A Summary of Weather Station Comparisons and Weather Conditions in Lake Havasu City, Arizona between 2003 and the Summer of 2006 – Doyle C. Wilson, Water Resources Coordinator

Abstract

Lake Havasu City lays in one the warmest climates in the world, having recorded a temperature of 128^{o}F in 1994, the hottest for a city in North America. This kind of extreme temperature has been absent the past few years, which has prompted a study to compare weather station readings in the area and to compare the high temperatures over the past 3 ½ years (from 2003 to mid-2006). High temperatures and dew point temperatures from three to six weather stations, four of which were established since 2003 (see Figure 1 and Table 1), were analyzed to determine if and how the stations varied from each other and to get a sense of how hot and humid it really has been in Lake Havasu City.

A summation of the preliminary findings is given below:

- Weather station temperature trends follow each other well, setting a confidence level that the temperatures are realistic.
- Warming and cooling patterns around the summer months from year to year show either gradual or very quick changes (see Figures 2 to 6).
- Weather station average high temperatures are dictated, in part, by elevation with the warmest areas in the lower parts of the city, below 600 feet.
- There is no overriding "lake effect" that guides temperatures, although there could be some minor influence that is not yet documented.
- Only six days in the past four summers have reached 120^{o}F or higher.
- 2003, the warmest of the completed years in the study period, had four months averaging over 100^{o}F, although it looks as if 2006 will be even warmer when finished.
- The 3 ½ year average high temperature for Lake Havasu City is over 86^{o}F.
- May and June 2006 each averaged 3^{o}F+ warmer than in the same months any of the other years.
- 2006 may also have the longest high humidity period, extending from June into September.

Introduction

Citizens of Lake Havasu City have noticed that the high summer temperatures reported from the 1970's to 1990's were higher than those reported over the past few years. Some attribute the change to the move in 2001 of the City's weather station (consisting of a thermometer and rain gauge) from its former location at Fire Station #5 on Lake Havasu Blvd. to its new location closer to Lake Havasu at the Public Works Maintenance Facility (PWMF) on London Bridge Road (Figure 1). A hypothesis brought to light proposes that a closer proximity to the lake means cooler temperatures due to a "lake effect" of cooler air over the lake, which can move inland to the new site. A new, comprehensive weather station was installed at Fire Station #5 near the end of April, 2006 to provide a public service for current weather information very close to the historic location, but in an area less susceptible to re-radiation from an asphalt parking lot and cement-block walls which probably plagued the old weather station.

Installation of the new weather station prompted a comparison study of weather stations in Lake Havasu City covering a 4 year period to determine the cause of variances in daily high temperature readings from different locations within the City and variances in the weather, including dew point temperatures from year to year. Most weather stations accessible for this study in Lake Havasu City prior to 2003 either had no capability to store weather information beyond temperature and rainfall statistics or did not have sensors beyond the aforementioned parameters. The Lake Havasu Regional Airport has had a weather station for aeronautics for many years, but only has archived temperature, rainfall, and wind speed records beginning in 2002.

In 2003, a fully instrumented weather station was established at the Mohave Community College (MCC) campus off of West Acoma Blvd (Figure 1). This station which records temperature, barometric pressure, wind speed and direction, relative humidity, dew point, heat index, wind chill, UV and solar intensities, and evapo-transpiration, can be accessed on the college's web site (www.mohave.edu/pages/463.asp). In the same year, a similar weather station was installed at a residence (by Dave Eaton) on the south side of the city and began recording in 2004. Mohave County established a new weather station at the Lake Havasu City Hall site in late 2004 as part of their County Flood Alert Program (accessed at http://weather.co.mohave.az.us/perl/SensorDataDisplayOptions.pl). This station records temperature, wind speed and direction, barometric pressure, and relative humidity. Lastly, the City's newly installed station is the same model as at MCC and its current weather information can be accessed at http://project5.na.amec.com/lhweather/). The elevation of each of these stations has been recorded (Table 1). The daily high temperatures of each station, as they came on line, were compared from 2003 to August 2006 (the process is on-going). Three stations were available for the comparison in 2003, four stations in 2004, five stations in 2005, and six stations in 2006. A summary of results from these comparisons are as follows:

Table 1: Weather Station Names and Elevations above Sea Level.

Station	PWMF	Fire Station #5	MCC	Mohave Co. - City Hall	Lake Havasu Regional Airport	South Lake Havasu City
Elevation (ft)	472	503	640	730	740	1057

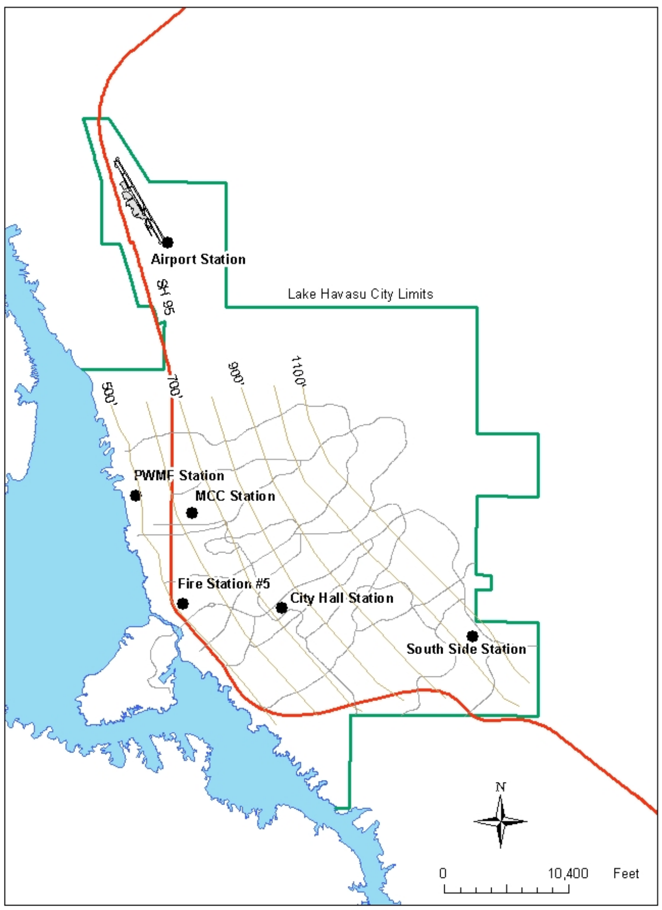

Figure 1: Weather Station locations used in this comparative study.

Station to Station Comparison Summary:

This evaluation was made in an attempt to determine any significant difference between station locations, particularly with respect to the newly established Fire Station #5 location. One of the single most sensitive meteorological parameters to location is temperature, and since many citizens in Lake Havasu City follow the daily high temperatures, particularly in the summer, daily high temperatures were used to determine whether there are significant differences between the station locations.

High temperature yearly profiles show a remarkable similarity from station to station (Figures 2-5), yet significant statistical trends suggests that station elevation could be one reason for the overall two to three degree separation range (Table 2). Although each year's set of profiles shows daily temperature variances between stations as high as 23^{o}F, due possibly to cloud cover effects in portions of town, the average deviation over each year's profile is under 3^{o}F. This difference between stations is statistically significant when the stations are lumped by elevation. The PWMF and Fire Station locations are not significantly different (from t-tests and correlation coefficients), but can, as a group be separated from the City Hall, MCC, Airport, and the south side locations. In addition, the south side location can be separated from the City Hall. MCC, and Airport group. For the period from May to July 2006, the PWMF and the Fire Station locations (lowest elevations) experienced the highest temperatures and the south side station (highest elevation) averaged the coolest temperatures. A "lake effect" may have a presence at the PWMF station during certain times of the day or night, but the daily high temperatures recorded at this station do not support an overwhelming effect.

To make sure that other weather information was not also differentiated between the station locations, the barometric pressure and relative humidity were compared. These factors tend to have a more regional effect and are not dependent on sunlight variations due to cloud cover and vary little in the short elevation range of the city. Initial statistical tests indicate no differences could be discerned from the three stations (MCC, City Hall, and south side) that had this data; however, this analysis has not been concluded. If these stations prove to show no real differences in the air pressure and humidity information, then they are relatively closely calibrated to each other and form a dependable network.

Year to Year Comparison Summary:

The daily high temperatures from all of the individual stations were averaged by month and for each year. The monthly station averages were then combined to get overall monthly averages for each year, which were in turn, averaged to get the combined yearly average for 2003, 2004, 2005, and up to July 2006. Lastly, the combined monthly and the yearly averages were combined from each year to give a 4-year average (3-year for August through December). The combined data yielded an average high temperature of 86^{o}F per year, only 4^{o}F cooler than Death Valley's yearly average of 90^{o}F. Figure 6 displays a comparison of composite average high temperatures for each year. Lake Havasu City has 4 months (June through September) whose temperatures are over 100^{o}F with July averaging the warmest at 109^{o}F.

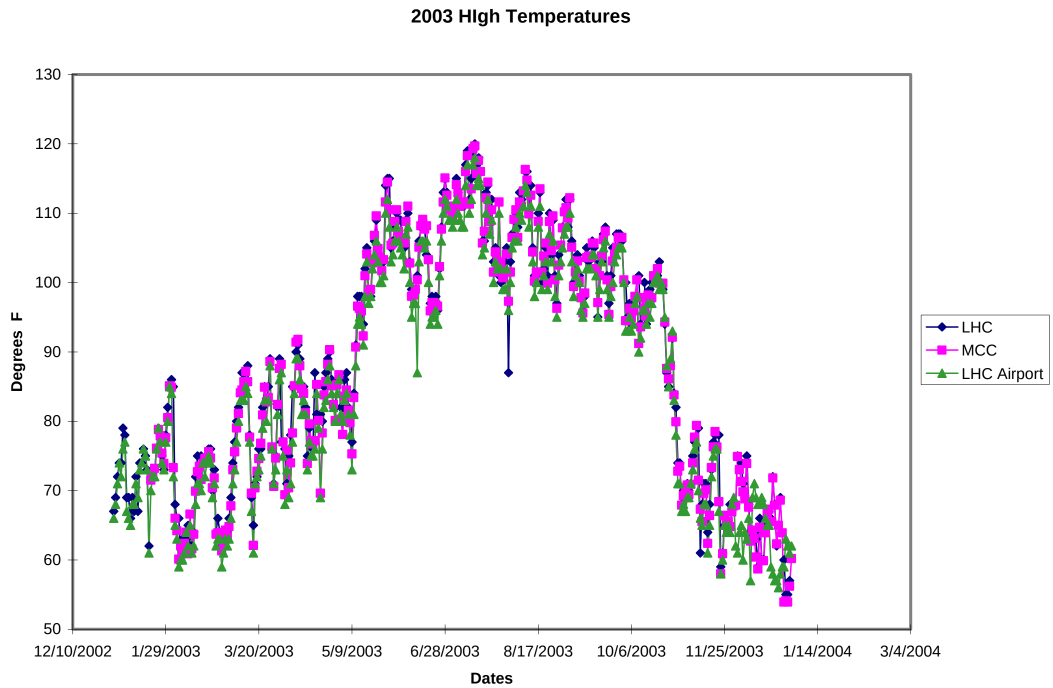

Figure 2: Year-long high temperature data comparisons for 2003.

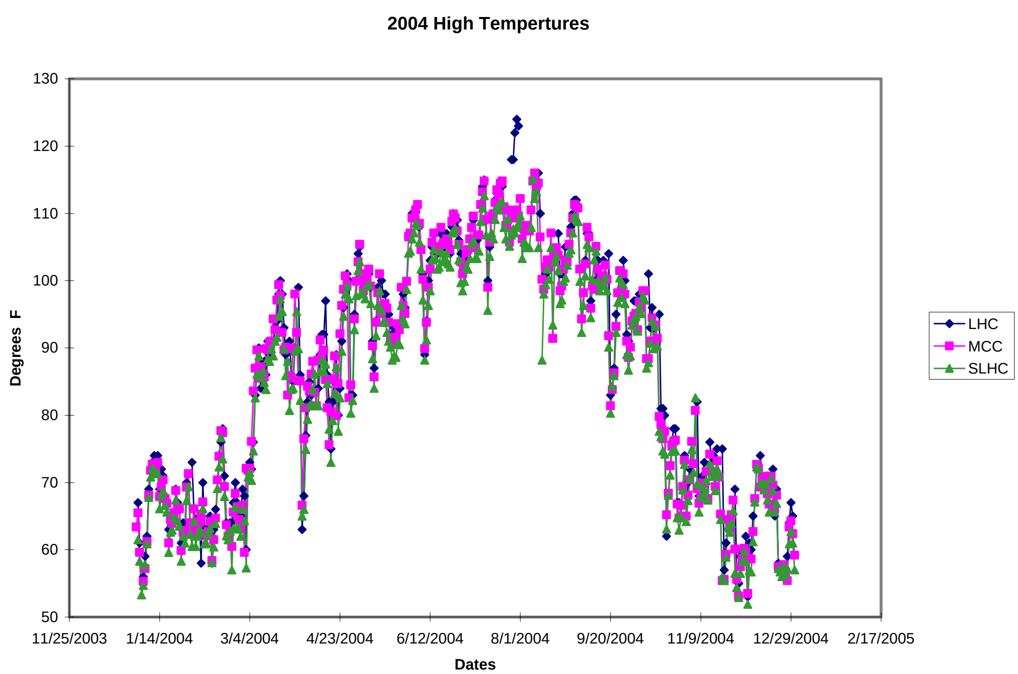

Figure 3: Year-long high temperature data comparisons for 2004.

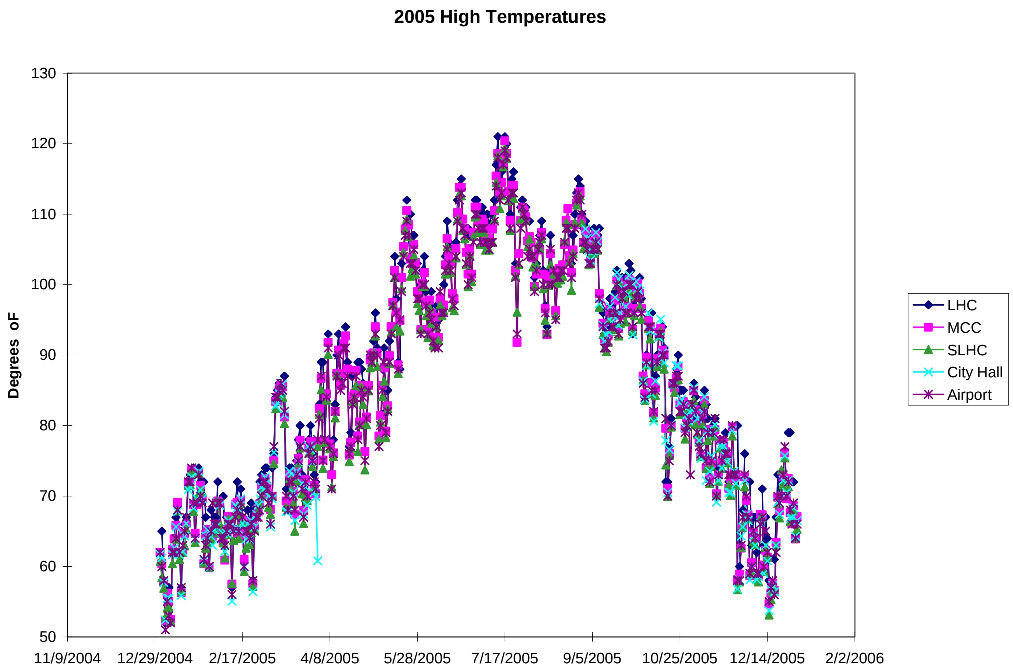

Figure 4: Year-long high temperature data comparisons for 2005.

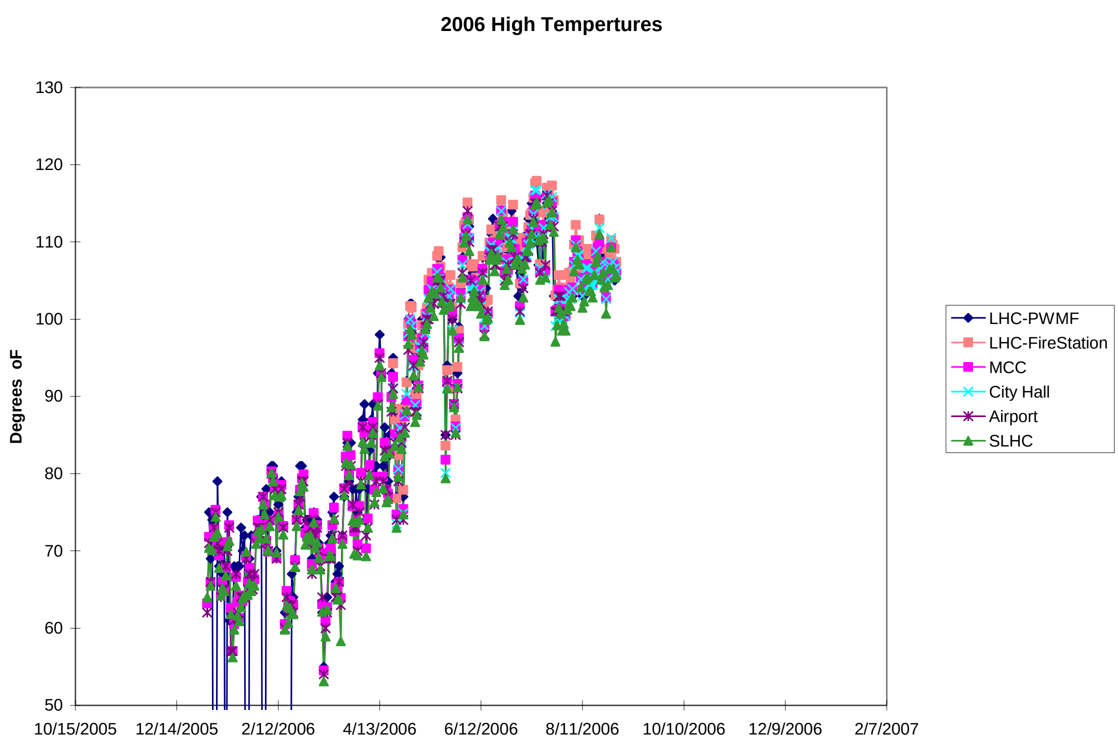

Figure 5: January to August 31st 2006 high temperature data comparisons.

Table 2: Combined High Temperature Comparisons from 2003 to mid 2006. Temperatures in bold indicate the highest for that month over the four year period.

	2003	2004	2005	2006	4-Year Average Total
Average Combined Monthly Temperatures (ºF)					
January	**73.9**	65.7	64.1	67.3	67.8
February	68.1	65.2	65.7	**72.7**	68.0
March	75.9	**85.5**	74.6	71.0	76.8
April	81.0	**84.7**	78.4	84.3	82.1
May	95.3	95.4	95.1	**98.2**	96.0
June	104.1	103.9	101.7	**107.4**	104.3
July	110.09	108.0	**110.13**	108.9	109.3
August	105.9	105.1	104.3	**106.3**	105.5
September	102.8	98.5	99.2		100.2 3-Year Ave.
October	94.9	83.6	86.2		88.2 3-Year Ave.
November	69.4	67.8	75.3		70.8 3-Year Ave.
December	64.3	63.0	65.5		64.3 3-Year Ave.
Average Combined Yearly High Temperature	87.14ºF (89.4ºF to 8-31-03)	85.6ºF	85ºF	89.52ºF to 8-31-06	86.81ºF
Highest Temperature of the Year	120ºF	124ºF	121ºF	118ºF	
Greatest Temp. Difference bt. Stations	14ºF	19ºF	23ºF	10ºF	
Average Yearly Temp. Difference bt. Stations	2.08ºF	2.99ºF	2.95ºF	3.00ºF	
Number of Days over 100ºF	129	117	106	112	As of 8-31-06
Number of Days over 110ºF	40	30	24	38	As of 8-31-06

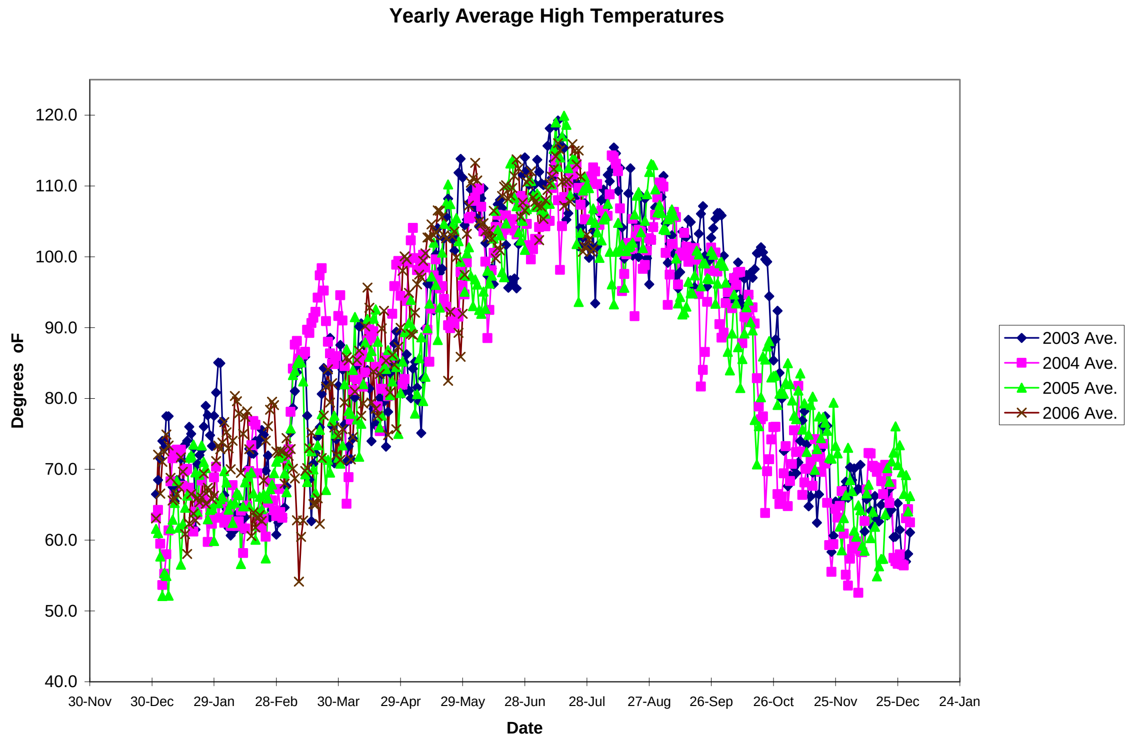

Figure 6: Composite average high temperatures for 2003 through mid-2006. Note the early start of elevated temperatures in 2004, but the lower mid-July temperatures.

Curiously temperatures above 120°F over the 4-year period were recorded on only 6 days, all in July and all from the PWMF station. The highest temperature recorded in this interval was 124°F on July 30th, 2004. The MCC station, the only other station to record over 120°F, reached that mark on only two of the six days.

The year 2003 had an average high temperature of 87.14°F, but 2006 is very similar and could prove to be the warmest if temperatures remain above normal through October. When comparing which year has the warmest months (Table 2), 2006 has so far, four warmest months (February, May, June, and August), whereas 2003 has definitely one warmest month (January), but could also hold September, and October warmest months, pending the results of 2006. May and June of 2006 averaged 3°F warmer than 2003, quite a jump, and for the period up to August 31st, the year 2006 had 16 more days over 100°F and 1 less day above 110°F than 2003. 2005 was the coolest of the four years, but had the warmest July at 110.13°F.

The pattern of the yearly temperature profiles in this short 4-year comparison shows two general ways in which the Lake Havasu area leads from winter to summer to fall. Profiles for 2003 and 2004 show abrupt rises and descents in the spring and early fall, respectively, yet in 2005 and so far in 2006, the temperatures increased and decreased more gradually. Regional upper atmospheric weather patterns such as the rapidity and geographic location of high pressure establishment or the timing and intensity of passing cold fronts usually guide surface temperature trends. The big picture documents what most citizens in Lake Havasu City already know, that this area has two dominating seasons, summer and winter, with spring and fall acting as quick transitions.

Another factor to consider during the summer season in Lake Havasu City is the effect of the monsoonal humidity. When the dew point temperature reaches over 55^{o}F for 4-5 days in a row, then the monsoon is officially called by the weather professionals in Arizona. However, evaporative coolers (swampers) become increasingly inefficient as the dew point rises over 40-45^{o}F. Dew point temperatures associated with daily high temperatures were compared for the period between June and September from 2003 through mid-2006 (June – August) from the MCC and south side stations, the only two stations with this information over this period.

The average dew point temperatures over the period from June 1st to August 31st for each of the four years were 46^{o}F for 2003, 42^{o}F for 2004, 44^{o}F for 2005, and 47^{o}F for 2006. The similarity in dew point values between 2003 and 2006 again indicate the two years are roughly following each other, however, the 2006 high humidity period began to elevate in the first of June (to over 40^{o}F) and soared in the last week of June to over 50^{o}F, at least 2 weeks earlier than normal (Figure 7). The 2003 dew point temperatures remained high through September and there is no reason why the 2006 dew points should not also remain high. 2005's monsoon season, in contrast, was very short beginning in late July and ending in mid-August.

Also note from Figure 7 that the front end (May to early July) of the graph for years 2003 through 2005 depicts a relatively rapid rise in dew point temperatures, and in all years, a ragged tail end of the high dew point temperatures. In simple terms, the seas like the Gulf of Mexico and Gulf of California take time to heat up and increase their evaporation rate, which are the sources of the high humidity that migrates with winds from the south and southeast into Arizona. These same bodies of water are slow to cool down as summer turns towards fall and they continue their high evaporation rates. Remember that September is the peak of the hurricane season because the seas contain so much stored heat energy. The ragged nature of the late summer dew point profile on the graph reflects changing wind patterns, which at one time may draw in the humid air and at other times bring in drier air from the north or west. Eventually, the combination of declining sea temperatures and developing cold fronts from the northwest lower this area's humidity and associated dew point temperatures.

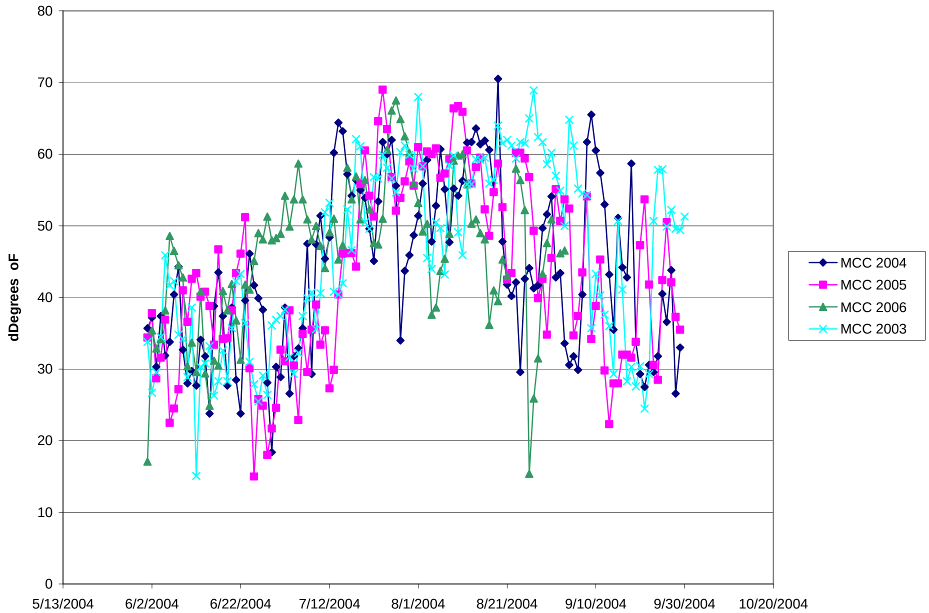

Figure 7: Dew point temperatures for the MCC station for 2003, 2005, and 2006 (to August 31st). Note the early rise in due points in 2006 (green) and the short humid or "monsoon" season for 2005 (magenta).

Concluding Remarks

The system of weather stations involved in this study show a general consistency to current conditions among each other and would appear to be valid sources of weather information. Weather is ever changing and the temperatures experienced in Lake Havasu City during the last part of the 20th century have little bearing on what is experienced today other than within a gross sense of the climate we reside. Temperatures may or may not have declined; depending at what level one scrutinizes the information. Were the observation conditions optimal at former recording sites or was this area in a slightly different climatic mode? At any rate, the temperatures measured from the stations included in this short study indicate that 120^{o}F+ temperatures are uncommon and there is an elevation component to temperatures even in the less than one thousand feet difference between the lake level and the top of the platted city. Although extreme temperatures have been absent in 2006, if the current conditions persist as they have been this summer, then 2006 will be the warmest and possibly the most humid of the four years considered in this study.

Acknowledgements

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