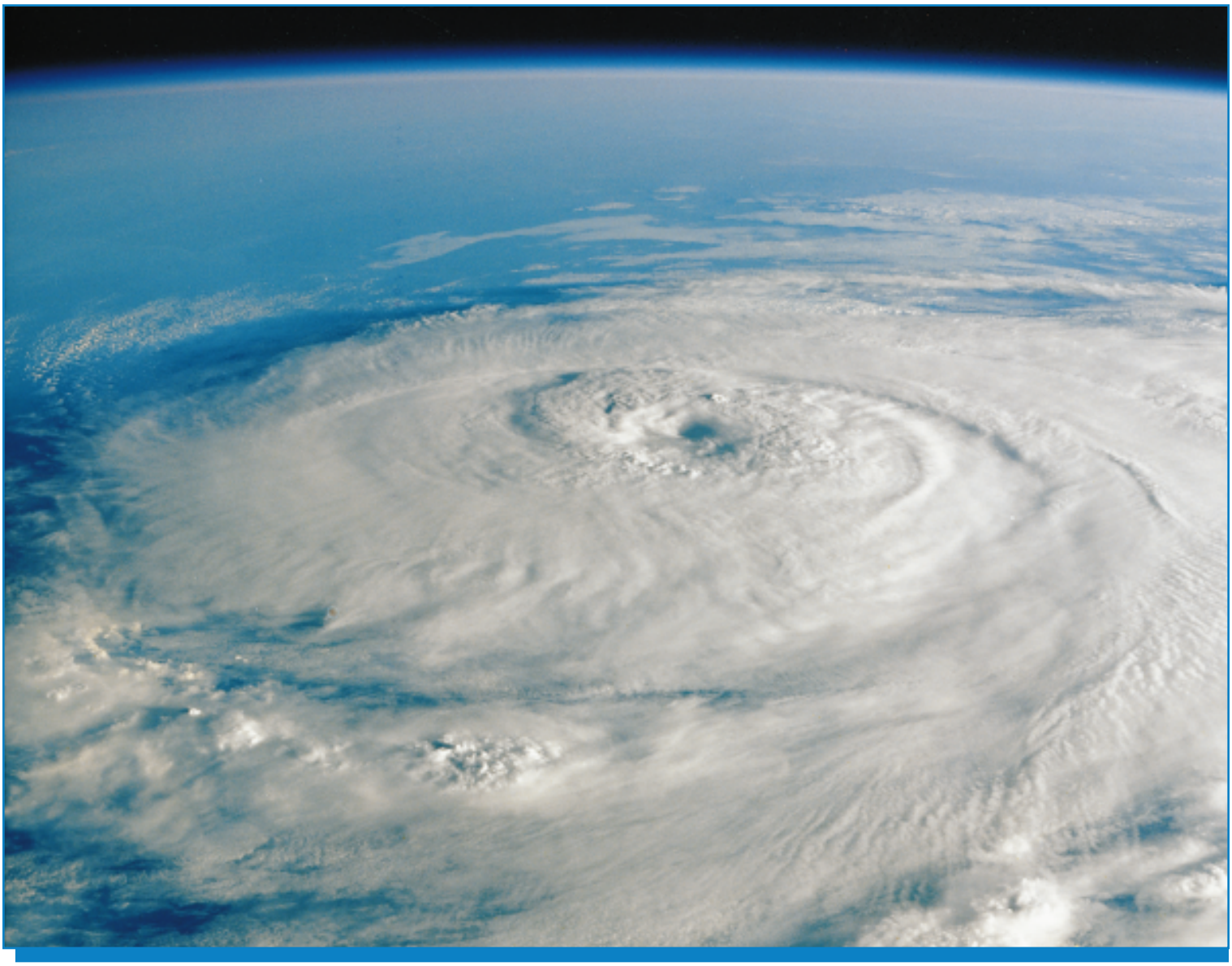
hurricanes...

Unleashing Nature's Fury



Hurricane Elena from Space Shuttle Discovery, 1985/NASA

A PREPAREDNESS GUIDE

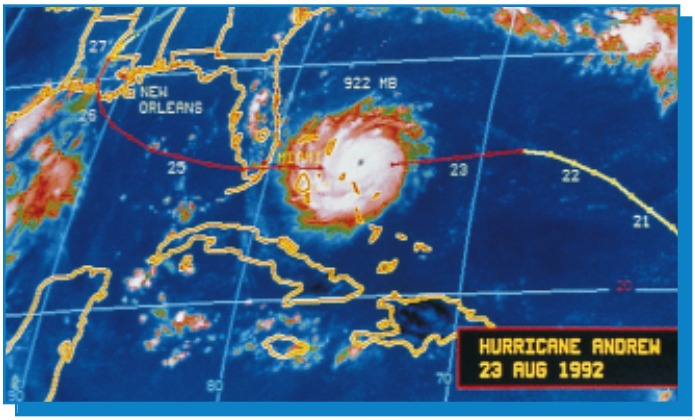
U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service

Revised March 1996

American Red Cross

Hurricanes...

There are no other storms like hurricanes on earth. Views of hurricanes from satellites located thousands of miles above the earth show how unique these powerful, tightly coiled weather systems are.



Hurricane Andrew, August 1992/NOAA

What is a hurricane?

A hurricane is a type of tropical cyclone–the general term for all circulating weather systems (counterclockwise in the Northern Hemisphere) over tropical waters. Tropical cyclones are classified as follows:

- ***Tropical Depression*** – An organized system of clouds and thunderstorms with a defined circulation and maximum sustained winds of 38 mph (33 knots) or less.
- ***Tropical Storm*** – An organized system of strong thunderstorms with a defined circulation and maximum sustained winds of 39 to 73 mph (34-63 knots).
- ***Hurricane*** – An intense tropical weather system with a well defined circulation and maximum sustained winds of 74 mph (64 knots) or higher. In the western Pacific, hurricanes are called "typhoons," and similar storms in the Indian Ocean are called "cyclones."

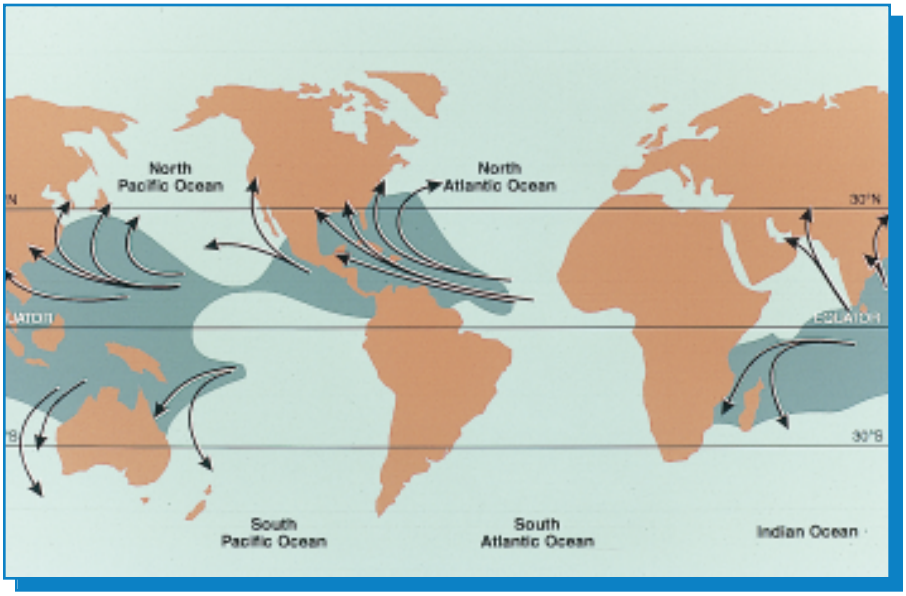
Hurricanes are products of the tropical ocean and atmosphere. Powered by heat from the sea, they are steered by the easterly trade winds and the temperate westerlies as well as by their own ferocious energy. Around their core, winds grow with great velocity, generating violent seas. Moving ashore, they sweep the ocean inward while spawning tornadoes and producing torrential rains and floods. Each year on average, ten tropical storms (of which six become hurricanes) develop over the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico. Many of these remain over the ocean. However, about five hurricanes strike the United States coastline every 3 years. Of these five, two will be major hurricanes (category 3 or greater on the Saffir-Simpson Hurricane Scale).

Saffir-Simpson Hurricane Scale

Scale Number (Category)	Sustained Winds (MPH)	Damage	Examples (States Affected)
1	74–95	Minimal	Florence 1988 (LA) Charley 1988 (NC)
2	96–110	Moderate	Kate 1985 (FL Panhandle) Bob 1991 (RI)
3	111–130	Extensive	Alicia 1983 (N TX) Emily 1993 (NC Outer Banks)
4	131–155	Extreme	Andrew 1992 (S FL) Hugo 1989 (SC)
5	>155	Catastrophic	Camille 1969 (LA/MS) Labor Day Hurricane 1935 (FL Keys)

Timely warnings have greatly diminished hurricane fatalities in the United States. In spite of this, property damage continues to mount. There is little we can do about the hurricanes themselves. However, NOAA's National Hurricane Center and National Weather Service field offices team up with other Federal, state, and local agencies; rescue and relief organizations; the private sector; and the news media in a huge warning and preparedness effort.

and how they form



Planet Earth: Storm/Bill Hezlep © 1982 Time-Life Books, Inc.

Breeding Grounds

In the eastern Pacific, hurricanes begin forming by mid-May, while in the Atlantic, Caribbean, and Gulf of Mexico, hurricane development starts in June. For the United States, the peak hurricane threat exists from mid-August to late October although the official hurricane season extends through November. Over other parts of the world, such as the western Pacific, hurricanes can occur year-round.

Developing hurricanes gather heat and energy through contact with warm ocean waters. The addition of moisture by evaporation from the sea surface powers them like giant heat engines.

Storm Structure

The process by which a disturbance forms and subsequently strengthens into a hurricane depends on at least three conditions. Warm waters and moisture are mentioned above. The third condition is a wind pattern near the ocean surface that spirals air inward. Bands of thunderstorms form, allowing the air to warm further and rise higher into the atmosphere. If the winds at these higher levels are relatively light, this structure can remain intact and allow for additional strengthening.

The center, or eye, of a hurricane is relatively calm. The most violent activity takes place in the area immediately around the eye, called the eyewall. At the top of the eyewall (about 50,000 feet), most of the air is propelled outward, increasing the air's upward motion. Some of the air, however, moves inward and sinks into the eye, creating a cloud-free area.

Insight Magazine/Melody Warford

Storm

Storm Surge

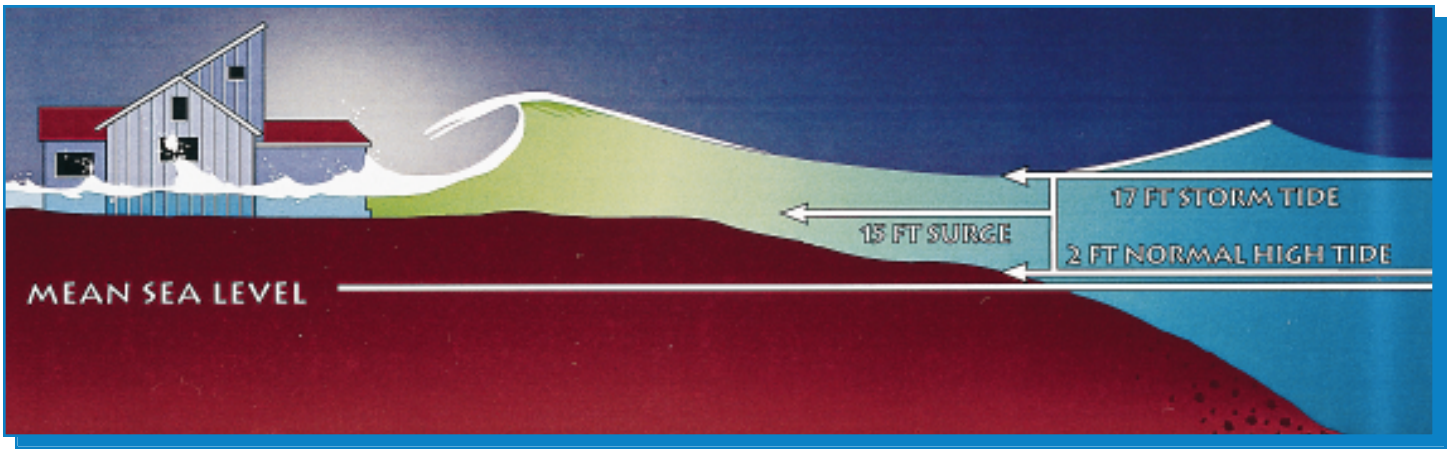
Storm surge is a large dome of water often 50 to 100 miles wide that sweeps across the coastline near where a hurricane makes landfall. The surge of high water topped by waves is devastating. The stronger the hurricane and the shallower the offshore water, the higher the surge will be. Along the immediate coast, storm surge is the greatest threat to life and property.

Before — Folly Beach, SC/NOAA

After — Folly Beach, SC/NOAA

Storm Tide

If the storm surge arrives at the same time as the high tide, the water height will be even greater. The storm tide is the combination of the storm surge and the normal astronomical tide.



The hurricane moves ashore. In the above example, a 15-foot surge added to the normal 2-foot tide creates a storm tide of 17 feet. This mound of water, topped by battering waves, moves ashore along an area of the coastline as much as 100 miles wide. The combination of the storm surge, battering waves, and high winds is deadly.

Storm Tide Facts

- Over 6,000 people were killed in the Galveston Hurricane of 1900–most by the storm tide.
- Hurricane Camille in 1969 produced a 25-foot storm tide in Mississippi.
- Hurricane Hugo in 1989 generated a 20-foot storm tide in South Carolina.

Fury

Charlotte, NC/NOAA

Winds

Hurricane-force winds, 74 mph or more, can destroy poorly constructed buildings and mobile homes. Debris, such as signs, roofing material, siding, and small items left outside, become flying missiles in hurricanes. Winds often stay above hurricane strength well inland. Hurricane Hugo (1989) battered Charlotte, North Carolina (which is about 175 miles inland), with gusts to near 100 mph, downing trees and power lines and causing massive disruption.

Heavy Rains/Floods

Widespread torrential rains often in excess of 6 inches can produce deadly and destructive floods. This is the major threat to areas well inland.

- Tropical Storm Claudette (1979) brought 45 inches of rain to an area near Alvin, Texas, contributing to more than $600 million* in damage.
- Long after the winds of Hurricane Diane (1955) subsided, the storm brought floods to Pennsylvania, New York, and New England that contributed to nearly 200 deaths and $4.2 billion* in damage.
- Hurricane Agnes (1972) fused with another storm system, producing floods in the Northeast United States which contributed to 122 deaths and $6.4 billion* in damage.

* Adjusted to 1990 dollars.

Houston Office of Emergency Management

La Place, LA/NOAA

Tornadoes

Hurricanes also produce tornadoes, which add to the hurricane's destructive power. These tornadoes most often occur in thunderstorms embedded in rain bands well away from the center of the hurricane. However, they can also occur near the eyewall.

Areas At Risk

Coastal Areas and Barrier Islands

Miami Beach, FL/NOAA

All Atlantic and Gulf coastal areas are subject to hurricanes or tropical storms. Although rarely struck by hurricanes, parts of the Southwest United States and Pacific Coast suffer heavy rains and floods each year from the remnants of hurricanes spawned off Mexico. Islands, such as Hawaii, Guam, American Samoa, and Puerto Rico, are also subject to hurricanes. During 1993, Guam was battered by five typhoons. Hurricane Iniki struck the island of Kauai, Hawaii, on September 11, 1992, resulting in $1.8 billion damage.

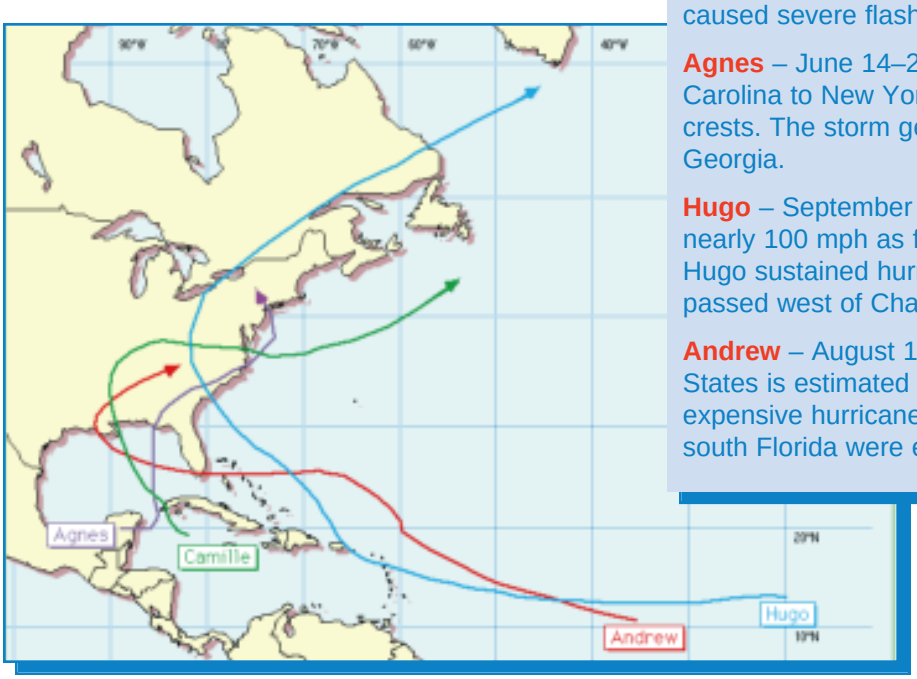
Due to the limited number of evacuation routes, barrier islands are especially vulnerable to hurricanes. People on barrier islands and in vulnerable coastal areas may be asked by local officials to evacuate well in advance of a hurricane landfall. If you are asked to evacuate, do so *IMMEDIATELY!*

Pine Woods Villa, FL/NOAA

© Houston Chronicle

Inland Areas

Hurricanes affect inland areas with high winds, floods, and tornadoes. Listen carefully to local authorities to determine what threats you can expect and take the necessary precautions to protect yourself, your family, and your property.



NOAA

Camille – August 14–22, 1969: 27 inches of rain in Virginia caused severe flash flooding.

Agnes – June 14–22, 1972: Devastating floods from North Carolina to New York produced many record-breaking river crests. The storm generated 15 tornadoes in Florida and 2 in Georgia.

Hugo – September 10–22, 1989: Wind gusts reached nearly 100 mph as far inland as Charlotte, North Carolina. Hugo sustained hurricane-strength winds until shortly after it passed west of Charlotte.

Andrew – August 16–28, 1992: Damage in the United States is estimated at $25 billion, making Andrew the most expensive hurricane in United States history. Wind gusts in south Florida were estimated to be at least 175 mph.

The United States Hurricane Problem

Population Growth

The United States has a significant hurricane problem. Our shorelines attract large numbers of people. From Maine to Texas, our coastline is filled with new homes, condominium towers, and cities built on sand waiting for the next storm to threaten its residents and their dreams.

There are now some 45 million permanent residents along the hurricane-prone coastline, and the population is still growing. The most rapid growth has been in the sunbelt from Texas through the Carolinas. Florida, where hurricanes are most frequent, leads the Nation in new residents. In addition to the permanent residents, the holiday, weekend, and vacation populations swell in some coastal areas 10- to 100-fold.

A large portion of the coastal areas with high population densities are subject to the inundation from the hurricane's storm surge that historically has caused the greatest loss of life and extreme property damage.

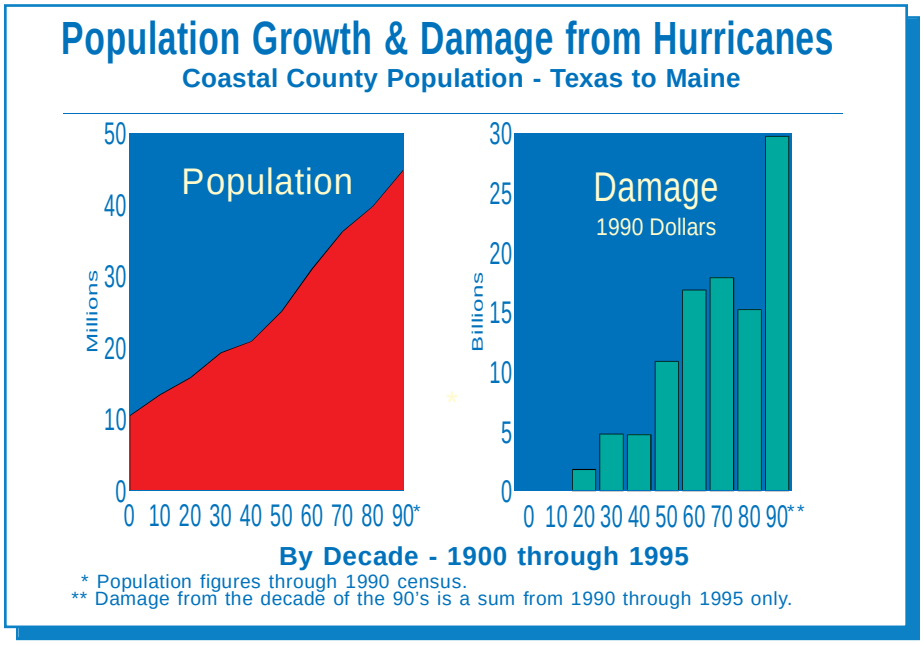
Perception of Risk

Over the past several years, the warning system has provided adequate time for people on the barrier islands and the immediate coastline to move inland when hurricanes have threatened. However, it is becoming more difficult to evacuate people from the barrier islands and other coastal areas because roads have not kept pace with the rapid population growth. The problem is further compounded by the fact that 80 to 90 percent of the population now living in hurricane-prone areas have never experienced the core of a "major" hurricane. Many of these people have been through weaker storms. The result is a false impression of a hurricane's damage potential. This often leads to complacency and delayed actions which could result in the loss of many lives.

Frequency of Hurricanes

During the 70's and 80's, major hurricanes striking the United States were less frequent than the previous three decades. With the tremendous increase in population along the high-risk areas of our shorelines, we may not fare as well in the future. This will be especially true when hurricane activity inevitably returns to the frequencies experienced during the 40's through the 60's.

In the final analysis, the only real defense against hurricanes is the informed readiness of your community, your family, and **YOU.**



NOAA

Surveillance and Forecasting

Geostationary Operational Environmental Satellite/NOAA

Satellite

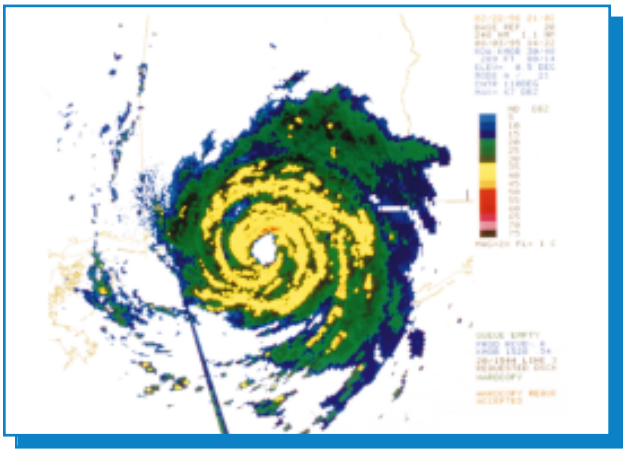
Geostationary satellites orbiting the earth at an altitude of about 22,000 miles above the equator provide imagery both day and night. The satellite imagery helps provide estimates of the location, size, and intensity of a storm and its surrounding environment.

WP-3 "Orion"/NOAA

Reconnaissance Aircraft

The U.S. Air Force Reserve uses its specially equipped fleet of USAFR C-130 aircraft to conduct most operational reconnaissance. Pilots fly aircraft into the core of a hurricane to measure wind, pressure, temperature, and humidity as well as to provide an accurate location of the center of the hurricane. The National Oceanic and Atmospheric Administration also flies aircraft into hurricanes to aid scientists in better understanding these storms and to improve forecast capabilities. The state of the art NOAA G-IVSP High Altitude Research Aircraft and the NOAA P-3 Orion complement the U.S. Air Force Reserve hurricane surveillance. The mission of the NOAA G-IVSP will focus on high altitude environmental sampling of tropical cyclones.

NOAA G-IVSP High Altitude Research Aircraft



Doppler Radar Image of Hurricane Erin, August 1995/NOAA

Radar

When a hurricane gets close to the coast, it is monitored by land-based weather radars. The National Weather Service is currently installing Doppler weather radars across the country which will add new dimensions to hurricane warning capabilities. They will provide detailed information on hurricane wind fields and their changes. Local NWS offices will be able to provide more accurate short-term warnings for floods, tornadoes, and inland high winds.

Tropical Prediction Center's National Hurricane Center Models

The National Hurricane Center uses several different numerical computer models to aid in forecasting the path, speed, and strength of hurricanes. Data from weather satellite sensors, reconnaissance aircraft, and other sources are fed into these computer models. The National Hurricane Center also has a computer storm surge model. This model provides guidance on storm surge height and the extent of flooding it will cause.

What To Listen For...

NOAA

NOAA Weather Radio is the best means to receive warnings from the National Weather Service

The National Weather Service continuously broadcasts updated hurricane advisories that can be received by NOAA Weather Radios sold in many stores. The average range is 40 miles, depending on topography. Your National Weather Service recommends purchasing a radio that has both a battery backup and a tone-alert feature which automatically alerts you when a watch or warning is issued.

TROPICAL STORM WATCH:	Tropical Storm conditions are **possible** in the specified area of the Watch, usually within 36 hours.
TROPICAL STORM WARNING:	Tropical Storm conditions are **expected** in the specified area of the Warning, usually within 24 hours.
HURRICANE WATCH	Hurricane conditions are **possible** in the specified area of the Watch, usually within 36 hours. During a Hurricane Watch, prepare to take immediate action to protect your family and property in case a Hurricane Warning is issued.
HURRICANE WARNING	Hurricane conditions are **expected** in the specified area of the Warning, usually within 24 hours. Complete all storm preparations and evacuate if directed by local officials.
SHORT TERM WATCHES AND WARNINGS:	These provide detailed information on specific hurricane threats, such as tornadoes, floods, and high winds.

Information for Local Decision Makers

The **PUBLIC ADVISORY** issued by the National Hurricane Center provides critical hurricane warning and forecast information.

The **TROPICAL CYCLONE FORECAST/ADVISORY** issued by the National Hurricane Center provides detailed hurricane track and wind field information.

The **TROPICAL CYCLONE DISCUSSION** issued by the National Hurricane Center outlines the meteorological reasoning behind the warnings and forecasts.

STRIKE PROBABILITY FORECAST provides a measure of the forecast track accuracy. The probabilities have no relation to tropical cyclone intensity.

HURRICANE LOCAL STATEMENTS issued by local National Weather Service offices give greater detail on how the storm will impact your area.

The **SHORT TERM FORECAST** provides updated information on what the weather will be over the next few hours in the immediate area.

All of the above information must be used to make an informed decision on your risk and what actions should be taken. Remember to listen to your local official's recommendations and to NOAA Weather Radio for the latest hurricane information.

Personal and Community Preparedness

Before the Hurricane Season

- ✔ Know the hurricane risks in your area.
- ✔ Learn safe routes inland.
- ✔ Learn location of official shelters.
- ✔ Review needs and working condition of emergency equipment, such as flashlights, battery-powered radios, etc.
- ✔ Ensure that enough non-perishable food and water supplies are on hand.
- ✔ Obtain and store materials, such as plywood, necessary to properly secure your home.
- ✔ Clear loose and clogged rain gutters and downspouts.
- ✔ Keep trees and shrubbery trimmed.
- ✔ Determine where to move your boat in an emergency.
- ✔ Review your insurance policy.

FEMA

Individuals with special needs or others requiring more information should contact their local National Weather Service office, emergency management office, or American Red Cross chapter.

During the Storm

When in a Watch Area…

- ✔ Frequently listen to radio, TV, or NOAA Weather Radio for official bulletins of the storm's progress.
- ✔ Fuel and service family vehicles.
- ✔ Inspect and secure mobile home tie downs.
- ✔ Prepare to cover all window and door openings with shutters or other shielding materials.
- ✔ Check batteries and stock up on canned food, first aid supplies, drinking water, and medications.
- ✔ Prepare to bring inside lawn furniture and other loose, light-weight objects, such as garbage cans, garden tools, etc.
- ✔ Have on hand an extra supply of cash.

Plan to evacuate if you...

- ✔ Live in a mobile home. They are unsafe in high winds, no matter how well fastened to the ground.
- ✔ Live on the coastline, an offshore island, or near a river or a flood plain.
- ✔ Live in a high-rise. Hurricane winds are stronger at higher elevations.

When in a Warning Area…

- ✔ Closely monitor radio, TV, or NOAA Weather Radio for official bulletins.
- ✔ Complete preparation activities, such as putting up storm shutters, storing loose objects, etc.
- ✔ Follow instructions issued by local officials. *Leave immediately if told to do so!*
- ✔ If evacuating, leave early (if possible, in daylight). Stay with friends or relatives, at a low-rise inland hotel/motel, or go to a predesignated public shelter outside a flood zone.
- ✔ Leave mobile homes in any case.
- ✔ Notify neighbors and a family member outside of the warned area of your evacuation plans.
- ✔ Put food and water out for a pet if you cannot take it with you. *Public health regulations do not allow pets in public shelters, nor do most hotels/motels allow them.*

FEMA

What to bring to a shelter: first-aid kit; medicine; baby food and diapers; cards, games, books; toiletries; battery-powered radio; flashlight (one per person); extra batteries; blankets or sleeping bags; identification, valuable papers (insurance), and cash.

☞ ***Reminder!*** **If you ARE told to leave, do so *immediately!***

If Staying in a Home…

Only stay in a home if you have *NOT* been ordered to leave. Stay inside a well constructed building. In structures, such as a home, examine the building and plan in advance what you will do if winds become strong. Strong winds can produce deadly missiles and structural failure.

- ✔ Turn refrigerator to maximum cold and open only when necessary.
- ✔ Turn off utilities if told to do so by authorities.
- ✔ Turn off propane tanks.
- ✔ Unplug small appliances.
- ✔ Fill bathtub and large containers with water for sanitary purposes.

Bill Bunting

If winds become strong…

- ✔ Stay away from windows and doors even if they are covered. Take refuge in a small interior room, closet, or hallway.
- ✔ Close all interior doors. Secure and brace external doors.
- ✔ If you are in a two-story house, go to an interior first-floor room, such as a bathroom or closet.
- ✔ If you are in a multiple-story building and away from the water, go to the first or second floors and take refuge in the halls or other interior rooms away from windows.
- ✔ Lie on the floor under a table or another sturdy object.

Be Alert For:

- ☞ TORNADOES which often are spawned by hurricanes.
- ☞ The calm "EYE" of the storm. After the eye passes, the winds will change direction and quickly return to hurricane force.

After the Storm

FEMA

- ✔ Keep listening to radio, TV, or NOAA Weather Radio.
- ✔ Wait until an area is declared safe before entering.
- ✔ Roads may be closed for your protection. If you come upon a barricade or a flooded road, *turn around and go another way!*
- ✔ Avoid weakened bridges and washed out roads. Do not drive into flooded areas.
- ✔ Stay on firm ground. Moving water only 6 inches deep can sweep you off your feet. Standing water may be electrically charged from underground or downed power lines.
- ✔ Check gas, water, and electrical lines and appliances for damage.
- ✔ Do not drink or prepare food with tap water until you are certain it is not contaminated.
- ✔ Avoid using candles and other open flames indoors. Use a flashlight to inspect for damage.
- ✔ Use the telephone to report life-threatening emergencies only.
- ✔ Be especially cautious if using a chainsaw to cut fallen trees.

Community Preparedness Plans

Each community subject to a hurricane threat should develop its own hurricane safety plan. After you have developed a personal/family safety plan, you may want to find out about your community safety plan. Your local officials should have the most detailed information for your immediate area. Please listen to and follow their recommendations both before, during, and after the storm.

FAMILY DISASTER PLAN

Families should be prepared for all hazards that could affect their area. NOAA's National Weather Service, the Federal Emergency Management Agency, and the American Red Cross urge every family to develop a family disaster plan.

Where will your family be when disaster strikes? They could be anywhere—at work, at school, or in the car. How will you find each other? Will you know if your children are safe? Disaster may force you to evacuate your neighborhood or confine you to your home. What would you do if basic services—water, gas, electricity or telephones—were cut off?

Follow these basic steps to develop a family disaster plan...

I. **Gather information about hazards.** Contact your local National Weather Service office, emergency management office, and American Red Cross chapter. Find out what type of disasters could occur and how you should respond. Learn your community's warning signals and evacuation plans.

II. **Meet with your family to create a plan.** Discuss the information you have gathered. Pick two places to meet: a spot outside your home for an emergency, such as fire, and a place away from your neighborhood in case you can't return home. Choose an out-of-state friend as your "family check-in contact" for everyone to call if the family gets separated. Discuss what you would do if advised to evacuate.

III. **Implement your plan.** (1) Post emergency telephone numbers by phones; (2) Install safety features in your house, such as smoke detectors and fire extinguishers; (3) Inspect your home for potential hazards (such as items that can move, fall, break, or catch fire) and correct them; (4) Have your family learn basic safety measures, such as CPR and first aid; how to use a fire extinguisher; and how and when to turn off water, gas, and electricity in your home; (5) Teach children how and when to call 911 or your local Emergency Medical Services number; (6) Keep enough supplies in your home to meet your needs for at least three days. Assemble a disaster supplies kit with items you may need in case of an evacuation. Store these supplies in sturdy, easy-to-carry containers, such as backpacks or duffle bags. Keep important family documents in a waterproof container. Keep a smaller disaster supplies kit in the trunk of your car.

A DISASTER SUPPLIES KIT SHOULD INCLUDE:

A 3-day supply of water (one gallon per person per day) and food that won't spoil • one change of clothing and footwear per person • one blanket or sleeping bag per person • a first aid kit, including prescription medicines • emergency tools, including a battery-powered NOAA Weather Radio and a portable radio, flashlight, and plenty of extra batteries • an extra set of car keys and a credit card or cash • special items for infant, elderly, or disabled family members.

IV. **Practice and maintain your plan.** Ask questions to make sure your family remembers meeting places, phone numbers, and safety rules. Conduct drills. Test your smoke detectors monthly and change the batteries two times each year. Test and recharge your fire extinguisher(s) according to manufacturer's instructions. Replace stored water and food every 6 months. Contact your local National Weather Service office, American Red Cross chapter, or local office of emergency management for a copy of "Your Family Disaster Plan" (L-191/ARC4466).

LOCAL SPONSORSHIP:

NOAA/PA 94050
ARC 5030