CA Climate Change is Caused by the Pacific Decadal Oscillation, Not by Carbon Dioxide

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Science & Public Policy Institute
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SPPI Original Paper ♦ September 16, 2010

California Climate Change is Caused by the Pacific Decadal Oscillation, Not by Carbon Dioxide

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Abstract

The long term trends in monthly minimum temperature from 34 California weather stations have been analyzed. These trends can be explained using a variable linear urban heat island effect superimposed on a baseline trend from the Pacific Decadal Oscillation (PDO). The majority of the prevailing California weather systems originate in the N. Pacific Ocean. The average minimum monthly temperature is a measure of the surface air temperature of these weather systems. Changes in minimum surface temperature are an indicator of changes in the temperature of the tropospheric air column, not the ground surface temperature. The PDO provides a baseline minimum temperature trend that defines the California climate variation. This allows urban heat island effects and other possible anomalous temperature measurement effects to be identified and investigated. Some of the rural weather stations showed no urban heat island effects. Stations located in urban areas showed heat island effects ranging from 0.01 to over 0.04 $C.yr^{-1}$. The analysis of minimum temperature data using the PDO as a reference baseline has been demonstrated as a powerful technique for climate trend evaluation. This technique may be extended to other regions using the appropriate local ocean surface temperature reference. The analysis found no evidence for CO_2 induced warming trends in the California data. This confirms prior 'Null Hypothesis' work that it is impossible for a 100 ppm increase in atmospheric CO_2 concentration to cause any climate change.

Introduction

The weather is always changing on a daily basis and climate is often evaluated using long term averages of daily maximum and minimum temperatures and precipitation. This is the weather station record that is available from about 1880 onwards. However, the meteorological surface air temperatures (MSAT) are recorded by a thermometer located in an enclosure placed at eye level, 1.5 to 2 m above the ground.[1] The surface or 'skin' temperature is the temperature of the ground itself below the thermometer. This is set by the dynamic energy balance at the surface between the short wave (solar) flux, the long wave infra red (LWIR) flux, surface evaporation and convection. It also includes subsurface heating and cooling. The incoming solar flux can reach 1000 $W.m^{-2}$ and the night time LWIR cooling flux can easily vary between 0 and 100 $W.m^{-2}$, depending on cloud cover and humidity. The increase in downward atmospheric LWIR flux from the observed 100 ppm increase in CO_2 concentration over the last 200 years is 1.7 $W.m^{-2}$ under ideal 'clear sky' conditions. When this CO_2 flux is added to the daily flux balance with fluctuations that can exceed 1100 $W.m^{-2}$, it becomes clear that there can be no CO_2 'signature' in the MSAT record.[2]

The minimum MSAT temperature is a measure of the bulk air temperature of the local weather system. This is related to the atmospheric temperature profile or lapse rate that extends up through the troposphere. Since the Earth's surface is over 75% ocean, the weather systems in many land locations are formed over the oceans. In these cases, long term changes in average minimum MSAT are an indicator of ocean surface temperature changes in the region of formation of the weather system. The maximum MSAT is a measure of the daytime surface solar heating, coupled through convective mixing to the MSAT thermometer. Instead of considering the daily maximum and minimum MSATs or their average, the minimum MSAT and the daily temperature rise, the difference between the minimum and maximum MSAT, contain the energy transfer information. In particular, the minimum MSAT often contains the 'signature' of the ocean surface temperature in the region of origin of the weather system. The temperature anomaly for the 48 continental states also tracks the combined Atlantic and Pacific Ocean surface temperature index.[3]

In the California, most of the prevailing weather systems form in the NE Pacific Ocean, so any long term changes in the minimum MSAT record should be associated with changes in Pacific Ocean temperature specifically, the Pacific Decadal Oscillation (PDO). In addition, the difference in slope between the PDO trend and the weather station data is an indicator of the local urban heat island effect and other local anomalies on the station record. This is demonstrated here for 34 California weather stations.

MONTHLY MINIMUM MSAT ANALYSIS FOR 34 CALIFORNIA WEATHER STATIONS

The monthly minimum temperature records for 34 California weather stations were downloaded from the Western Region Climate Center web site and used 'as is'.[4] Pierce College data was obtained from the college website.[5] Stations with a minimum record duration of 50 years were selected to be representative of the full geographical and climate extent of California. The monthly minimum MSAT data were processed to generate a 5 year rolling average of the annual temperature anomaly, by subtracting the long term annual mean from the annual average data. The data for each station was plotted with the 5 year rolling average of the PDO over the same time period and the linear fit to the data sets was calculated using the linear 'Trendline' algorithm in Excel™. The PDO data was downloaded from the University of Washington website.[6] The long term temperature trend ($C.yr^{-1}$) in the weather station data was calculated by subtracting the PDO slope from the station data linear fit. As discussed below, some of the station data showed obvious anomalies and in these cases, the station data were reprocessed using shorter time periods to avoid the anomalous region. The objective of this study was to evaluate the effect of the PDO on the minimum MSAT data using a simple linear fit analysis. In some cases, the station data was 'detrended' to remove the linear heat island slope, but no other data processing was conducted.

Figure 1 shows the 5 year rolling average for the PDO from 1904 to 2009. The linear fits to selected portions of the graph are also shown. The linear trend for the full data set is small, 0.003 $C.yr^{-1}$. However, the slope over shorter time scales can vary substantially. In the analysis presented here, the slope of the PDO data was determined over the same time line as the temperature record data. To illustrate the analysis technique, Figure 2 shows the 5 year rolling average data for Healdsburg from 1904 to 2009. The temperature record shows a slope of almost 0.03 $C.yr^{-1}$, indicating a probable urban heat island effect. However, the distinct 'fingerprint' of the PDO can still be seen superimposed on the temperature data. In this example, the temperature data were 'detrended' to remove the heat island slope and this data is also plotted on the graph. The recent cooling of the PDO is clearly visible in the detrended data from the late 1980s onwards.

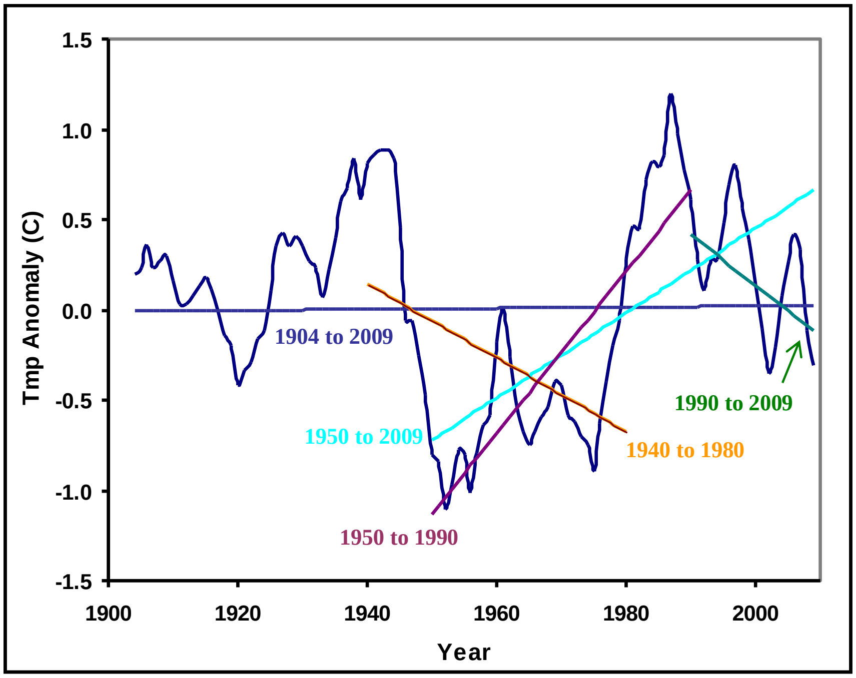

Figure 1: The Pacific Decadal Oscillation (PDO) from 1904, 5 year rolling average. The linear fits to selected regions of the curve are also shown.

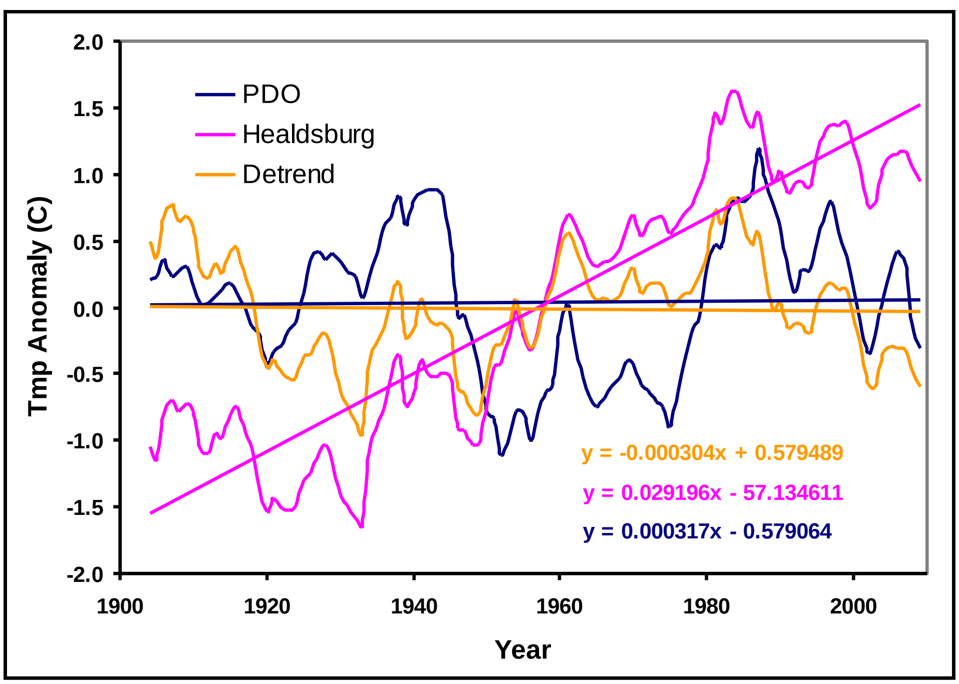

Figure 2: Minimum monthly temperature anomaly, 5 year rolling average for Healdsburg, plotted with the PDO. The 'detrended' temperature data are also shown.

The linear slope data for the 34 stations analyzed in this work are plotted in Figure 3 sorted using increasing slope. A number after the station name indicates a data set that was reprocessed over a shorter time period to avoid obvious anomalies in the dataset. This is discussed in more detail below. To facilitate an analysis of the results, the station data were divided into four groups. The first group was 'coastal' which included 10 coastal weather stations from Crescent City to San Diego. The second group was 'rural' which included 9 stations with warming trends below 0.01 $C.yr^{-1}$. These were mainly located in rural areas. The third group was 'urban' which included 14 stations with warming trends above 0.01 $C.yr^{-1}$. Most of the reprocessed data sets fell into this category. The fourth group was 'anomalous' where visual inspection of the station data indicated obvious discrepancies associated for example with changes in location, that require further investigation. In most cases, the anomaly only impacted part of the data set and the rest of the data could be processed normally with a reduced time scale. The warming trends for the separate station groups are plotted in Figure 4. The station locations and thumbnail plots of the data are given in Figure 5 and Figure 6. Plots of the individual station data, and tabular summaries, including the period of record are given in the Appendix. The warming trends for the four groups will now be considered separately.

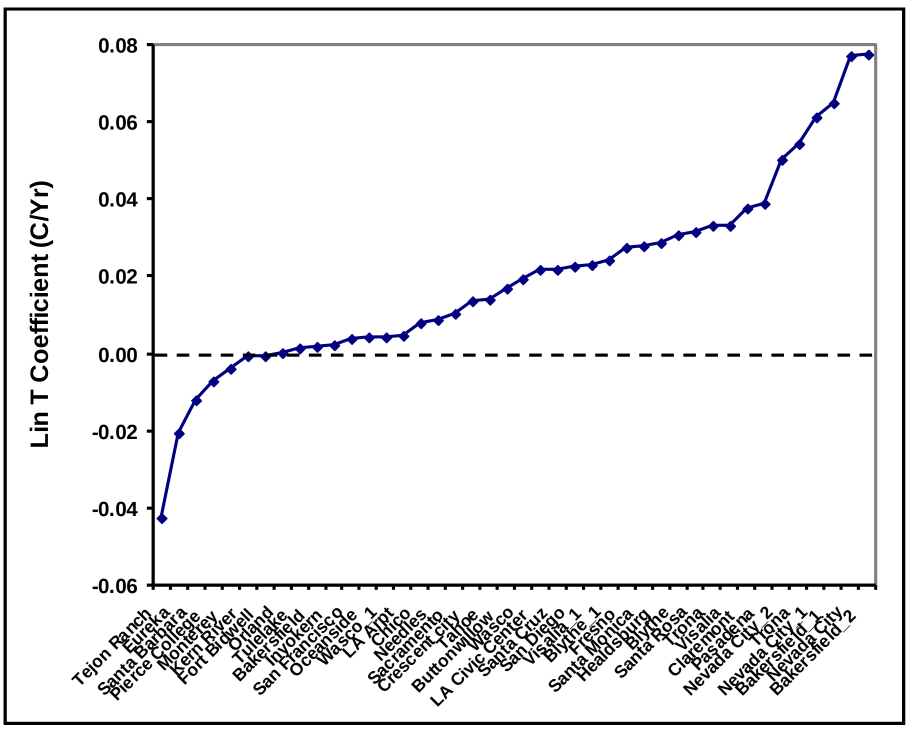

Figure 3: Warming trend data for the full weather station set. Stations with numbers after the name indicate reprocessed data over more limited time periods.

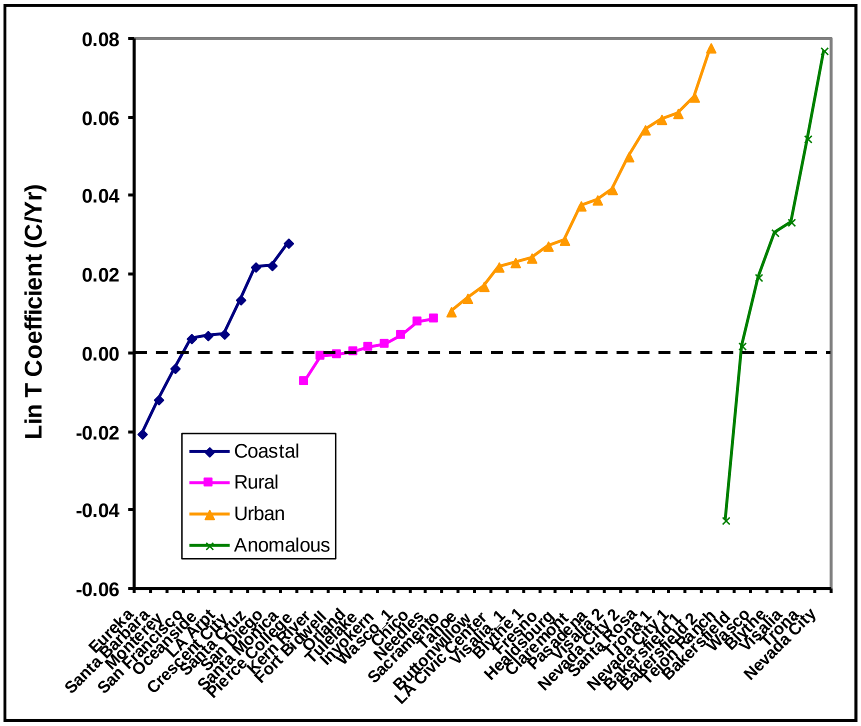

Figure 4: Warming trend data for the weather stations divided into four groups. See text for further discussion.

Station Group 1: Coastal

The 10 coastal stations were selected to cover a range of coastal cities along the full length of the coast of California. Because of ocean influences related to the marine layer, the coastal city temperatures do not show the large temperature fluctuations characteristic of locations further inland. This also reduces the urban heat island effects. These are related to increased surface heat storage and higher ground temperatures that require both urban development and solar heating. Two of the coastal city stations, Eureka and Santa Barbara had negative temperature coefficients of -0.021 and -0.012 $C.yr^{-1}$. Both temperature records are relatively short, 59 and 49 years and both stations were moved in the 1980s. Four of the stations, Los Angeles Airport, Monterey, Oceanside and San Francisco had temperature coefficients below 0.01 $C.yr^{-1}$, and the remaining four, Crescent City, San Diego, Santa Cruz and Santa Monica had temperature coefficients in the 0.01 to 0.03 $C.yr^{-1}$ range. These trends are consistent with the coastal locations and urban growth patterns. More detailed analysis will require consideration of station configuration changes and microclimate effects. The temperature trend data are summarized in Table 1.

Table 1
Temperature coefficients ($C.yr^{-1}$) for the coastal stations

Coastal	T coeff
Eureka	-0.021
Santa Barbara	-0.012
Monterey	-0.004
San Francisco	0.004
Oceanside	0.005
LA Arpt	0.005
Crescent City	0.014
Santa Cruz	0.022
San Diego	0.023
Santa Monica	0.028

Station Group 2: Rural

Nine stations were identified as 'rural' with temperature coefficients below 0.01 $C.yr^{-1}$. One of these stations, Pierce College was located at the west end of the San Fernando Valley in Los Angeles, but the site location and prevailing weather conditions blocked any urban heat island effect from Los Angeles. The rural sites covered a wide range of climate zones, from Fort Bidwell in the NE corner of the state with an annual average minimum temperature of 1 C to Needles, on the lower Colorado River with an annual average minimum temperature of 16 C. In general, the 5 year averages of the minimum temperatures tracked the 5 year average of the PDO. The Wasco station record contained two negative temperature peaks greater that 2 C near 1910 and 1920 that increased the overall temperature coefficient. However, when the data were processed from 1934 onwards, the 75 year data set fell in the rural category. The rural temperature trend data are summarized in Table 2.

Table 2
Temperature coefficients ($C.yr^{-1}$) for the rural stations

Rural	T coeff
Pierce College	-0.007
Kern River	-0.001
Fort Bidwell	0.000
Orland	0.000
Tulelake	0.001
Inyokern	0.002
Wasco_1	0.005
Chico	0.008
Needles	0.009

Station Group 3: Urban

Fifteen stations were identified as urban. However this group included 8 datasets that were reprocessed with shorter time scales to avoid obvious data anomalies. For two of these stations, Nevada City and Bakersfield, the data anomalies occurred in the central region of the complete dataset, so the data were reprocessed as two separate subsets. This gave a total of seventeen urban datasets with temperature coefficients between 0.01 and 0.08 $C.yr^{-1}$. In this group, Sacramento had the smallest temperature coefficient, 0.01 $C.yr^{-1}$ and Bakersfield 2 (reprocessed) had the largest, 0.078 $C.yr^{-1}$. The urban temperature trend data are summarized in Table 3.

Table 3
Temperature coefficients ($C.yr^{-1}$) for the urban stations

Urban	T coeff
Sacramento	0.010
Tahoe	0.014
Buttonwillow	0.017
LA Civic Center	0.022
Visalia_1	0.023
Blythe 1	0.024
Fresno	0.027
Healdsburg	0.029
Claremont	0.038
Pasadena	0.039
Visalia 2	0.042
Nevada City 2	0.050
Santa Rosa	0.057
Trona 1	0.059
Nevada City 1	0.061
Bakersfield 1	0.065
Bakersfield 2	0.078

Station Group 4: Anomalous

Seven stations had temperature records that showed obvious anomalous behavior. Blythe, Visalia and Wasco had distinct negative peaks near the start of the temperature records. Trona had a large positive peak near the end of the temperature record. In these cases, a shorter record was processed that did not include the anomalous region. The length of the new record was selected by simple visual inspection of the data. The record for Bakersfield showed a significant decrease between 1980 and 1990, so the record was split between 1984 and 1985 and the two sets were processed separately. The observed decrease does not appear to be associated with any station relocation. The record for Nevada City showed a significant increase between 1970 and 1980. This may be associated with a relocation of the station in 1976. The record was split and the two sections either side of the shift were processed separately. The Tejon Ranch station showed a large negative coefficient. Part of this may be attributed to land use changes and a shift from ranching to irrigated crops that began in the late 1930's. However, recent data after 2003 showed another large negative shift of nearly 10 C, so these recent data were not included in the analysis. There are land use, site and instrument bias issues that need to be investigated for this station. The urban temperature trend data are summarized in Table 4.

Table 4
Temperature coefficients ($C.yr^{-1}$) for the urban stations

Anomalous	T coeff
Tejon Ranch	-0.043
Bakersfield	0.002
Wasco	0.019
Blythe	0.031
Visalia	0.033
Trona	0.055
Nevada City	0.077

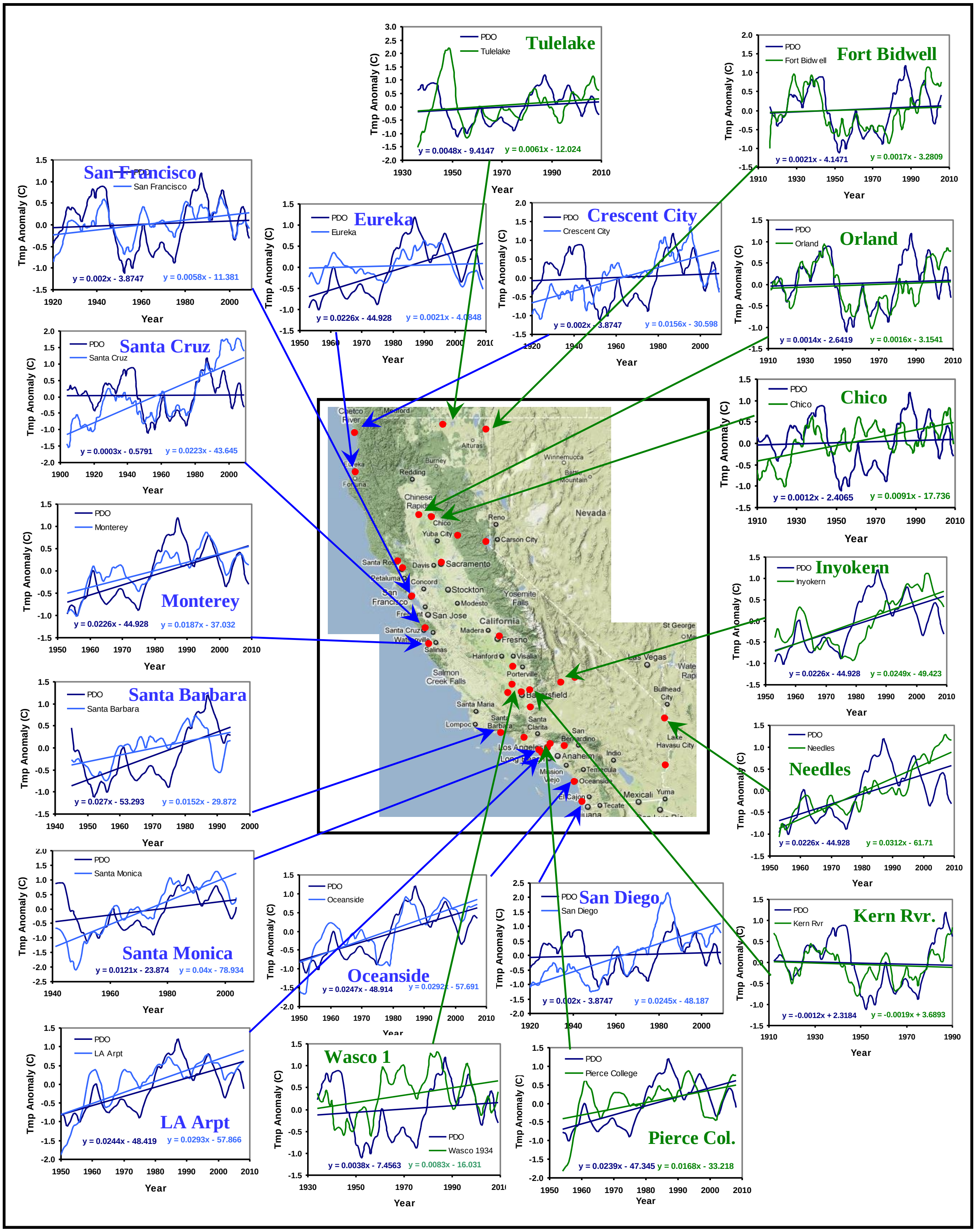

Figure 5: Locations and thumbnail data plots of the coastal and rural stations.

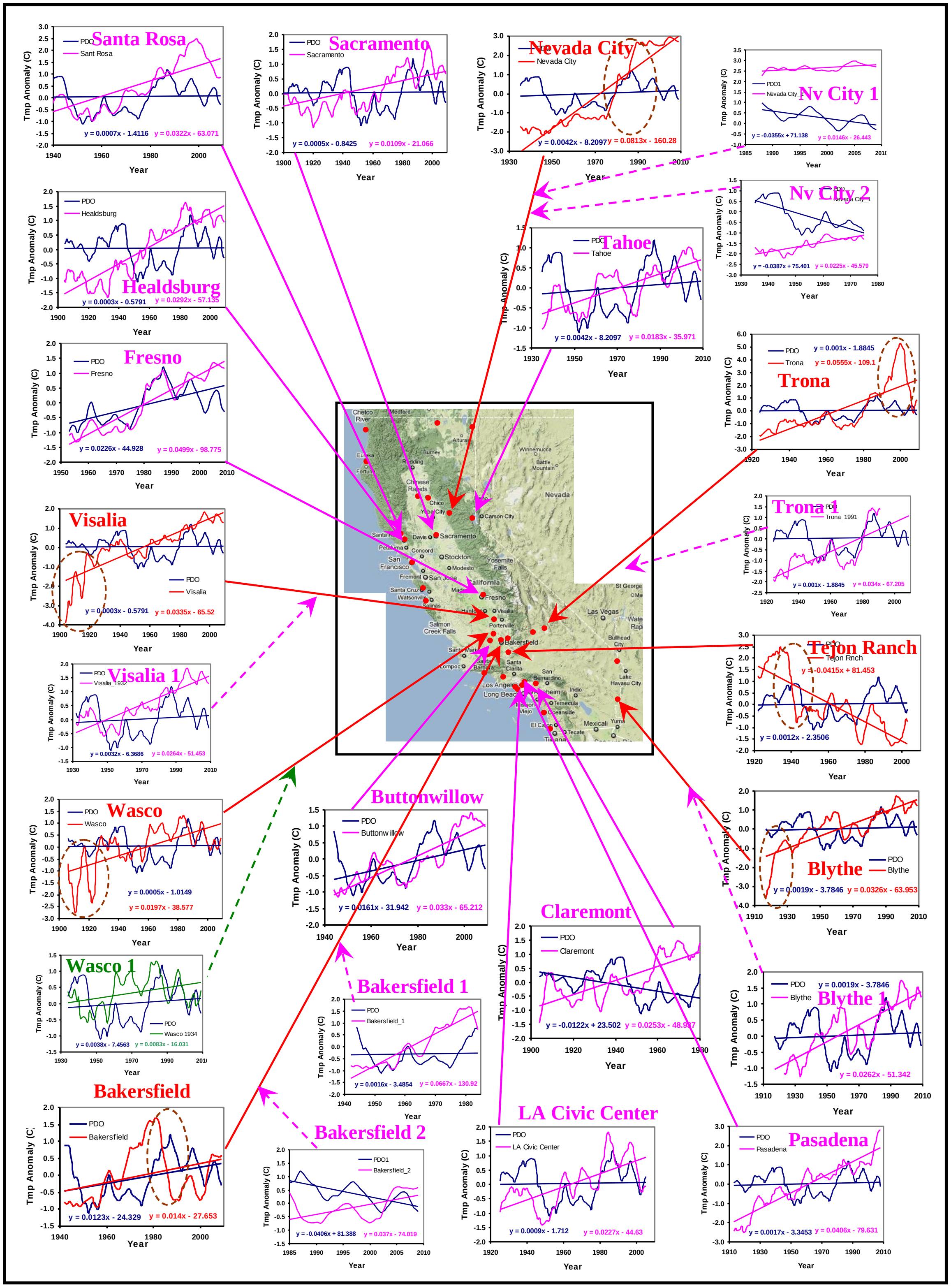

Figure 6: Locations and thumbnail data plots of the urban and anomalous stations. The anomalies are circled in the thumbnail plots.

CONCLUSIONS

The dominant factor that determines the climate of the State of California is the variation in N. Pacific Ocean temperatures related to the PDO. This has been clearly demonstrated by an analysis of the long term minimum temperature data from 34 widely spaced California weather stations. The PDO record provides a baseline that can be used to identify urban heat island effects and anomalous data in the station records. This provides a powerful technique for investigating climate change in California and may be extended to other Western States and other areas of the world where there is an ocean influence on the climate that may be used to provide a local reference. Unexplained 'adjustments' made to weather station records for use in climate trend analysis have now become a major concern.[7,8] This technique may also provide an independent reference for the analysis of climate trends in weather station data to detect such 'adjustments'. This analysis used a simple linear fit to the station data. By combining the weather station data with other meteorological data and climate simulations, a more detailed analysis of the effect the PDO and other factors on the climate of the State of California may be performed. However, this is not a 'one size fits all' approach and each data set needs to be examined carefully on a case by case basis to evaluate all of the factors that may bias the data. These results also confirm earlier work which demonstrated that it was impossible for the observed changes in atmospheric CO_2 concentration to cause any climate change.[2] There is no CO_2 'signature' in any of the temperature records that were analyzed. The recent decrease in the PDO with the triple peak 'signature' from 1985 onwards is clearly visible in most of the temperature data sets. Predictions for CO_2 induced global warming indicate a monotonically increasing 'equilibrium surface temperature' for this period. The empirical concept of CO_2 induced global warming has no basis in the physical reality of climate change.

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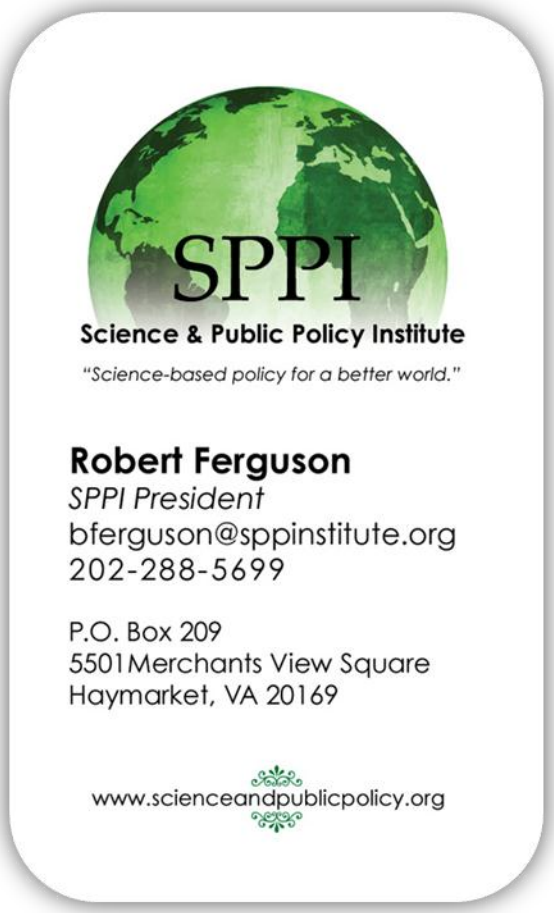
Cover photo: Point Reyes National Seashore, California.



Appendix

Table A-1

Temperature trend results and years of record used

Station	Start Yr	End Yr	Years	Fit Slope	PDO slope	T Coeff
Tejon Ranch	1922	2003	81	-0.042	0.001	-0.043
Eureka	1950	2009	59	0.002	0.023	-0.021
Santa Barbara	1945	1994	49	0.015	0.027	-0.012
Pierce College	1953	2009	56	0.017	0.024	-0.007
Monterey	1953	2009	56	0.019	0.023	-0.004
Kern River	1912	1990	78	-0.002	-0.001	-0.001
Fort Bidwell	1916	2006	90	0.002	0.002	0.000
Orland	1911	2009	98	0.002	0.001	0.000
Tulelake	1936	2009	73	0.006	0.005	0.001
Bakersfield	1942	2009	67	0.014	0.012	0.002
Inyokern	1953	2009	56	0.025	0.023	0.002
San Francisco	1918	2009	91	0.006	0.002	0.004
Oceanside	1948	2009	61	0.029	0.025	0.005
Wasco_1	1934	2009	75	0.008	0.004	0.005
LA Arpt	1949	2008	59	0.029	0.024	0.005
Chico	1910	2009	99	0.009	0.001	0.008
Needles	1953	2009	56	0.031	0.023	0.009
Sacramento	1904	2009	105	0.011	0.001	0.010
Crescent city	1918	2009	91	0.016	0.002	0.014
Tahoe	1935	2009	74	0.018	0.004	0.014
Buttonwillow	1944	2009	65	0.033	0.016	0.017
Wasco	1906	2009	103	0.020	0.001	0.019
LA Civic Center	1925	2005	80	0.023	0.001	0.022
Santa Cruz	1904	2009	105	0.022	0.000	0.022
San Diego	1918	2009	91	0.025	0.002	0.023
Visalia_1	1932	2009	77	0.026	0.003	0.023
Blythe_1	1923	2009	86	0.026	0.002	0.024
Fresno	1953	2009	56	0.050	0.023	0.027
Santa Monica	1941	2004	63	0.040	0.012	0.028
Healdsburg	1904	2009	105	0.029	0.000	0.029
Blythe	1917	2009	92	0.033	0.002	0.031
Santa Rosa	1907	2009	102	0.032	0.001	0.032
Trona	1924	1991	67	0.034	0.001	0.033
Visalia	1904	2009	105	0.034	0.000	0.033
Claremont	1904	1980	76	0.025	-0.012	0.038
Pasadena	1913	2009	96	0.041	0.002	0.039
Nevada City_2	1988	2009	21	0.015	-0.036	0.050
Trona	1924	2009	85	0.056	0.001	0.055
Nevada City_1	1935	1975	40	0.023	-0.039	0.061
Bakersfield_1	1942	1984	42	0.067	0.002	0.065
Nevada City	1935	2009	74	0.081	0.004	0.077
Bakersfield_2	1985	2009	24	0.037	-0.041	0.078

Table A-2

Station Data

From NCDC Station Historical Listing for NWS Cooperative Network
ObsTyp: t-Temperature-1, p-Daily precip-2, w-(blank), s-(blank), e-Evap-5
h-Hourly precip - 6 0.01" Universal, or - 7 0.10" Fisher-Porter
U - Observed, but beginning date is uncertain

Count	Number (Coop)	Station Name (From NCDC listing)	Lat ddmm	Long dddmm	Elev ftx10	Start yy mm	ObsTyp t	p	w	s	e	h	End yy mm
140	040442-5	BAKERSFIELD WB ARPT	3525	11903	49	33 1	U	U	U				45 12
141	040442-5	BAKERSFIELD WB ARPT	3525	11903	50	46 1	U	U	U				57 12
142	040442-5	BAKERSFIELD WB ARPT	3525	11903	49	58 1	U	U	U				74 5
143	040442-5	BAKERSFIELD WB ARPT	3525	11903	49	74 5	U	U	U				78 12
144	040442-5	BAKERSFIELD WB ARPT	3525	11903	49	78 12	U	U	U				99 99
261	040924-7	BLYTHE	3337	11436	27	31 1	U	U					99 99
375	041244-5	BUTTONWILLOW	3524	11928	27	40 1	U	U					85 8
376	041244-5	BUTTONWILLOW	3524	11928	27	85 8	1	U					87 4
377	041244-5	BUTTONWILLOW	3524	11928	27	87 4	1	2					99 99
533	041779-6	CLAREMONT POMONA COLLEG	3406	11743	120	31 1	U	U					80 12
655	042147-1	CRESCENT CITY 1 N	4144	12412	7	31 1	U	U					46 1
656	042147-1	CRESCENT CITY 1 N	4146	12412	4	57 4	U	U					87 12
657	042147-1	CRESCENT CITY 1 N	4146	12412	4	87 12	1	2					99 99
503	041715-2	CHICO EXPERIMENT STN	3942	12149	19	31 1	U	U	U		U		51 4
504	041715-2	CHICO EXPERIMENT STN	3942	12147	21	51 4	7	4			2		
505	041715-2	CHICO EXPERIMENT STN	3942	12149	19	74 2	U	U	U		U		86 6
506	041715-2	CHICO EXPERIMENT STN	3942	12149	19	86 6	1	2			5	7	99 99
845	042910-1	EUREKA WSO CITY	4048	12410	8	31 1	U	U	U				82 1
846	042910-1	EUREKA WSO CITY	4048	12410	6	82 1	U	U	U				88 9
847	042910-1	EUREKA WSO CITY	4048	12410	6	88 9	1	2	U				99 99
928	043157-3	FORT BIDWELL	4151	12008	450	31 1	U	U					86 5
929	043157-3	FORT BIDWELL	4151	12008	450	86 5	1	2					99 99
970	043257-5	FRESNO WB AIRPORT	3644	11949	28	31 1	4	9			7		
971	043257-5	FRESNO WB ARPT	3647	11942	34	49 8	U	U	U		U		60 12
972	043257-5	FRESNO WB ARPT	3646	11943	33	61 1	U	U	U		U		81 3
973	043257-5	FRESNO WB ARPT	3646	11943	33	81 3	U	U	U				81 5
974	043257-5	FRESNO WSO AP	3646	11943	33	81 5	U	U	U				85 2
975	043257-5	FRESNO WSO AP	3647	11943	34	85 2	1	U	U				99 99
1160	043875-1	HEALDSBURG	3837	12252	10	31 1	U	U					48 6
1161	043875-1	HEALDSBURG	3837	12250	10	48 7	U	U					62 5
1162	043875-1	HEALDSBURG	3837	12252	10	62 5	U	U					99 99
1271	044278-7	INYOKERN FIRE STATION	3539	11749	244	48 7	U	U					87 3
1272	044278-7	INYOKERN	3539	11749	244	87 3	1	U					99 99
1332	044520-5	KERN RIVER PH 1	3528	11847	97	31 1	U	U					99 99
1540	045114-6	LOS ANGELES WSO ARPT	3356	11823	12	44 8	U	U	U				46 12
1541	045114-6	LOS ANGELES WSO ARPT	3356	11823	12	47 1	U	U	U				67 12
1542	045114-6	LOS ANGELES WSO ARPT	3356	11824	10	68 5	U	U	U				99 99
1543	045115-6	LOS ANGELES WB CITY	3403	11815	36	31 1	U	U	U				39 12
1544	045115-6	LOS ANGELES WB CITY	3403	11814	31	40 1	U	U	U				64 7
1545	045115-6	LOS ANGELES CIVIC CENTER	3403	11814	27	64 7	1	2			6		99 99
1763	045795-4	MONTEREY	3636	12155	26	49 1	U	U					51 5
1764	045795-4	MONTEREY	3636	12154	27	51 5	U	U					57 2
1765	045795-4	MONTEREY	3636	12154	34	57 2	U	U					63 9
1766	045795-4	MONTEREY	3636	12154	39	63 9	U	U					82 1
1767	045795-4	MONTEREY	3636	12154	38	82 1	U	U					85 3
1768	045795-4	MONTEREY	3636	12154	38	85 3	1	U					88 4
1769	045795-4	MONTEREY	3636	12154	38	88 4	1	2					99 99
1884	046118-7	NEEDLES FAA AIRPORT	3446	11437	89	40 3							41 12
1885	046118-7	NEEDLES FAA AIRPORT	3446	11437	92	42 1							78 7
1886	046118-7	NEEDLES FAA AIRPORT	3446	11437	91	78 7							83 1
1887	046118-7	NEEDLES FAA AIRPORT	3446	11437	91	83 1	1	2					99 99
1891	046136-2	NEVADA CITY	3916	12102	260	31 1	U	U					48 6
1892	046136-2	NEVADA CITY	3916	12102	252	48 7	U	U					50 10
1893	046136-2	NEVADA CITY	3916	12101	252	50 10	U	U					76 8
1894	046136-2	NEVADA CITY	3915	12102	260	76 8	U	U					85 4
1895	046136-2	NEVADA CITY	3915	12101	278	85 4	U	U					99 99
1971	046377-6	OCEANSIDE, CAMP PENDLETON	3313	11724	6	53 1	U	U					62 8
1972	046377-6	OCEANSIDE	3312	11723	8	62 8	U	U					77 4
1973	046377-6	OCEANSIDE MARINA	3313	11724	1	77 4	1	2					99 99

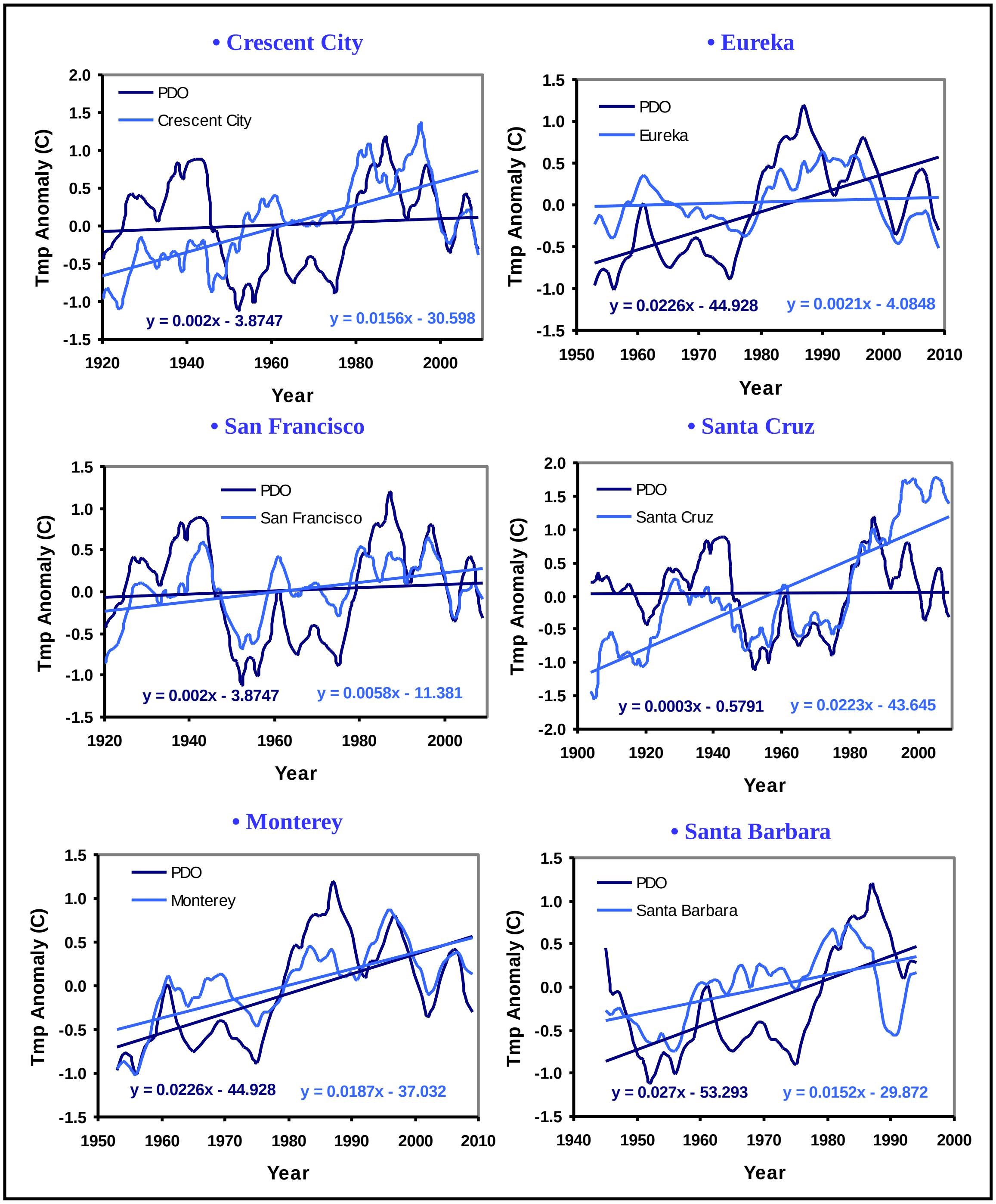


Figure A-1: Station and PDO data plots, 5 year averages and linear fits. Coastal stations are plotted in blue, rural stations in green, urban stations in magenta and anomalous stations in red. The anomalies are circled on the plots.

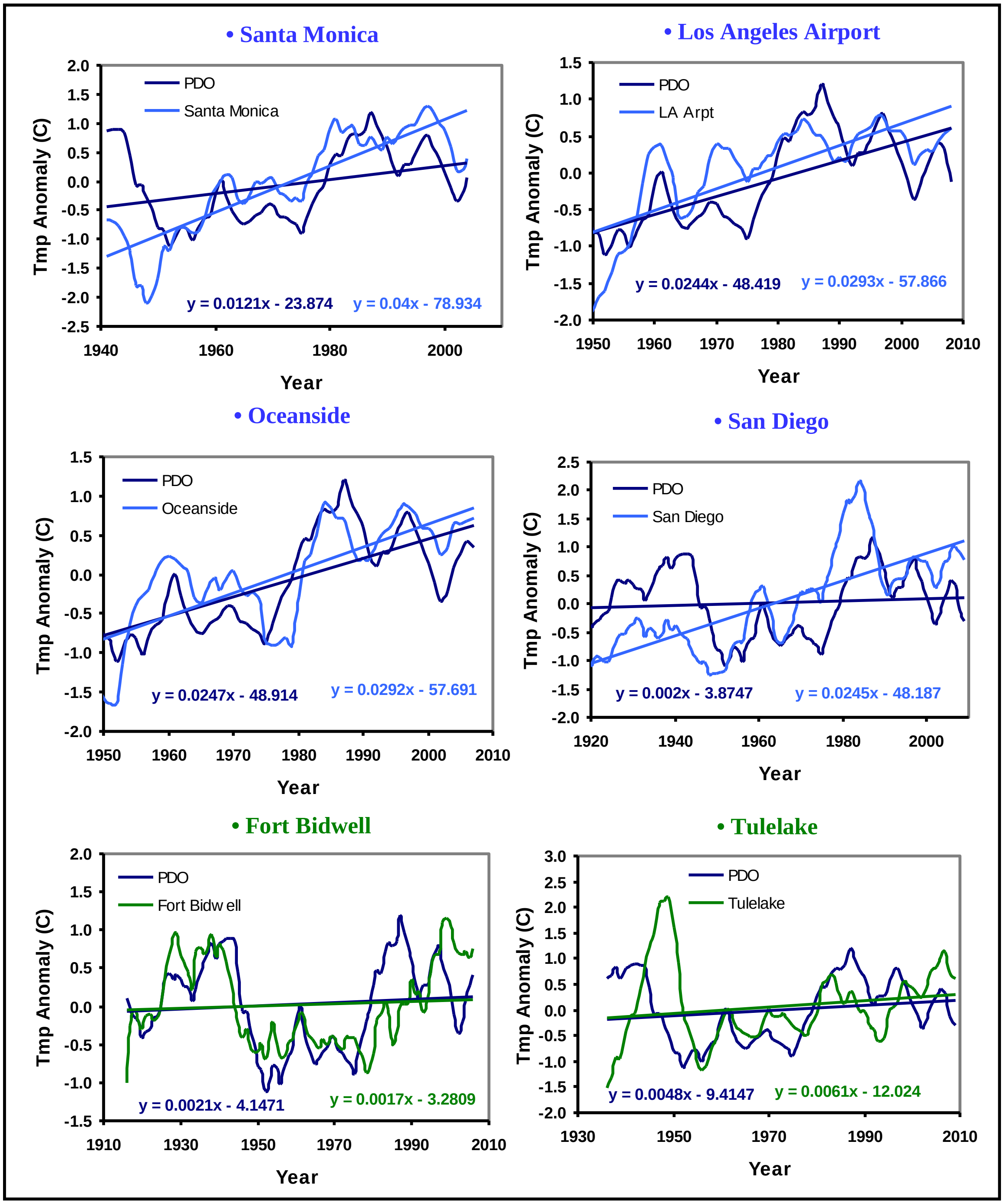


Figure A-1/Continued.

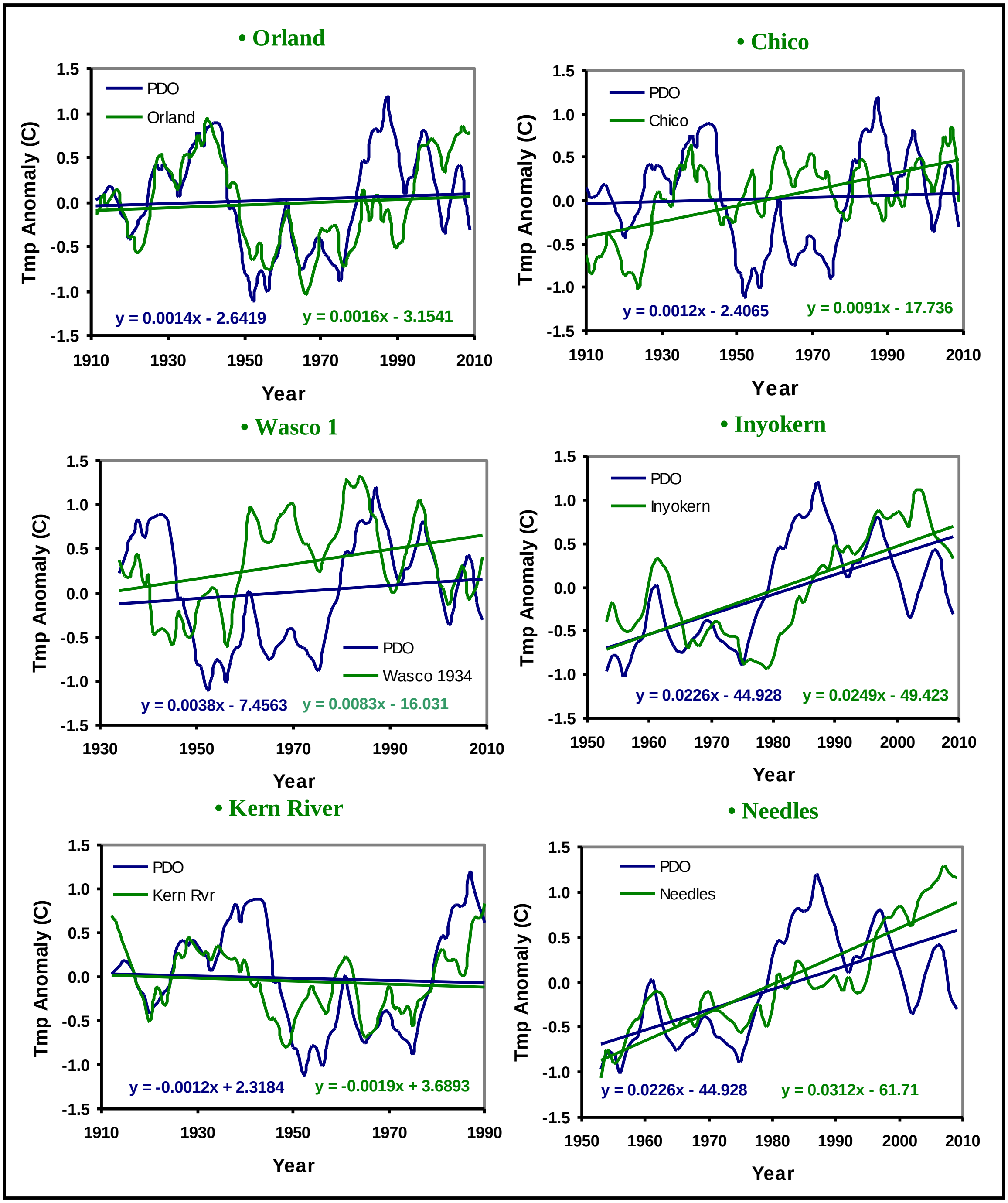


Figure A-1/Continued.

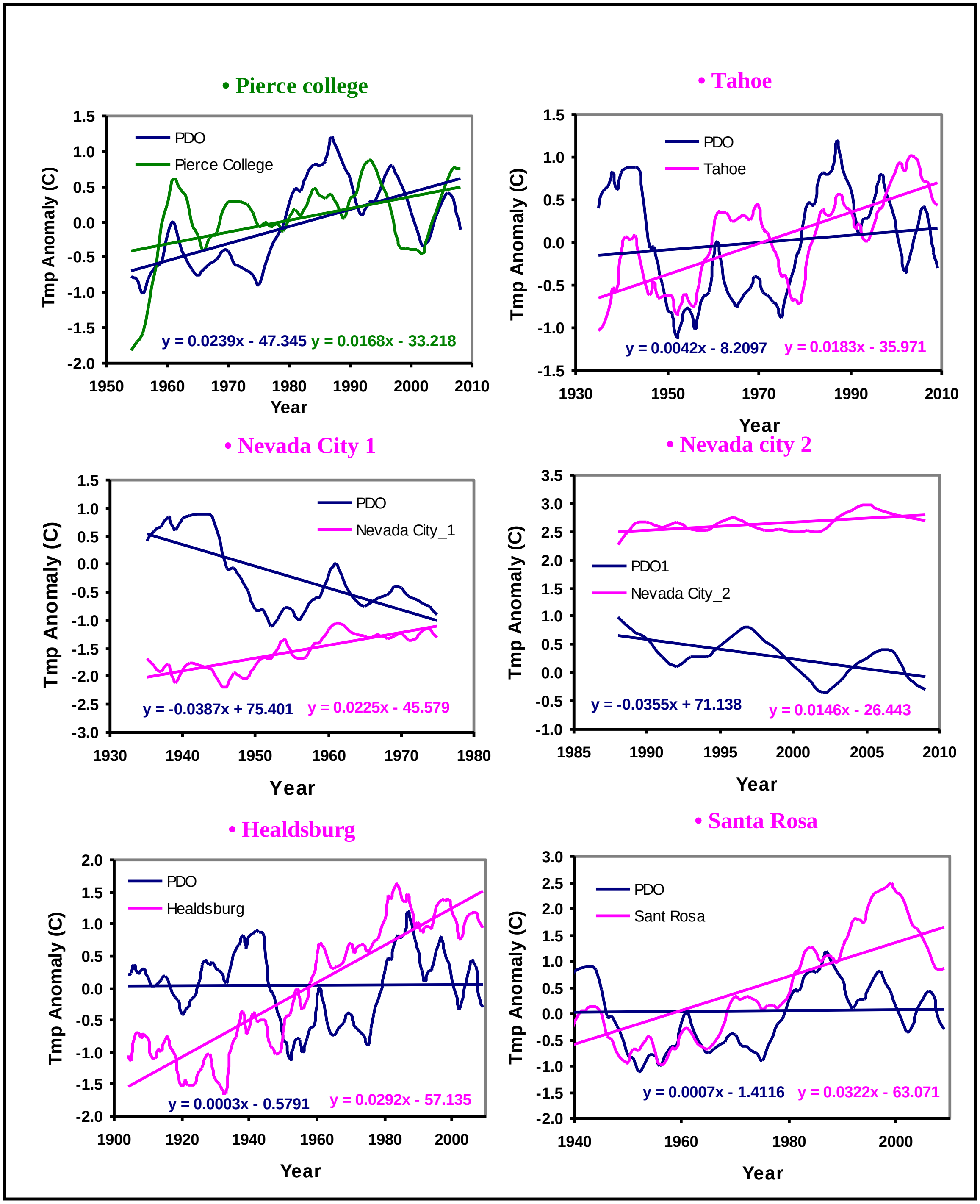


Figure A-1/Continued.

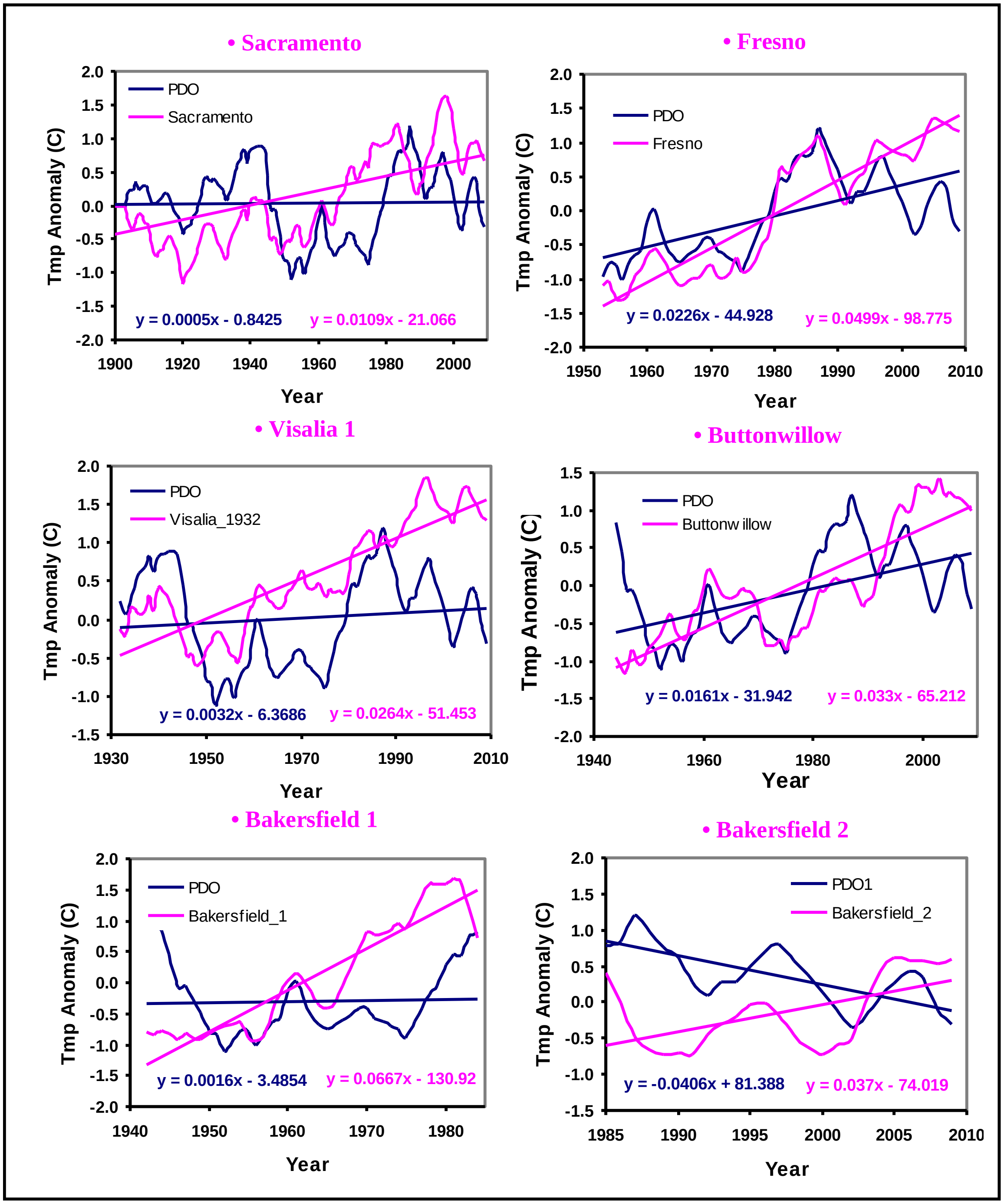


Figure A-1/Continued.

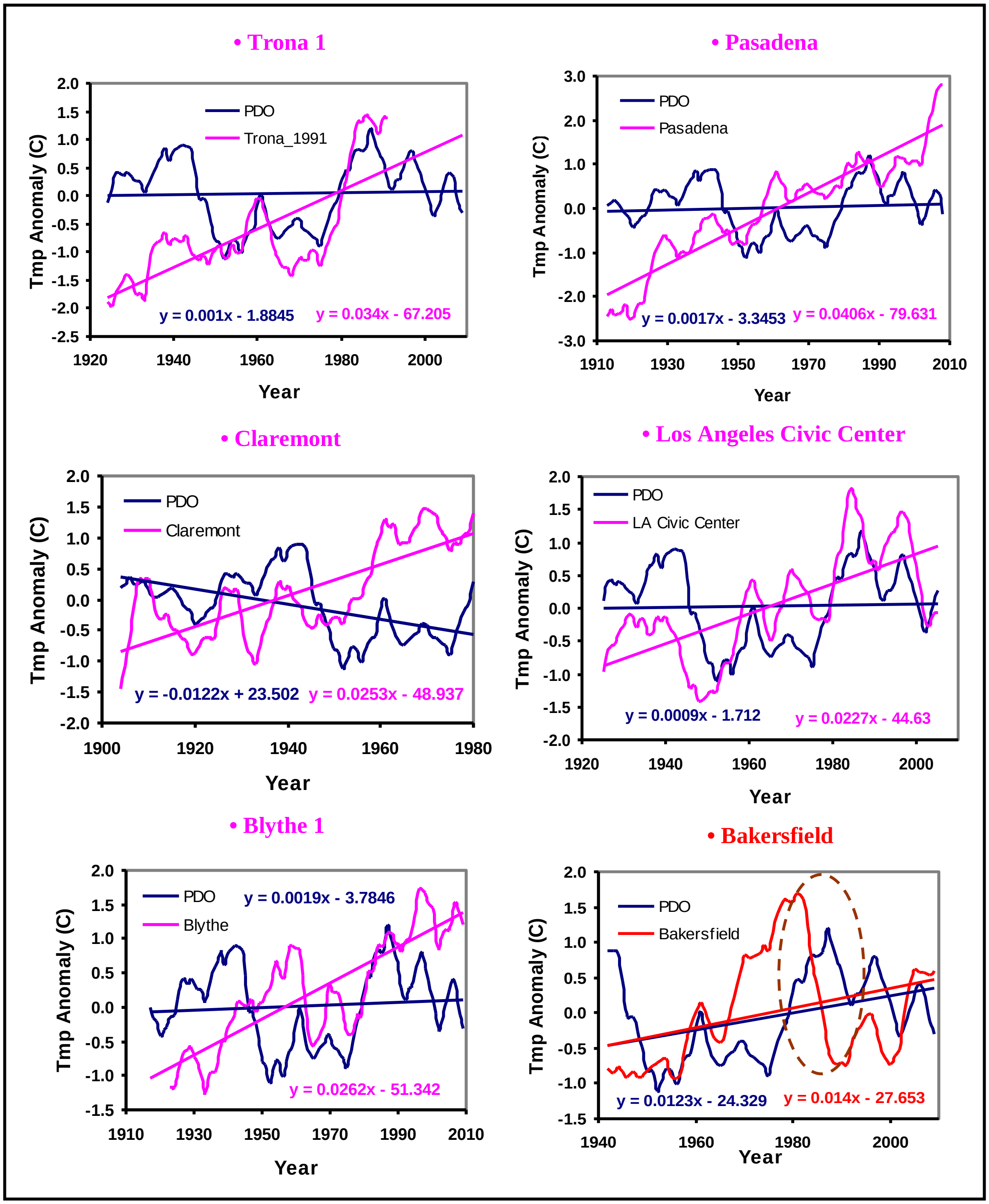


Figure A-1/Continued.

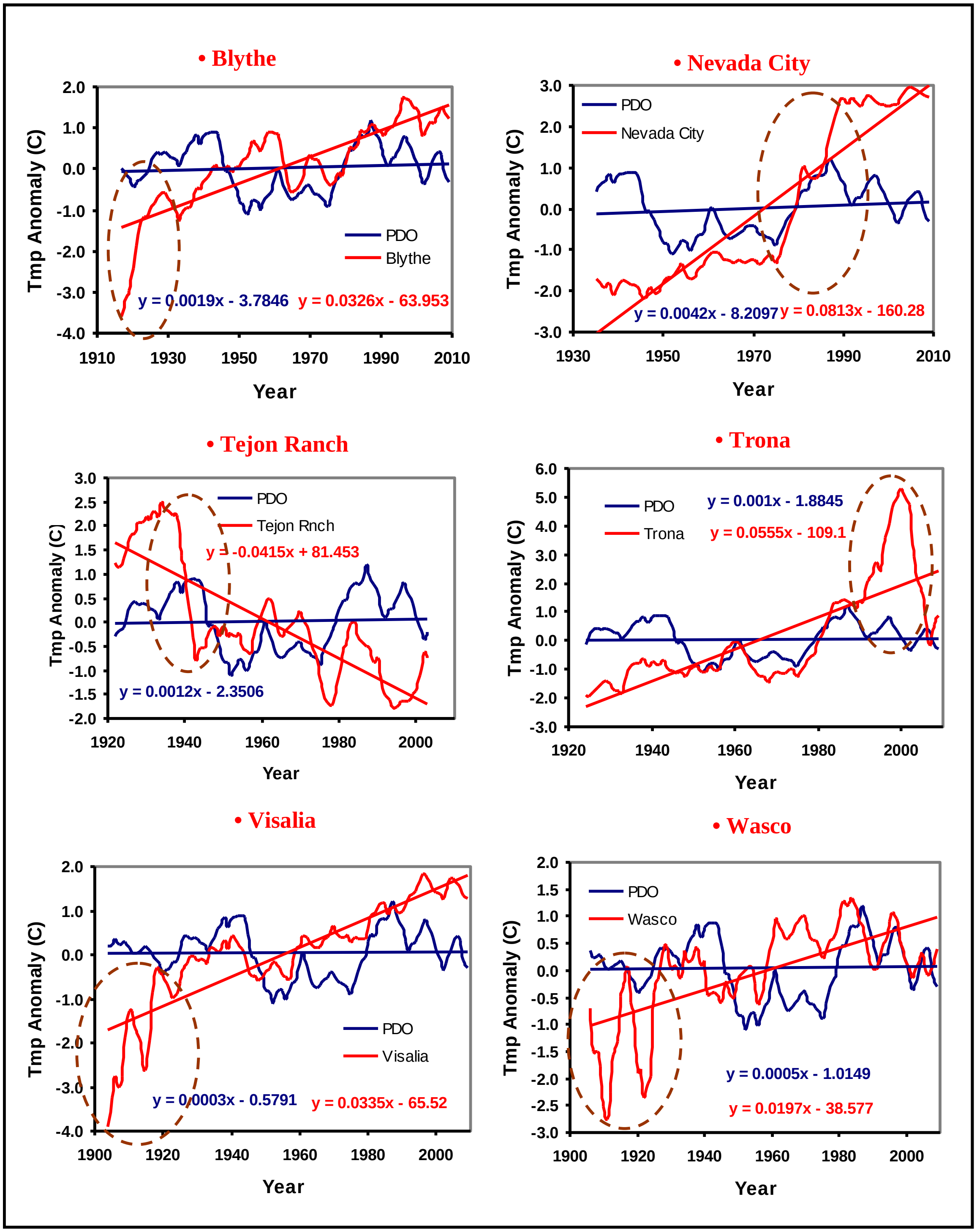


Figure A-1/Continued.