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


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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

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.
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.
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.
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.
Chandeleur Islands
STORM SURGE
from SLOSH -- NOAA NHC

\( \eta = 0.6 \text{ m} \)

\( \eta = 3.2 \text{ m} \)

Lili
2002

Katrina
2005
**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.
Overwash regime
Du ne  B ase
Du ne
Crest
dune erosion
No Net Change
Net Dune Erosion
Net Onshore Transport
Order 100 meters
Net Onshore Transport
Order 1,000 meters
IMPACT LEVEL 1
Swash Regime
IMPACT LEVEL 2
Collison Regime
IMPACT LEVEL 3
Overwash Regime
IMPACT LEVEL 4
Inundation Regime
overwash deposit
dune erosion
Sallenger (2000)
Extreme coastal change

Chandeleur Islands, LA
Chandeleur Islands, Louisiana

Pre Katrina

Post Katrina

July 17, 2001

August 31, 2005
EROSION

- 2 d to 2 m -> 53%
- 2m to 12 m -> 57%
- 12m to 22m -> 69%
- 22m to 34m -> 54%
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