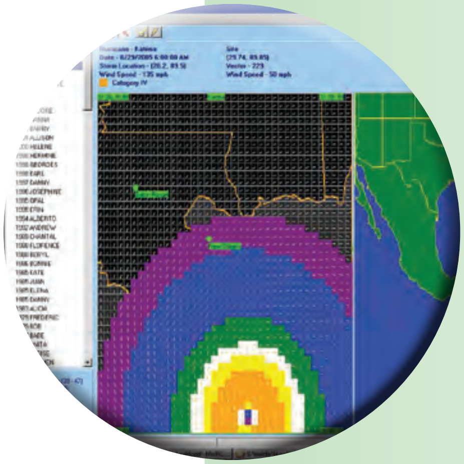

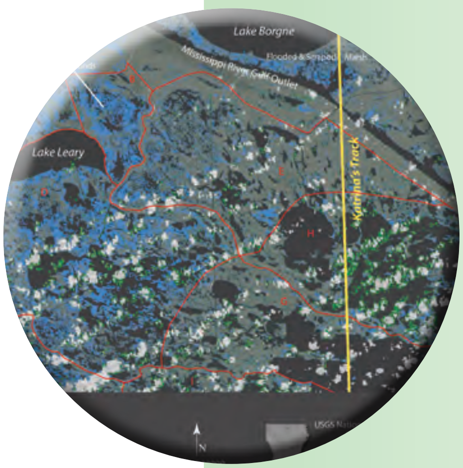

Chapter Four: How Technology Helps

Technology in many forms enables U.S. Geological Survey scientists to assess conditions before and after storms. These technologies include near real-time geospatial monitoring systems, geospatial support for emergency responders, Web-accessible data, and satellite imagery.

USGS Rocky Mountain Geographic Science Center's 2005 Hurricane Response and Recovery Activities

By Jill J. Cress, Susan E. Goplen, Jeff L. Sloan, Jennifer L. Stefanacci, and Stanley R. Wilds

Sophisticated monitoring systems and analysis products were key components to emergency response and Federal recovery activities during the 2005 hurricane season. The U.S. Geological Survey's (USGS) Rocky Mountain Geographic Science Center worked with a number of Federal agencies to provide these types of near real-time geospatial monitoring systems and analysis products in support of crucial preassessment activities and posthurricane response.

Overview

During major hazard events such as those associated with the 2005 hurricane season, information sharing is critical. Response and recovery efforts can be dramatically enhanced by providing accurate data quickly to a wide range of Federal and local emergency responders and decision makers in affected locations and other parts of the country. The USGS Rocky Mountain Geographic Science Center (RMGSC) provided support to the response and recovery activities associated with Hurricanes Katrina, Rita, and Wilma. Standard and custom geospatial products, data exploitation and analysis, and geospatial support were made available to Federal emergency responders and decision makers through Web-enabled monitoring.

In addition, RMGSC has several ongoing scientific research efforts that provide landscape monitoring and strategic awareness tools to Federal and State management organizations. These tools include the Interagency Operating Picture (IOP) for the U.S. Department of Defense U.S. Northern Command (USNORTHCOM), the U.S. Department of the Interior (DOI) Watch application for the DOI Watch Office, and the Natural Hazards Support System (NHSS) for the general public (*http://nhss.cr.usgs.gov*) (fig. 1). Each of these systems contains a broad base of geospatial data combined with a wealth of integrated, near real-time, natural hazard event information. These tools

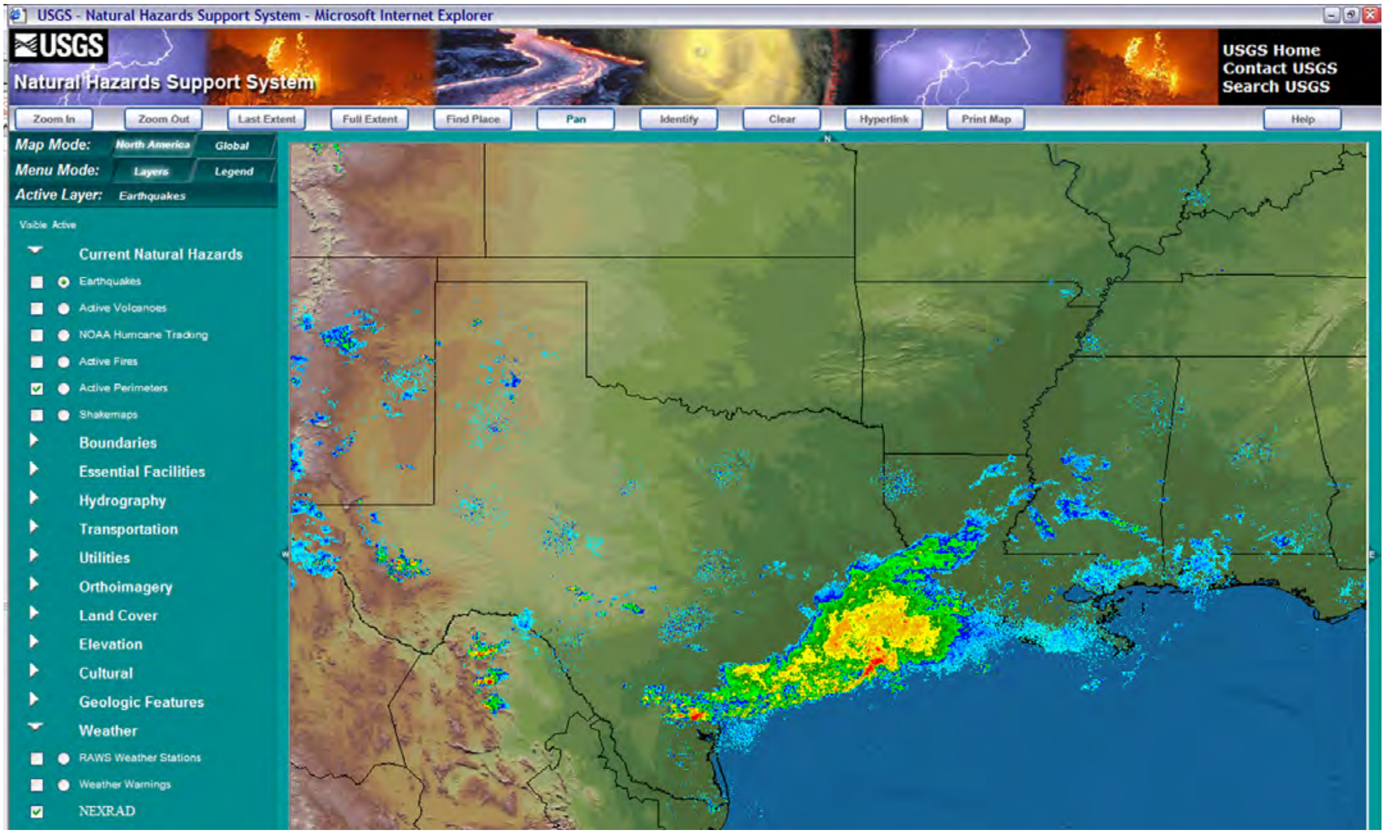

Figure 1. The Natural Hazards Support System is a near real-time natural hazard monitoring tool that was developed at the U.S. Geological Survey's (USGS) Rocky Mountain Geographic Science Center. This image shows a snapshot of the Texas Gulf Coast with near real-time NEXRAD weather information displayed on geospatial base layers. These are the type of near real-time capabilities that were used to monitor the approaching storms during the 2005 hurricane season.

were vital during the 2005 prehurricane monitoring and posthurricane response activities. The RMGSC was also called upon to quickly enhance the geospatial data contained in these monitoring systems, as well as generate a wide variety of accurate customized products in support of the hurricane response activities of the Bureau of Reclamation, USNORTHCOM, U.S. Army National Guard troops, and other Federal partners.

Rapid Response Imagery Exploitation and Application Enhancement

A key to RMGSC's ability to quickly meet the landscape monitoring and geospatial data needs of the 2005 hurricane season was the collection, integration, and exploitation of before- and after-event high-resolution imagery. A variety of existing airborne-derived imagery—including USGS digital orthophoto quarter quadrangles (DOQQs), high-resolution urban area imagery, and the National Agriculture Imagery Program (NAIP) aerial photography—were acquired for use prior to hurricane landfall to support strategic and tactical assessment of populated areas, infrastructure, and environmentally sensitive areas such as coastal wetlands.

In late August 2005, as Katrina reached landfall, the National Geospatial-Intelligence Agency (NGA) and other Federal agencies began a massive campaign of collecting high-resolution commercial satellite and airborne imagery. The huge quantity of collected imagery presented significant challenges in terms of processing, integration, and exploitation of the various data sets. Using their ClearView and NextView contracts for collection of commercial satellite data, NGA targeted the Gulf Coast from Florida to the Mississippi River Delta; however, much of the imagery could not be used because cloud cover obstructed the areas of interest. The RMGSC addressed the data issues by developing a method to rapidly process and exploit QuickBird (Digital Globe, Longmont, Colo.) and IKONOS (Space Imaging®, Thornton, Colo.) panchromatic and multispectral commercial satellite imagery (fig. 2).

Figure 2. Posthurricane satellite image of New Orleans, La., collected on September 3, 2005, by the Quickbird multispectral sensor. The dark areas throughout the central portion of the image are inundated with water as a result of Hurricane Katrina. This image is displayed as a false color composite by using the near-infrared, red, and green multispectral bands; vegetation is portrayed in red. Copyright 2005 Digital Globe.

The RMGSC developed a process to quickly determine which images would be most useful and to convert them into readily usable formats, including Web-based applications, file downloads, and hardcopy maps provided to search and rescue teams and other responders (fig. 3). The processing began with the acquisition of satellite data via NGA's online archive systems. Once downloaded, the data were previewed by an image analyst to determine spatial extent and usability, including image quality and duplication, off-nadir angle, and cloud cover. Images determined to be valuable were converted to GeoTIFF format, and the separate bands of the IKONOS imagery were processed into composite multispectral images. The imagery was then input into the Raster Archive and Provisioning System (RAPS) built on EarthWhere (SANZ Inc., Englewood, Colo.), which allowed RMGSC to maintain and access large amounts of imagery quickly. From this system the data were provisioned for Web-based downloads, pansharpened and used in hardcopy maps, and optimized for loading into ArcSDE. Once in ArcSDE, the imagery was seamlessly integrated into Web-based applications that were used by a variety of decision makers and emergency response personnel. With these procedures in place, RMGSC was able to provide posthurricane imagery within hours of receipt and disseminate the information to Federal agency decision makers. As a result of the lessons learned from the development of this process, further refinements have been made. In the future, much of the work done in the preprocessing and enhancement steps will be handled by the RAPS EarthWhere software, streamlining the data flow and enabling quicker delivery of quality data to the field.

Before- and after-hurricane imagery was incorporated into the Web-enabled IOP and the DOI Watch to facilitate hazards monitoring and situational awareness (figs. 4 and 5). The prehurricane imagery provided coverage for the New Orleans area, coastal Texas, and the western coast of Florida, with post-Katrina imagery covering the New Orleans area. These data enhanced the use of these tools by

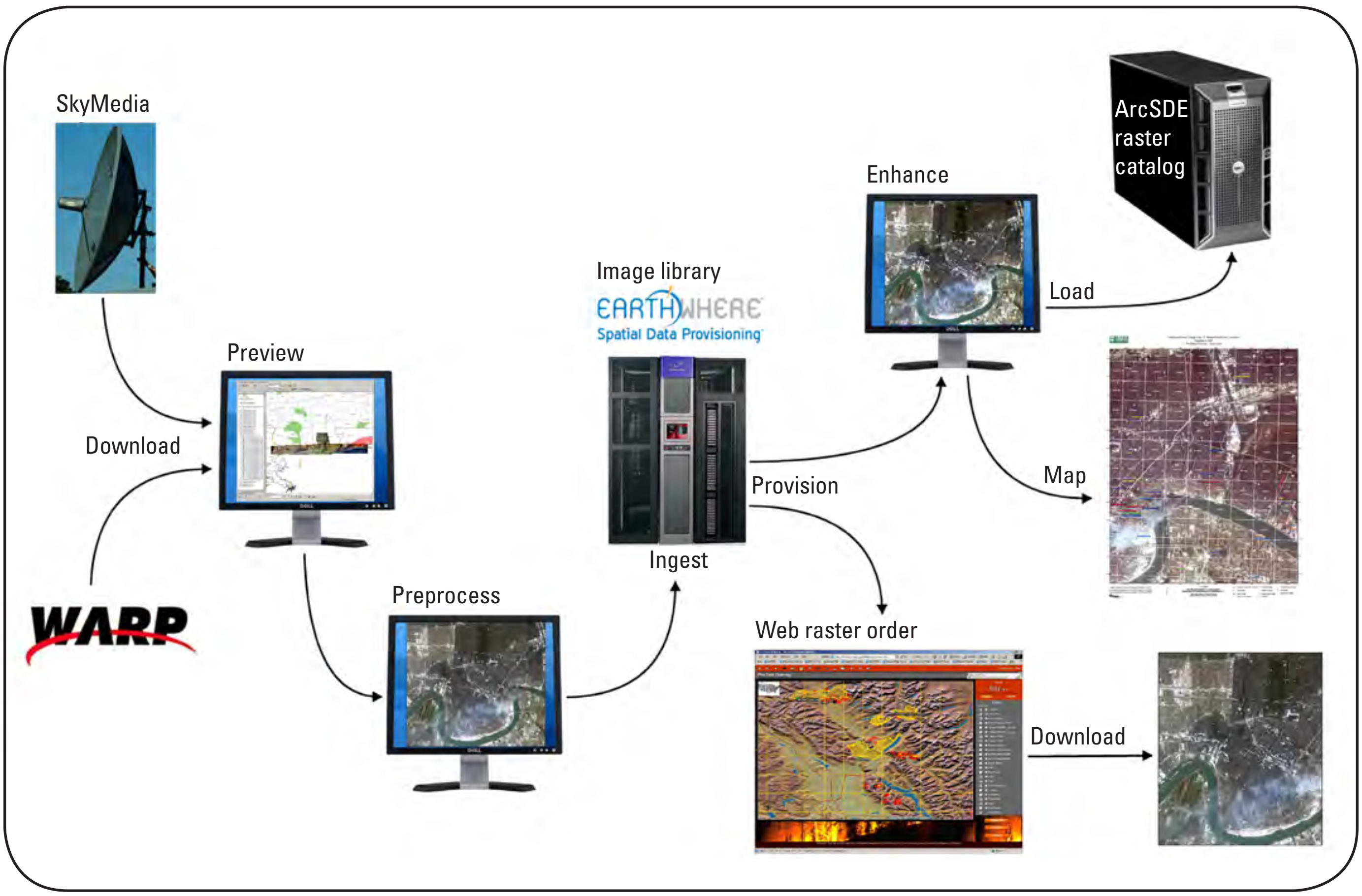

Figure 3. Process flow of posthurricane imagery acquisition, processing, and delivery steps developed by the U.S. Geological Survey's Rocky Mountain Geographic Science Center to support emergency responders. Copyright 2005 Space Imaging, LLC.

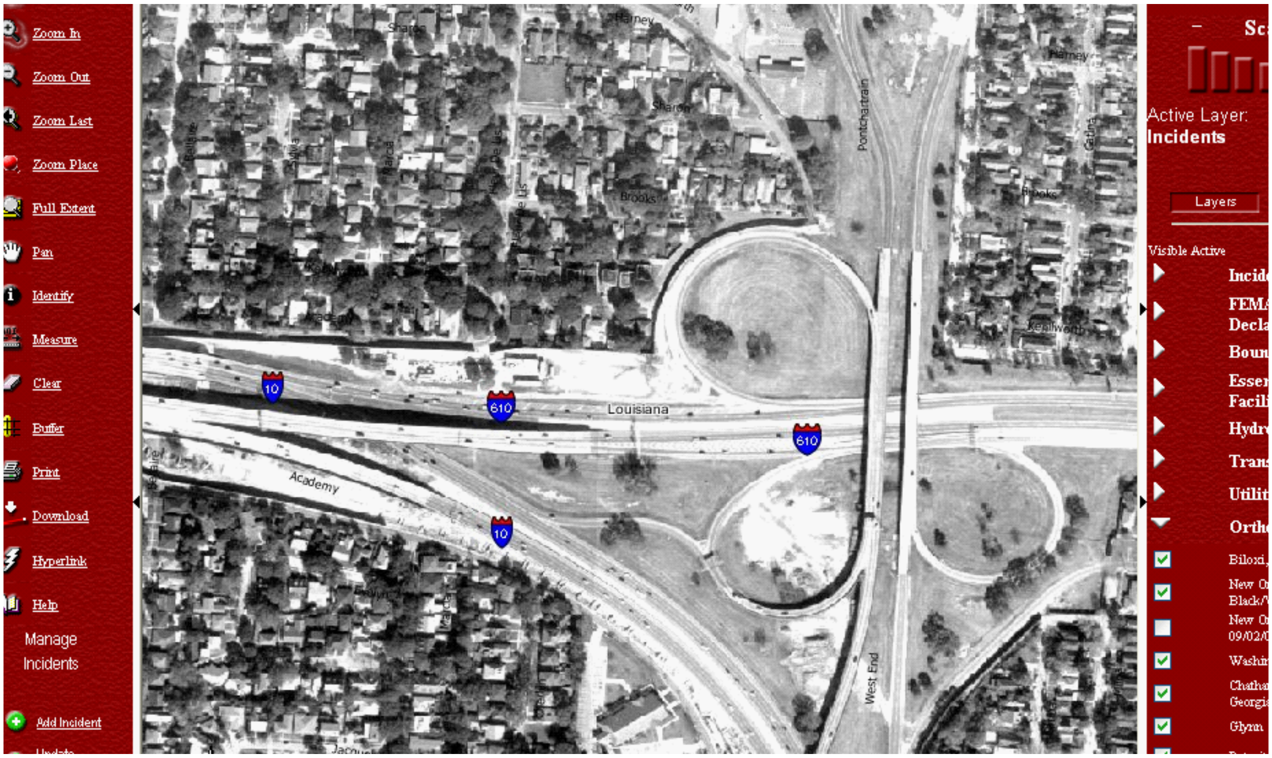

Figure 4. The Interagency Operating Picture (IOP) showing pre-Hurricane Katrina imagery at the New Orleans, La., Interstate 10 interchange.

Figure 5. The Interagency Operating Picture (IOP) showing post-Hurricane Katrina imagery at the New Orleans, La., Interstate 10 interchange. Copyright 2005 Space Imaging, LLC.

USNORTHCOM and the DOI Watch Office for monitoring the potential impact of the hurricanes.

Additional geospatial information for critical infrastructure such as hospitals, cellular phone towers, petroleum platforms in the Gulf of Mexico, airports, and roads and railroads, as well as ZIP codes, were incorporated to enable the Federal response community to analyze storm damage to critical facilities, residences, and transportation systems. The IOP allowed USNORTHCOM to rapidly share hurricane impact information by providing the ability to interactively add specific points of interest during the hurricanes and to attach associated documentation.

The IOP and DOI Watch were further enhanced with the addition of hurricane-specific data including flood-inundation areas, sustained windspeeds, and Federal Emergency Management Agency (FEMA) response information (fig. 6). This information was acquired from a variety of sources including FEMA, the National Oceanic and Atmospheric Administration (NOAA), and the Dartmouth Flood Observatory. These data were used to enhance the applications and also to produce hardcopy and digital products based on the most current information available (fig. 7). This wealth of hurricane-specific geospatial data was used to provide timely custom mapping support to Federal search and recovery teams in the form of before- and after-hurricane mapping, search and recovery maps, and damage assessment analyses. Search and recovery image maps were created for the Colorado Army National Guard by using IKONOS commercial satellite imagery collected on September 2 and September 8, 2005. These multispectral images served as baselines for identifying the extent of flooding throughout Orleans and St. Bernard Parishes (fig. 8).

Satellite image maps were created for the New Orleans region during the first 3 weeks of September to portray flooded areas in relation to critical infrastructure, to display the location of levee breaches and pumping stations, and to monitor sediment plume development in Lake Pontchartrain. The issue of increased sediment loads entering Lake Pontchartrain surfaced with the commencement of floodwater pumping from the Greater New Orleans area. Commercial satellite imagery was used to generate a time series of image maps depicting the growth of sediment plumes in the lake and their proximity to pumping stations (fig. 9). These maps were used by hydrologists to determine the characteristics of the sediment plumes based on water samples collected from the lake.

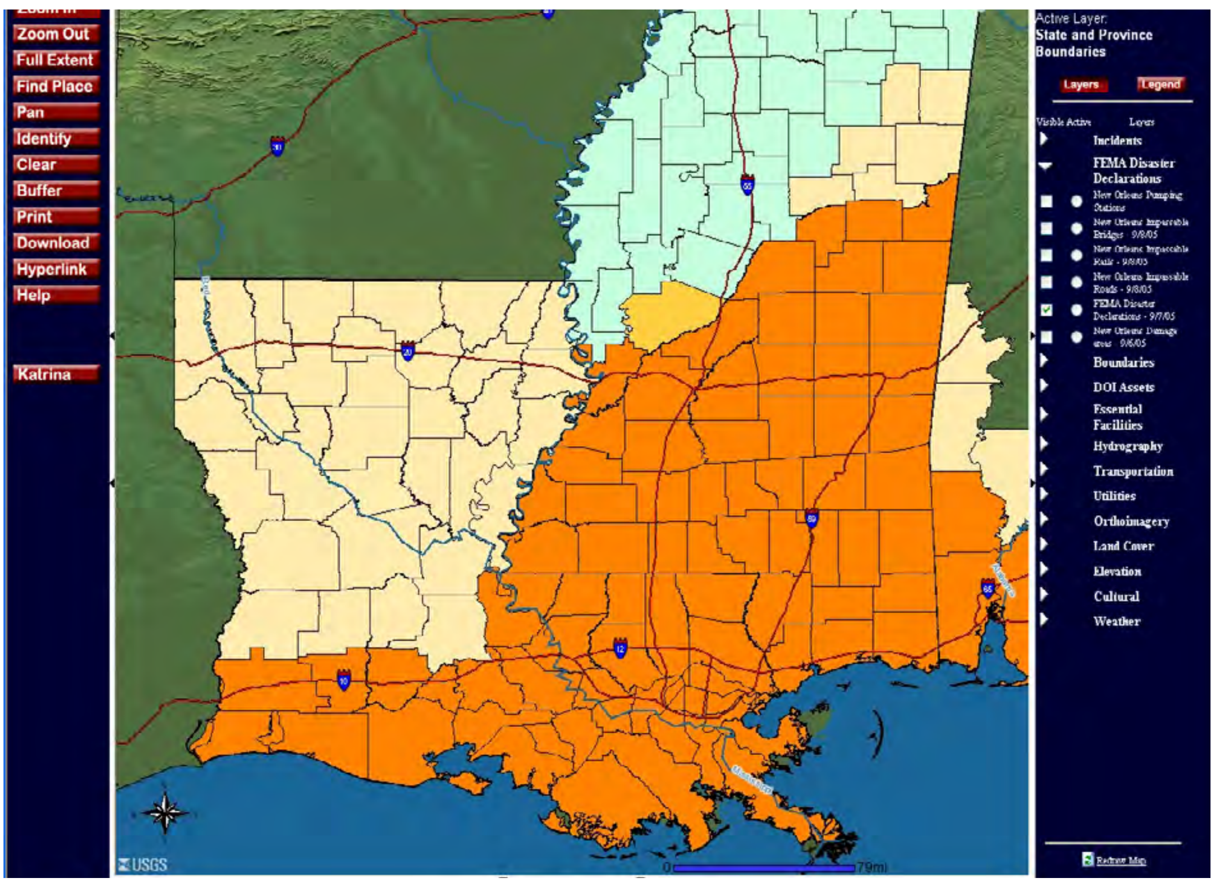

Figure 6. The U.S. Department of the Interior (DOI) Watch application showing post-Hurricane Katrina county and parish disaster declarations generated by the Federal Emergency Management Agency (FEMA).

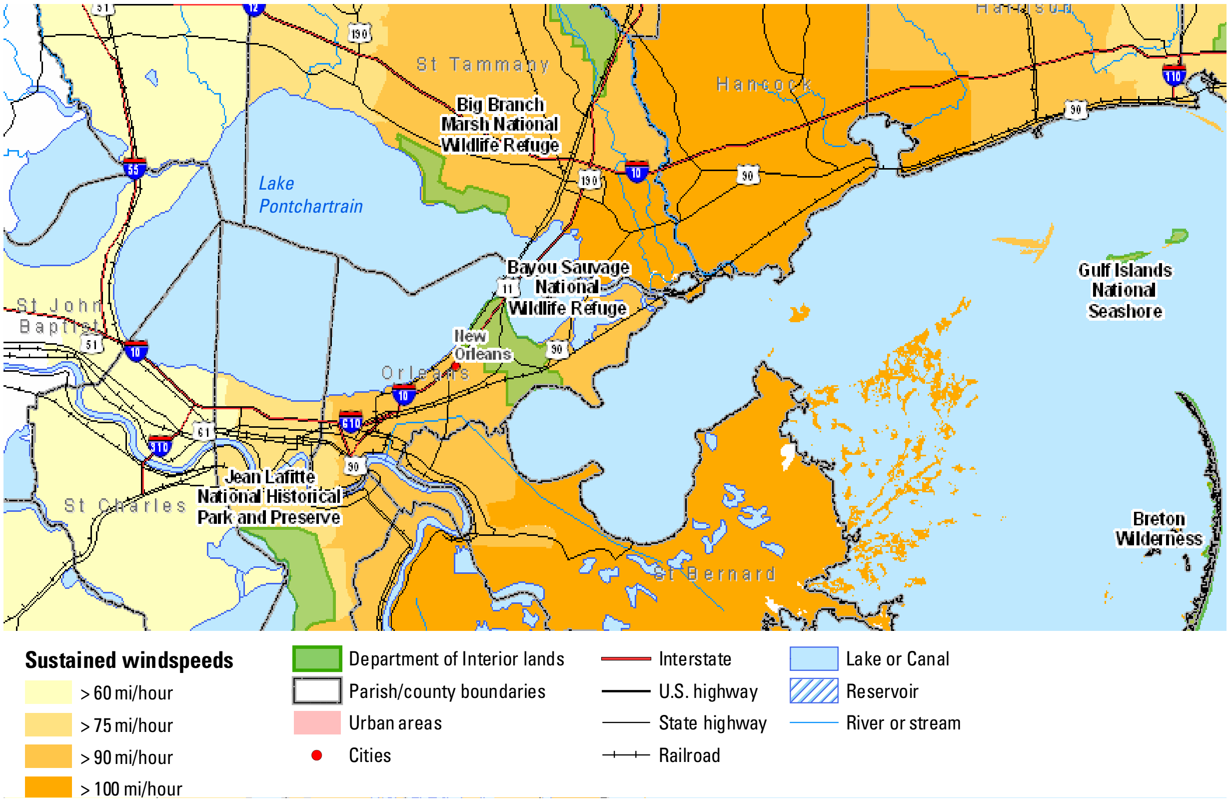

Figure 7. Portion of a sustained windspeed map showing the Mississippi River Delta area. Sustained windspeed polygons were created by Applied Research Associates Inc., Albuquerque, N. Mex., under contract with the Federal Emergency Management Agency (FEMA). The sustained windspeed data were collected by parish and county and were aggregated for display purposes.

Figure 8. Post-Hurricane Katrina satellite image map of a portion of St. Bernard Parish, La. The map combines satellite imagery collected on September 2, 2005, with integrated vector data to show locations of critical infrastructure such as hospitals, pipelines, and parish boundaries. The image used in the map is displayed as a true color composite using the red, green, and blue multispectral bands. Copyright 2005 Space Imaging, LLC.

Figure 9. Post-Hurricane Katrina satellite image of a portion of Orleans Parish and Lake Pontchartrain, La., collected on September 8, 2005, by the Quickbird multispectral sensor. Sediment plumes can be seen forming in the lake as water was pumped out of the parish through the canal system. This image is displayed as a false color composite, using the near-infrared, red, and green multispectral bands; vegetation is portrayed in red. Copyright 2005 Digital Globe.

Summary

During the 2005 hurricane season, sophisticated monitoring systems and analysis products clearly demonstrated their value to the success of emergency response and Federal recovery activities associated with the major storm events. Near real-time geospatial monitoring proved crucial to enabling decision makers to assess potential impacts of natural and human hazards to critical assets (e.g., hospitals, roads, airports), and analysis products were helpful in determining the most appropriate recovery response.

Web sites like NHSS, IOP, and DOI Watch, which contained information on hurricane trajectories integrated with near real-time information on stream levels, windspeeds, and precipitation, allowed Federal agencies to maintain a strategic awareness of the potential impacts of the hurricanes. In addition, posthurricane impact analysis products that were quickly developed at RMGSC aided various Federal recovery and response activities. The USNORTHCOM used these products to develop regional inventories of assets in affected areas, distinguish impacted areas, address information requests about affected transportation systems, and provide change detection of critical infrastructure in affected areas.

In conclusion, emergency responders and Federal agencies were able to quickly use RMGSC's natural hazards monitoring systems and sophisticated image exploitation capabilities as key tools for their response and recovery activities.

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