Quantifying the impact of hurricanes, mid-latitude cyclones, and other weather and climate extreme events on the Mississippi-Alabama Barrier Islands using remotely sensed data

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SUMMARY OF KEY FINDINGS:

- Catastrophic events now primary driver of change in area on all four islands
- Hurricanes erode more than other events even though they are less frequent
- Winter storms and thundertorms erode nearly equal amounts of area

West Ship Island (WSI) surface area was 215 ha (less than 1 square mile) on the last image date of the study period, about **25%** smaller than its 1972 area.

East Ship Island (ESI) settled at around 110 ha (less than 0.5 square mile) at the end of the study period, about **39%** smaller than its 1972 area.

Petit Bois Island (PBI) continued to erode but stabilized at around 400 ha (1.5 square miles) at the end of the study period, though its changes became more abrupt and intense after Hurricane Katrina, leaving the island **38%** smaller than it was in 1972.

Sand Island grew **900%** during the study period.

WSI, ESI, and Sand Island are all in accelerated growth periods, while PBI still experiences an overall decline in surface area.

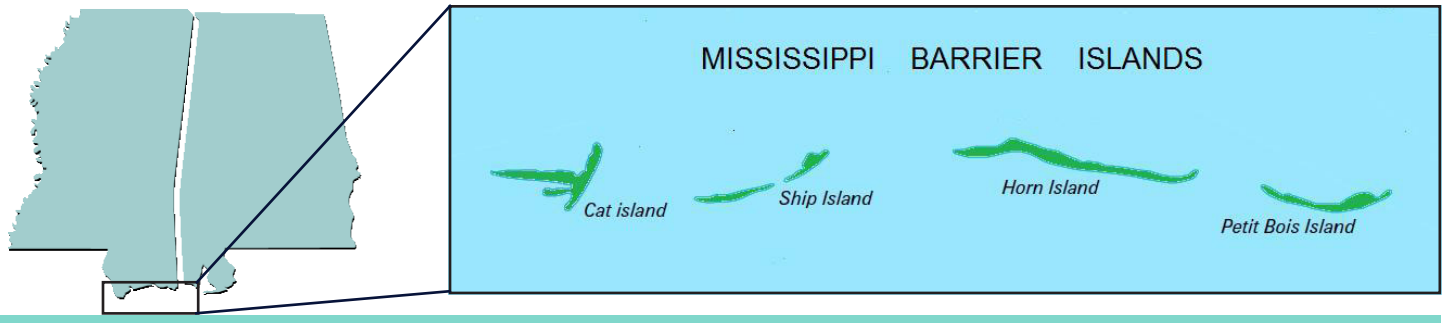
PURPOSE

Recent high-profile hurricanes have demonstrated the destructiveness of extreme events on coastal landscapes to the world. Barrier islands across the planet are disappearing, exposing vulnerable coastal cities to the damage caused by extreme events. Growing resolve among scientists regarding climate change's connection to tropical cyclones heightens the concern around intensifying extremes and landscape dynamics. Studying how extreme weather and climate events could assist coastal agencies in planning restoration and preservation projects.

Thesis objectives:

- Quantify damage caused by extreme weather events
- Determine long-term trends across the system
- Examine relationship of various climate factors with island area

Rebekah Jones was born in central Pennsylvania, but grew up in south Mississippi, about 25 minutes from the Ship Island ferry dock. She is a Geography major with a minor in Mass Communication at Louisiana State University. Rebekah earned her B.A. from Syracuse University with dual majors in geography and journalism in August 2012. She currently works through an assistantship for the Southern Climate Impacts Planning Program (SCIPP), where she edits, writes and designs publications about climate-change related risks and hazards for a variety of audiences and stakeholders. Rebekah will be pursuing a Ph.D. in Geography at the University of South Carolina starting Fall 2015.

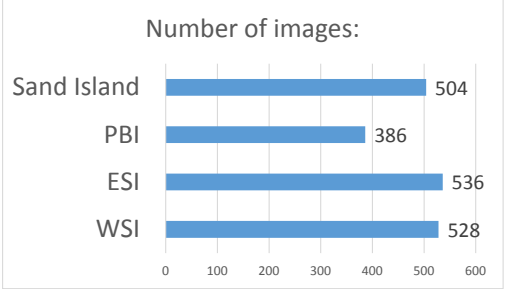


METHODS

This study uses more than 600 Landsat satellite images to measure the impact of extreme events on the islands (above) from 1972-2014.

WSI, ESI, PBI, and Sand Island, were measured for area in hectares (ha) 14 times per year on average, with more images before and after storms.

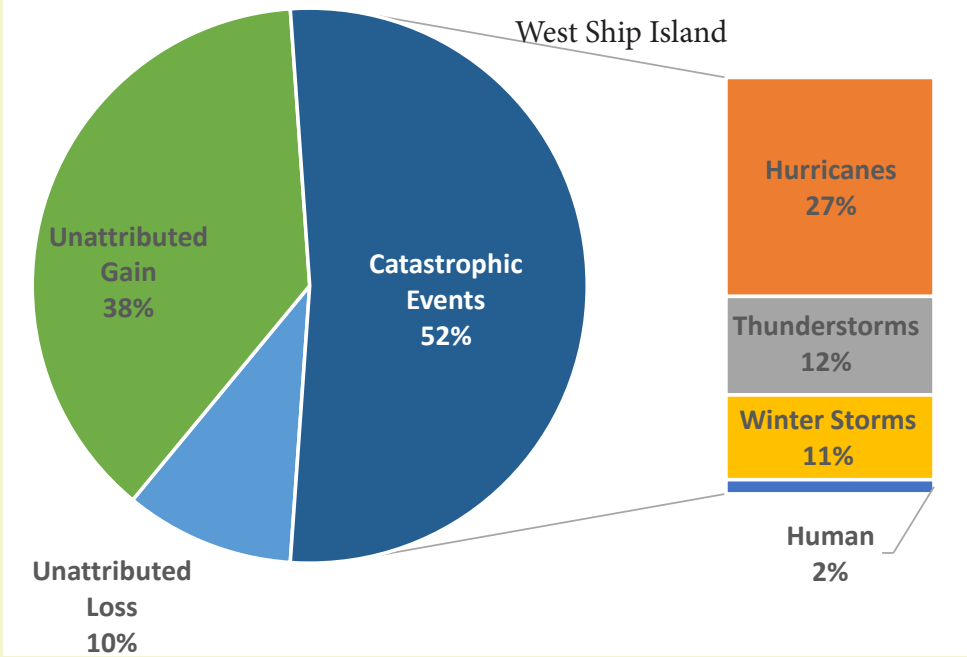
The islands were measured using a drawing tool in ErdasImagine, a GIS software system. Each island's area was recorded, and using the open-source statistical software R, calculations of change and other statistical analysis were done using the area data taken from the images.



RESULTS

The results reveal that extreme events, specifically hurricanes, mid-latitude cyclones, and thunderstorms, shape the islands more than gradual erosion and accretion processes across all islands.

- Catastrophic events caused 52-59% of all land area change on the islands during the study period.
- Hurricanes caused 24-37% of all change across the islands, thunderstorms 11-13%, and mid-latitude cyclones 11-14%.
- Three of the islands lost at least one-quarter of their 1972-1973 areas: WSI 25%, ESI 39%, and PBI 38%.
- WSI, ESI, and Sand Island are all in post-Katrina (2005) regrowth periods while PBI has destabilized and continues to experience net erosion.



The amount of observed change and variability fluctuated by "Periods," split into blocks of time according to the trends determined using break point analysis. Period I: 1972-84; Period II: 1984-98; Period III: 1998-2005; Period IV: 2005-14.

VARIABILITY BY ISLAND AND BY TIME PERIOD

	Period I	Period II	Period III	Period IV
WSI	324.99	142.06	315.56	371.32
ESI	272.549	122	952.71	482.87
PBI	--	122.32	1510.78	726.46
Sand Island		49.02	27.61	88.45

Sand Island experienced the opposite patterns of variability, increasing from Period I to II, decreasing from Period II to III, and increasing from Period III to IV. This opposite pattern of growth, erosion, and variance on Sand Island appears throughout all of the results.

STATISTICAL ANALYSIS IN R

A linear regression model of surface area on WSI with sea level and time resulted in a 0.7603 R2, a 2.2-16 p-value and an F-statistic of 828.7 (Table 4.2). Highest sea level also correlated with change as a percentage of area over time along with extreme precipitation days: -0.189 R2 and -0.173 R2 on WSI, and -0.247 R2 and -0.171 R2 for highest sea level and extreme precipitation days, respectively. Both highest sea level and extreme precipitation days could be signaling extreme events (for example, storm surge and intense rainfall), which would increase the R2 value. So while sea level data reflects the seasonal rise and fall of the ocean, it also reflects the intensity of extreme events.

FACTOR	WSI	ESI	PBI	SAND
Petit Bois Area	0.923	0.881	1	-0.791
West Ship Island Area	1	0.876	0.923	-0.648
East Ship Island Area	0.876	1	0.881	-0.756
Sea Level (Pensacola, Fla.)	-0.424	-0.419	-0.308	0.151
Time Series	-0.854	-0.818	-0.894	0.920
Days Per Month Above 32*C	-0.142	-0.174	-0.281	0.132
Min Temp Below 0*C	0.157	0.116	0.031	0.225
Extreme Maximum Temperature	-0.232	-0.219	-0.279	-0.035
Extreme Minimum Temperature	-0.263	-0.213	-0.216	-0.094
Mean Monthly Temperature	-0.259	-0.219	-0.220	-0.064
Mean Minimum Temperature	-0.270	-0.215	-0.193	-0.093
Total Monthly Precipitation	-0.156	-0.031	-0.077	-0.034
Extreme Daily Precipitation	-0.169	-0.008	-0.020	-0.065

QUICK FACTS:

- Sea level is highly correlated with area and area change
- Sea level likely primary driver of observed seasonality
- Continued sea level rise likely to lead to island destabilization/ submergence for ESI
- Island segmentation likely for PBI
- PBI experienced higher rates of variability and sensitivity to changes in sea level than the other islands in the study area.
- Events eroding more than 10 ha remain rare on Sand Island, but have become slightly more frequent during Period IV. Sand Island surpassed ESI in total area following Hurricane Katrina (2005) and continues to grow at PBI continues to decline.