

Temperature Extremes in California

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Abstract

In this study, National Weather Service temperature datasets are analyzed to determine the hottest and coldest places in California. Data problems include a lack of spatial coverage of weather stations, and inaccurate or missing observations. The hottest place in California overall is Death Valley, whose mean July temperature is well above that of any other station. But in mean yearly temperature and mean yearly maximum temperature, Death Valley is not significantly hotter than other stations in the Salton Sea, Mojave Desert, and along the Colorado River. Bodie measures out to be the coldest spot in California, but colder temperatures do occur on the un-instrumented highest peaks of the Sierra Nevada and White Mountains. California hot and cold spots are then compared to those of the conterminous United States as a whole. The lack of a comprehensive weather station network, temperature data inaccuracies, and stations with close temperature values are all major problems that make it difficult to conclude that one place in California overall is the hottest or coldest.

Introduction

THERE IS MUCH public interest in weather extremes (Burt 2004). Americans especially want to know about temperature records. David Hickcox (1981), a geographer who wrote an annual temperature extremes article in the journal *Weatherwise* for twenty years, stated: "Americans love bigness and have a special fascination for extremes." For example, most American newspapers publish the daily hottest and coldest temperatures in the nation. Some California newspapers, such as the *San Francisco Chronicle*, include the daily temperature extremes within the state. Also, weather Internet sites, such as *USA Today*, list national highs and lows. The online *USA Today* weather section *Ask the Experts* has an entire Web page of frequently asked questions about temperature records (*USA Today* 2007). One of that site's most common questions is where the hottest and coldest temperatures occur in the nation or a particular state.

California is a fascinating area to examine temperature extremes. In the conterminous United States—that is, the lower 48 states—it is the second-largest state in area after Texas. California has the largest north-south extent of any state. And it contains the highest (Mt. Whitney at 14,494 feet) and lowest (Death Valley, -282 feet) elevations in the conterminous United States. Because of its large area, numerous high mountains, and long coastline with a major cold ocean current, California has a greater diversity of climates than any state.

Data and Methodology

The purpose of this study is to determine the hottest and coldest locations in California, using data from the National Weather Service. As with all climatological analyses using weather station measurements, this study of California temperature extremes is based on available data. Any analysis of temperature data is limited by the fact that weather station measurements are point data that are not uniformly spatially sampled. Most weather stations are located on valley floors, where there are people living day to day. Very few long-term weather stations are located on mountain tops.

The National Weather Service (NWS) has just less than six hundred Cooperative Observer Program (COOP) stations where volunteers record daily temperature measurements, and slightly over one hundred Automated Surface Observing System (ASOS) stations, mostly located at airports (Commission on Engineering and Technical Services 1998; National Weather Service 2003).

The majority of the temperature data used in this study came from the National Oceanic and Atmospheric Administration's (NOAA) *Monthly Station Climate Summaries, 1971–2000* (National Oceanic and Atmospheric Administration 2004). The NOAA dataset is composed of temperature data for 257 California weather stations during the thirty-year period 1971–2000. Almost all this temperature data are from NWS COOP weather stations.

Figure 1 shows the geographic distribution of the 257 weather stations of the NOAA 1971–2000 dataset. As can be seen on the map, these NWS stations are located in inhabited places where there are people to record weather observations. Areas of California with few stations include the Sierra Nevada and northern coastal ranges, most of the Mojave Desert, northeastern California, and the Carrizo Plain area.

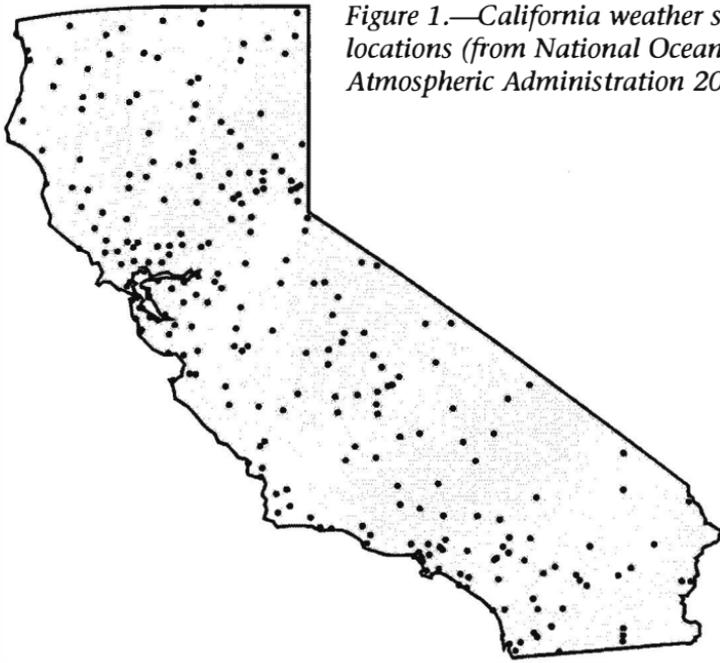


Figure 1.—California weather station locations (from National Oceanic and Atmospheric Administration 2004).

The NOAA 1971–2000 dataset does not contain all weather stations in California. Most of the missing stations are located in California urban areas where there are dense weather-observing networks in place: the Los Angeles Basin, San Diego, Bay Area, and Sacramento-Stockton metropolitan regions. To augment the NOAA 1971–2000 dataset, additional weather data compiled by the Western Regional Climate Center (WRCC) and the Midwestern Regional Climate Center (MRCC) were used in this study (Western Regional Climate Center 2008; Midwestern Regional Climate Center 2006). The WRCC dataset contains climate data for 1,158 active and historic stations in California, while the MRCC mean yearly maximum and minimum temperature data are for 559 active and historic stations.

Since the WRCC and MRCC data are for different time periods, they cannot be directly compared with the NOAA 1971–2000 dataset. Because weather varies considerably from year to year, only station data from the same time period can be analyzed. The WRCC and MRCC datasets were used to determine whether there were any hotter or colder California weather stations missing from the NOAA 1971–2000 dataset, and also to check for data errors.

Of great significance to determining the hottest and coldest places in California is the problem of inaccurate temperature data. In a report by the Commission on Engineering and Technical Services (1998), it was determined that 10 to 20 percent of weather data recorded by volunteers at NWS COOP weather stations contained incorrect thermometer readings, had data-entry errors, or was incomplete (days without any observations). As will be discussed below, the lack of data accuracy is very important in analyzing temperature values that are close to each other.

The standard temperature measures utilized in this study were mean yearly temperature, mean yearly maximum temperature, mean yearly minimum temperature, mean July maximum temperature, mean January minimum temperature, and highest and lowest temperatures recorded during 1971–2000. All temperature measurements used in this study are expressed in Fahrenheit degrees.

Hottest Temperature Results

Table 1 lists the ten hottest stations in California while Figure 2 shows the geographic locations of the ten hottest stations.

Table 1. Ten Hottest Places in California, 1971–2000 (Fahrenheit temperatures).

Weather Station	Elev. (feet)	Mean Yearly Temp.	Mean Yearly Max. Temp.	Mean July Max. Temp.	Highest Temp. Recorded 1971–2000
Death Valley	-194	76.0	90.2	114.9	129
Mecca Fire Station	-180	72.7	90.0	108.6	122
Indio Fire Station	-21	74.5	89.2	107.1	126
Iron Mountain	922	74.1	87.2	109.0	123
Needles Airport	887	74.0	87.0	109.1	122
Thermal Region Airport	-112	72.6	89.1	107.5	122
Blythe	268	72.3	87.8	108.5	126
El Centro 2 SSW	-30	72.8	88.3	107.0	122
Parker Reservoir	738	74.0	86.1	107.5	124
Brawley 2 SW	-100	72.0	88.6	107.0	122

The ten hottest places in California are distributed among four general areas: Death Valley, Salton Sea Basin, Iron Mountain in the Mojave Desert, and along the Colorado River. The hottest area in California overall is Death Valley, whose only permanent residents are a small

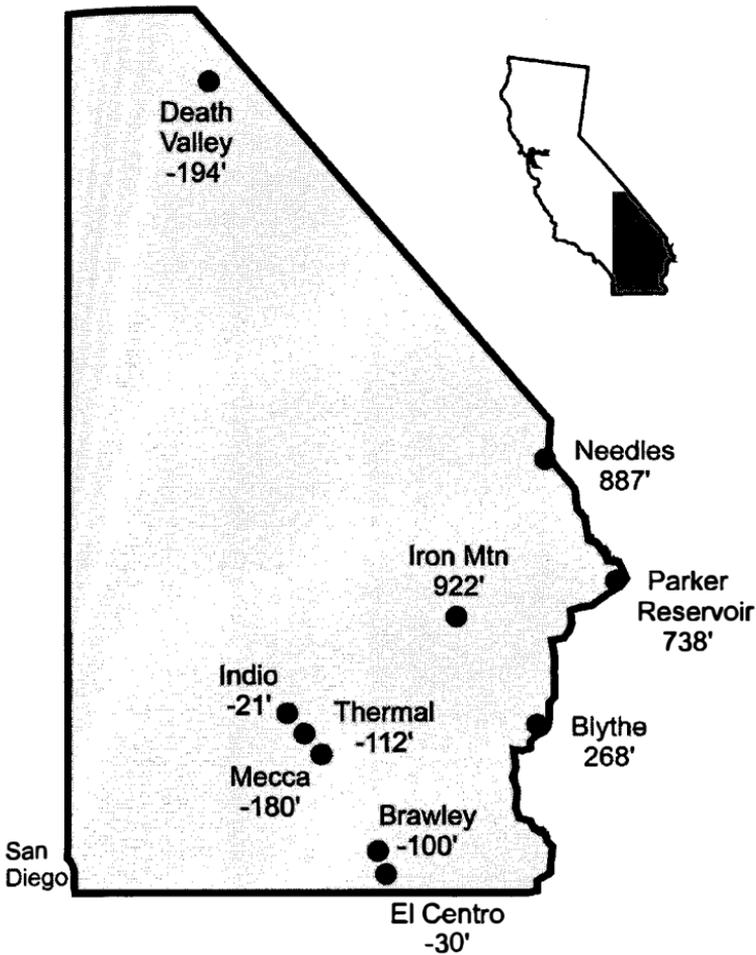


Figure 2.—The ten hottest places in California, 1971–2000. Elevations in feet.

number of Native Americans and National Park Service workers, has a mean July maximum temperature 5.8 degrees warmer than that for the Needles Airport, the next hottest place. In mean yearly maximum temperature, Death Valley is only 0.2 degrees warmer than Mecca Fire Station. In mean yearly temperature, the valley is only 1.5 degrees warmer than Indio Fire Station. Death Valley's hottest temperature during 1971–2000 was three degrees warmer than any of the ten stations. Death Valley also holds the all-time highest temperature record of 134°F for the western hemisphere (National Oceanic and Atmospheric Administration 2009). It was recorded at the old Greenland Ranch weather station, which is less than a mile from the present NWS weather station location at the park visitor

center. The Death Valley all-time temperature record is two degrees less than the world's highest official temperature, recorded in Al Aziziyah, Libya (National Oceanic and Atmospheric Administration 2008). The current Death Valley National Park weather station is at an elevation of minus 194 feet below sea level. If that weather station was moved to the lowest point in Death Valley (-282 feet), also the lowest elevation in North America, it might eventually acquire the world's hottest temperature record.

The second area for the hottest temperatures in California is the Salton Sea Basin. The hottest stations there are Mecca and Indio Fire Stations, Thermal, El Centro, and Brawley, which are all below sea level in elevation. Their mean temperatures are all within a few degrees of each other.

The third hot area is along the lower Colorado River border of California. The weather stations in Needles, Parker Reservoir, and Blythe all have mean temperatures within two degrees of each other.

The final hot area is Iron Mountain, which is a pumping station along the Colorado Aqueduct in the central Mojave Desert. Its mean July maximum temperature is 109°F. Iron Mountain has the distinction of being the highest station (922 feet) of the ten hottest places in California.

Given that almost all of the temperature values used in this study are from COOP weather observations, which contain inaccuracies in their datasets (Commission on Engineering and Technical Services 1998), it needs to be emphasized that except for the measure of mean July maximum temperature, Death Valley is not significantly hotter than the Mecca and Indio Fire Stations. Also, the nine non-Death Valley stations shown on Table 1 are all too close together in temperature values—three degrees or less—to declare any one as being significantly hotter than the others. In addition, if a thirty-year time period other than 1971–2000 were used, Borrego Desert Park, ranked at number eleven, might move to the list since its mean temperature values are less than a degree cooler than other stations on the list.

As previously mentioned, a problem in determining the hottest places in California is the lack of weather stations in the Mojave Desert and Death Valley areas (see Figure 1). For example, Iron Mountain, the fourth-hottest place on the list, has no other weather stations within hundreds of square miles of its location.

Coldest Temperature Results

Table 2 lists the ten coldest stations in California, while Figure 3 shows the geographic locations of the ten coldest stations.

Table 2. Ten Coldest Places in California, 1971–2000 (Fahrenheit temperatures).

Weather Station	Elev. (feet)	Mean Yearly Temp.	Mean Yearly Min. Temp.	Mean January Min. Temp.	Lowest Temp. Recorded 1971–2000
Bodie	8,370	38.0	19.4	5.8	-33.0
Bridgeport	6,470	41.9	23.9	8.1	-31.0
Boca	5,575	42.8	24.5	11.2	-43.0
Sagehen Creek	6,337	41.0	25.3	14.1	-33.0
Tahoe Val. Airport	6,254	42.3	26.7	15.1	-29.0
Donner State Park	5,937	42.4	27.3	14.4	-31.0
Lodgepole	6,735	41.8	28.3	15.3	-16.0
Twin Lakes	8,000	40.5	28.8	17.8	-24.0
Truckee Ranger St.	6,020	44.4	28.7	16.3	-23.0
Portola	4,850	45.2	29.3	17.8	-28.0

All the coldest places on the list are within the Sierra Nevada, with the exception of Bodie and Bridgeport, which are on the eastern border of that range. Bodie is the coldest on the list, with mean temperatures significantly lower than those for the other stations on the list. Bodie is an old mining ghost town that is now a state park. Its elevation of 8,370 feet makes it one of the highest areas of human settlement in California. During its peak mining boom in the late nineteenth century, Bodie boasted a population of over seven thousand (Piatt 2009). Today Bodie is a ghost town whose only year-round residents are a few park rangers. Bodie's cold temperatures are due to it being situated in a high-elevation valley where cold mountain air pools up. An additional cooling factor is its location in the rain shadow of the Sierra Nevada; clear desert nights produce much radiation cooling.

But is Bodie really the coldest spot in California? Common sense would dictate that the state's many highest mountain peaks have colder climates. Unfortunately there is a paucity of NWS data for mountain peaks. Exceptions in California are two short-term weather stations that recorded temperatures along the high crest of the White Mountains between 1955 and 1980. The higher of the two was the

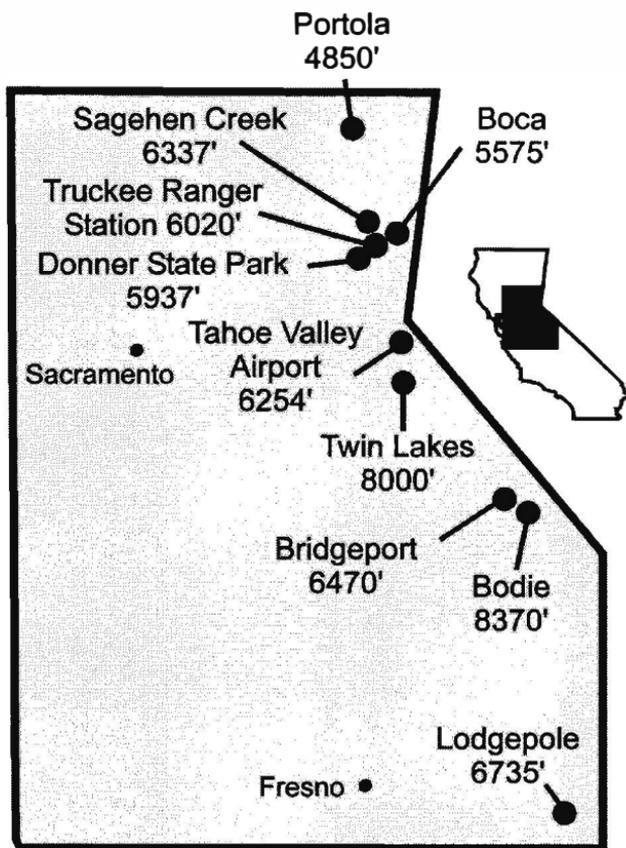


Figure 3.—The ten coldest places in California, 1971–2000. Elevations in feet.

White Mountain 2 station, located at 12,470 feet elevation. This station was situated below the highest elevation in the range, White Mountain Peak at 14,246 feet. Using the 1955 to 1980 temperature data for White Mountain 2 and comparing it with data from other stations with more complete records, the Western Regional Climate Center (2009) produced a predicted 1971–2000 temperature record for the station with a mean yearly temperature of 27.5°F (10.5 degrees lower than Bodie), mean yearly minimum temperature of 18.3°F (1.1 degrees lower than Bodie), mean January minimum temperature of 7.0°F (1.2 degrees lower than Bodie), and a record low temperature of -35°F (Bodie's is -33°F). In mean yearly temperature, the more than 4,000-foot higher elevation White Mountain 2 station is significantly cooler than Bodie. This is due to the much-warmer daytime temperatures of Bodie (mean yearly maximum temperature of 56.5°F, versus 36.8°F for White Mountain 2). The similarity of

White Mountain 2 and Bodie in minimum temperatures shows the importance of nighttime mountain air drainage and radiation cooling. Since the White Mountain 2 predicted 1971–2000 temperature data is based on a model rather than actual measurements, Bodie officially remains the coldest place in California. It is safe to say that Bodie is the coldest *inhabited* place in California.

Bridgeport is a close second to Bodie in mean yearly January minimum temperature—only 2.3 degrees different. In mean yearly and mean minimum yearly temperatures, Bridgeport is respectively 3.9 and 4.5 degrees warmer than Bodie. Bridgeport's cold temperatures, like Bodie's, are due to cold mountain-air drainage.

After Bodie and Bridgeport, the eight other coldest places are in four areas. Boca, Sagehen Creek, Donner Memorial State Park, and the Truckee Ranger Station are along the upper Truckee River drainage just below Donner Pass. Tahoe Valley Airport is on the south side of Lake Tahoe. Lodgepole, the most southern location, is in Sequoia National Park. Twin Lakes, at the highest elevation of 8,000 feet, is in the Carson Pass area. Portola, with the warmest temperatures, is the most-northern and lowest-elevation station (4,850 feet) on the list, and is located in the Feather River Drainage just below Sierra Valley. In all these eight places, cold air drainage from surrounding mountains is a major climate factor in producing low temperatures.

Boca has the distinction of attaining the lowest temperature recorded during 1971–2000, -43°F, a full ten degrees lower than Bodie. Boca also recorded the lowest temperature ever observed in California, -45°F (National Oceanic and Atmospheric Administration 2009). Cold mountain air being funneled down the narrow Truckee River canyon is the cause of Boca's record cold temperatures.

California Temperature Extremes Compared to those of the Conterminous United States

Using 1971–2000 data compiled by King (2007), California's hottest and coldest temperature locations are contrasted with those of the other lower 48 states. The temperature values used in this comparison are rounded off to whole numbers. Figure 4 shows the comparison of mean yearly temperatures. Because Death Valley cools off in the winter (mean January minimum temperature is only 38.7°F), it is not as warm as Key West, Florida, the most southern place in the conterminous United States. The surrounding warm waters of the Gulf of Mexico keep Key West warm year-round. The coldest mean

King: Temperature Extremes in California

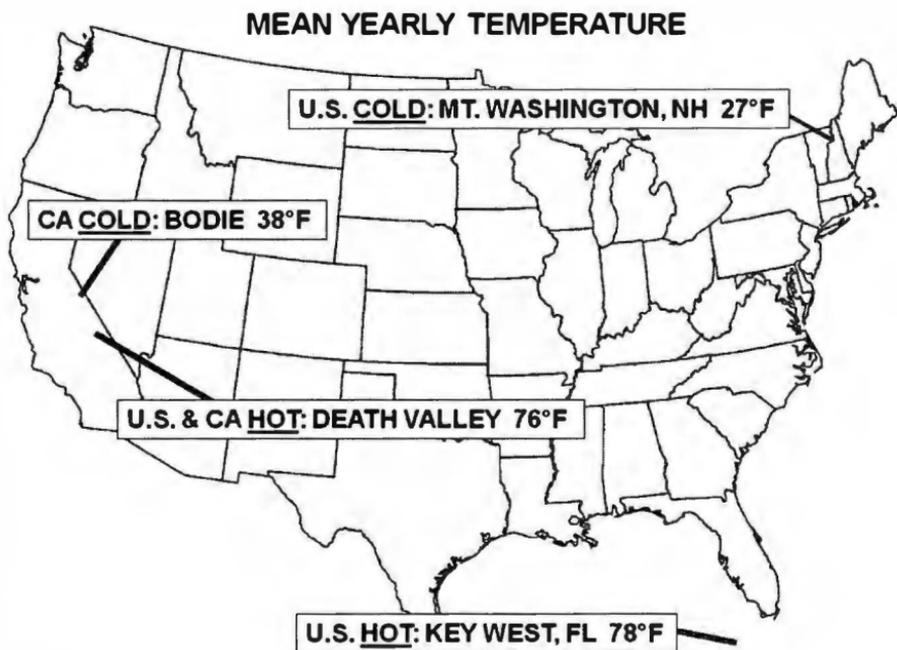


Figure 4.—Comparison of California and conterminous U.S. mean yearly temperature extremes 1971–2000.

yearly temperature for the conterminous United States is at the top of Mount Washington, New Hampshire, which is eleven degrees cooler than Bodie. Major climate factors for Mount Washington's low mean yearly temperature are its latitude, its elevation of 6,288 feet (the highest in the Atlantic Northeast), and the fact that it receives very cold continental air off the Canadian Shield during the winter.

Figure 5 compares mean yearly maximum and minimum temperatures. Death Valley has the highest mean yearly maximum temperature (90°F) in California, but it ties with Lake Havasu City, Arizona, for being the hottest place in the conterminous United States. The lowest mean yearly minimum temperature occurs at Darwin Ranch, Wyoming, which is five degrees cooler than Bodie. Darwin Ranch is located in a high-elevation valley (8,160 feet) where cold air from surrounding much-higher mountains pools up in both the summer and winter.

Mean July maximum and January minimum temperatures are shown on Figure 6. Death Valley has the highest mean July maximum temperature (115°F) for both California and the United States. For

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Figure 5.—Comparison of California and conterminous U.S. mean yearly maximum and minimum temperature extremes 1971–2000.

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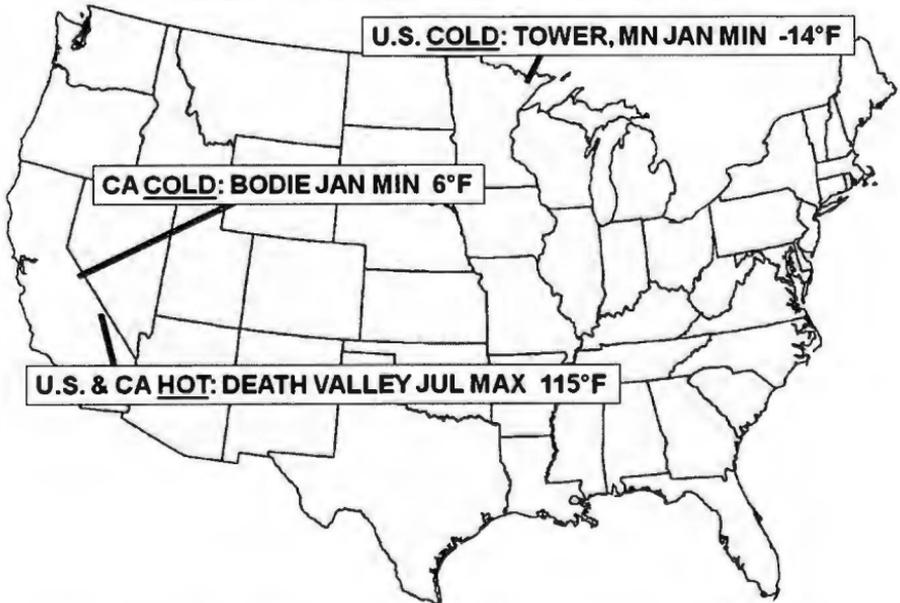


Figure 6.—Comparison of California and conterminous U.S. mean July maximum and January minimum temperature extremes 1971–2000.

mean January minimum temperature, Tower, Minnesota, is six degrees cooler than Bodie. Tower is located in the middle of the North American continent, far away from any temperature-moderating influence of ocean water.

The all-time record high and low temperatures of California and the conterminous United States are displayed in Figure 7. Greenland Ranch, the old Death Valley weather station, recorded 134°F on July 10, 1913. As previously mentioned, this is the highest temperature ever recorded in the western hemisphere, and is only two degrees less than the world-record temperature measured in Al'Aziziyah, Libya. The lowest recorded temperature of minus 70°F, recorded at Rogers Pass, Montana, is twenty-five degrees cooler than that for Boca, California. The world's lowest record temperature of minus 129°F was measured at Vostok station in the interior of Antarctica (National Oceanic and Atmospheric Administration 2008).



Figure 7.—Comparison of California and conterminous U.S. all-time record temperature extremes.

Conclusion

The most important and popular question to answer in a study of California temperature extremes is: "What are the hot and cold spots in California?" Death Valley is the hottest spot of California, using the measure of mean maximum July temperature. In the other measures of mean yearly temperature and mean yearly maximum temperature, Death Valley is not significantly hotter than Mecca and Indio Fire Stations, respectively. Given the problem of errors in NWS COOP weather station data cited above, Death Valley's choice as the overall state hot spot is less than conclusive. However, Death Valley does have the record for the hottest temperature ever measured in North America.

Using existing weather data, Bodie is officially the coldest spot in California, but colder temperatures do occur on the highest peaks of the Sierra Nevada and White mountains. Unfortunately, the lack of high mountain weather stations prevents determining where the coldest spot is located. It can be stated that Bodie is the coldest *inhabited* place in California.

The lack of a comprehensive weather station network, temperature data inaccuracies, and weather stations with close temperature values are all major problems in determining the hottest and coldest spots in California. These problems make it difficult to definitely conclude that one place in California is overall the hottest or coldest.

References

- Burt, C. C. 2004. *Extreme Weather*. New York, New York: W. W. Norton and Company.
- Commission on Engineering and Technical Services. 1998. *Future of the National Weather Service Cooperative Observer Network*. Washington, D.C.: National Academies Press. <http://www.nap.edu/openbook.php?isbn=0309061466>
- Hickcox, D. H. 1981. Temperature extremes during 1981. *Weatherwise* 35:169–172.
- King, G. 2007. The hottest and coldest places in the conterminous United States. *Association of Pacific Coast Geographers Yearbook* 69:101–114.
- Midwestern Regional Climate Center. 2006. *Annual temperature extremes for the continental United States: California*. http://mcc.sws.uiuc.edu/climate_midwest/mwclimate_data_extremes.htm

- National Oceanic and Atmospheric Administration. 2009. *Temperature Extremes and Drought*. <http://www.ncdc.noaa.gov/oa/climate/severeweather/temperatures.html>
- . 2008. *Global Measured Extremes of Temperature and Precipitation*. <http://www.ncdc.noaa.gov/oa/climate/globalextremes.html>
- . 2004. *Monthly Station Climate Summaries, 1971–2000: California*. Climatography of the United States No. 20. <http://cdo.ncdc.noaa.gov/climatenormals/clim20/state-pdf/ca.pdf>
- National Weather Service. 2003. *Automated Surface Observing System Station Information*. <http://www.nws.noaa.gov/asos>
- Piatt, M. H. 2009. What the historic record reveals about Bodie's peak population. <http://www.bodiehistory.com/population.htm>
- USA Today online. 2007. *FAQ: temperature Records*. <http://www.usatoday.com/weather/resources/askjack/faq-temperature.htm>
- Western Regional Climate Center. 2008. *Western U.S. Climate Historical Summaries*. <http://www.wrcc.dri.edu/Climsum.html>