



Weather History on the Bishop Paiute Reservation 1925-2011

For additional information contact

Toni Richards, Air Quality Specialist
760 873 7845 toni.richards@bishoppaiute.org

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BACKGROUND

Location of Bishop Reservation

The Bishop Paiute Reservation is located in the Owens Valley in eastern California, near the Nevada border. The area is sometimes known as “the deepest valley” it is flanked by two 14,000-foot ranges – the Sierra Nevada to the west and the White Mountains to the east. The region includes some of the most spectacular scenery in the United States. Both mountain ranges are comprised of National Forest and National Park lands that include substantial wilderness areas. From time immemorial, the Paiute People have been shepherds of the Valley from crest to crest. Map 1 depicts the Owens Valley.

Map 1. Owens Valley Satellite View



The Reservation itself comprises 875 contiguous acres and is flanked by the City of Bishop to the east. It is surrounded by private lands and by lands owned by the Los Angeles Department of Water and Power. Approximately 1,200 people live on the Reservation. Nearly all of the land on the Reservation is assigned to individual families, with a limited number of acres set aside for public and commercial facilities. Despite substantial population growth since the creation of the Reservation in 1939, many of

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the assigned lands are in agriculture (pasture or alfalfa, primarily) or are open lands. Map 2 shows the Reservation.

Map 2. Bishop Paiute Reservation



Bishop Paiute Reservation Meteorology 2005-2011

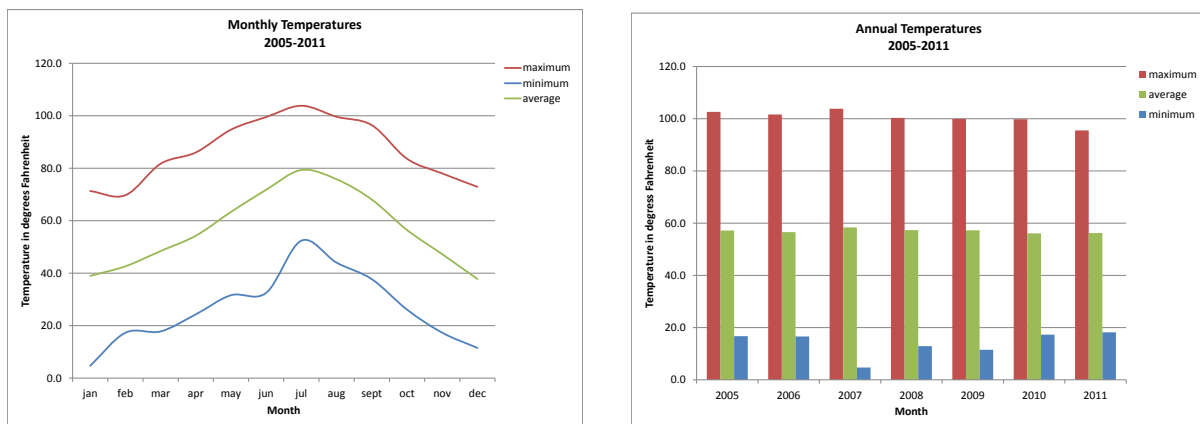
We begin with an overview of recent weather conditions on the Bishop Paiute Reservation, then we will discuss historical data. The Owens Valley is at the western edge of the Great Basin. The climate is high desert. Summary weather information from the Tribe's meteorological station for the period 2005-2011

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is provided in the graphs, below. The weather is moderate. However, due to the desert climate, daily temperatures can vary by 40 to 50 degrees. Historical data from Bishop Airport show the record high as 110 degrees F and the record low as - 8 degrees F. Precipitation is low.

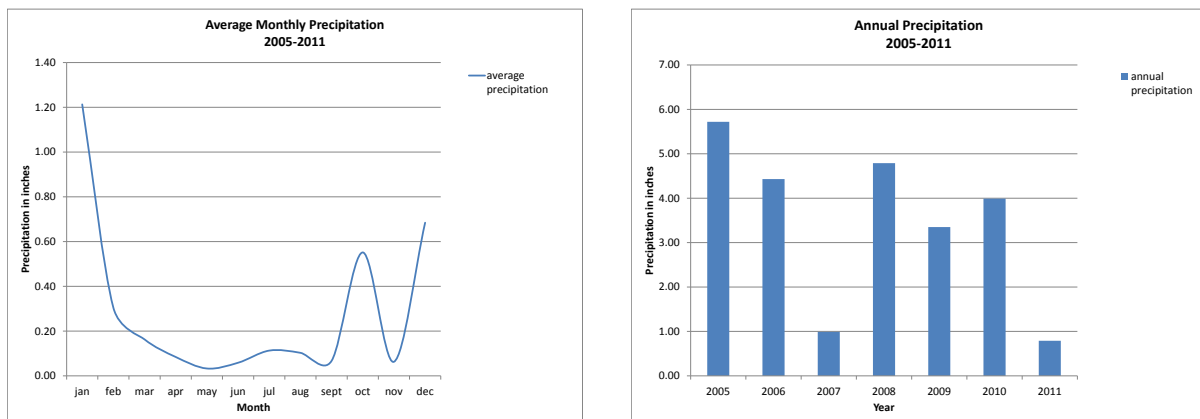
The left panel of Figure 1 shows the seasonal weather pattern and the right panel shows the annual summary as measured at the Bishop Tribe’s Environmental Management meteorological station. Typically, July is the hottest month with maximum temperatures reaching or exceeding 100°F. January is the coldest month with minimum temperatures in the single digits or teens. Annual highs, lows and averages have been fairly stable over the period, with 2007 standing out as having the highest high and the lowest low.

FIGURE 1 – TEMPERATURE SUMMARY BISHOP PAIUTE RESERVATION 2005-2011



The left panel of Figure 2 shows the monthly pattern for the period 2005-2011 and the right panel shows annual precipitation. Due to the high desert climate, precipitation can vary widely from one year to the next and the annual total can be dependent on as little as a single storm. Again 2007 stands out as a dry year as well as one of temperature extremes. 2005 is the wettest year and 2011 is the driest. Winter is the wettest season and is storm-driven. January typically has the most precipitation that may be in the form of snow. Summer precipitation is dependent on monsoonal flow and generally quite low. Fall precipitation is highly variable.

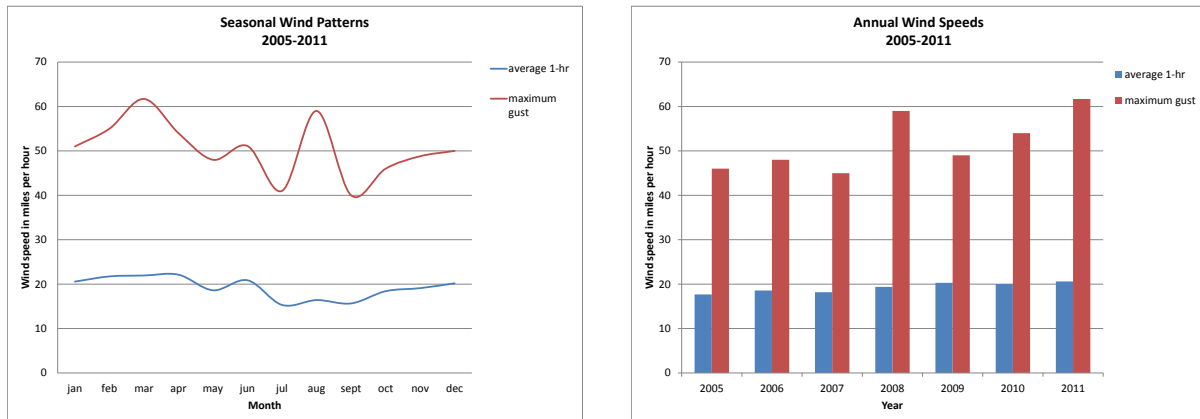
FIGURE 2 – PRECIPITATION SUMMARY BISHOP PAIUTE RESERVATION 2005-2011



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Winds are the driving force behind much of the air pollution in the Owens Valley and are also of meteorological interest. In any month maximum wind gusts exceed 40mph and in most months, they can exceed 50mph, particularly in the winter and spring, although the highest gust measured was in March. Average winds are around 20mph. Average winds do not vary substantially from year to year, and high gusts are observed in all years. 2011 had the highest winds and 2005 had the lowest.

FIGURE 3 – WIND SPEED SUMMARY BISHOP PAIUTE RESERVATION 2005-2011



HISTORICAL WEATHER FOR THE OWENS VALLEY

Station Locations and Observation Period

Data were downloaded from the National Climatic Data Center (NCDC). All stations in the Owens Valley, Eastern Sierras or White Mountains were included. 15 stations in addition to the Bishop Tribe’s EMO station were identified. These stations are listed in Table 1 below. The initial data request was made in August 2012, so that the most recent complete year of data used in this analysis is 2011. Only a few stations have long observation periods. The two oldest stations are Lake Sabrina and South Lake, with reporting periods starting in 1925. Both are located in the Eastern Sierra at elevations that exceed 9,000 ft. Not all stations have complete data for all years. We consider annual information to be incomplete if fewer than 10 months of data are reported. A number of sites have less than one year of information and therefore are not used. These include Deep Springs 11 NW, and some of the newer CoCoRaHS sites.

TABLE 1 – WEATHER STATION SUMMARY INFORMATION

Station name	Elevation (feet)	Latitude	Longitude	Start year	End year
Bishop 0.6 SE	4,140	37.3626	-118.3883	2009	2012
Bishop 1.7 NW	4,181	37.3878	-118.4141	2010	2012
Bishop 8.5 WSW	6,002	37.3227	-118.5404	2009	2012
Bishop 8.8 WNW	4,537	37.4115	-118.5474	2011	2012
Bishop Airport	4,111	37.3667	-118.3667	1948	2012
Bishop Creek	8,500	37.2306	-118.5972	2003	2012
Bishop Crk Intake 2	8,154	37.2480	-118.5813	1959	2010
Bishop FS	4,108	37.3683	-118.3647	1996	2004
Bishop Tribe EMO	4,226	37.3667	-118.4167	2005	2012
Bishop Union Carbide	9,396	37.3667	-118.7167	1957	1969
Deep Springs College	5,233	37.3667	-117.9833	1948	2007
Deep Springs 11 NW	10,509	37.4333	-118.1667	1948	1951

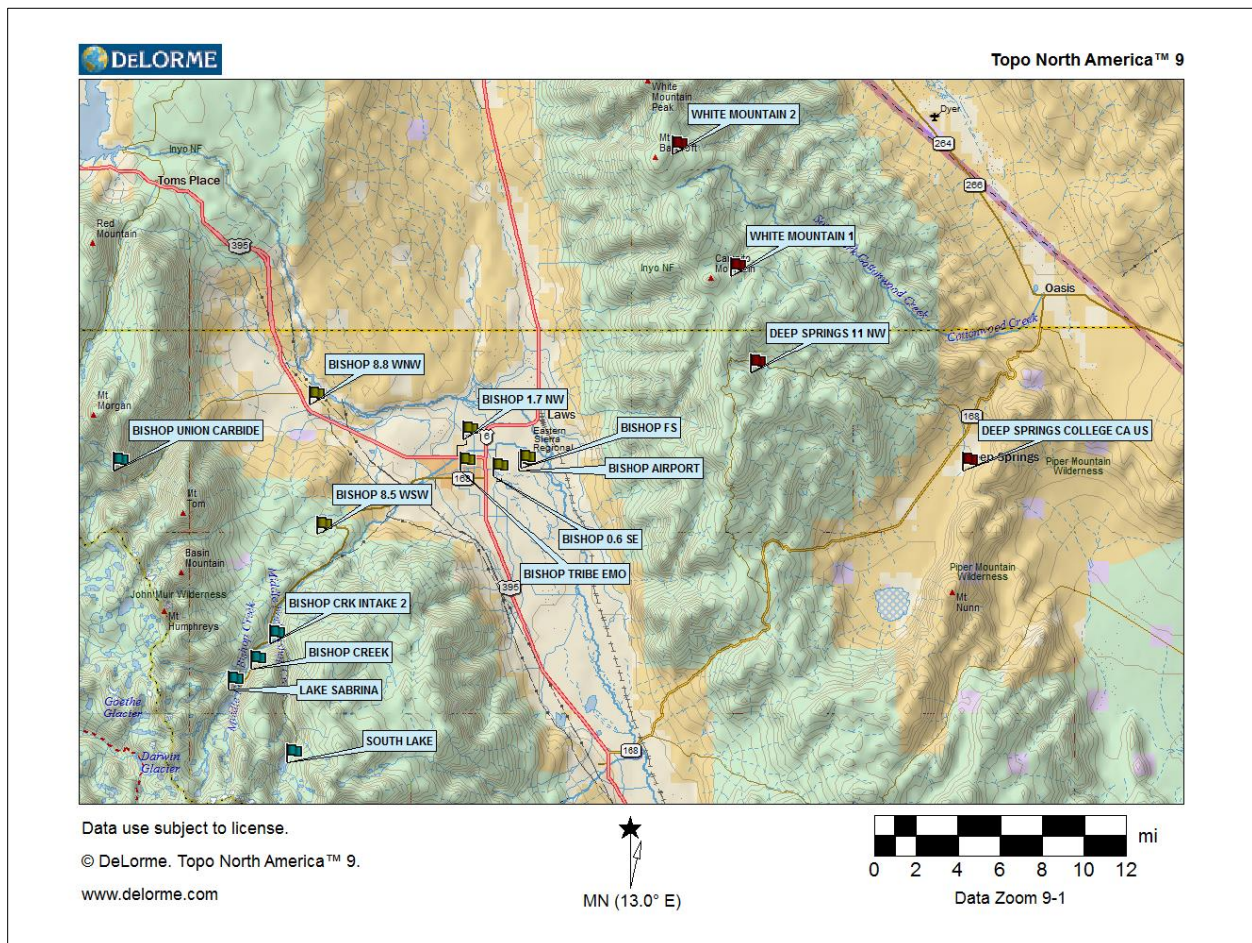
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Station name	Elevation (feet)	Latitude	Longitude	Start year	End year
Lake Sabrina	9,075	37.2167	-118.6167	1925	2010
South Lake	9,626	37.1667	-118.5667	1925	2010
White Mountain 1	10,150	37.5000	-118.1833	1955	1977
White Mountain 2	12,470	37.5833	-118.2333	1955	1980

Stations range in elevation from 4,000 to 11,000 feet. The earliest data are from the South Lake and Lake Sabrina stations where data collection started in 1925. The locations of the stations are shown in Map 3 below. Flag color on the map indicates approximate climate zone, where blue is used for the Eastern Sierra slopes, tan for the Owens Valley and dark red for the White Mountains. In general, the Eastern Sierra slopes stations are higher, cooler and receive more precipitation, particularly snow. The Owens Valley stations are lower, hotter and dryer. And, the White Mountain Stations are higher, cooler, but for a given elevation, tend to be somewhat drier than comparable Eastern Sierra locations.

Map 3. Weather Station Locations



Data Availability

We initially examined daily records, but quickly determined that only a few parameters were available for the majority of stations and that these were already compiled into monthly summaries by NCDC. Temperature and precipitation are the two commonly available parameters from all stations for the relevant historical period. We therefore focus on these 2 parameters. The graphs below show data availability for each station. The vertical axis represents elevation. Panel 4a shows the results for temperature, and panel 4b shows the results for precipitation. From these graphs, it is apparent that there is considerably more information available for precipitation than for temperature. For example all of the CoCoRaHS stations report only precipitation, and the two oldest stations (Sabrina and South Lake) stopped reporting temperature in the late 1940's. The combination of elevation and data availability complicates analysis. The oldest information comes from two high elevation stations, located in the Eastern Sierras. The middle of the observation period includes a combination of high and low locations. This means that the data from the 1920's to the mid 1940's are not comparable to later data, and the later data include a changing mix of information from different elevations. Our strategy is to group information by climate zone and elevation and to examine separately Eastern Sierra slopes, Owens Valley and White Mountain data. Each climate zone is color coded: blue for Eastern Sierra, olive for Owens Valley and rose for White Mountains. In the legend, stations are sorted by altitude.

FIGURE 4 – DATA AVAILABILITY BY ELEVATION OF STATION

Figure 4a – Temperature

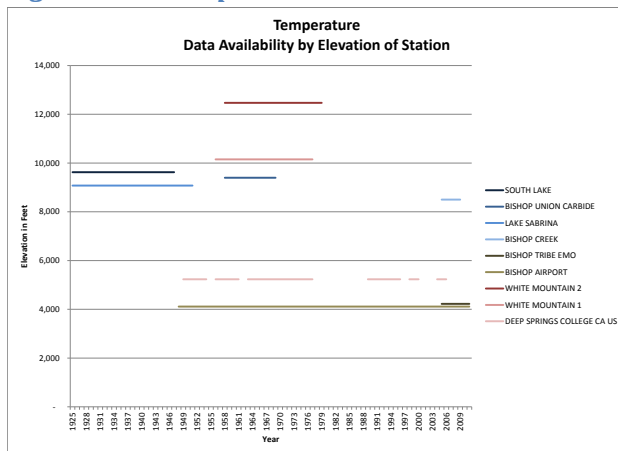
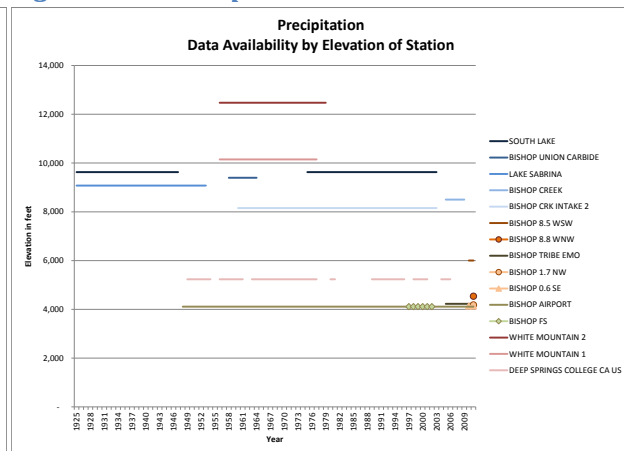


Figure 4b – Precipitation



Descriptive Analyses

Temperature

Minima

The 3 graphs in Figure 5 below show minimum temperatures for each of the climate zones. These graphs reveal some interesting regularities as well as some important differences. Stations that are near one another and in the same climate zone tend to be correlated. Examples are Sabrina and South Lake, the 2 White Mountain Stations, and for their short overlap, Bishop Airport and Bishop Tribe EMO. Minimum temperatures vary by elevation, with Union Carbide and Bishop Creek standing out as

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somewhat of an aberration, with warmer than expected temperatures for its altitude. The lack of overlap makes more detailed comparisons difficult.

FIGURE 5 – MINIMUM TEMPERATURES

Figure 5a – Eastern Sierra Stations

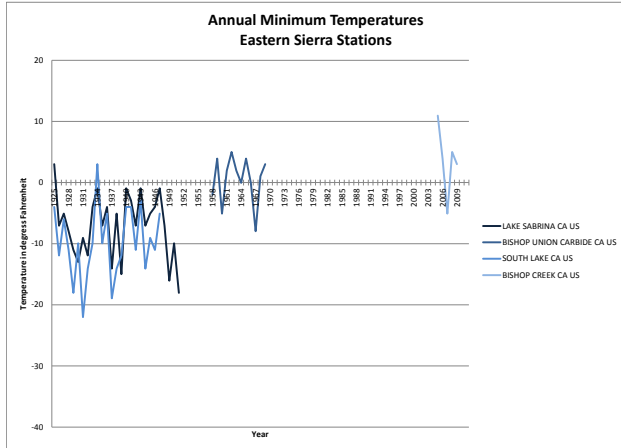


Figure 5b – Owens Valley Stations

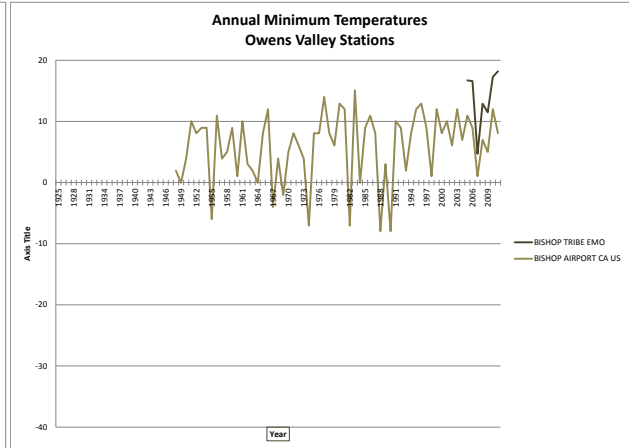
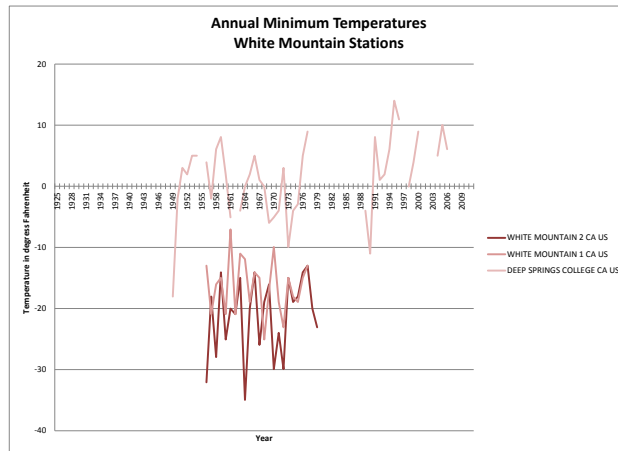


Figure 5c – White Mountain Stations



Maxima

The 3 graphs in Figure 6 below repeat the exercise for maximum temperatures in each of the climate zones. When nearby stations overlap for a time period, there is less apparent correlation with maxima than was seen with the minima just discussed.

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FIGURE 6 – MAXIMUM TEMPERATURES

Figure 6a – Eastern Sierra Stations

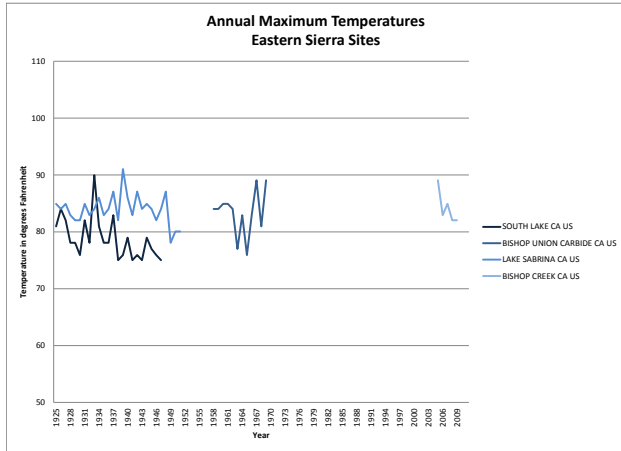


Figure 6b – Owens Valley Stations

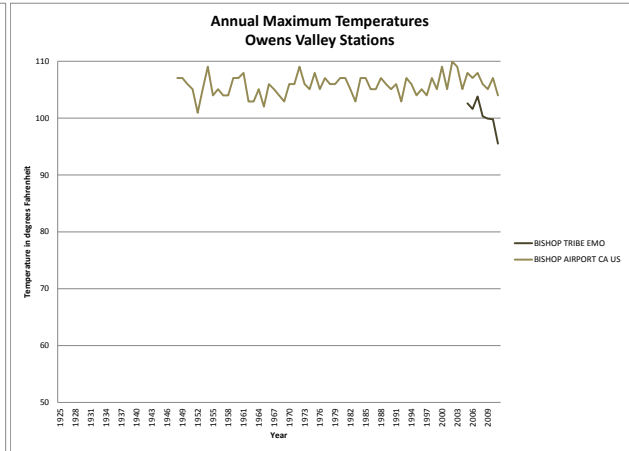
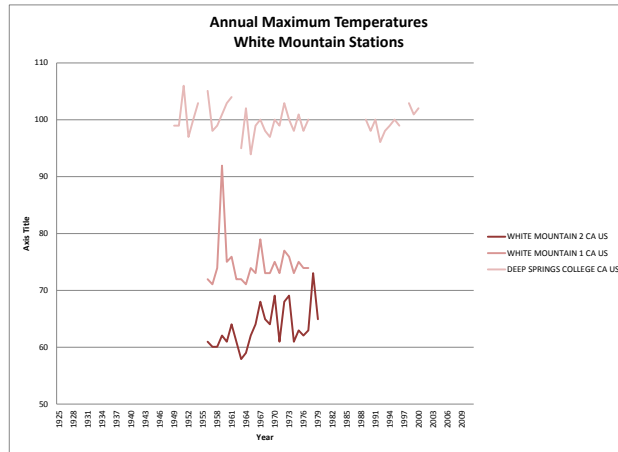


Figure 6c – White Mountain Stations



Averages

The 3 graphs in Figure 7 below show the results for average temperatures. There is considerable correlation for adjacent stations in the Eastern Sierra and in the Owens Valley when observation periods overlap, but less in the White Mountains. Significant reporting gaps in the Deep Springs College series make the comparisons difficult.

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FIGURE 7 – AVERAGE TEMPERATURES

Figure 7a – Eastern Sierra Stations

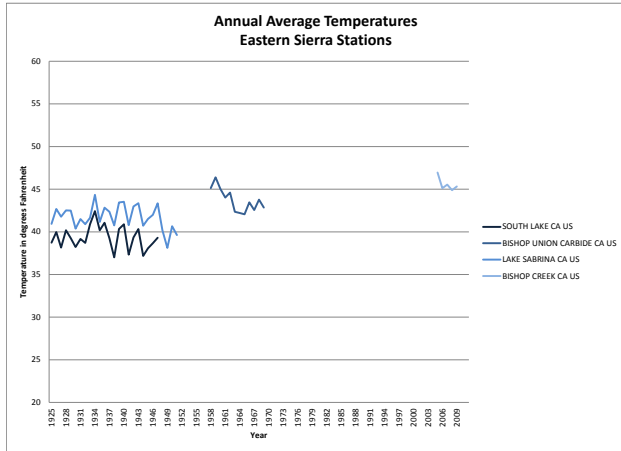


Figure 7b – Owens Valley Stations

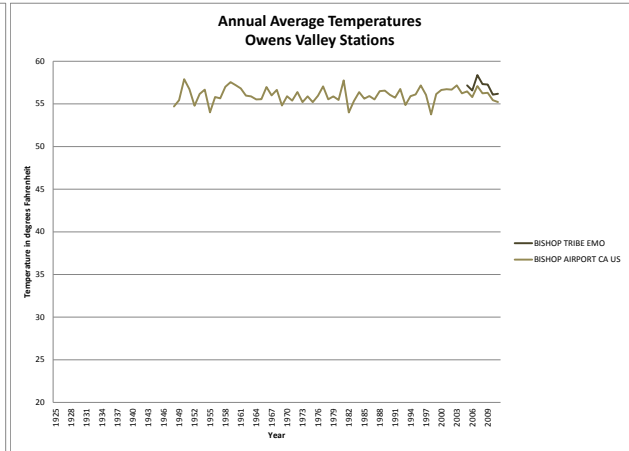
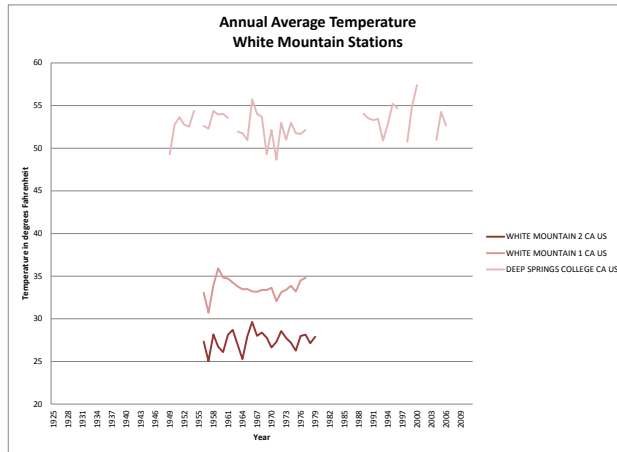


Figure 7c – White Mountain Stations



Precipitation

Precipitation is notoriously variable from year to year in the area we are examining. The graphs in Figure 8 below show annual precipitation for each of the climate zones. As noted earlier, there is considerably more historical information on precipitation than there is for temperature. The regional interest in precipitation, particularly for the Eastern Sierra sites comes from power generation at Sabrina, South Lake, Bishop Creek and Bishop Creek Intake 2, and from mining at Bishop Union Carbide. The 2 White Mountain sites have been used for research. There is additional interest in precipitation due to water exports by the Los Angeles Department of Water and Power. Within each of the climate zones, precipitation levels for adjacent stations are quite similar and follow similar patterns. However, the mix of stations, particularly for the Eastern Sierra sites changes considerably over time and there is considerably less data from the 1950's through the 1970's than in any other period, whereas stations in other regions start reporting data in the 1950's.

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FIGURE 8 – ANNUAL PRECIPITATION

Figure 8a – Eastern Sierra Stations

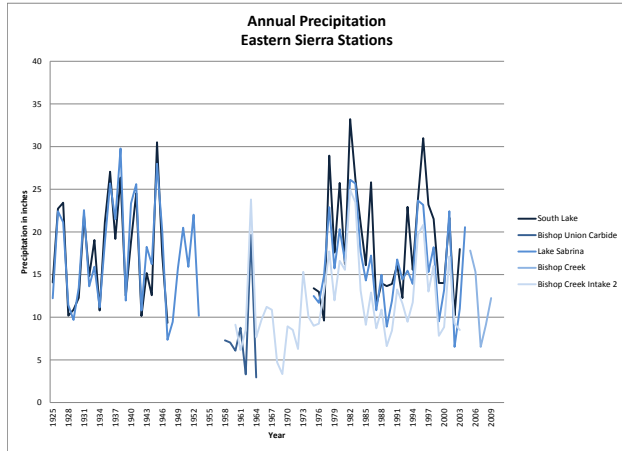


Figure 8b – Owens Valley Stations

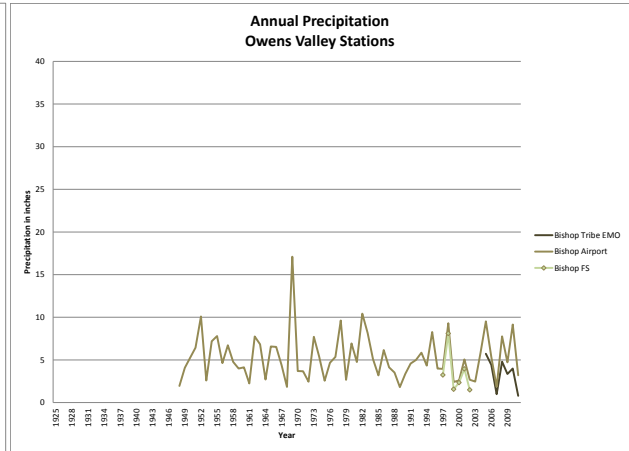
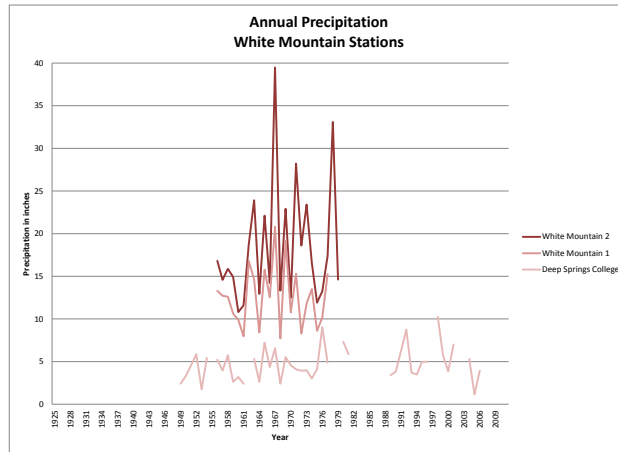


Figure 8c – White Mountain Stations



Combined Series for Climate Zones

In an effort to examine historical patterns, we have constructed combined series, averaging sites within each climate region. For this purpose, we have excluded the Deep Springs site due to its location, east of the White Mountain Crest, placing it in a somewhat different climate zone than the other 2 White Mountain stations and due to significant missing data.

The next step in the analysis will be to subtract the long-term average for the subseries with the goal of removing the effects of altitude and local climate, then to construct a single composite series for the entire region. The goal is to begin to answer questions about longer term weather patterns.

Temperature

Average temperatures for each climate zone are shown below. To construct a single series, we will subtract the long-term mean from each sub-series. In the case of the Eastern Sierra, we will use separate long term means for each portion of the series, because the 2 series that comprise the first

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portion (Sabrina and South Lake) seem to have a slightly different climate from the series that makes up the second portion of the series (Union Carbide) and third portion of the series (Bishop Creek).

FIGURE 9 – AVERAGE TEMPERATURES FOR CLIMATE ZONES

Figure 9a – Minima

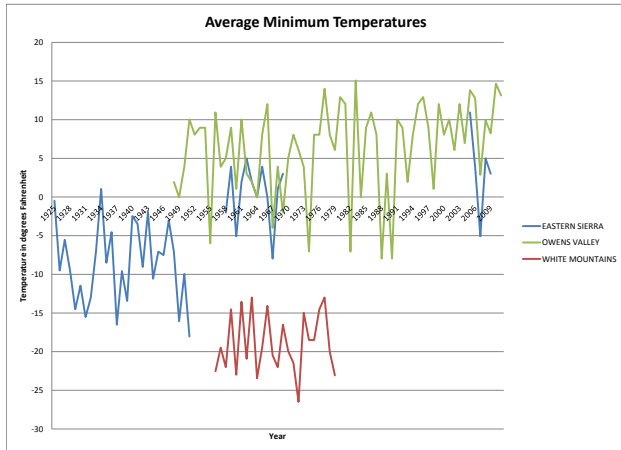


Figure 9b – Maxima

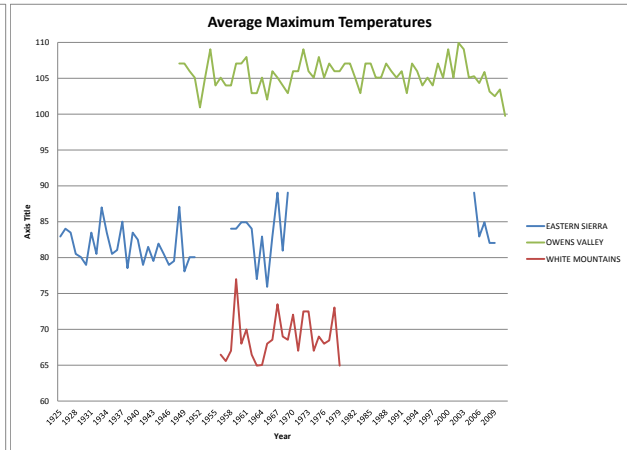
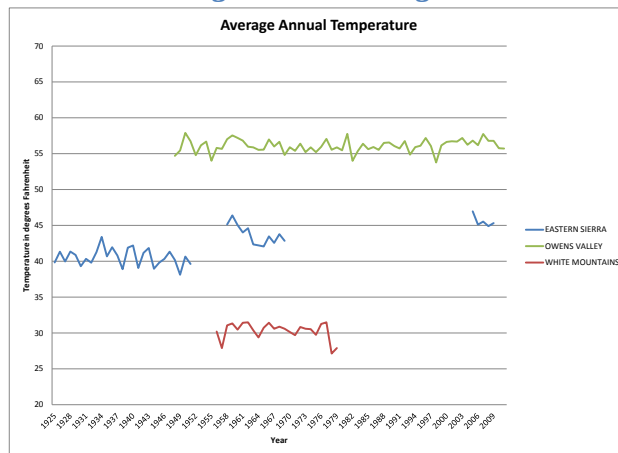


Figure 9c – Average

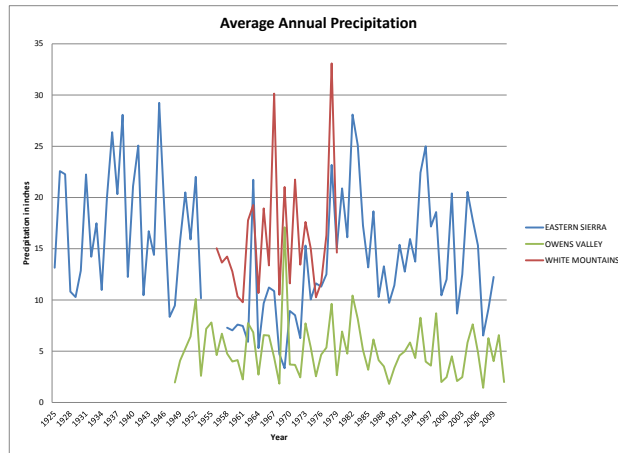


Precipitation

As noted earlier, adjacent stations tend to be strongly correlated. In the case of precipitation, we excluded the CoCoRaHS sites because most have only 1 or 2 years of data and we are unable to evaluate whether stations reports were similar to other nearby stations. Based on the relatively close association of Eastern Sierra series and more extensive overlap of the precipitation data, we have combined series for that climate zone. The main aberration in Figure 10 below is 1969, a year with unusually high precipitation. Bishop Creek Intake 2 did not report data in January and February, possibly due to access problems, thus the total for that year is most likely underreported for that year in the Eastern Sierra. This is unfortunate because it is believed to be one of the highest precipitation years for the region.

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FIGURE 10 – AVERAGE ANNUAL PRECIPITATION FOR CLIMATE ZONES



Combined Series for the Region

To further examine historical patterns, we have subtracted the mean from each series to remove persistent local effects and the effect of altitude. The new series are centered on zero by definition, but can be used to examine historical trends because these have not been removed.

Temperature – Deviations from long-term averages

The figure below shows temperatures for each of the climate zones with the long-term average removed. Minimum temperatures show more variability than do maxima, and averages are most stable, as expected. In general, the three series show reasonable correspondence from year to year, suggesting that averages may be representative of the region.

FIGURE 11 – AVERAGE TEMPERATURES FOR CLIMATE ZONES – Deviations from Long-Term Averages

Figure 11a – Minima

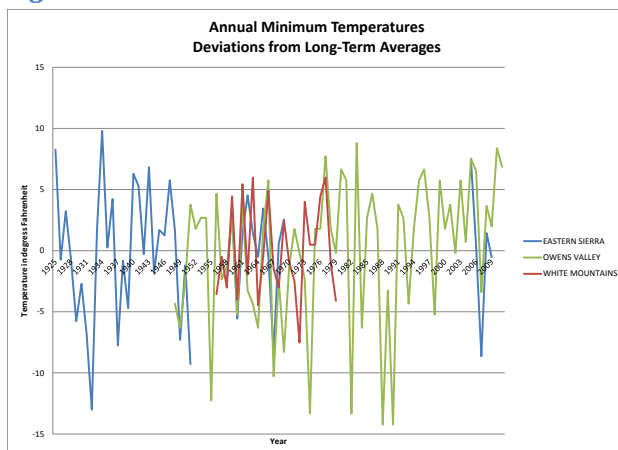
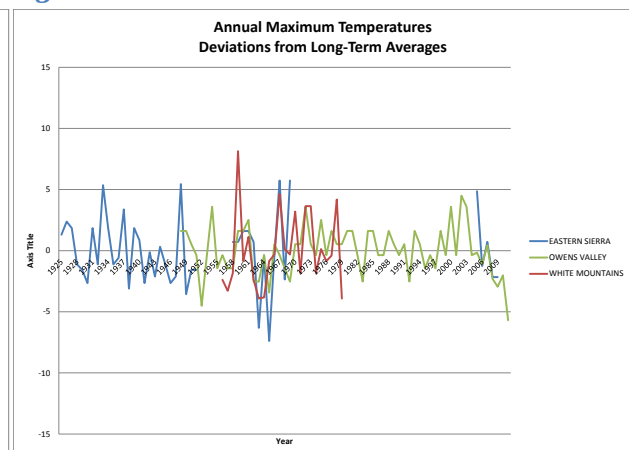
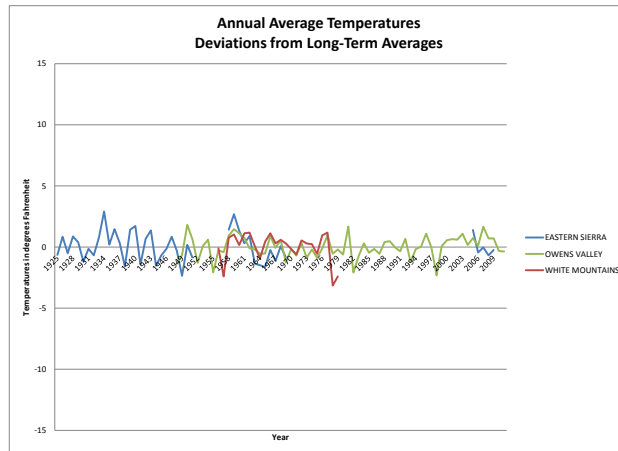


Figure 11b – Maxima



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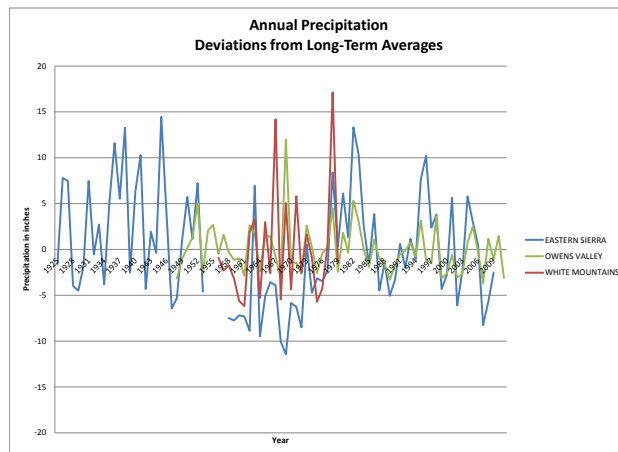
Figure 11c – Average



Precipitation – Deviations from long-term averages

Precipitation is show below. There is reasonable year-to-year correspondence as there was with the temperature information. However, there appears to be some reduction in level and in variability starting in the 1980’s. It is possible that this is due to changes in the mix of stations that comprise the series. Consequently, any long term trends based on composite series must be viewed with caution. We will repeat these analyses using standardized data later in this report.

FIGURE 12 – AVERAGE ANNUAL PRECIPITATION FOR CLIMATE ZONES – Deviations from Long-Term Averages



Temperature – Combined Series

The figures below show deviations from long term averages for the combined temperature series, along with a trend line for each series. In general, linear trends are able to explain less than 2% of the variance in temperatures and slopes are near zero, indicating no strong long-term pattern. More complex functional forms were examined, but no significant improvement of the fit was obtained.

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FIGURE 13 – COMPOSITE TEMPERATURE SERIES – Deviations from Long-Term Averages
Figure 13a – Minima *Figure 13b – Maxima*

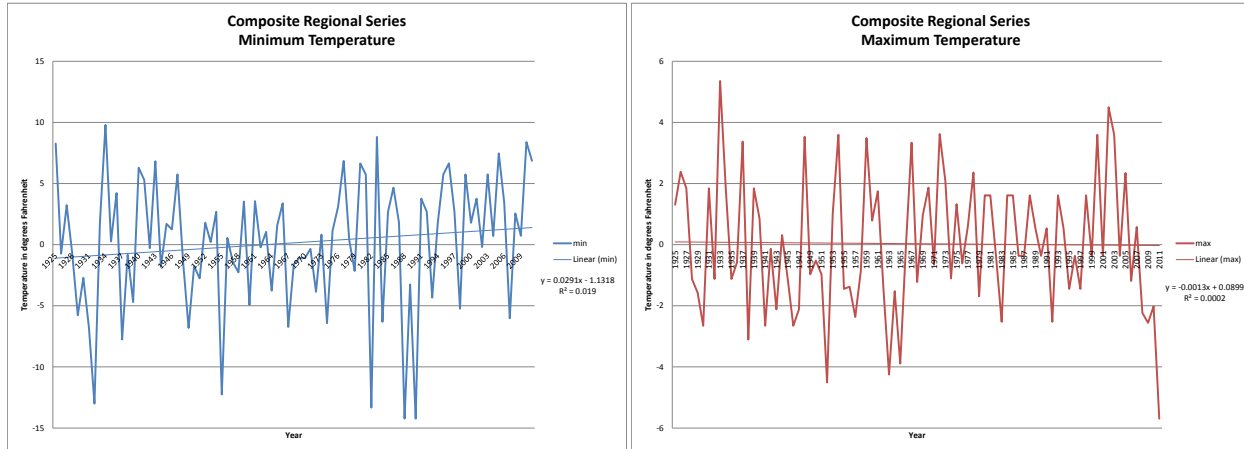
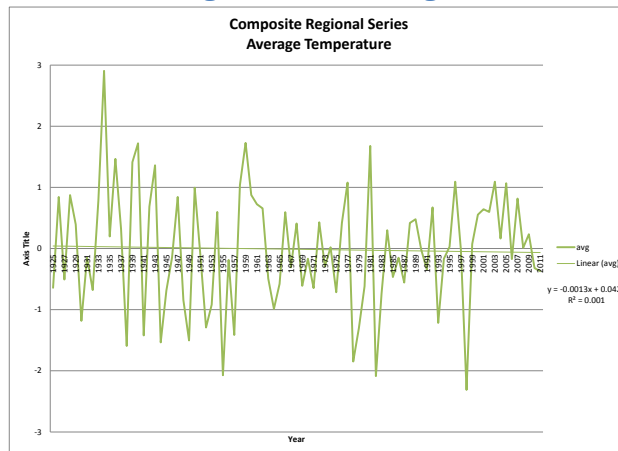


Figure 13c – Average



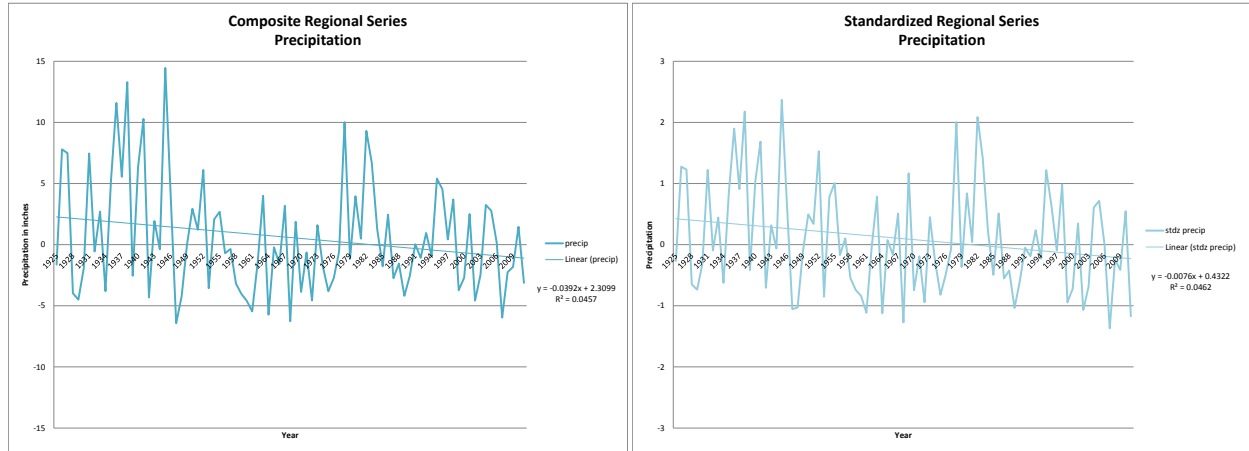
Precipitation - Combined Series

The figure below shows deviations from long term averages for the composite precipitation series. There is considerable reduction in variability over the period. As mentioned earlier, this may be an artifact of changes in the mix of stations represented in the composite series. To account for this, we have standardized each series by dividing the deviations from the long-term mean by the standard deviation. Standardization does not substantially change the results, giving us somewhat more confidence in the findings, despite variability in the stations reporting. There is a mild downward trend that likewise may be an artifact, although a linear trend explains less than 5 percent of the variance and more complex functional forms did not significantly improve the fit.

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FIGURE 14 – COMPOSITE PRECIPITATION SERIES

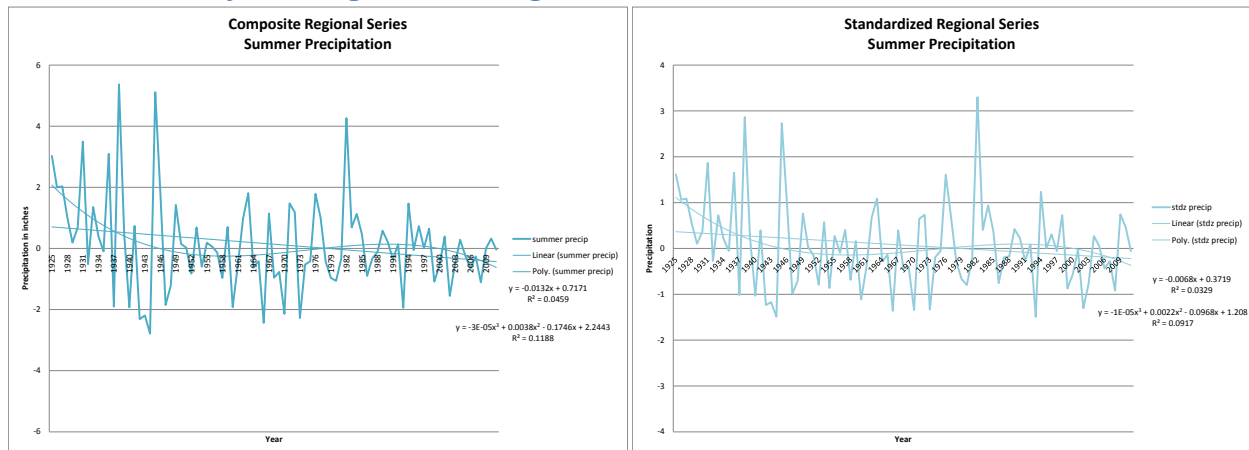
14a – Deviations from Long-Term Averages 14b – Standardized Precipitation



In the Bishop region, winter and summer precipitation are caused by different weather patterns and there is an interest in summer precipitation. We therefore repeated the exercise using only precipitation from May through October of each year. We present only the final composite series with deviations from long term averages and standardized series. The reduction in variability over the study is even more apparent for summer than for annual precipitation and is consistent whether we use deviations from the long-term mean or standardized values. For descriptive purposes, we fit both linear and cubic polynomial trends. The linear trend accounts for 5 to 8 percent of the variation, while the cubic equation is able to account for 8 to 12 percent. The cubic equation picks up the high variability in the first 20 years of the series, but there is insufficient information to draw any strong conclusions. Unfortunately, longer series are not available for our region.

FIGURE 15 – COMPOSITE SUMMER PRECIPITATION SERIES

15a – Deviations from Long-Term Averages 15b – Standardized Series



SUMMARY AND CONCLUSIONS

In an attempt to gain a better understanding of historical weather patterns for the region surrounding the Bishop Paiute Reservation, we collected information from all stations reporting to the National

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Climatic Center. Including the Reservation's own station, this yielded 16 stations reporting for various time periods from 1925 to the present, with 2011 being the last calendar year included in the analysis. The goal was to create a combined series that could be examined for long term patterns. A number of stumbling blocks were encountered in the analysis. The most significant problem arose from the wide difference in altitudes for the stations reporting and from the fact that different portions of the study period had different mixes of stations from different climate zones. We examined variability of nearby stations and constructed composite series using deviations from long term averages to abstract from persistent local climate characteristics. In the case of precipitation, we also looked at standardized series. For temperature, we find no evidence of long term trend. For precipitation, the results show a reduction in both level and variability over the period. We suspect that to a substantial degree, this may be due to changes in the mix of reporting stations, although we have tried to reduce this potential artifact through standardization. The results suggest the possibility that there may be long-term cycles in Bishop regional precipitation. Unfortunately, existing data series are not long enough to investigate this further