AV An Overview of Extreme Storms in the U.S. Gulf of Mexico and Their Coastal Impacts*

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Abstract

During the past decade, the U.S. Gulf of Mexico coast has been subjected to the landfalls of 14 hurricanes. Each of these storms forced changes to the coast, some recovering naturally within months, others persisting to the present. The magnitudes of change can be scaled in terms of storm wave-runup elevation, R, and still-water elevation, η (which includes storm surge, wave setup, and astronomical tide), relative to the peak elevation of the foredune, Dhigh. As R/Dhigh and η/Dhigh increase, thresholds will be crossed that define regimes of increasing impact magnitude, progressing from runup colliding against the dune and eroding it landward, to runup overwashing the dune (R/Dhigh > 1), to still water level completely submerging the beach system (η/Dhigh > 1). The greatest coastal changes have been observed during this latter inundation regime, which can occur locally on a barrier island and cut an inlet, as occurred during Hurricanes Charley (2004), Ivan (2004), and Katrina (2005), or can submerge tens of kilometers of coast, as occurred on the Bolivar Peninsula, Texas, during Ike (2008) and on the Chandeleur Islands, Louisiana, during Katrina (2005). Airborne Lidar surveys showed the inundated Chandeleurs lost 82% of their surface area and their Gulf-front shores eroded landward ~250 m. These islands line the Mississippi Delta, which is subsiding. This induced a relative sea-level rise that conditioned the coast for extreme storm changes. Should global sea-level rise accelerate in the future as predicted, barrier islands worldwide may respond similarly when inundated during storms.

References

Penland, S., J.R. Suter and R. Boyd, 1985, Barrier island arcs along abandoned Mississippi River deltas: Marine Geology, v. 63/1-4, p. 197-233.

Sallenger, A., 2000, Storm impact scale for Barrier Islands: Journal of Coastal Research, v. 16/3, p. 890-895.

Website

USGS St. Petersburg Coastal and Marine Science Center: Coastal Change Hazards; Hurricanes and Extreme Storms, http://coastal.er.usgs.gov/hurricanes

Coastal-Change Impacts of Hurricanes along the U.S. Gulf of Mexico Coast

USGS

Presenter's Notes:

Bit of a different view of area impacted by Katrina…

Yet you cannot understand what happened without knowing a little about the delta, its recent history, and how it operates.

One cannot consider what happened at Chandeleur Islands separate from the system.

U.S. Gulf Coast, Land-falling Hurricanes, 2000-2009
http://coastal.er.usgs.gov/hurricanes

Shoreline experiencing hurricane force winds
…at least once = 1537 km or 58%
…twice = 400 km or 15%

Presenter's Notes:

Active decade for the Gulf, 12 hurricanes.

Shows hurricane force winds, spatial extent, 1 and 2 co-occurrences.

Focus here on 3 hurricanes—Lili, Gustav, Katrina.

Orange Beach, Alabama

USGS

Presenter's Notes:

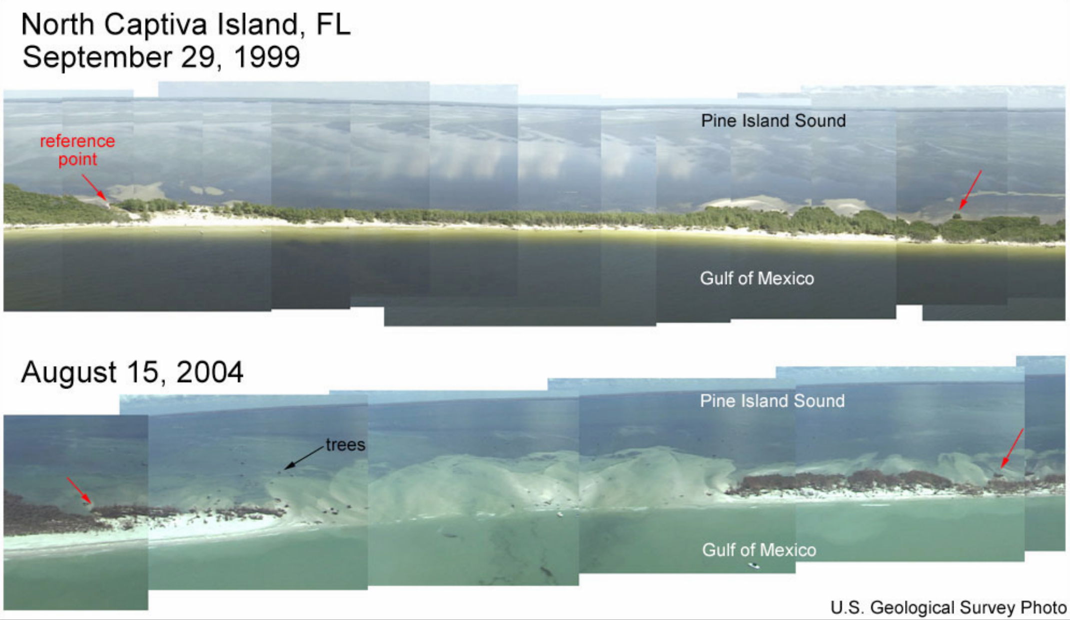
What happened here? what do you see?

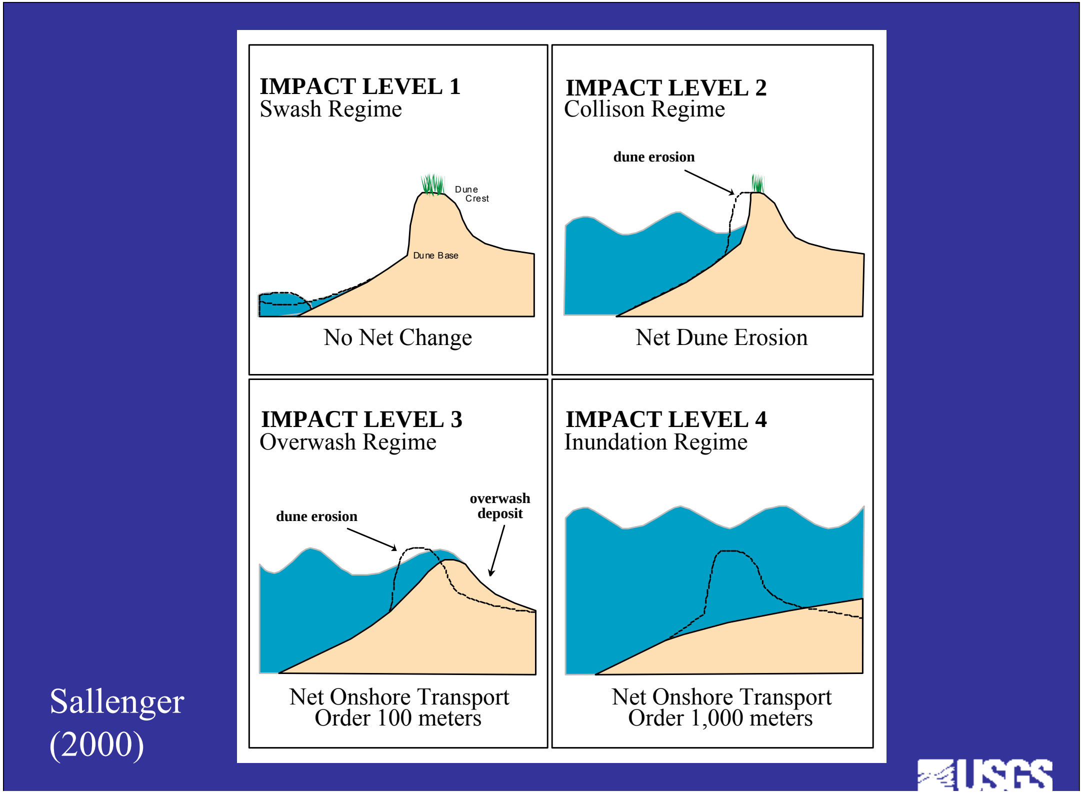
-photos from two different times of a beach, from an aircraft flying over beach about 500 ft, swimming pool, long walkways, as if coming down from the pool, perched high.

--And of course of the two buildings, one survived; one did not--the bigger one did not survive; the flimsier one did.

--It was not demolished to make way for a parking lot; people lived there.

Charley's Breach, FL



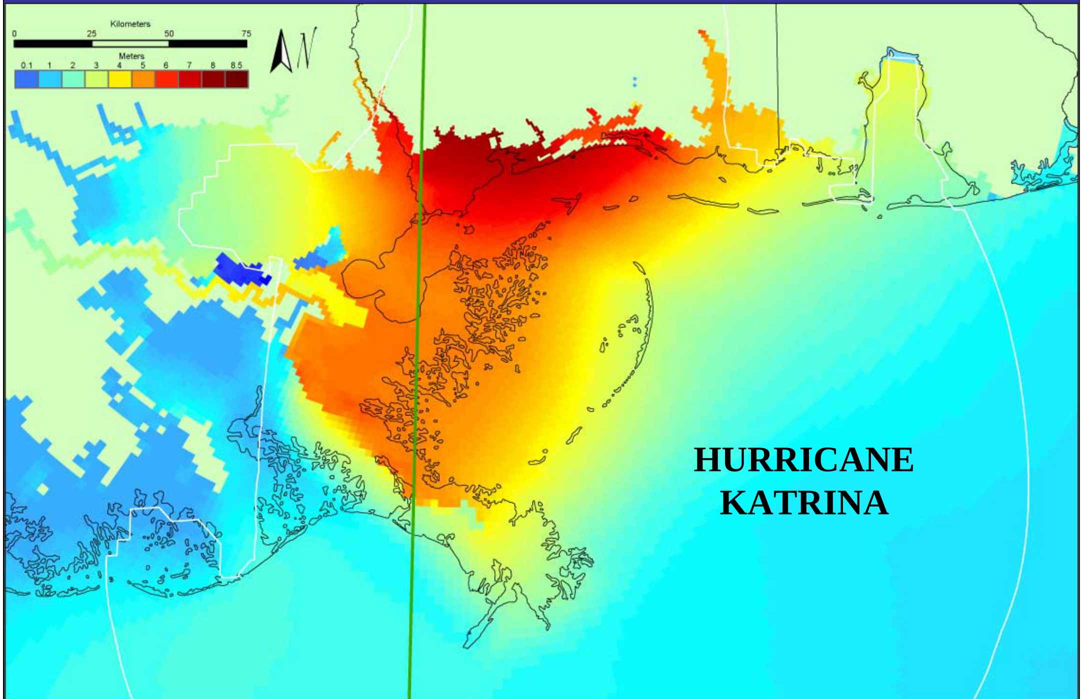


Presenter's Notes:

•This lead us to conceive of a scaling of storm impacts…. formalized and quantified in this presentation. The determination of regime is a function of elevation versus total runup; i.e., surge+setup+runup on the beach.

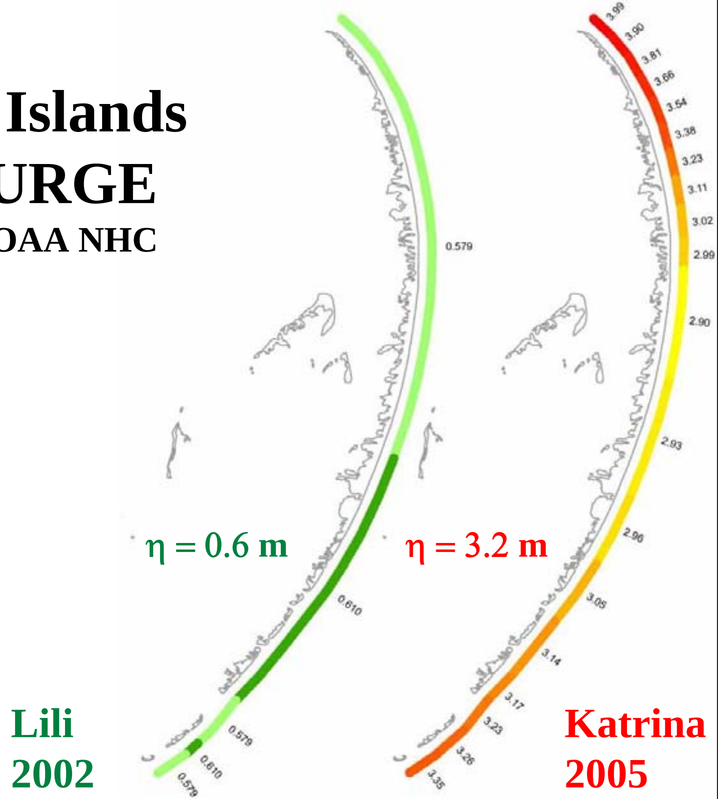
•Andrew scales here in the inundation regime---complete submergence; sand bodies driven inland on the order of 1km.

•Now during Lili much of the impact was primarily overwash with sand driven inland on the order of 100 m, but also major land loss was experienced, with shoreline retreat of 150 m. --- I'll show examples of that.



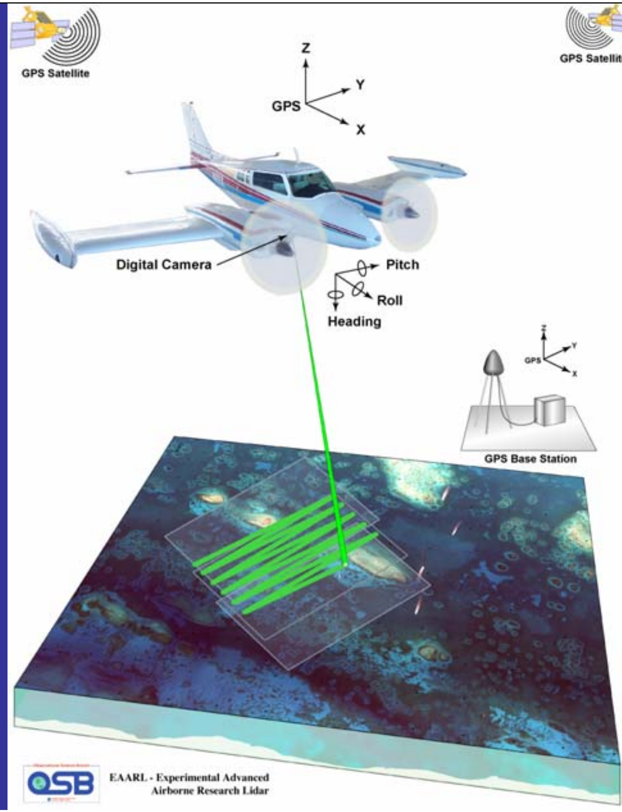
SLOSH - NOAA NHC

Chandeleur Islands
STORM SURGE
from SLOSH -- NOAA NHC



USGS

EAARL: Experimental Advanced Airborne Research Lidar



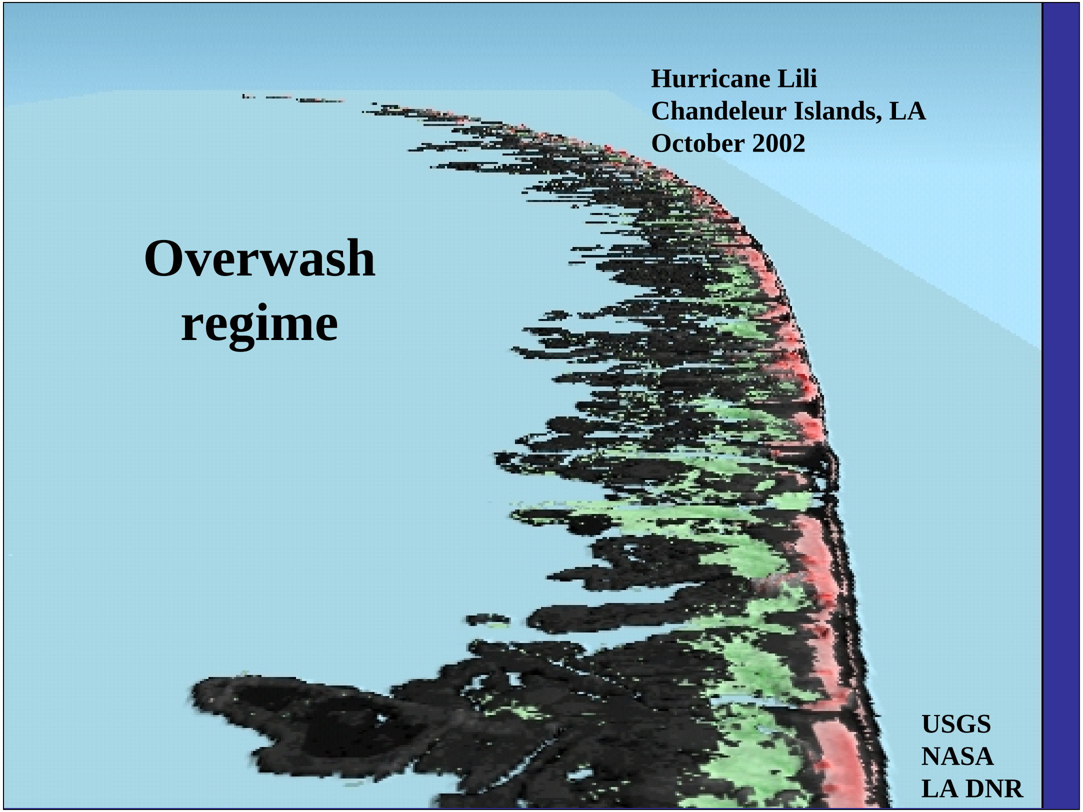
Presenter's Notes:

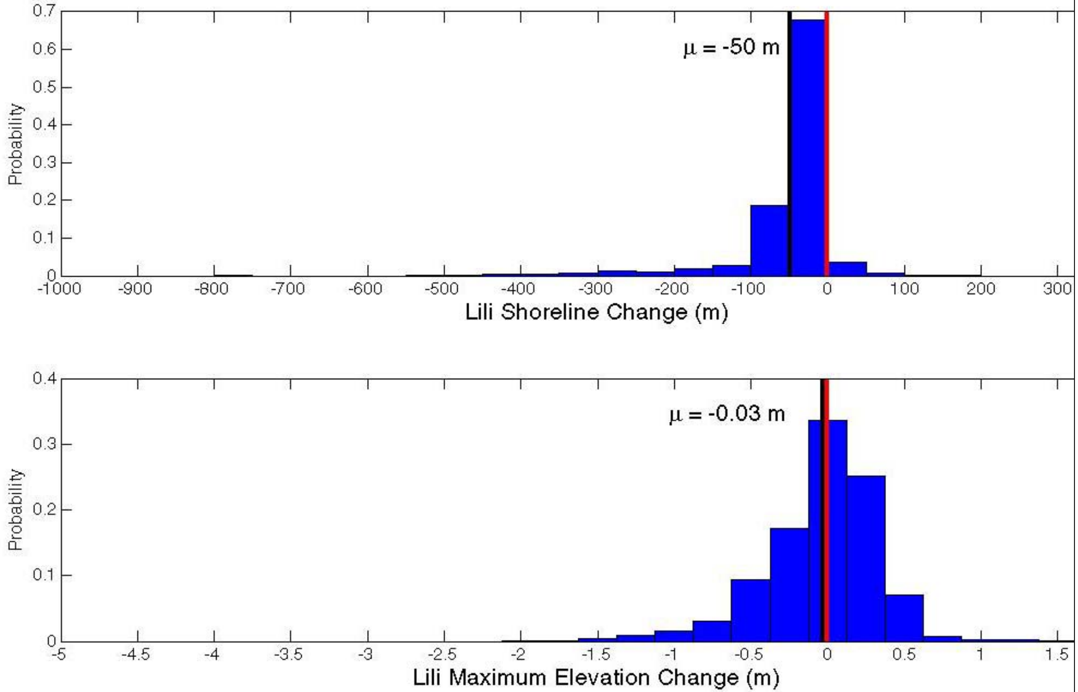
USGS uses Lidar to understand hurricane impacts:

--fly before and after storms to detect change.

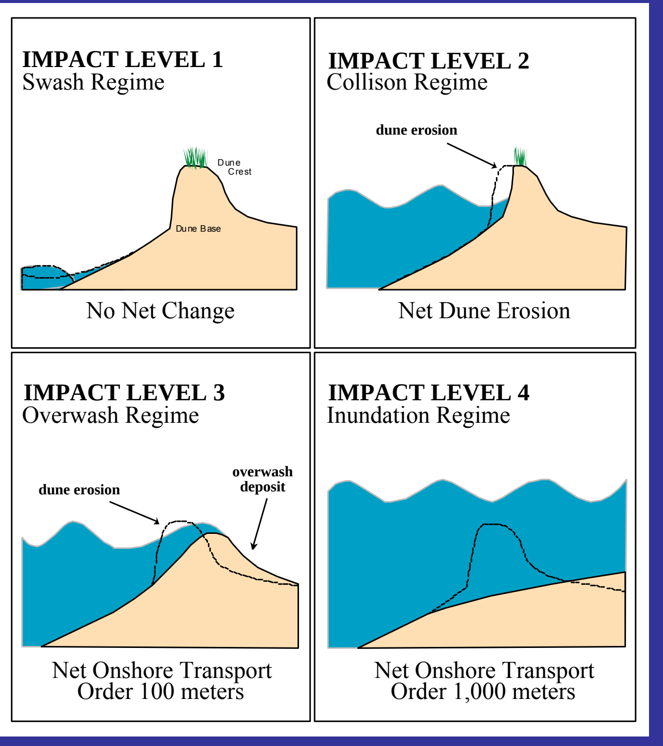
--accuracy, plus or minus 15 cm.

--used various LIdars through the program.


Hurricane Lili
Chandeleur Islands, LA
October 2002
Overwash
regime
USGS
NASA
LA DNR

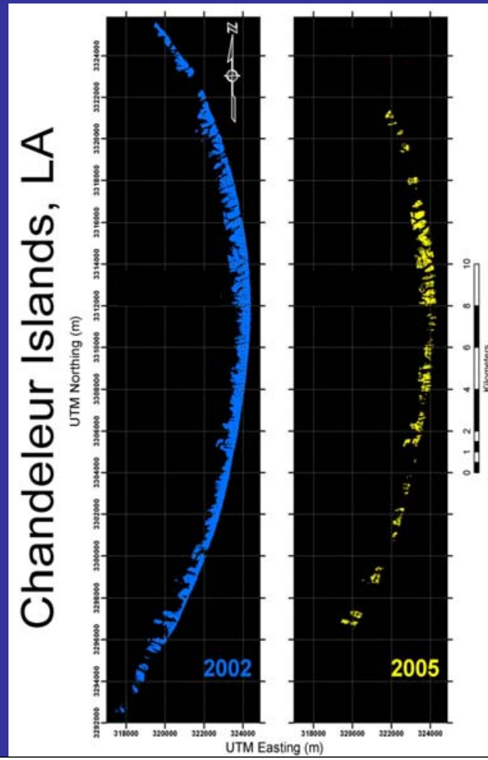


μ = -50 m
Probability
Lili Shoreline Change (m)
μ = -0.03 m
Probability
Lili Maximum Elevation Change (m)



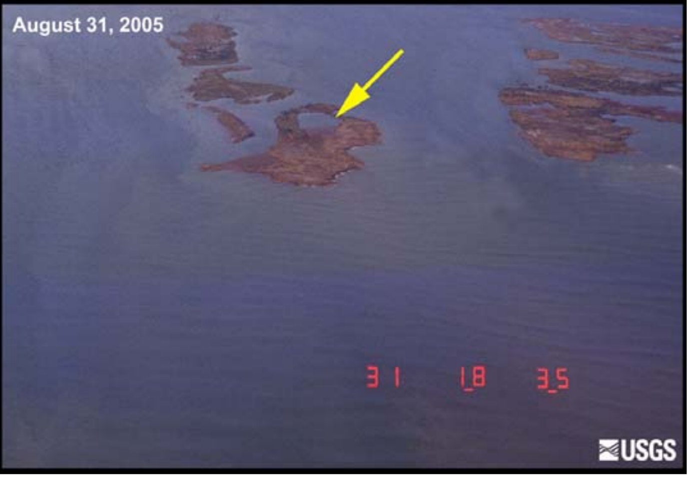
Sallenger (2000)

Extreme coastal change



Chandeleur Islands, Louisiana

Pre Katrina



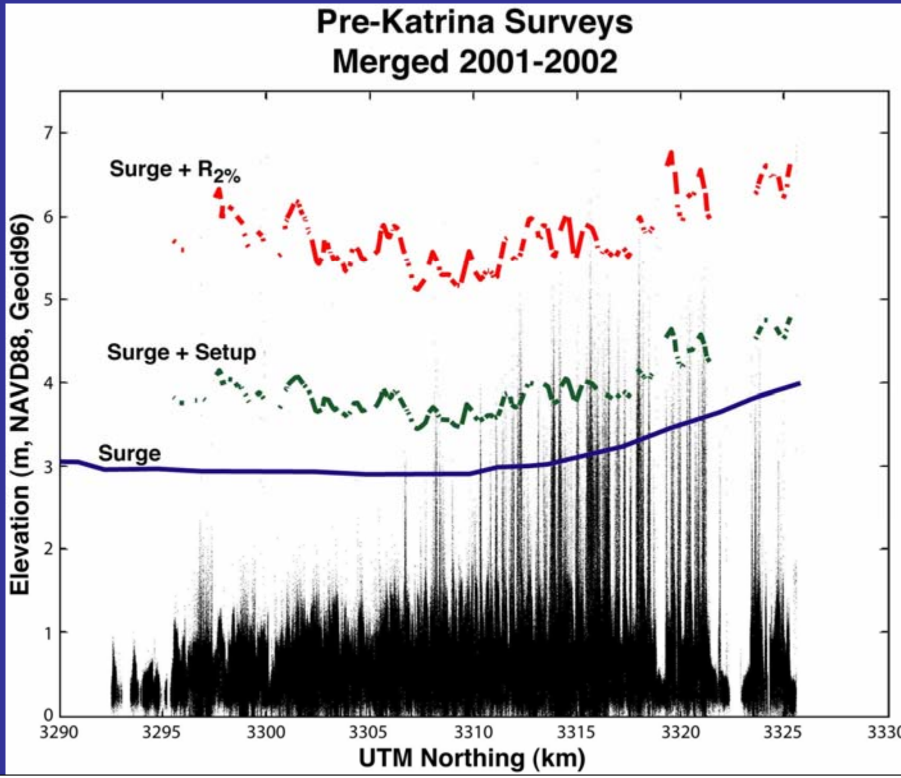
Post Katrina

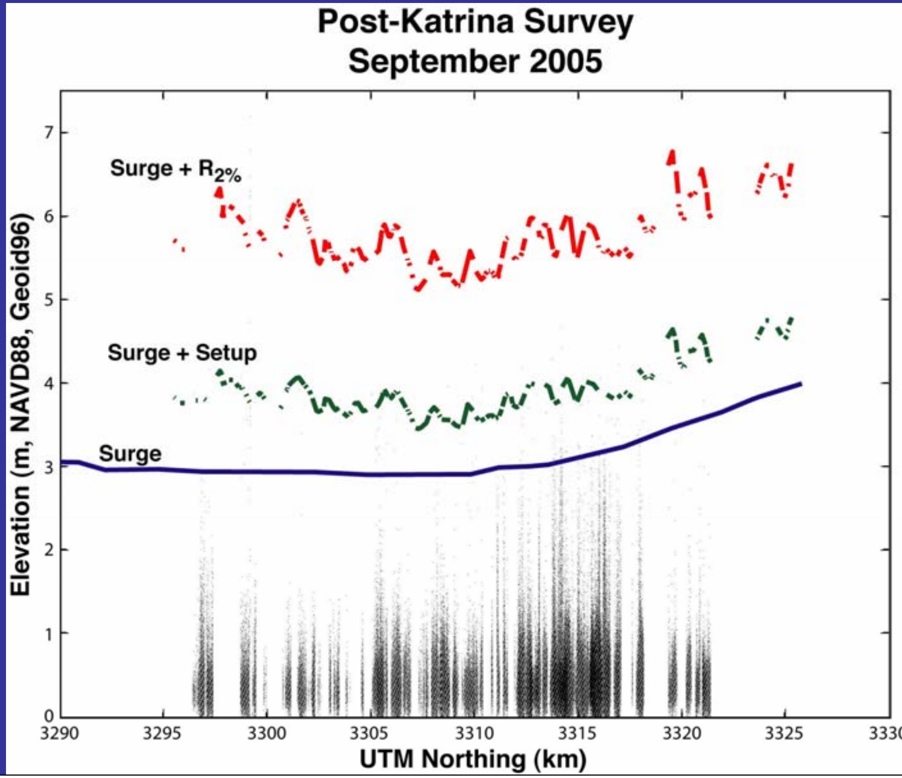
USGS

Pre Katrina

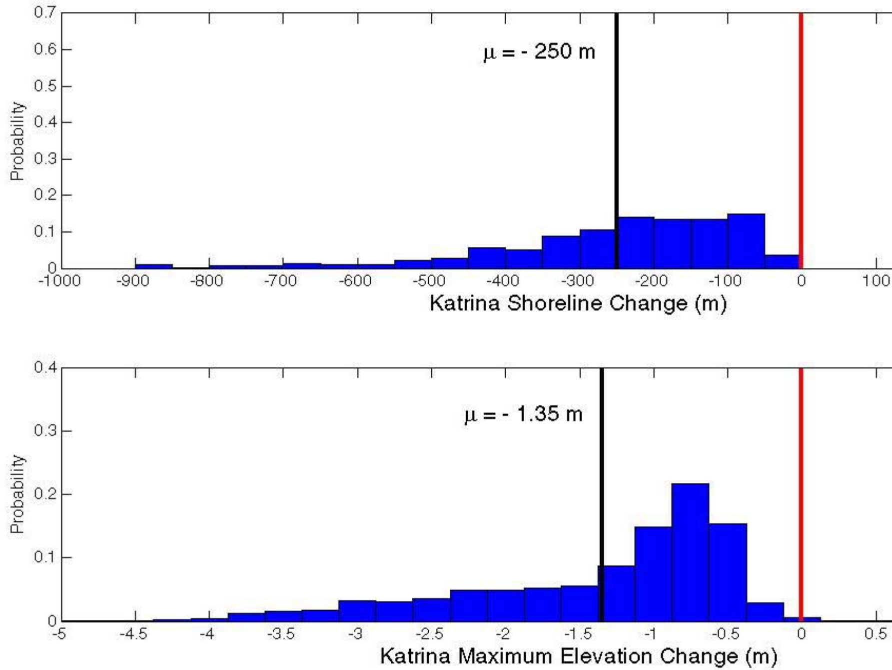
Post Katrina

USGS

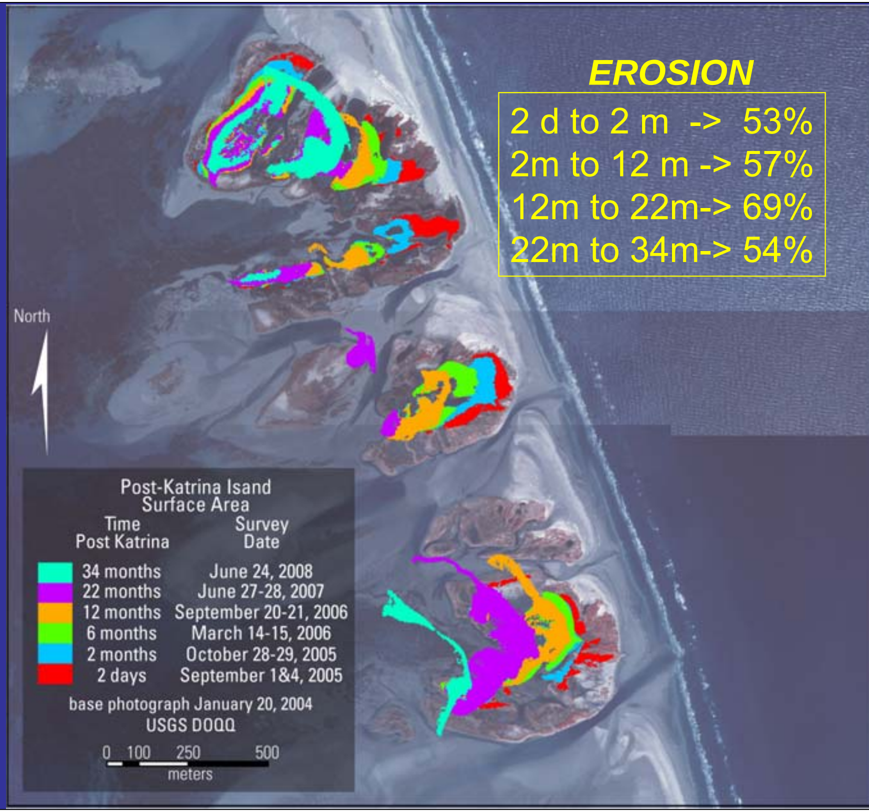

Pre-Katrina Surveys
Merged 2001-2002
Surge + R2%
Surge + Setup
Surge
Elevation (m, NAVD88, Geoid96)
UTM Northing (km)
0
1
2
3
4
5
6
7
3290
3295
3300
3305
3310
3315
3320
3325
3330



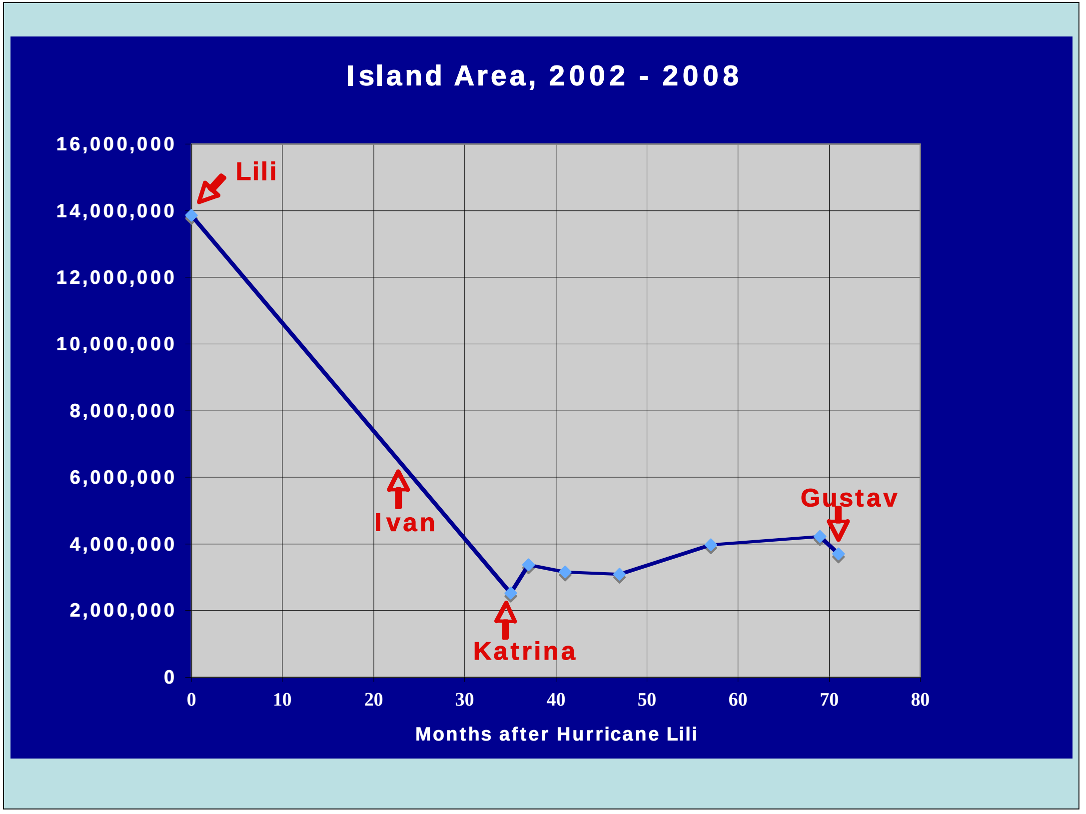
Post-Katrina Survey
September 2005
Surge + R2%
Surge + Setup
Surge
Elevation (m, NAVD88, Geoid96)
UTM Northing (km)
0
1
2
3
4
5
6
7
3290
3295
3300
3305
3310
3315
3320
3325
3330

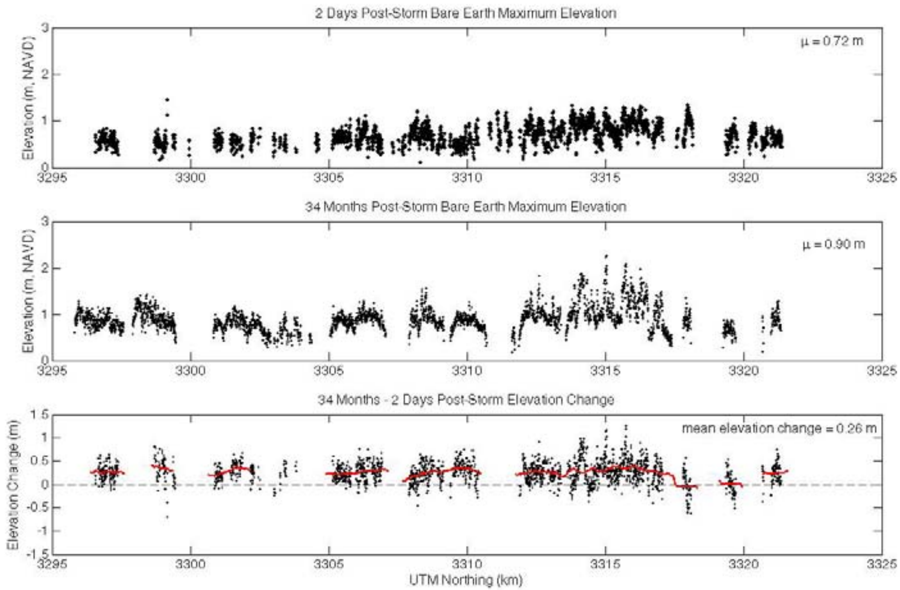


Probability
μ = - 250 m
Katrina Shoreline Change (m)
Probability
μ = - 1.35 m
Katrina Maximum Elevation Change (m)

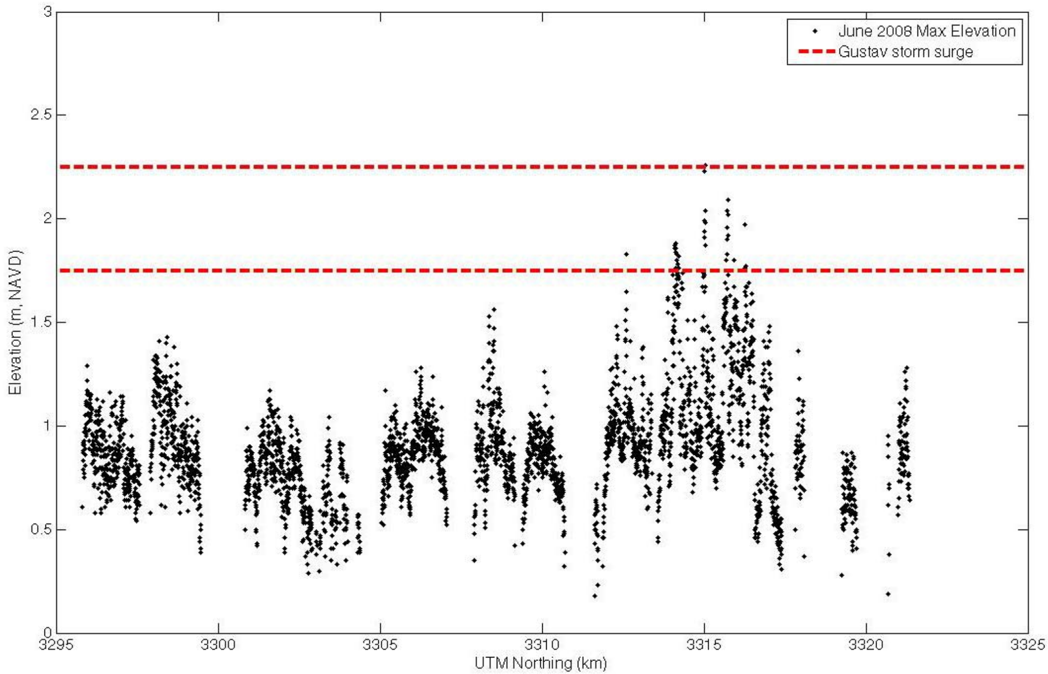


EROSION
2 d to 2 m -> 53%
2m to 12 m -> 57%
12m to 22m-> 69%
22m to 34m-> 54%
North
Post-Katrina Isand
Surface Area
Time
Post Katrina
Survey
Date
34 months June 24, 2008
22 months June 27-28, 2007
12 months September 20-21, 2006
6 months March 14-15, 2006
2 months October 28-29, 2005
2 days September 1&4, 2005
base photograph January 20, 2004
USGS DOQQ
0 100 250 500
meters

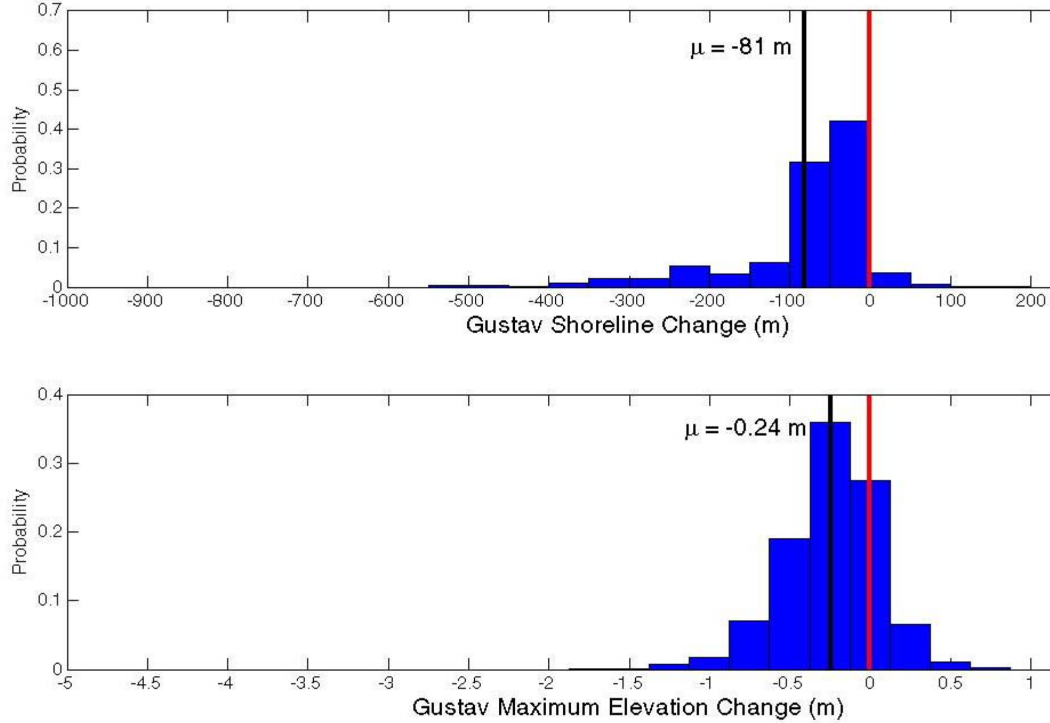

Island Area, 2002 - 2008
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
0
10
20
30
40
50
60
70
80
Months after Hurricane Lili
Lili
Ivan
Katrina
Gustav

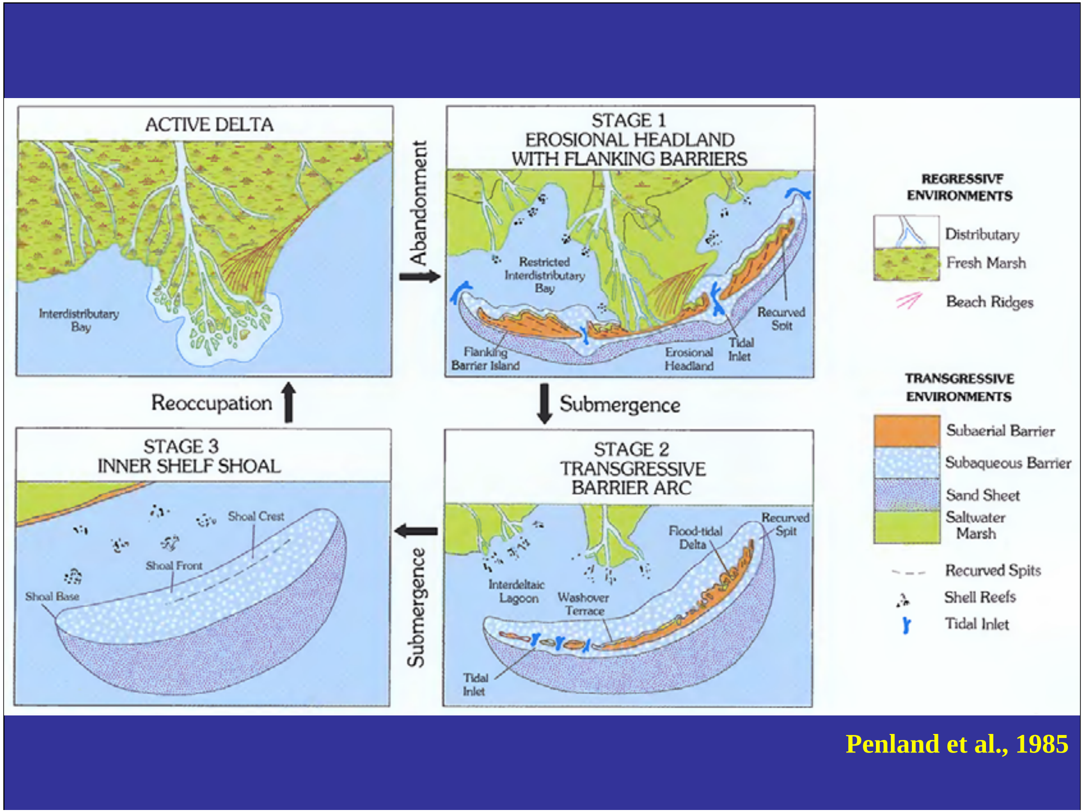


2 Days Post-Storm Bare Earth Maximum Elevation
μ = 0.72 m
Elevation (m, NAVD)
34 Months Post-Storm Bare Earth Maximum Elevation
μ = 0.90 m
Elevation (m, NAVD)
34 Months - 2 Days Post-Storm Elevation Change
mean elevation change = 0.26 m
Elevation Change (m)
UTM Northing (km)



June 2008 Max Elevation
Gustav storm surge
Elevation (m, NAVD)
UTM Northing (km)
0
0.5
1
1.5
2
2.5
3
3295
3300
3305
3310
3315
3320
3325


μ = -81 m
Probability
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-1000
-900
-800
-700
-600
-500
-400
-300
-200
-100
0
100
200
Gustav Shoreline Change (m)
μ = -0.24 m
Probability
0.4
0.3
0.2
0.1
0
-5
-4.5
-4
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
Gustav Maximum Elevation Change (m)



Presenter's Notes:

Active delta looks like the picture, as does the St Bernard; yet they are really a continuum…showing the response of the system to changes in the balance between sediment supply and sea level rise….

-- How can man adversely affect this system???; levee…

--So this is the setting when Katrina hit--an active delta and an older one, a thousand or more years old, with the SURGE.

Presenter's Notes:

To compensate for the sinking of the delta, the land surface is built higher, by sediments spewing across the delta during floods.

Starvation can happen in two ways: 1) levees, human made, 2) channel switching, that changes MS to Atchafalaya, starving the area.

This switching has occurred a half dozen times or more in the past few thousand years…

TWO FACTORS --LEVEES, --SWITCHING

Coastal-Change Impacts of Hurricanes along the U.S. Gulf of Mexico Coast

USGS