Lake Havasu City 2012 Weather Summary

Doyle Wilson, Water Resources Coordinator

Introduction

Records from five weather stations were collected in 2012. Four of the stations, at the Operations Maintenance Facility (formerly PWMF), at City Hall, at Mohave Community College (MCC) and at Fire Station #5 (FS5), continued to supply data as years before (for details of these stations, please see the 2006, 2007 and 2011 summary reports). A fifth station established at the City's airport in December 2011, marks the return from a four and a half year hiatus. The station's elevation is 741 feet amsl, on par with the station at City Hall (730 feet amsl). The airport weather station experienced a couple of bugs in 2012 though resulting in incomplete data for the months of January, February, April and October.

The year 2012 in Lake Havasu was overall average concerning high temperatures, but there were some record days and months. Rainfall was much above normal, but not evenly distributed.

Temperatures

Nationally, 2012 was rated as the warmest year on record according to the National Oceanic and Atmospheric Administration (NOAA - http://www.ncdc.noaa.gov/sotc/national/2012/13#over). The official average temperature was 55.3^{o}F. The temperatures for 2012 around Lake Havasu City made a contribution to this record as they were for the most part, warmer than normal. The five station high temperature annual average was 88.35^{o}F, the highest since 1996 when only two weather stations were present to average. This temperature though is well below the record of 91.69^{o}F set in 1989, but that was only from one station (original PWMF station located at the old airport on the Island). The average annual low temperature in 2012 probably had a stronger contribution posting a 64.67^{o}F, just shy of the record of 65.34^{o}F set in 1996. The average five station overall annual temperature for 2012 in Lake Havasu City was 76.51^{o}F, above both the 10-year (75.13^{o}F) and 34-year (74.62^{o}F) averages. The 2012 high and low daily temperature profile is presented in Figure 1.

With the above in mind and for the first time since 2000, there were no monthly high temperature averages in 2012 that set a record for the warmest or coldest for that month. November's monthly high temperature average of 78.31^{o}F was the fourth warmest since records have been kept and only the fifth time the average was 78^{o}F or higher. The warmest November was in 1995 with an average of 81.55^{o}F, but that average is only from two stations, the PWMF (which at the time was at the Fire Station #5 location) and the old airport station.

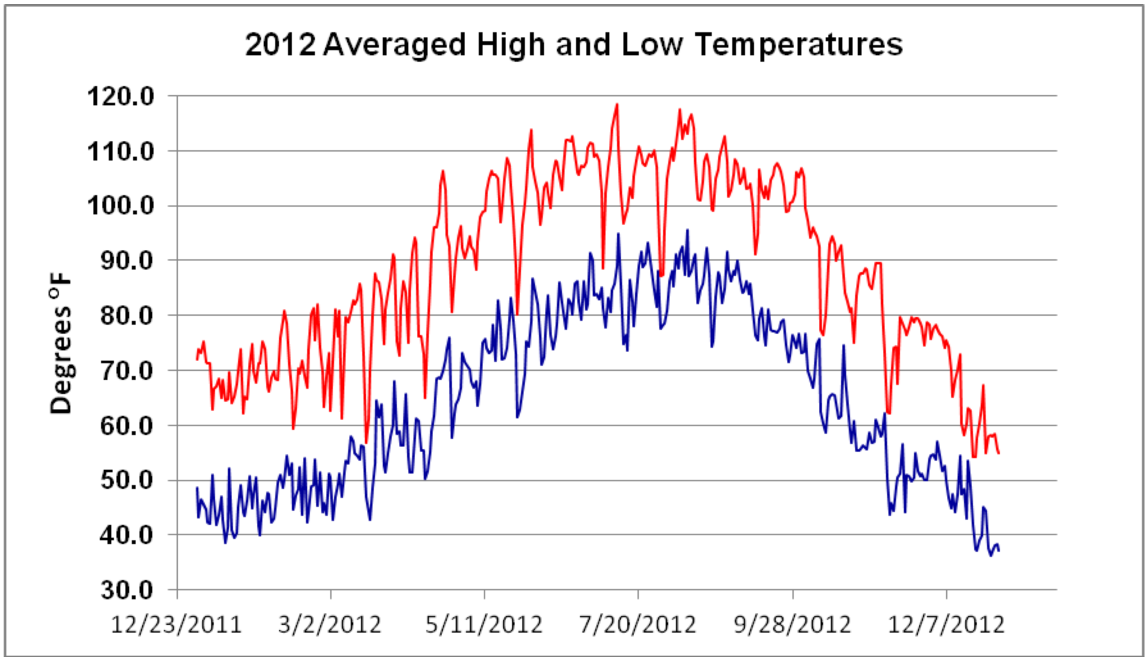


Figure 1: 2012 high and low averaged (over five stations) temperature profiles for Lake Havasu City.

Although no monthly high temperature averages were exceptional, there was one monthly low temperature average, December at 48.48°F, that set a warm record, but by only 0.64°F over the 47.84°F average set in 1996. In addition, June was one of only six Junes that recorded an average low temperature above 80°F at 81.47°F.

A few official record high or low temperatures were set in 2012. There were five record high temperatures set and four that tied old records (Table 1). The FS5 weather station recorded seven unofficial record high temperatures. Only three official low record temperatures were recorded, surprisingly all in July. They were all associated with monsoonal storm systems that brought in significant precipitation. A record minimum high temperature was set on July 4th at 90°F (unofficially 85.7°F at MCC), the first time that day has been below 100°F during the past 35 years that records have been kept. A second minimum high temperature record of 86°F occurred on July 30th, which also is the lowest daily high temperature ever recorded in July. July 30th also experienced a record low temperature (75°F) earlier in the day.

Although not many record temperatures were set in 2012, it was still typically hot in Lake Havasu with 141 days above 100°F and 50 days above 110°F. The 141 days is only the fifth time since temperature records have been kept(starting the 1978) that that many days were above 100°F. The average number of days above 100°F is 125. The 50 days above 110°F is exactly the 34 year average. The average highest daily temperature over this time frame is 120°F. The coolest daily summer high temperature was 116 °F, achieved three times, in 1982, 2002 and 2004. Nineteen of the 34 years, the highest temp did not reach 120°F.

Table 1: Record or tied (t) temperatures set in 2012. Official temperatures are from the weather station at the Public Works Maintenance Facility on London Bridge Road. The data from this station is sent daily to the National Weather Service. Unofficial high temperatures are from the Fire Station #5 weather station.

Date	Official High Temp.	Unofficial High Temp.	Official Minimum High Temp.	Unofficial Minimum High Temp.	Official Low Temp.
April 21	104°F	106°F FS#5			
April 22	107°F	108.2°F FS#5			
May 31	112°F				
June 1	115°F t	116.3°F FS#5			
July 4			90°F	85.7°F MCC	
July 9		119°F FS#5			
July 10		121.5°F FS#5			
July 13					73°F
July 14					73°F
July 30			86°F		75°F
August 12		118°F FS#5			
November 28	80°F				
November 29	78°F	79°F FS#5			
December 2	80°F t				
December 4	78°F t				
December 6	75°F t				

The first 100°F day of the year was on April 20th and the last 100°F day was on October 4th, while the first 110°F day was on May 31st and the last was on September 30th. There were 18 overnight low temperatures above 90°F in 2012 with 3 of those nights bottoming above 95°F. The maximum recorded low temperature was 98.4°F at the airport. The official highest low temperature at the PWMF station was 95°F. The number of days over 90°F is about average to subpar compared to other years. For example, 2010 experienced 33 days over 90°F for overnight low temperatures.

<u>Monthly Temperature Quirks</u>

Every spring and fall, cold fronts move in over the area at anytime of the day or night that bring in a quick cool snap followed by a rapid rise in temperature. This happened twice in March (3rd to 4th and 7th to 8th) when the high temperature rose by 10°F.

On April 13th, a cold front passed through in the evening and the low for the day was at 11:30pm, only 6 hours before the low on the 14th. The same thing happened on

December 18 when another front entered the area during the day to cause an 11:30 pm daily low temperature and another low 5 hours later on the 19th.

This phenomenon can also exist during the monsoon season when convective storms may be present. On August 16th, the low for the day was 77.7°F at 9:00pm because of a thunderstorm and the low for the next morning at 6:00am was 84.5°F. This was repeated on August 22nd when the low for the day was at 10:30pm (74.9°F) and the low for the next day was 75.8°F at 6:00am. Oddly, the low on August 21st was also late in the evening (11:00pm - 89°F), but no rain was associated with this event. Finally, on September 11th monsoon precipitation created the low daily temperature of 72°F at 7:30pm, only 3 ½ hours after the day's high temperature of 95°F (Figure 2).

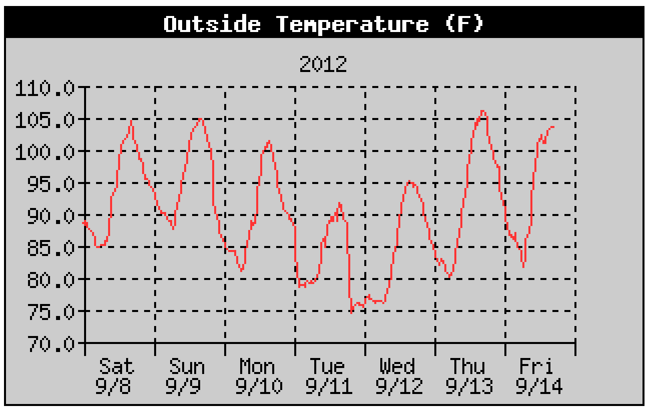


Figure 2: Temperature trend of FS5 for the week of September 8th through the 14th showing the temporary effects of a monsoon precipitation event in which the temperatures changed almost 20°F (over 20° F at the PWMF station).

July 10th saw the highest official temperature of the year at 119°F (PWMF) and the FS5 weather station recorded 121.5°F. The following morning, the temperatures were under 100°F for only three and half hours. The low was 97.5°F at FS5.

Most of the time in Lake Havasu City, the daily high and low temperatures remain fairly constant within a particular season, but large temperature trends may also occur. These are caused by a variety of reasons, such as the passage of cold fronts, the building of high pressure ridges that replace cooler air, the waning of these high pressure ridges to more moderate conditions, and even the development of monsoonal action. For example, the first few days in June experienced a cool down after a tied record high temperature on June 1st (Figure 3) indicating that a high pressure center that was over Lake Havasu City, slowing moved east, easing the heat conditions. The opposite happen in the first part of July after a monsoon storm on July 4th created the above mentioned minimum record high temperature (Figure 4). High pressure quickly built over the area the next six days that created temperatures up to 121°F.

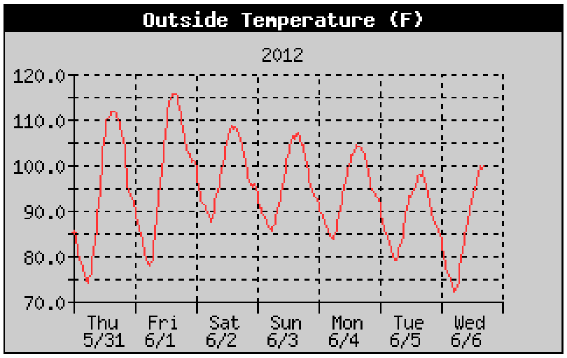


Figure 3: High pressure movement to the east of Lake Havasu let cooler air take over depressing temperatures to more seasonal levels at the first of June.

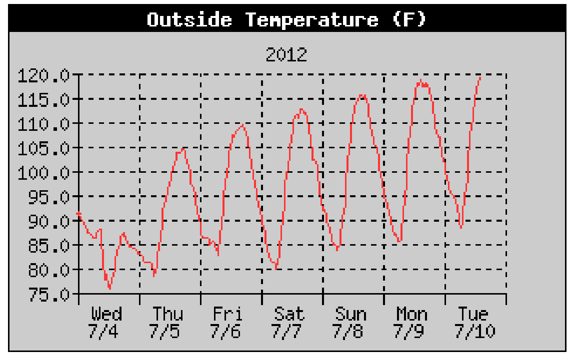


Figure 4: A record low high temperature from a July 4th storm quickly gave way to a high pressure ridge that built over the area, increasing temperatures by 30^{o}.

Precipitation and the Monsoon Season

The annual report by NOAA also noted that 2012 was the 15th driest on record in the United States. Lake Havasu City definitely did not follow that trend. The city's average annual rainfall amount is 4.24" over 42 years, but in 2012 the city experienced an average 6.75" based on three stations. Only three stations could be used to average the rainfall for this year, PWMF, FS5 and City Hall, because incomplete data exists for MCC and the airport stations. The City Hall station recorded the largest volume at 8.07", much of which fell on July 13th and 14th in monsoonal storms (see below). Most of the rain fell in the second half of the year (particularly in July - Figure 5), but there was some action from cold fronts in March and April (Figure 6). Compared to the 10-year and 42-year precipitation averages, the 2012 July-August period and December were most out of step. This includes the wettest July (ave. 2.74") and wettest monsoon season (July-August ave. 3.69") in Lake Havasu City's 42 years of record keeping. August was the rainiest in 7 years at 1.21" at PWMF. Also note that the past 10 years have been wetter than the combined 42 year average, despite the southwest's drought since 1999.

The 2012 monsoon season began the first of July, including an unusually rare July 4th storm and continued with dew points temperatures up to the 70^{o}F range all the way through September. The season ended to about October 4-6th when dew points finally lowered. Remember from early annual summaries, that the monsoon does not end like a light switch turned off. It instead comes and goes starting in mid-September, dependent on the arrival of cold fronts and the placement of the jet stream. Finally the high humidity air from the Gulf of California and Gulf of Mexico is exhausted as the sun's decreasing angle in the sky is unable to intensely heat those bodies of water.

The monsoon and precipitation highlight of the year was the Friday, July 13th 50-100 year storm. This storm was preceded earlier in the day by a rain event lasting about five hours

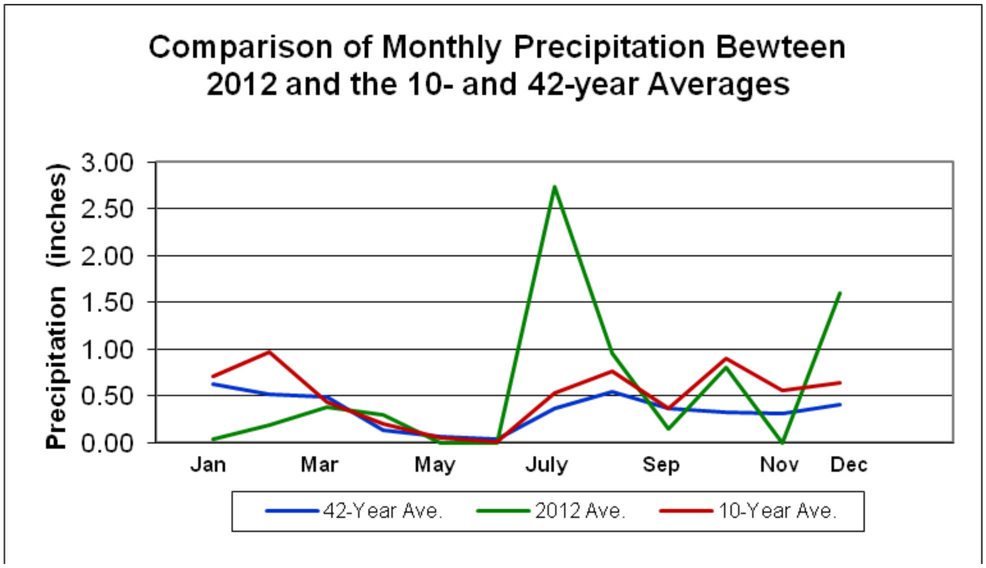


Figure 5: Average monthly rainfall (over four stations) for 2012 compared with the City's 10-year and 42-year monthly averages.

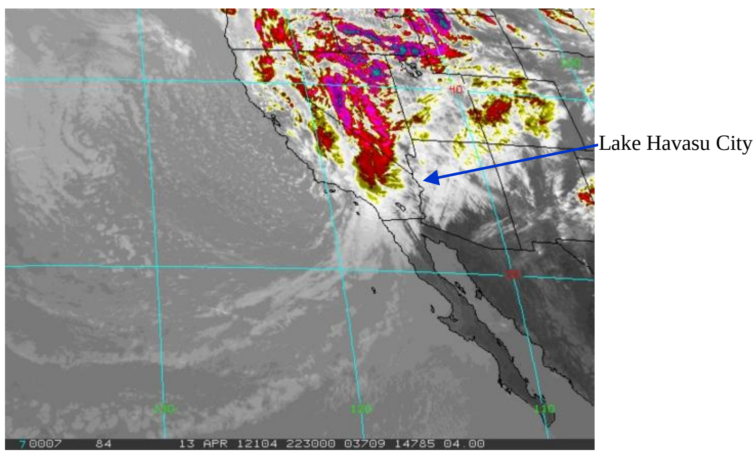


Figure 6: Cold front in April approaching the southwest that produced rain in LHC.

from 5:30 am to 10:30 am and dropping 0.35" (City Hall & FS5 stations). This event caused washes in town to run and at the very least partially saturated the ground. The main event later that day lasted only from about 5:30 to 6:30 pm. The volume of water involved caused washes throughout the main part of town to run in torrents. El Dorado and Pima washes topped their banks, destroyed infrastructure at road crossings, and built deltas into Lake Havasu. This storm came in from the east over the Mohave Mountains according to radar images. More, but lighter precipitation fell for another 2 ½ hours later that night. A lot more rain fell in the late evening of the next day on already saturated soils (1.19" FS5). Figure 7 shows a radar image of the intensity of the July 14th storm.

The two day total precipitation amounts from the five weather stations and several other rain gauges in the area sponsored by Mohave County and Lake Havasu City for these monsoon storms was mapped to show the rainfall distribution (Figure 8). Note that the north end of the city by the airport received the smallest amount of rain.

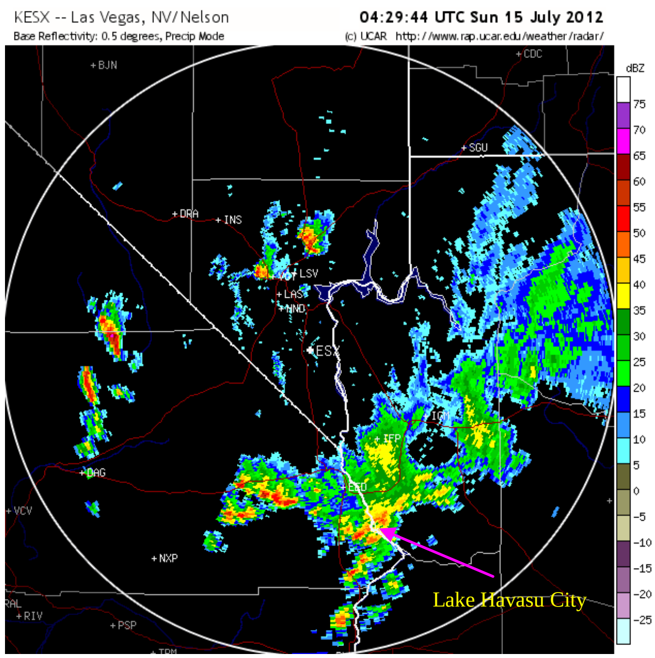


Figure 7: Radar image showing intensity of rain (reds are most intense) over the Lower Colorado River and almost centered on Lake Havasu City.

Rain in October was isolated to just the 11th and 12th, both associated with an upper atmosphere closed low pressure system, which produced a total of 0.88” (PWMF) over the north half of the city. I have used the term “cut-off low" in past annual summaries when some of those low pressure centers may have been "closed lows" instead. Both are upper atmospheric low pressure systems that form a sort of bowl or depression of low pressure (like a crater). The difference between the two is that closed lows are not completely removed from the influence of the basic westerly winds and the jet stream. A closed upper-level low that has become completely displaced (cut-off) from westerly currents, and moves independently of those currents is called a cut-off low. Cut-off low pressure centers may remain nearly stationary for days, or on occasion may move westward opposite to the prevailing flow aloft (i.e., retrogression). Close lows also move slowly and can produce a lot of rain, but that is not guaranteed. For example a closed low passed over the area from November 15th to the 17th, and although there was considerable cloudiness and the subtropical jet stream was right over us, no rain in fell Lake Havasu City from this system (Figures 9 and 10).

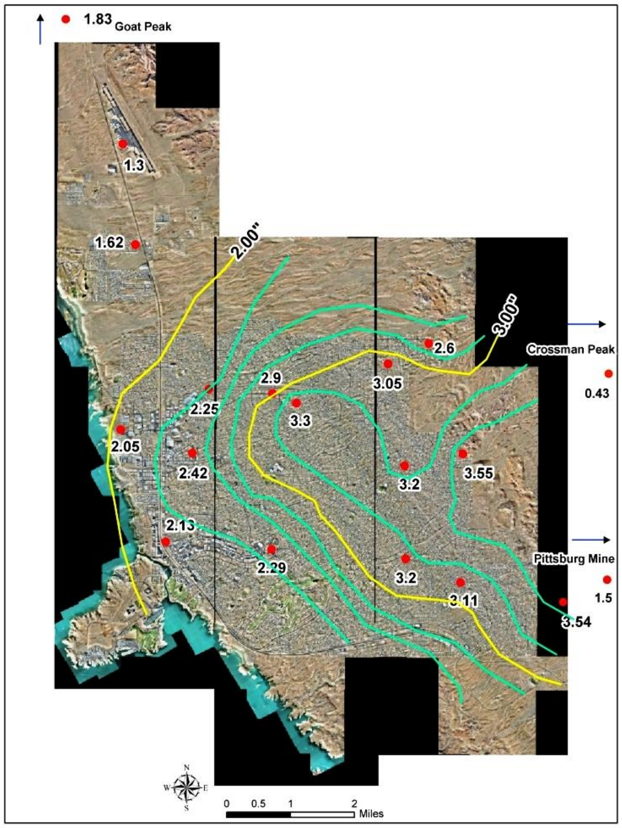


Figure 8: Rainfall amounts of the July 13 and 14 rain period. The central to south east section of the city received the most rain overall.

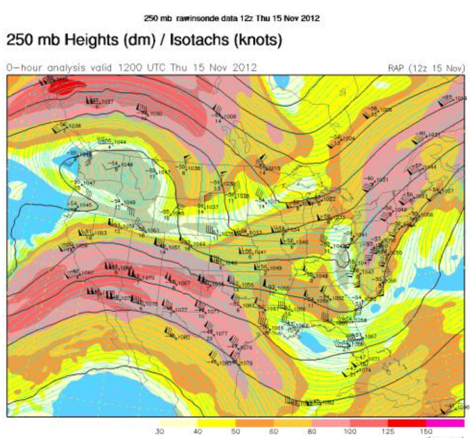


Figure 9: Upper atmosphere pressure map showing the jet streams (in red/pink) on November 15th. The southern one is almost cut off from the northern one.

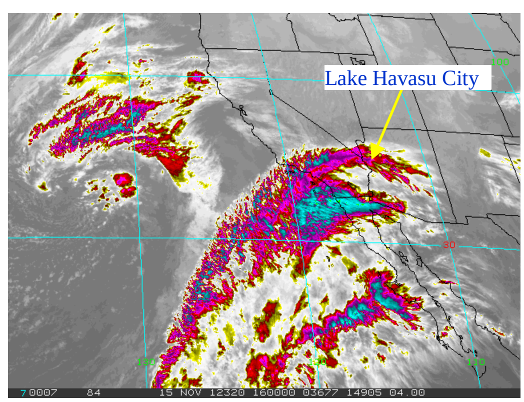


Figure 10: Infrared satellite photo of the closed low pressure system on Novemeber. 15th showing cloud temperature and associated rain (blue equals the rainiest areas).

December also had a couple of cold fronts pass through on the 14th / 15th and again on the 18th, that produced a cumulative rainfall between 1.31" to 1.85", as recorded by the five weather stations. Only two other years on record have over an inch of rain in December. The five station average of 1.60" tied the amount in 2008, but almost an inch under the 2.54" reported at the airport in 1994.

Dew Point Temperatures

Three of the five weather stations, FS5, MCC and the new airport station, record dew point temperatures and they displayed two apparent extremes to the dew point temperatures in 2012. The first may be an error; however, it is worth noting. On May 7th, extremely dry air associated with high pressure was over the region. Between 6 and 7 pm, the airport station calculated a dew point of -26^{o}F, which is by far the lowest number since dew point temperatures have been documented in the city (2003). The relative humidity at the time was 1%, which means there was essentially no water vapor in the air. To put this into perspective, the air temperature would have to fall to -26^{o}F in order to get clouds to form and rain. Although the other two stations also calculated low dew points, they were not near this extreme (4^{o}F @ FS5; 11^{o}F @ MCC). Another very low dew point recorded at the airport on June 19th (-12.7^{o}F) did correlate with another very dry air mass, but FS5 was the only other station to make a reading at the same time (23^{o}F). So it seems there may be an error in determining low dew point temperatures at the airport site. However, they seem to be on par with the other two stations in most other conditions, including the next topic.

The second extreme dew point temperature was real in the sense that during July in the heart of the monsoon season, the highest recorded dew point temperature associated with a daily high summer temperature occurred. All three stations calculated a dew point temperature over 70^{o}F on July 30th just before a monsoon storm. The air temperature at the time was 87^{o} – 88^{o}F and the relative humidities ranged from 59-61%. This was the first time a May to October daily high temperature was associated with a dew point temperature over 68^{o}F since record keeping began in 2003.

Peak Wind Speeds

For the most part, the peak winds in 2012 were typical compared with other years, yet the new airport station is revealing that the wind speeds at the airport are, on average, consistently higher than stations further south in the main part of the city (Table 2). This may not be too surprising since the airport has more open space than the land around the other three stations and is located closer to the Topock Gorge/Blankenship Wash area that tends to funnel wind movement north or south along the river. The monthly averages show that June was the windiest month in 2012 and November the least windy as is usually the case. In fact, the 6.20 mph average peak wind speed in November is the lowest average yet determined. Individually, the top wind speed recorded was in March at 59 mph (Table 3), fully 10 mph higher than the previous record set at the MCC station in March 2008. This wind speed is typical tropical storm strength.

Table 2: Peak wind speed monthly averages (mph) in 2012 for each station and the monthly composite averages.

Month	FS #5	MCC	City Hall	Airport	Average
January	8.60	8.75	7.71		**8.35**
February	9.82	10.32	9.12		**9.76**
March	10.51	10.89	9.72	12.75	**10.97**
April	10.11	10.72	9.66		**10.16**
May	10.60	11.23	10.12	13.00	**11.24**
June	10.98		10.46	12.55	**11.33**
July	9.72	9.68	9.31	11.41	**10.03**
August	8.88	8.31	8.87	10.12	**9.05**
September	7.65	6.82	7.78	9.50	**7.94**
October	7.43	6.36	7.08		**6.96**
November	5.94	4.81	6.20	7.84	**6.20**
December	7.56	6.34	6.89	9.22	**7.50**
Average	8.98		8.58		**8.78**

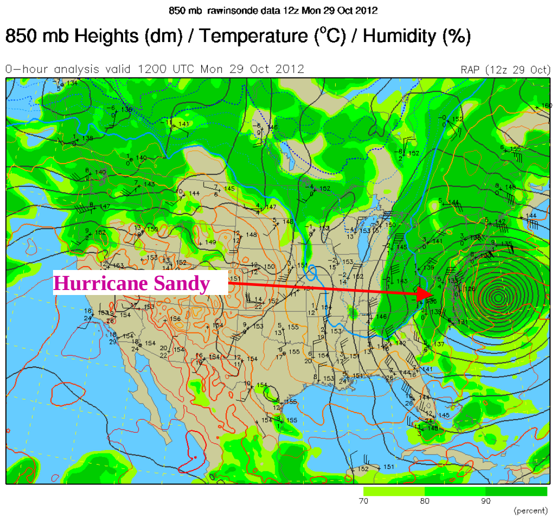
Table 3: Individual top wind speeds (mph) at each weather station for each month in 2012. Note that the airport station consistently had the highest wind speeds, when data was available.

Month	FS #5	MCC	City Hall	Airport
January	35	32	34	
February	32	31	29	36
March	40	35	36	**59**
April	36	37	33	
May	38	36	31	39
June	31		24	31
July	37	33	40	44
August	43	42	33	47
September	33	36	35	39
October	29	28	24	36
November	32	27	26	42
December	31	32	28	40

A Quick Lesson on Hurricanes and their Extent in the Atmosphere

Lastly and unrelated to weather in Lake Havasu City, I thought it would be instructive to take advantage of some information obtained during the Hurricane Sandy event and relate that to other low pressure systems that do pass over the desert southwest. As shown in upper elevation pressure maps earlier in this report (Figure 9) and in the 2011 report (Figure 10), cold fronts and closed or cut-off low pressure system that affect our weather occur over a broad vertical range from near surface to over 35,000 ft high. Hurricanes; however, occur mostly from the surface to mid-elevation levels (up to ~20,000 feet). The following pressure maps made at different elevations in the atmosphere show the distribution of Hurricane Sandy and the approaching cold front (low pressure trough) from the west (Figures 11 to 16). These maps show a particular constant air pressure in units of millibars (for example 850mb; ~4,500 feet range above the surface), which changes with elevation from place to place. The black lines, called contour lines, represent an elevation in the atmosphere where the particular air pressure occurs. The lines are not labeled with an elevation, but the general rule of thumb is the elevation (which is in decameters; 1 decameter = 10 meters) decreases towards the north. When the black lines form a U or V shape pointing south, they are representing a low pressure trough or wave (these shapes are best seen in the 500mb, 300mb and 250 mb maps below). If they point north, they represent a high pressure ridge. The distance between the contour lines represents the strength of the air pressure gradient. The closer they are together, the faster the wind speeds and air always travels from high pressure to low pressure just like pressurized air in a tire or balloon will escape quickly to the lower air pressure outside those objects if given the chance. The blue lines between the black lines on the 250 mb (~33,000 feet range) and 300 mb (~30,000 feet range) maps show the wind direction and the colors show the intensity of the wind speed, which helps to highlight the jet stream (usually purples and reds are the highest speeds and the yellow color the slower speeds – all in knots, in which 1 knot = 1.15 mph).

The next five figures illustrate the conditions in the atmosphere on October 29, 2012, a few days before during Hurricane Sandy landed on the east coast. The lower to mid-atmospheric levels indicate the dominant low pressure center of the hurricane with very closely spaced contours, but there is not an obvious indication of the cold front to the east at these levels (Figures 11 and 12). The 700 mb map (~10,000 feet range) does show a hint of the low pressure trough as indicated in Figure 12. With ascending progression into the atmosphere, the hurricane has less influence on the air pressure distribution and the low pressure trough takes over (Figures 13 to 15). In fact the pattern of the upper atmospheric pressure can dramatically impact the tropical system by weakening them if upper level winds run counter to the storm circulation, by facilitating storm strength if the opposite occurs and by simply affecting the storm’s navigation (direction and ground speed). Hurricane Sandy did not move quickly once in the mid-Atlantic states area and it gained strength through interactions with the upper level low pressure system. Figure 16 shows the upper atmospheric pressure pattern (250 mb) about a week later after the hurricane came on shore.



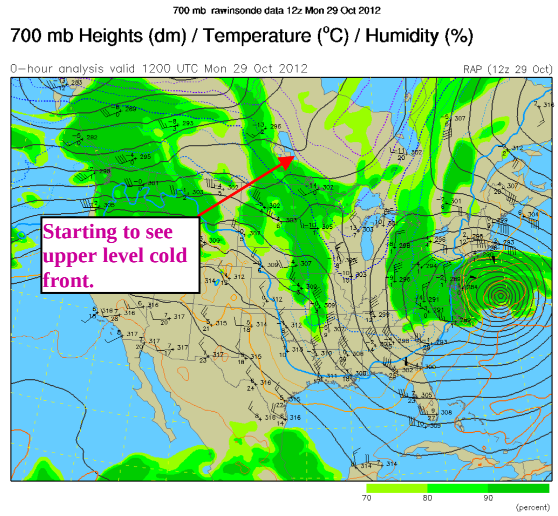
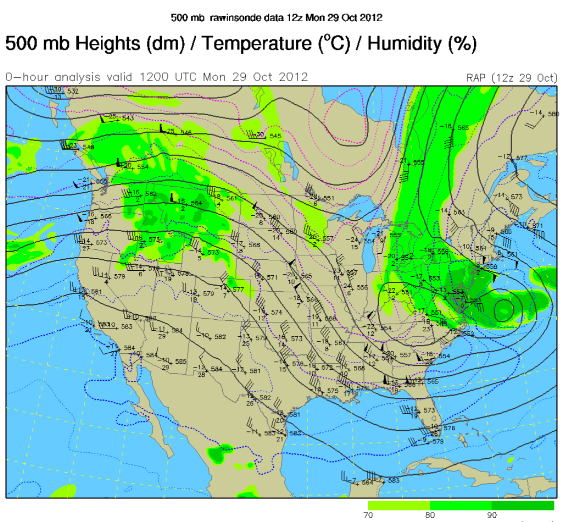


Figure 11: 850 mb air pressure map (~4500' range) showing lots of rainy regions (greens) and very tightly wound contours around Hurricane Sandy. The closeness of the contours means very high winds. (October 29, 2012)

Figure 12: 700 mb air pressure map (~10,000' range) showing the pressure gradient of Hurricane Sandy is not as strong as in Figure 11. This means the winds are less intense, but still significant at this elevation. The east moving cold front can just be seen by the dipping south contours. (October 29, 2012)



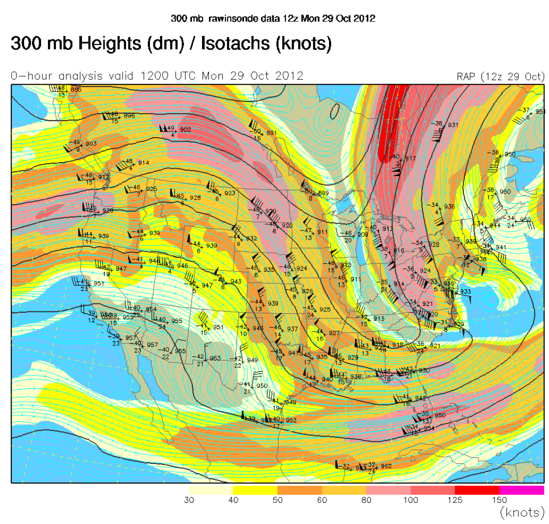


Figure 13: 500 mb map (~17,500') showing less hurricane presence and more of the low pressure trough that will move east and over the hurricane. (October 29, 2012)

Figure 14: 300 mb map (~30,000') shows almost no indication of the hurricane and dominance of the trough and jet stream flow. (October 29, 2012)

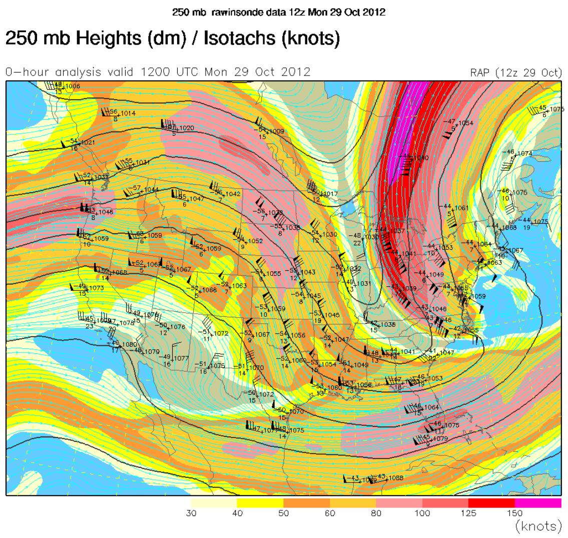


Figure 15: 250mb (~33,000') shows the jet stream pattern and the large low pressure trough extending far south. By the way, there is a broad ridge of high pressure over the western half of the country, including LHC. (October 29, 2012)

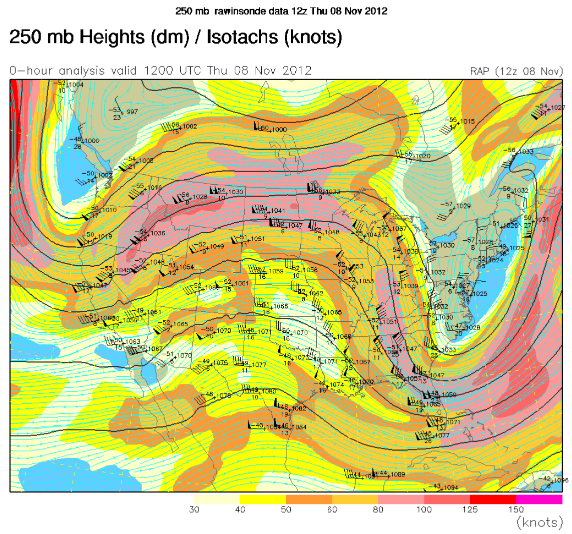
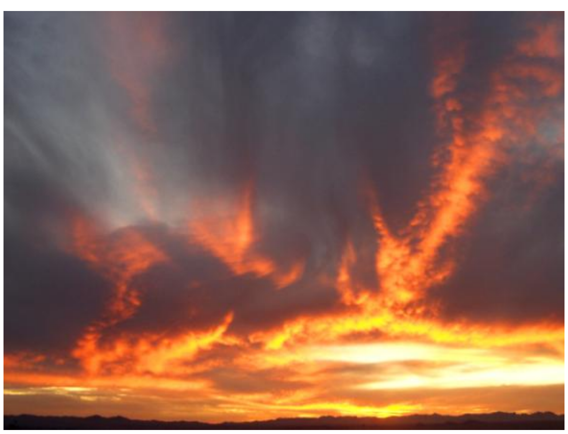


Figure 16: November 8th 250 mb map after Hurricane Sandy went on shore. At this elevation, there is no evidence that the tropical storm is present. Another low pressure trough is moving into the western U. S.

Selected sunsets over Lake Havasu City in 2012



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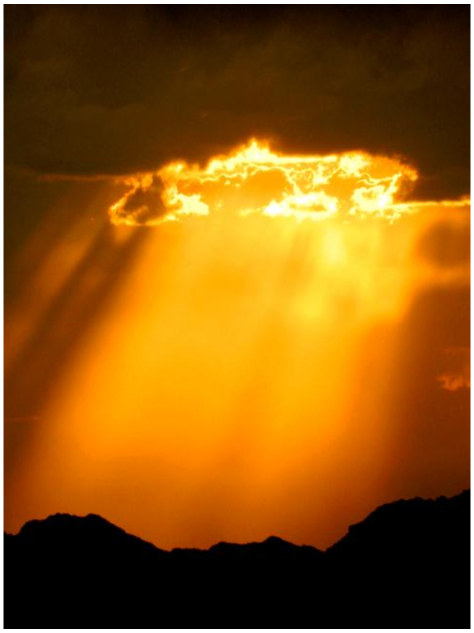
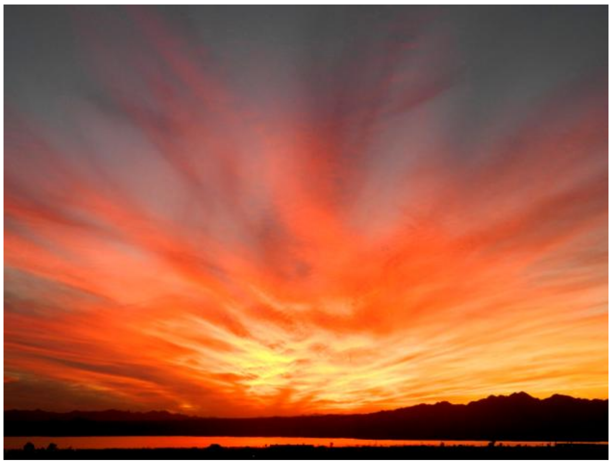
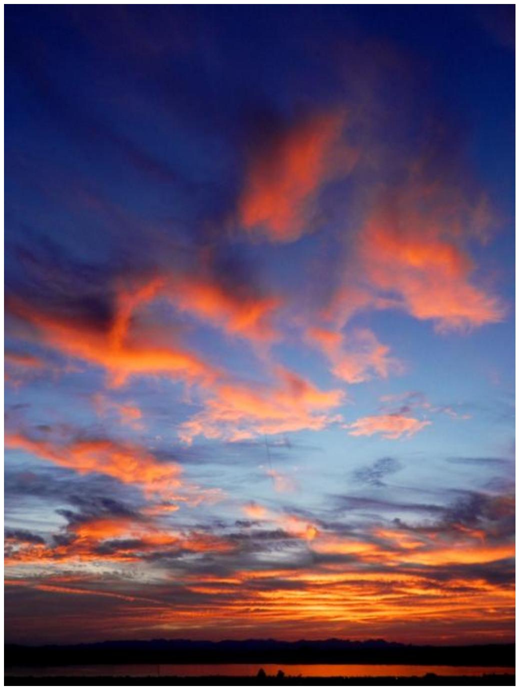
2-23-2012



8-13-2012

10-5-2012





10-6-2012

11-1-2012

11-27-2012

12-2-2012