U.S. Department of the Interior
U.S. Geological Survey
National Wetlands Research Center,
Coastal Restoration Field Station
Baton Rouge, Louisiana

Map ID: USGS-NWRC 2006-11-0049
Map Date: January 16 , 2006

Water Area Changes in Southeastern Louisiana After Hurricanes Katrina and Rita Detected with Landsat Thematic Mapper Satellite Imagery

Sidebar Text

Multiple scenes of Landsat Thematic Mapper (TM) satellite imagery were acquired from the USGS Earth Resources Observation and Science (EROS) Data Center to identify water area changes in southeastern coastal Louisiana after Hurricanes Katrina and Rita (landfalls Aug. 29 and Sept. 24, 2005, respectively). Identification of new water areas relied on visual assessments of imagery, image classification to determine land-water areas by date, and spatial comparison of the resultant classified land-water datasets to identify changes in water area after the hurricanes. Complete coverage of southeast Louisiana was obtained by acquiring two adjacent, north-south image paths, one covering two-thirds and the other covering the remaining one-third of the eastern deltaic plain. Each path contained two images acquired contemporaneously. The interval between path acquisitions ranged from 3 weeks to 1 week for the fall 2005 imagery. Sixteen scenes were acquired and classified to represent fall 2001, fall 2004, and fall 2005 land-water conditions by using a standard classification methodology developed for prior land-water assessments in coastal Louisiana (Barras and others, 2003; Morton and others, 2005). Some images contained small areas obscured by clouds and cloud shadow. The classified data sets were corrected for cloud coverage and mosaicked together to provide complete land-water coverage for each period.

A fall 2004 dataset incorporating available imagery acquired on October 15 and November 7, 2004, was used to represent pre-hurricane conditions. Two land-water datasets (A and B) acquired after the hurricanes were used to address land-water variation possibly caused by remnant flooding from the hurricanes, normal tidal and meteorological variation between images, and aquatic vegetation fluctuations. Dataset A is compiled from imagery acquired on September 16 and October 9, 2005, while Dataset B uses imagery from October 18 and October 25, 2005. Water level conditions upon image acquisition for Datasets A and B were identified by using daily and seven-day water level averages obtained from the National Oceanic and Atmospheric Administration's National Ocean Service (NOAA-NOS) Grand Isle, La., tide gauge (NOS #8761724) readings as applied by Morton and others (2005) and review of USGS Hydrowatch water elevation data (http://la.water.usgs.gov/hydrowatch.htm). Dataset A (Sept. and Oct. 2005) was acquired during above-normal water level conditions, while Dataset B (mid-Oct. 2005) was acquired during average-to-low conditions.

Interpretation of water level conditions was based on prior TM land-water classifications (Morton and others, 2005).

Quantification of land-water changes was based on comparison of the fall 2004 land-water mosaic with Dataset B . This comparison was selected because the water level conditions expressed in Dataset B are a closer approximation of normal water level conditions than in Dataset A. In addition, the acquisition dates of the fall 2004 and Dataset B imagery share seasonal similarity. Finally, Dataset B features a longer post-hurricane acquisition period than Dataset A, thus providing more time for temporary hurricane impacts to be normalized. The land-water classifications from the fall 2001 data and Dataset A were used to provide land-water area variability estimates. The land-water mosaics were masked to match the Louisiana Coastal Area (LCA) boundary to provide spatial consistency with prior land-water change assessments (Barras and others, 2003). Data areas were summarized by major hydrologic basin as defined by the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) (1993) and were masked to match the LCA area, excluding fastlands. Remnant hurricane flooding located within leveed fastlands was not included in the land-water area comparison. Total increase in water area within the 9,742-mi2 area, between fall 2004 and mid-October 2005 was 118 mi2.

New water areas appearing after the hurricanes were identified by spatially comparing the classified land-water datasets to produce an output change dataset identifying new water and land areas occurring by mid-October 2005. The land-water change dataset was filtered to remove changes below 2.5 acres, to remove "noise," and to increase the confidence of the new-water area interpretation.

Changes in water area that were identified by Landsat were verified by review of multi-date, multi-resolution imagery bracketing the hurricanes, by small-plane overflight of TM-identified new water bodies on November 18 and December 9, 2005, and by limited field investigations. The imagery review indicated origin, variability, and duration of new water bodies. The small-plane overflight provided a quick and efficient way to verify the existence of new or expanded water bodies over southeastern Louisiana. Field investigations provided water depth information for selected new water bodies adjacent to Lake Leary, within the Breton Sound basin. According to the NOS Grand Isle gauge, daily average water levels during both verification flights were within 2.4 inches of the lower water levels shown on the October 25, 2005, Landsat image that covered the majority of the study area. The smallest new water body identified with TM imagery and verified by small-plane overflight was approximately 4 acres in the Bayou Biloxi marsh. The largest new lake was approximately 1,200 acres in the upper Breton Sound basin.

The map depicts Katrina's and Rita's direct impacts to the coastal wetlands of southeastern Louisiana. New water bodies and expanded water bodies formed on the eastern side of the Mississippi River basin; the northwestern portion of the Breton Sound basin, from Delacroix to Caernarvon; the northern and eastern shorelines of Lake Borgne; and along the north shore of Lake Pontchartrain from Mandeville to the Mississippi border, including extensive impacts in the Pearl River basin. Many of the new water areas consist of shallow ponds where the marsh surface has been sheared or ripped to the root mat or to the underlying firm substrate of clay by storm surge. Remnant marsh balls and other debris, not large enough to be identified with TM imagery, litter some of the sheared areas, while other areas appear as large shallow ponds or lakes with large areas of exposed mud flats that vary depending on water level. Groups of small interconnected ponds have been expanded in some areas by the shearing of the intervening marsh. Areas of floating fresh marsh and some scrub/shrub were completely removed in the northern Pearl River basin, while a series of shears was cut across the southern portion of the basin. The fresh marsh in northwestern Breton Sound basin was completely rearranged, displaying multiple NW-SE trending shears. Large deposits of wrack accumulated adjacent to and/or on top of spoil banks and natural distributary channels and often completely surrounded willows and shrubs. Shallow mudflats, peppered by marsh balls and other debris, were present throughout the area. Over ninety percent of the new water area appearing after the hurricanes in Breton Sound basin occurred within the 2001 fresh and intermediate marsh communities classified in 2001 (Chabreck and others, unpub.data, 2001).

The more mineral-rich brackish and saline marshes appeared to have fared better, as indicated by the lack of large new water areas in central Breton Sound basin and the Bayou Biloxi marsh. Fringing shoreline erosion, as well as the formation of small ponds, was observed in the brackish-saline marshes, but the greatest impacts occurred in the more organic fresh and intermediate marshes of the Mississippi River basin, upper Breton Sound basin, and Pearl River basin. Compression features of a mile or more in length were observed in upper Breton Sound basin. Smaller but distinct compression features were also observed in the North Shore marsh. The eastern Mississippi River basin also suffered some impacts from Hurricane Ivan in October 2004, as observed when comparing the fall 2001 to the fall 2004 imagery.

Areas west of the Mississippi River, with the exception of the areas east of Katrina's landfall, were impacted more by Rita than by Katrina, as observed by comparison of Landsat imagery acquired on September 15, 2005, after Katrina but before Rita's landfall. Areas of significant shoreline erosion, possibly caused by Katrina's winds were, however, detected along the southern shorelines of Lake Salvador and Little Lake in central Barataria basin. Rita's surge rearranged Katrina's wrack in upper Breton basin and caused the formation of limited new ponds and some expanded ponds from central Barataria basin across the Terrebonne basin to the Atchafalaya River. These impacts primarily occurred in fresh and intermediate marshes, although similar effects were observed in brackish marshes.

Areas of submerged and floating aquatic vegetation were shifted or removed by Rita’s surge. Some of the new water and land area changes in the floating fresh marshes of western Terrebonne basin were caused by the presence or absence of floating and submerged aquatic vegetation and by hurricane impacts. Water level effects are also noticeable in the marshes north of Lake Boudreaux, as evidenced by exposure of flats during low water level conditions on the October, 25, 2005, image versus higher water levels on the November 7, 2004, image.

The combined impacts of Katrina and Rita (identified using TM imagery from 1983 to the present) exceeded impacts from other hurricanes in coastal Louisiana (including Hurricane Andrew). The largest TM-identified new shear area from Hurricane Lili (Oct. 3, 2002) was 175 acres, although new shears and reactivated shears were observed from central Terrebonne basin to East Cote Blanch Bay. Either Hurricane Lili or Tropical Storm Isidore (Sept. 26, 2002) formed a 50-acre shear and many smaller, linear shears trending from northeast to southeast in the upper Breton Sound basin. The increase in water area between 2004 and 2005 in Breton Sound basin was equivalent to 60 percent of the total increase in water area between 1956 and 2004.

References:

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