

Hurricane Field Program Accomplishments

AOML's Hurricane Research Division (HRD) completed its 2005 hurricane field program on September 30th. This year's research focus included several experiments that were part of the Intensity Forecasting Experiment (IFEX). IFEX is a five-year effort developed in partnership with NOAA's Environmental Modeling Center and National Hurricane Center (NHC) to improve the prediction of tropical cyclone intensity change and rainfall.

Key accomplishments for IFEX, which began with the 2005 season, include:

- A total of 81 missions conducted from aboard NOAA aircraft into 11 tropical storms and hurricanes.
- Observations of five tropical cyclones (Dennis, Gert, Katrina, Ophelia, and Rita) from the beginning to the end of their life cycle (other storms sampled over portions of their life cycle included Cindy, Emily, and Wilma).
- Observations from NOAA's WP-3D aircraft during the Genesis experiment that led to NHC upgrading soon-to-be Gert to a tropical depression.
- Use of stepped-frequency microwave radiometers (SFMRs), global positioning system (GPS) dropsondes, and airborne Doppler radar to provide an unprecedented amount of data during Hurricane Dennis' landfall along the Florida panhandle and Hurricane Katrina's landfalls in Florida and Louisiana. These instruments documented the surface wind structure of both Dennis and Katrina as they came ashore.

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Record Breaking 2005 Atlantic Hurricane Season Ends

The turbulent 2005 Atlantic hurricane season ended officially on November 30th, but not before it had churned out 26 tropical storms, 14 hurricanes, and seven "major" hurricanes (winds above 111 mph). From Arlene to Wilma, to Alpha to Epsilon, 2005 will most likely be remembered as the busiest hurricane season since 1851 when records began. With Hurricane Katrina's catastrophic landfall along the Gulf coast in late August, 2005 will also likely be remembered as the year that produced the costliest natural disaster in United States' history.

Driving the hectic pace at which storms developed was a combination of oceanic and atmospheric conditions that favor busy hurricane seasons. The ongoing active phase of the Atlantic multi-decadal signal, above average sea surface temperatures in the Atlantic Ocean, and reduced levels of vertical wind shear all contributed to creating a rich environment that fueled storm formation and intensification.

Based upon these optimum conditions, NOAA's team of hurricane specialists accurately predicted with almost 100% certainty that 2005 would be an extremely active season. This forecast reflected NOAA's highest level of confidence for an above-normal hurricane season since its forecasts were first introduced in 1998.

Living up to expectations, the season began as the most active on record. In little more than a month after the official June 1st start date, four named storms had already been observed (Arlene, Bret, Cindy, and Dennis). This momentum would continue for the duration of the six-month season, shattering records as one storm followed another.

Hurricanes Dennis, Katrina, Rita, and Wilma established a new record for the most major hurricanes striking the U.S. in a single season. Wilma's barometric pressure of 882 mb was the lowest ever recorded for a storm in the Atlantic basin, exceeding the record previously set by Hurricane Gilbert in 1988 (888 mb). Hurricane Vince became the first Atlantic tropical system to ever impact Europe, making landfall as a tropical depression near Huelva, Spain on October 11th.

Tropical Storm Alpha in late October marked the first time since the early 1950s that the Greek alphabet was used to name a storm, as the list of prescribed names for 2005 had already been exhausted. Hurricane Epsilon, the 14th hurricane of the season, surpassed the total of 12 hurricanes set in 1969, making 2005 the year that (continued on page 2)



Satellite image of Hurricane Katrina as the powerful storm made landfall along the Louisiana/Mississippi border on August 29th.

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Additional 2005 accomplishments include:

- The first NOAA Gulfstream-IV aircraft research experiment (Saharan Air Layer Experiment—SALEX) to investigate the role of the Saharan Air Layer on tropical cyclone development and intensity change.

- The first extra-tropical transition (ET) experiment conducted in cooperation with the Canadian Meteorological Centre (due to Ophelia, which made landfall in Nova Scotia).

- The first transmission of real-time, quality-controlled airborne Doppler radar observations and analyses to NHC from NOAA aircraft in Hurricane Katrina. Analyses were also transmitted to NHC during flights into Hurricanes Ophelia, Rita, and Wilma for a total of 38 real-time analyses transmitted via SATCOM.

- The first season where surface wind estimates were transmitted to NHC from both NOAA WP-3D aircraft operating with newly designed stepped-frequency microwave radiometers (SFMRs). Numerous storms with extremely strong winds enabled an evaluation and modification of the operational algorithm to improve surface wind estimates exceeding 50 m/s.

- The first successful flight (and recovery) of an Aerosonde unmanned aerial vehicle into the core of a tropical cyclone (Ophelia).

- Surveys of the Gulf of Mexico using expendable probes deployed from NOAA and Air Force aircraft that document the response of the upper ocean to the passages of Katrina and Rita.

- 44 operational surveillance missions completed in direct support of the National Weather Service, including all major U.S. landfall cases. Preliminary results show a 19-30% model improvement (GFS model) for Rita in the 72 hours before landfall, and up to a 29% improvement in Wilma. HRD scientists also provided targeting information for six Taiwanese DOTSTAR surveillance missions.

- Transmission of real-time flight level and lower fuselage radar data to NHC during Hurricane Wilma via high-speed satellite communications. Along with the data stream, the satellite communications provided real-time chat capability between the ground and the aircraft, as well as aircraft to aircraft. This data link also enabled transmission of real-time satellite imagery from the ground to the aircraft.

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generated the greatest number of hurricanes in the Atlantic. Of course, 2005's 26 named storms easily topped the record set in 1933 when 21 tropical storms formed that year.

Hurricanes Katrina, Rita, and Wilma all strengthened into catastrophic storms with winds in excess of 155 mph, denoting the first time three category 5 hurricanes ever developed in a single season. These powerful storms impacted south Florida but, fortunately, not during their peak intensity.

Katrina made landfall along the Miami-Dade/Broward County line as a category 1 hurricane during the evening of August 25th, dropping more than a foot of rain, downing trees, and leaving millions in the dark as the storm took a southwestwardly trek across the State towards the Gulf of Mexico. Rita skirted across the Florida Straits on September 20th, flooding portions of the Florida Keys and pelting south Florida with gusty, tropical storm force winds.

Wilma battered Mexico's Yucatan Peninsula for more than 24 hours before taking aim at Florida's southwest coast. The storm came ashore just north of Everglades City, near Cape Romano, as a category 3 hurricane early in the morning on October 24th. In less than five hours, Wilma barreled across the State, leaving more than 6 million Florida Power and Light customers without electricity and causing widespread damage to homes and businesses. The Miami-Fort Lauderdale-West Palm Beach area, Florida's most populated region, was particularly hard hit.

By far the most catastrophic event of the 2005 season, however, was the landfall of Hurricane Katrina along the Gulf coast. After cutting across south Florida, Katrina entered the Gulf of Mexico and began to strengthen, with top winds reaching 175 mph. On August 29th, Katrina came ashore near Buras-Triumph, Louisiana, with pounding winds of 140 mph, flooding coastal communities in Plaquemines, St. Bernard, and St. Tammany Parishes and grazing eastern New Orleans. Katrina made a third landfall several hours later near the Louisiana-Mississippi border with 125 mph winds.

More than 200 miles of continuous coastline stretching from southeast Louisiana, to Mississippi, Alabama, and the Florida panhandle was inundated and subsequently destroyed by the storm surge generated by Katrina. This storm surge, along with heavy rainfall and strong winds, breached portions of the levee system that protected New Orleans from surrounding lakes and canals, resulting in large parts of the historic city being submerged. At least 1,300 people perished (most from drowning), making Katrina the deadliest hurricane to strike the United States since 1928. Estimated costs for damages will likely exceed \$80 billion dollars.

The 2005 season ended with then Tropical Storm Epsilon teetering on the verge of becoming a hurricane. While not a threat to land, the tenacious system survived more than a week before dissipating in the cooler waters of the North Atlantic. Coastal communities across the Caribbean and southeast U.S. bid the extraordinary season a weary good riddance.



Biscayne Bay as seen from the apartment building of Dr. Silvia Garzoli during Hurricane Wilma's passage over south Florida on October 24th.



AOML Deputy Director Judy Gray inspects damage to a screened patio area at AOML after Hurricane Wilma's passage on October 24th.

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New Coral Reef Monitoring Station Installed in Puerto Rico Marine Preserve

After two days of intense underwater work, scientists with AOML's Ocean Chemistry Division deployed a new Integrated Coral Observing Network station (ICON, formerly known as the Coral Reef Early Warning System [CREWS]) in La Parguera Marine Reserve, Puerto Rico. Four NOAA working divers completed the installation on October 19th while principal investigator Jim Hendee organized future maintenance and research aspects of the station with the staff of the University of Puerto Rico's Department of Marine Science on Mayaguez Island.



Jeff Absten and Jules Craynock with the new Integrated Coral Observing Network (ICON) station before deployment in La Parguera Marine Reserve, Puerto Rico.

Currently, the only operational part of the station is the navigational light. This apparently is the sole navigational light between Cabo Roja and Ponce, and will serve as a good entrance channel marker to the Reserve and general embayment area. The instruments and electrical infrastructure for the station are scheduled to be installed during the week of January 9, 2006. Final rigging adjustments will also be made at that time.

Sensors will include those for measuring wind speed and direction, barometric pressure, relative humidity, precipitation, photosynthetically available radiation (PAR, above and below water), ultraviolet radiation (UV 305, 330, 380 nm, above and below water), state of the tide, sea temperature, salinity, and partial pressure of dissolved carbon dioxide.

The effort to install the ICON coral monitoring stations is a component of NOAA's Coral Health and Monitoring Program, which seeks to improve and sustain the health of coral reefs throughout the world.

Meetings Explore Opportunities for Collaborative Research

A small group of Russian scientists visited AOML in late November to engage in a series of discussions aimed at increasing opportunities for collaborative research. Dr. Sergey Lappo, Director of the P.P. Shirshov Oceanology Institute of the Russian Academy of Sciences, along with Dr. Vladimir Lappo of Moscow State University and Dr. Alexie Voychinski of Florida Atlantic University, met with AOML researchers to explore several possible avenues of mutual scientific endeavor. As a result of these discussions, the following oceanographic and ecosystem activities will likely be pursued by AOML and/or the Russian delegation:

- Host postdoctoral associates and visiting scientists (through the National Research Council program).
- Train Russian observers in the use of NOAA's onboard observations.
- Execute joint research cruises.
- Exchange data acquired by research vessels and volunteer observing ships.
- Exchange publications.
- Encourage scientist-to-scientist exchanges in the context of studies related to the Atlantic meridional overturning circulation.
- Cooperate to bring to fruition a proposed joint ecosystem research project to acoustically survey the ocean along the Atlantic tracks traversed by two Russian research vessels during their transits between Kaliningrad and Argentina using acoustic Doppler current profilers (ADCPs). This research will help improve knowledge of the spatial characteristics of the distribution of zooplankton in the ocean.
- Deploy CO₂ semi-automated sampling equipment for greenhouse gas/global warming research on Russian vessel(s) as part of a developing global carbon observing system.
- Involve the Oceanology Institute in future meetings regarding management of the regional Argo centers for the North and South Atlantic Oceans.

These proposed activities are possible due to 1993 and 2003 Memoranda of Understanding between NOAA and the Russian Academy of Sciences that promote the pursuit of joint science and technology projects.



Drs. Tsung-Hung Peng (AOML), Sergey Lappo (P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences), David Palmer (AOML), and Alexie Voychinski (Florida Atlantic University).



Drs. Sergey Lappo (P.P. Shirshov Institute of Oceanology, Russian Academy of Science) and Silvia Garzoli (AOML).

Several trees on the AOML grounds were toppled following Hurricane Katrina's south Florida landfall on August 25th. To help replenish the canopy, a number of salt tolerant, indigenous trees known for their ability to withstand hurricane-force winds were planted. Some of the new plantings include Krug's Holly (an endangered species), Inkwood or Ironwood, Spanish Stopper, Lignum Vitae (an endangered species), Tear-shrub or Pearlberrry (an endangered species), Willow Busic (a rare tree), Alvaradoa (an endangered species), and Jamaican Caper. Most of the trees withstood Hurricane Wilma's south Florida landfall on October 24th, although a few were crushed by falling branches. Watch for flowers throughout the year as these hearty new fledglings grow to maturity.

Welcome Aboard

Andrew Stefanick joined the staff of AOML's Physical Oceanography Division in November as a CIMAS Research Associate to provide technical support for activities related to the South Florida Ecosystem Research and Monitoring Program, as well as several of the Division's other oceanography projects. Andy is a native Miamian and holds a Bachelor's of Science degree in environmental studies from Florida International University.

Farewell

LT Jeffrey Judas, a NOAA Corps officer working with AOML's Ocean Chemistry Division, resigned from the NOAA Corps and from AOML in November to return to his hometown of Middleton, New Jersey. While at AOML, Jeff assisted with research activities related to the Florida Bay and Coral Health and Monitoring Programs. He recently obtained an MBA degree from the University of Miami.

Erik Stabenau, a National Research Council post-doctoral scientist working with AOML's Ocean Chemistry Division (Coral Health and Monitoring Program), departed in December to accept a research position with Everglades National Park in Homestead, Florida. While at AOML, Erik assisted in developing chromophoric dissolved organic matter analyses for the Integrated Coral Observing Network, as well as with pCO₂ and coral bleaching-related data analysis.

LCDR Scott Stolz, Associate Director and senior NOAA Corps officer at AOML, departed in December after retiring from the NOAA Corps with 20 years of service. During Scott's two years with AOML's Office of the Director, he initiated and managed several facility infrastructure improvement projects, served as Chairman of AOML's Safety Committee, and participated in staging efforts to deploy Integrated Coral Observing Network stations in St. Croix and Puerto Rico.

Congratulations

Gloria Lockett, a mathematician with AOML's Hurricane Research Division assigned to the Storm Surge Group at the National Hurricane Center/Tropical Prediction Center in Miami, is NOAA's December employee of the month. Among Lockett's many duties, she performs analyses using the Sea Lake Overland Storm Surge from Hurricanes (SLOSH) computer model to estimate storm surge heights associated with tropical cyclones. These analyses assist hurricane forecasters in producing accurate and timely warnings, as well as Federal Emergency Management Agency (FEMA) officials in their post-hurricane assessment reports. During the 2005 hurricane season, Lockett provided real time potential storm surge values for landfalling Tropical Storm Arlene and Hurricanes Katrina, Ophelia, Rita, and Wilma, contributing to NOAA's mission of saving lives and mitigating property losses.



Friends and co-workers gathered in the lobby on December 2nd to decorate AOML for the holidays, trim a tree, and sample a delectable array of goodies for the annual holiday dessert contest. A fun and festive time was had by all.

Photos courtesy of Armando Cuervo



Travel

Kelly Goodwin and Michael LaGier attended and made presentations at the 2005 Sustainable Beaches Conference in St. Petersburg, Florida on October 31-November 2, 2005.

Jules Craynock worked with the staff of the Australian Institute of Marine Science and the University of Queensland to conduct a site survey of the Great Barrier Reef along Australia's east coast for the location of a new Integrated Coral Observing Network (ICON) station on October 31-November 12, 2005.

Robert Kohler, Nirva Morisseau-Leroy, and Sonia Otero attended the NOAA Tech 2006 Conference in Silver Spring, Maryland on November 1-3, 2005.

David Enfield attended and made a presentation at the Climate Science in Support of Decision Making Workshop in Arlington, Virginia on November 14-16, 2005.

Rik Wanninkhof attended the First Annual Carbo-Ocean Conference in Amsterdam, the Netherlands on November 22-24, 2005.

Sim Aberson attended the International Workshop on Tropical-Extratropical Interactions and the Third International Workshop on Extratropical Transition in Perth, Australia on December 5-9, 2005.

Charles Featherstone, Elizabeth Johns, Christopher Kelble, Nelson Melo, Peter Ortner, Ryan Smith, and Jia-Zhong Zhang attended and made presentations at the 2005 Florida Bay and Adjacent Marine Systems Science Conference in Duck Key, Florida on December 11-14, 2005.

Robert Rogers attended a NASA-sponsored Global Precipitation Measurement Mission meeting in Monterrey, California on December 12-16, 2005.

Gustavo Goni and Rik Wanninkhof were invited by NOAA's Office of Oceanic and Atmospheric Research to participate in U.S.-Korea seminars on tide gauges, ocean observations, and drifting buoys in Seoul and Pusan, Korea on December 12-16, 2005.

Recent Publications*

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SCHMID, C., 2005: Impact of combining temperature profiles from different instruments on an analysis of mixed layer properties. *Journal of Atmospheric and Oceanic Technology*, 22(10):1571-1587.

Shoosmith, D.R., M.O. BARINGER, and W.E. Johns, 2005: A continuous record of Florida Current temperature transport at 27°N. *Geophysical Research Letters*, 32(23):L23603, doi:10.1029/2005-GL024075.

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*Names of AOML authors appear in capital letters.

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