Assessing Hurricane Katrina Damage to the Mississippi Gulf Coast Using IKONOS Imagery

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Discussion Items

• Project Background
• Research Objectives
• Remote Sensing Data Acquisition and Processing Methods
• Results
• Concluding Remarks
Project Background

- Hurricane Katrina hit southwestern Mississippi on August 29, 2005, at 10 a.m. CDT as a category 3 event with storm surges up to ~9 m and sustained winds of ~120 mph
- The hurricane ravaged several coastal towns, destroying or severely damaging hundreds of homes
- Hurricane Katrina deposited millions of tons of debris and caused severe damage to coastal forests
- In response, several Federal agencies have been using a broad range of remotely sensed data (e.g., IKONOS) to aid damage assessment and disaster recovery efforts
- This presentation discusses an effort to use IKONOS data for damage assessment, based on data collected over southwestern coastal Mississippi on September 2, 2005
Hurricane Katrina’s Swath

Tropical Storm and Hurricane Force Wind Swaths of Katrina from Advisories 1 through 31

- Hurricane Force Winds
- Tropical Force Winds

Approx. Distance Scale (Statute Miles)
Katrina’s Approach of Mississippi
Shown on GOES-12 Satellite Imagery

Image Shown Below Acquired at 9:02 a.m. CDT

Red – Relative Location of Hurricane Eye
IKONOS Data Used in Study

IKONOS Color Composite – Bands 4,3,1 Loaded into RGB

Includes material © Space Imaging LLC
Federal Efforts to Assess Katrina Damage with IKONOS Data

• Several Federal agencies have been using IKONOS and other commercial remote sensing data for assessing damage from Hurricane Katrina, including NOAA, USGS, NASA, NGA, and FEMA
  – NOAA Coastal Services Center (CSC) used IKONOS data and Feature Analyst software for mapping storm debris in Gulfport, MS
  – DHS/NGA/FEMA used heads-up digitizing to map debris zones apparent on high resolution satellite (e.g., IKONOS) and aerial data
  – The USGS, NOAA, FEMA, and others are using mid- to high-resolution remote sensing data to map and assess flood extent, coastal land loss, and vegetation condition; IKONOS imagery is being used to support these efforts
Example Debris Map from IKONOS Data
Source: NOAA Coastal Services Center

Data Acquired 9/2/2005
Location – Gulfport, Mississippi

Includes material © Space Imaging LLC
Objectives of Study

• Assess pan-sharpened multispectral IKONOS data for visualization of Hurricane Katrina storm damage
  – Damaged buildings, wood-dominated debris, denuded forest, and mud covered open areas

• Assess traditional image classification techniques for classifying storm damage types from pan-sharpened IKONOS data
  – ISODATA unsupervised clustering and/or Maximum Likelihood supervised classification

• Longer term: Assess hurricane damage using change detection techniques in conjunction with before and after storm IKONOS data
  – Damage to residential and industrial areas, forests, and marsh land
Examples of Hurricane Damage in Waveland, Mississippi

Saint Clare's Catholic Church
Looking North from Coast

Waveland Coast - East View
from Saint Clare’s Church

House and Forest Damage
1.2 km from Waveland Coast

Tree Damage at Former Home
0.4 km from Waveland Coast

Acquired 9/4/2006

Acquired 11/25/2006

Acquired 9/4/2006
Preparing IKONOS Data for Classification

- Acquired IKONOS data from a USGS Katrina Web site in GeoTIFF format for subsequent processing with ERDAS Imagine software
- Stacked visible and NIR multispectral band tiffs into multiband image
- Applied “bootstrap” haze correction to individual bands as needed
  - Used minimum value subtract technique (Jensen, 1996)
- Ran pan-sharpening algorithm to produce 1-meter pan-sharpened multispectral image
  - Used Local Mean and Variance Matching (LMVM) filtering technique described by de Béthune et al. (1998), as implemented in ERDAS IMAGINE® via the Spatial Modeler toolbox
- Developed and applied appropriate look-up table stretch to visually enhance storm damage features of interest

Sources:

IKONOS Color Composite – Bands 4,3,1 Loaded into RGB
Imagery Enhanced with Gamma LUT Stretch

Includes material © Space Imaging LLC
IKONOS Pan-Sharpened Multispectral Data – 9/2/2006

St. Clare’s Church on Left

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IKONOS Image Classification Methodology

• Ran series of ISODATA unsupervised classifications to collect signatures needed for supervised classification
• Appended signatures from 10 individual unsupervised classifications into master signature file
• Subjected master signature file of 191 cluster classes and pan-sharpened data to supervised classification with the maximum likelihood (ML) algorithm
• Applied contrast-enhanced color look-up table to classification results to resemble an enhanced 431 RGB composite of the pan-sharpened data
• Evaluated preliminary results of ML classification, refining as needed to produce final classification product
• Assessed classification results compared to reference data
Independent Unsupervised Classifications were Produced for 10 Subset Areas

- Green Marsh
- Urban
- Beach Sand
- Debris
- Water
- Non-Green Marsh
- Forest
Example IKONOS Classification Results
vs. Bands 4,3,1 RGB Color Composite

ML Classification – Pseudo Color LUT

IKONOS 4,3,1 RGB

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Select IKONOS Classification Results vs. Bands 4,3,1 RGB Color Composite

ML Classification – Select Classes Colored
Other Classes – Bands 3,4,1 RGB LUT

IKONOS 4,3,1 RGB

Includes material © Space Imaging LLC
NOAA NGS 0.5-Meter Digital Aerial Data

Data Acquired 8/30/2005 Before Road Clearing

- Storm Debris
- Exposed Concrete Slabs
- Flooded Marsh
IKONOS Classification Result

- Water
- Sand
- Woody Storm Debris
- Brown Grass with Mud
- Exposed Pavement
IKONOS Data Acquired 9/2/2005

Includes material © Space Imaging LLC
Visualization of Hurricane Damage on the IKONOS RGBs

• Several flood and wind damage effects can be viewed on IKONOS RGBs, including green vegetation loss and dieback, multi-tree blow downs, flood water, house damage or loss, flood-deposited mud, and debris in coastal water.

• Deciduous forests were largely defoliated by the storm, whereas the pine-dominated evergreens were green although greatly reduced by storm damage. The 1-meter spatial resolution was insufficient to show single-tree blow down on a consistent basis, although mass tree blow downs were evident in some cases.

• Flooded, defoliated wetland forests and marshes can be clearly seen.

• Several marsh conditions were evident, apparently because of variability in greenness and saltwater conditions.

• Mud-covered surfaces were evident, such as mud on lawns and paved surfaces.

• The September 2nd acquisition date of the IKONOS data was close in time to the hurricane’s landfall and does not necessarily show vegetation stress effects that take a longer period to be manifested.
“Traditional” Classification of Storm Damage from Pan-Sharpened IKONOS Data: Initial Findings

- Wood-dominated storm debris was classified for open areas but was not classified in areas obscured by sufficiently dense forest. Some classification commission error was also noted for this storm damage type.
- The classification of woody storm debris was realized without having to resort to sub-pixel or contextual supervised classification software and techniques.
- Effective wall-to-wall land use/land cover classification was not achieved, in part because of time constraints in evaluating and refining classification results.
- Some confusion was noted between pavement, roofing, and mud-covered surfaces. Concrete and bright roof types were also confused. Forest cluster classes were difficult to categorize, in part because of storm damage effects.
- The classification process demonstrated here requires trial and error processing, which is not unusual for supervised classification of targeted surface cover types.
- The pan-sharpened output was similar to the input multispectral image in appearance yet retained the texture of the 1-meter panchromatic image. This output enabled targeted ground features to be visualized and classified at the 1-meter scale.
Final Remarks

• Additional classification refinement is needed to complete a wall to wall land cover classification

• More work is also required to quantify accuracy of storm damage types as well as land use/land cover types from the IKONOS pan-sharpened multispectral data

• Future work will involve use of multitemporal IKONOS and Landsat data for understanding MODIS change detection results in monitoring vegetation damage and recovery from Hurricane Katrina
Additional Information
Efforts to Assess Katrina’s Forest Damage

• The U.S. Forest Service is assessing Katrina forest damage and recovery in part via the Healthy Forests Initiative (http://www.healthyforests.gov/)
  – Assessments of forest damage as well as forest health due to post-storm insect outbreaks, diseases, and wildfire

• NASA is aiding the Federal effort to assess forest damage impacts from Hurricane Katrina, initially via analysis of multi-temporal MODIS data for monitoring forest vegetation greenness and moisture indicators
  – This effort uses multi-temporal Landsat and IKONOS data as reference data to aid analysis of MODIS-based change detection
Preliminary Map of Katrina Forest Damage

1 = Scattered, Light
2 = Light
3 = Moderate
4 = Severe

Hurricane Force Winds
Tropical Storm Winds

Map Source: USFS Forest Inventory and Analysis
http://www.srs.fs.usda.gov/katrina/