**Temporal Study of Landscape Change After Hurricane Katrina**

**Nicholas J. Occhipinti**

**Department of Geosciences**

1. **ABSTRACT**

The purpose of this project was to conduct a temporal study that would show how remote sensing technology could be used to assess the impact of Hurricane Katrina and detect growth/rebuilding trends after the hurricane. To prove my hypothesis, I developed three objectives. The first objective was to perform spatial analysis on pre and post Katrina land classification datasets to show how much developed land was reclassified in 2006. The second objective was to perform the same spatial analysis where areas that were classified as “Unconsolidated Shore” (beaches, bars, flats) in 2005, were classified differently in 2006. This would indicate the amount of shoreline erosion as a result of Hurricane Katrina. Lastly, my third objective was to identify growth trends in the population and redevelopment after hurricane Katrina through a combination of visual interpretation and analysis tools. By accomplishing these three objectives I would be able to calculate areas with high flood concentration, areas of beach erosion and show patterns of rebuilding and growth after Katrina.

1. **BACKGROUND AND DESCRIPTION OF STUDY AREA**

In August of 2005 Hurricane Katrina went through the states of Louisiana, Mississippi, Alabama and Florida. It reached a category 5 level and became the largest natural disaster in the U.S. Over 1800 people were killed and many survivors were without homes or shelter. Its destruction cost has been estimated at 81 billion dollars worth of damage [Stoker, Tyler, Turnipseed, Wilson Jr., & Oimoen, 2009].

Among the hardest hit areas from Hurricane Katrina was New Orleans, LA. One of the key factors of why New Orleans incurred such tragic devastation was that the levee system failed, causing major flooding and storm surges to enter the city, of which the majority of the area is below sea level [Stoker, Tyler, Turnipseed, Wilson Jr., & Oimoen, 2009].

1. **DESCRIPTION OF DATA AND METHODS**

One key dataset used was from the National Oceanographic and Atmospheric Administration (NOAA) which provide land classifications values for pre and post Katrina time periods. The extent of the dataset study area spans as far west as Texas and as far east as Florida, and can be seen in Figure 1 of the Appendix. The dataset was based off of images from the Landsat TM sensor. I also obtained Landsat 7 ETM imagery from multiple time periods using the United State Geological Survey (USGS) Earth Explorer website (earthexplorer.usgs.gov) to visually show areas of flooding, and how vegetation was changed as a result. The Landsat MRLC/MTBS Reflectance sensor imagery was also obtained from the Earth Explorer website, and used to show trends in population and development after Hurricane Katrina. All the data acquired and used in this project have a pixel size of 30x30 meters.

Using the NOAA dataset I wanted to perform calculations based on change detection of different land categories to put a quantitative figure on how the landscape changed. To accomplish this I created a model in ArcGIS ModelBuilder that executes GIS processes in a certain flow to calculate the final output. To briefly describe the entire process of the model the two datasets are clipped to the extent of Orleans Parish, LA. The purpose of this was to perform calculations to see how the small study area correlates with the entire study area. The first step was to extract the land categories of interest, both pre and post, into separate raster datasets. Those datasets were then reclassified where the pixel value was either 1 if it contained the land classification, or 0 if it did not. Raster math tools were then utilized to calculate the change of each category from pre and post Katrina datasets. The Plus tool shows which areas changed, and which areas stayed the same. The Times tool was used to show what land classifications the pixels were changed to from 2005 to 2006. The results of the Plus and Times process operations were then created into tables summaries which can be seen in Tables 1 and 2 of the poster.

Landsat 7 ETM imagery was acquired around the same time of year as Hurricane Katrina at different time periods for the area surrounding New Orleans, LA; Landsat satellite track path 22 row 39. The data was then clipped to the extent of Orleans Parish, LA, because this was the primary study area used throughout the project. The clipped images were then brought into ArcMap, where I identified differences between each of the time periods that highlighted how the landscape changed and has been redeveloped over time.

The Landsat MRLC/MTBS imagery was also acquired around the same time of year as Hurricane Katrina at different time periods in order to discover trends of growth in developed areas after the hurricane. The type of growth that was of interest in this part of the study was population. The thermal band was extracted and used to detect temperature in the red, green and blue bands. The high red areas indicate high urban/residential areas, while the green band detects vegetation and the blue band detects water.

1. **RESULTS**

The results calculated from the NOAA dataset show a large increase in the “Open Water” classification, as seen in Table 1a of the poster. Figure 2 shows the new areas that were classified as “Open Water”, which are possible areas that underwent large amounts of flooding. In Table 1b we see the “Unconsolidated Shore” decrease in both the full dataset and in the Orleans Parish, LA extent. This change could indicate the amount of shoreline erosion due to the tremendous amount of flooding that occurred along the coastline. The calculations in Table 2a of the poster shows that over 10% of the “Unconsolidated Shore” pixels from 2005 were classified as either “Bare Land” or “Open Water” in 2006. The results for Orleans Parish, LA follow a similar trend as seen in Table 2b. An example of this shoreline transformation can be seen in Figure 1a and 1b of the poster, which shows an area outside of New Orleans, LA, where there is a high abundance of “Unconsolidated Shore” in 2005 that then becomes “Open Water” in 2006. The developed land also shows a decrease in the number of pixels classified from 2005 to 2006 as seen in Table 1c of the poster. The increase in “Open Water” and decrease in “Unconsolidated Shore” and “High and Medium Intensity Developed” areas show negative correlation of how flooding has affected these areas.

The second set of results are from Landsat 7 ETM imagery for the time periods of 8/15/2005 (Pre Katrina), 9/15/2005 (Post Katrina), 9/2/2006 (One Year After Katrina), and 9/13/2010 (Five Years After Katrina). Through this imagery I was able to compare two areas of Orleans Parish, LA. The first area in Figure 3a of the poster identified the residential areas and open land with healthy vegetation and wetlands. When comparing imagery of the same area after Hurricane Katrina in Figure 3b, we see that areas of water have expanded, meaning that severe flooding has occurred. Vegetation and wetlands that were once bright green have changed to a darker color of green that indicates a high amount of water and moisture is present. To assess the progress of redevelopment over time, I examined a different area in Orleans Parish, LA seen in Figure 3c. In this area we can see patches of bright green healthy vegetation mixed in with patches of bare land that has not grown in. Also some areas of land are still partially overrun with water. To assess if there was positive growth in that area I examined imagery from five years after Hurricane Katrina in Figure 3d. We can see that areas of bare land have grown and developed into healthy vegetation, and also that the flooded areas have subsided.

The third set of results are from Landsat MRLC/MTBS Reflectance imagery of the thermal band in Orleans Parish, LA. The purpose of using the thermal band was to assess population growth trends through temperature. Figure 4a of the poster depicts conditions before the hurricane. There is a high amount of reflectance in the red band which indicates high temperatures, which can also be classified as high population density and urban areas. The green and blue bands show areas of vegetation and water respectively. To confirm that the different colors represent urban areas, vegetation, and water, I overlaid this data onto an imagery map service. As you can also see in Figure 4 the red color in the thermal band is highest in area of New Orleans, LA, a highly populated area. In Figure 4b there is shift where the blue band is higher in areas once red and green. This indicates areas where flooding has occurred. Figures 4c and 4d are used to measure the growth trend of redevelopment after Hurricane Katrina. In Figure 4c, one year after, we can see that the blue band decreases while the red and green bands increase. This indicates that the flooding in areas has subsided and that areas have started being redeveloped and repopulated. Further down the road to recovery in Figure 4d we see a positive growth trend of more areas being redeveloped. While this is positive, we see that almost 4 years after the hurricane, the population is not quite as high as it was pre Hurricane Katrina in 2005.

1. **SOURCES OF ERRORS**

The NOAA datasets from 2005 and 2006 have a classification accuracy of 85%. When acquiring Landsat 7 ETM imagery, one trouble was finding areas that were not filled with large amounts of cloud cover for each time period. The main problem cloud cover caused in this analysis was that the shadows from clouds are very similar to water, so when trying to detect flooding, I had to rule out the shadows first. There were also scan lines that ran diagonally across every image. This appeared to be an instrumentation issue with the scanner.

1. **DISCUSSION AND CONCLUSIONS**

The main purpose of this study was to calculate the impact of Hurricane Katrina through remote sensing in order to show how the landscape changed over time. I have used three different sources of data to perform the analysis. I feel that using multiple sources of data to see how each set of data correlates with proving your objectives, makes the hypothesis stronger. The NOAA dataset allowed for change detection of different types of land to provide a quantitative figure about how different land types were affected by Hurricane Katrina. We can see that there is a negative correlation where water is increasing while the developed land and shoreline area decreased. The Landsat 7 ETM data involved a large amount of analog processing, but I was able to identify areas that encountered flooding to show how the land and vegetation developed over time. To assess population growth and redevelopment over the course of time, I utilized data from the Landsat MRLC/MTBS Reflectance sensor thermal band which allowed me to distinguish between urban areas, open land and water. We see a dramatic difference before and after the hurricane and see positive progress made to rebuild the area and to get it back to what it once was.

In conclusion I feel that the NOAA dataset was the most important piece of data collected for the fact that it provided a quantitative analysis to assess landscape change. Information such as this could be of interest to other government departments and agencies in order to aid in their own Hurricane Katrina related studies. I have also learned how different bands could be used to detect certain patterns. Through the application of Landsat 7 ETM, I have found that the vegetation change is best used in the visible or near-infrared bands, while the thermal band in the Landsat MRLC/MTBS Reflectance sensor offered a way of utilizing temperature to show population density. Overall I would say that the study has shown the landscape impact of Hurricane Katrina and how the area has progressed over time.

**REFERENCES**

NASA, N. A. (n.d.). *The Thematic Mapper*. Retrieved 10 2012, from http://landsat.gsfc.nasa.gov/about/tm.html

National Oceanic and Atmospheric Administration (NOAA) - Coastal Services Center. (n.d.). *Coastal Change Analysis Program Regional Land Cover*. Retrieved 10 2012, from http://www.csc.noaa.gov/digitalcoast/data/ccapregional/

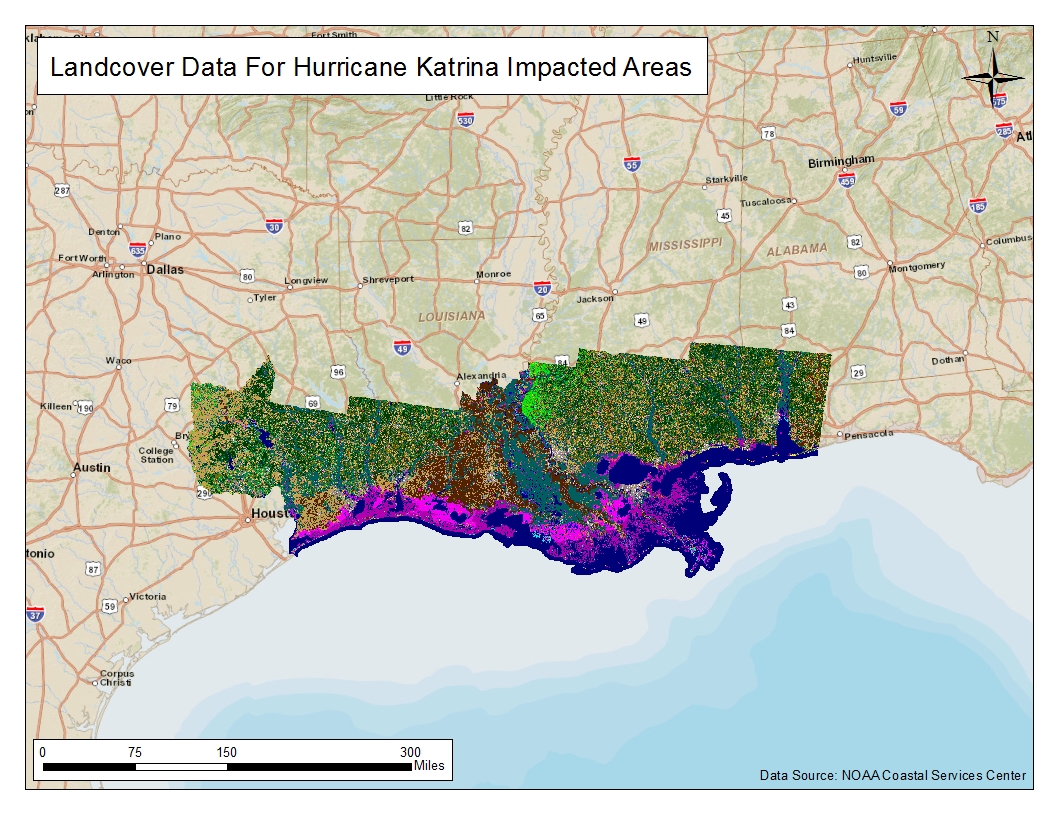
National Oceanic and Atmospheric Administration (NOAA) - Coastal Services Center. (n.d.). *Land Cover Data for Hurricane Katrina Impacted Areas*. Retrieved 10 2012, from http://www.csc.noaa.gov/crs/lca/katrina/

Stoker, J. M., Tyler, D. J., Turnipseed, P., Wilson Jr., V., & Oimoen, M. J. (2009). Integrating Disparate Lidar Datasets for a Regional Storm Tide Inundation. *Journal of Coastal Research*, 66–72.

Yuan, F., Sawaya, K. E., Brian, L. C., & Bauer, M. E. (2005). Land cover classification and change analysis of the Twin Cities (Minnesota). *Remote Sensing of Environment*, 317-328.

**APPENDIX**

Figure 1: Map of Hurricane Katrina Impacted Areas from the National Oceanographic and Atmospheric Administration (NOAA) Coastal Services Center (CSC)/Coastal Analysis Program(C-CAP) dataset.

****