Storm Signals

Houston/Galveston National Weather Service Office

Volume 81 Summer 2009

First Half of 2009 Trends Drier and Warmer Than Normal

By Charles Roeseler

JANUARY						
SITE	AVG HIGH	AVG LOW	AVG MONTH	DEP	RAIN	DEP
IAH	66.5	41.4	53.9	+2.1	0.49	-3.19
GLS	64.5	48.1	56.3	+0.5	0.34	-3.74
CLL	66.0	39.6	52.8	+2.6	0.70	-2.62
HOU	66.9	43.6	55.2	+0.9	0.37	-3.88
PSX	67.0	42.3	54.6	+1.7	0.15	-3.03
CXO	65.6	36.9	51.3	+1.4	0.62	-3.59
UTS	64.7	39.9	52.3	+3.5	0.55	-3.73
LVJ	66.4	41.9	54.2	-0.6	0.38	-2.64
SGR	68.0	40.8	54.4	+0.3	0.30	-3.66
DWH	66.8	39.1	53.0	-1.1	0.50	-2.54
LBX	68.0	40.2	54.1	-0.1	0.25	-4.51
HGX	65.5	42.3	53.9	+0.5	0.26	-5.17

The first half of 2009 will be noted for its extremes. January and February were rather warm and dry. Rainfall returned to normal levels in March. Several freakish rainstorms developed in April. These storms produced extreme rainfall, sometimes in excess of 6 inches per hour. Hobby Airport recorded its wettest April in history while Intercontinental Airport had its third wettest April. It is either feast or famine with regard to rainfall. Famine returned in May and June. Rainfall was rather sparse in these months. Houston had its eight driest May on record. If not for the extreme rain in April, the annual rainfall deficit would have run 10 to 12 inches below normal. Drought conditions were exceptional to extreme across the southwest half of the region. Communities like Edna, Danevang, Bay City and Lake Jackson had yet to receive 10 inches of rain for the year. The two month rainfall total of May and June was one of the driest on record for many communities across Southeast Texas, including Houston.

January was warmer and drier than normal. Due to a building drought which began in December, fire weather hazards were increasing. Cold fronts crossed the area but these fronts did not have much moisture to work with so very little rain was produced. The fronts did usher in drier air and stronger winds which ultimately increased the threat for wildfires.

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FEBRUARY						
SITE	AVG HIGH	AVG LOW	AVG MONTH	DEP	RAIN	DEP
IAH	72.4	50.0	61.2	+5.8	1.52	-1.46
GLS	68.6	55.4	62.0	+4.0	1.05	-1.56
CLL	72.6	48.2	60.4	+5.9	0.68	-1.70
HOU	71.9	52.3	62.1	+4.4	1.18	-1.83
PSX	72.0	51.8	61.9	+6.1	0.72	-1.73
CX0	72.1	44.9	58.5	+4.9	1.17	-1.74
UTS	71.1	48.0	59.6	+6.6	1.65	-1.49
LVJ	71.0	51.4	61.2	+5.2	1.90	-0.92
SGR	73.5	50.2	61.8	+5.8	1.83	-1.29
DWH	73.1	47.6	60.4	+5.5	1.53	-1.36
LBX	72.5	49.5	61.0	+4.7	0.43	-4.33
HGX	69.8	51.8	60.8	+4.1	1.58	-1.87

First Half of 2009 Trends Drier and Warmer Than Normal continued

MARCH						
SITE	AVG HIGH	AVG LOW	AVG MONTH	DEP	RAIN	DEP
IAH	73.2	52.5	62.8	+0.5	4.08	+0.72
GLS	70.1	57.1	63.6	-0.5	3.73	+0.97
CLL	73.2	51.1	62.2	+0.6	5.07	+2.23
HOU	72.9	54.1	63.5	-0.7	2.52	-0.67
PSX	73.3	55.5	64.4	+2.3	2.07	-0.63
CXO	72.1	48.9	60.5	-0.6	4.14	+1.23
UTS	71.5	50.2	60.8	+0.3	3.31	-0.16
LVJ	72.0	52.7	62.4	-0.4	2.13	-0.02
SGR	74.2	52.4	63.3	+0.3	3.91	+1.42
DWH	73.1	50.1	61.6	-0.6	4.76	+2.18
LBX	73.7	51.6	62,6	-0.1	1.57	-3.19
HGX	70.7	52.6	61.7	+0.0	2.17	-1.34

APRIL						
SITE	AVG HIGH	AVG LOW	AVG MONTH	DEP	RAIN	DEP
IAH	78.6	58.6	68.6	+0.1	10.38	+6.78
GLS	76.0	63.9	70.0	0.0	5.23	+2.67
CLL	78.2	57.2	67.7	-0.2	6.11	+2.91
HOU	78.5	60.6	69.6	-0.4	15.61	+12.15
PSX	79.1	62.3	70.7	+2.2	2.02	-0.78
CXO	77.5	53.6	65.6	-1.8	7.54	+3.70
UTS	76.5	56.1	66.3	-0.9	6.53	+3.03
LVJ	77.9	59.0	68.4	-1.0	16.61	+13.84
SGR	79.0	58.9	68.9	-1.7	8.10	+5.48
DWH	78.2	56.7	67.4	-2.5	9,59	+6.67
LBX	78.8	57.6	68.2	-1.6	3.40	-0.37
HGX	76.5	59.0	67.8	0.0	13.63	+9.64

February temperatures were quite warm. Temperatures were 4 to 6 degrees warmer than normal. Both College Station and Houston Hobby Airport recorded their sixth warmest February on record. A few strong thunderstorms rolled through the region on the 1st. These storms produced nickel size hail in Galveston and Walker counties. Other strong storms rolled through the region on the 11th, bringing gusty winds and producing damage. Trees and power lines were down in Houston and Montgomery counties.

March started out dry but rainfall returned during the mid and latter half of the month. Rainfall for the month was generally near to slightly above normal. Temperatures were generally near normal for the month. Strong thunderstorms on the 25th and 26th produced wind damage in Montgomery, Walker, San Jacinto and Liberty counties.

MAY						
SITE	AVG HIGH	AVG LOW	AVG MONTH	DEP	RAIN	DEP
IAH	87.6	68.7	78.2	+2.5	0.38	-4.77
HOU	86.9	70.6	78.8	+1.9	0.66	-4.45
GLS	84.0	73.3	78.7	+1.9	0.19	-3.51
CLL	87.0	68.1	77.6	+2.2	1.41	-3.64
PSX	86.5	71.2	78.9	+3.2	5.69	+1.14
UTS	86.7	65.8	76.3	+1.9	1.73	-3.35
CXO	86.5	64.7	75.6	+1.0	2.31	-3.31
LVJ	86.1	69.5	77.8	+1.7	1.54	-2.21
LBX	86.1	67.6	76.9	+0.6	1.10	-3.66
DWH	86.6	66.5	76.5	+0.4	2.34	-0.42
SGR	88.0	68.6	78.3	+1.1	0.32	-3.30
HGX	84.7	69.3	77.0	+1.6	1.51	-3.07

An active weather pattern prevailed during April. Thunderstorms erupted on the 12th and produced large hail and wind damage across Harris and Liberty counties. Strong to severe storms developed on the 18th. Damaging winds knocked down trees and power lines in Wharton and Galveston counties. The storms began to cluster over parts of southeast Harris and northern Galveston counties. This resulted in very heavy rain over parts of Friendswood and League City. A one hour rainfall total of 6.9 inches fell at a gage located at FM 528 and Clear Creek. There were several reports of daily rainfall exceeding 10 inches in League City and Friendswood. A week later, another cluster of storms developed with additional reports of heavy rain. Over 4 inches of rain fell on the south side of Houston. A third heavy rain event developed on April 27th and 28th. This heavy rain affected parts of western and northwest Harris County. Parts of Jersey Village received around 10 inches of rain while other pockets of heavy rain affected Addicks Reservoir. Houston Hobby Airport had its wettest April in history and Houston Intercontinental Airport had its third wettest April.

First Half of 2009 Trends Drier and Warmer Than Normal continued

JUNE						
SITE	AVG	AVG HIGH	AVG LOW	DEP	RAIN	DEP
IAH	96.7	74.6	85.6	+4.3	0.27	-5.08
HOU	94.8	74.8	84.8	+2.5	1.39	-5.45
CLL	97.5	74.5	86.0	+4.4	TRACE	-3.79
GLS	89.7	79.0	84.4	+2.5	0.32	-3.72
PSX	89.8	77.8	83.8	+2.7	0.02	-4.29
CXO	95.9	69.7	82.8	+2.0	0.14	-4.44
UTS	96.9	73.6	85.3	+4.7	0.19	-4.47
LVJ	92.8	72.6	82.7	+1.4	1.27	-6.18
SGR	96.4	72.9	84.7	+3.0	0.78	-4.26
DWH	95.0	71.7	83.4	+2.7	TRACE	-7.26
LBX	92.1	71.6	81.8	+1.0	0.62	-4.14
HGX	91.6	73.7	82.7	+2.4	0.87	-6.49

JULY						
SITE	AVG	AVG HIGH	AVG LOW	DEP	RAIN	DEP
IAH	96.8	77.9	87.4	+3.8	2.84	-0.34
HOU	96.1	77.4	86.7	+2.2	3.62	-0.74
CLL	100.7	77.5	89.1	+4.5	2.42	+0.50
GLS	91.9	80.6	86.2	+1.9	2.72	-0.73
PSX	91.8	81.3	86.5	+3.1	TRACE	-3.99
CXO	96.6	74.1	85.4	+1.9	2.46	-0.78
UTS	98.1	76.6	87.4	+3.8	2.60	-0.07
LVJ	94.7	75.6	85.2	+2.6	4.20	-0.88
SGR	99.1	76.5	87.8	+4.5	0.96	-3.34
DWH	96.7	75.1	85.9	+3.0	1.58	-2.48
LBX	94.8	75.3	85.0	+3.8	2.73	-1.04
HGX	93.8	76.0	84.9	+2.6	4.31	+1.08

The rain shut off in May. The area went from excessively wet to excessively dry in a very short period of time. Houston Intercontinental Airport and Houston Hobby Airport endured their eighth driest May in recorded history. Rainfall was generally less than an inch near the coast with slightly heavier totals inland. An isolated pocket of heavy rain affected parts of Jackson and Matagorda counties on the 27th bringing excessive rain. Palacios received 5.16 inches of rain on the 27th. Temperatures averaged 2 to 2.5 degrees warmer than normal. College Station had its tenth warmest May on record and Galveston suffered through it's sixth warmest May on record.

The drought which began in May continued through June. Intercontinental Airport had 31 consecutive days without measurable rain. Thunderstorms on June 25th ended the dry spell. Huntsville had gone 34 consecutive days without measurable rain and had only received a trace of rain in June. Extreme to exceptional drought conditions were now affecting much of Southeast Texas. A heat wave developed around June 9th and excessive heat lingered through the end of the month. New temperature records were established at several climate sites on the 23rd, 24th, 25th and 26th. Houston established its all time record high temperature for the month, reaching 104 degrees on the 24th and 26th. College Station and Huntsville reached 106 degrees on the 24th. The heat at the end of June rivaled other significant heat waves of the past including the brutal summers of 1980 and 1906.

July could be summarized with one word – HOT! The average monthly temperature was about 2.5 to 4.5 degrees warmer than normal. Both Houston Hobby and College Station endured their hottest average July temperature. It was also the warmest average monthly temperature ever recorded at those two climate sites. Houston recorded its second warmest average July temperature, just falling short of the oppressive July 1980. Overnight low temperatures were also very warm averaging between 77 and 78 degrees. Houston also had its warmest June/July combination in recorded history. College Station had its second warmest June/July and Galveston its third warmest June/July. Again, to put it succinctly, it was HOT! Rain returned to the region but monthly totals were generally below normal. Houston had its driest May through July in recorded history. Houston Hobby and College Station had their 4th driest May through July and Galveston endured its 7th driest May through July. On July 26th, severe thunderstorms produced widespread wind damage in Madison County and also large hail in Harris County. On the 17th, severe storms produced winds estimated at 90 mph in Brazos County. The winds produced widespread damage and downed approximately 70 trees.

El Niño Conditions Have Returned

By Lance Wood

What is El Niño?

Near the end of each calendar year, ocean surface temperatures warm along the coasts of Ecuador and northern Peru. In the past, local residents referred to this annual warming as "El Niño", meaning "The Child", due to its appearance around the Christmas season. The appearance of El Niño signified the end of the fishing season and the arrival of the time for Peruvian fishermen to repair their nets and maintain their boats. Every two to seven years, a much stronger warming appears along the west coast of South America, which lasts for several months and is often accompanied by heavy rainfall in the arid coastal regions of Ecuador and northern Peru. Over time, the term El Niño began to be used in reference to these major warm episodes. This coastal warming, however, is often associated with a much more extensive anomalous ocean warming to the International dateline and it is this Pacific large scale phenomenon that forms the link with the anomalous global climate patterns. The atmospheric component tied to El Niño is termed the ``Southern Oscillation''. Because the atmosphere and ocean are coupled, the term ENSO, short for El Niño-Southern Oscillation is used to describe the entire phenomenon. El Niño then corresponds to the warm phase of ENSO. The opposite ``La Niña'' (``the girl'' in Spanish) phase consists of large scale cooling of the tropical Pacific and thus the cold phase of ENSO.

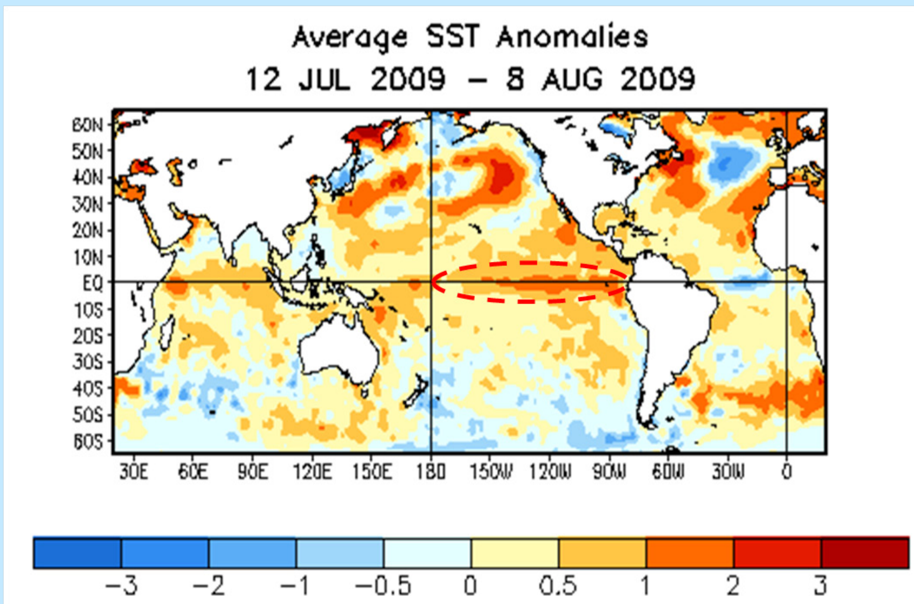


Figure 1: Positive Sea Surface Temperature Anomalies Along the Equator

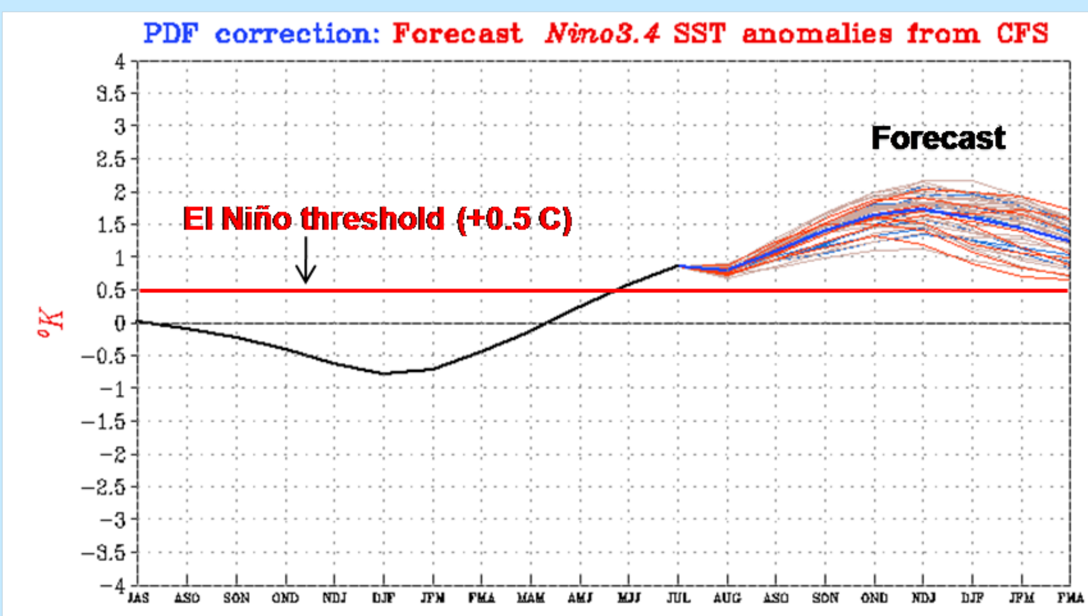


Figure 2: El Niño forecast through the start of 2010

El Niño Conditions Have Returned

Current ENSO state and forecast

El Niño conditions returned to the equatorial Pacific Ocean during June 2009. Positive Sea Surface Temperature (SST) anomalies continue across the equatorial Pacific Ocean (Figure 1). Dynamical moded forecasts indicate that warming is expected to strengthen and that El Niño will persist through the remainder of the summer and through the winter (Figure 2).

To quantify El Niño events, scientists use the Oceanic Nino Index (ONI). This index is the principal measure for monitoring, assessing, and predicting ENSO, and it is defined as the three-month running-mean of SST departures in the Niño 3.4 region (Figure 3). The ONI is used to place current events into a historical perspective. In addition, NOAA's operational definitions of El Niño and La Niña are keyed to the ONI.

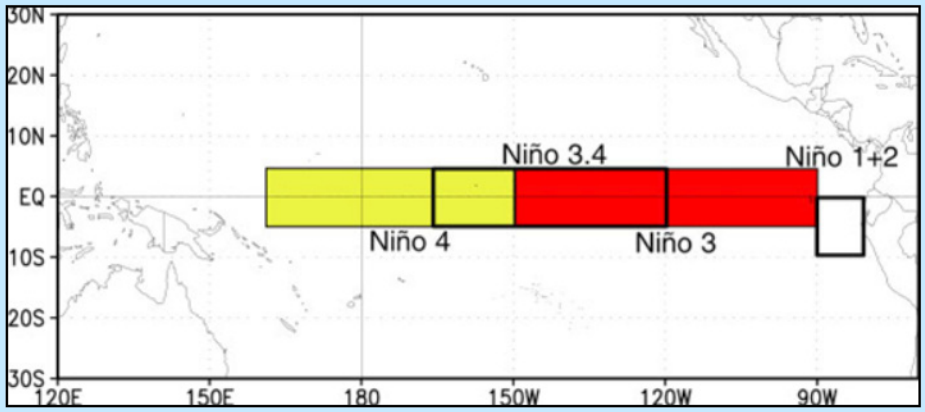


Figure 3: Pacific Ocean Regions where El Niño conditions are studied

The latest weekly SST departure from normal in the Niño 3.4 region is +0.8 ºC. This value is above the +0.5 El Niño threshold that is used to define El Niño conditions. However, the ONI is derived from a three month average, so there is a time lag between the beginning of El Niño conditions and reaching the operational definition of an El Niño event. The latest ONI value (May-July) is 0.6 ºC, which also exceeds the El Niño threshold. Therefore, an El Niño event officially began in early August.

El Niño and the Hurricane season

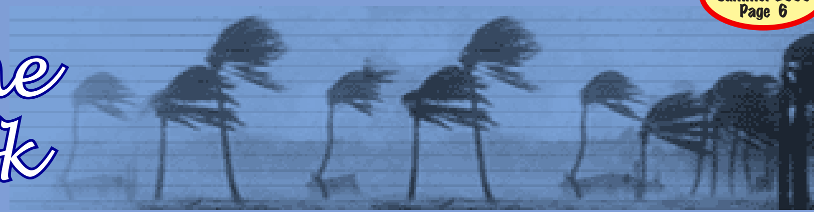
The developing El Niño has ramifications for the Atlantic Basin hurricane seasonal activity. Although we have been in a more active period since 1995, there have been a few seasons where near-normal or below-normal activity was observed, and these seasons correspond to El Niño events (1997, 2002, 2006). Moderate to strong El Niño events result in greater wind shear across the tropical Atlantic, and it is this wind shear that inhibits tropical cyclone development. For this hurricane season, it is believed that the current El Niño will inhibit tropical cyclone development. According to its August Atlantic hurricane season outlook, NOAA now expects a near- to below-normal Atlantic hurricane season. NOAA now predicts a 50 percent probability of a near-normal season, a 40 percent probability of a below-normal season, and a 10 percent probability of an above-normal season. The outlook calls for a 70 percent chance of seven to eleven named storms, of which three to six could become hurricanes, including one to two major hurricanes (category 3, 4 or 5). The main change from the May outlook is an increased probability of a below-normal season, and an expectation of fewer named storms and hurricanes.

Where can I find more information on ENSO?

The Internet is the greatest source of information on El Niño, La Niña and weather and climate data. NOAA has created one primary web site that allows you to link to many other resources: **http://www.elnino.noaa.gov**.

Specific information on ENSO predictions and other background is available at NOAA's Climate Prediction Center: **http://www.cpc.ncep.noaa.gov**.

2009 Hurricane Season Outlook



In their August 6th outlook, NOAA forecasters called for a near to below-normal Atlantic hurricane season. The outlook calls for a 50 percent probability of a near-normal season, a 40 percent probability of a below-normal season and a 10 percent probability of an above-normal season. Global weather patterns are imposing a greater uncertainty in the 2009 hurricane season outlook than in recent years. Forecasters say there is a 70 percent chance of having 7 to 11 named storms, of which 3 to 6 could become hurricanes, including 1 to 2 major hurricanes (Category 3, 4 or 5). NOAA's seasonal hurricane outlook does not project where and when any of these storms may hit. Landfall is dictated by weather patterns in place at the time the storm approaches.

Shaping this seasonal outlook is the possibility of two competing climate factors. The ongoing multi-decadal signal remains in place and has been associated with elevated levels of hurricane activity since 1995. This climate pattern produces key ingredients of an active hurricane season including warmer than average sea surface temperatures in the North Atlantic Ocean and Caribbean Sea, reduced vertical wind shear, and favorable winds that strengthen cloud systems coming from Africa. Offsetting this signal is El Niño, which developed in the tropical Pacific Ocean during June and is already producing increased wind shear in the Main Hurricane Development Region (MDR, consisting of the tropical North Atlantic Ocean and Caribbean Sea). This combination of climate factors indicates a 50% chance of a near-normal hurricane season for 2009, and a 40% chance of a below normal season. An above-normal season is not likely (10% chance). It must be noted that above-normal, near-normal or below-normal seasons can produce landfalling hurricanes, and it only takes one landfalling storm to make it a bad season.

Tropical systems acquire a name upon reaching tropical storm strength with sustained winds of at least 39 mph. Tropical storms become hurricanes when winds reach 74 mph, and become major hurricanes when winds increase to 111 mph. An average season has 11 named storms, including 6 hurricanes with 2 becoming major hurricanes.

The following are the names for the 2009 Hurricane Season:

Ana	Henri (ahn-REE)	Odette (o-DET)
Bill	Ida	Peter
Claudette (claw-DET)	Joaquin	Rose
Danny	Kate	Sam
Erika (ERR-ree-ka)	Larry	Teresa (te-REE-sa)
Fred	Mindy	Victor (VIC-ter)
Grace	Nicholas (NIK-o-las)	Wanda

Much more detail on NOAA's August outlook can be found on the internet at…

www.cpc.ncep.noaa.gov/products/outlooks/hurricane2009/August/hurricane.shtml

Saffir-Simpson Hurricane Wind Scale

The current Saffir-Simpson Hurricane Scale (SSHS) dates to 1975 and is based on expected hurricane wind speed, but includes storm surge ranges and other storm-related information. The inclusion of storm surge information is scientifically inaccurate because surge is a product of many factors not considered in the scale such as storm size and forward speed, and bathymetry and characteristics of the coastline in the landfall location. Storm surge values for each category are frequently incorrect. A most recent example of this is Hurricane Ike in 2008. The storm made landfall with Category 2 winds. However, the storm surge along portions of the Upper Texas Coast was equivalent to what

Saffir-Simpson Intensity Scale

Expresses hurricane in terms of wind speed and potential damage-----Major Hurricanes CAT 3 - 5

Category	Pressure	Winds	Surge	Bay Surge	Damage	Storm Examples
1	980 +	74 - 95	4 - 5	4 - 7	Minimal	Jerry 1989
						Claudette 2003
2	965 - 979	96 - 110	6 - 8	8 - 12	Moderate	Ike 2008
3	945 - 964	111 - 130	9 - 12	13 - 18	Extensive	Alicia 1983
						Katrinia 2005
						Rita 2005
4	920 - 944	131 - 155	13 - 18	19 - 24	Extreme	1900 - Galveston
						Carla 1961
5	<920	> 156	18 +	24 +	Castastrophic	1935 Labor Day
						Camille 1969
						Andrew 1992

is currently defined for the Category 3-4 storm range. The National Hurricane Center (NHC) and Weather Forecast Office (WFO) Houston provided deterministic forecasts in their products on the extreme storm surge, but reports from Emergency Managers came back with many residents stating they would not evacuate because the storm was only a Category 2. Other examples include: Hurricane Charley in 2004, a Category 4 storm at landfall on the SSHS for winds but with storm surge equivalent to the Category 2 range; and Hurricane Katrina in 2005, a Category 3 storm at landfall for winds but with storm surge equivalent to the Category 5 range.

On an experimental basis for the 2009 Tropical Cyclone Season, these storm surge ranges and flooding references will be removed from the definition/effects for each category (1-5). The revised content will be included experimentally this year in a scale called the "Saffir-Simpson Hurricane Wind Scale (SSHWS)." See table below.

Saffir - Simpson Hurricane Wind Scale

Category	Wind Speed (MPH)	Damage	Hurricane Name
1	74 - 95	Minimal	Claudette
2	96 - 110	Moderate	Ike
3	111 - 130	Major	Alicia
4	131 - 155	Extreme	Carla
5	> 155	Catastrophic	1935 FL Keys
			Camille
			Andrew

The purpose of the new SSHWS is to help eliminate any confusion on the potential danger that a storm might bring with it. The new SSHWS will provide only information concerning the potential wind speed of an approaching storm. Information concerning all of the hazards of a hurricane will be included and emphasized in other products produced by the NHC and the local WFO. At the local WFO, graphical hazard products will be available on their homepage that will give detailed information concerning each of the four hazards that accompany a hurricane.

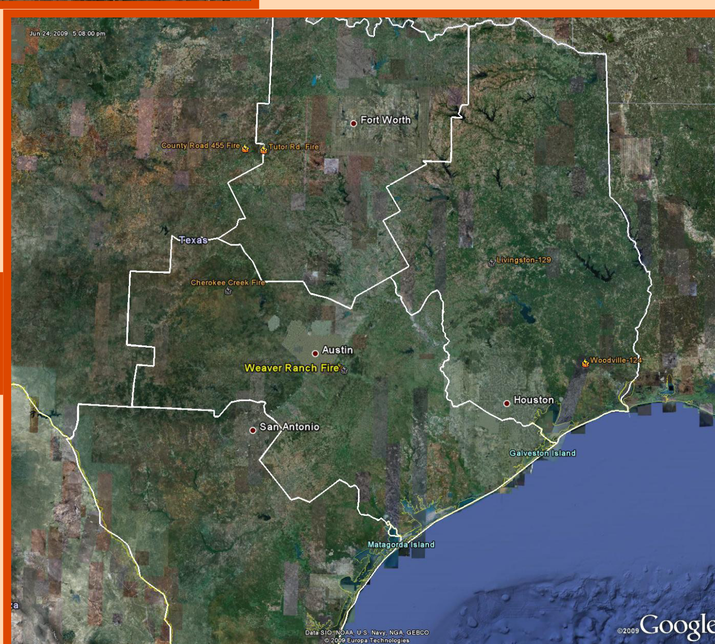
All citizens are encouraged to always understand their vulnerability and be prepared for those hurricane hazards that might impact their location.

Fire Weather Support provided to the Texas Forest Service Emergency Operations Center

By Kent Prochazka

Texas is a unique state. The shear size of the state allows a variety of weather conditions to affect regions of the state differently. This variability in weather conditions affects agriculture, tourism, transportation and fire fighting. As part of the National Weather Service's fire weather support, meteorologists are sent to College Station during the winter and spring to provide weather support for the Texas Forest Service. During the Winter 2009 Fire Season, five forecasters were deployed to the EOC from the Center Weather Service Unit at Bush Intercontinental Airport and the NWS office in Houston/Galveston with durations of 8 to 14 days. The fire season during the winter and spring was a dangerous one with more than 590,000 acres consumed in fires; this is nearly an area the size of Montgomery County. More than 8800 homes were saved with only 212 homes being lost. The Texas Forest Service had dropped more than 3.1 million gallons of water to suppress fires. The meteorologists detailed to support the Texas Forest Service use their expertise to assist decision makers in planning and logistics to move firefighters, pumper trucks, bulldozers, firefighting helicopters and fixed wing aircraft around the state, to areas that have a heightened risk of fire danger.

Image courtesy of the Texas Forest Service - A helitanker loading up for another fire suppression drop on the Miller Fire in Coleman County, TX.



The Texas Forest Service uses Google Earth Imagery to keep track of wild-fires across the state of Texas.

Fire Weather Support continued

Wildfires are more common during periods of drought and on a seasonal basis during the winter and well into spring after the grasses cure. The increase in fire danger this year was due to an ongoing drought that began in earnest last fall. By the middle of winter, much of the state was below normal with respect to rainfall and large sections of the West, Hill County and South Texas were experiencing moderate to severe drought. And with the end of winter and early spring come storm systems that sweep through the Southern Plains bringing very strong southwesterly winds to much of this drought plagued area in Texas. In addition, dry air from the mountains to the west and south sinks across Texas as these systems approach lowering the humidity even further heightening the dangers of difficult to control wildfires. Dry lightning is a phenomenon that is associated with thunderstorms that produce very little rainfall due to the rain falling into dry air below the thunderstorm and evaporating. Dry lighting strikes the ground potentially starting a wildfire without the quenching rains of the thunderstorm. Occasionally dry lightning would accompany cold fronts that swept into Texas. Last but not least during the period, the warm, dry and windy conditions across the state would be aggravated by cold fronts that would sweep through the state bringing

Images courtesy of the Texas Forest Service. Nighttime fire behavior on the Two-Bush Road Fire in Jack County. The fire was mostly controlled when severe weather on April 9th caused it to flare back to life. The fire ultimately burned 2,190 acres.

Fire Weather Support continued

only slightly cooler temperatures and strong winds from the northwest or north driving fires in a different direction prior to the frontal passage and making firefighting even more difficult and dangerous.

The meteorologist detailed to College Station may work as many as 14 days as part of Predictive Services with the Texas Forest Service. The duties vary a bit depending on the weather scenario and the fire weather threats. Generally, the work begins around 6 AM to evaluate the overnight weather and to self brief on the latest computer model forecasts. After settling on the forecast, the forecaster creates a series of maps to be used for a morning briefing focusing on the weather hazards across the state for the next seven days. These maps would be used by an Incident Meteorologist (IMET) in Granbury during an aviation briefing. The first map prepared is a Branch Map. This map highlights Fire Weather Watches and Red Flag Warnings across the state. The other two maps were general hazard maps for the current and following day. These maps show expected wind speeds and direction, afternoon relative humidity values and areas with critical and elevated risks for fire weather. These graphics were included in an Incident Action Plan to assist firefighters out on the fires providing a quick and easy way to interpret visual graphic of the expected weather hazards for the day. The rest of the morning was used to prepare a power point weather briefing for the staff at the Texas Forest Service Emergency Operations Center and via a live and interactive webcast to other sections of the Texas Forest Service, U.S. Forest Service, U.S. Fish and Wildlife, City and Volunteer Fire Departments, and the Texas Air National Guard. The weather briefing was generally 8 to 15 minutes in length and focused on the problem of the day and to give a heads up concerning weather coming in the next week. The remaining 10 to 20 minutes of the briefings involved the status of the fuels, such as the grasses, trees and shrubs, assets like aircraft, equipment needs and availability of firefighting crews. The briefing is held at 930 AM in Emergency Operations Center of the Texas Forest Service. Following this briefing, the meteorologist would assist the Regional Operations Center duty officer at Southern Region National Weather Service headquarters during the State of Texas Office of Emergency Management briefing. The forecaster on duty would use the remainder of the morning to analyze new model data, start preparing the afternoon forecast and continue to monitor weather conditions. During the afternoon, the forecaster would refine the forecast and prepare two new hazard maps. The first map would be for the next day and the day 2 map would be for the day after that. The hazard maps would then be transmitted to the IMET at Granbury by 230 PM to be incorporated into the IMET's afternoon briefing for the overnight hours and next day. The rest of the afternoon was spent looking at model data, doing analysis and monitoring the weather. The day would end sometime between 5 and 9 PM depending on the weather situation. A narrative weekly weather summary was prepared on Sunday night describing weather conditions expected over the upcoming week.

The equipment used to prepare the forecasts was a little different than what is typical at the WFO. FX-Net was used, a similar application to AWIPS that is used by NWS forecasters across the county to review computer model data, animate satellite, radar pictures and review national guidance. FX-Net is a bit slower as it gets its data via the web rather than locally as the AWIPS workstations utilizes data. Adobe Illustrator was used to prepare the Branch Map, and the Hazard maps were prepared using Microsoft PowerPoint. The staff at the Texas Forest Service was professional, friendly and made a great team to work with during this season. Perhaps we will return to work with the Texas Forest Service again this winter, if not sooner should the need arise.

SE Texas April Heavy Rainfall Event

by Paul Lewis

Heavy rainfall affected large portions of southeastern Texas on April 18th and 19th, 2009. Rainfall rates equaled and sometimes exceeded those that were measured during Tropical Storm Allison in 2001. Devastating flooding, albeit on a small scale as compared to Allison, occurred in conjunction with the heavy rain, much of it due to the amazing rainfall rates. April saw two more periods of heavy rainfall toward the end of the month. All three events led to monthly rainfall totals exceeding 15 to 20 inches in some communities surrounding northern Galveston Bay.

A tropical like airmass was in place over southeast Texas the mornings of the 17th and 18th. This can be seen by analyzing the precipitable water vapor (or PW for short). PW is one way of measuring the moisture levels in the atmosphere and can be found by calculating the entire available water vapor in inches of water from a temperature/dew point temperature sounding. Historical PW values have been researched for Corpus Christi (CRP) and Lake Charles (LCH), two upper air sounding stations nearby the Houston and Galveston metropolitan area. Maximum measured PW values for April 18th – 19th ranged from 1.8 to near 2.0 inches, which was almost or just above 2 standard deviations of normal for mid April at CRP and LCH (see Figures 1a and 1b for PW analysis). These values indicated the potential for heavy rainfall.

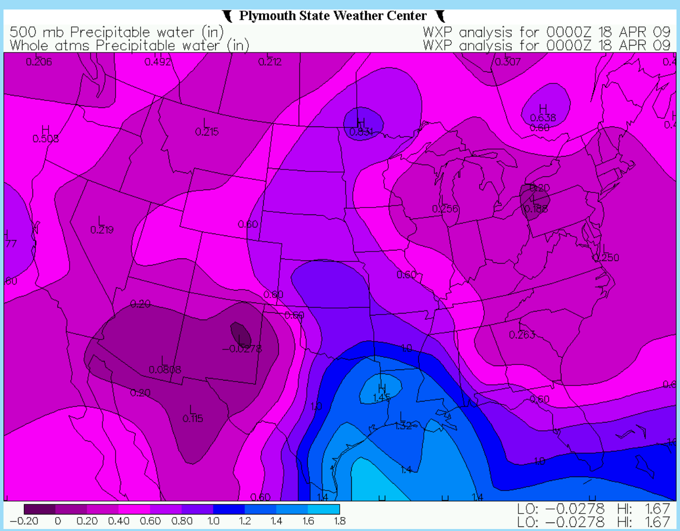


Figure 1a – 7:00 PM 17 April 2009
precipitable Water Analyzed from Sounding Data
Courtesy of Plymouth State University Weather Center

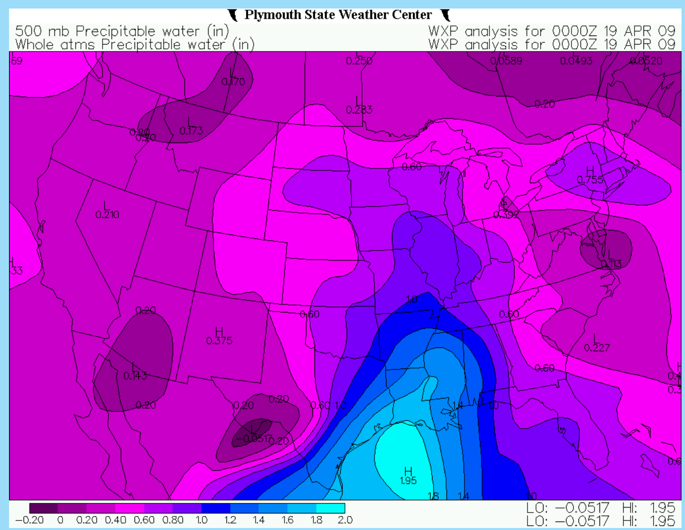


Figure 1b – 7:00 PM 18 April 2009
precipitable Water Analyzed from Sounding Data
Courtesy of Plymouth State University Weather Center

The event began on April 17th as a large thunderstorm complex developed in advance of a cold front over central Texas. These storms produced heavy rainfall over the western areas of the HGX county warning area. After diminishing during the night, another round of thunderstorms spread east of those locations affected the previous day. Rainfall for the two-day event averaged in excess of 8 to 9 inches across much of an area that extended from northern Chambers County west toward Austin County (see Figures 2a and 2b) and isolated totals exceeded 14 inches (see Table 1). One remarkable observation about event is the rainfall rates. Clover Field in Pearland measured 1.33 inches of rain in 12 minutes. Houston Hobby Airport recorded rainfall rates of 0.96 inches in 10 minutes, 1.48 inches in 16 minutes, and 2.52 inches in 35 minutes. A Harris County Flood Control gauge presented another example of the incredible rainfall rates – 6.02 inches in 1 hour at the Clear Creek and FM-528 location. This rate is comparable to those measured during Allison.

Two other rainfall events occurred toward the end of April. The storms of April 23rd and 24th affected communities mainly around Galveston Bay. Thunderstorms on the 27th and 28th produced heavy rains mainly west of the Houston metro area. For the month, communities across the Houston metropolitan area and around the northern half of Galveston Bay received in excess of 15 to 20 inches (Figure 3). Departures from normal rainfall for the month ranged from 4 to 8 inches across all of southeastern Texas (Figure 4).

SE Texas April Heavy Rainfall Event continued

Location	April 17th	April 18th
Houston IAH	1.9	2.98
Houston HOU	2.64	5.15
Pearland	1.29	6.65
Cleveland	4.04	2.26
League City (NWS)	1.77	7.88
Frelsburg	7.66	
Brenham	5.85	1.50
Columbus	5.10	
League City 1.2 N		10.63
El Campo 2.5 WSW		4.41
Winnie 4.4 NNW		6.25
South Houston 4.0 SSW		6.49
Winnie 2.9 NNW		6.23
League City 2.4 W		9.17
Buker Hill Village (Houston)		4.40
Burton (Washington County)	5.45	2.64
Washington (Washington County)	2.38	2.49
Houston Heights	2.54	3.77
Taylor Lake Village	1.53	4.66
Crosby	2.75	4.62
Missouri City 4.8 SSE	0.56	8.48
Richmod 5.6 ESE	0.25	5.87
El Campo 2.5 WSW	0.06	4.41
Wharton 0.3 E		5.83
Bellville	6.19	

Table 1: Rainfall totals for 17-18 April 2009

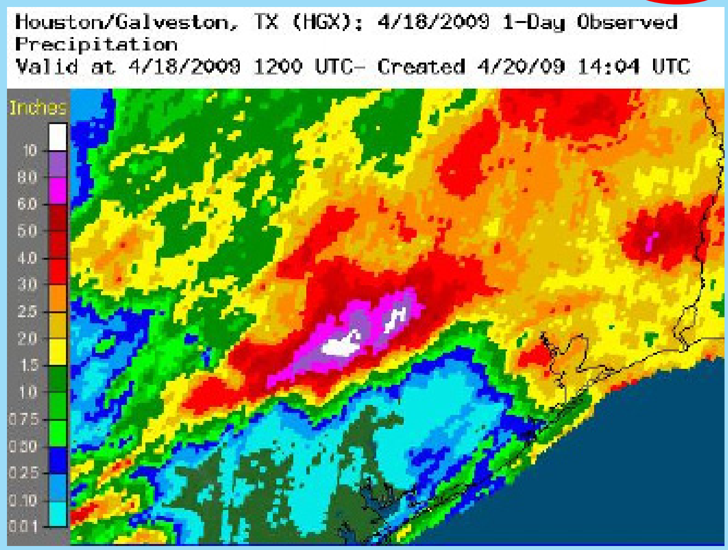


Figure 2a: Radar Estimated 24-Hour Rainfall ending 7AM April 18th

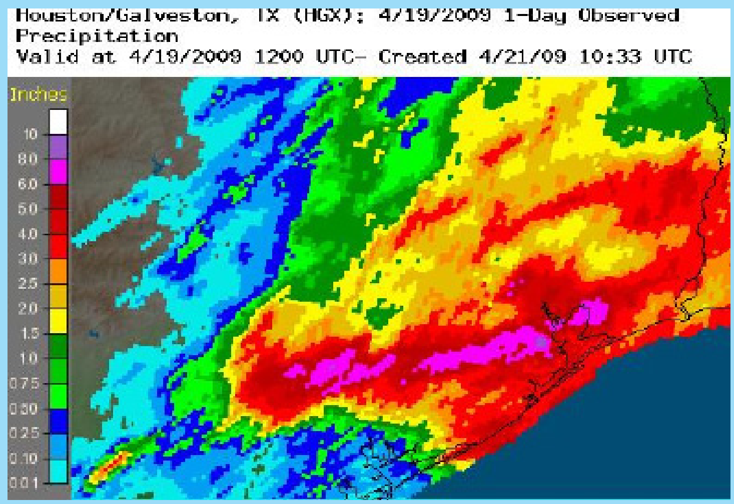


Figure 2b: Radar Estimated 24-Hour Rainfall ending 7AM April 19th

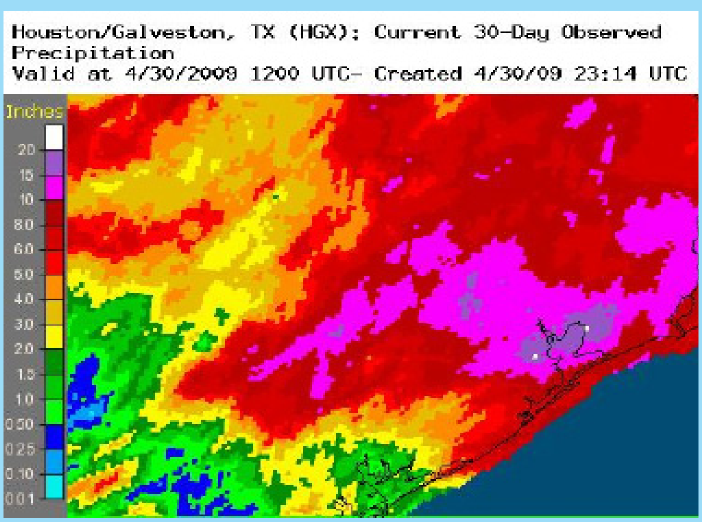


Figure 3: April 2009 Total Rainfall

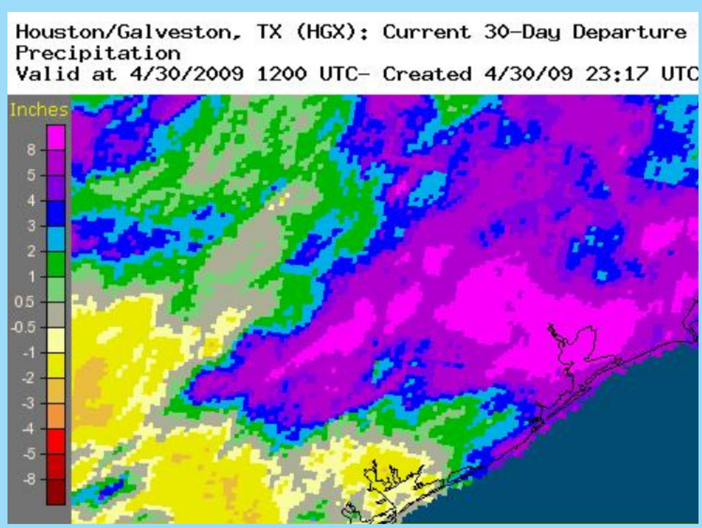


Figure 4: April 2009 departure from normal rainfall

Improved Hydrologic Services in the National Weather Service

David C. Schwertz, CFM
Senior Service Hydrologist

On average, flooding kills more than 100 people (Figure 1) and causes in excess of $4 billion damage (Figure 2) annually according to the U.S. Army Corps of Engineers (COE) Annual Flood Damage Report of 1998. Statistics show that Texas consistently suffers more deaths and damages from severe weather and flooding than any other state. Of 42 flood events between 1980 and 1998 causing more than one billion dollars in damage, 4 were in Texas. From 1978 to 2001, flood damage in the state of Texas amounted to 2.25 billion dollars, more than California, New York, and Florida combined. A testament to the potential intensity of rainfall and flash flooding in Texas is highlighted by the damages caused by Tropical Storm Allison (2001) in which 73,000 homes were flooded in Harris County alone. The result has been a focus on continued improvements in availability and accessibility of high quality hydrologic information within the NWS.

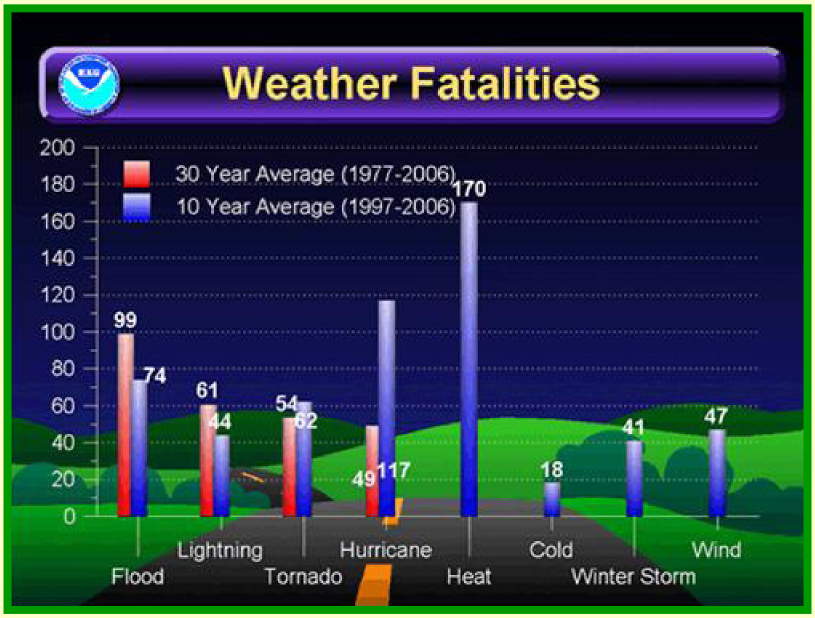


Figure 1: Average annual weather related fatalities

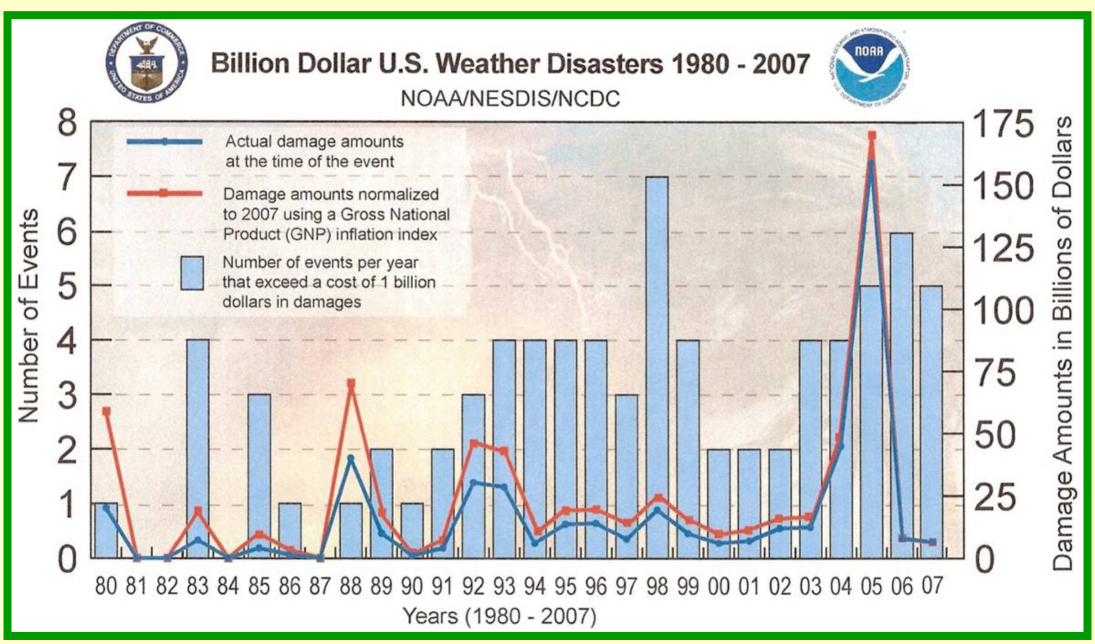


Figure 2: Weather related property damage one billion dollars or more

The Modernization and Restructuring (MAR) of the NWS in the 1990's increased the capacity of the NWS to complete its mission. The cornerstone of the MAR was development and deployment of the WSR-88D NEXRAD Weather Radar. This tool has aided in the capability of increased detection of real-time precipitation as well as estimating precipitation amounts critical to hydrologic forecasting. Another improvement was deployment of the Advanced Weather Interactive Process System (AWIPS), high-tech scientific workstations that run a variety of meteorological and hydrological support software. Key within this hydrological support software is the Weather Forecast Office Hydrologic Forecast System (WHFS). WHFS allows for detailed analysis of hydrologic data while providing the capability to create hydrologic forecasts.

FORECAST PROCESS

A great deal of meteorological and hydrological data continuously flows between the Weather Forecast Office (WFO) and River Forecast Center (RFC). The WFO provides hourly WSR-88D precipitation estimates, cooperative rainfall observations, and data from many sources to the RFC. Agencies outside the NWS such as the United States Geological Survey (USGS) and the COE also provide significant hydrological data as well as volunteer organizations such as CoCoRAS and local storm spotters. The RFC ingests this data, as well as quantitative precipitation forecasts (QPF), into their hydrologic models to provide the best available meteorological assessment of future precipitation. This in turn leads to increased lead times and greater accuracy of hydrologic forecasts.

Hydrologic forecasts from the WFO consist of site-specific as well as areal watch and warning products. Site-specific forecasts include stage or flow forecasts as well as flood warnings and statements for a specific location on a watershed for a particular time duration. Area wide products include Hydrologic Outlooks, Flood and Flash Flood Watches, Flash Flood Warnings and Urban and Small Stream Flood Advisories.

NEW FORECAST TOOLS

A significant improvement to hydrologic services is the deployment of the Advanced Hydrologic Prediction System (AHPS). AHPS are enhanced hydrologic information and products through the infusion of new science and technology. These services improve flood warnings and water resource forecasts to meet the diverse and evolving needs of our customers and partners. AHPS features cover a full spectrum of hydrologic events ranging from floods to droughts for various time durations. Information is displayed in graphical and numerical formats to maximize usefulness. AHPS provides rapid menu-driven navigation between products to obtain all information needed for hydrologic decision making as well as consistency of format and information content for a core suite of products to allow for easy interpretation across the Nation.

Improved hydrologic forecast tools now available to the WFO as part of WHFS include the Multi-sensor Precipitation Estimator (MPE), the Site Specific Model and Flash Flood Monitoring and Prediction (FFMP). MPE is used to adjust the rainfall estimates from the WSR-88D by comparing the radar estimates to ground truth from rain gages. MPE is used as input to the Site Specific Model which allows the WFO to issue warnings for small fast responding streams that are not easily modeled by the RFC. FFMP is used to assist forecasters in recognizing flash flood threats prior to the onset of flooding. FFMP uses a high resolution GIS database of basins, gridded flash flood guidance produced at the RFC, and MPE to rank the probability flash flooding on small watersheds within a county. Critical to the expansion site specific warnings is the higher resolution real-time data being made available from the USGS and its cooperators. The next generation of hydrologic tools available through AHPS includes Probabilistic Forecasts and Inundation Flood Mapping.

PROBABILISTIC FORECASTS

Models for the large river systems throughout the United States are run at the 13 RFCs within the NWS. This model, the National Weather Service River Forecast System (NWSRFS), is based on the Sacramento Soil Moisture Accounting Model (SAC-SMA) with significant adjustments. The portion of NWSRFS that produces probabilistic forecasts of stream flow and streamflow related variables is the Ensemble Streamflow Prediction (ESP) system. ESP is not configured to use standard weather forecasts as input, rather the model uses multiple years of historical temperature and precipitation time series data, short and long term forecast information, and current basin conditions to create an ensemble of streamflow traces (Figure 3). These traces are then statistically analyzed using the ESP Analysis and Display Program to produce probabilistic forecast graphics of various streamflow variables such as stage, flow, volume, and reservoir inflow volumes.

MODEL REQUIREMENTS

A component of the NWSRFS, the ESP System, requires a continuous rainfall-runoff model. This is accomplished by the creation of historical time series of mean areal precipitation. Ideally fifty years of water data is desired, however, all available data will be used. Values are derived using the Thiessen polygon weighting method. Recalibration of SAC-SMA Model utilizing historical streamflow and precipitation data allows model parameters to be defined such that historical events can be accurately simulated and a hydrograph is created for each year of historical data. The model produces trace simulations for each year in the period of record and each simulation reflects what would happen if that particular years' historical weather regime occurred with the current soil moisture conditions. Two types of simulations are produced; conditional and historical. Conditional simulations reset the model to the current model states when each water year is simulated. Historical simulations start the model at current model states and run nonstop through the entire input record allowing the model to become "wetter" or "drier" than current conditions prior to the run interval simulated. Trace simulations are then used in statistical calculations to produce the probabilistic forecasts. Since ESP output are conditional simulations based upon current conditions, this separates the NWS probabilistic forecasts from other types issued from other sources.

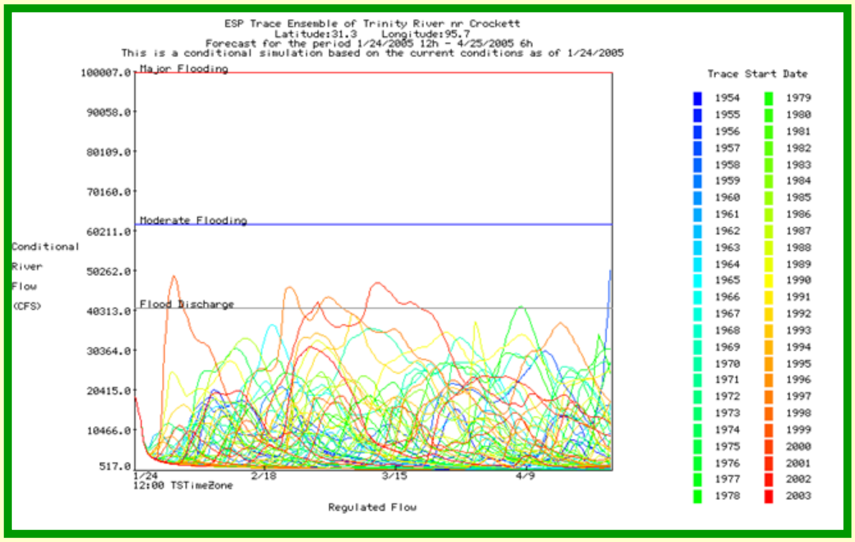


Figure 3: ESP Trace Ensembles

PROBABILISTIC FORECAST PRODUCTS

Currently probabilistic forecasts are produced on the third Thursday of each month for a period of 90 days. Public products for stage, flow, and volume include the exceedance probability curves and the weekly probability histogram. The exceedance probability curve is valid for the entire 90 day window and includes the conditional and historical simulations (Figure 4). The weekly probability histogram is valid for the 90 day window in weekly increments using maximum weekly values from the conditional simulation and empirical distribution the probability values (Figure 5). These values range from 10-25%, 25-50%, 50-75%, 75-90%, and greater than 90%.

INUNDATION FLOOD MAPPING

For over 30 years the NWS has utilized a three tiered, impact based flood severity scale. Stages associated with each flood severity category - minor, moderate, and major - are established in cooperation with local entities and jurisdictions for each NWS river forecast point location. Through customer surveys, users have indicated they understand and are familiar with NWS flood severity categories, find them useful, and do not want changes made to the existing flood severity indices. On the other hand, they also think the use of inundation graphics (maps) will better communicate the flood risk.

In September 1999, Hurricane Floyd produced devastating flooding across eastern North Carolina. This was the fourth hurricane to impact the North Carolina coast since 1996 and resulted in over 4,000 homes and business being destroyed. As a result, the governor requested a program to address flood mapping since there was no detailed flood data for specific waterways. The Federal

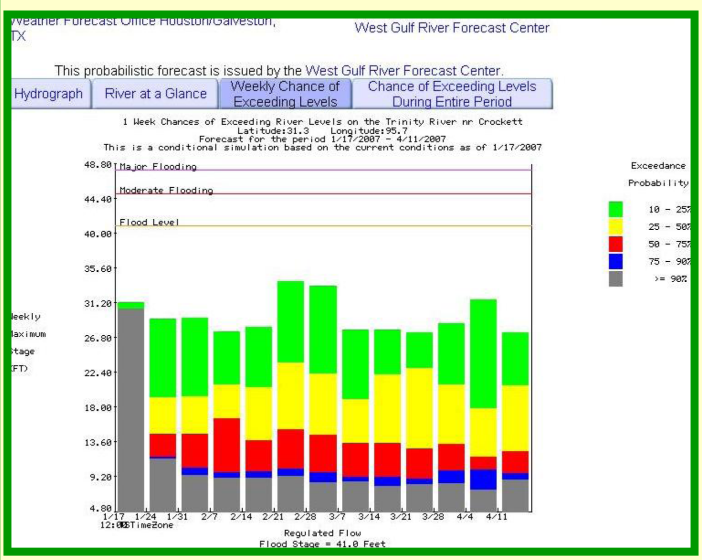


Figure 4: Chance of exceeding levels for entire period

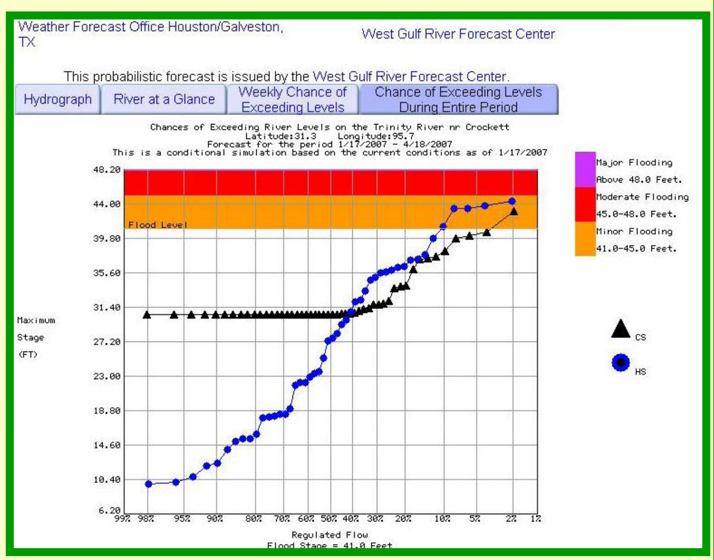


Figure 5: Weekly chance of exceeding levels

Improved Hydrologic Services continued

Emergency Management Agency (FEMA) and the North Carolina Department of Emergency Management contracted for hydraulic studies to establish approximate base flood elevations 1% (100 year) flood. Watershed Concepts was sub-contracted to complete these studies for seven eastern North Carolina counties. Additionally, the NWS was working with FEMA's Flood Mapping Modernization team to determine the feasibility of developing static flood inundation map libraries for water levels above flood stage to enhance the communication of flood risk through a graphical approach instead of text based wording only. These maps would be linked with observed and forecast river stages, and include NWS flood severity categories as well as regulatory FEMA flood frequency events. In 2000, the NWS formally agreed to partner with the North Carolina Flood Mapping Project (NCFMP), FEMA, and the USGS to develop prototype graphics to better convey the flood threat. Initial efforts concentrated on the Tar River in eastern North Carolina, the object being to provide flood inundation maps to emergency managers during flood events. Using partnered data (LiDAR, etc.) from FEMA and the NCFMP, an unsteady hydraulic model was developed for 73 miles of the Tar River. The flood forecasts were mapped in GIS and the results presented on an easy to read format over the web. These maps were used operationally by the Southeast River Forecast Center during Hurricane Isabel in September 2003. As of October 2007, flood inundation map libraries for sixteen North Carolina river forecast points have been available on the web.

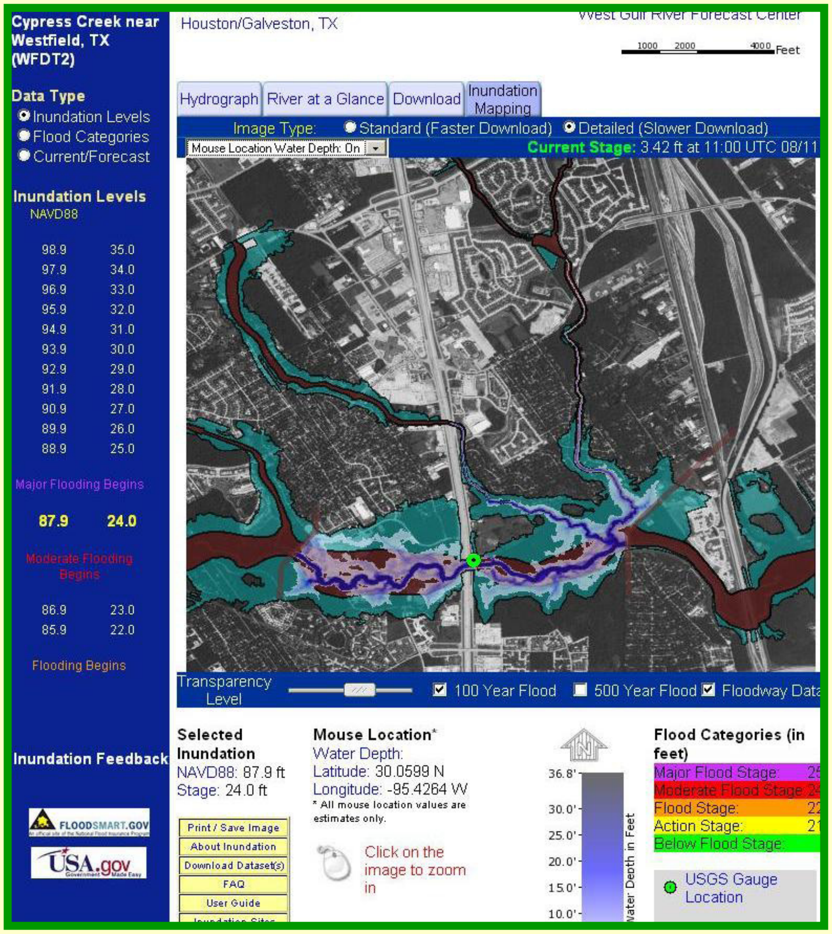


Figure 6: Detailed inundation map for Cypress Creek near Westfield

Following the success of the Tar River Project, Hurricane Katrina and Hurricane Rita supplemental funds were used to create an additional 25 to 35 libraries in four gulf coast states - Texas, Louisiana, Mississippi, and Alabama. Criteria for selection of these sites included a significantly long period of record, updated topographical data (LiDAR), and updated hydraulic models. For the Houston/Galveston Weather Service office a total of nine sites, all in Harris County, which met these criteria, were selected. The first of these maps; Buffalo Bayou at Piney Point Drive, Buffalo Bayou at Shepherd Drive, Cypress Creek at I-45, and the West Fork of the San Jacinto River at U.S Highway 59 came online in June 2008. An additional three maps; Spring Creek at I-45, the East Fork of the San Jacinto River at FM 1485, and the San Jacinto River below Lake Houston near Sheldon came on line in September 2008. Features to be included on these maps include standard (street map) and detailed (areal photograph) image options, predefined river stage levels and associated NAVD88 water surface elevations, mouse over water depth, categorical flood inundation levels, and flood frequency and floodway data (Figure 6).

Inundation map layers are available for download as GIS shapefiles or KMZ files. From a public stand point the usefulness of a mapping approach showing street names, familiar landmarks, and location to local channels is more meaningful than a text based product and helps to convey the overall extent and depth of both current and forecasted flooded levels. Such maps can also help emergency managers in the ordering of evacuations and prepositioning of rescue equipment and supplies along with an additional tool to support critical decision making. Flood inundation maps are also a useful tool when used in conjunction with contingency forecasts. One can look at a range of forecasts for various rain scenarios and examine the associated inundation levels.

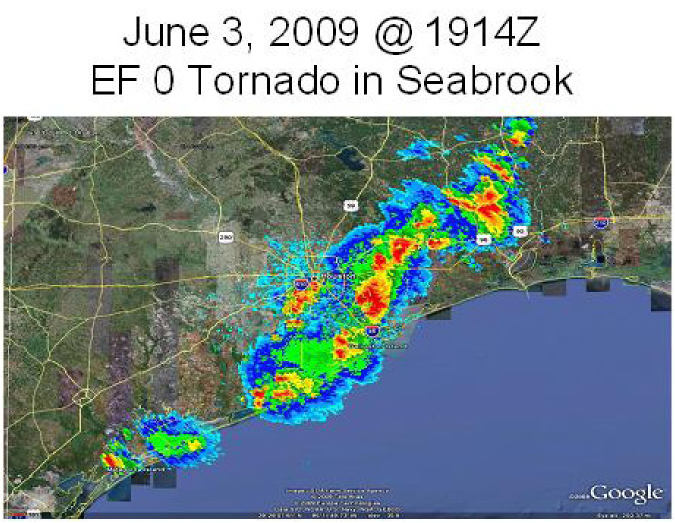
CONCLUSION

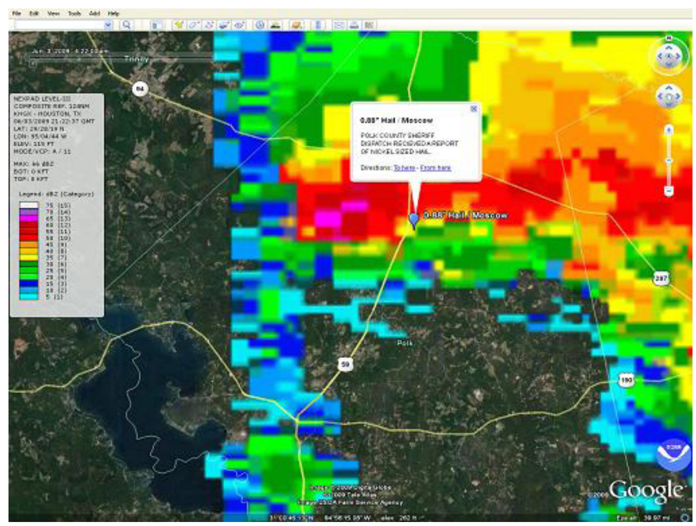
The advantages of probabilistic forecasts are clear from longer forecast lead times to simulating a range of potential river flows. These forecasts provide information on relative risk to water managers and can be used for contingency forecasts, simulating high and low flow conditions, and examining worst case scenarios using specific years of historical data. Flood inundation maps have proven their usefulness in communicating the threat and severity of flooding to emergency officials and other concerned citizens. The NWS is now partnering with other agencies, such as the Lower Colorado River Authority, who have shown interest in developing flood inundation maps for their areas of concern. Finally, AHPS has demonstrated much more than simply the rollout of new graphical products. It involves enhancement of capabilities, development of new models, and expansion of partnerships. Future enhancements to the NWS Hydrologic Service Program will include Distributed Hydrologic Modeling which will allow finer scale modeling resulting in better, more representative forecasts, the Water Resources Initiative to provide nationally consistent water and soil forecasts delivered by a national database, and the Community Hydrologic Prediction System which will pull together all available resources to provide a full range of hydrologic services.

Google Earth & Storm Data:
Integrating our local storm reports into GIS software

The accurate and thorough archiving of our local area's storm report data is of utmost importance to the public. Thus, to better streamline and enhance the quality of this data, we will begin utilizing Google mapping software in archiving our future storm reports. In the past, paper records were kept in a thick binder in a back room whereas the public could only retrieve recent information (within 2 months due to the national archive lag time) via a phone call or fax. Archiving these records through GIS software allows the user to *view* the geographical location of any particular event that meets the National Weather Service's severe weather criteria.

The unique feature that this new archiving method will introduce will be its ability for the user to *visualize* the exact location of the occurrence via a geo-referenced (satellite) map. For example, a tornado will have its track outlined on either a 2-D map (or 3-D globe) with pop-up damage images along its path. These "balloons" that pop up will not only contain a thumbnail image of the storm survey photo, but also include the pertinent summary of damage at that particular point. Our goal is to have every photograph taken at a storm survey site stamped with its appropriate latitude and longitude that, when imported into GIS software such as Google Maps/ Earth, will accurately display the exact location of damage. Another example is one where large hail falls over a non-populated region causing little or no damage. The location of the hail will be place-marked within the software with an information window giving you the essential vitals (i.e., time of occurrence, size of hail, reporter, etc…).





Another "wow" feature of archiving Local Storm Report (LSR) data via Google Earth images is the overlaying of radar data. In many cases, when the public requests a certain report, the NWS employee can access a static image, or screen shot, of the event with the appropriate overlain radar image. In other words, a .gif or .jpg image that can be e-mailed to requestor will take the place of a spreadsheet entry. This gives the user a visual way of interpreting the data; all of the pertinent information will be there, but now on top of a geo-referenced map with radar imagery and possibly complimentary survey photos. If the report is of high wind damage and we receive photos, we will overlay radar velocity data over the location with a pop-up window containing the image and appropriate information (time of occurrence, reported wind magnitude, etc…). We have the choice and flexibility to attach and overlay the most appropriate radar image(s) to the event; Reflectivity or Vertically Integrated Levels for hail / Precipitation Accumulation products over flooding events. Depending on the event, we may want to archive numerous radar images to one report. A perfect example of this would be damage caused by a super cell that produced high downburst winds and large hail. The storm report would not only be mapped and summarized through the GIS software, but also be linked with various radar images that best tell the story of what ultimately caused the damage. Larger events, such as hurricanes, will produce numerous storm damage reports. This data would be archived the same way, but with a longer summary detailing the larger scale picture (i.e., formation and evolution of hurricane, environmental conditions that led to the heavy rainfall, etc…).

In summary, connecting storm data reports and their inclusive information with radar imagery through GIS software will be an all-in-one method of communicating and archiving future storm events across southeastern Texas.

Lightning

Figure 1: Lightning stroke with multiple branches

Lightning is an awe-inspiring and beautiful natural phenomenon. As a storm grows in size, it starts lifting a large amount of moisture from the lower levels of the atmosphere into higher heights. Some of this moisture, in the form of water vapor and small water droplets, freezes. This ice is a critical part of the thunderstorm electrification process. As a result of the collision of ice particles and water droplets, both the ice particles and water droplets can become charged. These particles are then carried to different parts of the storm by the storm updraft. This charge separation leads to large areas of the same charge at different heights. This creates an electric potential due to the difference in the electric fields at those heights. Lightning occurs as a means to reduce this difference in the electric fields.

Lightning can occur in two forms: cloud-to-ground and intracloud. There can be up to 10 times more intracloud flashes than cloud-to-ground flashes within a thunderstorm. Cloud-to-ground lightning can bring either positive or negative charge to ground, but 90% of cloud-to-ground flashes lower negative charge. Also, a single lightning flash can contain multiple "strokes." The first stroke occurs when the charge lowered by the cloud reaches the ground and the channel is illuminated. A lightning channel can be up to 5 miles long and reach temperatures of 50,000°F. Multiple strokes may follow, using the same channel as the first return stroke. This process is what causes some lightning to appear as if it is flickering. The first stroke usually has multiple branches as seen in Figure 1, while additional strokes do not, as seen in Figure 2. A negative cloud-to-ground flash has an average of three different strokes. The first stroke is usually the strongest, with an average peak current of 30 kiloamperes (kA).

Cloud-to-ground lightning that lowers positive charge to the ground occurs less frequently, but is still very dangerous. Positive lightning is more likely to occur away from the primary core of a thunderstorm since it originates from higher heights in the storm. Positive lightning usually has a longer duration than negative lightning, making it more likely to start fires. It is impossible to tell if a strike is going to be positive or negative before it occurs.

Lightning is the most-commonly encountered form of hazardous weather due to its frequency of occurrence. There is an average of 25 million cloud-to-ground lightning strikes over the continental United States every year. From 1941 through 2008, lightning caused more fatalities than any other weather hazard with a total of 9,119 (tornadoes caused 6,754 fatalities while flooding caused 7,216 fatalities). From 1959 through 2008, Texas ranked second in the number of lightning deaths with a total of 207. During the past 30 years, lightning killed an average of 58 people per year, the majority of those outside. Therefore, it is extremely important to take the proper precautions when at risk. Here are a few tips:

- Know the weather forecast
  - Know whether or not thunderstorms are expected and make plans accordingly.
- Watch for developing thunderstorms
  - Look for tall, puffy clouds as a signal that a thunderstorm could be forming.
  - Look at the weather radar or call the National Weather Service to determine if storms are moving into your area.
- Seek Safe Shelter
  - If you hear thunder, you are within striking distance and need to stop your current activity and seek shelter immediately!
  - Get to a large building or enclosed vehicle.
  - While inside, stay away from phones, computers, or any other electrical equipment as well as any plumbing.
- Wait!
  - Wait until AT LEAST 30 minutes after the last clap of thunder before resuming your outdoor activities.
  - It is always better to wait than rush back outside.
- Resources
  - Weather Forecasts: www.weather.gov
  - Lightning Safety Tips:
    - www.lightningsafety.noaa.gov
    - www.LightningSafety.com
  - General Info
    - www.nssl.noaa.gov
    - www.struckbylightning.org

Figure 2: Lightning stroke without multiple branches

Heat Waves

Know What These Terms Mean...

* Heat wave: Prolonged period of excessive heat and humidity. The National Weather Service steps up its procedures to alert the public during these periods of excessive heat and humidity.
* Heat index: A number in degrees Fahrenheit (F) that tells how hot it really feels when relative humidity is added to the actual air temperature. Exposure to full sunshine can increase the heat index by 15 degrees F.
* Heat cramps: Heat cramps are muscular pains and spasms due to heavy exertion. Although heat cramps are the least severe, they are an early signal that the body is having trouble with the heat.
* Heat exhaustion: Heat exhaustion typically occurs when people exercise heavily or work in a hot, humid place where body fluids are lost through heavy sweating. Blood flow to the skin increases, causing blood flow to decrease to the vital organs. This results in a form of mild shock. If not treated, the victim may suffer heat stroke.
* Heat stroke: Heat stroke is life-threatening. The victim's temperature control system, which produces sweating to cool the body, stops working. The body temperature can rise so high that brain damage and death may result if the body is not cooled quickly.
* Sunstroke: Another term for heat stroke.

If a Heat Wave Is Predicted or Happening...

* Slow down. Avoid strenuous activity. If you must do strenuous activity, do it during the coolest part of the day, which is usually in the morning between 4:00 a.m. and 7:00 a.m.
* Stay indoors as much as possible. If air conditioning is not available, stay on the lowest floor, out of the sunshine. Try to go to a public building with air conditioning each day for several hours. Remember, electric fans do not cool the air, but they do help sweat evaporate, which cools your body.
* Wear lightweight, light-colored clothing. Light colors will reflect away some of the sun's energy.
* Drink plenty of water regularly and often. Your body needs water to keep cool.
* Drink plenty of fluids even if you do not feel thirsty.
* Water is the safest liquid to drink during heat emergencies. Avoid drinks with alcohol or caffeine in them. They can make you feel good briefly, but make the heat's effects on your body worse. This is especially true about beer, which dehydrates the body.
* Eat small meals and eat more often. Avoid foods that are high in protein, which increase metabolic heat.
* Avoid using salt tablets unless directed to do so by a physician.

Signals of Heat Emergencies...

* Heat exhaustion: Cool, moist, pale, or flushed skin; heavy sweating; headache; nausea or vomiting; dizziness; and exhaustion. Body temperature will be near normal.
* Heat stroke: Hot, red skin; changes in consciousness; rapid, weak pulse; and rapid, shallow breathing. Body temperature can be very high-- as high as 105 degrees F. If the person was sweating from heavy work or exercise, skin may be wet; otherwise, it will feel dry.

Treatment of Heat Emergencies...

* Heat cramps: Get the person to a cooler place and have him or her rest in a comfortable position. Lightly stretch the affected muscle and replenish fluids. Give a half glass of cool water every 15 minutes. Do not give liquids with alcohol or caffeine in them, as they can make conditions worse.
* Heat exhaustion: Get the person out of the heat and into a cooler place. Remove or loosen tight clothing and apply cool, wet cloths, such as towels or sheets. If the person is conscious, give cool water to drink. Make sure the person drinks slowly. Give a half glass of cool water every 15 minutes. Do not give liquids that contain alcohol or caffeine. Let the victim rest in a comfortable position, and watch carefully for changes in his or her condition.
* Heat stroke: Heat stroke is a life-threatening situation. Help is needed fast. Call 9-1-1 or your local emergency number. Move the person to a cooler place. Quickly cool the body. Immerse victim in a cool bath, or wrap wet sheets around the body and fan it. Watch for signals of breathing problems. Keep the person lying down and continue to cool the body any way you can. If the victim refuses water or is vomiting or there are changes in the level of consciousness, do not give anything to eat or drink.

Heat Index °F (°C)

Relative Humidity (%)

Temperature	40	45	50	55	60	65	70	75	80	85	90	95	100
110 (47)	136 (58)												
108 (43)	130 (54)	137 (58)											
106 (41)	124 (51)	130 (54)	137 (58)										
104 (40)	119 (48)	124 (51)	131 (55)	137 (58)									
102 (39)	114 (46)	119 (48)	124 (51)	130 (54)	137 (58)								
100 (38)	109 (43)	114 (46)	118 (48)	124 (51)	129 (54)	136 (58)							
98 (37)	105 (41)	109 (43)	113 (45)	117 (47)	123 (51)	128 (53)	134 (57)						
96 (36)	101 (38)	104 (40)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	132 (56)					
94 (34)	97 (36)	100 (38)	103 (39)	106 (41)	110 (43)	114 (46)	119 (48)	124 (51)	129 (54)	135 (57)			
92 (33)	94 (34)	96 (36)	99 (37)	101 (38)	105 (41)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	131 (55)		
90 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	103 (39)	106 (41)	109 (43)	113 (45)	117 (47)	122 (50)	127 (53)	132 (56)
88 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	98 (37)	100 (38)	103 (39)	106 (41)	110 (43)	113 (45)	117 (47)	121 (49)
86 (30)	85 (29)	87 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	102 (39)	105 (41)	108 (42)	112 (44)
84 (29)	83 (28)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	92 (33)	94 (34)	96 (36)	98 (37)	100 (38)	103 (39)
82 (28)	81 (27)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	91 (33)	93 (34)	95 (35)
80 (27)	80 (27)	80 (27)	81 (27)	81 (27)	82 (28)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	86 (30)	87 (31)

Category	Heat Index	Possible heat disorders for people in high risk groups
Extreme Danger	130°F or higher (54°C or higher)	Heat stroke or sunstroke likely.
Danger	105 - 129°F (41 - 54°C)	Sunstroke, muscle cramps, and/or heat exhaustion likely. Heatstroke possible with prolonged exposure and/or physical activity.
Extreme Caution	90 - 105°F (32 - 41°C)	Sunstroke, muscle cramps, and/or heat exhaustion possible with prolonged exposure and/or physical activity.
Caution	80 - 90°F (27 - 32°C)	Fatigue possible with prolonged exposure and/or physical activity.

Precautions To Take Against Excessive Heat

Increase your intake of non-alcoholic, non-carbonated, caffeine free beverages such as water and juice.
Wear clothing that is light in color and loose fitting.
Avoid the outdoors during extreme heat. Stay out of the sun.
Stay in an air-conditioned environment if possible. Shopping malls offer relief if your home is not air-conditioned.
Check on the elderly. They are especially susceptible to heat related illness.
Eliminate strenuous activity such as running, biking and lawn care work when it heats up.

Heat Related Illnesses And Their Symptoms

SUNBURN - Redness and pain in the skin. In severe cases there is also swelling, blisters, fever, and headaches.
HEAT CRAMPS - Heavy sweating and painful spasms usually in the leg or abdomen muscles.
HEAT EXHAUSTION - The person becomes weak and is sweating heavily. The skin is cold, pale and clammy. Fainting and vomiting accompanies heat exhaustion.
HEATSTROKE/SUNSTROKE - High body temperature (106 degrees or higher) along with hot dry skin and a rapid and strong pulse. Unconsciousness is possible.

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