Estimation of Post-Katrina Debris Volume: an Example from Coastal Mississippi

By Mark Hansen, Peter Howd, Asbury Sallenger, C. Wayne Wright, and Jeff Lillycrop

Hurricane Katrina severely impacted coastal Mississippi, creating large quantities of building and vegetation debris. This paper summarizes techniques to estimate vegetation and nonvegetation debris quantities from light detection and ranging (lidar) data and presents debris volume results for Harrison County, Miss.

Introduction

Hurricane Katrina made landfall as a very strong category 3 storm in Plaquemines Parish, La., on August 29, 2005. The U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the U.S. Army Corps of Engineers (USACE), and the University of New Orleans are cooperating in a research project investigating coastal change that occurred as a result of this extreme storm. Aerial video, still photography, and aircraft-based laser surveys of poststorm beach conditions were collected from August 31 through September 8, 2005, for comparison with prestorm data. The resulting data products are being made available to local, State, and Federal agencies to assist with their missions of disaster recovery and erosion mitigation. Other papers in this volume (Sallenger and others, this volume; Stockdon and others, this volume) demonstrate how these data may be used to describe the nature, magnitude, and spatial variability of coastal changes such as beach erosion, overwash deposition, and island breaching during hurricanes. A new application of these data—the rapid estimation of debris volume in need of removal during poststorm cleanup—is presented in this paper.

The USGS assisted State and local officials in the coastal counties of Mississippi in estimating the quantity of debris created by Katrina. The USGS approach to estimating debris volumes utilizes high-resolution aerial photography and topographic lidar data. It was evident from the poststorm aerial photography that, in addition to the major structural damage to homes and businesses, a large number

Figure 1. Location map of the Mississippi coast after Hurricane Katrina in 2005 with computational zones for debris-volume estimates in red. Light detection and ranging (lidar) coverage is represented in blue, and the storm surge debris line is represented in red.

of trees had fallen as a result of the storm. From a waste-management perspective, vegetation debris is often handled and disposed of differently than is structural debris (U.S. Environmental Protection Agency, 1995). Therefore, for the benefit to waste managers, we developed a technique to estimate quantities of vegetation and nonvegetation debris. The methodology used to produce debris quantity estimates is presented in Hansen (2006).

The highest reported storm surges during Katrina occurred in eastern Louisiana and the three coastal counties of Mississippi: Hancock, Harrison, and Jackson. Harrison County, the focus of this paper, encompasses the coastal towns of Pass Christian, Long Beach, Gulfport, and Biloxi (fig. 1). The towns are a mix of residential, commercial, and gaming property (casino) development. Harrison County was hit with an estimated 16–23 ft (5–7 m) storm surge (Federal Emergency Management Agency, 2006), and as a result a large percentage of the private and commercial structures within 0.3 mi (0.5 km) of the coastline were damaged or destroyed (fig. 2).

Data Sources

Pre-Katrina lidar data were acquired in March 2003 by Earth Data, Inc., and provided to the USGS for hurricane-related emergency management studies. Immediately after the storm, we used NASA's Experimental Advanced Airborne Research Lidar (EAARL) to conduct extensive coastal surveys on September 1–8, 2005. The lidar data coverage for Harrison County extends approximately 0.4 mi (0.6 km) from the shoreline north to Railroad Street, a road that runs parallel to the coast along most the county (fig. 1). High-resolution, 1 ft (0.3 m) per image pixel, georectified aerial photography mosaics were produced by the National Oceanic and Atmospheric Administration (NOAA) based on flights from August 30 and 31, 2005.

Calculation of Debris-volume Estimates

The poststorm aerial photography was used to identify areas of debris (fig. 3) and to guide the calculation of debris volumes. To do this, we applied standard image classification techniques to the poststorm NOAA photography. Eight photo mosaics were used to cover coastal Harrison County. For each mosaic, groupings of land-cover types were identified and pooled to represent vegetated and nonvegetated areas, based on their color signature. The two classes are used later in the volumetric analysis to differentiate between vegetation and nonvegetation debris quantities. Because of similar color characteristics, a limited

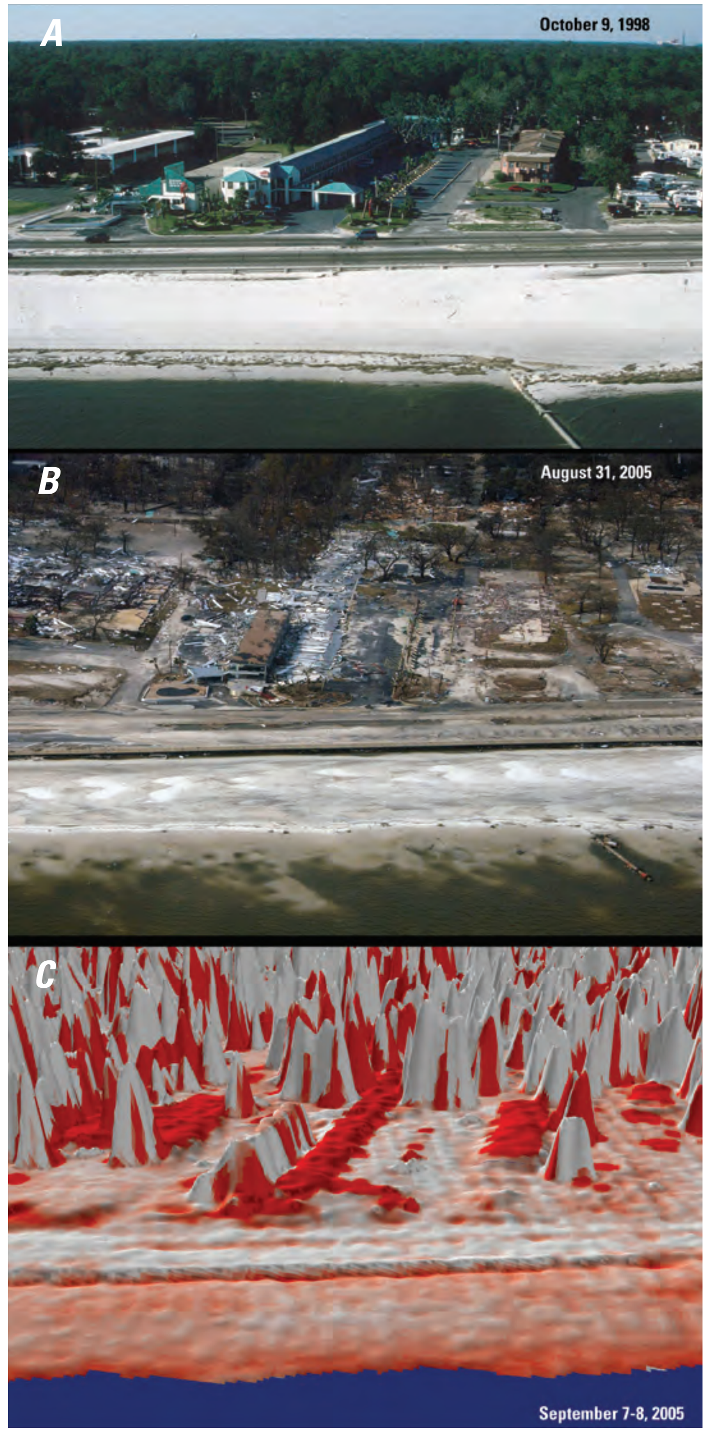

Figure 2. Oblique photography from before (*A*) and after (*B*) Hurricane Katrina in 2005 from the Gulfport, Miss., area along with the vertical change derived from light detection and ranging (lidar) viewed at a similar angle (*C*). In the lidar change panel (*C*), the shades of red and pink represent areas where elevation has decreased through beach erosion (the pink foreground) or where buildings have been destroyed (the deeper red areas). The color-coded elevation changes are draped on poststorm topography. This view does not contain the debris field, shown in figure 3, located farther inland.

Figure 3. National Oceanic and Atmospheric Administration post-Hurricane Katrina photograph of Gulfport, Miss., showing "debris fields" of materials from destroyed buildings.

number of nonimpacted roof tops and level areas (parking lots and some roads) were classified as vegetation. This error did not present a problem for these analyses since the elevation difference in these misclassified areas is zero and does not contribute to the volumetric estimates.

Two grid raster masks were then developed from the classified mosaics, one for vegetated areas and the other for nonvegetated areas (fig. 4). A grid raster mask, in this case, can be thought of as a simple "yes/no" coding for the vegetated state of each pixel in the photo mosaic. This allows both fast and separate debris volume calculations for fallen trees and structural debris.

A simple total volume loss versus gain analysis is not appropriate for this application because the volume of prestorm structure or tree is not equal to its respective debris quantity. A priori assumptions were that (1) an elevation gain between surveys is primarily attributed to debris accumulations, with some exceptions, and that (2) debris quantities are computed from only elevation gains between the pre- and posthurricane surveys. It is assumed that elevation gains are a result of destroyed structural components and vegetation moved from its original location and deposited in adjacent areas.

Debris-volume Summaries

Harrison County was divided into two computational sections, west and east (fig. 1). The west section (zone 1) encompasses the area from Pass Christian to Gulfport, and the east section (zone 2) encompasses the area from Gulfport to Biloxi. Debris quantities for each section are summarized in table 1.

The quantity of vegetation debris in zone 1 was 3,583,786 yd^3 (2,740,000 m^3), and the quantity of nonvegetation debris was 5,820,382 yd^3 (4,450,000 m^3). Total quantity of debris for zone 1, the area encompassing the coastal towns of Pass Christian, Long Beach, and Gulfport, was 9,404,168 yd^3 (7,190,000 m^3) or 1,668,380 yd^3/mi^2 (492,499 m^3/km^2).

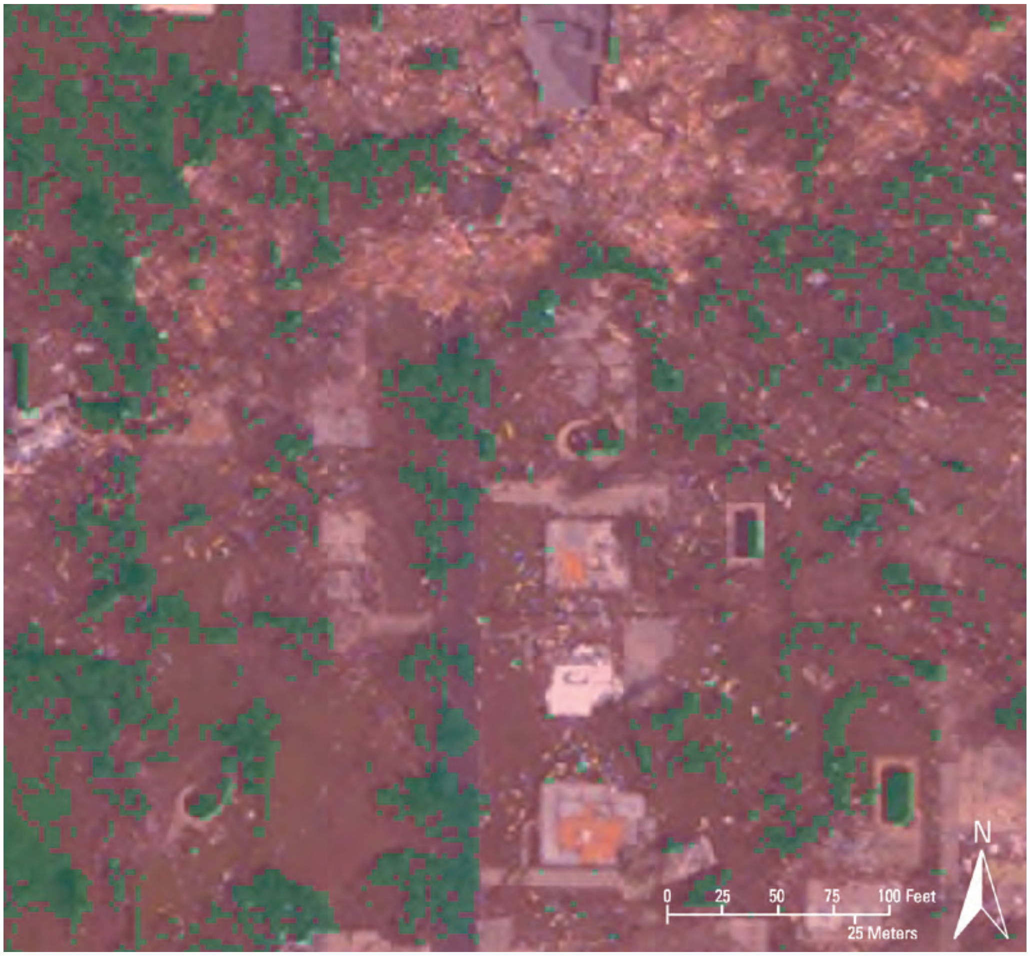

Figure 4. Grid raster masks representing results of image classification overlain on post-Hurricane Katrina photograph. Green pixels represent the areas classified as vegetated, and red pixels indicate the nonvegetated areas.

Table 1. Summary of debris quantities immediately after Hurricane Katrina (August–September 2005) along coastal Mississippi.

[Zone 1 encompasses the area from Pass Christian to Gulfport; zone 2 encompasses the area from Gulfport to Biloxi]

Zone	Area (mi^2)	Vegetation (yd^3)	Nonvegetation (yd^3)	Total (yd^3)	yd^3/mi^2
1	5.637	3,583,786	5,820,382	9,404,168	1,668,380
2	3.557	914,258	1,449,210	2,363,467	664,498
Total	9.193	4,498,043	7,269,592	11,767,635	1,279,998

Zone	Area (km^2)	Vegetation (m^3)	Nonvegetation (m^3)	Total (m^3)	m^3/km^2
1	14.599	2,740,000	4,450,000	7,190,000	492,499
2	9.212	699,000	1,108,000	1,807,000	196,157
Total	23.811	3,439,000	5,558,000	8,997,000	377,851

Interpretation of poststorm aerial photography suggests that a large portion of debris was concentrated in "debris fields," presumably along the landward edge of the maximum water level (fig. 3). Within the debris fields, it appears that a portion of structural debris deposited within areas classified as vegetation. Thus, the quantity of nonvegetation debris may be underestimated, and the quantity of vegetation debris may be overestimated.

For zone 2, the area encompassing the town of Biloxi, the quantity of vegetation debris was 914,258 yd^3 (699,000 m^3), and the quantity of nonvegetation debris was 1,449,210 yd^3 (1,108,000 m^3). Total quantity of debris for zone 2 was 2,363,468 yd^3 (1,807,000 m^3) or 664,498 yd^3/mi^2 (196,157 m^3/km^2). Interpretation of poststorm aerial photography suggests that nonvegetative debris is more scattered in zone 2 than in zone 1 and that large debris fields are less common in zone 2.

As a result of Katrina, we estimate that a total of 11,767,636 yd^3 (8,997,000 m^3) of structural and vegetation debris was created in Harrison County. The results were based upon pre- and poststorm topographic lidar data and poststorm color photography. The area of calculation, 9.194 mi^2 (23.811 km^2), was for all of coastal Harrison County extending from the shoreline to Railroad Street, a distance of approximately 0.4 mi (0.6 km). For zone 2, the area encompassing the town of Biloxi, there was approximately one-half the quantity of debris per unit area as identified in zone 1. This shift may be a result of fewer residential areas and more commercial zones with larger structures, large parking lots, and less associated vegetation. While useful for emergency planning purposes, the debris quantities presented in this report are approximate and should not be used in place of actual "hauled volume" for contracting purposes.

Acknowledgments

All vertical aerial photographs were provided by the NOAA. The prestorm (1998) oblique photography in figure 2 is courtesy of the University of New Orleans.

References

Federal Emergency Management Agency, 2006, Hurricane Katrina flood recovery (Mississippi), *http://www.fema.gov/hazard/flood/recoverydata/katrina*, accessed June 2006.

Hansen, M.E., 2006, Estimation of debris quantities after Hurricane Katrina—Harrison County, MS: U.S. Geological Survey Open-File Report 2006-1225, 14 p.

U.S. Environmental Protection Agency, 1995, Planning for disaster debris, EPA document no. 530K95010, 30 p.

Contact Information

Mark Hansen, Oceanographer (*mhansen@usgs.gov*); Peter Howd, Oceanographer (*phowd@usgs.gov*); and Asbury Sallenger, Oceanographer (*asallenger@usgs.gov*)

U.S. Department of the Interior
U.S. Geological Survey
Florida Integrated Science Center, St. Petersburg
600 4th St. South
St. Petersburg, FL 33701

C. Wayne Wright, Aeronautical Engineer (*wright@lidar.wff.nasa.gov*)
National Aeronautics and Space Administration
Wallops Flight Facility
Wallops Island, VA 23337

Jeff Lillycrop, Coastal Engineer (*jeff.lillycrop@usace.army.mil*)
U.S. Army Corps of Engineer, Mobile
7225 Stennis Airport Dr., Suite 100
Kiln, MS 39556