Wetland attenuation of Hurricane Rita's storm surge

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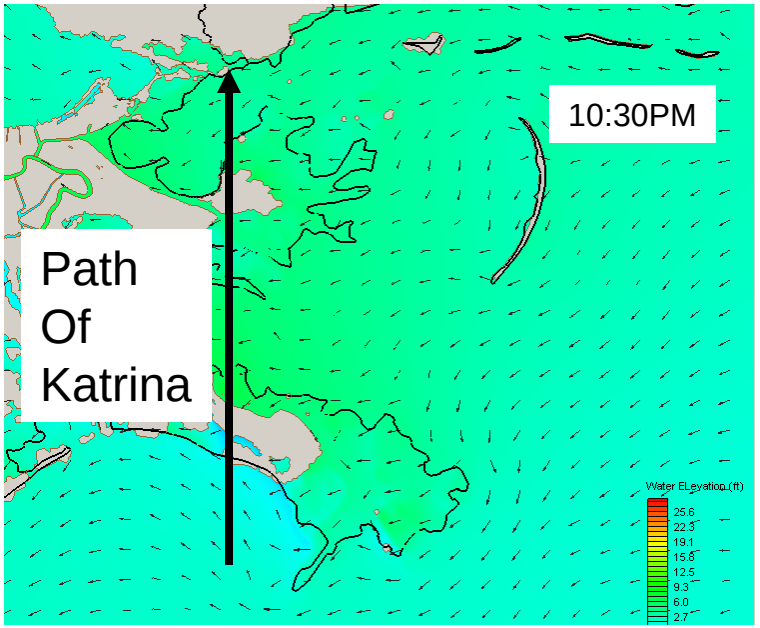
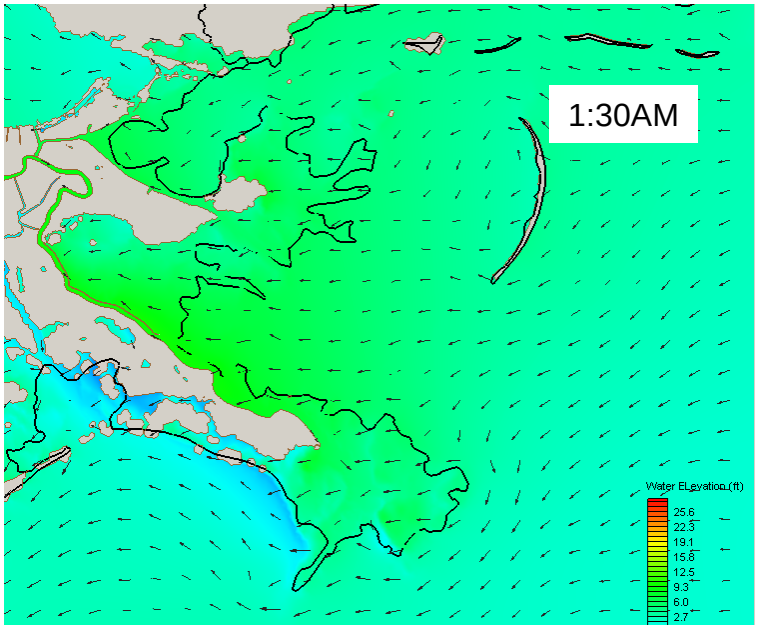
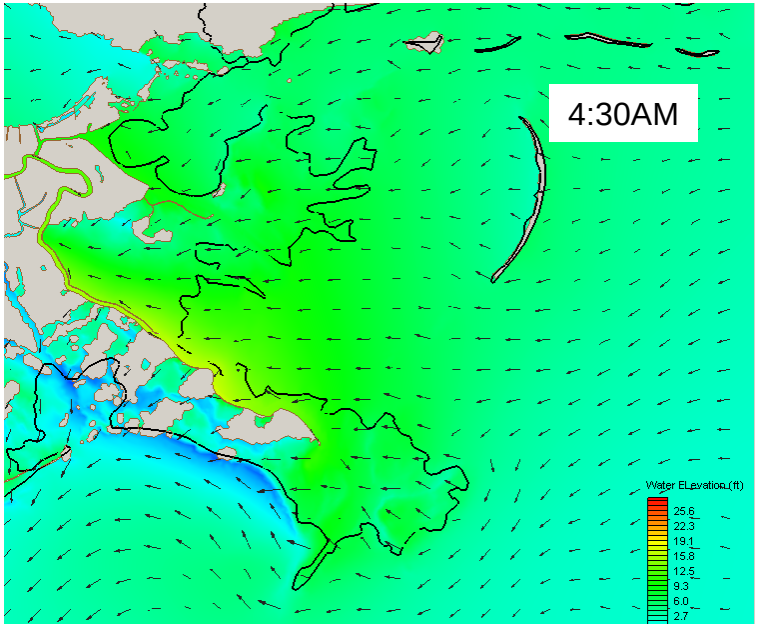
Sponsors: NOAA &
Northern Gulf Institute

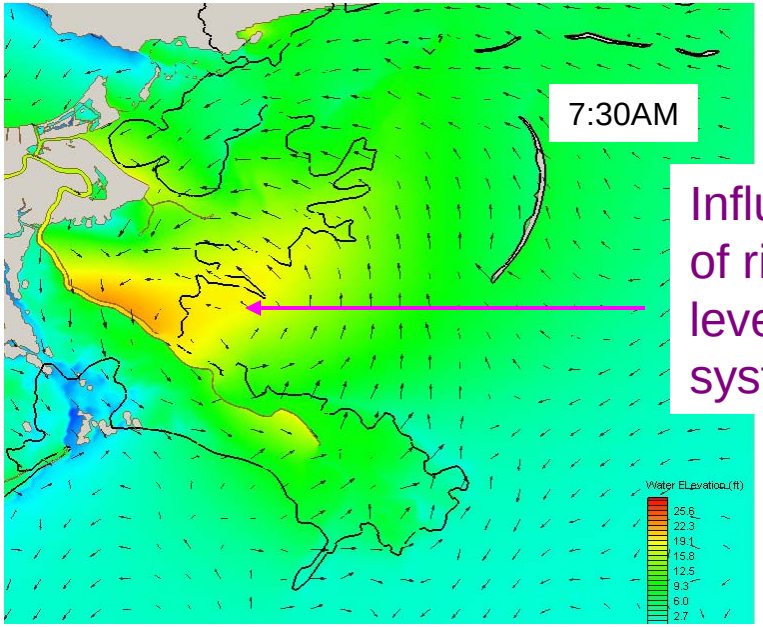
I. Influence of river levees

Computer simulation of Katrina storm surge in Louisiana marsh

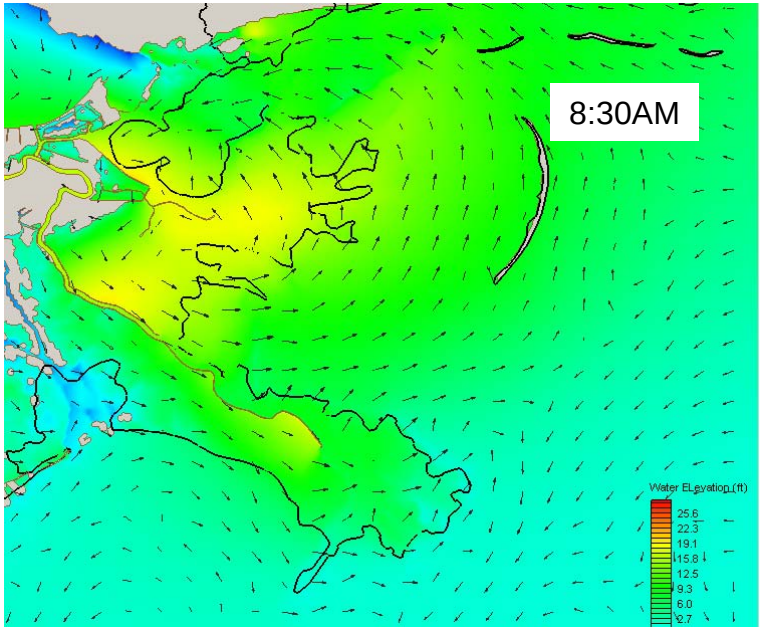


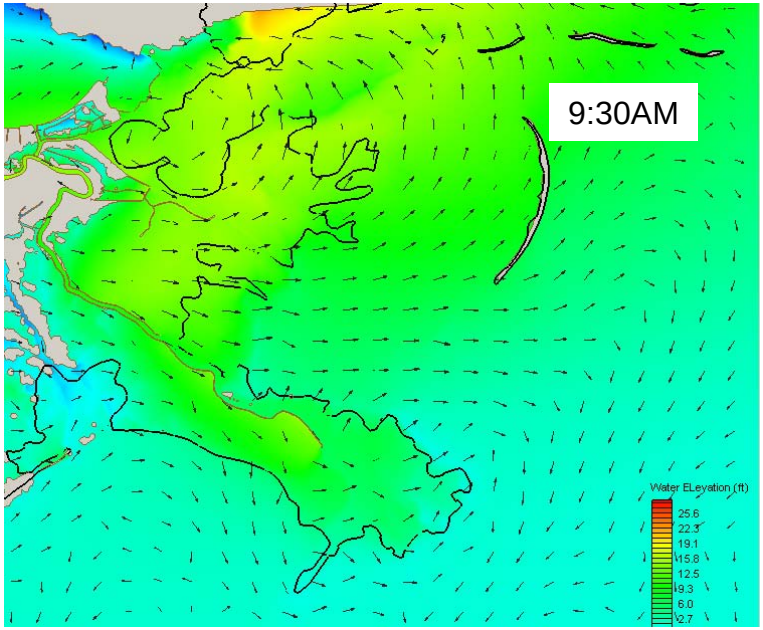


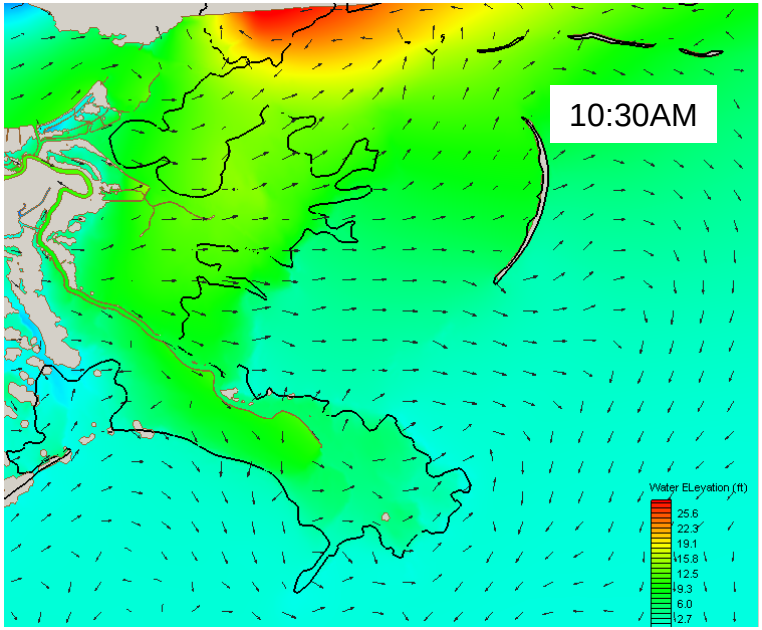


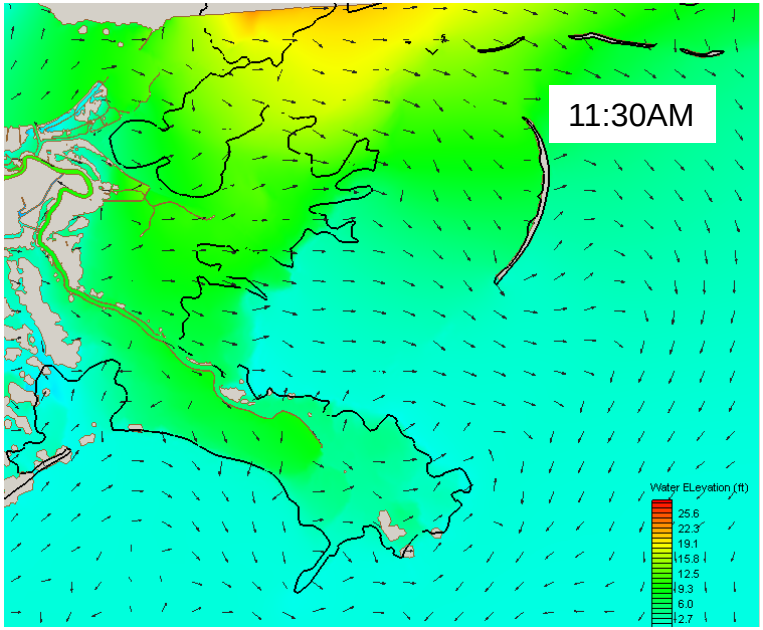


Computer simulation of Katrina storm surge in Louisiana marsh









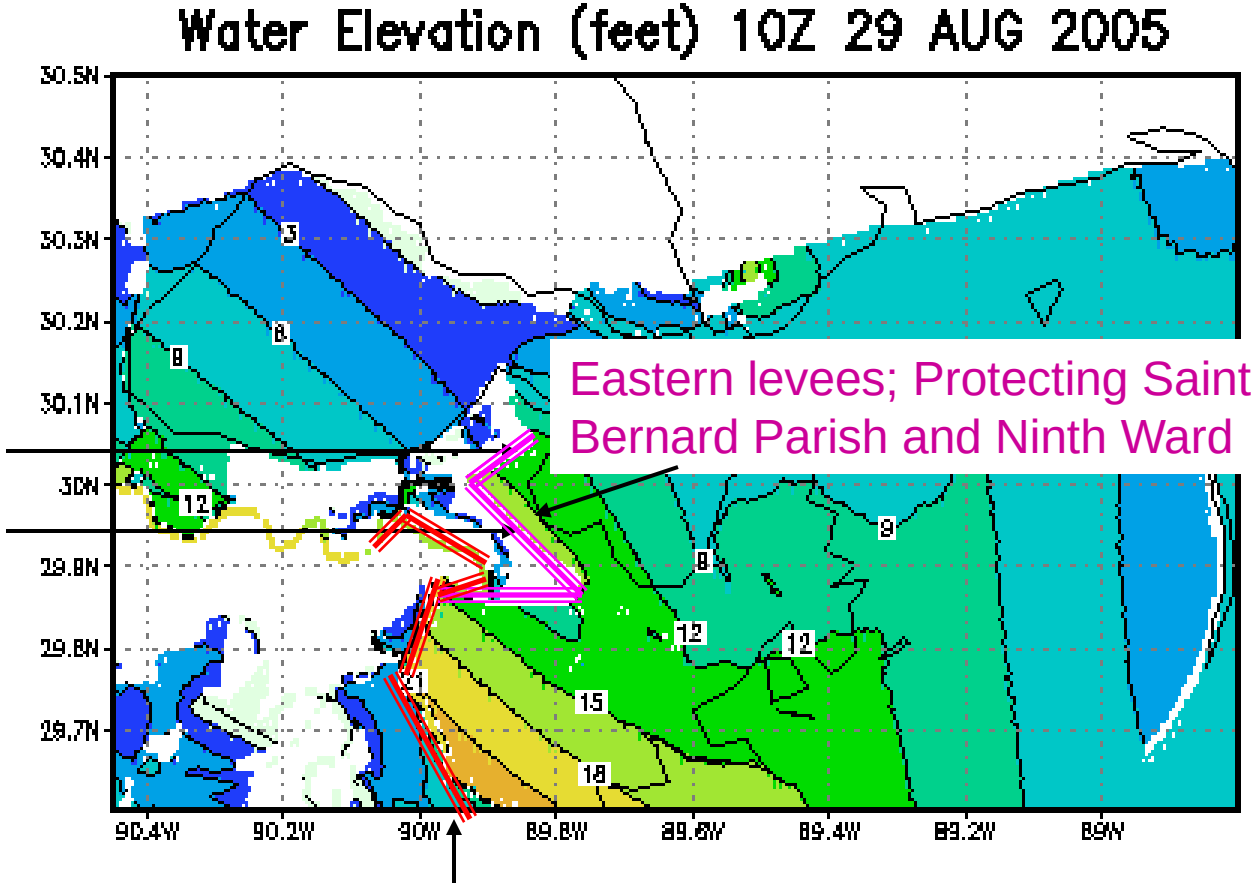
Methodology

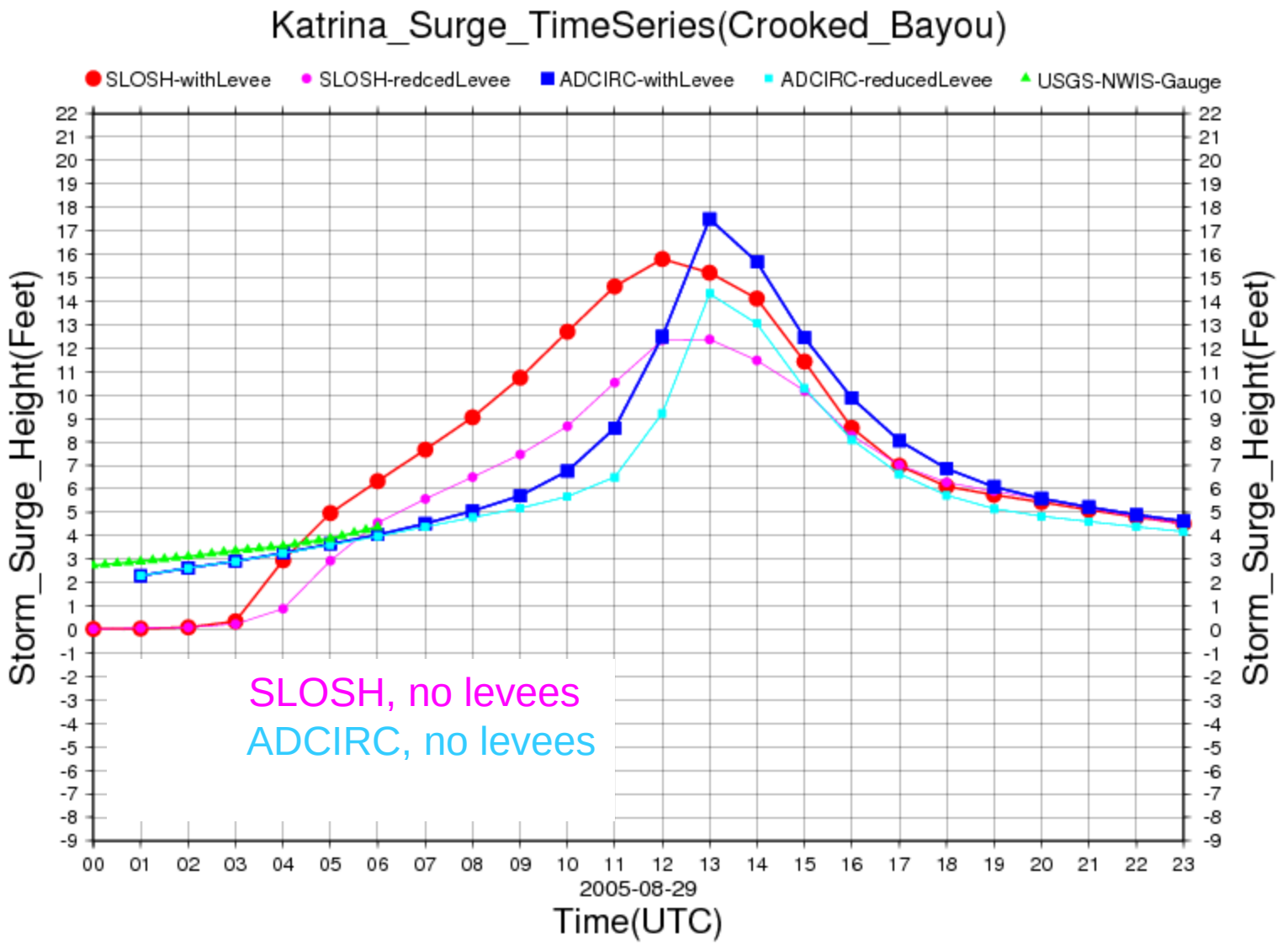
- Goal – Examine the impact of the Mississippi River levee system in enhancing Katrina's storm surge
- Land elevation is reduced to 4 feet to mimic the natural ridge along the river system from Venice to Chalmette.
- This allows the surge to overflow into the river and into the Barataria Bay system, as it would have before 10-15 feet river levees were added in the 1930s.

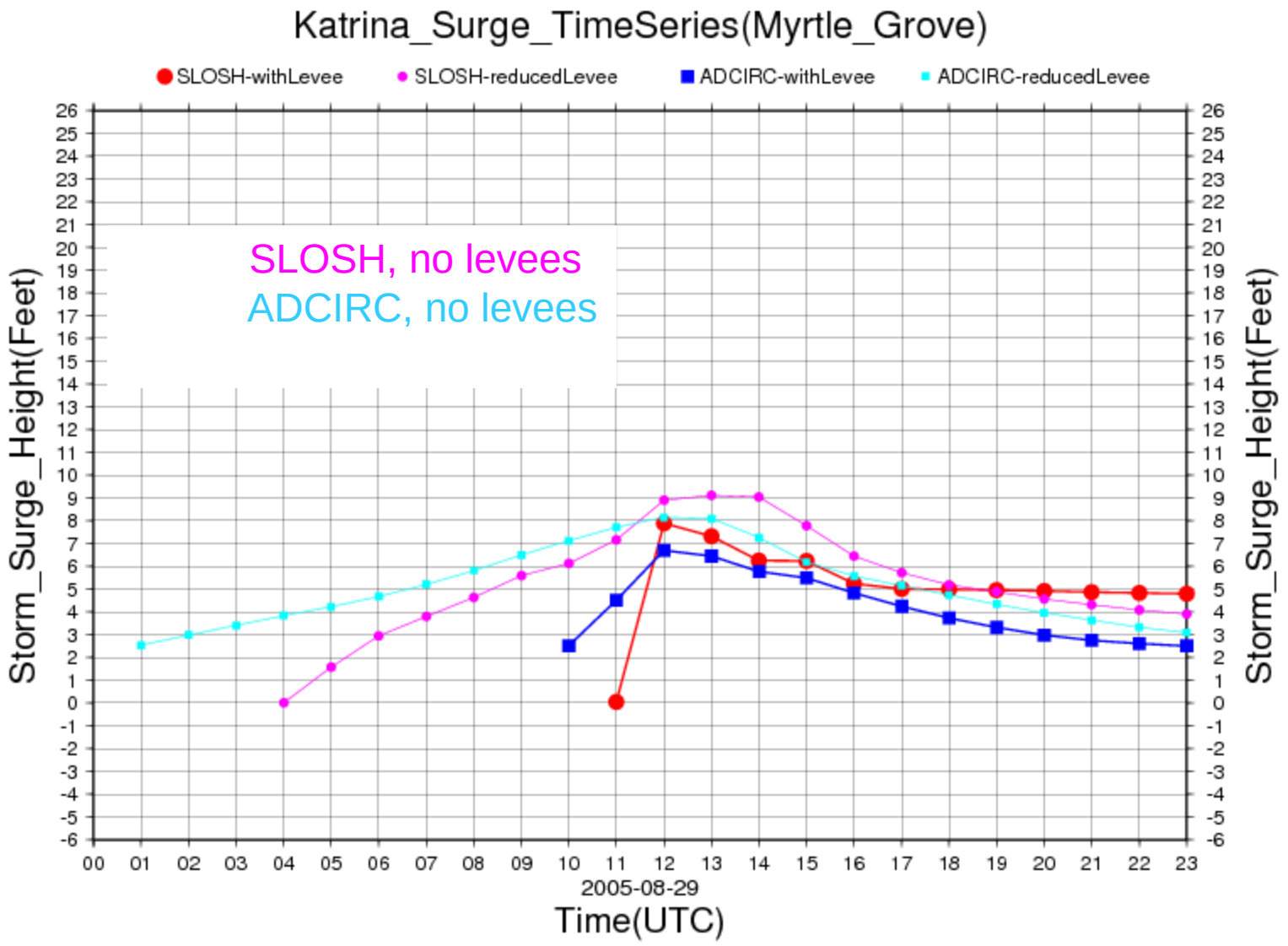
Control run, with river levees

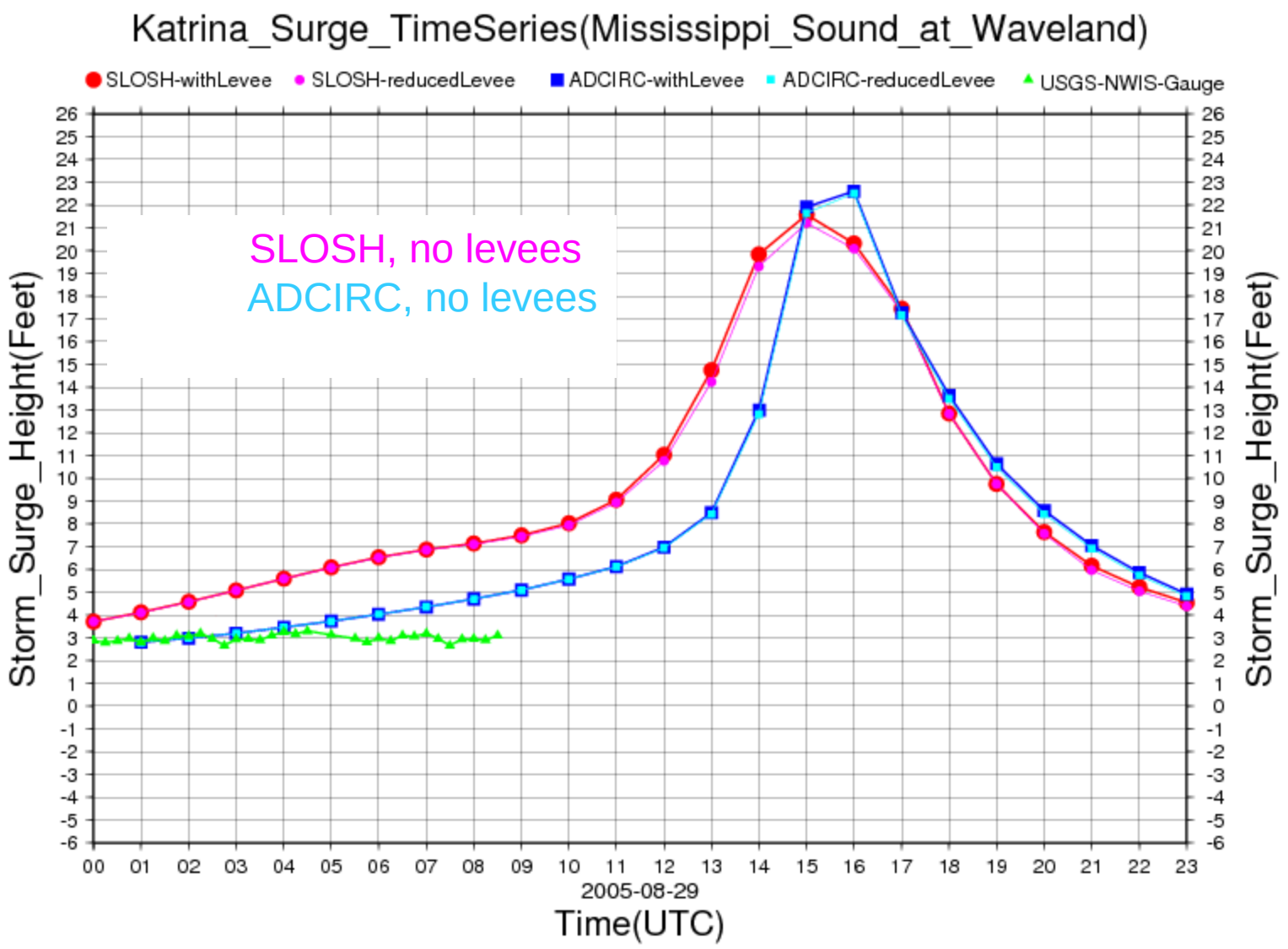
4AM

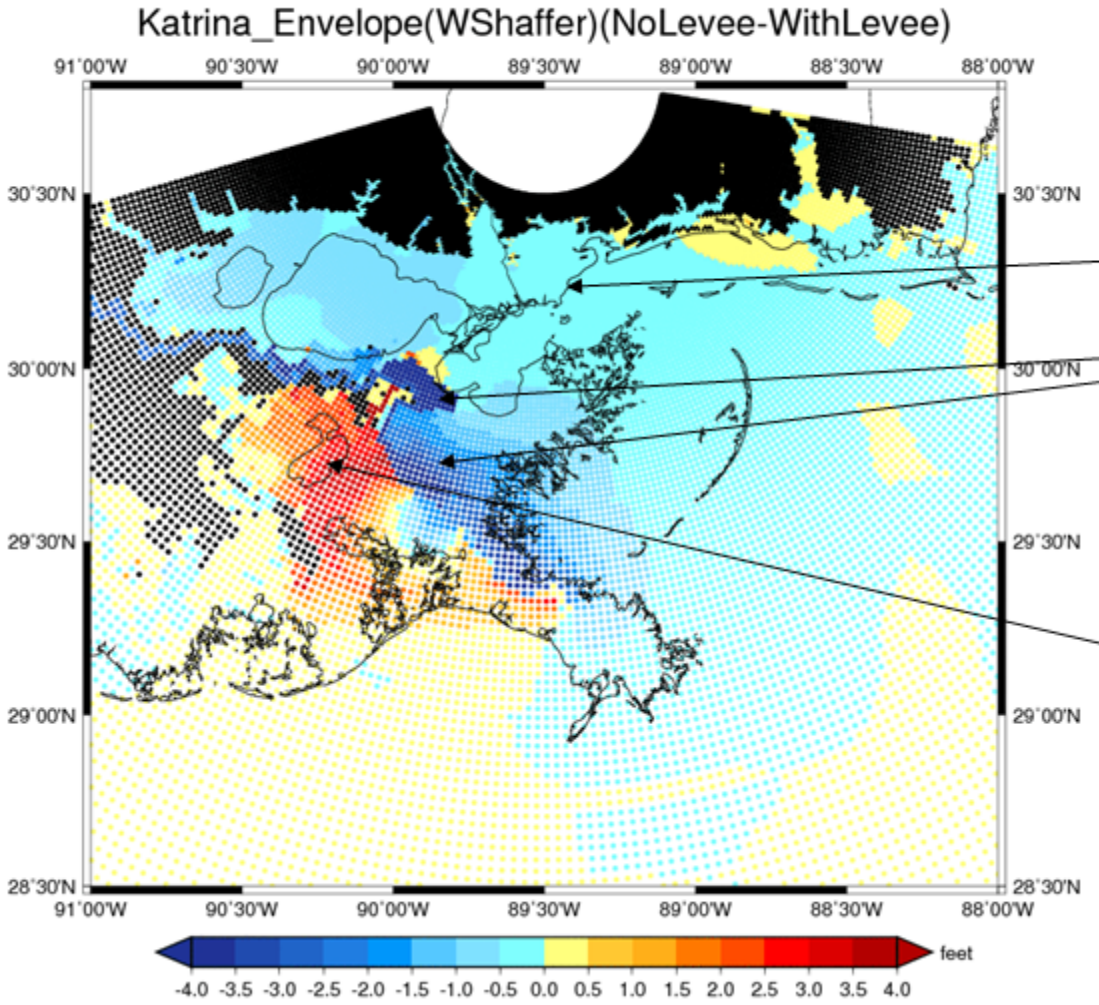
No water over levees east of city




Katrina_Surge_TimeSeries(Crooked_Bayou)
SLOSH-withLevee
SLOSH-redcedLevee
ADCIRC-withLevee
ADCIRC-reducedLevee
USGS-NWIS-Gauge
Storm_Surge_Height(Feet)
Storm_Surge_Height(Feet)
SLOSH, no levees
ADCIRC, no levees
2005-08-29
Time(UTC)


Katrina_Surge_TimeSeries(Myrtle_Grove)
SLOSH-withLevee
SLOSH-reducedLevee
ADCIRC-withLevee
ADCIRC-reducedLevee
SLOSH, no levees
ADCIRC, no levees
Storm_Surge_Height(Feet)
Storm_Surge_Height(Feet)
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
2005-08-29
Time(UTC)


Katrina_Surge_TimeSeries(Mississippi_Sound_at_Waveland)
SLOSH-withLevee
SLOSH-reducedLevee
ADCIRC-withLevee
ADCIRC-reducedLevee
USGS-NWIS-Gauge
SLOSH, no levees
ADCIRC, no levees
Storm_Surge_Height(Feet)
Storm_Surge_Height(Feet)
26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6
00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23
2005-08-29
Time(UTC)



No impact

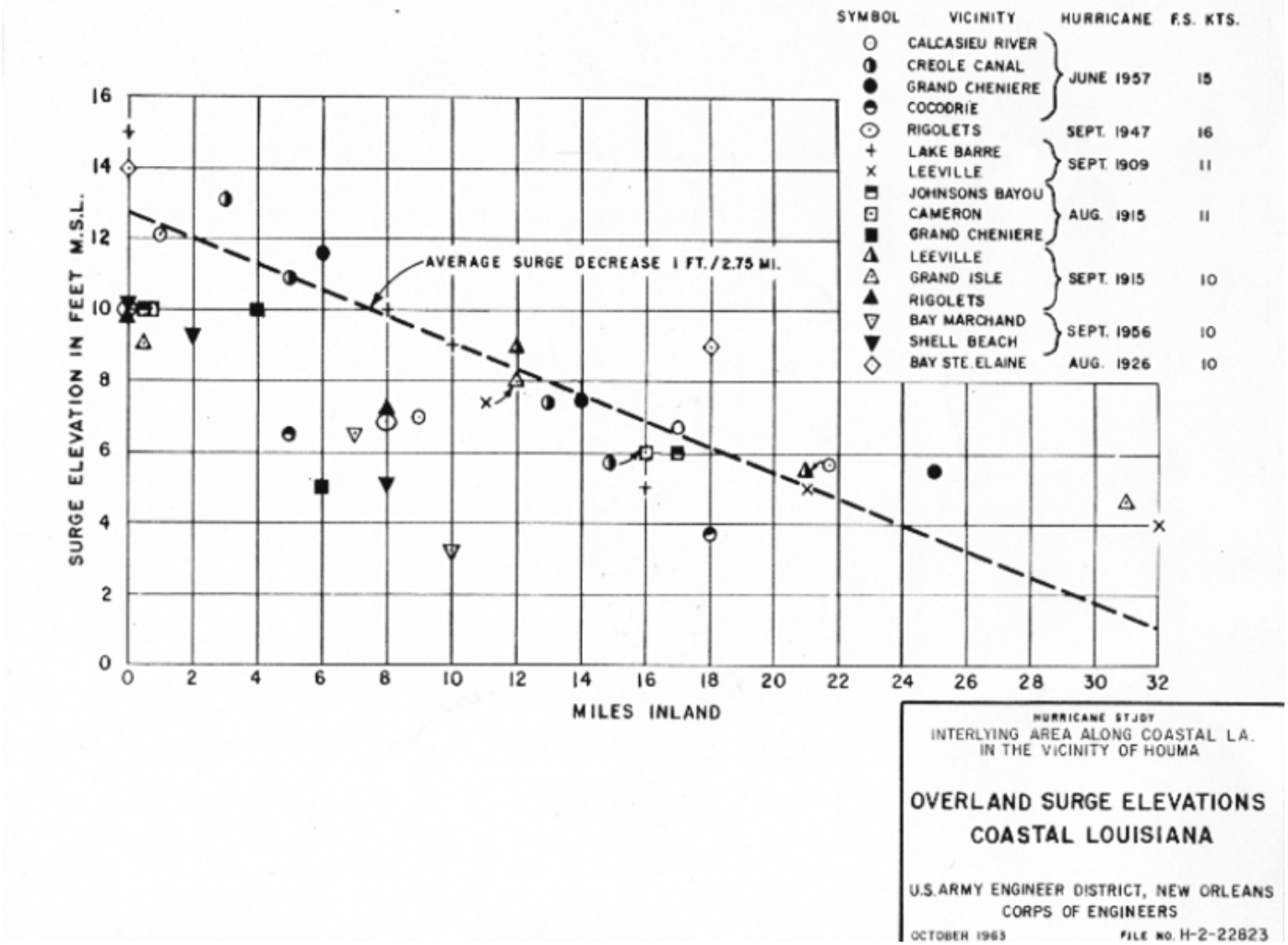
More surge, St. Bernard Parish & eas

Less surge

Summary, river levee influences

- Surge 2-3 feet higher east of river within 15 miles of levees
- Surge 1-3 feet lower west of river due to levees (north of landfall); surge also arrives later
- SLOSH suggests less overtopping (no overtopping) of parish levees if river levees did not exist; ADCIRC contradicts this result;
- The Louisiana levee system did not alter the surge impact on the Mississippi coast

II. Influence of wetlands



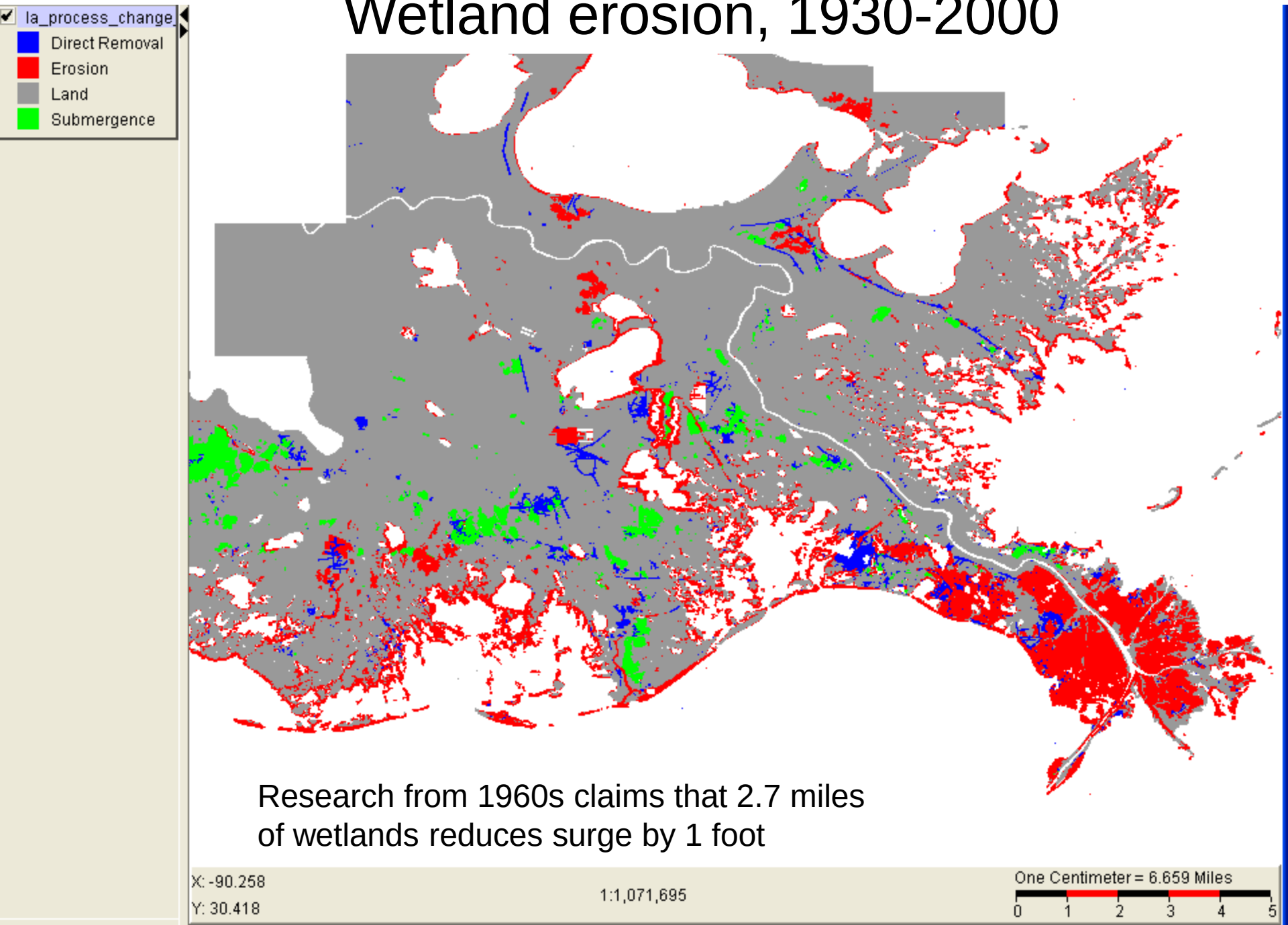
HURRICANE STUDY
INTERLYING AREA ALONG COASTAL LA.
IN THE VICINITY OF HOUMA

OVERLAND SURGE ELEVATIONS COASTAL LOUISIANA

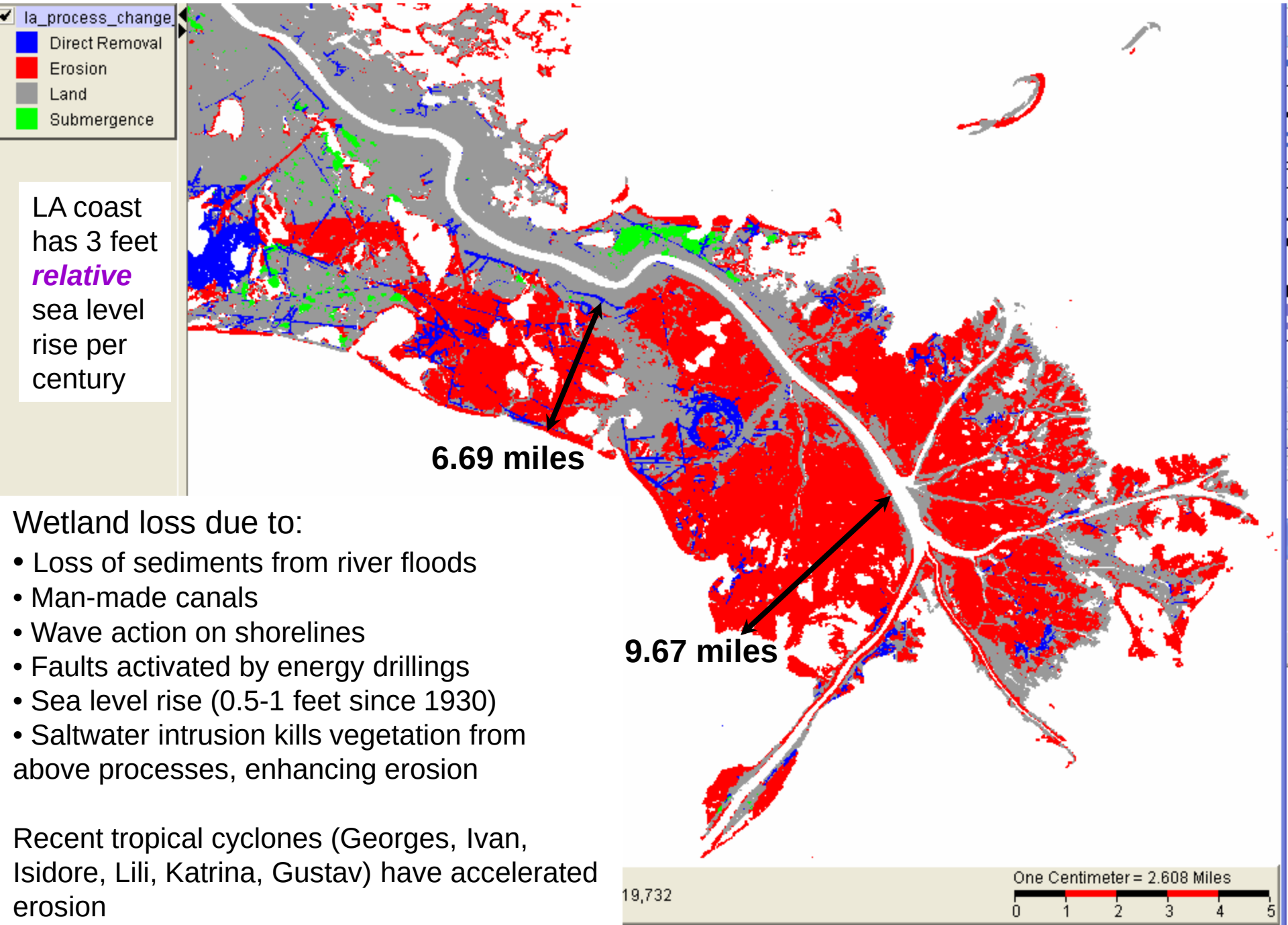
U.S. ARMY ENGINEER DISTRICT, NEW ORLEANS
CORPS OF ENGINEERS

OCTOBER 1963 FILE NO. H-2-22823

Wetland erosion, 1930-2000



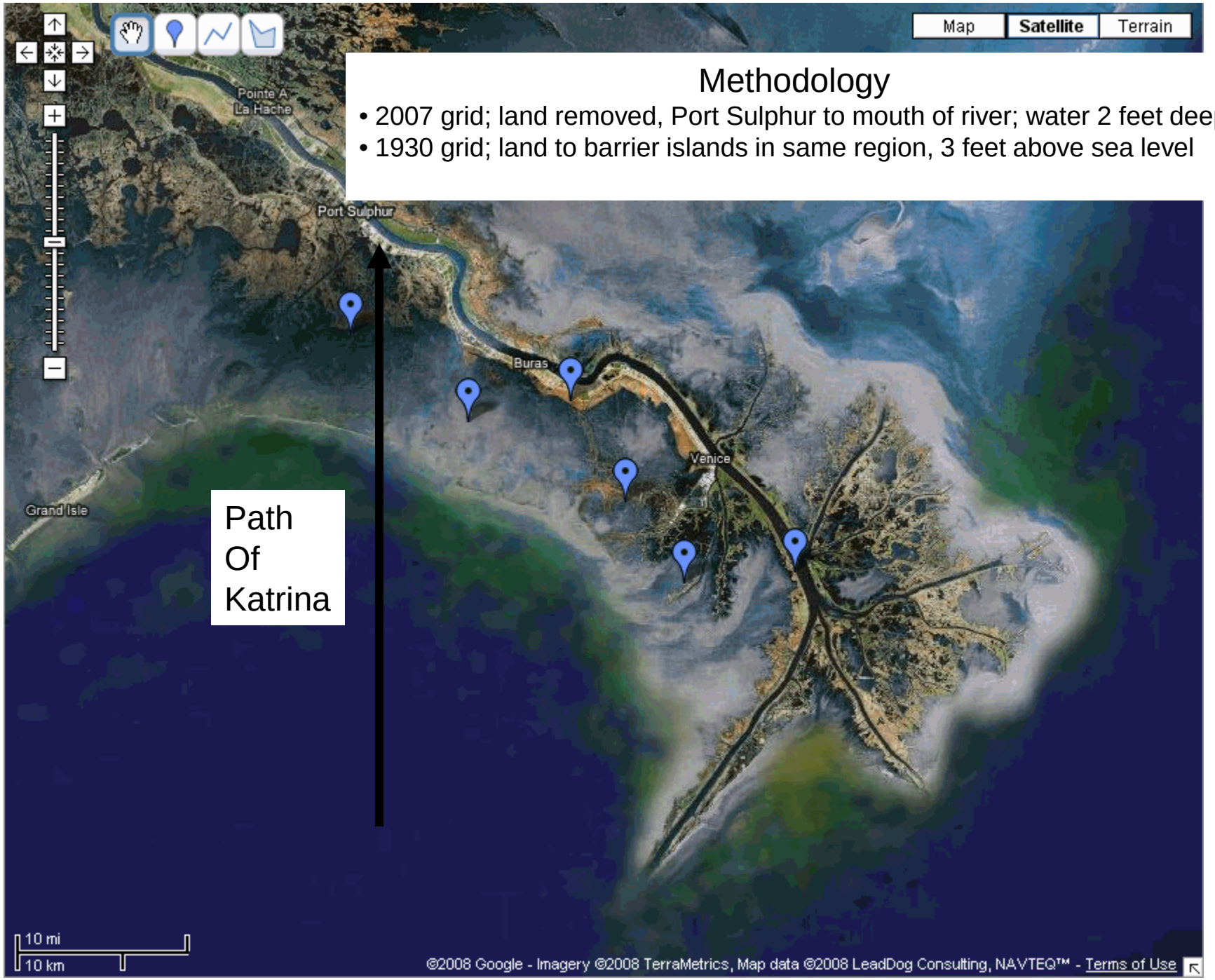
Research from 1960s claims that 2.7 miles of wetlands reduces surge by 1 foot



Wetland loss due to:

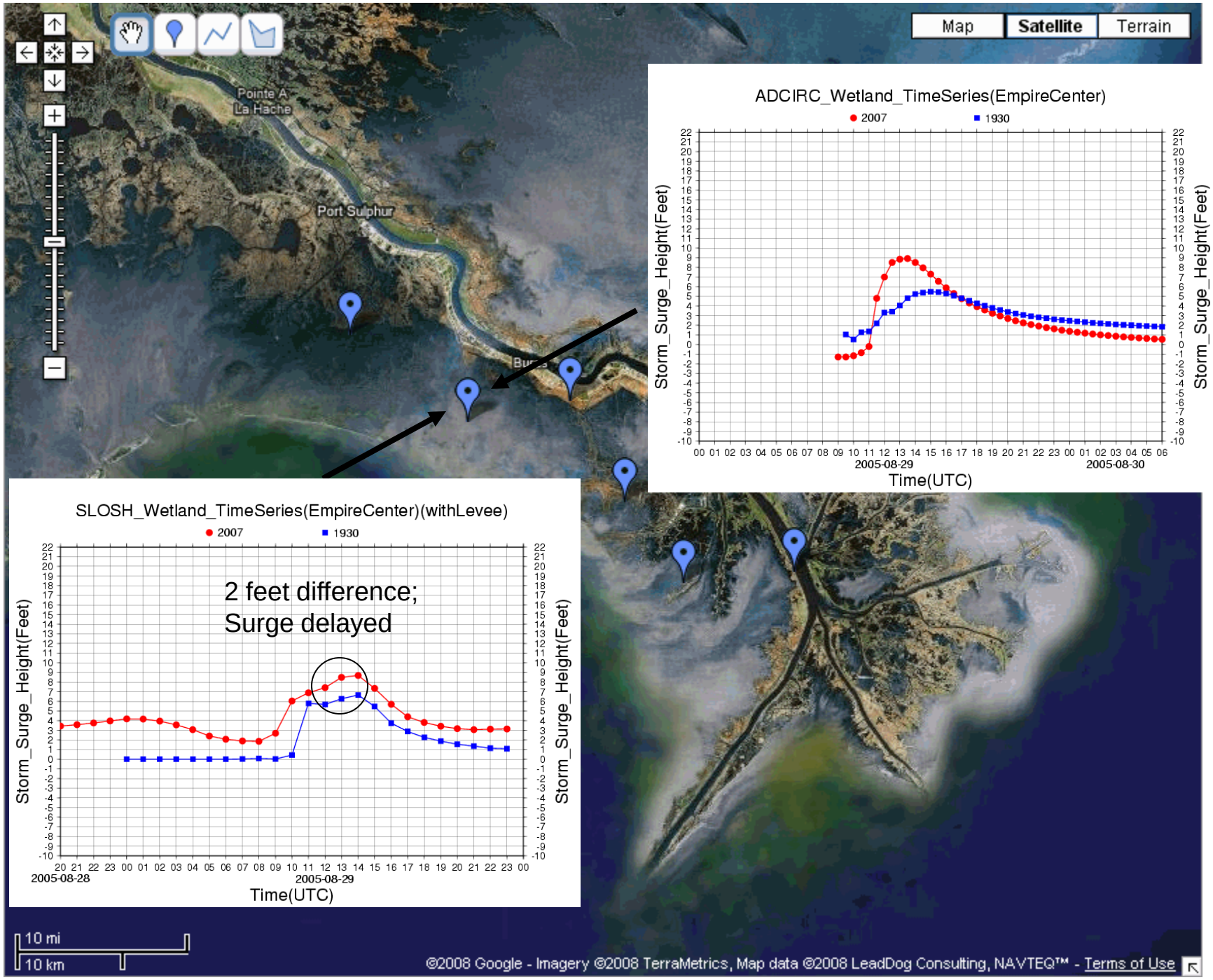
- Loss of sediments from river floods
- Man-made canals
- Wave action on shorelines
- Faults activated by energy drillings
- Sea level rise (0.5-1 feet since 1930)
- Saltwater intrusion kills vegetation from above processes, enhancing erosion

Recent tropical cyclones (Georges, Ivan, Isidore, Lili, Katrina, Gustav) have accelerated erosion



Methodology

- 2007 grid; land removed, Port Sulphur to mouth of river; water 2 feet deep
- 1930 grid; land to barrier islands in same region, 3 feet above sea level


Map
Satellite
Terrain
Pointe A La Hache
Port Sulphur
ADCIRC_Wetland_TimeSeries(EmpireCenter)
2007
1930
Storm_Surge_Height(Feet)
Time(UTC)
2005-08-29
2005-08-30
SLOSH_Wetland_TimeSeries(EmpireCenter)(withLevee)
2007
1930
2 feet difference;
Surge delayed
Storm_Surge_Height(Feet)
Time(UTC)
2005-08-28
2005-08-29
10 mi
10 km
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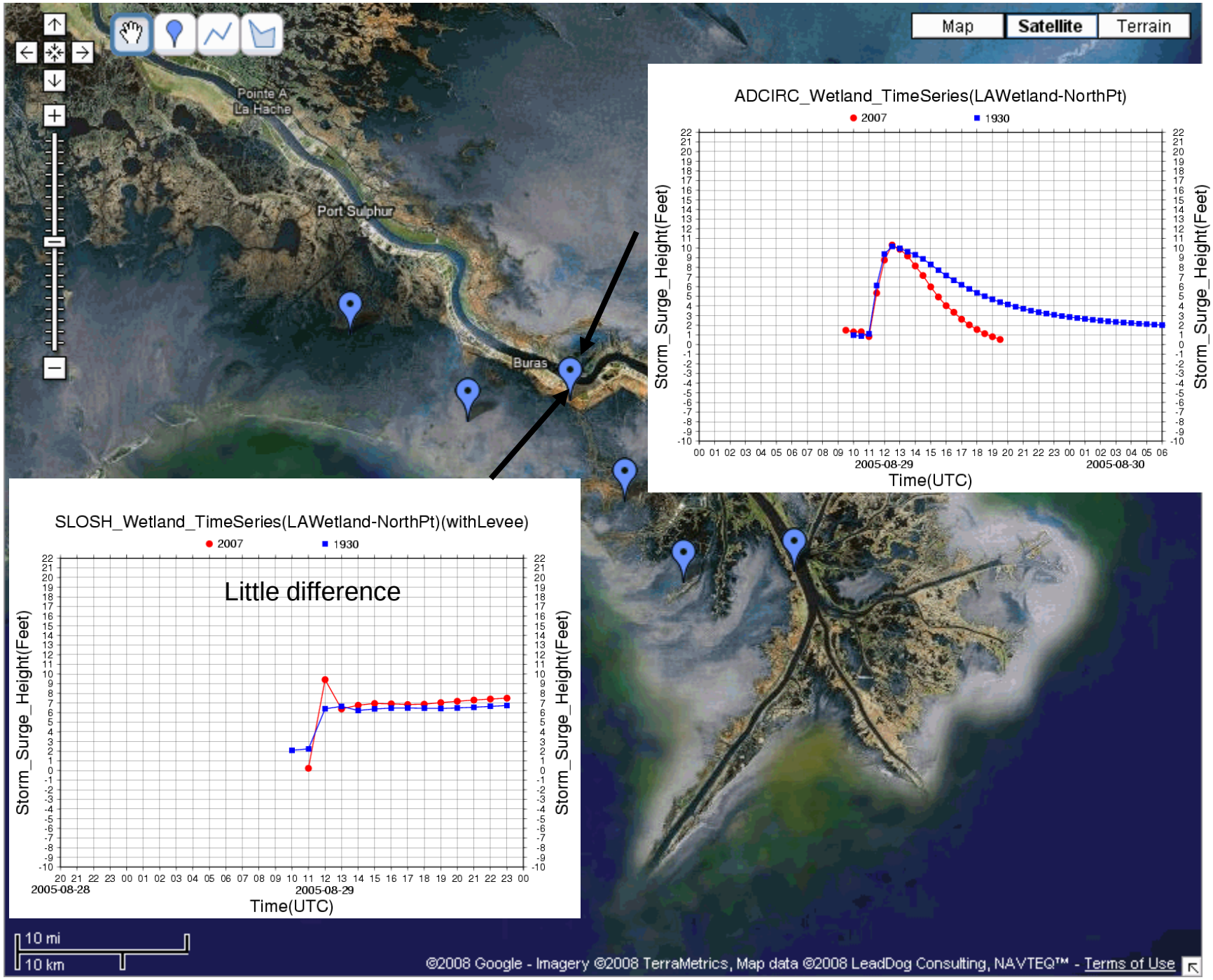
Map
Satellite
Terrain
Pointe A La Hache
Port Sulphur
Buras
ADCIRC_Wetland_TimeSeries(LAWetland-NorthPt)
2007
1930
Storm_Surge_Height(Feet)
Time(UTC)
2005-08-29
2005-08-30
SLOSH_Wetland_TimeSeries(LAWetland-NorthPt)(withLevee)
Little difference
2005-08-28
2005-08-29
10 mi
10 km
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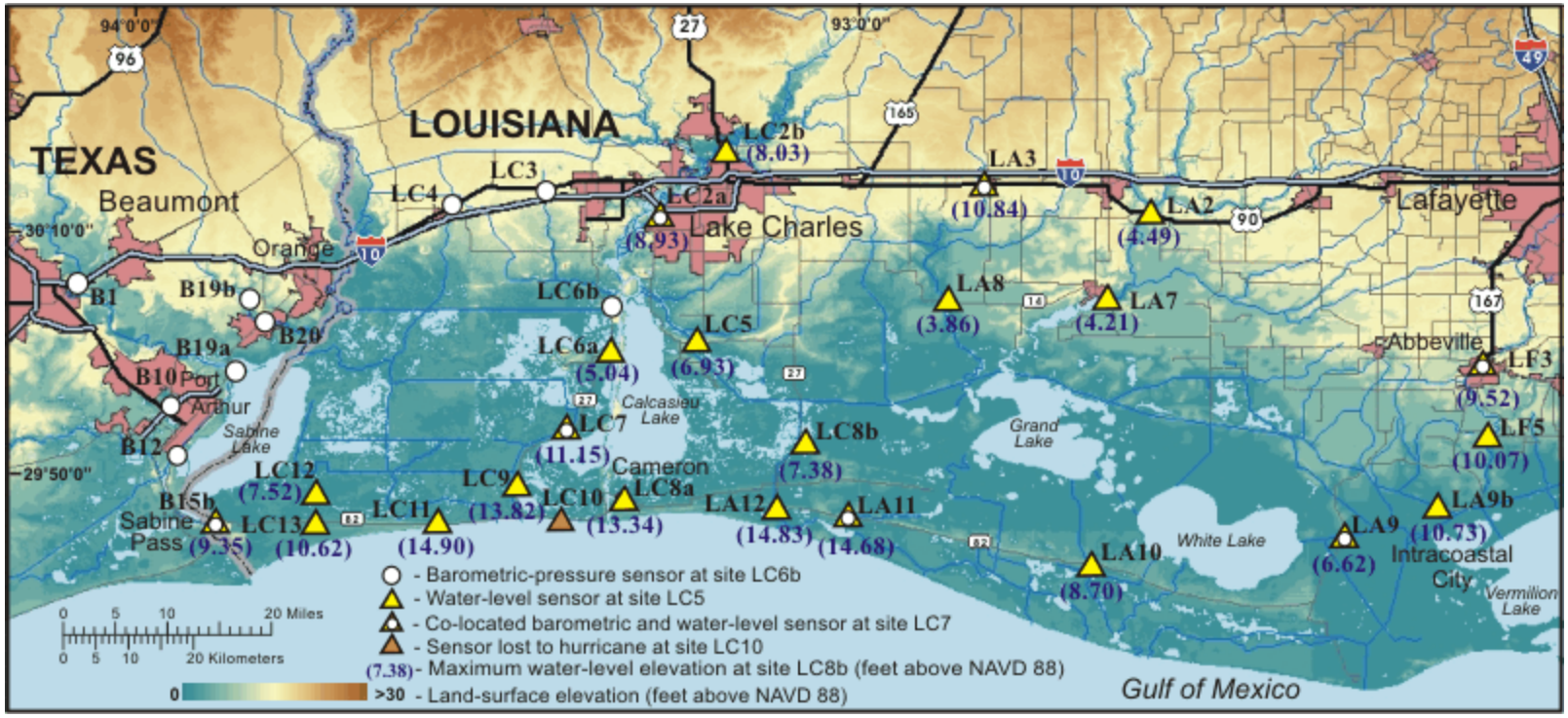
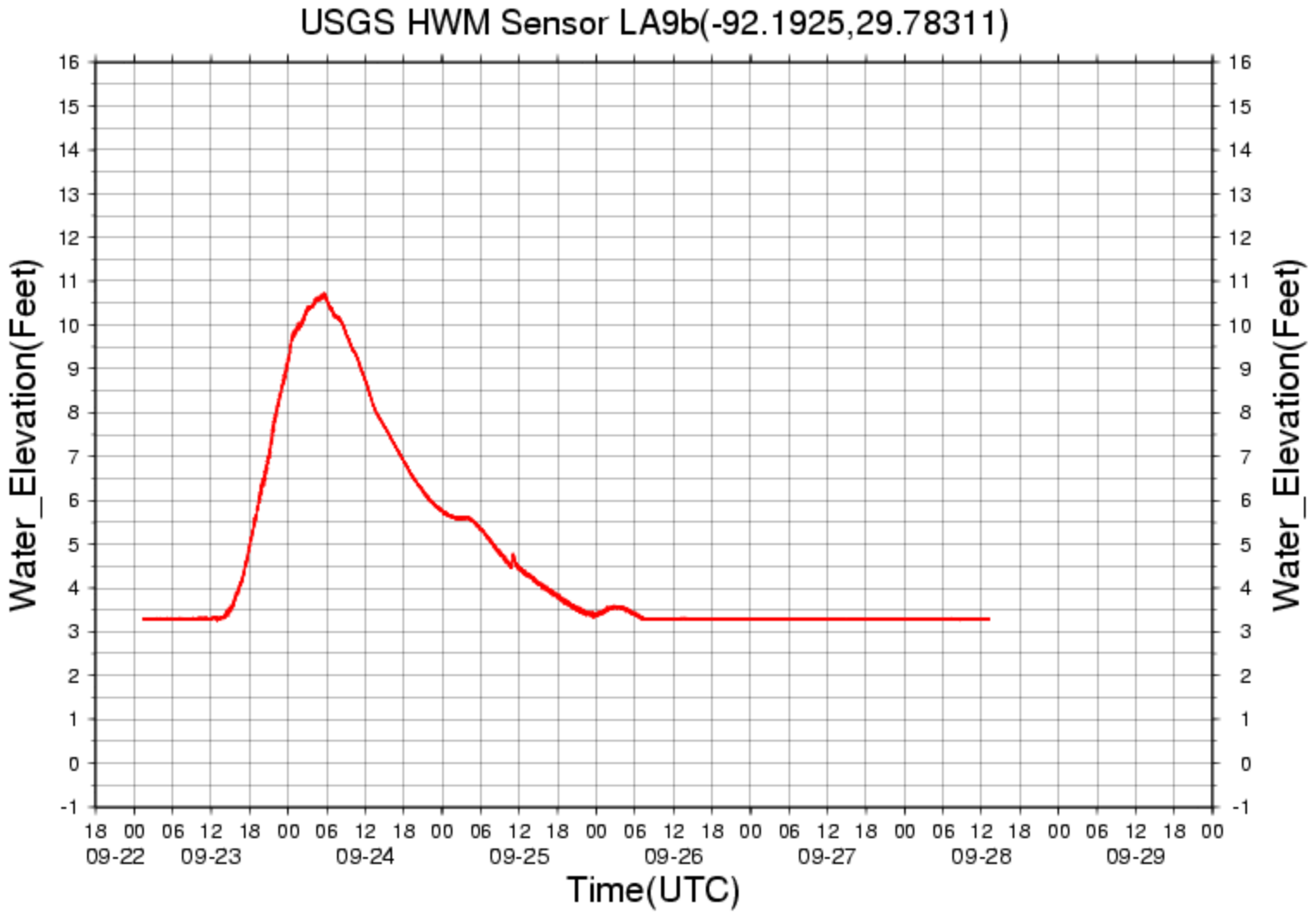
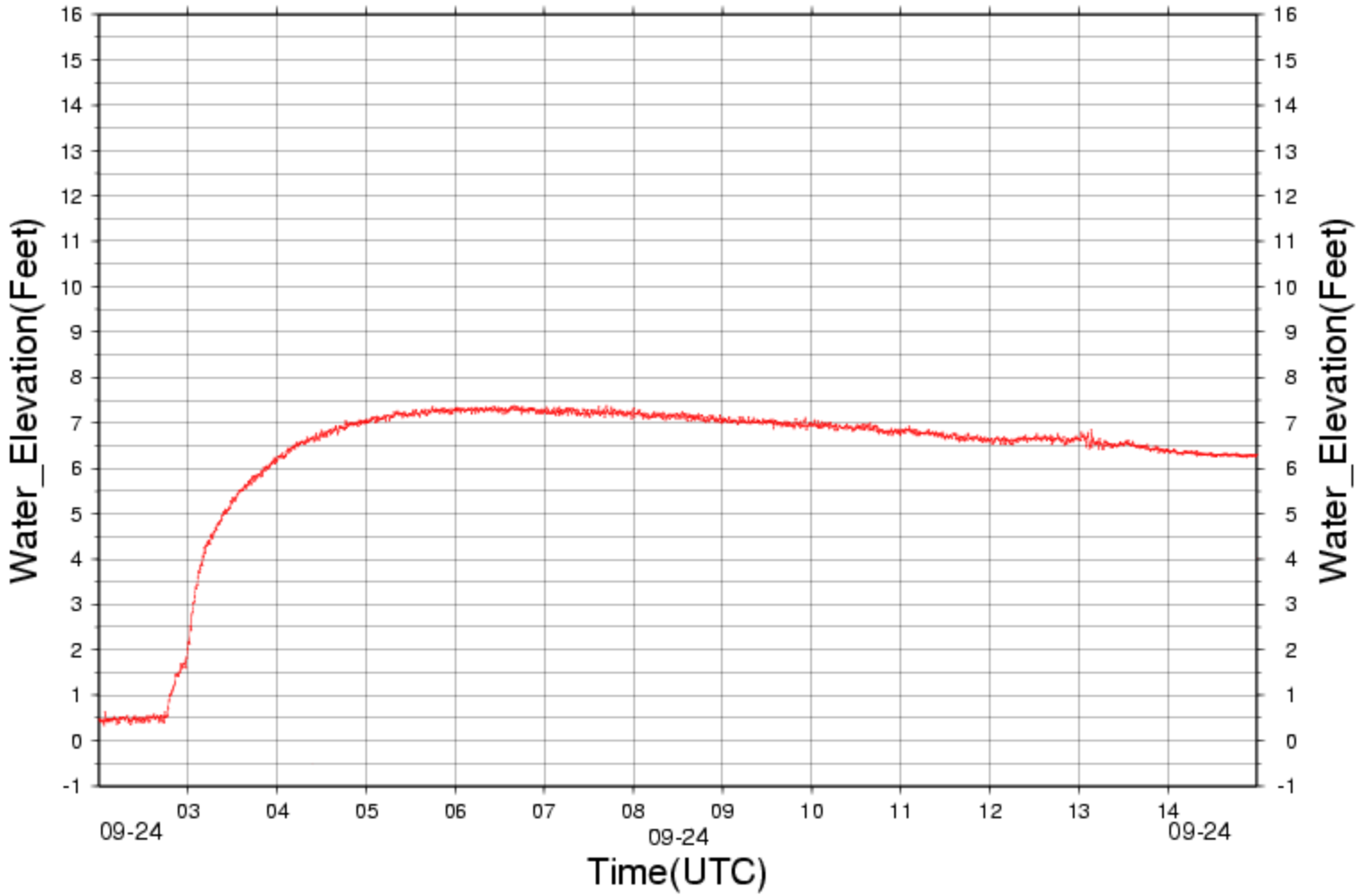
What do observations show about wetland attenuation?


94°0'0"
93°0'0"
30°10'0"
29°50'0"
TEXAS
LOUISIANA
Beaumont
Orange
Port Arthur
Sabine Lake
Sabine Pass
Lake Charles
Calcasieu Lake
Cameron
Grand Lake
White Lake
Abbeville
Lafayette
Intracoastal City
Vermilion Lake
Gulf of Mexico
B1
B19b
B20
B19a
B10
B12
B15b
LC2b (8.03)
LC3
LC4
LC2a (8.93)
LA3 (10.84)
LA2 (4.49)
LC6b
LC6a (5.04)
LC5 (6.93)
LA8 (3.86)
LA7 (4.21)
LF3 (9.52)
LF5 (10.07)
LC7 (11.15)
LC8b (7.38)
LC8a (13.34)
LC12 (7.52)
LC9 (13.82)
LC10
LC11 (14.90)
LC13 (10.62)
LA12 (14.83)
LA11 (14.68)
LA10 (8.70)
LA9 (6.62)
LA9b (10.73)
- Barometric-pressure sensor at site LC6b
- Water-level sensor at site LC5
- Co-located barometric and water-level sensor at site LC7
- Sensor lost to hurricane at site LC10
(7.38)- Maximum water-level elevation at site LC8b (feet above NAVD 88)
0 >30 - Land-surface elevation (feet above NAVD 88)
0 5 10 20 Miles
0 5 10 20 Kilometers

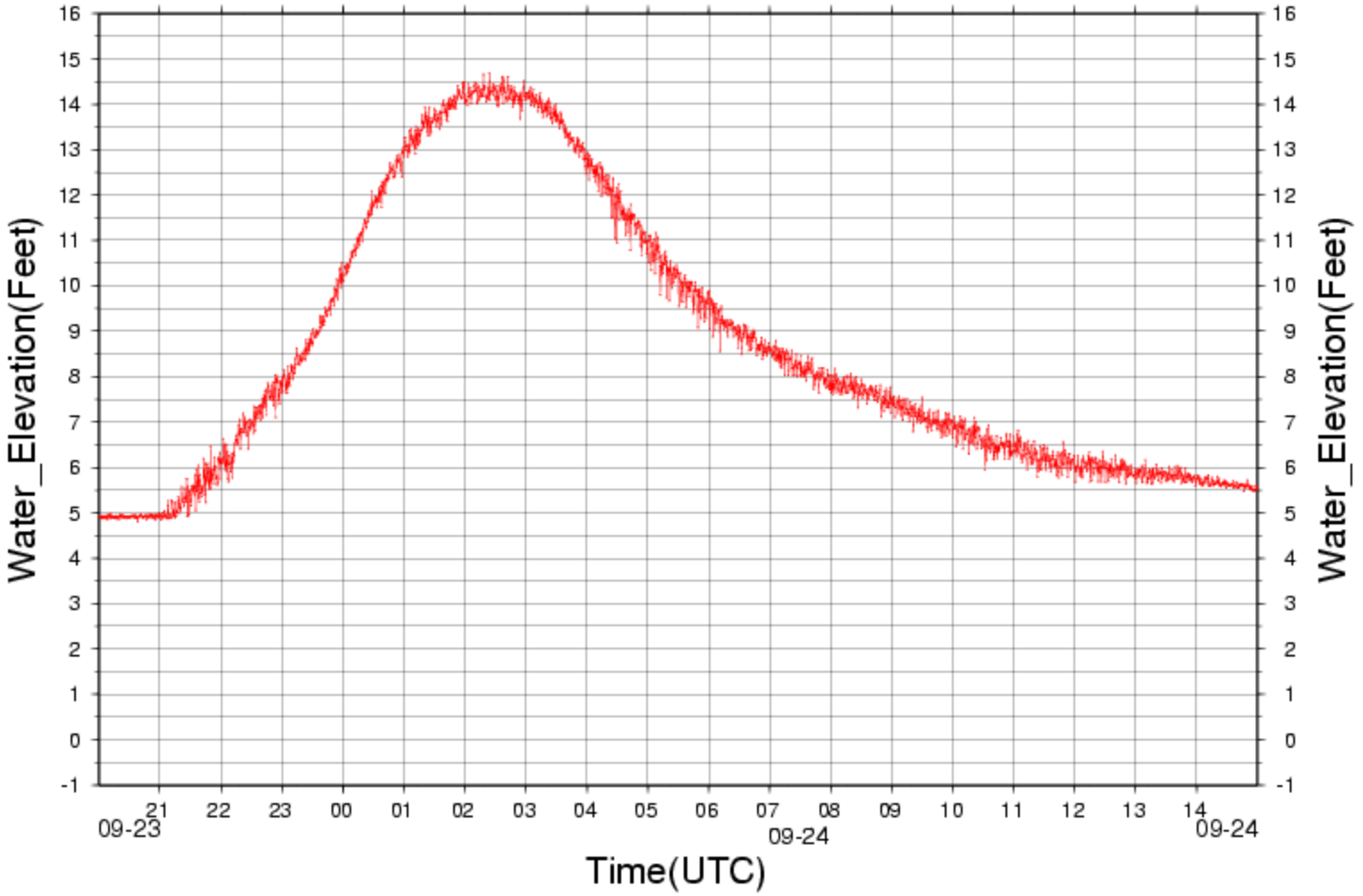
Pressure sensor strapped to a power pole at site LC4 near Vinton, La.


USGS HWM Sensor LA9b(-92.1925,29.78311)
Water_Elevation(Feet)
Water_Elevation(Feet)
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00 06 12 18 00
09-22 09-23 09-24 09-25 09-26 09-27 09-28 09-29
Time(UTC)

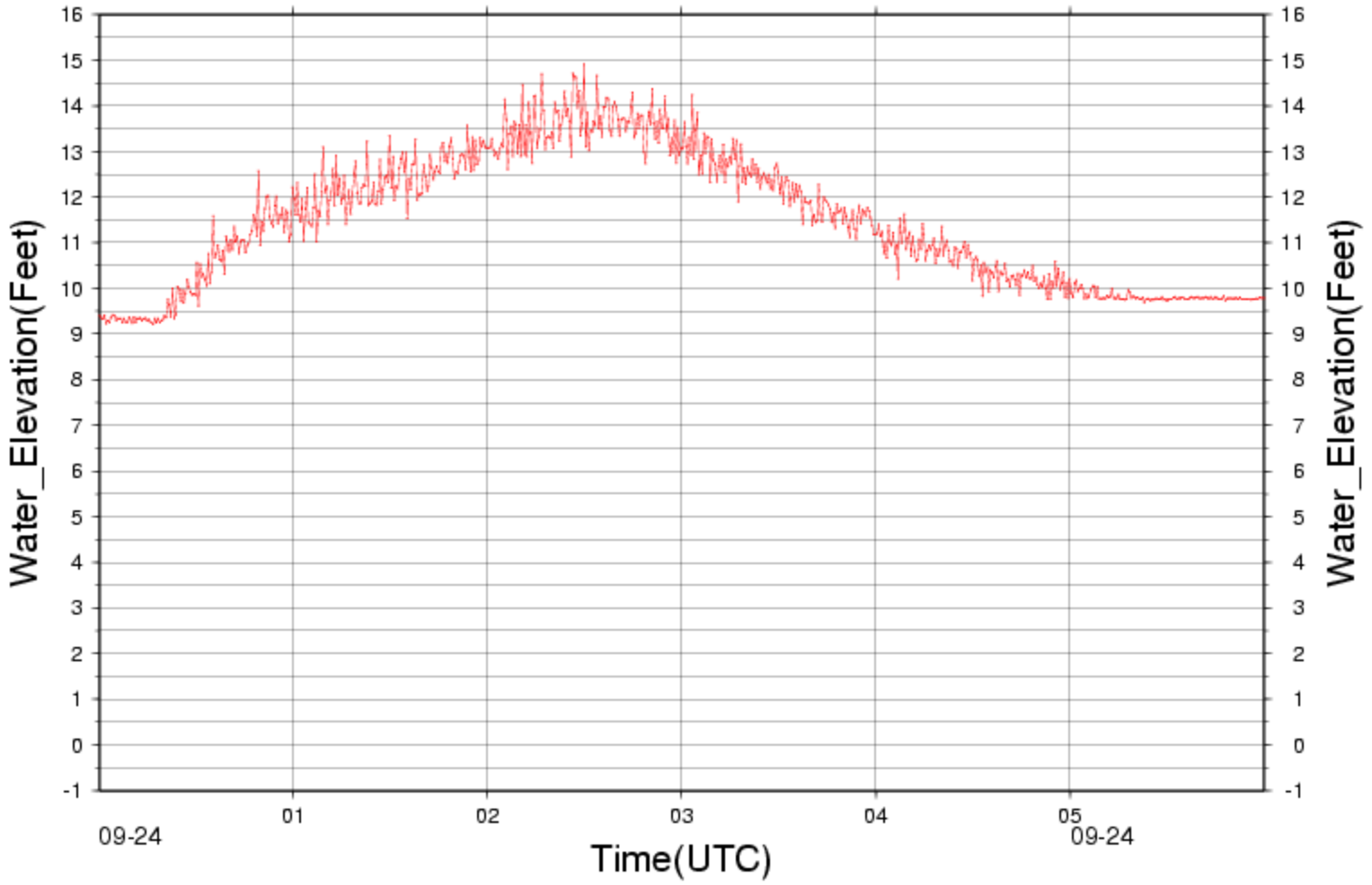
USGS HWM TimeSeries for Harmonic(Sensor LC8b)



USGS HWM TimeSeries for Harmonic(Sensor LA11)



USGS HWM TimeSeries for Harmonic(Sensor LC11)



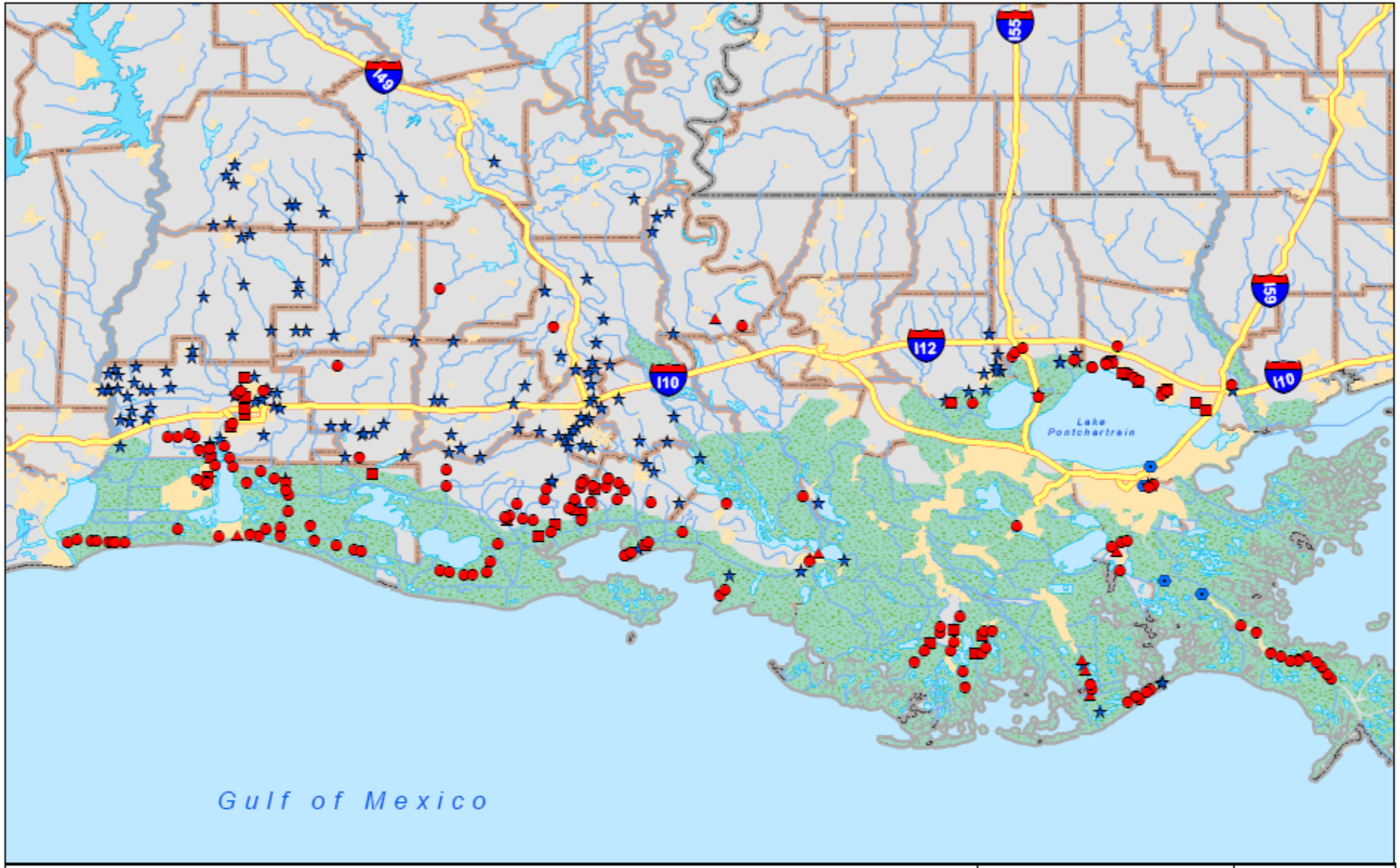


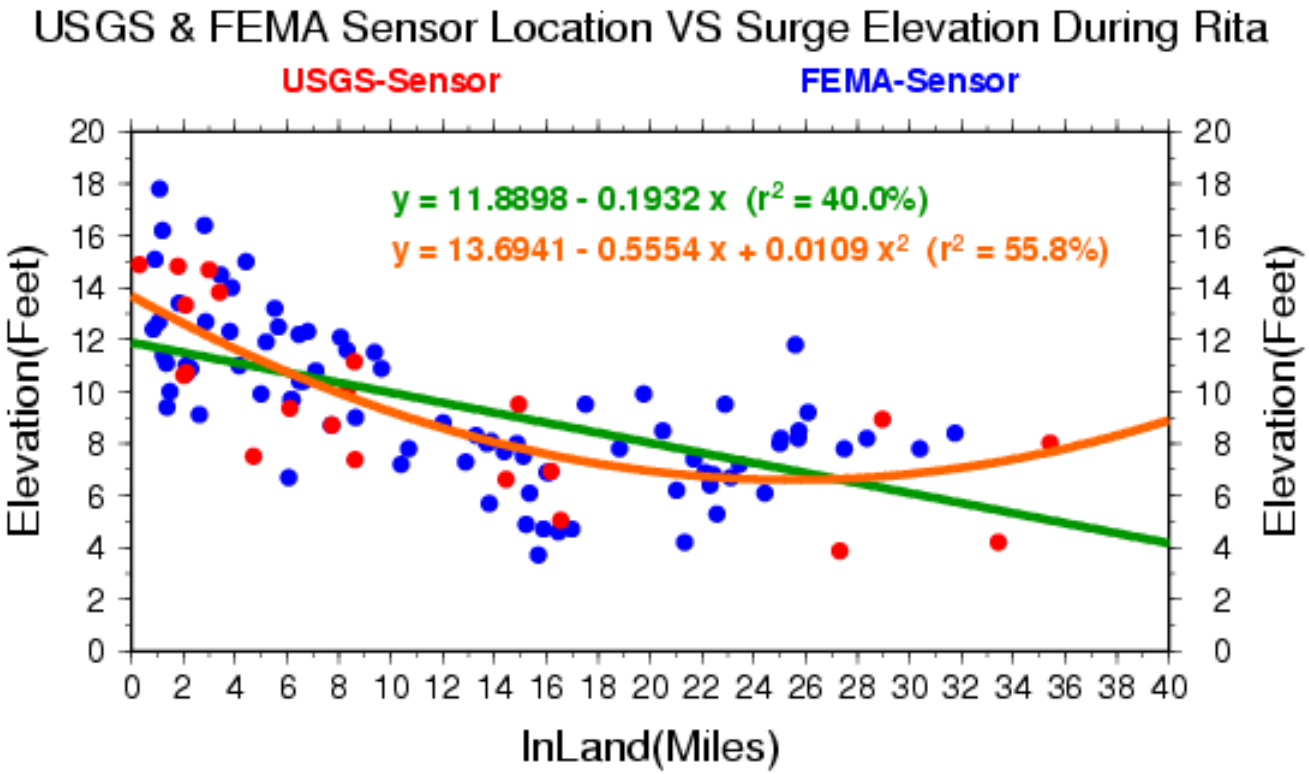
Figure 4 : Hurricane Rita, Louisiana
Surveyed Locations of High Water Mark Elevations

- Coastal- Surge Only
- Coastal- Wave Height
- Riverine
- Inset
- Municipalities
- Water Body
- Hydrology

Road Classification
- Limited Access

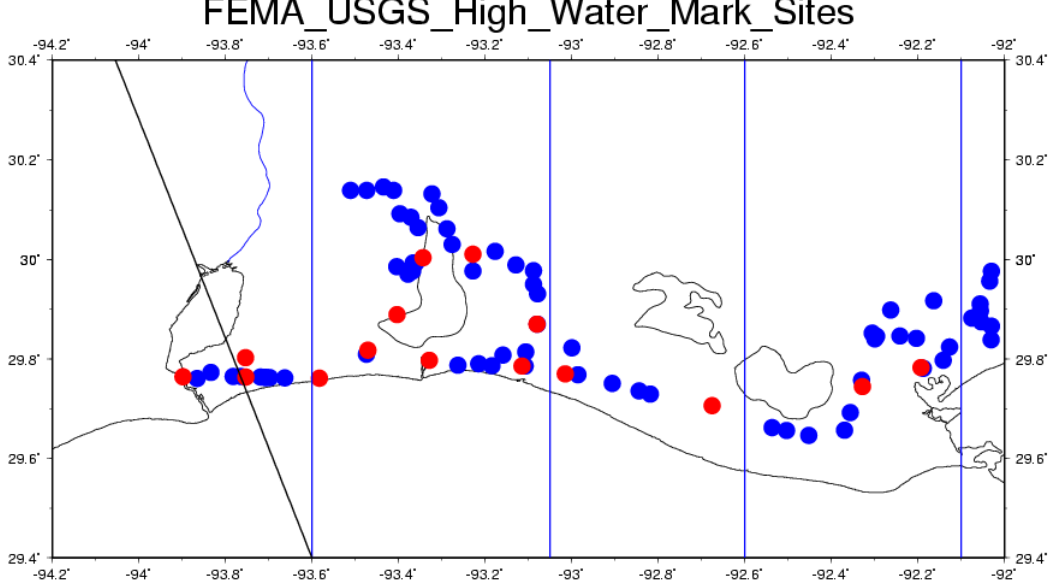
FEMA

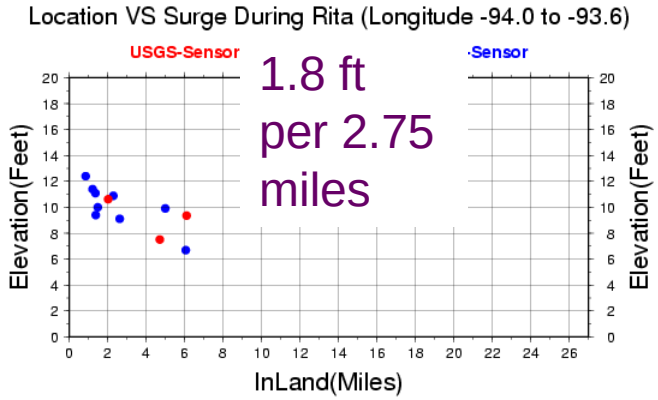
0 3.5 7 14 21 28
Miles



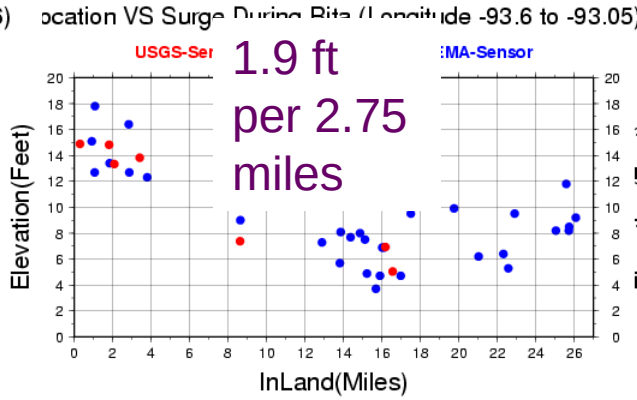
1 foot reduction every 2 miles seven miles inland (1.4 ft per 2.75 miles)

0.5-0.8 foot reduction every 2 miles afterwards

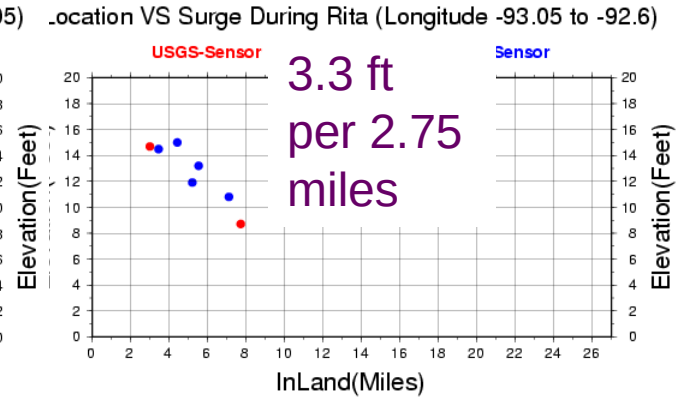




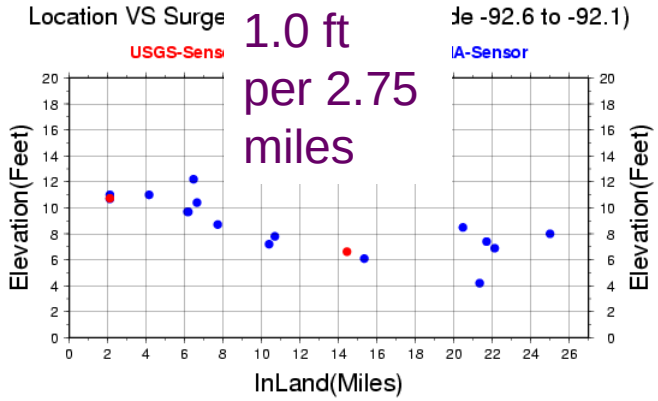
1.8 ft per 2.75 miles



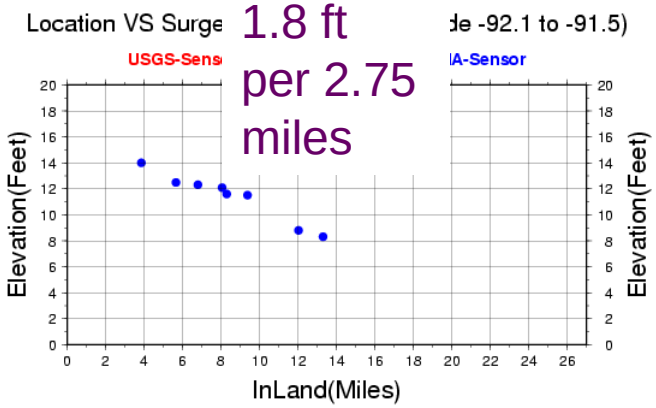
1.9 ft per 2.75 miles



3.3 ft per 2.75 miles



1.0 ft per 2.75 miles



1.8 ft per 2.75 miles

Multiple regression results: R^2=59.5%

Variable	Normalized coefficient	P value
Distance	-1.43	0.0000
Surge-elevation	0.26	0.0023
Distance squared	1.00	0.0000

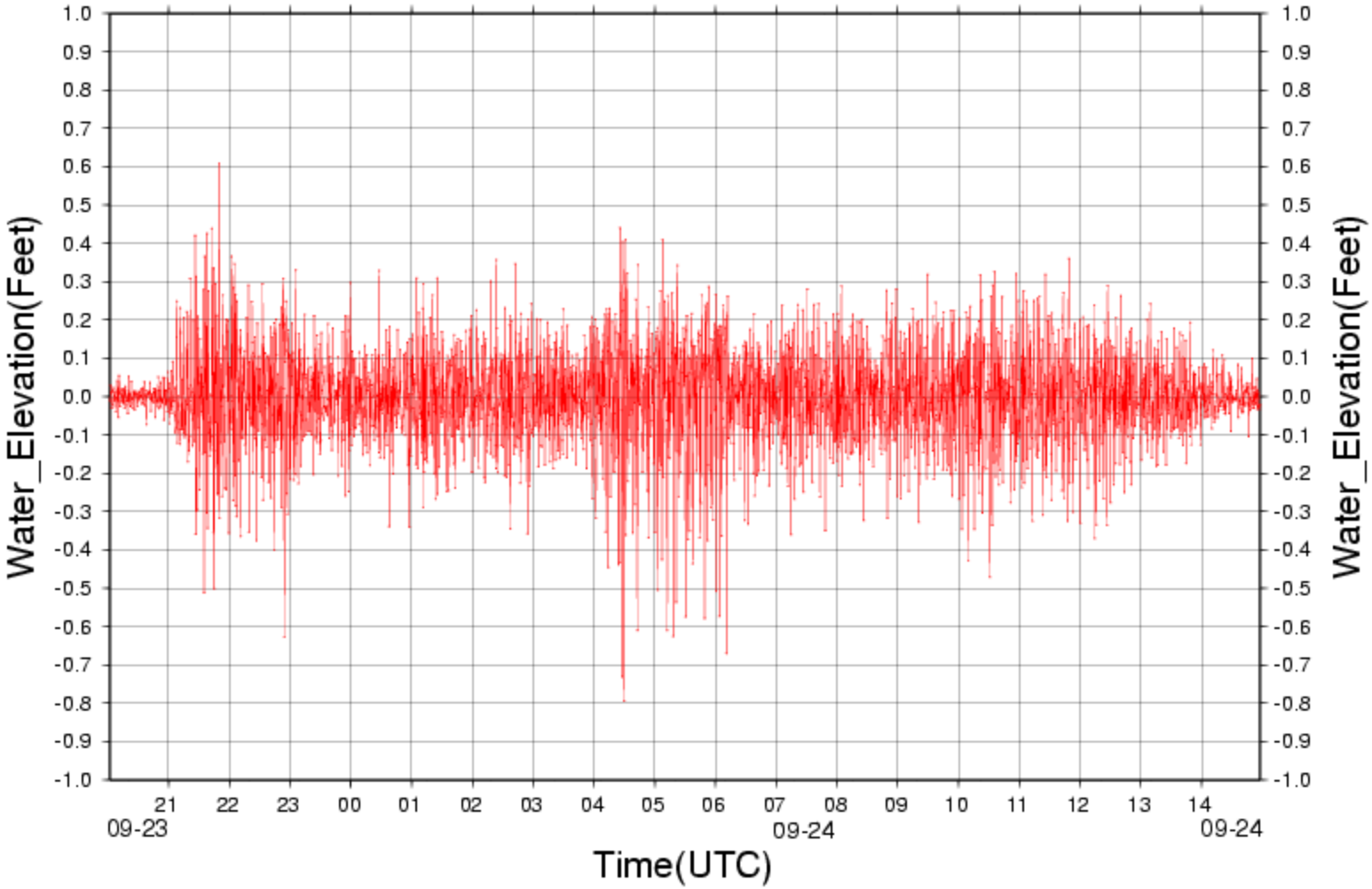
r for distance and distance squared is 0.95. Highly correlated, but necessary to make the regression residuals normally distributed.

This means the distance normalized coefficient is actually -0.43 (-1.43 + 1.00). This represents the influence of the dissipative effects of the wetlands.

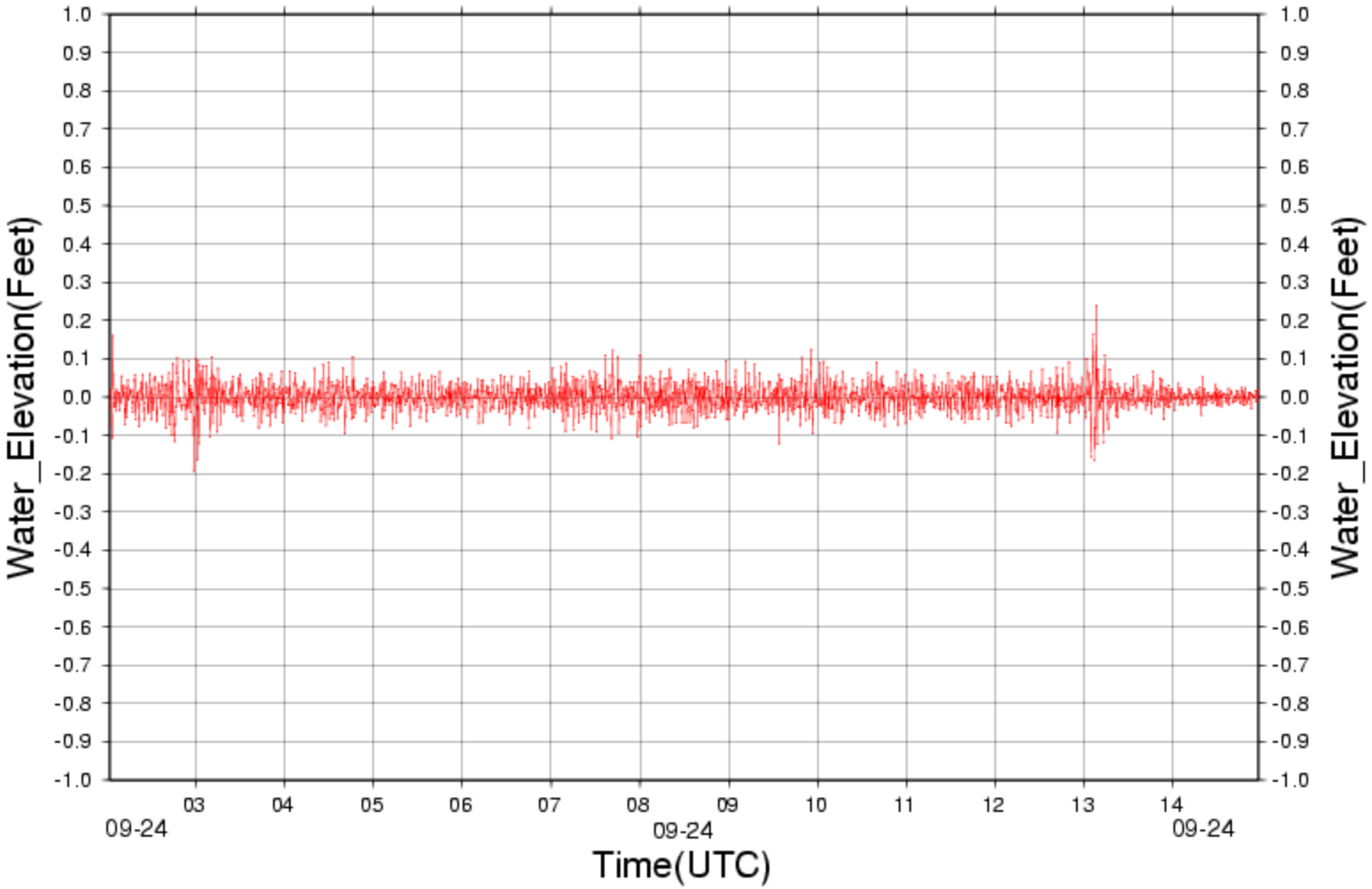
The elevation is 40% less influential than dissipative effects with a normalized coefficient of 0.26. This indicates the impact of subsidence.

Nonlinear multiple regression was also tried with a variety of function types, but the explained variance did not increase.

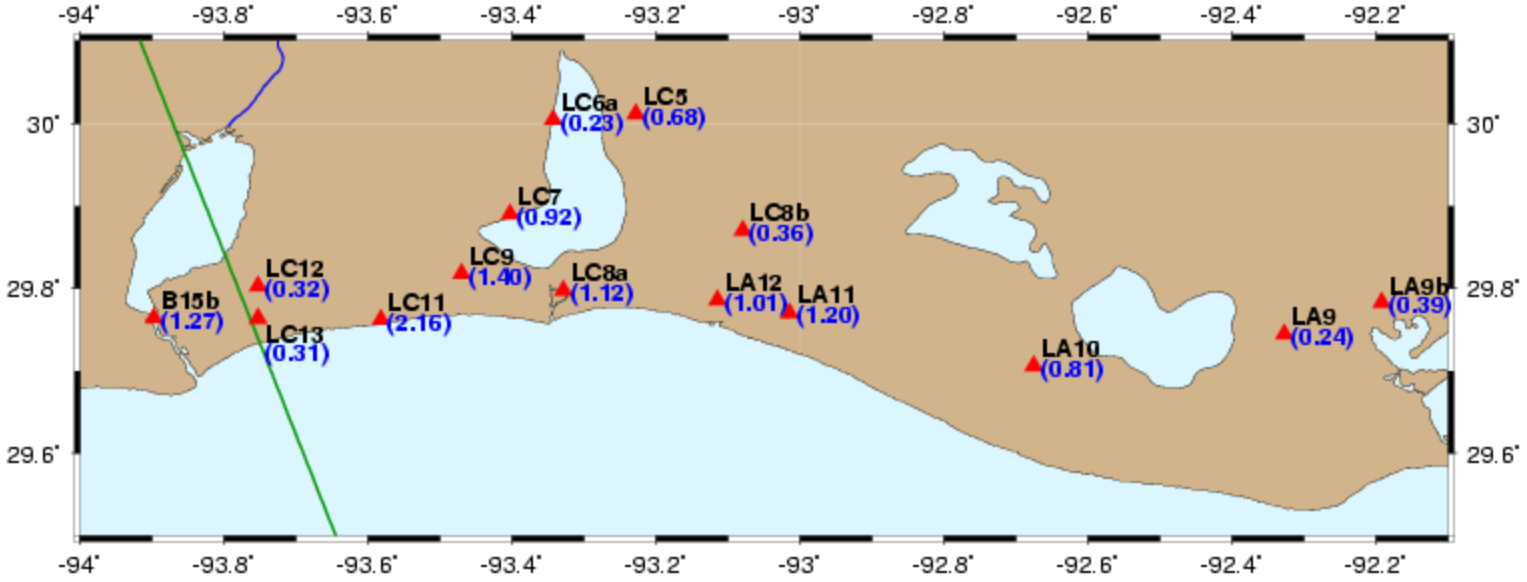
Reduction of waves on storm surge by wetlands

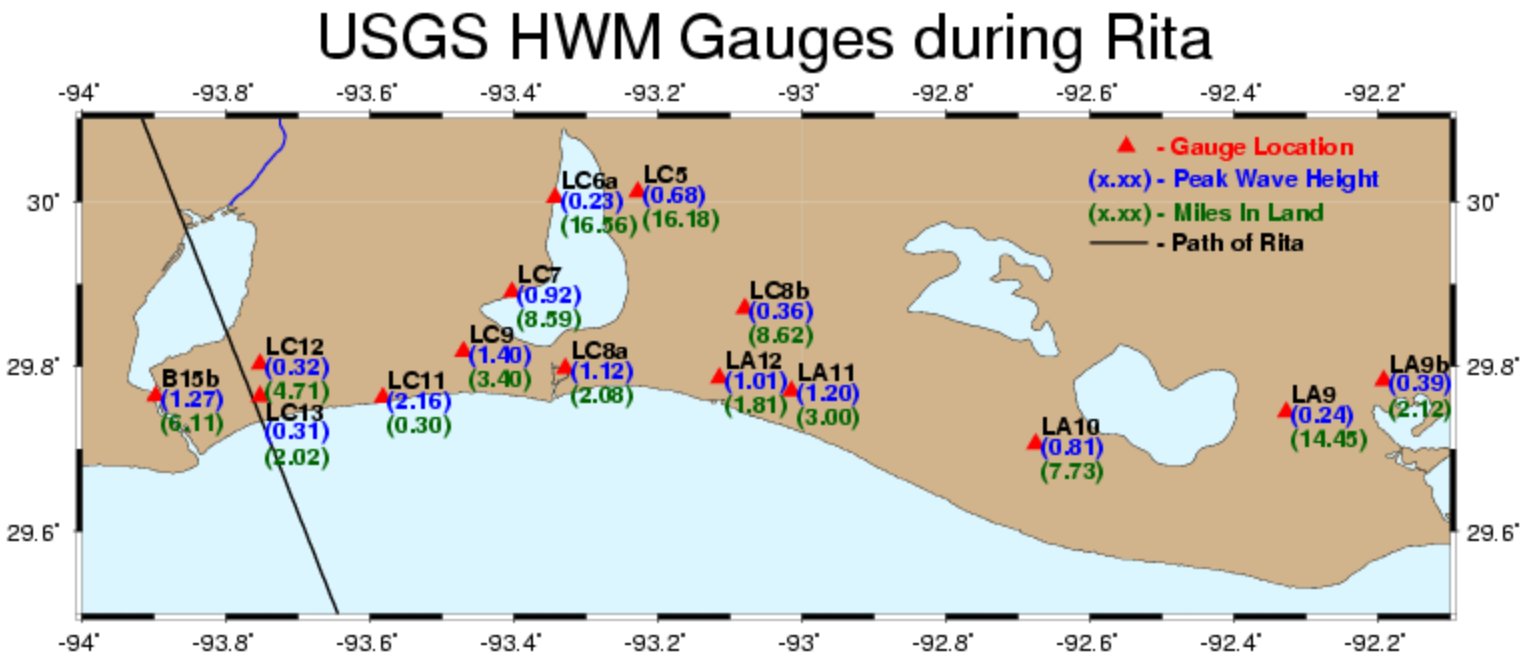

Observed-Mean55 TimeSeries(Sensor LA11)
Water_Elevation(Feet)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
21
22
23
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
09-23
09-24
09-24
Time(UTC)

Observed-Mean55 TimeSeries(Sensor LC8b)



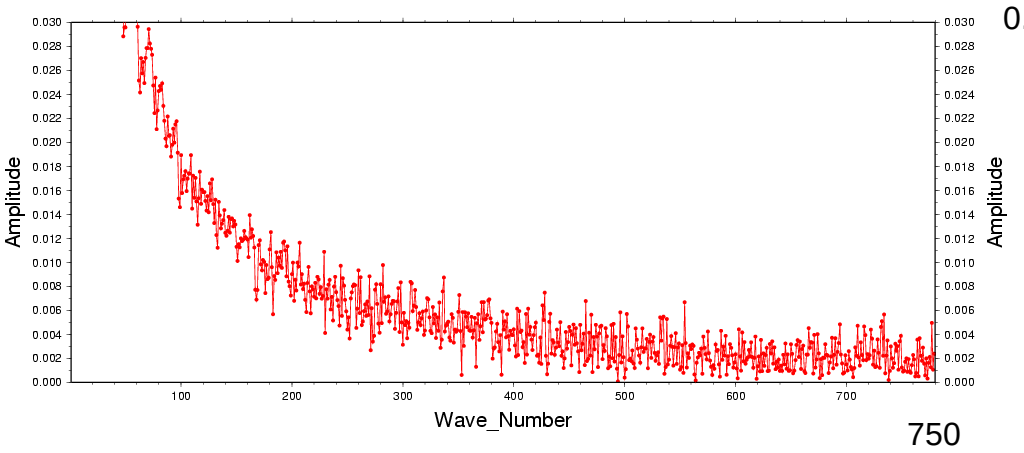
Peak Wave Height(feet) for USGS Gauges during Rita



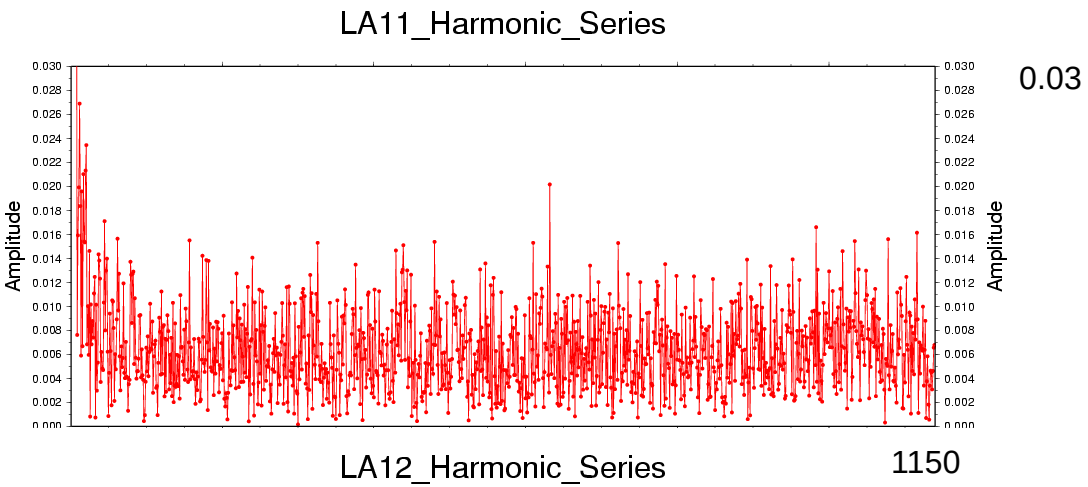


LC8b reduced 64-70% 5.5-6.8 miles inland (compared to LA12 and LA11)
LC8a reduced 48% 1.8 miles inland (compared to LC11)
LC9 reduced 36% 3.1 miles inland (compared to LC11)

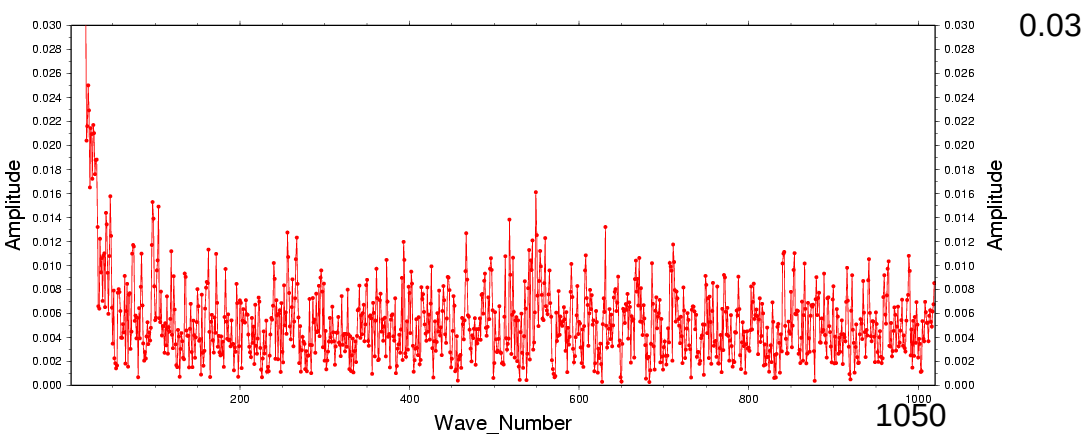
8.6 miles from coast



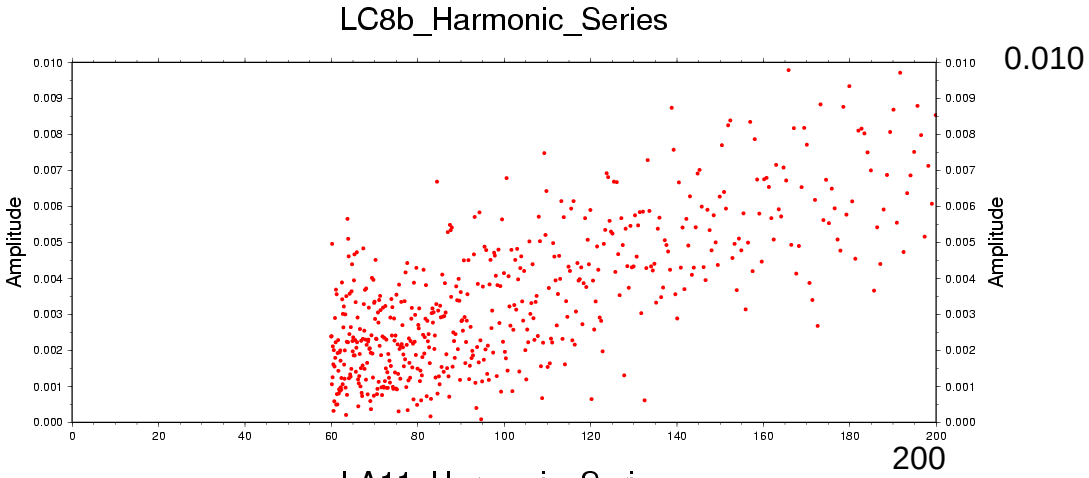
3.0 miles from coast



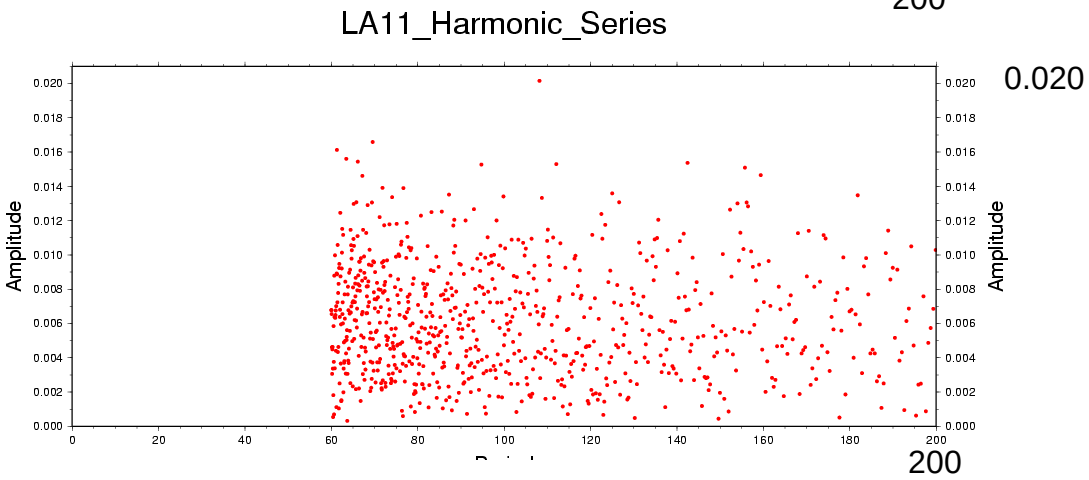
1.8 miles from coast



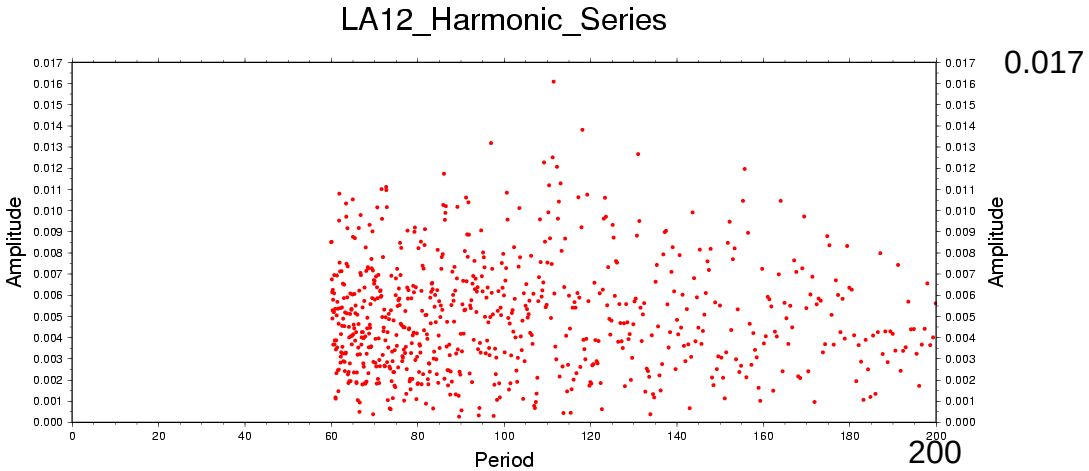
8.6 miles from coast



3.0 miles from coast



1.8 miles from coast



Summary, wetland impact

- Storm surge simulations suggest 2 feet reduction in surge every 3 miles of wetlands (twice as much as other research suggests).
- But, near levees, where water becomes trapped and reaches an equilibrium, wetland erosion does not reduce surge. Topographic forcing must be considered separately.
- Rita observations, when carefully stratified, also suggest same results (2 feet reduction every 3 miles).
- Rita observations also suggest the buffer impact may decrease further inland. However, multiple regression shows this could be due to higher land elevation impact. But…… this also shows that subsidence is an important issue.
- Wave heights reduced 50% 2 miles inland, and 65-70% 6 miles inland.
- Shortest period waves tend to be damped the most, and this effect increases inland
- GIS elevation data suggests that HWY 82 and HWY 27 may have also attenuated surge immediately east of Lake Calcasieu