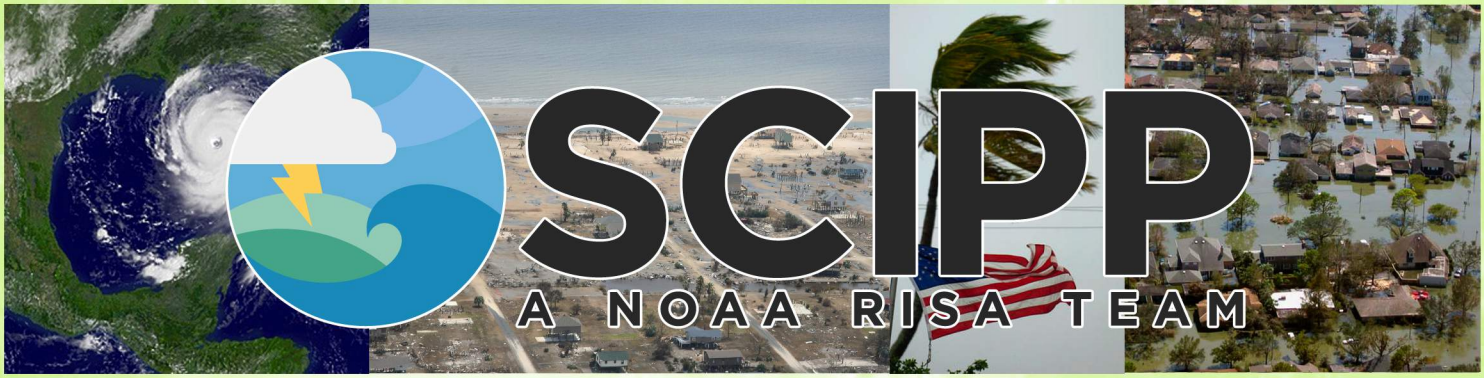


SCIPP HURRICANE INFORMATION DOCUMENT

INTRODUCTION TO HURRICANES :

Since 1980, hurricanes and tropical storms have been responsible for $367.3 billion in damage out of all billion dollar U.S. climate and weather disasters identified by the National Oceanic and Atmospheric Administration (NOAA). That's 51% of the total damages incurred by all types of disasters on the billion dollar list and 28% of the total cost has occurred in the Southern Climate Impacts Planning Program (SCIPP) region. The size of these storms, often 300 miles wide or larger, is one factor that can make them particularly effective at causing widespread damage. Hurricanes threaten the U.S. Gulf Coast every year during hurricane season, June 1 to November 30, but just how often do they occur in your area and what are the potential threats? The SCIPP Gulf Coast is most susceptible to the hazards of hurricanes, namely high wind and flooding due to storm surge. Further inland a hurricane and its remnants can produce excessive rainfall, the threat of tornadoes, and cause various other impacts to infrastructure, transportation, and commerce.

Figure 1: Hurricane Ike viewed from the International Space Station, 2008

DESCRIPTION:

A hurricane is a type of tropical cyclone, or low pressure weather system that originates in the tropics. A tropical cyclone is classified as a hurricane when the one-minute average maximum sustained wind speed is 74 mph or greater with a well defined counterclockwise (in the Northern Hemisphere) circulation. Other types of tropical cyclones include tropical storms, with maximum sustained winds of 39-73 mph, and tropical depressions, with maximum sustained winds of 38 mph or less. Once a tropical cyclone reaches tropical storm strength it becomes a named storm. Although not as strong or as organized as hurricanes, tropical storms and depressions can still produce excessive amounts of rainfall if moving slowly or remaining stationary over an area. Hurricane is a regional term; similar storms are called typhoons or cyclones in other parts of the world. The Saffir-Simpson Hurricane Wind Scale, adopted in its current form in 2010, runs from one to five and categorizes a hurricane by its maximum sustained surface wind speed at the time of issuance (Table 1). Hurricanes of Category 3 or greater are classified as major hurricanes.

Table 1: Saffir-Simpson Hurricane Wind Scale (NHC)

Saffir-Simpson Hurricane Wind Scale			
Category	**Sustained Winds**	**Description**	**Example**
1	74-95 mph	Very dangerous winds will produce some damage	Dolly (2008)
2	96-110 mph	Extremely dangerous winds will cause extensive damage	Ike (2008)
3	111-130 mph	Devastating damage will occur	Katrina (2005)
4	131-155 mph	Catastrophic damage will occur	Audrey (1957)
5	155+ mph	Catastrophic damage will occur	Camille (1969)

The winds in a landfalling hurricane can diminish by one category within a short distance, perhaps as little as a half a mile, from the coastline. Despite this decrease, even a Category 1 hurricane can produce damage. Stronger storms can maintain hurricane force well inland. Please visit the National Hurricane Center (NHC) link #8 on the last page of the report for a full description of expected structural damage associated with the wind speeds of each category.

The Saffir-Simpson Scale does not address the potential for other hurricane-related impacts such as storm surge, floods, and tornadoes. However, flooding from a hurricane is the threat that claims the largest number of lives. Public storm statements issued by the NHC and National Weather Service (NWS) address other hurricane threats in addition to the winds. Specific storm features are different for every hurricane and characteristics like hurricane size, depth of near-shore waters, topography, the hurricane's forward speed and approach to the coast all affect storm impacts and the surge that is produced. While the Saffir-Simpson Scale indicates the relative strength of a hurricane based on winds, it is important to consider all the associated impacts that these storms produce.

SCIPP HURRICANE CLIMATOLOGY:

The NHC defines the Atlantic hurricane season as the period from June 1 to November 30. Tropical cyclones occur with greatest frequency during that time period, which is when the sea surface temperatures are warmest, but can still occur outside of the official season.

Hurricanes are a regular threat to the SCIPP Gulf Coast and should be planned for each season. Of the top 10 deadliest and top 10 costliest (adjusted for inflation, 2006) tropical cyclones to make U.S. landfall, five in each list have occurred along the SCIPP coast. From 1851-2006 128 hurricanes have affected the Texas, Louisiana, or Mississippi coastline, 58 of them have been major hurricanes of Category 3 or greater.

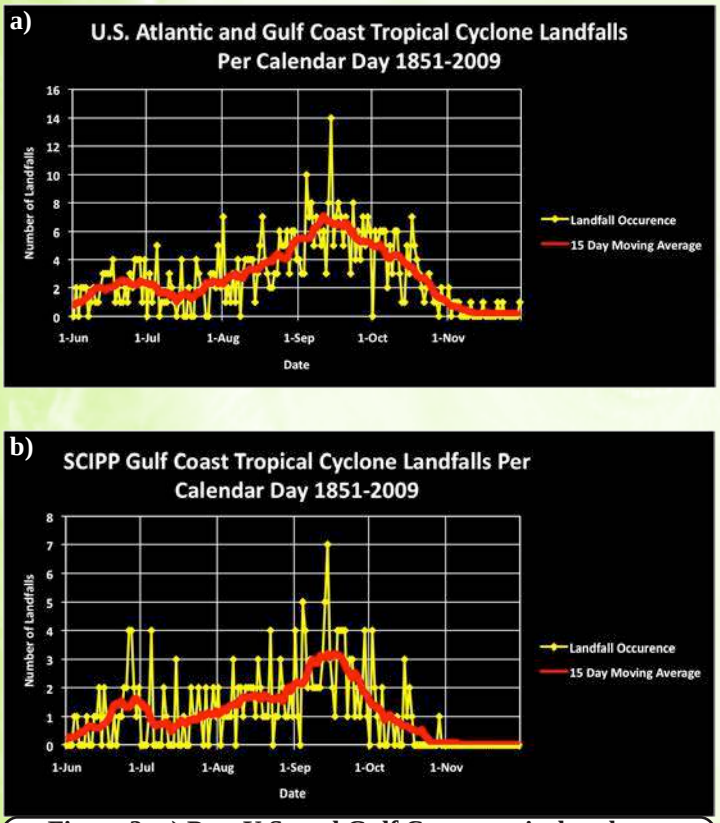


Figure 2: a) Past U.S. and Gulf Coast tropical cyclone landfalls per day b) Same for SCIPP Gulf Coast

The two charts above depict the number of times a tropical cyclone has made landfall for each day of the hurricane season over the entire period of record 1851-2009. Hurricane, tropical storm, and tropical depression landfalls are all included. The red line plotted is the 15 day moving average. Plotting the moving average smooths out high and low points for individual days in order to better show the seasonal trend. The moving average identifies a minor early season maximum for both the SCIPP Gulf Coast and the entire U.S. Gulf and Atlantic coast followed by a gradual increase in landfall frequency until the season maximum in mid September. The occurrence of SCIPP tropical cyclone landfalls quickly decrease from the maximum, whereas the U.S. coast as a whole observes a gradual decrease. During the latter part of the hurricane season, landfall occurrences shift from the Gulf Coast to the U.S. east coast.

The relative return frequency of hurricane landfalls can give us a statistical idea of just how often we can expect a hurricane at a specific spot along the Gulf Coast. A return period represents the average amount of time that passes between hurricane events at any one location based on the historical record. Figure 3 depicts the return frequency for some notable beaches in the SCIPP domain, from 1900-2005 records. For all of the beaches analyzed in the study, a tropical cyclone can by expected every 3-5 years and a hurricane every 7-15 years. Major hurricanes are much more rare and, based on past storm events, have a return period of 26 or 52 years for most of the beaches.

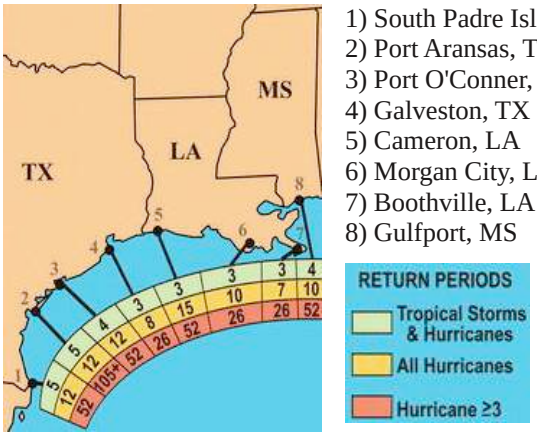


Figure 3: Average return periods for tropical storms, hurricanes, and major hurricanes (Keim 2007)

Figure 4 depicts the number of hurricanes that have crossed each SCIPP Gulf Coast county or parish from 1900-2009. Even though county size may have some influence, it is interesting to note that the Houston-Galveston area, southeast Louisiana, and the Mississippi coast have historically observed a high number of hurricanes compared to other areas.

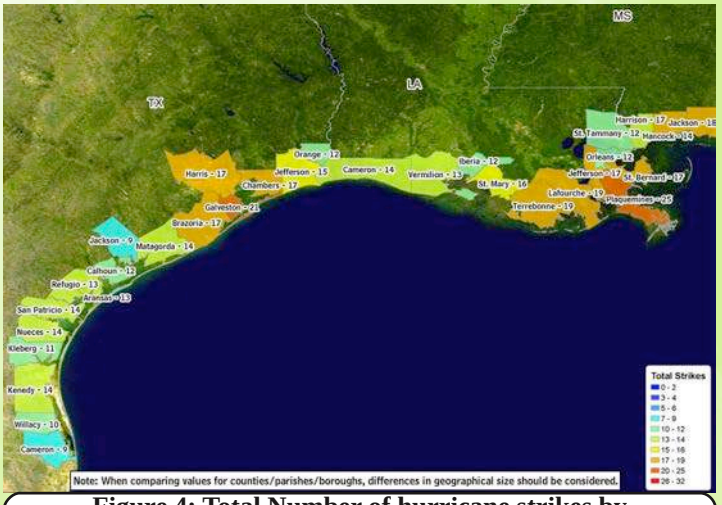
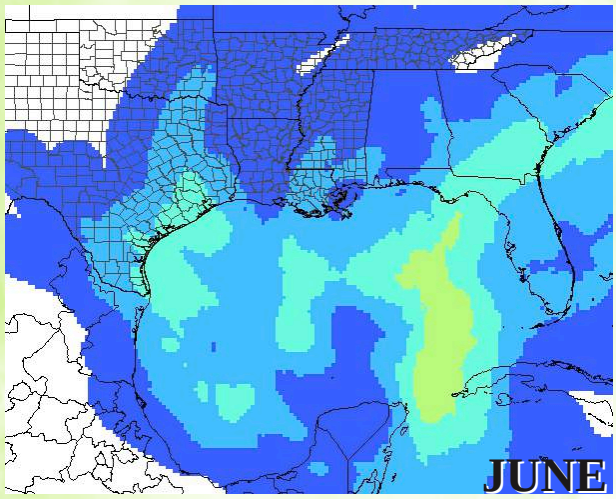
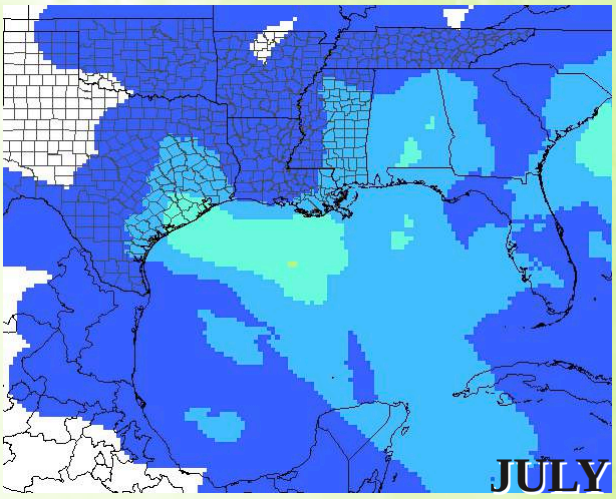


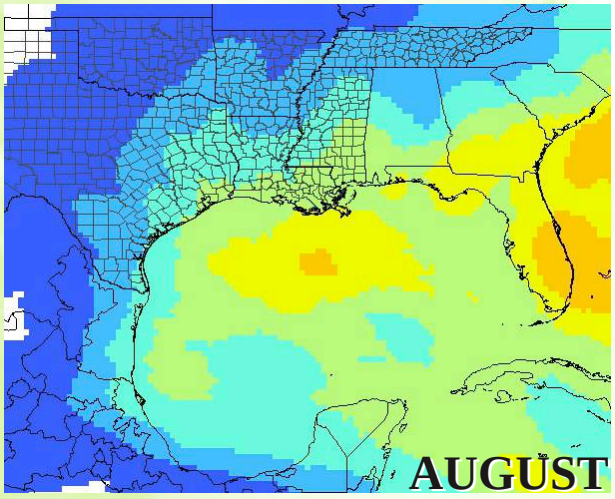
Figure 4: Total Number of hurricane strikes by counties/parishes, 1900-2009 (NHC)

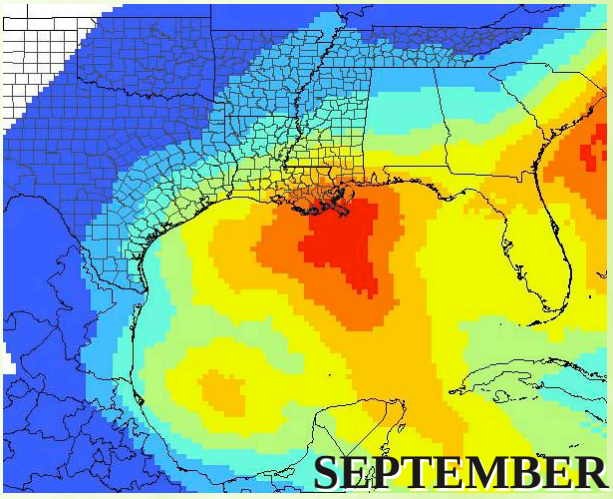
MONTHLY HURRICANE CLIMATOLOGY:

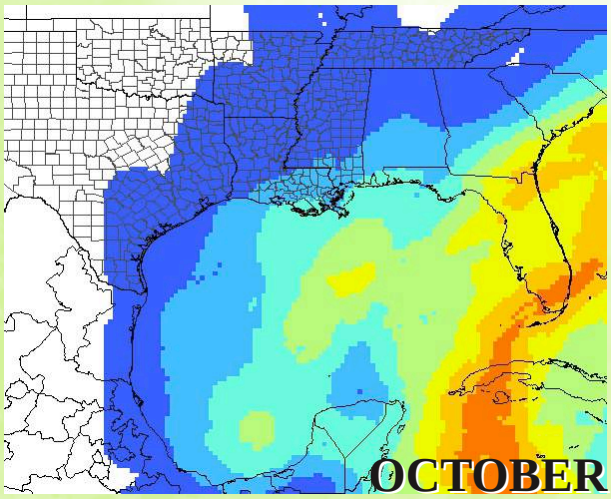
Depicted below is the tropical cyclone track density for the Gulf of Mexico and SCIPP region for each month of the hurricane season. These images represent the concentration of all past tropical cyclone tracks, 1851-2009. Keep in mind that tropical cyclones are much larger than the center track, so these maps just give a relative idea historically of where tropical cyclones have tracked each month. The red colors represent many past tropical cyclone tracks in the area and the blue colors represent fewer past tracks. The season's climatalogical maximum occurs in September.









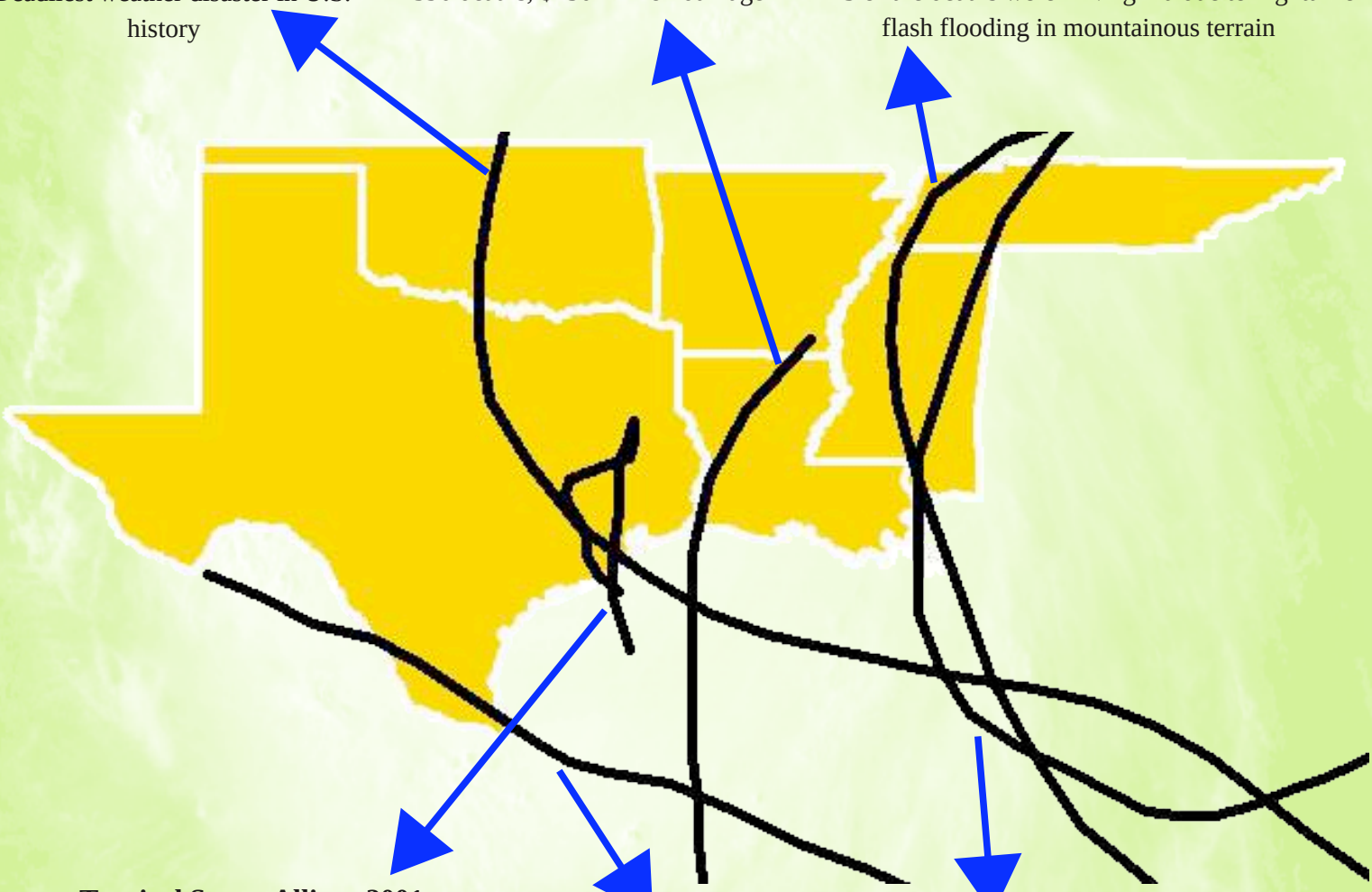


PAST STORMS IN THE SCIPP REGION

Galveston 1900:
• September 8 landfall near Galveston, TX
• Category 4, 8-15 foot storm surge
• 8,000+ deaths, $30 million damage
• Deadliest weather disaster in U.S. history

Hurricane Audrey 1957:
• June 27 landfall near TX-LA border
• Category 4, 8-12 foot storm surge
• Rapid strengthening prior to landfall
• Surge flooded up to 25 miles inland
• 390 deaths, $150 million damage

Hurricane Camille 1969:
• August 17 landfall along MS coast
• Category 5, 24.6 foot storm surge recorded
• 120 mph sustained winds recorded 75 miles inland
• 256 deaths, $1.42 billion damage
• 113 of the deaths were in Virginia due to nighttime flash flooding in mountainous terrain



Tropical Storm Allison 2001:
• June 5 landfall at Freeport, TX
• Formed immediately off the TX coast, made landfall the same day
• Weakened to a depression but remained over southeast TX June 6-9
• Areas of Houston observed 30+ inches of rain
• 23 tornadoes
• 41 deaths, $5+ billion damage
• Deadliest and costliest tropical storm in U.S. history

Hurricane Allen 1980:
• August 9 landfall north of Brownsville, TX
• Category 3, 12 foot storm surge
• 2 deaths, $600 million damage
• Reached Category 5 strength three different times while crossing the Carribbean and Gulf of Mexico

Hurricane Katrina 2005:
• August 29 landfall at Buras, LA and then near the LA-MS border
• Category 3, 25-28 foot surge
• 33 tornadoes
• 1,200+ deaths, $75 billion damage
• Deadliest U.S. storm since 1928 and costliest on record
• Flooded the city of New Orleans

* Dollar amounts given are in the year that the hurricane occurred

HURRICANE FORECASTING

Short-term Forecasts

The National Hurricane Center is our nation's main office for hurricane forecasting. NHC meteorologists monitor the tropics year round for tropical cyclones, but are especially busy during hurricane season. The office issues special products when a tropical cyclone is active such as graphical forecast tracks, public weather statements, and tropical weather discussions. Your local NWS office issues detailed forecast information and disseminates the hurricane track forecast in conjunction with the NHC.

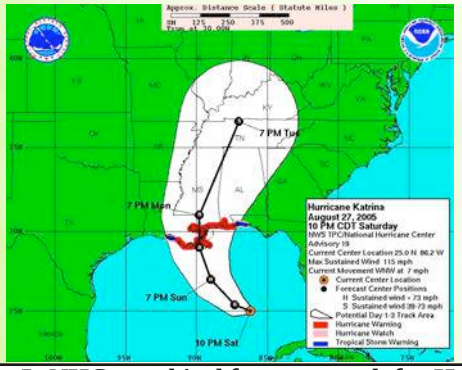


Figure 5: NHC graphical forecast track for Hurricane Katrina, 2005

The white area in Figure 5, called the cone of uncertainty, is meant to convey forecast uncertainty. At each forecast position the cone represents the enclosed area of 67% of the previous five years official forecast errors. Below is an excerpt from a NHC Public Advisory statement for Hurricane Katrina in 2005.

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BULLETIN
HURRICANE KATRINA ADVISORY NUMBER  23
NWS TPC/NATIONAL HURRICANE CENTER MIAMI FL
10 AM CDT SUN AUG 28 2005

...POTENTIALLY CATASTROPHIC HURRICANE KATRINA...EVEN
STRONGER...HEADED FOR THE NORTHERN GULF COAST...

A HURRICANE WARNING IS IN EFFECT FOR THE NORTH CENTRAL GULF COAST
FROM MORGAN CITY LOUISIANA EASTWARD TO THE ALABAMA/FLORIDA
BORDER...INCLUDING THE CITY OF NEW ORLEANS AND LAKE PONTCHARTRAIN.
A HURRICANE WARNING MEANS THAT HURRICANE CONDITIONS ARE EXPECTED
WITHIN THE WARNING AREA WITHIN THE NEXT 24 HOURS. PREPARATIONS TO
PROTECT LIFE AND PROPERTY SHOULD BE RUSHED TO COMPLETION.
```

The watches and warnings issued by the NHC when a tropical cyclone is threatening landfall are explained in the table below. The NHC attempts to first issue a watch 48 hours before the event and a warning 36 hours before the event to allow time for storm evacuations and other preparations. However, if a tropical cyclone is in or approaching the Gulf, you should monitor the NHC track forecasts and make preparations even before a watch or warning is issued.

Table 2: Tropical Cyclone Watches and Warnings (NHC)

Know The Difference	
Tropical Storm Watch	Issued when tropical storm conditions (sustained winds of 39 to 73 mph) are *possible* within the specified coastal area within 48 hours.
Tropical Storm Warning	Issued when tropical storm conditions (sustained winds of 39 to 73 mph) are *expected* somewhere within the specified coastal area within 36 hours.
Hurricane Watch	Issued when hurricane conditions (sustained winds of 74 mph or higher) are *possible* within the specified coastal area 48 hours in advance of the anticipated onset of tropical-storm-force winds.
Hurricane Warning	Issued when hurricane conditions (sustained winds of 74 mph or higher) are *expected* somewhere within the specified coastal area 36 hours in advance of the anticipated onset of tropical-storm-force winds.

Seasonal Forecasts

Meteorologists forecast the severity of each upcoming hurricane season and the number of named storms based on climate signals, seasonal conditions, and decadal trends.

For example in 2010 NOAA forecasted an "active to extremely active" hurricane season across the entire Atlantic Basin for the six month season with a 70 percent probability for:

- 14 to 23 Named Storms (top winds of 39 mph or higher), including:
- 8 to 14 Hurricanes (top winds of 74 mph or higher), of which:
- 3 to 7 could be Major Hurricanes (Category 3, 4 or 5; winds of at least 111 mph)

El Nino

The El Nino Southern Oscillation (ENSO), which is the name for large scale sea surface temperature changes in the east central Pacific Ocean, is one climate condition that has been shown to relate with tropical cyclone activity in the Atlantic. During El Nino episodes upper level wind shear above the Atlantic basin leads to an unfavorable environment for hurricane formation and development. Neutral and La Nina years tend to have a greater number of Atlantic tropical cyclones, as the wind shear is usually not present to suppress the storms.

A 2006 study found that approximately one hurricane made landfall along the Gulf Coast for every ENSO cold phase (La Nina), whereas one hurricane landfall occurs for every two ENSO warm phase (El Nino) periods from 1900-2004. It is important to be prepared every season, regardless of an above or below normal forecast, because major hurricanes can still occur in an otherwise quiet hurricane season.

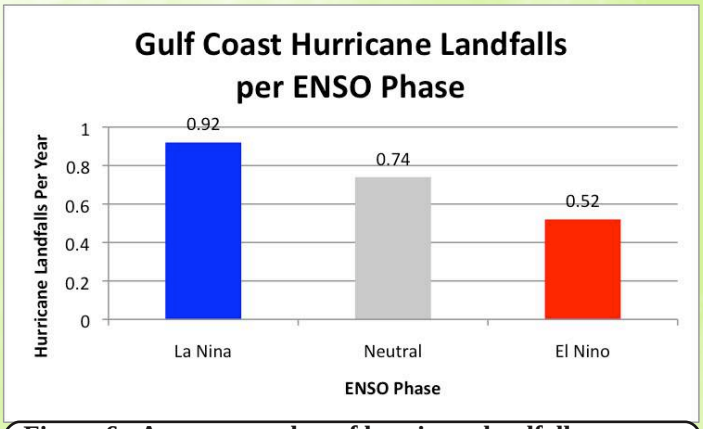

Figure 6: Average number of hurricane landfalls per year along the Gulf Coast (TX, LA, MS, AL) (Smith 2007)

SCIPP SPOTLIGHT

Hurricane Katrina, Lessons Learned

The widespread destruction in and around New Orleans and the Mississippi Gulf Coast from Hurricane Katrina was so immense that the storm and events following have since been categorized as a catastrophe. The devastation from the hurricane was compounded by the failure of an organized emergency response to the disaster. Victims of hurricane Katrina were subject to three catastrophes: the hurricane, flooding from levee failure, and the breakdown in emergency response. A recovery assessment panel found the shortcomings in the response so great that a federal framework for catastrophic recovery was recommended. Only through proper planning and mitigation can we ensure that the next environmental disaster does not also become a social catastrophe.

Figure 7: Flooding in New Orleans after hurricane Katrina.

Another impact of Hurricane Katrina was the societal repercussions due to the migration of displaced residents and evacuees. *USA Today* reported that immediately following the storm, the population of Baton Rouge doubled from 250,000 to 500,000 residents. In 2007 the population was still estimated to be 50-75,000 higher than before the Katrina evacuee surge, putting a marked strain on everything from schools to law enforcement to traffic and housing. Even though Baton Rouge was spared the devastating damage in New Orleans, the city suffered a major social crisis from the sudden influx in population.

City Vulnerability

A 2007 study analyzing the vulnerability of U.S. cities to environmental hazards, classified Houston, TX, Baton Rouge, LA, New Orleans, LA, Memphis, TN, and McAllen, TX as highly vulnerable cities in terms of an overall vulnerability index. The vulnerability index was compiled based on social vulnerability (ethnicity, age, wealth, race, gender), built environment vulnerability (urban density, presence of landmarks, infrastructure, property values) and hazard vulnerability (past human causalities, property loss, and characteristics of the hazard). McAllen, TX and Memphis, TN scored high on overall vulnerability because of a high social vulnerability index. Baton Rouge and Houston scored high on overall vulnerability because of the hazard vulnerability component and past experience with damages from hurricanes. New Orleans, identified as the most vulnerable city in the U.S. to environmental hazards, scored the highest due to contributions from all three components and the great losses incurred from Hurricane Katrina.

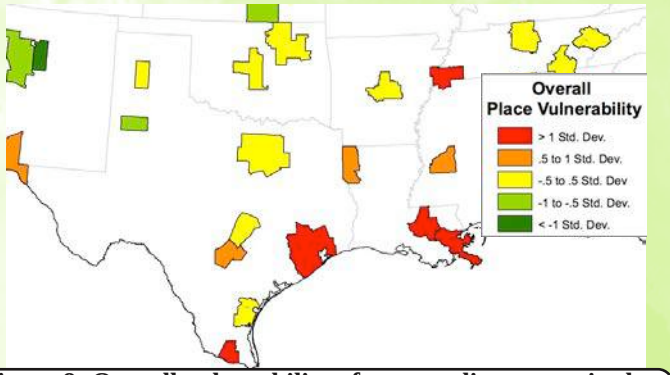

Figure 8: Overall vulnerability of metropolitan areas in the SCIPP region to environmental hazards. (Borden 2007)

Houston

In 2005 the U.S. saw the catastrophic results of a major hurricane striking a large city with Hurricane Katrina in New Orleans and the population stress put on Baton Rouge. Another especially vulnerable metropolitan area along the SCIPP Gulf Coast is Houston, TX. Houston is located in heavily populated Harris county. Just the city itself had a 2006 estimated population of more than 2.1 million residents. The U.S. Census estimated in 2006 that 45% of the city's population spoke a language other than English at home and 20.5% of residents were below poverty. Other factors that make Houston vulnerable include a dense urban population in poorly constructed housing and the network of bayous running through the city that could flood into populated areas. In addition to a large and vulnerable population, Houston is a major sea port and oil refinery center. Destruction from a major hurricane in Houston will have regional and national repercussions. Harris County has a hurricane return period of 11 years and the last direct hit by a hurricane in Harris County was by Hurricane Ike, Category 2, in 2008. The major hurricane return period for Harris County is 21 years and the last direct hit by a major hurricane in Harris County was by a Category 3 hurricane in 1941. Will Houston be better prepared than New Orleans when the next major hurricane strikes? Which SCIPP cities could expect a sudden population boom from displaced Houston residents?

Figure 9: Flooding in Houston from Tropical Storm Allison.

WHAT YOU CAN DO TO PREPARE:

A 2007 technical memorandum by the NHC reported, "In virtually every coastal city from Texas to Maine, the present and former NHC Directors have stated that the United States is building toward its next hurricane disaster." Education and preparedness, as well as long-term policy and planning, are critical to mitigate the threat from hurricane disasters.

Basic Safety Actions

- Know if you live in an evacuation area. Know your home's vulnerability to storm surge, flooding and wind. Have a written plan based on this knowledge.
- At the beginning of hurricane season (June 1st), check the supplies for your disaster supply kit, replace batteries and use food stocks on a rotating basis.
- During hurricane season, monitor the tropics.
- Monitor NOAA Weather Radio. It is an excellent and official source for real-time weather information and warnings.
- If a storm threatens, heed the advice from local authorities. Evacuate if ordered. Execute your family plan.

Your local National Weather Service office will have information regarding hurricane plans in your area. Many communities host informational fairs at the beginning of hurricane season or over the summer with information on hurricane preparedness, local plans, and evacuation routes.

Knowing the hurricane history, threats, and occurrence for your area, as well as flood plain proximity, are valuable assets that should be included in your hurricane plan. The knowledge gained from this information will help you to be as prepared as possible for a hurricane disaster.

Refrences:
Borden, K.A., M.C. Schmidtlein, C.T. Emrich, W.W. Piegorsch, and S.L. Cutter, 2007: Vulnerability of U.S. Cities to Environmental Hazards. *Journal of Homeland Security and Emergency Management*, 4(2) Article 5
Keim, B.D., R.A. Muller, and G.W. Stone, 2007: Spatiotemporal Patterns and Return Periods of Tropical Storm and Hurricane Strikes from Texas to Maine. *J. Climate*, **20** 3498-3509.
Smith, S.R., J. Brolley, J.J. O'Brien, and C.A. Tartaglione, 2007: ENSO's Impact on Regional U.S. Hurricane Activity. *J. Climate*, **20**, 1404-1414.

FOR MORE INFORMATION:

1) The National Hurricane Center
http://www.nhc.noaa.gov/

2) SCIPP Gulf Coast States Emergency Management
Louisiana: http://gohsep.la.gov/
Texas: http://www.txdps.state.tx.us/dem/
Mississippi: http://www.msema.org/

3) National Weather Service
http://www.weather.gov

4) United States Coast Guard Storm Center
http://www.uscg.mil/news/stormcenter/

5) Federal Emergency Management Agency
http://www.fema.gov/

6) The NOAA Regional Climate Centers:
Links to all six Regional Climate Centers. The climate centers are a national leader in climate service, climate data management and applied climate research and development.
http://www.srcc.lsu.edu/regional

7) State Climate Offices:
This website contains links to all state climatologist offices.
http://www.stateclimate.org

8) Saffir-Simpson Scale Full Description
http://www.nhc.noaa.gov/aboutsshws.shtml

9) FEMA Map Service Center
This website allows you to search FEMA flood plain maps by address.
www.msc.fema.gov/

10) NOAA State of the Coast
Interactive maps containing information and resources about U.S. coastline.
http://stateofthecoast.noaa.gov/

CONTACT US:

Please contact either one of our two program managers for more information about SCIPP or to get involved:

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Please also visit us at: **http://www.southernclimate.org**

SCIPP is a NOAA-supported Regional Integrated Sciences and Assessment (RISA) program.

Last updated August 6, 2010 by Alek Krautmann