11.6 CALCLIM: AN ACCESSIBLE DATA ARCHIVE TO MONITOR CALIFORNIA CLIMATE

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1. INTRODUCTION

Climate change and variability have crucial impacts on water supply, energy use, agriculture, biodiversity and numerous other aspects of California's environment and society. Because California's population is projected to double over the next several decades and at the same time the global climate is likely to undergo considerable changes, these impacts will probably be even greater than they are today. A number of studies (e.g., Roos (1993) and Dettinger and Cayan (1995), Stewart et al (2004)) have described reduced snowmelt runoff in Sierra Nevada watersheds and several others (e.g., Knowles and Cayan (2002) Dettinger et al. (2004), Hayhoe et al. (2004)) have shown how increasing temperatures will significantly change California's hydrological characteristics. Basic questions such as "Is California warming or cooling?" and "Is California getting wetter or drier?" are currently not answered with precision or certainty. As a result, the California Energy Commission (CEC) has established the California Climate Change Center to investigate and plan for potential climate impacts.

The CalClim project was established to be the data warehouse to support the research of the California Climate Change Center and other climate scientists, and to develop, archive and disseminate products for monitoring climate in California. California's physical and organizational landscape is extremely complex, and at the time when CalClim was conceived in 2003, climate data and information were spread over various agencies and sources. A time-consuming search for the necessary and relevant data and information was required. CalClim's California Climate Data Archive (CCDA) was designed to streamline the data access process, simplifying the hunt for appropriate climate data and information for the researcher by consolidating several data sources.

The Western Regional Climate Center (WRCC) at the Desert Research Institute, one of six NOAA Regional Climate Centers, was selected to build the CCDA. WRCC has established itself as a reliable and comprehensive resource for national and regional data sets, including NOAA data via the National Weather Service (NWS) Cooperative Network and the National Climatic Data Center. In addition, WRCC archives data from other federal networks such as the Remote Automated Weather System (RAWS), Natural Resources Conservation Services' Snowpack Telemetry (SNOTEL), and other networks. These archives provide a substantial base upon which to build a California-focused data archive.

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2. DATA AND INFORMATION

A website (http://www.calclim.dri.edu) has been designed as the gateway to the CCDA and other climate-related products for the public. This website combines both static and dynamic web pages to disseminate climate data and information. Our objective is to maintain a site that has straightforward navigation, yet is powerful enough to provide useful data and climate products to a varied audience. We view our audience as anyone interested in California climate, from research scientists, state and local agency employees to the public and media.

The website is split into three main categories: Data & Products, Climate Monitoring & Forecasts, and Climate Research. The Data & Products category includes the data download functions and data-derived products. Climate Monitoring & Forecasts includes the monthly *California Climate Watch* newsletter as well as climate prediction products from the Climate Prediction Center, Climate Diagnostics Center and elsewhere. The Climate Research category provides links to other areas of climate research in California.

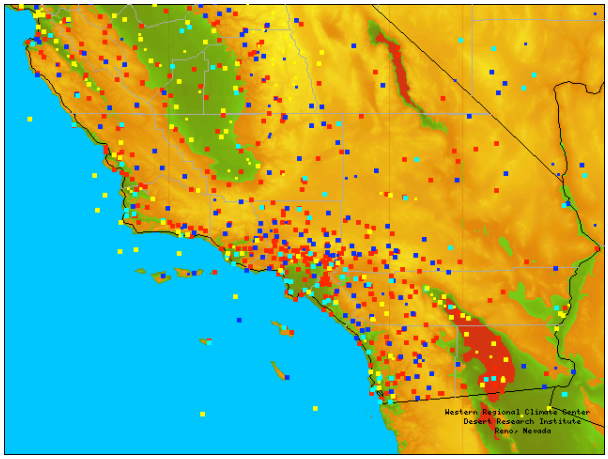

Figure 1. Southern California station selection map with "All Networks" option displayed. The color codes are: NWS Cooperative (red), RAWS (dark blue), SNOTEL (purple), Surface Airways (light blue), Miscellaneous (yellow).

2.1 *Data and Products*

The first objective, and as a result largest portion, of the website is the Data & Products category. Data can be quickly and easily retrieved using a 3-step process. The first step is to select a network. At this time, we employ a map-based interface. Map choices are divided by region (northern, central and southern California) and also by network (e.g. NWS Cooperative Network, RAWS). Figure 1 shows an example of the southern California map with all networks displayed.

A brief description of each network is available by selecting the "Network Descriptions" link on the left of the screen. Found here is such information as time interval (e.g. daily or hourly) and elements available (e.g. temperature, precipitation, snow depth).

Once a network has been selected, the second step is to select a station. Using the map interface, it is easy to view the station name and the network of which it is a part.

The third and final step is to choose the data or product that best suits the user's needs. Each station has a number of data-derived summary products dependent upon the network. This selection of products was chosen to provide the most commonly requested types of summaries. It is possible that the product you wish to develop is already compiled.

If the user opts to download the data, select "Data Lister" option in the left menu. There are many options here regarding the formatting of dates, flags, output type and so on. The data download process was designed in this manner to maintain data compatibility between networks, so that the output from the various networks can be used together in the same software.

This system of data retrieval has been made freely available to members of the California research community. To date, this group includes universities, state agencies (e.g. Department of Water Resources, CEC), local governments (e.g. counties and cities), and federal agencies with interests in climate (e.g. National Weather Service, US Forest Service, US Geological Survey). Using domain recognition, these groups can obtain climate data for free and at any time that is convenient for the user. Other users can contact the WRCC regarding an access code.

Currently, there are two data sets available for download, the NWS Cooperative Network comprised primarily of daily temperature, snow, and precipitation, and the RAWS network, comprised of hourly elements such as temperature, relative humidity, precipitation, and fuel moisture. In the RAWS network, the station operator determines which elements are measured at the individual sites. Additional observations to be accessible online in the future include data available through California Data Exchange Center (CDEC) and California Irrigation Management Information System (CIMIS). Access to data sets not yet online may be obtained by contacting WRCC's California Climate Data Specialist (the author).

2.2 Climate Montoring & Forecasts

The second objective of CalClim is to provide materials and information for monitoring California climate. To achieve this goal, a monthly newsletter has been developed for general audiences entitled *California Climate Watch.* Each issue contains a feature article on a climate topic that may be of interest to Californians, such as the Santa Ana wind, El Niño and the Southern Oscillation (ENSO), wildfire, and urban heat islands. The California state climatologist also submits a summary of the month's weather and climate.

Crescent City	Susanville 2 SW	Burbank
Eureka	Tahoe City	Campo
Arcata/Eureka	Tahoe Valley AP	Culver City
Fort Bragg 5N	Hollister	El Cajon
Kentfield	King City	Escondido 2
Napa	Morro Bay	Idyllwild Fire Dept
Santa Rosa	Oakland Museum	Lompoc
Ukiah AP	Paso Robles AP	Long Beach AP
Yreka	Redwood City	Los Angeles/USC
Alturas	Richmond	Los Angeles AP
Adin Ranger Stn	Salinas AP	Mt Wilson No 2
Blue Canyon	San Francisco	Riverside Citrus
Burney	San Francisco AP	Newport Beach Harbor
Dunsmuir	San Jose	San Diego AP
Grass Valley	San Luis Obispo	Sandberg WSMO
Marysville	Santa Cruz	Santa Ana Fire
Mineral	Bakersfield	Santa Barbara AP
Mt. Shasta	Coalinga	Santa Maria AP
Paradise	Fresno	UCLA
Portola	Glennville	Bishop
Quincy	Grant Grove	Blythe
Redding	Hanford 1 S	Daggett AP
Red Bluff FSS	Lodgepole	Imperial
Sacramento AP	Madera	Inyokern
Sacramento City	Porterville	Lancaster
Shasta Dam	Stockton WSO	Needles AP
Boca	Yosemite	Palm Springs
Bodie	Alpine	Thermal AP
Bridgeport	Anaheim	Twentynine Palms
Markleeville	Big Bear Lake	

Table 1. Current list of California climate index stations.

A set of stations has been selected to describe climate across the state. This is intended as a tool to siphon

hundreds of station data points down to a brief summary of California climate. The station selection process yielded almost 90 stations that have a relatively long record, of 30 years or longer, and were in geographically favorable locations. Other criteria used were the station's reliability and the timeliness of the observations. Ideally, the stations report daily and do not require significant review or editing of errors. The monthly data for this set of stations is published monthly in the *California Climate Watch.*

Other sections of the *California Climate Watch* may include brief summaries and figures of drought conditions, ENSO conditions and forecasts, temperature and precipitation outlooks, hydrological and snow information, and wildfire conditions and forecasts.

The last portion of the *California Climate Watch* is a selection of climate anomaly maps. These are produced through the Applied Climate Information System (ACIS) that has been developed at the NOAA Regional Climate Centers. A sampling of maps may include temperature departures from normal, precipitation departure from normal, and/or precipitation percent of normal.

These climate anomaly maps are also available on the CCDA website. They are updated daily, and archived monthly. Each day over 600 maps are produced for California alone, and more are available for the western region of the continental United States. These maps include many temperature, precipitation and degree day elements across a wide range of time frames from the last 7 days to 3 years, as well as current month, calendar year and water year.

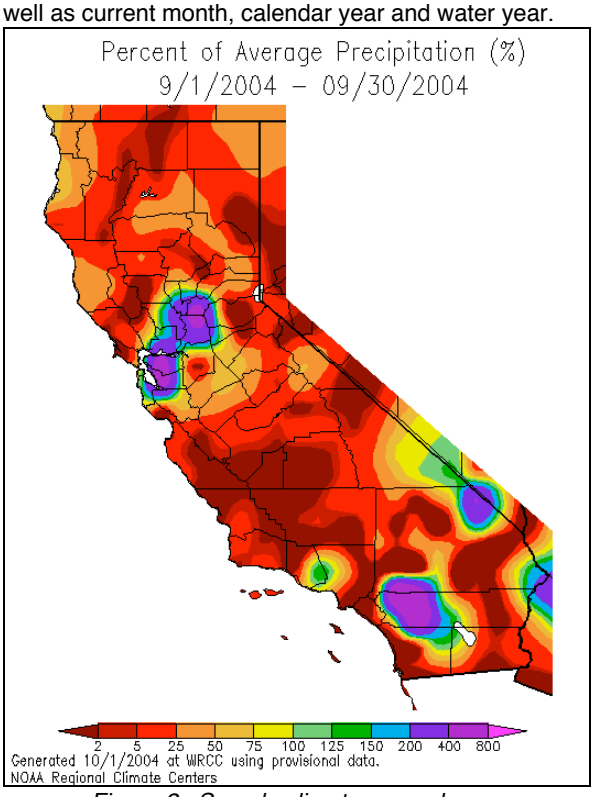

Figure 2. Sample climate anomaly map.

3. PARALLEL ACTIVITIES AND FUTURE DIRECTIONS

Several additional activities are planned for CalClim, including a California coastal climate data archive, merging federal and state snow data sets and assembling a comprehensive statewide climate data inventory.

3.1 A California coastal climate data archive

California's long coastline represents a zone of extreme economic and environmental importance. In addition, this zone marks a sharp transition in climate. The boundary between the cool marine air and hot interior is extremely important for air conditioning and other energy needs, considering that the majority of the state's population lives in coastal cities. There are many other reasons why the coastal region is integral to understanding California climate:

- Variations in the marine environment do not necessarily correlate with conditions inland;
- El Nino and Pacific Ocean conditions may affect the coast range and the Sierra Nevada in different ways (e.g. flood characteristics);
- Anadromous fish that spend their life cycles in both saline and freshwater environments are particularly sensitive to small changes in climate;
- Changes in upwelling and off shore productivity can have dire consequences for near shore commercial fisheries and redwoods and other terrestrial species that thrive on fog.

To desctibe this complex situation a large and disparate set of observations can be found but are scattered throughout various data collection groups. Preliminary work has begun to collect data the coastal climate data archive. There is more diversity in sources of information on the transition zone than in interior or terrestrial California. Some data sources include: U.S. Coast Guard, lighthouses, air quality districts, municipal piers, NOAA buoys, islands, oil platforms and so on. The purpose of this project is to bring these bewildering data arrays to people's fingertips in one-stop shopping.

3.2 A merging of the federal and state snowpack data

As with all western states, snowpack is a predominant source that is the lifeblood of California's economy. California is unique among the western states in that its snowmonitoring program pre-dates the federal monitoring program. The California program continues to this day as a primarily state activity, and is managed by the California Cooperative Snow Survey in Department of Water Resources. The federal SNOTEL program primarily covers 4 east-draining river basins in the central Sierra Nevada (Tahoe/Truckee, Carson, West and East Walker Rivers). The state and federal snowpack monitoring programs have been managed

independently, as have their resulting data sets. CalClim will work toward the widely desired goal of blending the records from these two sources as much as the circumstances and data permit. We see this as a prelude to developing snowpack indices for the Sierra Nevada and other major mountain ranges in the state. Recent studies such as Knowles and Cayan (2002) and Stewart et al. (2004) have recently demonstrated the vulnerability of snowpack to small changes in climate.

3.3 Assembling a climate data inventory

California's 158,000 square miles encompasses a wide variety of observing networks and platforms. It has been at least two decades since a comprehensive statewide climate data inventory has been compiled. At that time, State Climatologist Jim Goodridge had identified 8000 precipitation gauges in the state of California. Many additions and subtractions to this number as well as the nature of the gauges themselves have changed. Data routing management and quality control have also undergone changes. Our initial selection of almost 90 climate sites is likely to be revisited and revised once a current comprehensive inventory has been completed.

4. PARALLEL ACTIVITIES

CalClim provides a mechanism by which information being developed by a variety of California climate activities supported through other means can be shared and distributed. One such project is a high-altitude climate monitoring network that is being developed by CIRMOUNT. This project is designed to instrument the Sierra Nevada range along its length with a number of cross-range transects. Another project is underway to add instrumentation to Yosemite National Park to further hydroclimate studies. Additionally, an enhanced climate monitoring project is underway to instrument areas throughout California that are in need of climate-quality observations. CalClim can help to identify areas where high-altitude climate observing stations are needed and locations with important climate characteristics where additional climate-quality stations will add significant new information. CalClim will also provide an archive for the data once the stations are in place.

Other activities include research at the California Climate ChangeCenter at Scripps Institution of Oceanography that is investigating links between local and regional climate and global climate changes and variability in both marine and terrestrial environments. The California Applications Program at Scripps has also made possible a number of these research connections.

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