmax (F)	(-)	66.8	64.9	68.45	69.07	69.5	70.48	73.97	75.07	77.16	70.41	62.99	(-)
Manual	Tmin (F)	(-)	47.24	46.1	49.59	52.64	53.83	55.68	57.83	58.73	57.74	52.86	47.52	(-)
Santa Barbara Island	Tmax (F)	66.55	64.52	65.57	(-)	68.93	70.17	70.61	77.29	76.93	74.81	(-)	(-)	(-)
Manual	Tmin (F)	52.61	51.48	51.5	52.8	54.45	56.21	57.84	62.68	63.7	61.68	(-)	(-)	(-)
San Miguel Island	Tmax (F)	62.58	59.9	60.57	61.0	60.65	62.27	63.18	66.29	66.2	71.5	66.7	58.6	63.3
Manual	Tmin (F)	48.1	47.2	45.8	47.5	48.6	50.2	51.5	53.3	54.4	57.1	54.2	49.3	50.6

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, and during 2012 only the Santa Rosa Island RAWS had enough data to calculate AGDD statistics (Table 3). The reported values of AGDD40 = 6018 and AGDD50 = 2593 are slightly longer (105 – 113%) than the calculated values for 2010 and 2011 (Tercek 2011, 2012).

Table 3. Accumulated Growing Degree Days (AGDD) and days above or below critical temperature thresholds during 2012.

Station Name	Station ID	AGDD40	AGDD50	# days ≥ 80 F	# days ≥ 90 F	# days ≤ 32F
Anacapa Island	RAWS	(-)	(-)	(-)	(-)	(-)
Santa Rosa Island	RAWS	6018	2593.5	33	6	0
Santa Barbara Island	RAWS	(-)	(-)	(-)	(-)	(-)
Santa Cruz Island	RAWS	(-)	(-)	(-)	(-)	(-)
Santa Rosa Bechers Bay	Manual	(-)	(-)	(-)	(-)	(-)
Santa Cruz Scorpion	Manual	(-)	(-)	(-)	(-)	(-)
Santa Barbara Island	Manual	(-)	(-)	(-)	(-)	(-)
San Miguel Island	Manual	5893	2437	10	2	1

(-) = insufficient data for an accurate calculation

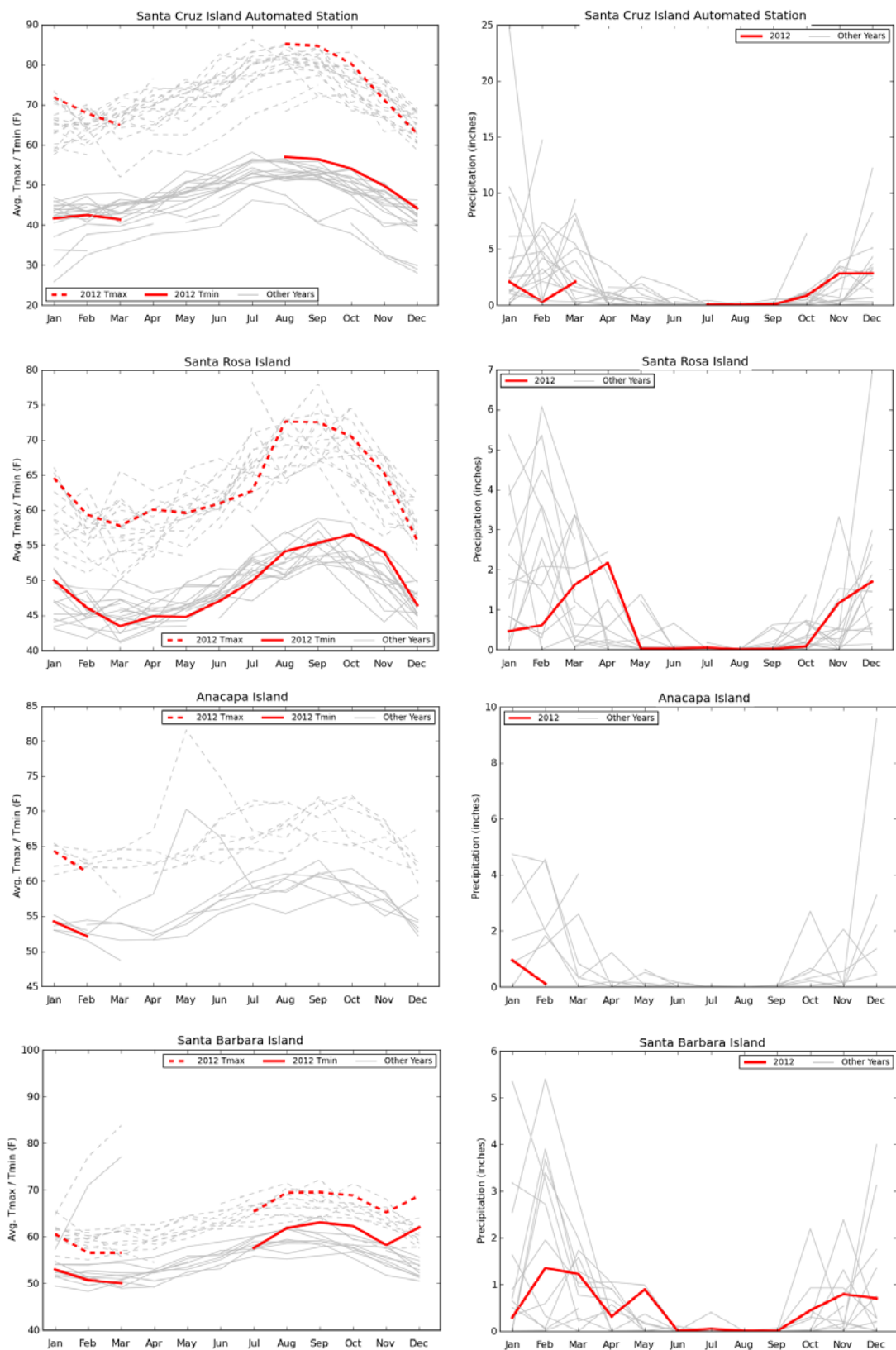


Figure 4a. Monthly precipitation and temperature data collected by RAWs in Channel Islands National Park. Red = 2012 measurements. Gray = other years.

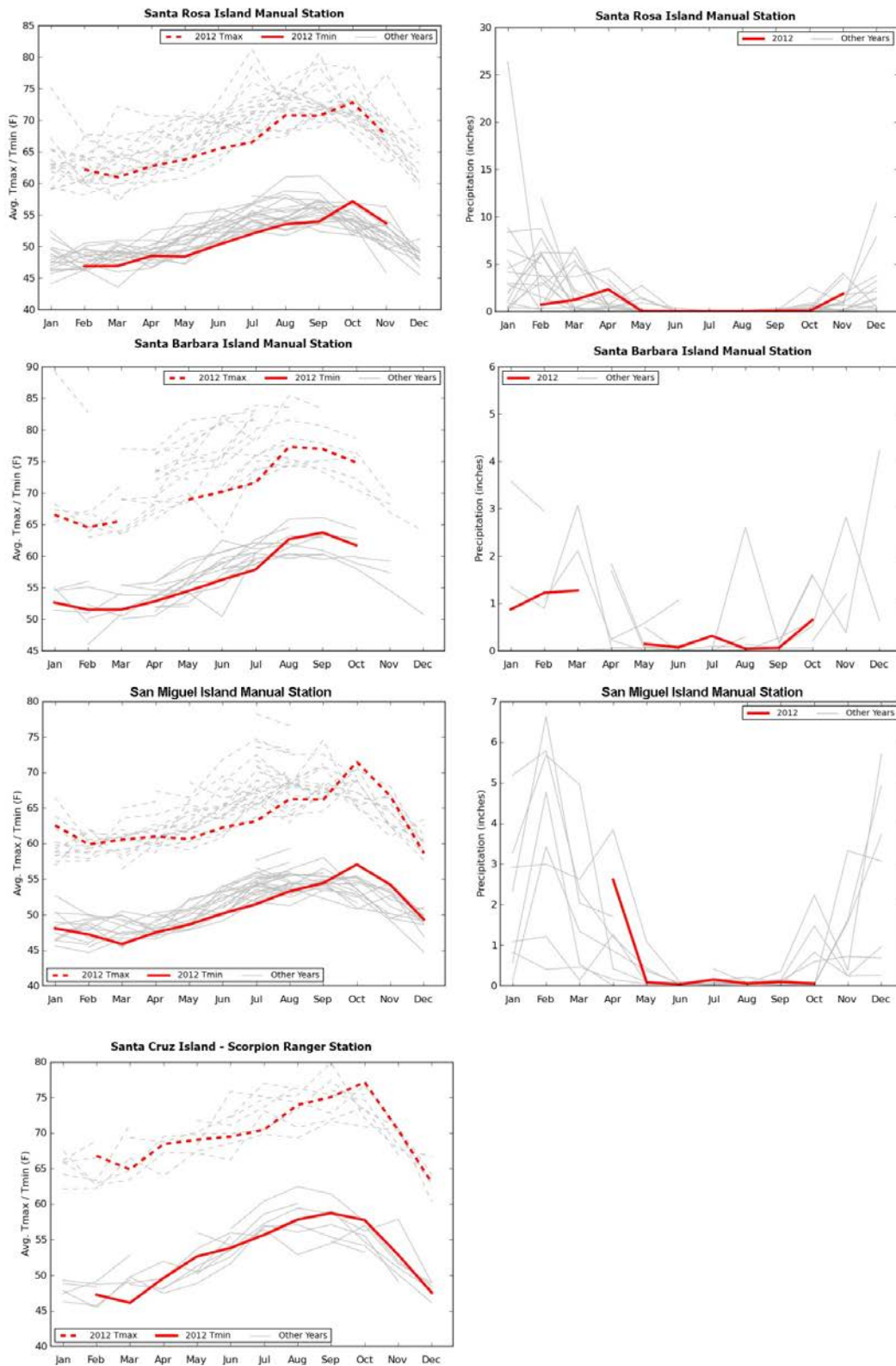


Figure 4b. Monthly precipitation and temperature data collected by manual “ranger” weather stations in Channel Islands National Park. Red = 2012 measurements. Gray = other years. Precipitation data for the Santa Cruz Island – Scorpion data were not complete enough to generate any 2012 summaries.

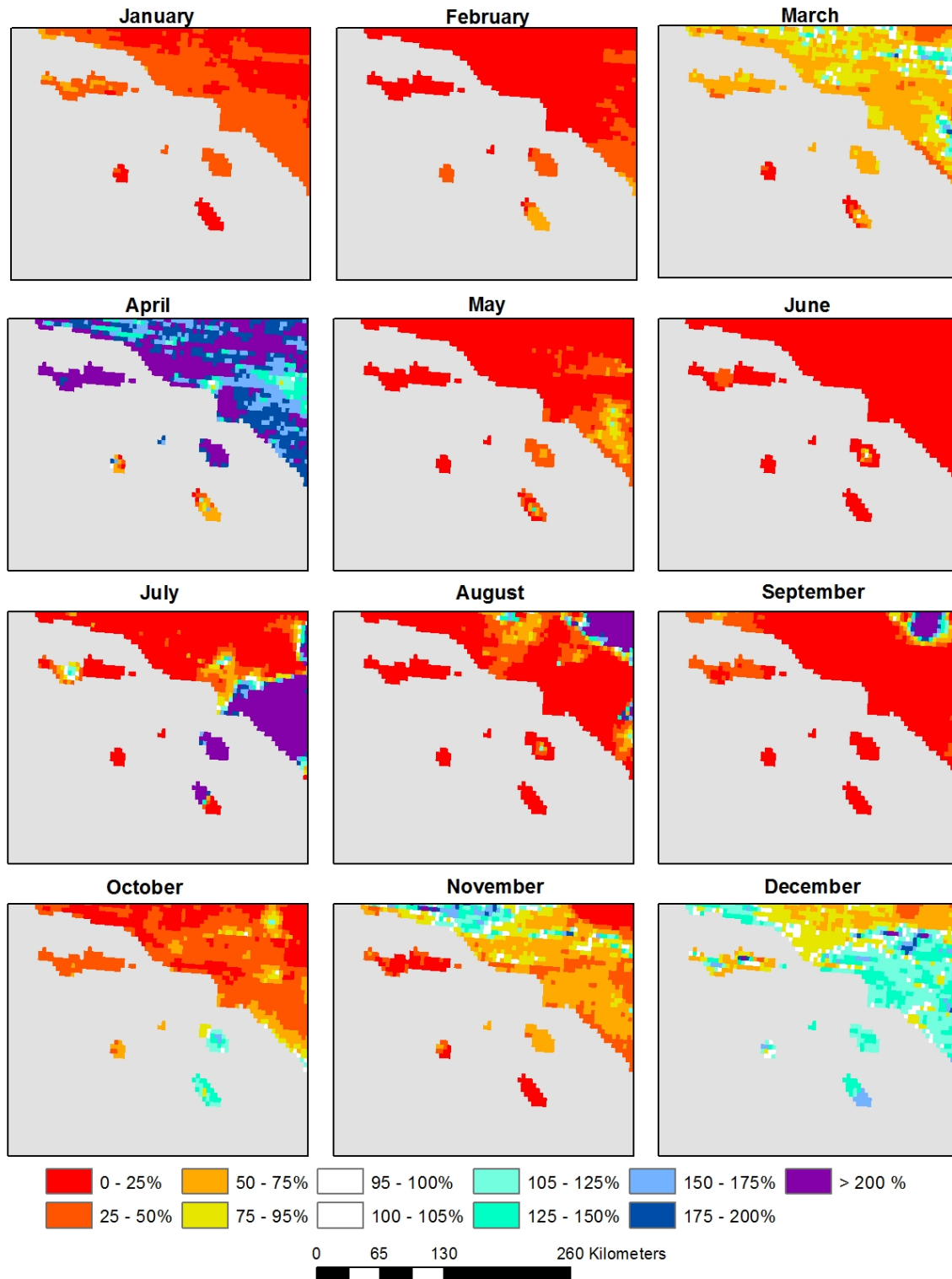


Figure 5. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing monthly precipitation as a percentage of 1981 – 2010 averages. Gray areas = Pacific Ocean. For more information, see <http://www.prism.oregonstate.edu/>.

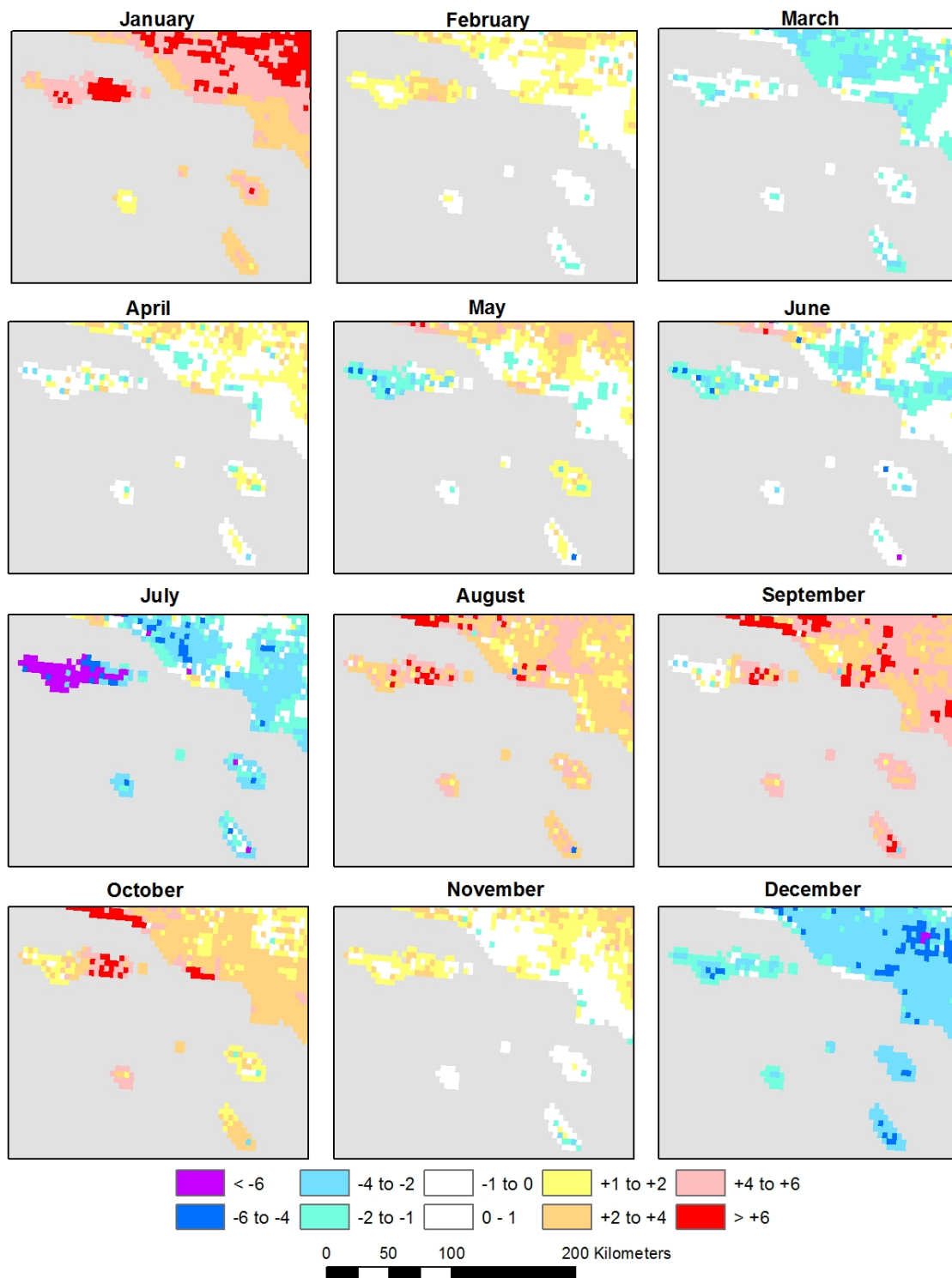


Figure 6. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing monthly average daily maximum temperature (Tmax) departure from 1981 – 2010 averages in degrees Fahrenheit. Gray areas = Pacific Ocean. For more information, see <http://www.prism.oregonstate.edu/>.

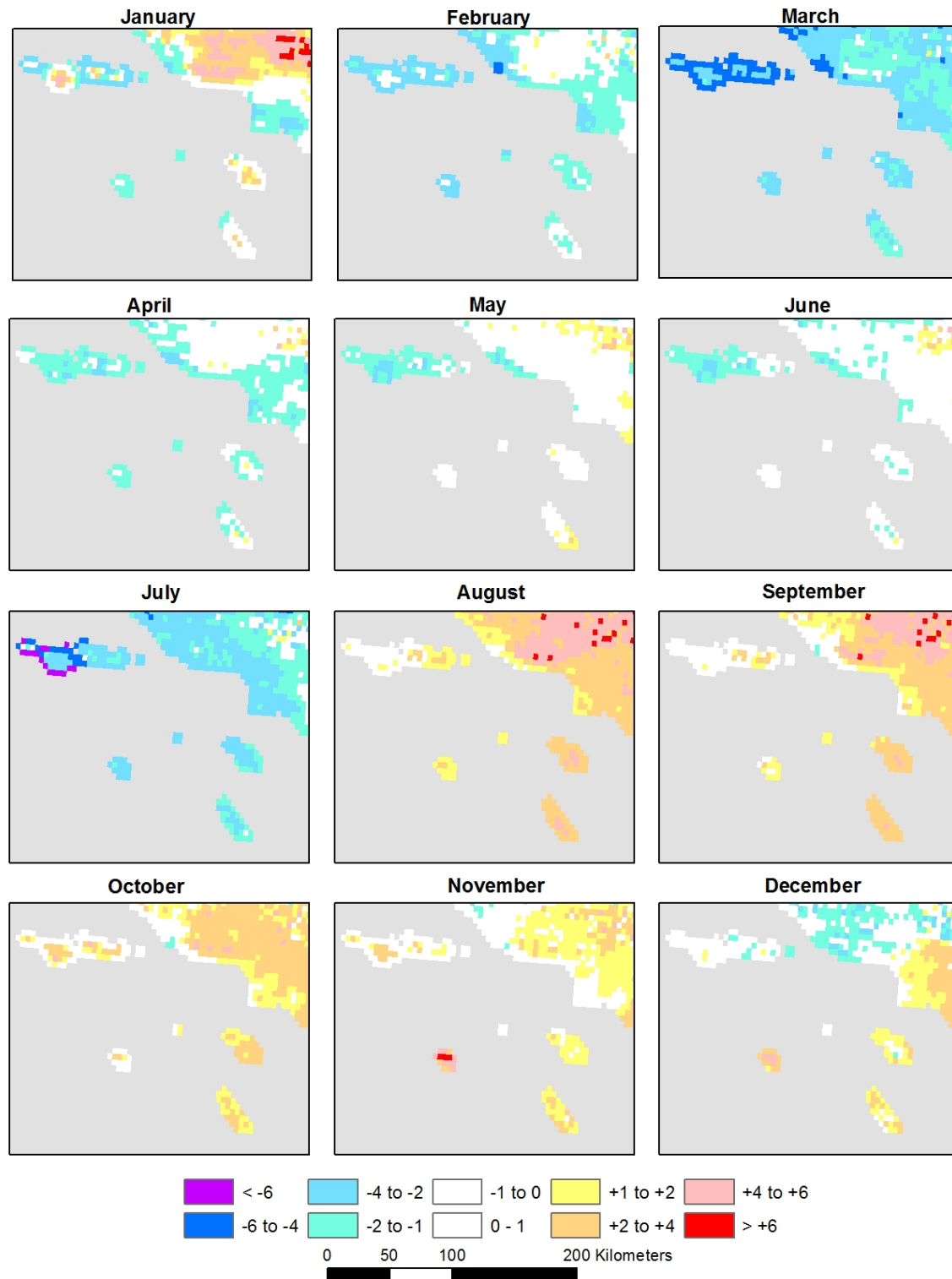


Figure 7. Parameter-elevation Regressions on Independent Slopes Model (PRISM) data showing monthly average daily minimum temperature (Tmin) departure from 1981 – 2010 averages in degrees Fahrenheit. Gray areas = Pacific Ocean. For more information, see <http://www.prism.oregonstate.edu/>.

Wind Speed and Direction

Compared to 2005 – 2010, winds on Santa Barbara Island during 2012 shifted slightly more toward westerlies. None of the differences among 2005 – 2010 vs. 2011 and 2012 appear significant (Figure 8).

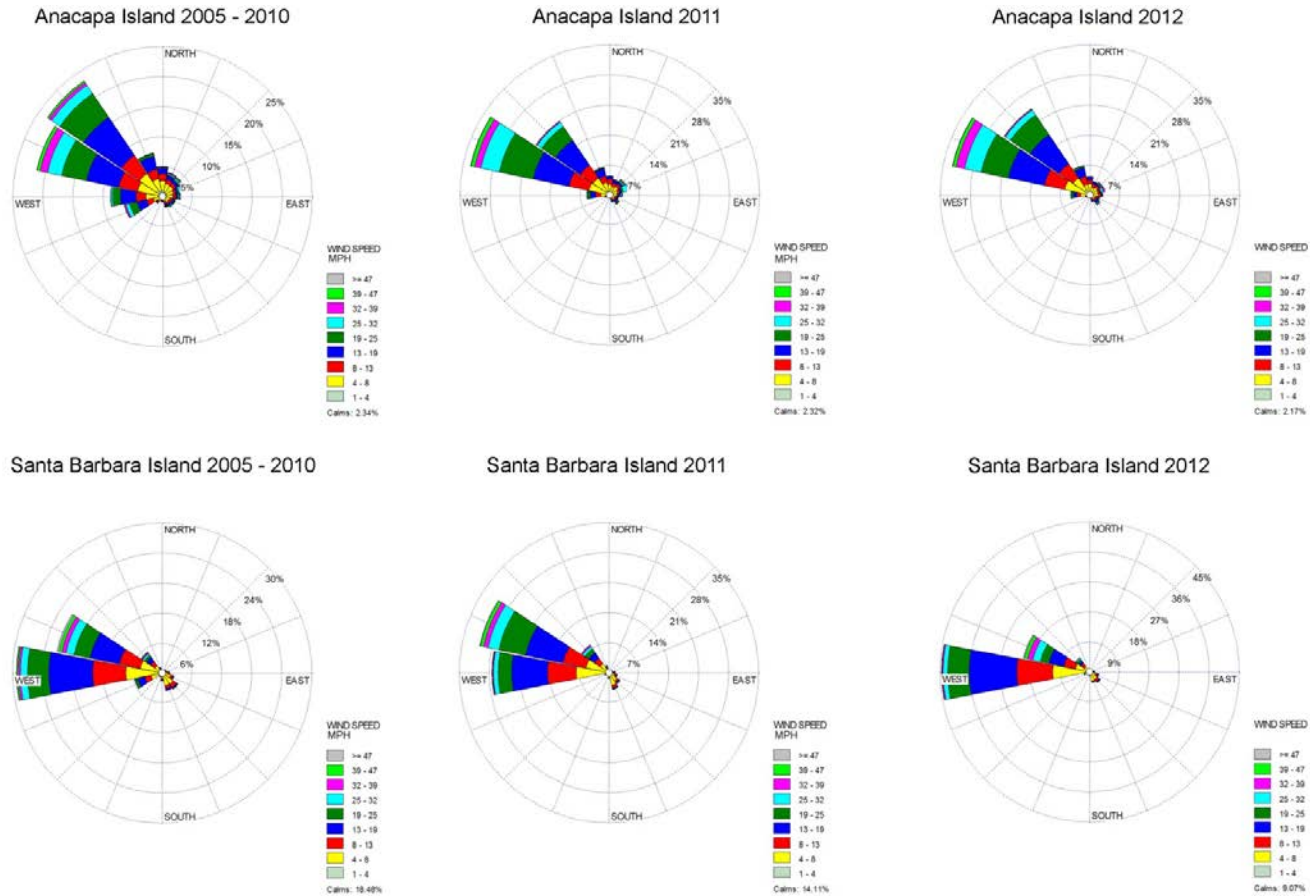
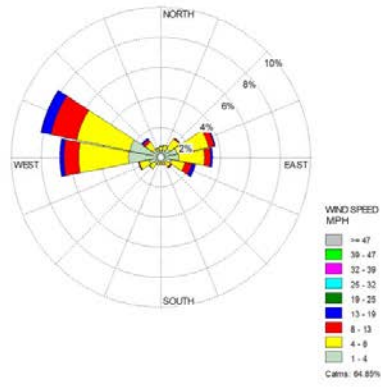
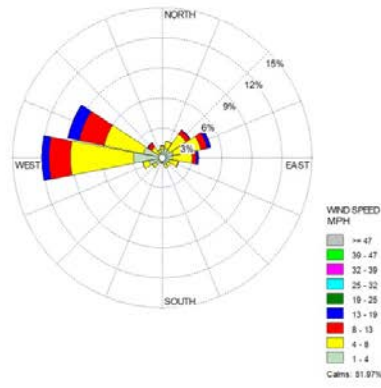


Figure 8. Wind roses for data from RAWS in Channel Islands National Park, contrasting calendar years 2011 and 2012 to the averages for 2005 – 2010. The orientation of a spoke indicates wind direction (compass heading, degrees from which the wind originated), and the length of a spoke indicates the amount of time (%) that wind from a given direction occurred. Colors within the spokes express the amount of time (%) that wind from each direction had the indicated velocity. Speeds are miles per hour.

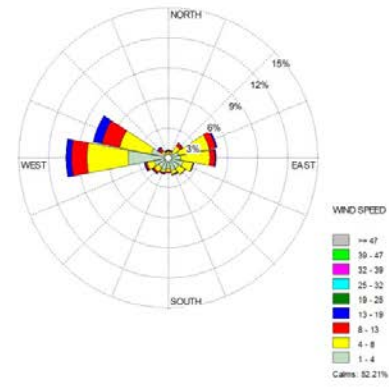
Santa Cruz Island 2005 - 2010



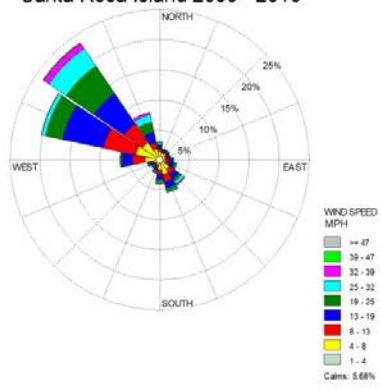
Santa Cruz Island 2011



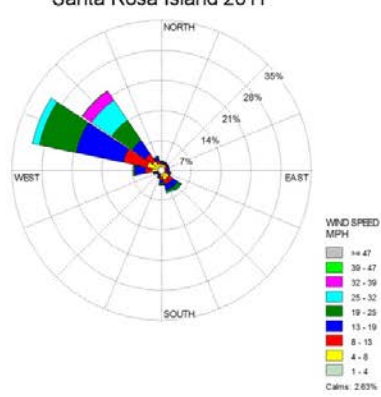
Santa Cruz Island 2012



Santa Rosa Island 2005 - 2010



Santa Rosa Island 2011



Santa Rosa Island 2012

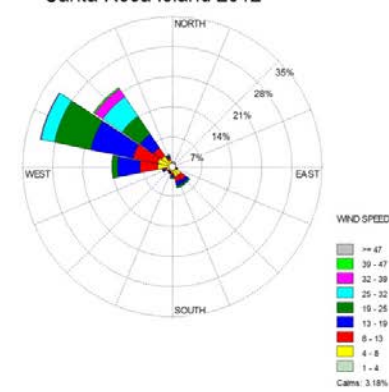


Figure 8. Continued

Conclusions

- After recovering from drought during 2010, the region remained drought free for the entirety of calendar year 2011 (Tercek 2012). Drought free conditions continued throughout the region until below average precipitation in January - March 2012 led to a return of drought in April 2012 (Figure 2).
- Despite the large number of missing measurements, the patterns seen during 1990 – 2012 on Santa Rosa Island are similar to those found on the mainland at the UCLA weather station during 1945 – 2012 (Figure 3), with the same water years scoring as above or below the long-term RDI baseline (positive or negative index values). For example, during the last 5 water years, 2009 – 2010 and 2010 – 2011 were wetter than average while 2007 – 2008, 2008 – 2009, and 2011 – 2012 were drier than average at both locations (Figure 3).
- April had generally above average precipitation; December had generally near to slightly below average precipitation, while the other months of 2012 were generally well below average (Figure 5).
- January and August – October had average daily maximum (Tmax) and average daily minimum temperatures (Tmin) well above the 1981 – 2010 averages (note the contrast between the red line and the gray traces from previous years in Figure 4), with some locations more than 6 degrees (F) warmer than normal. In contrast, February – July were generally cooler than average and December had below average Tmax but near-average Tmin (Figures 4 - 7, Table 2).

Literature Cited

- Allen, R., L. Pereira, D. Raes, and M. Smith. 1988. Crop evapotranspiration – guidelines for computing crop water requirements – FAO irrigation drainage paper 56. Available from this Internet address: <http://www.fao.org/docrep/X0490E/X0490E00.htm>
- 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.
- Davey, C. A., K.T. Redmond, D.B. Simeral. 2006. Weather and climate inventory National Park Service North Coast and Cascades Network. Natural Resource Technical Report NPS/NCCN/NRTR—2006/010. National Park Service, Fort Collins, Colorado.
- 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, USA.
- 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, USA.
- McEachern, K., P. Power, L. Dye, and R. Rudolph. 2008, Weather and climate monitoring protocol, Channel Islands National Park, California: U.S. Geological Survey Techniques and Methods 2–B1, 16 p.
- Redmond, K. and G. McCurdy. 2005. Channel Islands National Park: Design Considerations for Weather and Climate Monitoring. WRCC Report 05-02 July 2005, Western regional Climate Center Desert Research Institute, Reno, Nevada. 111 pps.
- 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.
- Tercek, MT. 2011. Channel Islands National Park – Climate of 2010. Report submitted to the National Park Service Mediterranean Coast Inventory and Monitoring Program.
- Tercek, MT. 2012. Channel Islands National Park – Climate of 2011. Report submitted to the National Park Service Mediterranean Coast Inventory and Monitoring Program.

Tercek, M.T. 2013. Santa Monica Mountains National Recreation Area – Climate of 2012. Report submitted to the National Park Service Mediterranean Coast Inventory and Monitoring Program.

Tsakiris, G. and H. Vangelis. 2005. Establishing a drought index incorporating evapotranspiration. *European Water* 9/10: 3 - 11

Appendix 1

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

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

Appendix 2

SBI

04/25/2013 11:34 Rocky Rudolph:
On April 2nd, 2013 Renee Robison swapped out malfunctioning RH/AT sensor.

07/16/2012 15:33 Rocky Rudolph:
7/1/12 Kris R. installed HMP45 and it now works fine.

06/25/2012 15:21 Rocky Rudolph:
On June 22 2012, R. Rudolph took marine patrol boat to SBI to swap DCP, RH/AT cable, and solar rad sensors. Equipment swap went well, but RH/AT sensor was still reading in the 90s, so it was taken and sent to RAWs on 6/26/12 via UPS. RAWs depo needs this failing sensor before it can be refurbished and sent back.

05/30/2012 12:10 ASANNICO:
Prep DCP for this station:
Asset# 122157
SN# 007179 old# 002921
Prog: G8-1109

05/07/2012 15:52 Rocky Rudolph:
On 5/3/2012 Sarah T. disconnected the RH/AT. She noticed the cable was separated from the threaded connector. This may have been from her method of cable removal or from a larger problem with the cable being defective. The sensor is now reading -32 degrees.

03/30/2012 11:54 Rocky Rudolph:
On 3/28/12 DCP was swapped by Rocky R. and Andrew Y. due to errors in Solar Rad and AT. On 3/29/12 the station was still not sending to WRCC, but Jim at the helpdesk said he was seeing transmission at 16:13:12. However, the tipping bucket was very slow to register (would tip but force scan would show the tip several minutes later). Also, the air temp was wrong (91 degrees or 32767). Checked tipping bucket with ohms multimeter and it was working correctly. Unplugging and replugging the tipping bucket cable would register the tips sooner. Next step is to order new RH/AT.

03/02/2012 10:54 BHOLLAND:
DCP prepared, sn 002921, program G8-1109

02/27/2012 14:57 Rocky Rudolph:
Feb 22nd, 2012 at 3pm Rocky R., Tim H., and Nicole S. serviced station for annual maint. Swapped GPS, GOES antenna, solar rad, solar panel, tipping bucket, WS/WD x-arm, and all cables for devices serviced. Solar radiation sensor still not reading correctly after swap.

01/11/2012 13:45 Rocky Rudolph:
At approx. noon at Jan 6, 2012, island tech Andrew Y. replaced malfunctioning RH/AT sensor and cable. Out: serial 0111. In: serial R18018.

ANI

01/14/2013 15:13 Rocky Rudolph:
On 1/9/2013 R. Rudolph replaced HMP RH/AT sensor. Readings that were in the 90's were back to normal after the switch.

07/18/2012 11:37 Rocky Rudolph:

On July 11-12, 2012 R. Rudolph conducted full replacement: DCP, GPS, Tipping bucket, FM/FT, RH/AT, Ultrasonic WS/WD, Goes, solar panel, solar rad, and all cables. Station now has HMP45 RH/AT with DCP program. Station was fully transmitting in WFMI. External plastic DCP case did not fit new DCP, so DCP is fully exposed to elements at this time. Need to go back to wrap in plastic bag as temporary protection.

07/06/2012 13:30 ASANNICO:

Prep DCP for this station:

Asset# 107967

SN# 007022 old# 6836

Time/Ch 00:23:20/160

Prog: G2-UB6R10-0712

06/25/2012 06:28 TMAIONE:

Updated parts and PM lists

SCI

07/10/2012 16:55 Rocky Rudolph:

On 7/9/12 C. Cowan replaced RH/AT with HMP45 model that now works with the DCP program. Readings look good.

07/05/2012 14:42 Rocky Rudolph:

7/3/12: R.R. visited station to install DCP program to use older 435C RH/AT, but due to technical difficulties was not able to load the program. Now the plan is to just order an HMP45 sensor and have Clark install it. The DCP is already programmed for this sensor, so no DCP program installation will be necessary.

07/02/2012 14:57 Robert Holland:

Emailed program G8-435C-0712

07/02/2012 10:56 Rocky Rudolph:

6/27/12 R. Rudolph visited to troubleshoot DCP. With support of helpdesk, the wrong settings were entered. We changed NESDIS ID and other settings. After the next transmission cycle, the station transmitted but had problems with RH/AT. It was determined that the wrong sensor was programmed for that DCP. The 435C is installed, but the DCP is programmed for a 435A. Another station visit will be needed to install the new program.

07/02/2012 10:47 Rocky Rudolph:

6/17/12 R. Rudolph and Andrew R. replaced DCP. Was not transmitting afterwards. It was determined that there was a communication issue and will need to revisit the station with more diagnostic troubleshooting.

06/29/2012 07:35 TMAIONE:

Updated parts and PM

04/25/2012 16:36 Rocky Rudolph:

On 4/24/12 Rocky R. visited the Main Ranch RAWS station to investigate intermittent readings. It appeared that the battery was losing charge

because
it was only transmitting at around noon, when peak sunlight could power the station for transmits. At the visit, with help from the Helpdesk, we discovered that it was faulty transmission signals and not likely low power or poor performing battery. A new DCP will be needed. When ordering, note the 35 style GPS needed for the program and to test a transmit message when installing the new DCP.

04/25/2012 16:28 Rocky Rudolph:
On 3/13/2012 SAMO fire crew changed out the following sensors
tipping bucket
wind speed, wind direction and crossarm
RH/Air temp
GOES antenna
Solar Radiation
GPS
New cables for all sensors

Tipping bucket was reset to zero on 3/13/2012
DCP was powered down and back up to reset the GPS
Station was in good condition. Fuel temp/fuel moisture sensor was sent out but
there isn't one programmed into the DCP for this station

SRI

07/02/2012 11:27 Rocky Rudolph:
6/27/12 Ed Smith installed new RH/AT sensor and now RH is working again.

06/29/2012 08:03 TMAIONE:
Update parts and PM lists

04/25/2012 16:41 Rocky Rudolph:
3/20/2012 SAMO fire crew changed out the following sensors

tipping bucket
wind speed, wind direction and crossarm
RH/Air temperature
GOES antenna
Solar Radiation
Fuel temp/fuel moisture
New cables for all sensors

Regular GPS was sent out but station has an Omni Sat GPS antenna instead so it wasn't replaced
Tipping bucket was reset to zero on 3/20/2012 - previous year amount was 10.42

Mice had knocked free the steel wool that had been placed to keep them out of the box and had made a nest. The nest was removed and the steel wool was replaced and duck taped in place to try and keep them out. The outer sheath of the wire to the Omni Sat antenna had been chewed on a little bit but had not

been compromised yet.

Turnbuckles on the tensioning wires for the mast are rusted and not functional.

They need to be replaced.

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 159/126202, August 2014

National Park Service
U.S. Department of the Interior



Natural Resource Stewardship and Science

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA TM