

# Los Angeles Weather Station's Relocation Impacts Climatic and Weather Records

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## **Abstract**

In August 1999, the official downtown Los Angeles weather station moved to the University of Southern California campus, 3.78 miles (almost 6 km) to the southwest of its previous location near the city center at the Department of Water & Power (DWP). This move resulted in a discontinuity in the weather records. A comparative study of daily temperatures and precipitation recorded at USC and DWP from 1999 to 2014 clearly shows that the move resulted in cooler, drier, and less-extreme conditions. Maximum temperatures averaged 2.4°F (1.3°C) higher at DWP, but minimum temperatures were nearly the same. Precipitation at USC for the study period averages about 0.77" (19.6 mm) less than the DWP location. Extreme record temperatures and precipitation are also less frequent at the USC site. Since the original station is still operational, DWP should remain the official LA downtown station, with USC becoming a Cooperative station, like UCLA. *Key Words:* weather station relocation, data inhomogeneity, weather records, climatic impacts.

ONE OF THE CHALLENGING ASPECTS of documenting climate change in long-term meteorological records is the integrity of the data. Often the history of a weather station includes one or several relocations and/or changes in recording instruments. Changes in location or instrumentation may create biases in the recorded data, which in turn impact interpretations and magnitude of climatic trends. Weather stations need to remain consistent, with unchanging environments, so that there are not external factors masking real climate change. Here we consider the impacts of station relocation and not of instrument changes, since the instrumentation has been consistent for the stations studied over the entire period of study.

In August 1999, the National Weather Service (NWS) moved the official downtown Los Angeles Civic Center weather station to the University of Southern California (USC) campus, or 3.78 miles (almost 6 km) to the southwest. Prior to the move, the station was located near the city center

at the Department of Water & Power (DWP). This move was not the first for the downtown weather station, but it was the largest one, and one that took it away from the built-up city center to a park-like setting on the USC campus (Figure 1). The station relocation to USC also placed it much closer to the coast, where coastal influences on local climate are considerable (Figure 2). The station elevation also changed from the original site, which is 270 ft. (almost 90 m) above MSL to the campus site at 180 ft. (almost 60 m). Since its establishment in 1877, the Los Angeles Civic Center station has been relocated seven different times, with resulting site elevation changes ranging from 4 to over 220 feet (approximately 1 to 67 m) above the ground (Bruno and Ryan 2000). Climatologists have suggested making a correction to data when a station moves substantially in the vertical (Davey and Pielke 2005; Karl and Williams 1987; Peterson 2006). Other station changes, such as a substantial horizontal movement or a shift to different land-use areas, can also alter the integrity of the climatic data significantly, so that a new station number is utilized (WMO 1996, NOAA 2014). Several studies have investigated weather station relocation issues and how to deal with discontinuities in climatic data (Alexandersson and Moberg 1997; Begert et al. 2005; Pandzic and Likso 2010; Yang et al. 2013). Most of these studies used



Figure 1.—The Civic Center station has been moved 3.8 miles (6 km) from downtown toward the coast (LAX).

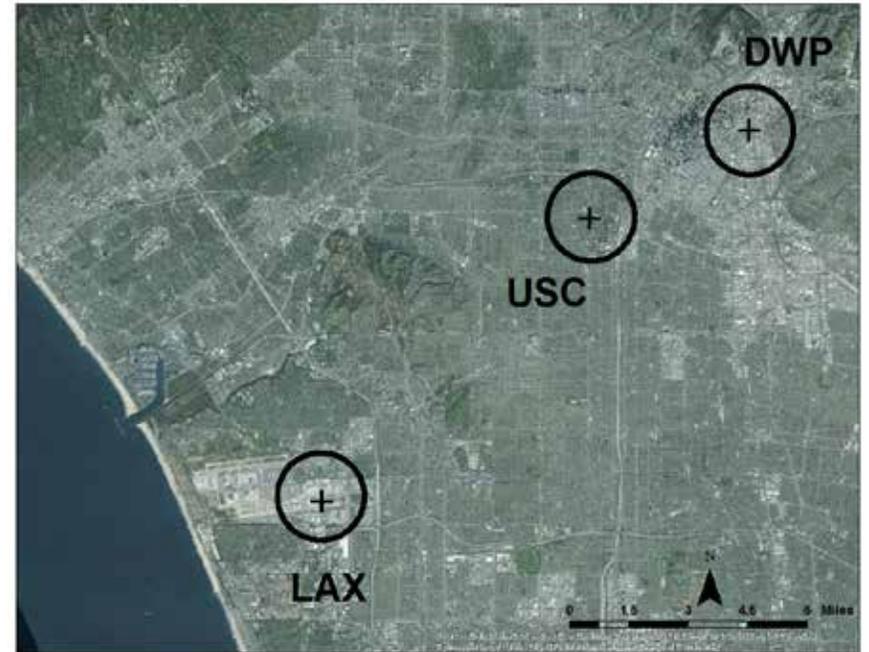


Figure 2.—The USC campus is about one-third the distance to the LAX airport.

the difference method, using differences in the means of an original station to a supplemented station, or the ratio method to adjust the supplemented station to an original station by applying an adjustment constant measured by the ratio of the sums of a variable (Thom 1971).

Aerial photos show that land-use differences exist between the two sites.

The USC site resembles a park, with tall shade trees just west of the instrument shelter (Figure 3). The shelter is also above a grassy area at a standard 4 feet above the ground. The DWP site is located on the roof of a two-story downtown parking structure, approximately 8 feet above the parking surface and 48 feet above street level, with no immediate vegetation or obstructions



Figure 3.—USC weather station is situated in a park-like setting, with tall shade trees to the west.



Figure 4.—DWP weather station is located atop a downtown parking structure.

(Figure 4). The DWP location is also closer to where one would expect the urban heat island effect to peak (Landsberg 1981).

From the station relocation seaward and to lower elevation, as well as to a different land-use area, it is not surprising that significant changes in both temperature and precipitation records have occurred.

In climatic studies, records from nearby stations can be used to test for discontinuities in the data and to determine whether the discontinuities are due to the relocation. In the present case, we are fortunate in that the DWP station is still in operation and that data collected from this site can be compared to the new site. This study builds on a previous investigation of the consequences of this station change by Patzert et al. (2007), which examined the magnitude of change in the records from 1999 to 2006. Here we combine previous data with additional data covering the period 2007–2014, to expand on earlier findings.

## Relocation Differences

If this latest station move from DWP to USC resulted in the inconsistency of data between the two stations, then a new station name and number would be appropriate. The NWS has specific guidelines, which are presented below, to judge whether station relocation calls for a new station name and number (NWS 2012).

The preferred method for determining climate data compatibility is to conduct parallel observations at the old and new sites (NWSI 2005). Climate data compatibility is maintained when the difference in daily maximum and minimum temperatures and 24-hour precipitation (including snowfall) between the original location and the new location are expected to be equal to or less than the difference in measurements that would occur by replacing the instrumentation. For example, the functional precision of the Maximum Minimum Temperature System over the vast majority of the temperature range being measured is about 1°F. Thus, if the difference between two locations is expected (or shown by parallel testing) to be equal to or less than 1°F for the daily maximum and minimum temperatures, data

compatibility for temperature between the locations is satisfied. A move is always assumed to be incompatible if the new equipment location is greater than 5 horizontal miles from the original equipment location and/or the difference in elevation is 100 feet or more. For moves less than 5 miles and/or elevation change of less than 100 feet, data compatibility still needs to be determined (NWS 2012). Here, we do a parallel comparison between the new USC location and old DWP station.

## Data and Methods

Monthly temperature data (mean, max, and min) for LA/USC for the period August 1999 through June 2014 are available from the LA NWS website at <http://www.nwsla.noaa.gov>. Monthly precipitation values examined for the same period for LA/USC are from the same website. DWP records for the same period were made available by Dan Resch, LA DWP, and are available from the corresponding author.

Monthly temperatures (mean, max, and min) and monthly precipitation values were compared between USC and DWP on a seasonal and annual basis. Monthly differences between the two stations were averaged over the 15-year record and graphed for both temperatures and precipitation. Two months of precipitation (February and March 2014) were not included in the comparisons, due to missing data at both stations. While calendar years were used in comparing temperatures, water years (July 1–June 30) were used for precipitation totals, since most rainfall occurs in the cooler months. Since there were several records for extreme temperatures and precipitation broken during this period, we also compared the two stations for these record events.

## Results

### Temperature

Table 1 shows the comparative annual Tmax and Tmin for the USC and DWP locations. For the entire period of nearly 15 years, DWP was warmer by 2.4°F (1.3°C) for the maximum, 0.2°F (about 0.1°C) cooler for the minimum, and 1.1°F (about 0.6°C) warmer for mean temperatures. For Tmax, the largest differences are from late summer to early winter (Figure 5), while the smallest differences are from February through May. For Tmin, DWP was cooler than USC in spring and summer and slightly warmer in fall and winter (Figure 6). Two possible explanations exist for these observations. The first is related to the distance from the ocean. In Southern California, the cool California ocean current keeps the coast cooler in summer and milder in winter than the

Year	Tmax			Tmin		
	DWP	USC	Diff	DWP	USC	Diff
1999	79.5	77	2.5	56.6	56.3	0.3
2000	75.8	74.3	1.5	56	55.8	0.2
2001	74.3	72.8	1.5	55.2	55.3	-0.1
2002	74.9	73.5	1.4	55.1	55.4	-0.3
2003	76.7	74.5	2.2	56.4	56.4	0
2004	76.1	74.3	1.8	56.1	56.5	-0.4
2005	75.5	73.9	1.6	56	56.2	-0.2
2006	76.5	76.3	0.2	56.4	57.2	-0.8
2007	75.7	75	0.7	56.1	56.2	-0.1
2008	77.2	76.1	1.1	56.5	56.7	-0.2
2009	77	75.5	1.5	56.1	56.9	-0.8
2010	75	74.4	0.6	54.8	57	-2.2
2011	75.5	73.1	2.4	54.1	54.7	-0.6
2012	76.3	74.8	1.5	56.6	56.2	0.4
2013	75.7	75.3	0.4	56.1	56	0.1
2014	75.3	74.8	0.5	55.5	55.7	-0.2
<b>AVERAGE</b>	<b>77.1</b>	<b>74.7</b>		<b>55.9</b>	<b>56.1</b>	
<b>DWP minus USC</b>	<b>2.4</b>			<b>-0.2</b>		

Table 1.—Average temperatures for DWP, USC, and differences for Aug. 1999–June 2014.

radiation, while the moisture from the watered lawns tends to absorb more heat than the drier, open DWP site, resulting in warmer Tmin at USC. In winter, the trees at USC provide more shading, resulting in less heating or cooling than in an open area such as DWP. Also, during spring and early summer, coastal cloudy conditions occur. The cloudiness along the coast extends inland more often during these months. Because it is closer to the coast, USC experiences more cloudiness than the inland DWP location, which in turn affects the range of temperatures at USC, with lower Tmax but higher Tmin. An example of the lessening penetration of the marine layer, with low clouds and fog, LAX averages 17 days of dense fog, while the Civic Center and Burbank airport average fewer than 2 days per year (Bruno and Ryan 2000). Overall, both land use and distance from the ocean

inland areas. In comparing the differences between USC and the coastal airport, LAX, the downtown inland site is twice warmer than LAX in summer as it is in winter (Bruno and Ryan 2000). The other explanation relates to land use. Because of the abundance of trees and grass, the park-like USC setting tends to be cooler during the day than the urbanized DWP site. At night, the trees can block outgoing

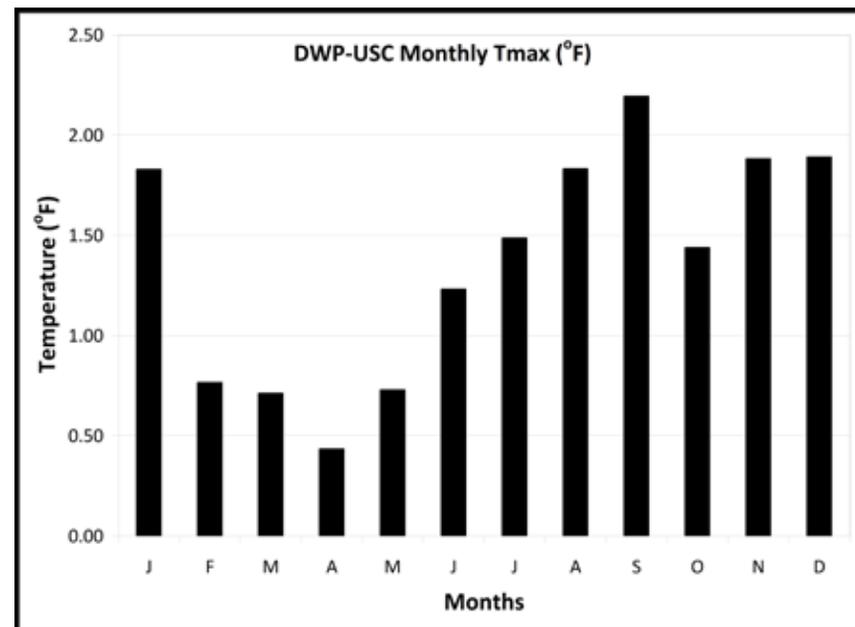


Figure 5.—Monthly Tmax differences between DWP and USC, 1999–2014.

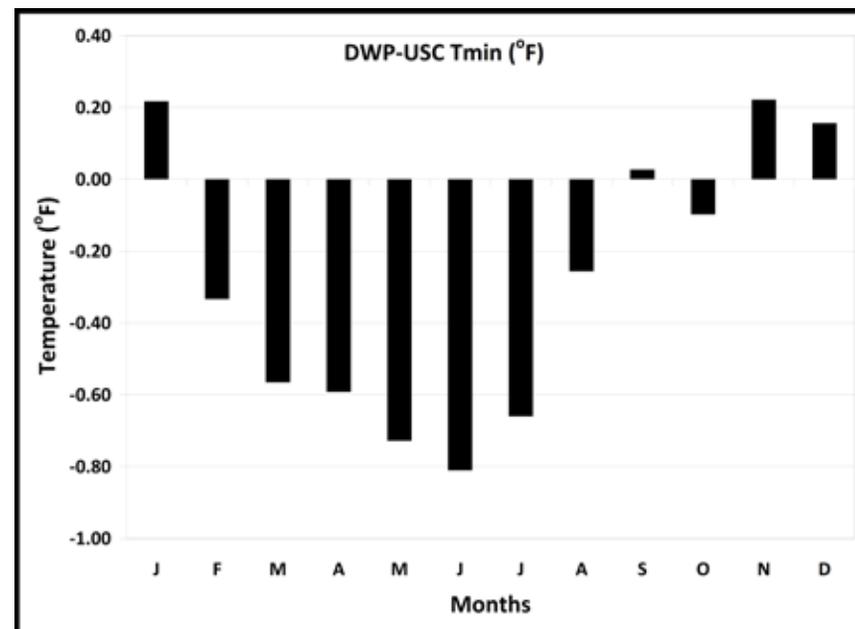


Figure 6.—Monthly Tmin differences between DWP and USC, 1999–2014.

account for the large drop in Tmax and very little change in Tmin between the two stations. At approximately 12 miles (20 km) between LA Civic Center (DWP) and LAX, the mean difference in annual temperatures is 3°F (1.7°C). The station move to USC of 3.8 mi, or nearly one-third the distance from DWP to LAX, resulted in an annual mean difference of 0.8°F (0.5°C). This mean difference in temperatures is roughly one-third of the temperature differences between DWP and LAX.

### Precipitation

Table 2 shows the annual differences in precipitation for USC and DWP. For the nearly 15 years of records analyzed, DWP averaged 0.77" (nearly 19.6 mm) more precipitation than USC. The annual differences between the two stations (DWP-USC) vary considerably, from +3.21" to -0.39" (+82 mm to -10 mm). The decreased precipitation recorded at USC is not surprising, as rainfall in the Los Angeles Basin generally increases with elevation and distance from the coast (Bruno and Ryan 2000). Rainfall comes mainly from Pacific winter storms moving inland from a westerly direction. As the air mass is lifted by coastal mountains, precipitation increases with elevation on the windward slopes. As previously mentioned, DWP is about 3.8 miles, or 6 km, further inland than USC, and more than 100 ft (30 m) higher at street level. Comparing DWP with the coastal airport station, LAX, downtown shows nearly 3" (76.2 mm) greater in annual precipitation inland than at LAX (14.77 (375.16 mm), compared to 12.01" (305.05 mm). USC, which is one-third the distance between LAX and DWP, exhibits one-third the difference in precipitation that exists between DWP and LAX.

YEAR	PRECIPITATION		
	DWP	USC	Diff
1999	12.01	11.57	0.44
2000	17.64	17.94	-0.3
2001	5.49	4.92	0.57
2002	19.71	16.49	3.22
2003	10.33	9.35	0.98
2004	<b>38.32</b>	<b>37.96</b>	0.36
2005	14.52	13.16	1.36
2006	<b>3.13</b>	<b>3.21</b>	-0.08
2007	13.42	13.53	-0.11
2008	9.32	9.08	0.24
2009	15.99	16.36	-0.37
2010	22.9	20.2	2.7
2011	9.27	8.69	0.58
2012	6.96	5.85	1.11
2013	1.19*	1.32*	-0.13*
<b>AVERAGE</b>	<b>14.22</b>	<b>13.45</b>	
<b>DWP minus USC</b>	<b>0.77</b>		

Table 2.—Average precipitation (in.) for DWP, USC and difference for the Water Years (July 1–June 30) 1999–2014. \*Feb., Mar. 2014 are excluded from calculations. *Italicized numbers represent record annual rainfall.*

Seasonally, DWP is wetter than USC in 7 out of the 12 months (Figure 7). Absolute differences are generally greater in the wettest months, October through April, while differences are least in the dry summer, which is to be expected. The low absolute differences in January and March may be a result of the high variability in southern California rainfall (Killam et al. 2014). In the rainfall year of 2004–05, the station relocation resulted in the official downtown station missing the designation of being the wettest year on record (see below).

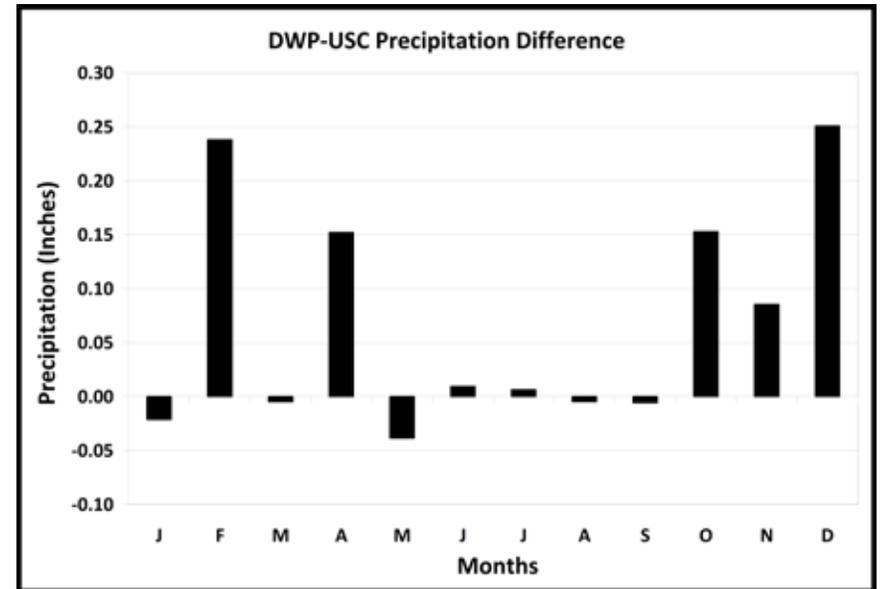


Figure 7.—Monthly differences between DWP and USC precipitation, 1999–2014. February and March data are missing for 2014 at DWP and is excluded in the comparison.

### Effect on Weather Records

In the 2004–05 water year (July 1–June 30), the USC rain total was 37.25" (946.2 mm), second only to 1883–84, which had 38.18" (969.8 mm). However, DWP recorded 38.32" (973.3 mm) for the same period, which would have made it the wettest year on record for downtown Los Angeles, had the station not moved. Conversely, two years later, in 2006–07, USC recorded 3.21" (81.5 mm) of precipitation, breaking the record for driest water year ever. However, at DWP it was even drier, at 3.12" (79.2 mm). In 2001–02, the second driest year on record was broken at USC, with 4.92" (about 125 mm) precipitation. Had the station not moved, the 2001–02 water year still would have been one of the driest years recorded at DWP, at 5.49" (139.4

mm). Similarly, the annual precipitation for the water year 2013–14 was officially 6.08" (154.4 mm) at USC, while DWP recorded 3.27" (83.1 mm); however, some DWP data were missing for days when rain did occur. By excluding the USC data corresponding to the dates of the missing DWP data, DWP was again drier than USC.

Heat waves in June and July 2006 broke several temperature records throughout the state, including several in Los Angeles. An all-time record high for a city station of 119°F (48.3°C) was set on July 22 at Pierce College, Woodland Hills. That same summer at USC, the all-time record for highest temperature minimum for the date June 4 was set, at 68°F (20°C) (the previous record being 66°F (18.9°C) in 1997). At DWP, the T<sub>min</sub> was 70°F (21.1°C) for the same date. At DWP, the highest minimum temperature would have been broken for the 3-day period of June 3–5, 2006. In July of the same year, USC temperatures broke or tied 7 all-time records, mostly for highest minima. DWP broke or tied 9 records for the same period. July 2006 was the hottest on record at both USC and DWP. USC's average temperature was 79.9°F (26.6°C), while DWP averaged 80.0°F (26.7°C), both beating the record set in 1985 at 79.2°F (26.2°C). The monthly average maximum and minimum at USC was 89.7°F (32.1°C) and 70.1°F (21.2°C), breaking the records of 88.8°F (31.6°C, 1985) and 69.6°F (20.9°C, 1984). DWP's monthly max and min were 90.3°F (32.4°C) and 69.6°F (20.9°C). The all-time highest temperatures recorded for Los Angeles (USC) was 113°F (45°C) on Sept. 27, 2010. DWP also recorded 113°F for that date.

## Conclusions

By moving the official LA downtown weather station location, weather is now recorded as cooler, drier, and less extreme than at its original DWP location. Climatologists have noted the problems concerning station moves. By shifting the official downtown Civic Center station to a park-like environment about 6 km closer to the beach, there appears to be a discontinuity in the records. Maximum and mean temperatures are cooler, especially T<sub>max</sub>. At over 2°F difference, non-compatibility is well beyond the 1°F NWS criteria. Minimum temperatures are similar for the two sites. DWP also records higher rainfall amounts, although there is great variability both monthly and inter-annually. Extremes occur less often at USC than at DWP. The USC landscape appears to make extremes less probable, and does not reflect a truly urban setting. Since the original downtown station is still operational, we suggest using DWP records as the official Los Angeles Civic Center station and making USC one of the many city Cooperative stations, such as its rival, UCLA.

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