Persistence in California Weather Patterns

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July 28, 2007

Summary

The evidence for a major climate shift since the mid 1970s is quite real. California indices of rainfall and temperature have both shown an increasing trend since 1975.

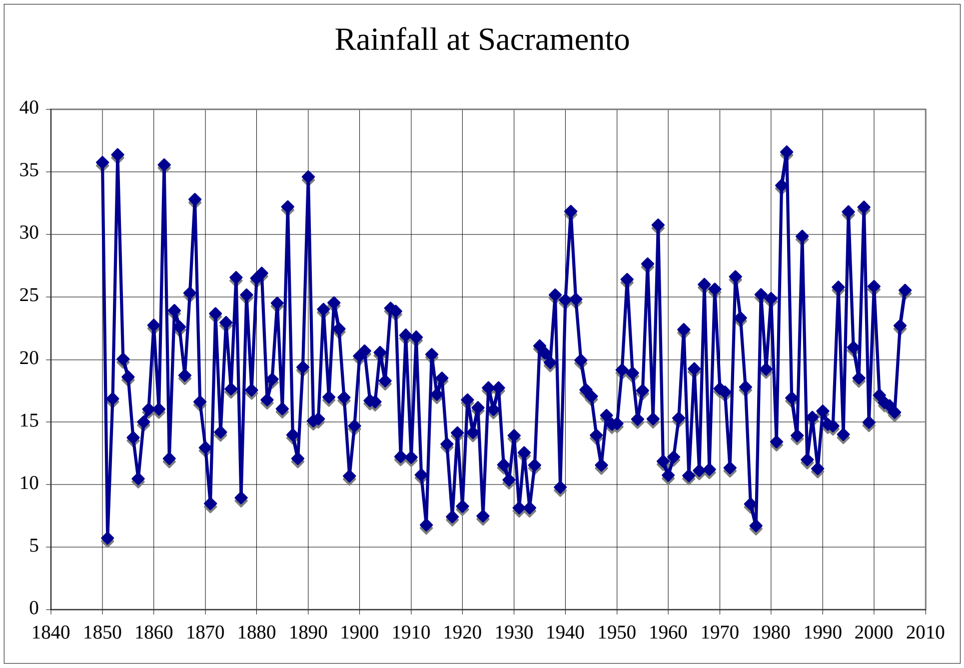
Physical changes in Earth weather systems that accompany the 1975 weather trend changes include the Pacific Decadal Oscillation (PDO) index, a 1975 change in the Atmospheric Angular Momentum (AAM) index and a 1940 increase in solar irradiance.

The PDO index is a measure of the East West sea surface temperature difference in the North Pacific Ocean. The AAM index is a measure of the ratio of East West vs. North-South winds on the planet that affect the earth rotation rate.

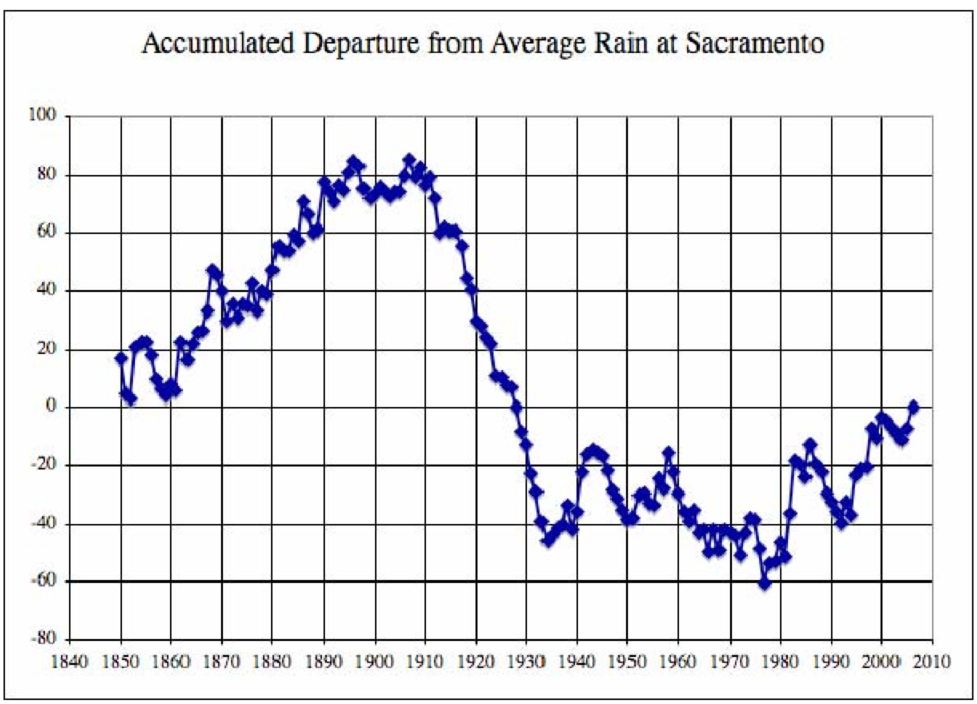
Solar irradiance has been monitored from satellites for three sunspot cycles. The sunspot numbers and solar irradiance were shown to be highly correlated. Since sunspot numbers have been increasing since 1940 the irradiance must also be increasing.

The several occurrences of 100-year storms on the American River in the last 50 years are suggestive of climate fluctuation. The search for a rhythm of the records is the object of this essay.

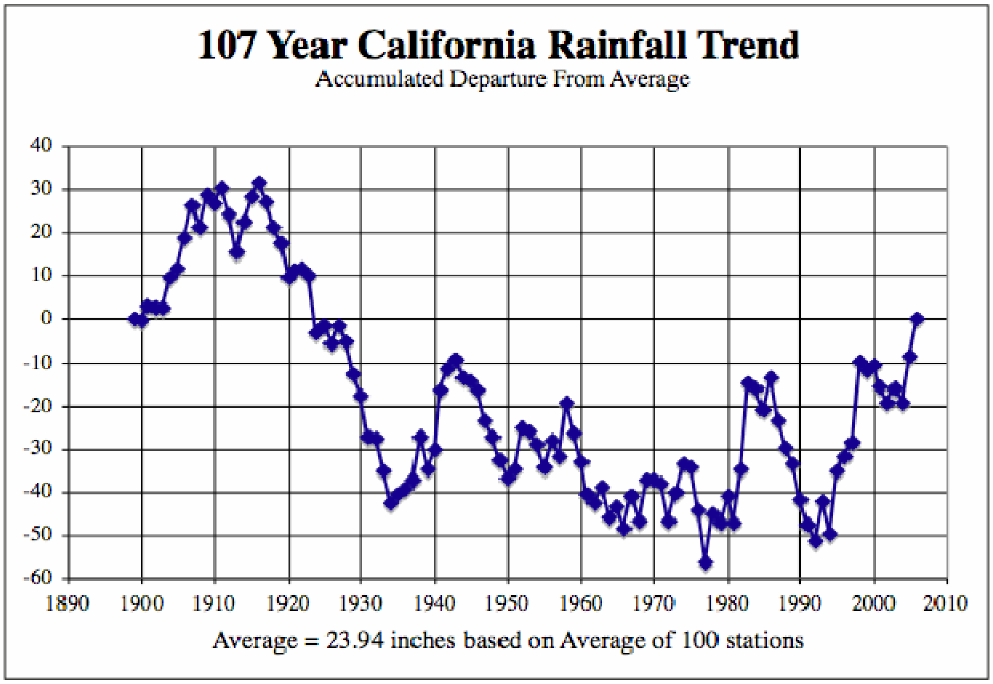
The rainfall record at Sacramento is used to illustrate how a clear view of trend can be obscured by a large number of data points. Rainfall has been measured at Sacramento since 1849. The measurements were originally compiled for the Smithsonian Institution. They were continued by the Army Signal Service and continue to this day with the National Weather Service (NWS). The records used here are tabulated as water year (October to September) totals. These records are used without any adjustment for possible changes due to the many station moves or other factors like changes of gage orifice height above ground surface.

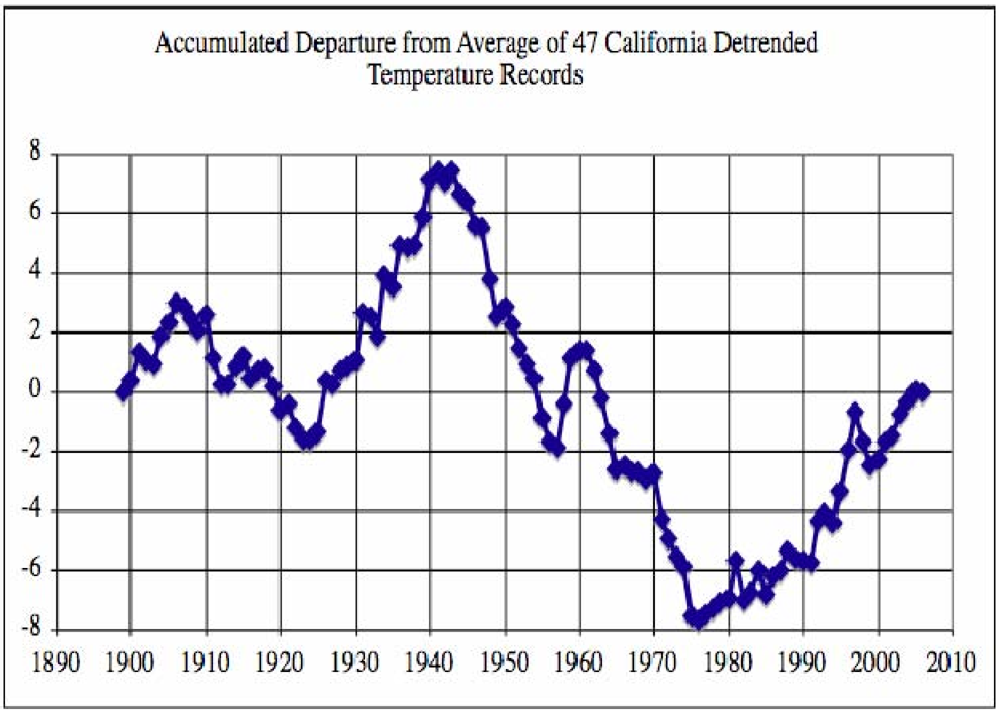


The long-term rainfall trends were clearly apparent when plotted as accumulated departure from average. The Sacramento rain record consists of a relatively wet period from 1850 to 1910 and a dry period from 1910 to 1936. These are not readily visible in annual data plot. An increase in rainfall trend followed the sever drought of 1977. This is quite apparent in the accumulated departure from average plot.

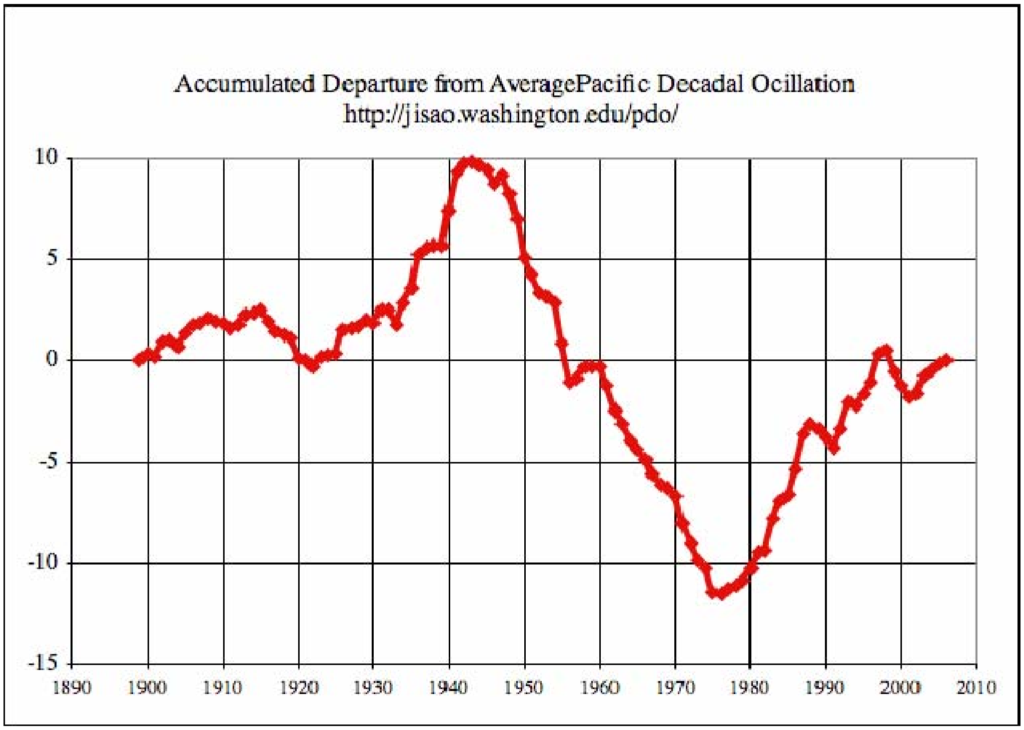


A temperature index was prepared for California by averaging all of the 47 station NWS records with complete data for the 1900 to 2006 period. These records were not examined for in - homogerities. The major factor in air temperature variation in coastal California is the influence of SST. Another factor is urban waste heat.





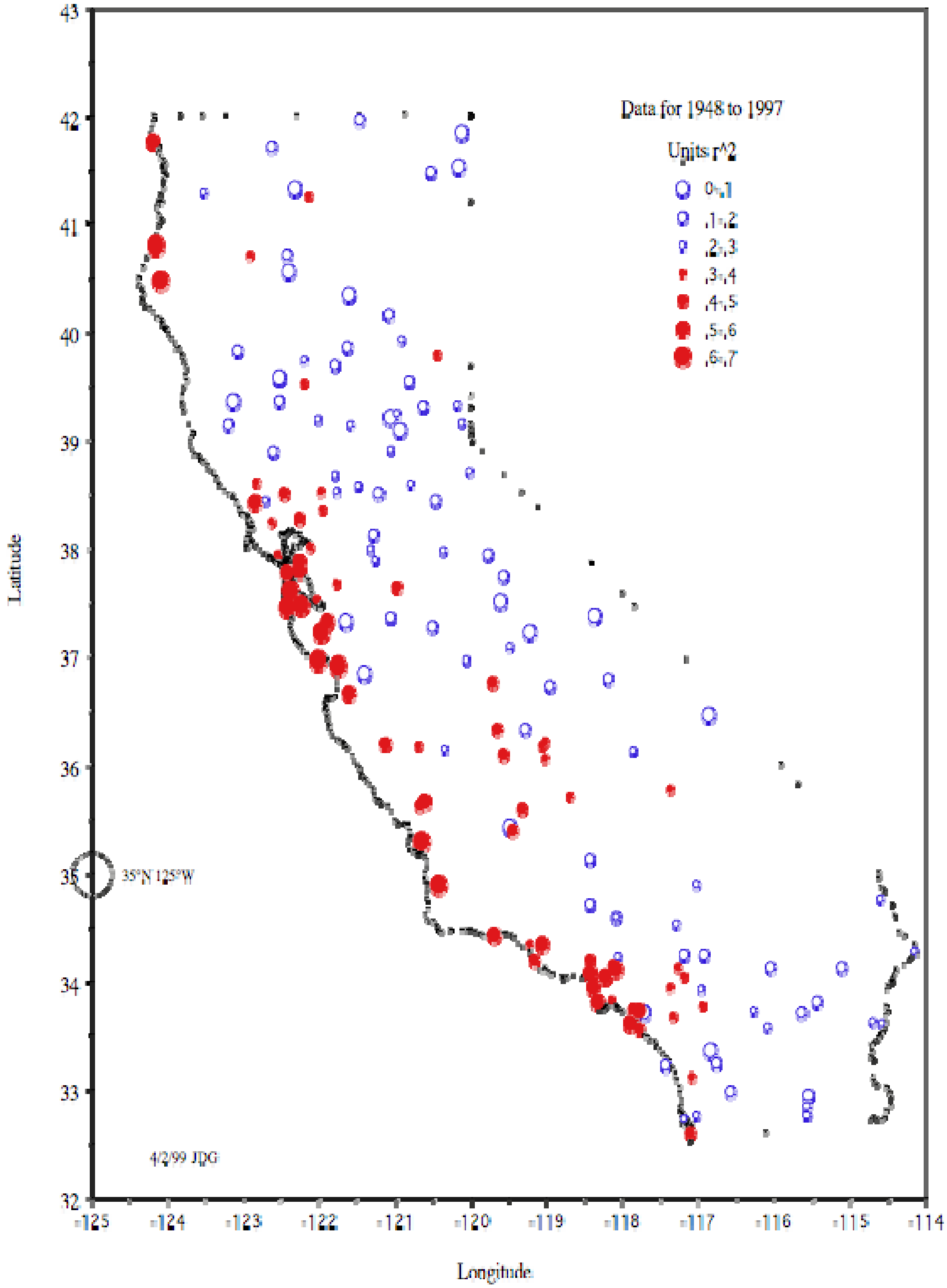
One of the key climate variation indicators for California is the Pacific Decadal Oscillation Index (PDO). This is calculated monthly at the University of Washington. Their web site is http://jisao.washington.edu/pdo/ . This indexes the East-West sea surface temperature (SST) difference in the North Pacific Ocean, North of 20° North latitude. The PDO index started in 1900 with SST measurements compiled from ship reports. It was more carefully calculated during the cold war era when accurate SST measurements were used to monitor the location of under sea vessels (submarines). Modern SST measurements are still based on ship reports but are now supplemented with satellite measurements.



The accumulated departure from average plot of the PDO index has a peak in about 1944 as well as during the current period of heating starting in 1975. The rising limb of this PDO index represents a warming period of SST on the West Coast coast, where as a declining trend represents a time of cooling. In general, cooling on the US Pacific Coast occurs when coastal North winds induce offshore coriolis force that result in off shore winds that lower tides that induce cold-water upwelling. This reflects the delicate hydrostatic balance of the oceans. Warming SST is associated with South winds that induce an onshore coriolis force with higher tides, which suppress cold-water upwelling.

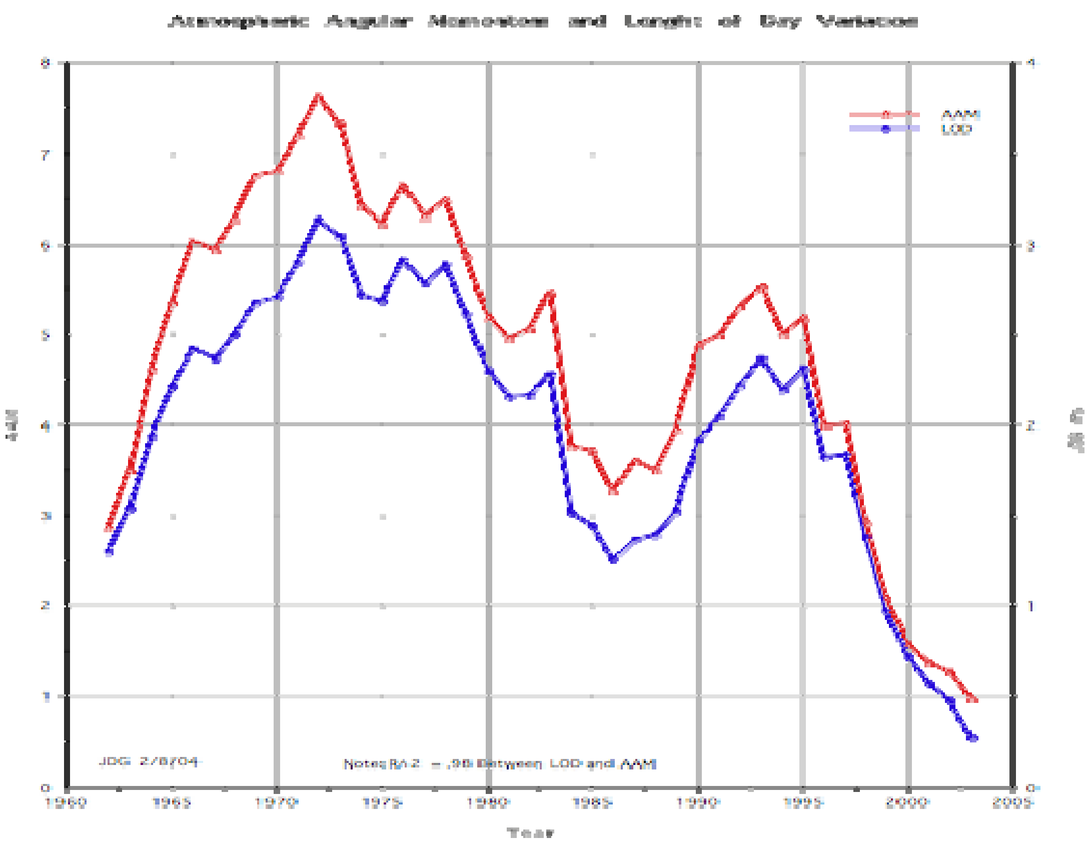
The average annual air temperature at California stations for 1948 to 1997 was plotted against the average annual SST at 35°N, 125°W. It was found to correlate with well (r^2 over 0.7) with SST at coastal stations. This indicates that up to 70 percent of annual average air temperature variation is similar to the average annual variation in SST at 35°N, 125°W. This ocean station was selected because of a great coherence the SST of ocean stations in the North-South California Current. The air temperature index was de-trended (by 2°F per century). This was to remove the urban affect so plots of the air temperature index and PDO index could be compared. Both plots show peaks in about 1944 and low values at the time of the major climate reversal of 1975.

California Air Temperature Vs. Sea Surface Temperature at 35°N 125°W

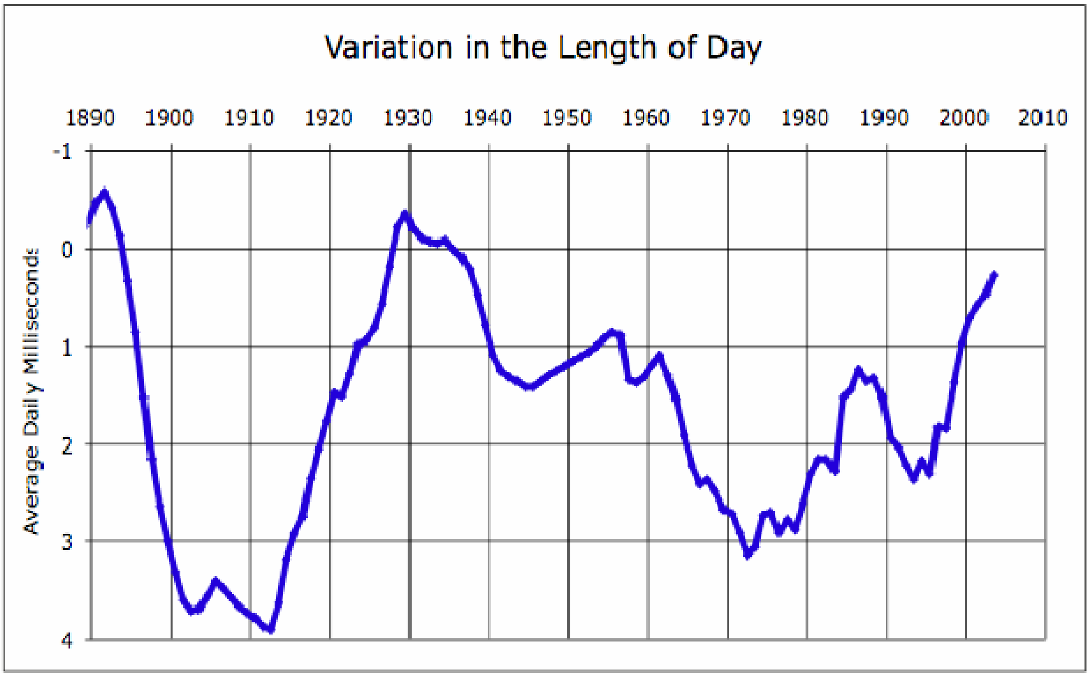


A rainfall index for California was compiled by averaging 100 rainfall records that were complete for the period from 1900 to 2006. This period was chosen to correspond with the period of the PDO index. The early part of the rain index doesn't correspond closely with the PDO index, but the PDO index peak of 1944 is clearly noticeable in the rainfall index. A low point in the PDO index seems to have preceded the major drought of 1976 and 1977. Most of these records were from the National Weather Service. Some were from other water Agencies such as the City of San Francisco or the Marin Municipal Water District. None of these records were checked for homogeneity

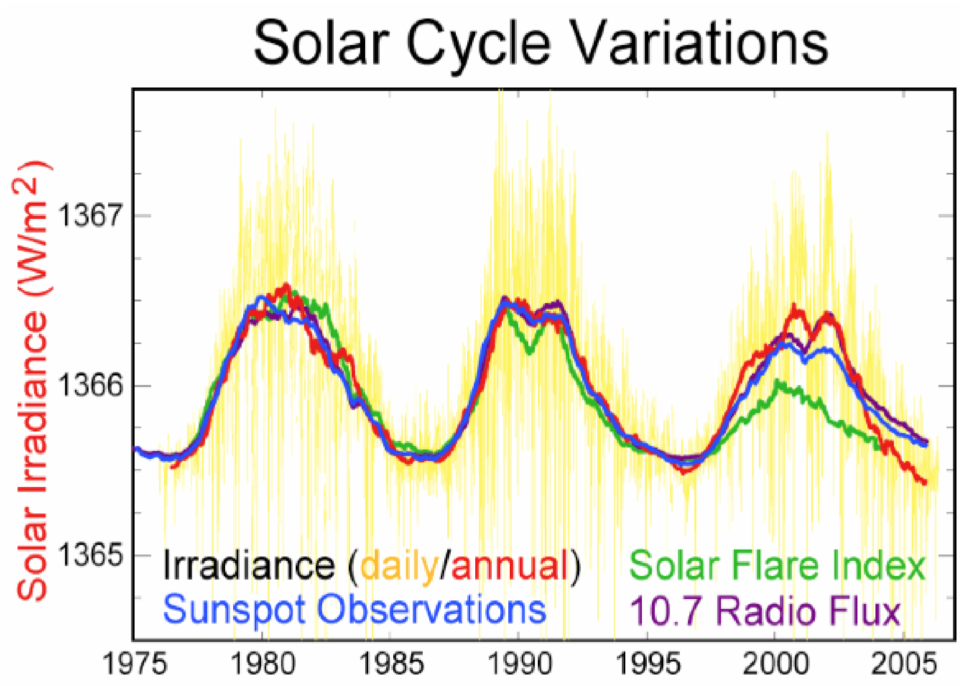
The Atmospheric Angular Momentum index (AAM) is a factor used in numeric weather forecasting. The AAM index is a measure of the ratio of East West vs. North South winds on the planet. The AAM index accounts for about 98 percent of the variation in Earth's length of day variation (LOD) (measured in milliseconds per day). LOD variation is measured daily by the Naval Observatory and has been monitored since 1640 at England's Greenwich Observatory. The annual average of the daily length of day is shorter after 1975. This reflects a greater North-South component in the worldwide wind patterns as well as a major change in California's rain and temperature trends.

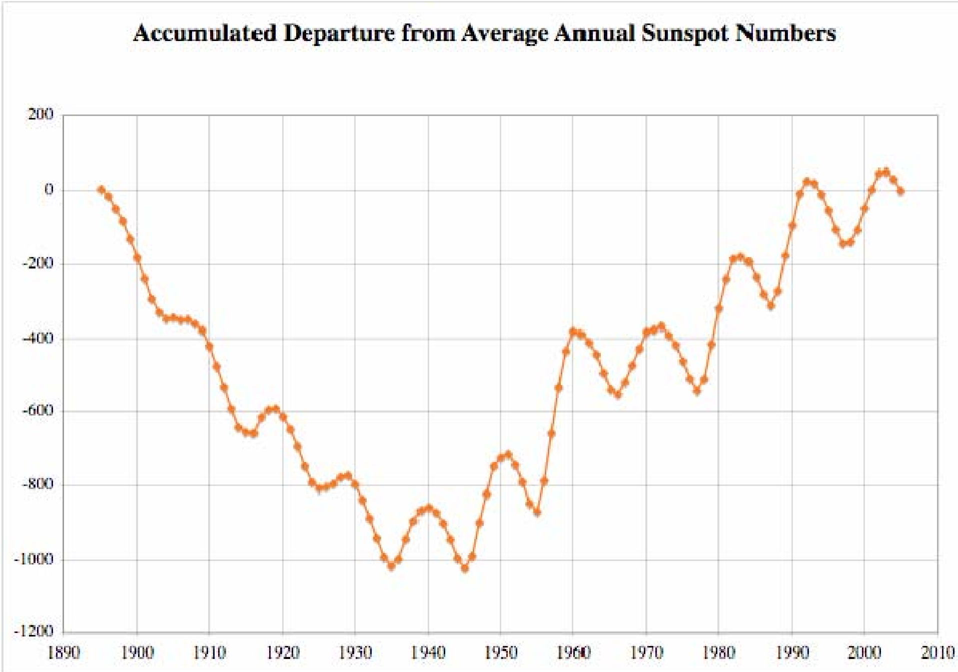


The sun was once considered to be constant in its heat output, hence the term "Solar Constant". Recent observations suggest that the sun is a variable star as are sun-sized stars. Observations of solar irradiance have been made with great precision from orbiting satellites since 1978. These observations indicate that the solar irradiance varies with the historic sunspot numbers. Using this relationship, 500 years of solar irradiance is easily inferred.



Sunspot numbers since 1900 were plotted as accumulated departure from average in order to compare them with weather variables. The rainfall, temperature, PDO and LOD indices were compared with the sunspot numbers. The sunspot number index indicates a declining trend for the 1900 to 1940 period and an increase from 1940 to 2005. The eleven-year cycle is clearly visible. An increase in irradiance since 1940 is plainly indicated.



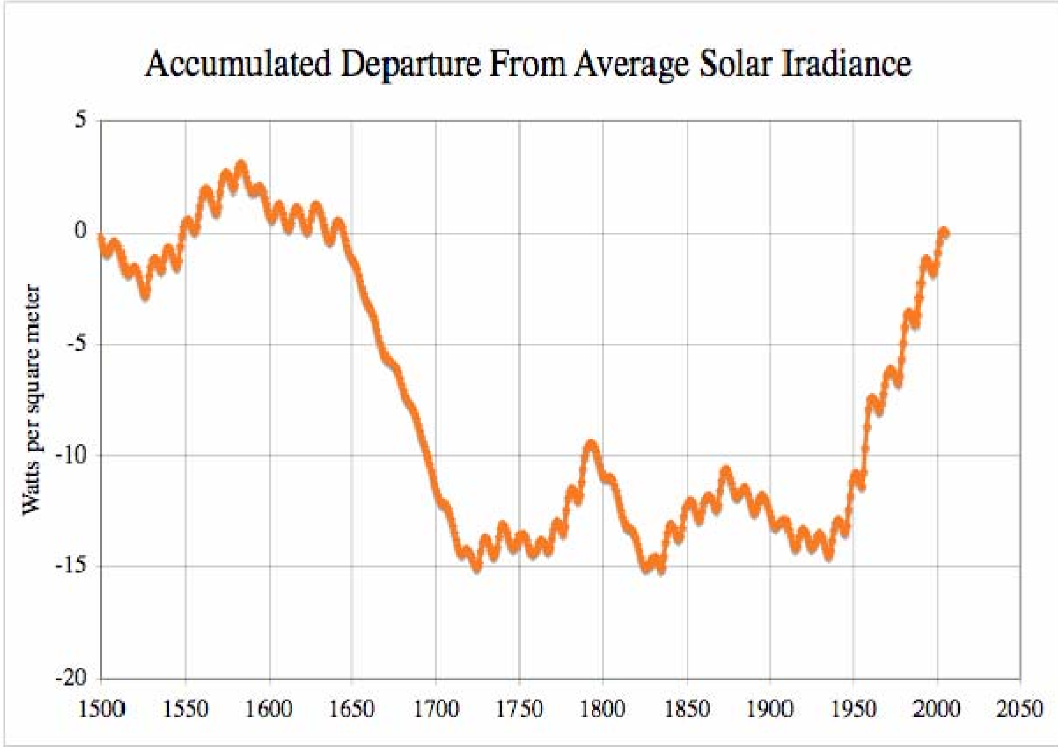


The accumulated departure from average California rainfall index indicates a declining rainfall from 1915 to 1934 and a general increase in rainfall corresponding to the major climate shift of 1975. This is suggestive of a 35-year lag time in solar influence, if that relationship is real.

A comparison of the accumulated departure from average of the California temperature and the Pacific Decadal Oscillation Index (PDO) indices indicate both peaking about 1943 and generally declining until the major climate shift of 1975. Again, this suggests a 35-year lag time in solar influence.

The variation in the length of day (LOD) index shows little similarity with the accumulated departure from average of the sunspot numbers before 1930, but the climate shift of 1975 is clearly noted, 35 years after the 1940 sunspot minimum.

Evidence for climate variation is inferred from the sunspot numbers. The "Solar Constant" sunspot relationship clearly suggests a long-range historic view of solar irradiance from 1500. The solar irradiance has been clearly increasing since 1940. The Maunder Minimum of sunspot numbers from 1660 to 1710 was clearly a time of worldwide cold temperatures. The year 1816 was known as the year without a summer. These historic cold periods are clearly visible on the accumulated departure from average graph of inferred solar irradiance derived from sunspot numbers. There have been published reports of solar influence on the surface changes of Mars resulting from increasing solar irradiance. See William K. Hartman, Traveler's Guide to Mars, Workman Publishers, 2003 page 406.



Another reference to sunspot activity is: http://www.ncdc.noaa.gov/paleo/pubs/solanki2004/
"Unusual activity of the Sun during recent decades compared to the previous 11,000 years"
Nature, Vol. 431, No. 7012, pp. 1084 - 1087, 28 October 2004.
By S.K. Solanki, I. G. Usoskin, B. Kromer, M. Schüssler, and J. Beer

The abstract of the Solanki et al paper reports the current occurrence of highest sunspot numbers of the last 11,400 years. They also point out that the "solar variability is unlikely to have been the dominant cause of the strong warming during the past three decades". The conclusion of "unlikely cause" is not in agreement with the recently established irradiance-sunspot number relationship. If a relationship of the last three sunspot cycles applies equally to the last three sunspot cycles then it must be assumed that it applies to the last 11,400 years. It would appear that whereas the direct solar irradiance may not be significant in itself the modifications to ocean and atmospheric currents might reflect some solar influence.

The preservation and protection of temperature measuring sites needs to be considered. The future of temperature measurement in urban regions is fast being modified by urban growth. Waste heat and environmental changes are underway at the present time. A question is; at what distance from a waste heat source is the temperature measurements being modified and how much? A monitoring program for temperatures in areas free of land use change and waste heat is much needed. Perhaps areas dedicated to no development like parks would be ideal monitoring sites for temperature measuring.