HURRICANE KATRINA

A LAND COVER CHANGE DETECTION ANALYSIS SPANNING 15 YEARS

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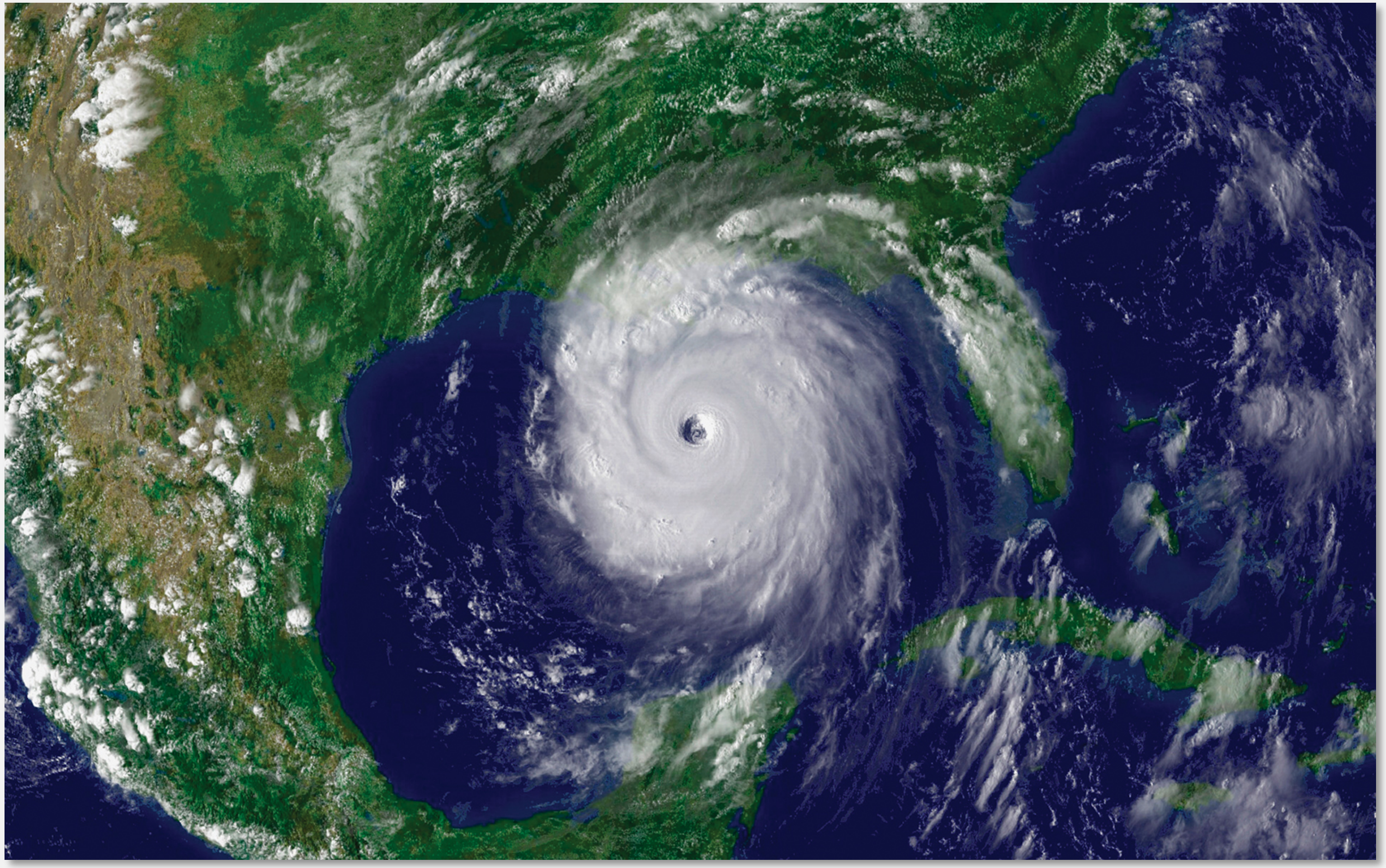
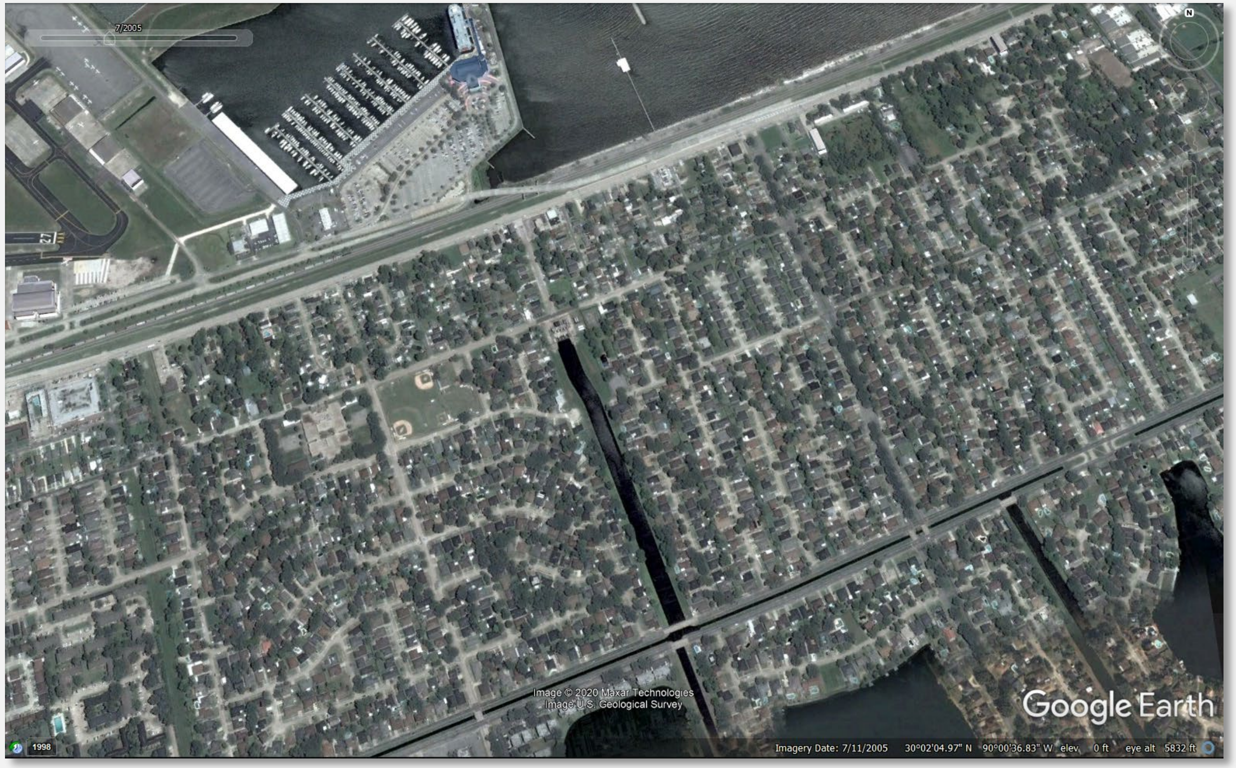
HURRICANE KATRINA

- Landfalling major hurricanes can cause catastrophic damage
- August 29, 2005
- Hurricane Katrina was one of the most catastrophic natural disasters in the US
- Hurricane Katrina will be used as an analog of land cover changes after catastrophic natural disasters

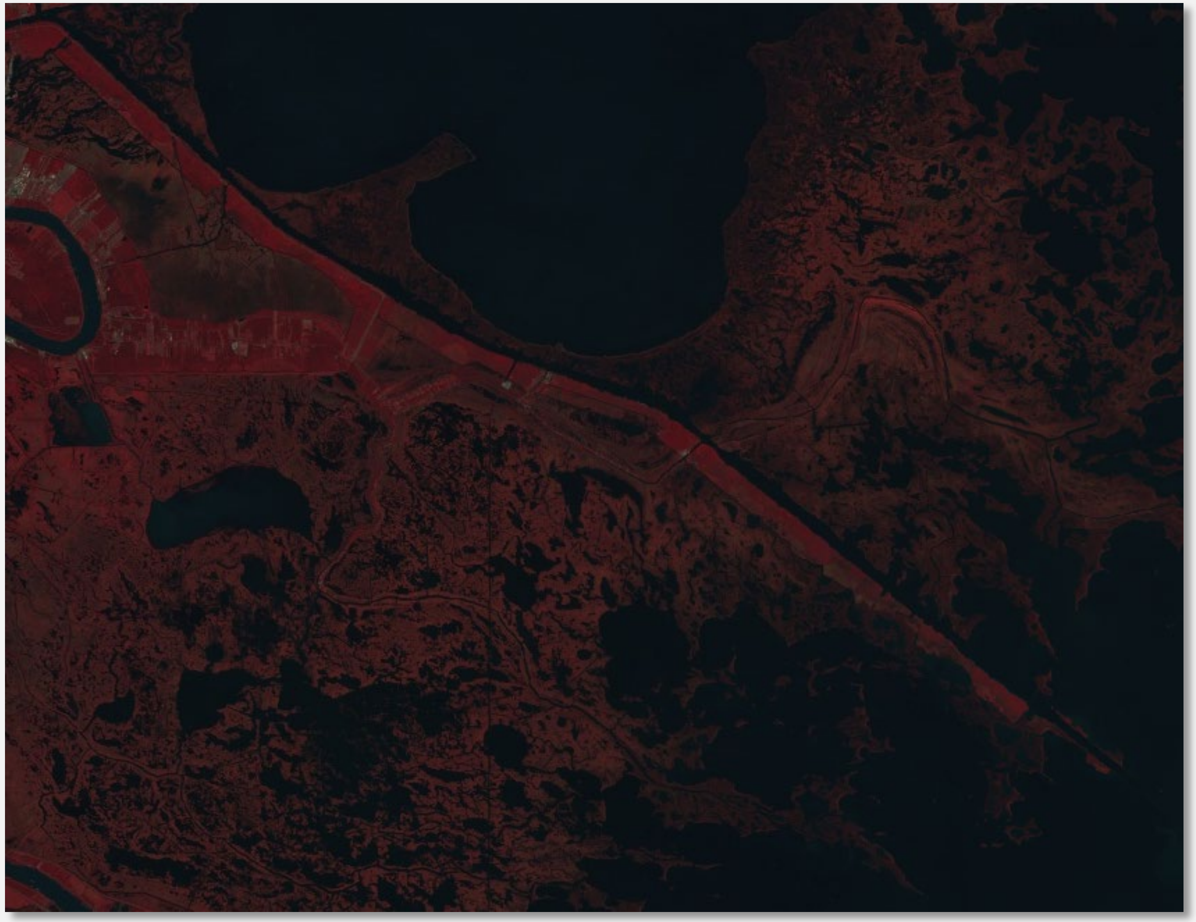


HURRICANE KATRINA DEVASTATION



- Significantly less greenness due to vegetation death from surge inundation
- Homes and boats destroyed (damage estimate is $125 billion US dollars)

WETLANDS BEFORE AND AFTER



USGS Landsat Imagery

USGS Landsat Imagery

- Redness = vegetation health

IMPORTANCE OF WETLANDS

- High levels of biodiversity
- Major source of carbon sequestration
- House numerous endangered/threatened animal species
- Mississippi delta wetlands home to 60% of the Gulf coastal wetlands
- Play an important role in buffering storms and reducing storm surge

https://mississippiriverdelta.org/

OBJECTIVES

- How did Hurricane Katrina change the landscape of southeastern Louisiana?
- How has the landscape recovered now that 15 years have passed since the disaster?

- This study uses medium resolution Landsat imagery in southeastern Louisiana, in order to create multi-temporal NDVI which will assist in highly accurate object-based land cover classification maps created within eCognition.
- These methodologies will be used as a means of classifying and quantifying vegetation changes

AREA OF INTEREST

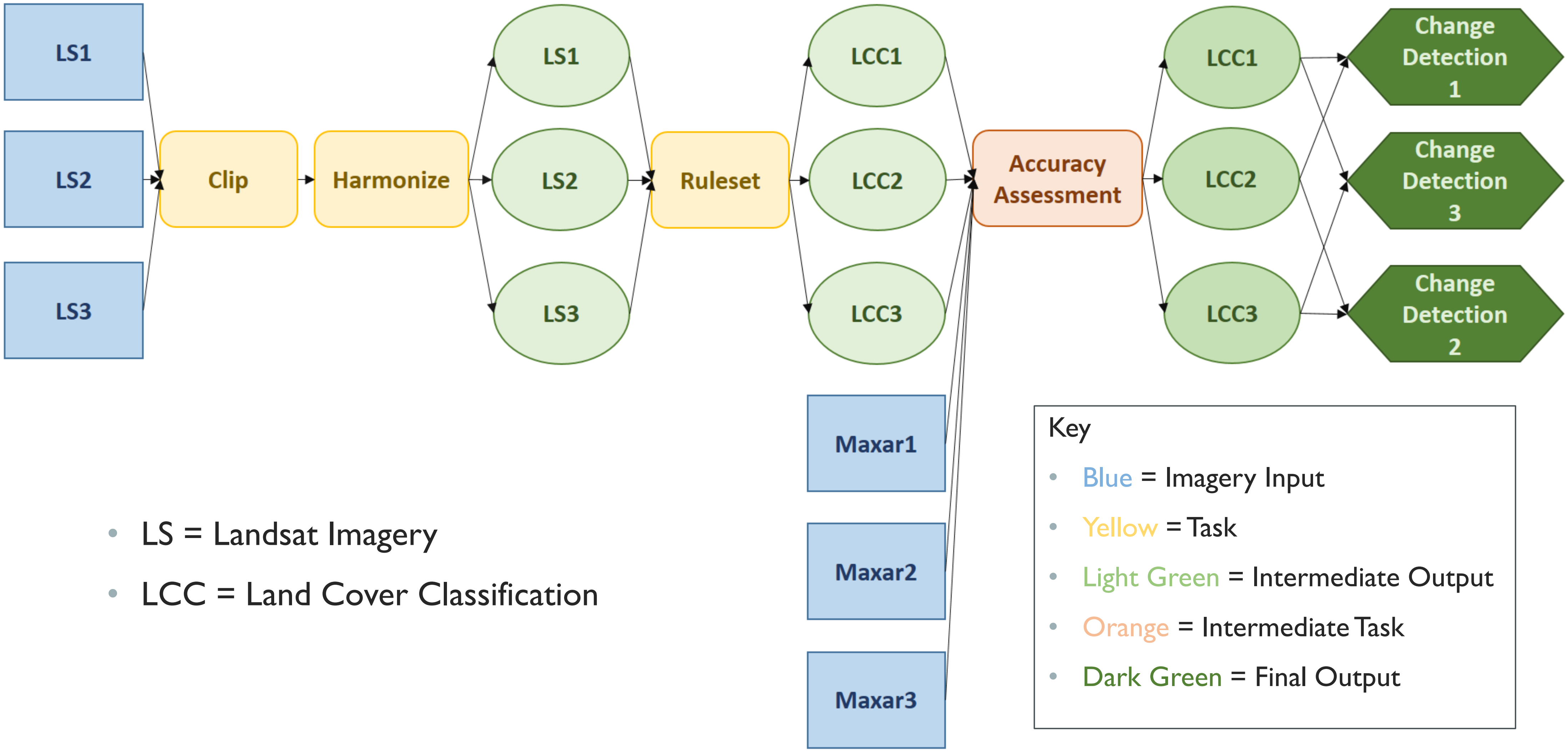
- Hurricane Katrina moved directly north over the Mississippi River Delta
- Landsat imagery (moderate resolution) will be used for analysis over the entire Area of Interest (AOI)
- Maxar imagery (high resolution) will be used to assess accuracy of the Landsat analysis

USGS Landsat Imagery and ESRI Basemap

IMAGERY DATES AND SENSORS

Reference	Satellite Sensor	Spatial Resolution	Image Date(s)
LS1	Landsat 5 TM	30 meters	11/7/2004
LS2	Landsat 5 TM	30 meters	10/25/2005
LS3	Landsat 8 OLI	30 meters	10/2/2020
M1	Maxar's Quickbird	2.4 meters	9/6/2003; 3/9/2004; 4/4/2004
M2	Maxar's Quickbird	2.4 meters	9/3/2005; 9/21/2005; 10/4/2005
M3	Maxar's WorldView-2	2 meters	4/30/2020

METHODOLOGY WORKFLOW

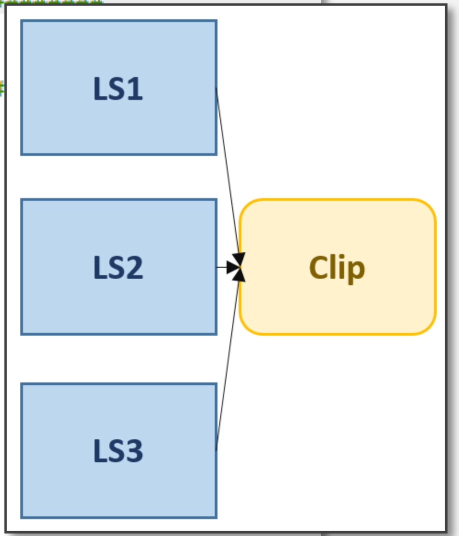


- LS = Landsat Imagery
- LCC = Land Cover Classification

Google Earth Engine

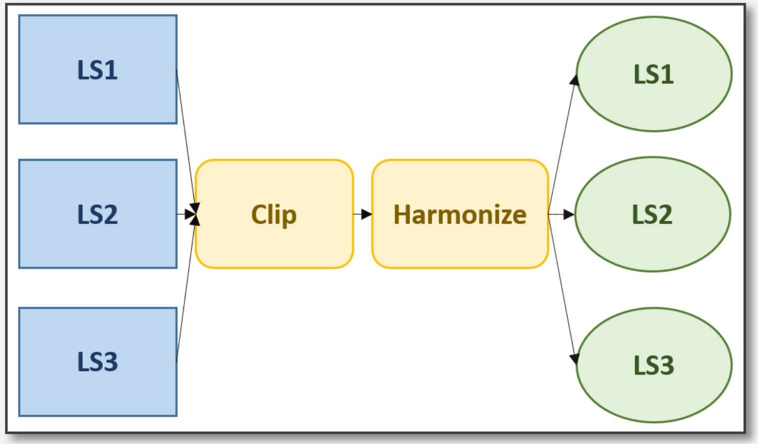
- Google Earth Engine (GEE) was used to prepare data
  - Gather imagery for all three time periods
    - Least cloudy
    - Clip to AOI
- T1 = November 7, 2004 (before Hurricane Katrina)
- T2 = October 25, 2005 (2 months after Hurricane Katrina made landfall)
- T3 = October 2, 2020 (15 years after Hurricane Katrina)

```
Imports (7 entries)
 var point: Point (-90.00, 29.78)
 var point2: Point (-90.00, 29.78)
 var point3: Point (-90.00, 29.78)
 var aoi: Polygon, 4 vertices
 var landsat: ImageCollection "USGS Landsat 5 Surface Reflectance Tier 1"
 var landsat3: ImageCollection "USGS Landsat 8 Surface Reflectance Tier 1"
 var landsat2: ImageCollection "USGS Landsat 5 Surface Reflectance Tier 1"

//###########################################################################
//Created by Alicia Williams March 2021
//Penn State University, MGIS Capstone
//#################################################################

var falseColor = {
  bands: ['B4', 'B3', 'B2'],
};

Map.centerObject(aoi, 9);

//Image reduction
//Image 1: August-November, 2004
var images = ee.ImageCollection(landsat
.filterBounds(point)
.filter(ee.Filter.calendarRange(2004, 2004, 'year')));
var growing = ee.ImageCollection(images
.filter(ee.Filter.calendarRange(8, 11, 'month'))
.sort('CLOUD_COVER_LAND')
.first()
);
var clipGrowing04 = growing.map(function(image){return image.clip(aoi)}) ;
print ('Growing Season 2004:', clipGrowing04);
Map.addLayer(clipGrowing04, falseColor, '2004 False Color');
var inputShell04 = clipGrowing04.toList(clipGrowing04.size());
var input04 = inputShell04.get(0);
print(input04);
```



LANDSAT HARMONIZATION

- T1 and T2 imagery comes from a different satellite sensor than T3
- In order to ensure accurate change detection, Landsat T1 and T2 (Thematic Mapper) were harmonized to T3 (Operational Land Imager)

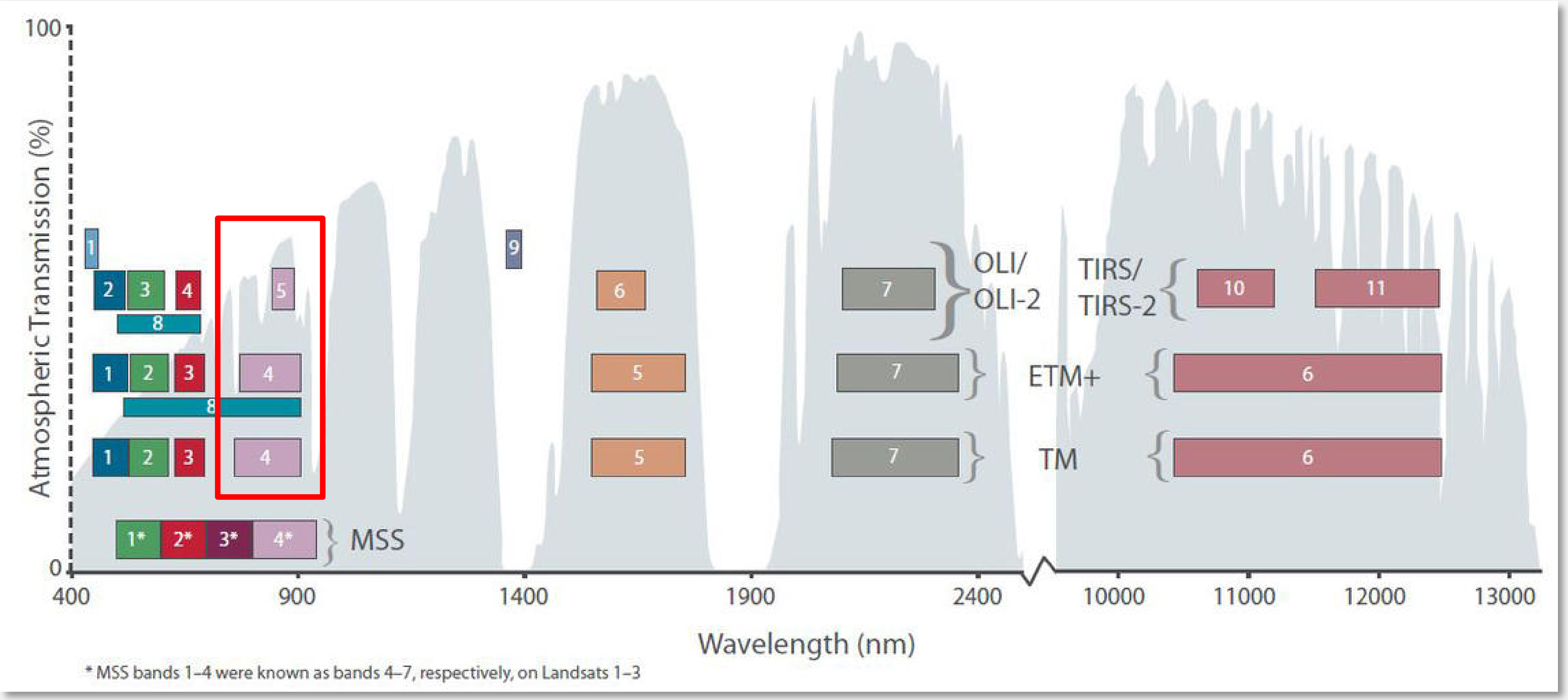



```
//#######################################################################
//Harmonize TM and Oli images


var coefficients = {
  itcps: ee.Image.constant([0.0003, 0.0088, 0.0061, 0.0412, 0.0254, 0.0172])
             .multiply(10000),
  slopes: ee.Image.constant([0.8474, 0.8483, 0.9047, 0.8462, 0.8937, 0.9071])
};

function renameOli(img) {
  return img.select(
      ['B2', 'B3', 'B4', 'B5', 'B6', 'B7', 'pixel_qa'],
      ['Blue', 'Green', 'Red', 'NIR', 'SWIR1', 'SWIR2', 'pixel_qa']);
}

function renameTm(img) {
  return img.select(
      ['B1', 'B2', 'B3', 'B4', 'B5', 'B7', 'pixel_qa'],
      ['Blue', 'Green', 'Red', 'NIR', 'SWIR1', 'SWIR2', 'pixel_qa']);
}

function TmToOli(img) {
  return img.select(['Blue', 'Green', 'Red', 'NIR', 'SWIR1', 'SWIR2'])
      .multiply(coefficients.slopes)
      .add(coefficients.itcps)
      .round()
      .toShort()
      .addBands(img.select('pixel_qa'));
}
```

Google Earth Engine

HARMONIZATION

- Harmonization standardizes data from different sensors so that they can accurately be compared
- Spectral transformation function
- Minimizes constraints of different spectral, spatial, and radiometric properties of the varying Landsat sensors
- Major differences in the NIR band



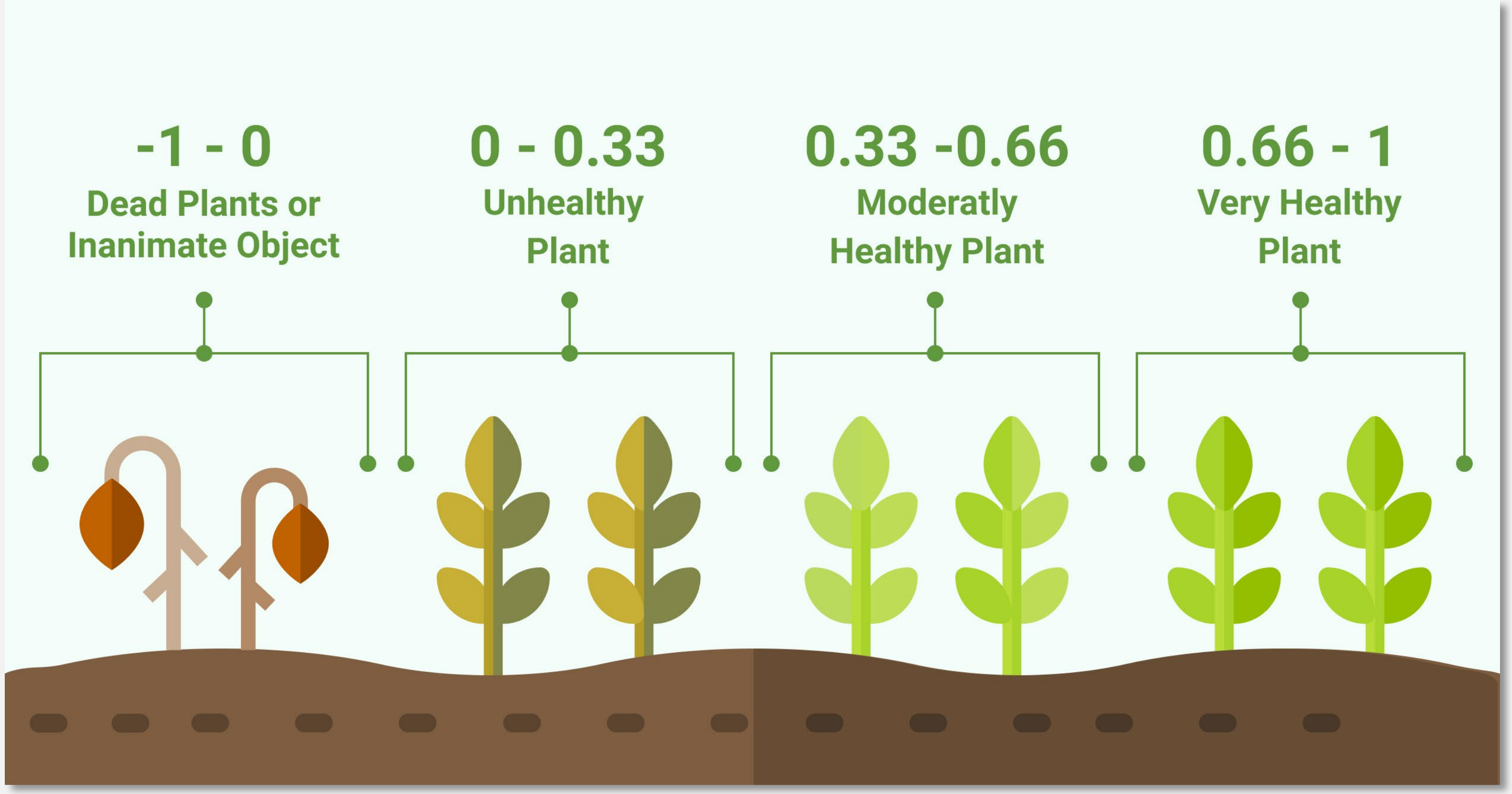
United States Geological Survey

NDVI

- Normalized Difference Vegetation Index:

$$NDVI = \frac{NIR - R}{NIR + R}$$

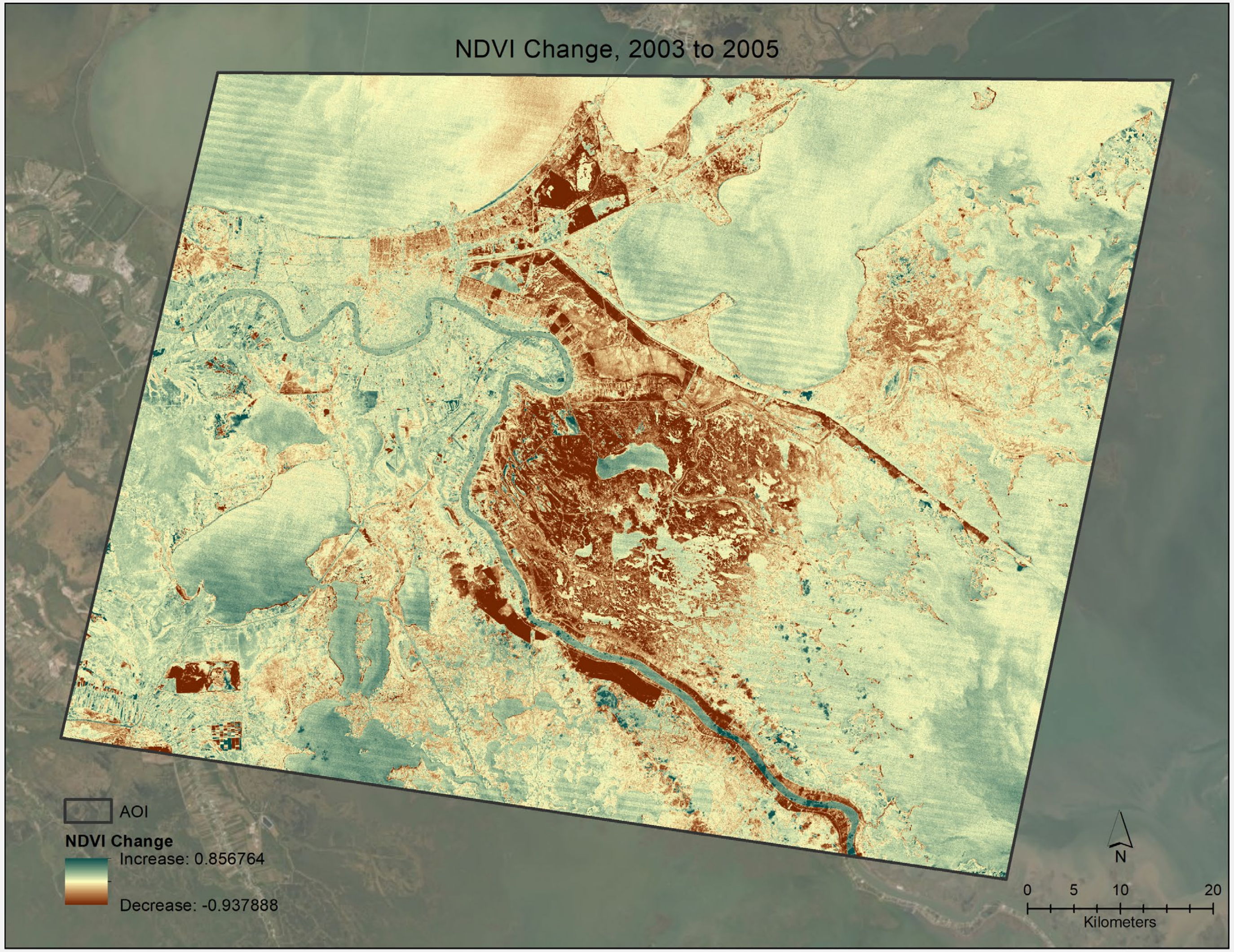
- Useful for mapping
  - vegetation health
  - change
  - biomass
- Successful in many coastal environments



https://eos.com

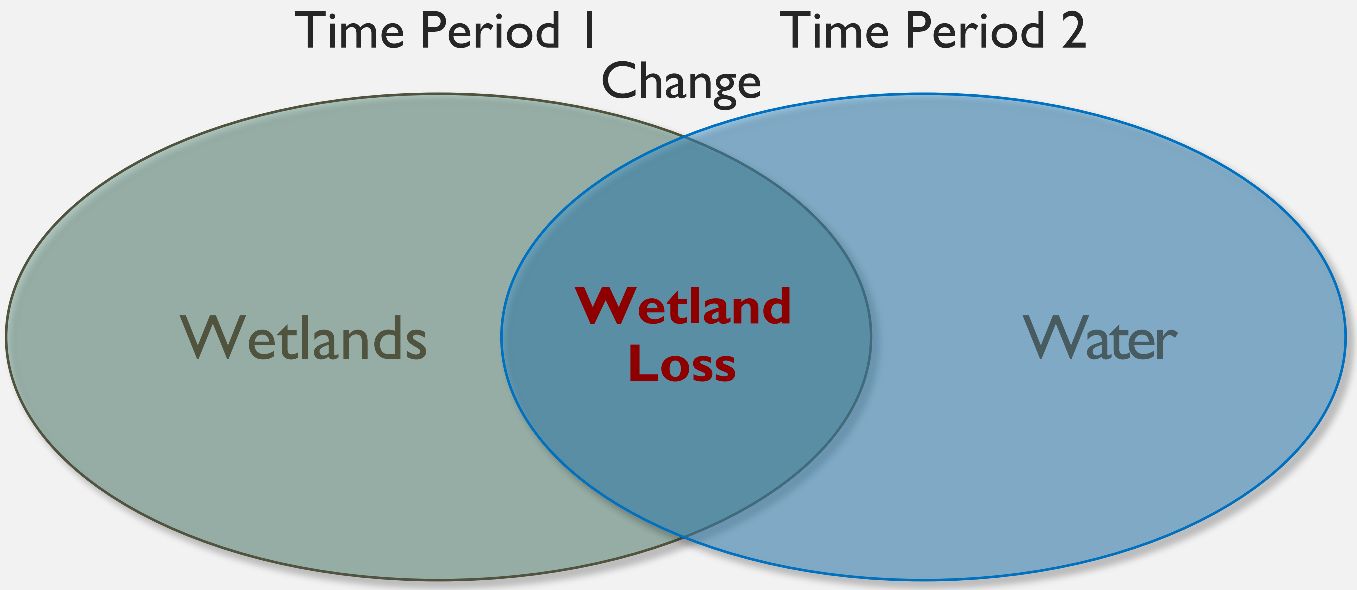
NDVI CHANGE

- This project is building on my previous work
- This image is a change analysis comparing the NDVI prior to Hurricane Katrina and after landfall
- The dark reddish colors designate areas of significant decrease in NDVI



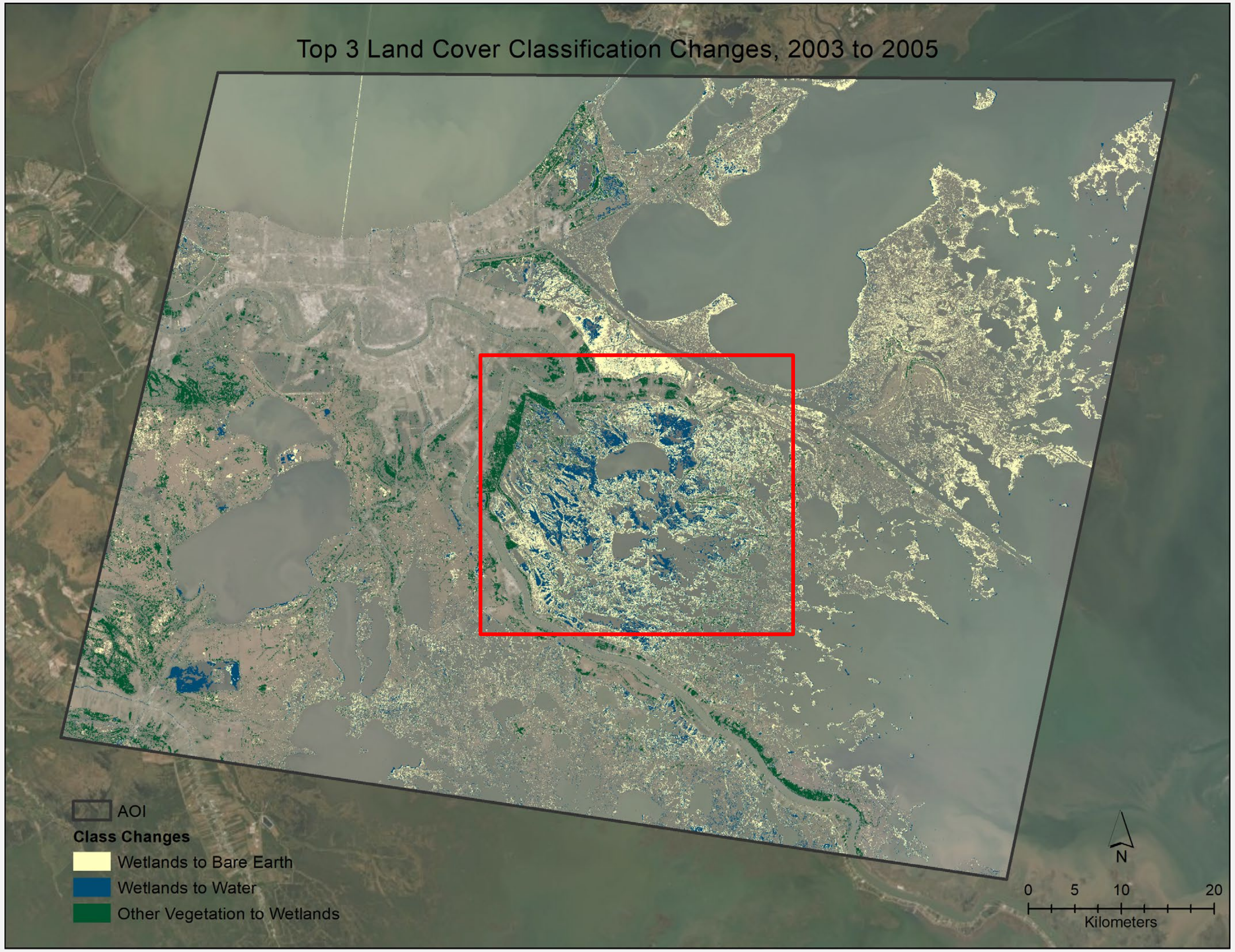
LCC

- Land Cover Classification
  - Observed (bio)physical cover on the earth's surface
  - Usually confined to vegetation and man made features
- Useful for giving a name to the types of changes discovered
- Quantify change area



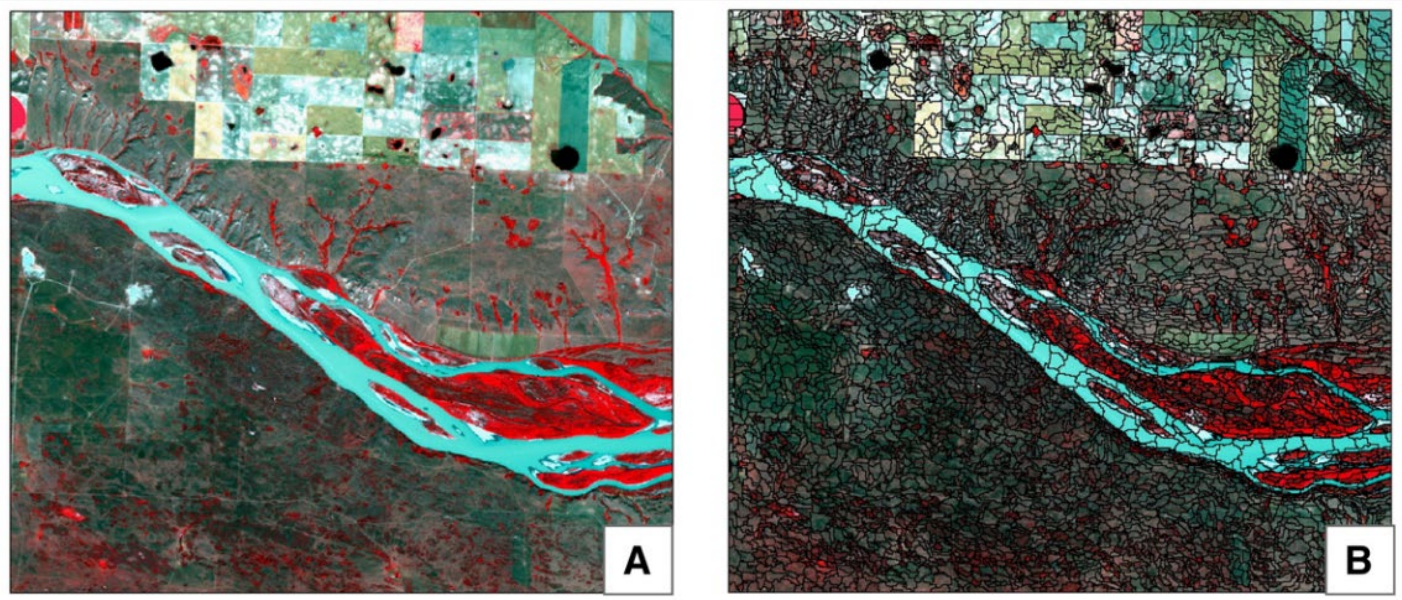
LCC

- Prior to Hurricane Katrina and two months after inundation:
- The blue color indicates a change from the wetland class to the water class
- The light beige color indicates a change from the wetlands class to the bare earth class
- One previous study measured the change of wetland to water after Hurricane Katrina as 230 square kilometers
- My previous work measured this figure as 258 square kilometers, but wetland to bare earth measured as 624 square kilometers

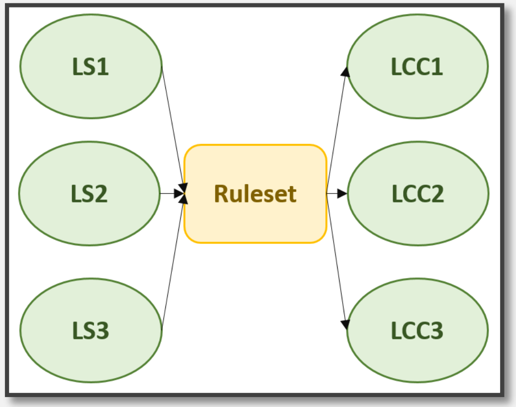


OBJECT BASED IMAGE ANALYSIS

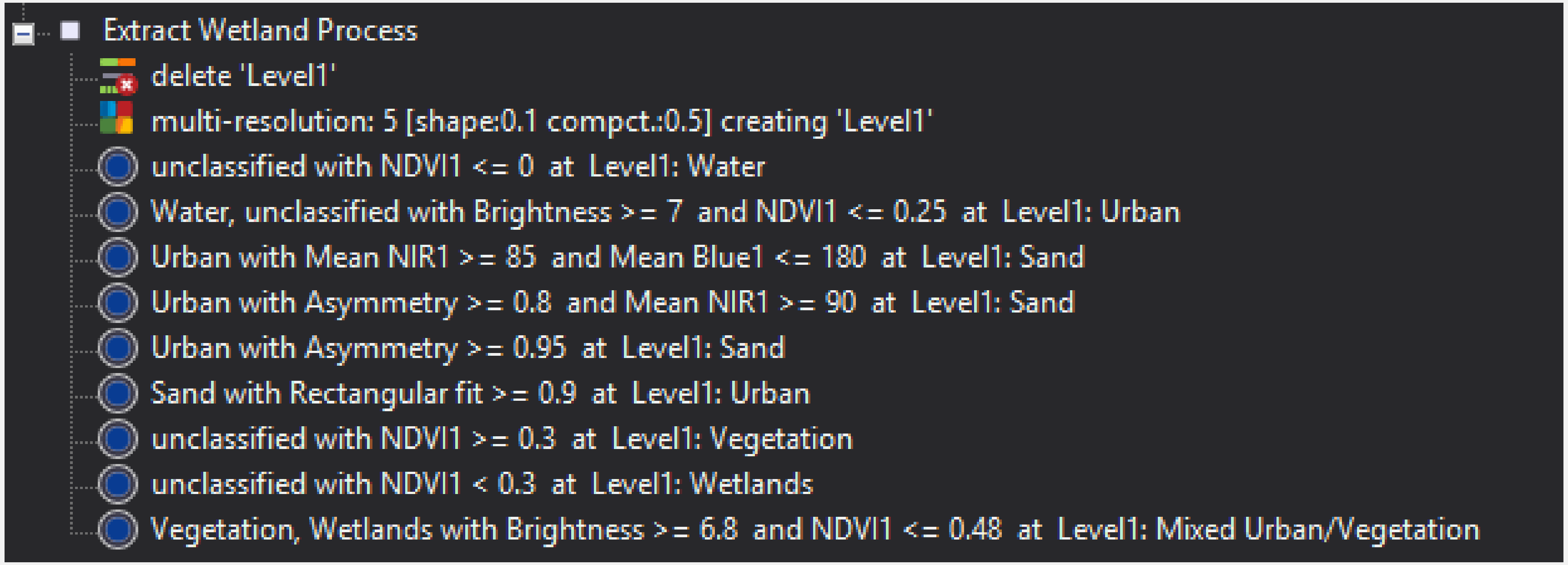
- OBIA useful for when different classes have similar spectral information
- With pixel-based classification there would be class confusion (think sand on a beach and bright rooftops)
- OBIA uses context clues (Rectangular shape? Surrounded by water?)
- eCognition
- OBIA increases LCC Accuracy 1.7-7.9% as compared to pixel-based classification



https://doi.org/10.1016/j.rse.2011.11.020



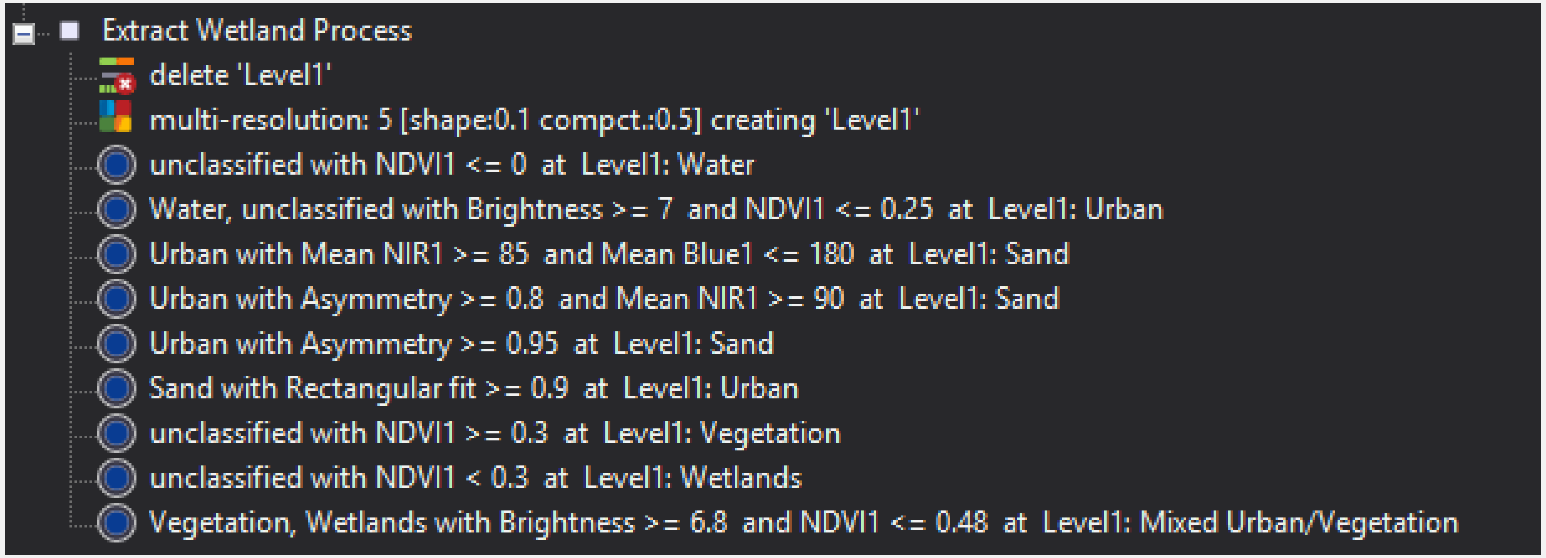
ECOGNITION



- Multi-resolution segmentation approach
  - Pixel
  - Neighboring pixels
  - Image Objects

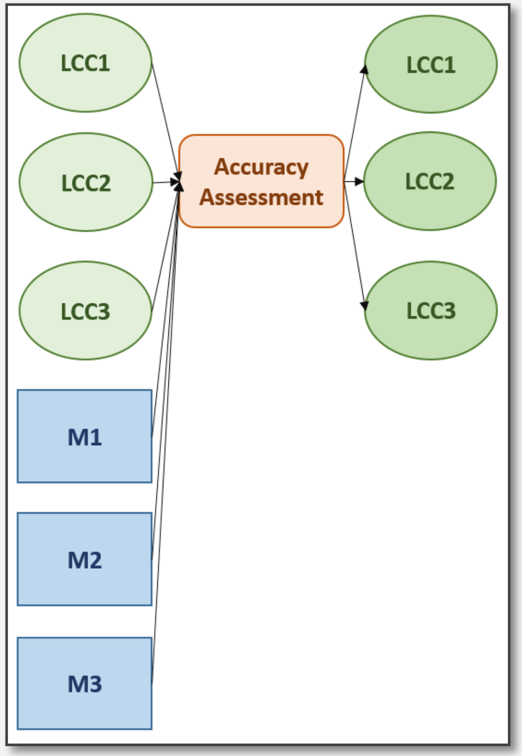
ECOGNITION

- NDVI, NIR, Blue, Asymmetry, Rectangular fit
- Classes: Water, Urban, Bare Earth, Vegetation, Wetlands, Mixed Urban/Vegetation
- Wetland in this study:
  - non-forested wetlands
  - wetland herbaceous vegetation
  - salt marshes
  - freshwater meadows
  - wet prairies
  - open bogs



ACCURACY ASSESSMENT

- Once satisfied visually with the OBIA classification output, extract as TIF, and import into ArcGIS Pro
- Perform accuracy assessment using 500 random points comparing the LCC output to the high resolution Maxar imagery (M1, M2, M3)
  - Error of Omission (Producers Accuracy)
  - Error of Commission (Users Accuracy)
  - Overall Error
  - Kappa Coefficient

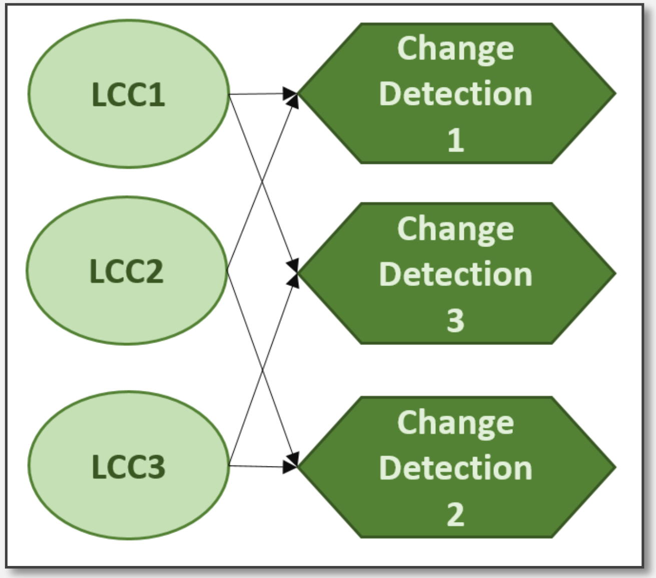


EXAMPLE ERROR MATRIX

Class	Wetlands	Vegetation	Water	Other	Total	User's Accuracy	Kappa
Wetlands	167	5	0	3	175	0.954286	0
Vegetation	4	30	0	0	34	0.882353	0
Water	2	0	249	1	252	0.988095	0
Other	2	0	5	32	39	0.820513	0
Total	175	35	254	36	500	0	0
Producer's Accuracy	0.954286	0.857143	0.980315	0.888889	0	0.956	0
Kappa	0	0	0	0	0	0	0.927998

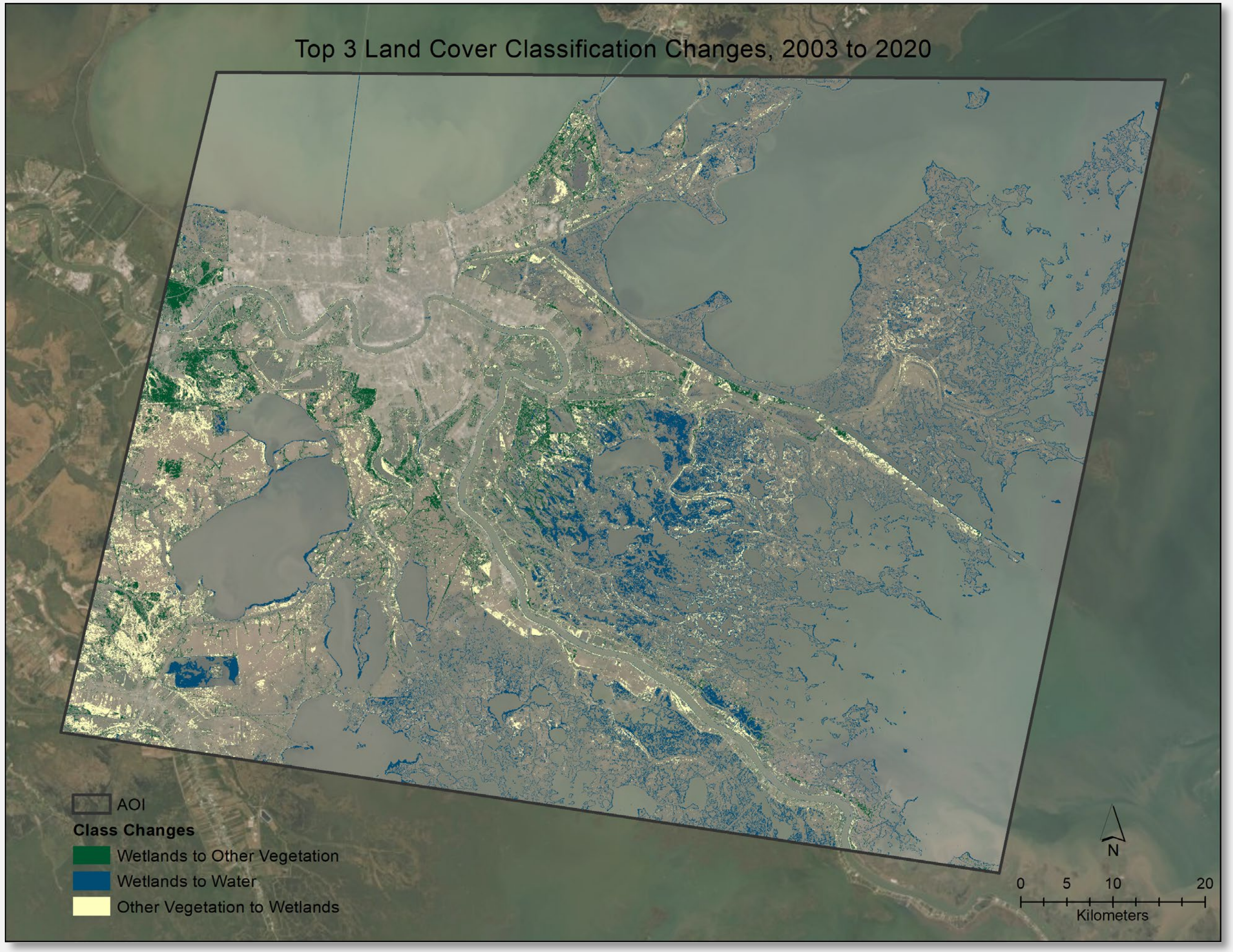
CHANGE DETECTION

- The results for T1 and T2, T2 and T3, and T1 and T3 will be analyzed and changes will be compared
- Possible change detection methodologies include
  - ENVI
  - ArcPy Scripting
  - Upload final datasets to GEE for Java coding
- Testing currently undergoing for efficiency and accuracy



ANTICIPATED RESULTS

- Anticipated results based on preliminary analysis shows significant changes from the wetland classification to the water classification
- This indicates significant wetland loss due to Hurricane Katrina that has still not recovered in the 15 years since the disaster
- Recovery after such a long time is unlikely, without mitigation



USGS Landsat Imagery and ESRI Basemap

PROJECT TIMELINE

Due Date	Due Out
2/25/21	596A paper and presentation draft due to professor for comments
3/4/21	Comments due from professor on 596A paper and presentation
3/10/21	596A paper and presentation completed (presentation at 11:30am)
4/1/21	Analysis completed
5/6/21	Results analyzed and compiled
6/3/21	Final draft and final presentation due to Professor for final comments
6/17/21	Professor completes final comments on paper and presentation drafts
7/1/21	Final paper edits completed and final presentation edits completed

ACKNOWLEDGEMENTS

Many thanks to:

- Maxar Technologies for the high resolution imagery for accuracy assessment
- Landsat 5 TM and Landsat 8 OLI imagery courtesy of the United States Geological Survey
- Dr. Doug Miller for his expertise and advisement which has been invaluable

THANK YOU

Any questions?