Lake Havasu City 2015 Weather Summary

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Introduction

2015 proved again to be the warmest year on record from a global perspective. However; Lake Havasu City only experienced part of that trend during the winter months. February was the warmest ever, topping the record set by February 2014. March was close behind, being the 2nd warmest recorded and one degree cooler than March 2004. The summer was not hotter than normal, but October had the warmest overnight lows ever for that month. Rainfall was either below or above average, depending on the location of a weather station. The official station at the Operations Maintenance Facility (OMF), which sends daily high and low temperature and rainfall data to the National Weather Service, recorded more rain than normal. There were some interesting storms before during the monsoon season this year. A very early tropical system in June, a repeating low pressure system in October and monsoon storms that led to massive flood waters into the Colorado River. This also marked the beginning of one of the strongest El Nino events in recorded history that extended into 2016. The typical El Nino weather pattern changes developed and really influenced the southeastern United States and gave our area cooler, windier late fall and early winter than experienced over the last few years, but not much rainfall.

There was a slight change in reporting weather stations this year. The MCC station is no longer accessible; however, the weather station, South Lake Havasu (see previous annual summaries), was back reporting, leaving five stations in the mix this year (Fire Station #5, Airport, City Hall and OMF are the other four). The details of this year's weather are given below.

Temperatures

Globally, 2015 was the warmest year on record at 58.62°F. Lake Havasu City's 2015 mean temperature was 76.59°F, which is 1.91°F higher than the city's 37-year average of 74.68°F. That difference was skewed a little more to the overnight low temperatures (2.75°F warmer) rather than the daily high temperatures (1.06°F warmer).

The winter months in Lake Havasu City certainly seem to reflect the warming trend. Although January was not among the warmest in Lake Havasu City's history; however; it was more than 3°F above the 37-year average. When a cold front pushed through the area, the cool weather did not last very long as exemplified by the follow chart showing a rapid rebound in air temperatures at the start of the year (Figure 1). February's daily high temperature average was the highest ever recorded in Lake Havasu City at 78.15°F, beating last year's February (76.73°F). February's overnight low temperature average of 52.38°F was also the warmest on record, again beating out

February 2014 (50.73°F). March's average high temperature of 83.96°F was the third warmest on record and its overnight low temperature average was the second warmest on record at 58.57°F. These daily overnight low temperatures show a more dramatic separation from the 10 and 38 year averages than the daily high temperatures and they support a warming trend over the past two decades as seen in the separation between the 10 and 38 year averages for daily low temperatures (Figure 2).

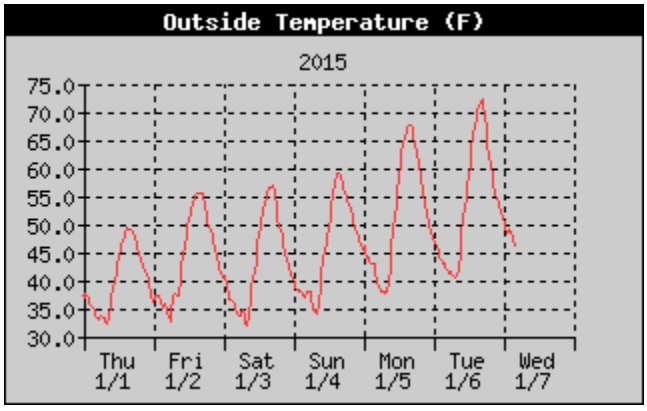

Figure 1: Temperature profile from January 1 to 7 showing a 23°F rise in daily high temperatures over that time.

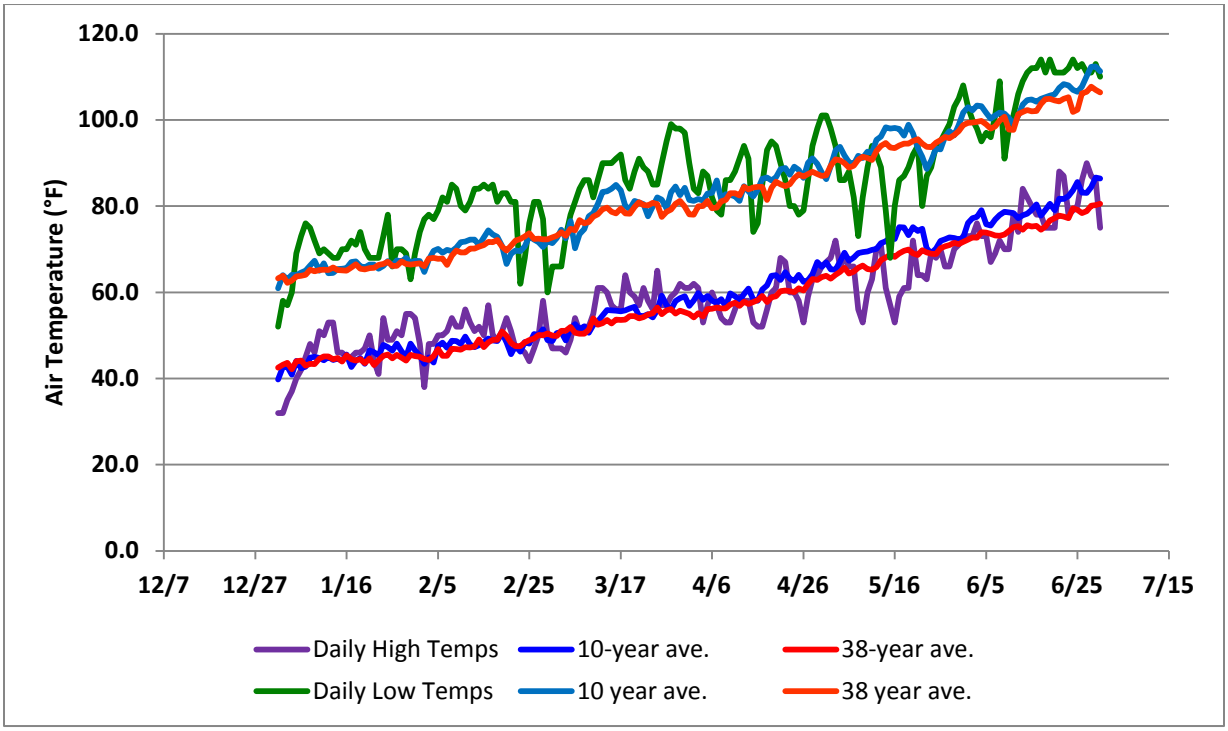

Figure 2: Daily high and low air temperatures in the first six months of 2015 and their comparison with the last 10 years and the 38 year average.

The spring and early summer seemed to buck the warming trend. April and June were average months as temperature goes, but May and July each had the coolest daily high temperatures on record. May's 89.22°F barely beat out 2010's 89.25°F and July's 104.62°F edged out 2012's 104.96°F average. Curiously, May's overnight low average of 68.17°F was about average for this month as was July's overnight low of 83.84°F, though this was the coolest since 2001. Still, there were the typical rapid temperature rises in the spring after cold fronts moved through the area (Figure 3).

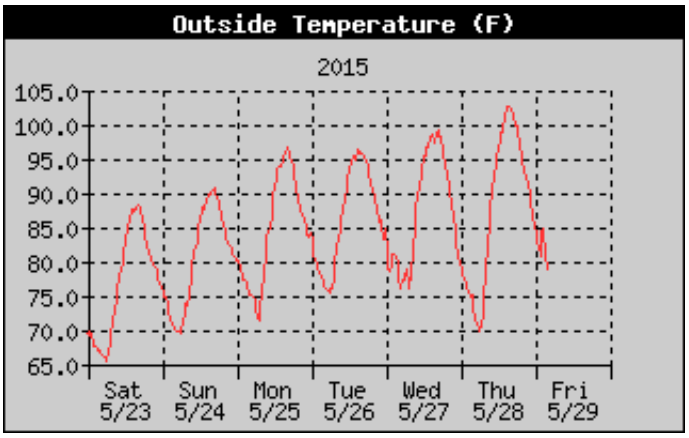

Figure 3: Late May temperature profile illustrating rapid rising temperatures after the passing of a cold front.

August began to reverse the trend again and was the second warmest in 18 years with average high temperature of 109.2°F over the five stations, yet FS#5 itself averaged 111.44°F. The overnight low average for August was the second highest ever at 87.69°F. September's daily high temperature average did not come close to breaking records, but the overnight low temperature average was the warmest on record at 81.58°F, more than a degree warmer than 80.4°F set in 1997 and a whopping 7.38°F warmer than the 37-year average. Similarly, October's daily high temperature average was a little above average, but its overnight low temperature average was the second highest on record at 69.35°F, almost 6°F warmer than the 37-year average. November was an average temperature month and December, with El Nino in full force, had the third coolest overnight average of 41.82°F with average daily high temperatures.

Eight official record temperatures were reported in 2015, four daily highs and four daily lows (Table 1). Unofficially, only one other record high temperature was recorded at 117°F, which was reported from the Fire Station #5 station (FS#5). There were also six temperature ties for record, four high temperatures and two low temperatures.

Table 1: Record and tied-record temperatures reported in 2015.

Date	Temperature	Previous Record	Weather Station	Comments
2/8/15	85°F	81°F in 2006	OMF	Record daily high temp.
2/13/15	84°F	tied	OMF	
2/14/15	84°F	tied	OMF	
2/20/15	83°F	tied	OMF	
3/28/15	99°F	97°F in 1986	OMF	Record daily high temp.
3/29/15	98°F	94°F in 1986	OMF	Record daily high temp.
3/30/15	98°F	96°F in 2004	OMF	Record daily high temp.
6/15/15	115°F	tied	FS#5	
6/17/15	117°F	115°F in 1985	FS#5	Unofficial Record daily high
11/29/15	37°F	39°F in 1990	OMF	Record low daily temp.
11/30/15	38°F	38°F - tied	OMF	
12/1/15	38°F	38°F - tied	OMF	
12/4/2015	38°F	39°F in 1993	OMF	Record low daily temp.
12/16/15	34°F	35°F in 1979	OMF	Record low daily temp.
12/28/15	31°F	31°F - tied	OMF	Record low daily temp.

The first 100°F day this year was on April 29th and the first temperature at or above 110°F was on June 14th at 111°F. The highest temperature recorded from any of the five weather stations was 119°F at FS#5 on August 16th. The official highest temp was 117°F the same day and the day before at the OMF weather station.

There were 111 days at or above 100°F, which was the fewest since 2010 and only the third lowest since 1998. There were 35 days at or above 110°F, which was higher than last year's all time low of 19 days, but still somewhat below average.

The official coldest temperature of the year was 31°F on December 28th, which tied a record for that date. There were 18 days with low temperatures below 40°F, cooler than last year's 9 days. On the other side of the coin, there were 11 days with overnight official lows above 90°F and no days at or above 95°F. Unofficially, at FS#5, two days had overnight lows above 95°F.

Precipitation

Lake Havasu City received an average amount (based on the five reporting stations) of precipitation in 2015 at 4.14 inches. The actual recorded results ranged from 4.91 inches at the official station (PWMF) to 3.33 inches at the Fire Station #5 weather station. The range is mostly due to widely scattered thunderstorms received during the spring and monsoon season. The most active months were January, March, June, and October with September the only month of the year not receiving any measureable rain. January held the top spot for the amount of rain

in 2015, averaging 0.94 inches. Some of that rain came with a closed or cut-off low pressure system (Figure 4). March rains consisted of one intense classic cold front on March 1st and 2nd over a 19 hour period. The upper atmosphere 250mb pressure map (at ~42,000 feet elevation) looked pretty impressive as the jet stream followed a south pointing sharp bend in the pressure trough (Figure 5).

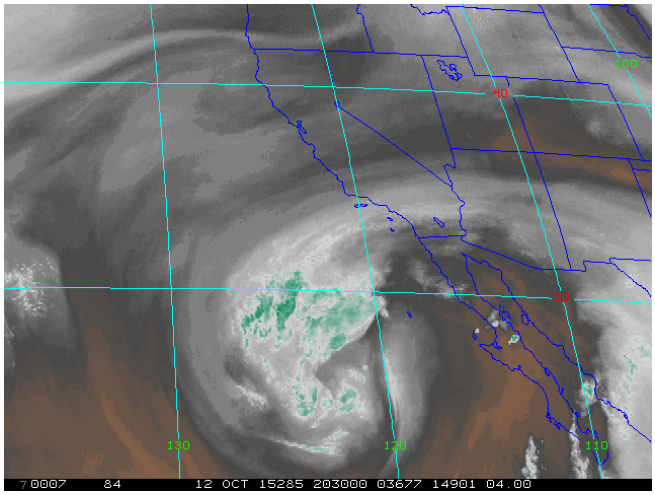

Figure 4: Water vapor image of a cut-off low pressure system hanging out off the southern California/Mexican coast with a streamer of humidity and rain extending east over the Lake Havasu City area and beyond.

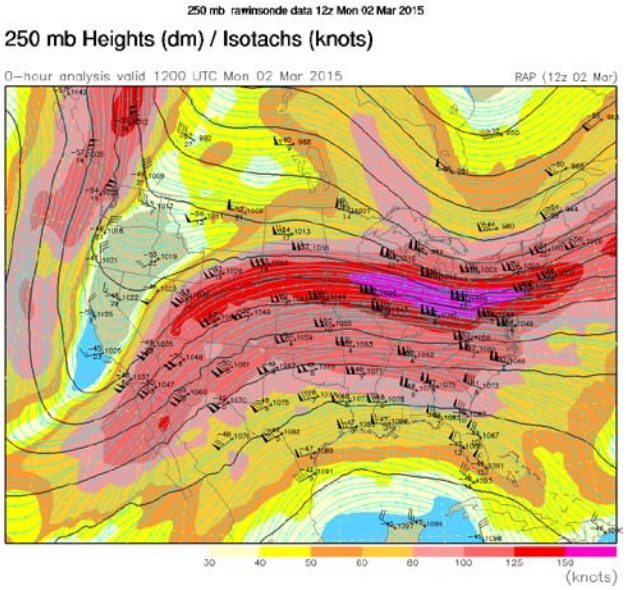

Figure 5: Upper atmosphere 250 mb pressure map showing a narrow low pressure trough over the western U.S. that brought rain to the region and Lake Havasu City. The red and purple colors indicate the fastest winds in the jet stream.

As mentioned in earlier annual summaries, rain in June in this part of the world is essentially non-existent, yet up to 0.23 inches were recorded (at the PWMF station) in the city and 0.12 to 0.22 inches at the other stations. The remnants of Hurricane Bianca, which was once a category 4 storm in the Pacific, drifted over the desert southwest and provided rain over the region June 9th and 10th (Figure 6). This was the earliest in the year a tropical storm has drifted over this region since records were kept in Lake Havasu City. Furthermore, this was only the second time in 46 years that those two dates recorded any rainfall. A Mohave County rain gauge in the Mohave Mountains recorded 0.32" with this event. The storm also ushered in an early monsoon season as dew point temperatures and humidity rose and stayed throughout the summer and early fall. Scattered thunderstorms came into the area in the middle of June (13th) and at the end of the month June (30th and July 1st) and left up to 0.10" of rain, truly one of the wettest Junes recorded.

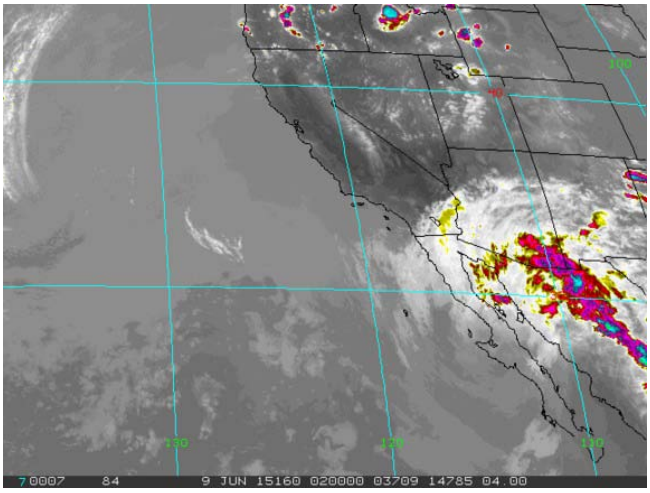

Figure 6: Remnants from Hurricane Bianca drifting over the desert southwest in early June, which brought rain into the Lake Havasu City area.

As will be shown later, the monsoon season lasted until late October, but July and August were the wettest part of the season. At the end of July the monsoonal flow from the southeast (Gulf of Mexico and Gulf of California) was well illustrated on satellite imagery as the four corners high was actually over the Texas and Oklahoma panhandles (Figure 7A and 7B). About two weeks later in August, the four corners high pressure dome had drifted west and set itself up very strongly over the Four Corners (where it usually sits), rotating humid tropical air from the south (mostly from the Gulf of California) in our region (Figure 8).

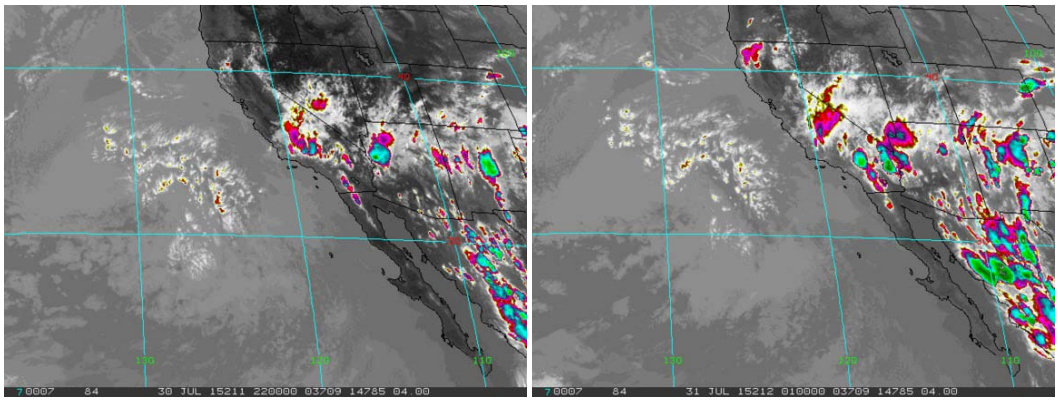

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Figure 7: Infrared satellite images showing convective thunderstorm development during monsoonal flow from the southeast. These images were taken 3 hours apart.

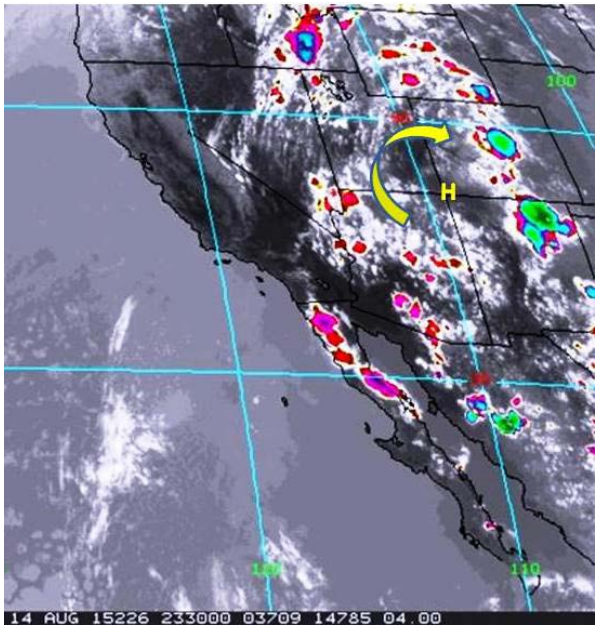

Figure 8: Infrared satellite image of the Four Corners high pressure dome (H) in August showing the circulation of humid, tropical air that creates convective thunderstorms during the monsoon season.

Curiously, no rain fell in September in the Lake Havasu area, but small amounts did occur just to the north. October had a significant rainfall amount, averaging 0.87 over the five weather stations and those rain events were spread out through the month. One of the very unique weather patterns experienced this year was an upper level closed low pressure system that slowly drifted east to west Texas after providing up to 0.59” (City Hall weather station) to the area on

October 5th. A closed low pressure system, as distinguished from the low pressure trough commonly associated with cold fronts, has a distinct center of cyclonic circulation whose isobar contours are closed loops on an air pressure map, but the low is still somewhat connected to the jet stream (Figure 9A). It is pulling away from the jet stream. What made this system unique is it then became detached (cut-off) from the jet stream (it is no longer steered by the jet stream – Figure 9B) and drifted south into Mexico and then west to the Pacific Ocean (called retrogression) and then slowly drifted east again to give our area a second shot of rain on October 16th. This is very uncommon to get a double shot of rain from the same system. The maps on the next couple of pages show the sequence over the 11 days (Figure 10 A-D). Yet another closed low pressure system developed later in the fall, but it only produced a minor amount of local precipitation.

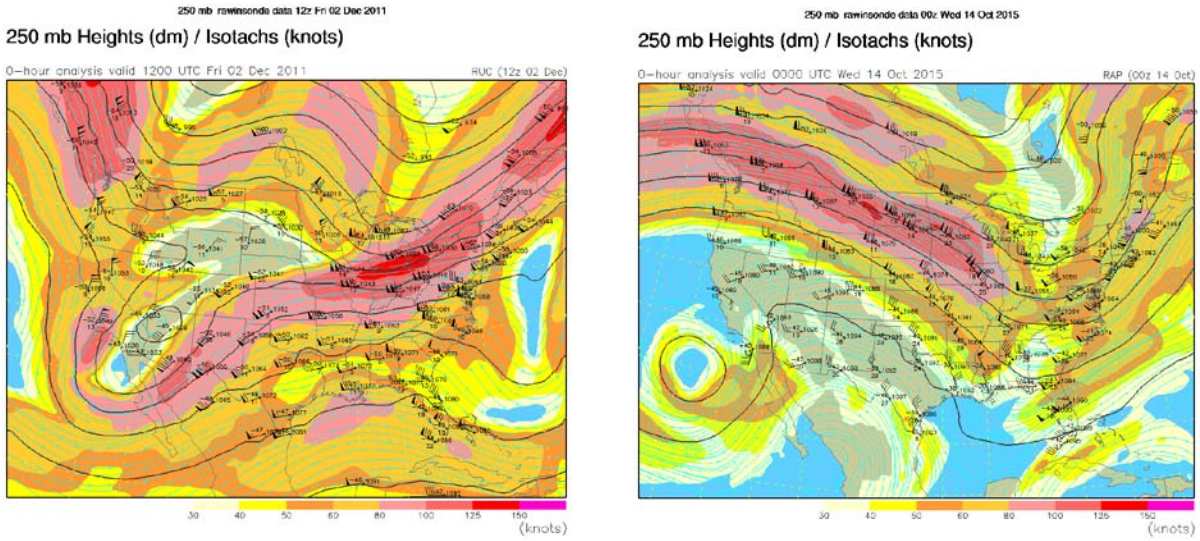

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Figure 9: Upper atmosphere 250 mb air pressure maps showing a closed low pressure bulls eye in December 2011 (note the black elevation loop centered over NW Arizona) compared to the cut-off low pressure bulls eye on October 14, 2015.

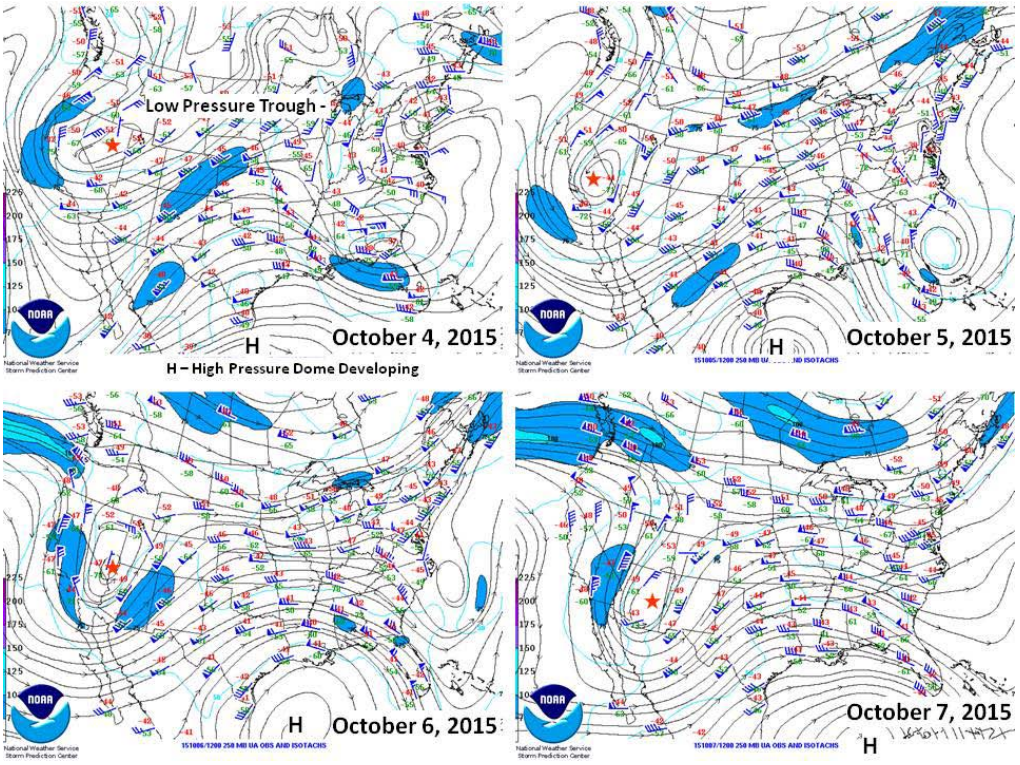

Figure 10A: Development and movement of a closed low pressure system (Orange star).

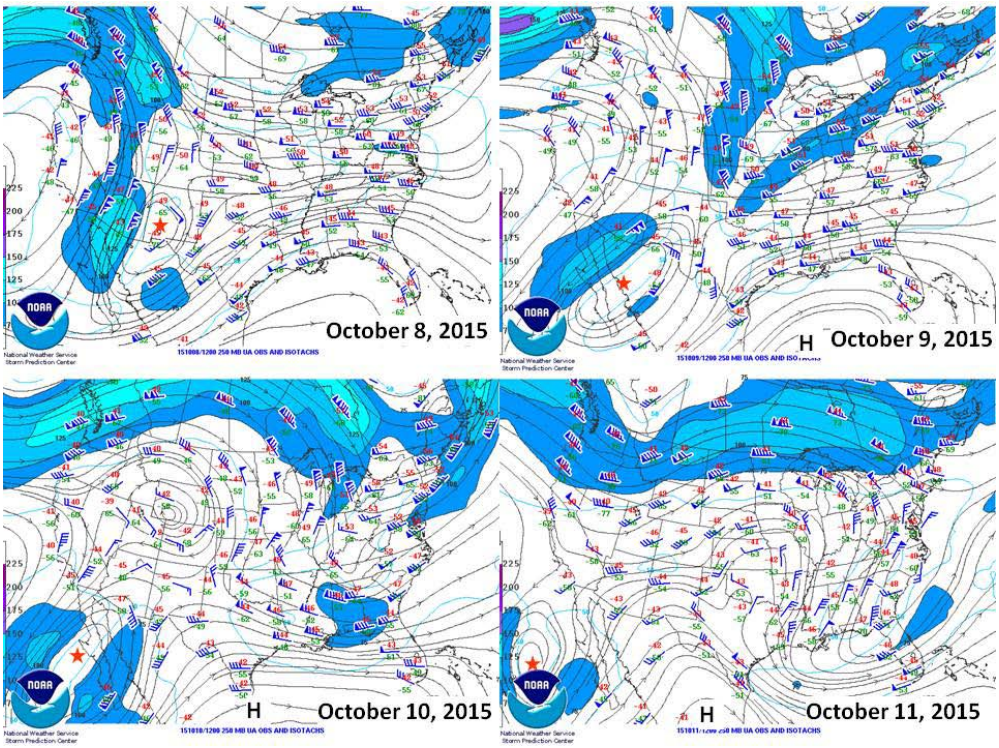

Figure 10B: The low pressure system is blocked and push west by high pressure (**H**) originating in the Gulf of Mexico and continues to cut itself off from the jet stream (blue).

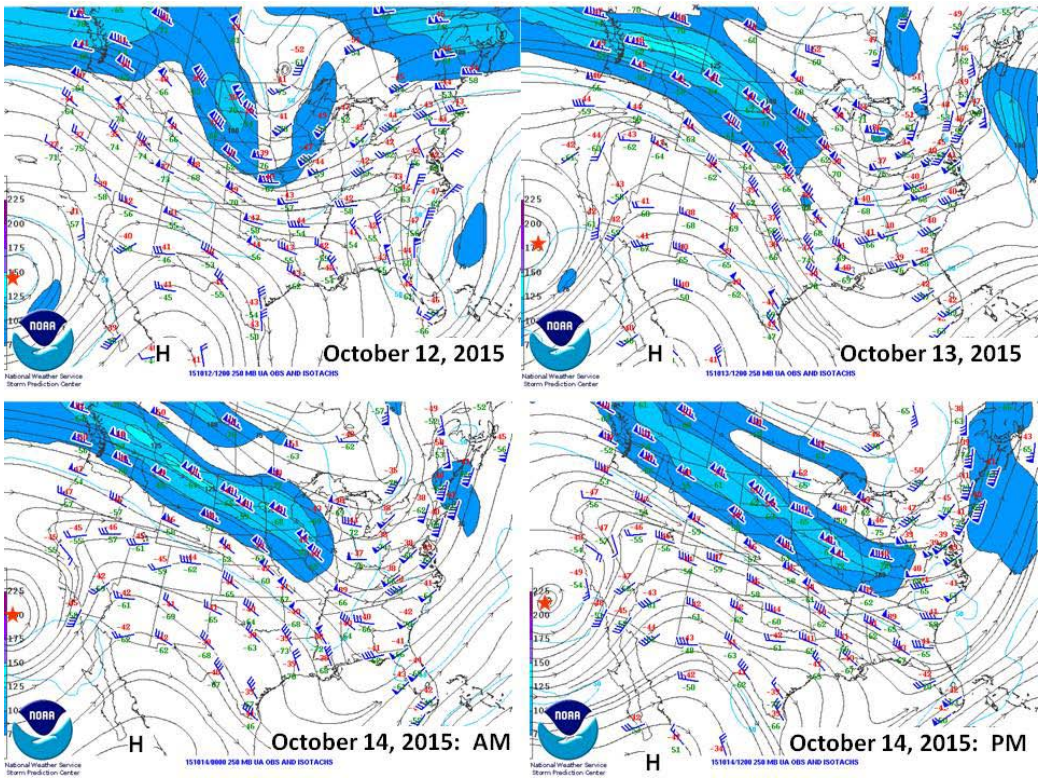

Figure 10C: Totally cut-off from the jet stream, the low meanders without a steering mechanism.

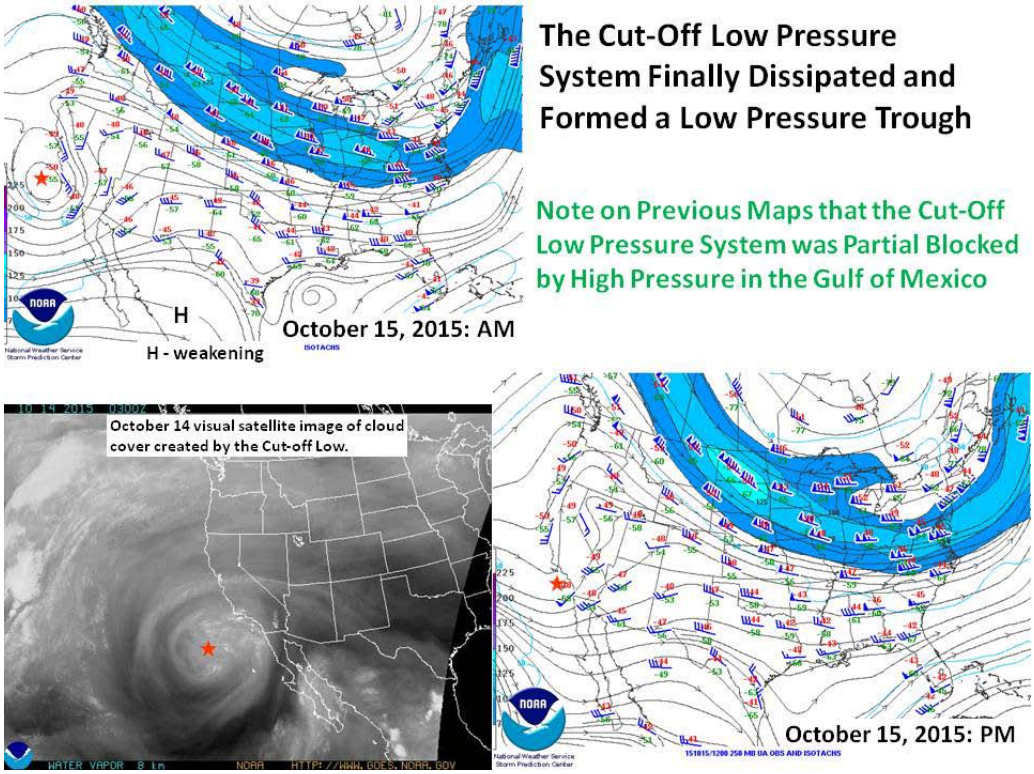

Figure 10D: The cut-off low begins to reconnect with the jet stream and forms a trough.

Although not emphasized in earlier reports, the Mohave County Flood Control District has set up an impressive array of rain and flood gauges throughout the county including 10 rain gauges in the Lake Havasu area (this includes the City Hall weather station). These rain gauges provide an opportunity to delineate the rainfall patterns of individual storms and over any period of time. The 2015 annual rainfall average given above is derived from the established weather stations in the city, but when considering the surrounding area, that value changes (Table 2). Rain amounts in the upper elevations of the Mohave Mountains are at or above seven inches for the year. Orographic lifting of warm, moist air to cooler environs accounts for some of the differences. However, the wide variance of some stations in a given month illustrate that even with a blanketing of clouds from a cold front or particularly, from monsoon derived scattered thunderstorms, that rain amounts are random outside of the gross elevation differences.

Table 2: 2015 Precipitation monthly totals (in inches) for 14 rain gauges in the Lake Havasu City area. Note that the rainfall amounts in the upper elevations

Elevations	472'	503'	1057'	730'	716'	4688'	2410'	1260'	682'	605'	675'	2395'	1045'	1556'	
	PWMF	LHCFS	LHC South Side	City Hall	Airport	Crossman Peak	Pittsburg Mine	Horizon Six	Desert Hills	Crystal Beach	North Havasu	Ram Peak	Castle Rock Wash	Mohave Mtns.	Ave. Monthly
January	1.20	0.92	0.89	0.92	0.78	1.28	1.24	0.80	0.96	1.00	1.06	0.76	1.04	1.04	0.99
February	0.18	0.10	0.12	0.12	0.15	0.20	0.12	0.08	0.16	0.16	0.16	0.16	0.20	0.24	0.15
March	1.01	0.75	1.23	0.92	0.81	1.60	1.92	1.12	1.08	1.08	0.92	1.48	1.28	1.64	1.20
April	0.97	0.10	0.13	0.16	0.17	0.36	0.40	0.16	0.12	0.20	0.20	0.04	0.36	0.20	0.26
May	0.07	0.04	0.08	0.16	0.07	0.92	0.44	0.00	0.04	0.00	0.00	0.00	0.08	0.04	0.14
June	0.23	0.14	0.22	0.12	0.13	0.08	0.08	0.04	0.12	0.04	0.20	0.16	0.08	0.32	0.14
July	0.21	0.22	0.38	0.52	0.87	0.64	1.20	0.40	0.44	1.08	0.40	0.36	1.04	1.32	0.65
August	0.17	0.12	0.05	0.32	n/a	0.28	0.16	0.00	0.04	0.08	0.12	0.08	0.12	0.16	0.13
September	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.24	0.02
October	0.71	0.76	0.85	1.16	0.89	1.32	1.28	0.72	0.64	0.84	0.92	1.08	1.48	1.40	1.00
November	0.10	0.00	0.06	0.00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.02
December	0.06	0.18	n/a	0.04	n/a	0.28	0.28	0.08	0.12	0.12	0.04	0.20	0.16	0.36	0.16
Yearly Total	4.91	3.33	4.01	4.44	3.88	7.00	7.12	3.40	3.72	4.60	4.02	4.40	5.96	6.96	4.84

Humidity-Dew Point Temperatures and Monsoon

Unlike many previous years, there were no extremely dry periods (<2% RH and < -5oF). There was only one recorded negative dew point temperature (-0.3^{o}F on April 4th) in 2015 and the lowest recorded relative humidity of the year was 3% on June 19th, which is not unusual for June. Yet, summer humidity seemed to arrive a bit early in 2015 with the remnants of Hurricane Bianca in early June. The humidity bounced up and down over the next couple of weeks, but by

the end of June, monsoon humidity was in full swing. The monsoon period usually lasts about 90 days and it usually has a ragged end with the passing of weak cold fronts in September. This year's season lasted much longer (>120 days) though it was punctuated with less humid intervals (Figure 11). A slow, but steady decline over a two week period at the end of October marked the end of the high humidity and dew point temperatures. This year's monsoon event continued a recent trend of extended high humidity before and after the traditional start and end of the monsoon season, one of two noticeable side effects of regional climate change (the other is higher overnight low temperatures mentioned earlier).

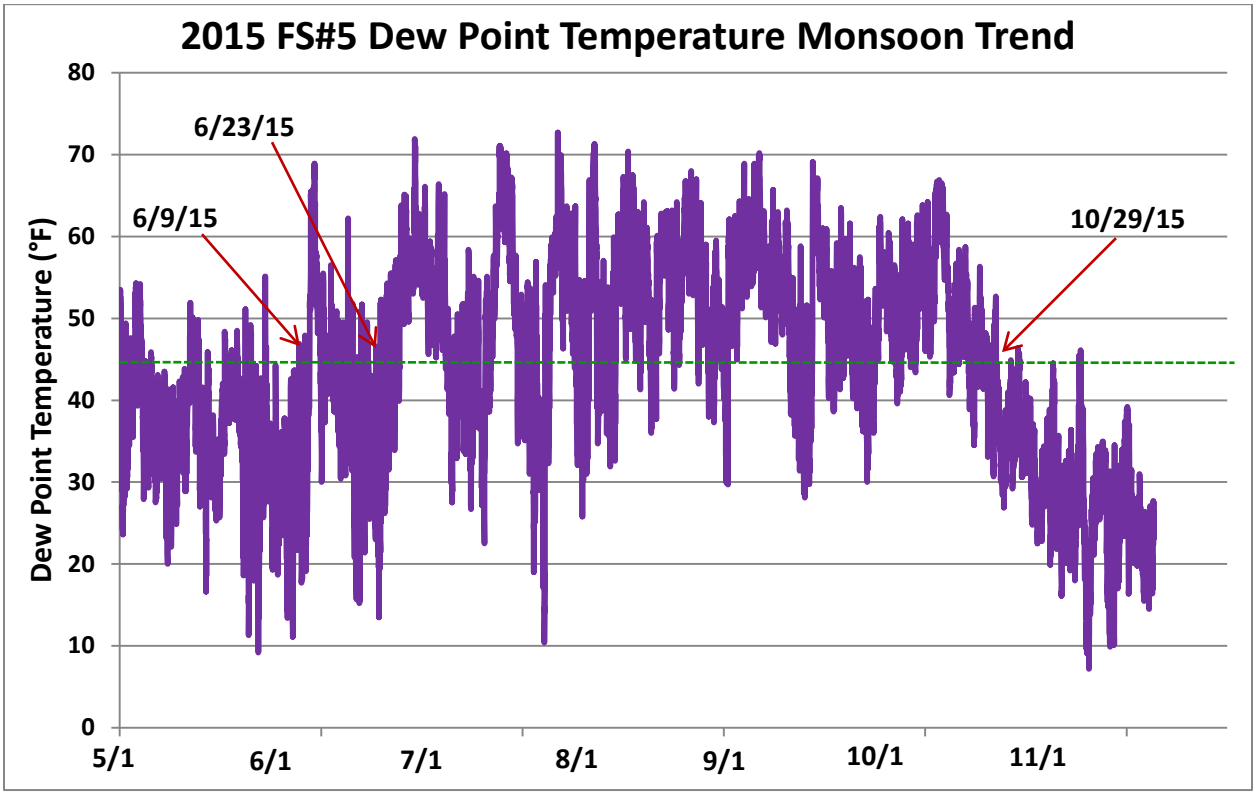

Figure 11: Dew point temperatures in 2015 from Fire Station #5 weather station over the period from May through November. The green dashed line is the 45°F mark in which evaporative coolers become progressively inefficient.

Peak Winds

Wind speeds in the Lake Havasu area may typically reach 35-40 mph during and right after a cold front passing through the area or during a thunderstorm in monsoon season. However, two stations this year, the Airport and South Lake Havasu, recorded wind gusts of 60 (6/13/2015) and 64 (7/30/2015), respectively. These are the highest gusts recorded since wind speeds were

regularly monitored beginning in 2003 and both came from convective thunderstorms related to tropical/monsoonal weather. The airport weather station also experienced a 51 mph peak wind in September and is month to month the windiest location of the four stations recording wind speed (Table 3). In 2015, May was the windiest month and January the least windy month.

Table 3: Monthly average of peak wind speeds for four weather stations recording wind speed. The airport monthly and annual averages are consistently higher than the other three stations.

Month	LHCFS	MCC	City Hall	Airport	ave.
January	6.14	5.36	6.86	8.30	6.66
February	6.05	6.04	7.43	7.83	6.84
March	7.71	6.66	7.99	9.38	7.93
April	10.01	9.71	9.91	12.07	10.43
May	11.29	10.32	10.69	12.36	11.17
June	10.44	9.86	10.32	n/a	10.20
July	10.78	9.62	10.35	12.51	10.82
August	10.32	9.41	9.87	n/a	9.87
September	9.23	8.89	8.78	10.83	9.43
October	7.56	n/a	7.54	9.78	8.29
November	9.28	7.50	8.78	11.10	9.16
December	7.98	n/a	8.16	n/a	8.07
Yearly Average	**8.90**	**8.34**	**8.89**	**10.46**	**9.07**

2015 Weather in Photos

Throughout the year, there were some interesting cloud formations, beautiful sunsets and some combination of both along with active weather. The following photos show examples of selected cloud types, virga, lightening, isolated showers, and the sun through a dusty, hazy sky at sunset, sun rays through clouds and below the horizon after sunset, and the smoke column from the Willow Fire in Mohave Valley. All photos were taken within LHC city limits.

Figure 12: Thin, morning fog layer over Chemehuevi Valley on 2-23-2015.

Figure 13: Altocumulus clouds near sunset on 2-28-2015.

Figure 14: Virga “over” the Turtle Mtns. looking from LHC at sunset 3-3-2015.

Figure 15: Clouds over Chemehuevi Mtns. look like a volcanic eruption plume (May 2015).

Figure 16: Sunrays after sunset over Chemehuevi Mtns. 7-7-2015.

Figure 17: Sunrays through clouds and a shower from a relatively small cumulonimbus cloud over the Chemehuevi Mtns. in the late afternoon 7-17-2015.

Figure 18: Morning virga from stratus clouds that have an ill-defined mammatus base 8-1-2015.

Figure 19: This is the smoke from the Willow Fire in Mohave Valley 8-8-2015. The view shows that once the smoke reaches a certain elevation, the much stronger winds aloft carry it eastward.

Figure 20: Lightening strike in LHC during a monsoon storm 8-13-2015. The object silhouetted near the ground is a palm tree, which was not hit during the storm.