



ASTER and USGS EROS Emergency Imaging for Hurricane Disasters

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Satellite images have been extremely useful in a variety of emergency response activities, including hurricane disasters. This article discusses the collaborative efforts of the U.S. Geological Survey (USGS), the Joint United States-Japan Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team, and the National Aeronautics and Space Administration (NASA) in responding to crisis situations by tasking the ASTER instrument and rapidly providing information to initial responders. Insight is provided on the characteristics of the ASTER systems, and specific details are presented regarding Hurricane Katrina support.

Introduction

When a natural disaster strikes, responding agencies require timely information regarding the affected areas in order to rapidly summarize the situation and to plan relief and recovery efforts. Sensors aboard Earth-orbiting spacecraft acquire data at useful temporal frequencies



and spatial resolutions within wavelength regions that enable the discrimination of surface features. Emergency response coordinators at the USGS Center for Earth Resources Observation and Science (EROS) have a lead role in acquiring and distributing such data to domestic and international organizations during times of crisis. The EROS Emergency Response team often calls upon staff at NASA's Land Processes Distributed Active Archive Center (LP DAAC), which is located at EROS, to assist in disaster response efforts. A petabyte-class facility (a petabyte is 1,024 terabytes, or 2^{50} bytes), the LP DAAC archive contains over 19 million scenes of satellite imagery acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). The LP DAAC group works closely with the ASTER Science Team to task this instrument and provide processed imagery. The data characteristics of the ASTER instrument are well suited to local and regional studies.

In addition to extensive data collection during the 2005 U.S. hurricane season, the ASTER instrument has imaged numerous international disasters. The map presented in figure 1 provides examples of the wide variety of situations supported by the ASTER and LP DAAC teams in recent years. During 2005, LP DAAC processed up to 200 scenes per month by using an emergency, or expedited, processing system. Processing consisted of using code received from affiliates in Japan to radiometrically calibrate and to geometrically coregister the data, applying intra- and intertelescope registration and including geolocation information. Intended to be a low-volume activity compared to standard acquisitions, the overall expedited mission production level peaked in February 2005, largely in response to an Asian tsunami. Higher production levels later that year represented imaging of areas affected by hurricanes in the United States.

In times of crisis, the value of the data is related to the information content as well as to the timeliness of delivery. Well-defined multiple-agency international processes and procedures were in place before the 2005 hurricane season for acquiring satellite images and distributing data. This document will briefly summarize the ASTER mission and data characteristics, describe pre-event coordination, and provide examples of Hurricane Katrina imagery acquired by ASTER and MODIS. The Emergency Response team distributes data through the USGS's The National Map Hazards Data Distribution System (http://gisdata.usgs.net/website/Disaster_Response/). Data specific to Katrina are provided at the USGS EROS Hurricane Katrina Disaster Response Web site (<http://eros.usgs.gov/katrina/>).

The ASTER Mission and Sensor Characteristics

The ASTER project is a collaborative effort involving NASA, Japan's Ministry of Economy, Trade and Industry, and Japan's Earth Remote Sensing Data Analysis Center (ERSDAC) (<http://asterweb.jpl.nasa.gov/>). The ASTER instrument was launched in 1999 on the Terra spacecraft as part of NASA's Earth Observing System. Though the nominal ASTER design life has already been exceeded, the instrument continues to successfully perform its global mapping mission. The Terra spacecraft orbits Earth in 98.88 minutes at an altitude of 438 mi (705 km), enabling ASTER to acquire repeat coverage of a location every 16 days or less with its 37.28-mi (60-km) swath width. Further, ASTER's three telescopes can also be pointed off-nadir, or cross-track, enabling faster repeat coverage. The ASTER instrument acquires data through scheduled observations at an 8 percent duty cycle. Emergency, or expedited, scheduling provides a rapid-response capability, with data processed and available for use by investigators typically within 6 hours after collection.

As depicted in figure 2, ASTER spectral coverage includes three bands in the visible and near infrared (VNIR), six bands in the shortwave infrared (SWIR), and five bands in the thermal infrared (TIR) regions of the electromagnetic spectrum. Ground resolutions are 49.21 ft (15 m), 98.43 ft (30 m), and 295.3 ft (90 m) in VNIR, SWIR, and TIR, respectively. The ASTER instrument has both a VNIR

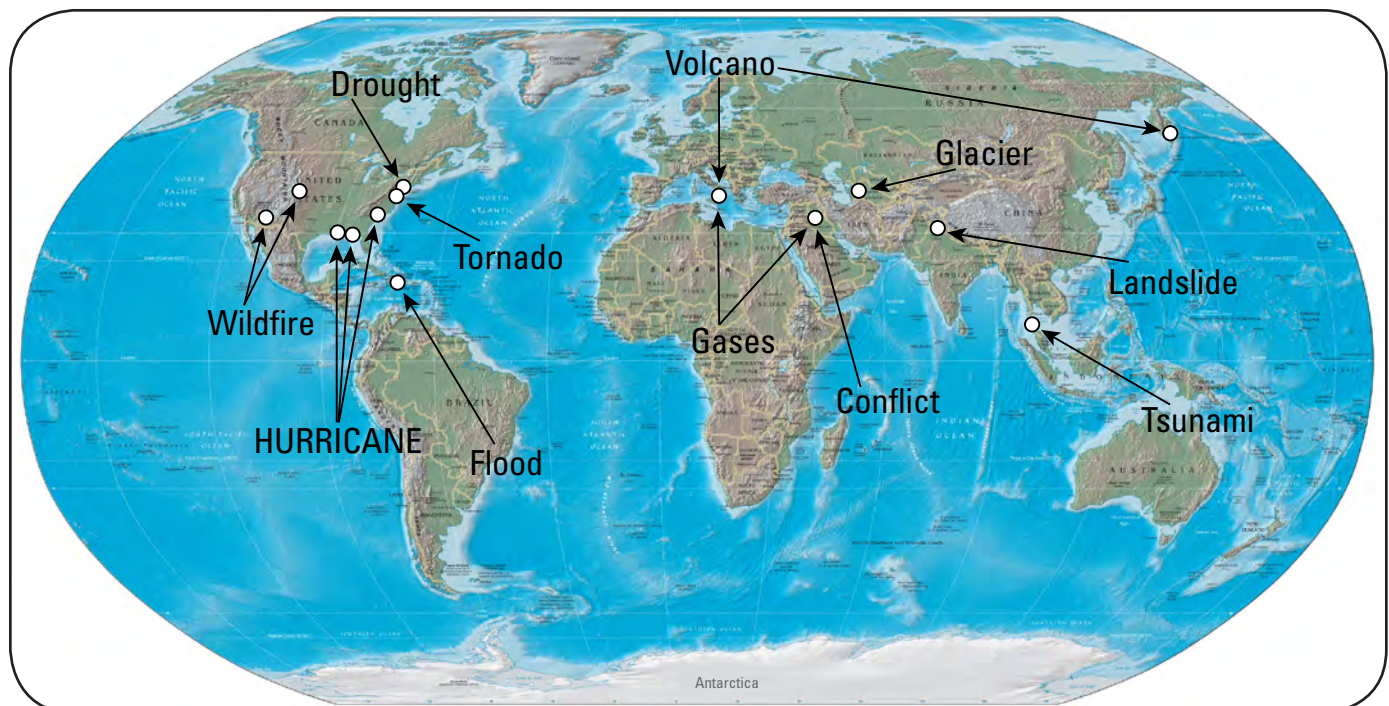


Figure 1. Examples of global situations imaged by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER).

Image Examples: Hurricane Katrina

Katrina made landfall along the Louisiana-Mississippi border on August 29, 2005, after having earlier crossed the Florida Peninsula. Loss of life and extensive property damage occurred. New satellite imagery was acquired over the affected areas as orbits and swath widths allowed. The first ASTER image collected in the area was of Baton Rouge, La., on August 30, 2005. By October 5, 2005, ASTER had acquired over 30 scenes along the Gulf Coast from Louisiana to Florida. In support of post-Katrina efforts, EROS distributed over half a million files of data, or 10 terabytes (a terabyte is 1,024 gigabytes or 2^{40} bytes) in volume, to over 15 Federal groups, to five States, and to several associations and universities.

The Aqua MODIS view of the Gulf Coast in figure 3 after Katrina made landfall in Louisiana portrays the value of coarser resolution data, from which wider area coverage

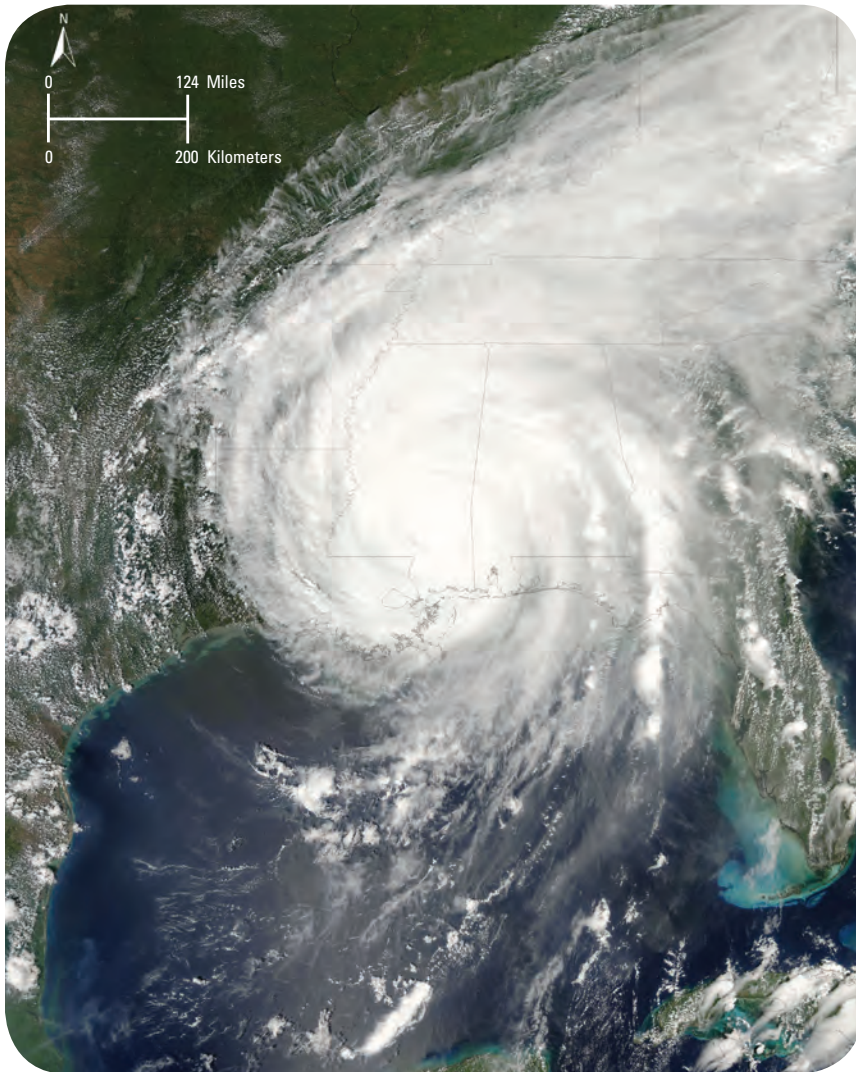


Figure 3. Aqua Moderate Resolution Imaging Spectroradiometer image of Hurricane Katrina acquired on August 29, 2005, after Louisiana landfall.

can be obtained at higher temporal resolution for regional studies. Many ASTER scenes were acquired along the Gulf Coast at the request of emergency coordinators after Hurricane Katrina made landfall. Figure 4 depicts the spatial extent of data acquired within approximately 5 weeks of the Louisiana landfall. In comparison with the MODIS image, the ASTER images in figure 5 before and after the event provide greater local detail. Flooded land areas appear dark in the lower image. In the ASTER excerpt enlarged in figure 6, more detail is apparent, and the demarcation between flooded and dry areas is visible as a near-vertical line south of the marina at top left, along the Jefferson-Orleans Parish boundary. Interstate 610 crosses the scene horizontally in the lower portion of the image, and the University of New Orleans is visible in the upper right corner. Street-level detail may be discerned from this ASTER data at 49.21-ft (15-m) ground resolution.

Conclusion

The widely distributed coordination, flight operations, scheduling, processing, and data distribution teams described in this summary worked effectively across institutional and international boundaries as they responded to calls for assistance from local, State, and Federal organizations. The strong demand experienced for timely, high-resolution satellite imagery to characterize the devastation of the 2005 hurricane season and other such catastrophic events suggests a continuing need for such data. The solid infrastructure in place prior to the catastrophes and the availability of an experienced workforce enabled rapid responses during times of crisis. Though operating beyond the nominal 5-year design life, the Terra spacecraft systems launched in 1999 currently remain available for future use as the need arises.

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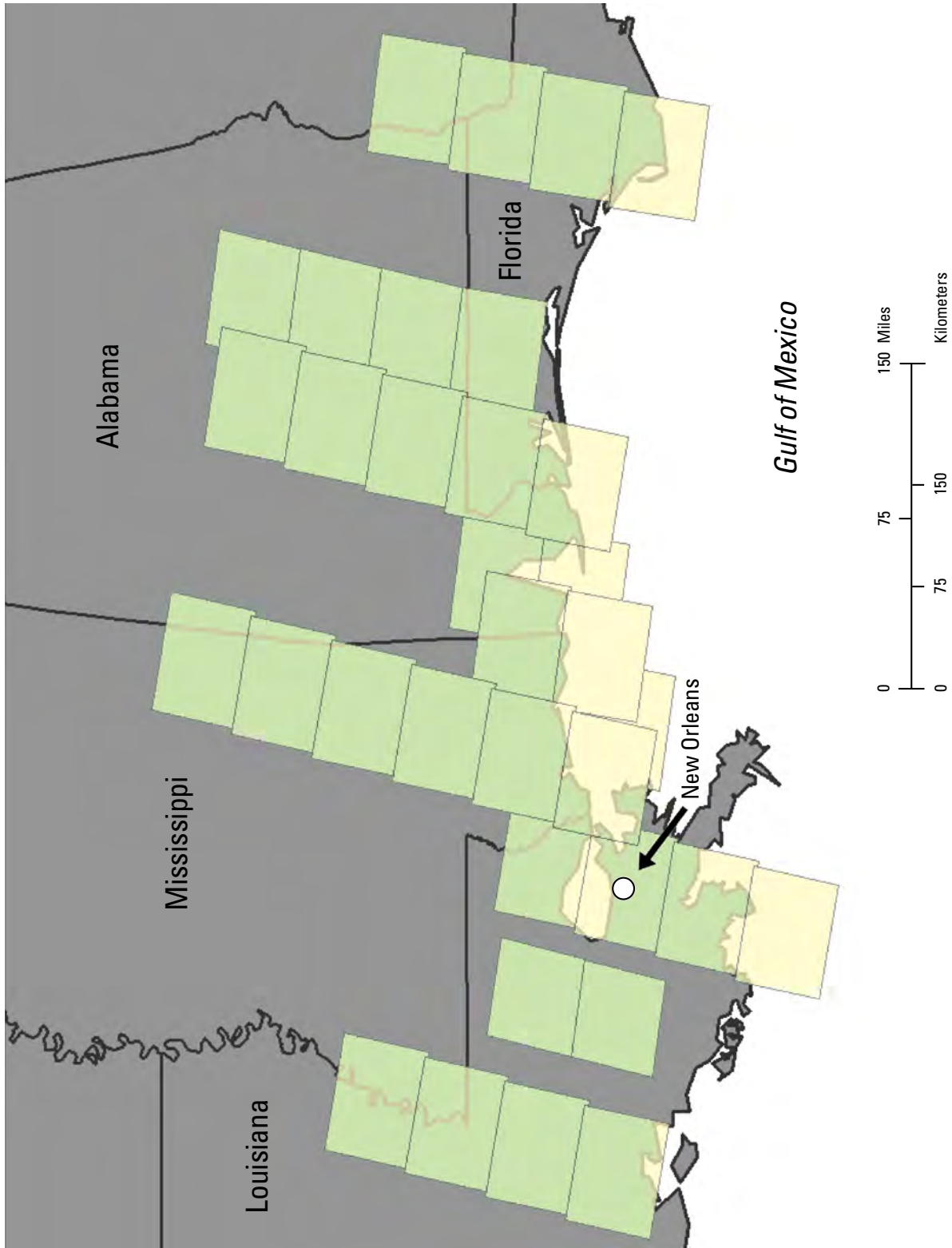


Figure 4. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) scene footprints depicting Hurricane Katrina coverage acquired through October 5, 2005. Each footprint, or rectangle, indicates the surface area covered by an acquired ASTER scene.



Figure 5. Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) images of New Orleans, La., before (A) and after (B) Hurricane Katrina. The top image (A) is a mosaic from April and September 2000. The bottom image (B) was acquired on September 13, 2005. The darker areas in the bottom image (B) represent flooded regions. The Jefferson-Orleans Parish boundary is represented by the dashed white line. Interstate 610 crosses the scene horizontally in the lower portion of the image. The University of New Orleans is visible near the shoreline in the central portion of the image.



Figure 6. September 13, 2005, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) image of New Orleans, La. The darker areas represent flooded regions. The demarcation between flooded and dry areas is visible as a near-vertical line south of the marina at top left, along the Jefferson-Orleans Parish boundary, which is represented by the dashed white line. Interstate 610 crosses the scene horizontally in the lower portion of the image, and the University of New Orleans is visible in the upper right corner.

ASTER data are courtesy of NASA, Goddard Space Flight Center; Japan's Ministry of Economy, Trade and Industry; Japan's Earth Remote Sensing Data Analysis Center; Japan Resources Observation System Organization; and the United States/Japan ASTER Science Team. Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) data are courtesy of the NASA Earth Observatory and the MODIS Science Team.

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