P138 WILL THE REAL LOS ANGELES STAND UP PART 2: IMPACTS OF A WEATHER STATION'S RELOCATION ON CLIMATIC RECORDS (AND RECORD WEATHER)

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1. INTRODUCTION

In August, 1999, the National Weather Service (NWS) moved the official downtown Los Angleles 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 forf 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. (Fig 1). The station relocation also places it much closer to the coast, which influences local climate considerably (Fig 2). The station elevation also changes 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 station at the Los Angeles Civic Center has been relocated 8 different times, with resulting elevation changes ranging from 4 to over 220 feet 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 integrity of the climatic data significantly, so that s a new station number (ie. WMO, COOP) is needed.

In climatic studies, where a station's time series is investigated, station relocations may cause a discontinuity in the record. Records from nearby

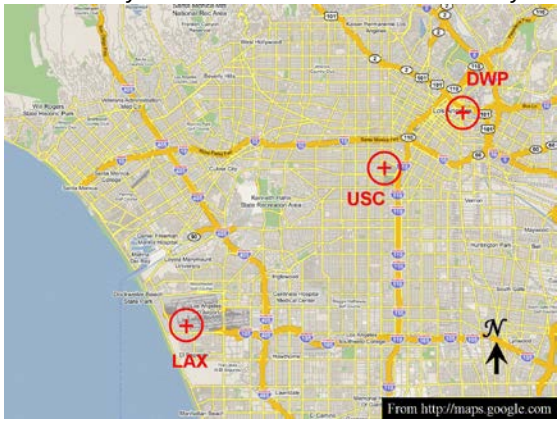

Fig. 1 The Civic Center station has been moved 3.8 miles (6 km) from downtown toward the coast (LAX)
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stations can be use to test for a discontinuity and to determne if the discontinuity is due to the relocation. In the present case, we are fortunate in that the original location (DWP) is still in operation and data collected from this sight can be compared to the new site.

Aerial photos show the land use differences between the two sites. The USC site resembles a park, with tall shade trees just west of the instrument shelter (Fig 3). The shelter is also above a grassy area. The DWP site is located on the roof of a two-story downtown parking structure, with no immediate vegetation or obstructions (Fig 4). The DWP location is also closer to where one would expect the urban heat island peak (Landsberg 1981).

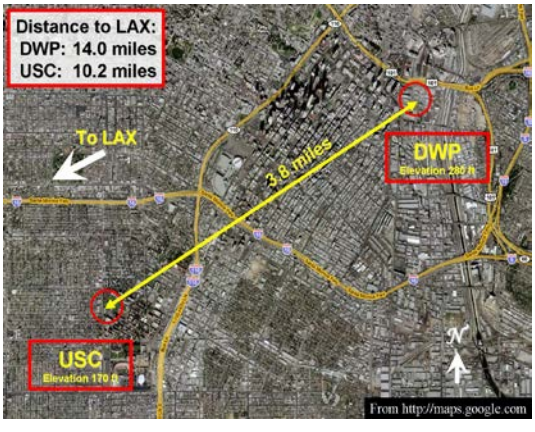

Fig 2 The USC campus is about 1/3 the distance to the LAX airport.

From the station relocation seaward and to lower elevation as well as to a different land use area, it is not surprising that a significant change to both temperature and precipitation records occurs.. This study builds on a previous investigation of the consequenses of this sation change by Patzert et al. (2007)which examined the magnitude of change in the records since 1999 to 2006, Here we present additional data covering the period 2002-2014 to .

2. 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 also from the same website. DWP records for the same period were made available by Dan Resch, LA DWPand are available from the corresponding author.

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

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

3. RESULTS

3.1 Temperature

Table 1 shows the comparative, 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) higher 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 (Fig 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, (Fig 6). Two possible explanations exist for this seasonality. The first deals with the distance from the ocean. In southern California, the cool ocean current keeps the coast cooler in summer and milder in winter than the inland areas. In comparing USC to the coastal airport, LAX, the downtown inland site is twice as warm as 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 one. At night, the trees can block outgoing radiation, while the moisture in the watered lawns tends to absorb more heat than the drier, open DWP site resulting in warmer Tmins at USC. In summer, the greater sunlight would increase the diuranal differences between the stations due to land use. In winter, the trees at USC would provide more shading due to the lower sun, 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 would experience more cloudiness than the inland DWP location which in turn affects the range of temperatures at USC, with lower Tmax, but higher Tmin. Overall, both land use and distance from the ocean 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 (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 1/3 of 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 a 1/3 of the temperature differences between DWP and LAX.

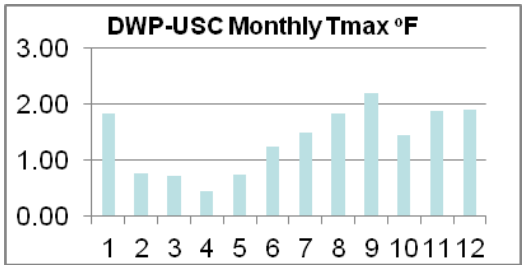

Fig 5 Monthly Tmax differences between DWP and USC, 1999-2014.

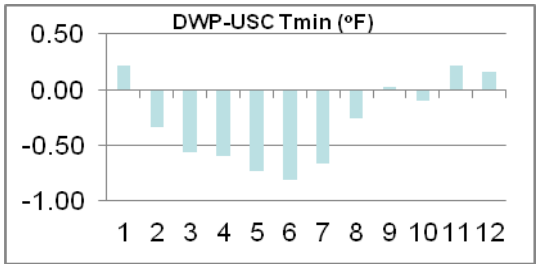

Fig 6 Monthly Tmin differences between DWP and USC, 1999-2014.

3.2 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 precipication 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 usually increases with elevation on the windward slopes. As previously mentioned, DWP is about 3.8 mi further inland than USC and over 100 ft (30 m) higher. Comparing DWP with the coastal airport station, LAX, downtown shows nearly 3" greater in annual precipitation inland than at LAX (14.77 compared to 12.01"). USC, which is 1/3 of the distance to LAX than DWP to LAX, receives a 1/3 of tthe difference in precipitation between DWPand USC.. 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).

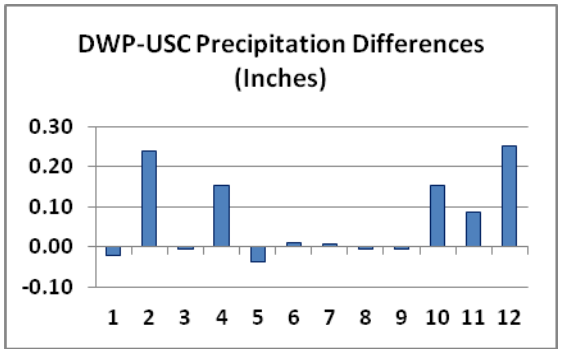

Fig 6.Monthly differences between DWP and USC precipitation, 1999-2014. Febuary and March data is missing for 2014 at DWP and is excluded in the comparison.

3.3 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 not the station moved. Conversely, in 2001-02 the second driest year on record was broken at USC, 4.91" (about 125 mm). Had the station not moved, the 2001-02 water year would have just been one of the driest recorded at DWP. 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^{o}F was set on July 22nd at Pierce College, Woodland Hills. At USC, the all-time record for highest temperature minimum for the date June 4th was set at 68^{o}F (previous record being 66^{o}F in 1997). At DWP, the Tmin was 70^{o}F for the same date. At DWP the highest minimum temperature would have been broken for the three 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^{o}F, while DWP averaged 80.0^{o}F, both beating the record set in 1985 at 79.2^{o}F. The monthly average maximum and minimum at USC was 89.7^{o}F and 70.1^{o}F, breaking the records of 88.8^{o}F (1985) and 69.6^{o}F (1984). DWP's monthly max and min were 90.3^{o}F and 69.6^{o}F. The all-time highest temperatures recorded for Los Angeles (USC) was 113^{o}F on Sept. 27th, 2010. DWP also recorded 113^{o}F for that date.

4. 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 Tmax. Minimum temperatures are similar for the two sites. DWP also records higher rainfall amounts, although there is great variability monthly and inter-annually. Extremes occur less often at USC than DWP.

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 COOP stations, such as its rival, UCLA.

Acknowledgments

The study would not have been possible without the assistance of Dan Resch, District Hydrographer, LA Metro Area, DWP, for providing DWP weather records.

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Table 1. Average temperatures for DWP, USC for Aug. 1999-June 2014

Year	Tmax		Tmin	
	DWP	USC	DWP	USC
1999	79.5	77.0	56.6	56.3
2000	75.8	74,3	56.0	55.8
2001	74.3	72.8	55.2	55.3
2002	74.9	73.5	55.1	55.4
2003	76.7	74.5	56.4	56.4
2004	*76.1*	74.3	56.1	56.5
2005	75.5	73.9	56.0	56.2
2006	*76.5*	76.3	56.4	57.2
2007	75.7	75.0	56.1	56.2
2008	77.2	76.1	56.5	56.7
2009	77.0	75.5	56.1	56.9
2010	75.0	74.4	54.8	57.0
2011	75.5	73.1	54.1	54.7
2012	76.3	74.8	56.6	56.2
2013	75.7	75.3	56.1	56.0
2014	75.3	74.8	55.5	55.7
AVERAGE	77.1	74.7	55.9	56.1
DWP *minus* USC	2.4		-0.2	

Table 2. Average Precipitation (in.) for DWP, USC for the Water Years (July1-June30) 1999-2014. *Feb, Mar. 2014 excluded due to missing data. Annual (water years) record rainfall shown in yellow boxes.

YEAR	PRECIPITATION	
	DWP	USC
1999	12.01	11.57
2000	17.64	17.94
2001	5.49	4.92
2002	19.71	16.49
2003	10.33	9.35
2004	*38.32*	*37.96*
2005	14.52	13.16
2006	*3.13*	*3.21*
2007	13.42	13.53
2008	9.32	9.08
2009	15.99	16.36
2010	22.9	20.2
2011	9.27	8.69
2012	6.96	5.85
2013	1.19*	1.32*
AVERAGE	14.22	13.45
DWP minus USC	0.77	