Researchers Swarm Over Hurricanes

NOOA's WP-3 'Orion' Hurricane Research Aircraft are among the most advanced airborne environmental research platforms for the study of severe storms, hurricanes and global climate change.

From August 20 to September 3 hurricanes Bonnie, Danielle and Earl illustrated both the power and limitations of hurricane forecasting. These storms, especially Bonnie and Danielle, were probably the most-intensively studied hurricanes ever.

A hurricane is a vortex of winds roaring around a nearly calm eye. It draws its energy from the heat released as water vapor in humid air condenses into thick, high clouds that make heavy rain. It's pushed along by surrounding winds.

Forecasting requires understanding as much as possible about how hurricanes work and measuring as many of the factors as you can that effect them.

Bonnie, Danielle and Earl showed "there has been definite improvement (in forecasting) but the problem hasn't been solved yet," says Mark DeMaria, head of applied research at the Hurricane Center in Miami.

Storms with a mind of their own

With Bonnie, as with all hurricanes that hit the USA, the Hurricane Center's hurricane warning covered areas that hurricane-force winds didn't hit. But, DeMaria says, since forecasters know they can't pinpoint where a storm is going to hit far enough ahead to post warnings, "we have to warn all the possible areas that are going to be hit. You don't want to risk having people hit by a hurricane by surprise."

As Bonnie came ashore in North Carolina, its winds weakened quicker than expected. When it moved back over the Atlantic Ocean south of Virginia Beach, Va., winds picked up more than expected. Bonnie illustrates the difficulty of predicting a storm's intensity.

Danielle, on the other hand, acted almost as though it were following a script written by Hurricane Center forecasters, turning away from the U.S. Coast exactly as predicted. No watches or warnings were issued for the USA. Twenty years ago, however, forecasters probably would have posted watches or even warnings because they wouldn't have been as sure that it would turn away.

Massive air drop of advanced weather instruments

Since hurricanes hold on to many of their secrets by spending most of their time over oceans, far from weather instruments, including the USA's network of Doppler radars that measure wind speeds and directions, researchers are taking increasingly sophisticated instruments to the hurricanes in airplanes.

During Bonnie and Danielle, Air Force Reserve WC-103s turboprops made their regular flights into the storms gathering data mainly for Hurricane Center forecasters. NOAA's two WP-3 turboprops

Weather Observations

During late August and early September 1998, a fleet of airplanes, a 16-inch long tube of instruments, satellites, more powerful computers, and even a couple of Doppler radars gave researchers more detailed views of hurricanes than ever before. But, predicting where these storms will hit and – especially – how strong they will be is still tricky business for the experts at the National Hurricane Center.

carried their onboard Doppler radars and other advanced instruments into the hearts of the hurricanes. NOAA's new Gulfstream G-IV jet flew around the storms as high as 40,000 feet collecting data. A NASA DC-8 flew over the tops of the storms at around 35,000 feet, and a NASA ER-2 – a version of the U-2 spy plane – flew at 65,000 feet, well above the storms.

All of these planes dropped the 16-inch package of instruments called GPS dropsondes around and in the hurricanes. As its small parachute lowers a dropsonde to the ocean, air pressure, temperature and humidity data are constantly being radioed back to the airplane. A Global Positioning System (GPS) module in the dropsonde uses radio signals from GPS satellites to get instantaneous wind data, which it radios to the airplane. Here, a computer calculates wind speed and direction at different altitudes.

The GPS dropsondes gather more precise data more often than earlier versions. Hugh Willoughby, head of the National Oceanic and Atmospheric Administration's (NOAA) Hurricane Research Division in Miami, estimates that around 700 of these were dropped in and around Bonnie, Danielle and Earl.

"Never before in the history of hurricane science have so few dropped so many dropsondes in so little time," Willoughby says, paraphrasing Winston Churchill.

Radar images dancing on the wind

When Bonnie came ashore August 26, the Doppler radars aboard the WP-3s, Doppler radars at coastal weather stations, and two "Doppler on Wheels" radars mounted on trucks from the National Severe Storms Research Lab in Norman, Okla., recorded the hurricane's winds and rain.

After Bonnie, the researchers turned their attention to Danielle out in the Atlantic. Willoughby says that since it was a small storm, "we got a good look at what was going on in the interior." In one experiment, "the two WP-3s did a minuet, they sort of danced around each other so their Doppler radar beams would cross," Willoughby says.

Researchers use computers to combine data from multiple Doppler radars to create three-dimensional images of storm winds.

Seeing through the clouds

Other kinds of computer images are aiding forecasters. Arthur "Fritz" Hasler of NASA's Goddard Space Flight Center in Greenbelt, Md., combines various kinds of satellite and other images to make 3-D storm pictures – Time Magazine used one of his Hurricane Fran images on a cover in 1996. Willoughby says a few hours looking at Hasler's images "taught me the most I've learned about hurricanes outside an airplane since I've been in this business."

Willoughby, by the way, made his 400th airplane trip into the eye of a hurricane or typhoon on an August 29 flight in Danielle, which was celebrated with a cake. He began storm flying as a Navy meteorologist in Typhoon Olga in the Pacific in 1970.

A storm in the Atlantic Ocean or in the Pacific Ocean east of the international date line (180 degrees longitude) is called a hurricane. The terms 'hurricane' and 'typhoon' are regionally specific names for a strong 'tropical cyclone'.

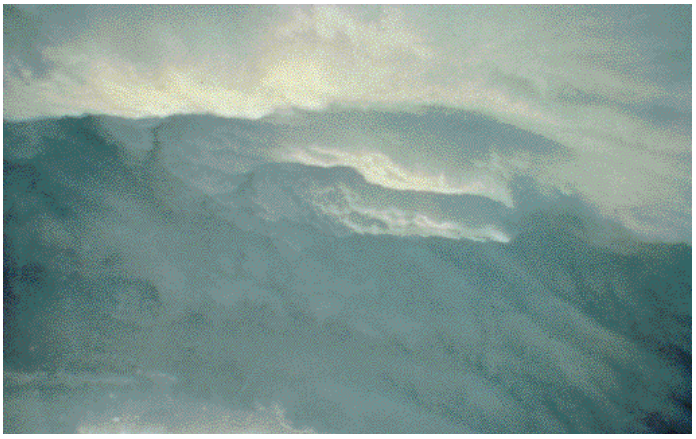


PHOTO COURTESY OF NOAA 1314

While researchers in airplanes have been swarming around hurricanes, the U.S. – Japanese Tropical Rainfall Measuring Mission (TRMM) satellite has been capturing new kinds of hurricane images.

TRMM was designed "to help us understand the large-scale, how things change from an El Niño to a La Niña year, how clouds and rain interact with climate," explains Joann Simpson, the NASA Goddard Chief Scientist for Meteorology. But, its instruments, including radar, can see through the high clouds that often hide the guts of a hurricane from regular weather satellites.

On September 2, TRMM captured images of Hurricane Danielle in the Atlantic, Earl in the Gulf of Mexico and Isis, which was about the hit Mexico from the Pacific. Even though the satellite would pass over any particular storm only twice a day, it will increase the amount of information from storms around the world, not just those that U.S. airplanes fly into. No other nation flies airplanes into hurricanes.

NOAA's Gulfstream jet runs with the storm

Successfully predicting where a hurricane is going and how fast it should move depends primarily on forecasting the upper-altitude steering winds, says DeMaria of the Hurricane Center.

The big new tool here is NOAA's Gulfstream jet, which can fly high and far enough to scatter dropsondes over a wide area around the storm. The Gulfstream began flying last year and seemed to prove its value in mid September when Pacific Hurricane Linda apparently threatened California. Linda, fueled by El Niño's warm water, had winds up to 180 mph and over the weekend of September 13 and 14, computer-forecasting models indicated it could hit south of Los Angeles.

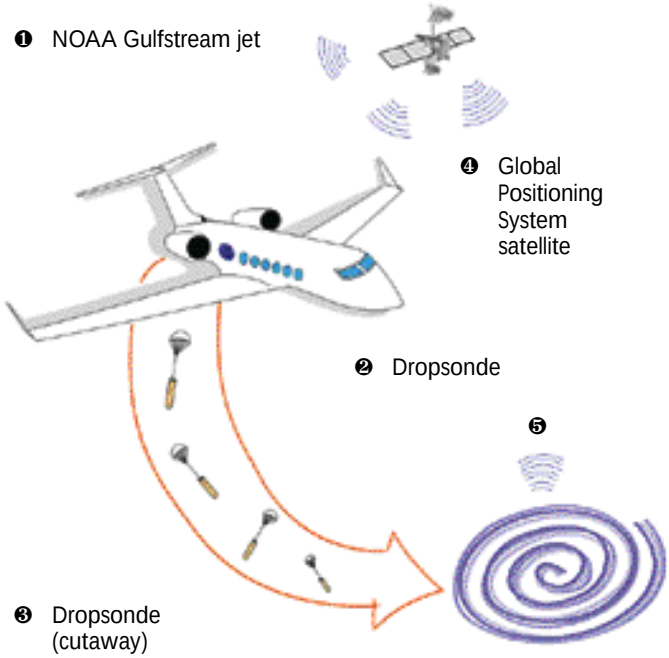
If it has headed for California, cold water off the coast would have weakened Linda, maybe to a tropical storm with winds less than 74 mph. Still, the only tropical storm on record as hitting California was in September 1939. That storm killed 45 people.

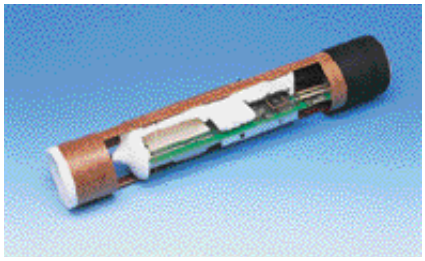
Linda "had West Coast forecasters really jumping out of their skins,'' says Naomi Surgi, the Hurricane Center's Gulfstream jet manager. But when data gathered by the Gulfstream was fed to the computer models, they showed the storm would turn away far out at sea, as it did.

Since then, the models have been run without using other data from the time, but not that collected by the jet. They keep the storm heading for California. "The figures on just one storm are not statistically significant, but they are extremely encouraging" Surgi says.

Instrument package drops into storms

Hurricane researchers are now using a new GPS dropsonde to get a better picture of what goes on in and around hurricanes.





1 NOAA Gulfstream G-IV jet is one of the several planes that use dropsondes.

2 Dropsonde slides down a tube and out of the plane's bottom. It descends carried by a small parachute to the ocean.

3 Instruments in it measure temperature, humidity, and air pressure.

4 Global Positioning System receiver and microprocessor track exact location.

5 All data, including position, are radioed back to the airplane.

To improve their forecasts of hurricane strength, researchers are focusing on interactions between the hurricane and upper-air winds, ocean water temperatures, and what happens when hurricane winds blow over the ocean.

The Gulfstream jet is expected to play a key role in learning more about winds at the tops of hurricanes. "This is where we feel the processes for intensity changes are located," Surgi says. Right now the jet doesn't fly into hurricanes, but NOAA plans to work slowly into sending it into the tops of storms.

DeMaria says complex relations between an upper-air low pressure area, called a "trough" over the Gulf of Mexico was responsible for making Earl so hard to predict as it formed and wobbled toward Florida on September 1, 2 and 3. The trough was working both to strengthen Earl and to tear it apart.

Data gathered by the Gulfstream may help researchers understand exactly what was going on.

Warm water spawns hurricanes

Scientists have known for decades that hurricanes need ocean water that is 79 Fahrenheit degrees or warmer in order to form and grow. But, it turns out to be more complicated than this.

In even the warmest oceans, warm water is normally a fairly thin layer – maybe 100 to 150 feet deep – atop cooler water. A hurricane that stalls, or a slow-moving storm can stir up the water enough to bring off colder water. This can weaken a storm.

A storm can weaken when it runs into cool water stirred up by a previous storm. This happened to Danielle on September 27 when it ran into cool water left by Bonnie and its highest winds dropped from 105 to 85 mph. In 1992 Hurricane Andrew's winds gained speed as it crossed the warm Gulf Stream right before slamming into Dade County, Fla.

But, sometimes eddies of warm water that are deeper than usual drift around in the Gulf of Mexico or break off from the Gulf Stream. If a slow-moving hurricane moves over one of these, as Opal did in 1996 before hitting Florida, it can grow stronger because the cool water is too deep to be stirred to the top of the ocean.

Since water expands when it warms, such deep pools of warm water actually make "mounds" maybe a foot or so high in the ocean. People can't see these in the confusion of ocean waves, but they are detected by the U.S. – French Topex-Poseidon satellite. Some day information from this satellite might become a regular part of forecasters' tools.

Computer modeling where wind and water meet

This year the Hurricane Center is working with University of Rhode Island scientists who are running a computer model of ocean circulation in tandem with one of the hurricane center forecasting models. DeMaria says researchers haven't yet had time to analyze what differences this makes to forecasts.

Researches are becoming more and more interested in trying to figure out exactly what goes on when 75 mph and faster winds rip across the ocean. Many who have been on ships caught in hurricanes say you can't tell where the ocean ends and the air begins because so much spray is flying around.

Scientists don't know whether this spray causes more water to evaporate into the air, making it more humid, or how it affects the temperature of the air flowing into the hurricane. Yet, this air flowing into the storm "is one of the ultimate sources of all the energy" that powers this storm, DeMaria says. "If you ever want to have any hope of modeling a hurricane and getting its intensity right, you need to understand this region of the storm."

DeMaria says the new GPS dropsondes, which keep sending useful data until they hit the ocean, might help answer some questions.

Simpson notes that ordinary airplanes can't safely fly low enough to learn what's going on right above the ocean or collect data that could help forecasters. She thinks the answer might lie in small, remotely operated aircraft with no pilot on board. The question is, she says, "how long will it live if it goes in under a hurricane?"

Willoughby paraphrases another of Winston Churchill's World War II statements to describe the last two weeks: "If the Hurricane Research Division and its circle of scientific collaborators were to last for a thousand years, men and women would say this was their finest hour." ■