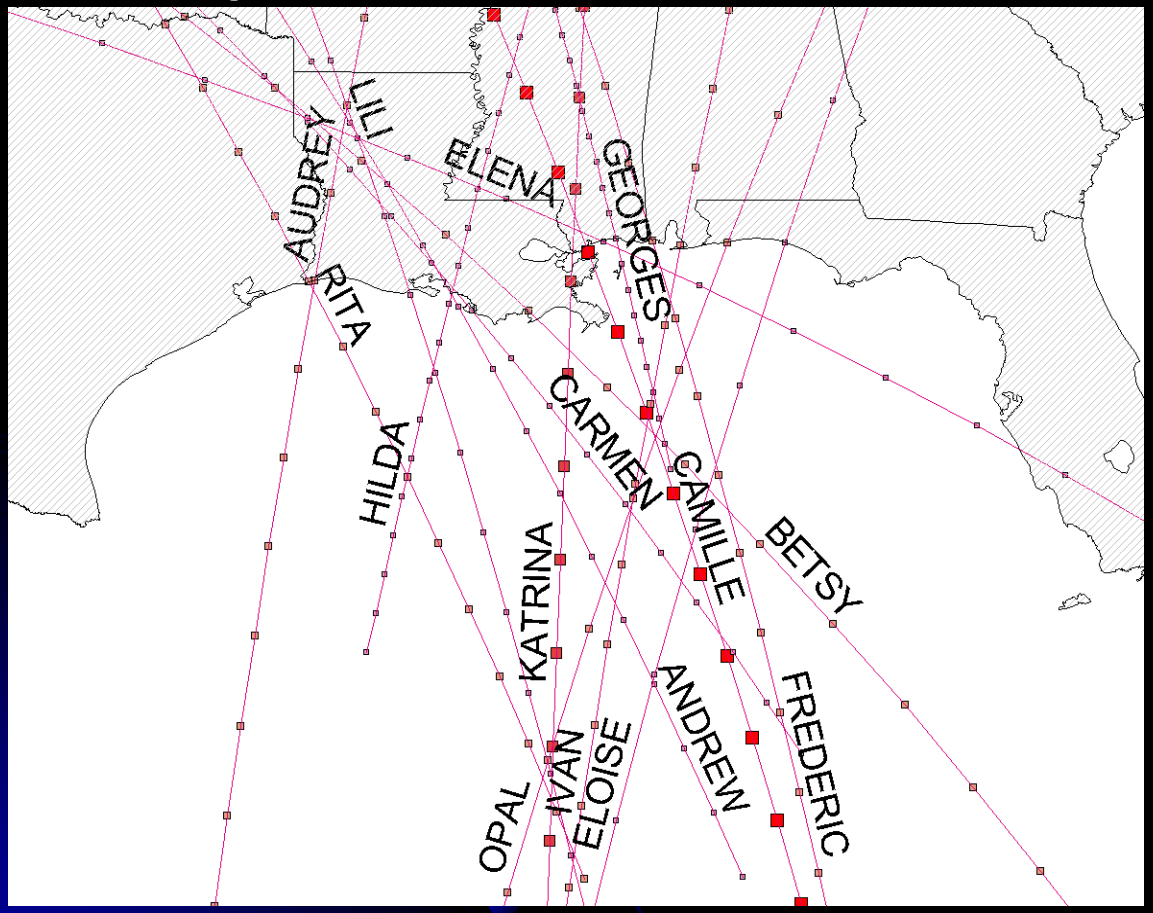
A Method for Rapid, High-Resolution Operational Estimates of Local Storm Surge

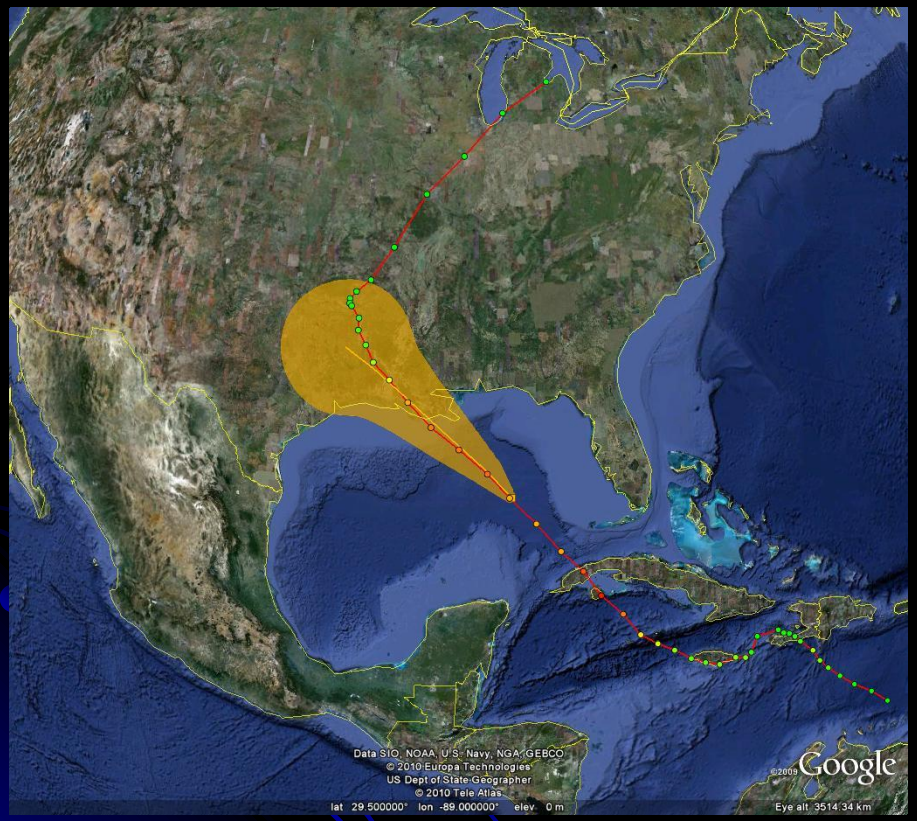
Himangshu S. Das, PhD, PE
NDCIEM
Jackson State University

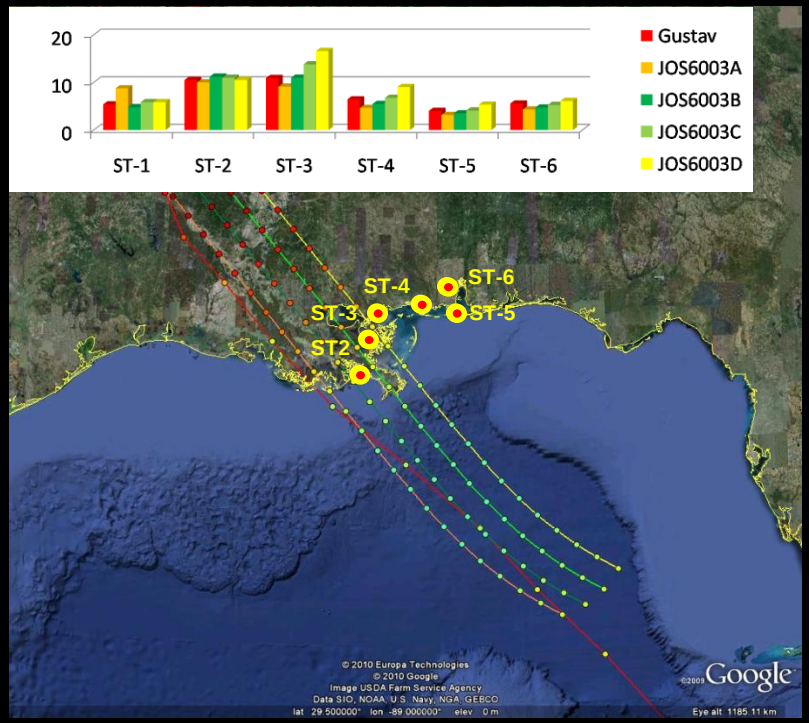
Motivation

Emergency managers need a tool for quickly and accurately estimating how, when, and where an approaching hurricane will affect local water levels, and for rapidly updating this information as new forecasts are issued by the National Hurricane Center.



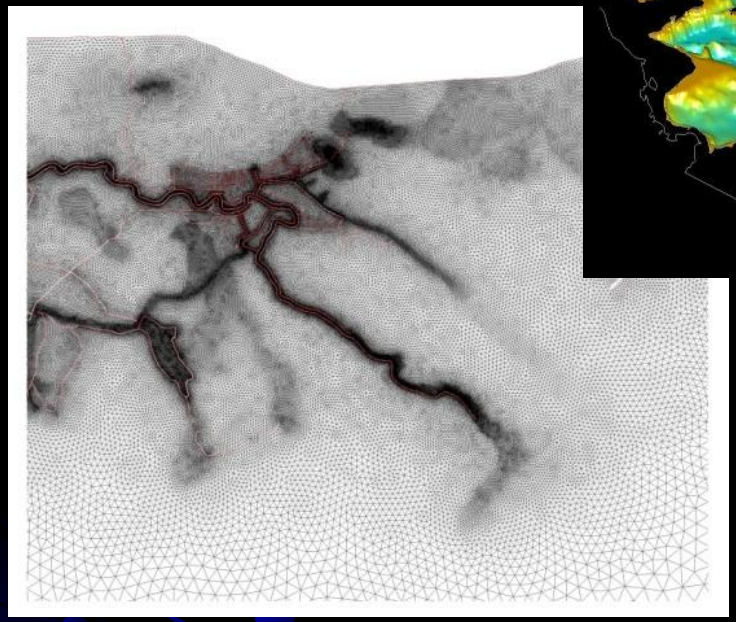
Why do we need a new tool ??

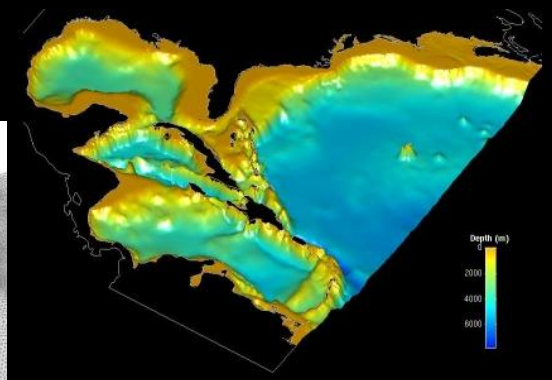


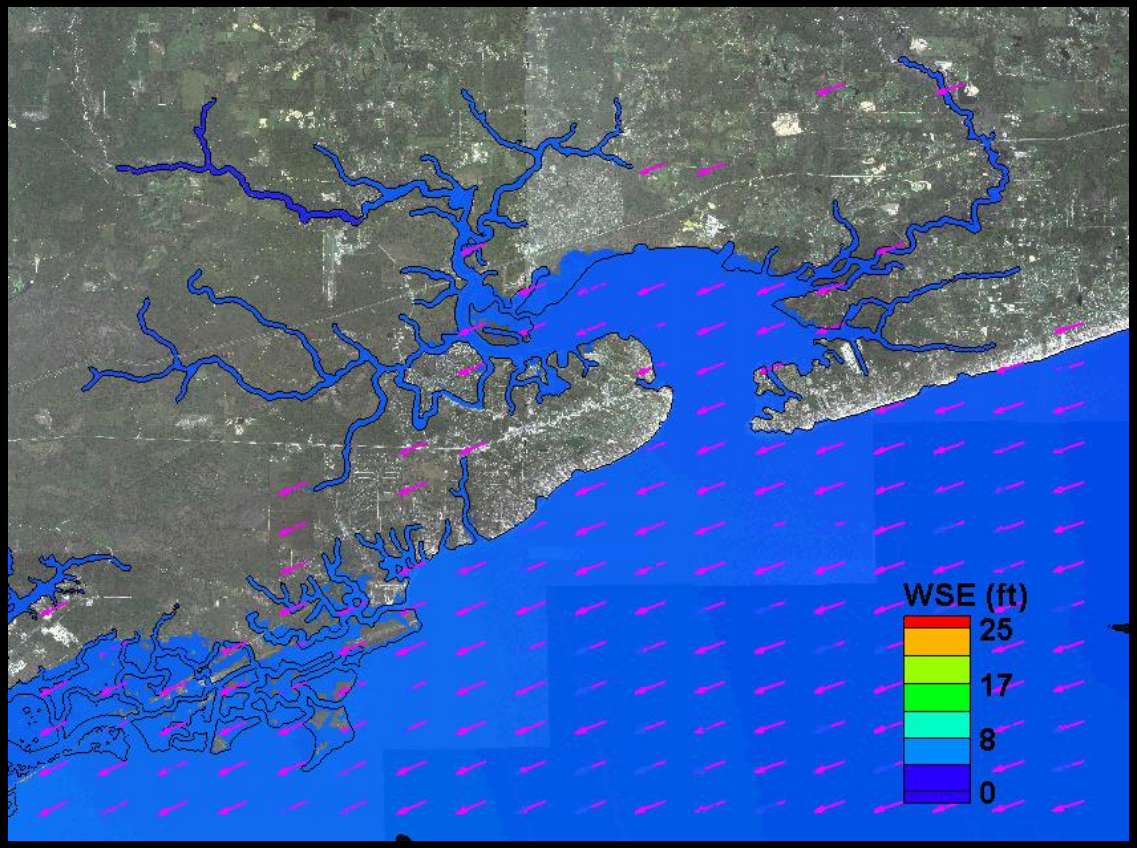


Uncertainty in the forecast hurricane track has a huge bearing on predicted surge.

Why do we need a new tool ??





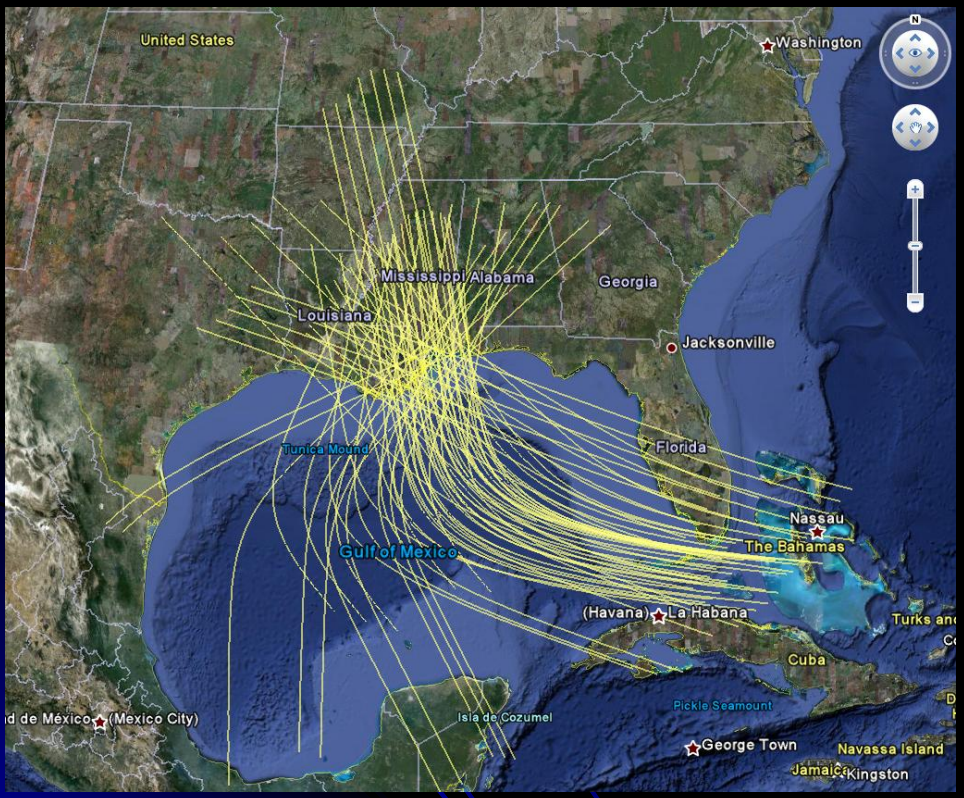


A single high-resolution model simulation takes 4-5 hours to complete.

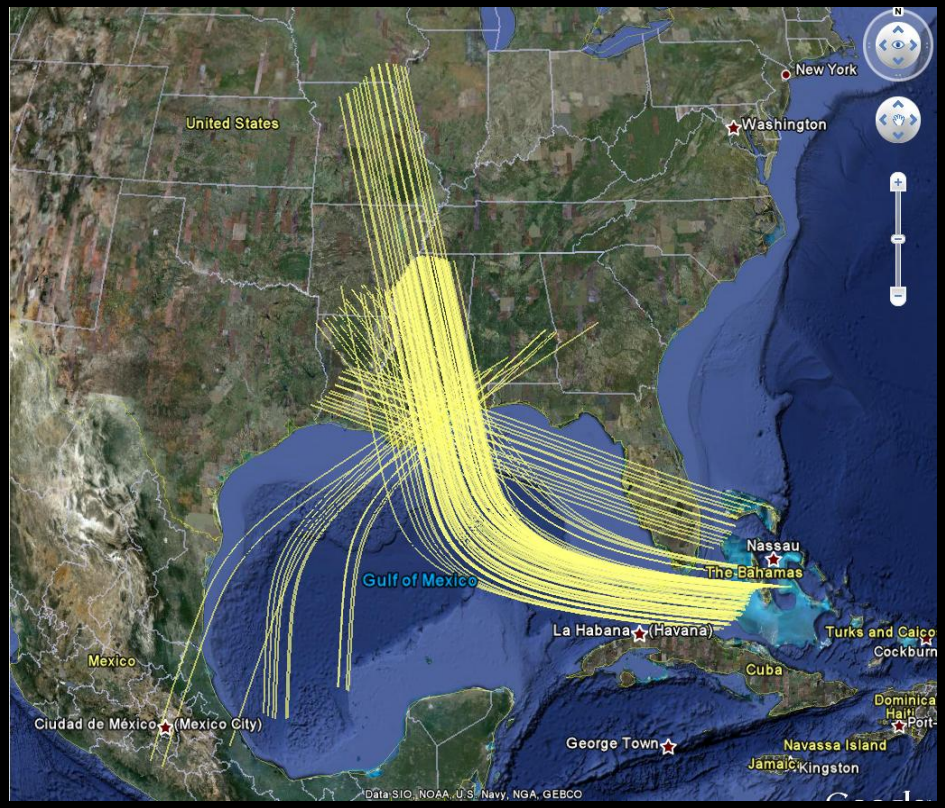
Can we use PRE-COMPUTED, high-resolution model data to generate accurate, time-dependent, operational estimates of local surge?

Let's Take The Mississippi Gulf Coast as an Example

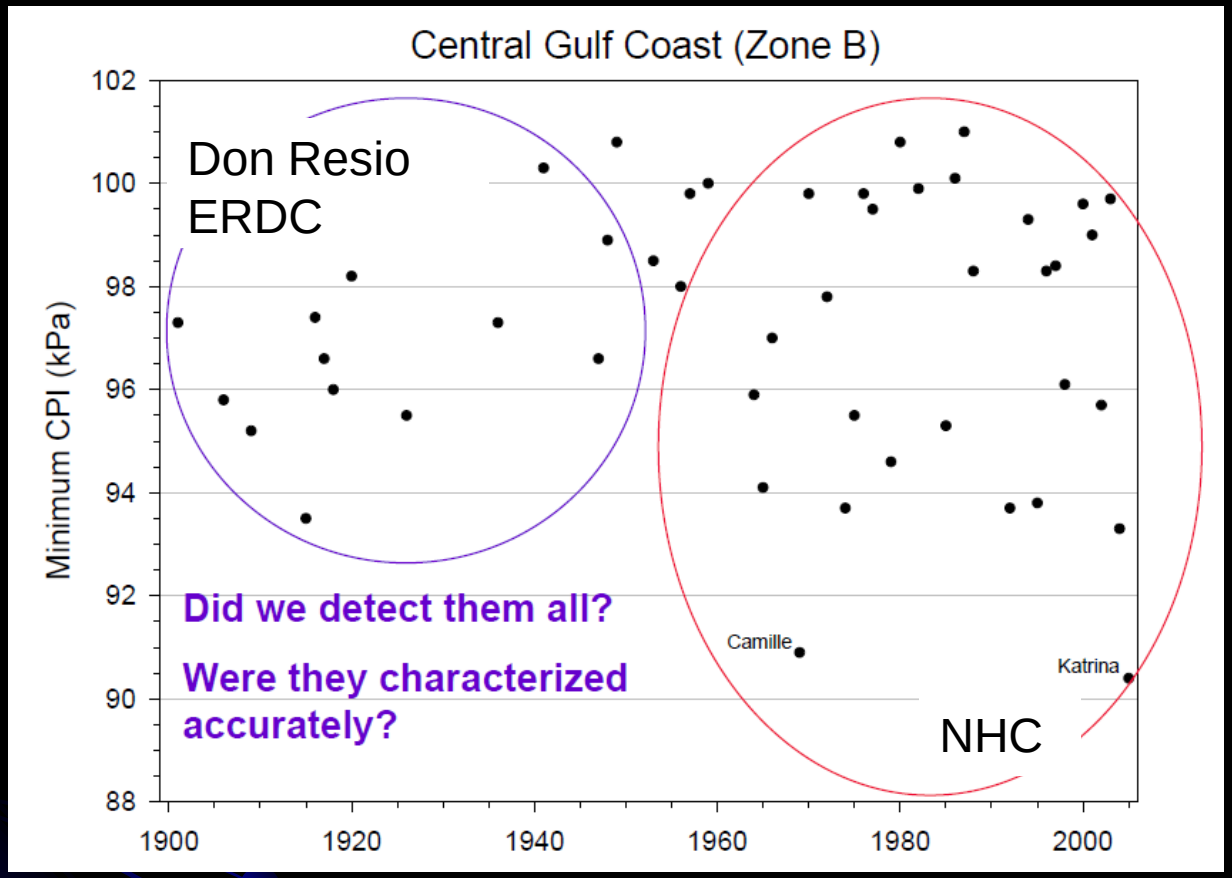
ERDC (2007-08)



FEMA (2007)



Approximately 300 high resolution storm surge simulations are archived. These simulations represents a wide variety of hurricane parameters and tracks representative for coastal Mississippi.



Synthetic <u>hurricane parameters</u> and <u>tracks</u> are blended from historical parameters related to Gulf coast

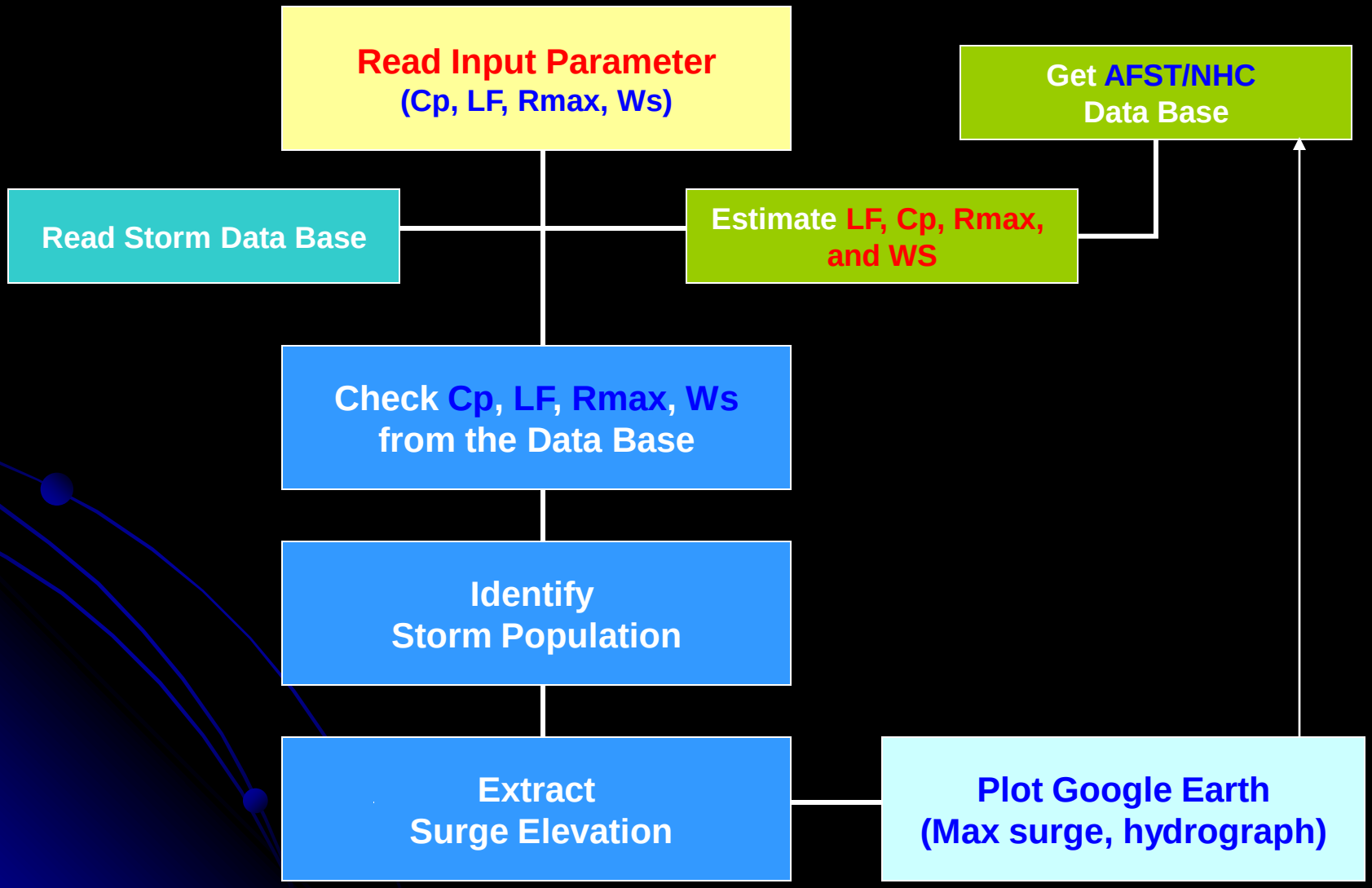
Distribution			
ΔP	Rp	Vf	Heading
4	3	6	5

(Niedoroda & Das, 2010)

"Cat."	3	4	5
ΔP range (mb)	45-70	70-95	95-135
Probability	0.657	0.261	0.082

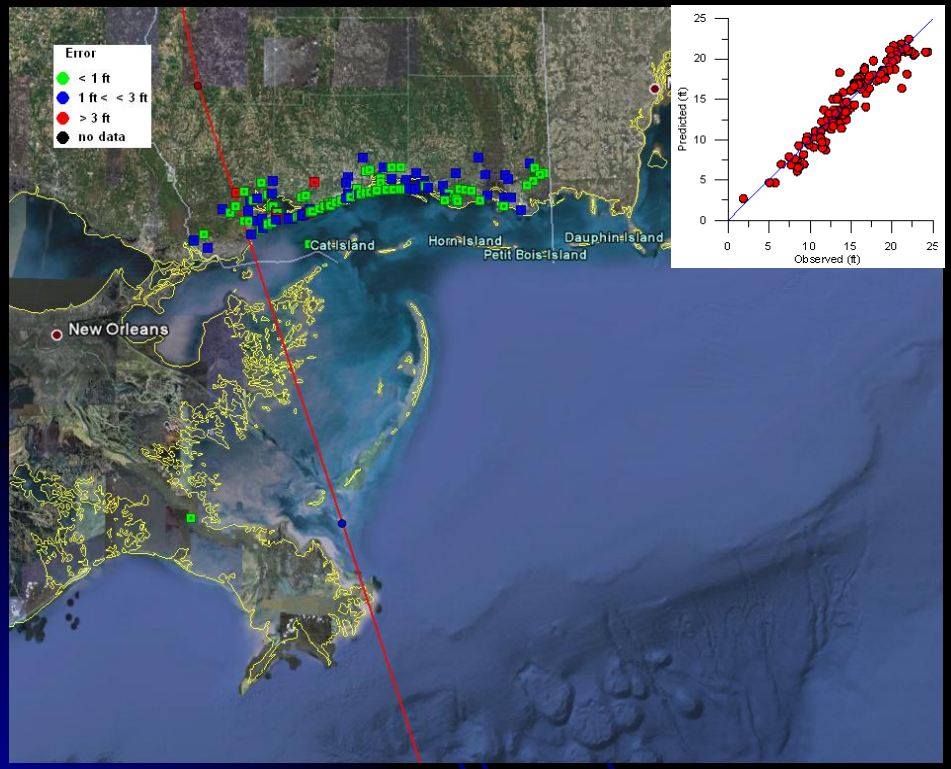
Assumption: Future hurricanes will be similar to ones already simulated

Schematic for REAL
(Rapid Estimates for Approaching Landfall)

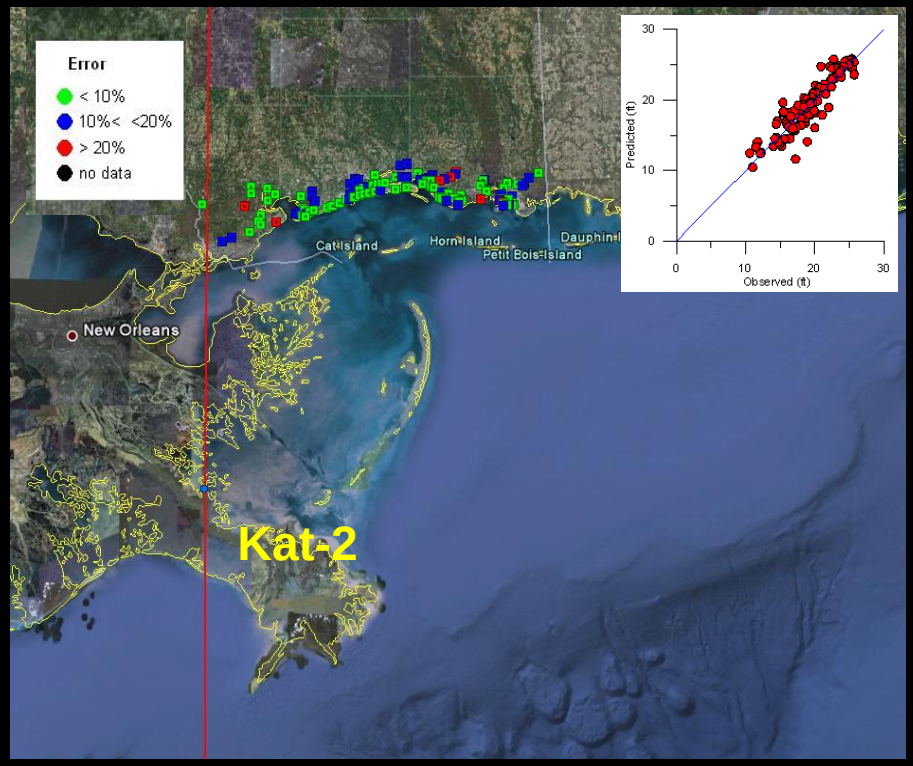


REAL Surge Estimates Compared to Historical Storms

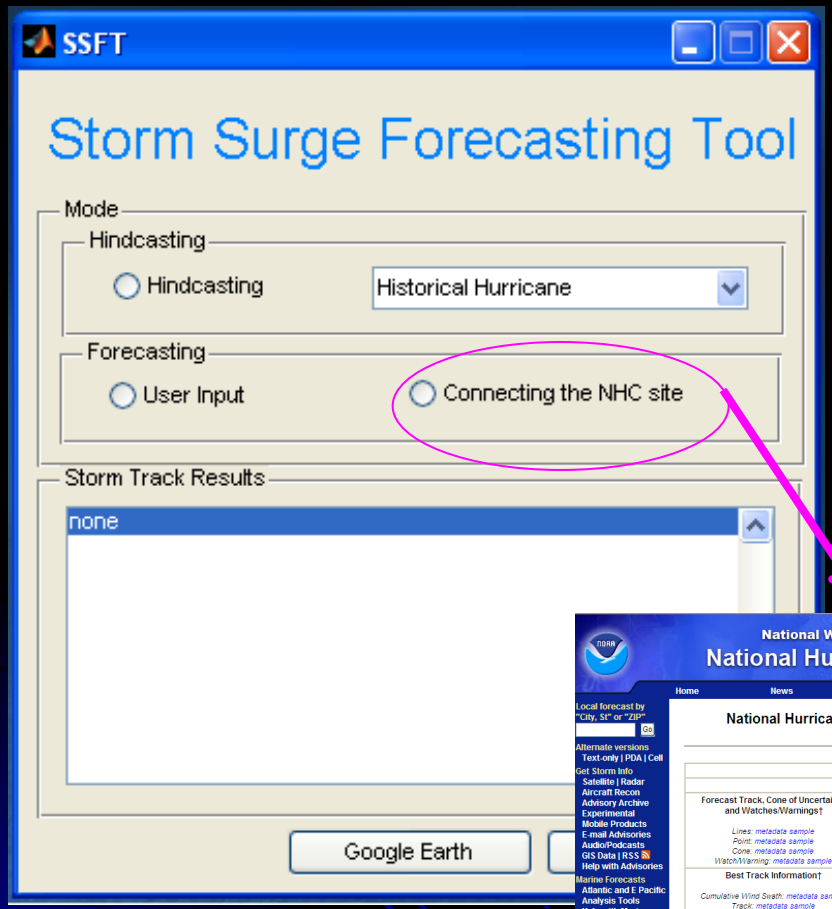
Hurricane Camille, 1969

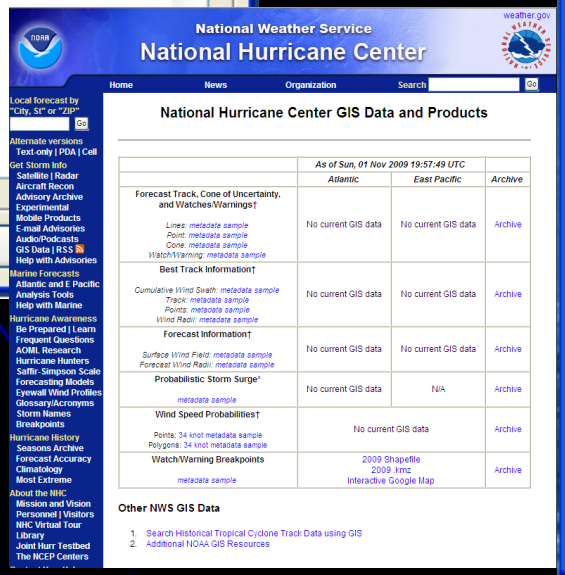


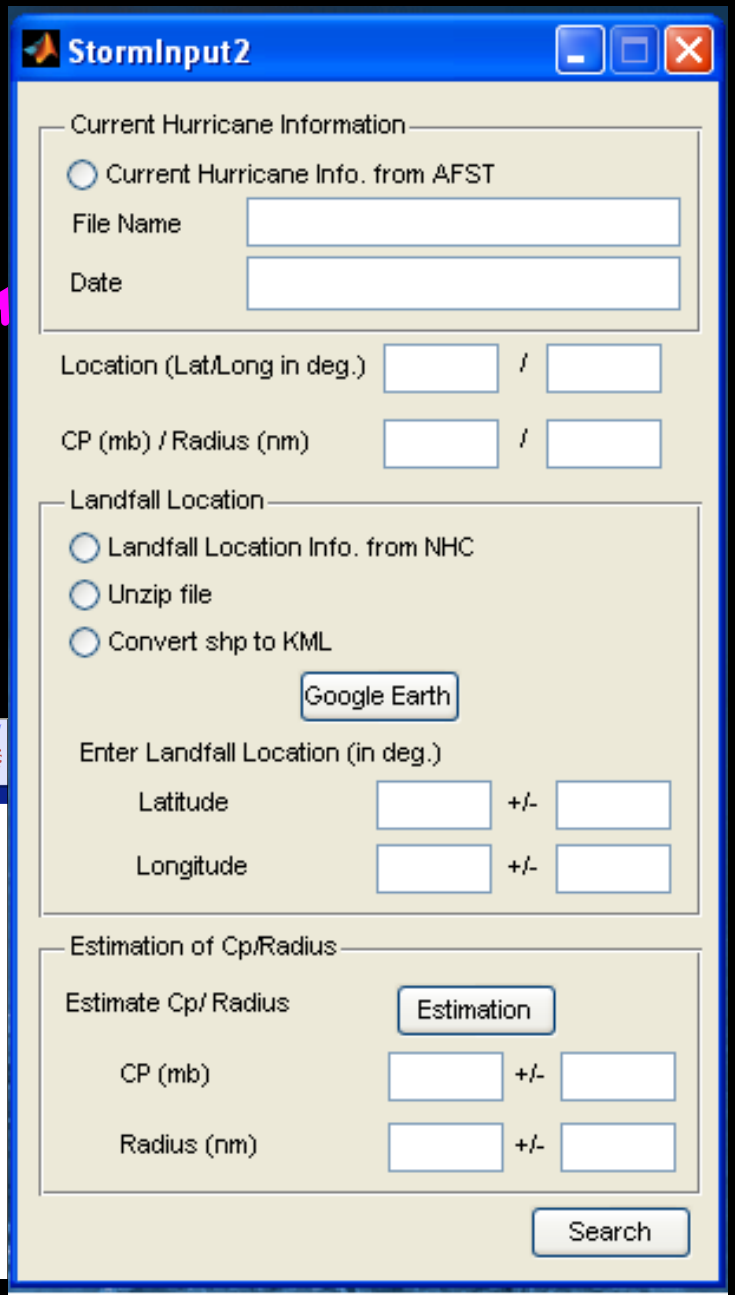
Hurricane Katrina, 2005



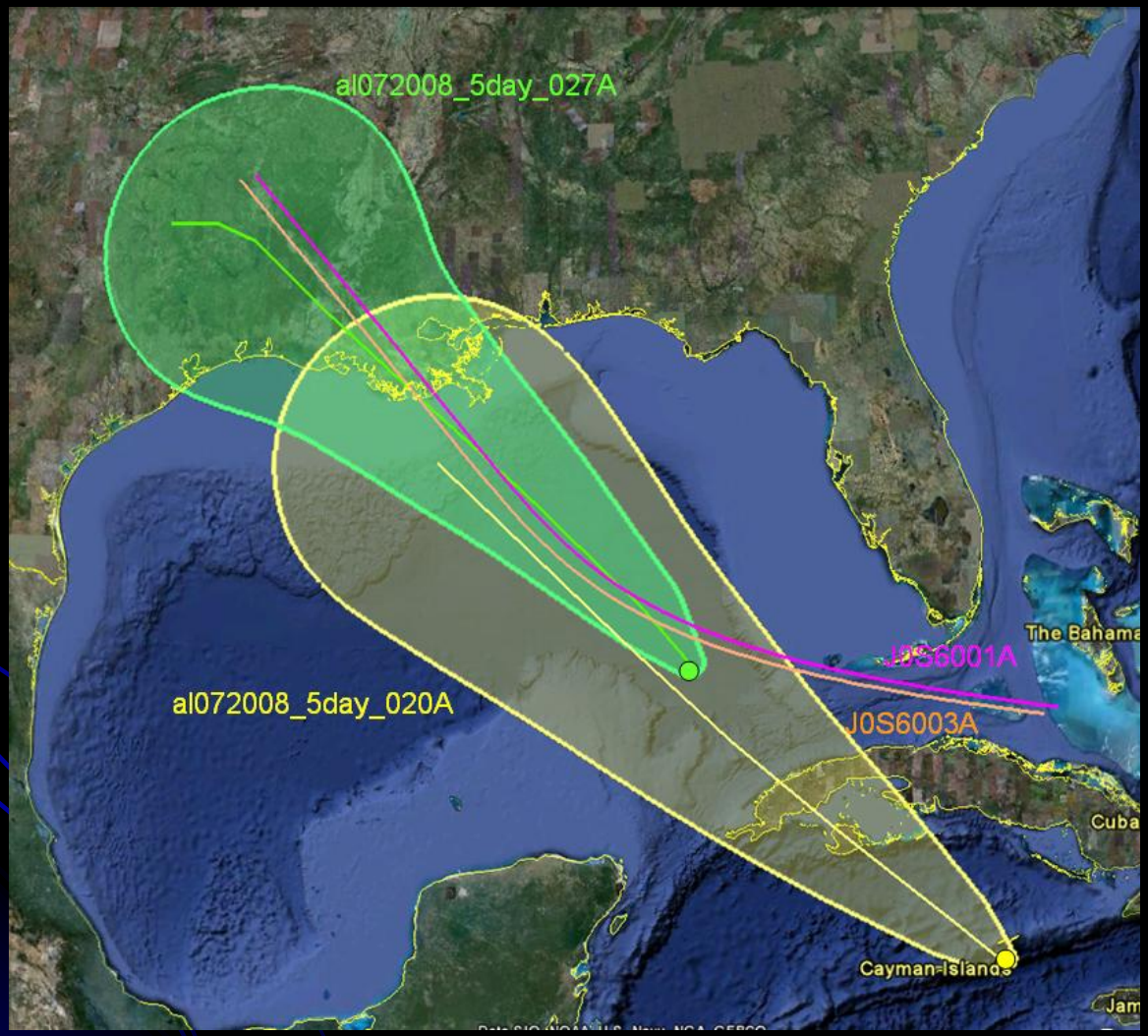
REAL User Interface







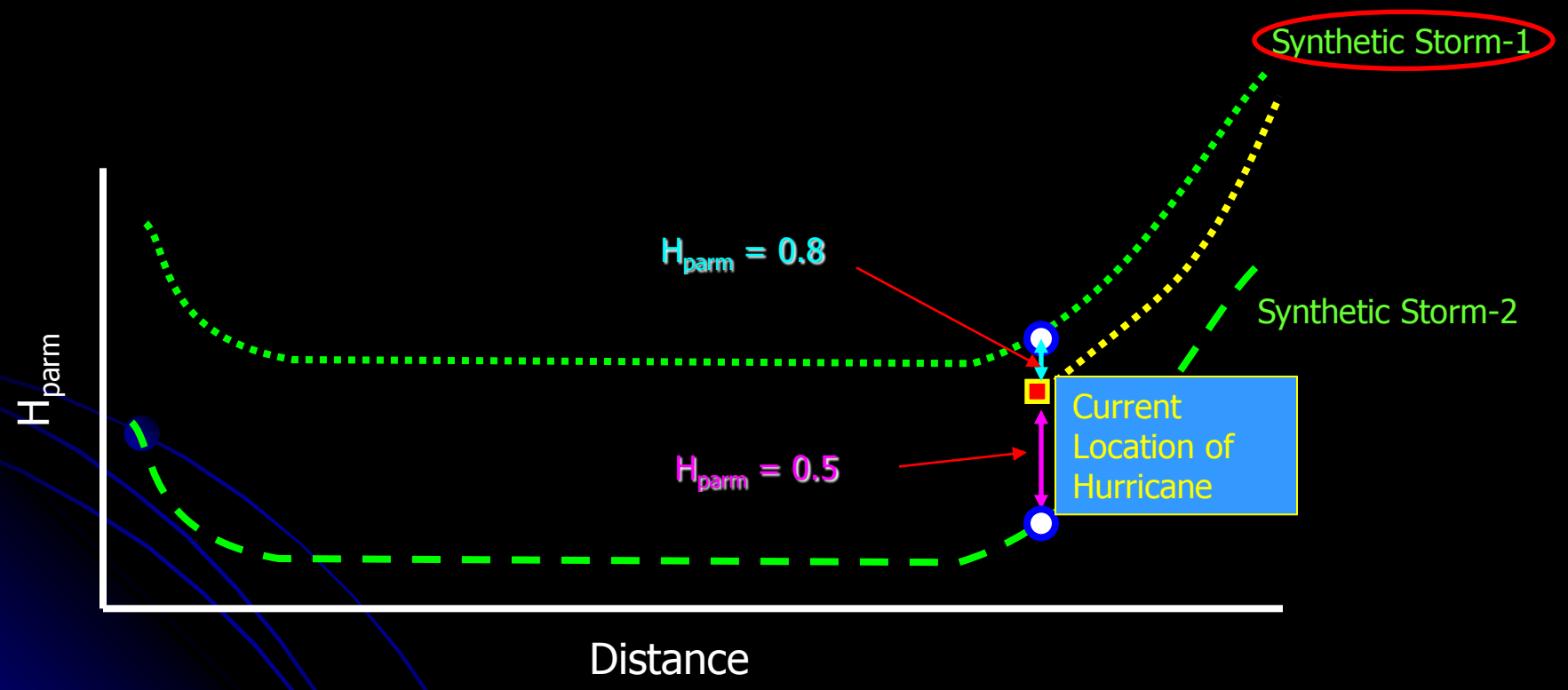
Computation



Storm Similarity Index (SSI)

- SSI = $a \cdot H_{parm1} + b \cdot H_{parm2} + c \cdot H_{parm3} + \ldots$
  - H_{parm} = weighting values of Hurricane parameter
  - (i.e., CP, Rmax, LF, ...; $0 \leq H_{parm} \leq 1$)
  - a, b, c,... = SSI weighting values
  - a + b + c + ... = 1
- Method 1
  - Real Time Deviation in Parameters
- Method 2
  - Forecasted Deviation in Parameters

Method 1

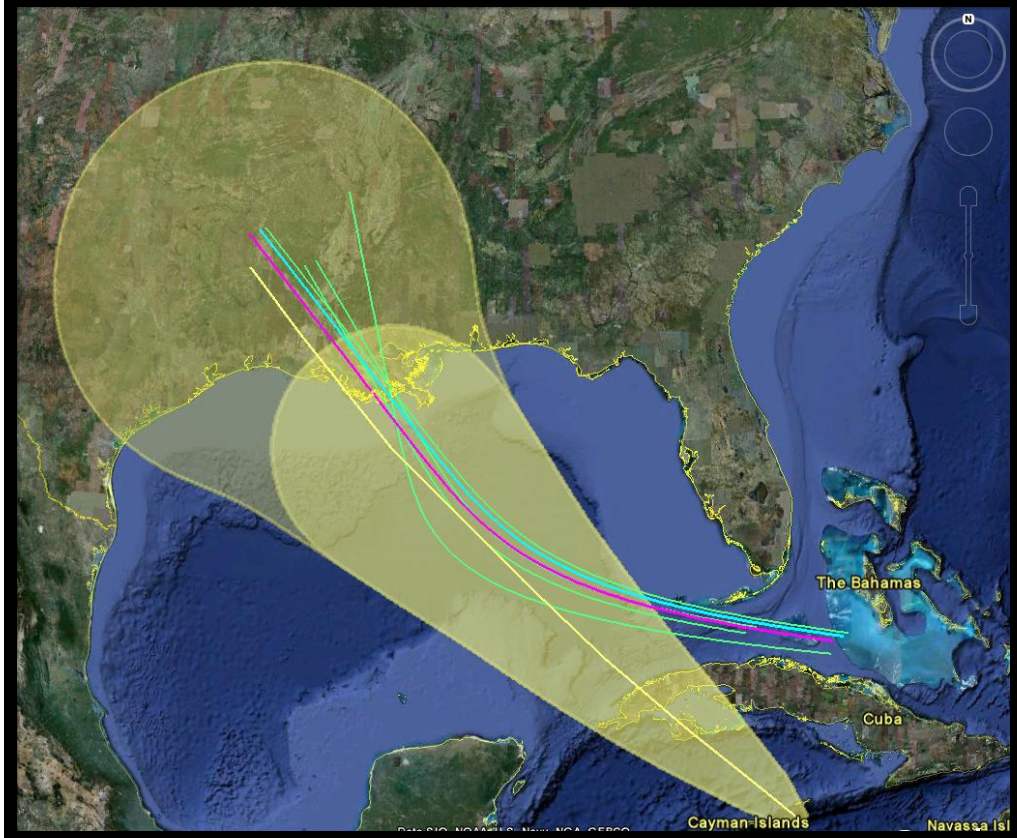

Synthetic Storm-1
Synthetic Storm-2
H_{parm} = 0.8
H_{parm} = 0.5
Current Location of Hurricane
H_{parm}
Distance

Method 1 - Distance

- $SSI=(a \cdot H_{LF}+b \cdot H_{CP}+c \cdot H_{Rmax}+d \cdot H_{FS})H_{TRK}$
  - H_{LF} = Landfall Location Similarity
  - H_{CP} = Cp Similarity
  - H_{Rmax} = R_{max} Similarity
  - H_{FS} = Forwarding Speed Similarity
  - H_{TRK} = Storm Track Similarity (0 or 1)
  - a = 0.3; b = 0.3; c = 0.2; and d = 0.2

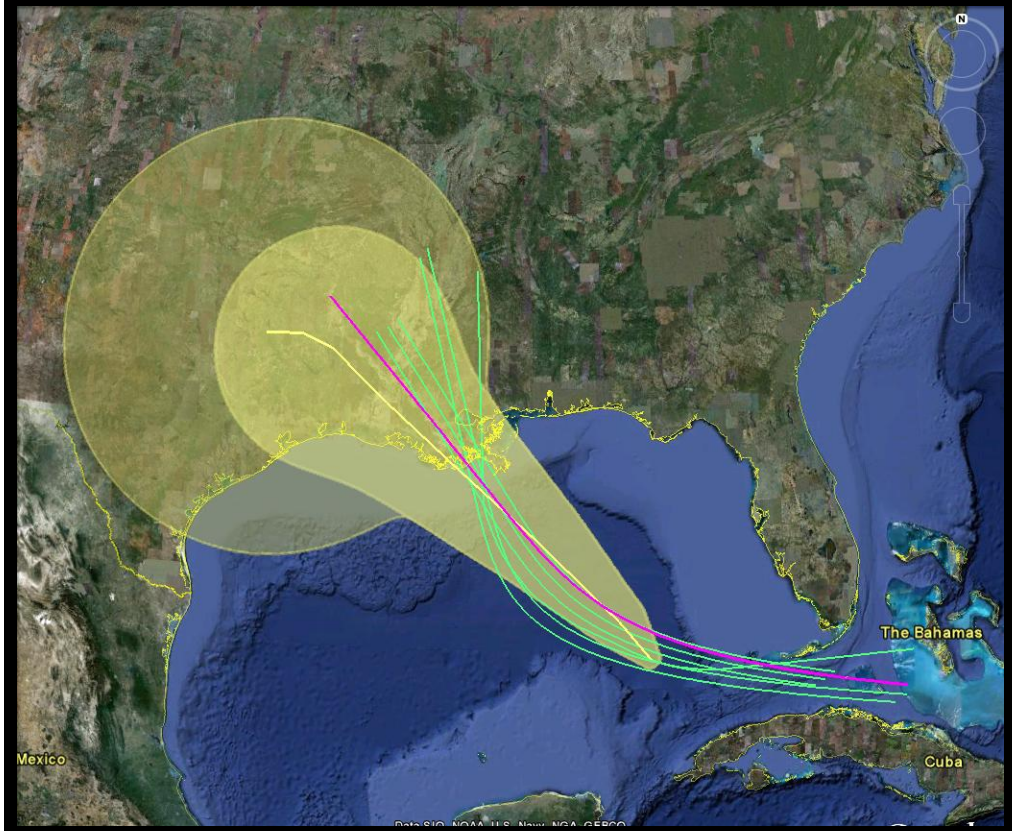
Method 1 – Results for Gustav (al072008_5day 020A)

Current Storm	Location (Lat/Lon)	19.3 / -80.0
	CP (mb)	980
	Rmax (mi)	20
	Forward. Spd (kn)	10.5
Landfall	Location (Lat/Lon)	29.1 / -91.0
Results	Storm Name	SSI
	JOS6003A	0.84
	JOS6001A	0.80
	JOS6011A	0.78
	CAT2008A	0.77
	JOS6003B	0.75
	CAT2008B	0.71

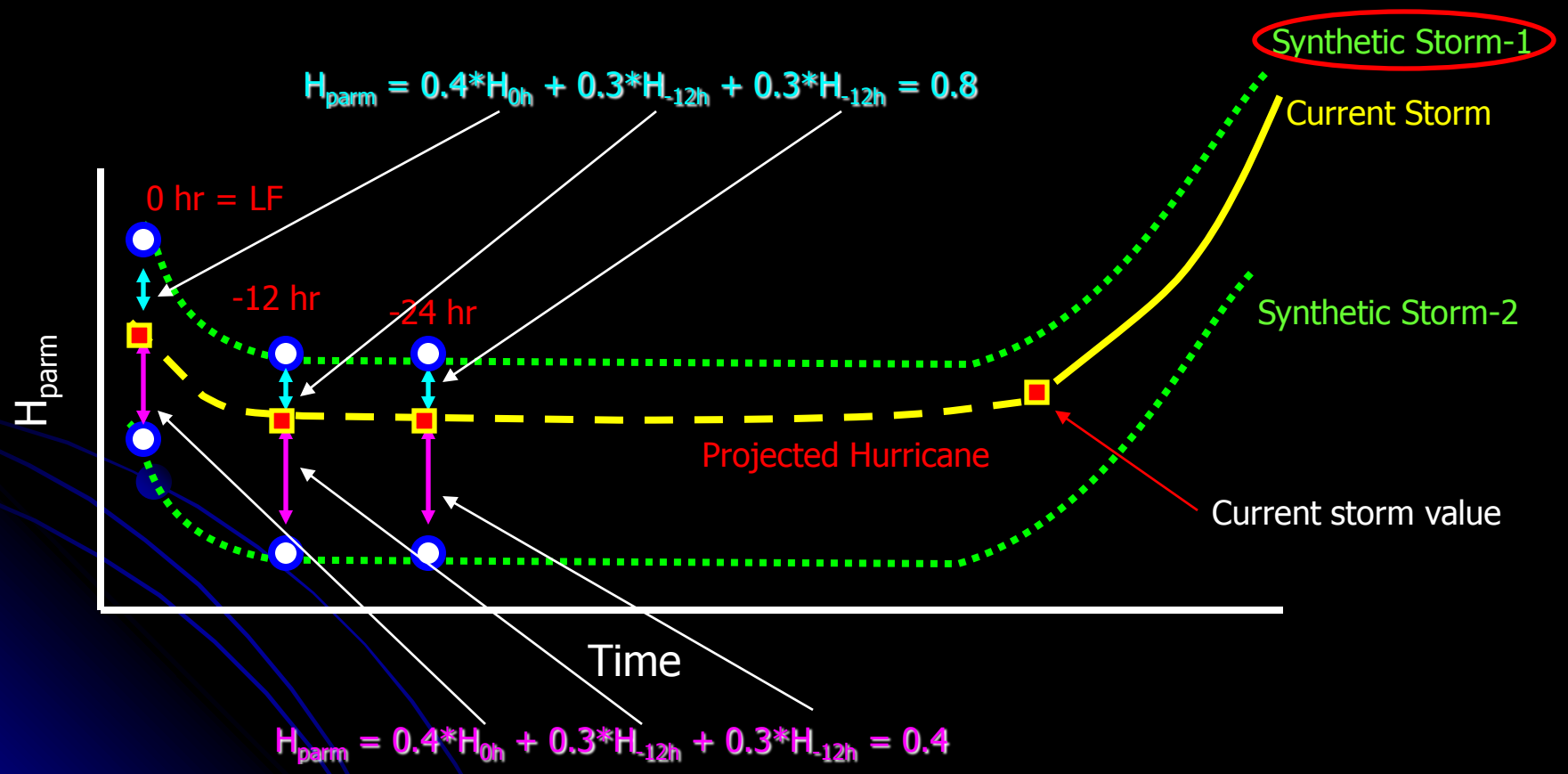


Method 1 – Results for Gustav (al072008_5day 027A)

Current Storm	Location (Lat/Lon)	24.7 / -85.5
	CP (mb)	958
	Rmax (mi)	15
	Forward. Spd (kn)	10.3
Landfall	Location (Lat/Lon)	29.1 / -90.4
Results	Storm Name	SSI
	JOS6001A	0.82
	CAT2008A	0.78
	JOS6001B	0.73
	CAT2008B	0.72
	JOS6004A	0.71
	CHL0810A	0.70
	CAT2008C	0.63



Method 2

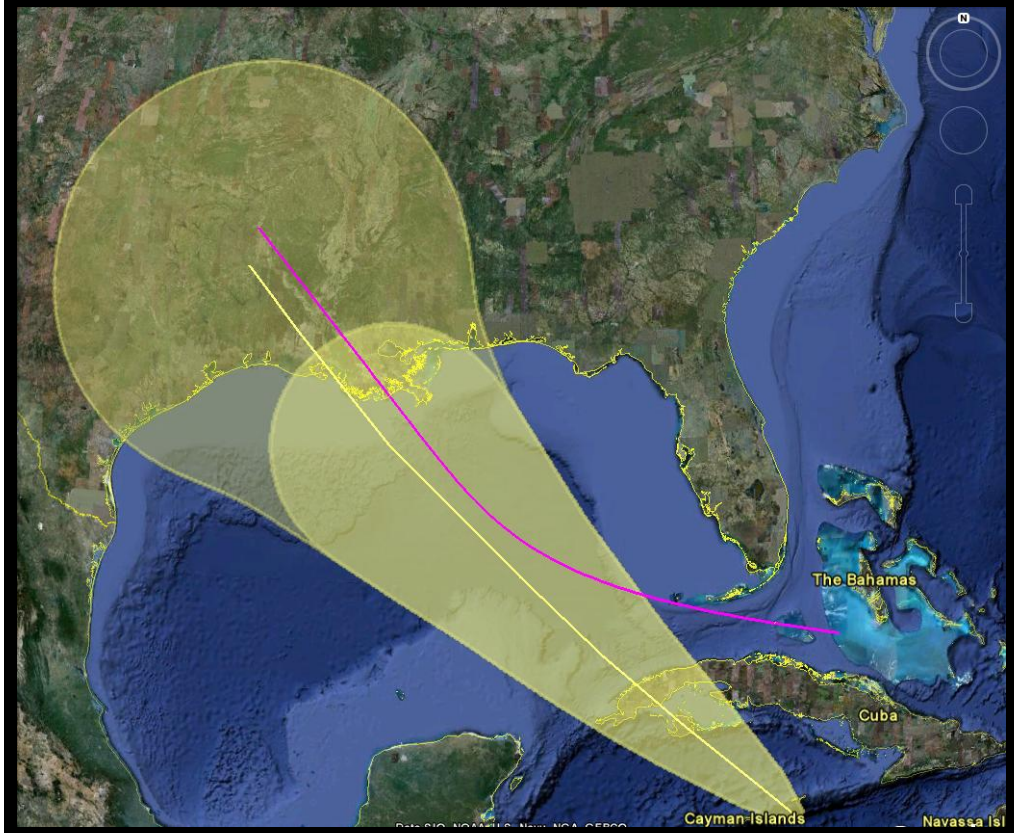

Synthetic Storm-1
$H_{parm} = 0.4*H_{0h} + 0.3*H_{-12h} + 0.3*H_{-12h} = 0.8$
Current Storm
0 hr = LF
-12 hr
-24 hr
Synthetic Storm-2
H_{parm}
Projected Hurricane
Current storm value
Time
$H_{parm} = 0.4*H_{0h} + 0.3*H_{-12h} + 0.3*H_{-12h} = 0.4$

Method 2

- $SSI = a \cdot H_{LF} + b \cdot H_{CP} + c \cdot H_{Rmax} + d \cdot H_{FS} + e \cdot H_{TRK}$
  - H_{LF} = Landfall Location Similarity
  - H_{CP} = Cp Similarity
  - H_{Rmax} = R_{max} Similarity
  - H_{FS} = Forwarding Speed Similarity
  - H_{TRK} = Storm Track Similarity
  - a = 0.2; b = 0.2; c = 0.2; d = 0.2 ; and e = 0.2

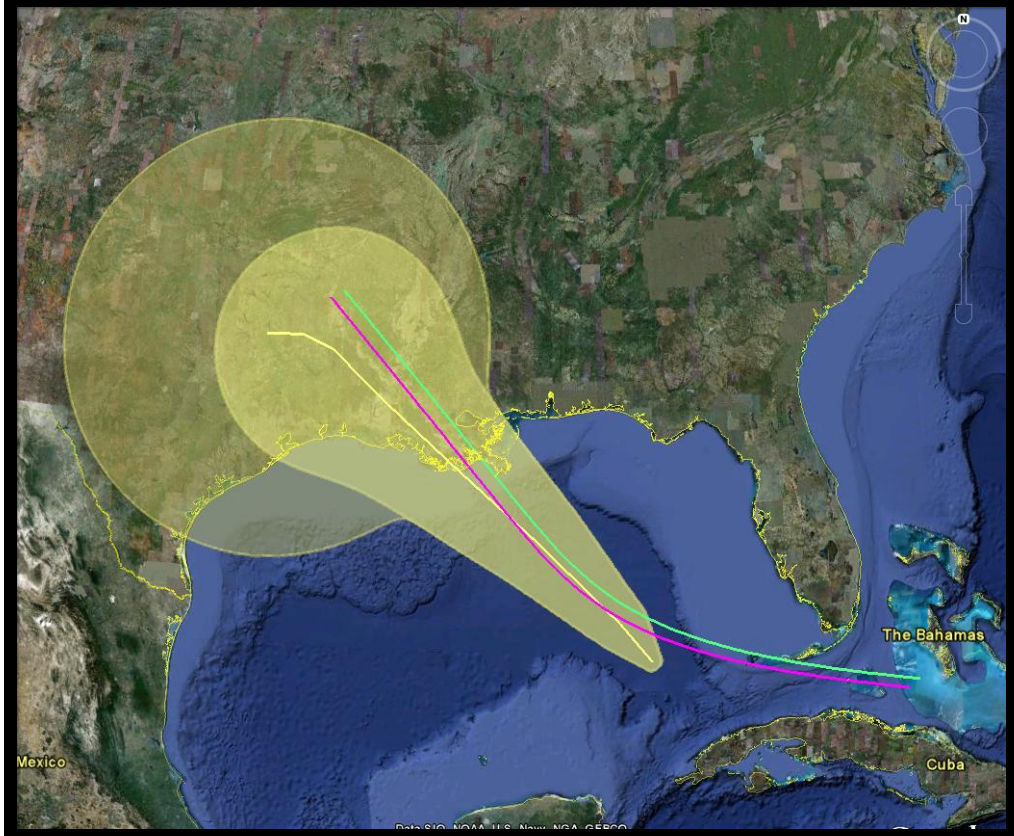
Method 2 – Results for Gustav (al072008_5day 020A)

Current Storm	Location (Lat/Lon)	19.3 / -80.0
	CP (mb)	980
	Rmax (mi)	20
	Forward. Spd (kn)	10.5
Landfall	Location (Lat/Lon)	29.1 / -91.0
Results	Storm Name	SSI
	JOS6001A	0.56

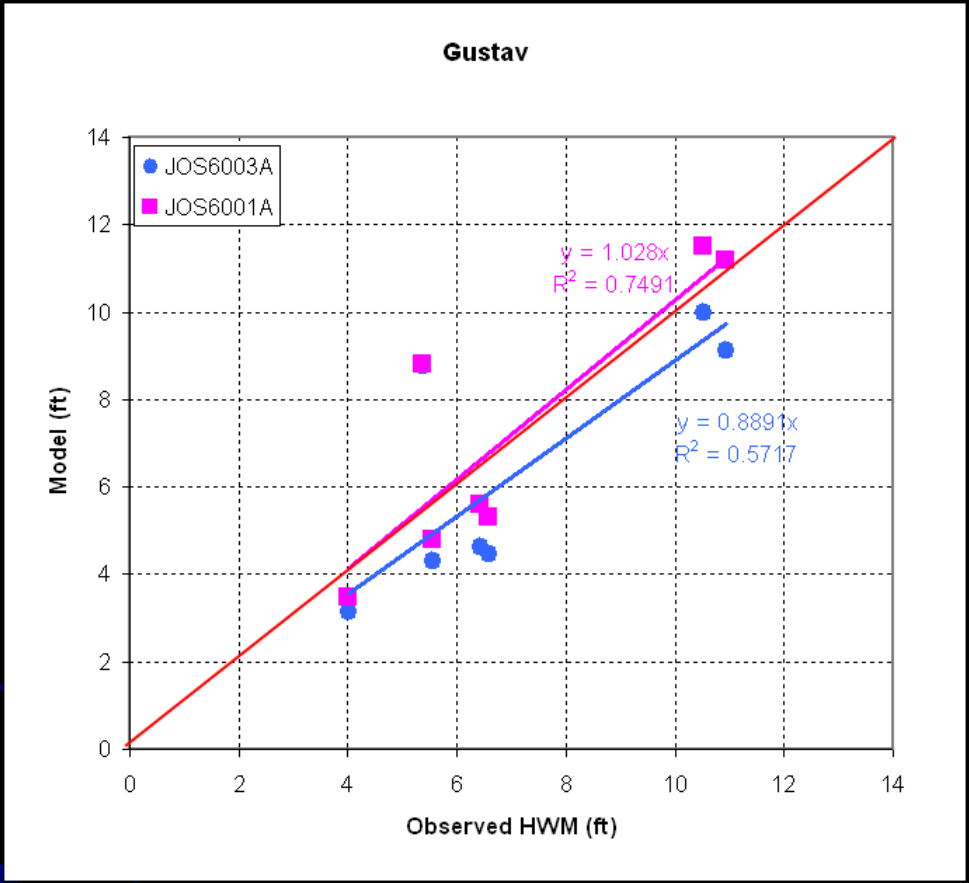


Method 2 – Results for Gustav (al072008_5day 027A)

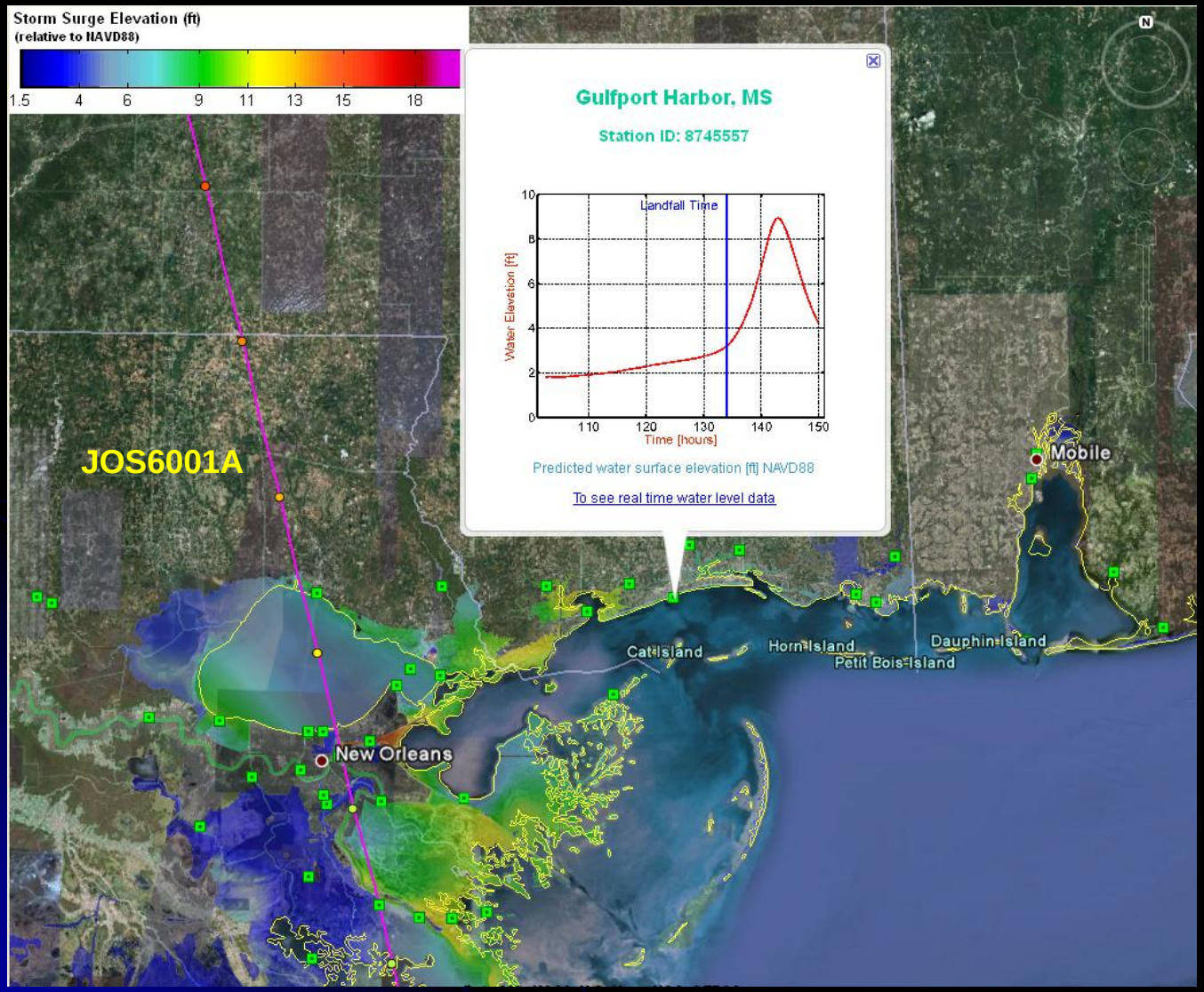
Current Storm	Location (Lat/Lon)	24.7 / -85.5
	CP (mb)	958
	Rmax (mi)	15
	Forward. Spd (kn)	10.3
Landfall	Location (Lat/Lon)	29.1 / -90.4
Results	Storm Name	SSI
	JOS6001A	0.74
	JOS6001B	0.68



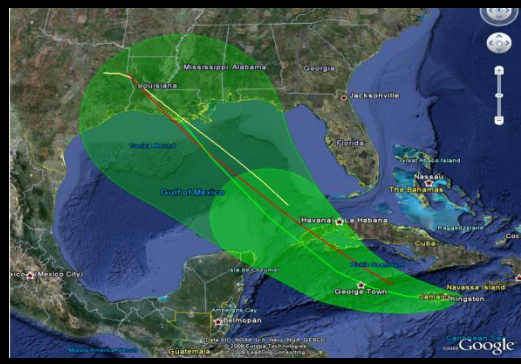
Comparison between Observed and Estimated



REAL Surge Estimating: Hurricane Gustav Demonstration

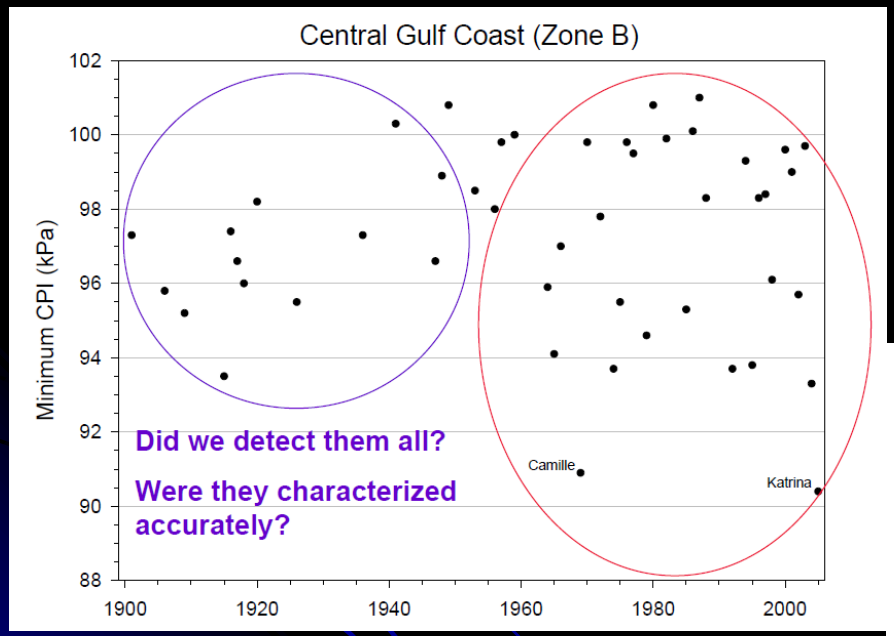


Advisory Number 27



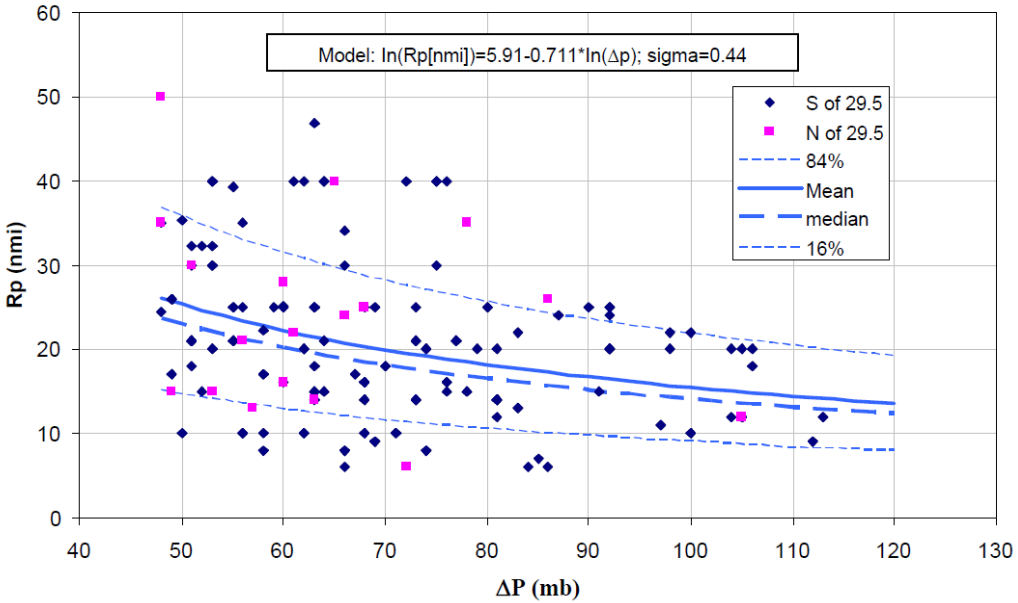
Continuing Work

Enhance database with additional simulations for Mississippi coast



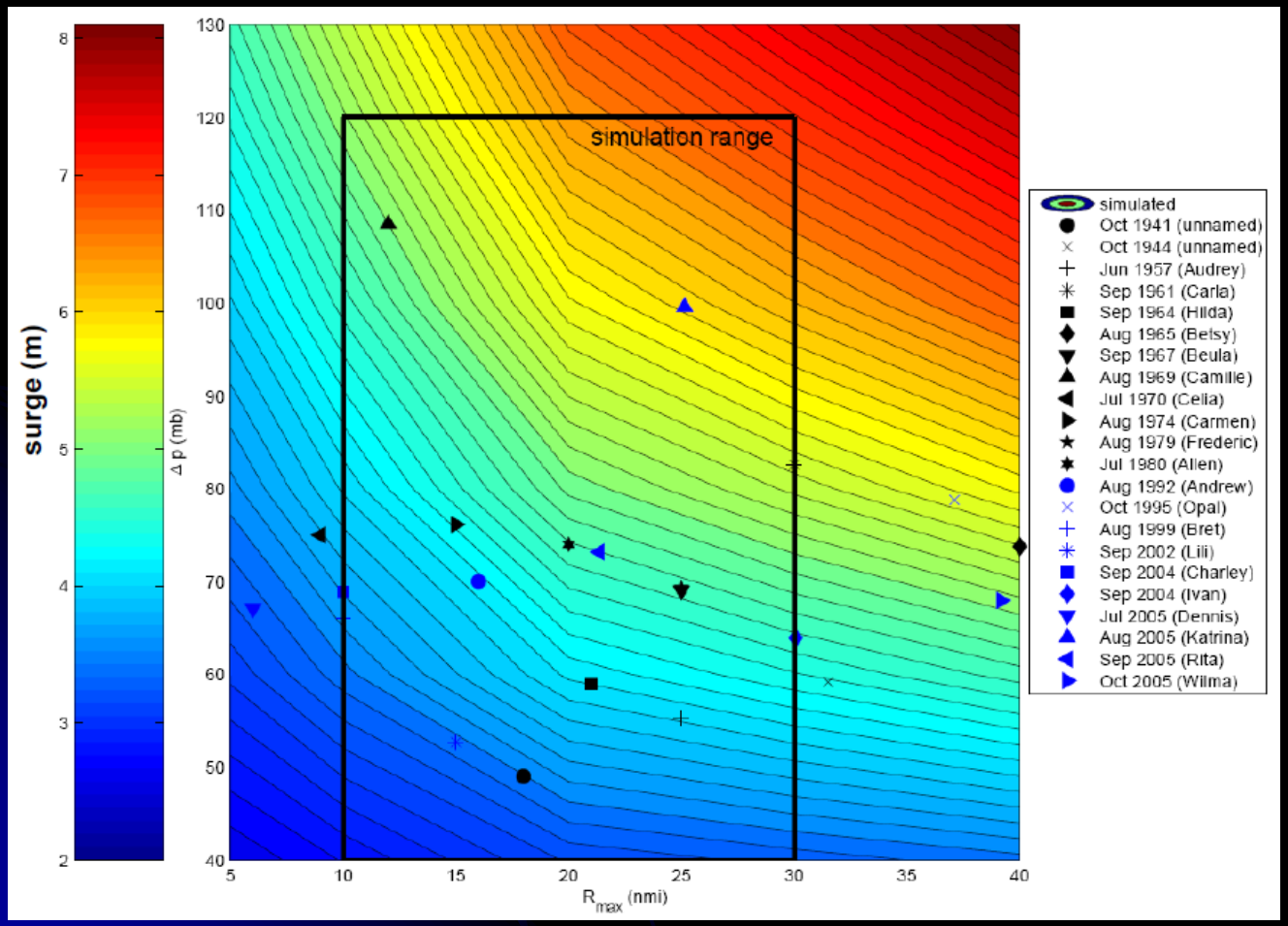
Increase combinations of Cp and Rp

Distribution			
ΔP	Rp	Vf	Heading
4	3	6	5



Continuing Work

Spatially interpolate surge response with varying Cp, Rp and landfall location



Jen Irish
et.al. (2009)