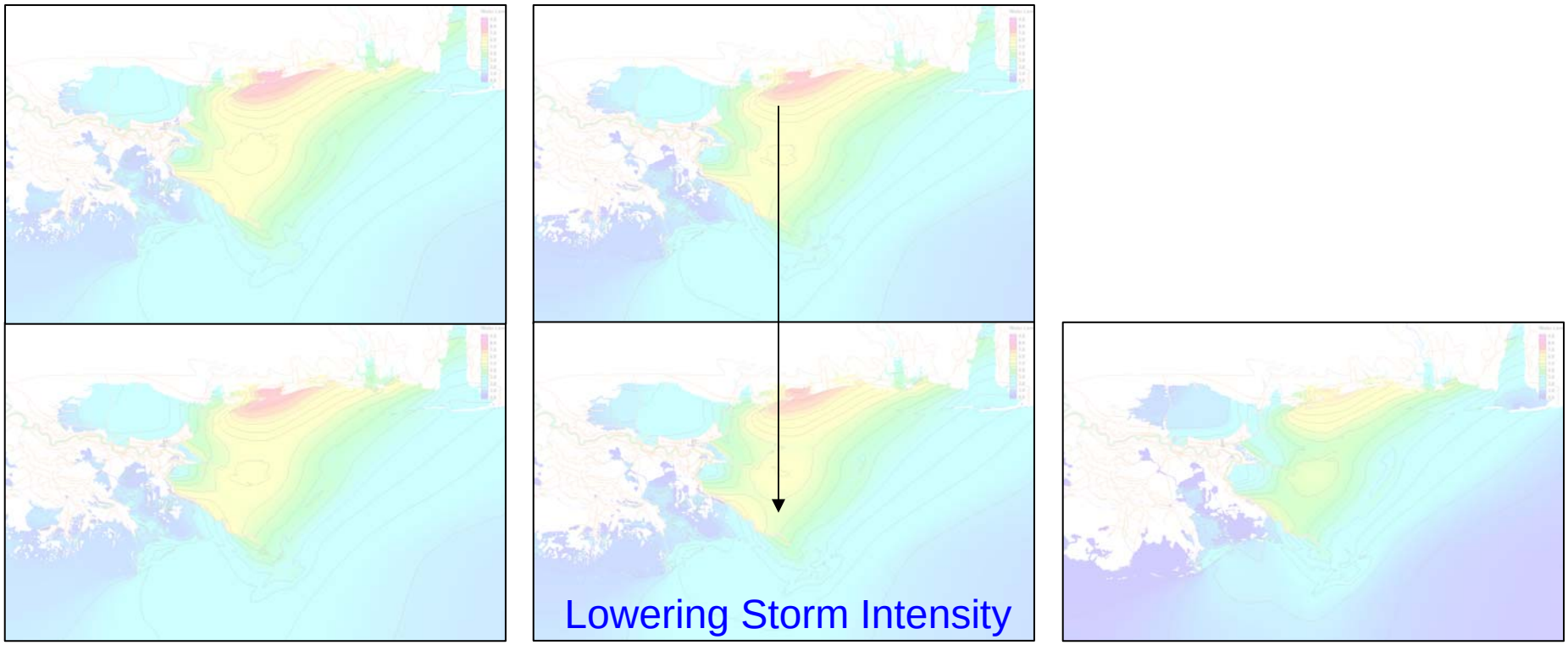
Impact of Climate and Sea Level Trends on Maximum Surge

Mary Cialone, Jennifer Irish, Alison Sleath, Tom Knutson, and Robert Jensen

Lowering Water Level →

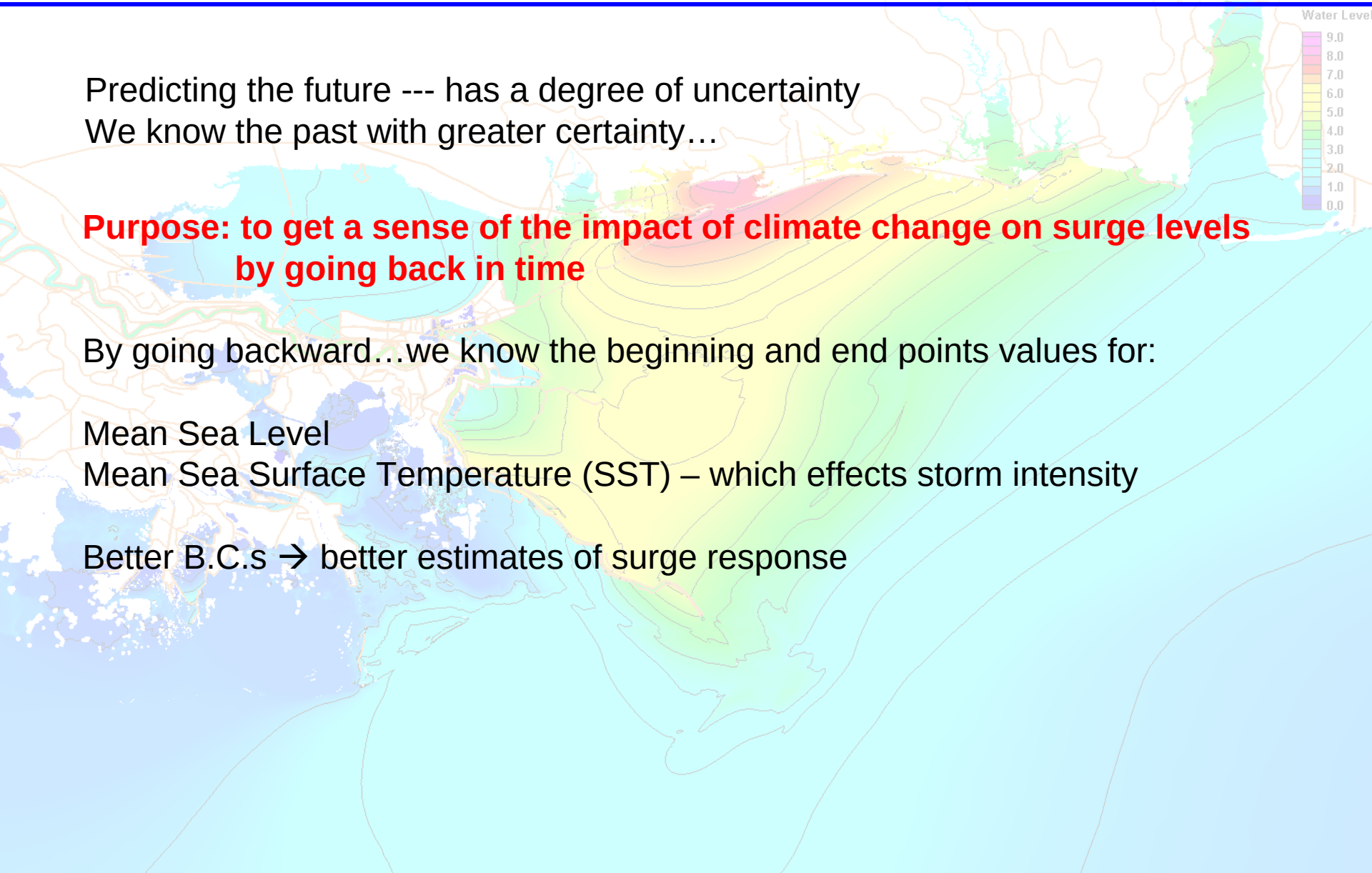


US Army Corps of Engineers
BUILDING STRONG®

VirginiaTech

GFDL Geophysical Fluid Dynamics Laboratory

Motivation for the Study



Predicting the future --- has a degree of uncertainty
We know the past with greater certainty…

Purpose: to get a sense of the impact of climate change on surge levels by going back in time

By going backward…we know the beginning and end points values for:

Mean Sea Level
Mean Sea Surface Temperature (SST) – which effects storm intensity

Better B.C.s → better estimates of surge response

Methodology

2005

Apply CSTORM-MS to simulate Hurricane Katrina as it occurred in 2005

1900 …one century ago….

Intensity

Mean SST in the Atlantic Basin was ~ 0.47^{o}C cooler

Tropical cyclones were less intense due to cooler ocean waters

De-intensify Katrina winds and pressures by:

1.7% weakening of wind speed; 3.8% drop in pressure differential

(3.7% ^WS/deg; 8% ^P/deg Knutson & Tuleya)

Sea Level

Mean eustatic water level: 0.18 m lower

Local sea level: 0.57 m lower

Simulate water levels 0.18 and 0.75 m lower than today

Apply CSTORM-MS to simulate Hurricane Katrina less intense & lower water levels

Summary

Incremental changes

Water level

0.18 and 0.75 m

Water level & frictional resistance

0.035 and 0.040

Storm intensity

Changes in mean water level → change in surge response & nonlinear surge response
The magnitude of the nonlinear response is greatest for surge propagation over wetlands

Changes in storm intensity → consistent change in surge response

Change in MWL & Friction → more change in surge response…..

Friction impact on surge – varies spatially

Setting historical friction values – source of uncertainty

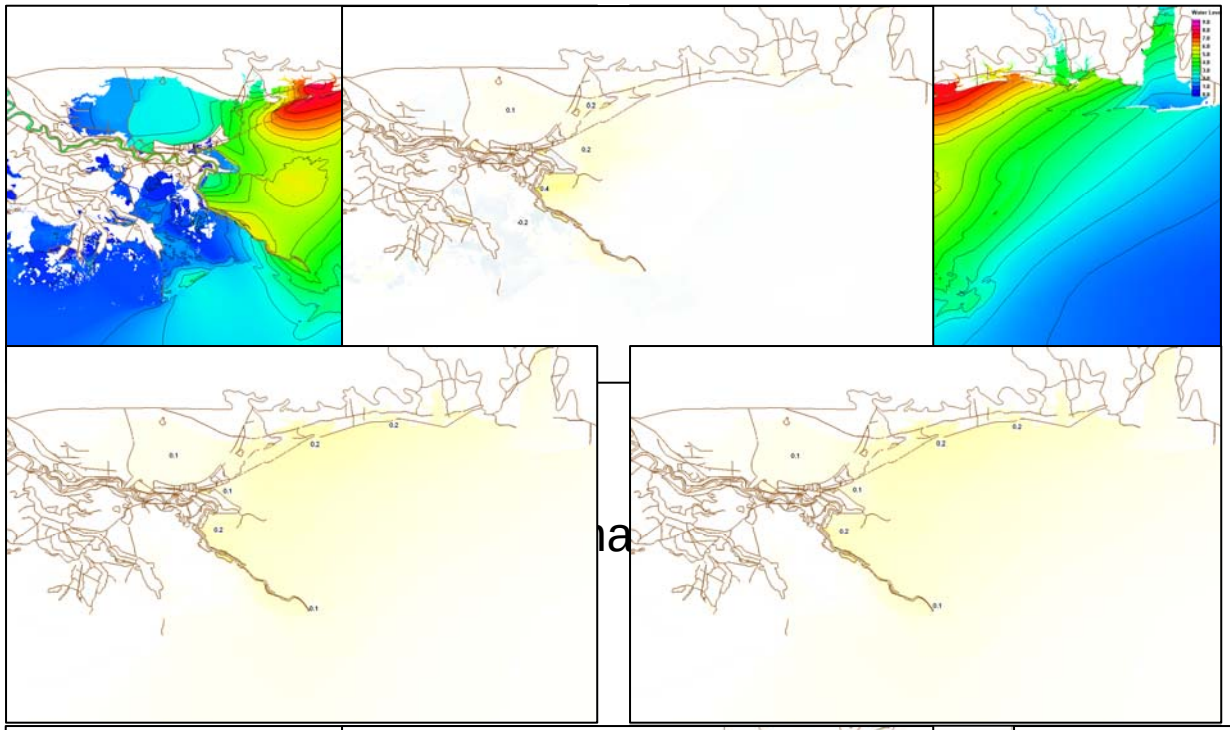
Maximum Surge Level, m NAVD 88 (2004.65)

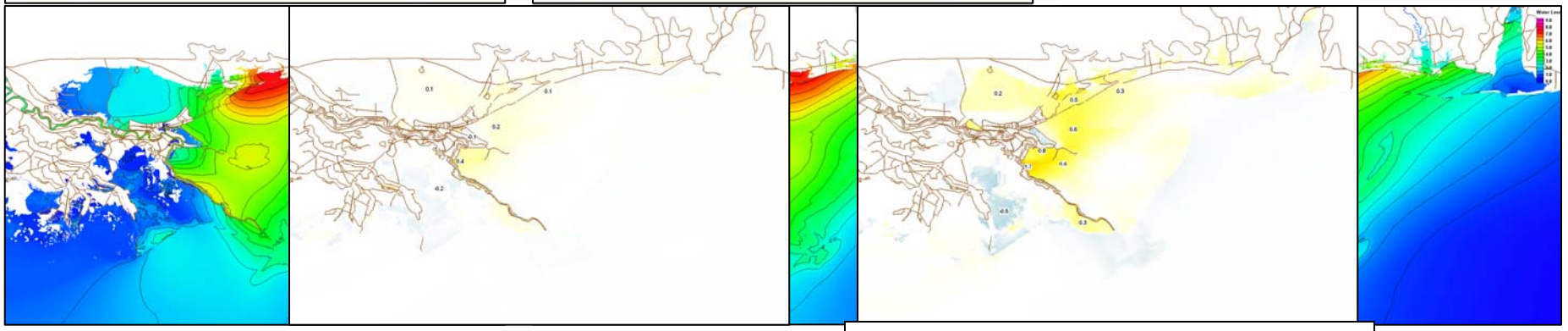
Water Level Adjusted Only

Historical Water Level | 0.18 m Lower | 0.75 m Lower

Historical Intensity

Less Intense





9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0

Difference, m

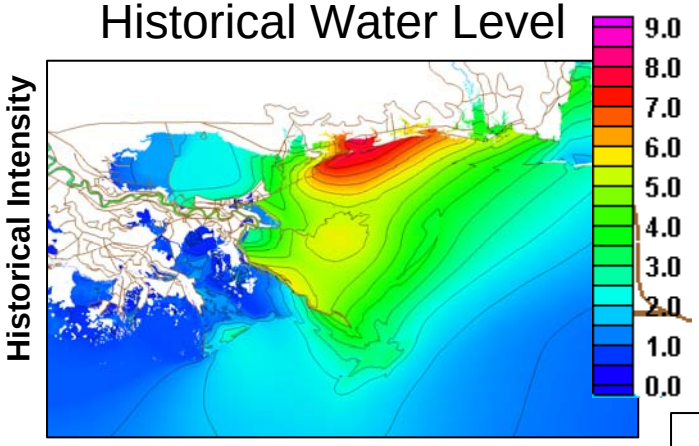
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0

Reduction back in time; increase forward in time

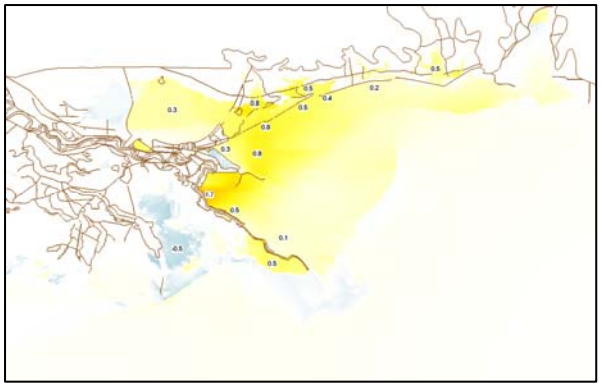
Historical Less Intense
Minus **0.75m Less Intense** minus 0.75m
These values therefore reflect the additional surge at
the higher water level over and above the sea level difference

Maximum Surge Level, m NAVD 88 (2004.65)

Historical Water Level

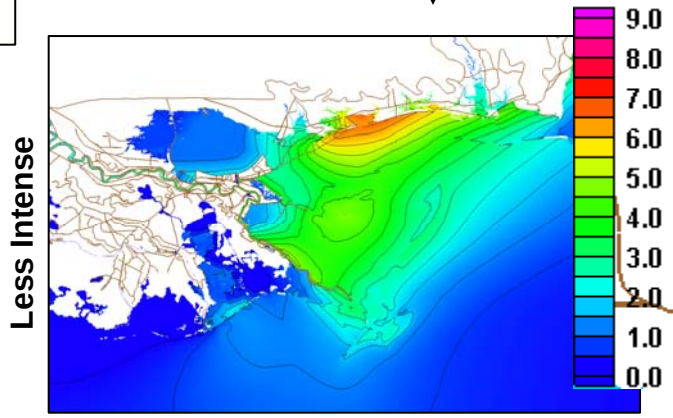


Water Level



De-intensification

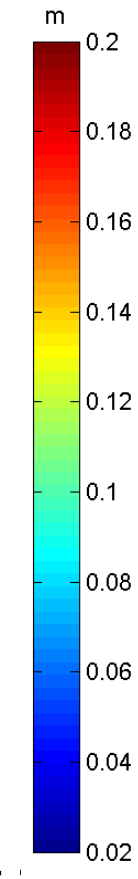
Conservative estimate because no friction changes yet



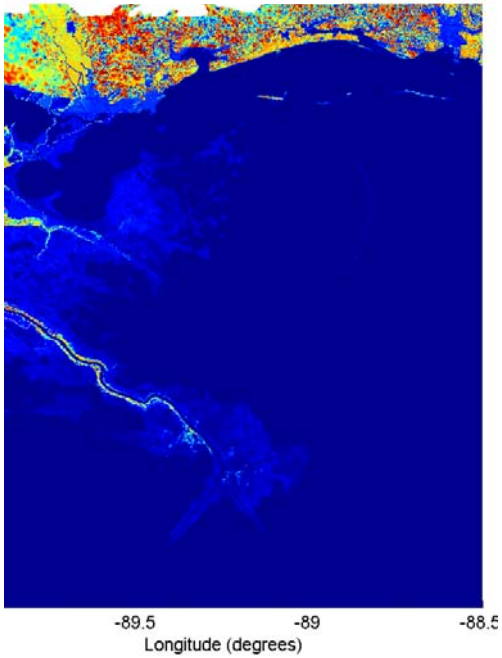
0.75 m Lower Water Level

Friction

Lower Sea Level 0.18 m

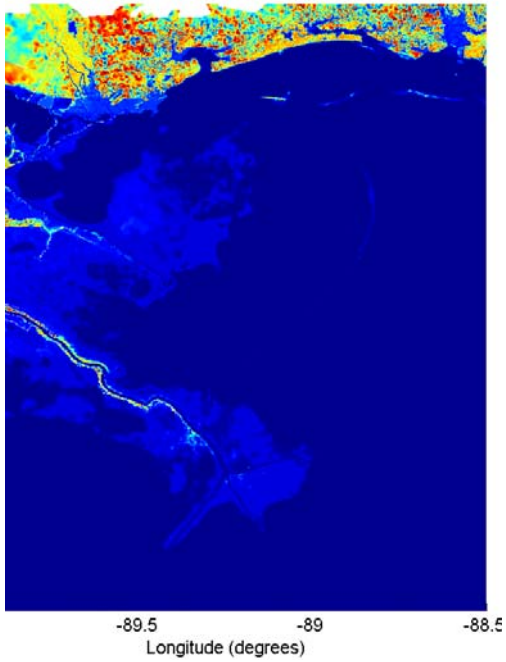


Base Friction

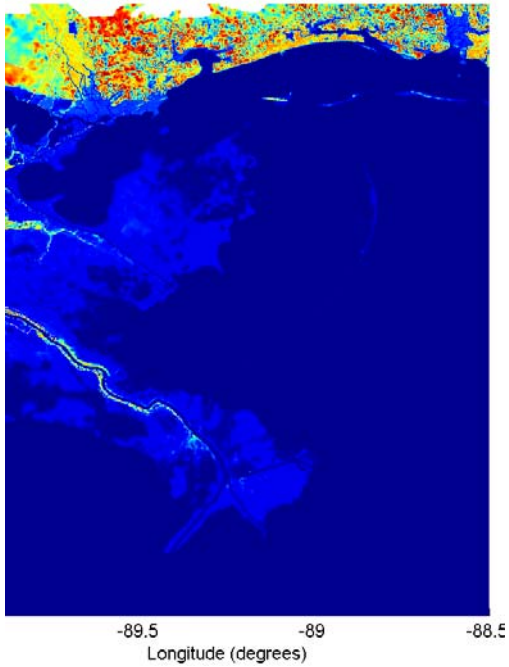


Used in IPET
Katrina Validation

A - Friction 0.035

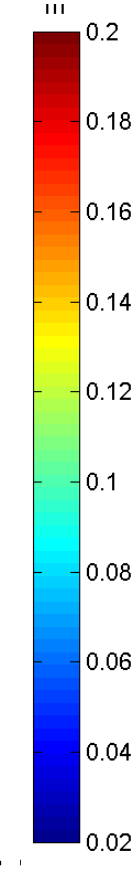


B – Friction 0.040

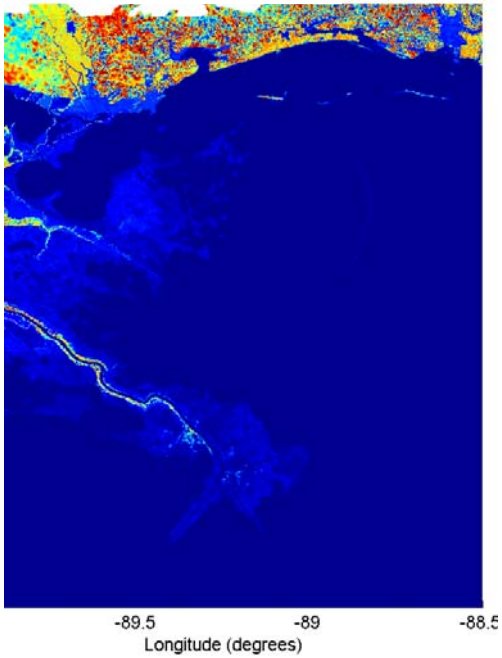


Friction

Lower Sea Level 0.75 m



Base Friction



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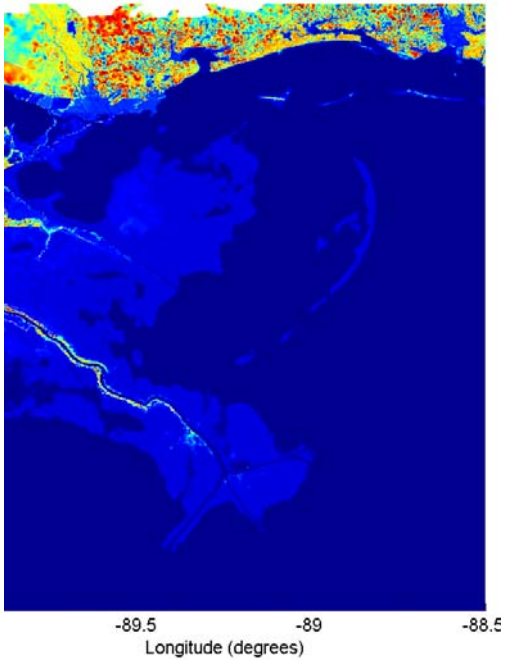

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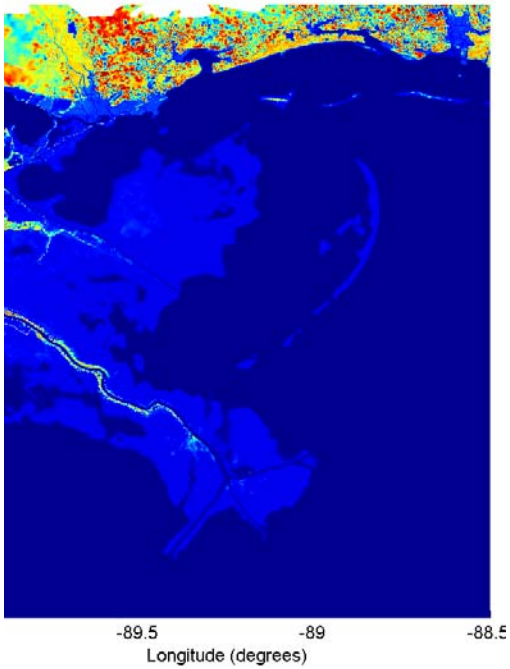
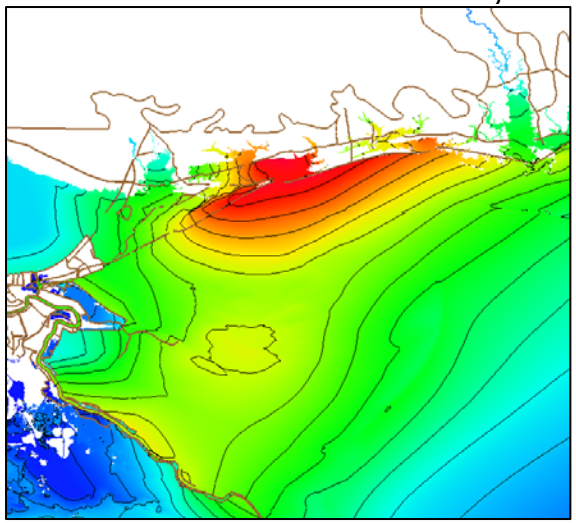
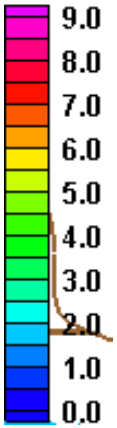
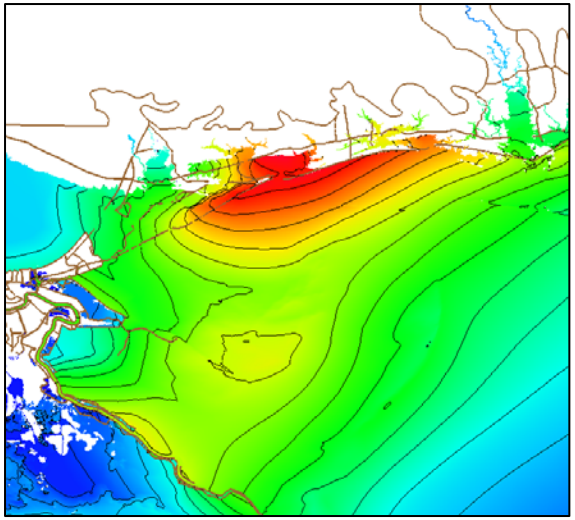


Maximum Surge Level Changes with Added Friction

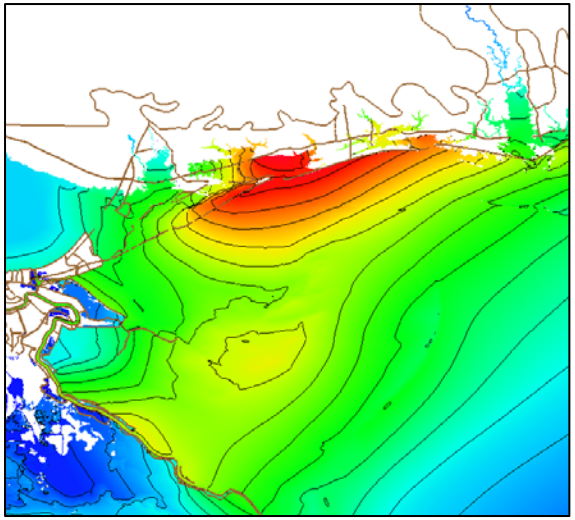
Historical Katrina with 0.18 m lower sea level; Base Friction







Friction A



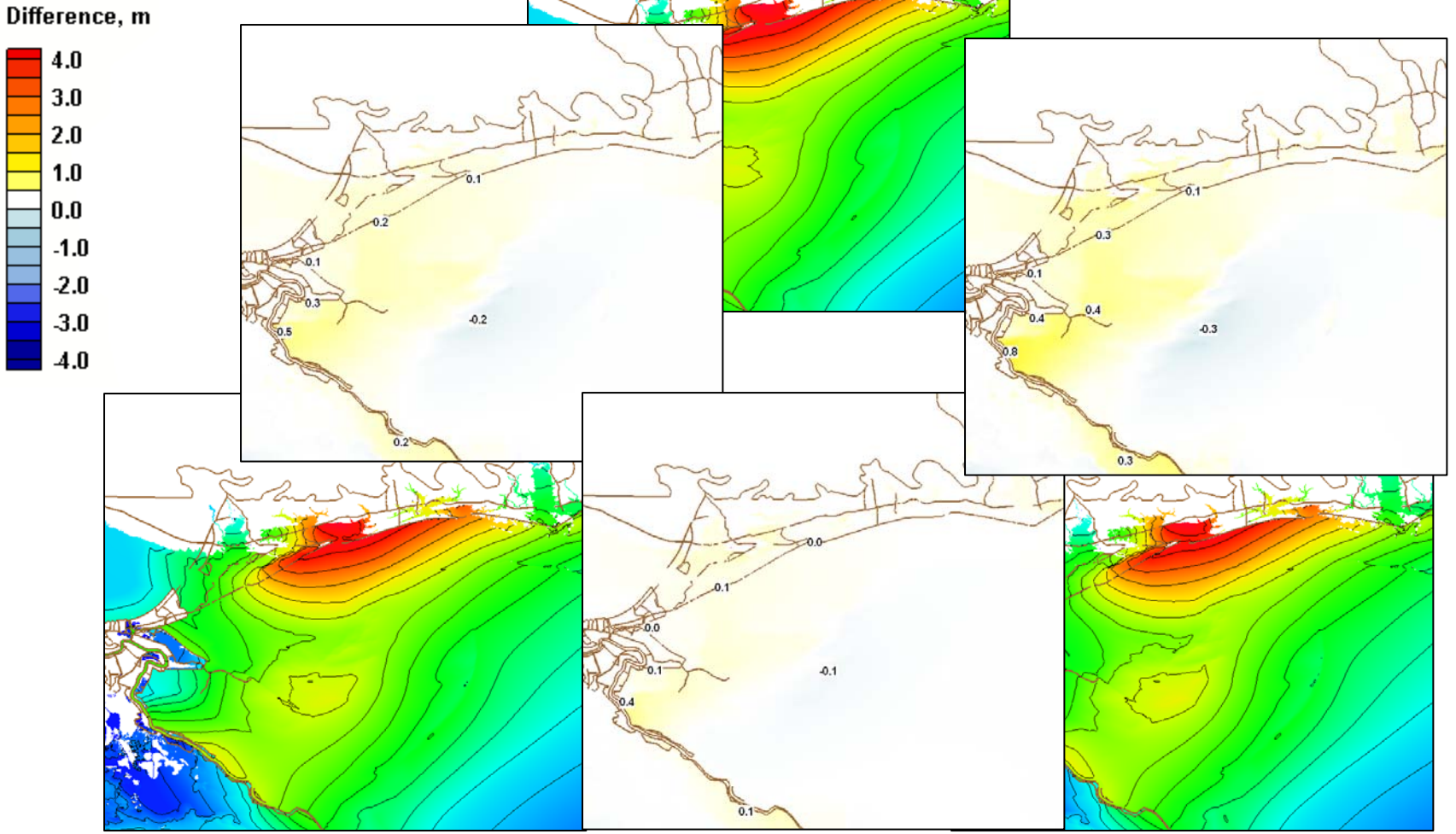
Friction B

Maximum Surge Level Changes with Added Friction

Historical Katrina with 0.18 m lower sea level; Base Friction

Reduction in friction
Increase in water level

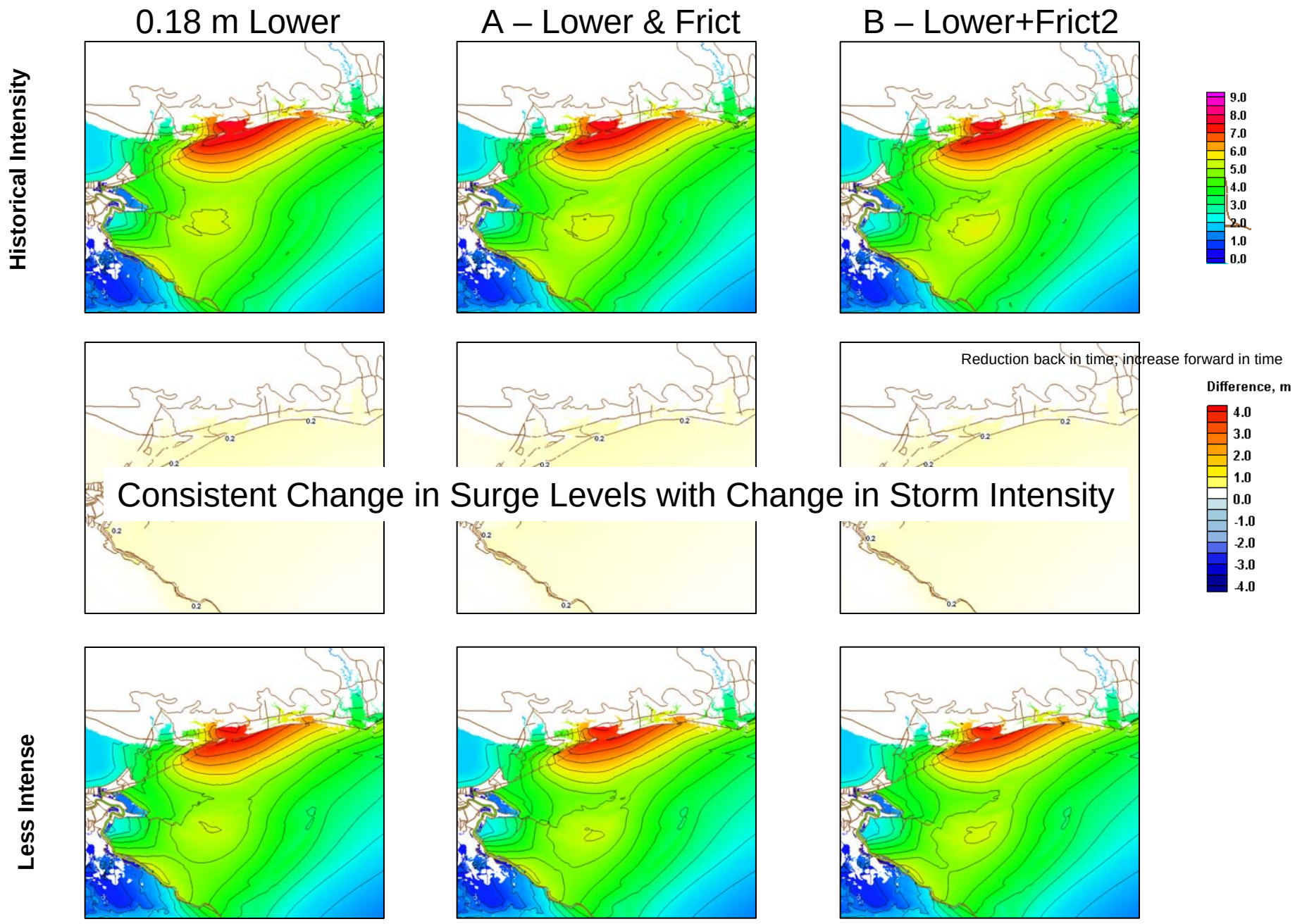
Reduction back in time; increase forward in time



Friction A **Friction B**

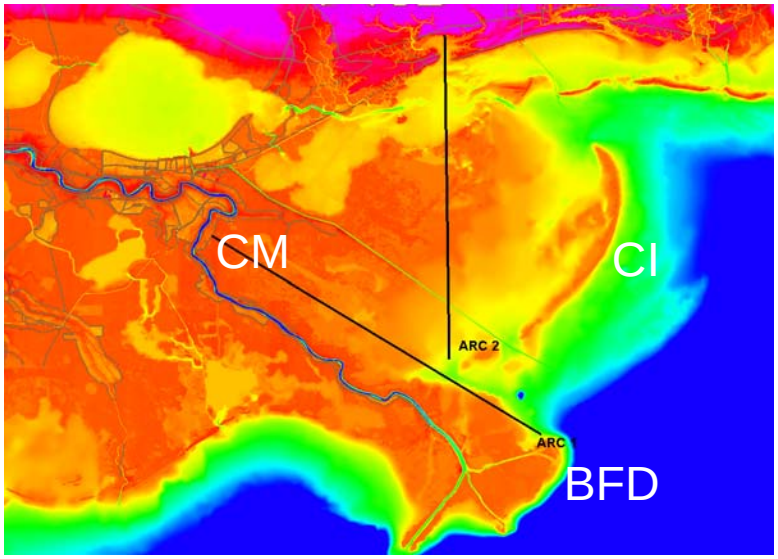
Increase in friction → reduction in water level

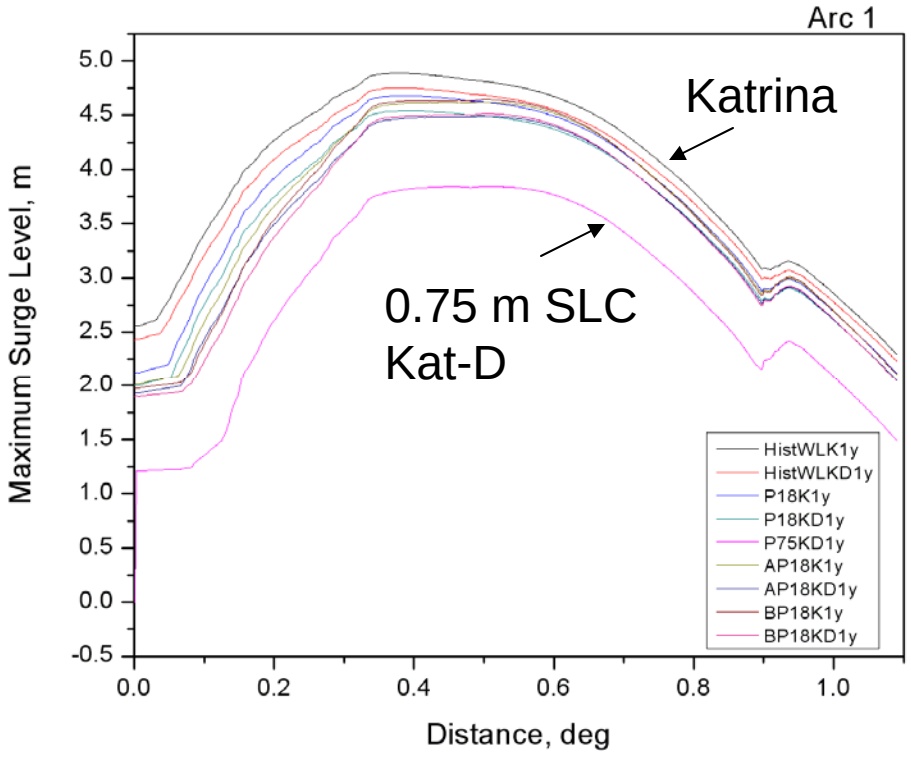
Effect of Lowering Storm Intensity on Maximum Surge Levels

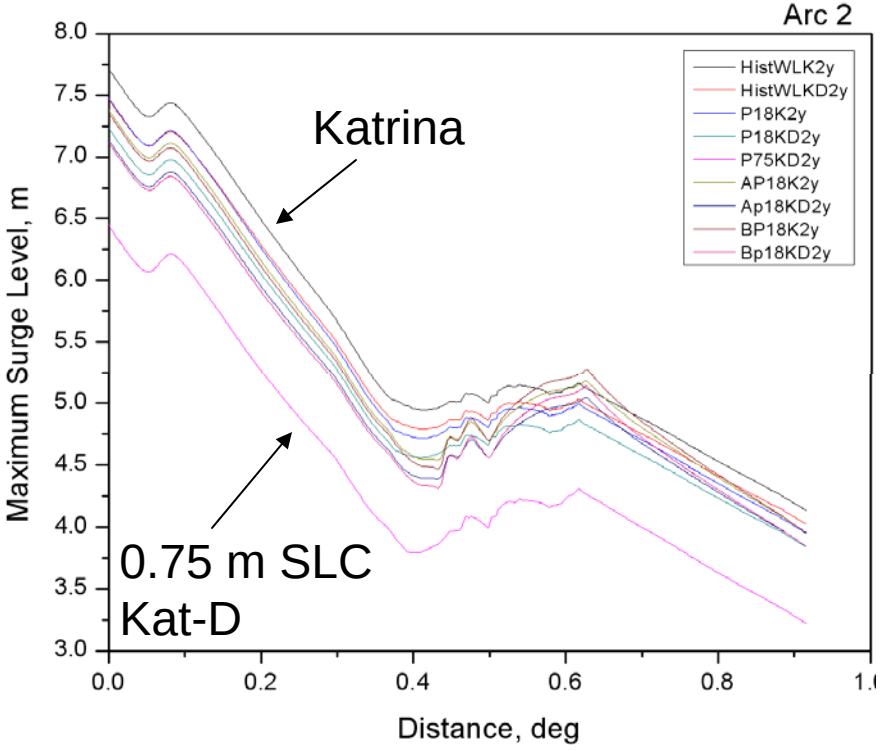


Maximum Surge Profiles

Variables:
Storm intensity
Water Level
Frictional resistance

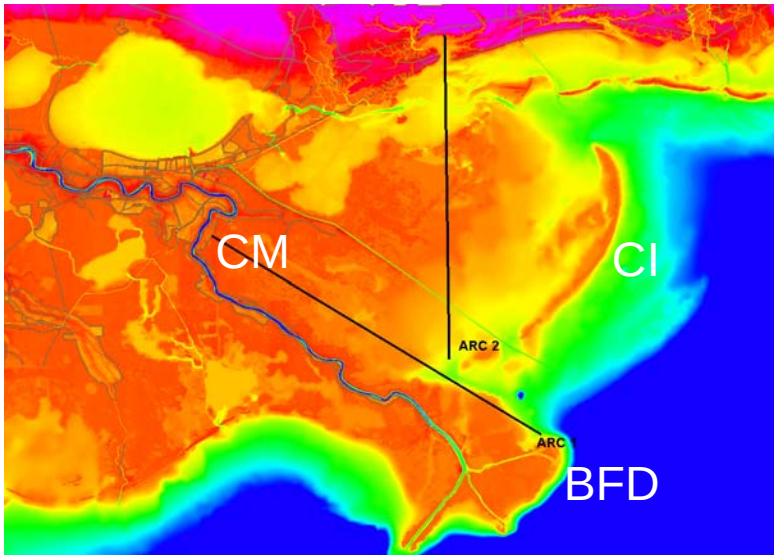


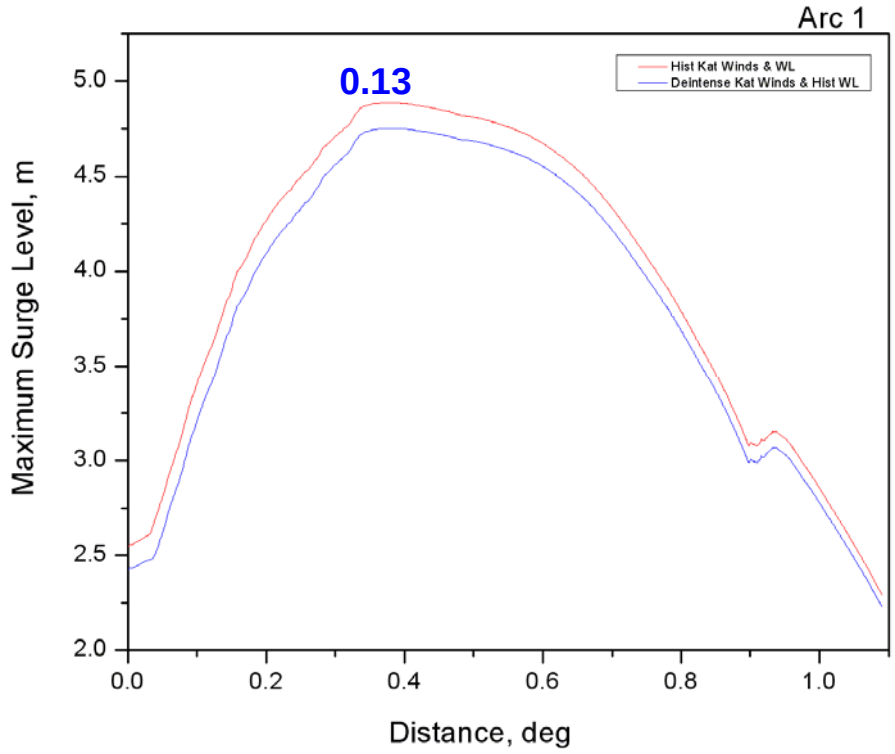


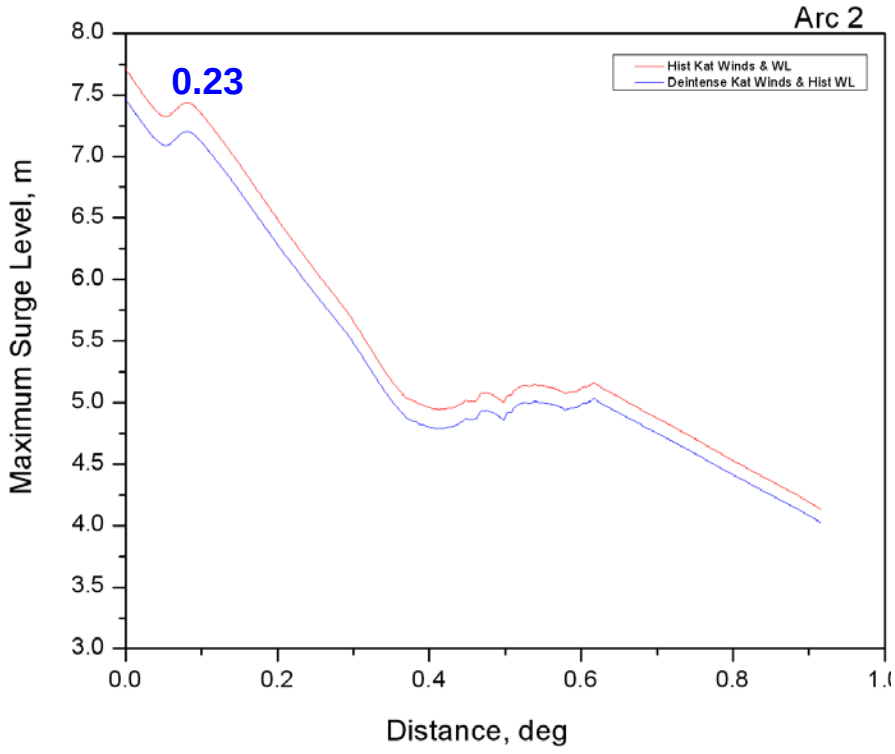


Maximum Surge Profiles

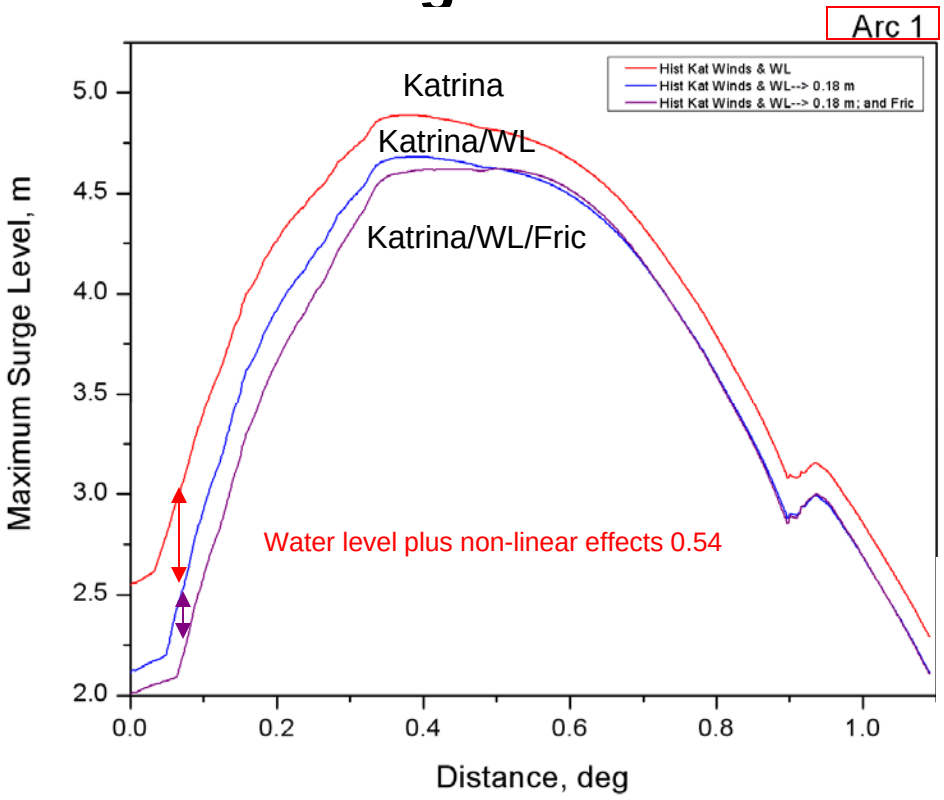
Variables:
Storm intensity
Water Level
Frictional resistance

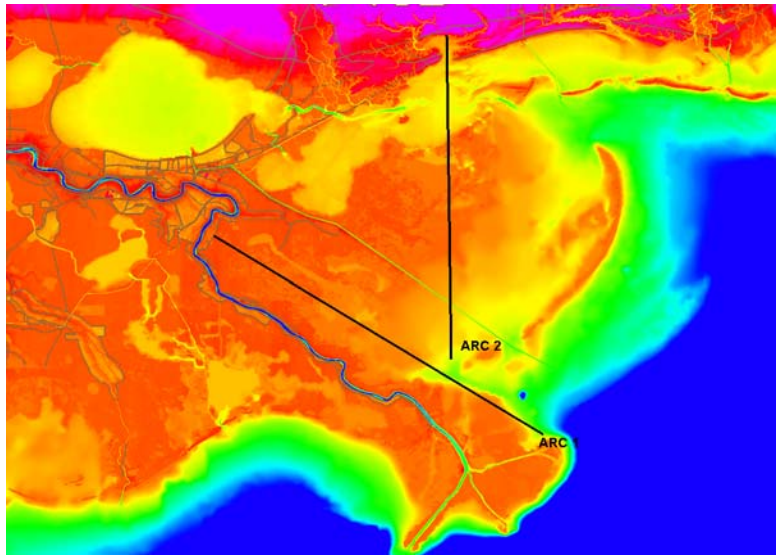


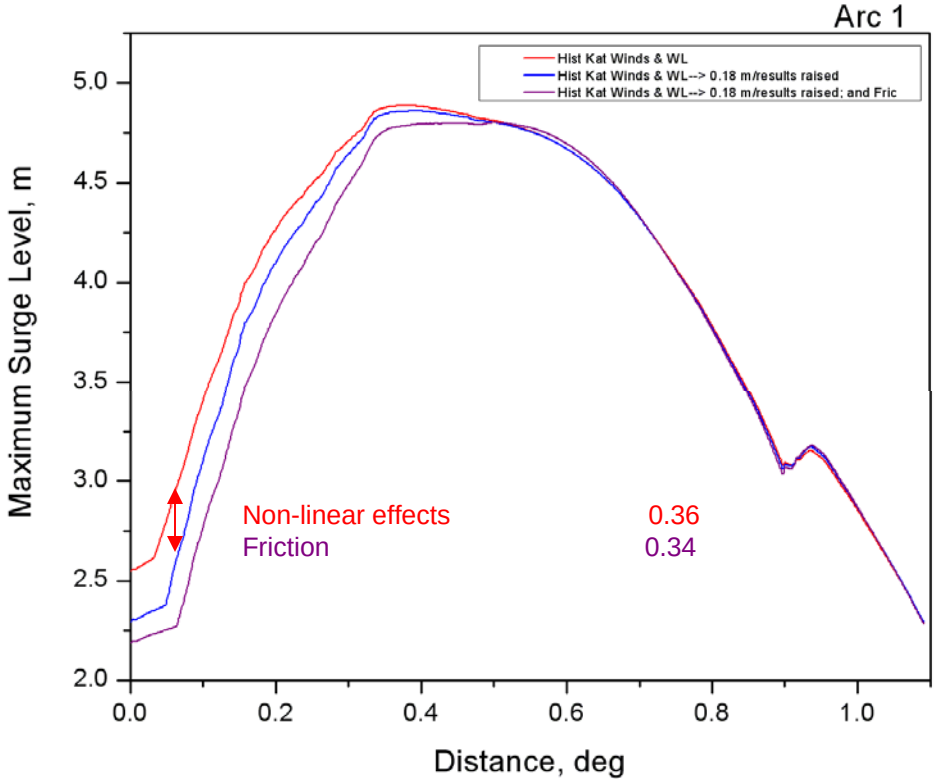




Maximum Surge Profiles

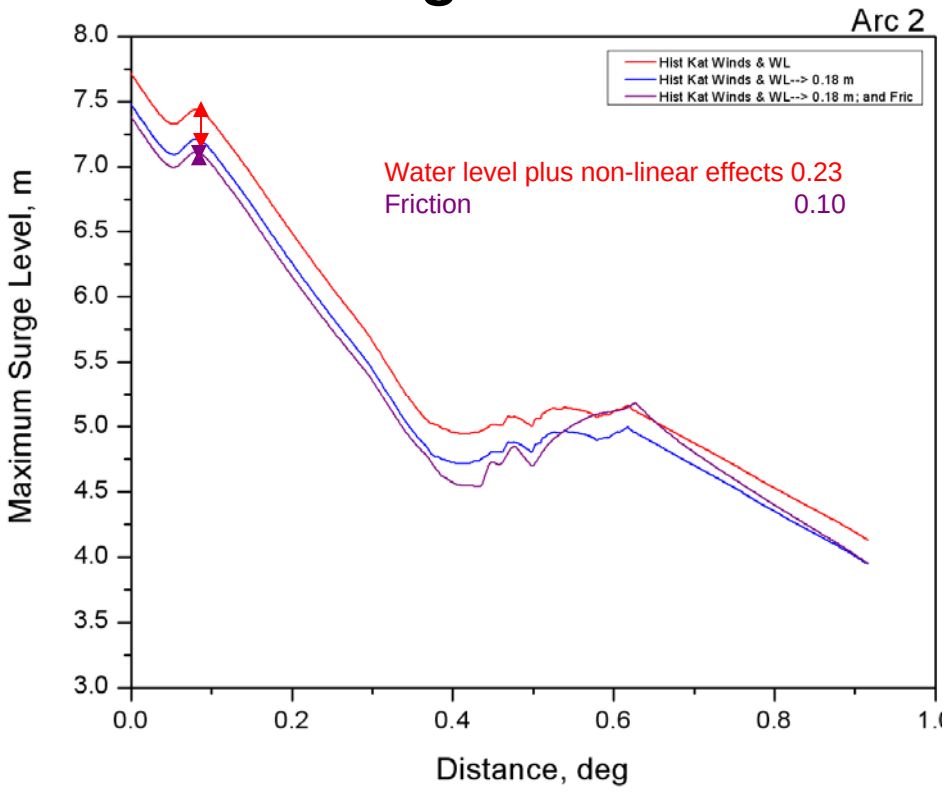


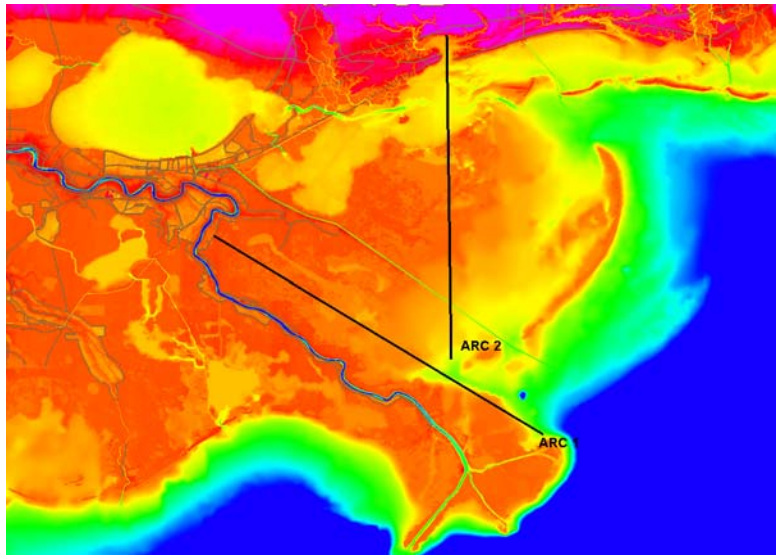


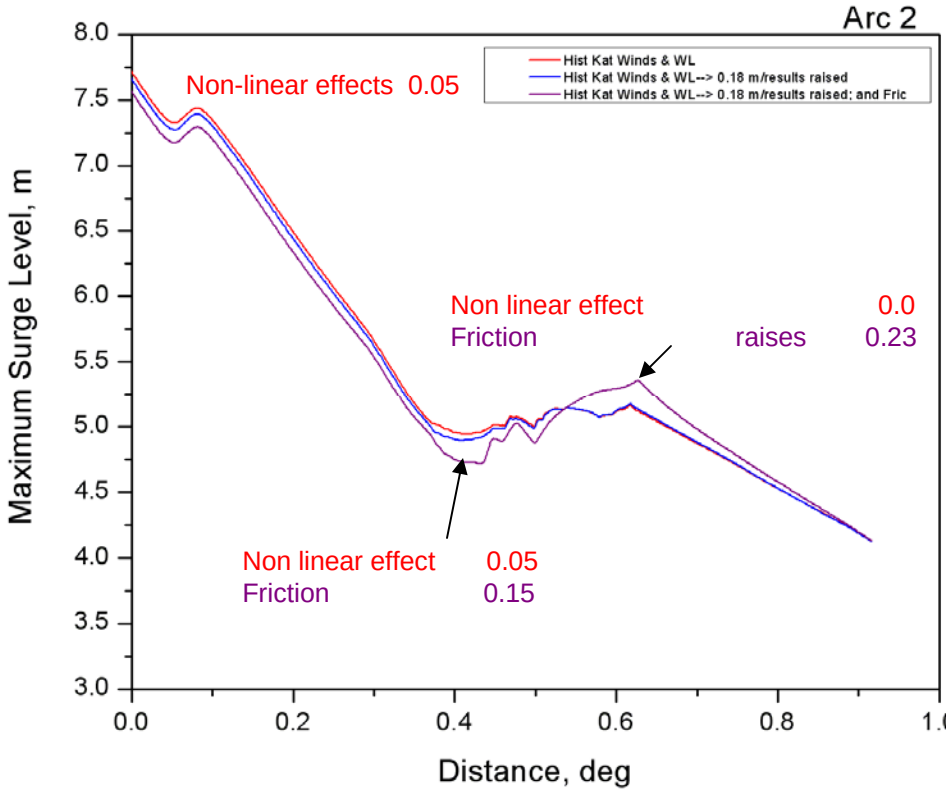


Variables:
Storm intensity
Water Level
Frictional resistance

Maximum Surge Profiles







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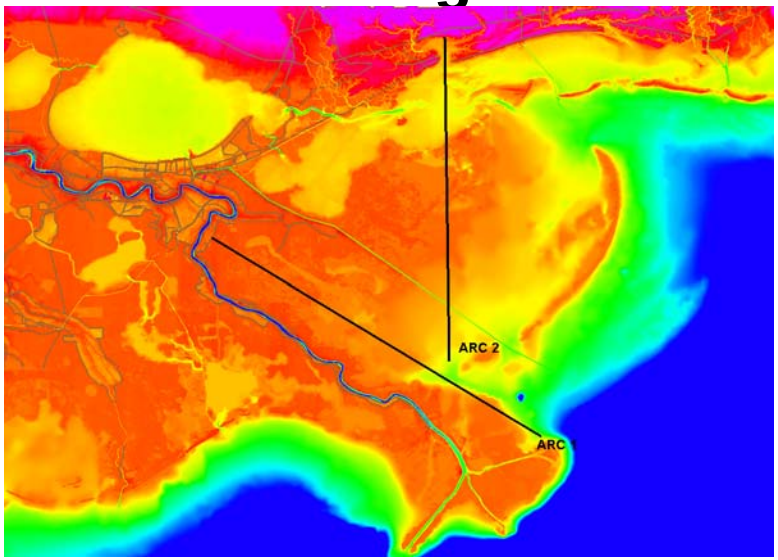
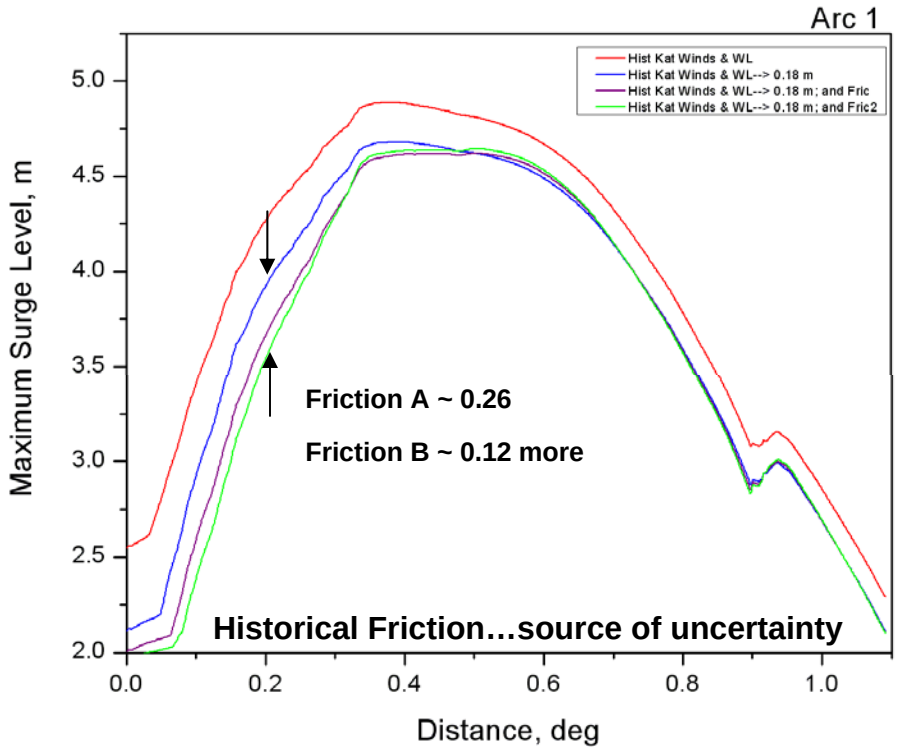
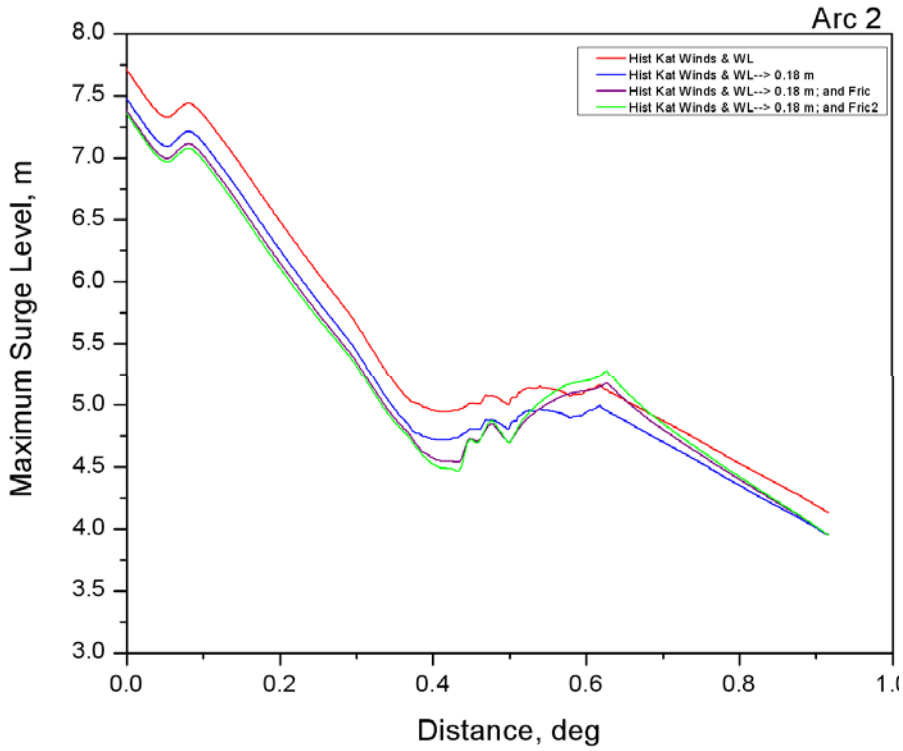


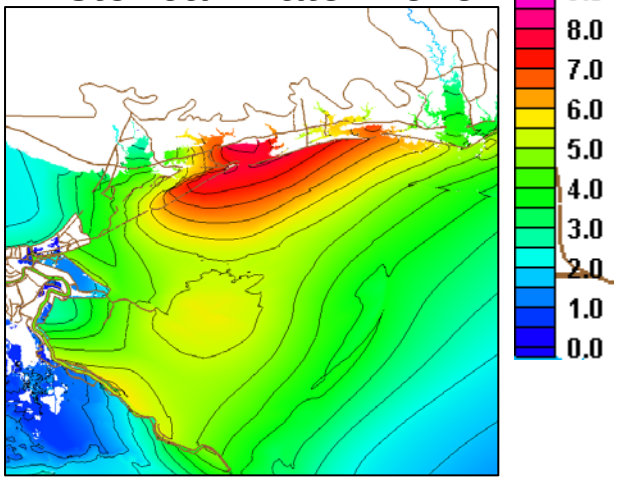


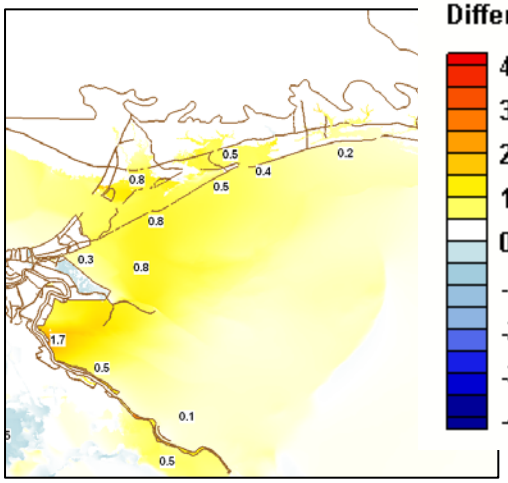


Maximum Surge Level, m NAVD 88 (2004.65)

Historical Intensity

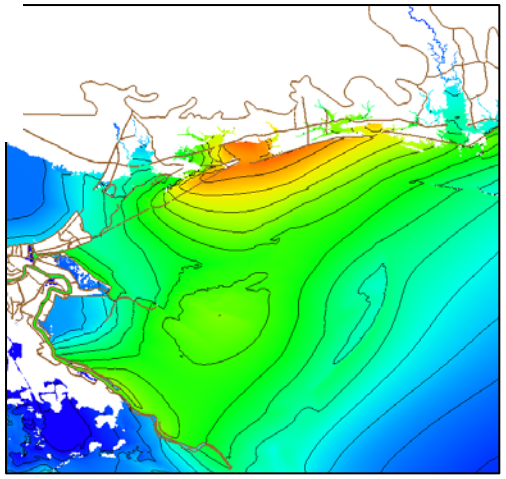
Historical Water Level

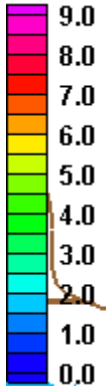




Difference, m

Less Intense

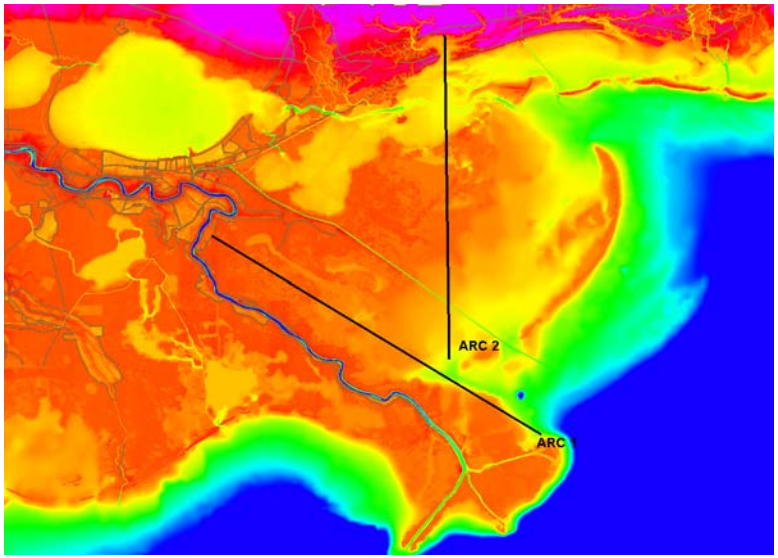


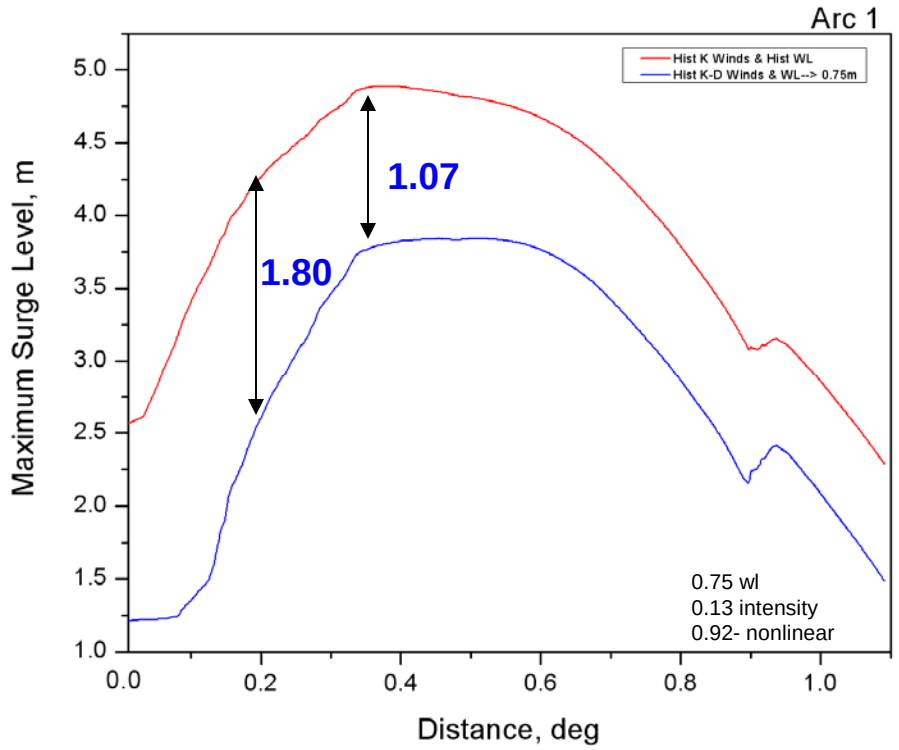


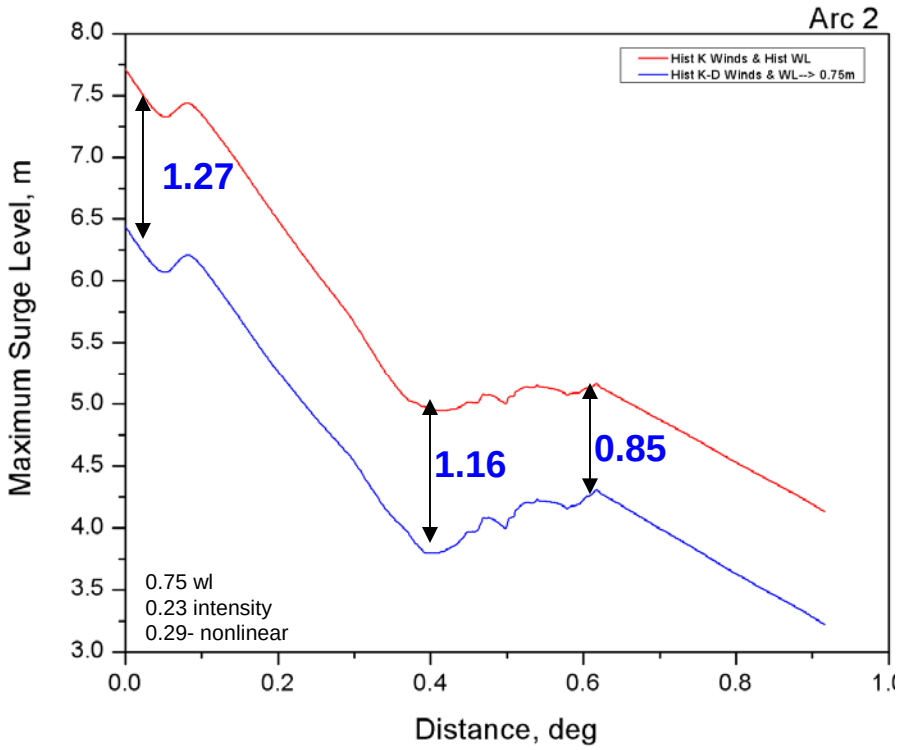
0.75 m Lower Water Level

Maximum Surge Profiles

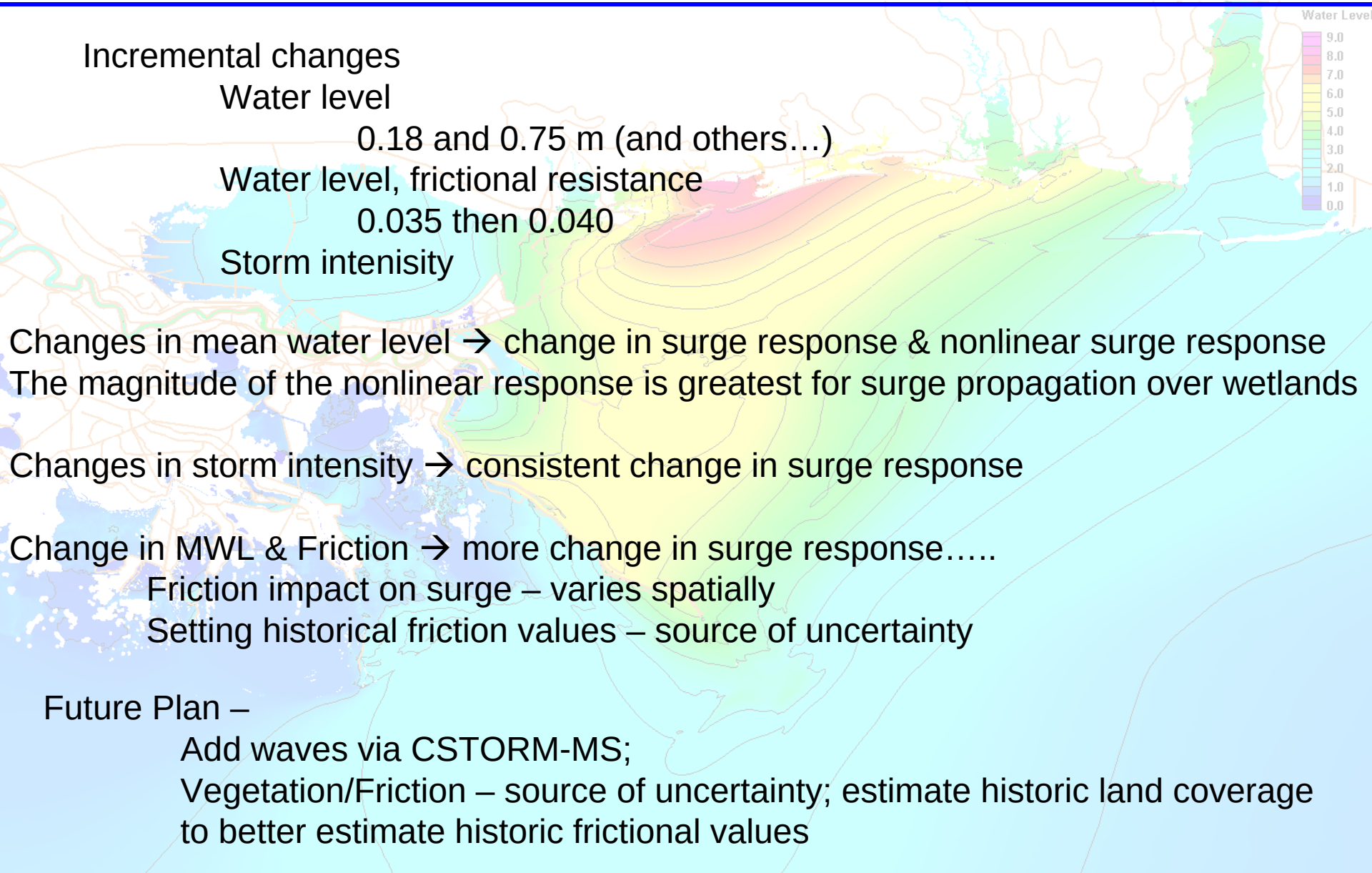
Variables:
Storm intensity
Water Level
Frictional resistance







Concluding Remarks



Incremental changes
- Water level
  - 0.18 and 0.75 m (and others…)
- Water level, frictional resistance
  - 0.035 then 0.040
- Storm intenisity

Changes in mean water level → change in surge response & nonlinear surge response
The magnitude of the nonlinear response is greatest for surge propagation over wetlands

Changes in storm intensity → consistent change in surge response

Change in MWL & Friction → more change in surge response…..
- Friction impact on surge – varies spatially
- Setting historical friction values – source of uncertainty

Future Plan –
- Add waves via CSTORM-MS;
- Vegetation/Friction – source of uncertainty; estimate historic land coverage to better estimate historic frictional values