

## 1) Introduction

### **Problem overview**

To what extent do large storm events play in coastal erosion rates, and what is the rate at which coastal erosion is occurring in sediment starved portions of the Mississippi delta?

### **Background Information**

The after-effects of Hurricane Katrina have highlighted the issue of land loss in the Mississippi River delta due to subsidence, sea level rise, and erosion. These are normal processes in the deltaic environment and are counteracted by the sediment deposition and redistribution. However, in the Mississippi river delta human structures have diverted or contained the Mississippi river in such a way that the sediments that would have been deposited in the delta are now being deposited in the river's mouth. Since the mouth of the river is at the continental shelf-slope break much sediment is being lost into deeper waters. "The result is a drowning delta. *Morton et al.* [2005] indicate a land loss rate of about 44 square kilometers per year over the past several decades" (Kim, 2009). While subsidence and sea level rise can occur as fairly steady state processes, erosion can be very high during storm events such as Hurricane Katrina, compared to normal conditions. Without new sediment input into the delta to counteract it, such storm events have caused extensive land loss through redistribution of sediment through hydraulic action. Of particular interest is the erosion of beaches and barrier islands by these events. Beaches and barrier islands serve as breakwaters that protect estuaries and interior lands from being inundated during flood events.

### **Project outline**

This project focuses on understanding coastal erosion in a sediment deprived portion of the Mississippi delta. Through the use of Digital Orthophotos, shoreline regression was tracked by comparing the shoreline positions in multiple years. Although a distribution of images evenly spaced in time would be the ideal base dataset for this project, there was a limitation on the availability of historic orthophotos. The years that were available for the project were 1998, 2004, and 2005 post-Katrina. Even though a yearly photo would be ideal to more concisely constrain erosion rates, these intervals are sufficient in comparing erosion rate during non-storm (or less severe storm) periods with that of a large storm event. In

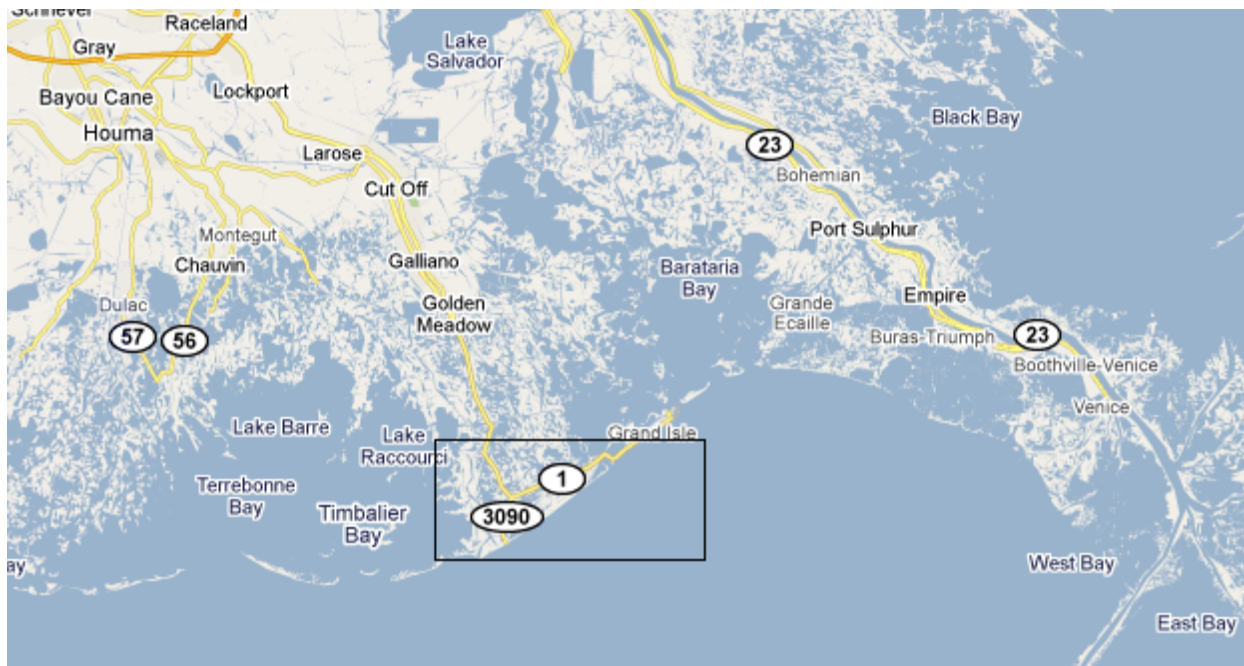
this experiment, the erosion during a period of 6 years pre-Katrina is compared with that of the 1 year during which Katrina occurred.

### Location

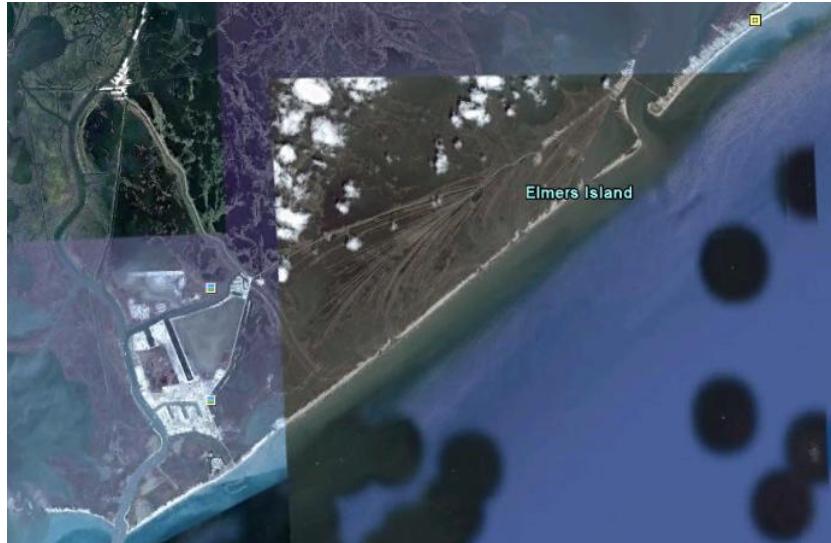
The location for analysis was chosen because of its close proximity to the most areas of highest storm intensity when it made landfall. Further contributing to the location was its isolation from the sediment supply of the Mississippi and Atchafalaya Rivers, although there is a large amount of sediment input and redistribution in these areas this area is somewhat removed from the 2 largest sediment sources. The final factor that contributed to the selection of location was the mapability of the coastline. Since the project requires digitizing the coast for multiple years a long consistent stretch of coast was preferred so that the shape of the shoreline could be easily compared between different cases. The area selected that best fulfilled these attributes was Elmer's Isle and a portion of Grand Isle in Lafourche Parish, Louisiana.

### Quantification of results

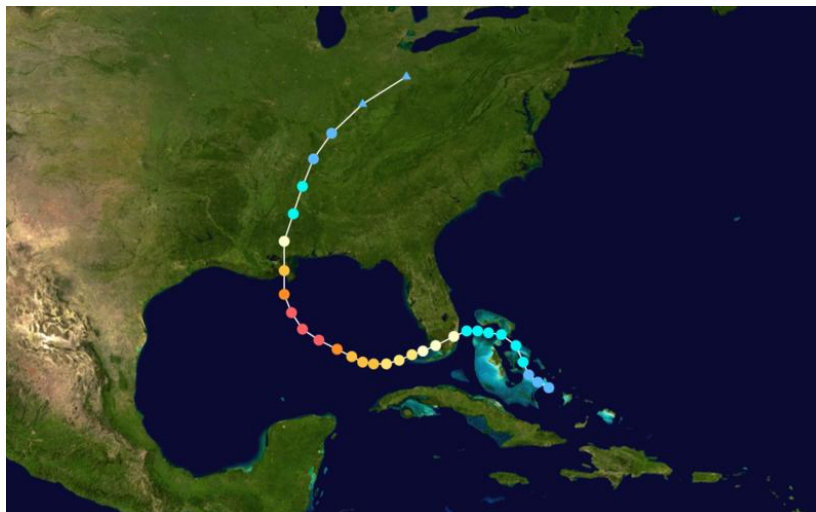
The results of this experiment come in two forms; the first is coastal erosion rates in terms of distance, and the second is coastal erosion in terms of area. Distance measurements proved to be easier to calculate than area estimates because of the straightforward procedure involved.











- 1) Map showing the area of interest with respect to the gross scale Mississippi delta, the area of high sediment input is to the east of the study area, where the Mississippi river is discharging into the Gulf.



Enlarged Google Earth image displaying the study area of Elmers Isle, this is seen as the black boxed area in the above image.



**Saffir-Simpson Hurricane Scale**

 Tropical depression	0–39 mph	0–62 km/h	 Category 3	111–130 mph	178–209 km/h
 Tropical storm	39–73 mph	63–117 km/h	 Category 4	131–155 mph	210–249 km/h
 Category 1	74–95 mph	119–153 km/h	 Category 5	≥156 mph	≥250 km/h
 Category 2	96–111 mph	154–177 km/h	 Unknown		

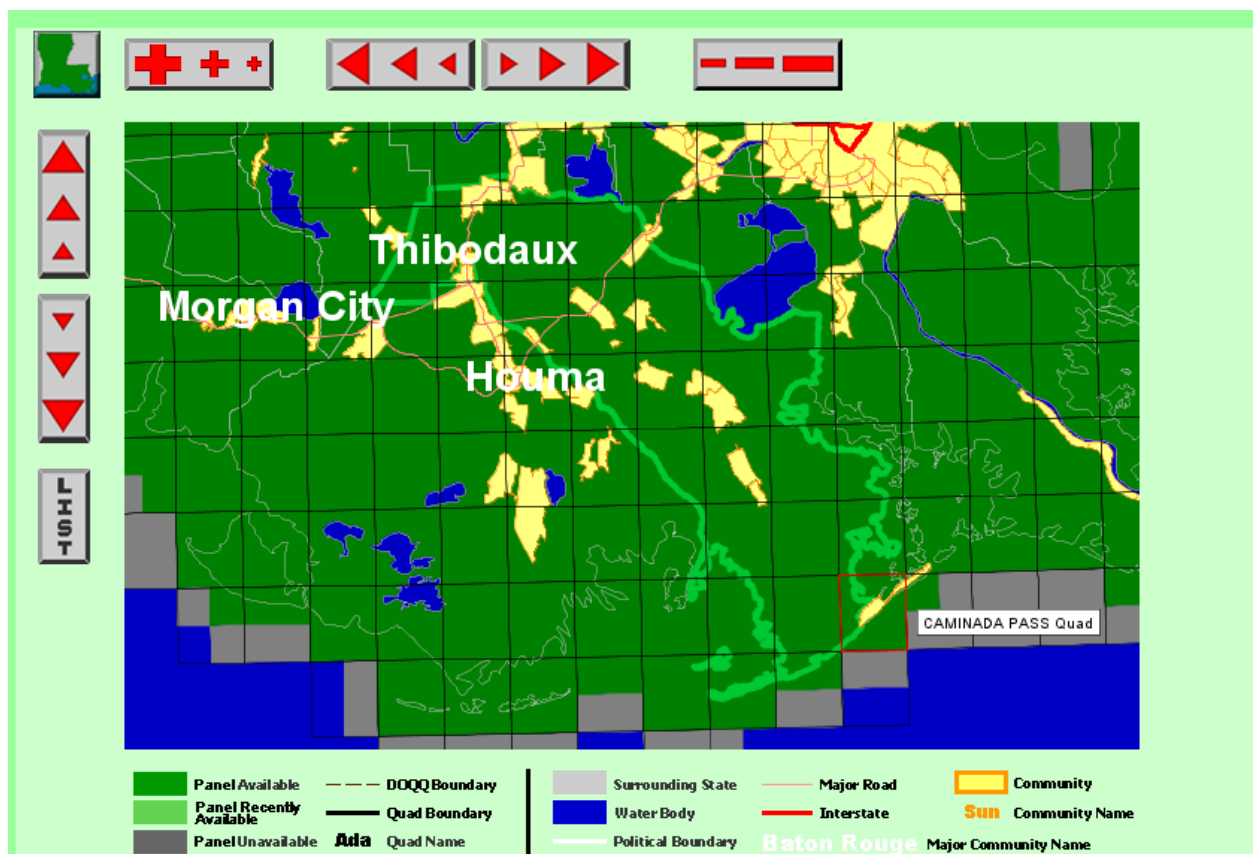
### Storm type

- Tropical cyclone
- Subtropical cyclone
- ▲ Extratropical cyclone / Remnant low / Tropical disturbance

Landfall map of Hurricane Katrina in August 2005, the study area is just west of the landfall of the eye of the hurricane.

## 2) Data

- a) Louisiana provides an extensive database for GIS information through the LSU Atlas database. The database contains DOQQ images from 1998 2004 and 2005. Each dataset has a different downloader that allows the downloading of  $\frac{1}{4}$  quadrangle DOQQ's. The data can be found at <http://atlas.lsu.edu/rasterdown.htm>



- 2) Screen capture of the Atlas downloader with the Caminada Pass Quadrangle highlighted, Caminada Pass contains the majority of Elmers Isle.
- b) The Quadrangles that were selected for the problem analysis are
  - i) Caminada Pass
  - ii) Leeville
  - iii) Belle Pass
  - iv) The unnamed quad south of Caminada Pass
- c) Metadata was available for all the raster files and was used to determine the exact date the data was collected as well as cell size and resolution.
- d) All data from these quadrangles were projected as NAD 1983 UTM Zone 15N

### 3) Procedure

#### Data Preprocessing

The first stage involved the downloading of data and file management. Since there were DOQQ files of the same area over multiple years, proper file management was necessary to ensure that there was no mix up of images as many shared the same name across multiple years. It was found that downloading and expanding using the stuffit default expander caused numerous computer issues so the files were downloaded in mass compresses and expanded later using the windows expansion program.

#### ArcGIS Processing

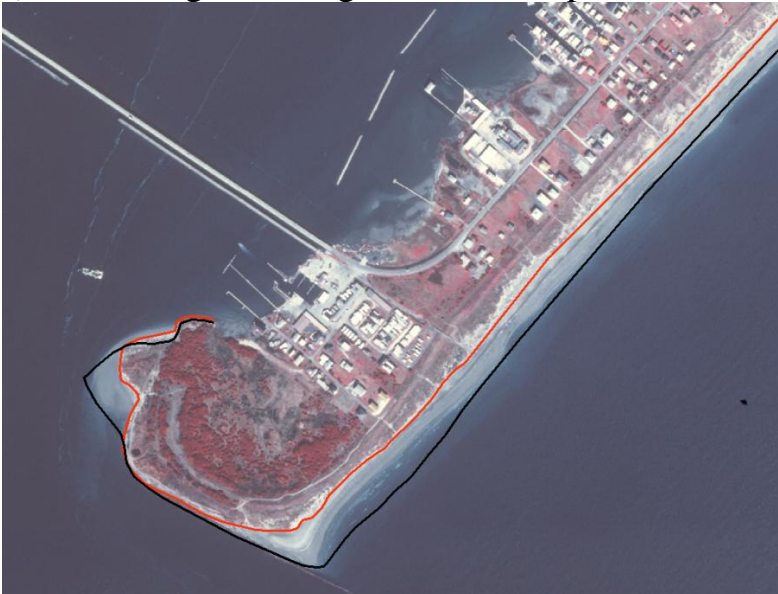
Phase 1: Distance of shoreline retreat calculation.

- 1) Since the initial experiment involved calculating the map-able distance of shoreline retreat it was necessary to create a methodology to compare shoreline position between multiple years. The easiest way to accomplish this was to create line files of the shoreline and compare the results of the shoreline line files of different years using the measure tool in ArcMap.
  - a. The raster files for 1998 were loaded into ArcMap
  - b. Using arcCatalog a new polyline shapefile was created to that the coastline would be saved into, this file was then added to the map document

- c. Using the editor toolbar the shoreline position in the raster image was digitized into the polyline shapefile by using the Create New Feature tool.
- d. Once this was completed the process was repeated for the 2004 and 2005 raster datasets, the following images show the shoreline progression for the southern end of Grande Isle.



1) 1998 image showing the shoreline position with black line



2) 2004 image showing the shoreline position in red, also visible is the 1998 shoreline position in black.



3) 2005 image showing shoreline position in yellow, again 1998 shoreline is shown in black and 2004 in red.

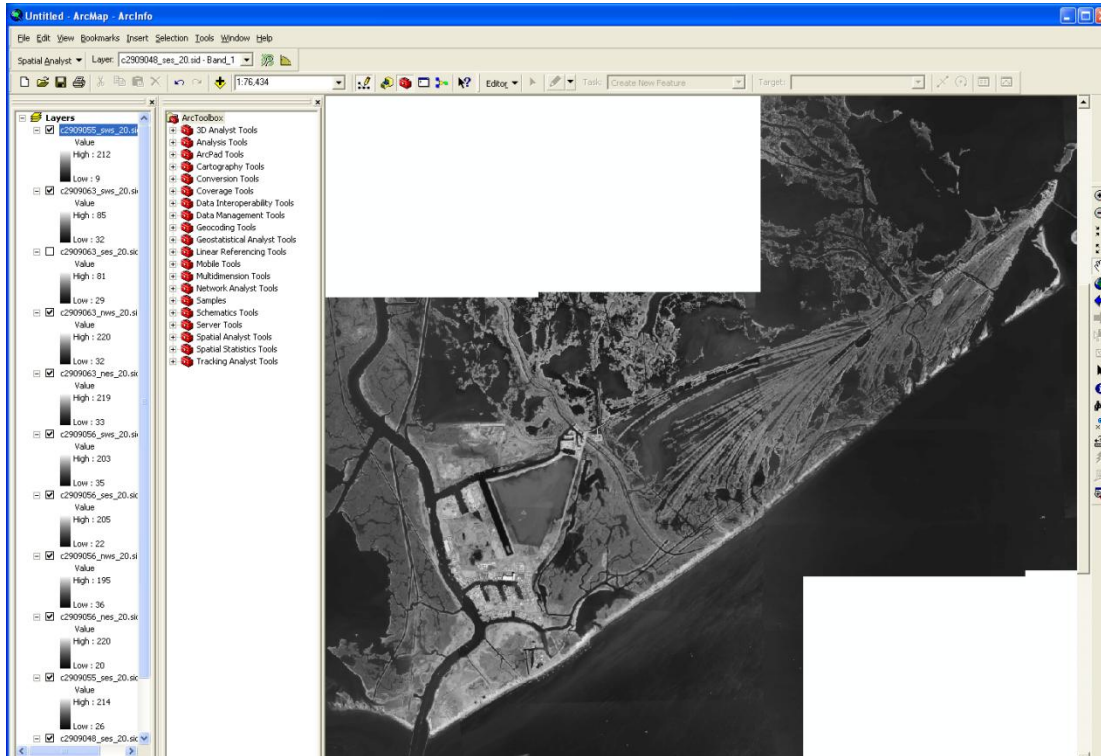
e) Once the shoreline positions were created they could be compared using the measure tool in ArcMap. To do this the 1998 and 2004 polyline files were loaded into a map document and the measure tool was used to calculate the distance between the lines by a perpendicular direction. This process was repeated ever 500 meters and the results were entered into excel so that an average shoreline retreat could be calculated.

## Phase 2: Coastal Area Loss Calculation Elmer's Isle

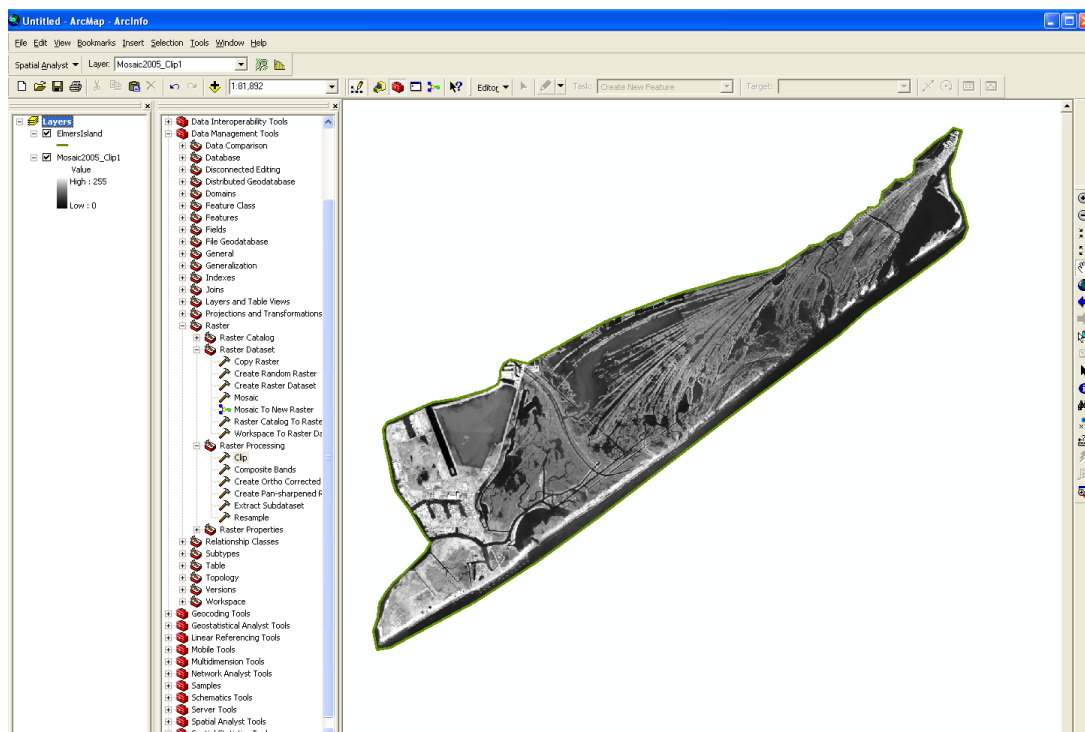
Calculating the change in land area between different years proved to be a much more complicated task than the distance calculation. Ideally the lidar datasets would be used that could accurately depict the transition from water to land. However this was not possible as there were not multiple lidar datasets readily available that showed the same location over multiple years. Therefore the calculations were done using DOQQ raster data.

- a) The first step was to load the red band of the DOQQ images into ArcMap. The red band was the one chosen for the calculation because it shows blue water as and high(dark) value and land as a low value
- b) After the correct spectral raster were loaded they were mosaiced into a single raster so that they would be easier to work with in subsequent steps,

this averaging also highlighted the difference in land and water and made the difference easy to distinguish.

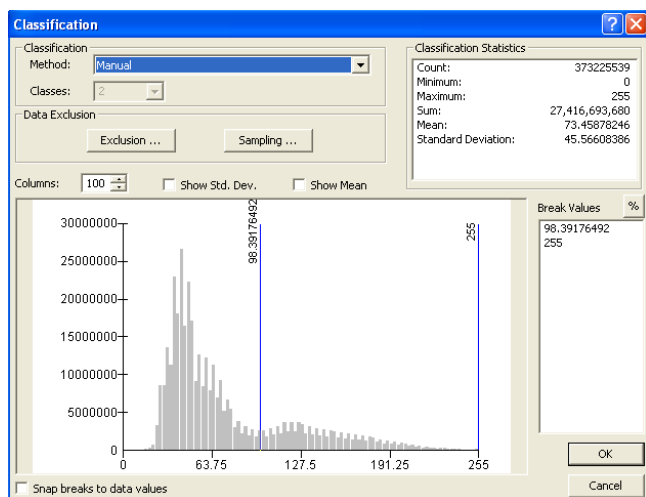


- 1) Mosaiced raster of 1998 spectral images, the mosaic tool can be found in ArcToolbox under Data management tools-Raster-Raster dataset- Mosaic to new raster.
- c) Once the mosaic is complete it was necessary to create a polyline file in ArcCatalog in order to define the area of Elmer's Isle that is being analyzed. Once this was created the shapefile was loaded into ArcMap and the outline of the Isle was digitized into a polyline. It was important to make sure that the polyline closed on itself and this was done using the editor snapping settings.
- d) The mosaiced raster was then clipped to the created outline of Elmer's Isle using the clip tool in the data management toolbox.



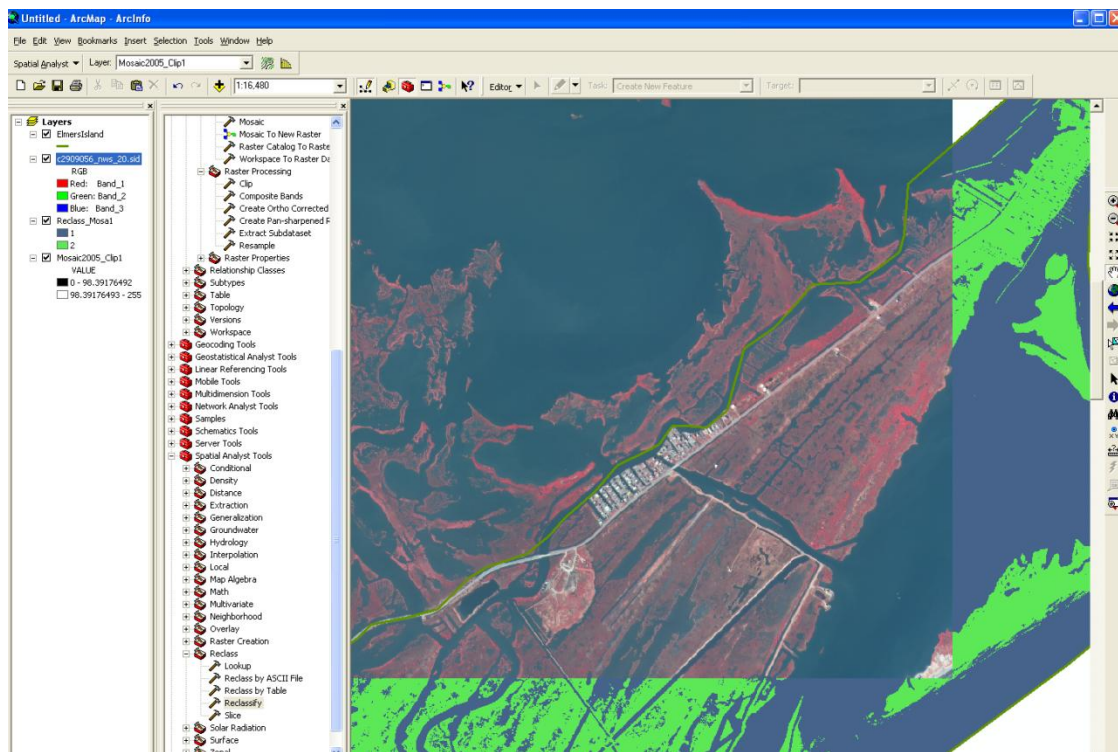
2) Clipped 1998 red spectral raster. The Elmer's Isle outline can be seen in green.

e) Once clipped the new raster is reclassified into two categories, land and water. The first step is to use the layer properties tab to define an intensity threshold of the spectral band that distinguishes land from water. This is done by changing the layer symbology into 2 classifications, it is necessary to do this several times until the correct threshold has been established.



3) Classification of breaks using manual method, the lower break value is adjusted until the best representation of land and water is achieved.

f) Once the best intensity threshold has been reached the raster can be reclassified into binary format using the calculated breaks.



4) Results of the reclassification overlain by a 3 spectral DOQQ this was a quality control test that was used to compare the results of the reclassification to the actual land vs. water areas. This reclassification provided good results.

g) Since the raster cell size was a 1 meter grid the count of the values for land was the equivalent to the sq meters of land area for the area. After steps a-f are repeated for years 2004 and 2005 the area of Elmer's Isle can be compared to get a rate of land loss over a non storm and storm period.

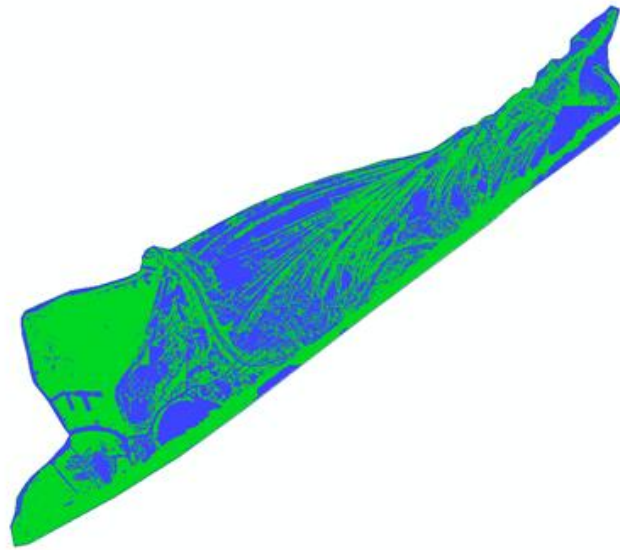
## Conclusion

The results of this experiment show a strong correlation between high shoreline erosion rates and storm events. In terms of distance of shore erosion the average displacement of the shoreline for the years 1998-2004 was 39.6 m or 6.6 meters per year while the average for 2004-2005 was 40.5 m.

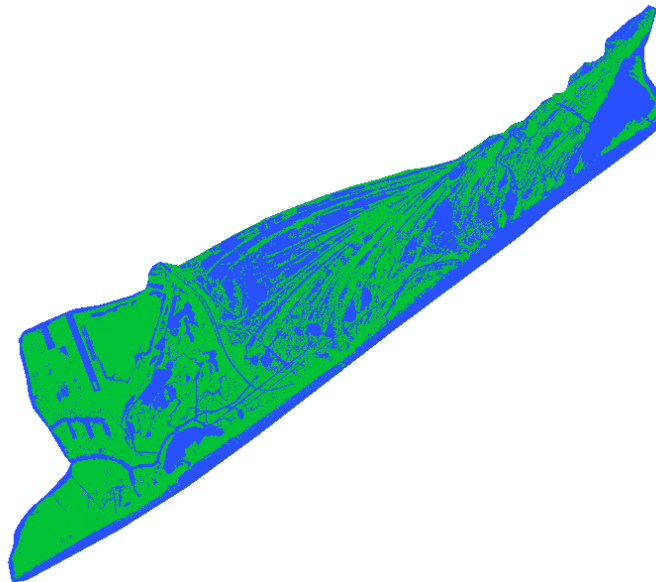
1998-2004		2004-2005	
point	measurement (meters)	point	measurement (meters)
1	62	1	141
2	30	2	39
3	10	3	24
4	15	4	25
5	27	5	24
6	11	6	5
7	28	7	0
8	72	8	18
9	55	9	43
10	13	10	34
11	19	11	34
12	30	12	30
13	33	13	35
14	37	14	15
15	40	15	41
16	32	16	70
17	29	17	93
18	46	18	72
19	33	19	54
20	67	20	79
21	60	21	40
22	25	22	47
23	0	23	58
24	8	24	30
25	-10	25	22
26	92	26	-8
27	206	27	30
avg	39.62963	avg	40.55556

Excel spreadsheet showing the differences in shoreline displacement between the years 1998-2004 and 2004-2005. Over a 6 fold increase between the erosion rates between the time periods.

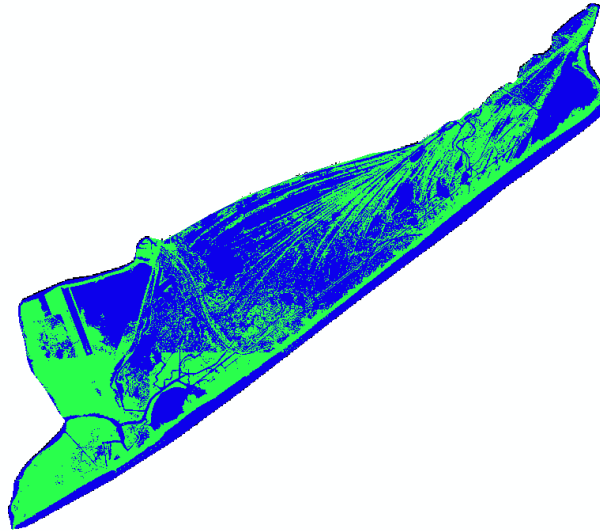
There was also a visible correlation between land area loss rates and storm events. In 1998 Elmer's Island had a above sea level land area of 43.59 km sq by 2004 this had shrunk to 41.78 km sq and by 2005 this had been reduced to 39.82 km sq. With these area estimates the yearly land area loss rate was .301 km<sup>2</sup> per year from 1998 to 2004 and 1.96 km<sup>2</sup> for 2005. The following images show the reclassified land area maps for years 1998, 2004, 2005.



1998: area = 43.59 km sq



2004: area = 41.78 km sq



2005: area = 39.82 km sq

### **Sources of error**

There was inevitable error in the calculations of these estimates. The first source of error comes from the tidal changes in sea level position in the images. I cannot say conclusively that the images were taken at the same tide position; however after reviewing the NOAA data for the region the tidal range is relatively small, on the order of a few feet change. Assuming a relatively gentle slope of the coastline, this could translate into an error on the order of 1-2 meters assuming a beach slope of 15 degrees. Also there was an inevitable source of error from picking a threshold intensity between the water and the land. In this case I did my best to remove as much noise as possible from the reclassified raster but there was always a bit left. In the case of this experiment I chose to error on the side of underestimating land area rather than overestimating. I attempted to be as consistent as possible between the different years.