

**WRITTEN TESTIMONY OF
DR. ROBERT ATLAS
DIRECTOR,
ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY
OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE**

**JOINT HEARING ON
TRACKING THE STORM AT THE NATIONAL HURRICANE CENTER**

**BEFORE THE
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT AND THE
SUBCOMMITTEE ON INVESTIGATION AND OVERSIGHT
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES**

JULY 19, 2007

Introduction

Mr. Chairman and members of the committee, I am Dr. Robert Atlas, Director of the Atlantic Oceanographic and Meteorological Laboratory in the Office of Oceanic and Atmospheric Research (OAR). OAR is a line office of the National Oceanic and Atmospheric Administration, within the Department of Commerce (DOC).

**NOAA's Atlantic Oceanographic and Meteorological Laboratory,
Hurricane Research Division**

NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) is located in Miami, Florida and specializes in hurricanes and open and coastal ocean research. Scientists at AOML study the relationship between the ocean and atmosphere by conducting research in both nearshore and open ocean environments. This research includes the dynamics of the ocean, its interaction with the atmosphere, and its role in climate change. AOML's research improves the understanding and prediction of hurricane track and intensity change, and the impacts from wind, storm surge, waves, and rain. Key to this work is the annual hurricane field program supported by the NOAA Aircraft Operations Center research/reconnaissance aircraft. AOML scientists cooperate with other federal, state, and local authorities to maximize research expertise for use in economically and environmentally important projects. AOML also provides and interprets oceanographic data collected via ships, satellites, aircraft, drifting buoys and floats, and conducts research relevant to annual-to-decadal climate change, coastal ecosystems and hurricanes.

Within the Hurricane Research Division (HRD) at AOML, scientists conduct research into hurricanes and related tropical weather phenomena, using theoretical studies, computer models, and an annual field program employing NOAA hurricane research

aircraft. This research has resulted in a deeper, scientific understanding and in numerous practical applications which have improved forecasts. HRD employs meteorologists, computer scientists, and other professionals, who collaborate with other governmental and academic scientists worldwide in this on going effort to advanced scientific knowledge and increase public safety. HRD coordinates parts of its programs with other NOAA organizations, e.g., the Aircraft Operations Center and the National Centers for Environmental Prediction, in particular the Environmental Modeling Center and the Tropical Prediction Center/National Hurricane Center (NHC).

NOAA's Hurricane Forecasting

NOAA strives to improve the reliability, accuracy, and timeliness of our predictions of hazardous weather, such as hurricanes, to help society cope with these high impact events. Over the last 15 years, hurricane track forecast errors have decreased by 50 percent, largely due to advances in hurricane modeling, an increased understanding of hurricane dynamics, improvements in computing and technology, and increased observations in both the region around the hurricane and in other data sparse regions. Today's five-day forecasts of a hurricane track are as accurate as three-day predictions were 20 years ago. Hurricane predictions are better today than they have ever been and will continue to improve in the future.

To help guide future research efforts and improvements, NOAA requested that the NOAA Science Advisory Board commission a Hurricane Intensity Research Working Group to provide recommendations to the agency on the direction of hurricane intensity research. The Working Group transmitted its final report to the Advisory Board in October 2006 (<http://www.sab.noaa.gov/reports/reports.html>). The Federal Coordinator for Meteorological Services and Supporting Research released a report in February 2007, *Interagency Strategic Research Plan for Tropical Cyclones: The Way Ahead*, to provide a strategy for continuing to improve the effectiveness of operational forecasts and warnings through strategic coordination and increased collaboration among the major players in the operational and R&D communities (<http://www.ofcm.gov/p36-isrtc/fcm-p36.htm>). Both of these reports call for accelerated research investments and a deliberate focus on moving research results to operations. In response, NOAA has created a Hurricane Forecast Improvement Project Team to develop a unified approach to define and accelerate hurricane forecast improvements over the next ten years. Objectives will be focused on improved tropical cyclone forecasting (intensity, track, precipitation, and uncertainty forecasts), storm surge forecasts, flooding forecasts, and information and tools to support community and emergency planning.

NOAA Hurricane Observations

Before I talk about the QuikSCAT satellite, I wanted to explain the systems NOAA uses to monitor hurricanes. Over the open oceans, continual images from our GOES satellites are the first reliable indicators of any storms or inclement weather. GOES provides near real-time critical data to help our forecasters determine a storms location, size, intensity, and movement. These satellites are so important we keep a spare in orbit. As tropical systems come closer to land, information from NOAA and Department of Defense (DOD) aircraft and ocean buoys provide real time direct measurements of the storm.

Within 200 miles of the coast, ground-based radars are used to track the storm. Computer models used to predict storm track and intensity require extensive amounts of data, which are mostly provided by NOAA and various National Aeronautics and Space Administration (NASA), DOD polar satellites, and where appropriate foreign environmental satellites. Together these systems provide the forecasters with layers of information critical to helping them make their forecast.

What is QuikSCAT?

QuikSCAT is a NASA satellite that has demonstrated the ability to measure ocean wind speed and direction from space with unprecedented coverage. QuikSCAT data is used for many applications, including climate monitoring, ocean research and weather prediction. It can be used to produce improved forecasts of hurricanes in three ways: its direct use by forecasters, its use as initial conditions for numerical weather prediction models, and its use as validation data in the development of advanced “next generation” weather prediction models. According to the forecasters at the National Hurricane Center, “QuikSCAT has become an important tool, especially for estimating the track, intensity and size of tropical and other strong marine storms.” In most cases, however, QuikSCAT has little demonstrated impact on hurricane intensity forecasts. In hurricanes, winds above 75 miles per hour typically occur over an area that is smaller than the QuikSCAT measurement resolution and are usually associated with heavy rain events. Thus QuikSCAT usually cannot distinguish winds above 75 miles per hour in a hurricane due to its lower than desired resolution and signal attenuation in heavy rain. However, QuikSCAT can distinguish winds above 90 miles per hour in extra-tropical cyclones where strong winds exist over larger regions of the ocean surface. In addition, until very recently, most numerical models did not have sufficient resolution to represent key processes leading to rapid intensity changes or the ability to assimilate much of the detailed information contained in the QuikSCAT observations.

QuikSCAT is well past its design life. NASA says QuikSCAT appears healthy and has fuel to last until 2011. It is not possible to predict how long QuikSCAT will continue to provide data. It could last several more years or cease to provide observations very quickly.

There are three studies that address the potential degradation to computer hurricane forecasts that might result from the loss of QuikSCAT. Each of these studies has limitations that prevent definitive conclusions, and additional studies are needed. In my opinion, the preponderance of evidence from the three studies indicates that computer model forecasts of landfalling hurricanes, especially in the 2-5-day time range, could be degraded if we do not mitigate the loss effectively. Forecasters at the NHC are able to improve upon the computer forecasts, so that the potential degradation can be diminished. This is especially true as the storms are approaching land in the shorter time ranges. In addition, NOAA has recently developed an effective mitigation plan that would make substantial use of other satellites as well as enhanced aircraft observations

What are the options to replace QuikSCAT data?

If QuikSCAT were to fail today, the NHC would still receive ocean wind speed and direction data from space. NOAA is now receiving data from a new instrument aboard a European satellite, called ASCAT – which has similar technology to QuikSCAT.

ASCAT will not provide the same quality data as QuikSCAT, especially in terms of coverage and resolution. NOAA is rapidly developing procedures for inserting the data into models and using the visual display of these data in forecasting. We are also examining how to increase the use of our hurricane hunter aircraft through more flight hours and outfitting the planes with more advanced technologies. In addition, we are researching the feasibility of placing scatterometers on Unmanned Aircraft Systems.

In June 2006, NOAA held a workshop at the National Hurricane Center to discuss the requirements for ocean wind speed and direction. Hurricane forecasters, researchers, and numerical modelers all prefer a next generation QuikSCAT, which they hope would be able to meet the new requirements. Such a satellite would be able to provide observations of ocean surface wind that would greatly enhance ocean surface wind measurements for hurricane intensity forecasting, as well as for weather, ocean and climate applications. In January 2007, Vice-Admiral Lautenbacher, the head of NOAA, was briefed on the conclusions of the workshop and the need to replace QuikSCAT data. After receiving our fiscal year 2007 appropriations, NOAA initiated a study with NASA's Jet Propulsion Laboratory, which built the original QuikSCAT, to examine replacement options. Those studies are due in January 2008 and from these studies, we will determine the best way to provide ocean surface wind speed and direction to forecasters.

Details on QuikSCAT

1. We now believe that the quality of ocean surface vector wind retrievals in storms at sea using any passive sensor (such as WindSat, or the Microwave Imager/Sounder on the National Polar-orbiting Operational Environmental Satellite System (NPOESS)) will never be comparable to those retrieved using an active sensor such as QuikSCAT. NPOESS will not provide an acceptable solution for ocean surface vector winds retrievals, but it will provide many other types of useful data and imagery.

2. QuikSCAT has provided many benefits but also has significant limitations. While it provides important additional data for estimating the intensity and size of tropical storms and other strong marine storms, it cannot be used for measuring the intensity of most hurricanes.

3. Data from any non-satellite platform could never replicate the coverage provided by a satellite. Therefore, no non-satellite option exists to replace QuikSCAT for wide-area measurements of ocean surface vector winds. Satellites are complementary to other data sources, such as aircraft and buoys, which have their own strengths and limitations. Satellites, aircraft, and surface-based observations are all critical components of the nation's weather monitoring and forecasting enterprise.

4. Data from the European ASCAT satellite instrument are just now becoming available

to National Weather Service (NWS) forecasters. ASCAT is not a replacement for QuikSCAT, since it provides only about 60% of the coverage and only about half the resolution of QuikSCAT. It will, however, provide partial mitigation against the eventual loss of QuikSCAT, and it will be fully evaluated for maximum possible use by NWS operational forecasters and models.

5. Since even QuikSCAT data do not meet NOAA operational requirements for ocean surface vector winds, serious consideration should be given to a sustained, more capable, next-generation satellite program for ocean surface vector winds using already existing technologies. A next-generation capability is needed to more accurately measure the strength and size of hurricanes and other intense marine storms, since aircraft data are not always available and only cover a small portion of the storm circulation. Such a capability would enhance operational NWS forecasts of many weather systems for the United States, and it would benefit research on the intensity of hurricanes and other marine storms that occur worldwide.

6. NOAA and NASA are working together during the next several months to examine the costs and benefits of options for what kind of satellite should replace QuikSCAT: a QuikSCAT copy, or a next-generation sensor. NOAA and NASA engineers will work directly with NWS operational forecasters during this study to provide recommendations by early 2008 on next steps for an ocean surface vector winds mission to replace QuikSCAT.

7. Track forecasts for landfalling storms have the added benefit of the national and international rawinsonde network (sensors to obtain detailed atmospheric profiles of wind, temperature, and dewpoint information), and from aircraft reconnaissance flights into and around the approaching hurricane. With these data, if QuikSCAT would fail, the impact on the track forecasts of hurricanes as they approach land would on average be smaller than for forecasts for storms in the open ocean. Studies on landfalling storms are insufficient to quantify the impacts. However, available experiments show that observations far away from the location of hurricanes can have a significant impact on model track forecasts. As such, NOAA's mitigation plan will attempt to minimize any degradation that might otherwise occur.

Current Research Studies of QuikSCAT in Models

Studies have shown either negligible or slightly positive impacts of QuikSCAT observations on track. The major drawback of these studies is the small number of cases examined. A more systematic study using cases from a number of seasons should be performed to clarify the impact. To date there are no studies of the impact of QuikSCAT data on tropical cyclone intensity forecasts. The main problem is that until this season models that forecast tropical cyclone intensity relied only upon coarse resolution global data assimilation system for their initial conditions. The impact on intensity must be tested in the future using very high resolution global and regional models, where inner core observations can be assimilated.

One study using the NOAA global data assimilation system and global forecast system tested the impact of QuikSCAT on track forecasts from two months of Atlantic storms in 2003 (Zapotocny *et al.*, 2007). The study, conducted at the NOAA/NASA/DOD Joint Center for Satellite Data Assimilation, examined storms in August-September 2003 and showed that a degradation in the 48 hour track forecasts of 10% and in the 72 hour track forecast of 16% when QuikSCAT was removed. A drawback of this study was the number of cases (only 25 cases at 48 hours and 19 cases at 72 hours). Nevertheless, this study provides the best available estimate of the degradation of model track forecasts that might result from a QuikSCAT failure.

A second study used the Navy Operational Global Atmospheric Prediction System and data assimilation system from two months in the 2004 Atlantic hurricane season (Goerss and Hogan, 2006). This study, using 8-10 times as many cases as the previous one, found little significant improvement in the track forecasts due to the inclusion of QuikSCAT observations of ocean surface vector winds beyond that at 24 hours, which showed a 3% improvement (2% improvement at 48 hours, and slight degradation at 72-120 hours. In my opinion, the impact of QuikSCAT data in this experiment was limited by the way in which the data was assimilated, and the results should apply only the Navy model used in the experiment.

A third study by NASA and NOAA (Atlas *et al.*, 2005) using the NCEP forecast system for two months of forecasts in 1999 showed a meaningful positive impact of QuikSCAT. In one case (Hurricane Cindy, 1999) the 60-hour forecast intensity and location with QuikSCAT observations of ocean surface vector winds was more accurate than the 24-hour forecast without them. This study should be considered in the context of two decades of numerical experiments with NASA models that have consistently shown improved predictions of storms over the oceans (Atlas *et al.*, 2001).

In summary, QuikSCAT provides vital data for a variety of important applications, including weather prediction for ships at sea, hurricane forecasting, atmospheric and oceanic research, and climate monitoring. NOAA has developed an effective mitigation plan that should reduce the impact of a QuikSCAT failure on hurricane forecasting while working with NASA to evaluate an advanced replacement for QuikSCAT.

LITERATURE CITED

Atlas, R., R.N. Hoffman, S.M. Leidner, J. Sienkiewicz, T.-W. Yu, S.C. Bloom, E. Brin, J. Ardizzone, J. Terry, D. Bungato, and J.C. Jusem, (2001) The effects of marine winds from scatterometer data on weather analysis and forecasting. *Bulletin of the American Meteorological Society*. **82(9)**: 1965-1990.

Atlas, Robert, Arthur Y. Hou and Oreste Reale. (2005) Application of SeaWinds scatterometer and TMI-SSM/I rain rates to hurricane analysis and forecasting. *ISPRS Journal of Photogrammetry and Remote Sensing*. **59(4)**: 233-243.

Goerss, J. and T. Hogan. (2006) Impact of satellite observations and forecast model improvements on tropical cyclone track forecasts. 27th AMS Conference on Hurricanes and Tropical Meteorology, Paper P5.2, available online from <http://ams.confex.com/ams/27Hurricanes/techprogram/paper107291>.

Zapotocny, T.H., J.A. Jung, J.F. LeMarshall, and R.E. Treadon. (2007) A Two Season Impact Study of Four Satellite Data Types and Rawinsonde Data in the NCEP Global Data Assimilation System. Submitted for publication in *Weather and Forecasting*. (available upon request from James Jung, Jim.Jung@noaa.gov)