Hurricane Floyd Symposium

September 17 & 18, 2009

Summary Report

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Dr. Jamie Kruse, Director, ECU Center for Natural Hazards Research

On the morning of Thursday, September 16, 1999, Hurricane Floyd made landfall at the mouth of the Cape Fear River. Rains associated with Hurricanes Dennis, Floyd, and Irene resulted in extensive flooding over a two-month period in eastern North Carolina, with most river basins exceeding the 500-year flood level. Flooding was worst along the Tar River, leaving the towns of Rocky Mount, Tarboro, Princeville, Greenville, and Washington devastated. In North Carolina, Floyd was directly responsible for 35 fatalities and several billions of dollars in property damages.

In 2004, the Center for Natural Hazards Research (CNHR), housed at East Carolina University, was established in order to provide support and coordination for research and outreach on natural hazards, including hurricanes, flooding, and coastal erosion. On September 17–18, 2009, the CNHR was proud to host the Hurricane Floyd Symposium that commemorated the storm's 10th anniversary and the 5th year of the CNHR's existence. The Hurricane Floyd Symposium gave us an opportunity to take stock of what we have accomplished so far and to consider our future direction. The public forum and research conference was designed to examine lessons learned from the disaster, the current status of the region, and highlight on-going natural hazards research relevant to hurricane risk. The public forum included presentations from state and local government, nonprofit organizations, and academia. During the research conference, over twenty researchers from eleven institutions presented findings. Areas of expertise were diverse, including atmospheric science, communications, economics, finance, geography, hydrology, meteorology, planning, and sociology.

This publication provides a summary of the presentations in the public forum and the research conference. The value of an endeavor like the symposium comes from how the information shapes the way we move forward. Therefore, this publication also serves as a benchmark so that we can measure our progress on hurricane risk mitigation. You can also find videos of the presentations online at www.ecu.edu/renci/floyd. We sincerely hope you find the information contained here and online interesting and informative.

Dave Gatley, FEMA News

Keynote Speakers

Public Forum Keynote
James B. Hunt, Jr., Governor of North Carolina, 1977–1985 and 1993–2001

James B. Hunt, Jr., was born in Greensboro, North Carolina. He received a bachelor's degree in agricultural education in 1959 and a master's degree in agricultural economics in 1962 from North Carolina State University. He earned a law degree from the University of North Carolina-Chapel Hill School of Law in 1964. He served as lieutenant governor from 1973 to 1977 and as governor from 1977 to 1985. After re-election in 1992, Governor Hunt then served a historic fourth term in 1996.

Following the events of Hurricane Floyd, Governor Hunt requested $5.3 billion from the federal government to help the state recover from Hurricane Floyd, and received $2.2 billion in aid. He also signed into law the Hurricane Floyd Recovery Act of 1999. The Floyd Disaster Fund established by Governor Hunt provided over $19 million in relief to families affected by the floods.

Dinner Speaker
The Honorable Richard Moore

Richard H. Moore is a native of Granville County, North Carolina. He is an honor graduate of Wake Forest University and the School of Law with a graduate degree in accounting and finance from the London School of Economics.

Governor Jim Hunt appointed Moore as secretary of the Department of Crime Control and Public Safety in 1995, where he led the state's emergency response to Hurricanes Fran and Floyd. As the state's chief law enforcement official, Moore oversaw the state Highway Patrol and National Guard. Moore co-authored *Faces from the Flood: Hurricane Floyd Remembered*, a book later developed into an Emmy-nominated documentary that aired on UNC-TV. Moore recently completed two terms as state treasurer of North Carolina. For his expertise on corporate governance issues as well as investment management, Moore has been profiled in *US News and World Report* and is regularly quoted in *The New York Times* and the *Wall Street Journal*. He has co-hosted CNBC's popular morning show, *Squawk Box*, numerous times and has appeared on the evening news programs of all the major networks.

Research Conference Keynote
Laura K. Furgione, NOAA Assistant Administrator, Office of Program Planning and Integration

Since August 31, 2008, Laura Furgione has served as the assistant administrator for the National Oceanic and Atmospheric Administration's (NOAA) Office of Program Planning and Integration. In this role, she is responsible for corporate management to coordinate the many lines of service of this $4 billion agency dedicated to understanding and predicting changes in the Earth's environment and conserving and managing coastal and marine resources. She is responsible for annual planning as well as long term strategic planning, performance evaluation, program integration through matrix management, and policy integration, including compliance with the National Environmental Policy Act. Her efforts are directed to ensuring that NOAA's investments and actions are guided by a strategic plan; are based on sound social and economic analysis; adhere to executive and legislative science, technology, and environmental policy; and integrate the full breadth of NOAA's resources, knowledge, and talent to meet its stated mission goal.

Daniel Siepert, RENCI at ECU

Public Forum (Day 1)

Introduction and Welcome

Dr. Jamie Kruse, Director, ECU Center for Natural Hazards Research

Dr. Kruse welcomed attendees to the symposium and recognized the victims of Hurricane Floyd by taking a moment of silence. Dr. Kruse then spoke about the hurricane as a focusing event, one which researchers can look back on and glean lessons from, such as improving technologies, better understanding of human behavior, and better understanding of information systems to reduce future storm impacts. The symposium was dedicated to exploring new solutions.

Dr. Alan White, Dean, College of Arts And Sciences

Dean Alan White welcomed attendees and recounted his experiences in large floods in North Dakota to demonstrate the shared experiences of people during natural disasters and how different regions can help each other. Pat Owens, the mayor of Grand Forks, who won an award for her management of the North Dakota flood, used her experience in flood recovery to help recovery efforts after Hurricane Floyd in North Carolina. Natural hazards research is helping us to learn from our experiences so that we can be better prepared.

Dr. Deirdre Mageean, Vice Chancellor, Research and Graduate Studies

Vice Chancellor Deirdre Mageean, highlighted the importance of universities coming together with other universities and communities to solve real world problems. She spoke of East Carolina University's mission to reach out into the community and of the high level of trust that communities have in universities. The symposium is an excellent example of universities bringing resources together with community collaborators to develop solutions to important problems such as natural disasters.

Emergency Preparedness Demonstration: Increasing Disaster Awareness and Preparedness in Disadvantaged Communities

Moderator: John T. Cooper, PhD, Program Director, MDC

Dr. Cooper introduced the panel discussion by pointing out that Hurricane Floyd was the first disaster that focused the nation's attention on the problems faced by disadvantaged communities during natural disasters. The research project at MDC began in 2005 just before Hurricane Katrina hit, and now more attention has been focused on preparing disadvantaged communities.

Panelist: Phillip R. Berke, PhD, Director, UNC Center for Sustainable Design

Dr. Berke's research project looked at how to design disaster plans for disadvantaged communities. He showed how communities with strong networks are able to get more money for projects to help vulnerable, underserved people. He outlined five lessons necessary to understanding how to plan in these communities. These included developing strong networks through diversity in participation and including important trust agents that can develop relationships between people with resources and those in need. Another principle was co-development of information in which community partners work with researchers. Coaching was used to motivate change, and accountable autonomy ensured that goals were clear and achievement was realistic and meaningful. The process was able to forge partnerships between communities and built capacity and sustainability beyond the period in which the researchers were involved.

Panelist: Thomas A. Birkland, PhD, Kretzer Professor of Public Policy, NCSU

Dr. Birkland spoke about politics as the process of allocation of resources. We measure government successes in different ways. Katrina was a successful evacuation in that 70% of people got out, but those who remained were poor, elderly, minorities, and the underserved. Why they did not get the help they needed is a lingering question. The nature of the damage is not evenly distributed in the community. In thinking about what we can do to prepare, we need to keep in mind that hurricane preparation is not always the most important issue on people's minds. The challenge is to maintain focus. The government cannot do everything, but it can bring in resources in the form of money and expertise. Government needs to build capacity and be committed to solving the problem. We need to use the knowledge base to prepare for and mitigate hazards. Government cannot do it all, but we are in it together and need to try understand everyone's needs, attitudes, objectives, and cultures so that we can avoid making the same mistakes.

Panelist: Emily Young, Assistant Director for Recovery, North Carolina Division of Emergency Management

Young helped with recovery during Hurricane Floyd and spoke about the importance of local knowledge during the recovery process as people sought help from FEMA and the North Carolina Division of Emergency Management. They trained individuals to understand that community members could get help to determine their eligibility from local offices. Local people needed to understand the reimbursement process. When the managers were allowed flexibility, they developed creative solutions such as morning conference calls to share concerns before they turned into big issues. After Katrina, more resources became available, and now the division has a recovery section. They also have developed a plan through this experience that they can implement in future disasters.

Human Dimensions of Hurricane Floyd

Moderator: Burrell E. Montz, PhD, Professor and Chair, Department of Geography, East Carolina University

Dr. Montz, introduced herself and the panelists. She emphasized that even as we increase capacities, we learn from each natural disaster event. The panel represents a diversity of fields in the human dimensions of natural disaster research and spoke about the lessons learned.

Panelist: Dr. Jimmy Tickel, DVM

Dr. Tickle spoke about the effect of hurricanes on animals and people through their animals. Officials during Hurricane Floyd did not anticipate that people would risk their lives for their pets. Now there are sheltering plans that include pets, but there are still no transportation systems for pets. Farmers also know they need to take care of themselves; they need generators, medical supplies, and ways to move their livestock. On the local level, animal control takes care of pets and North Carolina State University Extension Service works with farm animals. North Carolina has also created state and county animal response teams to plan for disaster. They partner with emergency management, but it is all very new. Researchers need to analyze the changes and make suggestions for improvement, but the system has come a long way.

Dave Saville, FEMA News Photo

Panelist: Catherine Smith, PhD, Professor of English, East Carolina University

Dr. Smith described the new perspective that has come from talking to residents, businesses, and municipal officials about hurricane communications. Her research team is asking people about the information they receive about storms, how they understand it, and how it affects their perceptions and actions. Since Floyd, people have increasingly used the Internet as an information source. The providers of emergency information can reconfigure themselves to the new higher levels of interconnectivity. People still use heritage systems such as UHF, VHF, radio and TV, so traditional methods of communication are still effective. Some people are also using newer technologies, such as social networks, that may become more important. People are more connected through new technologies, but may not always use these systems because of the use of technical language and reluctance to communicate with unknown individuals.

Panelist: Charles Fisher, Vice President, James Lee Witt Associates

Fisher spoke about the role of their firm, which assesses the emergency management of states around the country. He stated that North Carolina does a great job. Just two years after Hurricane Floyd, the attacks of 9/11 refocused money away from disaster preparedness, but now things have turned around. Hurricane Isabel affected utility companies heavily, and they have responded by changing their approach to restoring electricity. In the past, utilities didn't communicate their status, but now they update officials frequently. The role of utilities is not just getting the power on; it is about restoring the community. Public–private partnerships have also become more important. In 2004, when Hurricane Charlie went through Kissimmee, Florida, employees of Disneyworld were affected and the company helped them recover. When Floyd hit, people from other areas came out to help. Individuals coming up with solutions and helping with recovery are extremely important.

Keynote Speaker

James B. Hunt, Jr., Governor of North Carolina, 1977–1985 and 1993–2001

Introduction by Gavin Smith, PhD, Executive Director for the Study of Natural Hazards and Disasters, Department of Homeland Security Center of Excellence – Natural Disaster, Coastal Infrastructure, and Emergency Management (DIEM)

Dr. Gavin Smith introduced Governor Hunt by recounting his experiences as his advisor during and after Hurricane Floyd as assistant director of the North Carolina Division of Emergency Management. He spoke about the Governor's tireless conviction and dedication to obtaining resources from the federal government for the people of the state.

Governor Hunt described his experiences during Hurricane Floyd, which was the worst natural disaster to hit the area in recorded history. He spoke about the need to find out how to be better prepared in the future. During the recovery he was flying out every day to communities. FEMA did a lot, but not enough, so he threatened to call President Bill Clinton. He went to Congress, and they said come back later, but he persisted. He wore out President Clinton asking for money for North Carolina. He pushed and raised cane and told the human stories. He described how a lake filled up in one day and how water was covering I-95. From a helicopter, he saw caskets floating in Lenoir County and the death of millions of chickens and hogs.

After the recovery, he asked how we could do better at organizing and preparing. He spoke about hazard mitigation, actions before or after disaster to reduce future disaster impacts, and the recovery process. He said that the recovery process is least understood and done least well. We needed to figure out how to do a better job since federal programs do not address all the need in North Carolina. So they developed 22 new state programs at a cost of $836 million, including provisions for the purchase of hog farms and junkyards and the buy-out or elevation of flood-prone homes. Through the North Carolina floodplain mapping initiative, North Carolina now has accurate maps that guide development by identifying flood-prone areas.

Governor Hunt highlighted the problems faced by poor and rural people in recovery. He developed the Governors Relief Fund that allowed people to make donations from across the country and make sure it is distributed to people in a way that cut through red tape and bureaucracy. The governor urged the attendees to focus on prevention. We need to make sure people know where to go for answers and prevent loss of life in future natural disasters.

Emerging Technology for Hazard Risk Reduction

Moderator: Tom Allen, PhD, Director, RENCI at East Carolina University

Dr. Allen introduced the panel by posing a series of questions about how technology has changed and needs to be addressed in the future: Is there a digital divide? Are there mistakes in the mapping in technology? How has emerging technology affected North Carolina in the past, and how will it affect its future?

Panelists: John Cole and Sarah Jamison, NWS Newport/Morehead Forecast Office

Cole and Jamison discussed the evolution of forecasts from 1999 to 2008. During that time, average track errors have been cut in half, a dramatic improvement. Additionally, the length of hurricane watches has been decreased, with a lead time improved by 50 hours. The flood warning program, CI-FLOW, was developed in 1999, and the Advanced Hydrological Prediction Service (AHPS), which predicts flash floods, was developed in 2001. In 2006, the AHPS activated flood inundation maps that offer an interactive display depicting water depth, latitude/longitude, and flood category. These tools help people make decisions and assess risk.

Panelist: Brian Etherton, PhD, Senior Scientist, Disaster and Environmental Research Group, Renaissance Computing Institute

Dr. Etherton spoke about the role of computer models in forecasting the track of storms and how the advances in computer technology are helping forecasters better predict the size and intensity of storms. The newer models have higher resolution and can help predict storm surge, which then can be used with GIS to help emergency managers.

Panelist: John Dorman, Chief of Geospatial and Technology Management Section, NC Division of Emergency Management

Dorman's section created state flood maps, which cost $26 million, half of which came from the federal government. Residents can view these maps online and see if their property is in the floodplain. The Geospatial and Technology Management Section also has a real-time flood warning system for emergency managers. LIDAR (Light Detection and Ranging) data was used to determine elevation and combined with GIS digital imagery to better predict vulnerabilities in specific areas. People, however, still need to understand the hazard. Future work is to draw footprints for the millions of buildings which can allow data to match up with the modeling to better communicate risk factors.

Panelist: Ruth Little, PhD, Department of Public Health, East Carolina University

Dr. Little pointed out that effective warnings are especially important. Hurricanes present many public health threats including mold, mildew, and dead livestock. She stressed that the medically fragile will require special shelters. Mapping the medically fragile along with the storm surge can help with emergency management planning. Emergency management is complex; it requires prediction, response, recovery, and mitigation. With the proper toolkit aided by technology, effective emergency management is possible.

Panelist: Noel Lee, Director, Pitt County Emergency Management

Lee said that preparedness requires different agencies and communities. Scientists build tools that emergency managers can share with people. Communications need to be improved. One tool, Web EOC, is now available to facilitate communication. Local emergency managers and responders need a toolkit and proper training to be able to respond effectively and save lives.

Faces from the Flood
Jay Barnes, Director, NC Aquarium at Pine Knoll Shores

Jay Barnes shared photographs and stories from his book, *Faces from the Flood: Hurricane Floyd Remembered,* written with Richard Moore. Barnes emphasized that storytelling is one of the most important forms of hurricane communication. People need to keep telling those stories, because our memories help us understand hurricane impacts. As we share stories, a generational memory is made. Recent experiences have created valuable networks, the true test of hurricane preparedness. Our experiences make us much better prepared for the next storm. However, no two storms are alike; the risks are very different. Saving lives was at the heart of the Hurricane Floyd experience as the disaster lingered for weeks.

Faces from the Flood captured many stories, including rescues from attics and rooftops, which were some of the most chilling parts of the book. One story was that of Kurt Barnes, a city employee in Rocky Mount who saved 18 neighbors. He swam against the current up his street until he reached high ground, then he got his boat and spent six hours rescuing elderly neighbors. Another story is of Janice Bailey, who was visiting her niece, and decided that, rather than go home, she would stay to help. She helped sort through clothing so people could find what they needed. She was an example of the outpouring of humanity that helped people get back on their feet. There were a lot of groups to thank and unexpected heroes. Remembering where we have been is a very critical part of understanding our future, because we have more hurricanes coming.

Dinner Speaker
The Honorable Richard Moore

Moore recounted the experience of Hurricane Floyd and talked about many important lessons that were learned. He spoke of how he became one of the faces of the storm and the critical contributions of individuals to the state's emergency response. He credited Jay Barnes for making his dream of producing a book about the experiences of Hurricane Floyd a reality so that future generations might learn from the tragedy.

He spoke of how Hurricane Floyd required immediate action and cooperation among many different people. For example, they took C-130 airplanes from the military and turned them into air traffic control units.

Hurricane Floyd's rainfall was intense; a new reservoir that was expected to fill in years was filled in days. The flood waters had enough strength to take 150 trailers and crush them into a tiny space like an accordion. Moore called himself the barbecue king of North Carolina because he personally had to incinerate 50,000 animals that had been killed in the flooding. The North Carolina state government did a lot for people during Hurricane Floyd, but local communities need to be an important part of preparing for future storms. If you wait for the storm to come, it is already too late.

Research Conference (Day 2)

Facing Disaster: Forecasting and Assessing Floyd and Its Impacts on North Carolina
Jeff Orrock, NWS, Raleigh

Jeff Orrock reviewed the year of Hurricane Floyd, 1999. It was not a big hurricane year overall in the Atlantic, but very active for North Carolina. Hurricane Dennis was a welcome storm in that it brought 5 –8 inches of rainfall to break the drought. As Dennis moved out, Floyd was named. Just before Floyd's landfall, there was precursor rainfall. Then Floyd's outer bands moved onshore, and a cold front interacted with the hurricane. At that time, forecasters had just started to use hydrographs to measure river flooding. The river crests, which lasted for days, were above the record. The force of the water moved mobile homes and put them against trees. Precipitation forecasting was close to the actual rainfall. Forecasts are critical to predicting river crests since the first whole day of rainfall will help determine the amount of flooding for following days. The tools are much improved since 1999 when forecasters said flooding was going to be worse than Fran, but they didn't know by how much. Radar has improved for rainfall estimates. Now rainfall is digitized and can be mapped in GIS to see exactly where it is going. Hurricane forecasting has also been improved so that forecast are 3–4 days before landfall, enough time to evacuate people and prepare shelters. Forecasters need to further advance understanding so that we can predict and communicate better.
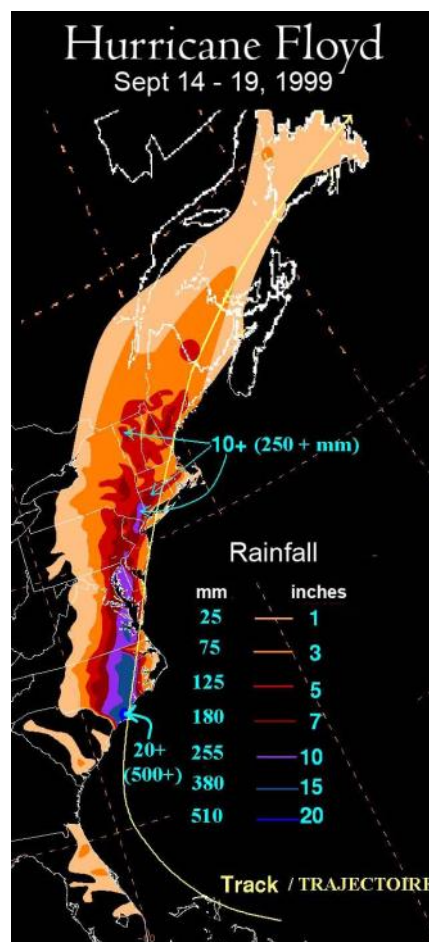
Back to the Future: Satellite Precipitation as a Tool to Reanalyze Hurricane Floyd and Forecast Probabilities of Extreme Rainfall in Eastern NC
Scott Curtis, East Carolina University

In order to answer questions about how much rain fell during Hurricane Floyd and its input into rivers, researchers looked at satellite, river gauge, and radar data. They took a radar map and put it into a GIS with watershed maps and the other data. The location of rainfall was tracked through gauges, and much of it was interpolated. The extent of the storm totals were compared using these different ways measuring rainfall. For the Tar River, rainfall input measures were close to the gauge measures. Researchers used a calculation in places where there weren't gauges or radar to estimate discharge. Greenville received 22.9 inches of rain during Floyd. Satellites measured rainfall over the ocean to get the full picture of rainfall during a storm. Extreme rainfall events are increasing due to climate change. The 1999 season was not the highest, but part of an upward trend. Prior to Dennis and Floyd, there was an extended pool of warm ocean water, and this led to increased rainfall. Rainfall rankings are a measure of relative climate change and show that Floyd was extreme in the global sense. Similar global rankings that include storms from the past may be helpful in predicting the future.

Changes in Flood Characteristics after a Major Event: Re-evaluating the Effect of Hurricane Floyd on Future Flood Response

Jennifer Arrigo, East Carolina University

Hurricane Floyd had immediate impacts on the relatively slow-changing environment and undeveloped, unregulated watershed. The total flood water was 95% of the volume of Pamlico Sound, and many locations exceeded the record for rainfall in a 24-hour period. North Carolina flood mapping and hydrology projects were started after Floyd. The high water

Dave Saville, FEMA News Photo

mark signs in the community reflect the social and policy legacy of the storm. When looking at long-term effects, the researchers did not see many changes in flow or channel characteristics based on stage–discharge relations and USGS rate curves. Data from three gauges were examined based on the NWS flood modeling program. At Rocky Mount, upstream of the Tar reservoir, flow is regulated. The inundation model is highly correlated with a well established relationship between stage and discharge. The timeline of Floyd follows the model very well; however, a moderate flood causes a different relationship between stage and discharge. The Tar River at Tarboro, using the same rating curve, showed change after Floyd. In Greenville, a partial duration series showed that, during extreme floods, the relationships are about the same, but there were changes at minor to moderate flood stage. Minor to moderate flood inundation maps might be different than the typical inundation maps currently used.

The 1999 Flood of the Century: Extraordinary Hydrometeorological Event or Human-Induced Catastrophe?

Scott A. Lecce and Erica S. Kotecki, East Carolina University

In 1999 the effects of Floyd, Dennis, and Irene caused unprecedented flooding, but was this a natural event or a human disaster? The researchers examined photographs of the effects of Hurricane Floyd and some other floods to compare flood stage. They also looked at drainage basins and census data to examine land use changes and how they have affected the drainage basins. Rainfall data at 21 stations were collected during Hurricane Floyd. Hurricane Dennis, which dumped 10–20 inches of rainfall in the Greenville area, saturated the soils, but did not cause major flooding. The three-week period including Hurricanes Dennis and Floyd was as much as 85% of annual rainfall. At these stations, there were 200- and 500-year recurrence intervals, which means this was an extreme event. Using parametric and non-parametric statistics they find a significant trend in annual mean discharge and flow, but not an association with human activities. There was no trend through time. In comparison to Mississippi River flooding, they found that floods are self-similar events and recurrence intervals are subject to a large amount of uncertainty. The largest events drown out human impacts since there is limited storage capacity of wetlands. During a period of rapid urbanization, there was little change in the stream flow at the scale of watersheds. Extreme precipitation plus the sequencing of storms means that there was not a difference due to human land use issues.

Material Transport in Coastal North Carolina following Hurricanes: A Remote-Sensing Perspective of Hurricane Floyd's Impact

Richard L. Miller, Stanley R. Riggs, and Christopher J. Buonassissi, East Carolina University and UNC Coastal Studies Institute

A hydrograph of the Tar River depicts an unprecedented amount of rainfall during Hurricane Floyd. This excess rainfall transported carbon in the form of dissolved organic carbon or Colored Dissolved Organic Matter (CDOM). It is important to understand the transport of CDOM because it can photo-oxidize, yielding carbon dioxide and carbon monoxide, which has implications for global warming. Using remote sensing, the color photographs from satellites of the Tar and Neuse rivers were examined before and after Hurricane Floyd. Pre-Floyd, sediments that were stirred up by Denis had begun to settle and the Tar and Neuse rivers were brightly colored. Post-Floyd, on September 17, 1999, the Tar and Neuse rivers were dark with CDOM. Ultimately, researchers want to be able to quantify the amount of carbon released during a storm to better understand the potential climate change implications.

Dave Gatley, FEMA News Photo

African Easterly Waves and Rainfall Variability in Niger during the 2006 AMMA Field Campaign

Rosana Nieto Ferreira and Thomas Rickenbach, East Carolina University

Dr. Ferreira showed that when Africa gets more rain, North Carolina gets more hurricanes. More than half of hurricanes, including Hurricanes Dennis and Floyd, form as African Easterly Waves (AEWs). The African Easterly Jet forms due to an interaction of warm air over the Sahara with cold air over the Gulf of Guinea, and the inter-tropical convergence zone causes convection. In this unique region, heating gets stronger and makes AEWs. Warmer air is north of the equator, not at the equator, so wind blows west. During the AMMA field campaign, NASA and MIT put radar off Africa to find out how these storms develop and if they can be used to predict Atlantic hurricanes. A total of 28 squall lines in 2006 produced 82% of all rainfall that year. AEWs propagate at two different latitudes depending on the jet. There is significant difference in the structure of systems further south and further north. More AEWs means more potential hurricanes, but factors like El Niño and wind shear will affect the production of hurricanes. Understanding the interactions between squall lines and AEWs may lead to better hurricane prediction.

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CI-FLOW: Evaluating and Testing New Technologies for Accurate and Timely Identification of Inland and Coastal Floods in the Tar-Pamlico and Neuse River Basins of Coastal North Carolina

Suzanne Van Cooten, Jack Thigpen, and Robert Bacon, National Severe Storms Lab, North Carolina Sea Grant Program, and South Carolina Sea Grant Program

CI-FLOW is a new technology being utilized to identify flood hazards. CI-FLOW stands for the Coastal and Inland Flooding Observation and Warning project. CI-FLOW was implemented ten years ago by the directors of Sea Grant and NOAA, along with other North Carolina partners and state agencies. The National Weather Service has one forecast point in Louisburg, NC, on the Tar River. The addition of additional USGS gauges is important for effective identification of flood hazards. The accurate and timely identification of flood hazards is important given the growing and seasonally fluctuating population of Dare County. Approximately one-half of the housing in Dare County is seasonal, and emergency mangers must account for this. For instance, it is estimated that in 2030, if a category three hurricane hit during a time of peak tourism, emergency managers would need to clear 30,000 vehicles in 31 hours. Given the importance flood identification, an integrated approach is needed for accurate and timely identification. The utilization of storm surge models and observations of weather and river levels, is key in flood identification. Three-dimensional images linked with real-time data can help assess the dangers of a flood and aid in emergency management decisions. CI-FLOW is being used to time crests and discharges along with a coupled model which links water and storm surge discharge. In conclusion, the CI-FLOW project is a multi-agency evaluation of new technologies to better identify floods in the Tar-Pamlico and Neuse river basins.

Prototyping a Hurricane-Flood-Landslide-Continuum Prediction System: A CI-FLOW Contribution to North Carolina and Broader Coastal Regions

Yang Hong, J.J. Gourley, Humberto J. Vergara Arrieta, Zonghu Liao, Suzanne Van Cooten, and Kevin Kelleher, University of Oklahoma and NOAA National Severe Storm Lab

A partnership between NASA and the US Agency for International Development (USAID) is examining prototyping a hurricane-flood-landslide continuum as part of CI-FLOW (Coastal and Inland Flooding Observation and Warning project). Using high resolution satellites, hydrological data can be used to monitor global flooding. The Terra and Aqua satellites use a key instrument called MODIS (Moderate Resolution Imaging Spectroradiometer) to map flood inundation. Aster flood maps are used to calibrate hydrologic modeling. Additionally, inland river flow and storm surge modeling is being done as a part of CI-FLOW. Part of the problem with the models is determining how to calibrate them effectively. Researchers examined a full spectrum of data calibration techniques. The guided DREAM technique performed the best in terms of minimizing bias. They also examined Hurricane Floyd, and, using a discharge simulation, the guided DREAM preformed well. Landslides can accompany floods, and LIDAR (Light Detection and Ranging) data can be useful in examining slope stability and rainfall. In order to effectively manage hazards, an integrated approach is necessary, using hydrological data and flood prediction systems. Recently, the prediction system has been implemented successfully.


CI-FLOW
Coastal and Inland Flooding Observation and Warning Project

Keynote: Charting the Course
Laura K. Furgione, NOAA Assistant Administrator, Office of Program Planning and Integration

Furgione reviewed NOAA's activities at the time of Hurricane Floyd in comparison to today's technology and integration. She reviewed the tracks and impacts of the 1999 series of storms—Hurricanes Dennis, Floyd, and Irene—and how important forecasting was to reducing the death toll. Since that time, the National Hurricane Center has gone from six to ten forecasters and has expanded its webpage to allow more users. In 2008, there was less storm track error and the forecast has been extended from three to five days. Wind speed probability and storm surge probability products are also new. Tornado forecasting lead time was ten minutes in 2001, and now it is 15 minutes. The hydrologic prediction service now has over 2,237 hydrographs, and the system is 56% complete. Future projects include advanced flood inundation mapping for North Carolina. Because of Floyd, North Carolina is ahead of other states in flood mapping. There is now a greater understanding of the ecological impacts of big storms and their run-off. NOAA is also working on information to help communities become more resilient and suffer less financial loss in the future. They have used the NOAA satellites to assess damage after Hurricane Isabel, and the Storm Ready program has also been developed. Finally, Furgione showed that climate change has not had a discernable effect on hurricane activity over the last 100 years. Global sea-level measurements, however, show that sea-level rise is occurring. Increased sea level is expected to increase storm surge impacts in the future.
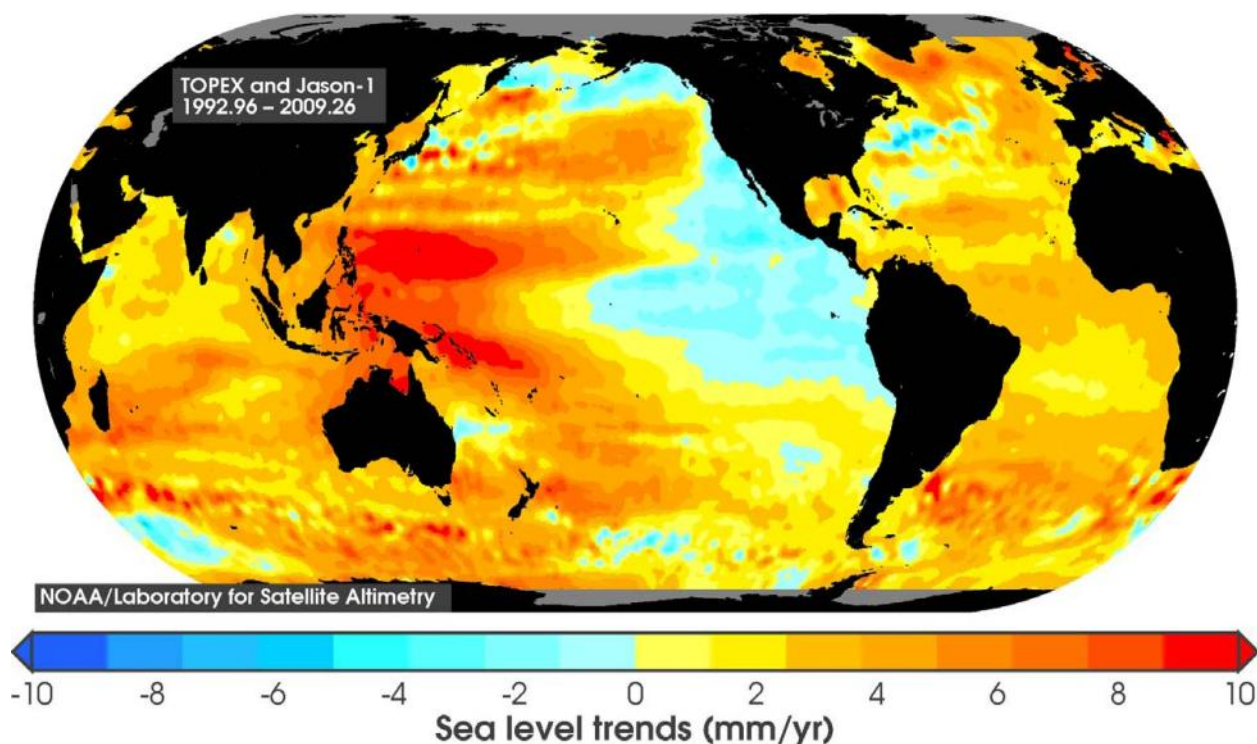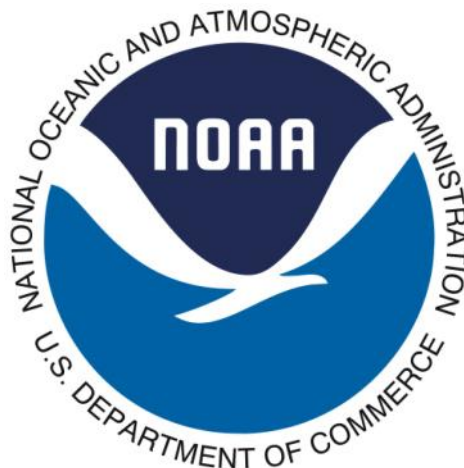
Flood Insurance Coverage in Dare County: Before and After Floyd

Craig E. Landry, East Carolina University

Dr. Landry started with an overview of how the flood insurance program works. Flooding is a catastrophe risk since flooding events cause multiple losses that are correlated across space; and given the rarity of flooding events, reliable information may not be available to predict likelihood of loss. Government provision for disaster relief can cause a "charity hazard" in that people may opt not to insure. As such, private companies have traditionally exhibited little interest in providing insurance against flooding loss, and the government has stepped in with a public option: the National Flood Insurance Program (NFIP). The program started by creating flood inundation maps and offering subsidized insurance, but most people did not buy it. Then the government made flood insurance mandatory if you had a federally backed mortgage. This has increased participation in NFIP. This study compared 1998 and 2008 flood insurance in Dare County, NC, a vulnerable area. In 1998 many properties did not have flood insurance, but in 2008 more did. There are also more mortgaged properties than ten years ago, and these have higher assessed values and higher amounts covered. Demand for insurance is not responsive to price, so raising or lowering flood insurance prices is not likely to have a large effect on coverage. Since people are required to purchase insurance if they have a mortgage, they don't have the option not to buy. Demand for flood insurance also increases with income and education level. Insurance coverage is greater for higher value buildings and riskier areas.

Property Values and Flood Risk: What Happens to Risk Premiums over Time?

Okmyung Bin and Craig E. Landry, East Carolina University

After Hurricane Floyd, property values in Pitt County were reduced when the properties were determined to be located in the flood plain. Bin and Landry used GIS data to look at the difference between homes sold in the flood plain between 1996–2002 and 2003–2008. It was difficult to distinguish the effect of Hurricane Floyd from other changes at the time, so they made a comparison between properties within flood zones and properties outside flood zones. They found that homes in a flood zone had a lower value in the 1998–2002 period. The home values reflected the awareness of the risk of flooding. There was no significant effect of location in the flood plain in the 2002–2008 period, which indicated that flood risk premiums associated with lower flood risk diminish over time.

Home-Buyer Sentiment and Hurricane Landfalls

Robert T. Burrus, Jr., J. Edward Graham, Jr., William W. Hall, and Peter W. Schuhmann, University of North Carolina–Wilmington

The researchers looked at how hurricanes impact real estate markets and home-buyer sentiment. Sentiment is related to the perception of risk by investors in the securities markets, but is not quantifiable, so the researchers looked at developing proxies. They used three proxies to determine the most meaningful one, which included the spread between listing and selling prices, the average days of a house on the market, and the number of single-family houses sold per month. They looked at homeowner sentiment from 1995 to 2002 in the Cape Fear region and the impact of Hurricanes Fran, Bonnie, and Floyd on the market. When they looked at the prices and days on the market, they found that after Bonnie there was not a difference in sentiment. Then after Fran there was some difference. Then after Floyd, more difference. The proxy impacted most was the days a home was on the market. The researchers concluded that the market suffers after successive hurricane landfalls, but that sentiment recovers a year or more after the hurricane.

Hurricanes & Homeowner Decision-Making

Robert T. Burrus, Jr., Christopher F. Dumas, and J. Edward Graham, Jr., University of North Carolina–Wilmington

The researchers conducted surveys between 2001 and 2002 that examined homeowner decisions concerning wind damage to homes from hurricanes. They collected information about current mitigation practices, expectation of damage, and willingness to pay for future mitigation improvements. Their key findings were that income, size of the deductible, and expected damages from a category three hurricane—but not category four or five hurricanes—were the main determining factors for people that do mitigation. Homeowners generally dismissed low probability events. They found that homeowner willingness to pay for mitigation devices is negative and requires subsidy in excess of $14,000. Willingness to pay is greater if insurance is not available. They concluded that most homeowners are not willing to purchase excessive mitigation devices.

Severe Weather-Related Risk and Emergency Communication in Coastal Communities

Donna Kain, Catherine F. Smith, and Ken Wilson, East Carolina University

The researchers want to learn how people in eastern North Carolina receive and use information regarding hurricanes. The researchers conducted face-to-face interviews with residents, businesses, and local government officials in six eastern counties; phone surveys were used in the 20 CAMA counties. They found that residents in coastal counties were more likely to have evacuated in the past than residents of other CAMA counties. All residents seek information to know how to respond to emergencies. Almost half of people never have evacuated during a hurricane, but they do seek information on how to prepare and make that decision. Current research shows that more people are likely have a disaster plan and know the location of a nearby emergency shelter than in past studies. Coastal residents are more likely than others to know if their homes are covered by evacuation orders, and 61% of residents said they were more likely to evacuate if an evacuation order was issued. Residents get most of their information from television, but social networks and the Internet are becoming more important. Coastal residents rate the quality of information high for television and low for newspapers and social networks. In interviews and focus groups, the researchers heard skepticism about television in terms of sensationalizing a storm. Future work will identify opportunities for using technologies already in residents' hands, such as cell phones and the Internet. They also are looking at watch and warning text messages, but they need to confront the problem that people don't understand the difference between a watch and a warning and they don't understand the cone of uncertainty in hurricane forecasting.

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A Methodology to Inject Sea-Level-Rise-Enhanced Storm Surge Modeling into the Long-Range Comprehensive Plans of Coastal Communities

Tim G. Frazier, Brent Yarnal, and Nathan Wood, Pennsylvania State University and USGS

This project implemented a comprehensive vulnerability assessment framework that used mapping and stakeholder input to create long-range land-use plans that took into account sea-level rise. They compared regular storm surge maps with sea-level-rise-enhanced storm surge maps in Sarasota, Florida, which is in the county with the second oldest population in the nation. The researchers used the SLOSH model with sea-level rise to predict flood inundation. They found that the storm surge inundation area increased and doubled the number of vulnerable elderly people. When looking at mitigating and planning for the future, they found that a category five hurricane places the entire population of the county in the storm surge zone. Using tax parcel information, the researchers found that several communities would not be very resilient since most of the buildings are in the storm surge zone. The researchers separated focus groups into planners, engineers, environmental advocates and business managers, and assigned them the task of looking at the hazard and finding solutions. When the groups saw the storm surge maps, they concluded that location of development was not appropriate. Overall the groups felt that the current urban plan needed to be revised and that urban boundaries should be relaxed to encourage development in less hazardous zones. The community also needed to relocate infrastructure and develop alternative evacuation routes in response to the impacts expected from sea-level rise.

Fatal Tradeoff? Toward a Better Understanding of the Costs of Not Evacuating from a Hurricane in Affected Landfall Counties

Jeffery Czajkowski and Emily Kennedy, Austin College

Federal Highway Administration

The researchers examined an economic behavior model of the evacuation decision. Hurricane fatalities decreased each decade until the 2000s, when deaths increased due to Hurricane Katrina. As more people move into coastal region, we need a new look at the cost of evacuation compared to the value of waiting. For mitigation and minimization of fatalities, the researchers examined the creation of an Ike dike that costs $40 million and questioned its value. The researchers modeled fatalities as related to the direct and indirect factors of storm characteristics, socioeconomic factors, forecasting technology, evacuation, and time. Most research is focused on coastal counties, but deaths often occur inland. For Floyd, of the 70 fatalities, only three were direct coastal fatalities. The researchers compared deaths from different storms, 93% with zero fatalities. They found a lowering of fatalities over time and high levels of evacuations. As evacuation levels rise, there were less fatalities. If there was no evacuation for Hurricane Andrew, the model predicted ten additional deaths. Early storms cause more fatalities, and fewer fatalities occur among people with higher median incomes. As forecast error is worsens, expected fatalities decrease because more people are warned and are better prepared. Although this research focused on the coastal region, an important extension would be to look at inland communities and compare with rainfall data.

Preserving Assets in Low-Income Communities Affected by Disaster
Christina Rausch and Tiki Windley, MDC, Inc.

MDC helps organizations and communities close gaps that separate people from opportunities and helps people to try to find a path out of poverty through education, work, and asset-building. The group has been active in disaster preparedness for low-income communities, which are typically less prepared and suffer greater loss. Preparation is a way that people can build and preserve their assets in the face of disaster. Many low-income people own businesses and cannot recover after a disaster. When a disaster hits a small business, people become unemployed, which leads to less consumer spending, making it tough on the community because the tax base decreases. The barriers to resilience in low-income communities include lack of access to capital and affordable insurance. MDC took a community development approach to creating disaster preparedness in low-income communities. They identify barriers for socially vulnerable communities and came up with solutions . They recommended improvement to land-use planning in hazardous areas and sufficient buy-outs when necessary. There is a need to reduce the costs of mitigation and provide insurance-sponsored mitigation. The researchers suggested developing relationships with trusted community agents, more effective disaster plans, and expanding access to financial products for recovery. Public–private partnerships and microloans could be critical in recovery for low-income communities.

Trauma Written in Plywood and Flesh: Hurricane Graffiti, Post-Katrina Tattoos, and the Value of Narratives to Hazards Research
Derek Alderman, East Carolina University

Dr. Alderman explained that narratives are an important way to understand how people were impacted by a hurricane. Graffiti and tattoos are visually evocative narratives written on plywood and flesh as opposed to paper. Hurricane graffiti can serve as a practical tool or as an indicator of tensions and needs. Post-hurricane tattoos serve as memoirs, vehicles for retelling hurricane stories, and as a way to express trauma. A visual content analysis was used to identify specific themes evident in hurricane graffiti inscriptions. Some of the major themes included history, defiance, desperation, territoriality, humor, politics, and

Cynthia Hunter, FEMA News Photo

prayer. An example of graffiti as history is a piece of graffiti outside of a store that said, "1) Charles, 2) Frances, 3) Ivan, 4) For sale." An example of graffiti as defiance is, "Take a hike Ike." An example of graffiti as desperation is, "We need power!" An example of graffiti as territoriality is, "Looters will be killed." An example of graffiti as humor is, "Santa's naughty list: Charles, Frances, Ivan."

In the tattoo study, tattoo artists were interviewed. One artist, Tom, decided to get a tattoo of an X on his leg after Hurricane Katrina, which references the rescue symbol. This tattoo, like many tattoos, elicits stories from others, allows him to retell his story, and serves to provide a collective memory. Narratives are significant because they are personal and social and provide tremendous insight. For this reason, these types of narratives are important to natural hazards research.

Hurricane Floyd Symposium

Daniel Siepert, RENCI at ECU

Donna Kain, RENCI at ECU

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THURSDAY, SEPTEMBER 16, 1999

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The onslaught begins

Floyd bears down on huge swath of N.C.

In harm's way

Wind Speed
74 mph +
57.5 to 74 mph
40 to 57.5 mph

Source: AccuWeather

By BOB WILLIAMS, JOHN WAGNER AND JOHN SULLIVAN
STAFF WRITERS

Hurricane Floyd ripped into North Carolina on Wednesday, scouring away fragile beaches, whipping the state with hurricane-force winds, dumping more than a foot of rain on many areas and leaving residents worried about what this morning's first light would reveal.

The dangerous storm was expected to make landfall very early today between Myrtle Beach and Wilmington, then scoot quickly into North Carolina, then Virginia and on up the East Coast.

Forecasters expected the destruction from Floyd's winds and waves to rival what was left when Hurricane Fran tore across the state in 1996, with massive power outages and widespread property damage. Extensive flooding was also expected, from the storm surge along the coast and from the heavy rains inland.

"An awful lot of people are going to have a Fran-like experience, or maybe worse," said Steve Harned, director of the National Weather Service office in Raleigh. "This storm has a huge area of extremely strong winds and torrential rains."

As with Fran, Harned said, North Carolinians probab-

See FLOYD, PAGE 15A

FOR THE LATEST

ncstormtrack.com

Get updates and follow Hurricane Floyd's path at www.ncstormtrack.com There you'll find the latest forecast, news, tracking maps and preparation tips from WRAL-TV and The N&O.

CITYLINE

For news on closings and cancellations, call CityLine at 549-8100 and enter category 1800 (In Wake Forest, Fuquay-Varina, Clayton and Smithfield, dial 836-2830.)

For the latest National Weather Service advisories, call 515-8209 and select option 1.

COPING

SURVIVAL GUIDE
Turn to Page 16A for a full page of information on shelters, insurance, how to volunteer to help, cancellations and safety tips.
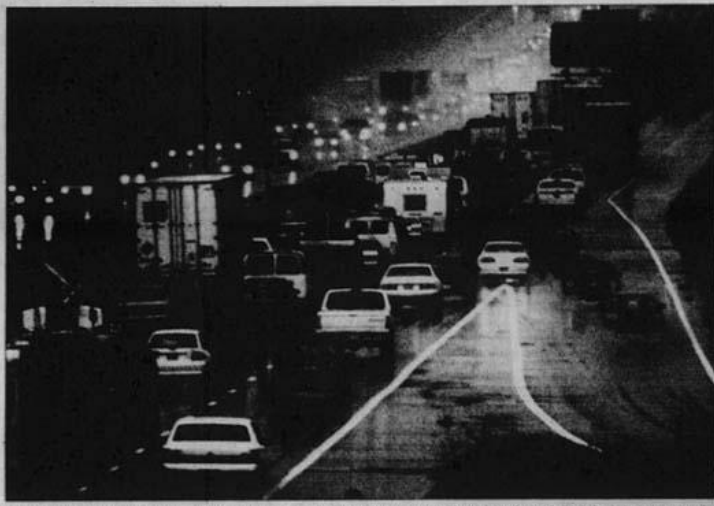
KEY TELEPHONE NUMBERS
In an emergency, call 911.
With questions about shelters or other non-emergency situations, call these numbers:
Wake County: 856-7044
Cary: 469-4090
Durham: 560-HELP
Orange County: 967-9251 ext. 2800
Johnston County: 989-5050
En español: Si habla español y necesita ayuda: 715-9234 or 1 (888) 835-9966.

TO OUR READERS

The hurricane will force some changes in The News & Observer today and tomorrow. Today's paper is coming out several hours early in an effort to complete delivery in advance of the storm. Today's Metro and Sports sections will be combined, the A section will be expanded, and the What's Up action usually published on Friday will be in today's paper. We will do our best over the difficult days ahead to produce the most complete and helpful paper we can.

INSIDE

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As thousands and thousands flee inward, traffic begins to bottleneck on Interstate 40 westbound near Raleigh-Durham International Airport. Hotel rooms were booked as far west as Knoxville and Chattanooga, Tenn., as residents hurried to flee Floyd's winds and rains.
STAFF PHOTO BY HARRY LYNCH

Weakened Floyd sideswipes Florida

By BRUCE SMITH
THE ASSOCIATED PRESS

MYRTLE BEACH, S.C. — A weakened but still terrifying Hurricane Floyd delivered only a glancing blow to Florida and Georgia on Wednesday as it churned its way up the Atlantic coast.

In northern and central Florida, Floyd snapped power lines, smashed piers into driftwood and knocked out electricity to 300,000 people. About 350 miles off the coast, the Coast Guard rescued three people from 18-foot seas churned up by the hurricane, while five others who fled a sinking tugboat in a life raft were missing.

But Floyd made a northward turn Wednesday that spared the state the catastrophic damage many had feared. NASA's Kennedy Space Center and its four shuttles were largely untouched.

The Carolinas, however, lay directly in the storm's path.

Myrtle Beach, a usually bustling resort, was a virtual ghost town as people fled or stayed indoors. Myrtle Beach authorities imposed a 3 p.m. curfew and turned off the water supply. The hospital sent its patients inland but kept a doctor and

South Carolina Gov. Jim Hodges banned price gouging on essential items, threatening fines of up to $100 or 30 days in jail. "All of us — no matter what our means — deserve the same access to lifesaving food and supplies," he said.

The last time South Carolina took a direct hit from a major hurricane was almost exactly 10 years ago, when Hugo struck near Charleston, S.C. with 135-mph winds. The storm killed 29 people and caused $5.9 billion in damage, making it the most costly hurricane to hit the U.S. mainland until Hurricane Andrew hit Florida in 1992.

Floyd weakened slightly Wednesday to a Category 3 storm, its winds down from a peak of nearly 155 mph when it battered the Bahamas. The storm, with hurricane-force winds extending 140 miles from its center, dumped rain along the coast from Florida to Connecticut, and kicked up surf up and down the East Coast.

Floyd's expected track takes its wind and rain up through the mid-Atlantic states and into New England and Canada by Saturday night.

SEVEN PAGES OF COVERAGE INSIDE

Wayne Peters, left, and Dave Phillips push a car out of high water in Wilmington, where Floyd was expected to make landfall.
STAFF PHOTO BY CHRISTOBAL PEREZ

■ **MAKING CLAIMS**
Insurance companies organize thousands of claims adjusters and hook up generators so they can process claims. ▶17A

■ **DOING BUSINESS**
The Triangle may be in the eye of the storm, but business doesn't stop for companies with international customers. ▶17A

■ **MOVING TO HIGHER GROUND**
Across the Triangle, residents and businesses in low-lying areas, prepare to move to higher ground. ▶17A

■ **WAITING OUT THE STORM**
Evacuees from three states crowd into 50 shelters across Georgia to wait for Hurricane Floyd to pass. ▶18A

■ **DAMAGE IN THE BAHAMAS**
In the Bahamas, winds ripped roofs from homes, beached boats, flooded condos and floated cars in 8-foot storm surges. ▶19A

■ **TRACKING THE STORM**
Meteorologists use the latest in computer technology along with "hur-

Triangle at the ready

Residents take storm seriously

By JOANNA KAKISSIS AND ALAN SCHER ZAGIER
STAFF WRITERS

Should Hurricane Floyd's high winds and torrential rains howl over the Triangle today, the region will be ready — at least officially.

"Stronger and meaner than Fran" was the phrase on most people's lips Wednesday, a reference to the 1996 hurricane that caught the Triangle unprepared and cost the state $6 billion in damage.

This time, though, local officials have been planning for potential disaster over the last two days, setting up schedules for crews to clear roads and yards of snapped trees and other debris, fix water problems and help people in flooded homes. Raleigh's public utilities department has generators at its wastewater treatment plant and at most of its 50 pump stations to run the water system if power fails.

Triangle school systems closed early Wednesday and will remain closed today.

Near the coast at Southport, Carolina Power & Light began taking its Brunswick nuclear plant off-line Wednesday morning as Floyd churned toward the mainland — the second time this month the plant had to shut down because of bad weather. CP&L was monitoring the storm to determine whether to also shut down the Harris plant in southwestern Wake County and the Robinson plant in Darlington County, S.C.

BellSouth urged its customers to refrain from making casual calls today so they won't tie up lines needed by people seeking emergency assistance.

But even with all the warnings and preparations, people expecting the storm couldn't keep anxiety entirely at bay.

Across the Triangle, the approach of Floyd conquered daily life. The sense of anticipation was palpable, as regular workday rhythms gave way to trips to hardware stores and supermarkets, early pickups of schoolchildren and reassuring long-distance phone calls to relatives.

Muhammad Alam, wet from the steady rain, took a break before his shift at Duke University Medical Center to pick up his two young sons from Frances Lacy Elementary on Holt Road in Raleigh, which — like all Wake schools — closed two hours early Wednesday. Alam, a 38-year-old lab technician, had never seen a hurricane, even

Dave Gatley, FEMA News Photo

Dave Gatley, FEMA News Photo