NASA's Role in Hurricane Research

NASAfacts

Why Does NASA Study Hurricanes?

NASA is the world's leader in developing state-of-the-art remote sensors that study all aspects of weather and climate. NASA uses this technology to study hurricanes and typhoons around the world and to help forecasters make better predictions on the storm's behavior.

Back in 1960, NASA launched the very first weather satellite called TIROS-1. TIROS-1 enabled approaching hurricanes that threatened the U.S. to be seen approaching from across the Atlantic for the first time. Today, NASA has several satellites circling the Earth looking at different aspects of hurricanes, including winds, ocean temperature, humidity, and rainfall in storms. NASA's research into hurricanes addresses two key questions:

1) How are global precipitation, evaporation, and the world's water cycle changing?

2) How can weather forecasts be improved and made more reliable over longer periods of time using satellites, unique airborne datasets, and computer modeling?
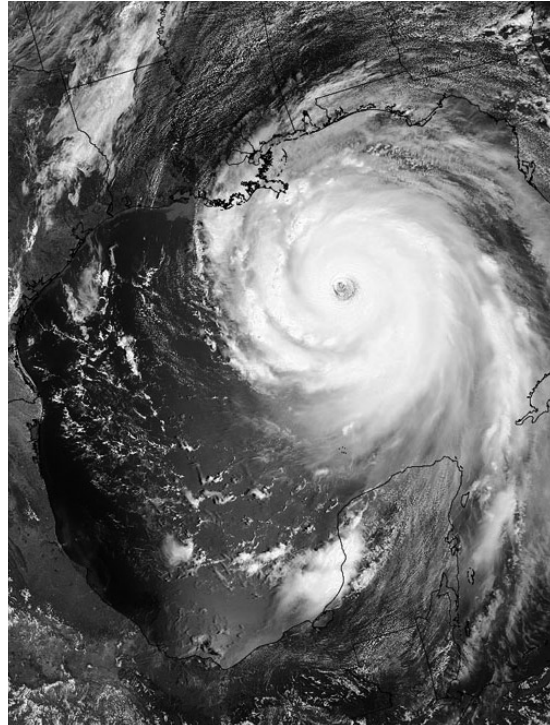
NASA's satellite instruments also provide unique data for meteorologists at the National Hurricane Center to help them with their hurricane forecasts.

Hurricane Katrina approaching New Orleans in August 2005. Katrina is likely to be the costliest hurricane to strike the U.S. in history. Assessments from the damage it caused along the Gulf Coast, including the city of New Orleans, indicate damages will far surpass 1992's deadly Hurricane Andrew, which brought over $26 billion in damages to south Florida and southeast Louisiana. Credit: NASA

What is a Tropical Cyclone?

A generic name for a tropical depression (winds up to 36 mph); a tropical storm (winds 37-73 mph); and a hurricane or typhoon (winds 74 mph to greater than 155 mph).

What Processes Control the Birth and Intensity Change of Tropical Cyclones?

Tropical cyclones form over tropical waters (between 8° and 20° North and South latitude) in areas of high humidity, light winds, and warm sea surface temperatures (typically 26.5° Celsius (C) or 80° Fahrenheit (F) or greater).

What Does NASA Provide?

NASA provides space-based satellite observations, field missions, and computer climate modeling. NASA also provides measurements and modeling of global sea surface temperatures, precipitation, winds and ocean heat content—all ingredients that contribute to the formation of tropical cyclones (which is the general name for typhoons, tropical storms and hurricanes).

## The Components of Hurricanes that NASA Studies

Winds

Winds can help storms form or tear them apart (wind shear). Hurricanes need strong currents of rising air to produce strong thunderstorm activity. NASA's QuikSCAT satellite can detect rotating surface winds before other instruments, providing early notice of developing storms to forecasters. Wind shear is simply a change in wind direction and speed at different heights in the atmosphere. When wind shear is present, it separates the low-level vortex from the tops of deep thunderclouds, disconnecting the storm's spin from its energy source.

Warm Sea Surface Temperatures

Warmer-than-normal sea-surface temperatures are a key player in hurricanes and their development. Ocean surface water temperatures of 80°F or greater fuel the evaporation of ocean water and rising air. That rising, moist air helps create the thunderstorms and helps give birth to tropical cyclones. NASA's Aqua satellite's Advanced Microwave Scanning Radiometer (AMSR-E) and the Tropical Rainfall Measuring Mission (TRMM) satellite's Microwave Imager can detect sea surface temperatures through clouds. This valuable information can help determine if a tropical cyclone is likely to strengthen or weaken. The Jason-1 satellite altimeter provides data on sea surface height, a key measurement of ocean energy available to encourage and sustain hurricanes.

Air Temperature and Humidity

Air temperature and humidity are also important factors in hurricane research. On NASA's Aqua satellite, the Atmospheric Infrared Sounder (AIRS) instrument reads air temperature and humidity around the
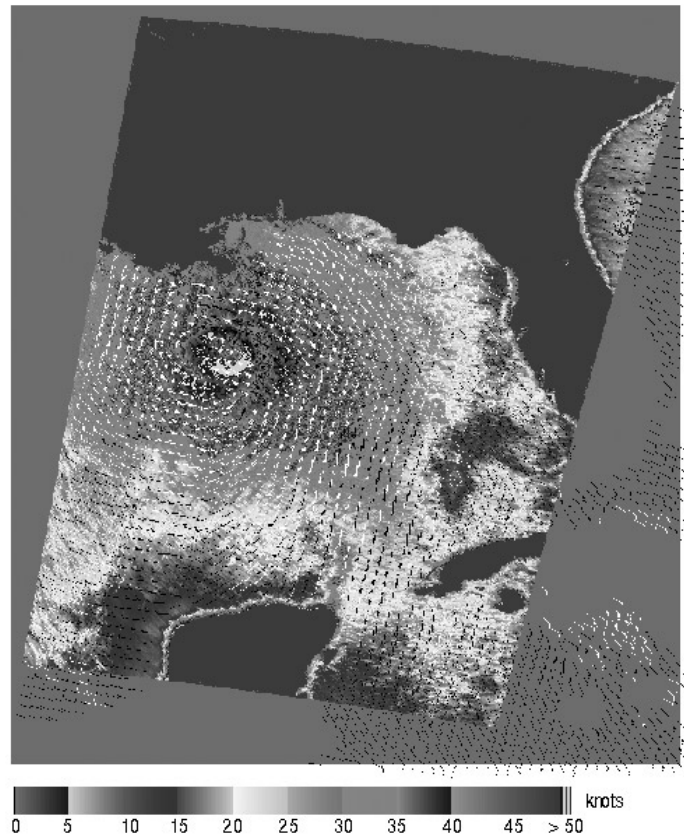
Katrina's Winds from Space: *Hurricane Katrina's Category 4 winds were observed by the SeaWinds scatterometer instrument on NASA's QuikSCAT satellite on Aug. 29, 2005, just before it made landfall. The small barbs on this image depict wind speed (in knots per hour) and wind direction. White barbs point to areas of heavy rain. The highest wind speeds surround the center of the storm. SeaWinds sends pulses of microwave energy through the atmosphere to the ocean surface and measures the energy that bounces back from the wind-roughened surface. The energy of the microwave pulses changes depending on wind speed and direction, giving scientists a way to monitor wind around the world. Credit: NASA JPL*

world on a daily basis. This may lead to improved weather forecasts, forecasts of storm strength, location and tracks, and the severe weather such as damaging winds, associated with tropical cyclones. The data have officially been incorporated into the National Weather Service's operational weather forecasts.

Rainfall in Hurricanes

NASA and the Japan Aerospace Exploration Agency's TRMM satellite provide CAT scan-like views of rainfall in the massive thunderstorms of hurricanes. The

TRMM Precipitation Radar (PR) instrument looks at rainfall intensity for the likelihood of storm development. TRMM also sees "hot towers" or vertical columns of rapidly rising air that indicate very strong thunderstorms. These towers are like powerful pistons that convert energy from water vapor into a powerful wind- and rain-producing engine. The taller the towers are, the greater the likelihood of intensification. Once a storm develops, TRMM can help identify the eye beneath layers of clouds and shows how organized and tightly spiraled the rain bands are—key indicators of storm intensity.

What Data do Scientists Rely on to Make Hurricane Forecasts?

Scientists rely on information gathered by the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Air Force Reserve personnel who fly directly into storms in hurricane hunter aircraft. Hurricane hunters drop sensors into hurricanes that measure winds, temperature, and air pressure. In addition to satellites from NOAA, NASA, and the U.S. Department of Defense, scientists use data from NOAA data buoys and weather radars. All that data goes into NOAA's computer forecast models to arrive at hurricane forecasts.

A NASA/NOAA Satellite

The joint NASA NOAA series of Geostationary Operational Environmental Satellites (GOES) play a major part in forecasting the approach of severe storms such as hurricanes, by graphically displaying the intensity, path and the size of the storm. Emergency personal rely on this tracking data to quickly identify and evacuate areas directly in the predicted path of the storm.

## What is NASA's Hurricane Computer Model?

NASA's Finite-Volume General Circulation Model runs (fvGCM) on the NASA Columbia Supercomputer, housed at the NASA Ames Research Center, Moffett Field, Calif. During 2004, the model was run in real time experimentally and produced remarkable hurricane forecasts and more accurate hurricane tracks. The fvGCM provides the highest-resolution hurricane simulations ever conducted in a climate computer model. These are still in experimental mode and will likely be useful in NOAA's hurricane forecasts in the future.

NASA Flies Planes into Hurricanes

The Tropical Cloud Systems and Processes (TCSP) mission is an Earth science field research investigation sponsored by NASA's Science Mission Directorate.The field phase was conducted from July 1 to July 27, 2005, out of the Juan Santamaria Airfield in San Jose, Costa Rica. The TCSP field experiment flew 12 NASA ER-2 aircraft science flights, including missions to Hurricanes Dennis and Emily, Tropical Storm Gert, and an eastern Pacific system.
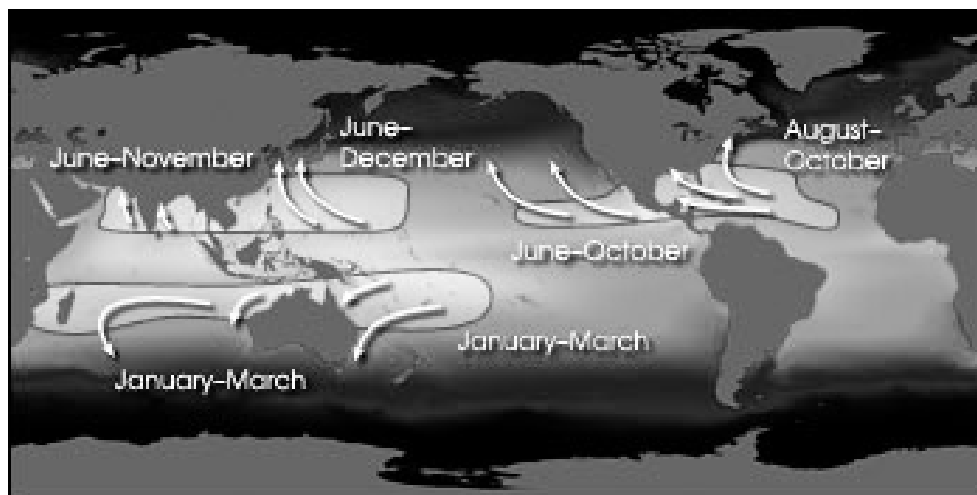
Where the World's Hurricanes and Typhoons Come From: Hurricanes and typhoons form over tropical waters in areas of high humidity, light winds, and warm sea surface temperatures. These conditions usually prevail in the summer and early fall months of the tropical North Atlantic and North Pacific oceans. That's why hurricane season in the Northern Hemisphere runs from June through November. (Graphic by Robert Simmon, NASA GSFC)

Sea Surface Temperature (°C)

-2   16.5   35
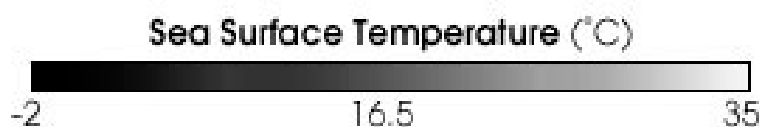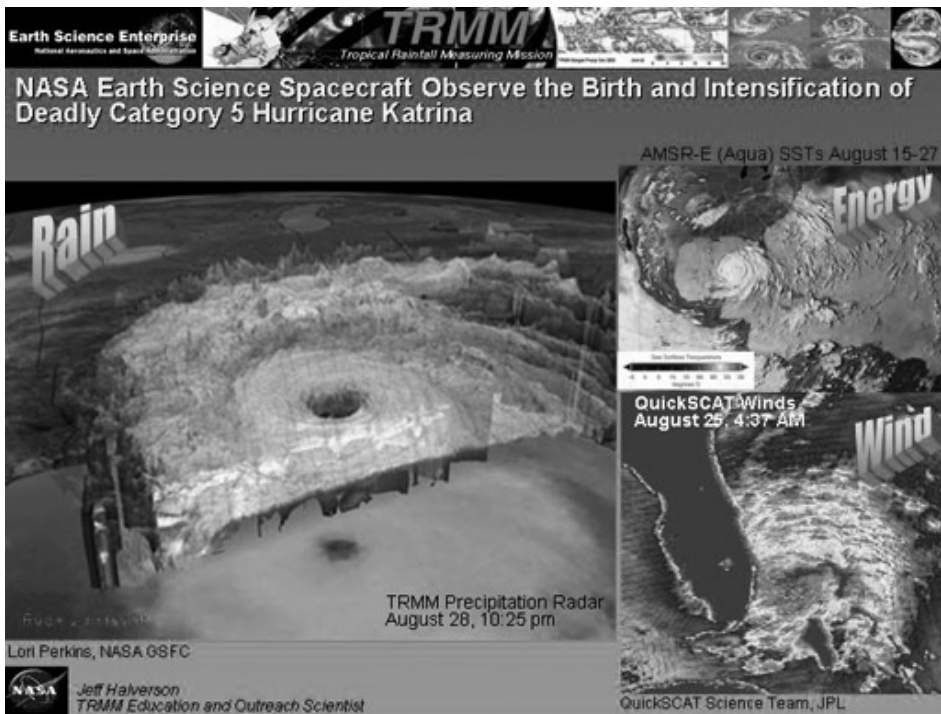
Tracking the Hurricane's Energy: This image shows different views of precipitation, energy and winds in 2005's Hurricane Katrina. These satellite images are from the TRMM satellite, Advanced Microwave Scanning Radiometer (AMSR-E) instrument from the Aqua satellite, and QuickSCAT, respectively. Credit: NASA

The P-3 aircraft from the NOAA Hurricane Research Division flew 18 coordinated missions with the NASA research aircraft to investigate developing tropical disturbances. Additionally, the Aerosonde uninhabited aerial vehicle flew eight surveillance missions, and the Instituto Meteorologico Nacionale of Costa Rica launched RS-92 balloon sensors daily to gather humidity measurements and provide validation of the water vapor measurements. NASA has flown previous missions called CAMEX (The Convection And Moisture EXperiment), a series of field research investigations. For more information about CAMEX, visit on the Web: http://camex.msfc.nasa.gov/. For more information about TCSP and images, visit on the Web: http://tcsp.nsstc.nasa.gov/tcsp/

NASA Helps Assess Damages

After Hurricane Katrina, NASA's Experimental Advanced Airborne Research Light Detection and Ranging (EAARL) system surveyed the Gulf of Mexico coastline. During the week of Sept. 5, 2005, the aircraft took high-resolution observations that can be used to assess the amount of damage to communities and the environment. This activity was conducted at the request of the U.S. Geological Survey in cooperation with the Federal Emergency Management Agency and the Army Corps of

Engineers. While making its observations of the land, the EAARL system, carried on a Cessna 310, has the ability to "see" through vegetation, like trees and shrubs, to view the land underneath. Near the coast it can map the beach surface under water. This will help in the recovery of the shoreline and help determine hazard areas and areas where the environment was damaged.

An image of a destroyed bridge on the east side of Biloxi, Miss. Credit: NASA