



Annual Weather/Climate Data Summary 2011

Pacific Island Network

Natural Resource Data Series NPS/PACN/NRDS—2013/492



**ON THIS PAGE**

Kaaha campground on the Pacific Ocean has entirely different weather patterns than Mauna Loa (on the cover). The Pacific Ocean is a huge influence on the island climate and weather patterns.
Photograph courtesy of Hawaii Volcanoes National Park, Hawaii.

ON THE COVER

Mauna Loa, translated from Hawaiian means “Long Mountain”. This active volcano stands 13,677 feet, last erupting on March 25, 1984. The cloud pattern is typical of the inversion layer caused by elevation and wind patterns. Due to climate change, the inversion layer is thought to be moving upward, causing habitat changes for many organisms.
Photograph courtesy of Hawaii Volcanoes National Park, Hawaii.

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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.

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Abstract/Executive Summary

Weather station data is presented for nine of the national parks in the Pacific Island Network (PACN). In 2012, seven of nine new Campbell Scientific (CS) stations were set up and have been recording data since February (Hawaii) and March (American Samoa). Data from these stations will be incorporated into the next report. An additional station at Kalaupapa National Historical Park and American Memorial Park will be established in 2013.

The report contains general information on Pacific physical weather phenomena including ENSO (El Niño/La Niña Southern Oscillation). Abbreviated hurricane and tropical cyclone data are presented for the Pacific basin. Large storms geographically adjacent to islands with a national park are summarized.

The results of each national park's weather stations are grouped. No stations in this year's report are within the boundaries in the National Park of American Samoa (NPSA) and American Memorial Park (AMME). Stations that have sufficient data and are within about 10 miles of a national park have been summarized.

Each station begins with a bold heading line that gives the station's most recent name, station type (COOP or RAWS), its WRCC identification number and the abbreviation for the park with which it is associated. A second line under the first gives all of the previous known names discovered by the author.

The Hawaii Drought Monitor is presented after the data.

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Acronyms

ALKA	Ala Kahakai National Historic Trail
AMME	American Memorial Park
COOP	Cooperative Observer Program
CS	Campbell Scientific
DRI	Desert Research Institute
ENSO	El Nino Southern Oscillation
GOES	Geostationary Operational Environmental Satellite
GPMN	Gaseous Pollutant Monitoring Network
HALEnet	Haleakala Climate Network
HAVO	Hawaii Volcanoes National Park
hPa	HectoPascal
IQR	Interquartile Range
KAHO	Kaloko-Honokohau National Historical Park
KALA	Kalaupapa National Historical Park
Ly	Langley
MS	Microsoft
NAS	Naval Air Station
NCDC	National Climatic Data Center
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPHQ	National Park Headquarters
NPS	National Park Service
NPSA	National Park of American Samoa
NRPM	Natural Resources Publications Management
NWS	National Weather Service
PACN	Pacific Island Network
PDO	Pacific Decadal Oscillation
PEAC	Pacific ENSO Application Climate Center
PUHE	Puukohola Heiau National Historic Site
PUHO	Puuhonua o Honaunau National Historical Park
RAWS	Remote Automated Weather Stations
SST	Sea Surface Temperature
TC	Tropical Cyclone
USGS	United States Geological Survey
VALR	World War II Valor in the Pacific National Monument
WRCC	Western Regional Climate Center
WSMO	Weather Service Meteorological Office
WSO	Weather Service Office

Introduction

Weather/climate monitoring is one of several long-term Vital Sign monitoring efforts of the Pacific Island Network (PACN). Climate and weather affect virtually all of the measured Vital Signs. Climate and weather affect benthic marine communities: warmer ocean temperatures affect coral growth and permutations can affect whole reef ecosystems. Climate/weather variations affect how invasive species fare in a terrestrial plant community. Precipitation directly affects groundwater dynamics, freshwater animal communities, and water quality. Land and sea birds are affected by the changes in seasons: rain and temperature signal insect breeding and abundance, which often precipitate breeding in many birds (Hogan 2010).

One of the primary goals of climate and weather monitoring is to determine the status and trends of weather patterns and long-term climate regimes, so managers can make informed decisions about the conditions of each national park. Similarly, monitoring of weather and climate may provide early warning of abnormal conditions.

Annual reports summarize data for a previous year and provide information from relevant weather stations. Long-term means determined by collected data and normals published by WRCC are compared to annual data for precipitation and temperature when available.

The weather and climate information for the PACN are primarily derived from two weather data collection systems. Remote Automated Weather Stations (RAWS) provide data gathered by automated instruments. The data are sent every 60 minutes to the Geostationary Orbit Environmental Satellite (GOES), which then sends the data to the Western Regional Climate Center (WRCC) and Desert Research Institute (DRI) for verification and publication on the Internet. We also use data from the Cooperative Observer Program (COOP). Individuals gather the data daily. National Oceanic and Atmospheric Administration (NOAA) personnel manage these stations. The data recorded are mainly precipitation and temperature, which is sent manually to the WRCC. The data are verified and available on the internet from the WRCC.

Climate is generally mild on our monitored Pacific islands. Weather patterns in the national parks are largely controlled by island geomorphology and the surrounding Pacific Ocean. The ocean temperatures vary only about six degrees throughout the year, from lows near 73° or 74° in March to 80° in August (PEAC 2010). Because there are no continents nearby, weather systems are moderated by the ocean.

Seasons are not strongly differentiated. Two seasons prevail in Hawaii, summer (April through October) and winter (November through March). Dry and wet seasons somewhat correlate with summer and winter, respectively. The wet season (winter) in American Samoa is from October through April and from July through November in the Marianas Islands (Saipan and Guam).

Interestingly, in Hawaii, the coldest months are not December and January as they are in the continental United States, but January and February. Cold winds come from the Arctic but the lower temperatures arrive one to two months later due to the lag in the Pacific Ocean's temperature (PEAC 2011).

The hottest months are also delayed, rather than the traditional continental high temperatures in June (7 states), July (34 states), and August (10 states) (NOAA 2011). Hawaii has the hottest days varying from July to September (PEAC 2011).

PACN national parks are located in Hawaii, Guam, The Commonwealth of the Northern Mariana Islands (Saipan), and American Samoa. (Table 1, Figure 1).

Table 1. National parks in the Pacific Island Network (PACN).

National Park	Island	Total size in acres (marine portion)	Terrestrial Elevation Range sea level to:
War in the Pacific National Historical Park (WAPA)	Guam	1,980 (990)	1,043 ft. (316 m.)
American Memorial Park (AMME)	Saipan	143 (0)	9ft. (3m.)
National Park of American Samoa (NPSA)	Tutuila, Ofu-Olosega, Tau	14,616 (5,261)	3,169 ft. (960 m.)
World War II Valor in the Pacific National Monument (VALR)	Oahu	17 (5)	75 ft. (23 m.)
Kalaupapa National Historical Park (KALA)	Molokai	11,251 (2061)	4,222 ft. (1279 m.)
Haleakala National Park (HALE)	Maui	29,032 (0)	10,022 ft. (3037 m.)
Ala Kahakai National Historic Trail (ALKA)	Hawaii	TBD	400 ft. (121 m.)
Puukohola Heiau National Historic Site (PUHE)	Hawaii	86 (7)	170 ft. (51 m.)
Kaloko-Honokohau National Historical Park (KAHO)	Hawaii	1,188 (536)	79 ft. (24 m.)
Puuhonua o Honaunau National Historical Park (PUHO)	Hawaii	571 (0)	899 ft. (272 m.)
Hawaii Volcanoes National Park (HAVO)	Hawaii	333,817 (0)	13,678 ft. (4145 m.)

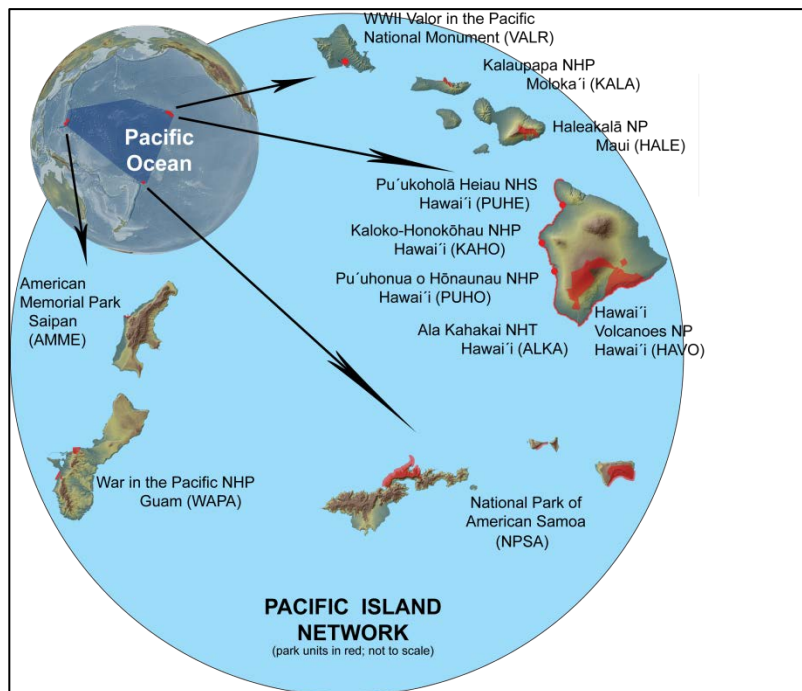


Figure 1. Map showing the extent of the Pacific Island Network; red areas indicate national park units.

Pacific Atmospheric Phenomena

Climate and weather across the Pacific are affected by many atmospheric phenomena. The following information was summarized from a variety of sources. Specifically, these phenomena and their sources include: the Hadley Cell, (NASA 2009, Windrim 2004), the Walker Circulation (Weier 2003, NOAA 2007), ENSO (PEAC 2011, Chu 2004, Chu and Wang 1997, Ropelewski and Halpert 1987, Lander and Guard 2003, and Lander 2004), Kelvin Waves (NASA Science 2005, NOAA 2006b), the Madden-Julian Oscillation (NOAA 2006a, Madden and Julian 1994), tropical cyclones/hurricanes (Angove and Falvey 2012) and the Pacific Decadal Oscillation (PDO) (JISAO 2000).

The Hadley Cell circulation pattern (Figure 2) accounts for thermal movement of air latitudinally from the Equator to the Tropic of Cancer and Tropic of Capricorn. Solar radiation is the largest cause of atmospheric circulation on Earth. As the air at the Equator heats, the warm air rises and moves up to about 17 kilometers (11 miles/58,080 feet) high at the tropopause (Figure 4). The air then moves northward and descends at roughly 30° latitude north and south, depending on the season. After descending, it moves towards the Equator near the surface. With the addition of the Coriolis Effect (Figure 3), caused by the rotation of the Earth on its axis, the trade winds are born. Coriolis action on the winds aloft creates the jet stream. The whole system also moves north and south with the seasons, as far as 23.5° north and south latitudes. Hawaii's national parks are located between 18 – 21° north latitude. Guam is 13° north latitude and Saipan is 15° north latitude. American Samoa is 14° south latitude.

The Intertropical Convergence Zone, (ITCZ) is where the north and south trade winds converge at the ocean surface near the Equator. This band of merging air masses creates a band of

thunderstorms across the Earth's surface (Figures 5 and 6). Further north and south, the Ferrell Cell (Figure 4) operates in the 30-60° latitudes; the circulation pattern is roughly the opposite of the Hadley Cell, although there are marked differences due to the Westerlies which are subject to passing weather systems and high and low pressure cells. It is not a closed system like the Hadley Cell and the Polar Cell.

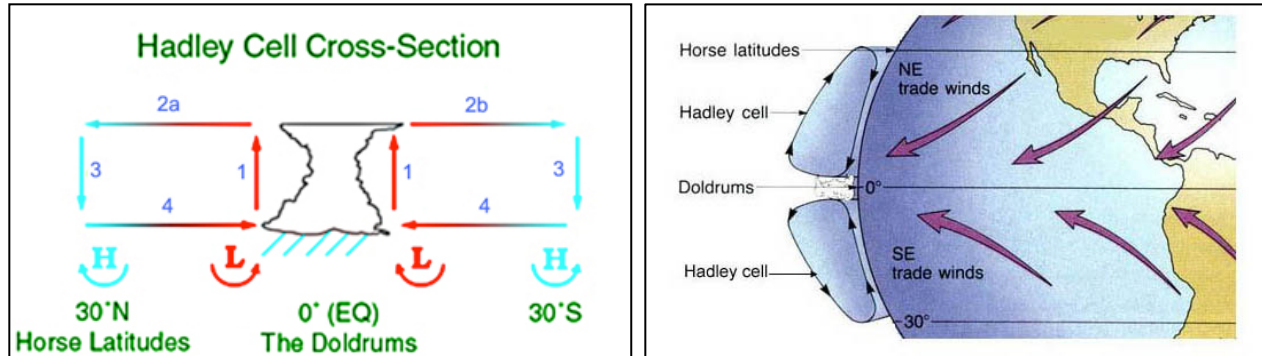


Figure 2. Hadley Cell Cross-Section and location of Hadley cell between the Tropic of Cancer and the Tropic of Capricorn (23° 26' north and south latitudes (Windrim 2004)).

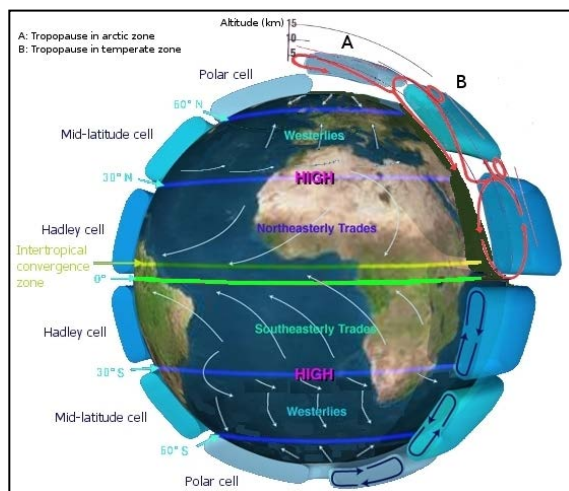


Figure 3. Illustration of the Earth's thermal circulation patterns (highly stylized) with the Coriolis Effect considered (NASA 2009).

The Hadley, Ferrel, and Polar cells are mainly latitudinal systems. There is also a longitudinal component to the Earth's circulation system. These patterns are largely due to the difference in the solar absorption and dissipation between water (oceans) and land. Oceans have a larger heat capacity and absorb and release more heat than land, but the temperatures are less extreme than land. Land temperatures have a much higher difference between day and night. This creates an imbalance that affects longitudinal weather and climate patterns. This atmospheric phenomenon is also what causes sea breezes in the morning. The cooler air from the ocean (sea breeze) comes in as the warmer air above the land rises as it is heated during the day. At night, the land temperatures cool faster than the ocean and cool winds go out to sea (land breeze).

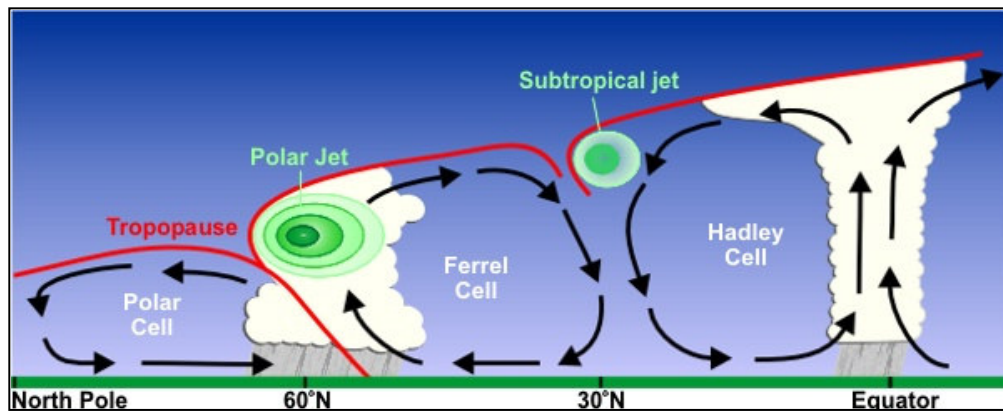


Figure 4. A cross-section of the Earth's atmosphere showing the tropopause, the boundary between the troposphere and the stratosphere (NOAA 2008).

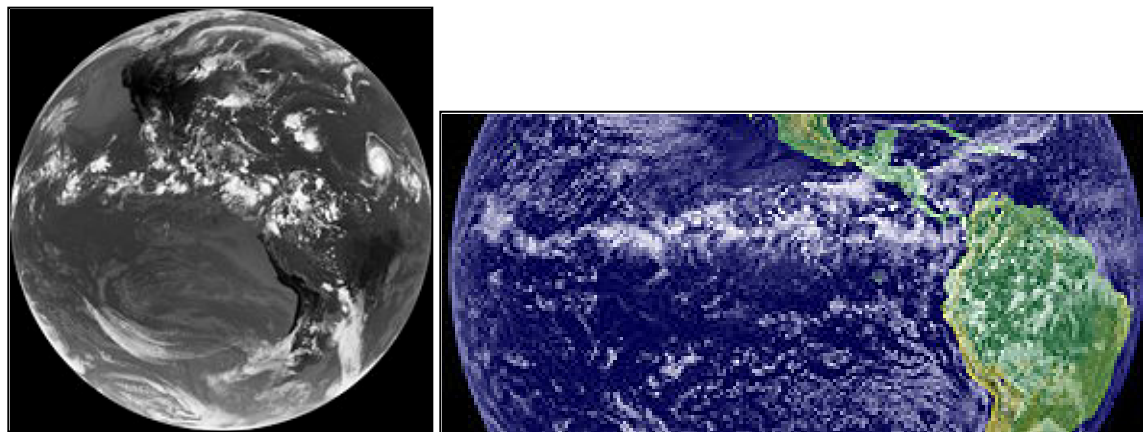


Figure 5. Satellite imagery of the Intertropical Convergence Zone, where the north and south trade winds converge, creating a band of thunderstorms, near the equator (NOAA-NASA GOES project 2011).

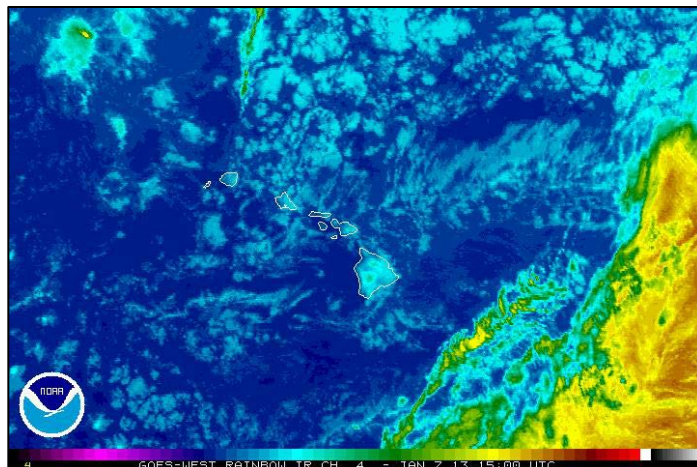


Figure 6. Rainbow color infrared imagery on cloud patterns from the lower to mid right indicates the Intertropical Convergence Zone phenomena near the Hawaiian Islands (mid-screen) (NOAA 2013.)

Walker Circulation

The Pacific Ocean generates weather patterns by differences in temperature from the east to the west Pacific. This tremendous system is called the Walker Circulation (Figures 7 and 8) and also influences weather patterns in the Atlantic and Indian oceans. This system of circulation is across the Equatorial Pacific and in the troposphere. It is caused by differences in the heat distribution between ocean and land (NOAA 2007).

The Walker circulation transports air east and west along both sides of the equator. Air currents rise high above the warm pool over the far western Pacific and the Indian oceans and then flow east towards the coasts of the Americas. The air currents then descend and travel west, skimming the surface of the Pacific and help create the trade winds (Weier 2003).

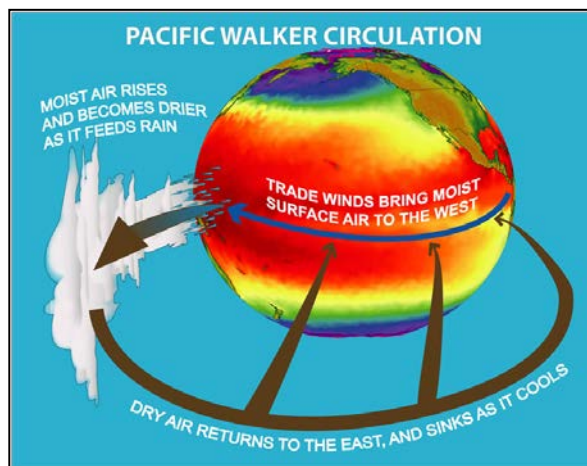


Figure 7. The Walker Circulation pattern across the Pacific Ocean (NOAA Geophysical Fluid Dynamics Laboratory 2001).

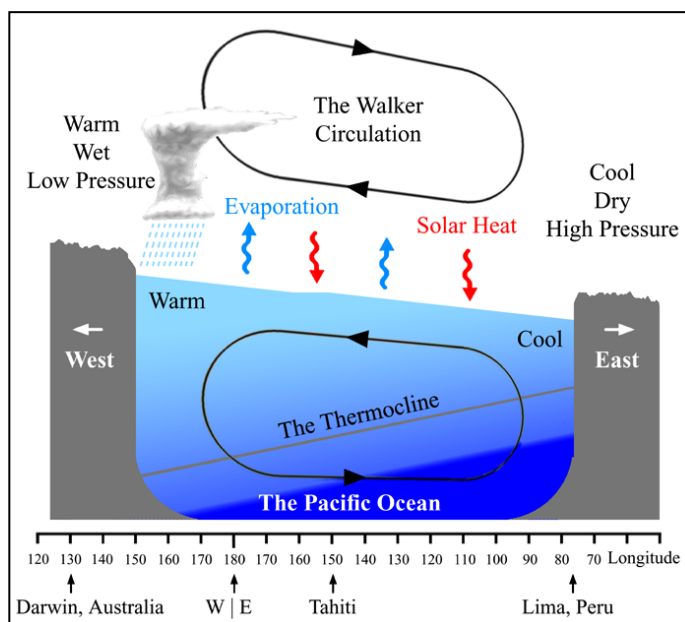


Figure 8. Schematic diagram of the quasi-equilibrium and La Niña phase of the southern oscillation.

The Walker Circulation is seen at the surface as easterly trade winds which move water and air warmed by the sun towards the west. The western side of the equatorial Pacific is characterized by warm, wet, low-pressure weather as the collected moisture is dumped in the form of typhoons and thunderstorms. The ocean is about 60 cm (23.6 in.) higher in the western Pacific as the result of this motion (PEAC-NOAA 2011). This sea level rise is associated with warmer water at the ocean's surface. Wherever this warm water moves across the Pacific, sea levels are higher. The water and air are then returned to the east. Both are now much cooler, and the air is much drier. An El Niño episode is characterized by a breakdown of this water and air cycle, resulting in relatively warm water and moist air in the eastern Pacific (NOAA 2001).

El Niño/La Niña Southern Oscillation (ENSO)

Another atmospheric phenomenon that affects weather and climate in the PACN is the El Niño/La Niña Southern Oscillation (ENSO). ENSO is responsible for cyclical weather patterns in the Pacific. El Niño and La Niña are determined by the sea surface temperature (SST) compared to a normal temperature across the central and eastern Pacific. It is a periodic function across the Pacific Ocean that follows an approximate two to seven year pattern. Within this cycle are often seven to nine month cycles called "conditions". When the cycles occur longer than this they are called "episodes" (PEAC 2011).

La Niña is the cold phase of ENSO where colder SST occur in the eastern Pacific then migrate west (Figures 8 and 9). The intense rains move to the west, causing dry conditions in the east. The start of La Niña is often an increase in the strength of the trade winds. This increases the abundance of tropical cyclones in the western Pacific, although the opposite happened in 2011.

During normal and La Niña conditions, water is concentrated in the western tropical Pacific, where it is essentially "piled up" by easterly winds pushing sun-warmed ocean waters in from as far away as South America. This maintains a comparatively thick layer of warm water called the "warm pool" in the Western Pacific, also causing sea levels there to be slightly higher than in the east (PEAC 1997). In the Commonwealth of the Northern Mariana Islands, on Saipan (AMME) and Guam (WAPA), very dry conditions prevail in the year following an El Niño (Ropelewski and Halpert 1987, Lander and Guard 2003, Lander 2004).

In American Samoa (NPSA), rainfall increases during all seasons of an El Niño year. In the following year rainfall is also increased, but to a lesser extent in all seasons except during summer when it is slightly decreased (PEAC 2011).

In Hawaii (HAVO, KAHO, PUHO, PUHE, ALKA, HALE, VALR, KALA), tropical cyclone activity in the Pacific Ocean is also affected by ENSO (Chu 2004). For example, tropical cyclones occurred near Hawaii during El Niño years with fewer storms during La Niña years (Chu and Wang 1997).

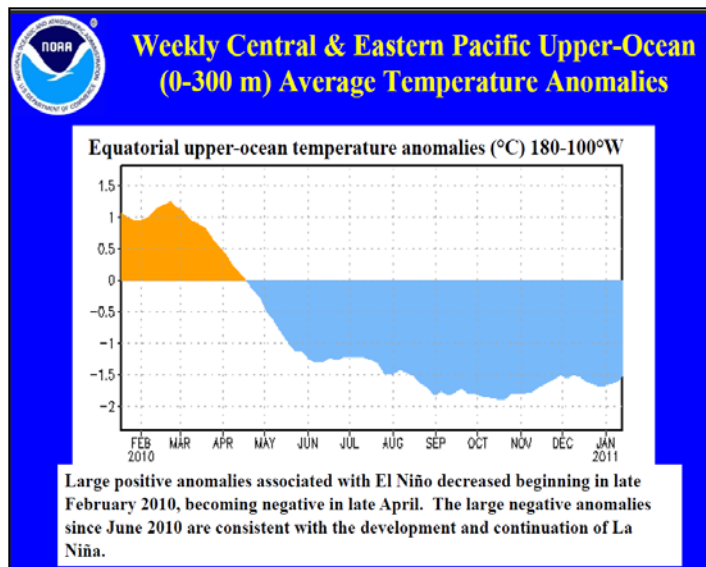


Figure 9. La Niña began in mid-April 2010 (NOAA 2011).

Kelvin Waves

Named for the discoverer of both equatorial and coastal waves, Lord Kelvin's wave is both atmospheric and oceanographic. It is the force balancing the Coriolis affect, and brings warm water from the west Pacific to the east. Normal conditions across the Pacific have trade winds blowing easterly pushing warm sun drenched waters from the Americas towards Indonesia. When the winds falter, reverse, and eddy for months, the water slides back to the east, and the El Niño Southern Oscillation occurs. These relatively warm subsurface waves of water a few centimeters high and hundreds of kilometers wide (Kelvin waves) (NASA Science 2005) (Figure 10) start to move across the Pacific from west to east. This warmth takes the cloud masses with it, lessening the chance of rain in the west and increasing the chance of rain in the east.

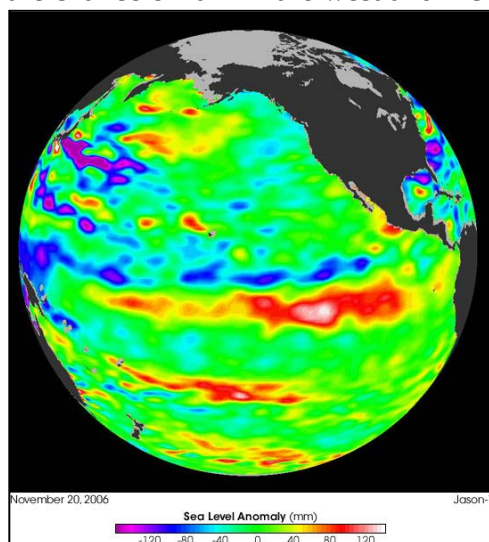


Figure 10. During El Niño Southern Oscillation this pulse of returning warm water (red), causing higher sea levels at the Equator, is called a Kelvin wave (NOAA 2006).

Madden-Julian Oscillation

The Madden-Julian Oscillation (MJO) is a 30-60 day wave of enhanced, then suppressed, rainfall or atmospheric moisture. One half of the oscillation is wet and the other dry. The MJO moves across the Pacific from west to east (Madden and Julian 1994). It is a coupling of atmospheric circulation and tropical deep ocean convection (upwelling) and often is characterized by irregular cloud formations that bring large amounts of rainfall across the Pacific. A phase of this oscillation has been dubbed “the Pineapple Express” for the large amounts of rain-enhanced clouds that form over the Hawaiian Islands and continue eastward to North America, dumping large amounts of precipitation on the west coast (NOAA 2006).

Tropical Cyclones

Tropical cyclones are known as tropical depressions, tropical storms, cyclones, typhoons, cyclonic storms, or hurricanes depending on location and strength. A tropical depression has winds less than 38 mph. A tropical storm is when the winds are between 38 mph and 74 mph. Above 74 mph, a storm in the NE Pacific or Atlantic is called a hurricane. In the NW Pacific a storm is called a typhoon. In the southern hemisphere or Indian Ocean they are called cyclones. Figure 11 illustrates three tropical cyclones in various stages of development at one time in the Pacific. Figure 12 is a diagrammatic cross-section of the structure of a “typical” tropical cyclone. Figure 13 illustrates all the hurricanes and typhoons in the world from 1985-2005. It is very interesting to note the lack of these storms in the SE Pacific and southern Atlantic.

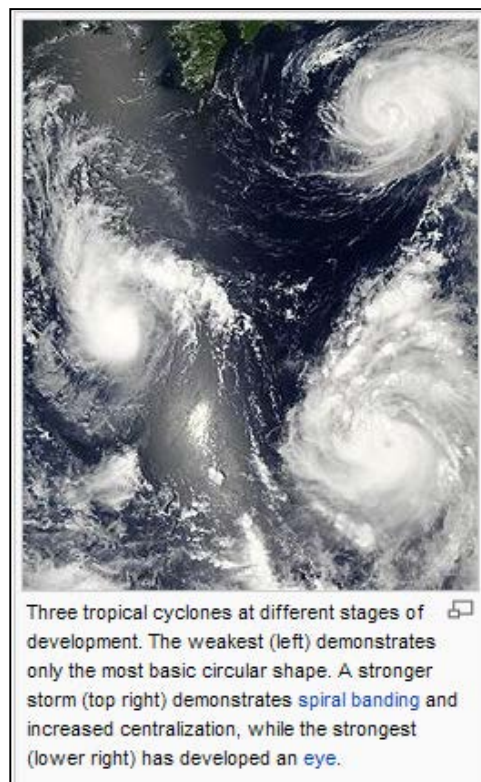


Figure 11. Three different tropical cyclones at various stages of development (NASA 2006).

The tropical cyclone season in Hawaii starts in June, normally lasting through November. In American Samoa, the season begins in November, extending through April. In the western Pacific, which includes Guam and Saipan, these storms are more frequent and often more intense than in the rest of the Pacific. While the majority of typhoons occur between June and November they may occur year-round.

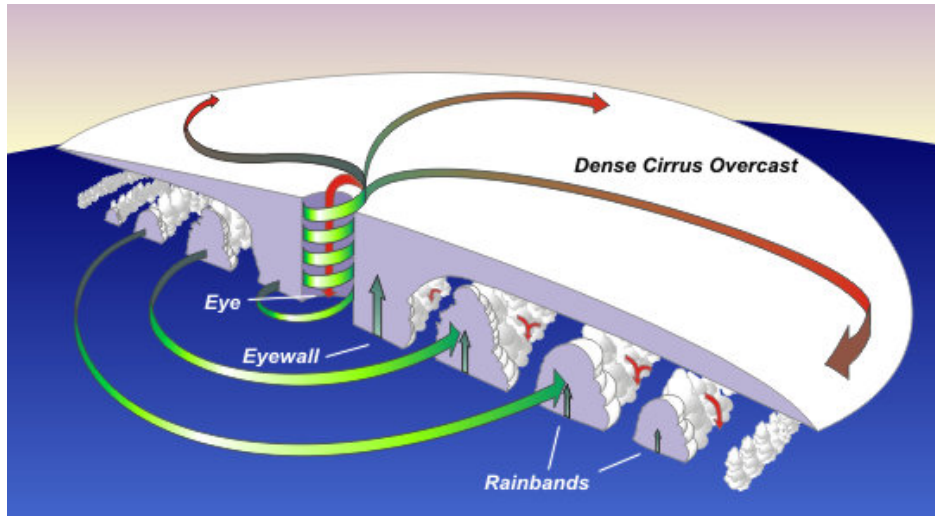


Figure 12. Structure of a tropical cyclone (NOAA 2010).

Tropical cyclones are areas of low atmospheric pressure (depressions), which intensify over the open ocean. Water vapor from a warm sea evaporates (condenses) and rises towards the troposphere. Condensation leads to higher wind speeds as a tiny fraction of the released energy is converted into mechanical energy. The faster winds and lower pressure associated with them, in turn, cause increased surface evaporation and thus even more condensation (NOAA 2010). This cycle is a positive feedback loop. While ocean temperatures remain conducive to condensation, the cyclone will continue, guided by the high and low pressure systems, wind shears, and Coriolis force. Generally, when a cyclone hits land, the condensation cycle stops and the storm dissipates.

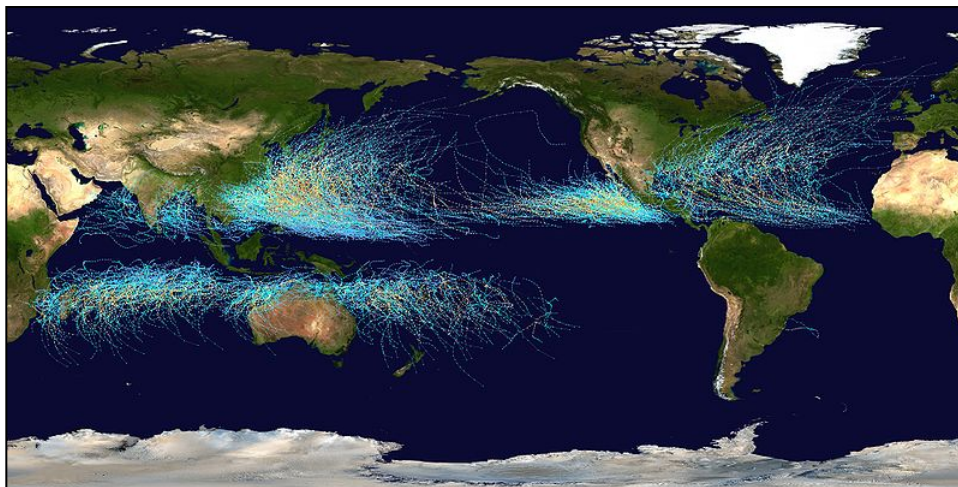


Figure 13. Map of the cumulative tracks of all tropical cyclones during the 1985–2005 time period. The Pacific Ocean west of the International Date Line sees more tropical cyclones than any other basin, while there is almost no activity in the Atlantic Ocean south of the Equator (Nilfanion 2006).

Pacific Decadal Oscillation (PDO)

The Pacific Decadal Oscillation (PDO) takes place in 20-30 year cycles. It is a sum of several atmospheric and oceanic processes and mechanisms such as ENSO teleconnections, an atmospheric bridge (Alexander et al. 2002), the SST reemergence (Deser et al. 2003), stochastic atmospheric forcing (Alexander and Penland 1996), advective resonance (Saravanan and McWilliams 1998), and the north Pacific oceanic gyre circulation (Jin 1997). The PDO is a cycle of warm and cold SST across the Pacific, north of 20°, just at the Hawaiian Island latitude (Figure 14).

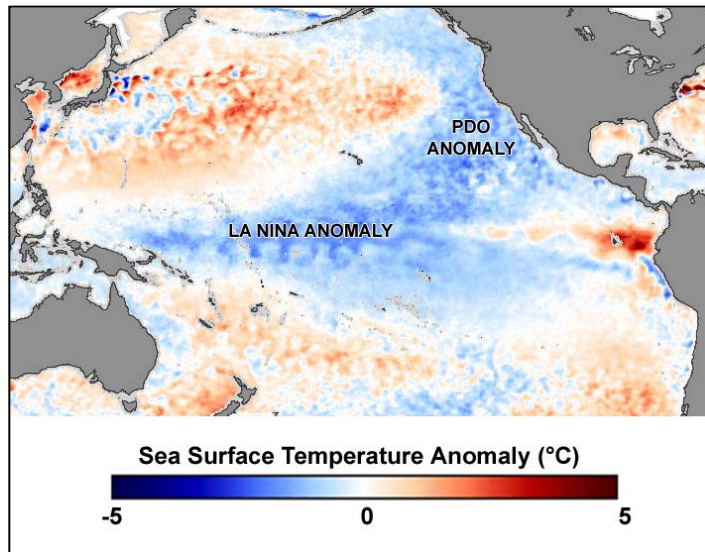


Figure 14. Pacific Decadal Oscillation (PDO) with La Niña. (NASA 2008).

PDO has a long cycle and was first discovered by Steven Hare, a fisheries scientist at the University of Washington (Hare 1996). The cycle has occurred twice in the last century; the cool phase from 1890–1924 and 1947–1976. The warm phase dominated from 1925–1946 and 1977 through the mid 1990's. These phases (Figure 15) have been directly related to marine productivity and probably affect Hawaii's marine systems as well (JISAO 2000).

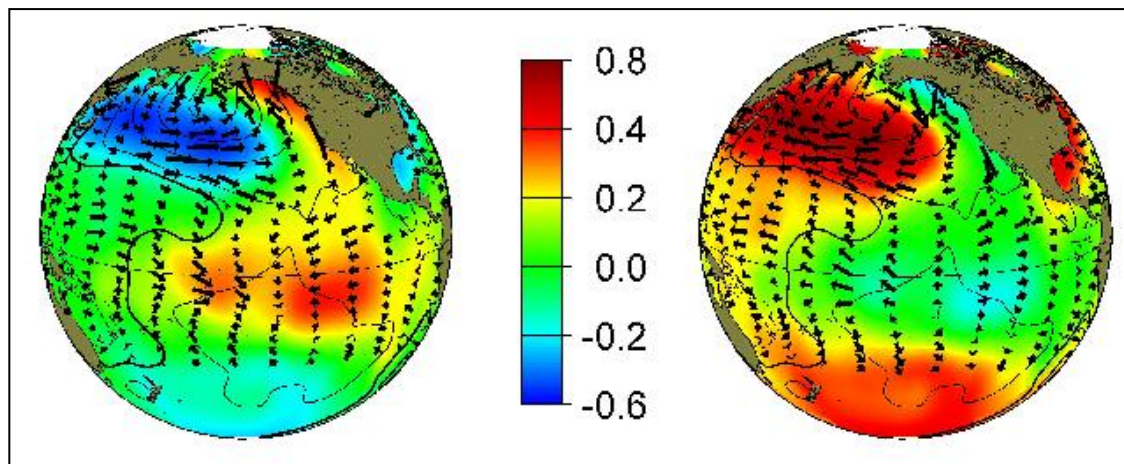


Figure 15. Cool phase (left) and warm phase (right) of the Pacific Decadal Oscillation (JISAO 2000).

Methods

Detailed methods of data collection for weather observations in the PACN are described in the PACN Weather/Climate Monitoring Protocol (Schlappa et al. 2011). In short, the PACN's weather monitoring efforts primarily rely on weather observations obtained from two national weather monitoring networks, the National Weather Service Cooperative Observer Program (COOP) and the Remote Automated Weather Station program (RAWS).

COOP weather stations observations are taken by park personnel, volunteers, or contractors. Most COOP stations in the PACN are read manually. They measure 24-hour precipitation totals and most stations measure daily maximum and minimum temperatures.

RAWS provide weather data that assist land management agencies with a variety of projects such as monitoring air quality, rating fire danger, and providing information for research applications. Hourly averages of meteorological variables are downloaded via the Geostationary Operational Environmental Satellite (GOES). Measured variables vary from station to station, but typically include temperature, precipitation, wind, humidity, solar radiation, barometric pressure, fuel temperature, soil temperature, and fuel moisture.

Weather data for RAWS and NWS COOP stations were acquired from WRCC and incorporated into a MS Access database that stores data for all stations included in PACN weather/climate monitoring. The acquired weather data consist of daily values, i.e. hourly RAWS data had already been summarized by WRCC.

Most of the 2011 data were downloaded directly from WRCC's COOP or RAWS internet sites. Some was sent directly from WRCC to the PACN when necessary. The WRCC also performs a preliminary data validation process. Data were converted into MS Excel spreadsheets and then downloaded into the PACN database. Data were imported into R (Version 2.12.0) (Gentleman, R. and R. Ihaka 1997) for data analysis and graphing.

Boxplot Analysis and Illustrations

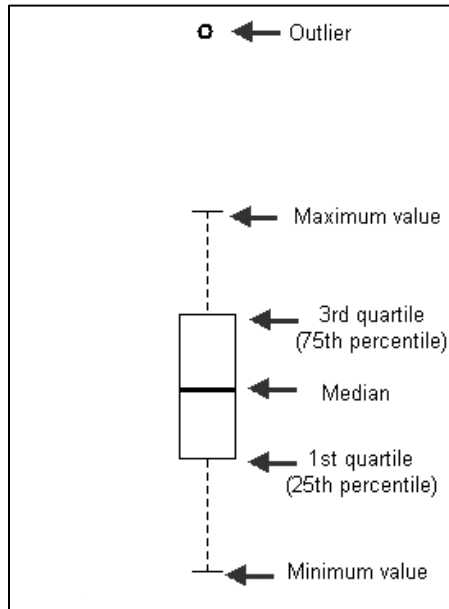


Figure 16. Anatomy of a boxplot.

Boxplots are used to place data from 2011 in context with the long-term variability for each station. Boxplots in R are constructed based on the original definition of a boxplot by (Tukey 1977). However, since in some publications different definitions are used, the features of a generic boxplot produced in “R” are illustrated above (Figure 16).

To understand boxplots the term “quartile” needs to be understood. Quartiles are dividing lines that separate a dataset into four equal parts: 25% (one quarter) of the data points are below the 1st quartile, 25% are between the 1st and 2nd quartile (2nd quartile = median), 25% of the data lie between the 2nd and 3rd quartile, and another 25% lie above the 3rd quartile.

Boxplots generally display at least five important pieces of information about a set of data: (1) the median (2nd quartile) of the data is represented by the line in the center of the rectangular box; (2) the lower end of the rectangle represents the 1st quartile; (3) the upper end of the rectangle is the 3rd quartile; (4) the lower whisker extends to the minimum value; and (5) the upper whisker extends to the maximum value. In addition, most boxplots show outliers of the dataset.

The rectangle defines the distance between the 1st and 3rd quartile, called the interquartile range (IQR). The minimum value of the dataset is defined as the minimum point within a distance of 1.5 IQR from the 1st quartile. The maximum value is a point within a 1.5 IQR from the 3rd quartile. Data points beyond either limit are considered outliers.

Boxplots are based on long-term datasets for temperature, precipitation, and relative humidity. Data points for 2011 are overlaid on the graphics to place the current year’s data into the context of long-term variability.

Wind Rose Graphs

Wind graphics are generated using the online data analysis tools for individual RAWS set up by WRCC and the DRI. These graphs show the wind directions and strengths. Annual graphs are shown as well as some specific monthly graphs. Directional wind shifts from land to ocean and vice versa is an interesting phenomenon that has been recorded and graphed in the morning and afternoon wind details. Some of these graphs show the effect of onshore and offshore winds extremely well, especially Kaloko-Honokohau NHP (Figure 43). Kaupo Gap Hawaii (Figure 55) also shows this daily wind switch at a higher elevation.

Period of Record for Data at Stations

The period of record varies for individual stations and is noted in each graph. A threshold of 85% valid daily records is used for calculating monthly means or totals. So if more than 15% of daily data is missing for any given month, the data is considered insufficient for the calculation of a monthly mean or total. Also, the long-term data record may be shorter than the period of record (found online in the metadata for each station). Most data analyzed begins on January 1 of a complete data year, rather than using data from partial years.

For months with insufficient data, we do not substitute data from nearby stations since often there are no nearby stations available. Sometimes, for precipitation, even nearby stations do not provide representative data for parks, given the steep, elevation-driven precipitation gradients on many of the islands.

A climate normal is defined as the arithmetic average of a climatological element such as temperature or precipitation for a 30-year period (Guttman 1989). The National Climatic Data Center (NCDC) computes climate normals for some of the COOP stations and no RAWS stations in the U.S. So we compare 2011 data for stations without climate normals to the long-term mean of that station's record.

Ideally, data for the 30-year period should not have missing values or inconsistencies such as changes in station location, instrumentation, and time of observation. In reality, since factors often result in missing values or changes due to instrumentation, records for some stations are adjusted using statistical methods to equalize the data prior to the calculation of averages. In addition the NCDC makes corrections to the datasets to adjust for the time of observation. The most current time period for published climate normals by NCDC is 1981 to 2010. Some stations have these normals published and some only have normals for earlier 30-year periods, 1961-1990 or 1971-2000. Normals are calculated by (a) each of the 12 calendar months must be complete in at least 10 of the 30 years and (b) for each day of the year, there must be at least 10 years in which at least 20 values are available within plus or minus 14 days of that day (Durre et al. 2011).

The locations for manually downloaded COOP stations are mainly based on ease of access and site suitability. RAWS stations site locations are generally determined by wildfire threat. The PACN's new Campbell Scientific (CS) station locations have been determined by the need for weather data to support other vital sign monitoring as well as other park specific needs (Davey et al. 2006).

RAWS stations are often located in the backcountry. Only AMME does not yet have a weather station located within park boundaries. The PACN plans to set up a new AMME Campbell Scientific station in 2013. In this report, data from a nearby COOP station are analyzed for AMME. Station locations are detailed on maps in Appendix B.

Seven of the nine new CS weather stations were set up in 2012: two in HAVO, one (of two in KALA), two in NPSA, one at PUHO (to replace the WeatherHawk instrumentation), and one at PUHE. As mentioned earlier, one will be set up in AMME in 2013. These stations will be automated RAWS stations and will use the GOES satellite.

Station names in this report appear exactly as they do in the NCDC and WRCC databases. For this reason, the spelling may be unusual (as in Puuhonuaohonaunau). If a station name has changed recently, the old name is noted under the title of that station's report.

Table 2. The stations used in the data collection and analyses.

Station Name	Program	In Park (P) or Nearby (N)	Elevation (m)	Record Length
War in the Pacific National Historical Park (Guam)				
Agat Pacific Islands (Isl.)	COOP	P	3	7/1978 to present
Guam International Airport formerly (Guam NAS, Pacific Islands)	COOP	N	77	5/1946 to present
American Memorial Park (Saipan)				
Capitol Hill 1	COOP	N	252	12/1994 to present
Amme CS	RAWS	P	TBD	TBD
National Park of American Samoa (Tutuila)				
Pago Pago WSO AP (Airport)	COOP	N	3	4/1956 to present
Toa Ridge ¹	RAWS	P	353	3/2012 to present
Siufaga Ridge ¹	RAWS	P	113	3/2012 to present
Kalaupapa National Historical Park (Molokai)				
Kalaupapa 563	COOP	P	9	10/1949 to present
Makapulapai	RAWS	P	23	3/1993 to present
Puu Alii Hawaii ¹	RAWS	P	1,140	2/2012 to present
Kala 2 CS	RAWS	P	TBD	TBD
Haleakala National Park (Maui)				
Haleakala RS 338	COOP	N	2,121	10/1949 to present
Oheo 258.6	COOP	P	37	1/1982 to present
Kaupo Gap	RAWS	P	1,228	1/1991 to present
Puukohola Heiau National Historic Site (Hawaii)				
Puukohola Heiau 98.1	COOP	N	41	1/1977 to present
Puhe Hawaii ¹	RAWS	P	39	2/2012 to present

Table 2. The stations used in the data collection and analyses (continued).

Station Name	Program	In Park (P) or Nearby (N)	Elevation (m)	Record Length
Kaloko-Honokohau National Historical Park (Hawaii)				
Honokohau Harbor Hawaii	COOP	N	9	1/1991 to present
Kaloko-Honokohau Hawaii	RAWS	N	8	12/2004 to present
Puuhonua o Honaunau National Historical Park (Hawaii)				
Puuhonua-o-Ha Hnp 27.4	COOP	P	5	11/1977 to present
Puho Hawaii ¹	RAWS	P	25	2/2012 to present
Hawaii Volcanoes National Park (Hawaii)				
Hawaii Vol NP HQ 54	COOP	P	1,210	10/1949 to present
Mauna Loa Slope Obs 39	COOP	N	3,399	5/1982 to present
Kahuku Hawaii	RAWS	P	1,796	11/2002 to present
Kealakomo Hawaii	RAWS	P	30	2/2008 to present
Keaumo Hawaii	RAWS	P	1,683	2/1999 to present
Pali 2 Hawaii	RAWS	P	847	7/1999 to present
Lower Kahuku Hawaii ¹	RAWS	P	942	2/2012 to present
Nene Cabin Hawaii ¹	RAWS	P	1,982	2/2012 to present

¹Stations will be used for 2012 data.

Results

General ENSO conditions and tropical cyclone activity for the year are described first. Then data for stations in the western North Pacific (AMME and WAPA) and the South Pacific (NPSA) are presented, followed by results for stations in national parks in the Hawaiian Islands. Finally, an overview of drought conditions in Hawaii is presented.

Hawaii ENSO Data from 2011 *El Niño/La Niña Conditions*

The following is verbatim from PEAC (Pacific ENSO Applications Climate Center) (PEAC 2012).

2nd quarter newsletter, reports on 1st quarter events

The final quarter in 2010 and the first quarter of 2011 were generally wet for most of the islands in the state of Hawaii with the exception of the Big Island. This is a very welcome change to the drought conditions present during the second half of 2010 on all the islands. In fact, all drought conditions have been eliminated on Oahu and Kauai. Also, heavy rainfall this winter has diminished drought conditions across the central Hawaiian Islands, which is typical for a La Niña winter.

3rd quarter newsletter, reports on 2nd quarter events

Most of the State of Hawaii has been receiving sufficient amounts of rain during the first half of 2011. Currently, no drought conditions are reported on Lanai, Oahu, or Kauai. Drought symptoms are improving on Maui as well. On the Big Island, conditions have been slowly improving but areas of severe and moderate drought still persist. Oahu experienced a particularly wet June, resulting in a 6-month total at 316% of normal.

4th quarter newsletter, reports on 3rd quarter events

Hawaii has reentered into very dry conditions. This is due to above normal temperatures and below normal rainfall throughout the 3rd Quarter of 2011. Drought conditions still persist and have even worsened on the Big Island and on Maui in the past few months. Rainy conditions in early November have been welcomed across the state. Additionally, relief may be in sight as the NOAA Climate Prediction center indicates that probabilities favor above-normal precipitation during early 2012 as a part of the forecast mature phase of La Niña.

January 2012 (1st quarter newsletter), reports on 4th quarter, 2011 events

The state of Hawaii overall in 2011 received a sufficient amount of rain with some exceptions. There seemed to be a line drawn over Maui where to the east (Big Island) received below-normal rainfall, while to the west (Oahu, Kauai, Molokai, and Lanai) collected above-normal rainfall during the first six months of 2011. Specifically, in the month of May an upper level low abided over top of most of the islands, which caused several thunderstorms. This tripled the normal

amounts of rainfall in Lihue (on Kauai) and Honolulu (on Oahu) for the month. The rainfall continued into June, causing the Punaluu Stream rain gauge (on the windward side of Oahu) to report an amazing 8.53 inches in three hours with a total of 10.13 inches in 24 hours on the 5th. The normal rainfall amount for June on Oahu is only 0.18 inches. However, in September and October as the climate shifted back into La Niña status, all islands saw well below-normal rainfall and warmer-than-normal temperatures. These conditions negatively impacted any strides made to eradicate drought on the islands (especially on the Big Island and Maui) at the beginning of the year. It should be noted that drought has been present in some capacity since June 2008 in the State. More rainfall is needed to promote a full recovery from this drought.

Although persistent trade winds in November and December helped bring abundant amounts of rainfall for the eastern areas on most of the Hawaiian Islands, the leeward sides received very little rain. This led to the end of the year rainfall totals of the Big Island and Maui near-normal rainfall totals, 90% and 83% respectively. Kauai and Oahu had well above-normal annual rainfall totals with 153% and 172% for the year of 2011.

Tropical Cyclone Activity

The Northern Hemisphere of the western Pacific was still below average with only 27 tropical cyclones (TC) in 2011 as compared to a long-term average of 31 per year (Figure 17). Four storms became super typhoons, as compared with one in 2010. Storms are also further north and west which is common in La Niña conditions. The Southern Hemisphere of the western Pacific also produced 21 TCs compared to the normal 28.

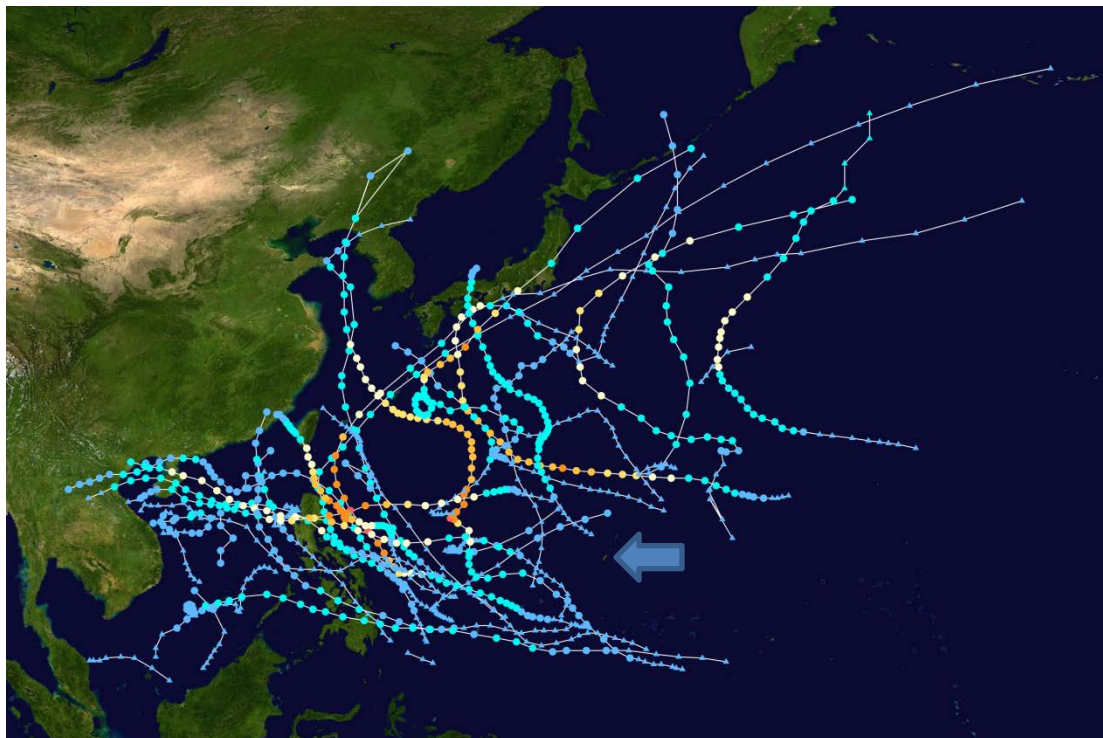


Figure 17. Western North Pacific typhoons (Edkins 2012). Blue arrow indicates WAPA and AMME.

In the eastern Pacific, the first storm of the 2011 season officially starting June 1, started as a tropical depression on June 7, 2011. It progressed to category 4 hurricane status as Hurricane Adrian. This storm was followed by hurricanes Beatriz on June 12, Calvin on July 7, Dora on July 17, Eugene on July 31, Fernanda on August 15, Greg on August 17, Hilary on September 21, Irwin on October 6, Jova on October 4, and Kenneth, the last storm of the season ended on November 25; right before the official end on November 30. One unnamed storm, Tropical Depression 12E, inundated Central America from October 12 – 13, killing 30 people. Fernanda came closest to Hawaii but did not increase precipitation measurements across the state (Figures 18 and 19).

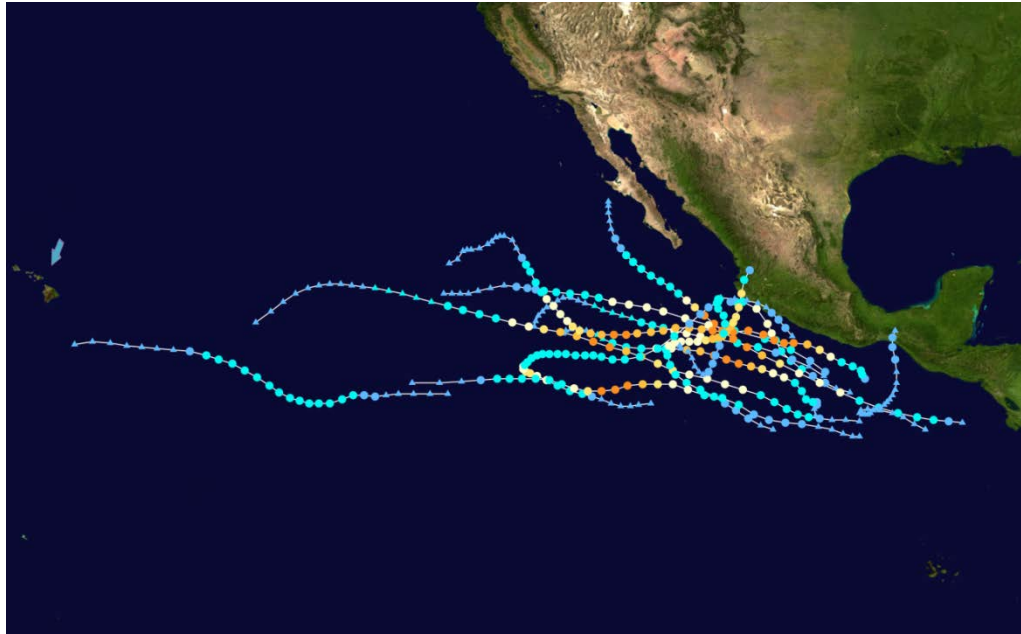


Figure 18. Eastern Pacific tropical cyclone season 2011. Hawaii (blue arrow) is at the left edge of the picture (compiled by Titoxd, with satellite photo by NASA 2012)

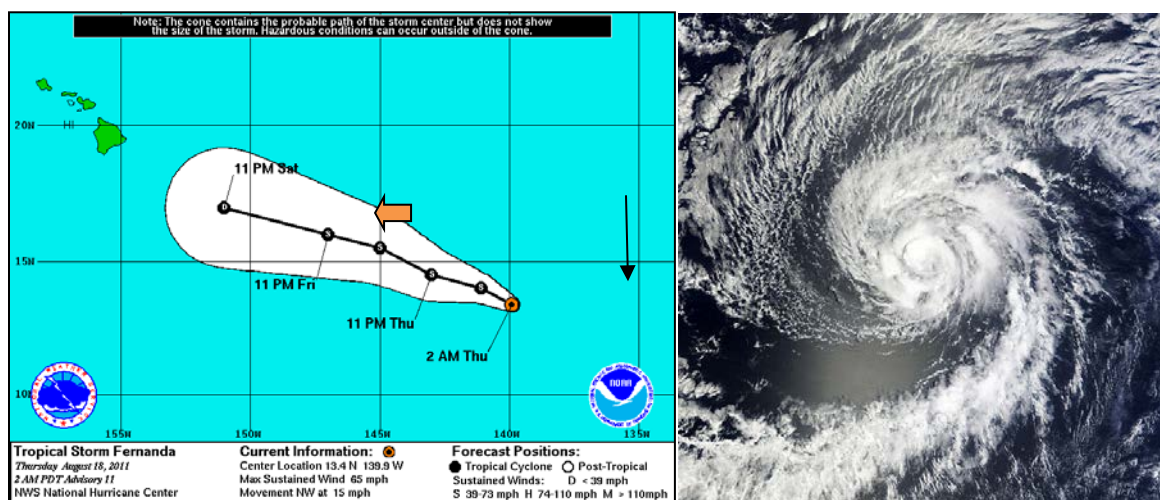


Figure 19. The path of Tropical Storm Fernanda on August 18, 2011. Hawaii is located in the northwest corner of the map (NOAA 2012, NASA 2012).

Parks in the Western North Pacific and the South Pacific

Tables 3 - 7 and Figures 20 - 23 present precipitation and temperature data for weather stations near WAPA on Guam, AMME on Saipan, and NPSA on Tutuila. Only the RAWS stations have wind, solar radiation, and relative humidity data.

Note that the Agat station on Guam is a rain gauge only (Table 4, Figure 20). Total rainfall in 2011 was 123% compared to only 30% of the 30-year average at this location in 2010. Less rain fell in April, May, November and December, but the rest of the year was well above average.

Guam International Airport, formerly called Guam NAS, Pacific Islands, (Table 5, and Figure 21) averaged 132% of its 30-year precipitation average for 2011.

On Saipan, Capitol Hill (Table 6, Figure 22) had an annual rainfall above the long-term mean (125%). Capitol Hill data shows temperatures were below the long-term mean for the entire year.

In American Samoa, Pago Pago (Table 7, Figure 23) had an annual rainfall total at 99% of the 30-year average. Months varied from 35 – 183 percent of the long-term mean.

Table 3. Stations for Western North Pacific and South Pacific national parks weather and climate data.

National Park	Weather station	Location	RAWS/COOP	Elevation (m)
WAPA	Agat	13.38944, 144.6575	COOP	3
	Guam Intl Arpt	13.483611, 144.796111	COOP	77
AMME	Capitol Hill	15.21361, 145.74972	COOP	252
	AMME CS (2013)	TBD	RAWS	TBD
NPSA	Pago Pago WSO Airport	-14.33056, -170.71361	COOP	4
	Toa Ridge (2012) ¹	-14.261, -170.6872	RAWS	392
	Suifaga Ridge (2012) ¹	-14.2761, -170.72194	RAWS	145

¹These stations will be used in the 2012 analysis.

War in the Pacific National Historical Park (WAPA), Guam

Agat, Pacific Islands, COOP station 914001, (WAPA)

Table 4. Agat, Pacific Islands, precipitation for 2011 compared to the NCDC normals (1971 – 2000) and long term means.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Agat, Pacific Islands (1979-2011) COOP ID: 914001 Park: near WAPA Elev. 10 ft. (3 m.)													
Precipitation													
NCDC normal 1971 -2000	4.3	3.2	3.1	3.8	4.6	6.4	11.5	15.1	11.9	11.6	9.1	6.5	91.2
Long-term mean	4.40	3.40	2.69	3.55	4.37	6.82	11.52	16.31	12.15	12.23	9.20	6.44	93.07
2011 mean	11.83	7.59	5.51	NA	4.00	7.44	16.04	19.31	17.23	17.40	NA	5.37	NA
Difference	7.43	4.19	2.82	NA	-0.37	0.62	4.52	3.01	5.08	5.17	NA	-1.07	NA
% Normal	275	237	177	NA	87	116	139	128	144	150	NA	83	NA
% Long-term mean	268	223	205	NA	91	109	139	118	142	142	NA	83	NA

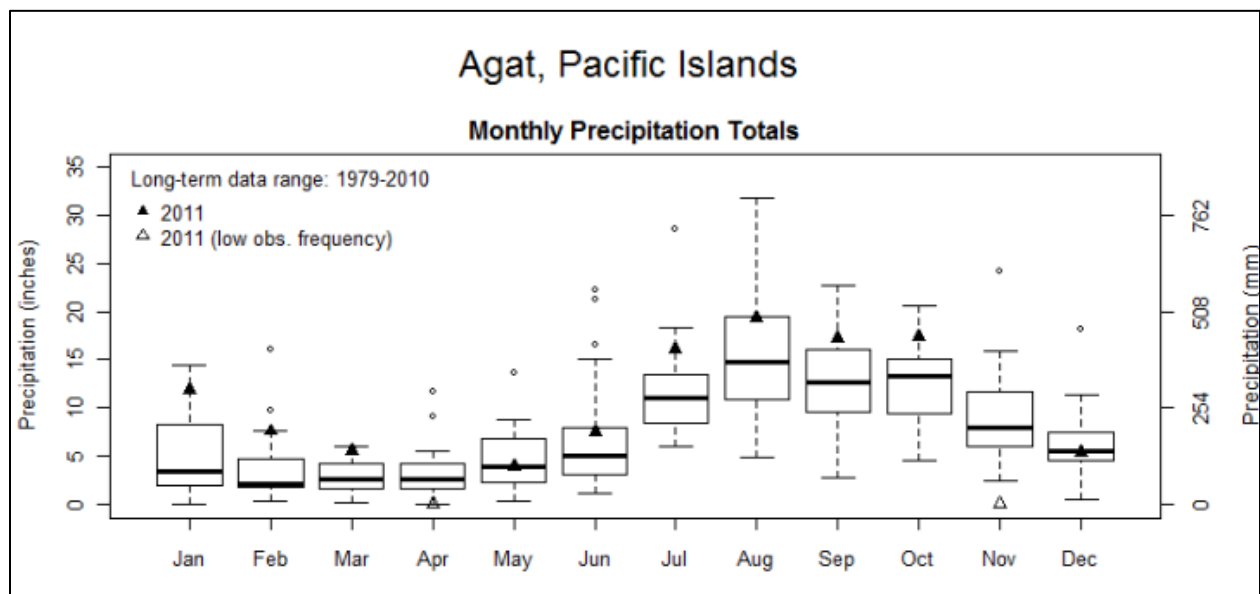


Figure 20. Boxplot for Agat, Pacific Islands, and monthly precipitation totals for 1979 - 2011.

Guam International Airport (Guam Intl Arpt), Pacific Islands, COOP station 914226, (WAPA)

Previous name: Guam NAS, Pacific Islands

Table 5. Guam Intl Arpt, Pacific Islands, precipitation and minimum and maximum temperatures for 2011 compared to the long-term mean.

Guam Intl Arpt, Pacific Islands (1950-2011) COOP ID: 914226 Park: near WAPA Elev. 254 ft. (77m.)													
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation (in)													
Long-term mean	4.3	3.4	2.4	3.2	4.8	6.2	10.1	13.9	13.2	12.0	8.3	5.5	87.3
2011 total	9.1	6.2	4.1	5.6	5.8	6.0	20.5	15.0	16.4	15.5	6.1	5.2	115.4
Difference	4.8	2.8	1.7	2.4	1.0	-0.2	10.5	1.1	3.1	3.4	-2.1	-0.2	28.1
% Long-term mean	212	182	171	175	121	97	203	108	124	129	73	94	132
Min. temp. (°F)													
Long-term mean	75.1	74.6	75.1	76.2	76.9	77.2	76.5	76.1	76.1	76.4	76.6	76.2	76.1
2011 means	76.5	75.5	76.8	77.7	79.1	79.4	77.5	76.5	76.2	75.8	76.4	76.6	77.0
Difference	1.5	0.9	1.7	1.5	2.2	2.2	1.0	0.3	0.1	-0.6	-0.2	0.5	0.9
Max. temp. (°F)													
Long-term mean	85.1	85.3	86.1	87.1	87.5	87.7	87.2	86.8	86.8	87.2	86.8	86.0	86.6
2011 means	86.8	85.9	87.3	87.6	88.8	89.4	87.8	86.3	85.9	86.1	87.1	86.3	87.1
Difference	1.7	0.6	1.1	0.6	1.4	1.6	0.5	-0.5	-0.9	-1.1	0.3	0.4	0.5

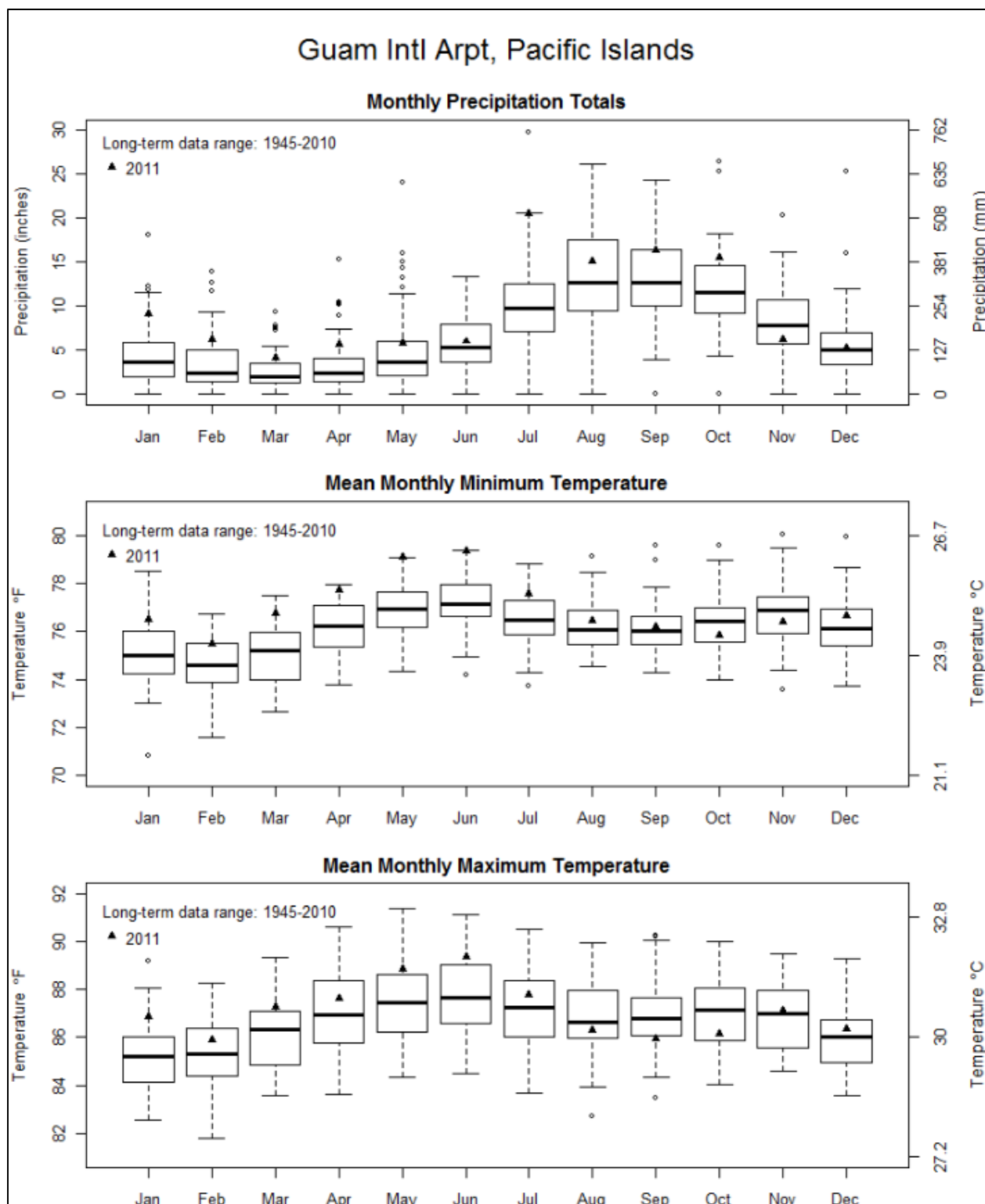


Figure 21. Boxplots for Guam Intl Arpt, Pacific Islands, precipitation, mean monthly minimum and maximum temperatures for 2011.

American Memorial Park (AMME), Saipan

Capitol Hill 1, Pacific Islands, COOP station 914080, (AMME)

Table 6. Capitol Hill 1, Pacific Islands, precipitation and minimum and maximum temperatures for 2011 compared to the long-term mean.

Capitol Hill 1, Pacific Islands (1995-2011) COOP ID: 914080 Park: near AMME Elev. 830 ft. (252 m.)													
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation (in)													
Long-term mean	3.6	4.0	3.1	3.7	3.5	5.2	9.9	12.6	11.3	10.6	7.8	6.1	81.4
2011 totals	7.2	0.0	2.9	5.3	8.0	6.9	12.6	16.5	17.3	16.3	2.8	6.0	101.6
Difference	3.6	-4.0	-0.3	1.6	4.5	1.7	2.7	3.9	6.0	5.8	-5.0	-0.1	20.3
% Long-term	200	0	93	143	228	133	128	131	153	154	36	98	125
Min. temp. (°F)													
Long-term mean	73.4	72.9	73.4	74.0	75.3	75.6	75.2	75.2	75.0	74.9	74.9	74.2	74.5
2011 means	NA	NA	72.6	72.8	73.4	73.5	71.8	71.9	70.5	70.0	71.4	71.6	NA
Difference	NA	NA	-0.8	-1.2	-1.9	-2.0	-3.4	-3.3	-4.5	-4.9	-3.5	-2.6	NA
Max. temp. (°F)													
Long-term mean	81.3	80.9	81.9	83.5	84.7	85.0	84.2	84.0	84.0	83.9	83.4	82.4	83.3
2011 means	NA	NA	81.7	81.4	83.0	83.5	81.9	80.1	79.4	79.7	79.9	78.9	NA
Difference	NA	NA	-0.3	-2.0	-1.7	-1.5	-2.4	-3.9	-4.5	-4.2	-3.5	-3.5	NA

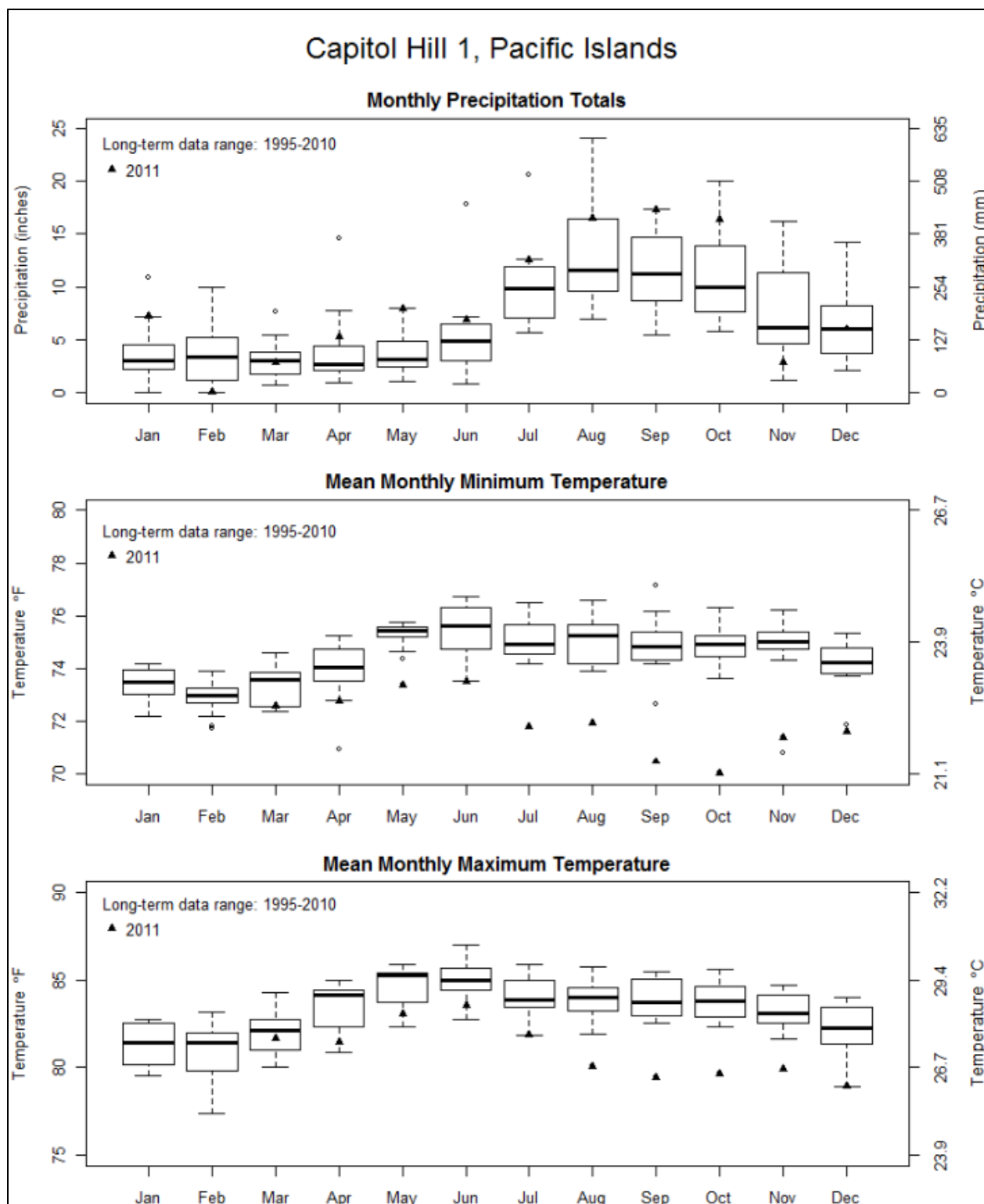


Figure 22. Boxplots for Capitol Hill 1, Pacific Islands station for monthly precipitation totals and mean monthly minimum and maximum temperatures for 2011.

National Park of American Samoa (NPSA), American Samoa

Pago Pago WSO Airport (AP), Pacific Islands, COOP station 914690, (NPSA)

Table 7. Pago Pago WSO Airport (AP), Pacific Islands, precipitation, minimum, maximum temperatures compared to the NCDC normals (1971 – 2000) and long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Pago Pago WSO Airport (AP) (1957-2011) COOP ID: 914690 Park: near NPSA Elev. 10 ft. (3 m.)													
Precipitation													
NCDC normal 1971-2000	14.0	12.1	11.2	11.2	10.4	5.9	5.8	6.4	7.4	10.0	11.2	13.4	119.0
Long-term mean	13.94	12.63	11.45	11.16	10.81	7.04	6.56	6.71	7.30	10.67	11.25	14.48	124.00
2011 means	25.72	13.39	5.77	4.01	3.69	7.01	2.31	3.85	13.21	12.67	15.91	9.69	117.23
Difference	11.78	0.76	-5.68	-7.15	-7.12	-0.03	-4.25	-2.86	5.91	2.00	4.66	-4.79	-6.77
% Normal	184	111	102	99	35	119	40	60	178	127	142	72	98
% Long-term mean	184	106	50	36	34	99	35	57	181	119	141	67	94
Min. temp. (°F)													
1971-2000 normal	76.1	76.3	76.6	76.3	76.2	76.1	75.5	75.5	75.8	76.2	76.5	76.4	76.1
Long-term mean	76.42	76.44	76.48	76.33	76.21	76.03	75.45	75.31	75.61	76.03	76.29	76.36	76.08
2011 means	76.06	75.50	76.58	77.27	76.45	76.90	77.58	75.32	76.77	76.52	76.13	76.68	76.48
Difference	-0.36	-0.94	0.10	0.94	0.24	0.87	2.13	0.01	1.15	0.48	-0.16	0.32	0.40
Max. temp. (°F)													
1971-2000 normal	86.8	87.2	87.3	86.9	85.6	84.5	83.8	84.0	84.8	85.2	85.8	86.9	85.7
Long-term mean	87.33	87.56	87.68	87.19	85.86	84.79	83.94	83.97	84.97	85.43	86.23	86.83	85.98
2011 means	85.74	84.89	86.87	87.37	86.13	85.53	85.81	84.94	85.83	86.55	85.53	86.65	85.99
Difference	-1.58	-2.67	-0.81	0.18	0.27	0.74	1.87	0.96	0.87	1.12	-0.69	-0.18	0.01

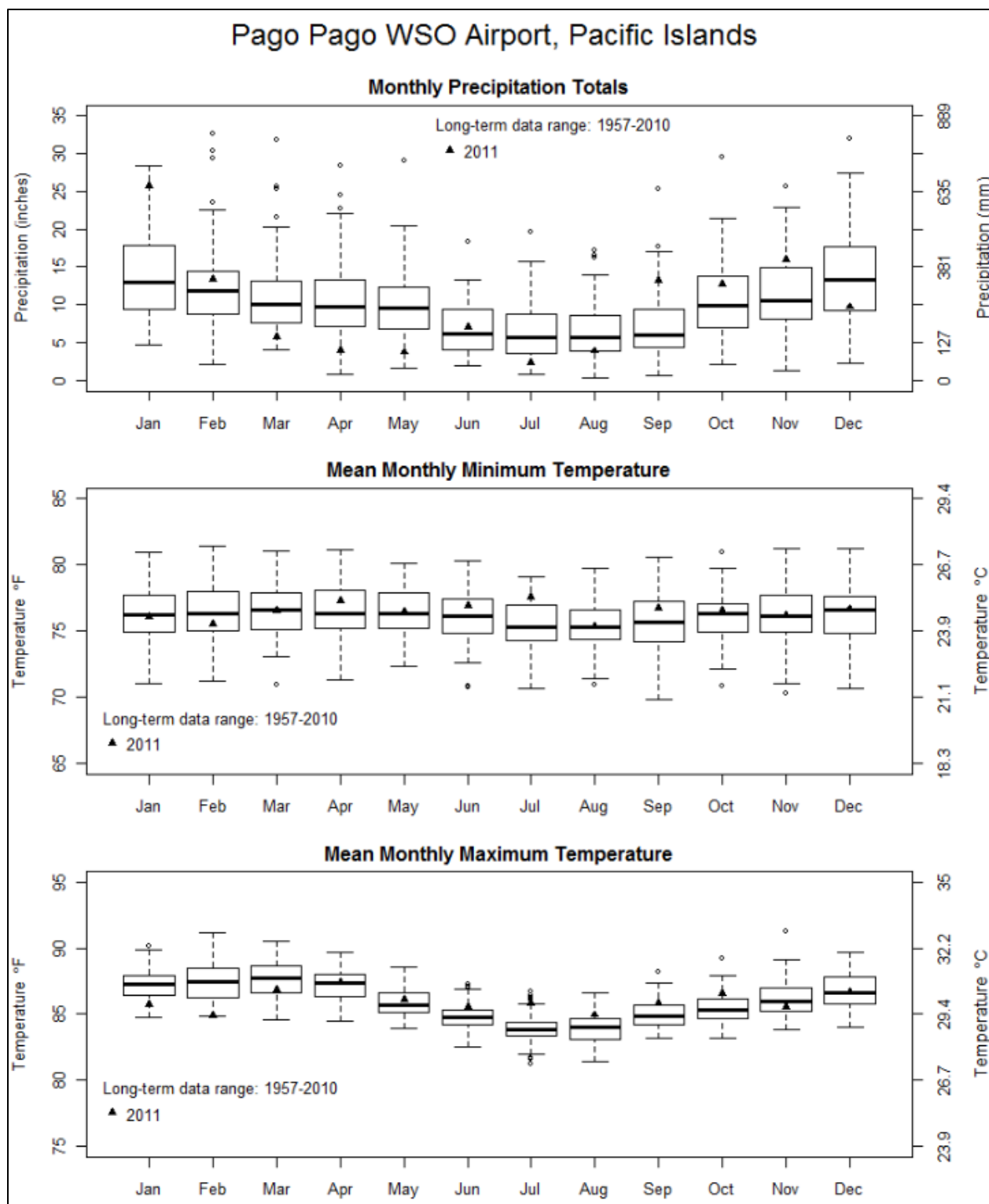


Figure 23. Boxplot of Pago Pago WSO Airport, Pacific Islands, monthly precipitation, mean monthly minimum and maximum temperatures for 2011.

Parks on Hawaii Island

Hawaii Volcanoes National Park (HAVO)

There are 16 weather stations in HAVO at this time; six are used in this report (Table 8). Two new stations will be added to the analysis in 2012, Nene Cabin Hawaii and Lower Kahuku Hawaii. Both of these stations started collecting data in February 2012. Of the six being used in the 2011 analysis, two are COOP stations and four are RAWS. Kealakomo Hawaii can be used for Ala Kahakai National Historic Trail (ALKA), as part of the trail is close.

Table 8. Stations used in the analysis of Hawaii Volcanoes National Park weather and climate data.

Weather station	Location	RAWS/COOP	Elevation (m)
Kahuku Hawaii	19.2322, -155.78	RAWS	1,796
Kealakomo Hawaii	19.2928, -155.1075	RAWS	30
Keaumo Hawaii	19.47361, -155.35889	RAWS	1,692
Pali 2 Hawaii	19.3175, -155.2922	RAWS	856
Nene Cabin Hawaii ¹	19.25638, -155.61444	RAWS	2,006
Lower Kahuku Hawaii ¹	19.10083, -155.66972	RAWS	954
Mauna Loa Slope Obs Hawaii	19.53944, -155.57917	COOP	3,399
Hawaii Vol NP HQ 54 Hawaii	19.4333, -155.2594	COOP	1,210

¹These stations will be used in the 2012 analysis.

Kahuku Hawaii, RAWs station HKHK, (HAVO)**Previous name: Kahuku 1****Table 9.** Kahuku Hawaii precipitation, temperature, relative humidity, and solar radiation means for 2011, compared to the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Kahuku Hawaii (2006-2011) RAWs ID: HKHK Park: HAVO Elev. 5,892 ft. (1,796 m.)													
Precipitation (in)													
Long-term mean	5.2	8.7	12.1	1.7	2.8	0.2	1.7	0.9	0.5	5.7	7	11.2	57.7
2011 totals	3.0	2.4	3.3	5.2	1.2	0.1	0.1	0.2	2.2	0.3	0.7	1.7	20.5
Difference	-2.2	-6.3	-8.8	3.5	-1.6	-0.1	-1.6	-0.7	1.7	-5.4	-6.3	-9.5	-37.2
% Long-term mean	58	27	27	327	43	50	6	22	440	5	1	15	35
Min. temp. (°F)													
Long-term mean	56.5	55.7	57.2	57.6	58.6	60.2	61.5	62.3	61.8	61.4	60.8	58.1	59.3
2011 means	56.7	57	58.1	57.8	59.4	60.5	60.4	61.7	60.2	60	59.8	58.2	59.1
Difference	0.2	1.3	0.9	0.2	0.8	0.3	-1.1	-0.6	-1.6	-1.4	-1.0	-0.1	-0.2
Max. temp. (°F)													
Long-term mean	71.2	70.4	70.1	72.5	73.7	77.2	78.5	79.4	78.1	76.7	75.5	71.8	74.6
2011 means	71.6	71.1	73.7	71.8	73.5	77.2	78.1	79.4	76.9	76.3	73.5	72	74.6
Difference	0.4	0.7	3.6	-0.7	-0.2	0	-0.4	0	-1.2	-0.4	-2.0	0.2	0
Avg. temp. (°F)													
Long-term mean	62.5	61.8	62.5	63.6	64.9	67.4	68.7	69.2	68.4	67.5	66.8	63.7	65.6
2011 totals	62.8	62.9	64.2	63.4	64.9	67.4	68.1	68.9	66.8	66.7	65.1	63.4	65.4
Difference	0.3	1.1	1.7	-0.2	0	0	-0.6	-0.3	-1.6	-0.8	-1.7	-0.3	-0.2
Avg. RH													
Long-term mean	86.9	87.5	88.2	82.8	83.5	78.7	74.9	73	75.1	80.3	84.3	89.7	82.1
2011 means	80.9	85.7	75.5	86.7	82.9	76.4	71.7	73.4	78.9	76	79.9	81.8	79.1
Difference	-6.0	-1.8	-12.7	3.9	-0.6	-2.3	-3.2	0.4	3.8	-4.3	-4.4	-7.9	-3.0
Solar Radiation (Ly)													
Long-term mean	368.9	453.5	494.7	485.5	425.8	548.1	529.6	589.5	524.9	386.5	367.4	313.1	5487.5
2011 means	306.4	295.3	464.2	357.4	437.7	522.1	510.5	532.8	377.7	379.3	332.8	322.5	4838.7
Difference	-62.5	-158.2	-30.5	-128.1	11.9	-26.0	-19.1	-56.7	-147.2	-7.2	-34.6	9.4	-648.7

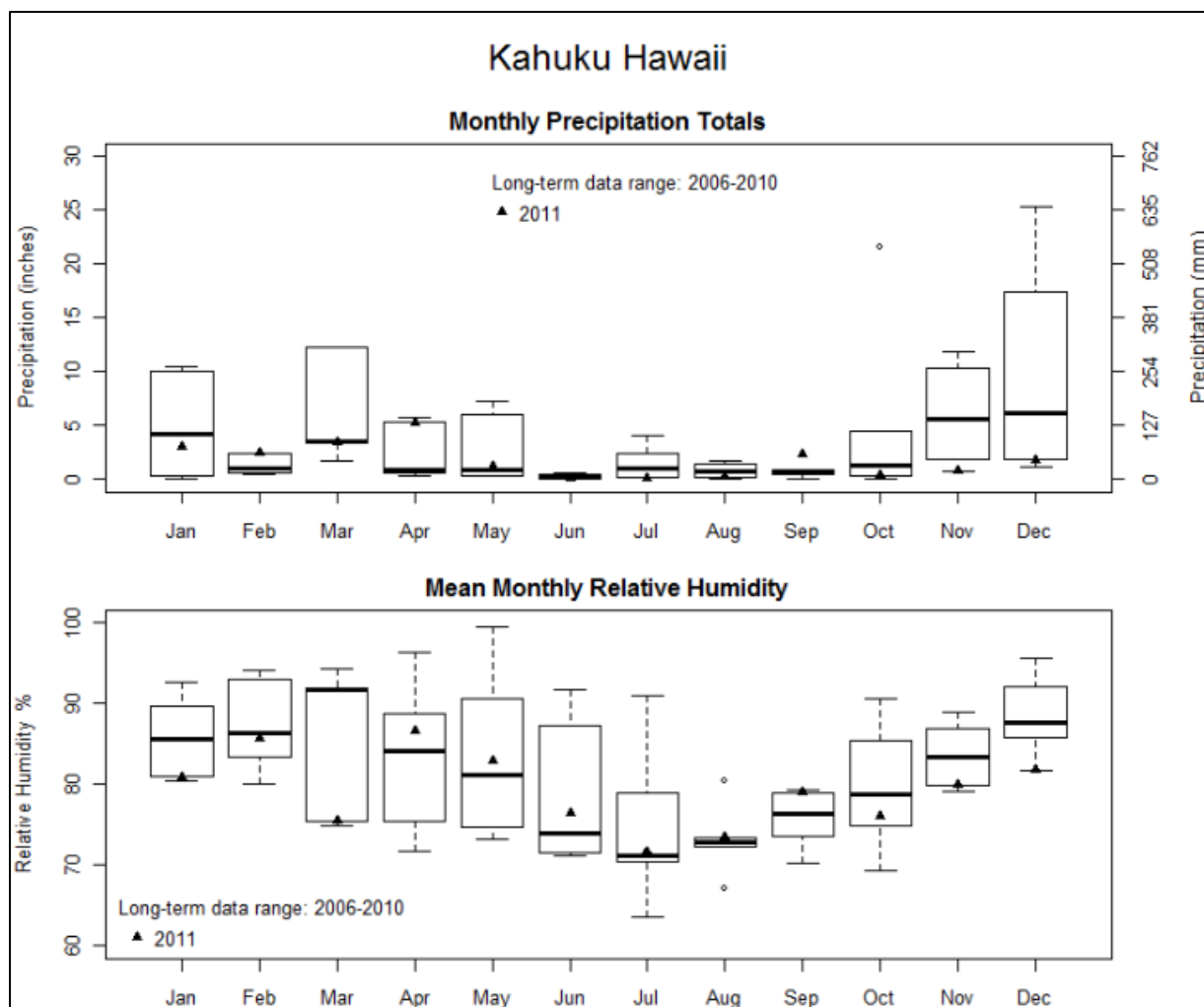


Figure 24. Boxplot analysis for Kahuku Hawaii monthly precipitation and mean monthly relative humidity for 2011.

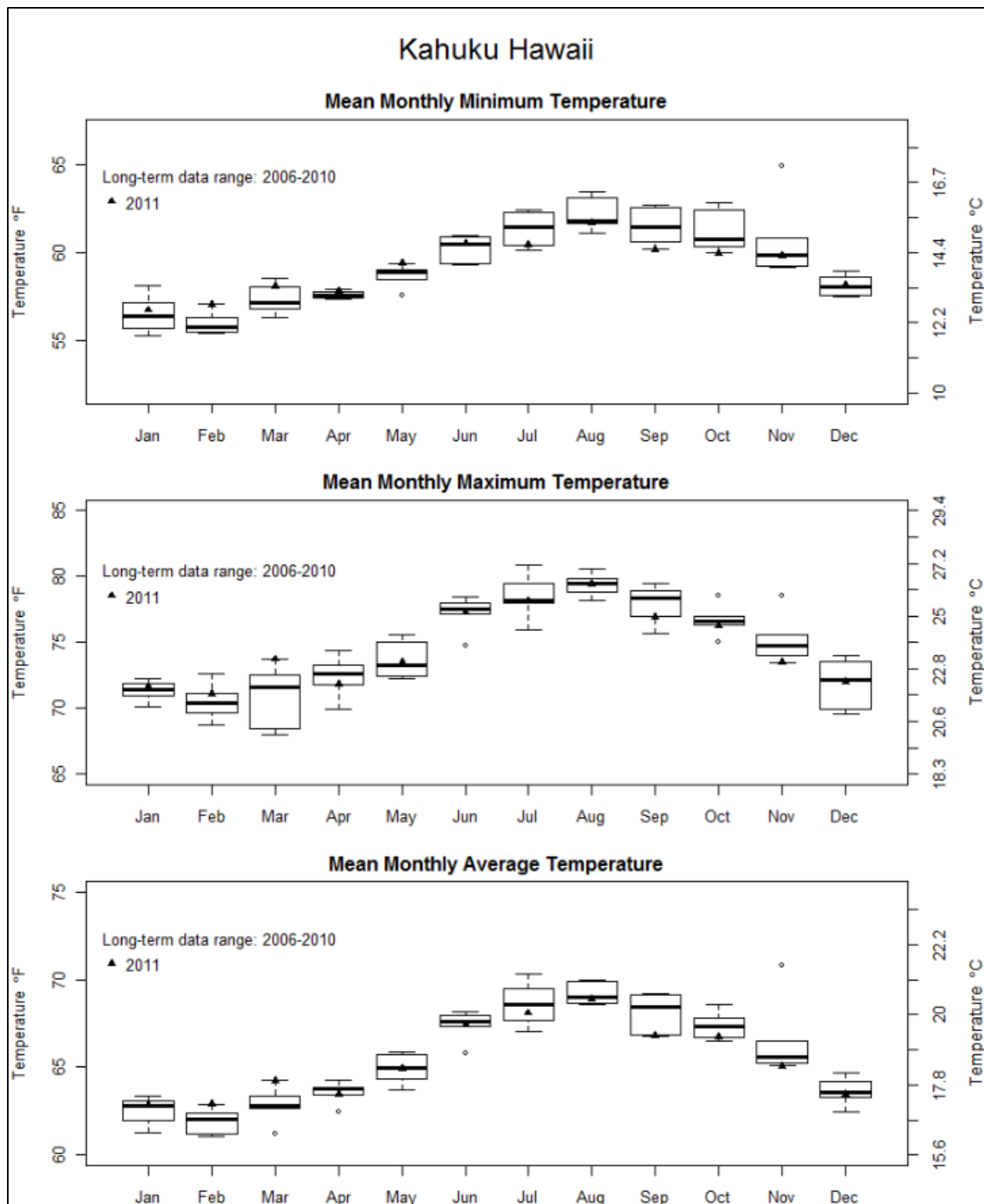


Figure 25. Boxplots for Kahuku Hawaii temperature data: mean monthly minimum, maximum and average temperatures for 2011.

Kahuku Hawaii

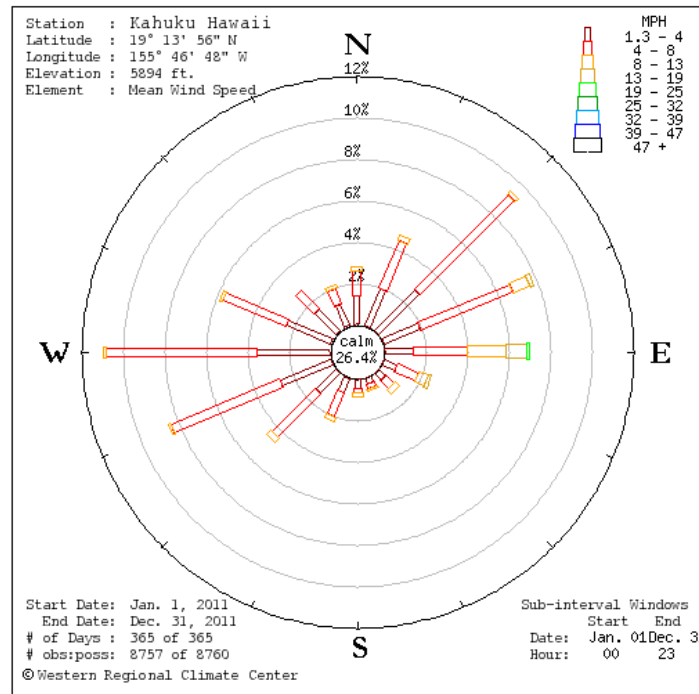


Figure 26. Annual wind rose graph for Kahuku Hawaii, 2011 (WRCC 2012).

Kealakomo Hawaii, RAWS station HKML, (HAVO)**Previous names: Kealakomo, Kealakomo 38.8 (COOP), Kealakomo #2****Table 10.** Kealakomo Hawaii precipitation from 2011 compared to the long-term mean from 1995 – 2011. Temperature maximums, minimums, averages, and relative humidity data are compiled for 2011 using 2009 - 2011 long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Kealakomo Hawaii (1995-2009) COOP, (2006-2011) RAWS ID: HKML Park: HAVO Elev. 97 ft. (30 m.)													
Precipitation (in)													
Long-term mean	7.45	5.57	7.90	3.31	3.13	2.09	2.25	1.70	1.98	4.08	6.96	7.54	53.97
2011 totals	4.12	2.84	1.76	3.22	4.53	0.59	0.52	0.18	0.95	1.04	2.55	5.18	27.48
Difference	-3.33	-2.73	-6.14	-0.09	1.40	-1.50	-1.73	-1.52	-1.03	-3.04	-4.41	-2.36	-26.49
% Long-term	55	51	22	97	144	28	23	10	48	25	37	69	51
Min. temp. (°F)													
Long-term mean	70.07	69.68	69.35	69.29	71.62	72.70	73.97	76.00	74.77	74.71	72.10	70.31	72.05
2011 means	69.06	69.21	70.39	69.33	70.26	71.45	72.97	73.61	72.77	72.87	71.17	70.13	71.10
Difference	-1.00	-0.46	1.03	0.04	-1.36	-1.25	-1.00	-2.39	-2.00	-1.84	-0.93	-0.18	-0.95
Max. temp. (°F)													
Long-term mean	82.20	81.54	81.32	80.27	82.59	84.27	85.42	87.42	85.73	85.42	83.18	82.16	83.46
2011 means	81.16	81.36	82.39	81.03	81.81	83.45	84.77	85.77	84.80	84.74	82.13	80.45	82.82
Difference	-1.04	-0.18	1.06	0.76	-0.78	-0.82	-0.65	-1.65	-0.93	-0.68	-1.05	-1.71	-0.64
Avg. temp. (°F)													
Long-term mean	75.70	74.78	74.19	74.14	76.61	77.94	79.08	80.57	79.58	79.42	76.83	75.73	77.05
2011 means	74.45	74.80	75.50	74.86	75.73	76.86	78.28	79.06	78.42	77.95	75.77	74.35	76.34
Difference	-1.25	0.03	1.31	0.72	-0.88	-1.08	-0.80	-1.51	-1.16	-1.46	-1.06	-1.39	-0.71
Relative Humidity													
Long-term mean	NA	62.52	65.43	74.86	75.94	73.20	72.29	70.00	70.20	78.77	70.95	74.31	NA
2011 means	72.10	78.14	69.97	76.90	75.32	73.93	68.10	68.68	69.33	67.87	NA	70.68	NA
Difference	NA	15.62	4.54	2.04	-0.61	0.73	-4.19	-1.32	-0.87	-10.90	NA	-3.63	NA

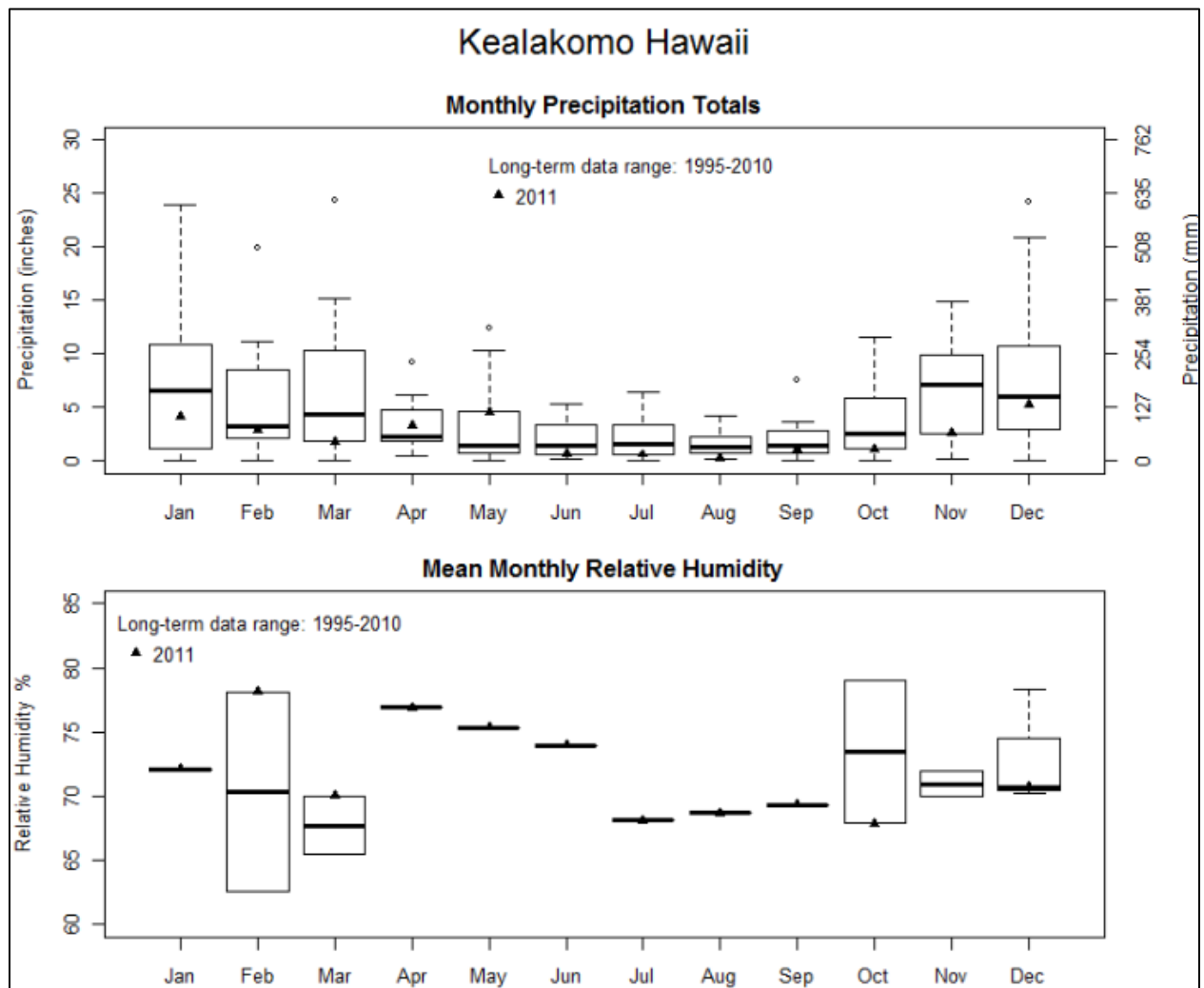


Figure 27. Boxplots for Kealakomo Hawaii monthly precipitation and mean monthly relative humidity data for 2011.

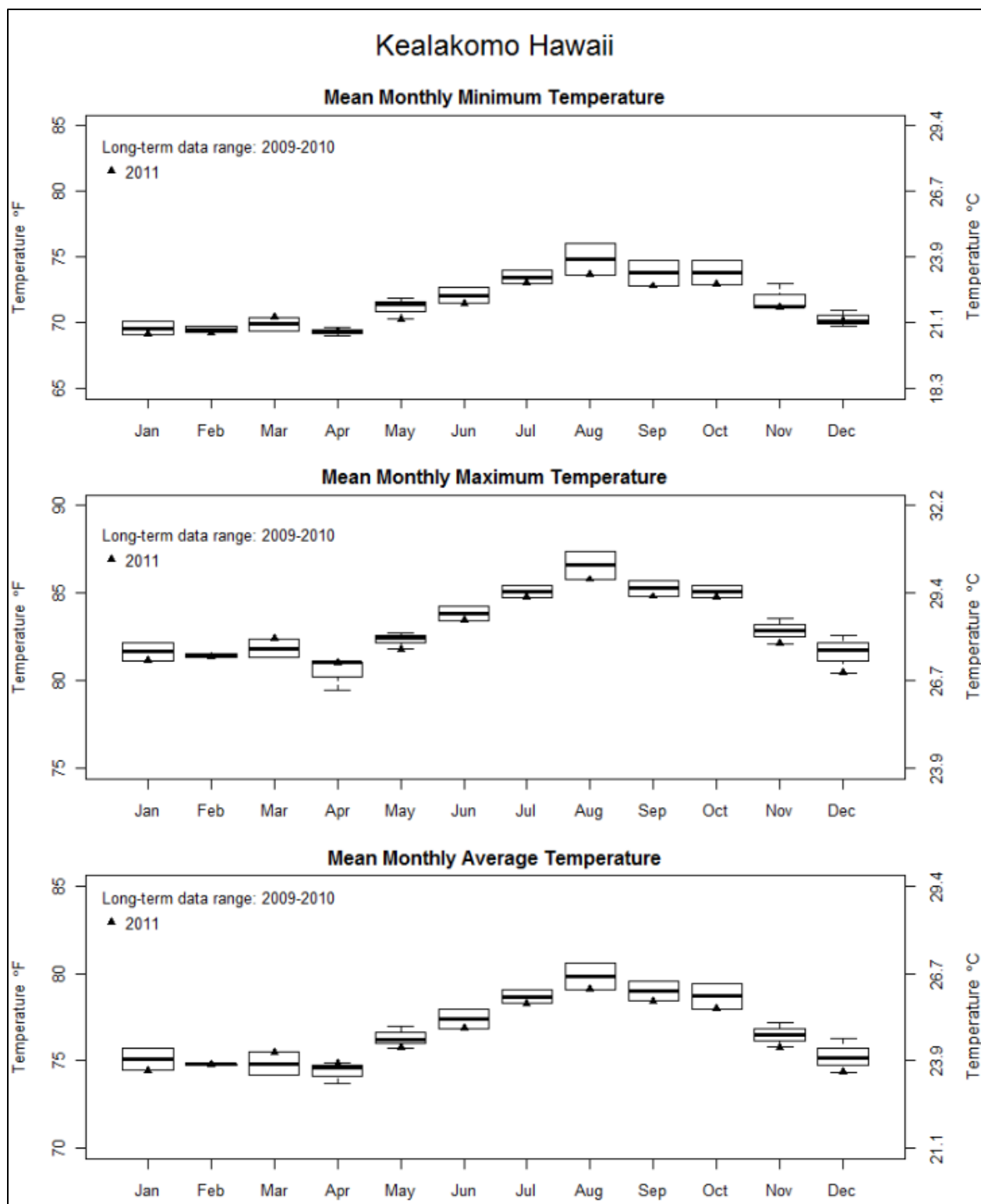


Figure 28. Boxplots for Kealakomo Hawaii mean monthly minimum, maximum, and average temperatures for 2011.

Kealakomo Hawaii

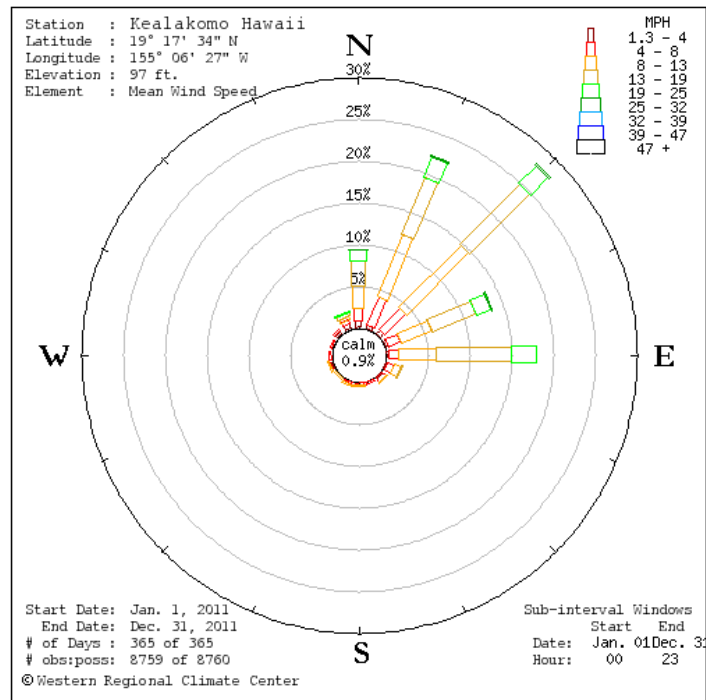


Figure 29. Wind rose graph for Kealakomo Hawaii for 2011 (WRCC 2012).

Keaumo Hawaii, RAWS station HKMO, (HAVO),
Previous name: Keaumo

Table 11. Keaumo Hawaii precipitation, temperature, and relative humidity means for 2011, compared to the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Keaumo Hawaii (2000-2011) RAWS ID: HKMO Park: HAVO Elev. 5,520 ft. (1,692 m.)													
Precipitation (in)													
Long term mean	5.4	4.7	6.1	2.3	1.9	0.8	1.8	2.1	2.6	3.2	8.1	5.9	44.9
2011 means	4.5	3.6	2.7	1.7	3.4	1.4	0.0	0.2	2.5	0.8	2.3	5.6	28.7
Difference	-0.9	-1.3	-3.4	-0.6	1.5	0.6	-1.8	-1.9	-0.2	-2.4	-5.8	-0.3	-16.2
% Long-term	85	75	45	75	180	169	0	9	94	24	28	95	64
Min. temp. (°F)													
Long-term mean	42.2	42.0	43.9	44.9	45.3	47.3	48.9	48.1	47.9	47.6	46.2	44.0	45.7
2011 means	42.6	42.1	45.5	42.2	46.6	47.7	45.9	47.1	44.5	44.8	47.7	46.2	45.2
Difference	0.4	0.1	1.6	-2.7	1.2	0.4	-3.0	-1.0	-3.4	-2.8	1.5	2.2	-0.5
Max. temp. (°F)													
Long-term mean	68.9	68.5	67.3	68.5	71.2	73.7	75.7	76.4	73.6	73.1	72.0	69.9	71.6
2011 means	67.9	68.1	69.6	68.5	67.7	72.8	74.7	75.3	73.2	72.3	70.6	68.2	70.7
Difference	-1.0	-0.3	2.3	0.0	-3.5	-0.9	-1.0	-1.1	-0.4	-0.7	-1.4	-1.7	-0.8
Avg. temp. (°F)													
Long-term mean	54.2	54.0	54.5	55.6	57.7	60.1	61.8	61.5	59.7	59.0	57.7	55.4	57.6
2011 means	53.9	53.8	56.2	55.1	56.6	60.0	60.3	60.9	57.7	57.6	57.2	55.4	57.1
Difference	-0.3	-0.2	1.7	-0.6	-1.1	-0.1	-1.5	-0.6	-2.0	-1.4	-0.5	0.0	-0.5
Relative humidity													
Long-term mean	70.2	70.8	80.9	78.6	73.5	69.1	65.3	69.5	70.7	72.1	70.8	69.9	71.8
2011 means	74.5	81.7	69.5	84.2	84.5	70.6	63.6	71.2	81.9	78.6	77.8	82.3	76.7
Difference	4.2	10.9	-11.5	5.6	10.9	1.4	-1.7	1.7	11.2	6.4	7.0	12.3	4.9

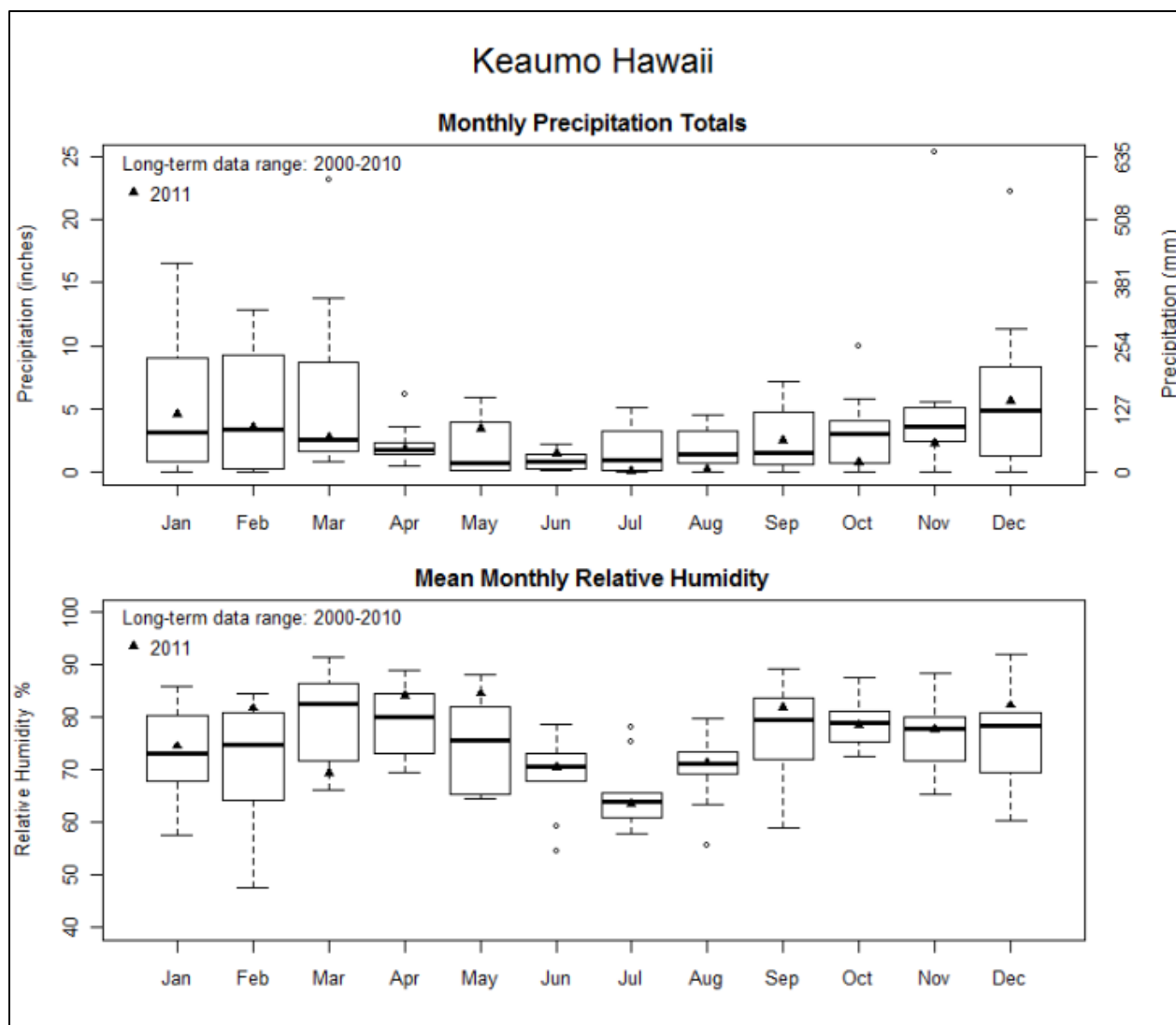


Figure 30. Boxplots for Keaumo Hawaii monthly precipitation and mean monthly relative humidity data for 2011.

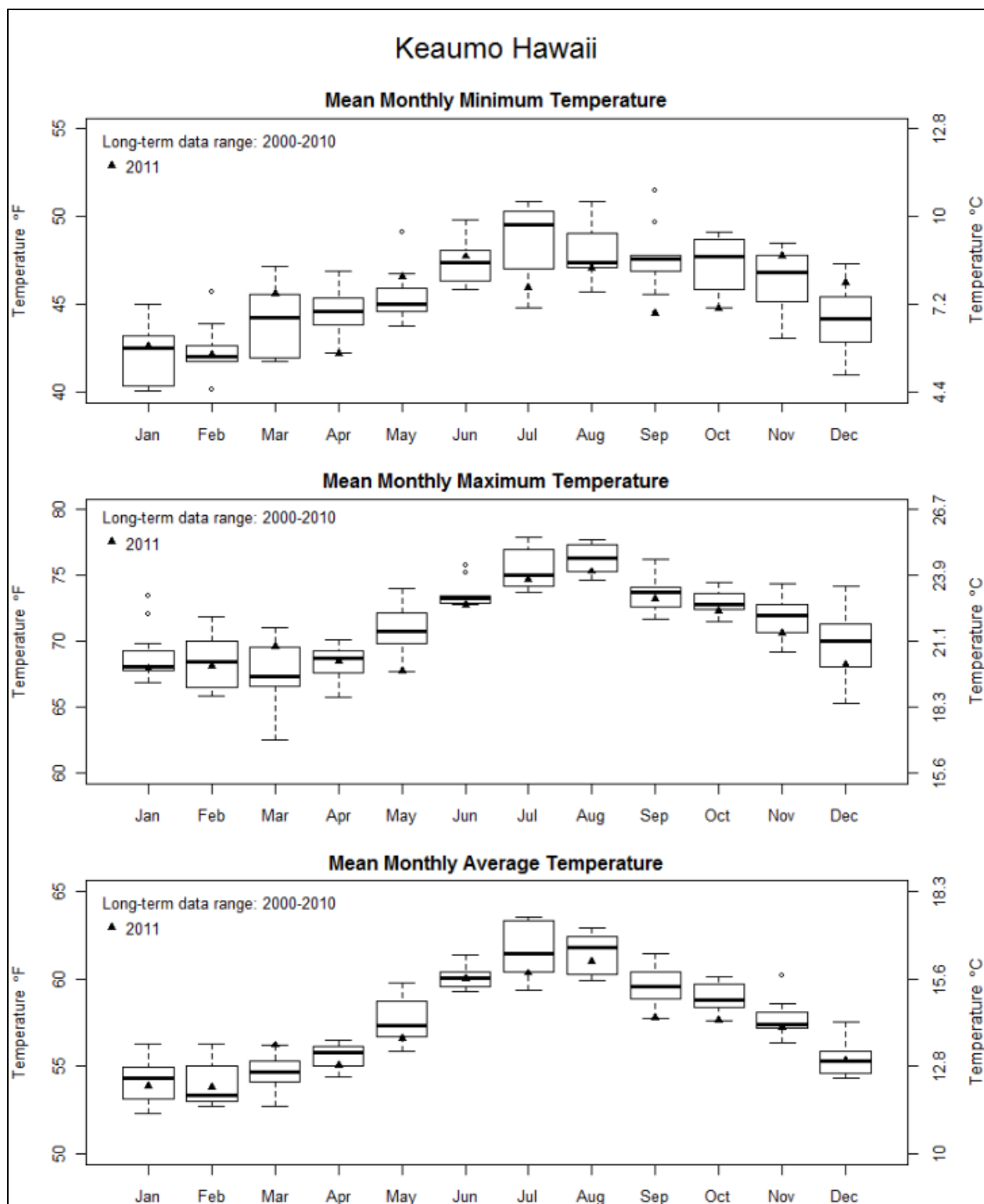


Figure 31. Boxplots for Keaumo Hawaii mean monthly minimum, maximum, and average temperatures for 2011.

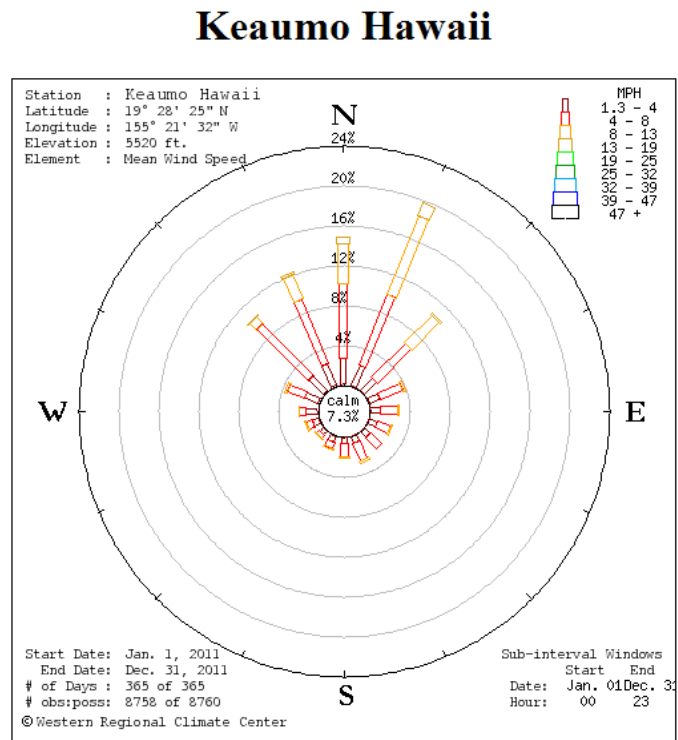


Figure 32. Annual wind rose graph for Keaumo Hawaii, 2011 (WRCC 2012).

Pali 2 Hawaii, RAWS station HPAL, (HAVO)**Previous name: Pali 2****Table 12.** Pali 2 Hawaii precipitation, temperature, and relative humidity means for 2011, compared to the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Pali 2 Hawaii (2000-2011) m.)	RAWS ID: HPAL					Park: HAVO					Elev. 2,780 ft. (856 m.)		
Precipitation (in)													
Long-term mean	7.6	7.0	9.0	1.7	1.8	0.4	1.2	1.6	1.4	4.7	8.1	6.8	51.2
2011 totals	3.0	2.4	3.4	5.2	1.2	0.1	0.1	0.2	2.2	0.3	0.7	1.8	20.5
Difference	-4.6	-4.5	-5.6	3.5	-0.6	-0.3	-1.1	-1.4	0.8	-4.4	-7.4	-5.1	-30.6
% Long-term	39	34	38	306	67	25	8	12	157	6	9	26	40
Min. temp. (°F)													
Long-term mean	56.6	56.1	57.2	57.9	59.1	60.4	61.9	62.7	62.2	61.6	60.4	58.1	59.5
2011 means	56.7	57.0	58.1	57.8	59.4	60.5	60.4	61.7	60.2	60.0	59.8	58.2	59.1
Difference	0.2	1.0	0.9	-0.1	0.3	0.1	-1.5	-1.0	-2.1	-1.7	-0.6	0.1	-0.4
Max. temp. (°F)													
Long-term mean	71.5	71.3	71.2	72.7	74.8	77.1	79.1	79.7	78.3	76.7	74.9	72.2	74.9
2011 means	71.6	71.1	73.7	71.8	73.5	77.2	78.1	79.4	76.9	76.3	73.5	72.0	74.6
Difference	0.2	-0.2	2.5	-0.9	-1.3	0.1	-1.0	-0.3	-1.4	-0.4	-1.4	-0.2	-0.3
Avg. temp. (°F)													
Long-term mean	62.8	62.3	63.0	63.9	65.7	67.4	69.1	69.6	68.7	67.6	66.3	63.8	65.9
2011 means	62.8	62.9	64.2	63.4	64.9	67.4	68.1	68.9	66.8	66.7	65.1	63.4	65.4
Difference	0.0	0.6	1.2	-0.4	-0.8	0.0	-1.0	-0.8	-1.9	-0.9	-1.3	-0.4	-0.5
Relative Humidity													
Long-term mean	85.9	83.8	84.8	82.0	79.8	77.6	73.0	72.0	74.5	80.0	83.0	80.8	79.8
2011 means	80.9	85.7	75.5	86.7	82.9	76.4	71.7	73.4	78.9	76.0	79.9	81.8	79.1
Difference	-5.0	1.9	-9.3	4.7	3.1	-1.2	-1.4	1.4	4.4	-4.0	-3.2	1.0	-0.6

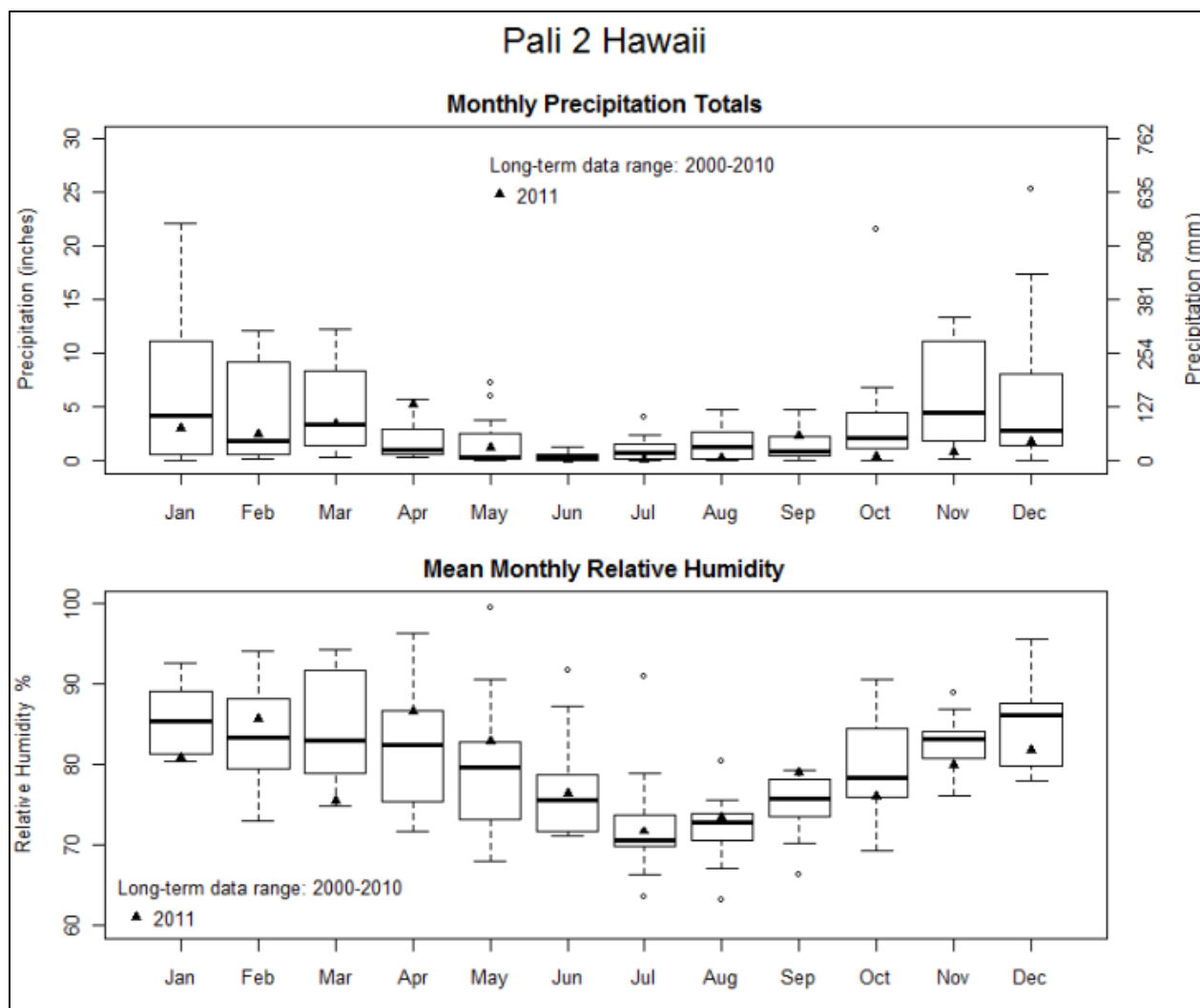


Figure 33. Boxplots for Pali 2 Hawaii monthly precipitation and mean monthly relative humidity data for 2011.

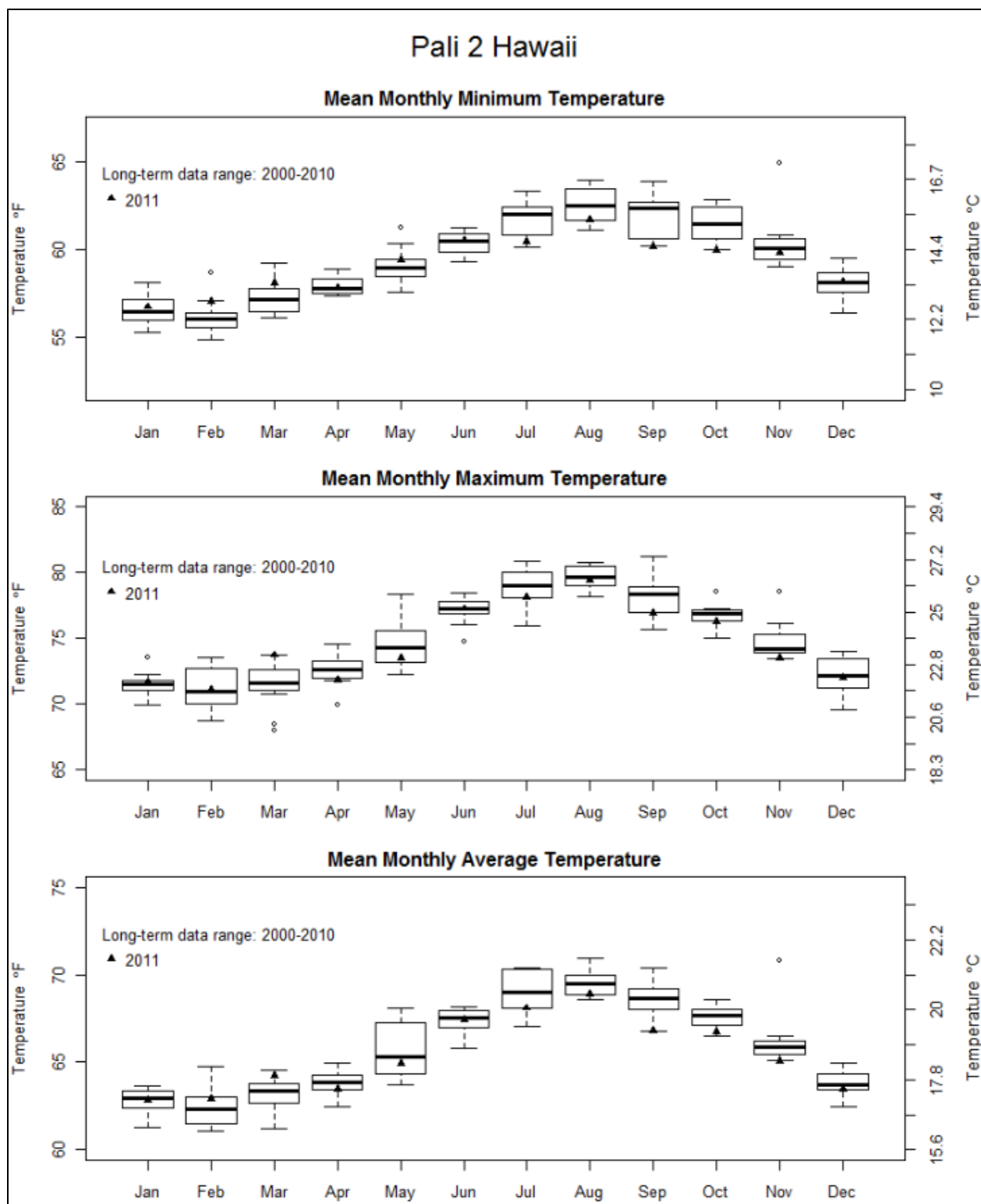


Figure 34. Boxplots for Pali 2 Hawaii mean monthly minimum, maximum, and average temperatures for 2011.

Pali 2 Hawaii

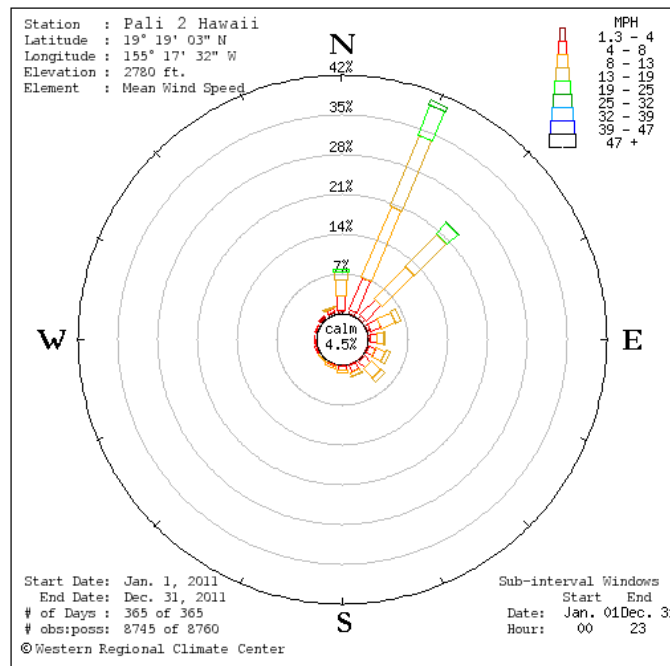


Figure 35. Annual wind rose graph for Pali 2 Hawaii, 2011 (WRCC 2012).

Mauna Loa Slope Obs Hawaii, COOP station 516198, (HAVO),**Previous names: Mauna Loa Slope Obs 1, MLSlope Obs., Mauna Loa Observatory****Table 13.** Mauna Loa Slope Obs Hawaii precipitation and temperature minimums and maximums for 2011, compared to the normals (1981 – 2010), and long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mauna Loa Slope Obs (1955-2011) COOP ID: 516198 Park: HAVO Elev. 11,150 ft. (3,398 m.)													
Precipitation													
1981-2010 normals	2.27	2.47	2.36	1.98	1.16	0.84	2.39	2.03	1.82	1.53	2.4	3.36	24.61
Long-term mean	2.03	1.29	1.36	1.27	0.93	0.47	1.09	1.44	1.29	1.12	1.31	1.80	15.40
2011 totals	0.67	0.38	1.37	1.07	1.59	0.75	0.09	1.63	0.50	0.05	0.77	NA	NA
Difference	-1.36	-0.91	0.01	-0.20	0.66	0.28	-1.00	0.19	-0.79	-1.07	-0.54	NA	NA
% Normal	29	29	58	54	137	89	4	80	27	3	32	NA	NA
% Long-term mean	33	15	100	84	171	159	8	113	39	4	59	NA	NA
Min. temp. (°F)													
1981-2010 normals	35.3	33.7	34.2	35.3	38.4	40.2	39.6	40.2	39.4	38.8	38.9	36.2	37.6
Long-term mean	33.3	32.9	33.2	34.6	36.6	39.4	38.8	38.9	38.4	37.8	36.2	34.3	36.2
Difference	2.0	0.8	1.0	0.7	1.8	0.8	0.8	1.3	1.0	1.0	2.7	1.9	1.4
Max. temp. (°F)													
1981-2010 normals	51.9	51.2	51.9	53.2	55.8	58.5	57.5	57.9	56.7	55.7	53.2	52	54.7
Long-term mean	49.8	49.6	50.2	51.8	53.9	57.2	56.4	56.3	55.7	54.7	52.6	50.6	53.2
Difference	2.1	1.6	1.7	1.4	1.9	1.3	1.1	1.6	1.0	1.0	1.6	1.4	1.5

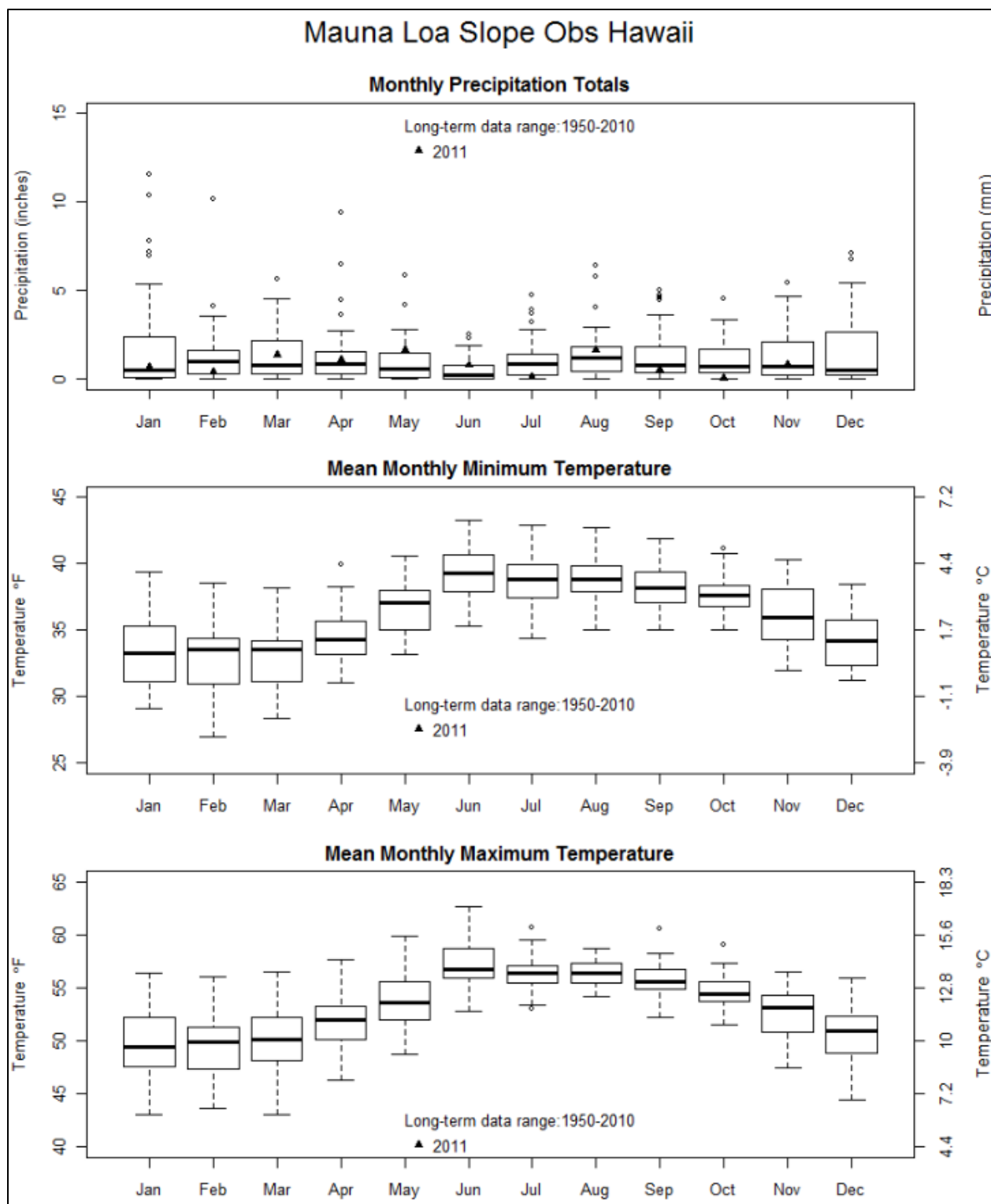


Figure 36. Boxplots for Mauna Loa Slope Obs Hawaii monthly precipitation and temperature data: mean monthly minimum and maximum temperatures for 2011.

Hawaii Volcns NP HQ 54 Hawaii, COOP station 511303, (HAVO)**Previous name: Hawaii Vol NP HQ 54****Table 14.** Hawaii Volcns NP HQ 54 Hawaii comparisons of precipitation and temperature data from 2011 with 1981 - 2010 normals and long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Hawaii Volcns NP HQ 54 Hawaii (1950 - 2011) COOP ID: 511303 Park: HAVO Elev. 3,971 ft. (1,210 m.)													
Precipitation													
1981-2010 normals	9.3	8.8	11.3	9.5	6.4	5.1	7.4	6.7	6.2	7.3	12.6	12.1	102.7
Long-term mean	11.2	10.4	13.2	10.4	7.1	4.8	6.1	6.7	5.3	6.9	12.8	11.7	106.5
2011 means	4.6	3.9	8.2	5.5	10.6	5.1	1.9	2.6	2.7	3.4	10.3	13.5	72.1
Difference	-6.6	-6.5	-5.0	-4.9	3.5	0.3	-4.2	-4.1	-2.6	-3.5	-2.5	1.8	-34.4
% Normal	43	43	58	53	169	98	26	41	45	50	73	123	67
% Long-term mean	41	37	62	53	149	106	31	39	51	49	80	115	68
Min. temp. (°F)													
1981-2010 normals	49.4	49.1	50.2	51.4	52.8	54.1	55.4	55.8	55.3	54.9	53.9	51.3	52.8
Long-term mean	49.6	49.5	50.4	51.5	52.7	53.8	55.0	55.4	55.0	54.6	53.4	51.2	52.7
2011 means	NA	51.1	51.4	50.4	54.1	53.8	NA	55.0	52.5	52.2	52.5	51.4	NA
Difference	NA	1.6	1.0	-1.1	1.4	-0.1	NA	-0.4	-2.5	-2.4	-0.8	0.3	NA
Max. temp. (°F)													
1981-2010 normals	68.1	68.0	68.0	68.0	70.5	71.4	72.3	73.4	73.1	72.4	70.2	68.3	70.3
Long-term mean	67.1	66.9	66.7	67.1	68.9	70.2	71.4	72.4	72.3	71.5	69.1	67.2	69.2
2011 means	NA	70.5	68.4	70.0	68.5	70.2	NA	71.3	71.6	71.0	67.1	65.8	NA
Difference	NA	3.6	1.7	3.0	-0.4	-0.1	NA	-1.0	-0.7	-0.5	-2.1	-1.4	NA

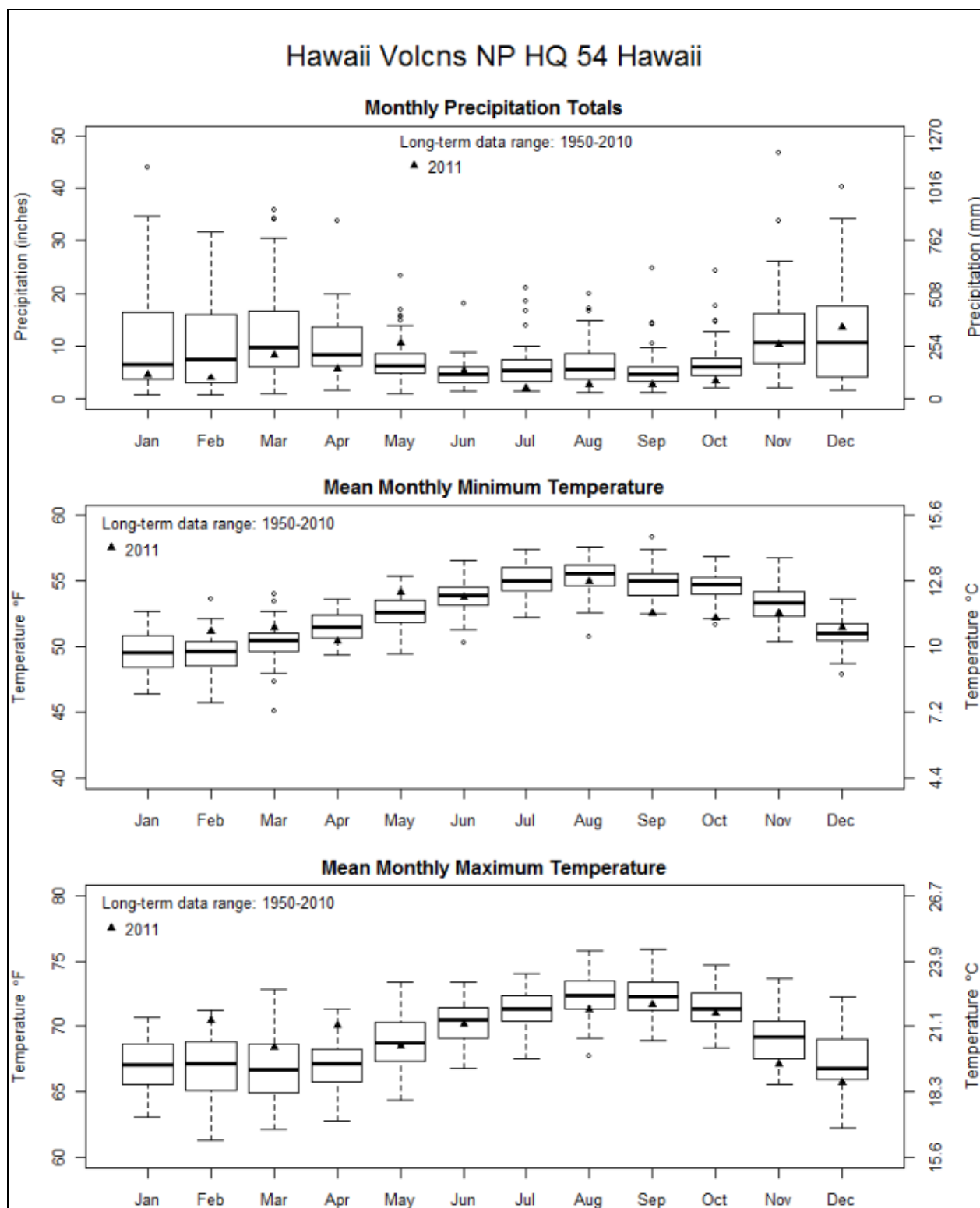


Figure 37. Boxplots for Hawaii Volcns NP HQ 54 Hawaii, monthly precipitation and mean monthly minimum and maximum temperatures for 2011.

West Hawaii National Parks

Weather station data is presented for West Hawaii national parks: one COOP station at Puuhonua o Honaunau National Historical Park (PUHO), one COOP and one RAWS at Kaloko-Honokohau National Historical Park (KAHO), one COOP at Puukohola Heiau National Historic Site (PUHE). Two new Campbell Scientific (CS) stations were set up, one at PUHO and one at PUHE, and have been recording data since February 2012. These stations are along Ala Kahakai National Historic Trail (ALKA) and can be used for the sections of trail that run through these parks.

Table 15. Stations for West Hawaii national parks weather and climate data.

National Park	Weather station	Location	RAWS/COOP	Elevation (m)
PUHO	Puuhonua-o-ha HNP 27.4 Hawaii	19 25, -155 55	COOP	6
	PUHO CS (2012) ¹	20 01 30, -155 49 16	RAWS	34
KAHO	Kaloko-Honokohau	19 40 22, -156 01 13	RAWS	8
	Honokohau Harbor	19 41, -156 01	COOP	9
PUHE	Puukohola Heiau 98.1	20 02, -155 50	COOP	42
	PUHE CS (2012) ¹	20 01 30, -155 49 16	RAWS	34

¹These stations will be used in the 2012 analysis.

Puuhonua o Honaunau National Historical Park (PUHO)

Puuhonua-o-Ha HNP 27.4 Hawaii COOP station 518552, (PUHO)

Previous name: Puuhonuaohonaunau 27.4

Table 16. Precipitation for Puuhonua-o-ha HNP 27.4 for 2011 compared with 1981 – 2010 normals and long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Puuhonua-o-ha HNP 27.4 Hawaii (1971 – 2011) COOP ID: 518552 Park: PUHO Elev. 16 ft., (5 m)													
Precipitation													
1981-2010 normals	1.85	1.85	1.63	1.44	2.02	2.21	3.01	2.43	2.58	2.4	1.93	1.89	25.24
Long-term mean	2.35	1.56	1.70	1.99	1.96	2.30	2.41	2.40	2.62	2.16	1.62	1.63	24.71
2011 means	1.25	1.61	3.91	0.89	2.14	1.33	0.00	1.19	0.00	0.00	0.00	0.10	12.42
Difference	-1.10	0.05	2.21	-1.10	0.18	-0.97	-2.41	-1.21	-2.62	-2.16	-1.62	-1.53	-12.29
% Normal	68	87	240	62	106	60	0	49	0	0	0	5	49
% Long-term mean	53	103	230	45	109	58	0	50	0	0	0	6	50

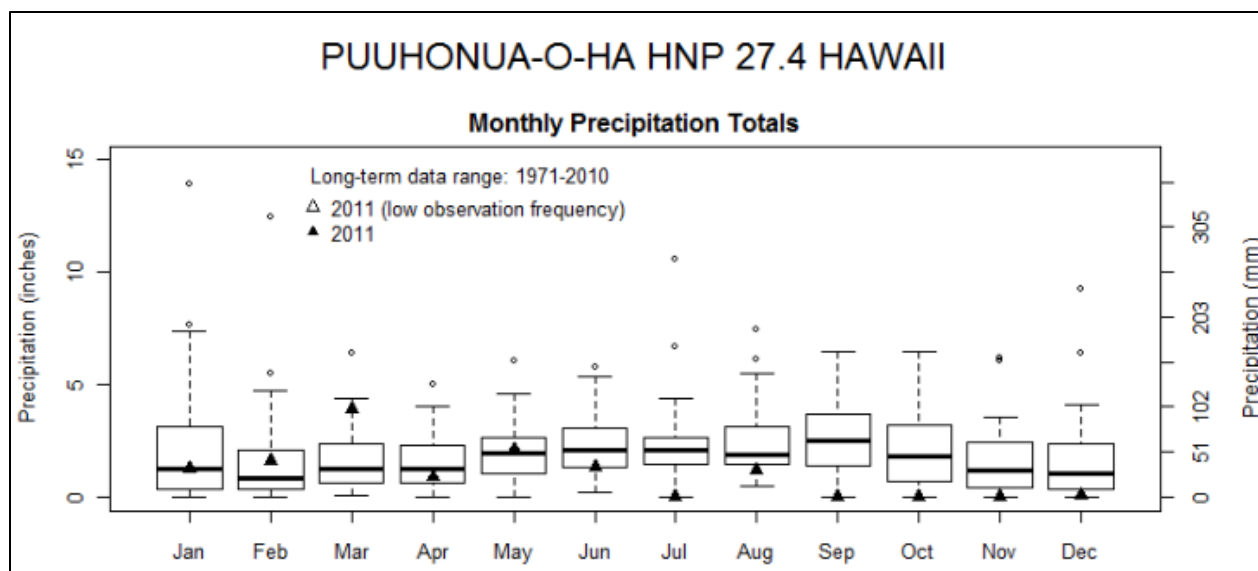


Figure 38. Boxplot of Puuhonua-o-ha HNP 27.4 Hawaii for 2011.

Kaloko-Honokohau National Historical Park (KAHO)

Kaloko-Honokohau Hawaii RAWS station HKAL (KAHO)

Table 17. Kaloko-Honokohau Hawaii precipitation and temperature data for 2011 with comparisons with long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Kaloko-Honokohau Hawaii (2006-2011) RAWS ID: HKAL Park: KAHO Elev. 25 ft. (8 m.)													
Precipitation (in)													
Long-term mean	0.66	1.42	0.86	0.86	0.84	0.92	1.80	0.50	1.06	1.43	0.69	3.24	14.27
2011 totals	1.94	3.12	1.59	6.31	4.33	3.04	0.39	0.92	1.38	1.19	1.45	0.20	25.86
Difference	1.28	1.71	0.73	5.45	3.49	2.12	-1.41	0.42	0.32	-0.24	0.76	-3.04	11.60
% Long-term	293	220	186	735	518	332	22	184	130	83	211	6	181
Min. temp. (°F)													
Long-term mean	66.42	66.06	67.64	68.03	66.06	71.40	71.92	72.33	71.59	71.60	69.83	67.57	69.20
2011 means	65.97	67.36	68.84	68.86	70.29	71.37	70.39	71.87	70.67	70.52	69.37	66.36	69.32
Difference	-0.45	1.30	1.20	0.83	4.23	-0.03	-1.53	-0.47	-0.92	-1.08	-0.46	-1.21	0.12
Max. temp. (°F)													
Long-term mean	82.14	81.62	81.57	82.11	82.32	84.13	84.75	85.71	85.35	85.54	84.18	83.25	83.56
2011 means	81.42	82.07	82.26	82.48	82.74	83.20	83.90	85.30	85.30	84.94	83.03	82.07	83.23
Difference	-0.72	0.46	0.69	0.37	0.42	-0.93	-0.85	-0.41	-0.05	-0.61	-1.15	-1.18	-0.33
Ave. temp. (°F)													
Long-term mean	74.32	73.92	74.60	75.38	75.44	78.18	78.67	79.39	78.76	78.69	76.83	75.34	76.63
2011 means	73.75	74.89	75.85	75.93	76.59	77.47	77.76	78.99	78.03	77.90	75.99	74.03	76.43
Difference	-0.57	0.97	1.24	0.55	1.15	-0.71	-0.91	-0.40	-0.73	-0.80	-0.84	-1.31	-0.20

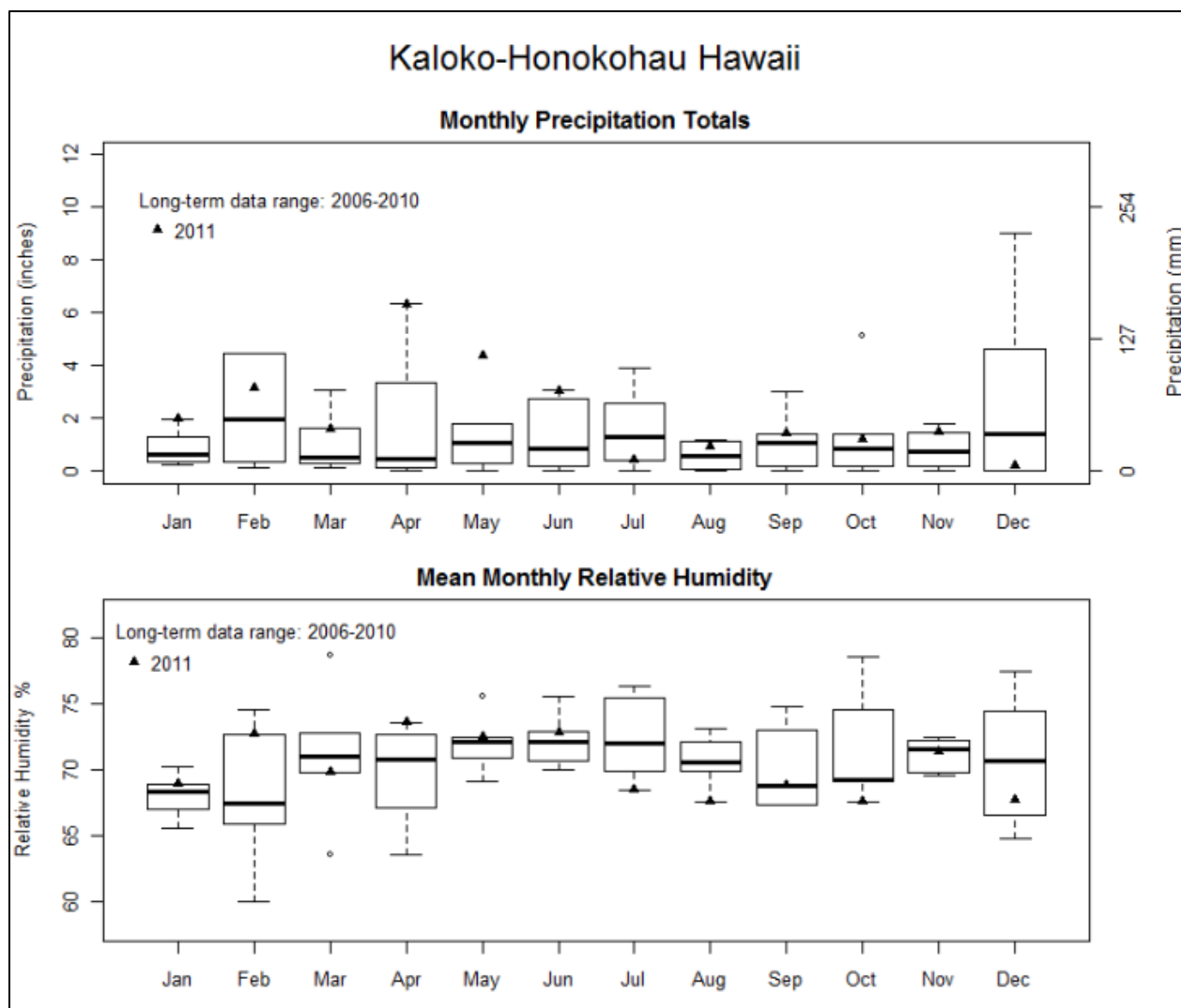


Figure 39. Boxplot for precipitation and mean monthly relative humidity for Kaloko-Honokohau for 2011.

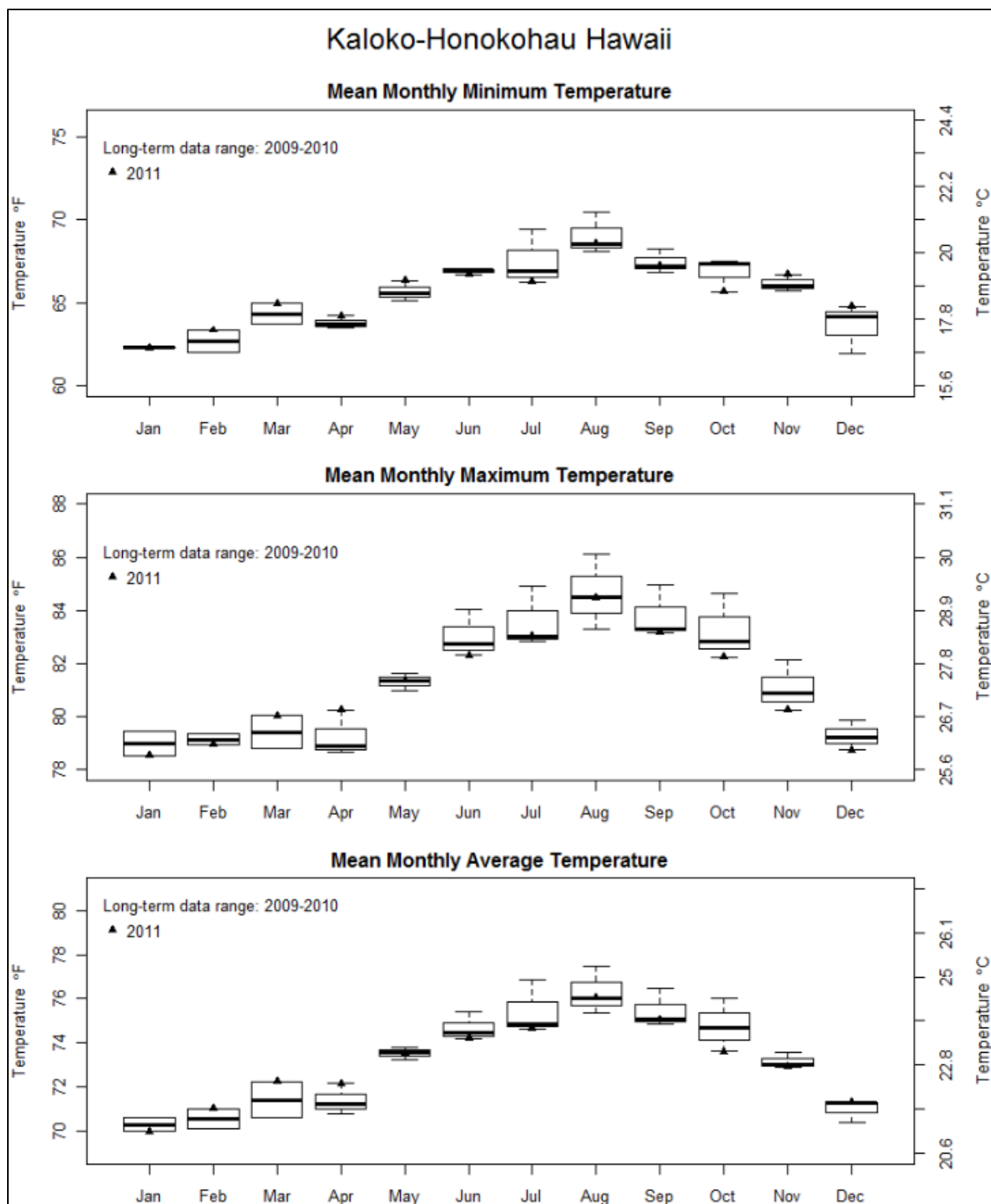


Figure 40. Boxplots for Kaloko-Honokohau Hawaii mean monthly minimum, maximum, and average temperature analysis for 2011.

Kaloko-Honokohau Hawaii

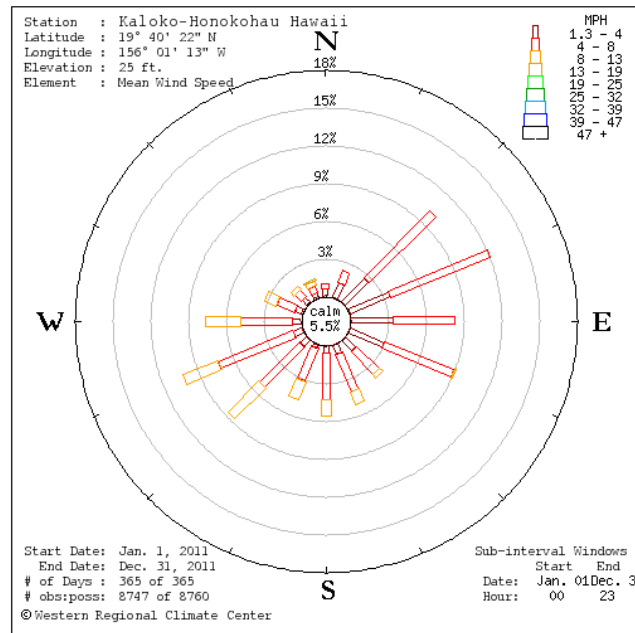


Figure 41. Annual wind rose graph for Kaloko-Honokohau Hawaii, 2011 (WRCC 2012).

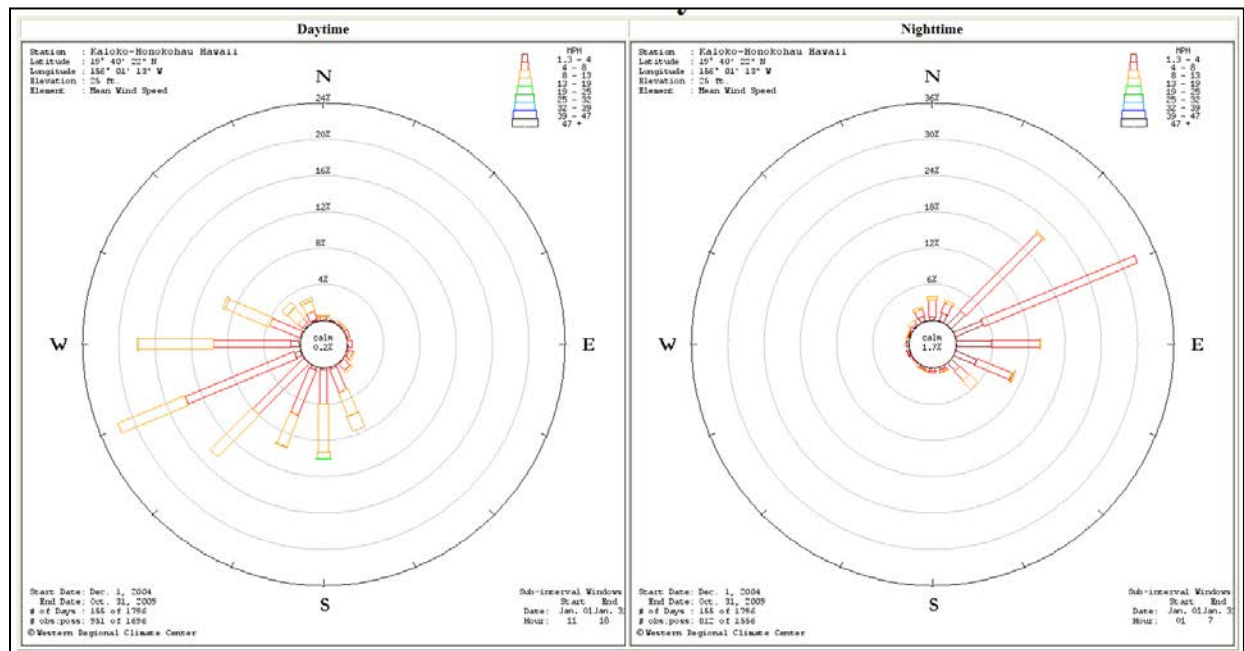


Figure 42. Wind rose graph for Kaloko-Honokohau Hawaii for January showing typical patterns for day and night from data from December 2004 to October 2009 (WRCC 2012). Ocean and land temperature differences create a wind direction change between day and night.

Honokohau Harbor Hawaii COOP station 511880, (KAHO)
Previous name: Honokohau Harbor 68.14

Table 18. Honokohau Harbor Hawaii precipitation data and NCDC normals for 1981 - 2010, compared to the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Honokohau Harbor Hawaii (1991-2011) COOP ID: 511880 Park: KAHO Elev. 30 ft. (9 m.)													
Precipitation (in)													
NCDC normals	2.12	0.78	1.44	2.21	0.77	1.10	1.02	1.12	1.50	1.47	0.72	1.06	15.3 1
Long-term mean	1.50	0.72	1.31	0.98	0.83	1.43	1.36	1.37	1.29	1.51	0.87	1.75	14.9 3
2011 data	1.97	3.85	3.65	3.55	4.87	2.79	0.27	1.17	0.00	0.00	0.00	0.00	22.1 2
Difference	0.47	3.13	2.34	2.57	4.04	1.36	-1.09	-0.20	-1.29	-1.51	-0.87	-1.75	7.19
% Normal	93	494	253	161	632	254	26	104	NA	NA	NA	NA	144
% Long-term mean	131	535	279	362	587	195	20	85	NA	NA	NA	NA	115

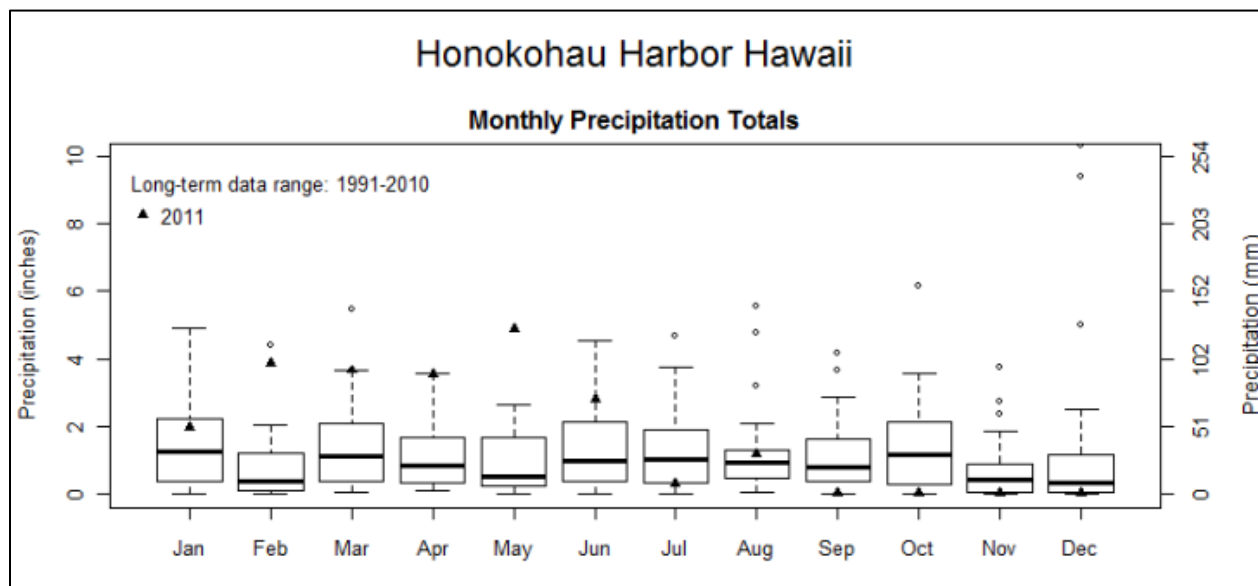


Figure 43. Honokohau Harbor Hawaii boxplot for precipitation for 2011.

Puukohola Heiau National Historic Site (PUHE)

Puukohola Heiau 98.1 Hawaii, COOP station 518422, (PUHE)

Table 19. Puukohola Heiau 98.1, Hawaii precipitation and temperature minimums and maximums for 2011 compared to the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Puukohola Heiau 98.1 Hawaii (1977-2011) COOP ID: 518422 Park: PUHE Elev. 140 ft. (43 m.)													
Precipitation (in)													
Long-term mean	1.7	1.0	1.0	0.8	0.5	0.6	0.3	0.6	0.6	0.7	1.0	1.7	10.5
2011	0.7	0.6	0.3	1.5	0.7	0.1	0.2	0.0	0.1	0.1	0.1	0.1	4.4
Difference	-1.0	-0.5	-0.7	0.7	0.2	-0.5	-0.2	-0.6	-0.5	-0.6	-0.9	-1.6	-6.0
% Long-term	41	60	30	188	67	14	66	1	16	14	10	6	42
Min. temp. (°F)													
Long-term mean	63.9	63.8	62.9	66.6	67.7	69.0	70.3	70.7	70.2	69.8	68.2	65.6	67.4
2011 mean	64.3	65.1	67.5	67.3	68.6	68.7	69.0	71.0	73.9	72.8	72.1	70.3	69.2
Difference	0.4	1.2	4.6	0.7	0.9	-0.3	-1.3	0.3	3.7	3.0	4.0	4.7	1.8
Max. temp. (°F)													
Long-term mean	80.4	80.3	79.1	83.1	83.6	85.1	86.2	86.7	86.2	85.4	83.4	81.6	83.4
2011	77.7	78.1	80.3	78.8	81.0	81.5	82.2	82.9	86.3	86.2	85.0	84.8	82.1
Difference	-2.7	-2.2	1.2	-4.3	-2.6	-3.6	-4.1	-3.8	0.0	0.7	1.6	3.3	-1.4

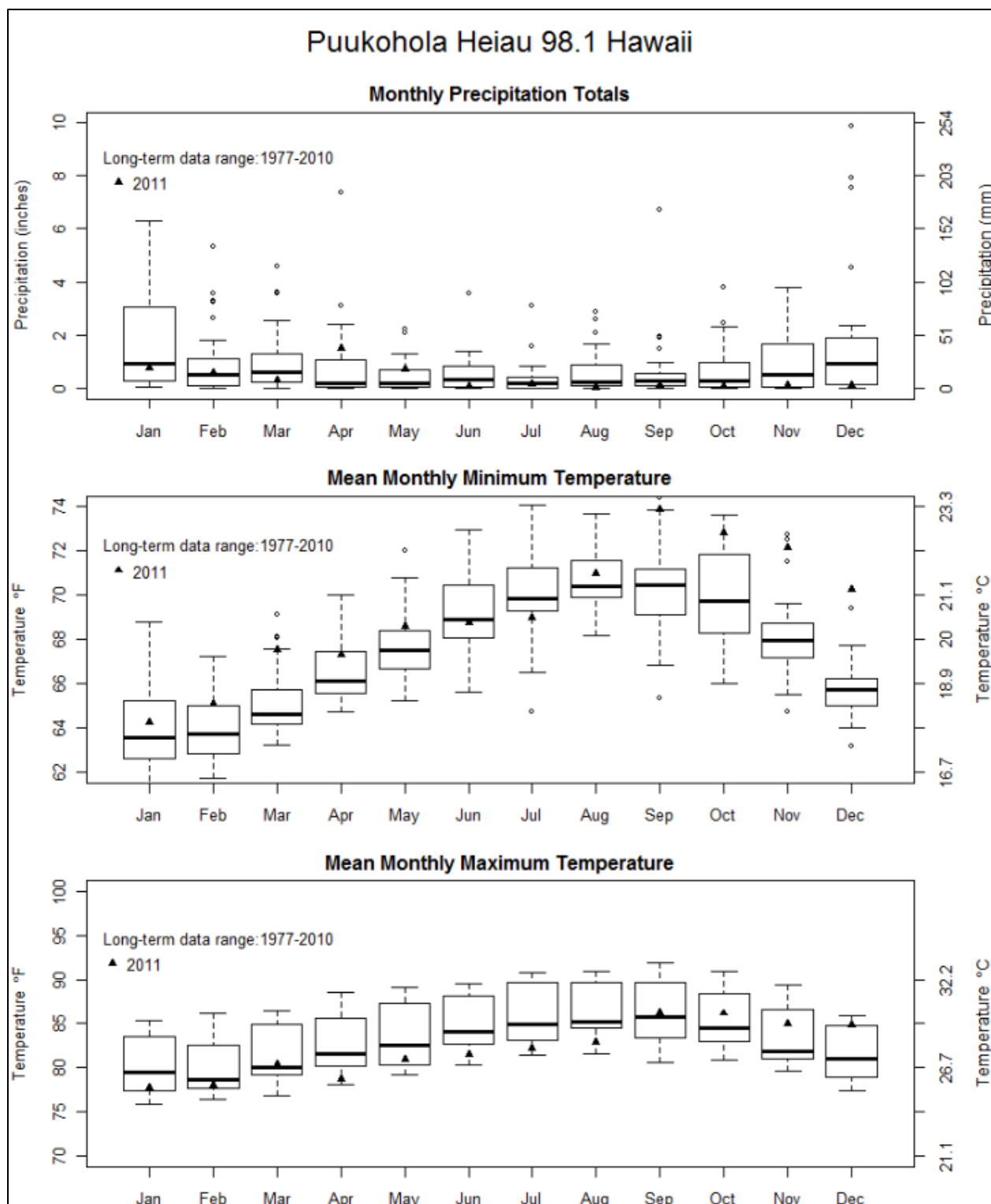


Figure 44. Puukohola Heiau 98.1, Hawaii precipitation and mean monthly minimum and maximum temperatures for 2011.

Parks on Molokai and Maui

Kalaupapa National Historical Park (KALA)

Table 21 and Figures 45 – 47 present precipitation, temperature, relative humidity, wind, and solar radiation data for Makapulapai Hawaii, a RAWS station located on the Kalaupapa Peninsula.

Kalaupapa 563 COOP station, currently only collects precipitation data, but through the long station record there have been intermittent years during which temperature data were also recorded as indicated in Figure 48. Precipitation data flags indicated that subsequent (S) days reported accumulated (A) data. To provide at least some information about rainfall in this area, data for all months are shown in Table 22 and Figure 48.

Wind graphics (Figure 47) illustrate the wind conditions on the peninsula. In January and February winds came out of the north or northeast, but during the rest of the year the predominant wind direction was directly from the east.

One of two new Campbell Scientific RAWS weather stations was installed in February 2012, Puu Alii Hawaii. The exact location for the second station is still being determined and should be erected in 2013.

Table 20. Stations used in the analysis of Kalaupapa National Historical Park weather and climate data.

Weather station	Location	RAWS/COOP	Elevation
Kalaupapa National Historical Park			
Makapulapai Hawaii	21° 12' 12", -156° 57' 58"	RAWS	75 ft. (23 m.)
Kalaupapa 563, Hawaii	21° 12', - 56° 59'	COOP	30 ft. (15 m.)
Puu Alii Hawaii ¹	21° 08' 07", -156° 54' 08"	RAWS	3805 ft. (1153 m.)
Campbell Scientific station ²	TBD	RAWS	TBD

¹This station will be used in the 2012 analysis.

²This station's location is still to be decided and will be used for analysis the year following its set-up.

Makapulapai Hawaii (RAWS) station HMAK, (KALA)

Table 21. Makapulapai Hawaii (RAWS) station with precipitation and minimum, maximum, and average temperatures compared to the long-term mean. Bold numbers are questionable because they are exceedingly low numbers for a site within a quarter mile of the ocean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Makapulapai Hawaii (1994-2011)	RAWS ID: HMAK					Park: KALA			Elev. 75 ft. (23 m.)				
Precipitation (in)													
Long-term mean	4.1	1.8	6.3	1.8	1.6	0.7	0.9	1.2	1.0	1.5	4.4	3.5	28.9
2011 totals	5.0	4.2	1.8	1.2	0.9	1.5	1.5	0.6	0.4	0.7	1.4	2.1	21.3
Difference	0.9	2.4	-4.5	-0.6	-0.8	0.7	0.5	-0.7	-0.6	-0.8	-3.0	-1.4	-7.6
% Difference	122	233	28	67	56	214	167	50	40	47	32	60	74
Min. temp. (°F)													
Long-term mean	67.7	67.5	68.1	69.4	71.7	73.5	74.2	74.5	73.7	73.6	71.2	69.4	71.2
2011 means	67.5	67.2	69.8	67.6	71.7	71.1	72.2	67.6	72.6	73.2	71.7	69.7	70.2
Difference	-0.2	-0.4	1.7	-1.8	0.0	-2.4	-2.1	-6.9	-1.1	-0.5	0.4	0.3	-1.1
Max. temp. (°F)													
Long-term mean	79.3	78.0	78.4	79.2	82.1	83.9	84.7	85.5	84.7	84.2	81.2	80.1	81.8
2011 means	80.4	81.5	79.6	82.3	82.2	82.3	83.4	84.5	85.1	83.7	80.4	78.2	82.0
Difference	1.1	3.4	1.2	3.1	0.1	-1.6	-1.4	-0.9	0.4	-0.5	-0.8	-1.9	0.2
Ave. temp. (°F)													
Long-term mean	73.1	72.5	72.9	73.9	76.5	78.2	78.9	79.5	78.7	78.4	75.8	74.4	76.1
2011 means	73.3	73.8	74.4	75.6	76.4	76.3	77.2	76.2	78.4	77.9	75.5	73.5	75.7
Difference	0.2	1.3	1.5	1.7	-0.1	-1.9	-1.7	-3.3	-0.3	-0.5	-0.3	-0.8	-0.4
Ave. Relative Humidity (%)													
Long-term mean	79.8	78.3	81.8	79.1	77.0	77.0	78.5	78.7	76.1	80.7	80.2	73.8	78.4
2011 means	37.3	83.0	79.7	78.6	78.3	81.6	81.5	83.1	72.3	71.1	74.3	77.6	74.9
Difference	-42.5	4.7	-2.1	-0.4	1.3	4.6	2.9	4.4	-3.8	-9.6	-5.9	3.8	-3.5

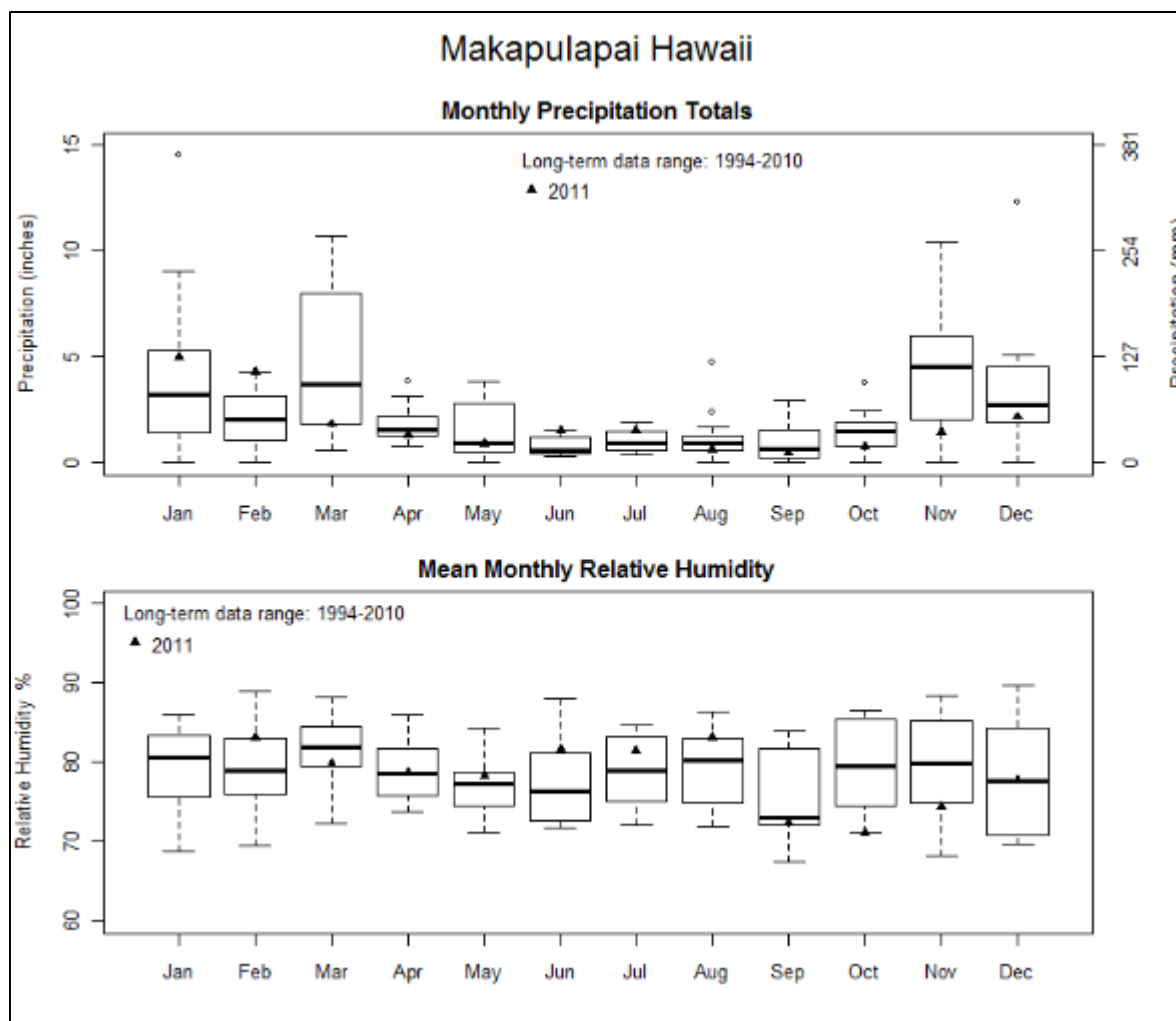


Figure 45. Boxplots for Makapulapai Hawaii RAWS precipitation and mean monthly relative humidity for 2011.

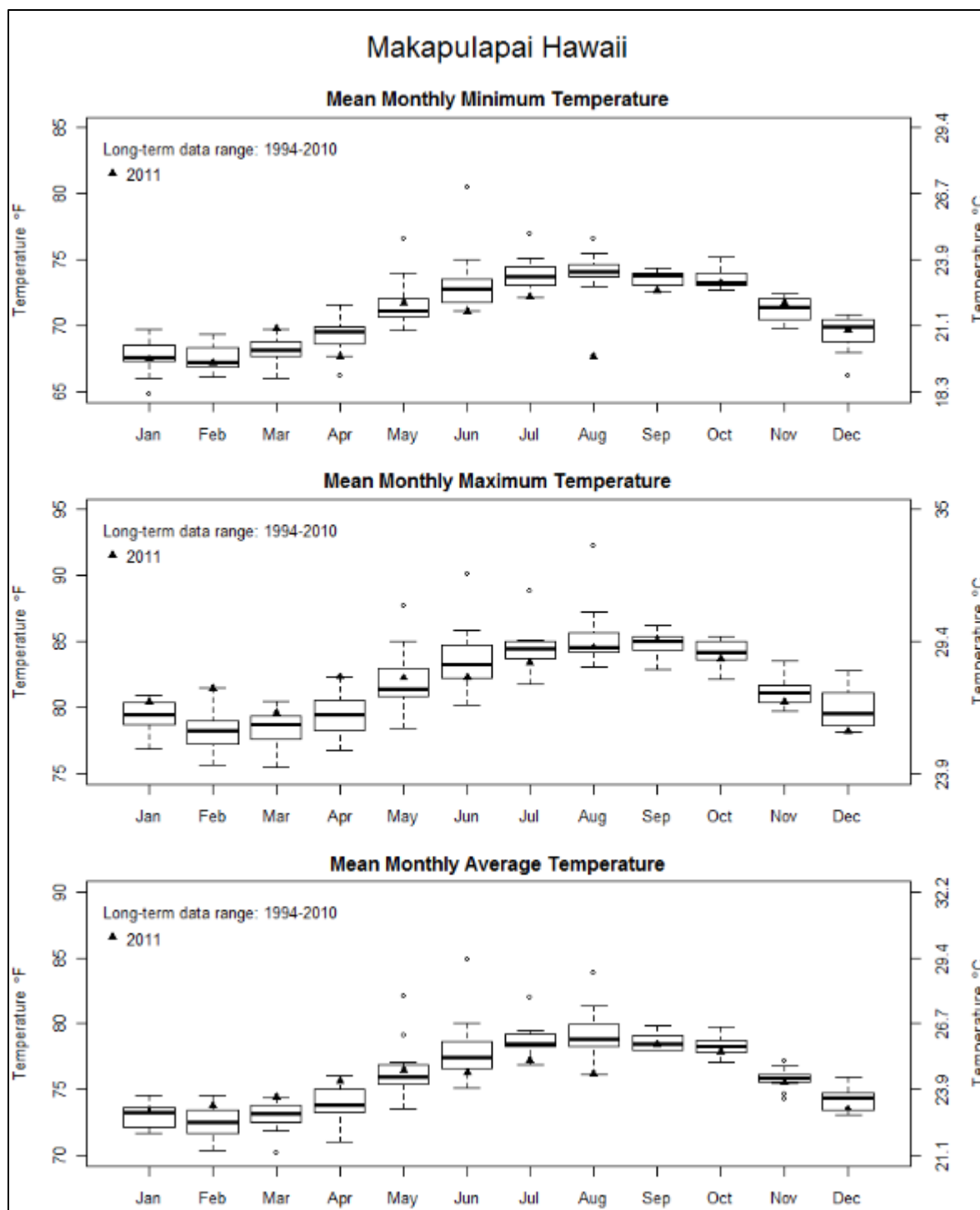


Figure 46. Boxplots of Makapulapai Hawaii mean monthly minimum, maximum, and average temperatures for 2011.

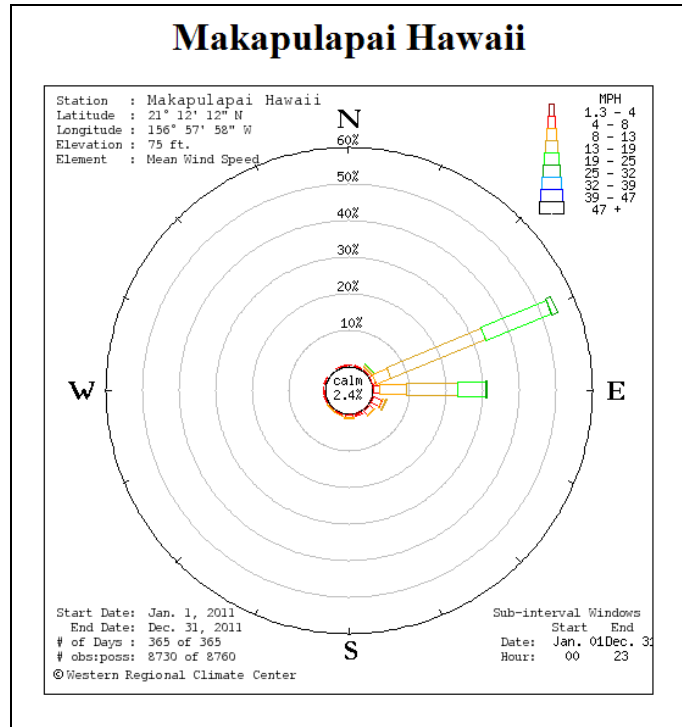


Figure 47. Wind rose graph of Makapulapai Hawaii for 2011 (WRCC 2012).

Kalaupapa 563, Hawaii COOP station 512896, (KALA)

Table 22. Kalaupapa 563, Hawaii COOP station precipitation data for 2011 compared with 1981-2010 normals and the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Kalaupapa 563, Hawaii (1949-2011)	COOP ID: 512896					Park: KALA			Elev. 30 ft. (9 m.)				
Precipitation (in)													
1981 - 2010 normals	5.11	4.11	5.27	3.47	2.28	1.17	1.57	1.85	1.5	2.66	4.15	5.49	38.63
Long-term mean	5.03	4.58	5.33	3.33	2.09	1.20	1.87	2.01	1.34	2.64	4.95	5.29	39.66
2011 totals	5.85	4.02	2.27	1.20	1.30	2.03	2.14	1.09	1.32	1.11	1.68	0.07	24.08
Difference	0.82	-0.56	-3.06	2.13	0.79	0.83	0.27	0.92	0.02	1.53	3.27	5.22	-15.58
% Normal	106	95	45	25	44	138	97	52	86	37	37	1	56
% Long-term mean	116	88	42	36	62	169	114	54	98	42	34	1	61

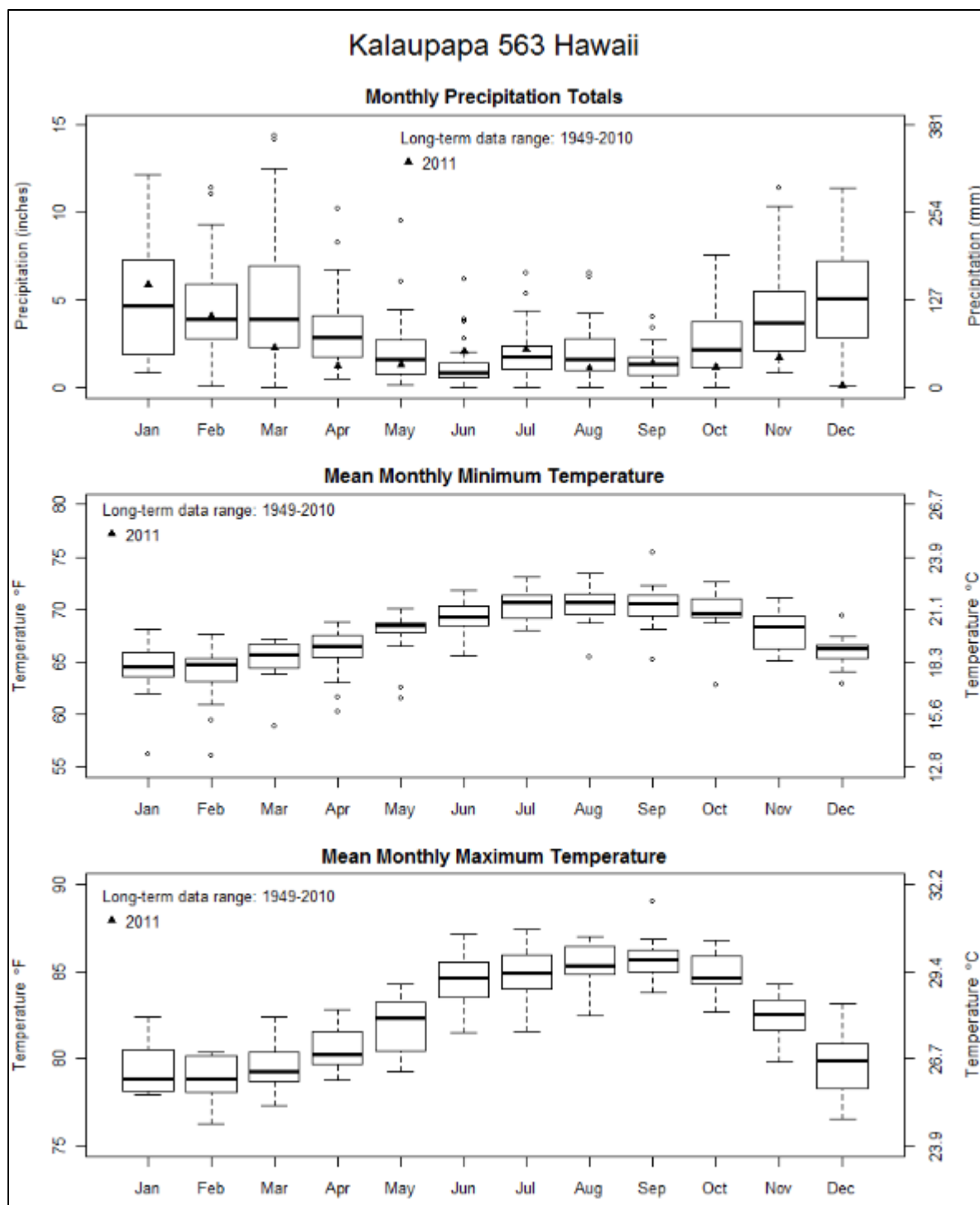


Figure 48. Boxplots for Kalaupapa 563, Hawaii monthly precipitation and mean monthly minimum and maximum temperatures for 2011.

Haleakala National Park (HALE)

Three stations are used to summarize Haleakala National Park's climate and weather (Table 23). Haleakala RS 338 is a COOP station and is summarized in Table 24 and Figure 49. Oheo 256.8 is another COOP station and is illustrated in Table 25 and Figure 50. Kaupo Gap Hawaii is a RAWS station and is summarized in Table 26 and Figures 51 – 54.

Figures 53 and 54 illustrate the wind data for the Kaupo Gap RAWS, showing that while the trade winds have a heavy influence in this area, wind direction is variable and southerly winds are also very common. Northerly winds tend to have the highest wind speeds.

Table 23. Weather stations used in this report for Haleakala National Park (HALE) for 2011.

Weather station	Location	RAWS/COOP	Elevation
Haleakala National Park			
Haleakala RS 338	20° 46', -156° 15'	COOP	7029 ft. (2130 m.)
Oheo 256.8	20° 40', -156° 03'	COOP	120 ft. (36 m.)
Kaupo Gap Hawaii	20° 41' 03", -156° 09' 07"	RAWS	4030 ft. (1221 m.)

Haleakala RS 338, Hawaii, COOP station 511004, (HALE)
Table 24. Haleakala RS 338, Hawaii 30-year climate normals for 1981-2010 compared to the 2011 data.

	Jan.	Feb.	Mar.	Apr	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Haleakala RS 338 (1950-2011) COOP ID: 511004 Park HALE Elev. 7,029ft. (2,130 m.)													
Precipitation (in.)													
1981-2010 normals	5.99	5.49	7.65	4.16	2.16	1.38	2.59	2.1	2.38	3.1	5.29	7.45	49.74
Long-term mean	8.21	6.41	6.85	4.55	2.11	1.20	2.27	2.65	1.87	2.86	5.51	6.85	51.34
2011	9.74	1.75	4.26	1.91	5.97	0.39	0.90	0.58	1.14	1.07	5.50	5.67	38.88
Difference	1.53	-4.66	-2.59	-2.64	3.86	-0.81	-1.37	-2.07	-0.73	-1.79	-0.01	-1.18	-12.46
% Normal	163	32	56	46	276	28	35	28	48	35	104	76	78
Mean													
%Long-term	119	27	62	42	283	32	40	22	61	37	100	83	76
Min. temp. (°F)													
1981-2010 normals	43.4	42.3	42.9	43.2	45.1	47.5	48.5	48.8	47.4	47.2	47	44.4	45.7
Long-term mean	42.2	41.5	41.9	42.8	44.4	46.8	47.5	47.7	46.4	46.2	45.6	43.6	44.7
2011 mean	NA	43.8	44.4	NA	46.8	49.1	48.4	46.9	NA	NA	45.3	NA	NA
Difference	NA	2.3	2.5	NA	2.4	2.3	0.9	-0.8	NA	NA	-0.3	NA	NA
% normal	NA	104	103	NA	104	103	100	96	NA	NA	96	NAS	NA
Max. temp. (°F)													
1981-2010 normals	60.6	59.6	59.9	60.4	62.7	65.3	65.6	66.2	64.5	64	63.3	61.3	62.8
Long-term mean	59.9	59.1	59.4	60.6	62.7	65.7	65.6	66.1	64.9	64.2	62.9	60.9	62.7
2011 totals	NA	59.8	61.3	NA	61.4	64.9	64.6	65.6	NA	NA	60.5	NA	NA
Difference	NA	0.7	1.8	NA	-1.3	-0.8	-1.0	-0.5	NA	NA	-2.4	NA	NA
%Normal	NA	100	102	NA	98	99	99	99	NA	NA	96	NA	NA

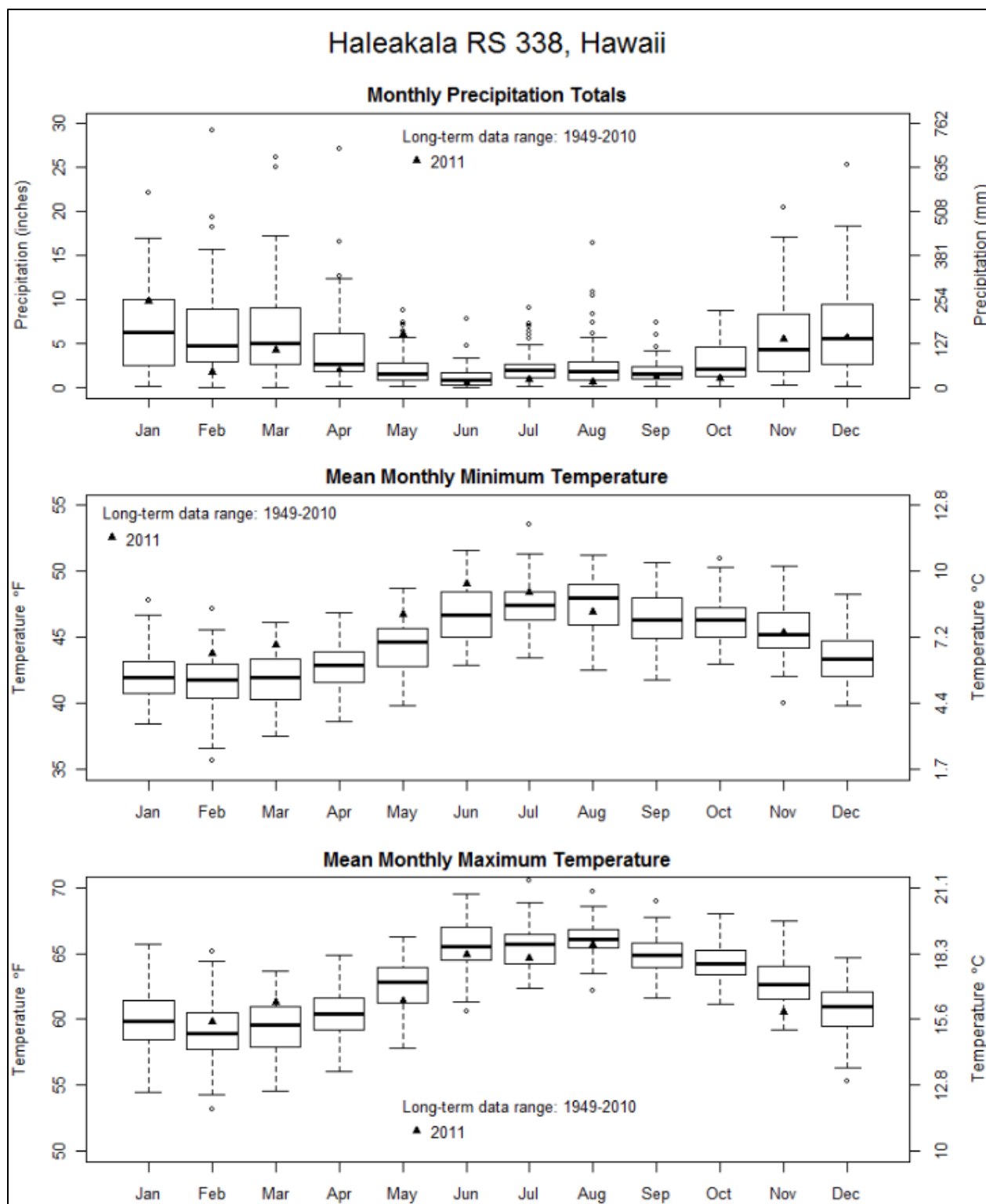


Figure 49. Boxplots for Haleakala RS 338, Hawaii monthly precipitation and mean monthly temperature data for 2011.

Oheo 258.6 Hawaii, COOP station 517000, (HALE)

Table 25. Oheo 258.6, Hawaii precipitation and temperature data for 2011, including comparisons to NCDC normals for 1981- 2010 and long-term mean.

Oheo 258.6 Hawaii (1982-2011)	COOP ID: 517000						Park: HALE				Elev. 120 ft. (37 m.)		
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Precipitation (in)													
Normal 1981 - 2010	7.81	5.29	8.22	6.45	5.23	5.36	7.26	6.72	6.94	8.24	8.64	7.86	84.02
Long-term mean	7.50	5.66	8.21	6.47	5.06	5.54	7.23	6.70	6.88	8.13	8.73	7.76	83.86
2011	4.57	4.44	4.7	1.76	5.14	5.86	6.27	5.66	6.09	6.34	6.88	4.14	61.85
Difference	-2.93	-1.22	-3.51	-4.71	0.08	0.32	-0.96	-1.04	-0.79	-1.79	-1.85	-3.62	-22.01
% Normal	58	84	57	27	98	109	86	84	88	78	79	53	74
% Long-term mean	61	78	57	27	101	106	87	84	88	78	79	53	74
Min. temp. (°F)													
Normal 1981 - 2010	67.3	66.7	67.1	67.3	69.5	70.9	71.3	72.1	71.8	71.1	70.3	69	69.5
Long-term mean	65.9	63.1	66.9	66.8	69.1	69.8	70.5	71.2	71.1	70.8	69.8	67.4	68.5
2011 means	56.9	50.1	0	68.1	70.2	68.5	65.7	69	66.3	69.7	68	62.5	59.6
Difference	-9	-13	NA	1.3	1.1	-1.3	-4.8	-2.2	-4.8	-1.1	-1.8	-4.9	-8.9
Max. temp. (°F)													
Normal 1981 - 2010	78.5	78.1	78.3	78	80	81.2	81.5	82.9	82.5	82.5	81.1	80	80.4
Long-term mean	77	73.5	77.8	77.4	80.1	80.2	80.7	81.4	81.6	81.5	80.6	78.2	79.2
2011 means	68.9	65.3	0	78.2	80.4	78.3	76.1	79.2	77.2	79.5	78.1	73.2	69.5
Difference	-8.1	-8.2	NA	0.8	0.3	-1.9	-4.6	-2.2	-4.4	-2	-2.5	-5	-9.7

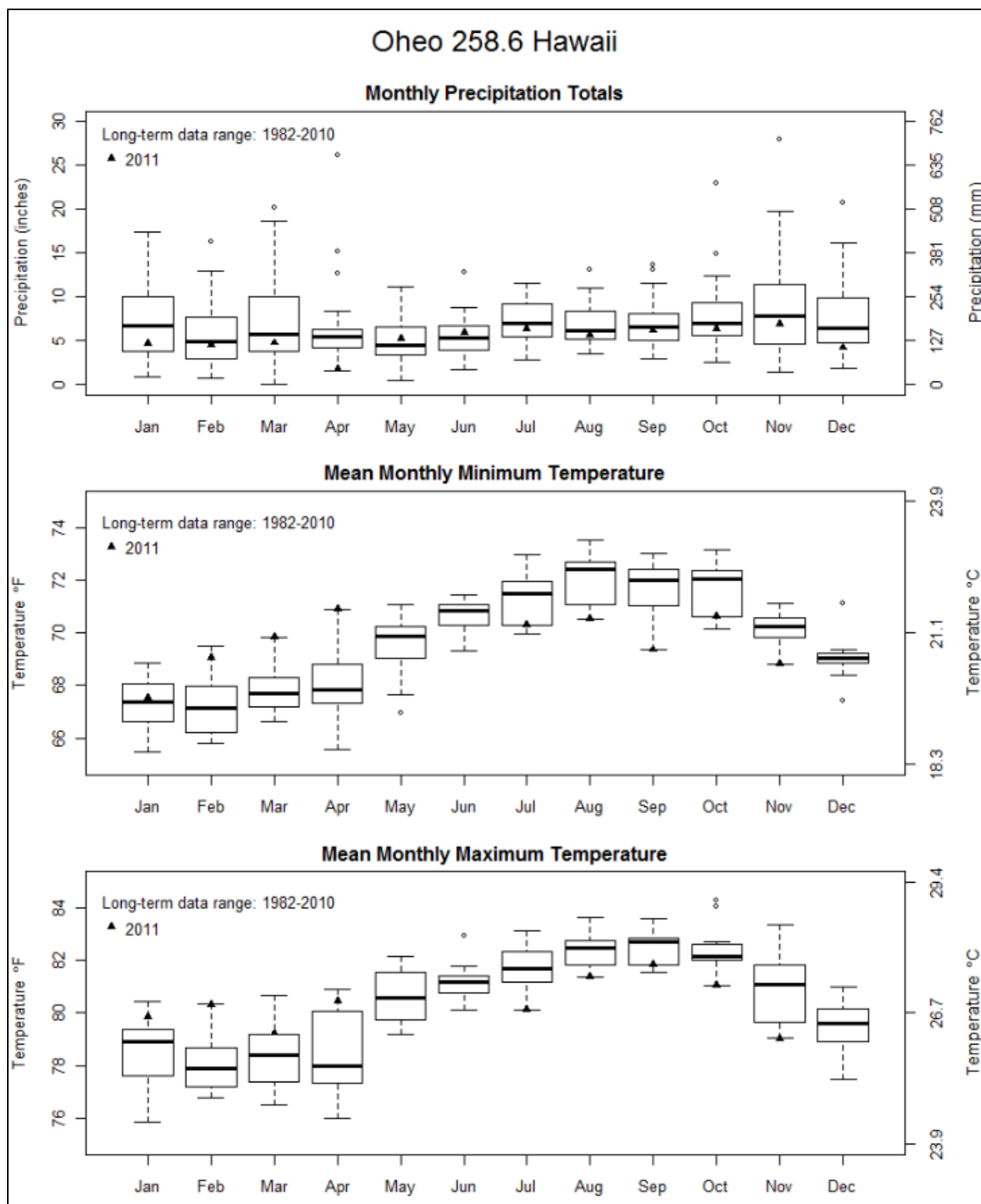


Figure 50. Oheo 258.6, Hawaii boxplots of monthly precipitation totals and mean monthly minimum and maximum temperatures for 2011.

Kaupo Gap Hawaii RAWS station HKAU, (HALE)

Table 26. Kaupo Gap Hawaii RAWS precipitation, minimum, maximum, average temperatures, and relative humidity data for 2011 compared to the long-term mean.

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Kaupo Gap Hawaii (1991-2011) RAWS ID: HKAU Park: HALE Elev. 4,030 ft. (1,228 m.)													
Precipitation (in)													
Long-term mean	11.82	6.43	11.01	3.53	1.88	1.24	0.88	2.44	2.52	4.57	4.81	7.87	58.99
2011 means	3.33	8.22	5.31	7.34	6.40	0.84	0.41	0.10	1.25	1.88	3.96	4.38	43.42
Difference	-8.49	1.79	-5.70	3.81	4.52	-0.40	-0.47	-2.34	-1.27	-2.69	-0.85	-3.49	-15.57
% Long-term	28	128	47	204	342	64	44	4	46	38	79	56	72
Min. temp. (°F)													
Long-term mean	53.59	52.22	53.84	54.30	55.27	57.19	58.66	58.94	58.80	58.41	57.55	55.01	56.15
2011 means	51.65	53.82	55.23	53.10	55.67	57.55	57.03	57.06	55.83	56.45	55.77	55.33	55.37
Difference	-1.95	1.61	1.39	-1.20	0.40	0.36	-1.63	-1.88	-2.97	-1.96	-1.78	0.32	-0.77
Max. temp. (°F)													
Long-term mean	67.53	67.19	68.05	69.52	71.41	73.67	75.82	76.47	75.29	74.02	71.82	68.91	71.64
2011 means	68.26	70.25	70.32	70.40	70.53	74.48	75.45	76.81	74.77	74.94	73.10	69.83	72.43
Difference	0.73	3.06	2.27	0.88	-0.88	0.81	-0.36	0.34	-0.53	0.91	1.28	0.92	0.79
Ave. temp. (°F)													
Long-term mean	59.58	58.70	59.85	60.90	62.54	64.66	66.49	66.76	65.81	65.00	63.55	60.80	62.89
2011 means	59.13	60.40	61.27	60.63	62.11	65.31	65.41	65.68	64.14	64.36	63.14	61.26	62.74
Difference	-0.45	1.70	1.42	-0.27	-0.43	0.66	-1.08	-1.08	-1.66	-0.64	-0.41	0.46	-0.15
Relative humidity (%)													
Long-term mean	77.30	77.49	78.13	69.62	76.13	75.08	64.51	71.97	74.27	77.73	81.70	80.49	75.37
2011 means	72.42	51.71	1.00	1.00	1.00	6.86	65.65	71.03	73.97	69.03	68.13	69.60	45.95
Difference	-4.88	-25.78	-77.13	-68.62	-75.13	-68.21	1.13	-0.94	-0.31	-8.70	-13.57	-10.89	-29.42

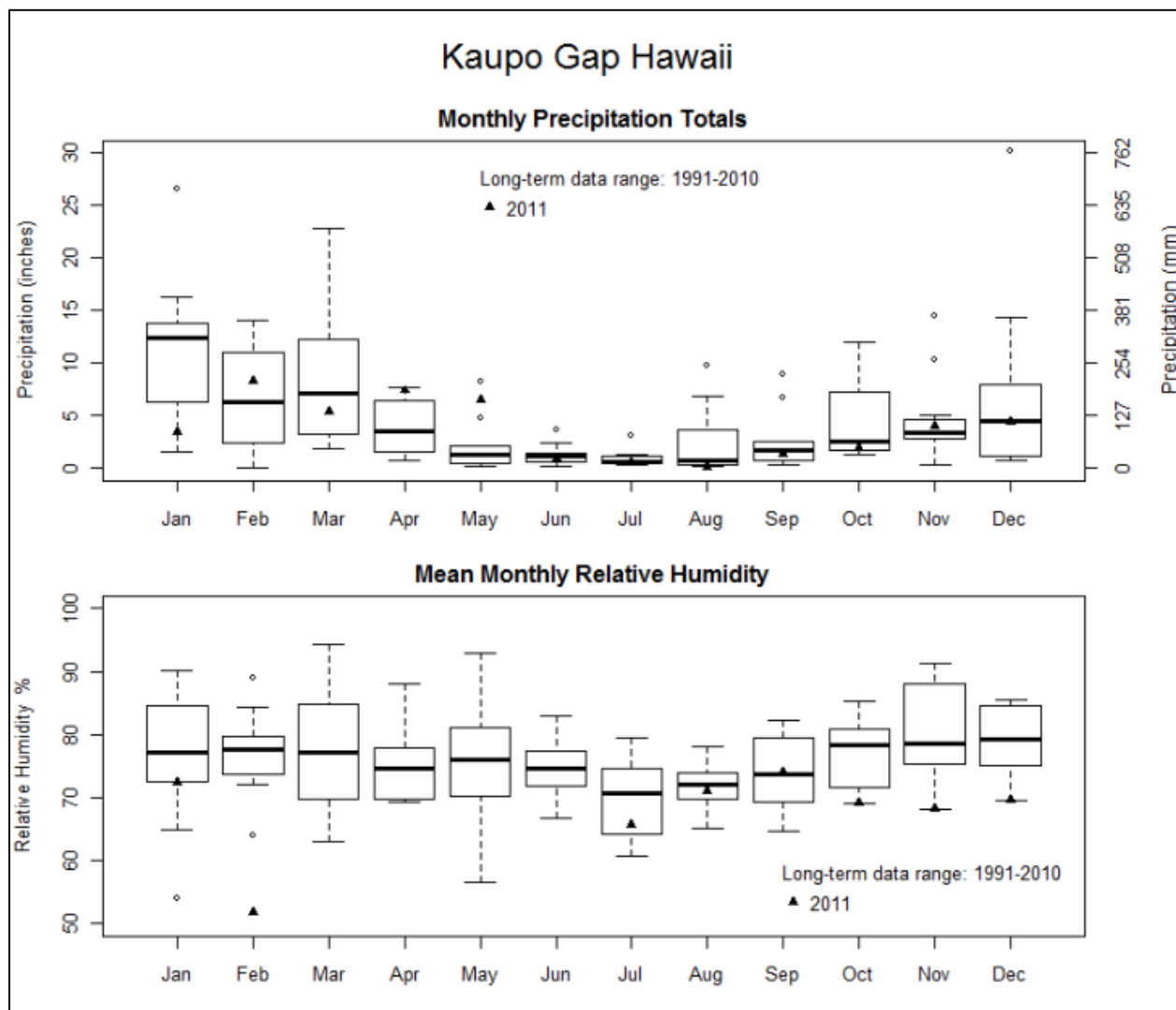


Figure 51. Boxplots of Kaupo Gap, Hawaii monthly precipitation and mean monthly relative humidity data for 2011.

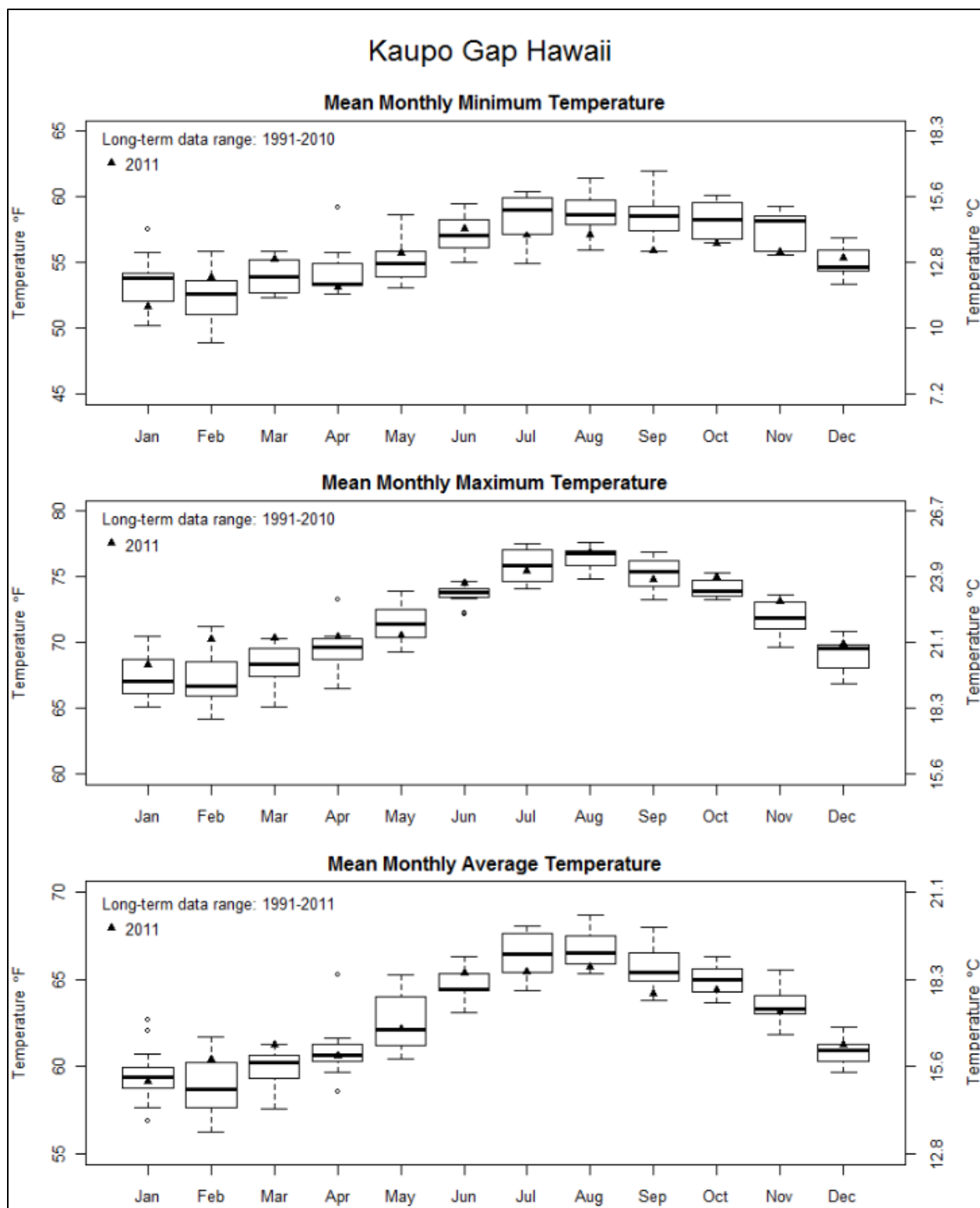


Figure 52. Boxplots for Kaupo Gap, Hawaii mean monthly minimum, maximum, and average temperature data for 2011.

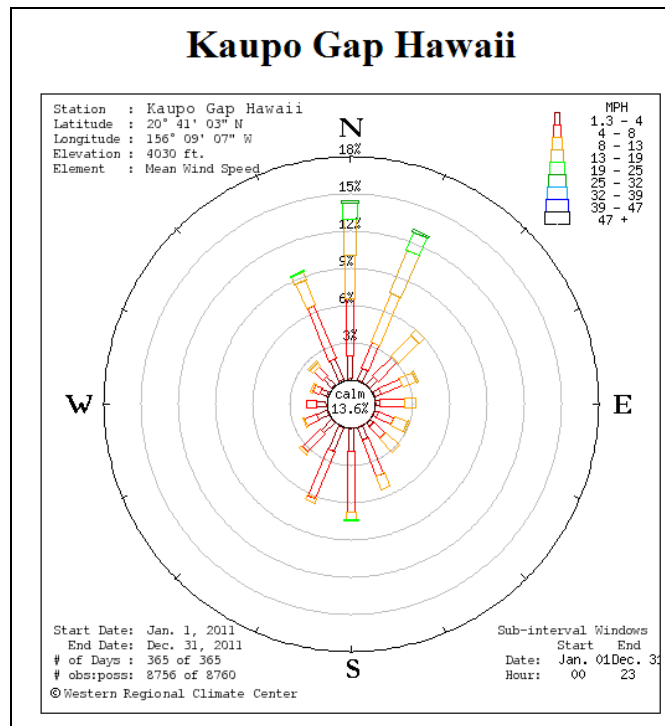


Figure 53. Wind rose graph for Kaupo Gap, Hawaii for 2011 (WRCC 2012).

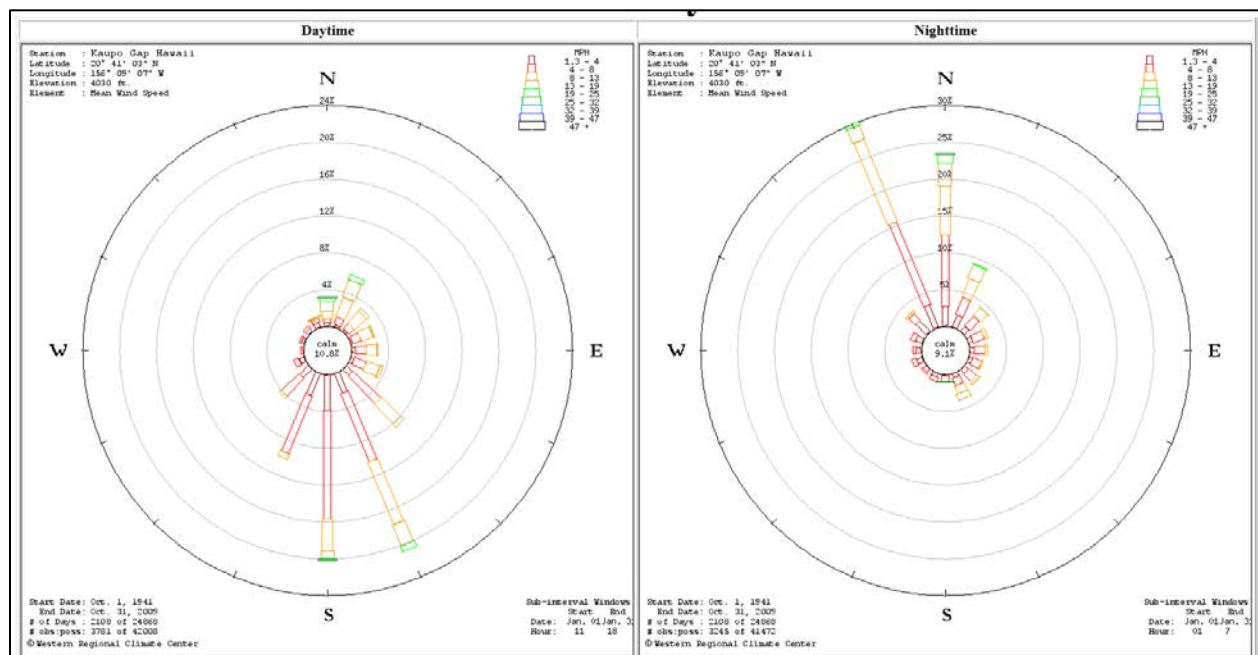


Figure 54. Wind rose graphs for Kaupo Gap, Hawaii day-time and night-time for 2011 (WRCC 2012). Notice the opposite wind directions for these times, representing diurnal and nocturnal wind direction changes often associated with oceanic islands due to warming and cooling of the land masses.

Hawaii Drought Conditions

As part of a comprehensive drought monitoring effort between the USDA, NOAA, and the National Drought Mitigation Center, the Drought Monitor (<http://hawaii.gov/dlnr/drought/>) publishes weekly updates of drought conditions in graphic form for all 50 states. The Hawaii Drought Monitor also has state-specific news on drought impacts and available assistance programs. Hawaii drought conditions are illustrated for bi-monthly time points throughout 2011 (Figures 55 - 58). The year started with extreme drought conditions in northwestern Hawaii in January, while conditions worsened through February and March to exceptional drought in northwest Hawaii. Rains in August and November finally lessened drought severity.

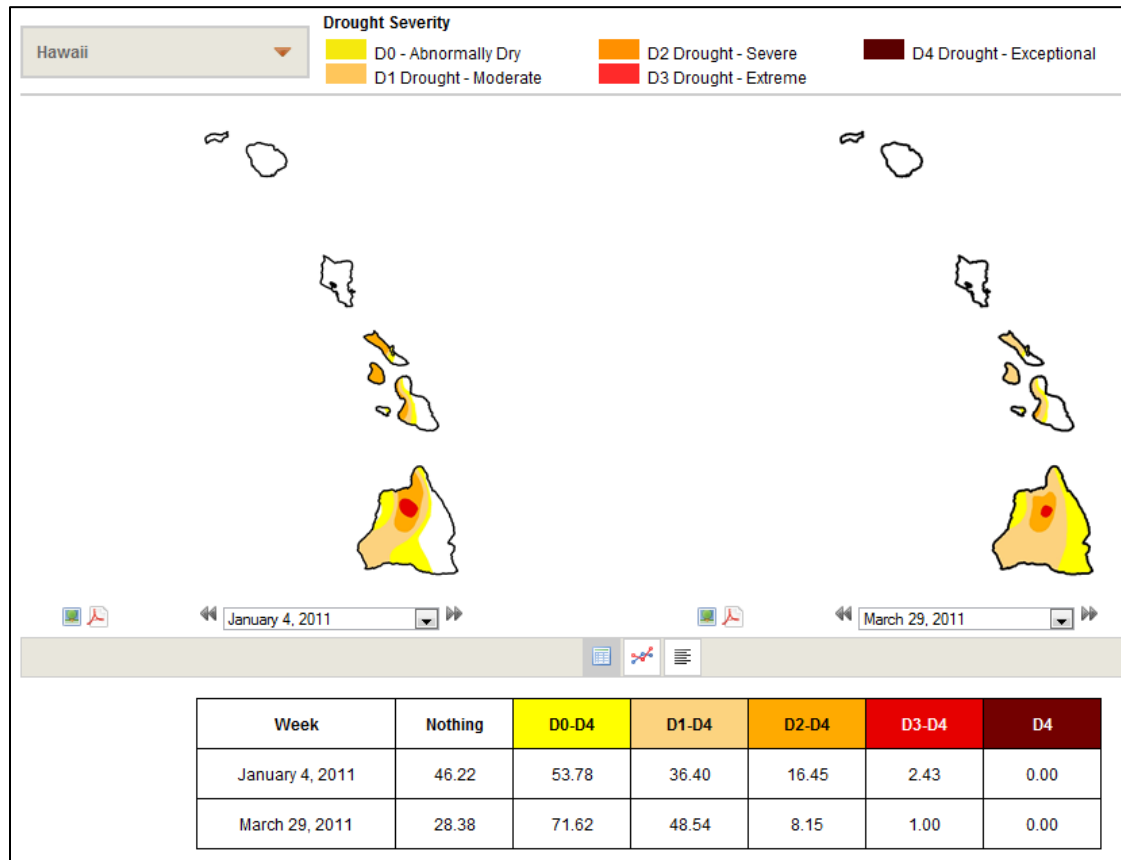


Figure 55. Drought conditions in the state of Hawaii in early January through late March 2011. Figure reproduced from the Hawaii Drought Monitor (2012).

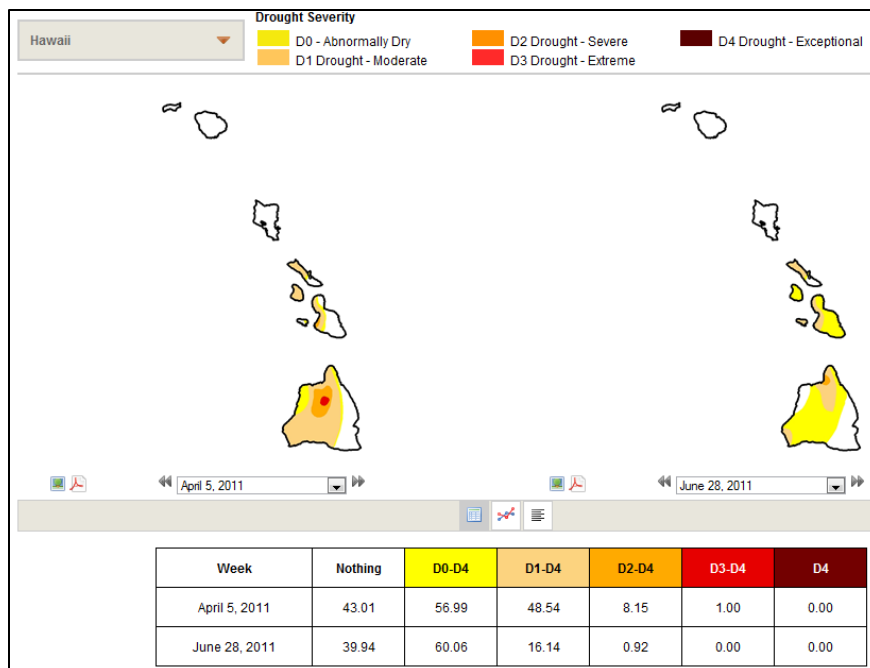


Figure 56. Drought conditions in the state of Hawaii in early April through late July 2011. Figure reproduced from the Hawaii Drought Monitor (2012).

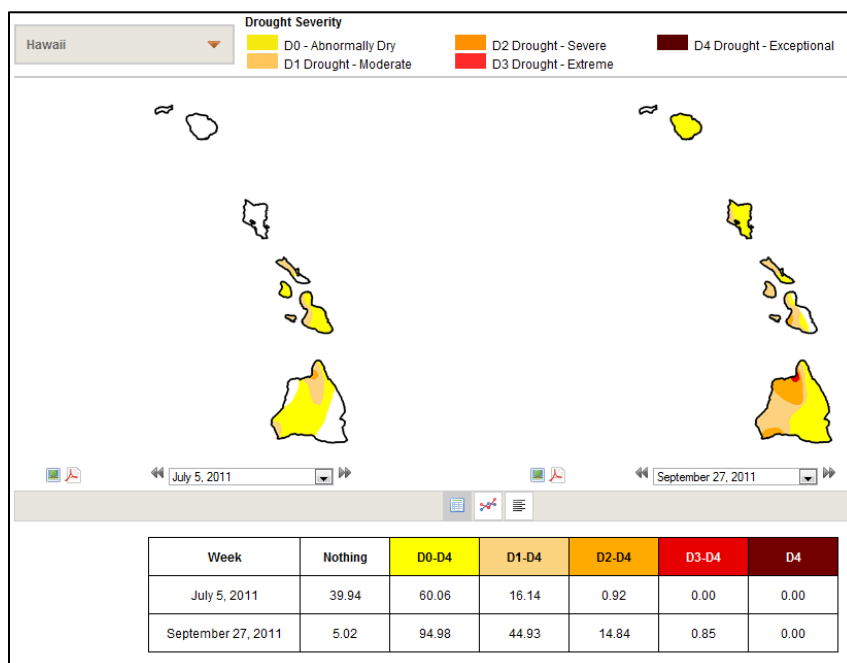


Figure 57. Drought conditions in the state of Hawaii in early July through late September 2011. Figure reproduced from Hawaii Drought Monitor (2012).

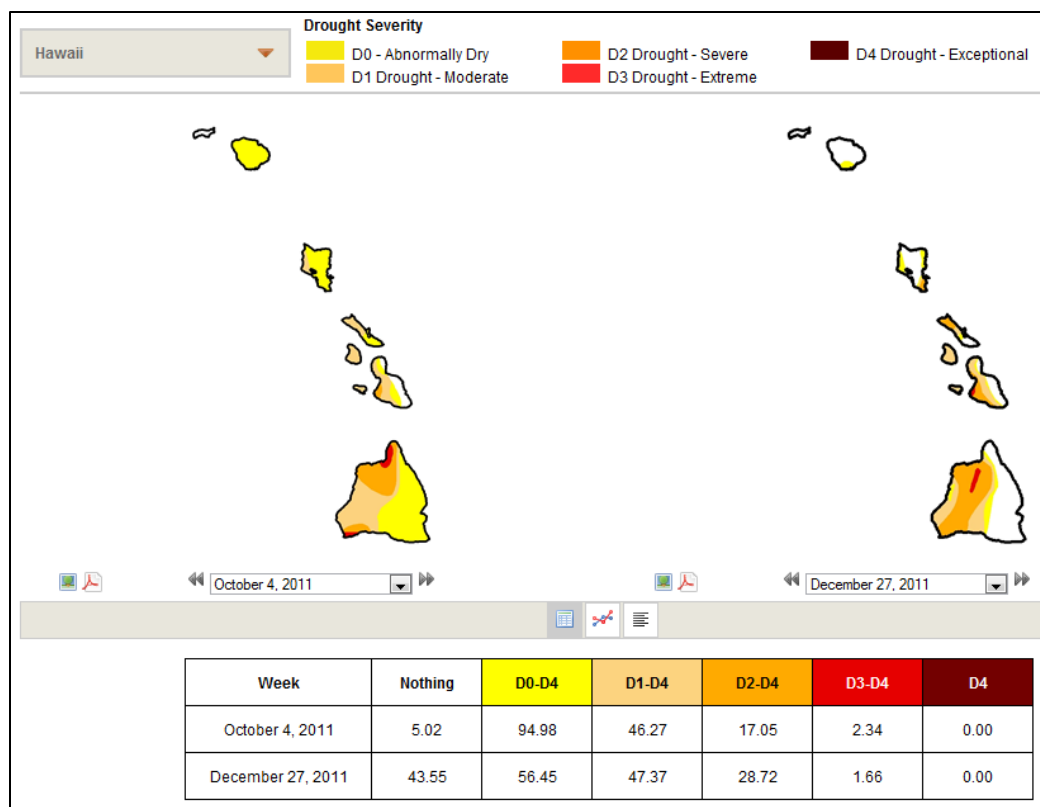


Figure 58. Drought conditions in the state of Hawaii in early October and late December 2011. Figure reproduced from Hawaii Drought Monitor (2012).

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Appendix A: COOP and RAWS Stations Available for Use in Data Collection and Analyses.

Table 1. COOP and RAWS stations available for analysis listed by park. Bold stations are in use.

Station Name	Program	In Park (P) or Nearby (N)	Elevation (m.)	Record Length
War in the Pacific National Historical Park (Guam)				
Agat Pacific Islands (Isl.)	COOP	P	3	7/1978 to present
Anderson AFB Guam	RAWS	N	183	12/2000 to present
Dandan Guam	RAWS	N	97	1/2005 to present
Guam International Airport prior (NAS)	COOP	N	77	5/1946 to present
Guam Pacific Islands	RAWS	N	91	9/1945 to present
Guam WSMO Pacific Islands	COOP	N	109	10/1958 to present
American Memorial Park (Saipan)				
Capitol Hill 1	COOP	N	252	12/1994 to present
Saipan Intl Arpt	RAWS	N	65	10/2003 to present
Amme CS	RAWS	P	8	TBD
National Park of American Samoa (Tutuila)				
Pago Pago WSO AP	COOP	N	3	4/1956 to present
Aasufou	COOP	N	406	1/1980 to present
Toa Ridge	RAWS	P	353	3/2012 to present
Siufaga Ridge	RAWS	P	113	3/2012 to present
World War II Valor in the Pacific National Monument (Oahu)				
Honolulu WB Airport 703	COOP	N	4	9/1982 to present
Kalaupapa National Historical Park (Molokai)				
Kalaupapa 563	COOP	P	9	10/1949 to present
Makapulapai	RAWS	P	23	3/1993 to present
Puu Alii Hawaii	RAWS	P	1,140	2/2012 to present
Kala 2	RAWS	P		TBD
Haleakala National Park (Maui)				
Haleakala RS 338	COOP	N	2,121	10/1949 to present
Oheo 258.6	COOP	P	37	1/1982 to present
Kaupo Gap	RAWS	P	1,228	1/1991 to present
Big Bog	HaleNet	P	1,650	6/1992 to present
Haleakala National Park HQ	HaleNet	N	2,120	6/1988 to present
Nene Nest	HaleNet	P	2,590	3/1990 to present
Pohaku Palaha	HaleNet	P	2,460	6/1992 to present
Summit	HaleNet	N	2,990	4/1990 to present
Treeline	HaleNet	N	2,260	6/1992 to present

Table 1. The stations that are available for use in the data collection and analyses (continued).

Station Name	Program	In Park (P)	Elevation	Record Length
		or Nearby (N)	(m.)	
Puukohola Heiau National Historic Site (Hawaii)				
Puukohola Heiau 98.1	COOP	N	41	1/1977 to present
Puhe Hawaii	RAWS	P	39	2/2012 to present
Kaloko-Honokohau National Historical Park (Hawaii)				
Honokohau Harbor 68.14	COOP	N	9	1/1991 to present
Kaloko-Honokohau	RAWS	N	8	12/2004 to present
Puuhonua o Honaunau National Historical Park (Hawaii)				
Puuhonuaohonaunau 27.4	COOP	P	5	11/1977 to present
Puho Hawaii	RAWS	P	25	2/2012 to present
Hawaii Volcanoes National Park (Hawaii)				
Halemaumau 52	COOP	P	1,110	10/1949 to present
Hawaii Vol NP HQ 54	COOP	P	1,210	10/1949 to present
Kahuku Mill Camp 6.3	COOP	P	668	2/1988 to present
Mauka Reservoir 3.11	COOP	P	1,521	5/1983 to present
Mauna Loa Slope Obs 39	COOP	N	3,399	5/1982 to present
Kahuku Hawaii	RAWS	P	1,796	11/2002 to present
Kealakomo Hawaii	RAWS	P	30	2/2008 to present
Keaumo Hawaii	RAWS	P	1,683	2/1999 to present
Pali 2 Hawaii	RAWS	P	847	7/1999 to present
The Observatory	GPMN	P	1,123	10/1999 to present
Visitor Center	GPMN	P	1,215	10/1986 to present
Ainahou	HAVO-RG	P	967	10/1986 to present
Keamoku	HAVO-RG	P	1,692	10/1986 to present
Kipuka Nene	HAVO-RG	P	1,021	10/1986 to present
Mauna Loa	HAVO-RG	P	2,042	10/1986 to present
Puu Loa	HAVO-RG	P	9	10/1986 to present
Lower Kahuku Hawaii	RAWS	P	942	2/2012 to present
Nene Cabin Hawaii	RAWS	P	1,982	2/2012 to present
Ala Kahakai National Historic Trail (Hawaii)				
Hawi 168	COOP	N	177	10/1949 to present
Honaunau 27	COOP	N	287	10/1949 to present
Honokohau Harbor 68.14	COOP	N	9	1/1991 to present
Kainaliu 73.2	COOP	N	457	10/1949 to present
Ke-Ahole Point 68.13	COOP	N	6	2/1981 to present
Kealakekua 26.2	COOP	N	451	7/1956 to present
Kealakomo 38.8	COOP	N	99	4/1995 to present
Kohala Mission 175.1	COOP	N	165	10/1949 to present

Table 1. The stations that are available for use in the data collection and analyses (continued).

Station Name	Program	In Park (P)	Elevation	Record Length
		or Nearby (N)	(m.)	
Kona Village 93.8	COOP	N	6	5/1968 to present
Middle Pen	COOP	N	418	4/1965 to present
Milolii 2.34	COOP	N	357	5/1985 to present
Naalehu 14	COOP	N	244	10/1949 to present
Napoopoo 28	COOP	N	122	10/1949 to present
Opihihale 2 24.1	COOP	N	415	4/1956 to present
Puuhonuaohonaunau 27.4	COOP	N	5	11/1977 to present
Puukohola Heiau 98.1	COOP	N	43	1/1977 to present
Sea Mountain 12.15	COOP	N	24	5/1982 to present
Waikoloa 95.8	COOP	N	268	7/1975 to present
Waikoloa Beach Resort	COOP	N	18	9/1989 to present
Waikoloa Hawaii	RAWS	N	296	3/2009 to present

Appendix B: Maps of Weather Stations in PACN Parks

War in the Pacific National Historical Park (WAPA), Guam

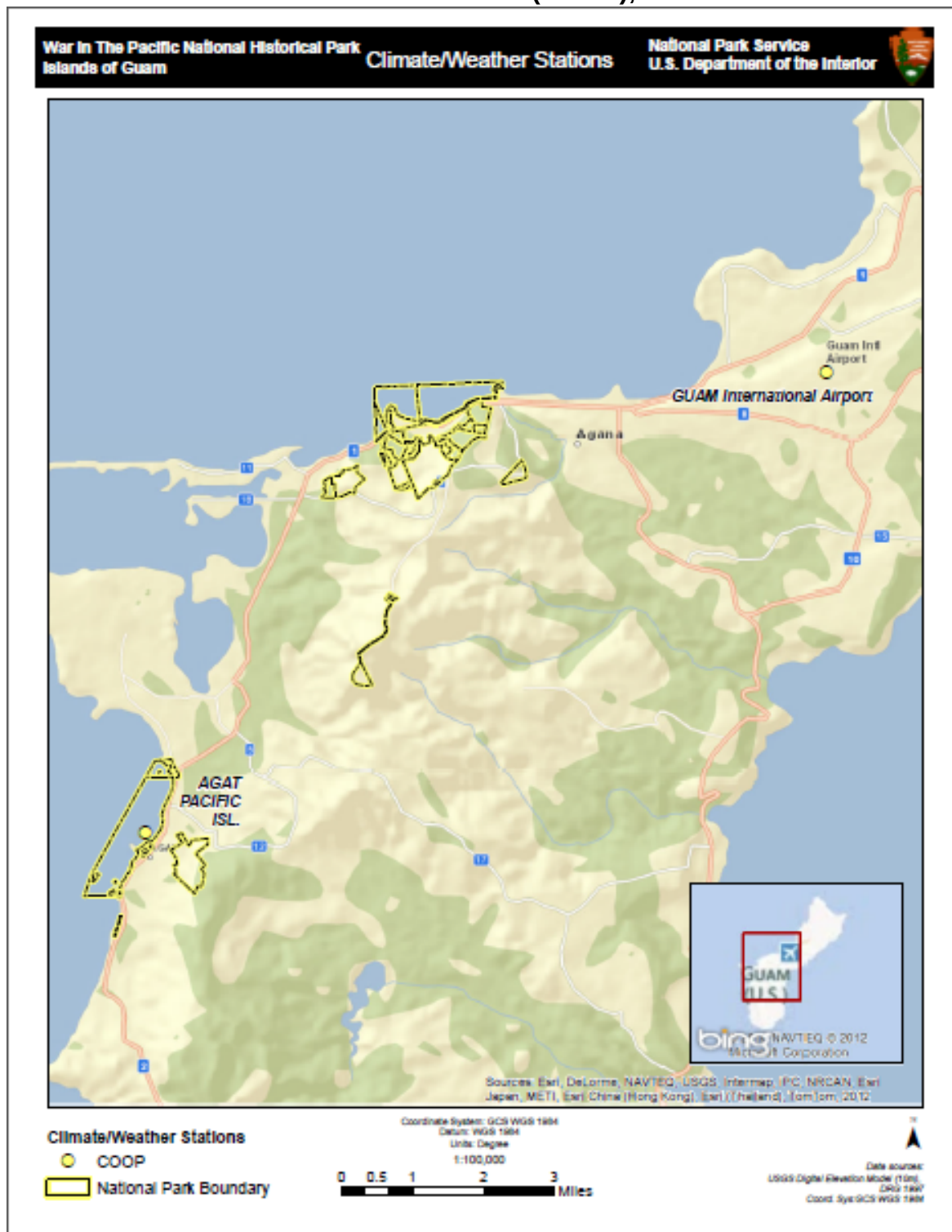


Figure 1. Weather stations in and near WAPA.

American Memorial Park (AMME), Saipan



Figure 2. Weather station near AMME.

The National Park of American Samoa (NPSA), Tutuila

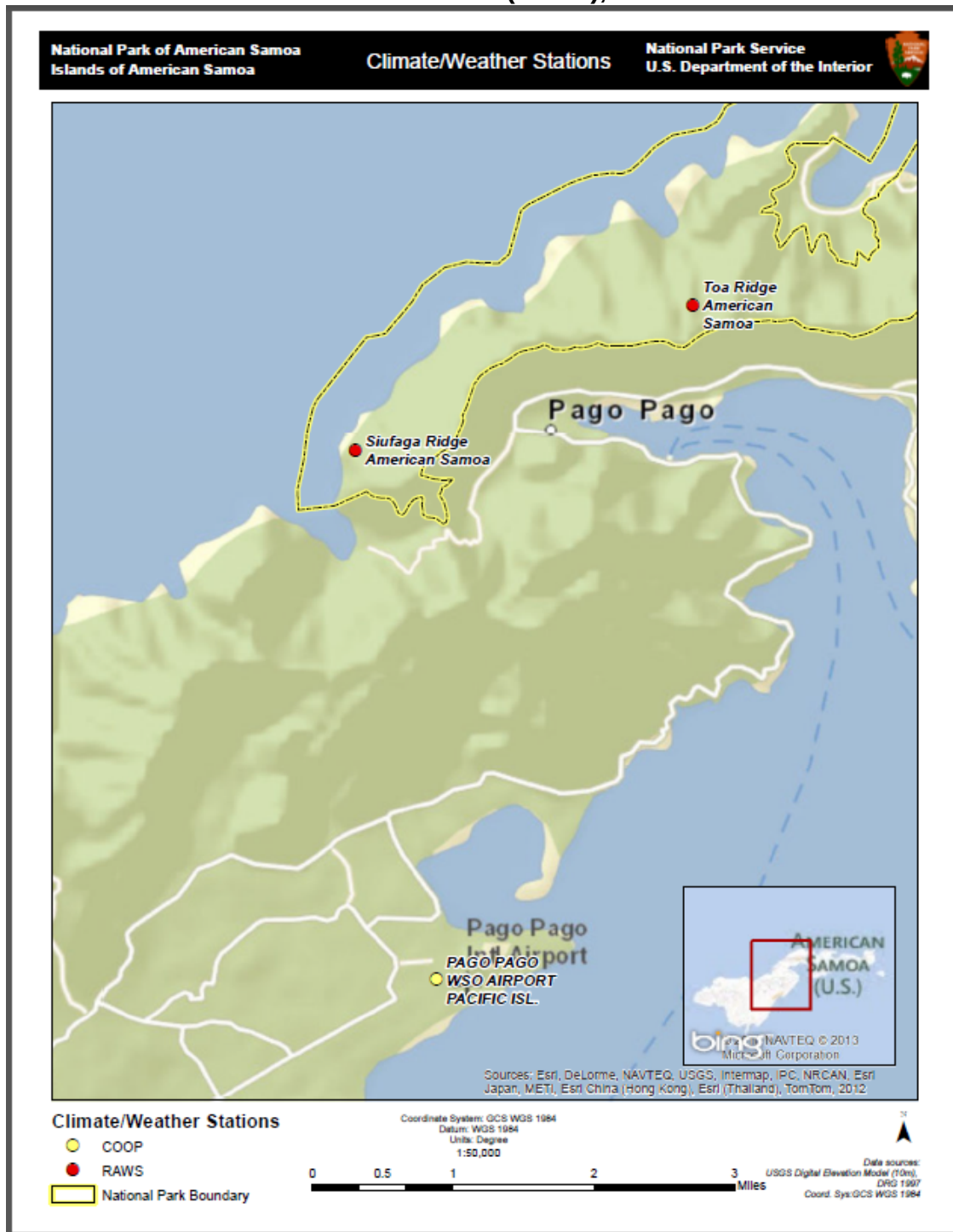


Figure 3. Weather stations in and near NPSA.

Hawaii Volcanoes National Park (HAVO), Hawaii

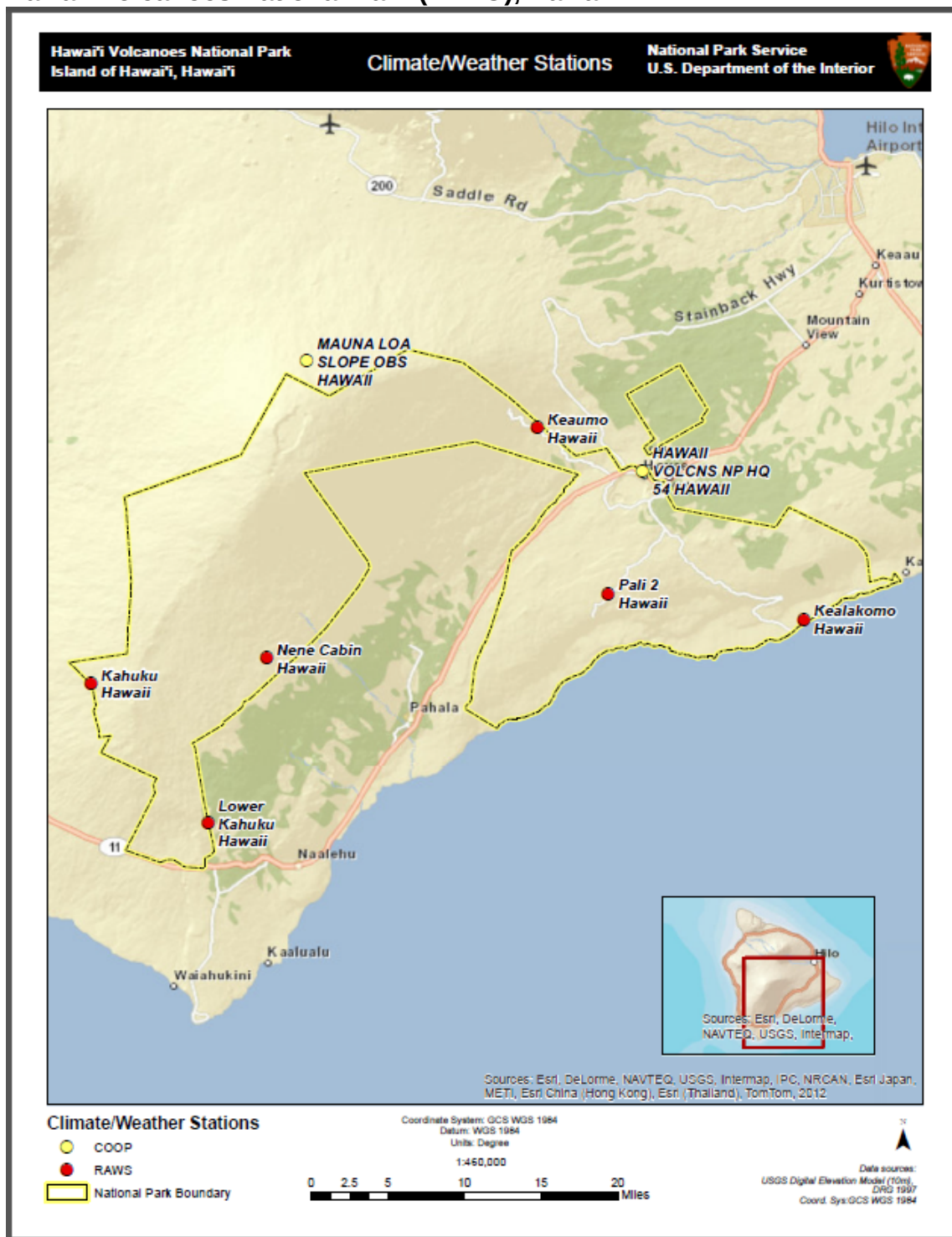


Figure 4. Weather stations in and near HAVO.

Puuhonua o Honaunau National Historical Park (PUHO), Hawaii



Figure 5. Weather stations in PUHO.

Kaloko-Honokohau National Historical Park (KAHO), Hawaii



Figure 6. Weather stations in KAHO. Honokohau Harbor was moved from the northern site to the Honokohau Harb 2 COOP eastern site in 2011.

Puukohola Heiau National Historical Site (PUHE), Hawaii

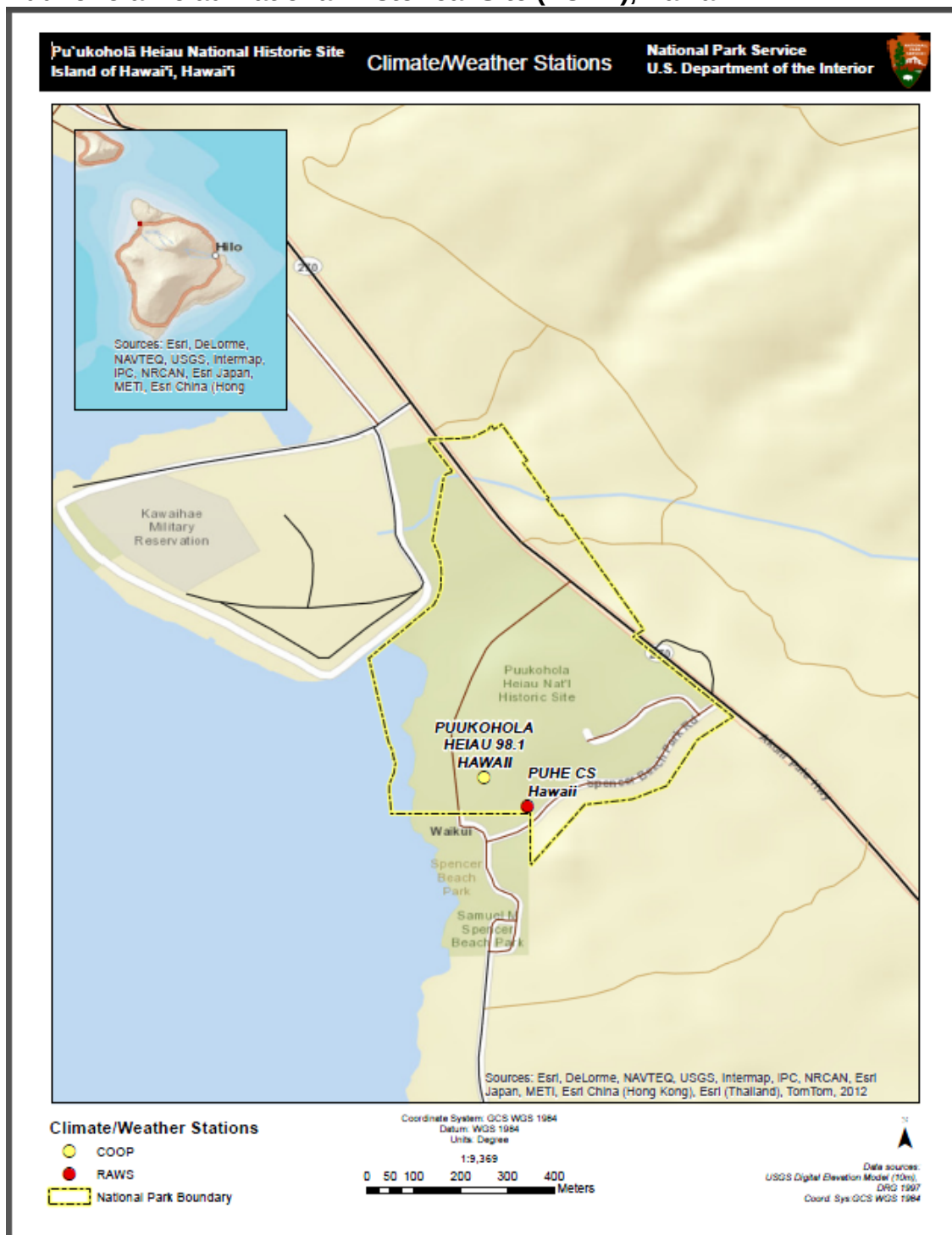


Figure 7. Weather stations in PUHE.

Kalaupapa National Historical Park (KALA), Molokai



Figure 8. Weather stations in KALA.

Haleakala National Park (HALE), Maui



Figure 9. Weather stations in HALE.