Storm Signals

Houston/Galveston National Weather Service Office

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Gulf Coast Tropical Cyclone Landfall Forecast Study

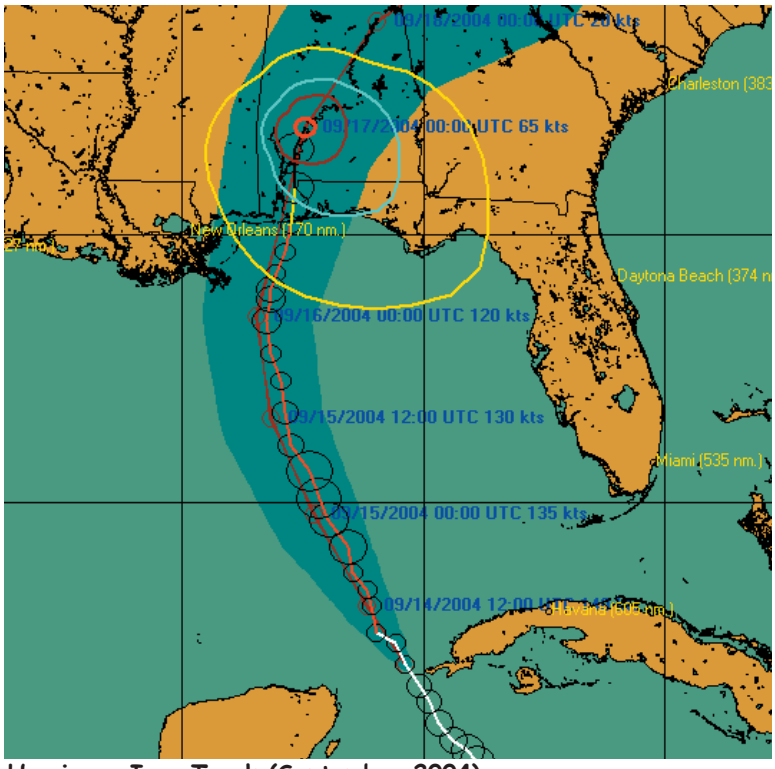
by Lance Wood

When a Gulf of Mexico tropical cyclone is forecast to make landfall, it is inevitable that many critical decisions will have to be made. Decision makers often ask, "What is the confidence of the track forecast?" Until recently, we did not have an objective tool to help answer this question. Knowing that the forecast is one of high or low confidence aids the decision making process. After the 2003 hurricane season, we decided to examine the Gulf landfall forecasts for the past 6 seasons (1998-2003) to see if we could use what we know about the cyclone (initial conditions) when the forecast is made to predict the future error of the track forecast. Being able to correlate initial conditions to future track error allows for an objective determination of confidence in the upcoming forecast.

In order to make the results from the study useable during a real-time tropical cyclone threat, a forecast confidence decision tree was developed from the results of the study. The decision tree categorizes the cyclone based on the intensity, speed of movement, formation location and center stability at the time the forecast is made. Results indicate that there is a wide range of error that can be expected based on these initial conditions. The greatest error and lowest forecast confidence can be expected from stationary, center reforming, tropical storms that develop in the Gulf of Mexico; whereas, the least error and highest forecast confidence can be expected from moderate moving, category 2 or greater hurricanes. In these extreme examples, average error differences are on the order of 250 miles at the 48 hour forecast point. During the study we also examined landfall timing errors and left/right coastal biases. It was found that the majority of landfall forecasts exhibited a left bias (forecast track is left of the actual track along the coastline). This bias was most significant for tropical storms that were forecast to make landfall between 37 and 72 hours. The majority of forecasts also depicted landfall later than the cyclone actually made landfall. Results indicate that for planning purposes, landfall timing errors of 6 and 14 hours are appropriate for landfall forecasts in the 12-36 hour and 37-72 hour periods, respectively.

We are hopeful that this new track confidence/error assessing tool will translate into improved evacuation decisions/ preparation activities during a tropical cyclone landfall threat episode. Considering that the preparation cost for a hurricane landfall threat is estimated at 1 million dollars per mile of coastline, just a small adjustment in the realistic error of a track forecast will have huge economic implications.

In this Issue



Hurricane Ivan Track (September 2004)

Hurricane Talks

The Houston/Galveston National Weather Service Office continues to offer informative hurricane talks to schools, businesses, and organizations. These talks include details on the dangers of tropical storms and hurricanes, the history of activity along the Southeast Texas coast, and ways to protect your life and property during a tropical threat. Brochures on hurricanes can also be made available to all attendees.

If you are interested in having a meteorologist come to you and talk about hurricanes, please contact Gene Hafele (gene.hafele@noaa.gov) or Joshua Lichter (joshua.lichter@noaa.gov) at (281)337-5074. The more you know about tropical storms and hurricanes, the better you will be prepared to survive when the next one strikes.

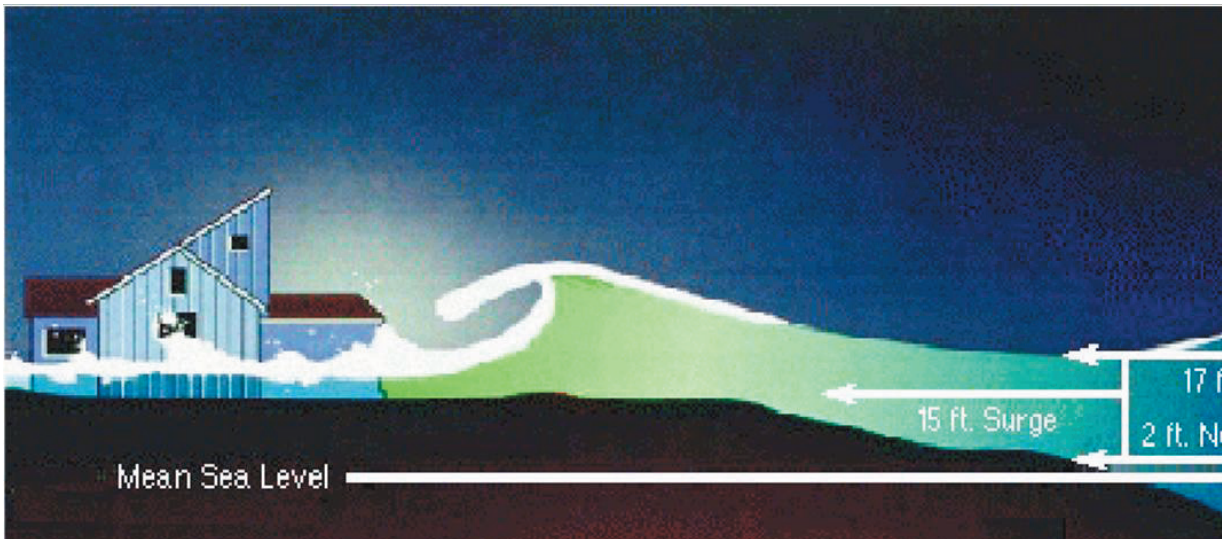
ARE YOU READY FOR A HURRICANE?

By Gene Hafele

Will 2005 be the year a major hurricane will make landfall on the upper Texas coast? If this happens, will you and your family be ready and know what to do and when to do it? The answer to the second question is probably"NO" for most families. Most families will probably wait until this major hurricane shows up in the Gulf of Mexico before they begin their hurricane preparations. I will try to cover some of the major points in being prepared for the possibility of a major hurricane sriking the upper Texas coast next year.

BEFORE THE HURRICANE…

You need to evaluate how vulnerable you are to a hurricane. Do you live in an area that will be impacted by the storm surge? To do this you need to determine your elevation above mean sea level and then visit your local emergency manager or National Weather Service office to determine the storm surge history of your area. If you determine that you do in fact live in a storm surge region, then evacuation of your family should be part of your hurricane plan. The next step is to determine where you will evacuate your family to and to decide a primary and alternate route to your evacuation destination.



Possible storm surge scenario along the coast.

Whether you evacuate inland or decide to stay at home, you will probably want to protect your home from the effects of the storm. Your windows and doors will need to be covered with boards or professionally installed shutters. This will help prevent missiles of destruction from compromising the integrity of the exterior of your home. If you use boards, they need to be pre-cut and ready for installation before the hurricane season. If you have trees in your yard, make sure you keep them trimmed to make them more resistant to the strong winds of a hurricane.

Your insurance policies need to be reviewed to make sure you are covered for all of the effects of a hurricane. If you do not currently have flood insurance, you probably will want to seriously consider buying this insurance as soon as possible. Unfortunately, flood insurance has a 30 day waiting period before going into effect. Without flood insurance, your home will not be insured against rising water. You should also complete a good inventory of your property (with video equipment if possible) to have for insurance purposes in the event of a major storm. A copy of your important papers and legal documents should be in a container that can easily be taken with you when you evacuate.

Check the status of your disaster supply kit. Does it have a first aid kit, flashlights, battery powered radio, non-perishable food, water containers for two weeks supply and a camping stove with fuel? You will also want to have some plywood and plastic on hand to make some minor repairs in the event of damage to your house.

A HURRICANE WATCH HAS BEEN ISSUED FOR YOUR AREA…

A hurricane watch means that hurricane conditions pose a possible threat to the watch area within 36 hours. The most important thing to do is "Keep Informed." You need to frequently monitor radio, TV, weather radio, or internet for the latest information on the storm. Make sure your vehicles are in good running condition and are full of fuel. Prepare to cover your windows and door openings with shutters or plywood. Store and secure outdoor lawn furniture and other loose, lightweight objects, such as garbage cans, garden tools, potted plants and other items that can become missiles of destruction during high winds.

Hurricane Andrew wind damage in South Florida (August 1992)

Check your disaster supply kit. Stock up on extra batteries and flashlights. Check prescription medicines and obtain at least a 10 day to 2 weeks supply. Obtain an extra supply of cash. Banks will be closed and ATM machines will not work after the storm.

If you live in a highly vulnerable area, such as a barrier island, local officials could recommend that you begin your evacuation during the hurricane watch. If local officials recommend that you evacuate inland, then that is what you should plan on doing.

A HURRICANE WARNING HAS BEEN ISSUED FOR YOUR AREA…

A hurricane warning means sustained winds of 74 mph or higher are expected in the warning area within 24 hours or less. The number one item you should do is "Keep Informed." If local officials advise for your family to evacuate, then you should do so immediately.

Complete preparation activities such as putting up storm shutters, storing loose objects and filling water containers. If you decide to evacuate, disconnect utilities such as phone and electricity as a precaution to prevent further damage. The gas company recommends that you turn your gas off at your appliances but do not turn it off to your house. If you decide to evacuate, do so during daylight hours if possible. Do not forget to notify

neighbors and relatives that you are evacuating and where you can be reached. Do not forget to take your important papers and your disaster supply kit.

If you decide to stay at home during the storm, these are things you should do to enhance your safety. Store water, fill jugs and bottles with two weeks supply of drinking water, fill bathtubs and other large containers with water for sanitary purposes, turn the refrigerator to maximum cold and open only when necessary, unplug small appliances and if you lose power, use flashlights rather than candles or open flames to move around in the darkness. If there is a threat that your home will be flooded, turn the main switch for electricity to off. This will prevent you from being electrocuted and could also save your major appliances.

During the storm, stay inside and keep informed. Make sure you have a battery powered radio or a weather radio to get the latest information on the storm. Stay away from windows and doors even if they are covered. Go to the lowest floor and secure and brace exterior doors.

AFTER THE STORM…

If you have evacuated inland, do not attempt to return to your home until officials announce your area is ready for you to return. Make sure you have proof of residency with you that will allow you back into the area after the storm. If your home has structural damage, do not enter until it is checked by local officials. Beware of outdoor hazards such as downed power lines and any water they may be lying in, poisonous snakes, washed out roads and weakened trees or limbs. Avoid using the phone unless it is an emergency. The system is usually jammed with calls during and after a hurricane. Guard against spoiled food. Use dry or canned food. Do not drink or prepare food with tap water until you are certain the water supply is safe for consumption. Notify your insurance agent about damage to your house. Take pictures of the damaged property and keep records of your clean up cost.

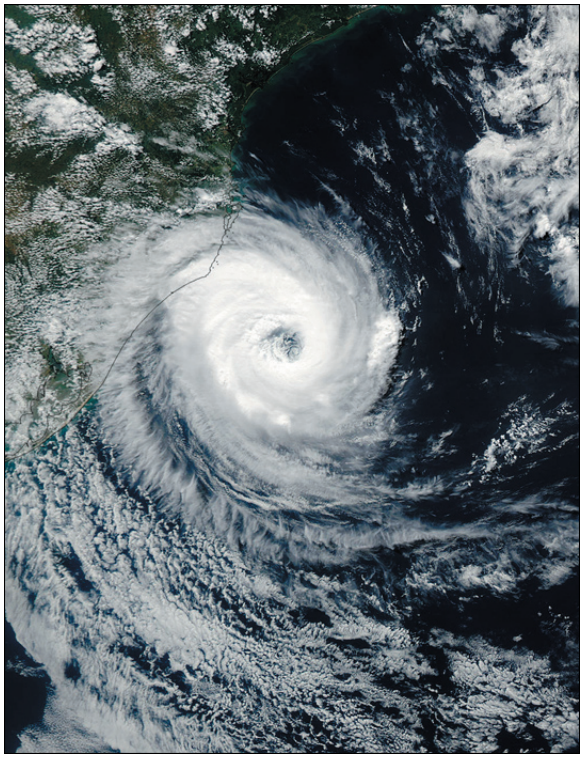
AFTER THE HURRICANE SEASON…

Hopefully, we will be able to say that the upper Texas coast was not affected by a hurricane in 2005. It is now time to begin preparing for the 2005 season and do the things that were not completed for 2004. Update your disaster supply kit, check your elevation above mean sea level and decide during the off-season whether your family will evacuate in 2005 if a hurricane threatens your area.

Flooding during Tropical Storm Allison in Friendswood (June 2001)

2004 Hurricane Season (through then end of September)

The following article was written from information obtained from the National Hurricane Center's monthly tropical weather summaries and from the National Climatic Data Center and Dr. William Gray.



Caterina Satellite (March 27, 2004)

Through early October, 2004 has had twelve named cyclones – eight hurricanes (six of which were major hurricanes) and four tropical storms. Three major hurricanes have made U.S. landfall (Charley, Ivan and Jeanne) and one Category 2 hurricane has also made landfall (Frances). At least one named storm existed on every day from August 25th through the end of September. There have also been two very long-lived major hurricanes (Frances for 7 ¼ days and Ivan for 10 days at major hurricane status). Ivan's 10 intense hurricane days are the most for any single tropical cyclone since 1900.

The official Atlantic hurricane season runs from June 1st to November 30th each year. Though tropical systems can form at any time of the year in the tropical Atlantic, they are comparatively rare outside of the official season. In March 2004, a hurricane developed in the South Atlantic. This was the first recorded hurricane in the South Atlantic basin since geostationary satellite records began in 1966. This storm came ashore along the coast of Brazil at Santa Catarina on March 28th with sustained winds of 75 to 80 mph and gusts of 95 mph. At least 3 people died and 38 were reported injured as a result of the storm. Hurricanes typically do not form south of the equator in the Atlantic due to higher wind speeds aloft, generally preventing the storms from gaining height and therefore strength. However, little is known about why they occasionally do form. Satellite imagery of the storm will allow researchers to study 'Hurricane Caterina' further.

In May, NOAA issued their forecast for the upcoming season and called for 12 to 15 named storms of which 6 to 8 would be hurricanes. 2 to 4 of the hurricanes were forecasted to become major hurricanes (category 3, 4 or 5 on the Saffir-Simpson Hurricane Scale).

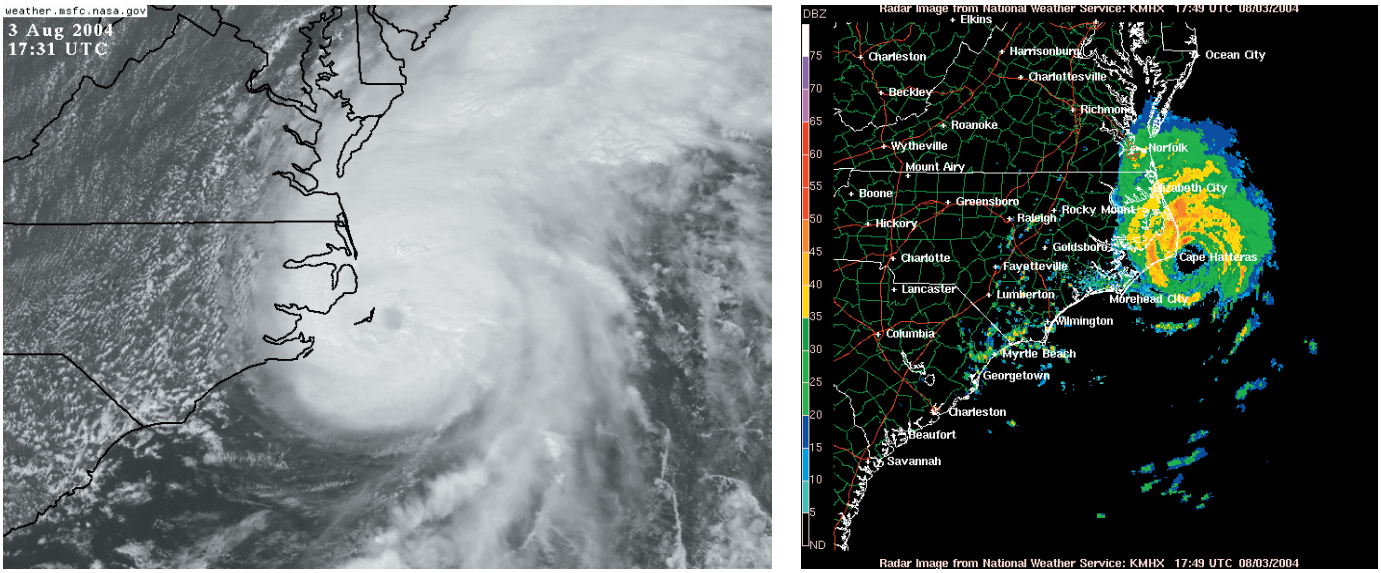
The 2004 Atlantic Hurricane Season got off to a slow start. No tropical storms or hurricanes developed in June. This is not unusual, with 50% of all Junes in the long-term record registering no tropical activity.

The first tropical system of the Atlantic season waited until July 31st to develop. Tropical Depression One formed approximately 175 miles south-southeast of Charleston, South Carolina. The depression was initially poorly organized and did not show signs of significant intensification. This system eventually strengthened into Tropical Storm Alex on August 1st.

Eight tropical cyclones reached storm strength in August (seven cyclones formed and Alex reached storm strength during the month). This is a new August record, breaking the previous record of seven set in 1933 and 1995. The eight named storms that formed through the end of August 2004 is twice the normal number of four.

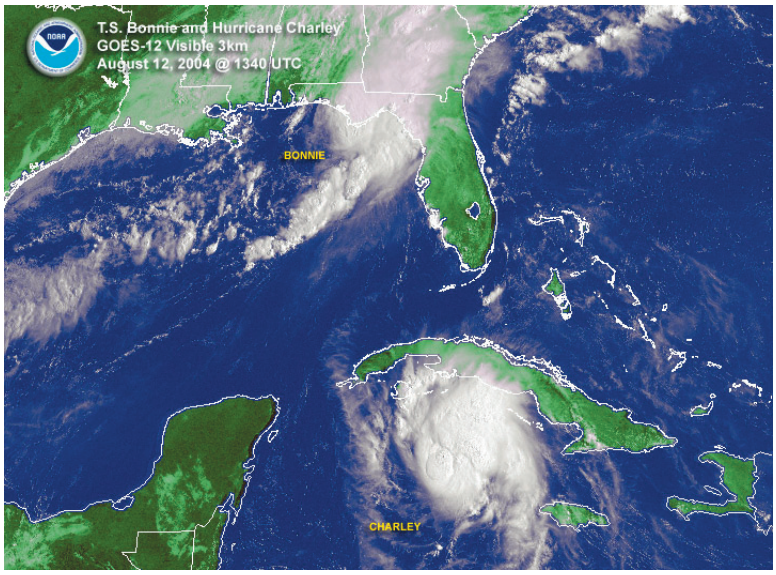
Hurricane Alex originated from a low pressure area and became a tropical depression off the northeast Florida coast on July 31st. It drifted erratically for two days, became a tropical storm on August 1st, and on August 2nd began moving northeastward along the southeastern U.S. coast. Alex became a hurricane on August 3rd and the center passed within about 10 miles of Cape Hatteras, North Carolina that afternoon with maximum winds near 100 mph – Category 2 on the Saffir/Simpson Hurricane Scale. Alex then accelerated northeastward across the western North Atlantic. Alex reached its peak intensity of 120 mph - Category 3 - August 5th as it was passing a few hundred miles south of the Canadian Maritimes. Alex became the strongest recorded Atlantic hurricane at such a high latitude (greater than 38 degrees north). Alex became extratropical in the far North Atlantic the next day. No deaths have been reported. Alex brought Category 1 hurricane conditions to the outer banks of North Carolina. Damage totals are not available at this time.

Tropical Storm Bonnie formed from a tropical wave and became a tropical depression on August 3rd over the tropical Atlantic several hundred miles east of the Lesser Antilles. The depression moved across the central Lesser Antilles the next day without



Alex Satellite and Alex Radar (August 3, 2004)

distinction and then degenerated into a tropical wave. The wave moved west to northwestward for several days and redeveloped into Tropical Storm Bonnie on August 9th just north of the Yucatan Peninsula in the Gulf of Mexico. Bonnie turned northward and northeastward August 10th and 11th and its winds reached 65 mph. Weakening on August 12th, Bonnie moved inland near Apalachicola on the Florida Panhandle with 50 mph winds. Heavy rain and localized severe weather (including tornadoes) occurred well inland.

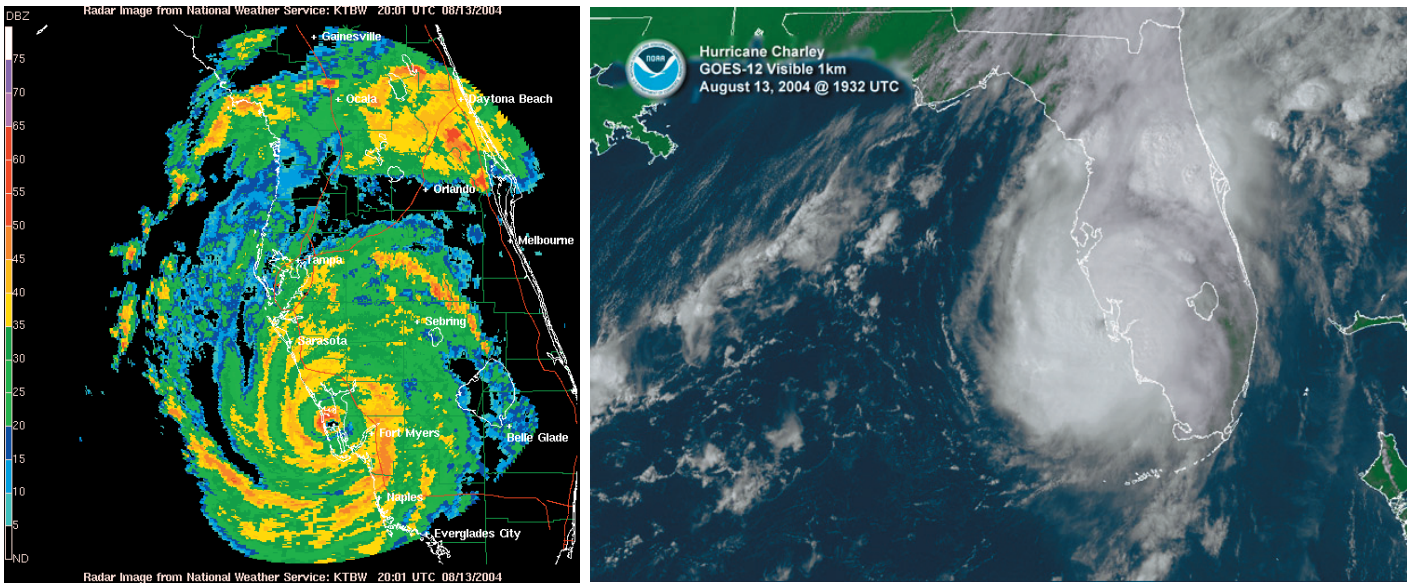


Bonnie-Charley Satellite (August 12, 2004)

Charley originated from a tropical wave and became a tropical depression on August 9th just east of Barbados. It moved quickly west-northwestward across the Caribbean while strengthening. It passed just south of Jamaica on August 11th as a hurricane and passed just north of Grand Cayman the next day. It turned toward the north-northwest and its center passed just east of the Isle of Youth early on August 13th. The hurricane made landfall near Playa Del Cajio with category 3 winds of 120 mph and moved over western Cuba. Havana, Cuba had 105 mph winds. Significant property damage (exceeding $1 billion) was reported in western Cuba with 8,300 houses completely destroyed. Charley was the worst hurricane in Cuba since Michelle in 2001 which caused $1.8 billion damage and left 200,000 homeless. Charley weakened some over the lower Florida Straits. Turning northward, the hurricane passed over the Dry Tortugas as a Category 2 hurricane. Charley then turned north-northeastward and accelerated toward the southwest coast of Florida, intensifying rapidly just prior to landfall. Charley made landfall on the southwest coast of Florida near Cayo Costa, just north of Captiva, during the afternoon of August 13th with maximum sustained winds tentatively estimated at 145 mph. Shortly thereafter, the eyewall impacted Punta Gorda and neighboring Port Charlotte with devastating results. The hurricane traversed the central Florida Peninsula resulting in a swath of destruction across the state. The center passed near Kissimmee and Orlando in the evening on the 13th by which time the maximum sustained winds had decreased to around 85 mph. Winds at the Orlando International Airport gusted to 105 mph, a new record wind gust for the city. Charley was still a hurricane when the center moved off the northeast coast of Florida near Daytona Beach.

After moving into the Atlantic, Charley came ashore again near Cape Romain, South Carolina in the morning on August 14th with highest winds of about 80 mph. The center then moved just offshore and made another landfall at North Myrtle Beach with winds near 75 mph. Charley soon weakened to a tropical storm over southeastern North Carolina. On August 15th, Charley became extratropical over Virginia while embedded in a frontal zone. Charley's extratropical remnants moved rapidly northeastward and were absorbed by the frontal zone near southeastern Massachusetts.

Charley was directly responsible for 10 deaths in the United States: 9 in Florida and 1 in Rhode Island. There were also 4 direct deaths in Cuba and 1 in Jamaica. An additional 16 U.S. deaths are indirectly attributable to Charley. The Florida citrus crop sustained severe damage. Charley was the strongest hurricane to hit Florida's west coast since Donna in September 1960, and it was the strongest hurricane to affect the state of Florida or the Unites States coastline since Hurricane Andrew in August 1992. The Property Claims Service reports Charley produced insured damages of $6.755 billion in Florida, $25 million in North Carolina and $20 million in South Carolina - a total of $6.8 billion in insured losses. The Insurance Information Institute reports an estimated total of $7.4 billion in insured losses. The preliminary estimates of the damage total range from $13 to $15 billion. This would make Charley the second costliest tropical cyclone in U.S. history.



Charley Radar and Charley Satellite (August 13, 2004)

Danielle developed from a tropical wave about 240 miles south-southeast of the Cape Verde Islands. It became a tropical storm late on August 13th a short distance south of the Cape Verde Islands. Danielle moved west-northwestward and became a hurricane the next day. It spent the rest of its existence over the open waters of the far eastern Atlantic, reaching a peak intensity of 105 mph before dissipating on the 21st about 855 miles west-southwest of the Azores.

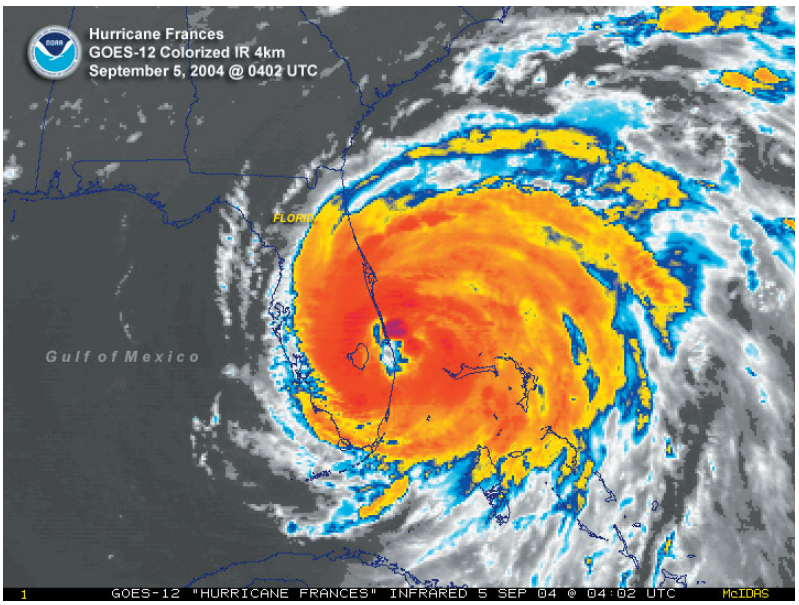
Tropical Storm Earl was short-lived. It formed from a tropical wave on August 13th over the central tropical Atlantic Ocean. It moved quickly westward, became a tropical storm on August 14th and then crossed the Caribbean Windward Islands on August 15th with brief but heavy rains and winds to 45 mph. Earl degenerated to an open tropical wave later that day over the eastern Caribbean Sea.

Frances formed from a tropical wave and became a tropical depression over the far eastern tropical Atlantic Ocean on August 24th. Moving west-northwest to northwestward, the depression became a tropical storm the next day and a hurricane on August 26th while located in the central tropical Atlantic. Steadily strengthening, Frances turned westward on August 30th. Frances passed about 125 miles north of Puerto Rico with winds of 140 mph on August 31st, then turned west-northwestward on September 1st. This brought the hurricane near the southeastern Bahamas and the Turks and Caicos Islands on September 2nd with winds of 145 mph - Category 4 on the Saffir-Simpson hurricane scale. Frances turned northwestward and weakened to a Category 3 hurricane as it passed over San Salvador Island later that day. It moved slowly west-northwestward through the northwestern Bahamas on September 3rd and 4th while weakening to a Category 2 hurricane. The center of Frances reached the Florida east coast near Sewall's Point early on September 5th, then continued west-northwestward across the central Florida peninsula to the northeastern Gulf of Mexico by early on September 6th. Frances weakened to a tropical storm over Florida, and it was still a tropical storm when it made a final landfall near St. Marks, Florida later that day. Frances moved generally northward across the eastern United States, finally dissipating over southeastern Canada on September 9th. In Florida, more than 1.8 million customers lost power and more than 90,000 people waited out the storm in over 300 storm shelters. Frances brought major flooding and some structural damage, and also dealt another significant blow to the citrus crop which had been devastated by Hurricane Charley in August. In the Appalachians, major flooding resulted from rainfall accumulations between six and twenty inches. Frances was also responsible for a record breaking 117 tornadoes on its track through the Southeast U.S., topping Hurricane Beulah's 115 tornadoes in September 1967. Frances was also responsible for at least 23 fatalities. Insured damage from Frances is estimated at around $4 billion, bringing the total damage estimate to around $8 billion.

Gaston developed slowly from an area of low pressure associated with a decaying frontal zone and became a tropical depression on August 27th about 140 miles southeast of Charleston, South Carolina. Drifting erratically, the depression became a tropical

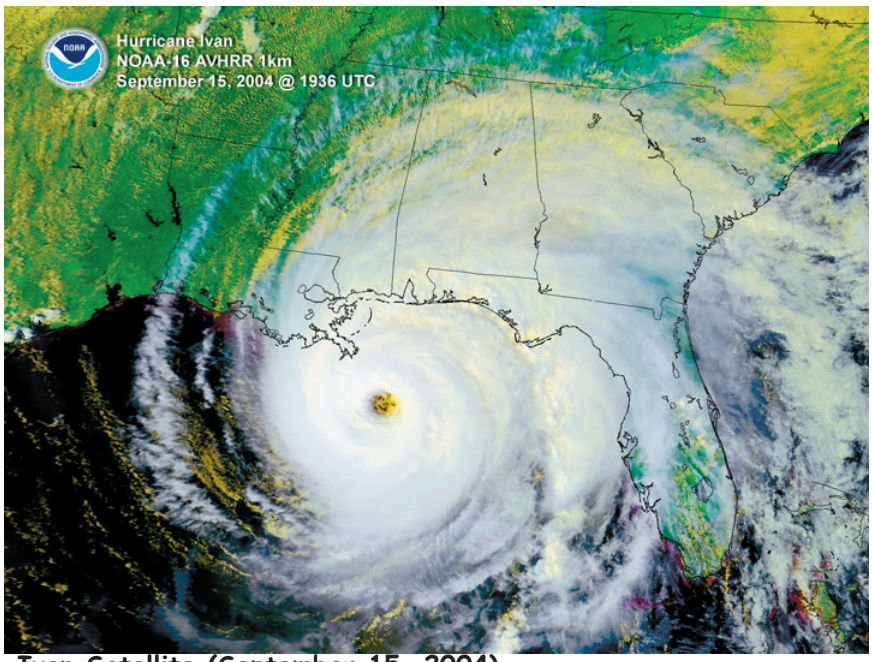
storm the next day and continued to strengthen as it began to move toward the coast. On the morning of August 29th, Gaston moved inland just west of McClellanville, South Carolina with maximum winds of about 70 mph. That evening, Gaston weakened to a tropical depression near Florence, South Carolina. Gaston moved northeastward over North Carolina and across the Delmarva Peninsula on August 30th and late in the day restrengthened to a tropical storm as it moved back over water. At months end, Gaston was beginning to lose tropical characteristics south of Nova Scotia. Gaston produced widespread flooding across South Carolina, North Carolina and Virginia with rainfall totals exceeding 12 inches in some locations. Casualty and damage statistics are not yet available.

Hermine formed on a frontal zone on August 29th over the western North Atlantic about 350 miles west of Bermuda. It moved northward the next day with winds reaching 50 mph. Hermine weakened and became extratropical early on August 31st as it moved across eastern Massachusetts with winds up to 35 mph.



Frances Satellite (September 5, 2004)

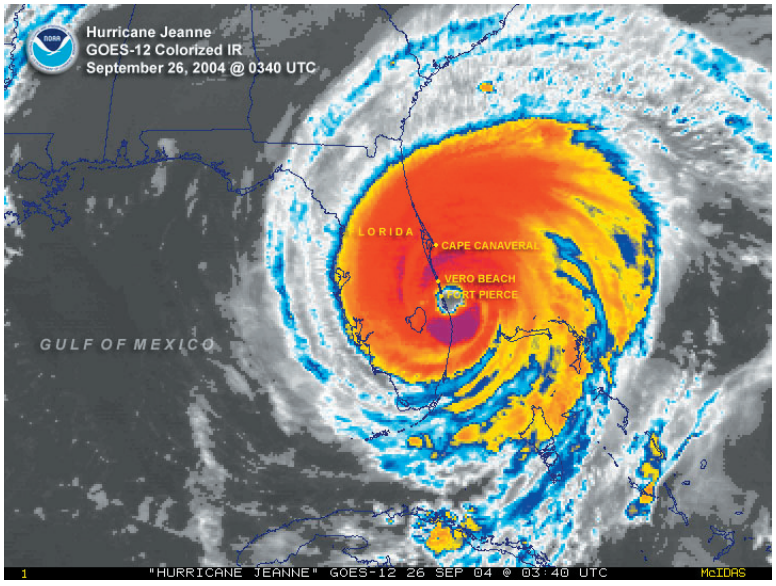
Ivan was a classical long-lived Cape Verde hurricane that made two landfalls along the U.S. coast and reached Category 5 strength three times. Ivan developed from a vigorous tropical wave that moved off the west coast of Africa on August 31st. The system quickly strengthened and became a tropical depression on September 2nd, a tropical storm on the 3rd, a hurricane early on the 5th, and a major hurricane later that same day. Ivan moved westward for the next several days and passed over the southern Windward Islands where it caused considerable damage and loss of life - especially on Grenada where 90 percent of the houses were damaged. Ivan then moved west-northwestward across the southern Caribbean Sea passing just north of Venezuela and the Netherlands Antilles. Ivan reached rare Category 5 strength while over the central Caribbean Sea early on September 9th as it moved toward Jamaica. As Ivan approached Jamaica, it weakened to a Category 4 hurricane later that day as the center moved slowly westward just south of the island. After passing Jamaica, Ivan briefly regained Category 5 strength on September 11th when the hurricane was south of the Cayman Islands. Once again, Ivan inflicted considerable damage - this time on Grand Cayman Island as the hurricane headed toward western Cuba. On Grand Cayman, nearly every building sustained some degree of roof damage. Ivan remained at Category 5 strength until early on September 12th. However, by early on September 13th, Ivan once again became a Category 5 hurricane for the third and final time. Western Cuba was spared the brunt of Hurricane Ivan as the small eye moved through the Yucatan Channel instead, but Ivan had already killed seventy-two people across the Caribbean and caused considerable destruction. For the next three days, Ivan moved northwestward over the Gulf of Mexico. Before landfall, offshore buoys in the Gulf of Mexico measured wave heights as high as 50 feet! Ivan slowly weakened as it moved toward the U.S. Gulf Coast and made its first U.S. landfall near Gulf Shores, Alabama as a Category 3 hurricane early on September 16th. Significant damage from winds and storm surge occurred along the coastline of Mississippi, Alabama and the Florida panhandle. Extensive destruction occurred in Pensacola and its suburbs. After landfall, Ivan gradually weakened over the next week while making a large clockwise loop. Ivan moved northeastward over the southeastern U.S. and emerged off the Delmarva Peninsula on September 19th as an extratropical low. The remnant circulation of Ivan then moved southwestward just off the southeastern U.S. coast and passed over South Florida and into the Gulf of Mexico on September 21st. Ivan became a tropical storm again on the 23rd and made its second landfall over extreme southwestern Louisiana on the



Ivan Satellite (September 15, 2004)

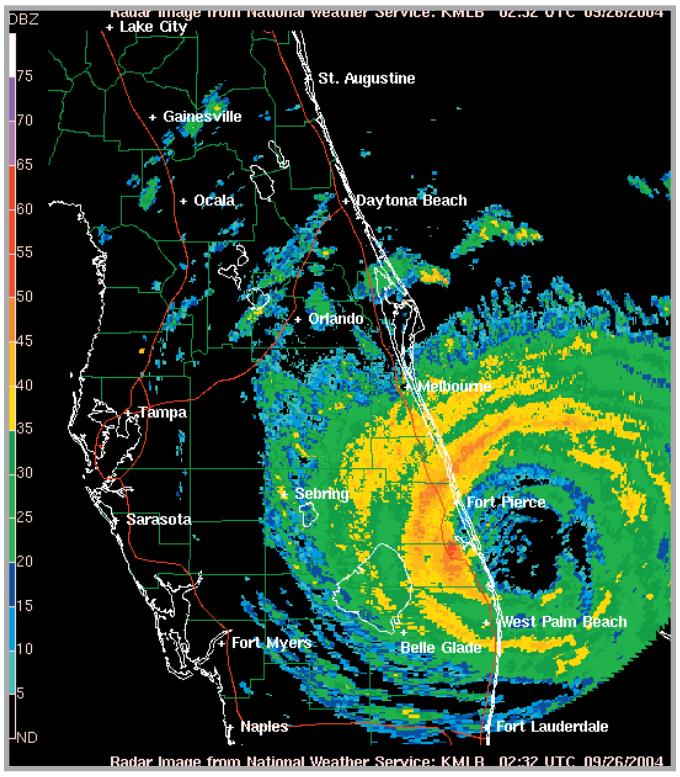
24th. Ivan finally dissipated inland over east Texas later that day. Ivan produced 104 tornadoes on its track across the United States. In Asheville, North Carolina, around $200 million in damage was caused in Buncombe County from the combined effects of Frances and Ivan in the span of a two week period. At least 50 direct and indirect deaths in the U.S. have been attributed to Ivan. Initial estimates of insured damage losses from Ivan range from $3-6 billion, bringing the total damage estimate to between $6-12 billion.

Tropical Depression Ten formed from an area of disturbed weather associated with a tropical wave that moved off the coast of Africa on August 29th. The weather area moved west-northwestward to westward for several days under strong vertical shear conditions before turning northward over the eastern Atlantic on September 7th. Early on September 9th, the disturbed area formed into a tropical depression about 420 miles west-southwest of the Azores Islands. The depression moved slowly northeastward and then turned southeastward before dissipating later that day about 380 miles west-southwest of the Azores.



Jeanne Satellite (September 25, 2004)

Hurricane Jeanne originated from a tropical wave and became a tropical depression on September 13th while located over the tropical Atlantic Ocean just east of the Leeward Islands. Jeanne moved west-northwestward over the Leeward Islands on the 14th while strengthening to a tropical storm. It moved slowly over the Virgin Islands and Puerto Rico on the 15th and then slowly over the Dominican Republic and Haiti on the 16th and 17th accompanied by torrential rains and winds to near hurricane force. Jeanne produced power outages for most of Puerto Rico's four million residents and left 600,000 people without running water. Jeanne briefly became a hurricane over the Mona Passage but then weakened while interacting with the high terrain of Hispaniola. Jeanne turned northward on the 18th and moved over the southeastern Bahamas as a tropical storm. Jeanne drifted northward and strengthened, becoming a hurricane on the 20th while located about 400 miles east of Freeport in the Bahamas. The hurricane moved along a slow clockwise loop for several days and strengthened to a Category 2 hurricane on the Saffir/Simpson scale. The loop was completed by the 23rd and Jeanne began a track just north of due westward. On the 25th, Jeanne's large eye directly hit Abacos Island and then Grand Bahama Island in the northwestern Bahamas while strengthening to a Category 3 hurricane (roofs were torn off and and hundreds of houses were severely damaged). The large eye made landfall on the east coast of Florida near Stuart at Category 3 stage. It is notable that hurricane Frances made landfall near this same location just twenty days earlier and also moved over the same islands in the northwestern Bahamas. Jeanne weakened to a tropical storm over central and northwestern Florida while turning northward. Jeanne weakened to a depression over Georgia and recurved over the mid-Atlantic coastal states on the 28th and 29th accompanied by heavy rain. On the 30th, Jeanne had become an extratropical frontal low located a few hundred miles south of Nova Scotia. The death totals in the Dominican Republic and Haiti are not yet known, but estimates from news sources are greater than 3000 in Haiti from inland flooding (the majority of the fatalities occured in the city of Gonaives). One direct death was reported in Puerto Rico and two direct deaths were reported in Florida. Jeanne produced a total of sixteen tornadoes. Initial estimates of insured damage range from $4-8 billion bringing the total damage estimate to between $8-16 billion.



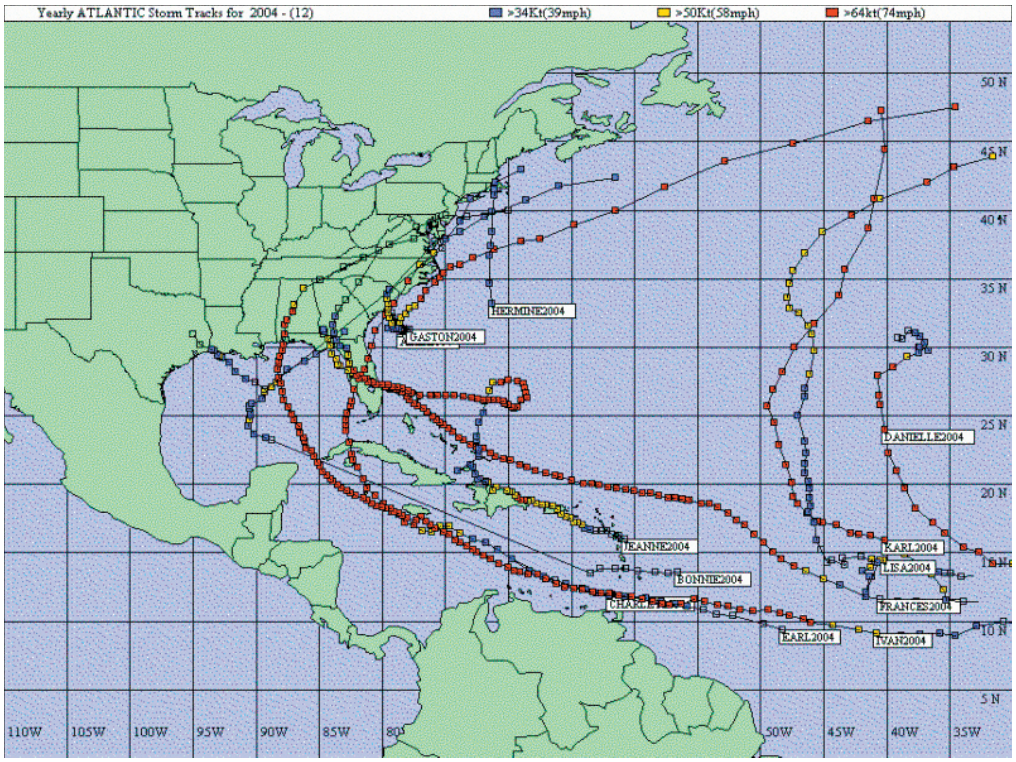
Jeanne Radar (September 25, 2004)

Hurricane Karl developed from a tropical wave, becoming a depression about 670 miles west-southwest of the Cape Verde Islands on September 16th. Initially moving westward, the cyclone turned west-northwestward as it became Tropical

Storm Karl on September 17th. Karl then turned nothwestward as it became a hurricane the next day. Karl moved west-northwestward to northwestward on September 19th and 20th as it became a major hurricane. Maximum sustained winds reached an estimated 140 mph on September 21st as Karl turned north-northwestward. Karl turned northward on September 22nd and northeastward the next day while showing flucuations in strength. It then turned northward and lost tropical characteristics about 935 miles northwest of the Azores on September 24th.

Tropical Storm Lisa developed from a tropical wave, becoming a depression on September 19th about 645 miles west-southwest of the Cape Verde Islands and a tropical storm the next day. Lisa moved westward for a couple of days and then interacted with another tropical disturbance approaching Lisa from the east. The disturbance and Lisa looped about each other on September 22nd and 23rd until the disturbance was absorbed into Lisa's circulation. Lisa then continued westward on September 24th before turning northward in the central Atlantic. Moving slowly for several days, Lisa gradually intensified, and after nearly two weeks of moving over the eastern Atlantic, became a minimal hurricane on the first of October. Later that evening, Lisa was downgraded to a tropical storm, and 24 hours later became extratropical while racing off to the east northeast across the cold North Atlantic Ocean.

2004 Storm Names	Dates	Max winds (mph)	Min Pressure (mb)
H. Alex (Cat. 3)	7/31 - 8/06	120	957
T.S. Bonnie	8/03 - 8/12	65	1000
H. Charley (Cat. 4)	8/09 - 8/15	145	941
Danielle (Cat. 2)	8/13 - 8/21	105	970
T.S. Earl	8/13 - 8/16	45	1005
H. Frances (Cat. 4)	8/25 - 9/10	145	935
T.S. Gaston	8/27 - 9/01	70	991
T.S. Hermine	8/29 - 8/31	50	1000
H. Ivan (Cat. 5)	9/02 - 9/18	165	910
Depression Ten	9/09 - 9/09	35	1013
H. Jeanne (Cat.3)	9/13 - 9/27	115	950
H. Karl (Cat. 4)	9/16 - 9/24	140	938
H. Lisa (Cat. 1)	9/19 - 10/03	75	987



2004 Hurricane Season Table and Tracks through the first week of October

Why Florida in 2004?

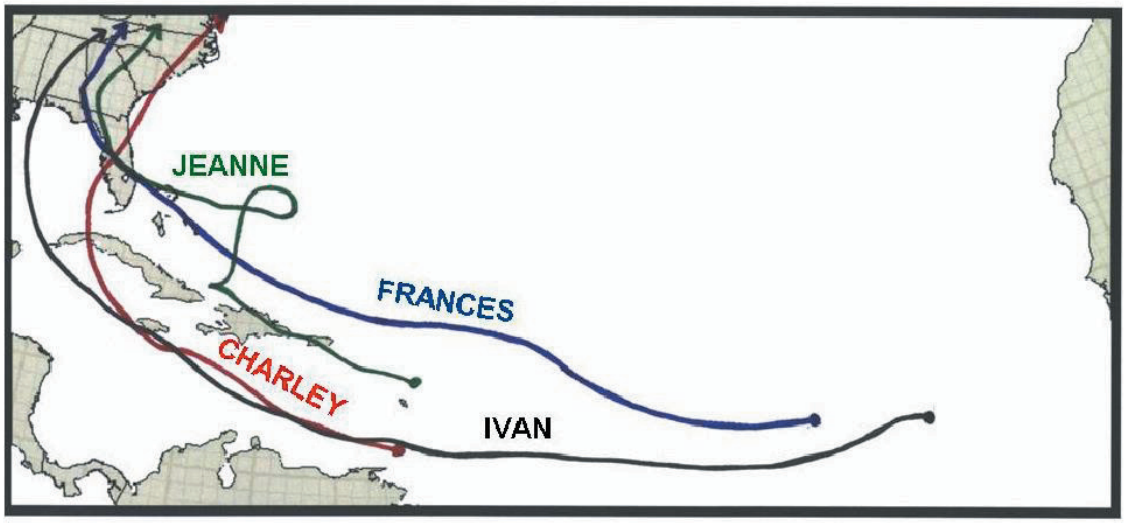
Information obtained from Dr. William Gray

Most of this year's hurricanes had long westward tracks that were atypical of the tracks of most hurricanes during the recent years of 1995-2003. During the years of 1995-2003, a North American East Coast trough acted to deflect the westward moving tropical hurricanes to the north and recurved them. Few made it far enough west to impinge on the United States. In this nine-year period, only three of the thirty-two major hurricane that developed hit the United States. In August-September 2004, a U.S. East Coast ridge kept most of the hurricanes moving westward. These cyclones did not recurve until they got in the longitude of the Southeast United States. As a result, three of six major hurricanes have struck the United States.

Florida's four destructive 2004 hurricanes (tracks below) came ashore along coastlines that were not very densely populated. Pensacola, FL was the largest Florida location feeling the direct brunt of one of these four damaging hurricanes. The coastal and inland areas around Punta Gorda-Port Charlotte (where Charley came ashore), and Stuart (where Frances and Jeanne came ashore) do not have large coastal populations. The three major Florida coastal population concentrations from Tarpon Springs to Sarasota, West Palm Beach to South Miami, and Daytona Beach to Melbourne (and inland to Orlando) were all removed from the direct brunt of these four hurricanes. Insurance claims payments from the four storms combined are estimated to total $22-23 billion, surpassing the $15.5 billion record set by Hurricane Andrew in 1992. Insured losses from Hurricane Andrew total $20 billion in today's dollars. Economic loss many times greater could have occurred if the center of any one of these four hurricanes had come into one of these more concentrated Florida population areas. For instance, it has been estimated that if Hurricane Andrew (1992) had come inland just 15-20 miles north of its actual landfall near Homestead, it would have caused two to three times the $40 billion in property loss that resulted.

Florida's five named storms (4 hurricanes, 3 of which were major, and 1 tropical storm) over a 48 day period are unprecedented in terms of historical records going back 130 years, although they are well within the range of natural climate fluctuations. What makes August-September 2004 so special in regards to landfalling hurricanes in Florida is the unusual combination of high hurricane activity and very favorable surrounding hurricane steering currents (East U.S. Coast ridging) that advected the hurricanes from the deep tropics across Florida.

It must be noted that Florida has been extremely fortunate in recent years. Between 1966 and 2003 (38 years), the Florida Peninsula has experienced the landfall of only one major hurricane (Andrew in 1992). In this long major hurricane lull period since the mid-1960s, Florida's population and coastal development has exploded. Few of the new Floridians have experienced a major hurricane hit. Most Floridians were not prepared for the unusual 2004 onslaught of four devastating storms in such a short period of time. But old-timers who lived in Florida in the 1930s through the 1950s remember that Florida used to be hit by many intense storms. Between 1928 and 1965 (41 years), the Florida Peninsula experienced 14 major hurricane landfalls (1 per 3 years). For many years, Dr. Gray has discussed how lucky Florida had been with regards to its few recent landfalling major hurricanes. He said it was inevitable that this period of few major hurricane strikes would end and that the long period climatology would eventually reassert itself. Gray acknowledges, however, that there was no way of knowing that the law of averages would try to catch up to its deficit so rapidly in one year.



Tracks of four of the most destructive 2004 storms to impact the United States.

Tropical Cyclone Induced Tornadoes of 2004

Information obtained from NOAA and TornadoProject.com

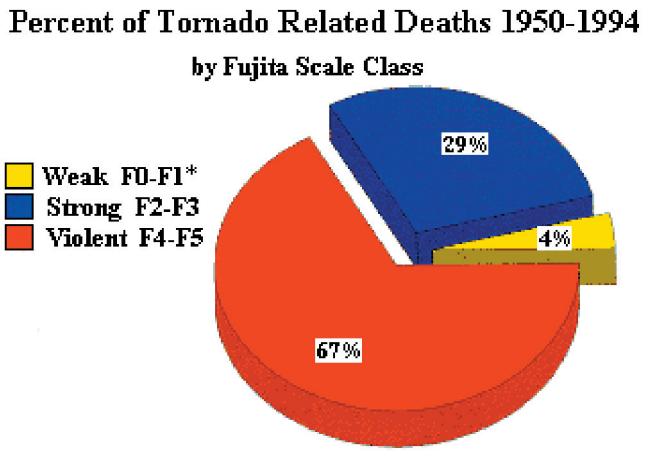
Preliminary numbers indicate a total of 247 tornadoes occured across the United States in September 2004. Of the 247 tornadoes, Hurricane Frances produced 117 of them, Hurricane Ivan produced 104 of them and Hurricane Jeanne produced 16 of them. Going back to 1950, the 247 significantly tops the previous September record of 139 tornadoes set in 1967. Other high numbers for September include 104 in 1998, 101 in 1996, and 84 in 2001. The average number of tornadoes in the U.S. during September is 47. September's record follows a record-breaking 173 reports during August, partially due to Tropical Storm Bonnie, with 30 tornado reports, and Hurricane Charley, with 25 tornado reports. With a total of 292 tornado reports associated with land-falling tropical systems, this has been the most active period since 1967. There has never been four tropical systems that have produced so many tornado reports affecting Florida northward into Maryland.

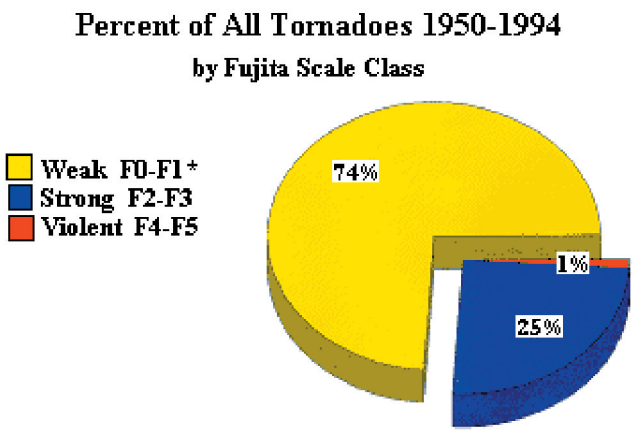
Hurricane Ivan may have spawned 5 killer tornadoes which would set a new record. One of these tornadoes was in Blountstown, Florida, where, for the 12th time in recorded history, a tropical cyclone spawned tornado killed four or more people.

Prior to Hurricane Ivan, only once in known tornado history has a tropical cyclone produced as many as four killer tornadoes. That event occurred on July 6, 1891, when a tornado killed 11 people at the Louisiana State Penitentiary, a second tornado killed two in homes near Gloster, MS, a third tornado killed one at a logging camp in Lincoln County, MS, and a fourth tornado killed one in a frail home in Madison County, MS. The hurricane went ashore near Houston, TX, then turned northeast and east, crossing northwest Mississippi. It may have been a prolific tornado producer, but only the tornadoes that caused a death were written up. The last time a hurricane produced three killer tornadoes was in Carla on September 10-12, 1961. Eight died in Galveston, TX, five died at Hodge, LA, and one died at Kaplan, LA. The last time a hurricane produced two killer tornadoes was with Hurricane David on September 3, 1979. One tornado killed one in a home crushed by a tree in Fairfax County, VA and another tornado killed one in a trailer in Chester County, PA.

Here are the deadliest tropical cyclone spawned tornadoes in chronological order.

→ 2004 (September 15-16) – Blountstown, FL (Hurricane Ivan). Four died in two mobile homes (F2 intensity?).
→ 1972 (June 22) – near Okeechobee, FL (Hurricane Agnes). Six people died in lightly-built homes (intensity unknown). This event is not officially recorded as a tornado.
→ 1967 (September 20) - Palacios, TX (Hurricane Beulah). Four died in small homes (F3 intensity).
→ 1964 (October 3) - Larose, LA (Hurricane Hilda). Twenty-two died as more than 20 homes were destroyed (F4 intensity).
→ 1961 (September 12) - Galveston, TX (Hurricane Carla). Eight died as 200 buildings were destroyed, most of which were evacuated prior to the hurricane (F4 intensity).
→ 1961 (September 10) - Hodge, LA (Hurricane Carla). Five died as about 20 homes were destroyed (F3 intensity).
→ 1959 (September 30) - Ivy, VA (Hurricane Gracie). Ten died in a frail apple picker's bunkhouse - one under the collapsed chimney of a nearby home (F3 intensity damage to other homes).
→ 1934 (July 24) - Morales, TX (unnamed hurricane). Five died - one in the open and four in one of four farm houses that were leveled (F3 intensity).
→ 1891 (July 6) - 8 miles S of Baton Rouge, LA (unnamed hurricane). Ten of eleven died in the commissary building of the state penitentiary where the upper floors were being used as a pants factory (F2 intensity).
→ 1882 (September 10) - Quincy, FL (unnamed hurricane). At least five died in frail tenant homes that were swept away (F2 intensity).
→ 1814 (September 30) - Beaufort County, SC (unnamed hurricane). Twenty-three drowned as the tornado (in its waterspout stage) hit a schooner in Port Royal Sound.
→ 1811 (September 10) - Charleston, SC (unnamed hurricane). Eleven died as homes were destroyed in downtown Charleston.





Heavy Rainfall Totals over Southeast Texas During the First Six Months of 2004

By Charles Roeseler

The first six months of the year were very wet across southeast Texas. Actually, rainfall has been above normal since October 2003. This trend of above normal rainfall came to an abrupt end in July when an upper level ridge of high pressure extended across Texas. How wet were the first six months of the year? In Houston, the first six months of 2004 were the wettest first six months in recorded history. Intercontinental Airport (IAH) in Houston received 45.04 inches of rain through the end of June. The normal rainfall for the same time period is 24.12 inches. Easterwood Field in College Station (CLL) received 37.01 inches of rain through June 30th. This is the second wettest period for the area. Only the first six months of 1968 were wetter than 2004. 37.23 inches of rain fell back in 1968 which was also the wettest calendar year in recorded history. Coastal sections received above normal rainfall, but the amounts were not nearly as heavy as those which fell over inland areas. Scholes Field in Galveston (GLS) received 28.52 inches of rain through June 30th. This is the 16th wettest start to the year. The wettest first six month period occurred in 1919 when 38.47 inches of rain fell. Here are the five wettest January through June for Houston, College Station and Galveston:

IAH	CLL	GLS
45.04 - 2004	37.23 - 1968	38.47 - 1919
43.33 - 1993	37.01 - 2004	35.98 - 1991
40.98 - 1989	34.84 - 1993	34.21 - 1929
40.37 - 1968	33.73 - 1922	31.69 - 1997
38.68 - 1946	33.56 - 1992	31.65 - 1884

The January through June rainfall is approximately 170 to 180 percent of normal! The average normal rainfall for Houston for an entire year is 47.84 inches. The area has already received 45.04 inches of rain. Basically, the area has received a years worth of rain in a half year. College Station received 37.01 inches of rain through June 30th. The normal annual rainfall is 39.67 inches. Again, the area received a years worth of rain in a half year time span.

The heaviest rain of 2004 fell during the months of May and June. Both College Station and Houston received more than half of their 2004 totals during May and June. During May and June, Houston, College Station and Galveston received 25.66 inches, 19.58 inches and 14.65 inches of rain, respectively. Here are the five greatest rainfall totals for the months of May and June:

IAH	CLL	GLS
29.84 - 1989	19.58 - 2004	25.45 - 1919
25.66 - 2004#	19.53 - 1968	17.85 - 1968
24.42 - 1968	18.38 - 1993	15.41 - 1991
24.40 - 1946	18.13 - 1905	15.26 - 1884
22.74 - 2001	17.42 - 1987	15.20 - 1996

#2004 was the only year in which a tropical system did not contribute to the heavy rainfall total.

June has been the wettest month of the year thus far. Houston received 18.33 inches of rain during the month. This is the second wettest June on record. Only 2001 (Tropical Storm Allison) was wetter. College Station recorded its third wettest June on record. 11.75 inches of rain fell during the month. Galveston received 10.99 inches of rain during June. This is the eighth wettest June in recorded history. Below are the five wettest Junes for each location:

IAH	CLL	GLS
19.21 - 2001	15.03 - 1905	15.49 - 1919
18.33 - 2004	12.63 - 1968	14.76 - 1961
16.28 - 1989	11.75 - 2004	13.03 - 1968
15.85 - 1919	11.12 - 1993	12.95 - 1925
14.66 - 1960	10.92 - 1921	12.35 - 1989

The great spigot in the sky was turned off in July. Area rainfall dropped off rather dramatically from the record setting rainfall of May and June. In fact, Intercontinental Airport recorded it's seventh driest July in recorded history. A paltry 0.79 inches of rain fell during the month. Galveston also had a dry July. The city received less than an inch of rain for the month.

Below is a list of 2004 data through the end of July for the three primary climate sites for Southeast Texas.

IAH - 2004

MONTH	AVG HIGH	AVG LOW	AVG DAILY	DEPARTURE	RAINFALL	DEPARTURE
Jan	62.9	46.5	54.7	+2.9	6.01	+2.33
Feb	62.0	45.2	53.6	-1.8	5.58	+2.60
Mar	76.4	58.2	67.3	+5.0	2.23	-1.13
Apr	78.8	60.2	69.5	+1.0	5.56	+1.96
May	85.8	68.1	76.9	+1.1	7.33	+2.18
Jun	88.6	73.6	81.1	-0.2	18.33	+12.98
Jul	93.6	75.6	84.6	+1.0	0.79	-2.39

GLS - 2004

MONTH	AVG HIGH	AVG LOW	AVG DAILY	DEPARTURE	RAINFALL	DEPARTURE
Jan	61.5	50.4	55.9	+0.1	4.78	+0.70
Feb	60.6	49.0	54.8	-3.2	4.18	+1.57
Mar	72.4	61.0	66.7	+2.6	2.41	-0.35
Apr	76.3	64.8	70.6	+0.6	2.50	-0.06
May	80.9	71.6	76.3	-0.6	3.66	-0.04
Jun	86.5	77.2	81.8	-0.4	10.99	+6.95
Jul	89.5	79.4	84.5	+0.2	0.86	-2.59

CLL - 2004

MONTH	AVG HIGH	AVG LOW	AVG DAILY	DEPARTURE	RAINFALL	DEPARTURE
Jan	61.9	44.4	53.1	+2.9	4.53	+1.21
Feb	59.0	41.9	50.4	-4.1	5.92	+3.54
Mar	75.6	56.9	66.2	+4.6	2.78	-0.06
Apr	78.5	59.1	68.8	+0.9	4.23	+1.03
May	85.3	67.3	76.3	+1.0	7.83	+2.78
Jun	88.0	72.5	80.2	-1.3	11.75	+7.96
Jul	92.3	73.6	83.0	-1.6	2.33	+0.41

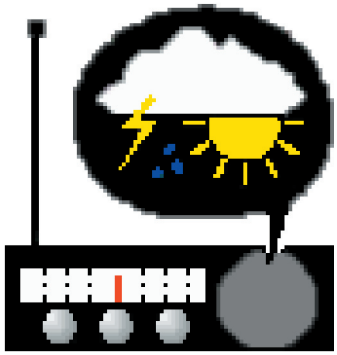
Heavy Rainfall Totals over Southeast Texas continued

Lastly, here are some of the rainfall totals from our wonderful network of co-operative volunteers. Their effort in providing this data is truly valued.

Site	Jan	Feb	Mar	Apr	May	Jun	Total
Angleton	5.33	5.33	2.63	4.85	5.80	12.68	36.62
Bay City	4.45	5.49	1.25	6.30	10.32	20.67	48.48
Baytown	5.12	7.59	1.93	4.33	7.34	14.35	40.66
Bellville	3.75	5.31	2.13	3.78	6.17	11.35	32.49
Brenham	5.04	6.09	2.27	4.16	4.01	15.69	37.26
Caldwell	3.80	5.10	2.60	4.31	6.98	17.77	40.56
Clevelan	5.00	5.92	2.94	4.47	10.05	10.36	38.74
Clodine	6.74	5.30	2.98	5.96	8.10	13.50	42.58
Columbus	4.67	3.78	1.66	8.67	4.35	16.53	39.68
Corrigan	5.48	7.09	4.46	2.79	6.91	13.83	40.56
Crockett	6.15	7.06	2.87	3.11	4.18	8.07	31.44
Danevang	3.81	3.17	1.62	5.68	11.46	7.29	33.03
Edna	3.70	3.90	1.13	5.79	8.46	13.31	36.29
Freeport	4.03	4.69	0.56	4.64	2.96	10.98	27.86
Hou-Heights	6.24	6.11	3.43	4.63	8.07	16.29	45.77
Hou-Westbury	5.88	4.84	1.99	4.41	7.12	11.74	35.98
Jamaica Beach	5.56	5.36	2.39	3.09	4.16	9.82	30.38
Katy	6.54	4.82	2.97	7.99	12.95	13.13	48.40
League City - HGX	5.26	7.35	3.09	4.42	9.88	12.41	42.41
Livingston	5.11	7.74	1.35	3.11	9.33	12.56	39.20
Madisonville	5.68	6.61	3.36	4.13	6.05	12.75	38.58
Matagorda	4.87	4.19	1.20	6.19	10.88	14.63	41.96
New Caney	7.96	5.17	3.29	6.77	6.96	15.00	45.15
Richards	4.32	6.60	4.53	4.86	6.38	11.40	38.09
Richmond	3.20	4.56	1.52	4.31	9.37	12.47	35.43
Thompsons	5.75	6.59	2.20	4.39	8.17	13.37	40.47
West Columbia	5.44	4.86	1.58	4.89	6.56	14.05	37.38
Wharton	3.53	4.58	2.17	4.19	4.80	12.68	31.95

NOAA All-Hazards Radio

By Don Oettinger



It's not just NOAA Weather Radio anymore. In an agreement between the Department of Commerce, the parent organization of the National Weather Service, and the Department of Homeland Security, NOAA Weather Radio will be used to broadcast national and regional hazard messages originating with the Department of Homeland Security.

All messages broadcast on NOAA Weather Radio (NWR) are assigned an Emergency Alert System Event Code, also known as an NWR-SAME Code. The SAME (Specific Area Message Encoder) code is a digital signature that is broadcast with each message indicating the area affected and the type of message. Users of NOAA Weather Radios with SAME capabilities can set their radios to alarm when specific message types are received.

Hazard messages originating with the Department of Homeland Security will be broadcast with the Event Codes of either CDW (Civil Danger Warning), CEM (Civil Emergency Message), or ADR (Administrative Message). The type of hazard will determine which of the Event Codes will be used.

In addition to Homeland Security Hazard messages, NOAA All-Hazards Radio will also be used to broadcast a variety of non weather related messages. These include Child Abduction Emergency (CAE), Shelter in Place Warning (SPW), and Local Area Emergency (LAE). A complete list of Emergency Alert System Codes can be found at http://weather.gov/os/eas_codes.htm.

The Houston/Galveston Weather Service Office programs five All-Hazards Radio transmitters in Southeast Texas. They are located in Bryan/College Station, Onalaska, Bay City, Houston, and Galveston. Information about them can be found at http://weather.gov/nwr

NOAA Weather Radio Facts

NOAA Weather Radio is provided as a public service by the Department of Commerce's National Oceanic and Atmoshpheric Administration.

NOAA Weather Radio broadcasts National Weather Service warnings, watches, forecasts and other hazard information 24 hours a day.

Weather Radios equipped with a special alarm tone feature can sound an alert and give immediate information about a life-threatening situation.

Weather radios come in many sizes and with a variety of functions and costs; from simple, battery-operated portables, to CB radios, scanners, and short wave sets. Radios are available at electronics stores across the country.

The hearing and visually impaired can receive watches and warnings by connecting weather radios alarm tones to other kinds of attention-getting devices, like strobe lights, pagers, bed-shakers, personal computers and text printers.

There are more than 480 NOAA Weather Radio stations in the 50 states and near adjacent coastal waters, Puerto Rico, the U.S. Virgin Islands and U.S. Pacific Territories.

Did you know that the audio you hear on the local cable channel is typically a rebroadcast of NOAA Weather Radio?

Winter Safety Rules

Although rare in southeast Texas, winter weather does occasionally occur. January is the month when snow, sleet, or freezing rain is mostly likely to be observed; yet, winter weather conditions can occur at anytime during the winter and early spring months. Also, people traveling into other parts of the country will likely encounter winter weather harsher than what occurs along the upper Texas Gulf coast.

The leading cause of death during winter storms is transportation accidents. Hypothermia and frost bite are other dangers from very cold winter temperatures. The Houston/Galveston National Weather Service Office would like to review some important safety information to help you and your family to prepare for winter weather.

→ Limit travel during periods of winter weather. Bridges, overpasses, and elevated roadways are especially vulnerable to ice and snow conditions given the lack of ground insulation under these structures.
→ Before the onset of winter precipitation, check your supplies and, if necessary, stock up on groceries, gasoline, and other necessities.
→ Have flash lights and extra batteries on-hand in case of possible power outages.
→ Wear layers of protective clothing if you are venturing outside—wind makes the air feel much colder.
→ Be alert to the signs of hypothermia. These include uncontrollable shivering, memory loss, disorientation, incoherence, slurred speech, drowsiness, and apparent exhaustion.
→ If hypothermia signs occur, seek immediate medical attention. If medical attention is not available, slowly warm the person's body core first by getting them into dry clothing and wrapping them in a warm blanket covering the head and neck. Giving warm broth and warm food is better than giving beverages or food that is hot. Alcohol should not be taken.
→ Be alert to the signs of frostbite. The most susceptible parts of the body are the extremities such as fingers, toes, ear lobes, or the tip of the nose. If frostbite occurs, seek immediate medical attention. If it is not available, the affected areas should be warmed slowly.

Concerning travel, make sure your vehicle is prepared for the onset of winter weather. Have a mechanic check the coolant system and fluid levels, the electrical system and lights, and the heater and defroster. Also, ensure good winter tires are installed. Keep a windshield scraper and small broom available for ice and snow removal. During periods of winter weather it is a good idea to maintain at least a half tank of gas. If you must travel, allow extra time to reach your destination and leave plenty of space between you and other vehicles. Ice- or snow-covered roadways are especially treacherous and stopping distances are greatly increased.

In the event of a winter storm, it is a good idea to carry a winter storm survival kit in your vehicle. Suggested items for the kit for southeast Texas residents include:

→ Flashlights with extra batteries
→ A first aid kit with a pocket knife
→ Necessary medications
→ Blankets and an extra set of winter clothes and rain gear
→ Matches and a candle for heat
→ A brightly colored cloth to use as a flag
→ A supply of food and water
→ A shovel and a small bag of sand for generating traction under wheels
→ Small tools and booster cables.

Remember, even though harsh winter weather is rare in southeast Texas, it still occasionally occurs. It is very important to stay informed about the possibility of winter weather in your area. This can be done by tuning into NOAA weather radio, commercial radio, or your local television station. If you would like more winter weather information, you can contact the Houston/Galveston National Weather Service Office.

Staff Spotlight: Bill Read

Name: Bill Read
Position: Meteorologist In Charge (MIC)
Favorite Movie: "Butch Cassidy and the Sundance Kid"

Personal Information
Hometown: Wilmington, DE
Status: Married, 1 kid, 3 dogs, 1 cat

NWS Background

1978-1978	NWS Test and Evaluation Division; Sterling, VA
1979-1979	NWS WFO San Antonio, Meteorlogical Intern
1983-1983	NWS WFO San Antonio, Journeyman Forecaster
1989-1989	NWS Headquarters (Silver Spring, MD); Flash Flood and Severe Storms Program Leader
1992-Present	NWS WSFO Houston/Galveston; Meteorologist In Charge

Favorite Color: Blue
Favorite Ice Cream Flavor: Neopolitan

Career Highlights / Achievments / Duties / Other Tidbits
- Regards taking the Houston office from a "satellite office" to a forecast office as a major career highlight
- Flew hurricane and weather reconnaissance in the U.S. Navy; from 1972-1973 was able to visit 33 countries
- President of the National Weather Association in 2003
- Duties: Management and leadership of all NWS weather forecast office activities
- Best Golf score: 70 (Olmos Park, San Antonio, 1981 and Delaware, 1967)

First "Real" Concert Attended: The Four Tops at Cherry Hill Park, NJ (1969)

Most memorable weather events?
- Tropical Storm Amelia floods (1978): It rained 46 inches in two days in the Texas Hill Country and there were about 30 deaths.
- Hurricane Allen (1980): The storm came ashore on birthday and evacuees from the Texas coast all seemed to converge on San Antonio
- November 1992 Tornado Outbreak (Southeast Texas)
- October 1994 Floods (Southeast Texas)

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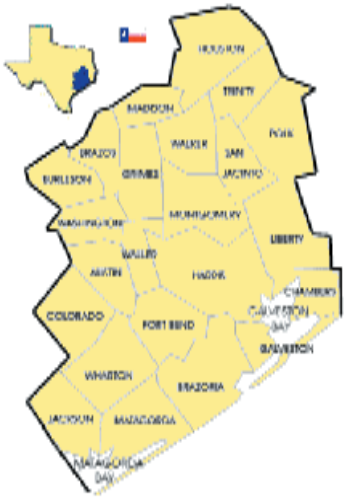

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