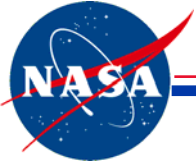


Assessing Hurricane Katrina Damage to the Mississippi Gulf Coast Using IKONOS Imagery

Joseph P. Spruce
Science Systems and Applications, Inc.
John C. Stennis Space Center, MS 39529

Rodney McKellip
NASA Project Integration Office
John C. Stennis Space Center, MS 39529

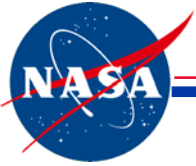
JACIE Civil Commercial Imagery Evaluation Workshop
Laurel, Maryland, USA
March 14–16, 2006



Discussion Items

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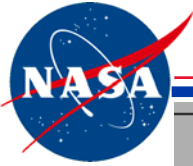
- Project Background
- Research Objectives
- Remote Sensing Data Acquisition and Processing Methods
- Results
- Concluding Remarks



Project Background

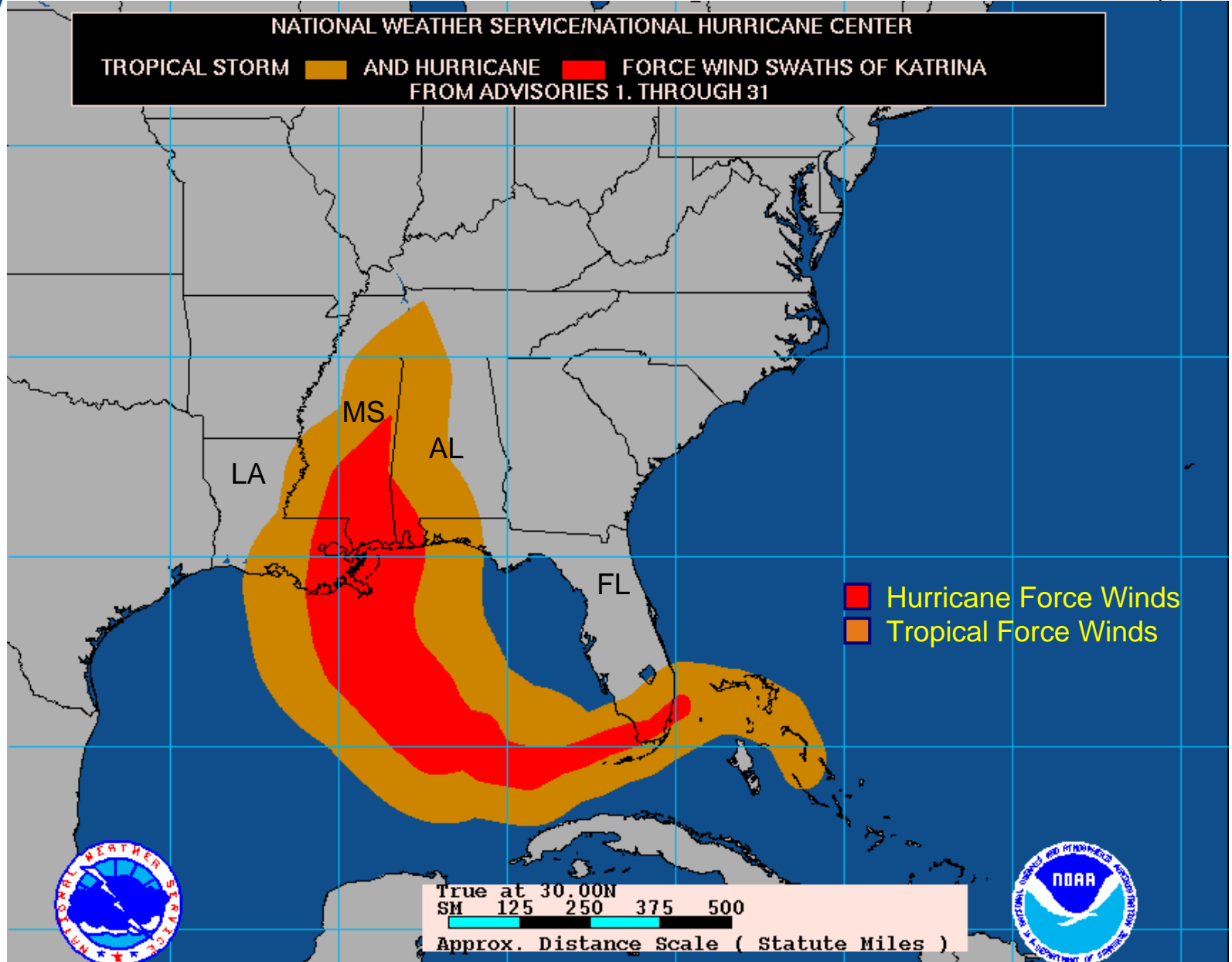
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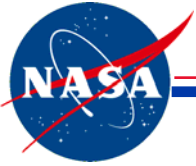
- Hurricane Katrina hit southwestern Mississippi on August 29, 2005, at 10 a.m. CDT as a category 3 event with storm surges up to ~9 m and sustained winds of ~120 mph
- The hurricane ravaged several coastal towns, destroying or severely damaging hundreds of homes
- Hurricane Katrina deposited millions 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

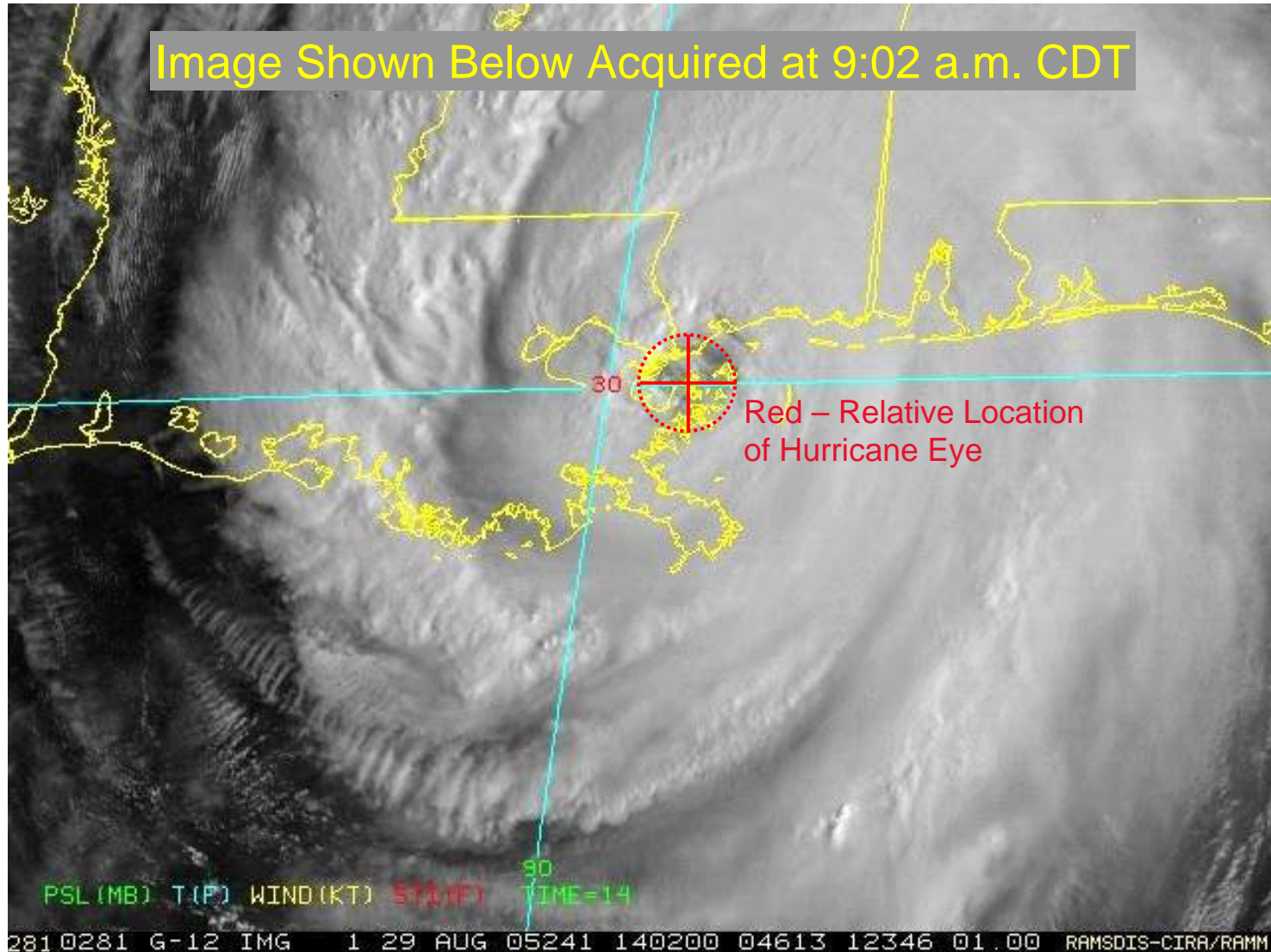
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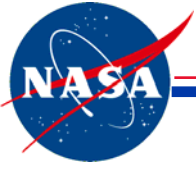




Katrina's Approach of Mississippi Shown on GOES-12 Satellite Imagery

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Location of Study Area in Southwestern Mississippi Gulf Coast

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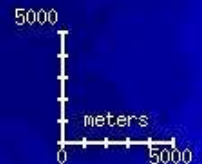


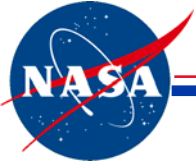
IKONOS Data
Acquired 9/2/2005

Pass
Christian

Waveland and
Bay St. Louis

Landsat 7 Mosaic from NASA Scientific Data Purchase in Background





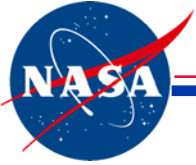
IKONOS Data Used in Study

Stennis Space Center

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



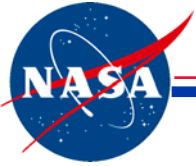
Includes material © Space Imaging LLC



Federal Efforts to Assess Katrina Damage with IKONOS Data

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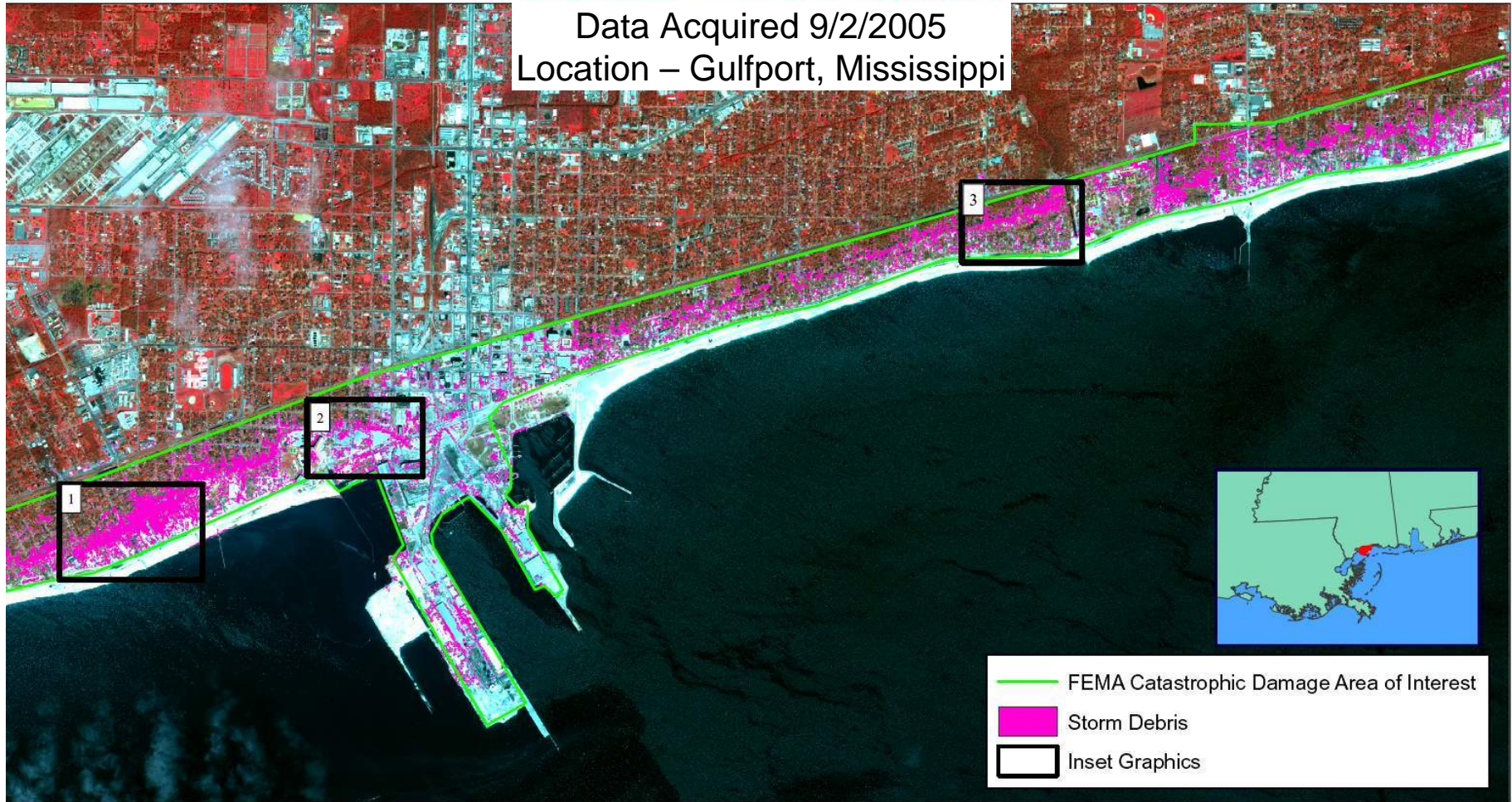
- Several Federal agencies have been using IKONOS and other commercial remote sensing data for assessing damage from Hurricane Katrina, including NOAA, USGS, NASA, NGA, and FEMA
 - NOAA Coastal Services Center (CSC) used IKONOS data and Feature Analyst software for mapping storm debris in Gulfport, MS
 - 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



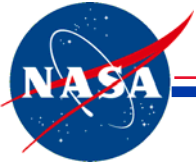
Example Debris Map from IKONOS Data

Source: NOAA Coastal Services Center

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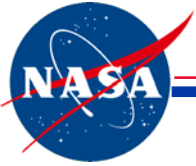
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Objectives of Study

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- 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

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Saint Clare's Catholic Church
Looking North from Coast



Acquired 9/4/2006

House and Forest Damage
1.2 km from Waveland Coast



Acquired 11/25/2006

Waveland Coast - East View
from Saint Clare's Church



Acquired 9/4/2006

Tree Damage at Former Home
0.4 km from Waveland Coast



Acquired 9/4/2006



Preparing IKONOS Data for Classification

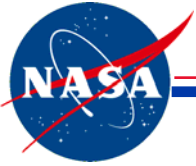
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- Acquired IKONOS data from a USGS Katrina Web site in GeoTIFF format for subsequent processing with ERDAS Imagine software
- Stacked visible and NIR multispectral band tiffs into multiband image
- Applied “bootstrap” haze correction to individual 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:

de Béthune, S., F. Muller, and J.-P. Donnay, 1998. Fusion of multispectral and panchromatic images by local mean and variance matching filtering techniques. Proceedings of the Second International Conference: Fusion of Earth Data: Merging Point Measurements, Raster Maps and Remotely Sensed Images. Sophia Antipolis, France, 28–30 January, (Thierry Ranchin and Lucien Wald, eds. published by SEE/URISCA, Nice, France), pp. 31–36.

Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective. 2nd ed. Upper Saddle River, New Jersey: Prentice Hall.



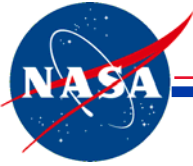
IKONOS Data Used in Study

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



Includes material © Space Imaging LLC



IKONOS Panchromatic Data – 9/2/2006

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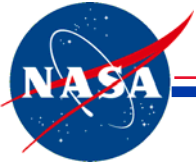
Zooms of Waveland, MS



100
meters
0 100



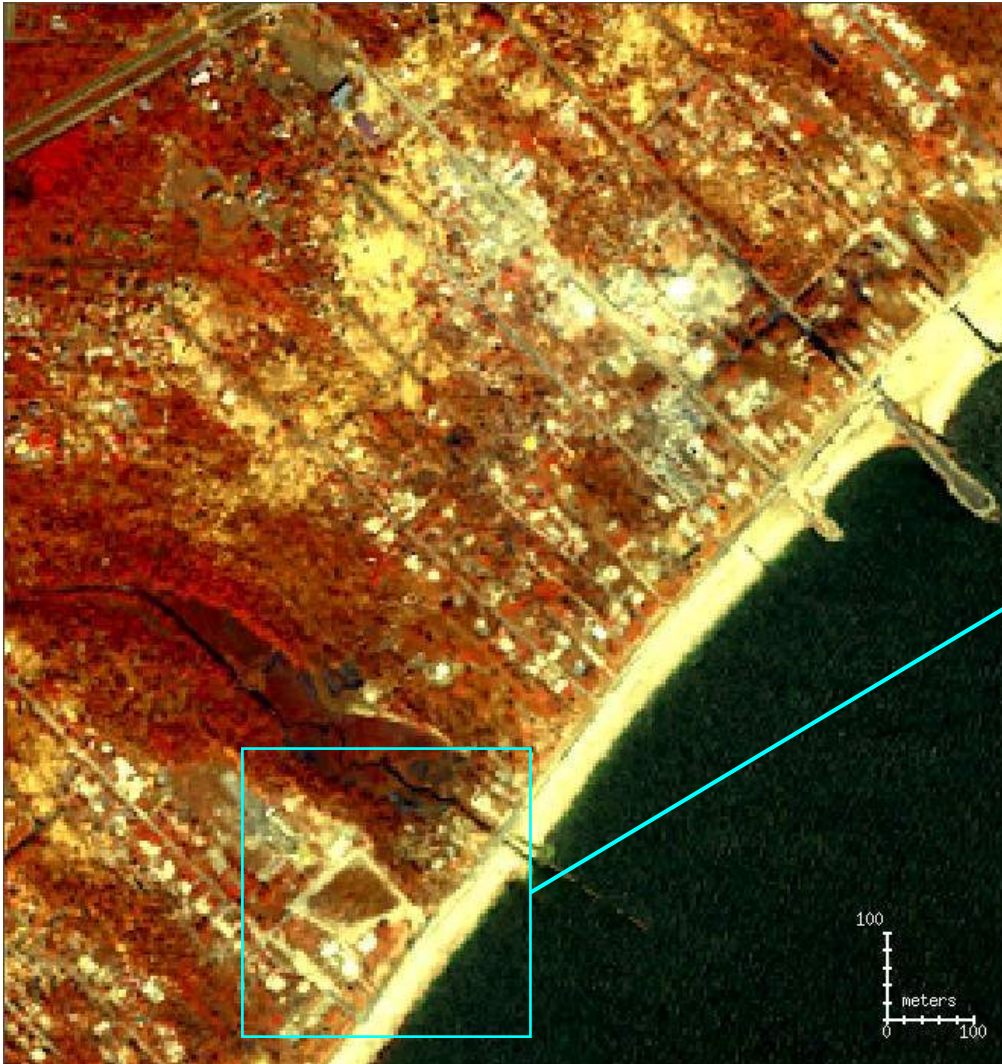
Includes material © Space Imaging LLC



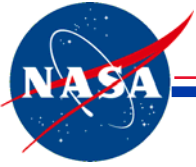
IKONOS Multispectral Data – 9/2/2006

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Zooms of Waveland, MS



Includes material © Space Imaging LLC



IKONOS Pan-Sharpener Multispectral Data – 9/2/2006

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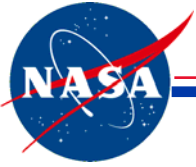


IKONOS Image Classification

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Methodology

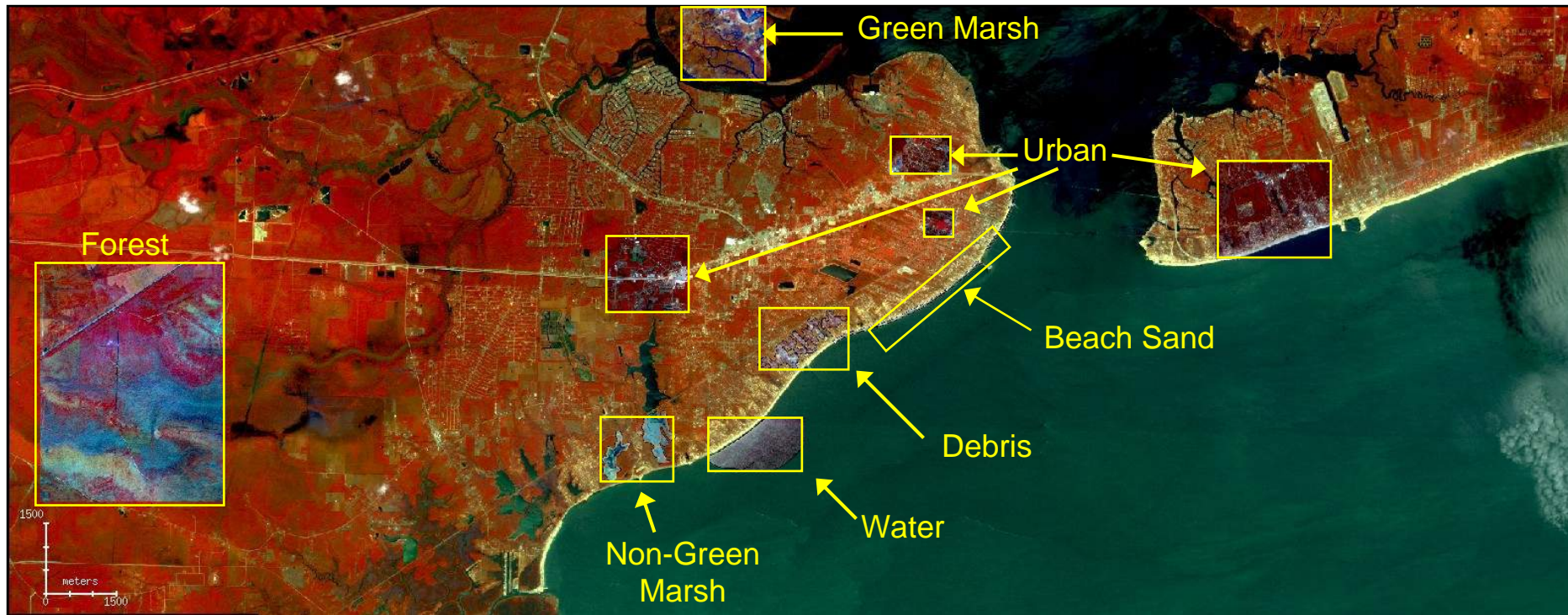
- Ran series of ISODATA unsupervised classifications to collect signatures needed for supervised classification
- Appended signatures from 10 individual unsupervised classifications into master signature file
- Subjected master signature file of 191 cluster classes and pan-sharpened data to supervised 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



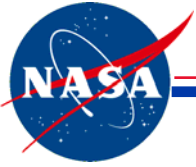
Selection of Training Areas for Collecting Classification Signatures

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Independent Unsupervised Classifications were Produced for 10 Subset Areas



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

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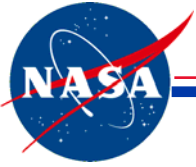
ML Classification – Pseudo Color LUT



IKONOS 4,3,1 RGB



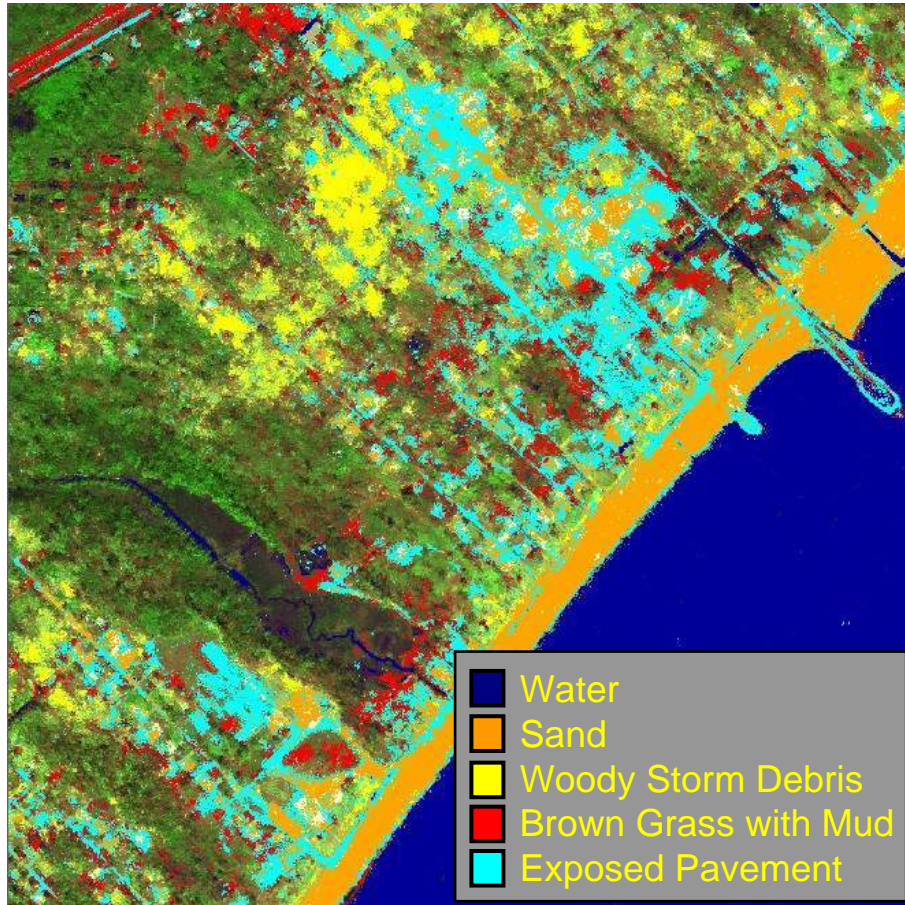
Includes material © Space Imaging LLC



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

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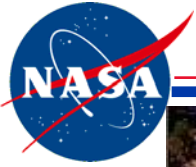
ML Classification – Select Classes Colored
Other Classes – Bands 3,4,1 RGB LUT



IKONOS 4,3,1 RGB



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NOAA NGS 0.5-Meter Digital Aerial Data

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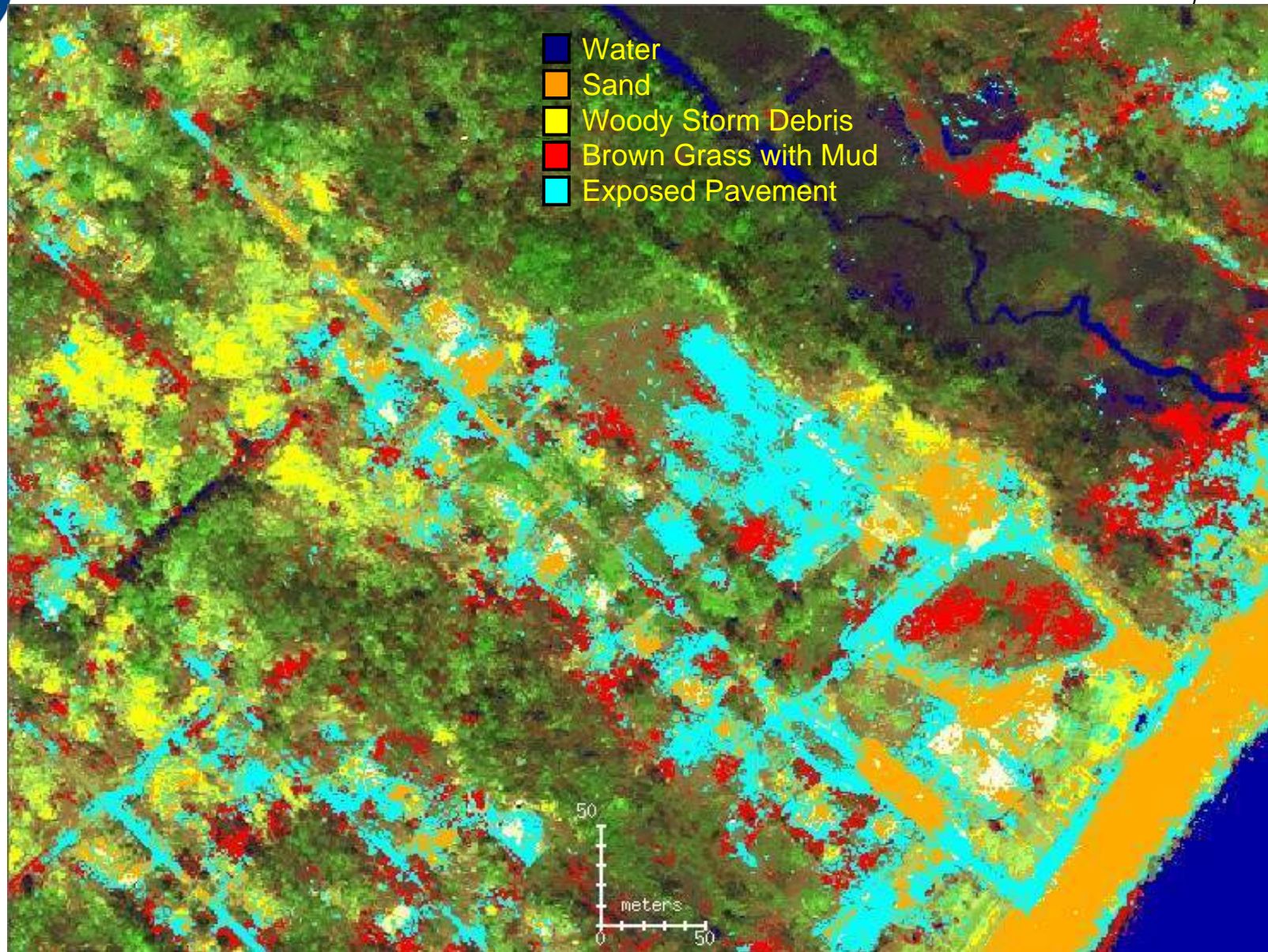
Data Acquired 8/30/2005 Before Road Clearing

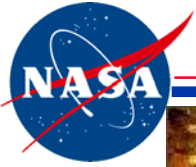




IKONOS Classification Result

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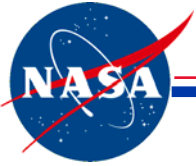




IKONOS Data Acquired 9/2/2005

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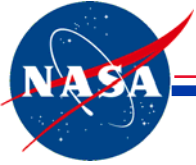




Visualization of Hurricane Damage on the IKONOS RGBs

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- 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.

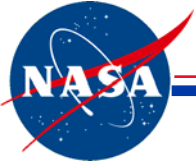


“Traditional” Classification of Storm Damage

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from Pan-Sharpended 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.

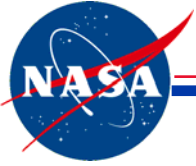


Final Remarks

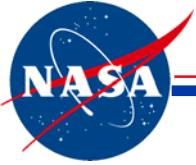
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- Additional classification refinement is needed to complete a wall to wall land cover classification
- More work is also required to quantify accuracy of storm damage types as well as land use/land cover types from the IKONOS pan-sharpened multispectral 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

Participation in this work by Science Systems and Applications, Inc., was supported by NASA at the John C. Stennis Space Center, Mississippi, under Task Order NNS04AB54T.



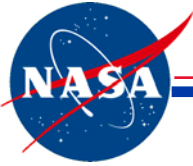
Additional Information



Efforts to Assess Katrina's Forest Damage

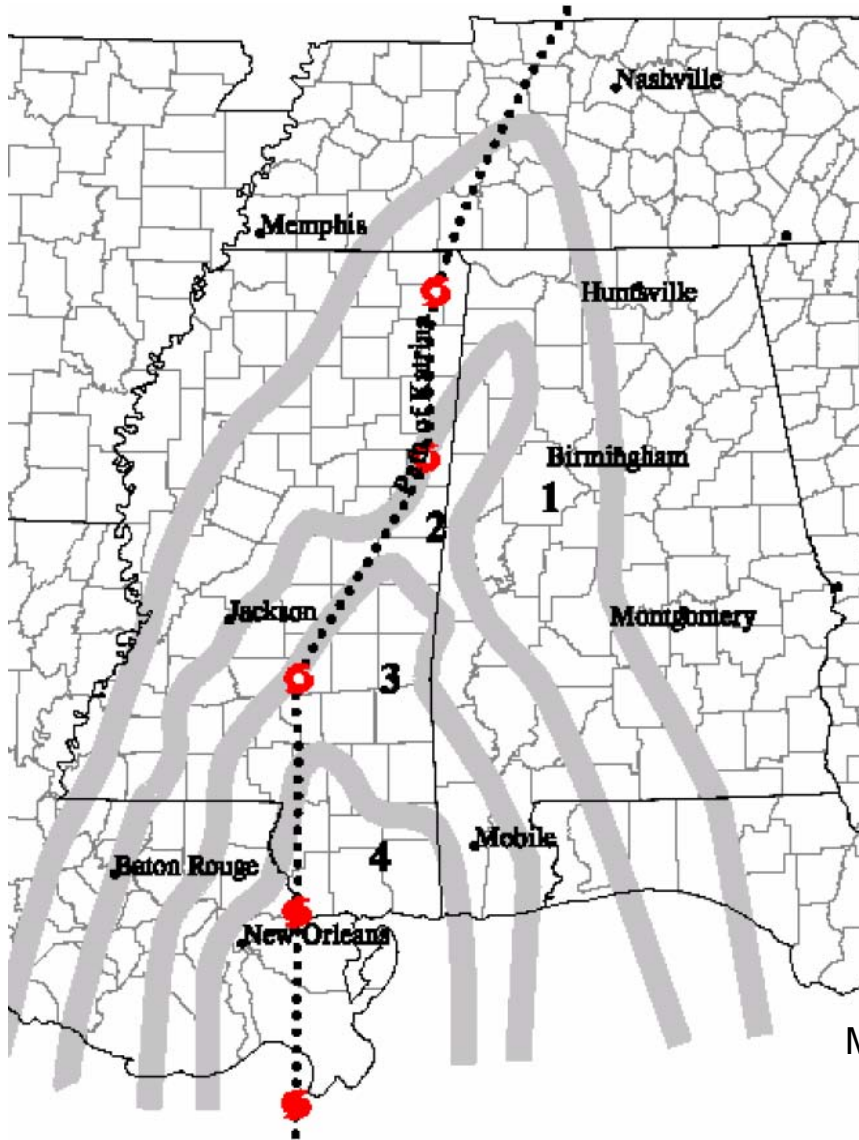
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- The U.S. Forest Service is assessing Katrina forest damage and recovery in part via the Healthy Forests Initiative (<http://www.healthyforests.gov/>)
 - Assessments of forest damage as well as forest health due to post-storm insect outbreaks, diseases,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

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- 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/>