TESTIMONY OF
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NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U. S. DEPARTMENT OF COMMERCE

OVERSIGHT HEARING ON
SEVERE WEATHER – HURRICANES

BEFORE THE
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
SUBCOMMITTEE ON DISASTER PREVENTION AND PREDICTION
UNITED STATES SENATE

JUNE 29, 2005

Mr. Chairman and Members of the Subcommittee, I am Max Mayfield, Director of the Tropical Prediction Center/National Hurricane Center (TPC/NHC). The National Hurricane Center is a part of the National Weather Service (NWS), of the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce. I am pleased to be here today to discuss NOAA's role in researching, forecasting, and warning the public about hurricanes.

The National Hurricane Center (NHC) has been the centerpiece of our Nation's hurricane forecast and warning program for 50 years. Our mission is to save lives, mitigate property loss, and improve economic efficiency by issuing the best watches, warnings, and forecasts of hazardous tropical weather, and by increasing the public's understanding of these hazards. Today, I would like to provide some background on our hurricane program, discuss current activities, and outline some of our goals for the future.

According to a 2003 report published by the American Geophysical Union, the NHC, along with our public and private sector partners, saves the lives of close to 200 people per year in the United States alone from hurricanes, tropical storms and tropical depressions collectively known as tropical cyclones. Since our efforts began in the 1950s, we have reduced tropical cyclone mortality in the United States by about 90%. Saving lives is paramount, but it is also important to recognize the enormous physical and economic damage caused in our country by tropical cyclones. The impact of hurricanes in the United States alone is an average of 20 deaths and $5.1 billion in property damage each year.

Public confidence in the NHC is high. A 2003 customer satisfaction survey conducted by Claes Fornell International indicated 87% of the respondents approved of the quality and usefulness of our products and services. Respondents also rated our improvements over the past five years at 86 out of 100. These scores are among the highest reported among

federal government agencies on similar questions, and reflect the significant gains we have made in analyzing and forecasting tropical cyclones. For example, our track forecast errors have been cut approximately in half in the past 15-20 years due to advances in weather forecast models enabling us to meet our Government Performance and Results Act (GPRA) performance measure every year.

We were honored last year to have President Bush visit our facility to thank our staff for their work during the very active 2004 hurricane season. I would like to express our appreciation to the Administration and Congress for their continuing support, highlighted by the Supplemental Hurricane Bill passed last year. The supplemental appropriation provided funding for additional observing systems (data buoys and observing sensors to be installed on U.S. Air Force hurricane reconnaissance aircraft), computer model development and supporting research, and is already beginning to pay dividends. The new weather buoys we were able to deploy because of the supplemental funding helped define the early characteristics of Tropical Storm Arlene.

The combination of improved forecasting, better communications, advanced emergency management practices, and an aggressive education program have contributed to a period of relatively few tropical cyclone related deaths in this country. However, with more than half of the U.S. population residing in coastal watershed counties, we are more vulnerable to a hurricane catastrophe today than at any time in our Nation's history. Despite our progress in tracking and forecasting storms, we have much work still to do. To meet the challenge of reducing the risk to our Nation from tropical cyclones, we must continue to improve our forecasts and warnings, and continue our outreach and public education efforts.

Our Challenge

Until 2004 we experienced relatively few hurricane landfalls in this country in recent decades and, in particular, very few "major" hurricanes — those of Category 3 or higher on the Saffir-Simpson hurricane scale (Category 1-5). Our good fortune ended last year when six hurricanes hit the United States, and three of those were major hurricanes.

We have entered a period of heightened hurricane activity. On average, ten tropical storms form during the Atlantic hurricane season, with 6 becoming hurricanes and 2-3 becoming major hurricanes. However, tropical cyclone activity in the Atlantic is cyclical, with a time period of multiple decades. During the 1940s through the 1960s, we experienced an above average number of major hurricanes, and during the period from the 1970s into the mid-1990s we experienced fewer hurricanes than average. Since the mid-1990s, activity increased sharply and this period of heightened activity could last another 10-20 years. In fact, there have been more hurricanes during the past ten years than in any other ten-year period since records began in 1851.

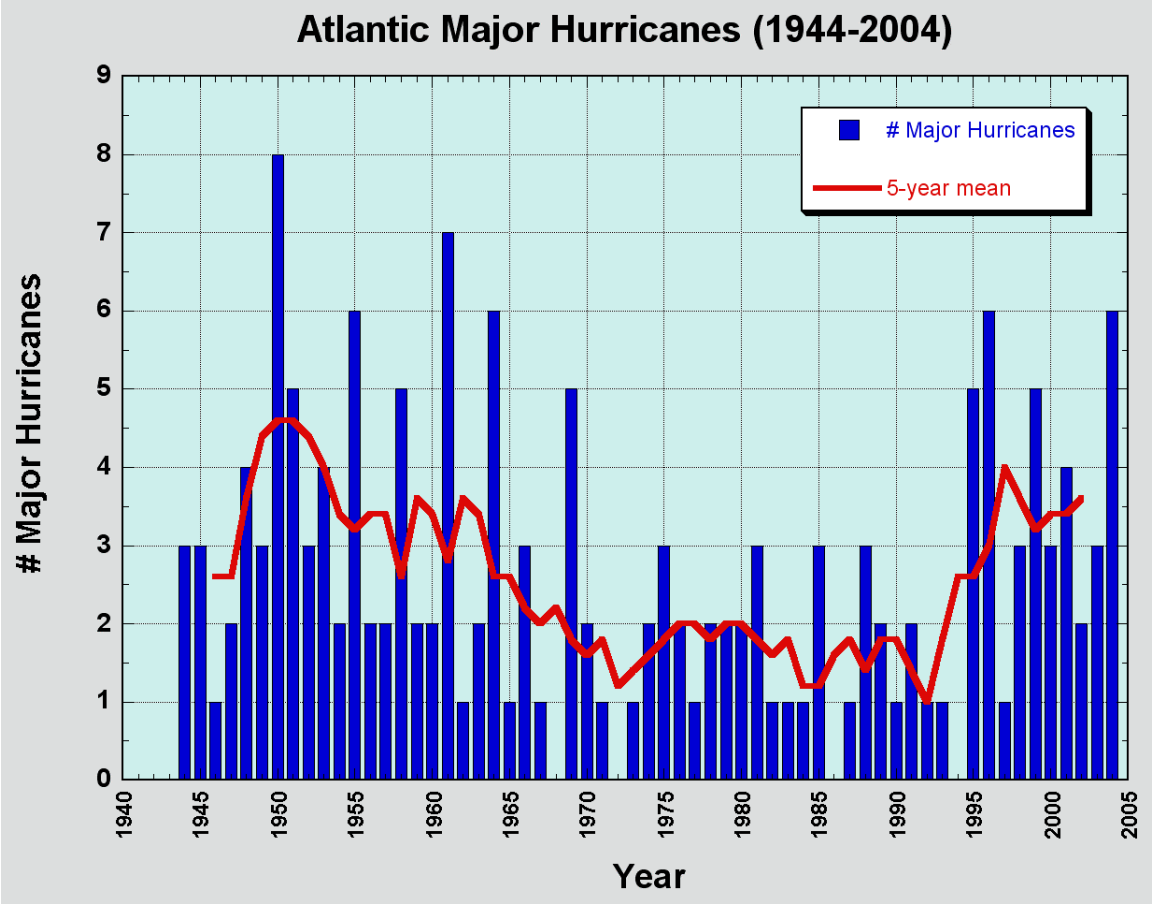

Figure 1. Number of Atlantic basin major hurricanes (blue bars) for the period 1944-2004. The red line indicates five-year average values.

This increased level of hurricane activity is occurring against a backdrop of a large and rapidly growing coastal population in this country as identified by the 2000 Census conducted by the DOC Census Bureau. Coastal populations are directly threatened by tropical cyclones, and are largely unfamiliar with the devastating impacts of these storms. About 85% of coastal residents have never experienced the core of a major hurricane. Population growth increases the overall risk by stressing the already crowded, and in some places overwhelmed, evacuation routes.

NHC structure and support

The NHC has a staff of forty-one, including six hurricane forecasters and support staff. Our area of responsibility encompasses the Atlantic Ocean, Gulf of Mexico and Caribbean, as well as the Eastern Pacific Ocean east of 140ºW. The central Pacific from 140ºW to the international dateline is monitored by the NWS Central Pacific Hurricane Center located in Hawaii. The NHC staff is extremely dedicated and, in 2004, worked tirelessly to provide the forecasts necessary during the very active hurricane season. Some individuals worked for many weeks without a day off to ensure forecasts and warnings were issued and our mission was upheld.

The NHC depends on numerous critical research and operational activities inside and outside NOAA, including NWS' Environmental Modeling Center (EMC), the Geophysical Fluid Dynamics Laboratory (GFDL) and the Hurricane Research Division (HRD) in NOAA's Office of Oceanic and Atmospheric Research, as well as the NWS's Central Operations, which is responsible for the computing infrastructure to run the forecast models. We also rely on the Department of Defense — in particular the U.S. Air Force Reserve Command's 53rd Weather Reconnaissance Squadron "Hurricane Hunters." These reconnaissance flights make the storm penetration flights and provide essential data about the structure of the storm. NOAA's Office of Marine and Aviation Operations conducts further reconnaissance missions when hurricanes approach land. The Office of Marine and Aviation Operations also pilots the Gulf Stream IV, which provides data from the large area surrounding a hurricane.

In the international arena, under the auspices of the World Meteorological Organization (WMO), a United Nations' Specialized Agency, the NHC is designated as a Regional Specialized Meteorological Center (RSMC). As an RSMC, NHC's forecasts provide guidance to two dozen countries in the Atlantic, Eastern Pacific and Caribbean. For their part, these countries provide the United States valuable weather observations that help in our forecasts for them and for us.

The NHC has strong ties to the meteorological research community as well as others in academia, international meteorological services, emergency management agencies, the media, amateur radio operators, the American Red Cross, and the private meteorological sector. It takes a true team effort to make the hurricane program work.

Our Products and Services

NHC tropical cyclone forecasts are issued every six hours and include text messages as well as a suite of graphical products depicting our forecasts and the accompanying probabilities and "cone of uncertainty," as it has become known. This information is available through many sources, including the media and the Internet. The media is an essential partner and helps us get the information to the public. Without the media, it would be very difficult get the information as widely distributed. The Internet has also become an excellent vehicle to provide our information to the public. NOAA websites recorded over 9 billion "hits" during the peak of the 2004 hurricane season.

Even with the majority of users saying they are "very satisfied" with our current products and services, we continue to develop new experimental products for the 2005 hurricane season to meet user needs. One of these products is a depiction of tropical cyclone surface wind speed probabilities at specific locations, and is available in both text and graphical formats. These new and expanded products help us better convey forecast uncertainties and have the potential to provide users with information that enhances their ability to make preparedness decisions specific to their situations. In accordance with the NOAA Partnership Policy, we consult with our users and partners to determine the usefulness of our products to ensure the products further the public-private enterprise as a whole and help us better meet our mission.

The NHC coordinates with many other agencies, both domestic and abroad, on tropical cyclone forecasts and watches/warnings. Forecast coordination calls occur one hour before each advisory release deadline. The calls include the U.S. Navy, the U.S. Air Force Weather Agency, the Federal Emergency Management Agency (FEMA), and NWS regional headquarters and local Weather Forecast Offices (WFO) of the affected area. NHC then constructs and disseminates the final advisory products within the hour after this coordination call is initiated.

Our Region Hurricane Operational Plan provides procedures for coordinating watches and warnings with other countries. This coordination, which is a challenging and important task for NHC, can involve up to six or more weather services at one time. While NHC provides forecast information and often initiates the coordination, it is ultimately up to each country to issue watches and warnings for their area(s) of responsibility.

The FEMA/NWS Hurricane Liaison Team (HLT), which I usually activate at NHC a few days in advance of a potential U.S. landfall, coordinates communications between NOAA and the emergency management community at the federal and state levels. After consulting with our local weather offices and our center, emergency managers make evacuation and other preparedness decisions. The HLT provides an excellent way to communicate with the large number of emergency managers typically impacted by a potential hurricane.

Our Performance

Great progress has been made in forecasting the track of tropical cyclones over the past half-century. Our average 48-hour track error, which was near 300 nautical miles in the early 1970s, is now near 100 nautical miles. Today's 5-day forecasts are as accurate as our 3-day forecasts were 15 years ago. These advances are largely the result of improvements made in operational numerical weather prediction, aided by investments in increasingly sophisticated computers and advances in satellite observations over the otherwise data-sparse oceanic regions where tropical cyclones are spawned.

An important part of this success story is the NOAA Gulf Stream IV jet aircraft. Following a highly successful HRD research program, Congress appropriated funds to obtain this jet in the mid 1990s. Data collected by the Gulf Stream IV now result in 36-48 hour forecast improvements averaging near 20% when tropical cyclones threaten land.

Our improvement in the accuracy of hurricane intensity forecasts has been more modest, in comparison to the progress made in track forecasts. The average 48-hour intensity forecast error has remained near 15 knots for at least the last 15 years. Anticipating rapid intensification, which occurred as Hurricane Charley made landfall last year, remains most challenging. As a result of forecast uncertainties, we advise emergency managers to prepare for a hurricane one category stronger on the Saffir-Simpson hurricane scale than what is being forecast. Improvements to the intensity forecast could substantially reduce

the indirect costs of tropical cyclones by reducing the scope of evacuations and other preparations.

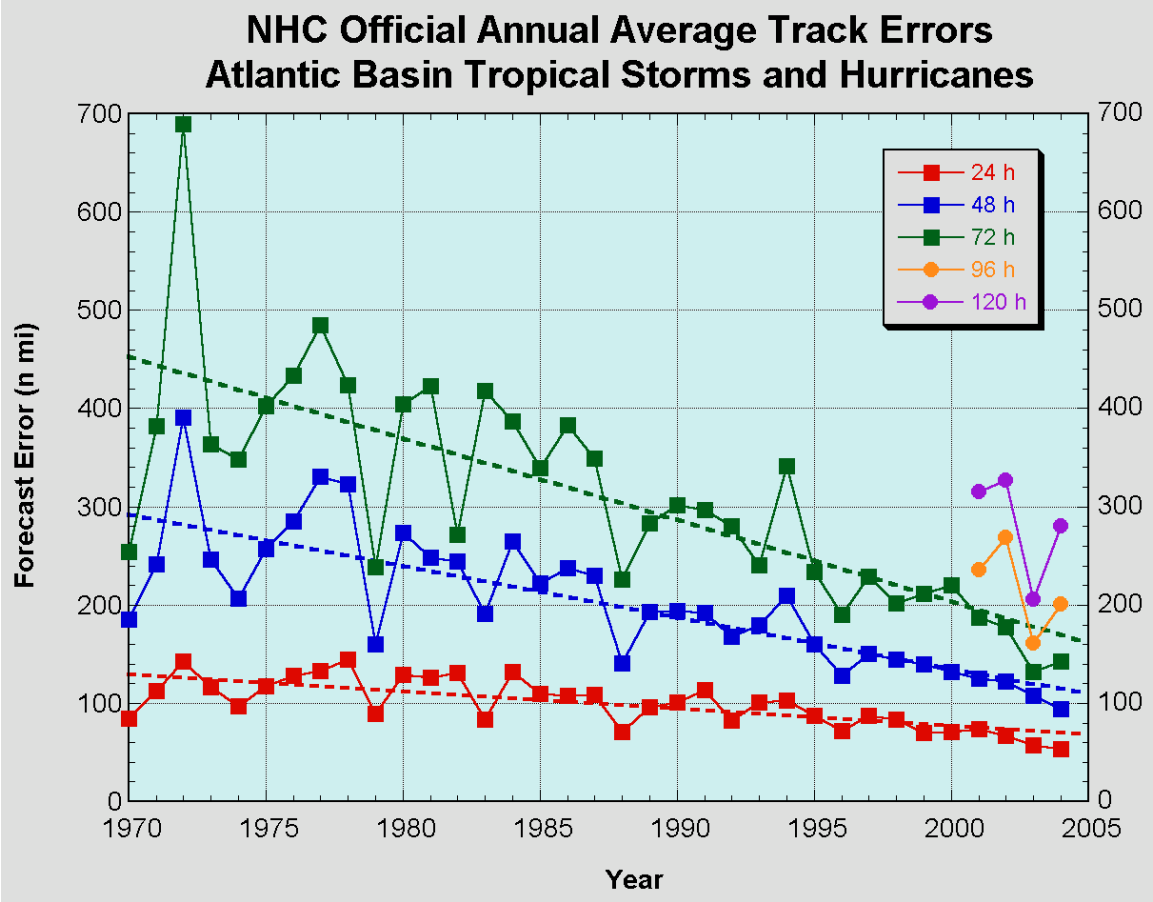

Figure 2. Annual average official track errors for Atlantic basin tropical storms and hurricanes for the period 1970-2004, with trend lines superimposed.

Outreach and Education

Further gains in forecast skill through improvements in science and technology are essential. Enhanced hurricane information will not, by itself, be enough if the information is not communicated to the at-risk public in a manner that can effect the best preparedness actions. For example, Dr. Jay Baker from Florida State University estimated that only 25-50% of the people who should have evacuated from last year's hurricanes did. Of those that did evacuate, a substantial number would have been safer remaining at home because their residence was well constructed and outside of a flood zone. Education and outreach events developed by NOAA, the emergency management community, and the media are essential to ensure the public has the information needed to protect lives and property.

We try to bring a "clear, calm and trusted voice" into households at risk. We conduct numerous media interviews each hurricane season. Efforts during the 2004 season reflect the magnitude of our effort. During this season NHC conducted more than 2600 interviews with radio, television and print outlets during hurricanes Charley, Frances, Ivan and Jeanne. Bilingual meteorologists satisfy our responsibility to inform the growing Spanish speaking population

NHC trains local, state, federal and international emergency managers on the limitations in hurricane forecasting and proper use of our products through workshops. More than 1,000 emergency managers have been trained at the NHC in the past 14 years. These workshops extend to the international community where tropical weather forecasters from around the world come to be trained in hurricane forecasting.

The Hurricane Awareness Tours that take place along the U.S. east and gulf coasts and in the Caribbean provide opportunities to advance hurricane awareness for the public and media in vulnerable communities. Doors to the "Hurricane Hunter" aircraft are open to thousands of people each year, where they learn about aircraft missions and the team effort between forecasters, emergency managers and the media. These events encourage every individual, family, business, and community to develop a hurricane plan, and to have that plan in place before the hurricane season begins. Despite these efforts, a Mason-Dixon Research Poll released in May 2005 revealed that 47% of people in coastal states do not have a hurricane plan. Clearly, more needs to be done and we will continue to address this with our partners through our education and outreach efforts.

In recent years, rainfall-induced freshwater floods have taken more lives in tropical cyclones than any other threat. We are taking steps in our operational procedures, education and outreach activities, and research and development to reduce the loss of life.

Storm Surge: A success story – so far

Storm surge has caused most of this country's tropical cyclone fatalities, and represents our greatest risk for a large loss of life in this country, particularly in hard to evacuate areas like the Florida Keys and New Orleans. Following Hurricane Camille in 1969, which resulted in at least 100 storm surge deaths, NOAA established a group that developed and implemented a storm surge model called SLOSH (Sea, Lake, and Overland Surges from Hurricanes). The plans for hurricane evacuation programs along the Atlantic and Gulf of Mexico coasts are based on SLOSH calculations. SLOSH and the resulting evacuation plans are credited largely with a dramatic decrease in the loss of life due to storm surge in the United States. Since Camille, the total number of deaths due to storm surge in this country is less than fifteen.

The SLOSH model calculates storm surge heights resulting either from historical, hypothetical or actual hurricanes. SLOSH incorporates bathymetry and topography, including bay and river configurations, roads, levees, and other physical features that can modify the storm surge flow pattern. Thirty-eight computational domains, or SLOSH basins, cover the U.S. east and gulf coasts, Puerto Rico, the Virgin Islands, Guam, and

the Hawaiian Islands of Oahu and Kauai. The SLOSH basins must be revised periodically to take into account new cuts in barrier islands, new levees or revision to older levees, waterway dredging and other significant changes to flow. NOAA recently formed a storm surge assessment team to examine our users' requirements for real-time storm surge information and products, to direct storm surge modeling within NOAA and to plan for future enhancement of, or the replacement of, the SLOSH model.

Comprehensive evacuation studies conducted jointly by FEMA, the U.S. Army Corps of Engineers (USACE), NOAA, and state and local emergency managers are based on the simulated surges computed by SLOSH. Mapping of the resulting potential surge inundations is done by the USACE as a step in determining hurricane evacuation zones.

The storm surge depends on the hurricane track and wind field. A slight difference in either can mean a huge difference in the surge. Last year's Hurricane Ivan is an example. The 12-hour forecast was off by only 25 miles, which is a very small amount. However, the difference in the predicted storm surge was large. The initial forecast called for a 14-foot surge in Mobile Bay and 5 feet in Pensacola Bay. But with the storm hitting 25 miles farther east, only a 4-foot surge occurred in Mobile Bay, while Pensacola Bay had a 12-foot surge. This is precisely why we use a mean envelope of high water for evacuation planning and training. An equally large difference is seen with the radius of maximum winds within a hurricane. When provided precise information, the SLOSH model performs well. Despite the tremendous success of the Nation's storm surge program, as our coastal regions become more populated the potential for a surge catastrophe remains.

Future Activities for the U.S. Hurricane Program

While we have made significant progress in hurricane forecasting and warnings, we have more work to do. For example, even in the areas with rapid advancement, such as track forecasting, we still cannot provide sufficient lead time to evacuate particularly vulnerable areas like the Florida Keys or New Orleans. From a scientific standpoint, the gaps in our capabilities fall into two broad categories: (1) our ability to assess the current state of the hurricane and its environment (analysis), and (2) our ability to predict the hurricane's future state (the forecast). Finally, we would like to improve public preparedness.

Improving analyses

Analysis is the starting point of the forecast process. Inaccurate assessments of a tropical cyclone's current position, intensity, and size lead directly to forecast errors. To improve the analysis of tropical cyclones, we need to enhance our observation network. Many of the enhancements required to improve hurricane analyses, particularly over the data-sparse ocean areas, will be addressed through such programs as the Global Earth Observation System of Systems (GEOSS), a 10-year international endeavor of which the United States is a member and NOAA a key participant. Further, additional observation improvements will be realized with funding from the Supplemental Hurricane Bill passed

last year, including 7 data buoys recently deployed and the sensors to be installed on Air Force "Hurricane Hunter" aircraft. We are working with the research community to develop some of the future observation technology. Advanced operational data assimilation systems will very soon combine all of the available observational data in very sophisticated Numerical Weather Prediction (NWP) analyses.

Improving forecasts

The accuracy of NHC tropical cyclone forecasts is closely tied to improvements in computer-based numerical weather prediction models (model guidance). Significant gains in intensity, precipitation and wind distribution forecasting await the next generation operational modeling system capable of incorporating high-resolution information from the hurricane core. Improvements will be based on state-of-the-art physics developed specifically to address these deficiencies.

We have increased our efforts to transfer research into operations. The United States Weather Research Program (USWRP) Joint Hurricane Testbed (JHT) was formed in late 2000. The mission of the JHT is to facilitate the transfer of new technology, research results, and observational advances of the USWRP, its sponsoring agencies, the academic community, and the private sector for improved operational tropical cyclone analysis and prediction. To accomplish this mission we identify promising and mature research and technology, and provide the infrastructure to test and evaluate the selected techniques in an operational setting. Federal assistance is provided to both federal and non-federal researchers to allow them to tailor their techniques for the operational environment and to collaborate in the testing and evaluation of their techniques by operational center staff.

We are very pleased thus far with the results of the JHT. Projects implemented thus far have made quantifiable enhancements to our operations including a 35% improvement in the computer model 3-day track forecast and significant improvements at other time scales. These advances helped NHC to establish new records for track forecast accuracy, both in 2003 and 2004.

Much of our improvement in tropical cyclone forecasting is attributed to advances in Numerical Weather Prediction (NWP). In collaboration with many scientists and developers in the domestic and international operational NWP centers, the EMC develops state of the art numerical modeling systems and is a recognized world leader. We are now at the point in improving intensity forecasts that we were a decade ago in improving track forecasts. Through our NWP advancements, our 2005 version of the GFDL high-resolution model improved some intensity forecasts over the statistical models when run on several 2004 Atlantic storms. To advance hurricane prediction, especially hurricane intensity and size forecasts, EMC is leading the development of the Hurricane Weather and Research Forecasting (HWRF) system. The HWRF system uses a collaborative approach among the research community and will apply advanced model physics as HWRF couples the atmosphere, land, and ocean into an integrated model. EMC will also couple an advanced wave model with a dynamic storm surge model to better predict coastal impacts of waves and storm surge.

Research efforts are being coordinated across NOAA to develop new technology and applications to improve NOAA's products, and provide outreach to the public. These research efforts address issues that have direct impact upon the ability of NOAA to provide tropical cyclone weather forecasting and warning services to the public.

We are making excellent progress. NOAA has a comprehensive plan to improve intensity forecasts along with our other difficult forecast challenges. While there are no quick fixes, we are very optimistic that we will continue to make advances in operational forecasts of tropical cyclone intensity, wind structure, size, and rainfall in the near future. We are leading the Nation in a large collaborative effort through a long-term commitment to these problems.

Increase the effectiveness of public preparedness

Our Nation's hurricane warning program requires more than meteorology. Mitigation of storm impacts demands an interdisciplinary approach to develop long-term policies and practices for better public safety. Such an approach requires, at a minimum, contributions from the public, private and academic sectors to address better land use, building codes, sheltering plans, identification and communication of risk, and public education. Mitigation of future storm impacts depends upon a more informed public who knows what the hazards are, how those hazards impact them, and what actions to take based on those hazards. Without this approach, our Nation is vulnerable to greater devastation from hurricanes in the coming decades regardless of forecast accuracy.

An example of how we can do more in outreach is through programs like the National Hurricane Survival Initiative. This public-private partnership includes the National Emergency Management Association, Florida Division of Emergency Management, the Salvation Army, NHC and corporate partners. Their collective aim is to educate and prepare communities at risk from hurricanes. Another example is the Federal Alliance for Safe Homes (FLASH®). FLASH is a non-profit, 501(c)3 organization dedicated to promoting disaster safety and property loss mitigation. A current FLASH® partnership with the NOAA/NWS, the Allstate Foundation, The Southwestern Insurance Information Service and the Texas State Parks and Wildlife is bringing greater visibility to a national Public Service Campaign named by the NWS "Turn Around Don't Drown". The campaign in Texas raises flood safety awareness using billboards, bilingual handouts for state park visitors and television public service announcements across major cities. These examples demonstrate how Federal-state and public-private partnerships are critical to pre-disaster planning, and targeted dissemination of outreach, education and information about the risks of severe weather.

Conclusion

We have come a long way in hurricane prediction. Our forecasts are better than they have ever been. We have an excellent working partnership with the emergency management community. Our partners in the private weather sector and the media work with us to make sure our information is disseminated and communicated as widely and

comprehensively as possible. Even with the substantive progress we have made over the last fifty years, we remain vulnerable to a hurricane catastrophe. To meet the challenge of reducing the risk to our Nation from tropical cyclones, we must continue to improve our forecasts and warnings, and continue our public education efforts.

Thank you for the opportunity to talk with you about our Nation's hurricane forecast and warning program, and for your support as we continue to provide our Nation with the highest-quality weather services.