Weather Conditions in Lake Havasu City, Arizona from 2001 through 2007 Update – Doyle C. Wilson, Water Resources Coordinator

Abstract

High and low temperatures, dew point temperatures, peak wind speeds, and precipitation amounts from six Lake Havasu City weather stations from 2001through 2007 have been examined to document weather patterns in the area. As shown in the 2006 report, the weather stations can be grouped by an elevation range that affect temperature recordings, but not necessarily the dew point temperatures, wind speed, or precipitation. Wind speed and dew points are more regional phenomenon less affected by station location, and precipitation amounts are selectively random, particularly during scattered summer monsoonal storms. This update report also presents a few unusual individual events and compares the 7-year temperature averages with all-time temperature records.
A summation of the findings is given below:

- The hottest and most humid month is July, the coolest month is December, and the windiest month is June (closely followed by April, May, and July).
- Warming and cooling patterns around the summer months from year to year show either gradual or very quick changes (see Figures 2 to 6).
- The average high and low temperatures in Lake Havasu City over the 7-year period are 86^{o}F and 64^{o}F, respectively
- January 2007 was the coolest month in the 7-year span.
- Five years each had two warmest months when comparing each month over the 7 year span.
- 2003, the warmest year in the study period, had four months averaging over 100^{o}F.
- Although 2005 was the coolest overall, it had the hottest month, July, with an average high temperature of 110.13^{o}F.
- 2006 had the longest high humidity period, extending from June into September.
- 2007 is the driest year since 2002 with less than 2 inches of precipitation.
- November 2006 experienced one of driest air masses when the dew point temperature dipped to -6.4^{o}F and July 2005 experienced the hottest heat index at 127^{o}F.

Introduction

The 2006 weather report focused on comparing the accuracy and reliability of the six weather stations present in Lake Havasu City spanning a distance from the regional airport near the northern city limit to a station close to the Jamaica Blvd. and McCulloch Blvd. intersection in the southeastern portion of the city (Table 1; Figure 1 and see http://project5.na.amec.com/lhweather/2006%20Weather%20Comparison.pdf). High temperature variations and summer dew point temperature trends over a 3 ½ year period from 2003 to August 2006 were also presented. Since the last report established the reliability of the weather stations used to collect meteorological information, this updated report will expand on the variations and extremes of temperature, dew point, humidity, and wind speed in our city.

As mentioned in the last report, most weather stations accessible for this study in Lake Havasu City prior to 2003 either had no capability to store weather information beyond temperature, peak wind speed and wind direction, 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 dating back to 1994. An examination of this data from 1994 to 2000, which is the only available data for this period, reveals the general weather conditions in the area, but this data may not reflect the extreme conditions experienced in the heart of the city. As an example, June 29, 1994 is the day in which Lake Havasu City reached its all time record high of 128^{o}F, as measured near State Hwy 95 and Mesquite Avenue (Fire Station #5). The airport's weather station recorded a high temperature of 119^{o}F on the same day. The following temperature information presented will include the time period from 2001 through 2007. Weather data from the Public Works Maintenance Facility and from the airport are available beginning in 2001. Dew point temperatures and peak wind speed data are only available from 2003, yet this information gives an indication of the relative monsoonal conditions and the monthly wind activity expected for Lake Havasu City.

High Temperature Trends

Over the past 7 years, the yearly high temperature trend presents two distinct patterns; one in which there is a marked jump and fall at the beginning and ending of the summer season (Figures 2 and 4), and the other a more gradual increase and drop in temperatures from the early Spring to the first part of winter (Figures 3 and 5). Along with increasing daylight hours and intensifying solar radiation as Spring goes into Summer, high air pressure systems in the upper atmosphere become dominant in the region, compressing and heating the atmosphere as air descends towards the Earth's surface (it is like pumping a bike tire with air – the pump feels hot as air is compressed). Evidently in some years, the high pressure systems onset rapidly and in other years there is a more gradual buildup. Sudden cooling in the fall reflects strong, southwestward moving cold air masses passing through the area, which weaken and push the high pressure system eastward out of the southwestern U. S.

The daily high and low 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 yearly high and low temperature averages during each of the last seven years. Lastly, these were combined from each year to give a 7-year average (Tables 2 and 3). The combined data yielded an average high temperature of 86.4^{o}F, less than 4^{o}F cooler than Death Valley's yearly average of 90.1^{o}F (Table 4). 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 (Table 2). The warmest year was 2003, yet the hottest July was in 2005, the overall coolest year during the period. When comparing each corresponding month over the 7-year period (e.g. each March, each August, etc.), five different years each had two warmest months so there really has not been any one year excessively warmer than the others. For example, 2007 experienced the warmest August and November, and had the most days over 110^{o}F at 66, yet also had the coolest January and December, which were each nearly 4^{o}F cooler than the 7-year average for their respective months.

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

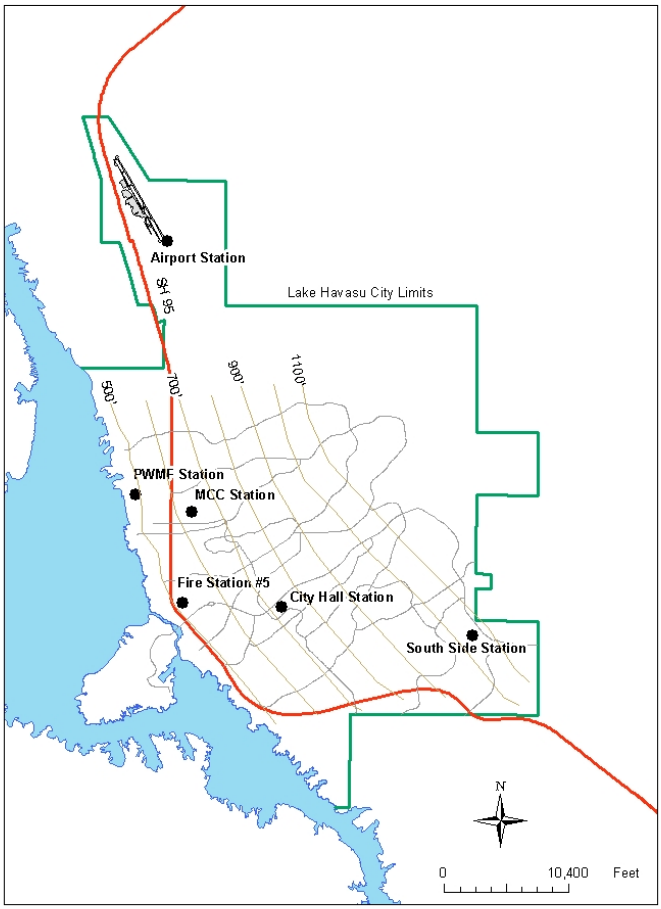

Figure 1: Weather Station locations used in this comparative study.

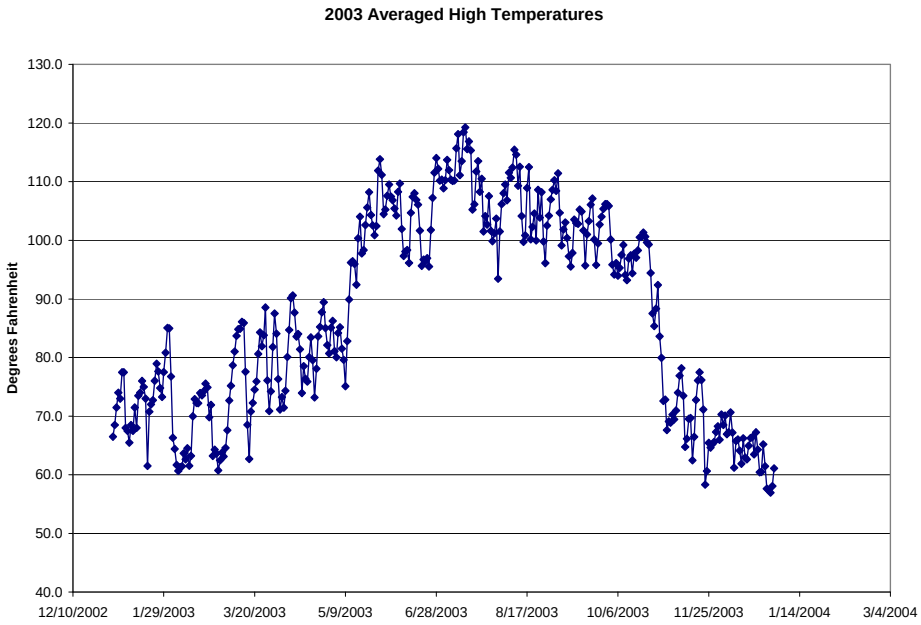

Figure 2: 2003 Averaged high temperatures exhibiting sudden jumps in heating and cooling bracketing the summer season.

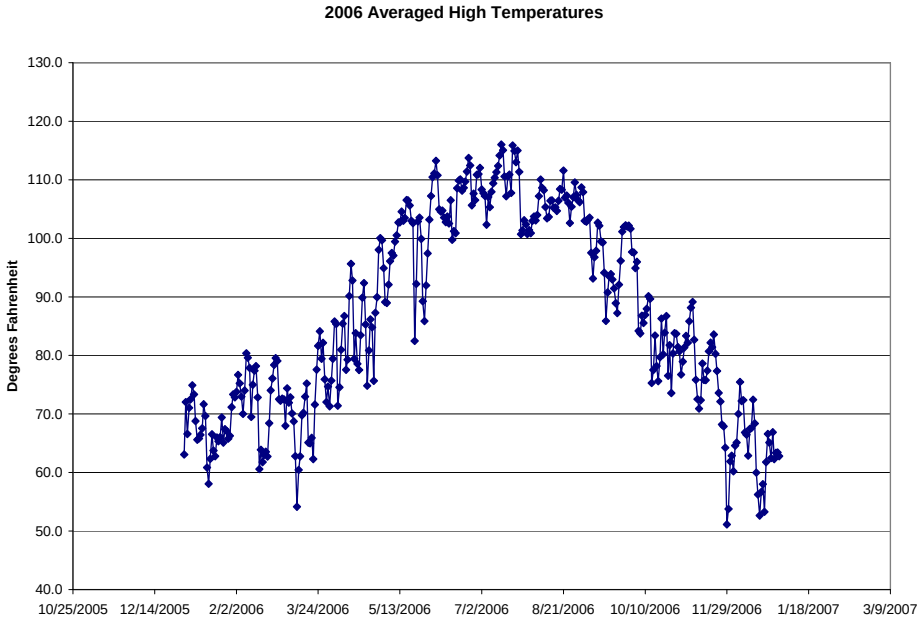

Figure 3: Averaged high temperatures for 2006 displaying more gradual warming and cooling trends.

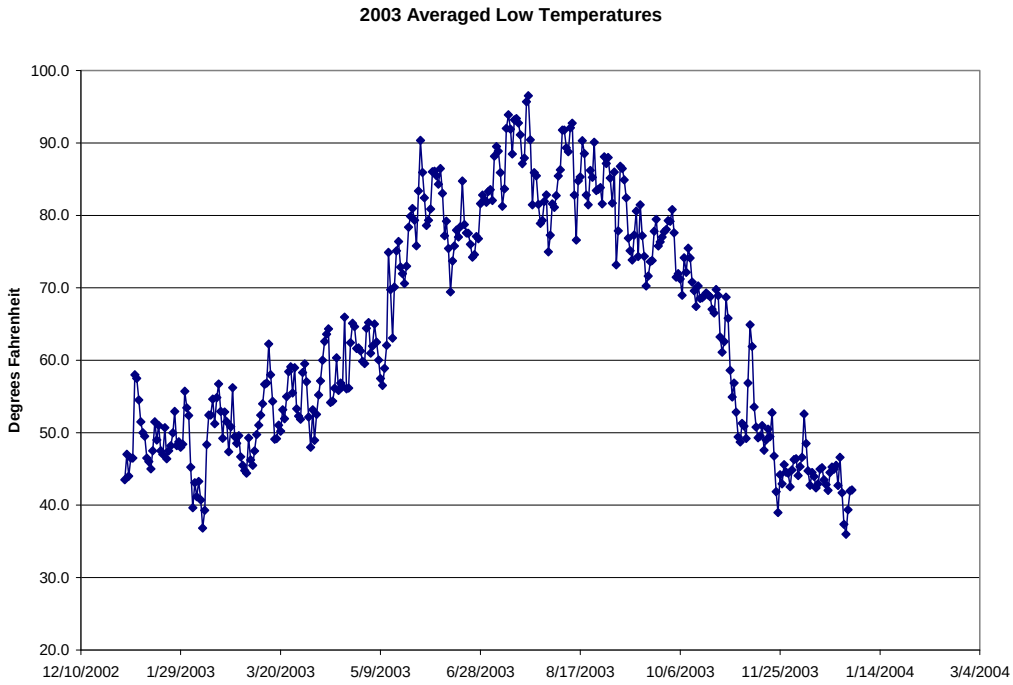

Figure 4: Averaged daily low temperatures in 2003 mimicking the temperature pattern of the high temperatures for the same year (Figure 2).

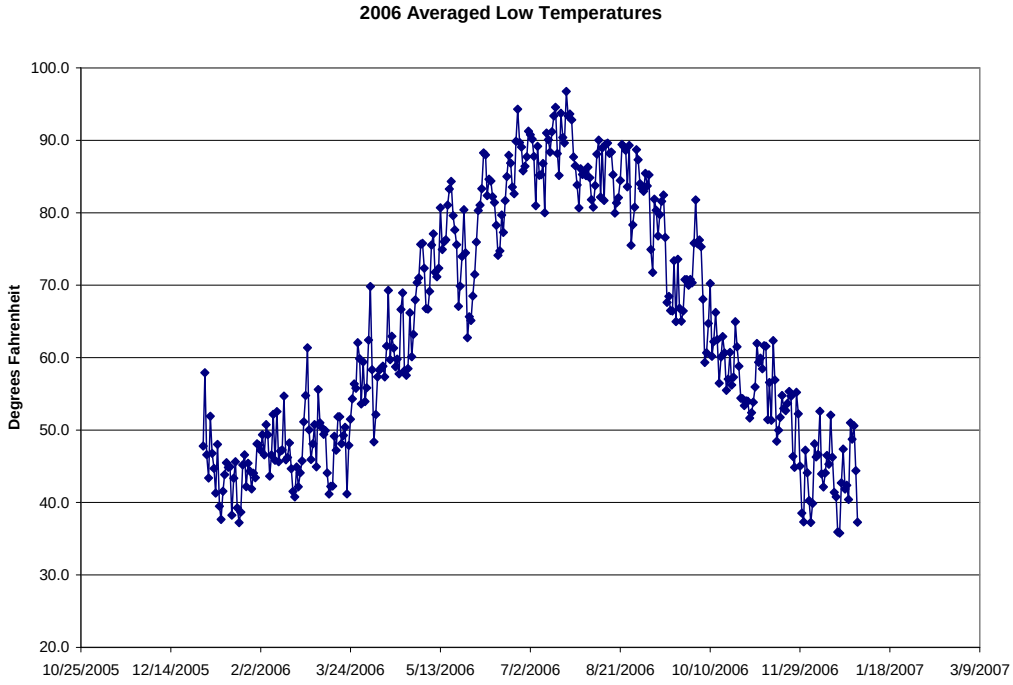

Figure 5: Averaged low temperatures for 2006 displaying gradual warming and cooling trends as with the 2006 high temperatures (Figure 3).

The lowest high temperatures from available records over the last seven years that occurred during July and August are 92°F (2005) for July and 90°F (2004) for August. The lowest high temperature during the same time period for December and January are 51°F (2006) for December and 43°F (2007) for January. So Lake Havasu City has not had a day during the 7-year period, in which the temperature remained below freezing. Examination of the airport weather station data back to 1994 also shows no day that has stayed below freezing.

Low Temperature Trends

Low temperature statistics were added to this report to show their variability and to compare with data from Death Valley. The lowest recorded official temperature in Lake Havasu City's history is 25°F on December 24th, 1990. Overall, December is the chilliest month on average, closely followed by January (Table 3). The 7-year combined average low temperature for Lake Havasu City is 63.8°F. When comparing corresponding months for the 7-year period, 2007 had only one coolest month, January, but had three months with the warmest low temperatures. This year was exceptional in that it also had 35 days where the thermometer did not dip below 90°F overnight (in July) and had 5 days below freezing (in January) including a 26.6°F reading (the lowest during the 7-year period). The highest low temperatures, which are of most interest for the humid summer months of July and August, are not an official record-keeping statistic, yet over the past seven years, the highest recorded overnight low temperature was 99°F on July 3, 2001 at the Public Works Maintenance Facility and on July 22, 2006 at the airport. As a side note, the overnight low reported in the News-Harold after the 128°F record high was 99°F, although it is very possible that some areas of Lake Havasu City stayed above 100°F.

Figure 6 displays a comparison of the 7-year composite average daily high and low temperatures with Lake Havasu City all-time record high and low temperatures. High and low daily temperatures averaged over the past seven years exhibit a parallel trend with an average separation of almost 23°F (Figure 6). May and June display the greatest temperature range (>25°F) due to a combination of high day time temperatures (the sun is higher in the sky and stays up longer) and low humidity, allowing more heat to escape near the Earth's surface at night. As monsoonal weather ensues in July, more water vapor in the air traps more heat radiating from the surface. The temperature differential increases back to 25°F in September as the monsoon humidity is replaced by cooler, drier air masses. Winter months have the least temperature difference, between 19-20°F, with less daytime heating. All-time recorded high and low temperature trends bracket the 7-year trends in Figure 6, revealing 40-50°F differences between the record highs and lows. Also note that the earliest 100°F date of the year recorded is in late March (20th) and the latest 100°F date of the year is in late October (21st). Twenty-nine dates of the year have recorded below freezing temperatures, whereas 180 dates experienced over 100°F temperatures, 139 dates have been over 110°F, and the thermometer has been over 120°F for 33 dates.

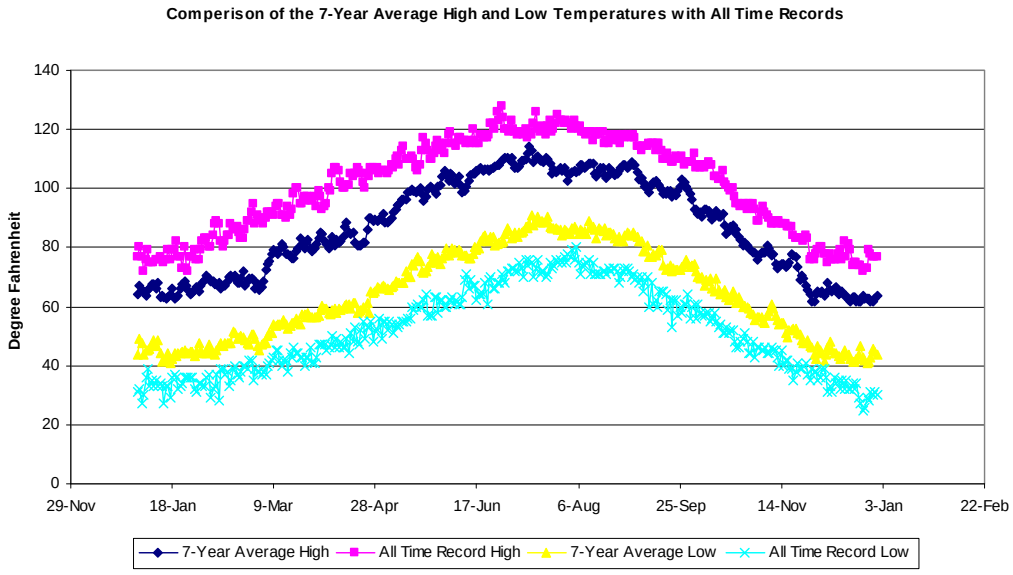

Figure 6: Seven-year average monthly high and low temperatures bracketed by all-time official record temperature extremes experienced in the city.

Table 2: Combined High Temperature Comparisons from 2001 through 2007. Temperatures in bold indicate the highest for that month over the seven year period. Note that there were only two recording stations in 2001 and 2002, with an additional station added each year through 2006.

	2001	2002	2003	2004	2005	2006	2007	7-Year Average Total
Average Combined Monthly Temperatures (ºF)								
January	61.3	65.1	**73.9**	65.7	64.1	67.3	61.6	65.6
February	65.2	71.3	68.1	65.2	65.7	**72.7**	71.2	68.5
March	75.5	72.8	75.9	**85.5**	74.6	71.0	80.8	77.6
April	82.7	**88.3**	81.0	84.7	78.4	84.3	85.8	83.6
May	**100.4**	93.7	95.3	95.4	95.1	98.2	95.9	96.3
June	106.0	106.5	104.1	103.9	101.7	**107.4**	105.1	105.0
July	107.2	109.5	110.1	108.0	**110.1**	108.9	109.1	109.0
August	107.7	107.5	105.9	105.1	104.3	106.3	**108.0**	106.4
September	**104.6**	102.3	102.8	98.5	99.2	97.7	98.9	100.5.
October	91.6	86.6	**94.9**	83.6	86.2	84.9	87.3	87.8
November	77.8	76.5	69.4	67.8	75.3	76.1	**77.5**	74.4
December	62.6	63.8	64.3	63.0	**65.5**	64.2	60.5	63.4
Average Combined Yearly High Temperature	86.9ºF	87ºF	87.1ºF	85.6ºF	85ºF	86.6ºF	86.8ºF	86.4ºF
Highest Temperature of the Year	119ºF	116ºF	120ºF	124ºF	121ºF	118ºF	123ºF	
Number of Days over 100ºF	143	119	129	117	106	112	128	
Number of Days over 110ºF	43	53	40	30	24	38	66	

Note: The above monthly temperatures are averaged from the multiple station recordings, but the highest temperature is from one individual weather station.

Table 3: Combined Low Temperature Comparisons from 2001 to September 2007. Temperatures in bold indicate the lowest for that month over the seven-year period. Note that there were only two recording stations in 2001 and 2002, with an additional station added each year through 2006.

	2001	2002	2003	2004	2005	2006	2007	7-Year Average Total
Average Combined Monthly Temperatures (ºF)								
January	43.7	43.1	49.1	44.1	46.9	43.8	**42.0**	45.2
February	46.8	**44.8**	48.6	45.5	49.0	47.5	48.3	47.8
March	54.9	**48.5**	52.2	59.4	52.6	49.6	56.3	54.0
April	58.6	62.2	58.1	62.8	**58.0**	61.9	63.3	60.8
May	72.9	67.3	**70.2**	71.5	70.3	73.6	72.2	71.6
June	79.7	79.7	79.2	80.0	**77.8**	83.6	79.1	80.0
July	**83.0**	87.1	87.2	86.2	87.1	88.7	87.1	87.2
August	85.5	84.4	85.2	83.8	**82.7**	84.8	88.3	85.0
September	78.0	77.0	78.2	75.0	75.2	**74.4**	77.5	76.0
October	67.8	63.3	69.9	62.8	64.9	**62.1**	62.2	64.4.
November	56.9	54.0	49.8	**49.5**	52.9	53.4	54.2	52.9
December	**40.8**	44.6	43.9	44.6	43.6	44.2	42.8	43.5
Average Combined Yearly Low Temperature	63.0ºF	63.0ºF	64.3ºF	63.8ºF	63.4ºF	64.0ºF	64.4ºF	63.8ºF
Lowest Temperature of the Year	35ºF	32ºF	30.9ºF	32.8ºF	30.7ºF	32.5ºF	26.6ºF	
Number of Days 32ºF and below	0	1	2	0	2	0	5	

Note: The above monthly temperatures are averaged from the multiple station recordings, but the lowest temperature is from one individual weather station.

Table 4: Death Valley National Park average monthly high and low temperatures and average precipitation amounts (from ww.nps.gov/death valley/climate/weather.html).

Weather Data for Furnace Creek, CA (Elev. 178 feet below sea level - Degrees F.)			
Month	**Avg. Max. Temp.**	**Avg. Min. Temp.**	**Avg. Precipitation**
January	64.6	39.1	0.24"
February	72.3	45.6	0.33"
March	80.4	52.8	0.24"
April	89.8	61.9	0.12"
May	99.3	70.7	0.07"
June	109.0	80.3	0.03"
July	115.3	87.8	0.11"
August	113.2	85.0	0.12"
September	105.8	74.9	0.11"
October	92.0	61.6	0.09"
November	75.7	48.1	0.19"
December	65.1	39.4	0.19"
ANNUAL	90.1	62.2	1.84"

Although all monthly averaged daytime high temperatures for Death Valley exceed the 7-year high temperature averages for Lake Havasu City, note that almost all monthly averaged overnight low temperatures in Death Valley are lower than those in Lake Havasu City and the overall minimum temperature is 1.6^{o}F less. When combining the yearly average high and low in both cases, Death Valley is only 1^{o}F warmer overall. The spread between Death Valley's average high and low temperatures is generally greater than that of Lake Havasu City presumably due to its overall lower humidity. The summer monsoon season is not as strong that far north, whose latitude also affects its winter temperatures as the sun is not as high in the sky as in Lake Havasu City.

Humidity and Dew Point Temperatures

Humidity and dew point temperatures are related in that both give an indication of the amount of water vapor (moisture) in the atmosphere. There are several ways of defining humidity, but the type most commonly reported is relative humidity, which is the amount of moisture in the air compared to the amount of moisture the air can hold at a given temperature. Hotter air can hold more water than cooler air, so when warm air containing a certain amount of water vapor is cooled, its relative humidity goes up. Relative

humidity is typically given in percent and when at 100%, the air is saturated with water vapor ready to condense out as liquid water (a glass of water with ice cubes usually experiences the formation of dew on its outer surface – the air next the glass is at 100% relative humidity). The dew point temperature is the air temperature when the relative humidity reaches 100% and condensation forms. Dew point temperatures vary according to both the amount of water vapor in the air and the air's ambient temperature (the near surface air temperature is much cooler in the winter than in the summer, so summer air can hold a lot more water vapor, as experienced during the monsoon period).

When the dew point temperature reaches over 55^{o}F for 4-5 days in a row, then the monsoon "season" is officially called by meteorologists in Arizona. However, evaporative coolers (swampers) become increasingly inefficient as the dew point rises over 40-45^{o}F. Although humidity and dew points were reported in the News-Harold in the 1990's, available archived relative humidity and dew point temperatures for Lake Havasu City only extend back to 2003.

Summer time dew point temperatures for the period between 2003 through mid-2006 were compared in the first report with 3-month averages (June 1st to August 31st) of 46^{o}F for 2003, 42^{o}F for 2004, 44^{o}F for 2005, and 47^{o}F for 2006. The dew point averaged for the same time period in 2007 was 45^{o}F. An averaged five-year dew point temperature trend is shown in Figure 7. As discussed in the last report, the length of the monsoon season varies from year to year as well as the intensity. Whereas the 2006 season began in June, the 2007 season began in early July, typical of most years. However, the 2007 monsoon season proved to be one of the driest on record (an average of 0.44" precipitation from only two rain events), despite normal humidity and dew point temperature intensities. The 2007 monsoon also had an abrupt ending when a cool air mass moved in on September 17th. This is noted due to an unusual and rapid shift in the dew point temperature. Within an eight hour period the dew point temperature decreased from 65^{o}F to -4.1^{o}F and rebounded to 32.5^{o}F eight hours later. The last dew point is typical of late summer, non-monsoonal conditions. During the same period, the humidity changed from 38% to 3% and to 19%, respectively, and the air temperature reached 104.6^{o}F during the fall of the dew point. Just prior to the start of the 2007 monsoon season, when the City experienced 122.9^{o}F on July 4th, the humidity at that time dropped to 1%, the lowest in the five year history that humidity values have been archived. Single digit humidities are common prior to the monsoon season and when dry cold fronts pass over the area in the winter, but are usually in the 4-7% range.

Another unusual dew point temperature and humidity event took place on November 29th, 2006 when an extremely dry cold front past over Lake Havasu City. The dew point temperature dropped from 23.6^{o}F to -6.4^{o}F in 18 hours, yet the air temperature was 47.6^{o}F at the time of lowest dew point and the relative humidity was 10%. Negative dew point (called frost point when below the freezing point of water) temperatures are rare along the Lower Colorado River Valley, but they can happen almost anytime of year when a dry air mass moves over the region as exemplified by the September event described above.

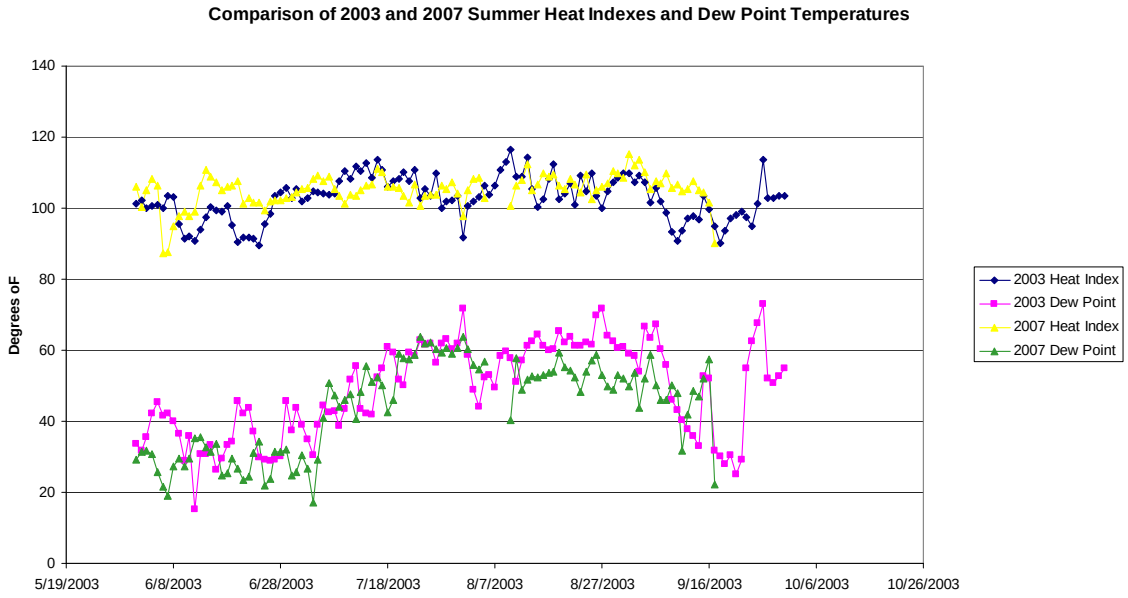

Figure 7: 2003 and 2007 summer heat index and dew point temperatures for the MCC station. 2003 dew points are elevated in June, but rise further in July about the same time as the significant increase in 2007. The 2007 monsoon lasted a little longer into September than in 2003.

Heat Index

The heat index is a measure of how hot the atmosphere feels to the human body. This factor takes into consideration the combined affects of the air temperate and the relative humidity. The higher the humidity, the hotter the air feels because less water will evaporate from the body, and evaporating water also takes away heat, thus cooling the body. Typical daytime high heat index temperatures during the summer monsoon range between 105^{o}F and 110^{o}F with occasional forays to 115^{o}F. Figure 7 shows summer heat indexes for 2003 and 2007. Another way that meteorologists gauge the impact of the weather on humans is to combine the air temperature, relative humidity, wind speed, and solar radiation to get a temperature of how it feels in the sunlight. This is called the THSW index and the highest recorded temperature over the past five years was 127.6^{o}F on July 25th, 2006. The air temperature at that time was 115.4^{o}F with a humidity of 15%, but a dew point temperature of 59.2^{o}F. The wind speed was only 3 mph at the time. To exemplify the affect of humidity on the THSW index, when the City experienced 122.9^{o}F, 1% humidity, and 7 mph winds on July 4th this year, the THSW index was 118.7^{o}F at that time.

Wind Speeds

Local news reports have indicated that April is the windiest month of the year in Lower Colorado River region. An examination of the last five years for peak wind speeds in Lake Havasu City shows that although April is windier than most months, it is not consistently the windiest month. This statistic is based on averaging the peak wind measured every 30 minutes during a month. June has the highest average peak wind speed (11.1 mph) over the past five years, closely followed by April, July, and May (Table 5). The lowest average peak wind speeds occur from October to January, averaging less than 10 mph, yet December 2007 with its series of cold fronts had an average peak wind speed of 10.56 mph. High winds can come through during cold fronts or during monsoonal thunderstorms. Winds associated with fronts may persist several days and the intensity of the winds is dependent on the difference of the interacting high and low air pressure centers and their geographic distribution. Generally speaking, the larger the pressure differential and the closer the air pressure centers, the faster the winds. Winds associated with thunderstorms are caused by intensified downdrafts from the storm cloud's (cumulonimbus) upper levels (up to 60,000 feet above the ground). Wind speeds can be very high, but short lived, lasting less than several hours.

Top peak winds recorded in 2007 at the Mohave Community College weather station exemplify that although June has the highest average wind speed, that month did not experience the highest wind gusts. June had a top wind gust of 32 mph, while July, October and April recorded top winds of 44, 41, and 40 mph, respectively. Rather than associated with fronts or thunderstorms (neither occurred in June), winds in June were more consistent as steady breezes, unlike the other months in which there were significant low wind periods between storm activity.

Table 5: Averaged 5-year monthly peak wind speeds and the averaged yearly peak wind speed.

5-Year Monthly Averaged Peak Wind Speed (mph)	
January	**8.69**
February	**8.65**
March	**9.16**
April	**10.86**
May	**10.50**
June	**11.10**
July	**10.78**
August	**9.63**
September	**9.34**
October	**8.39**
November	**7.04**
December	**7.97**
Yearly Average	**9.34**

Precipitation

Table 6 depicts the rainfall trend over the last seven years. This same time period has officially been in drought for the southwestern U. S. The National Weather Service has reported a 30-year precipitation average for Lake Havasu City at 3.5". The seven-year precipitation average for each weather station currently monitored is highly variable, which is mostly due to the hit and miss practice of summer monsoon thunderstorms. Clearly over this period, the fall of 2004 and winter of 2005 was the wettest with more than 13" recorded. This rain period completely saturated the mountain soils resulting in an extended runoff period during which mountain arroyos were running for many months and some up to more than a year after. Several springs developed in the alluvium slope within Lake Havasu City about three months after the cumulative rain events and they ran for up to five months.

At the opposite end of the spectrum, 2007 proved to be one the driest years since 2002 (which had an average rainfall of 1.65") with an average rainfall total of 2.36", including a 110 day precipitation-free period from March to July. Lake Havasu City only recorded 0.03" (all in one day) of rain over a 159 day period in 2002.

Table 6: Averaged precipitation totals (inches) over the 7-year period from 2001-2007.

Month	2001	2002	2003	2004	2005	2006	2007
January	1.58	0.01	0.60	0.03	2.68	0.01	0.38
February	1.92	0.00	2.11	0.99	3.02	0.09	0.06
March	0.56	0.04	2.13	0.04	0.50	0.52	0.16
April	0.18	0.00	0.11	1.11	0.03	0.06	0.00
May	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June	0.00	0.00	0.00	0.00	0.00	0.05	0.00
July	1.13	0.20	0.34	0.29	0.04	0.28	0.30
August	0.11	0.00	0.36	0.78	2.70	1.16	0.09
September	0.44	0.86	1.63	0.40	0.00	0.12	0.20
October	0.34	0.11	0.00	3.65	2.76	1.17	0.02
November	0.05	0.39	0.32	3.11	0.04	0.00	1.01
December	0.25	0.04	0.28	0.68	0.00	0.00	0.14
Yearly Total	6.56	1.65	7.88	11.07	11.78	3.47	2.36

Concluding Remarks

Lake Havasu City lies in one of the hottest climates in the western hemisphere and although the city holds the record for highest daytime temperature for a municipality in the United States, until recently there has been a paucity of other weather parameters to characterize the local climatic trends. High and low temperature data combined with humidity, dew point temperatures, peak wind speeds, and heat index have help to at least determine weather conditions during a significant drought period of unknown duration and highlight that the city's climate closely follows that of Death Valley. The data also better documents the monsoonal pattern along the Lower Colorado River, which typically demonstrates a quick entrance and a ragged tail off into the fall. Windier conditions prevail in the late spring and summer, tapering off in the winter, although some winter cold fronts can create blustery conditions. Continued monitoring and database development will help give a more long-term picture of the area's climate, possibly useful for commercial and energy development (solar and wind power?).

Acknowledgements

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