2010 Northern Gulf Institute
Annual Conference
May 18-20, 2010 Mobile, AL

Coupling of ADCIRC and wind-wave model for the Northern Gulf Coast

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Understanding Coastal Resiliency from Hurricane Impacts Using Integrated Modeling and Observations

09-NGI-08 - Active Project (11/01/2009 - 10/31/2011)
PI: Q. Jim Chen (LSU)

The long term goal of this study is to improve our understanding of coastal resiliency from hurricane impacts using integrated numerical modeling and in-situ observations and remote sensing techniques within an interdisciplinary and multiple-institutional approach.

- Improve the wind forcing input for storm surge and wave models (MSU/LSU)

- Extend the NOAA ocean wave prediction model WAVEWATCH III to coastal regions with wetlands (NOAA/LSU).

-Develop and test a coupled wave, surge and sediment transport model system for coastal regions using the Breton Sound and Wax Lake Delta as a natural "laboratory" (LSU/NOAA/MSU)

- Conduct numerical simulations to test hypotheses of resiliency (LSU/MSU/NOAA)

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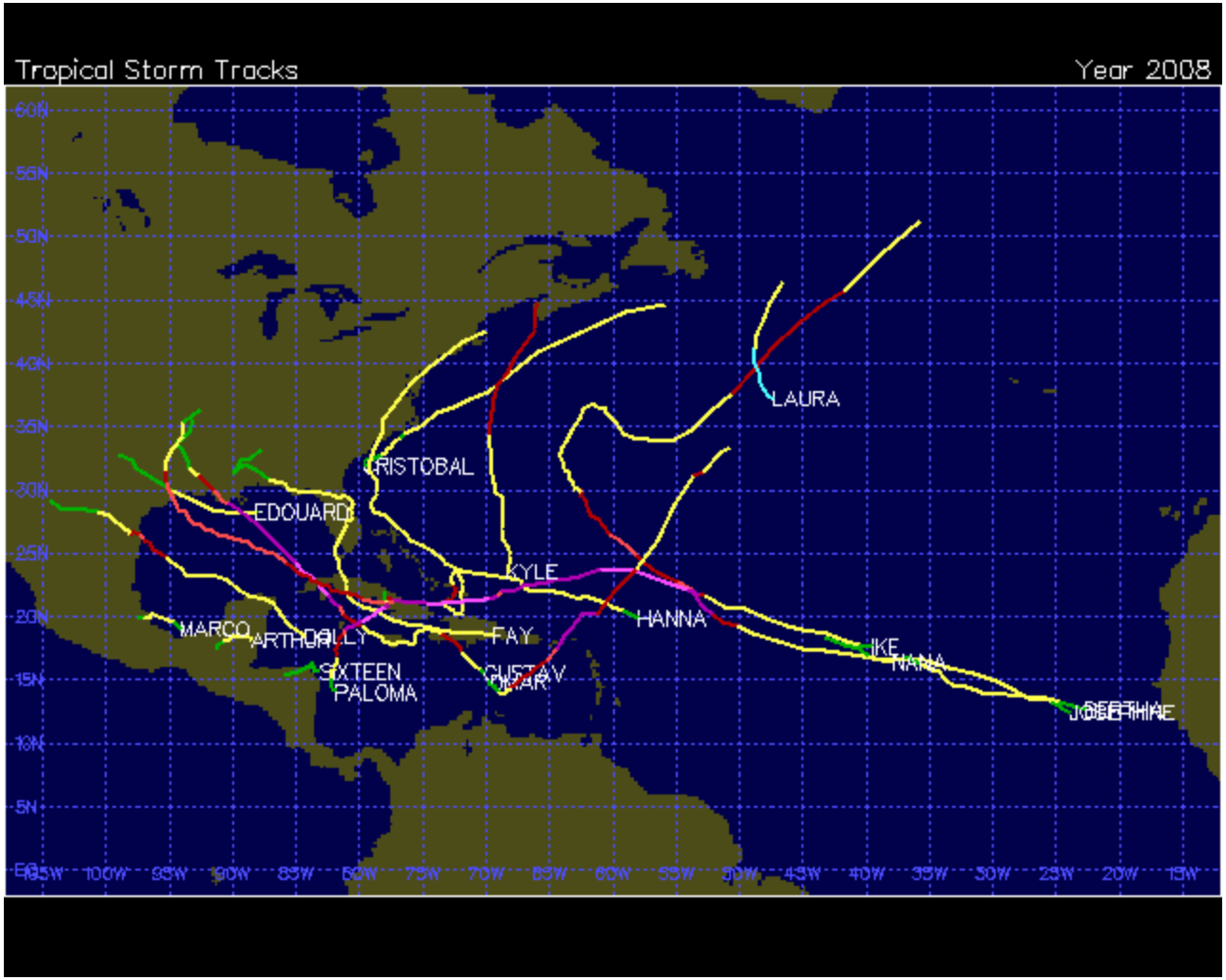
Outline

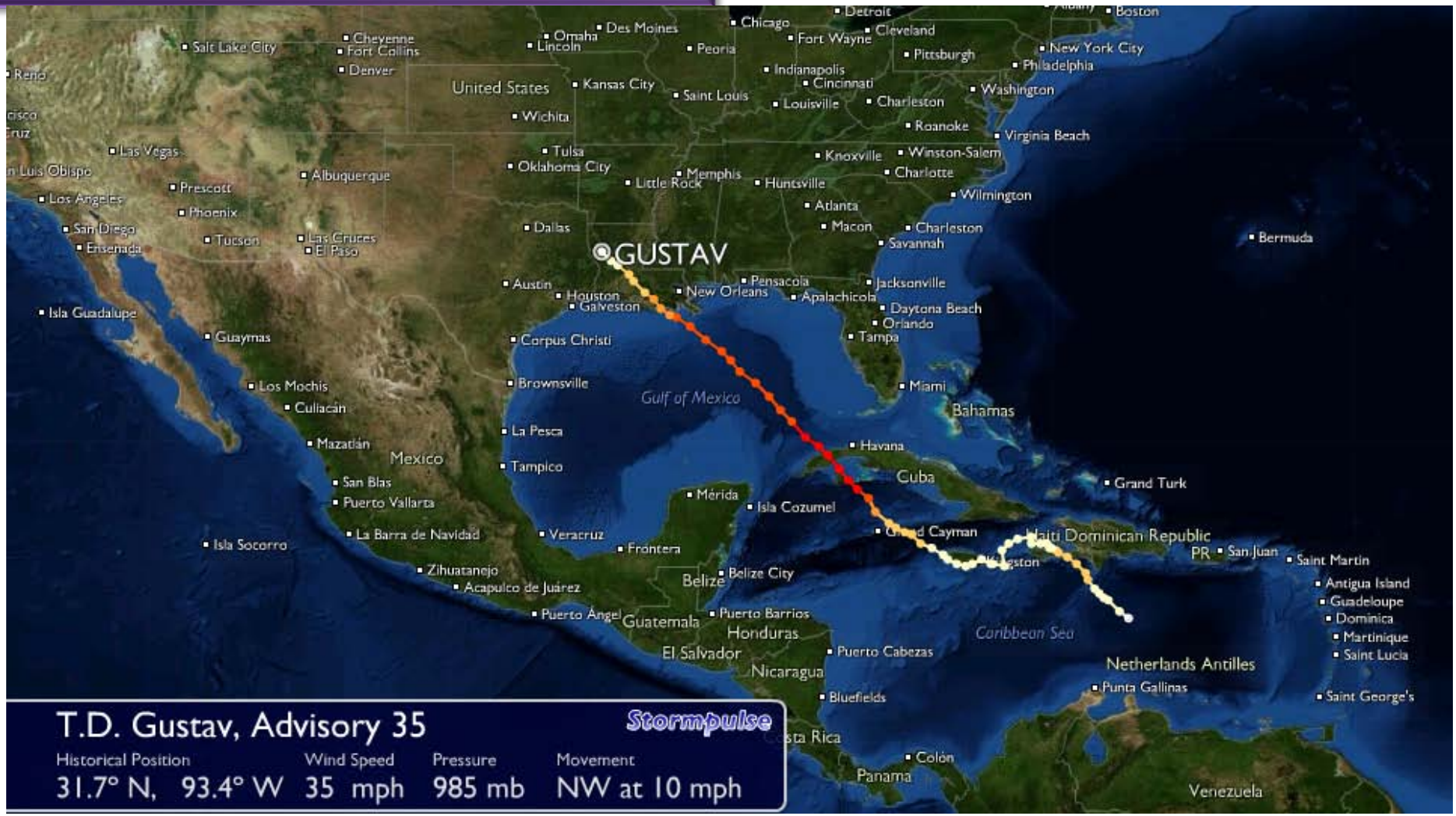
- Introduction
- Measurements
- Modeling
- Results
- Summary

Introduction



http://weather.unisys.com/hurricane/atlantic/2008H/track.gif

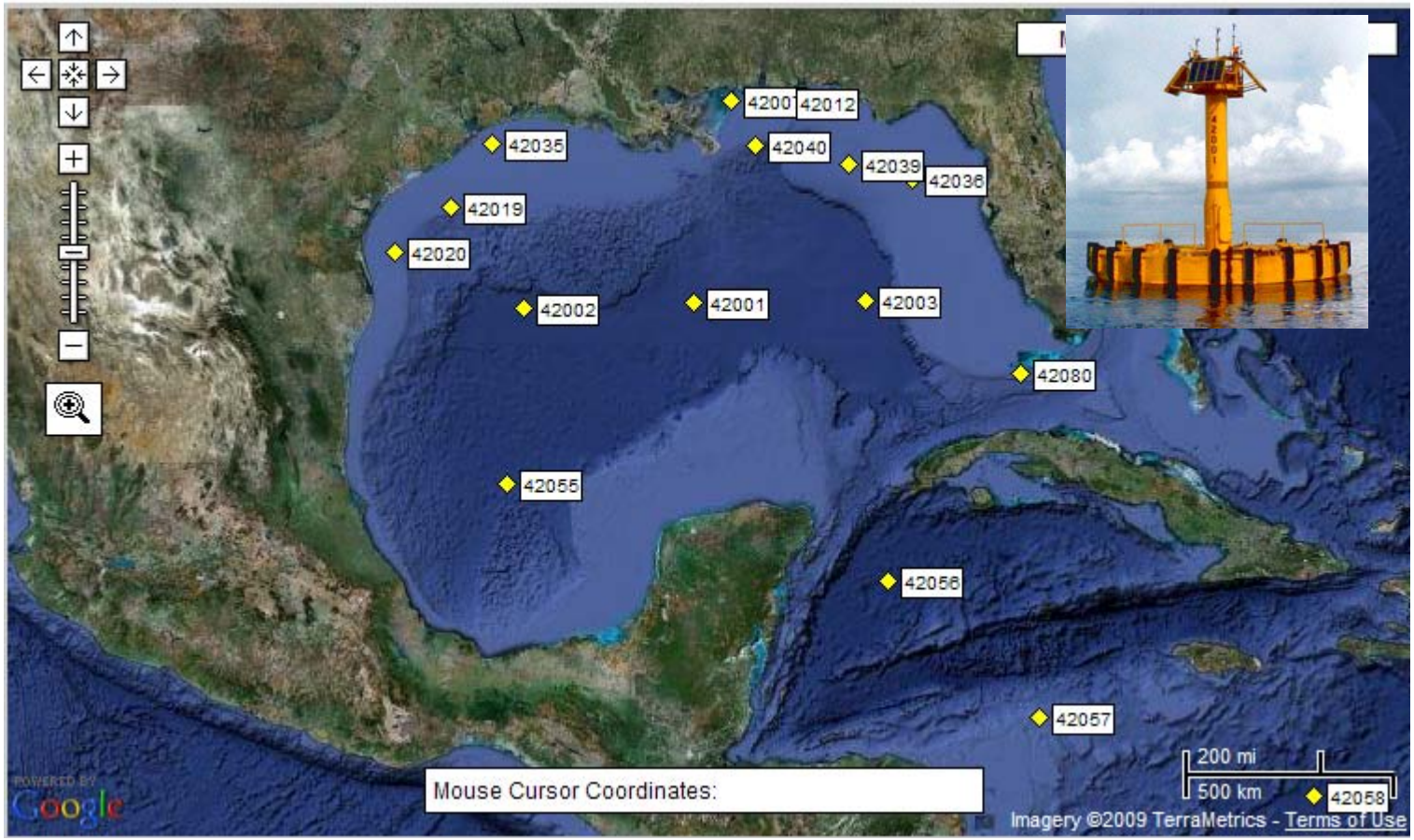
Introduction



http://www.stormpulse.com/hurricane-gustav-2008

Measurements

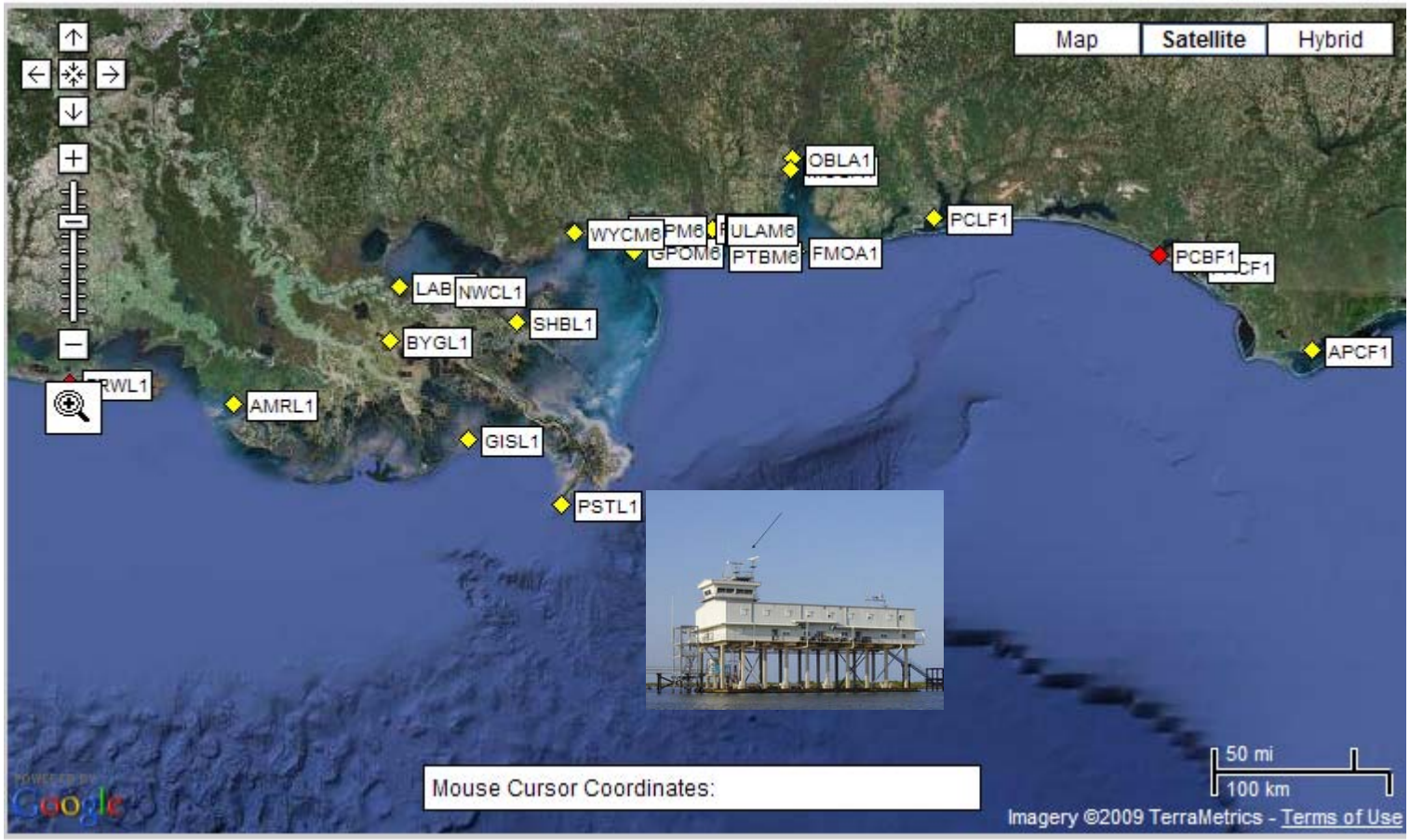
- National Data Buoy Center http://www.ndbc.noaa.gov/



Wind and waves

Measurements

- NOS/CO-OPS http://tidesandcurrents.noaa.gov/



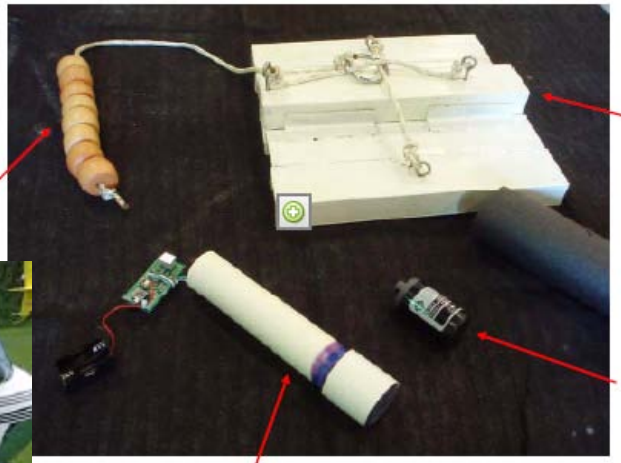
Wind and surge

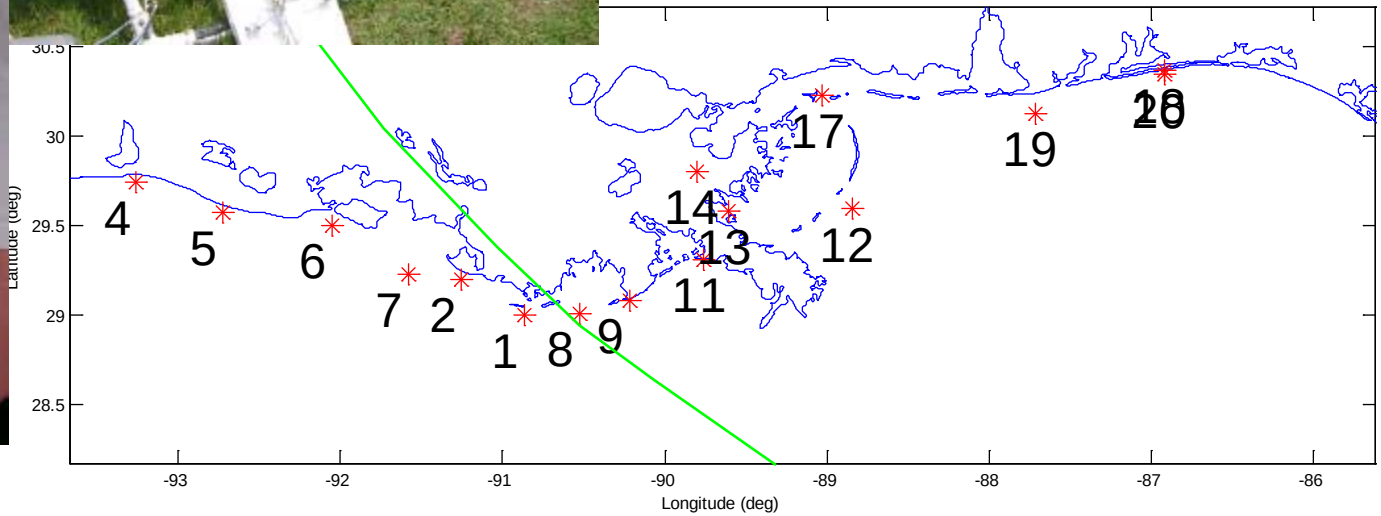
Measurements

- University of Notre Dame

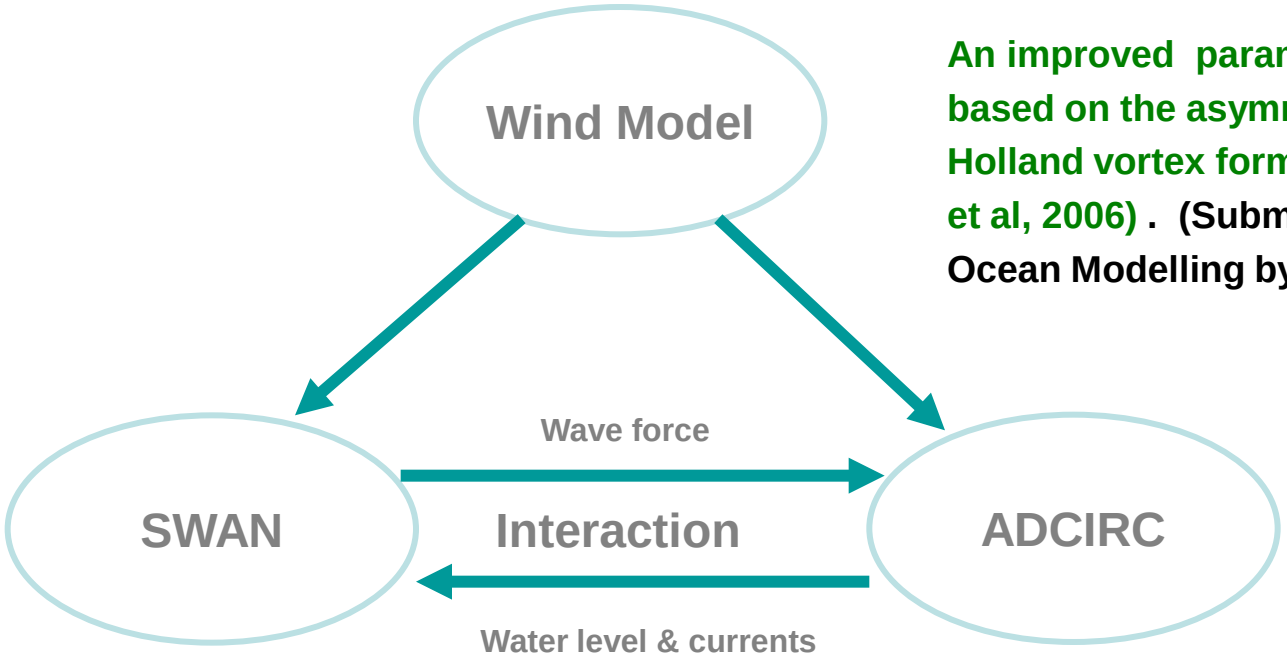
Surge and waves

Instruments





Modeling



An improved parametric model based on the asymmetric Holland vortex formulation (Xie et al, 2006) . (Submitted to Ocean Modelling by Hu et al.)

A third-generation wave model for obtaining realistic estimates of wave parameters from given wind, bottom and current conditions (by TU Delft)

(Submitted to Journal of Atmospheric and Oceanic Technology by Dietrich et al.)

A highly developed computer program for solving the equations of motion for a moving fluid on a rotating earth using the finite element method (by R.A. Luettich, Jr. and J.J. Westerink)

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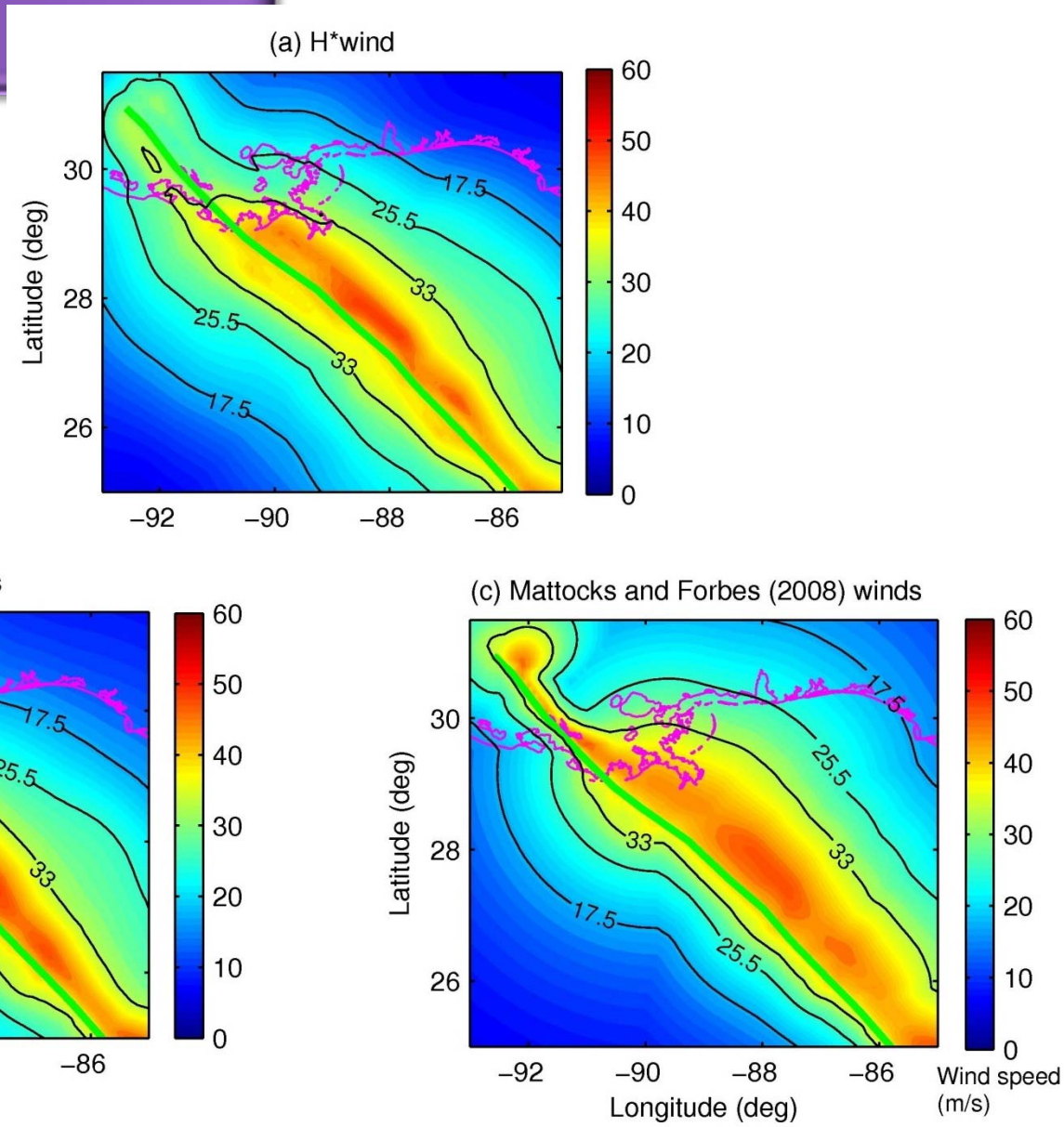
Wind model

- the Coriolis parameter is taken into account in the determination of the shape parameter B and the range limitation of B is released to eliminate the potential error in the modeled maximum wind speed.

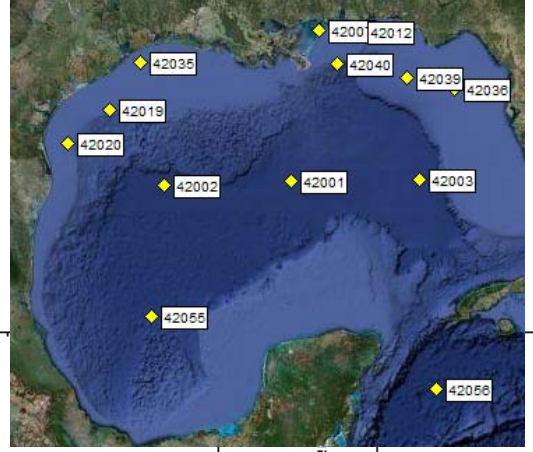
- the effect of the translational speed of a hurricane is excluded from the specified wind intensities before applying the Holland vortex.

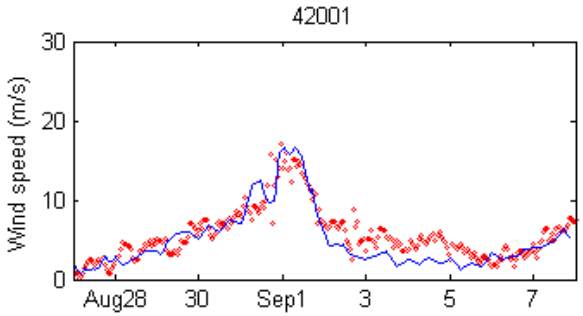
- a method has been introduced to develop a weighted composite wind field that makes full use of all wind parameters

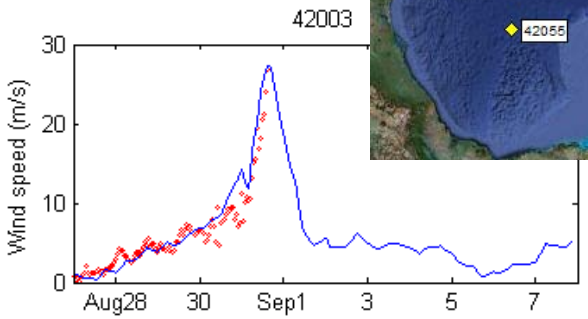
Wind swath

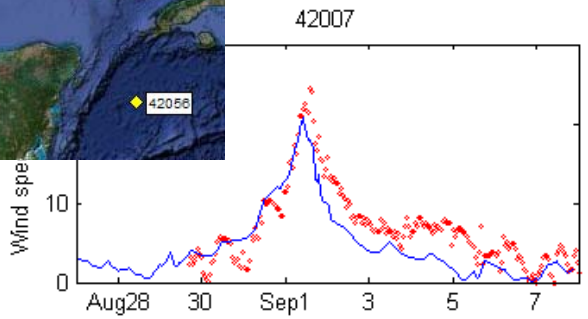

(a) H*wind
(b) SWIM winds
(c) Mattocks and Forbes (2008) winds
Latitude (deg)
Longitude (deg)
Wind speed (m/s)
17.5
25.5
33
30
28
26
−92
−90
−88
−86
60
50
40
30
20
10
0

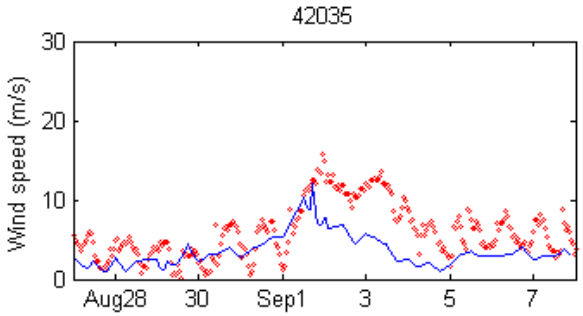
Wind comparison

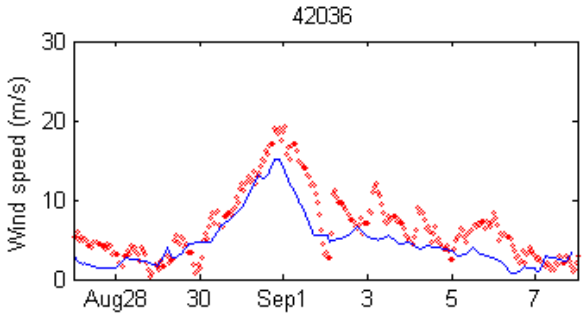


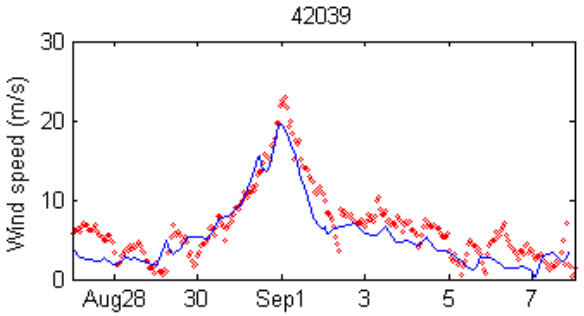


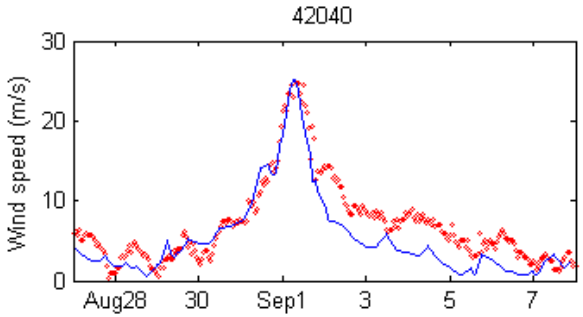


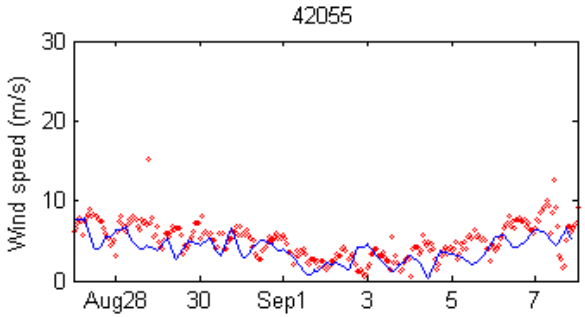


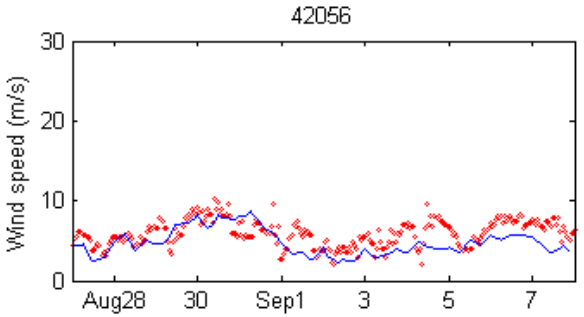












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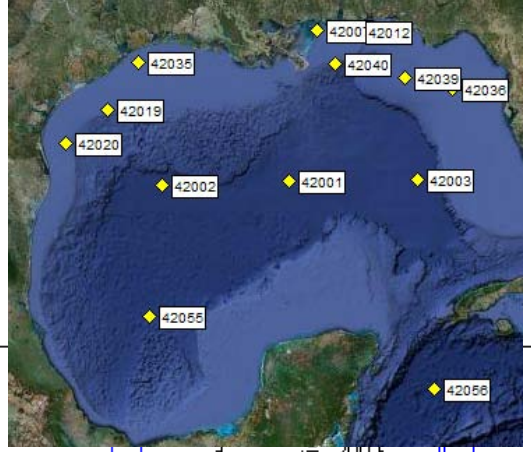
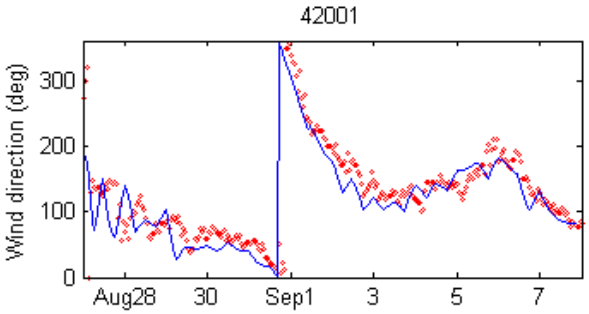
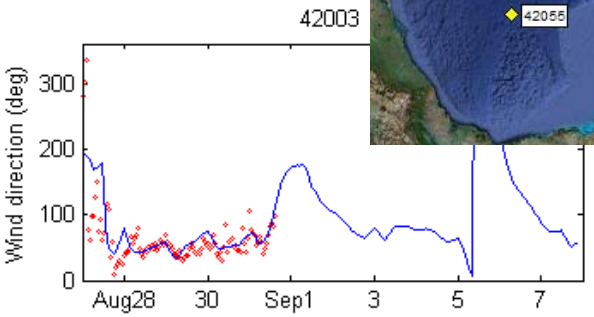
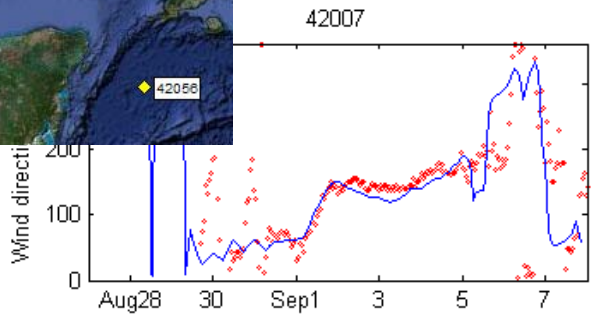
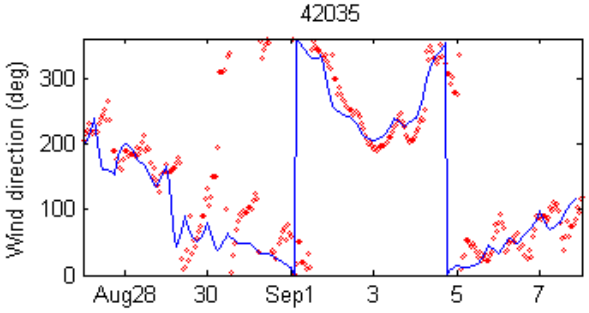
Wind comparison

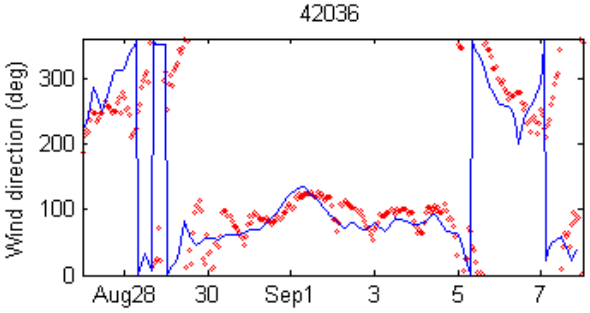


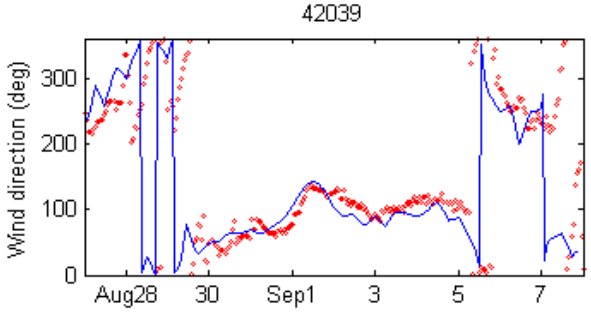


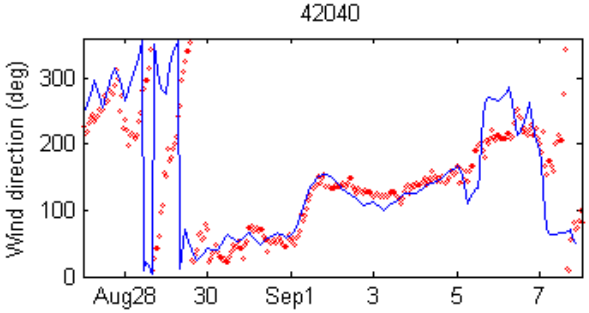


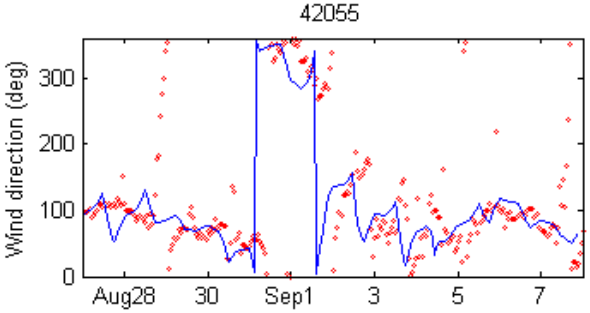


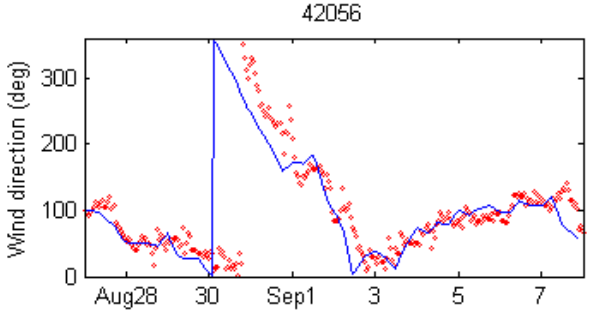












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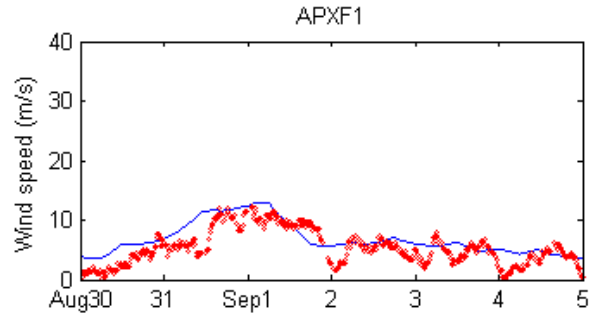
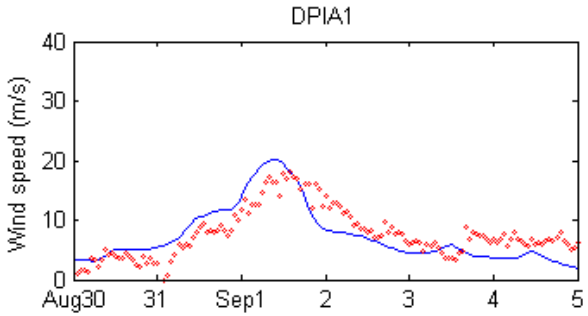
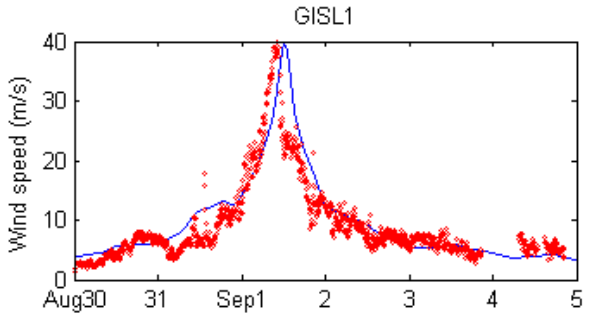
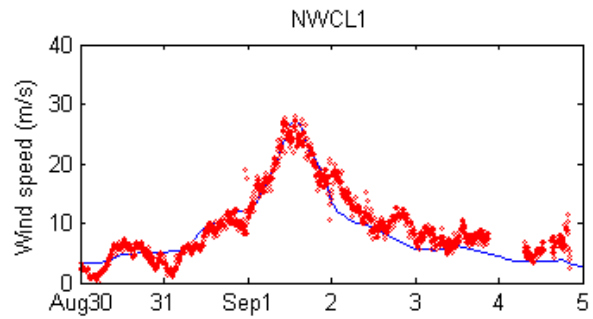
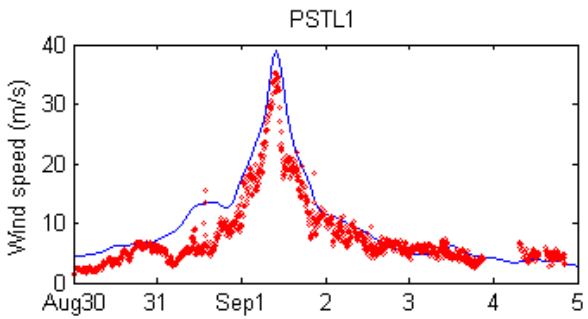
Wind comparison

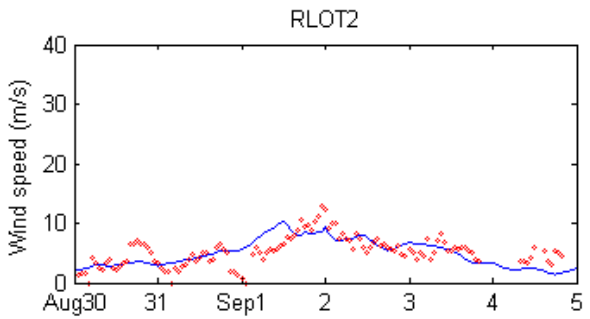


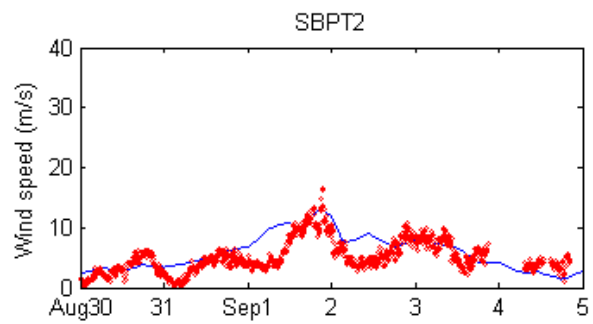


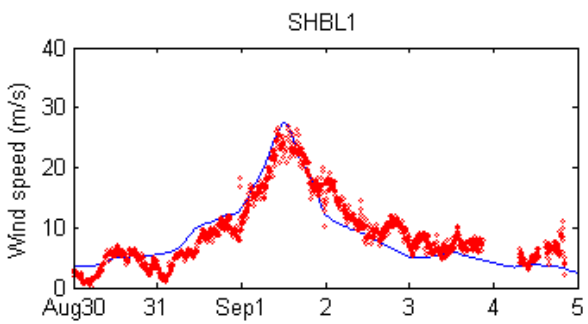


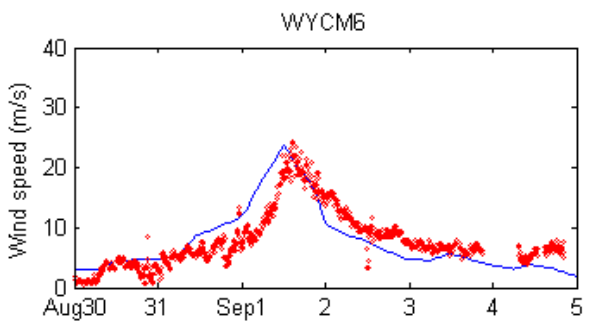












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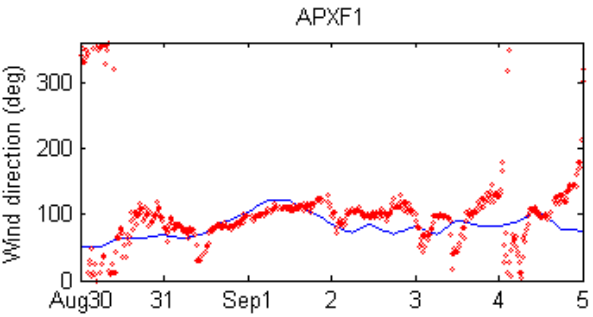
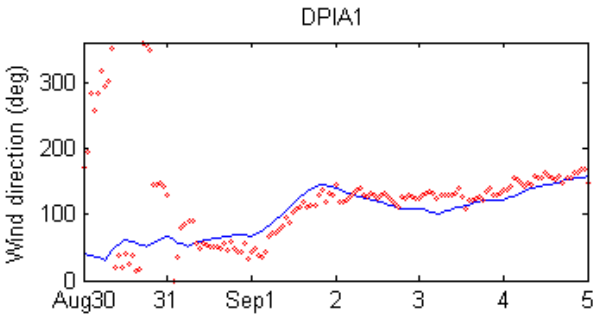
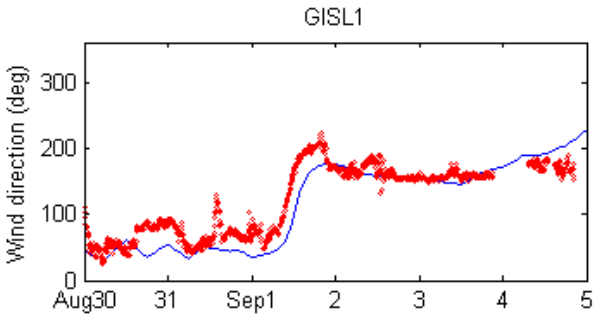
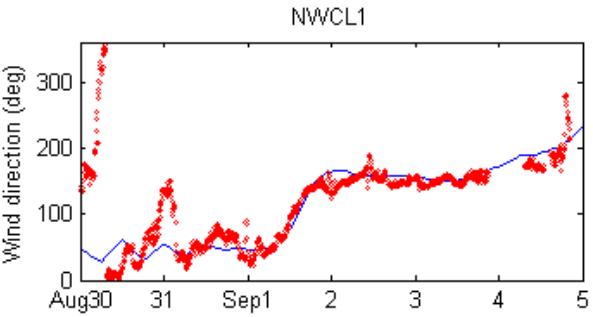
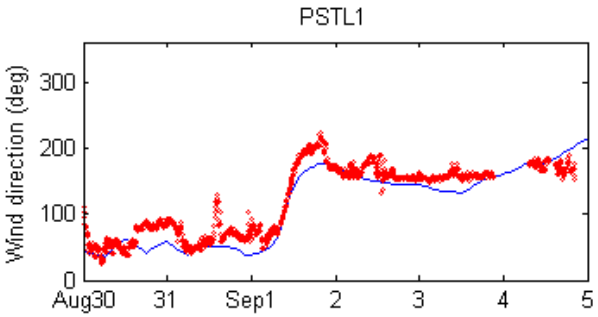
Wind comparison

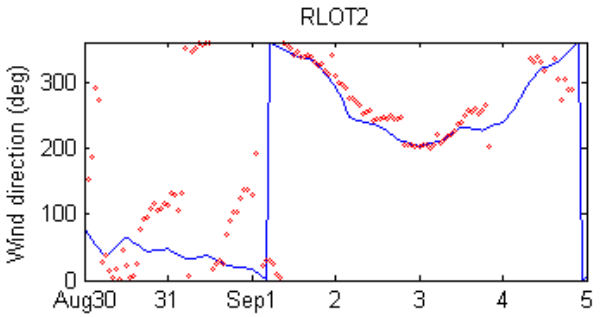


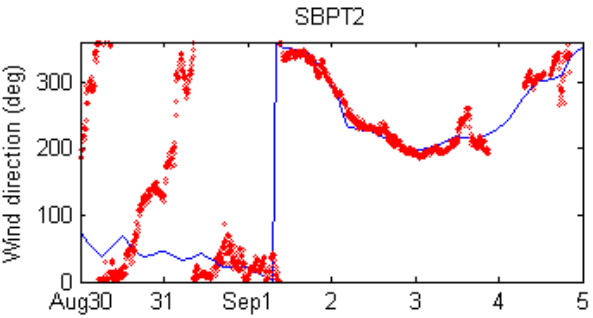


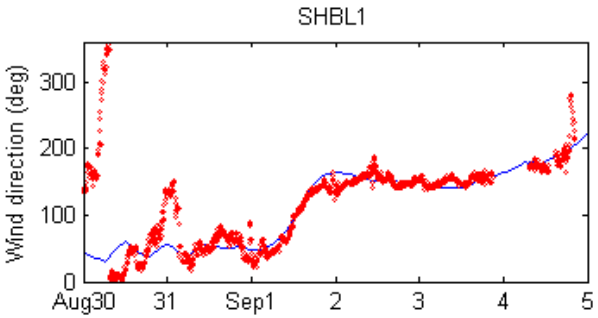


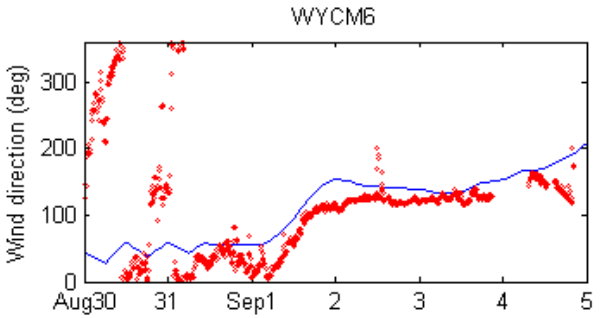












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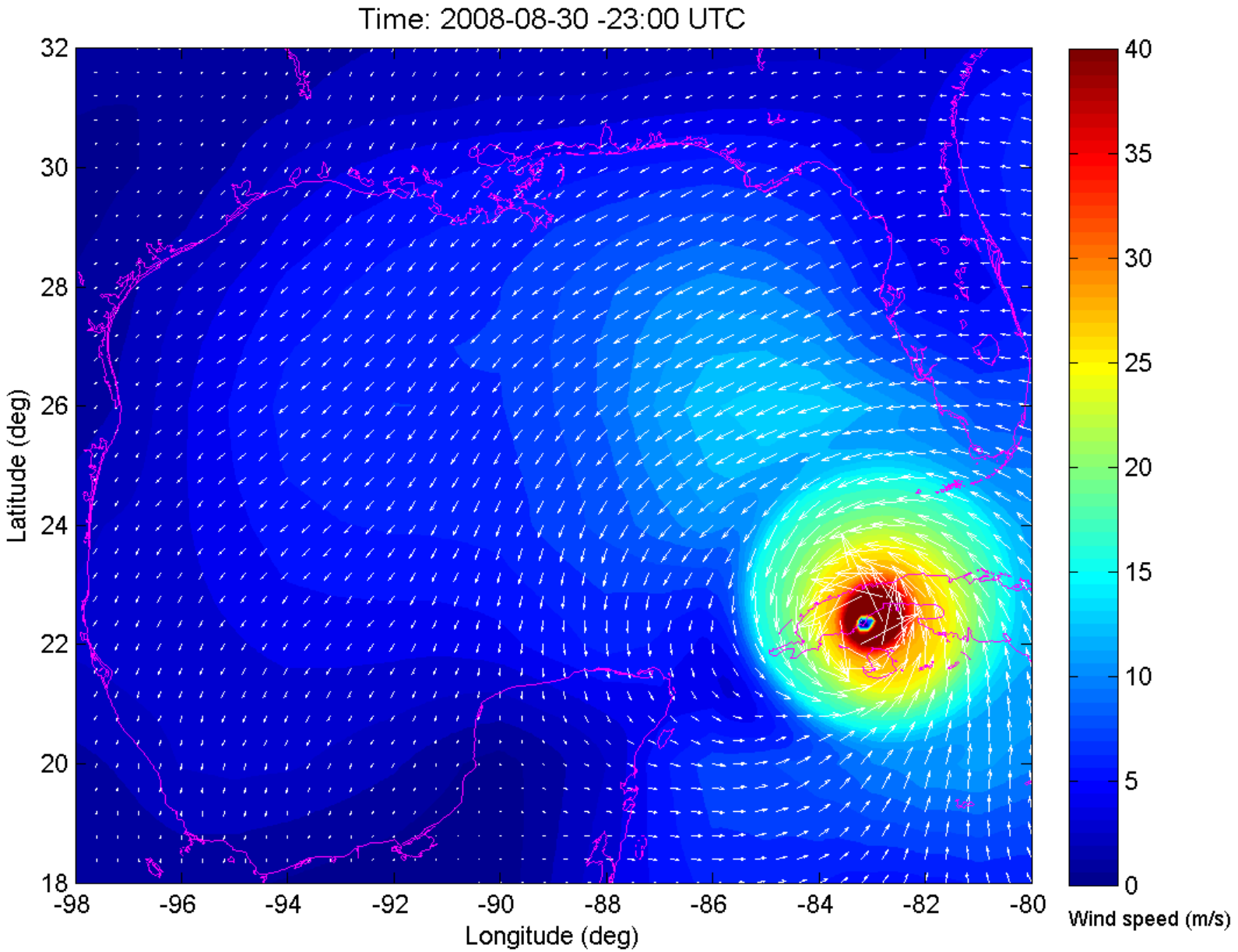

Time: 2008-08-30 -23:00 UTC
Latitude (deg)
32
30
28
26
24
22
20
18
-98
-96
-94
-92
-90
-88
-86
-84
-82
-80
Longitude (deg)
40
35
30
25
20
15
10
5
0
Wind speed (m/s)

ADCIRC +SWAN

Mesh SL15v7(2409635 nodes; 4721491 elements)

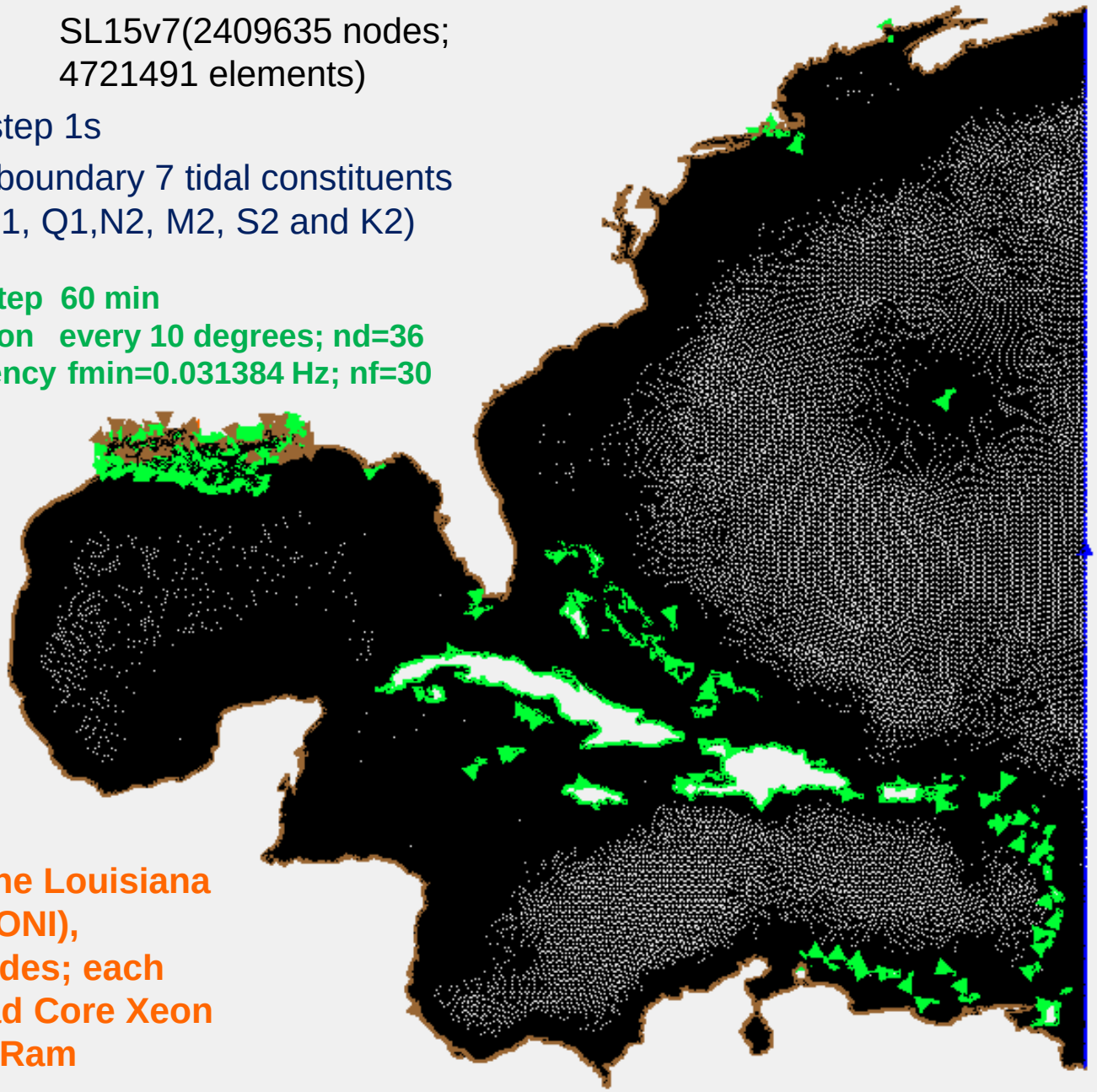
Time step 1s

Open boundary 7 tidal constituents (K1, O1, Q1,N2, M2, S2 and K2)

Time step 60 min
Direction every 10 degrees; nd=36
Frequency fmin=0.031384 Hz; nf=30

Hot start:
after 30 days of tide simulation

Parallel run:
816 processors*
run 24 hrs for 12 days' simulation (Aug 27 ~ Sep 7, 2008)



***on a supercomputer from the Louisiana Optical Network Initiative (LONI), Queenbee: 668 Compute Nodes; each node with two 2.33 GHz Quad Core Xeon 64-bit Processors and 8 GB Ram**

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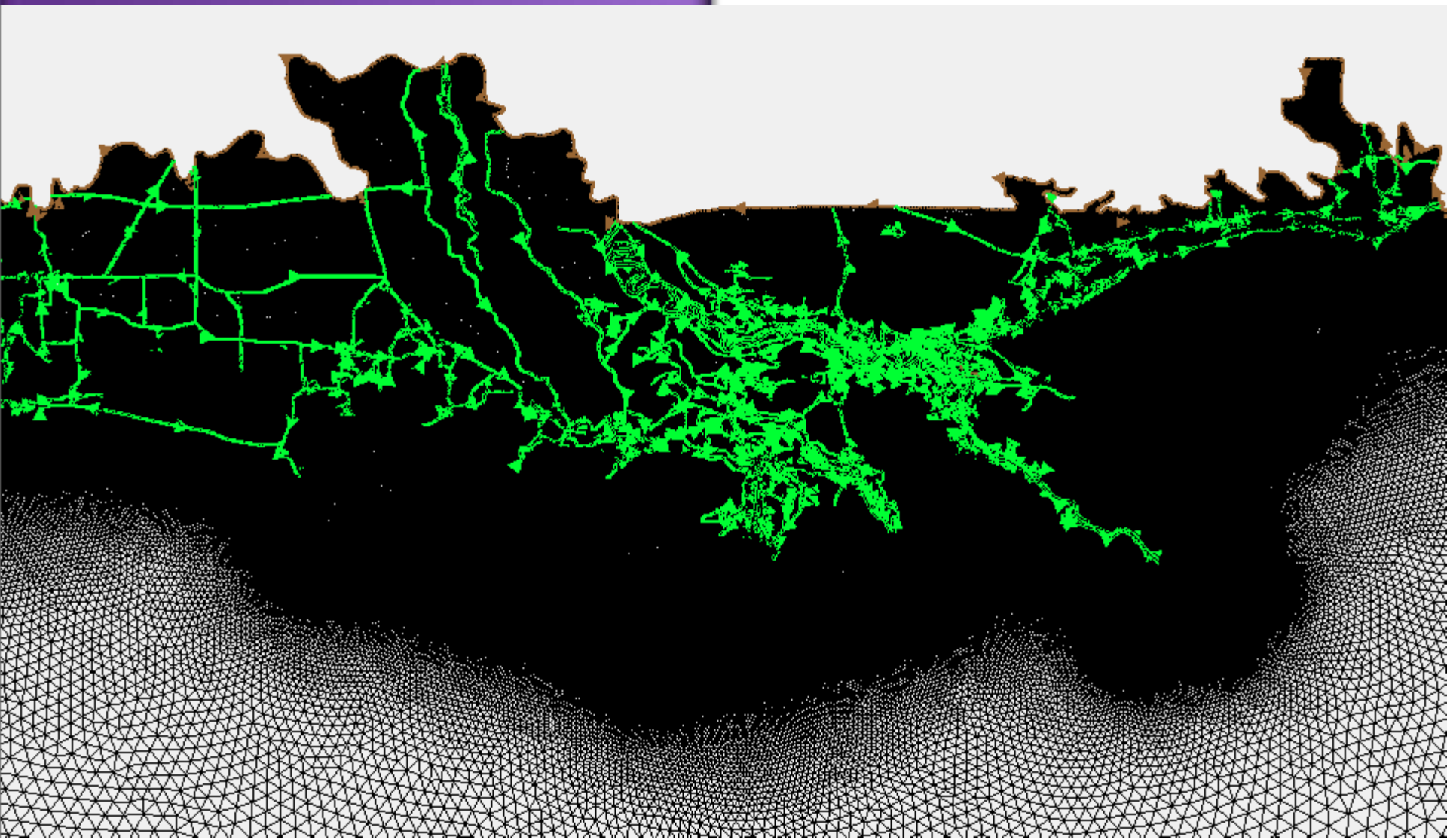
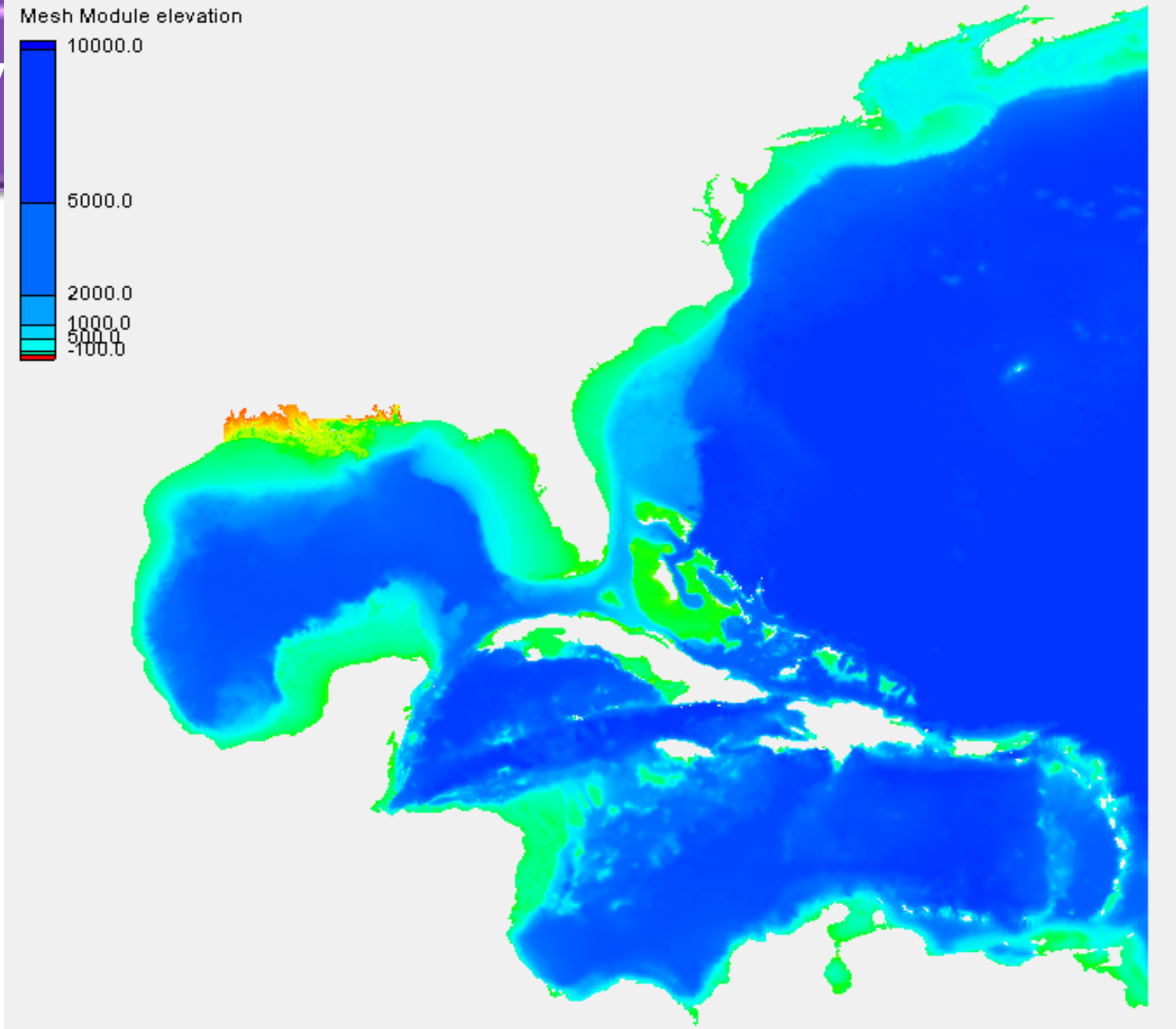
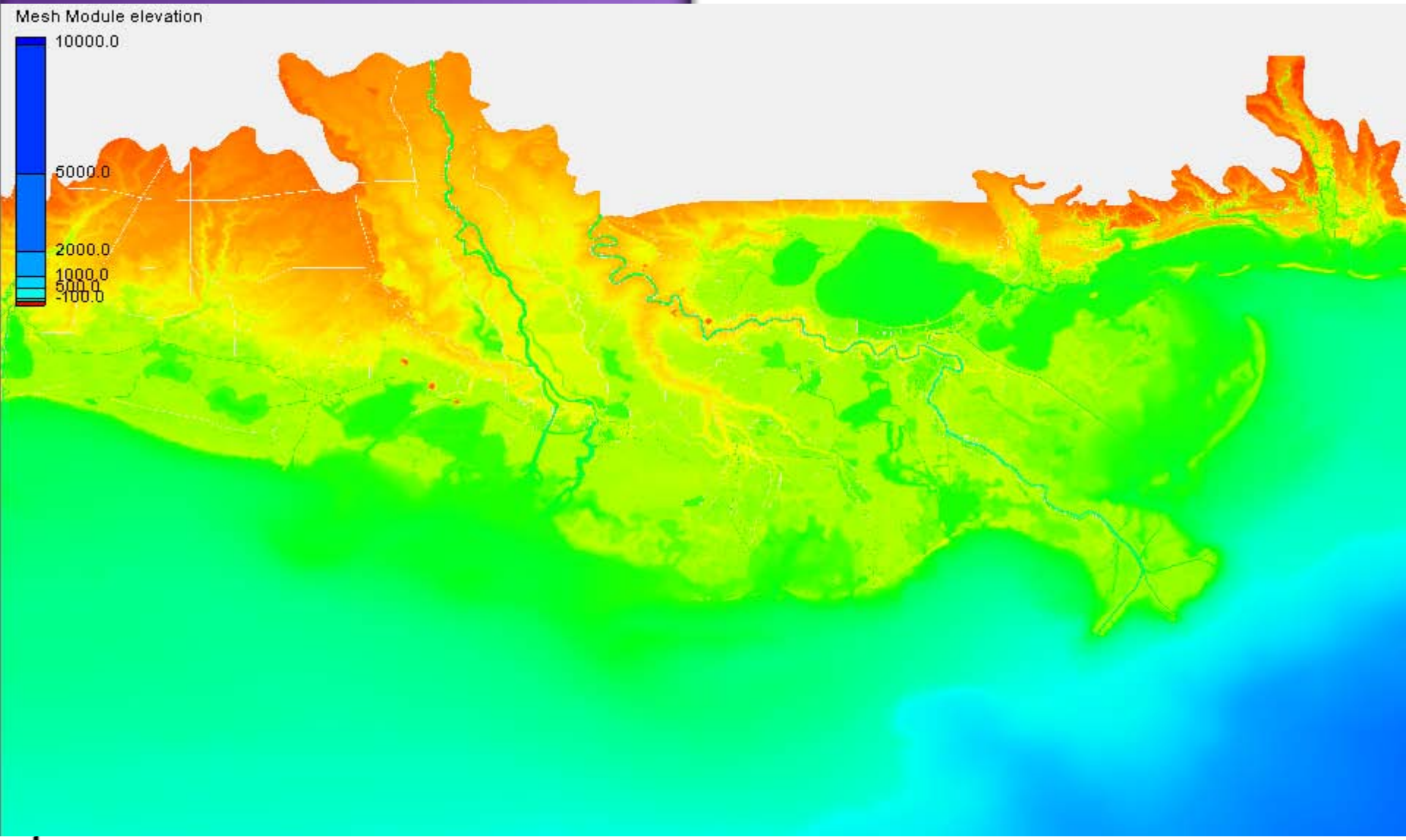
Mesh



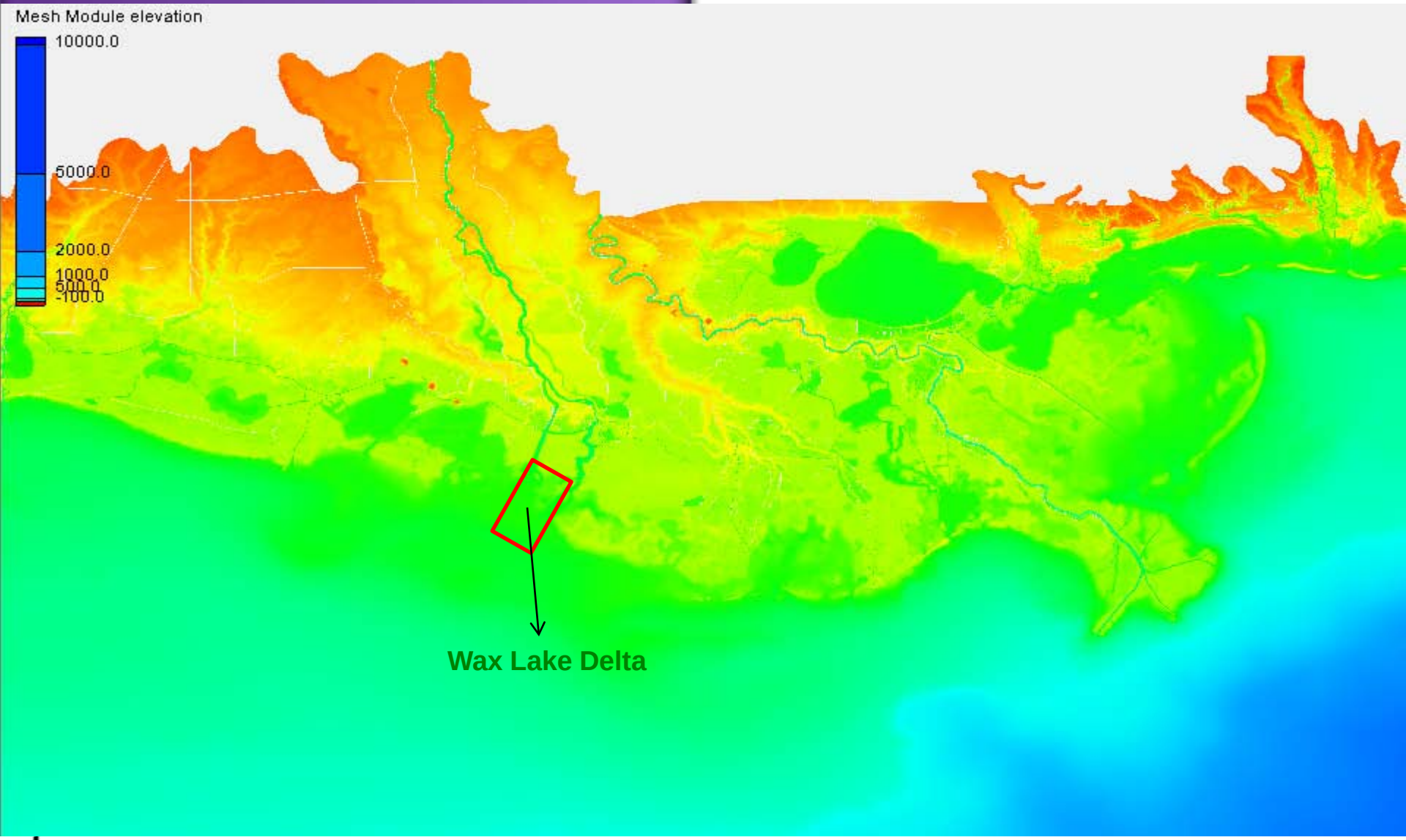
Bathymetry



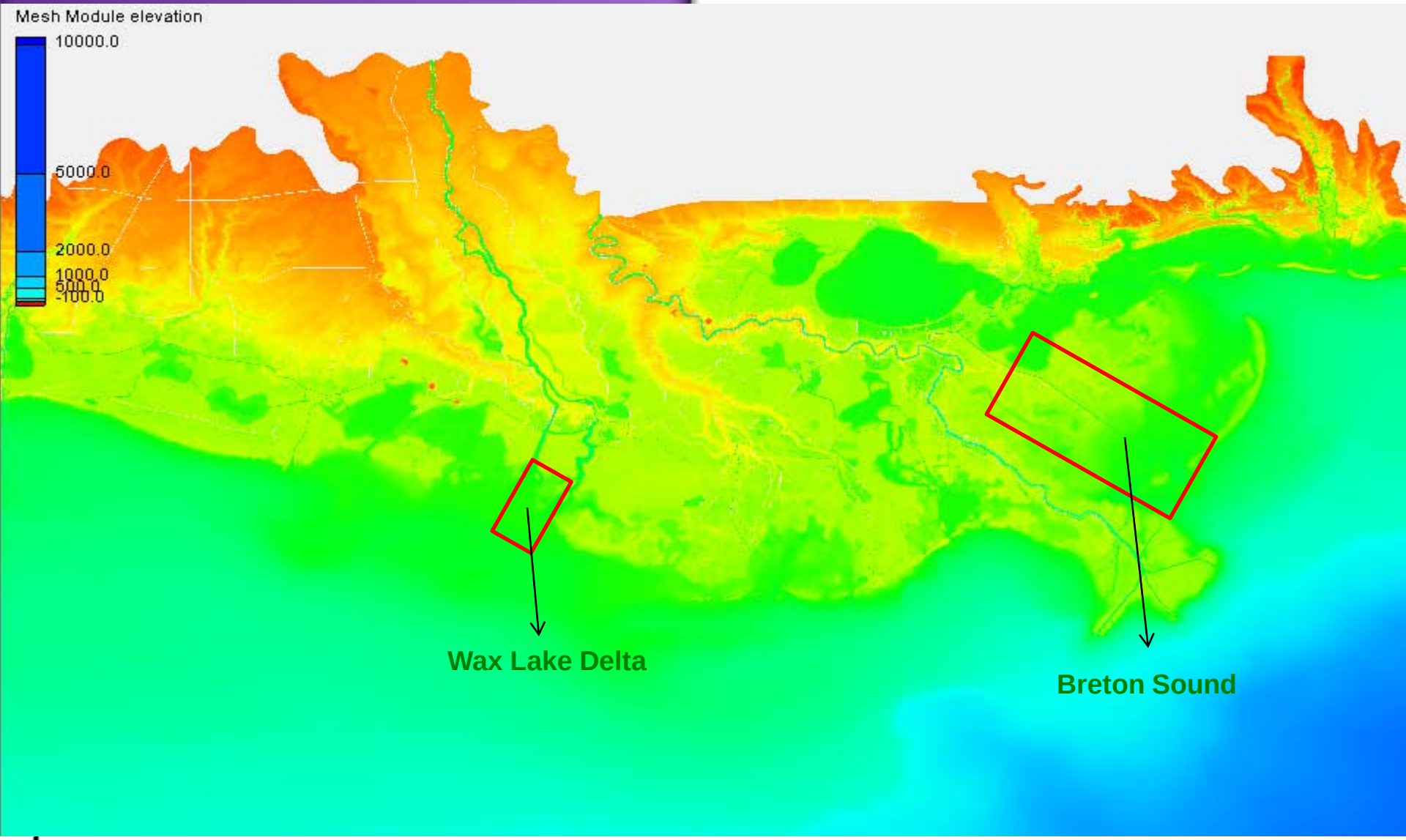
Bathymetry



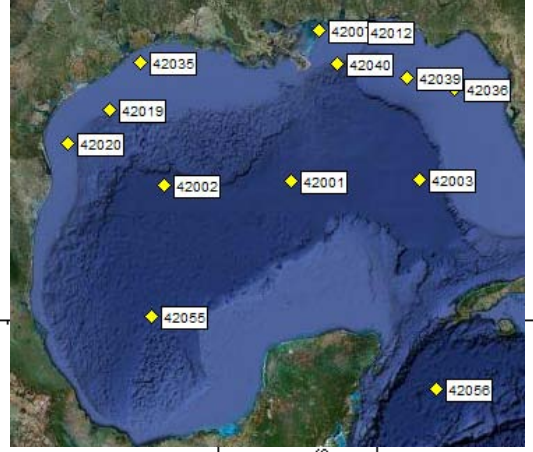
Bathymetry

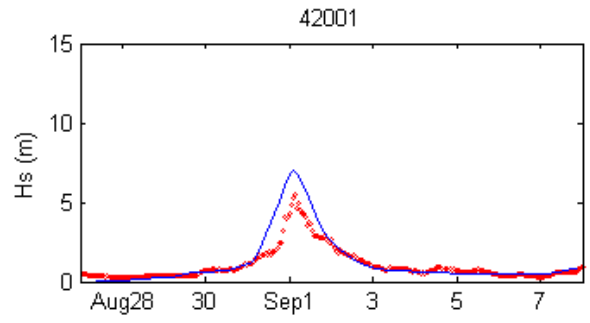

Mesh Module elevation
10000.0
5000.0
2000.0
1000.0
500.0
-100.0
Wax Lake Delta

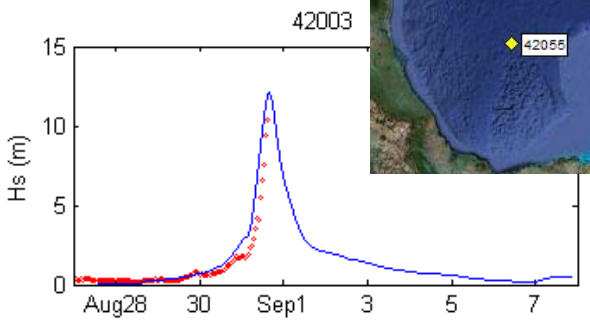
Bathymetry

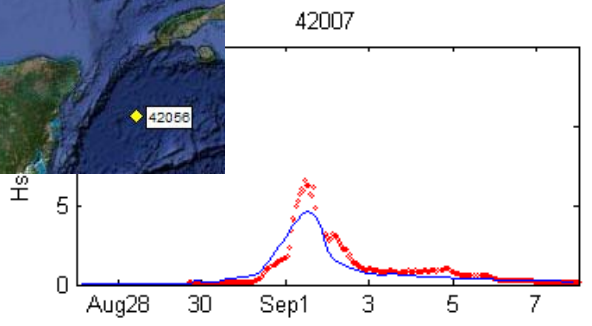

Mesh Module elevation
10000.0
5000.0
2000.0
1000.0
500.0
-100.0
Wax Lake Delta
Breton Sound

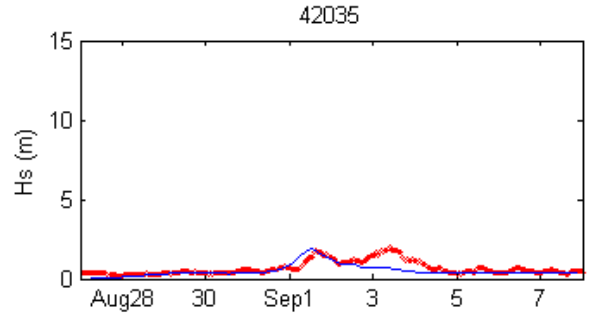
Hs

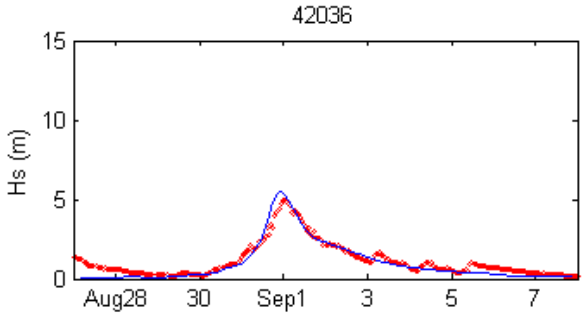

42001
42012
42035
42040
42039
42036
42019
42020
42002
42001
42003
42055
42056

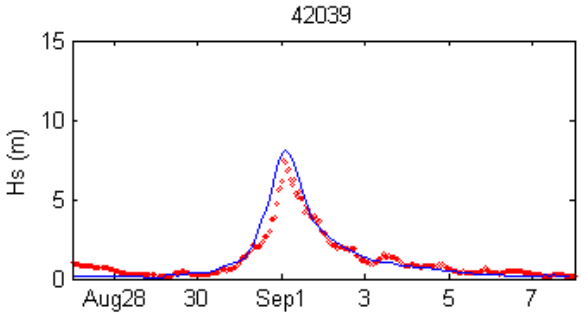

42001
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7

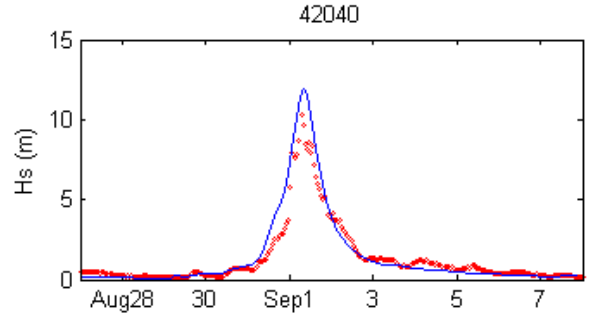

42003
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7

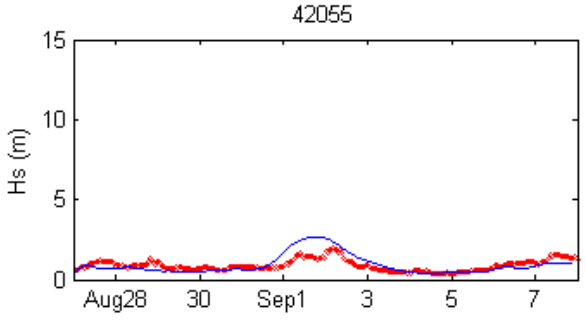

42007
Hs
0
5
Aug28
30
Sep1
3
5
7

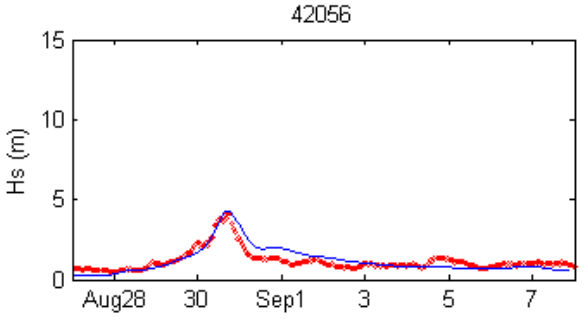

42035
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7


42036
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7


42039
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7

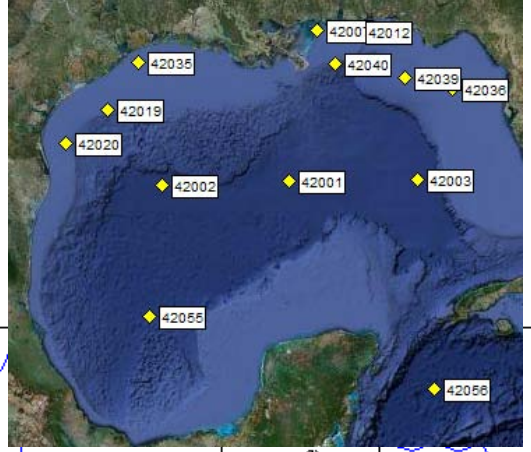

42040
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7

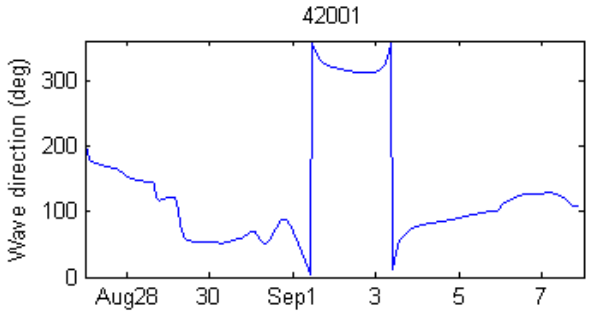

42055
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7

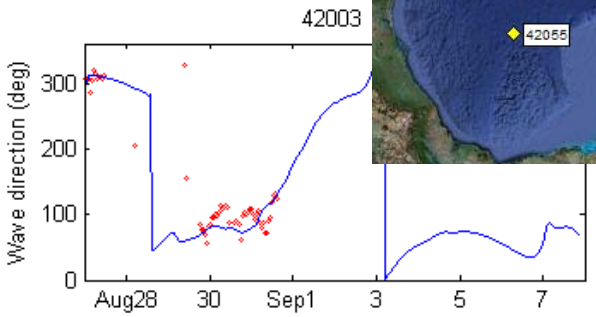

42056
Hs (m)
0
5
10
15
Aug28
30
Sep1
3
5
7

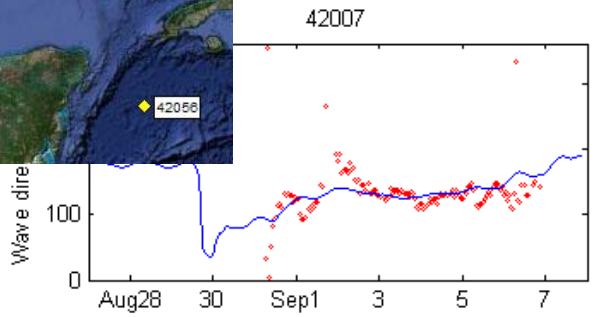
LSU

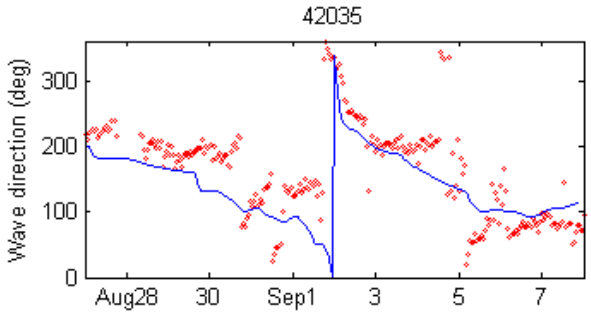
Wave direction

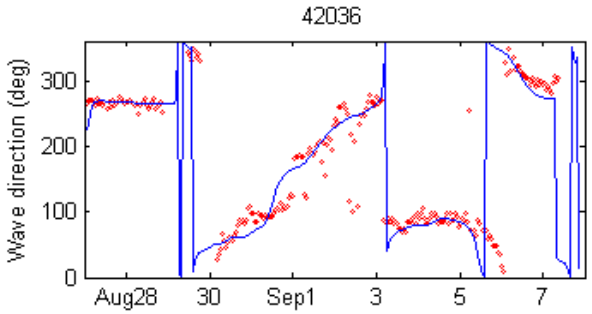


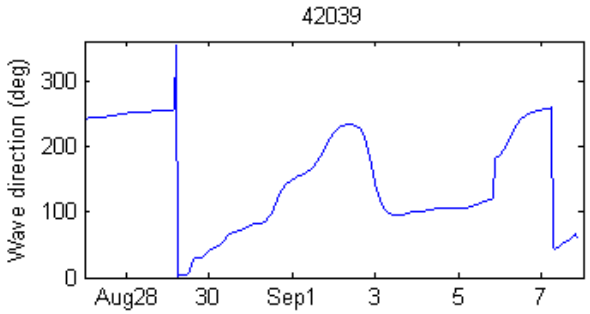


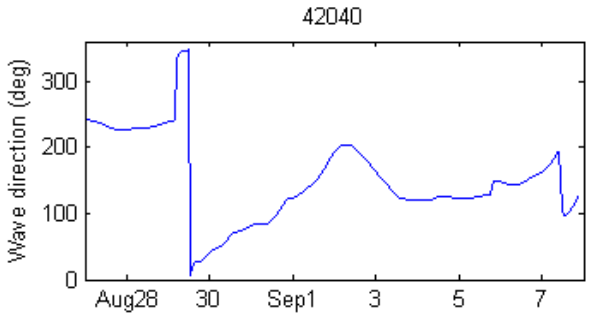


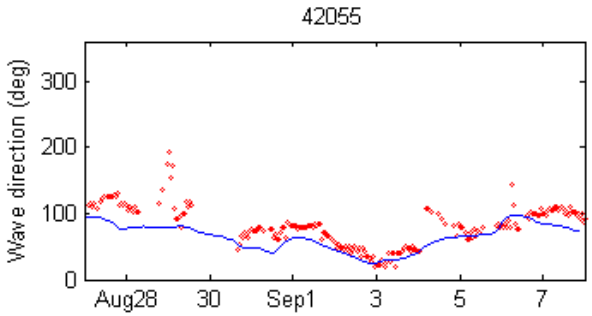


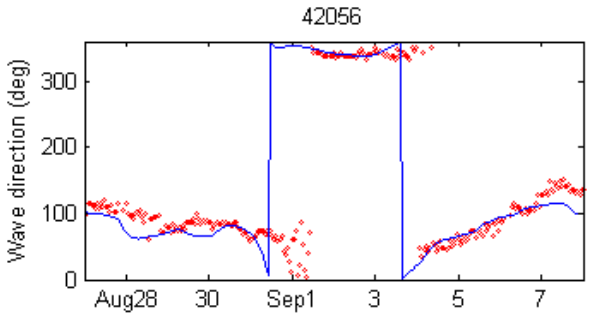






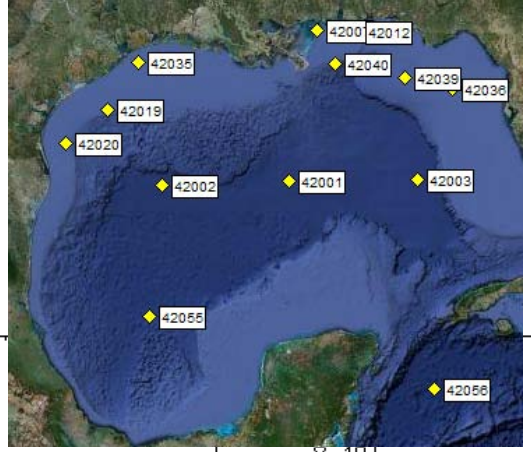


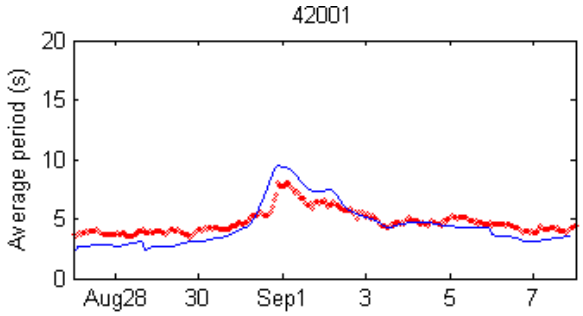


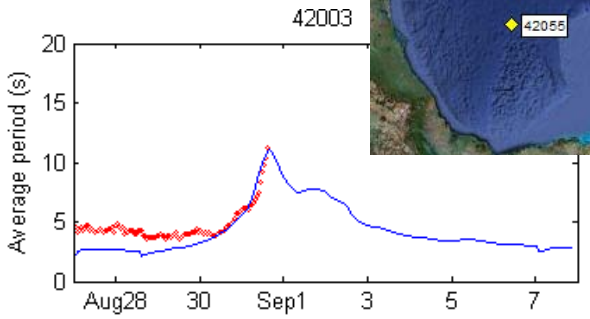


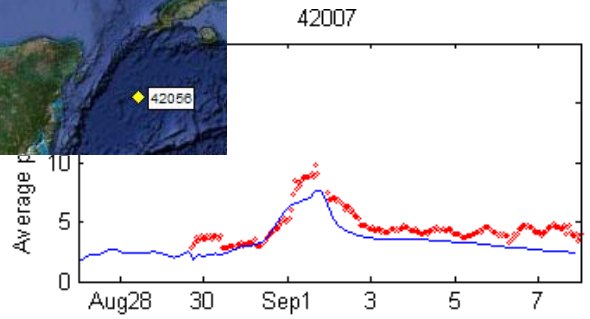
LSU

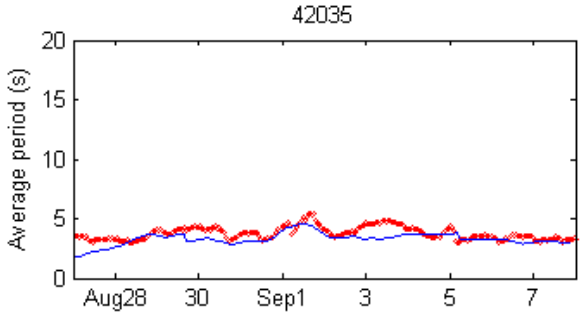
Average period

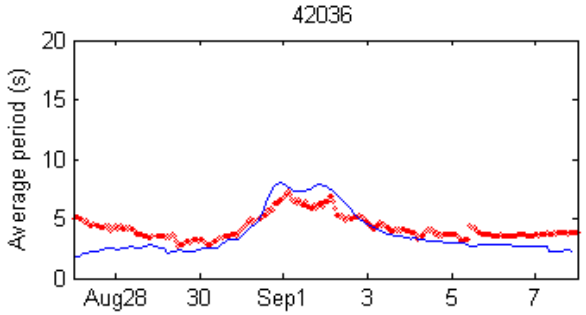


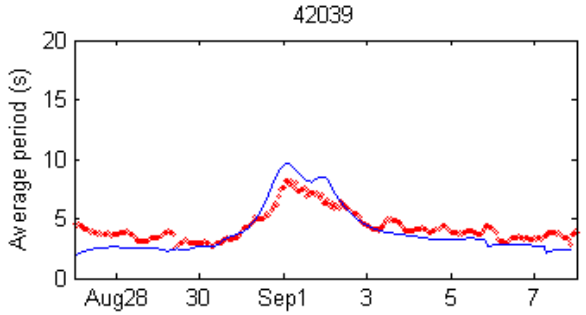


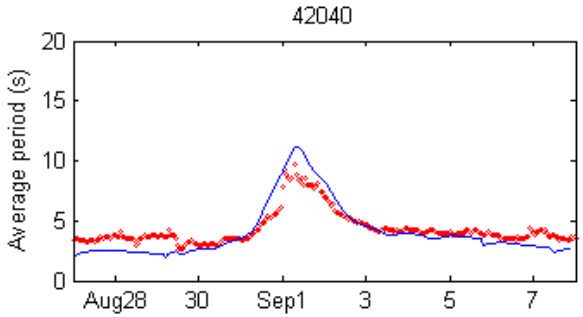


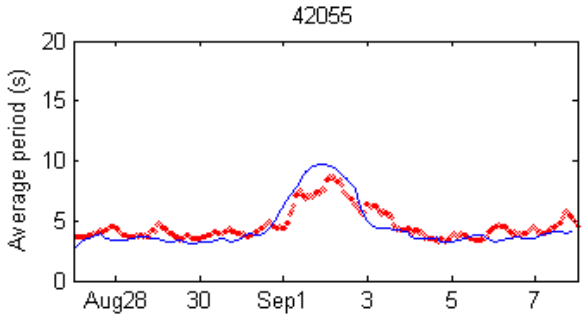


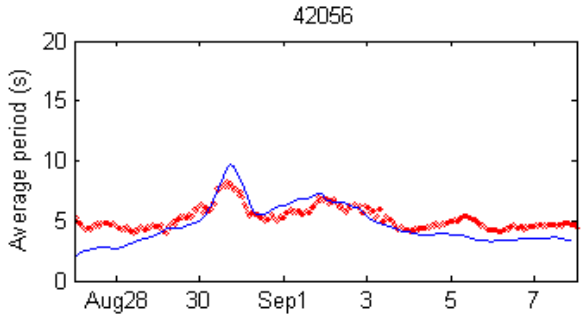






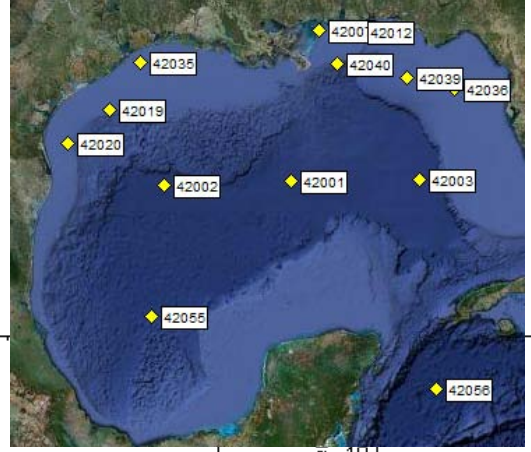


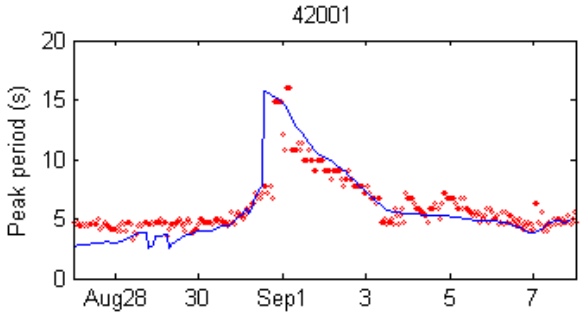


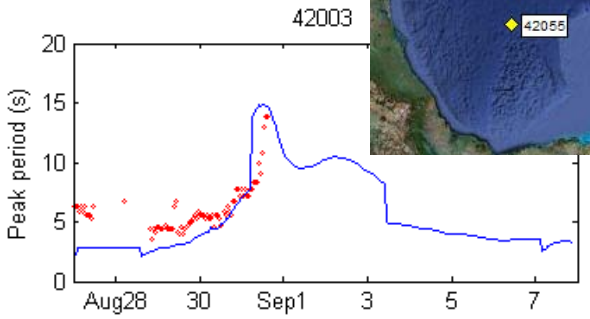


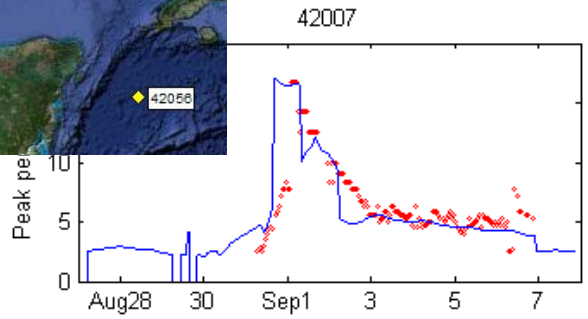
LSU

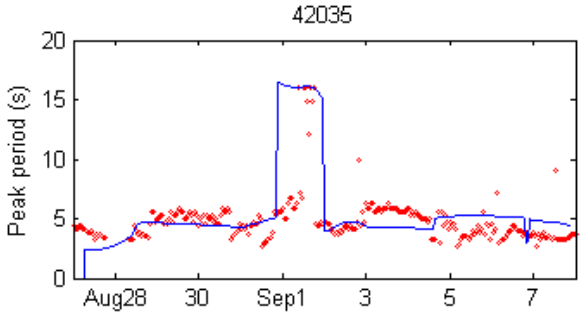
Peak period

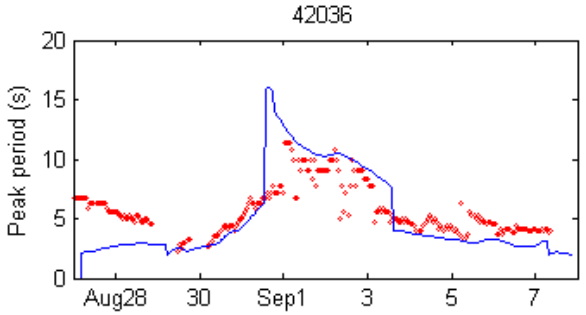


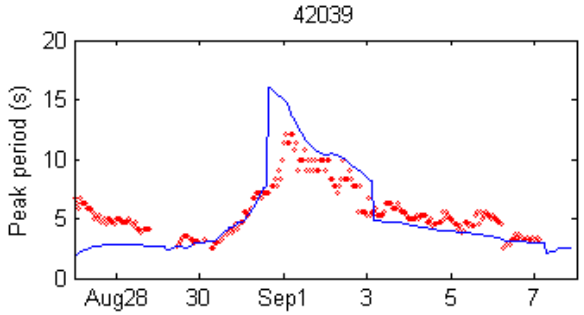


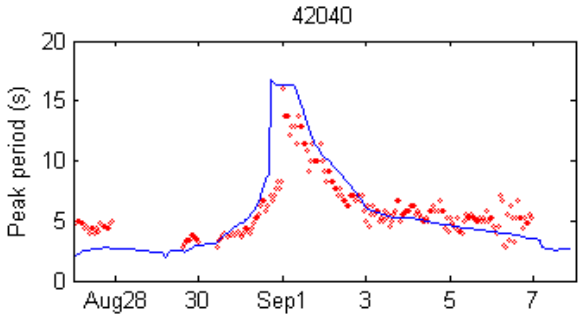


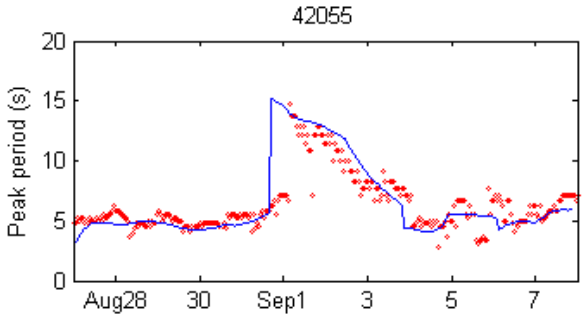


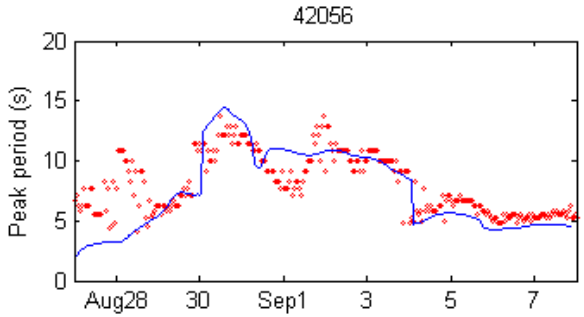






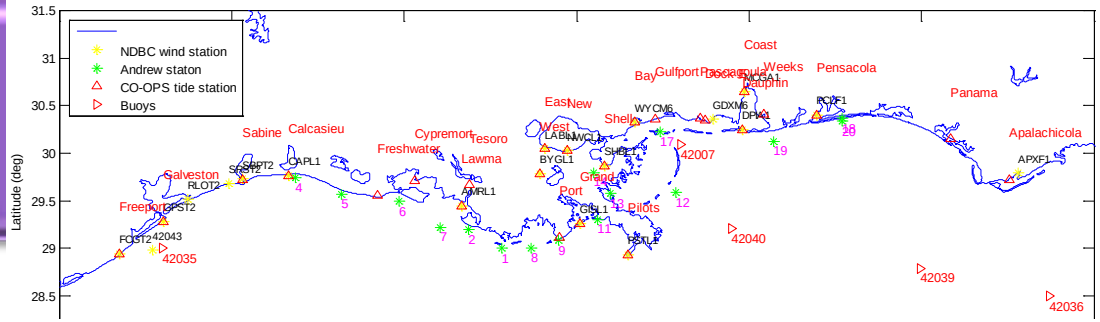


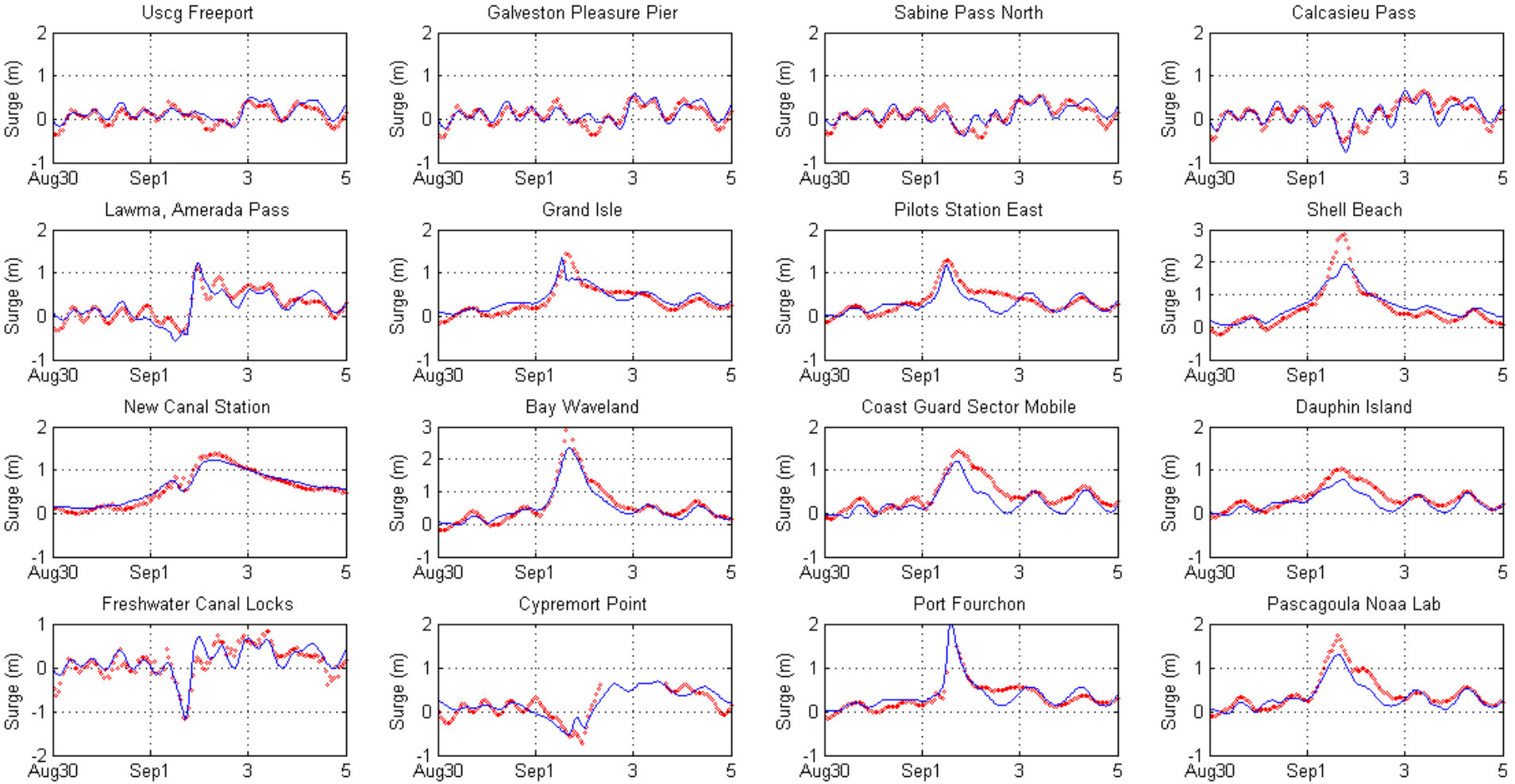




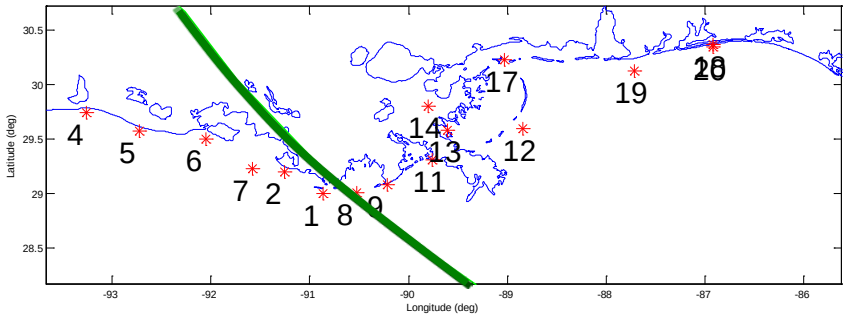
LSU

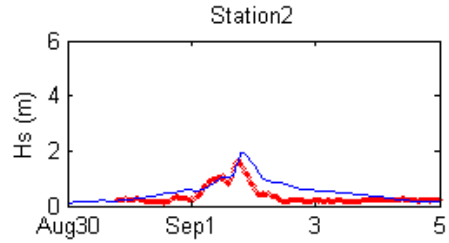
Surface elevation

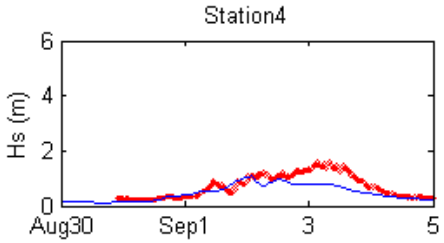


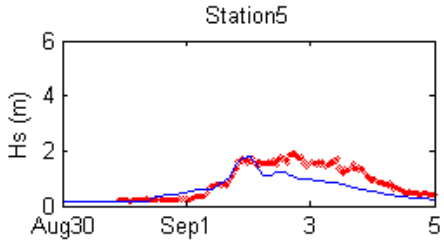


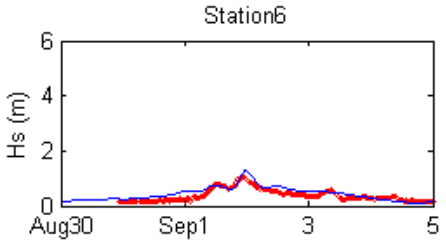
Hs

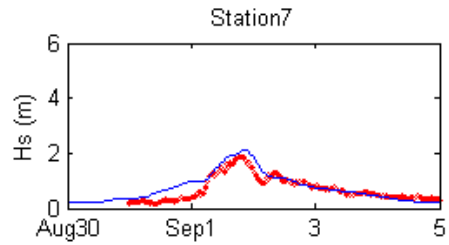

Latitude (deg)
Longitude (deg)
30.5
30
29.5
29
28.5
-93
-92
-91
-90
-89
-88
-87
-86
4
5
6
7
2
1
8
9
11
14
13
12
17
19
18
16

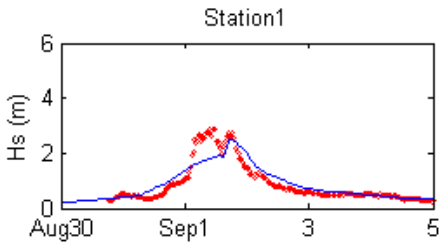

Station2
Hs (m)
Aug30
Sep1
3
5

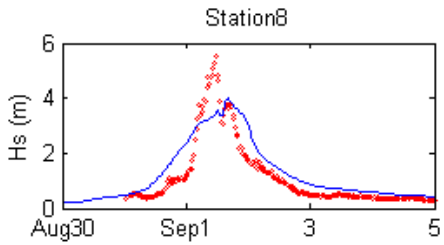

Station4
Hs (m)
Aug30
Sep1
3
5

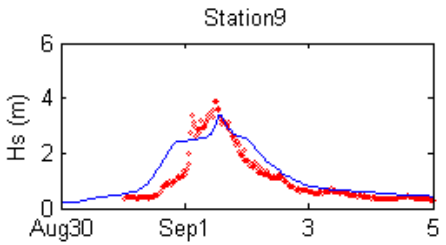

Station5
Hs (m)
Aug30
Sep1
3
5

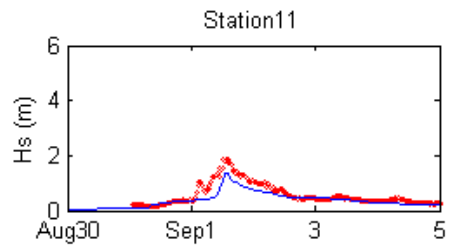

Station6
Hs (m)
Aug30
Sep1
3
5

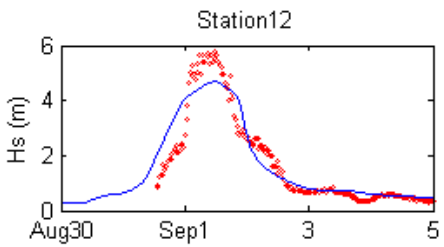

Station7
Hs (m)
Aug30
Sep1
3
5

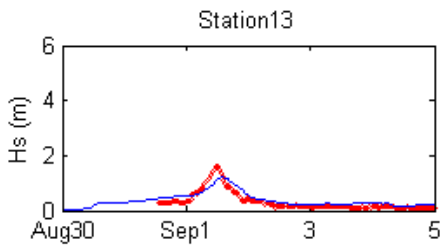

Station1
Hs (m)
Aug30
Sep1
3
5

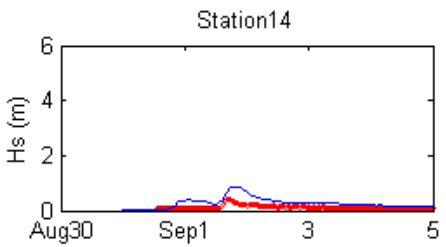

Station8
Hs (m)
Aug30
Sep1
3
5

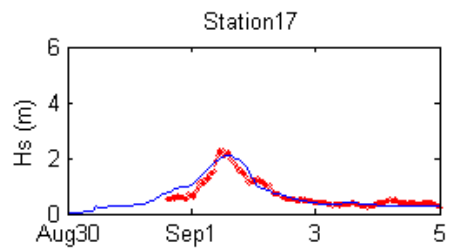

Station9
Hs (m)
Aug30
Sep1
3
5

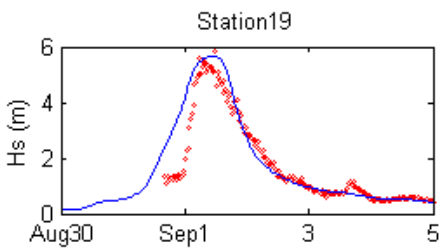

Station11
Hs (m)
Aug30
Sep1
3
5


Station12
Hs (m)
Aug30
Sep1
3
5

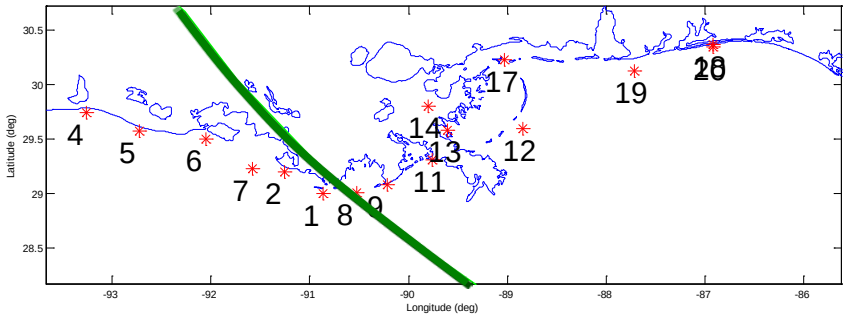

Station13
Hs (m)
Aug30
Sep1
3
5

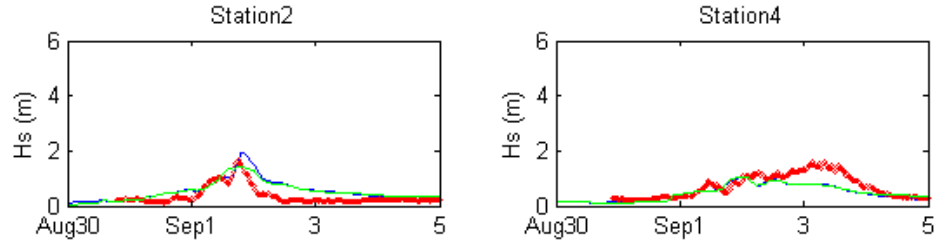

Station14
Hs (m)
Aug30
Sep1
3
5


Station17
Hs (m)
Aug30
Sep1
3
5

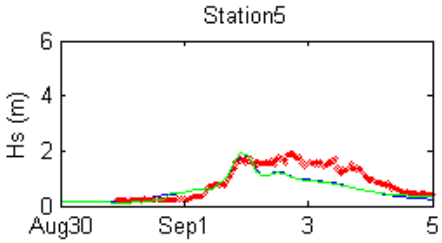

Station19
Hs (m)
Aug30
Sep1
3
5

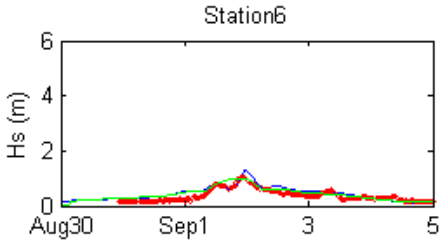
Hs

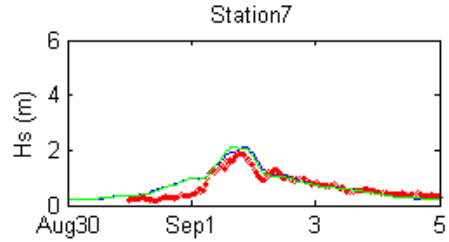

Latitude (deg)
Longitude (deg)
30.5
30
29.5
29
28.5
-93
-92
-91
-90
-89
-88
-87
-86
4
5
6
7
2
1
8
9
11
14
13
12
17
19
20

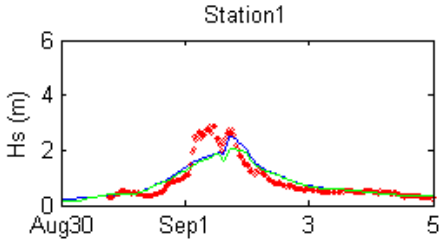

Station2
Hs (m)
Aug30
Sep1
3
5

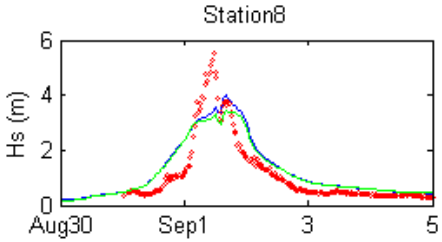
Station4
Hs (m)
Aug30
Sep1
3
5

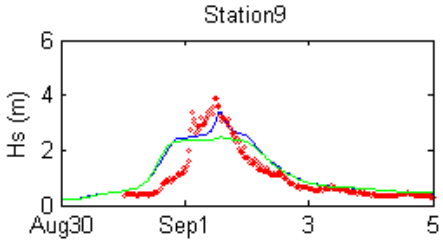

Station5
Hs (m)
Aug30
Sep1
3
5

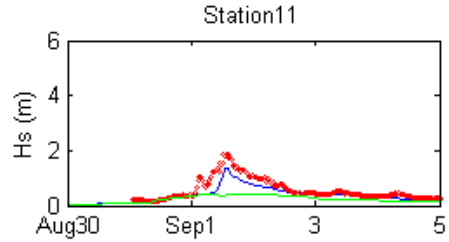

Station6
Hs (m)
Aug30
Sep1
3
5

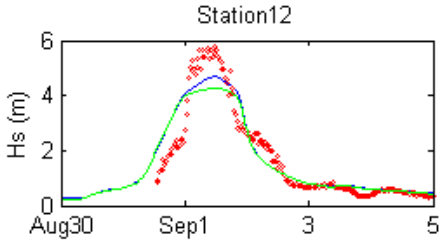

Station7
Hs (m)
Aug30
Sep1
3
5

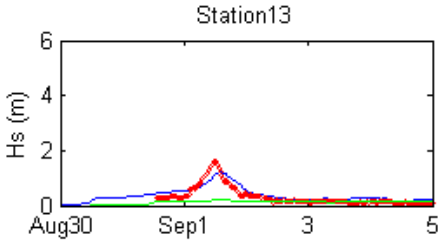

Station1
Hs (m)
Aug30
Sep1
3
5

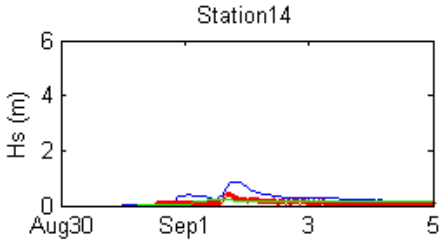

Station8
Hs (m)
Aug30
Sep1
3
5

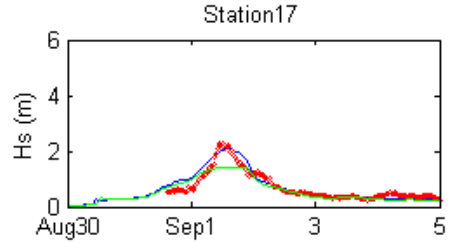

Station9
Hs (m)
Aug30
Sep1
3
5

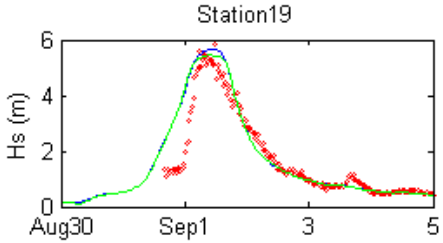

Station11
Hs (m)
Aug30
Sep1
3
5


Station12
Hs (m)
Aug30
Sep1
3
5

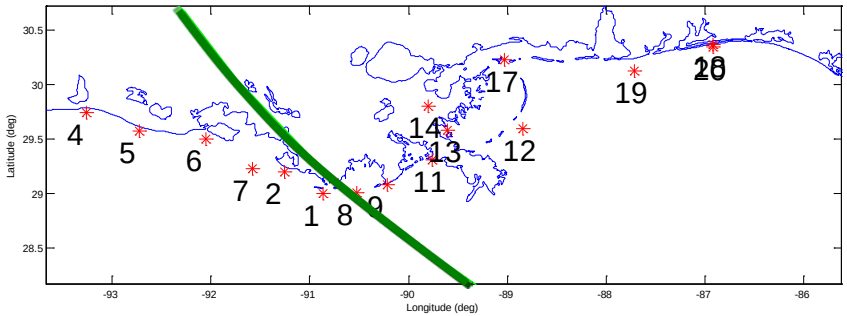

Station13
Hs (m)
Aug30
Sep1
3
5

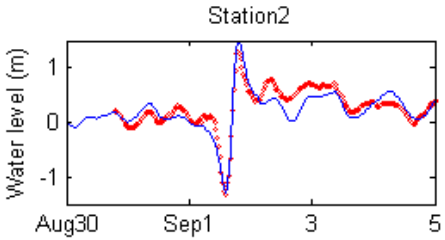

Station14
Hs (m)
Aug30
Sep1
3
5

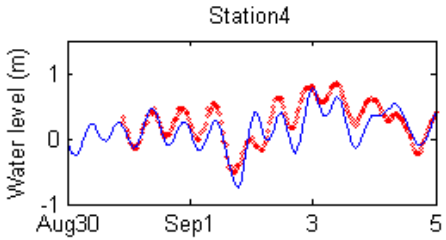

Station17
Hs (m)
Aug30
Sep1
3
5

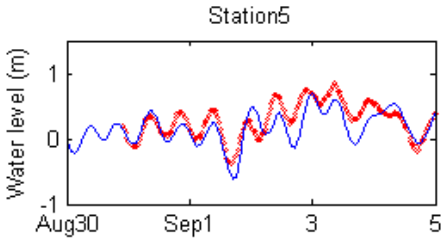

Station19
Hs (m)
Aug30
Sep1
3
5

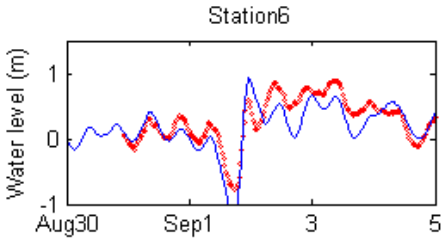
Surface elevation

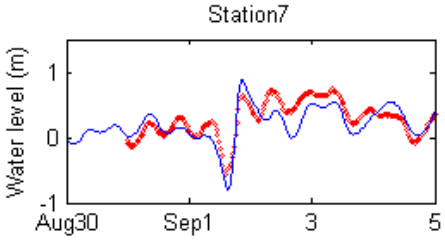


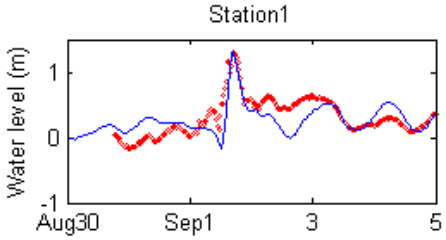


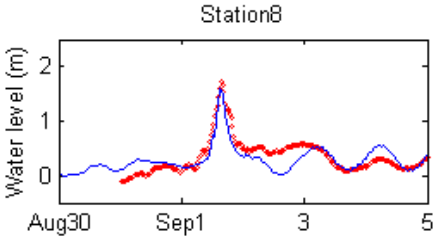


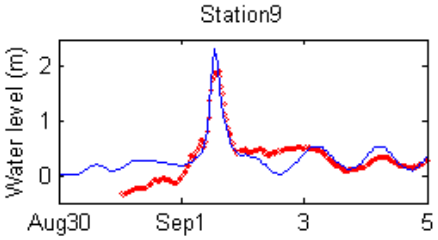


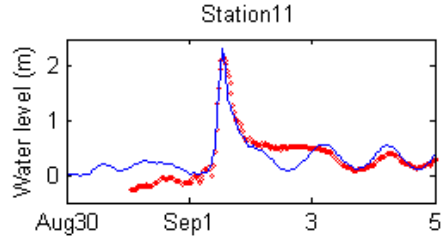


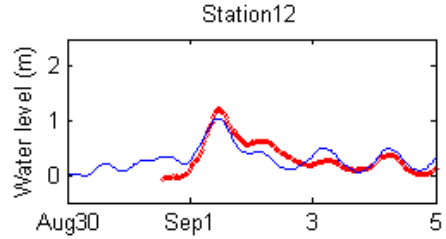


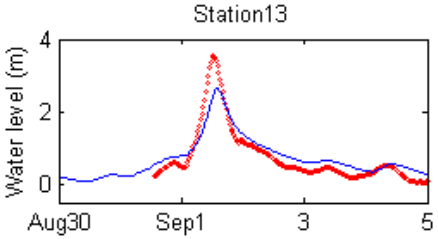


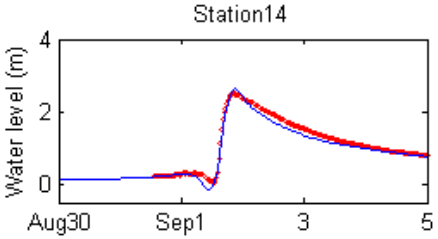


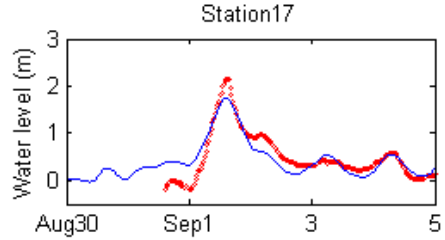


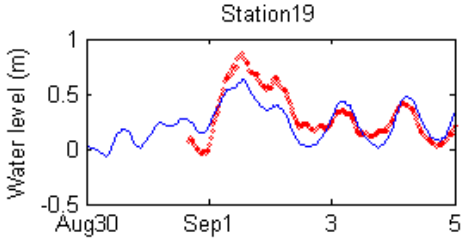




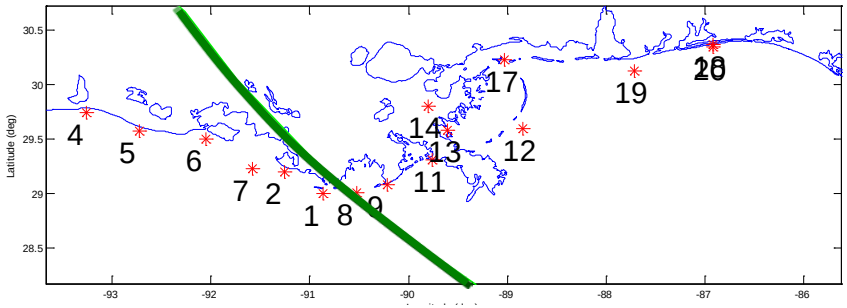


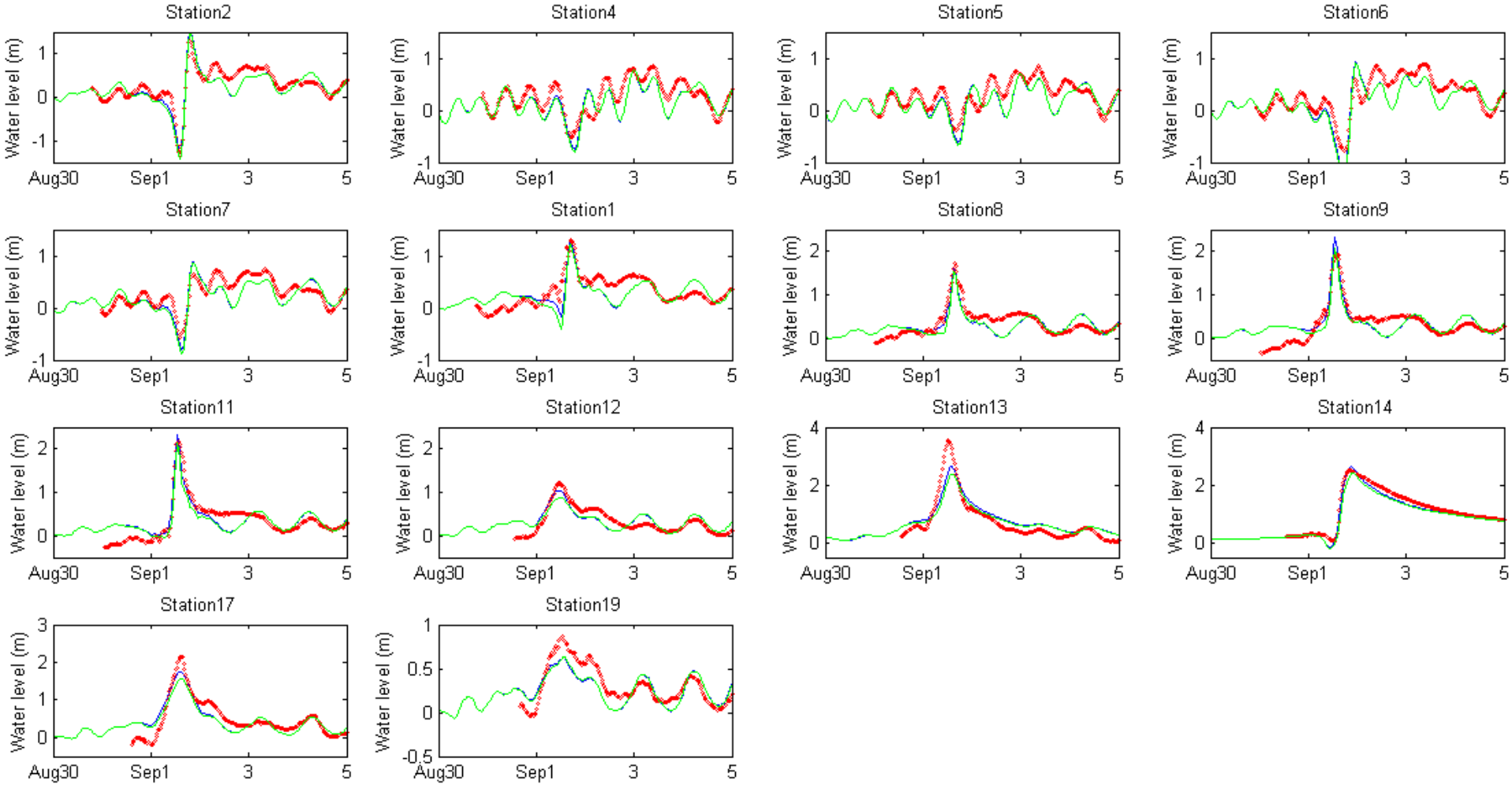




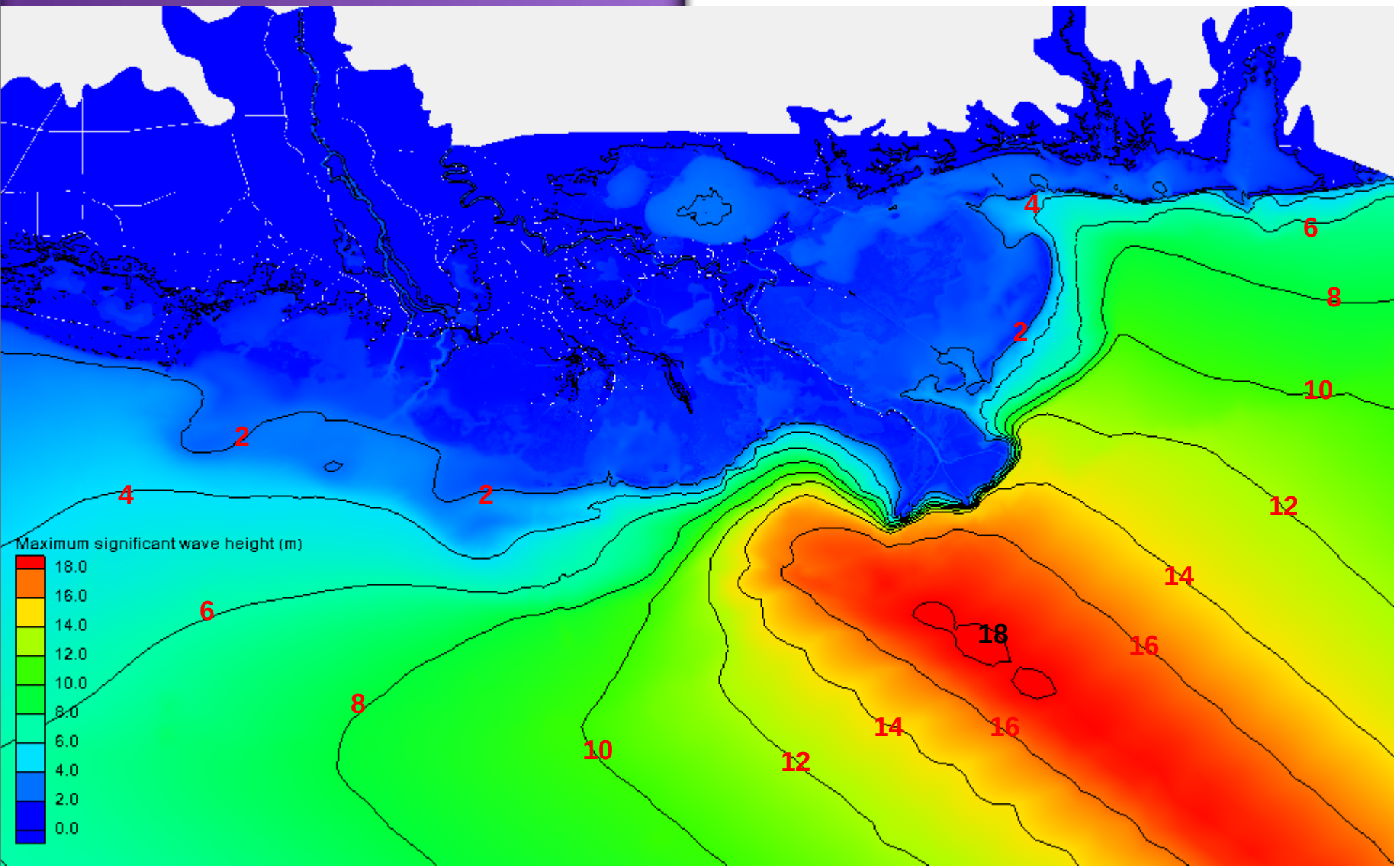


Surface elevation

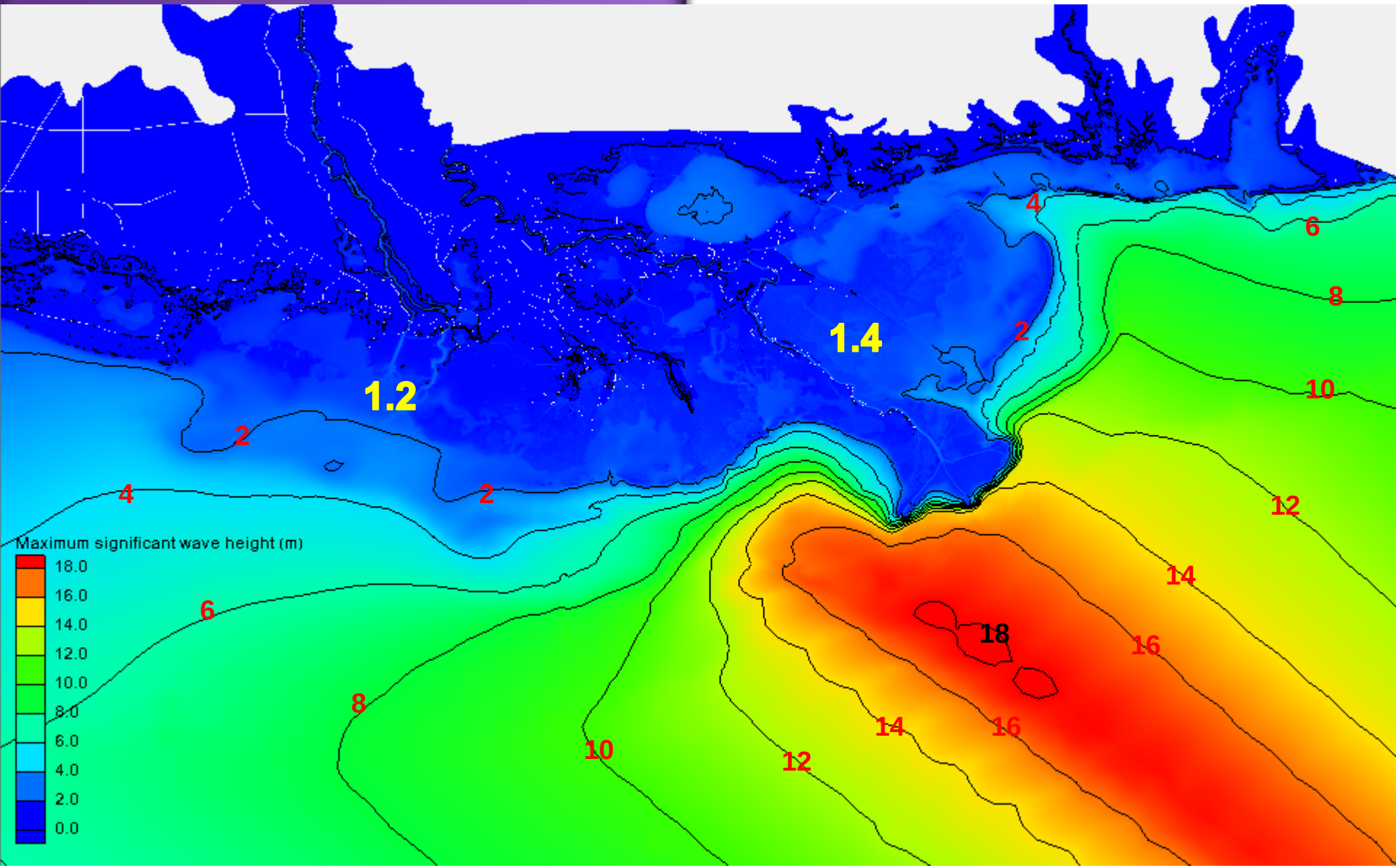




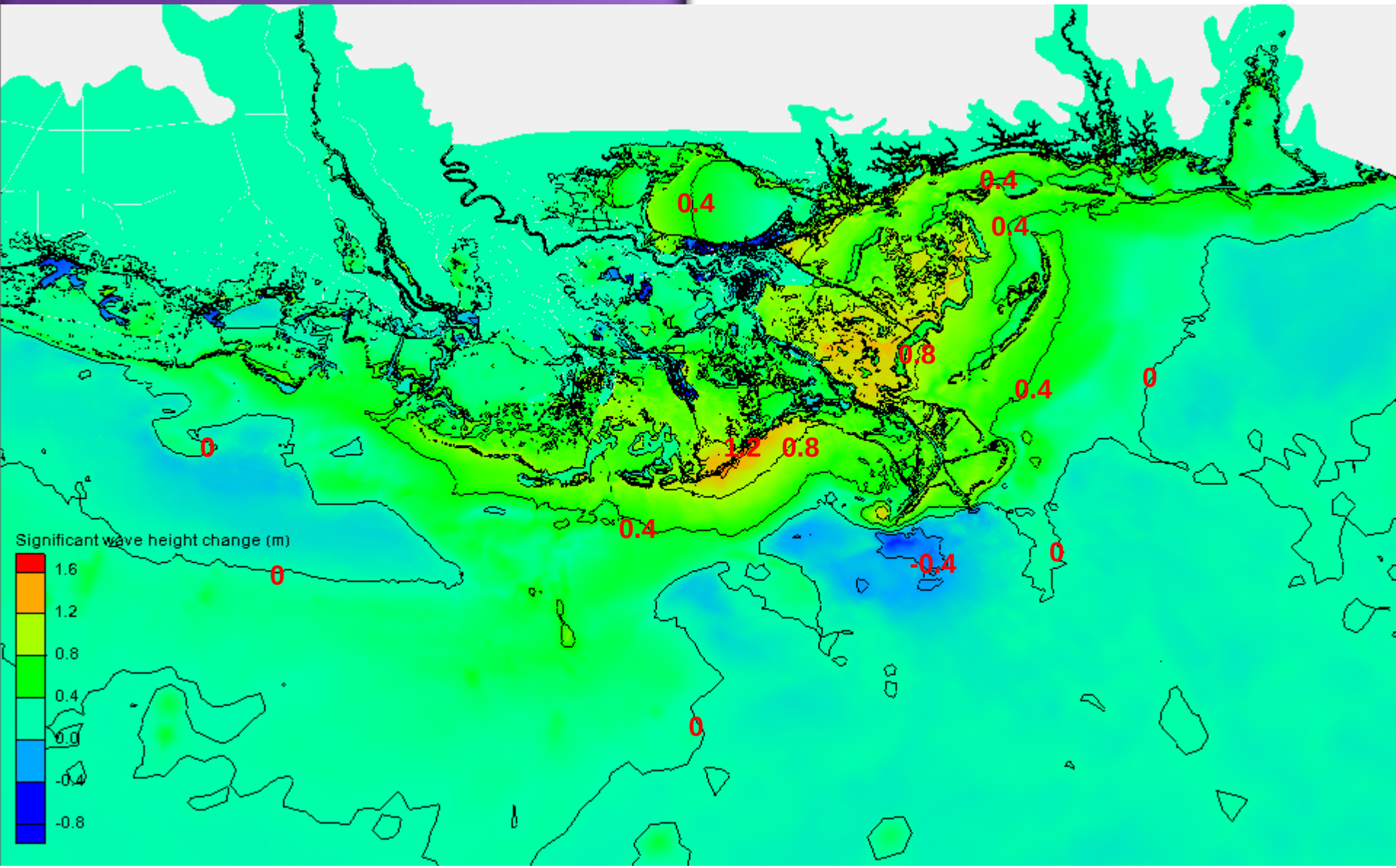
Maximum Hs


Maximum significant wave height (m)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
4
6
8
2
10
2
4
2
12
14
18
16
6
8
14
16
10
12

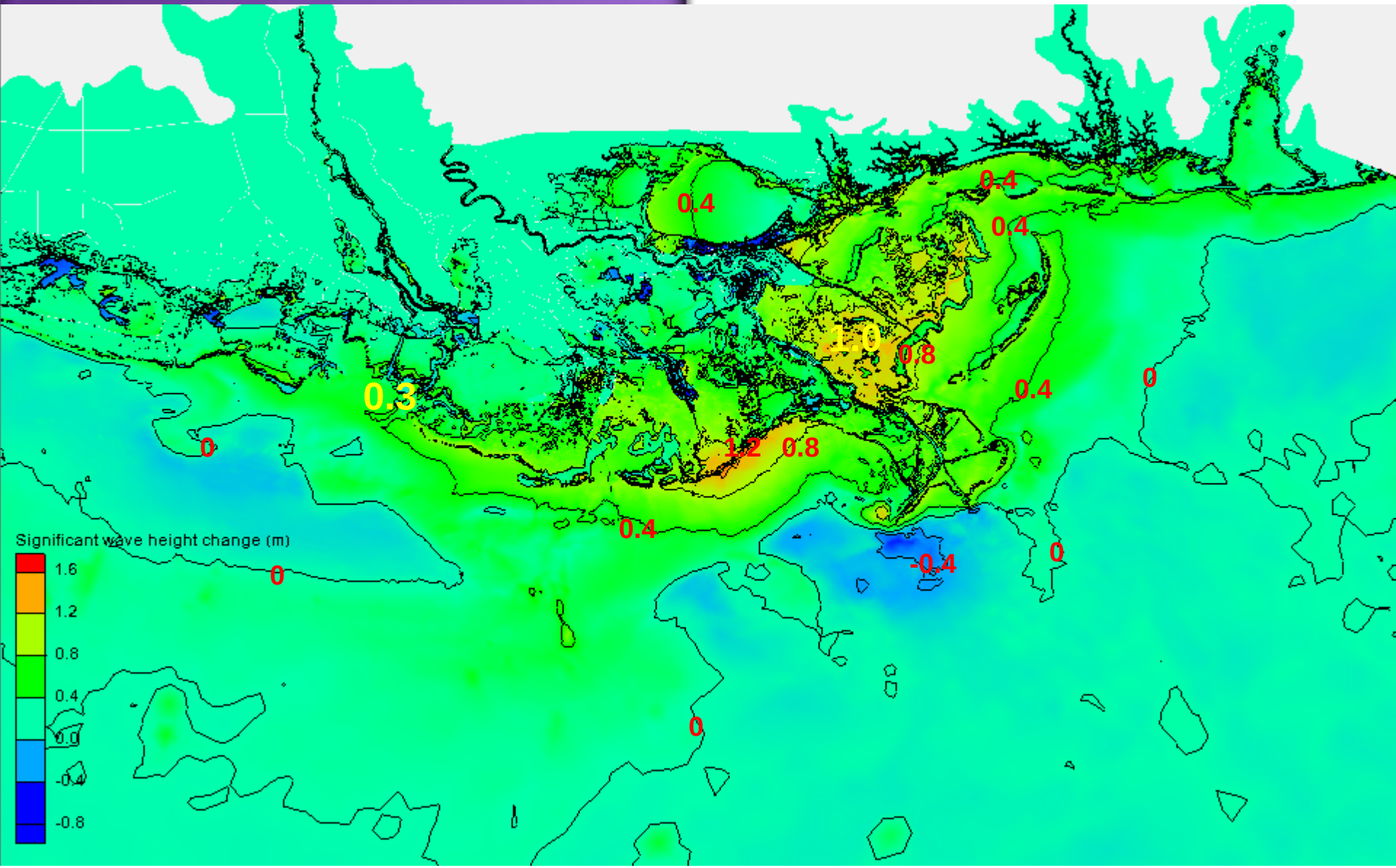
Maximum Hs


Maximum significant wave height (m)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1.2
1.4
2
4
6
8
10
12
14
16
18

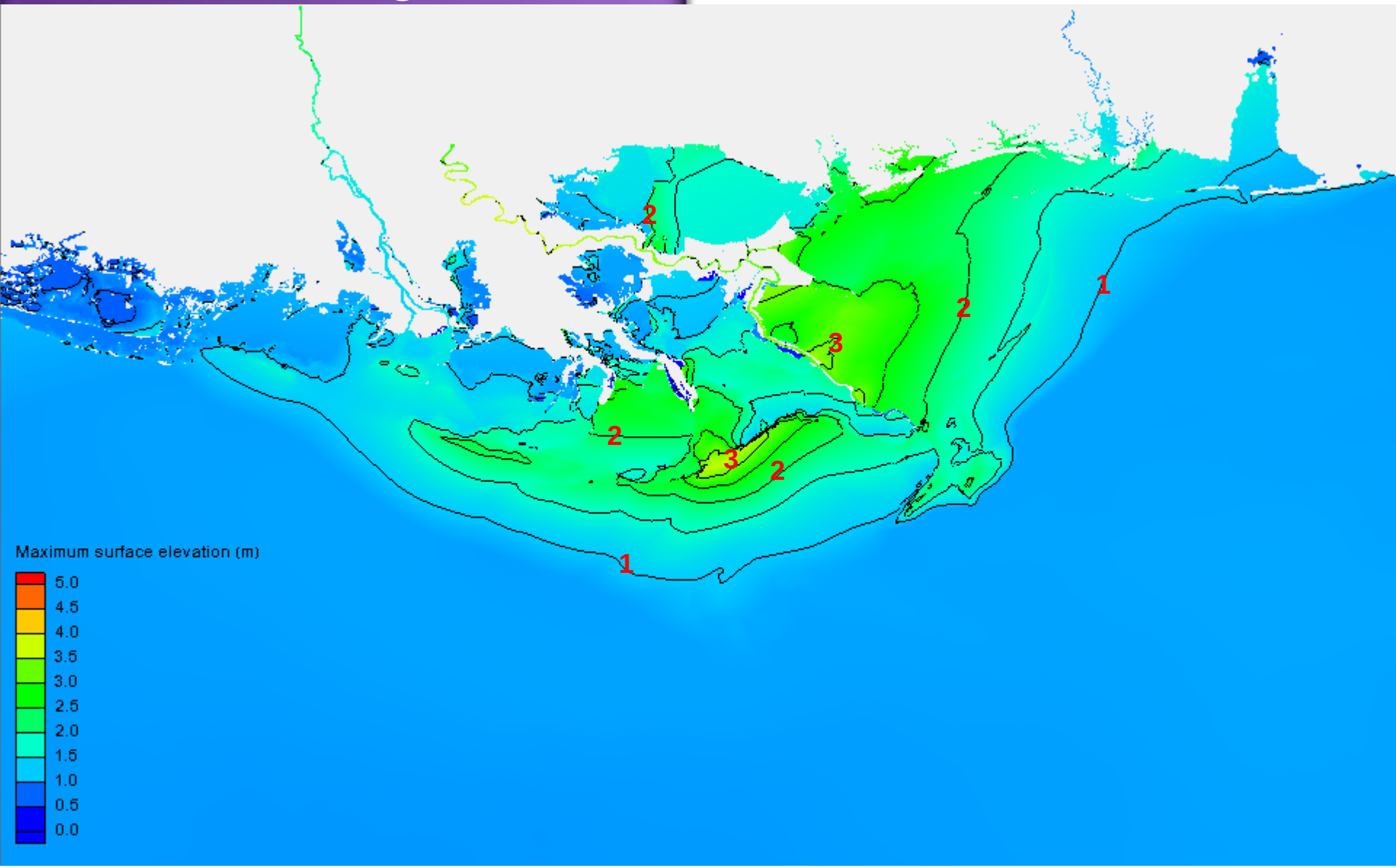
Contribution of surge to Hs



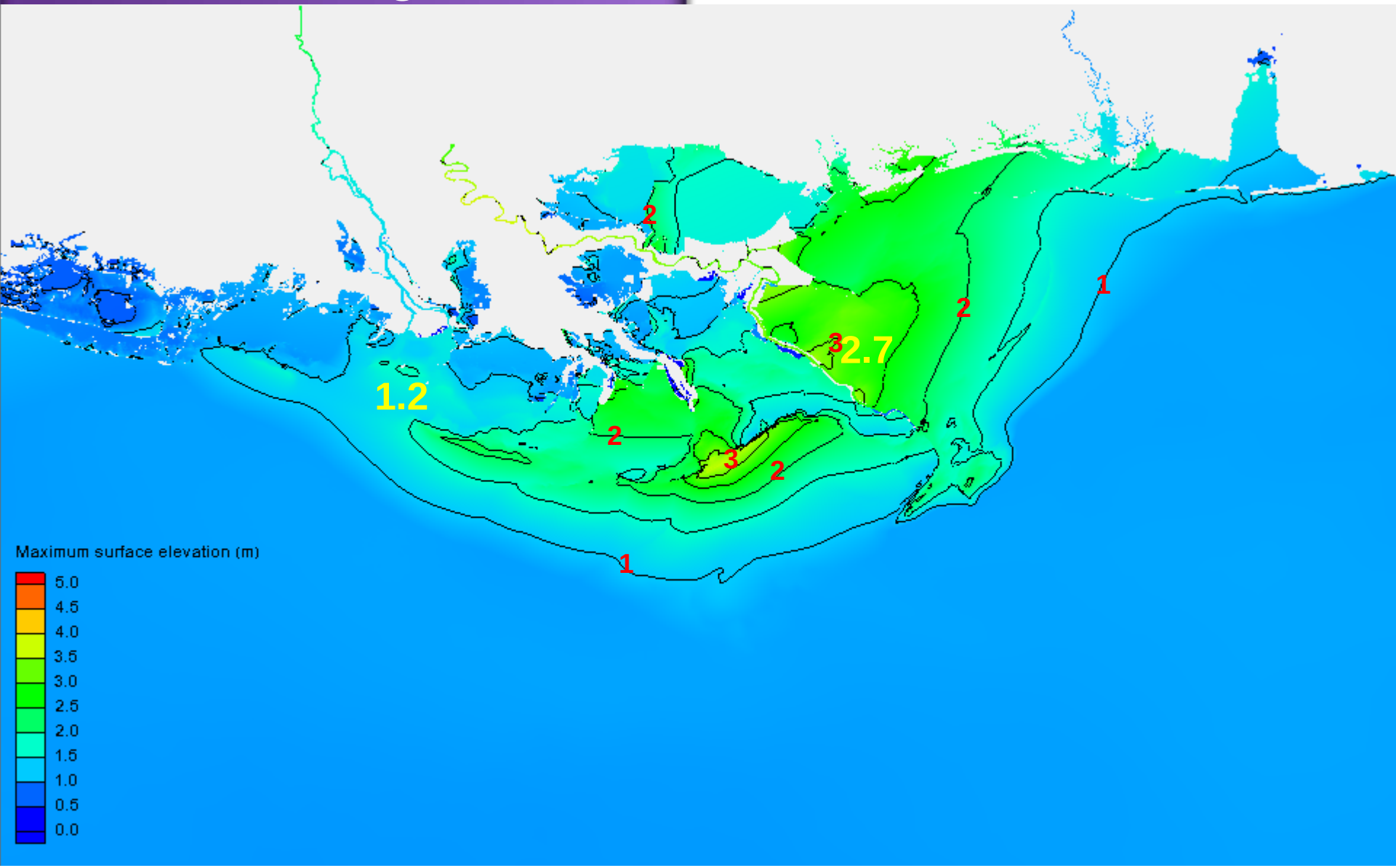
Contribution of surge to Hs



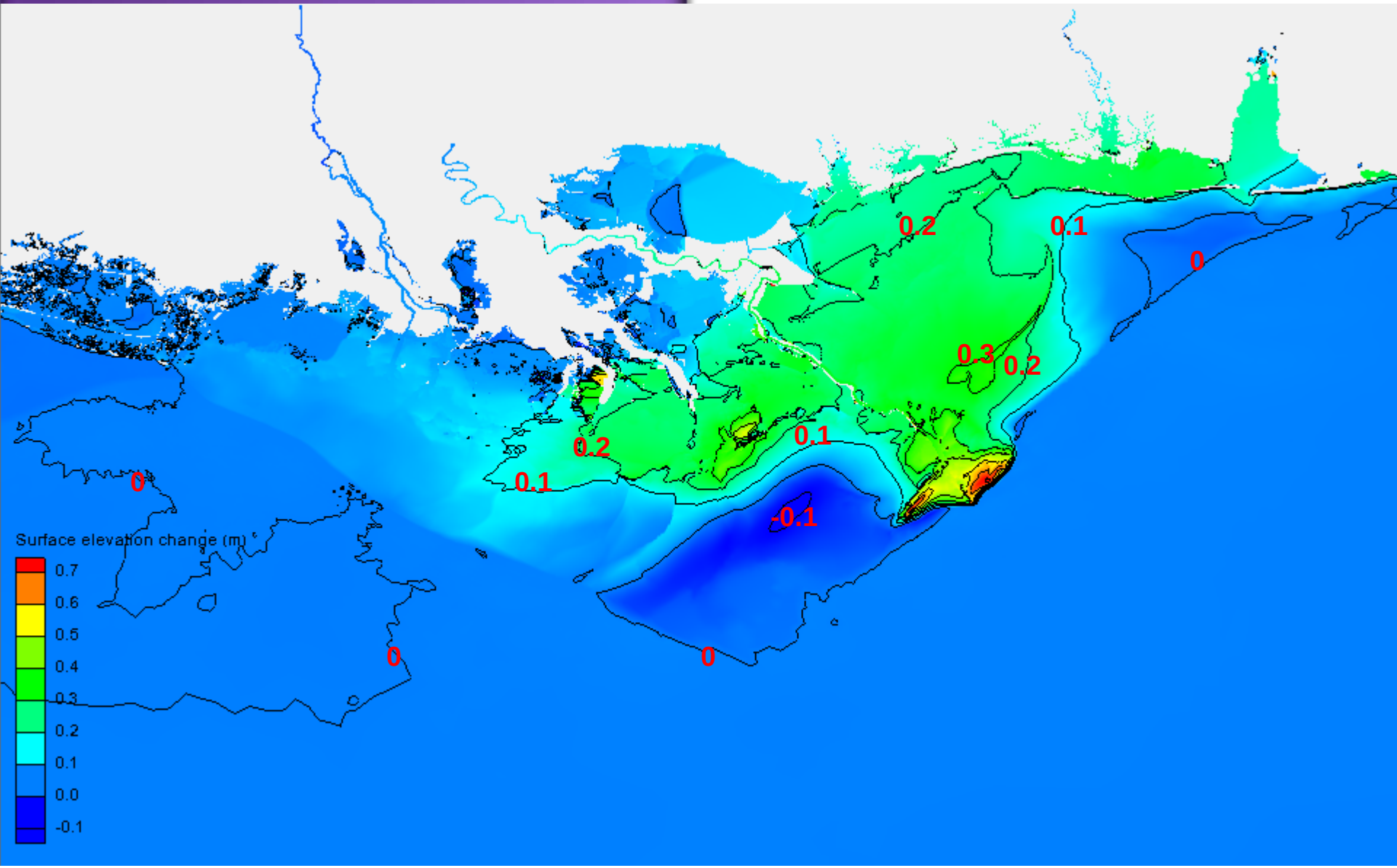
Maximum surge



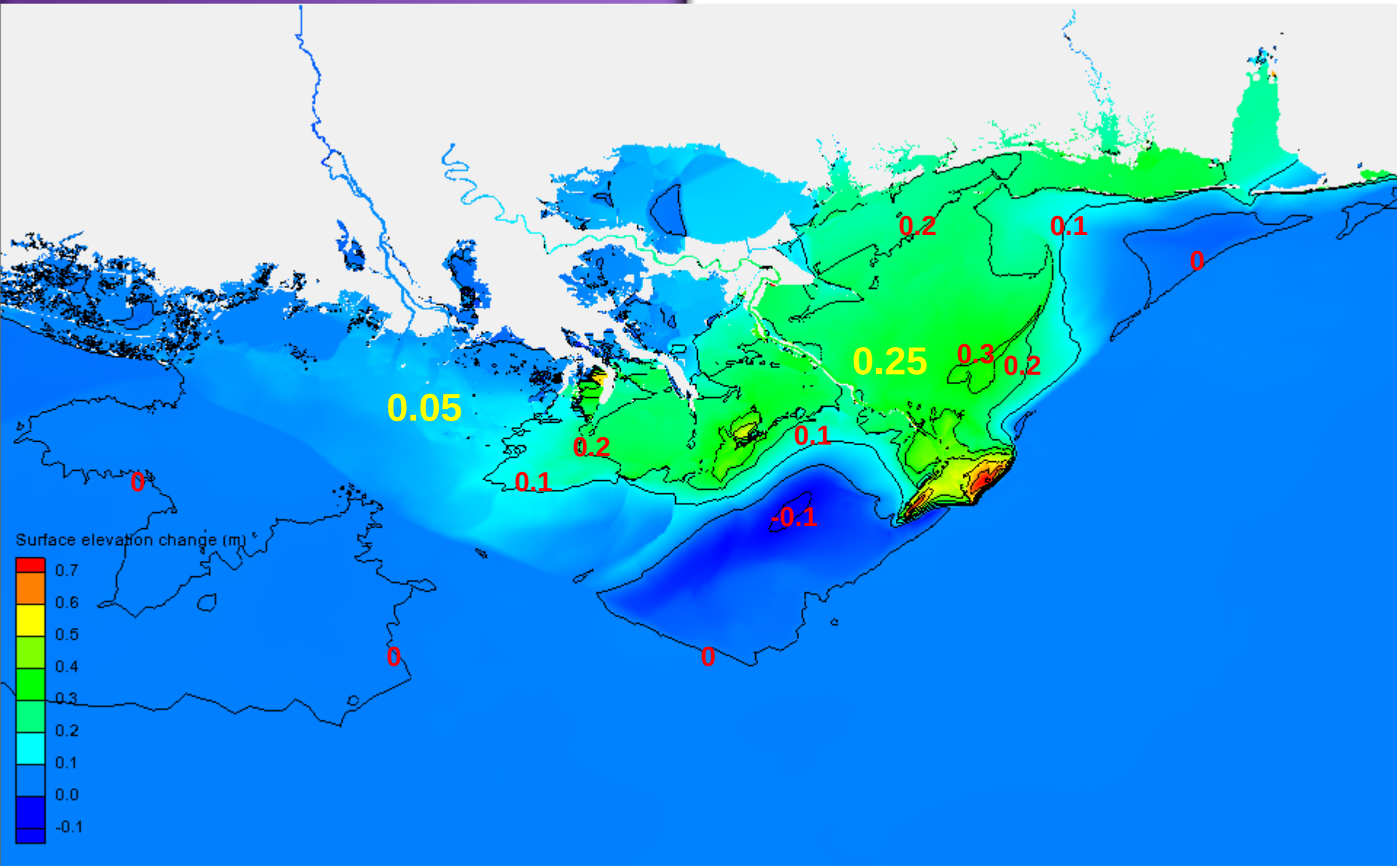
Maximum surge



Contribution of waves to surge



Contribution of waves to surge



Summary

- Coupling of ADCIRC and wind-wave model is essential and important for the rational simulation of both storm surge and hurricane waves in coastal areas, especially during an extreme hurricane event.
- Some wave parameters (e.g. wave breaking) in coastal areas need further validation.
- Bottom friction should be carefully calibrated for wetlands or salt marshes (vegetation effect).

Thank you!