ICCE 2018 (July 30 – August 3)
Baltimore, Maryland

# Modeling of the effect of land-building projects on storm surge and hurricane waves in coastal Louisiana


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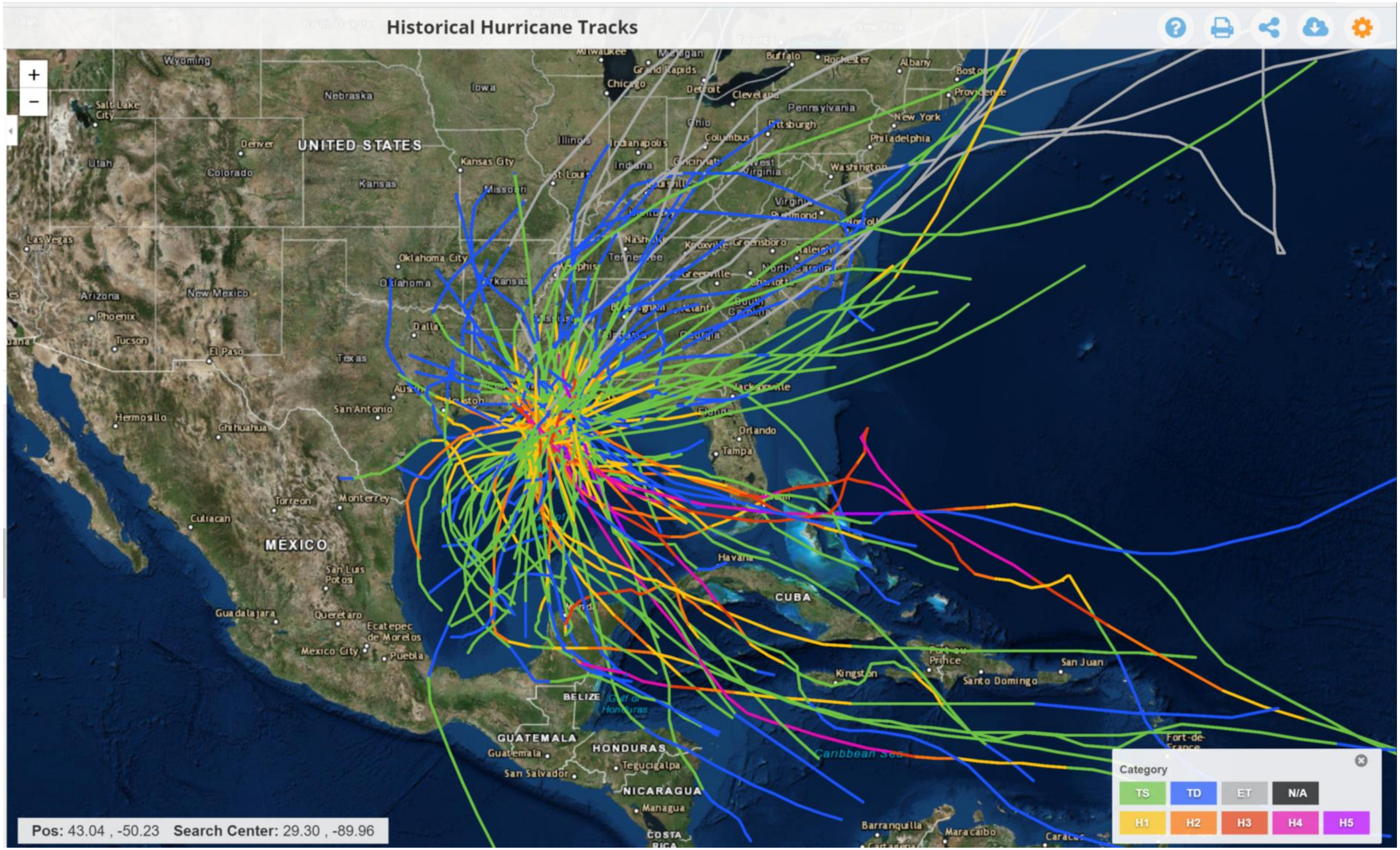
# Outline

- Introduction
- Model setup
- Model validation (Hurricane Isaac, 2012)
- Numerical experiments
- Conclusions

# Storm events in coastal Louisiana

NOAA Historical Hurricane Tracks
https://coast.noaa.gov/hurricanes/



# Storm events in coastal Louisiana

**NOAA Historical Hurricane Tracks**
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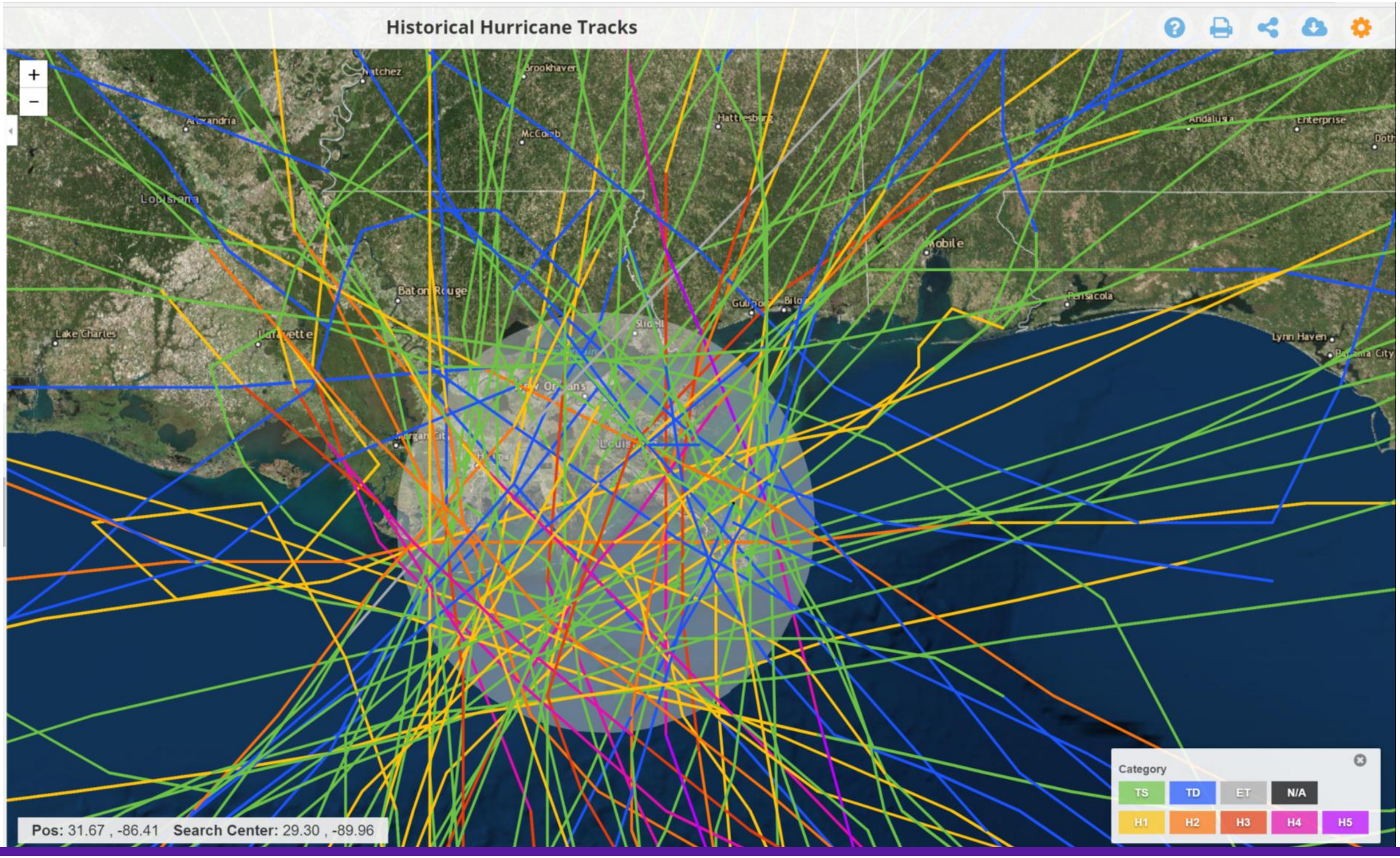
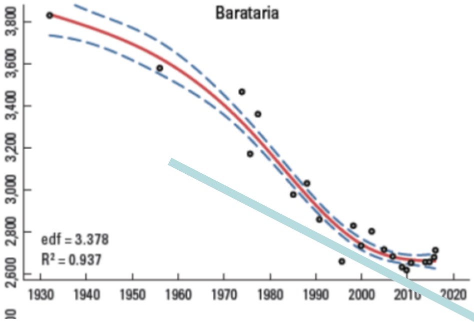
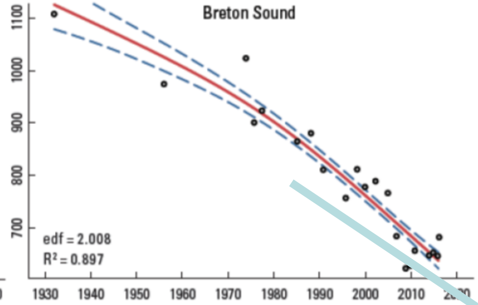
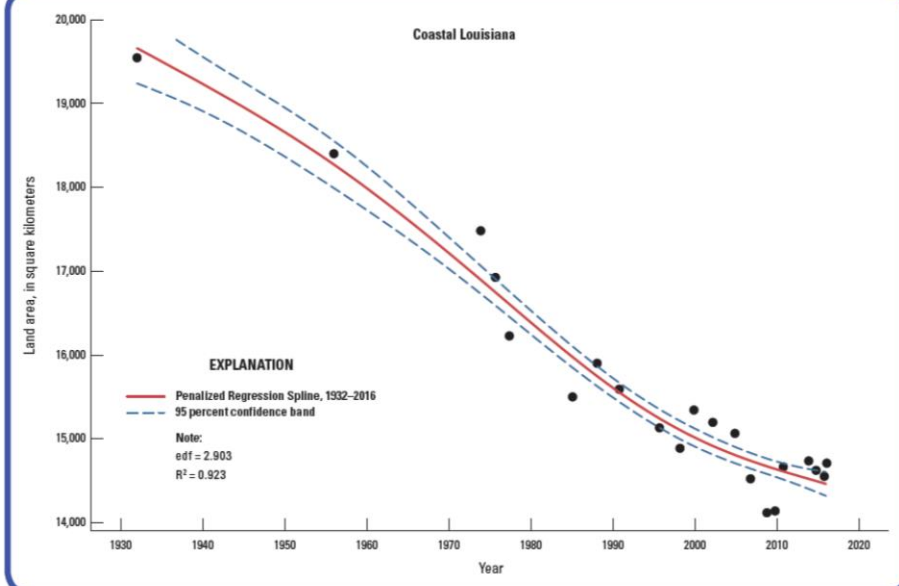


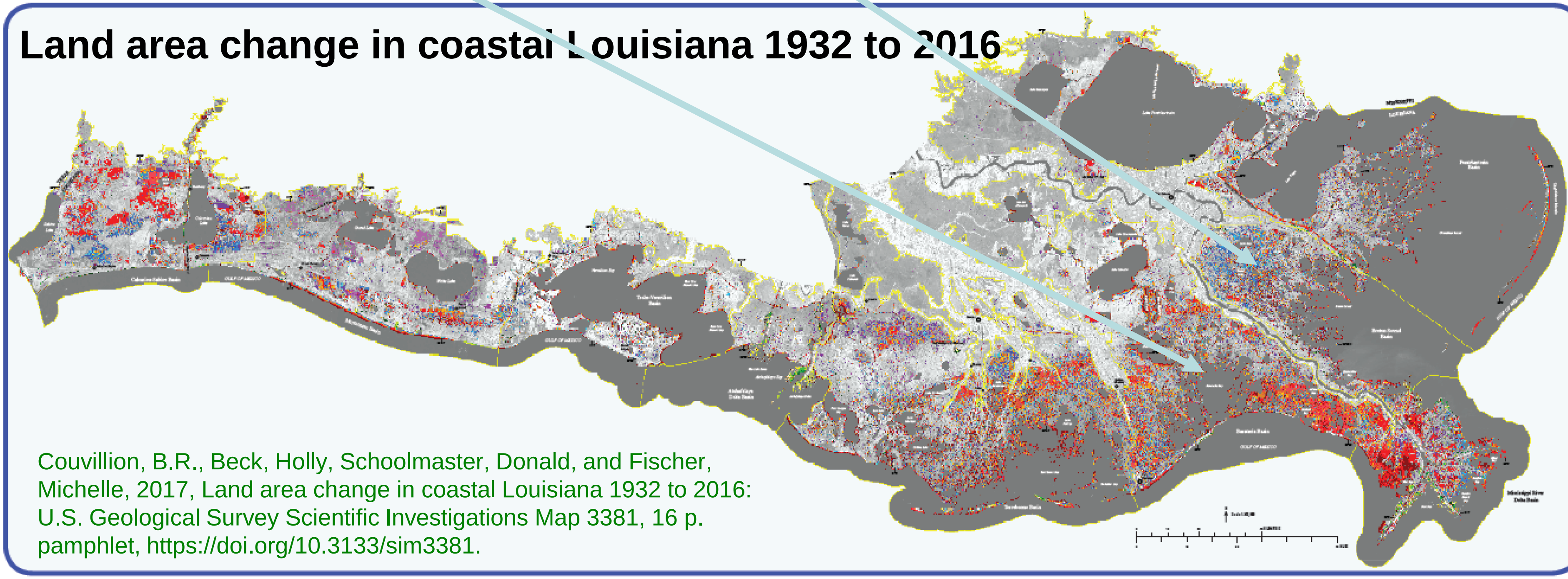
# Land loss in coastal Louisiana



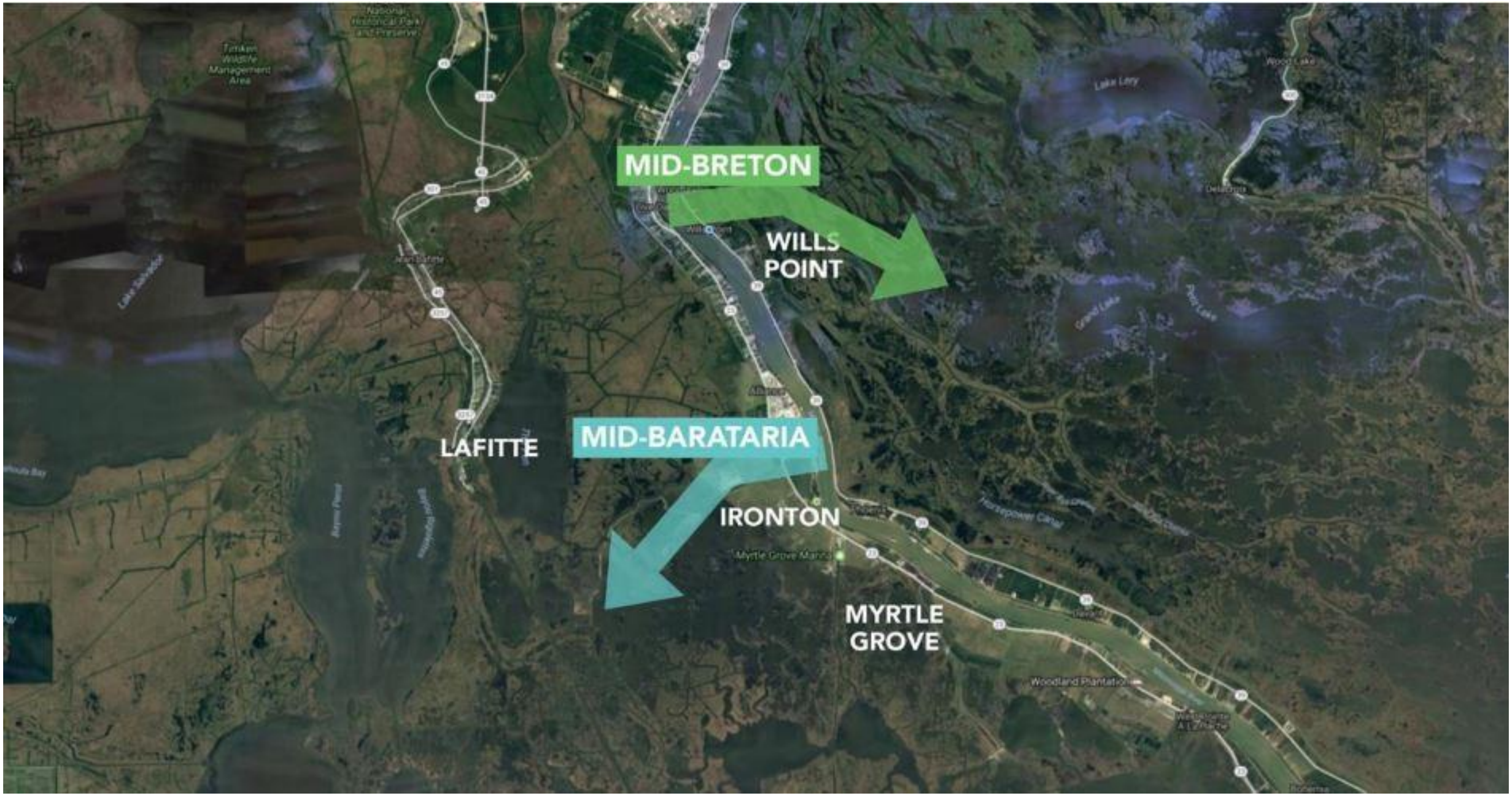




## Land area change in coastal Louisiana 1932 to 2016



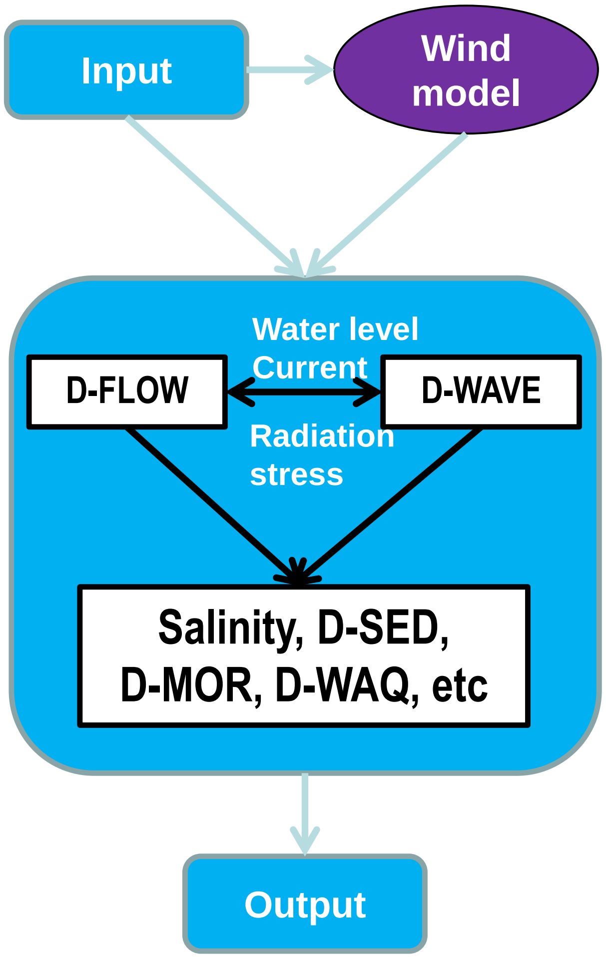
Couvillion, B.R., Beck, Holly, Schoolmaster, Donald, and Fischer, Michelle, 2017, Land area change in coastal Louisiana 1932 to 2016: U.S. Geological Survey Scientific Investigations Map 3381, 16 p. pamphlet, https://doi.org/10.3133/sim3381.

# Sediment diversion Projects by CPRA



# Delft3D

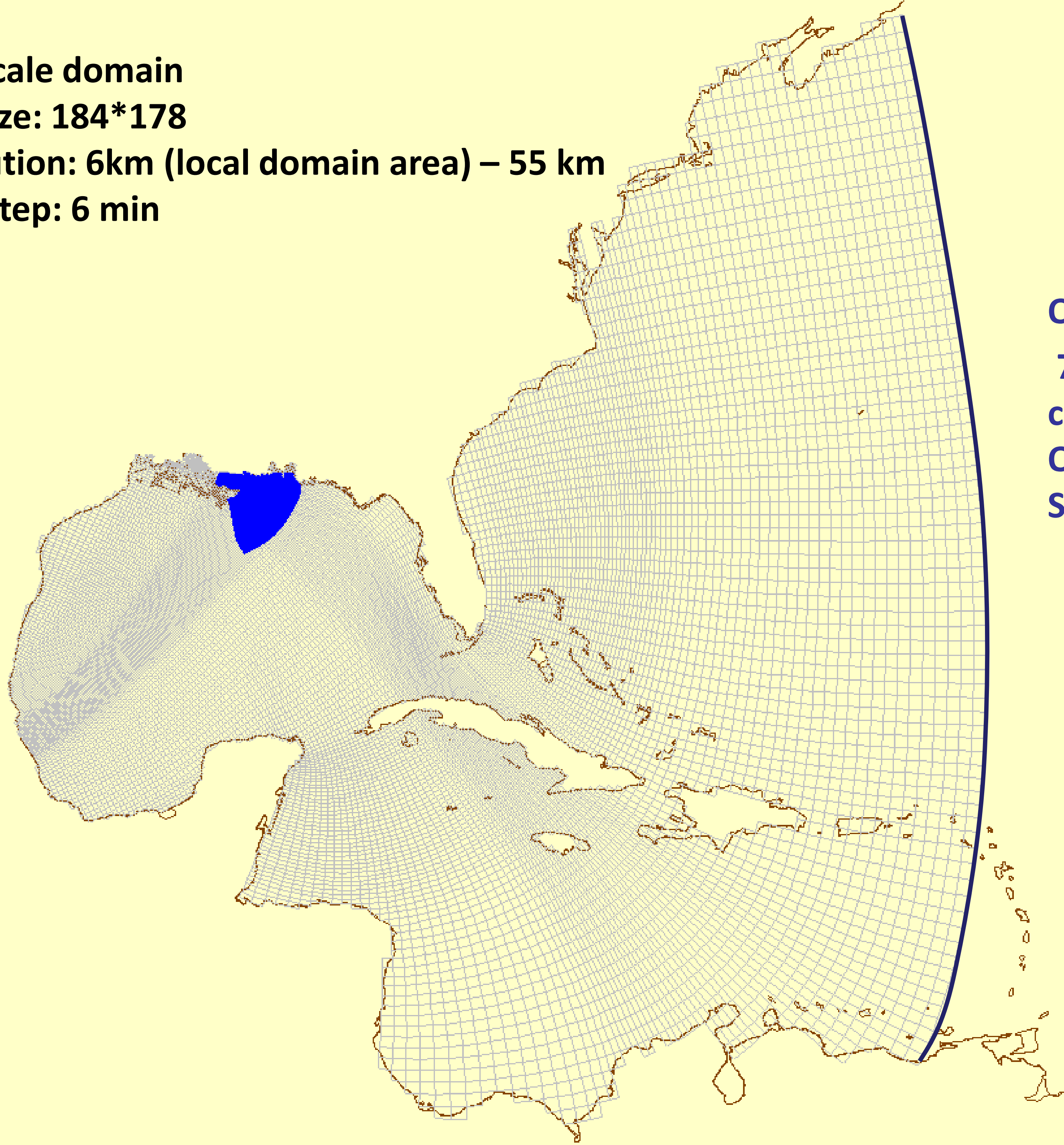
- The Delft3D suite, developed by Deltares, can carry out simulations of flows, sediment transports, waves, water quality, morphological developments and ecology.
- Delft3D-FLOW is a multi-dimensional (2D or 3D) hydrodynamic (and transport) simulation program which calculates non-steady flow and transport phenomena that result from tidal and meteorological forcing on a rectilinear or a curvilinear, boundary fitted grid.
- Delft3D-FLOW+Delft3D-WAVE



# Features

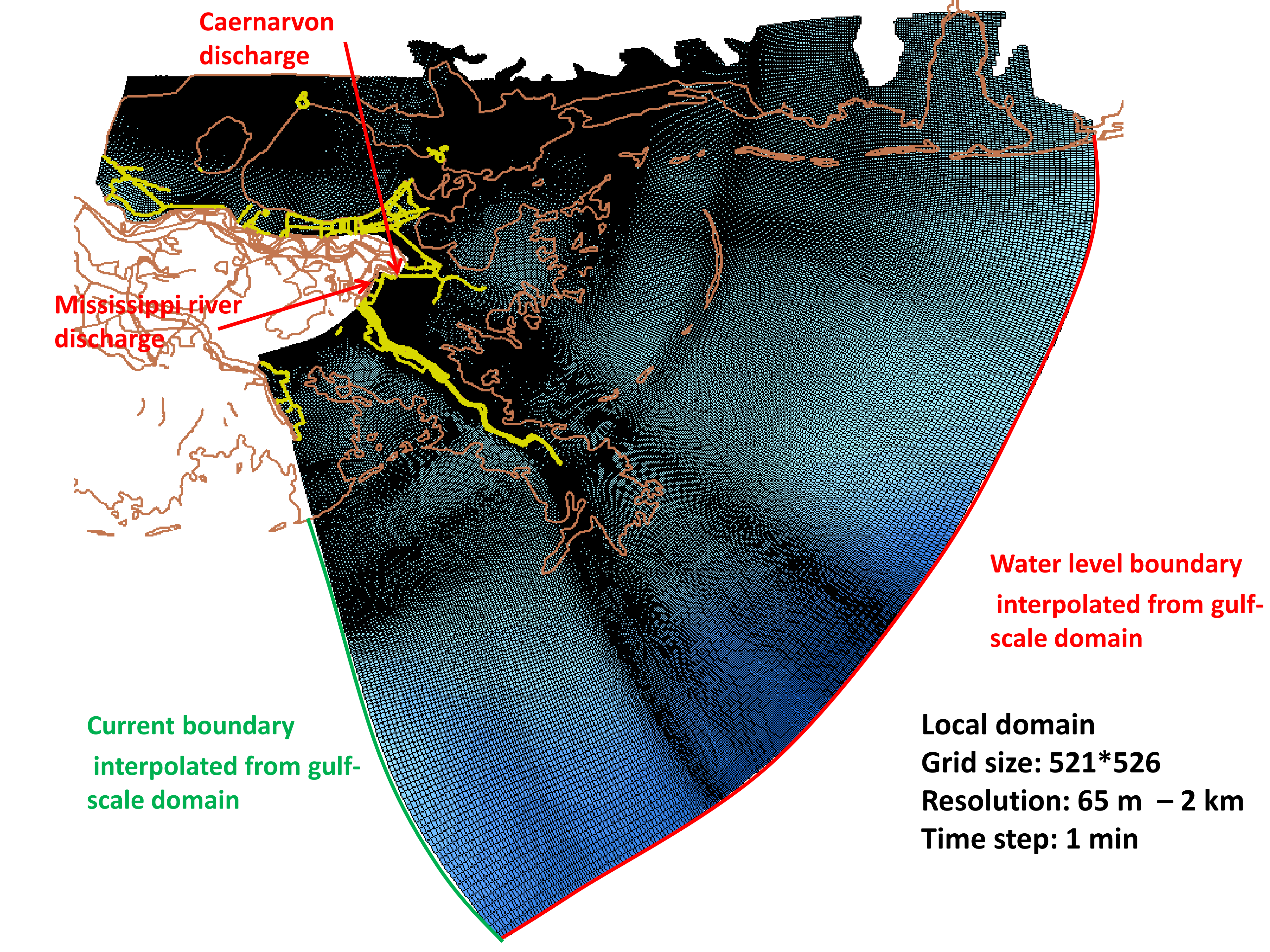
- Online coupling of FLOW and WAVE
- Nesting computation
- Levees
- Vegetation

**Gulf-scale domain**
**Grid size: 184*178**
**Resolution: 6km (local domain area) – 55 km**
**Time step: 6 min**



**Open boundary**

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



Caernarvon
discharge
Mississippi river
discharge
Water level boundary
interpolated from gulf-
scale domain
Current boundary
interpolated from gulf-
scale domain
Local domain
Grid size: 521*526
Resolution: 65 m – 2 km
Time step: 1 min

# Vegetation

The biophysical characteristics of various vegetation types.

| Vegetation type | Average stem height (m) | Average stem diameter (mm)[e] | Average stem density ($m^{-2}$)[e] |
|---|---|---|---|
| Fresh marsh | 0.76[a] | 5.59 | 578 |
| Intermediate marsh | 0.50[b] | 2.03 | 2095 |
| Brackish marsh | 0.50[c] | 1.50 | 740 |
| Saline marsh | 0.40[d] | 3.67 | 341 |

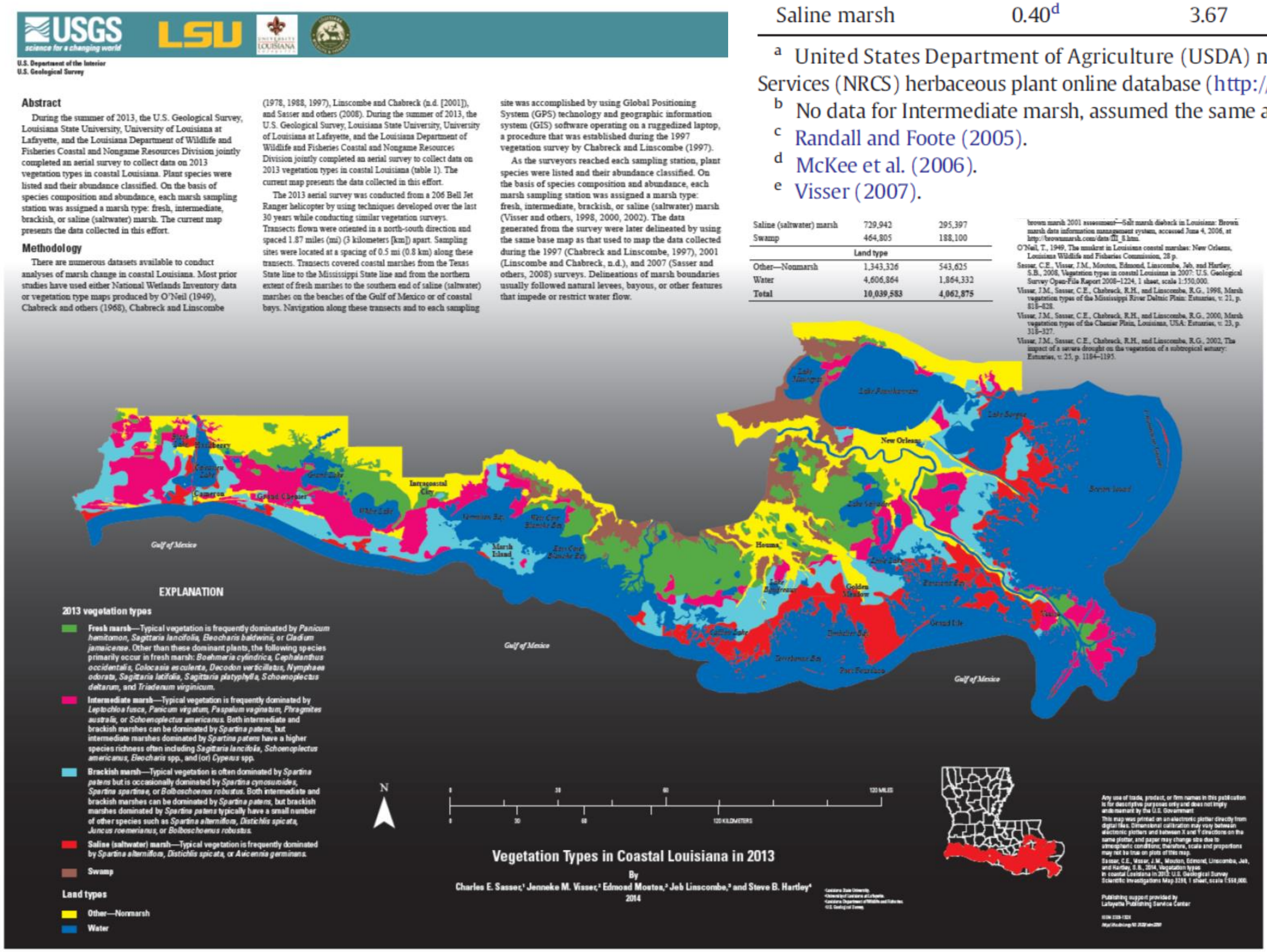
[a] United States Department of Agriculture (USDA) natural Resources Conservation Services (NRCS) herbaceous plant online database (http://plants.usda.gov/java/factSheet).

[b] No data for Intermediate marsh, assumed the same as Brackish marsh.

[c] Randall and Foote (2005).

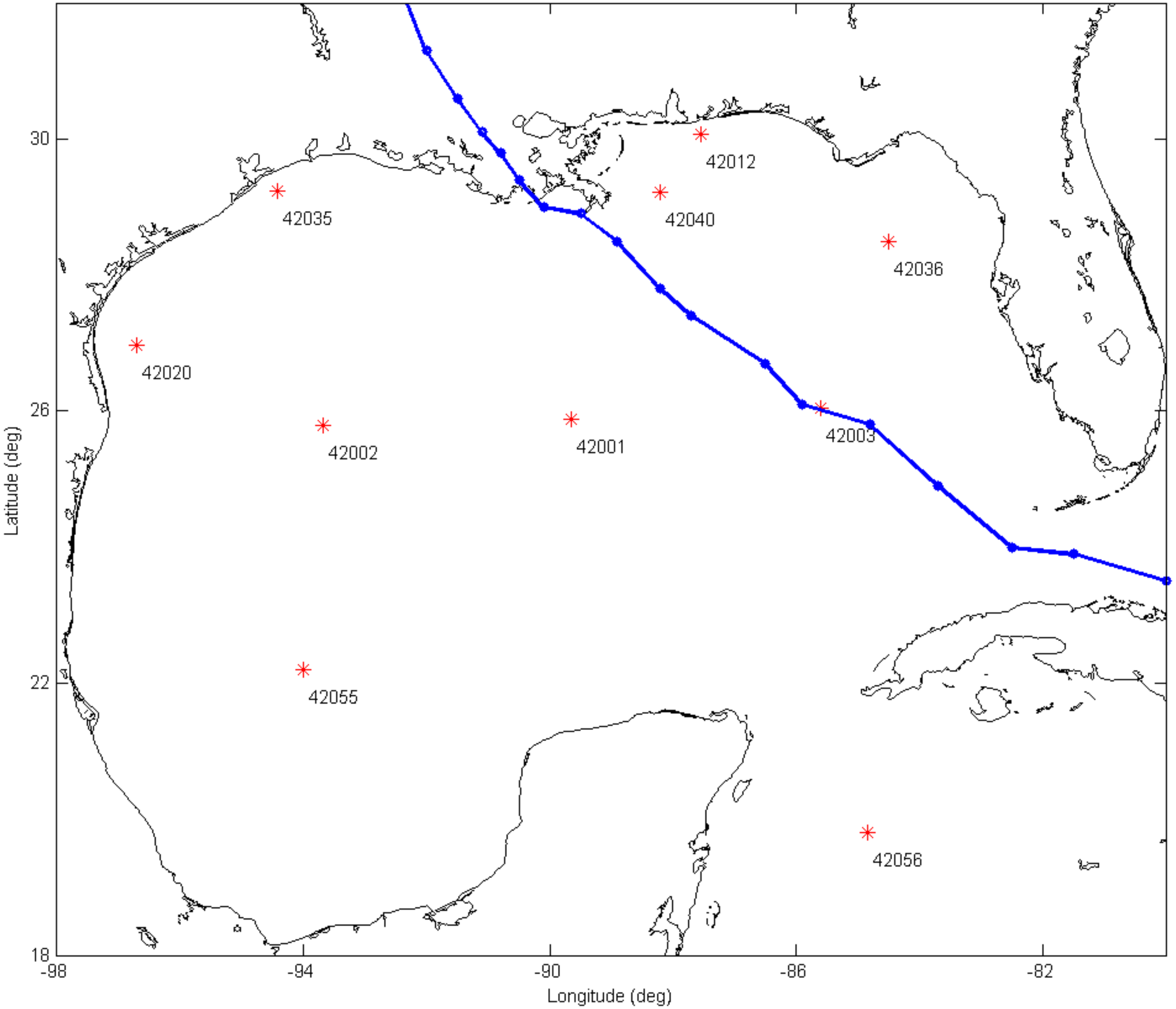
[d] McKee et al. (2006).

[e] Visser (2007).

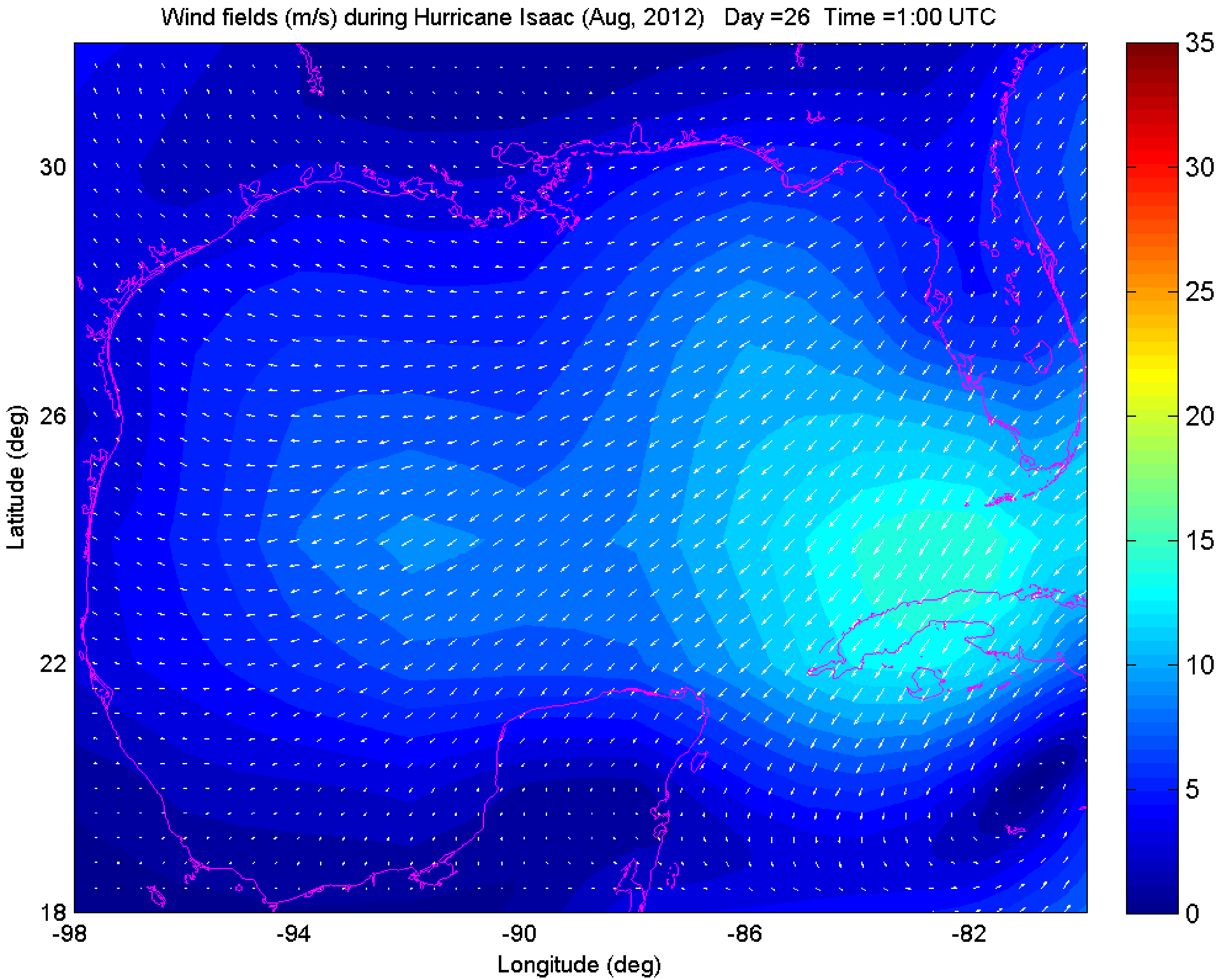


# Hurricane Isaac (2012)

**As a Category I hurricane near the Louisiana Coast on August 28, 2012, with winds of 80 mph (130 km/h) and lowest pressure of 965 mb.**

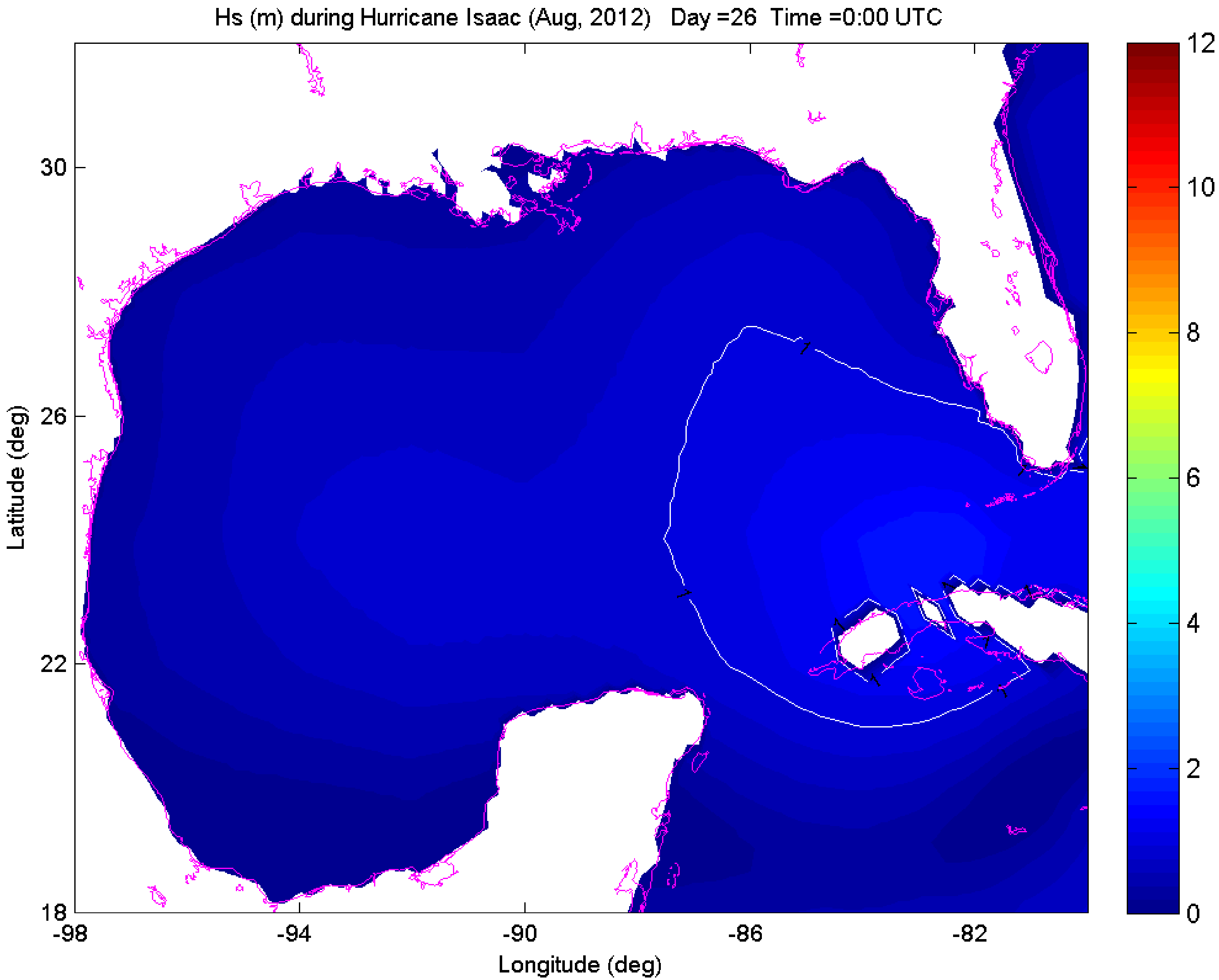


# Isaac winds



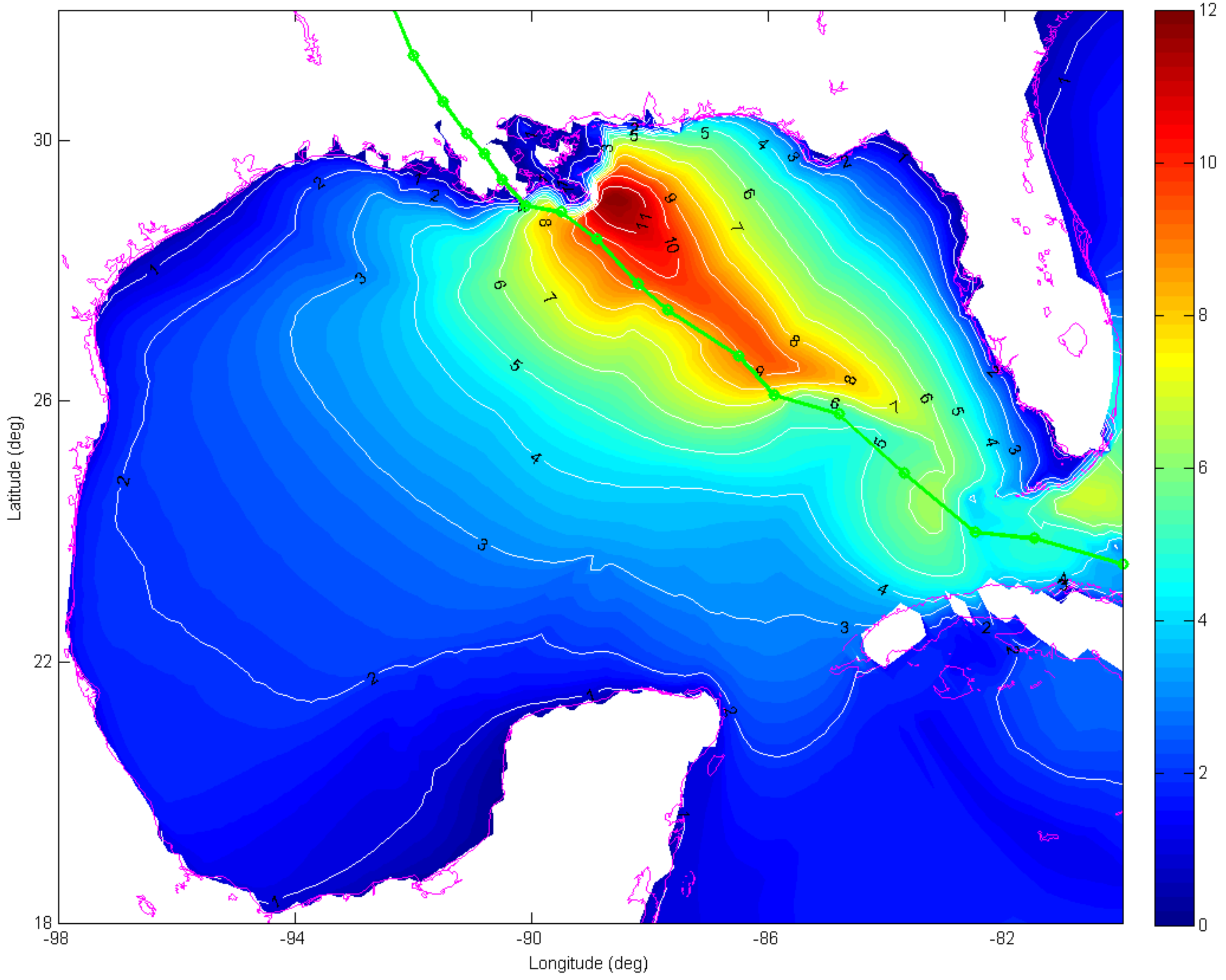

- Hu, K., Chen, Q., and Kimball, K.S., 2012. Consistency in hurricane surface wind forecasting: An improved parametric model, *Natural Hazards*, 61:1029–1050.

# Hs (m) by Isaac



Hs (m) during Hurricane Isaac (Aug, 2012) Day =26 Time =0:00 UTC
Latitude (deg)
30
26
22
18
-98
-94
-90
-86
-82
Longitude (deg)
12
10
8
6
4
2
0

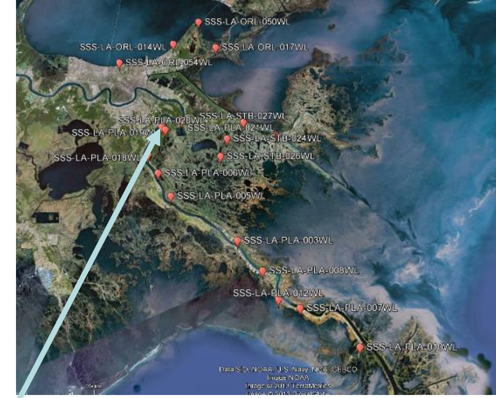
# Maximum Hs (m）

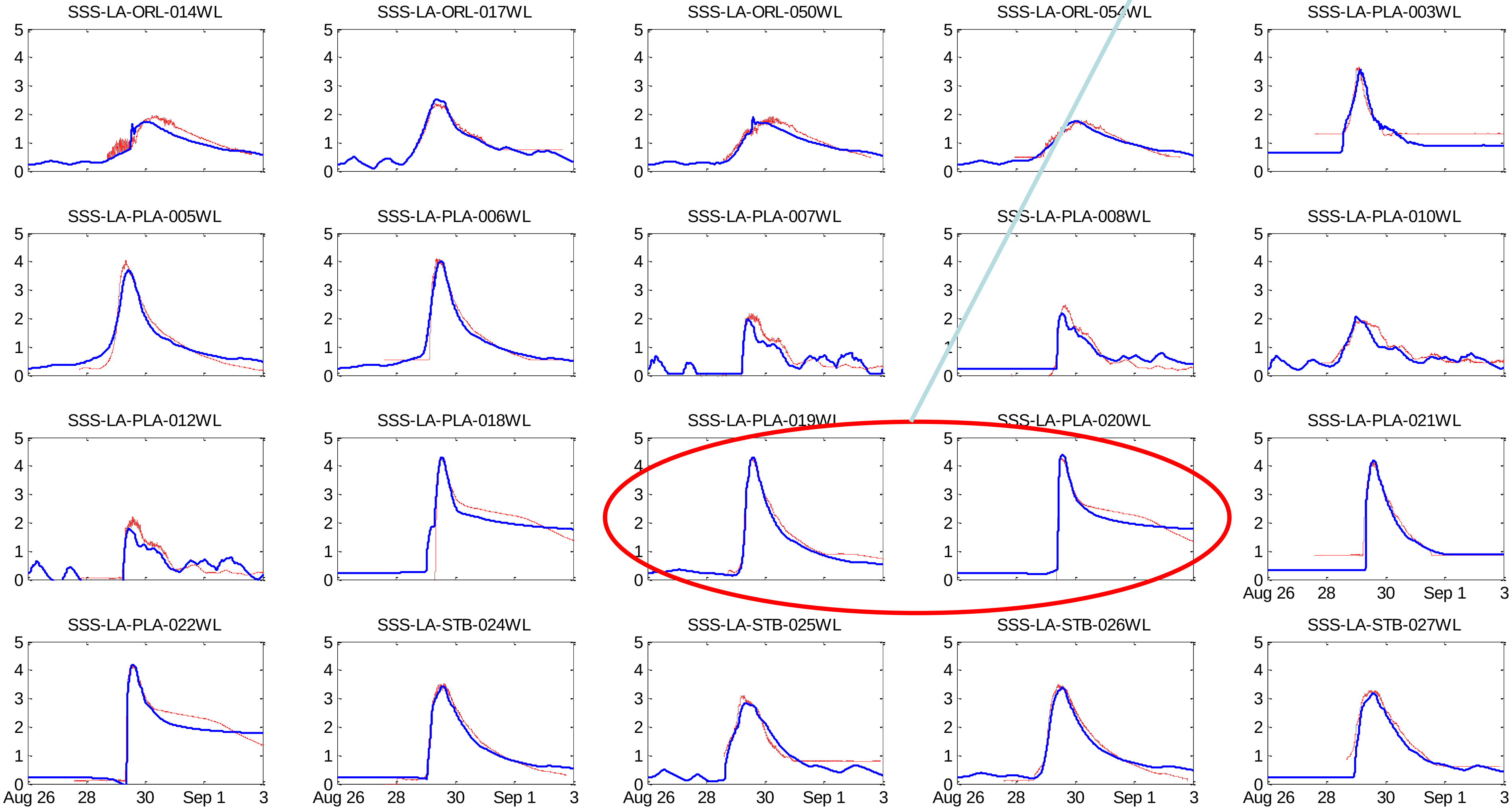


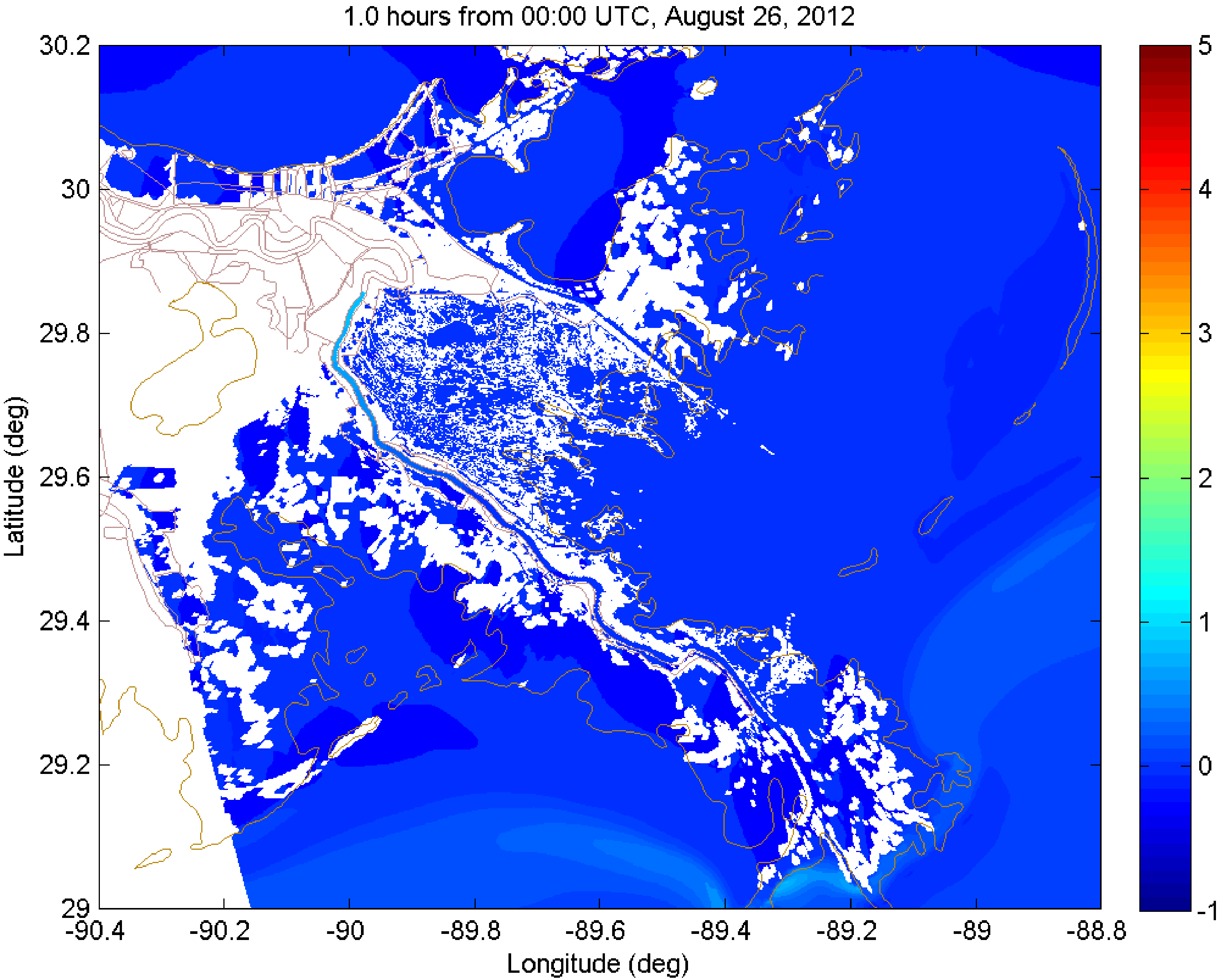
Latitude (deg)
Longitude (deg)
30
26
22
18
-98
-94
-90
-86
-82
12
10
8
6
4
2
0

# Water level comparison

(red line: observations; blue line: model results)

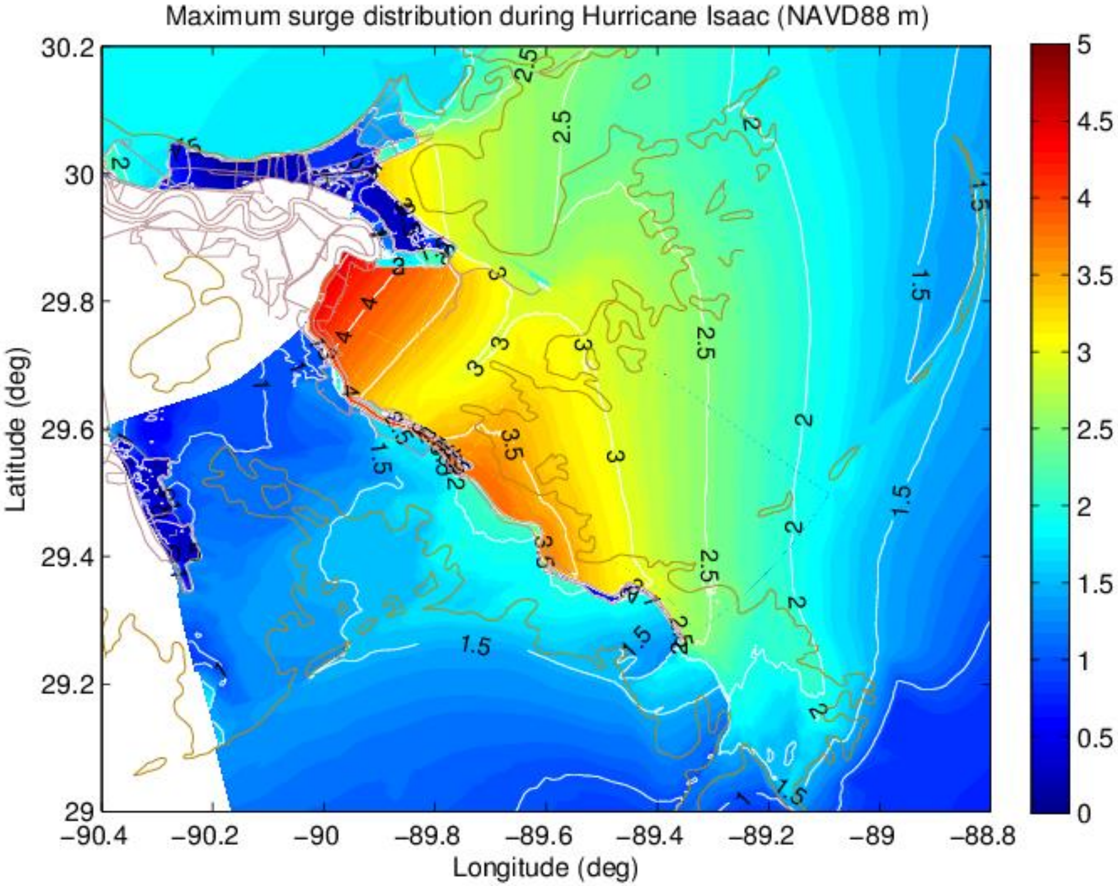


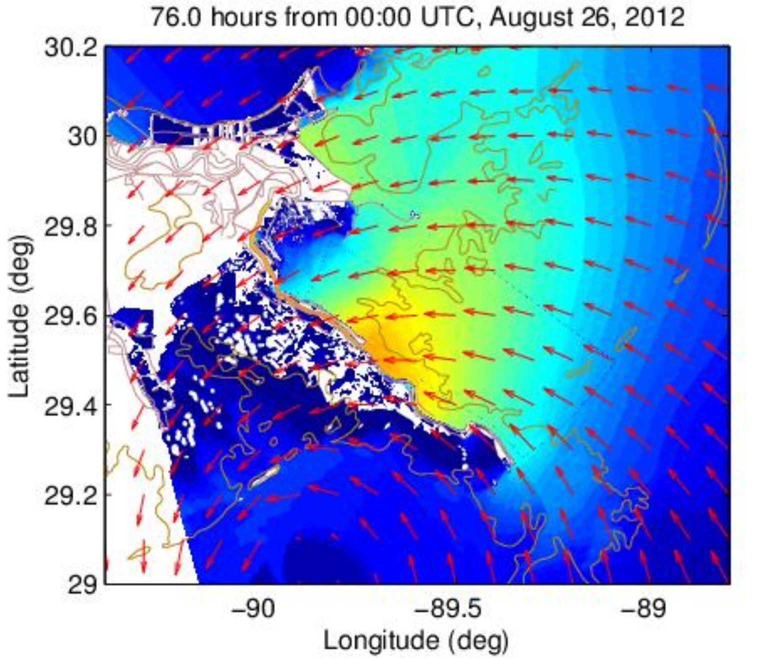


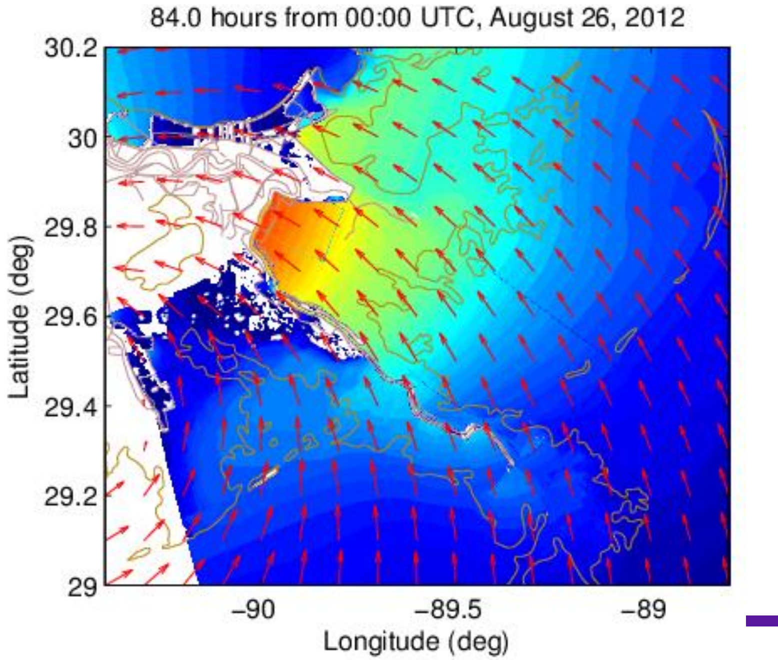


1.0 hours from 00:00 UTC, August 26, 2012
Latitude (deg)
Longitude (deg)
30.2
30
29.8
29.6
29.4
29.2
29
-90.4
-90.2
-90
-89.8
-89.6
-89.4
-89.2
-89
-88.8
5
4
3
2
1
0
-1

# Maximum surge (m)

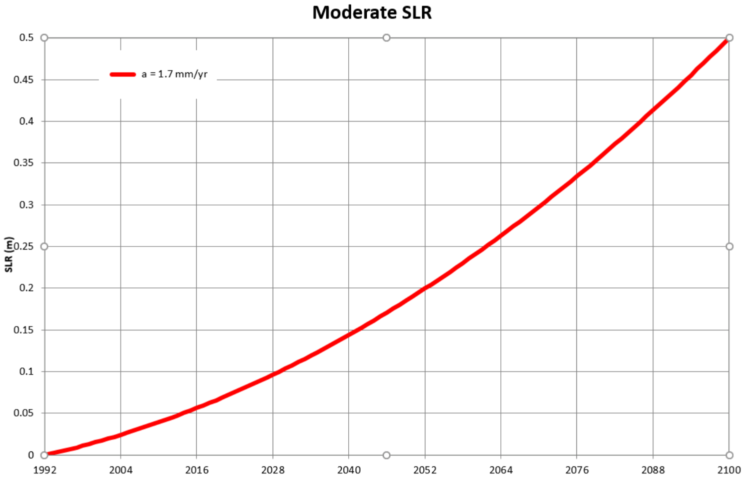


# Numerical experiments

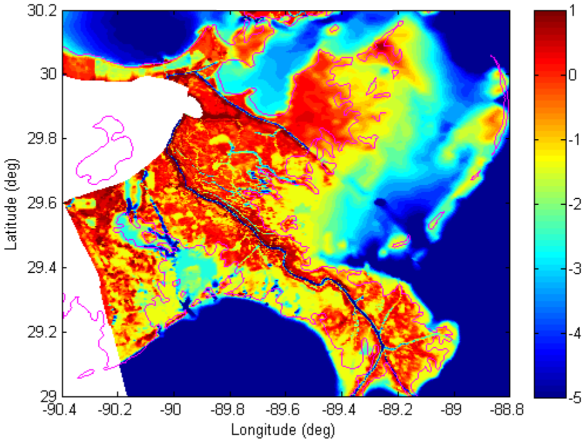
- Six years (2020, 2030, 2040, 2050, 2060 and 2070)
- For each year, input predicted bathymetry and vegetation map (with projects or w/o projects)
- Moderate sea level rise (SLR)
- Major factors
  - Diversion project
  - Vegetation
  - Waves
  - SLR



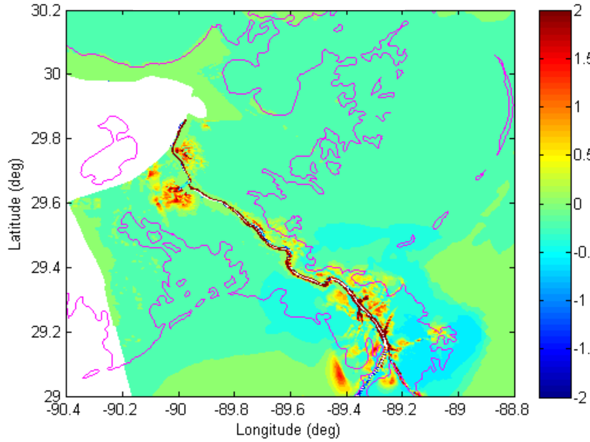

SLR_20=0.030 m
SLR_30=0.064 m
SLR_40=0.105 m
SLR_50=0.150 m
SLR_60=0.202 m
SLR_70=0.258 m

# Bathymetry and elevation changes (m) (with project)

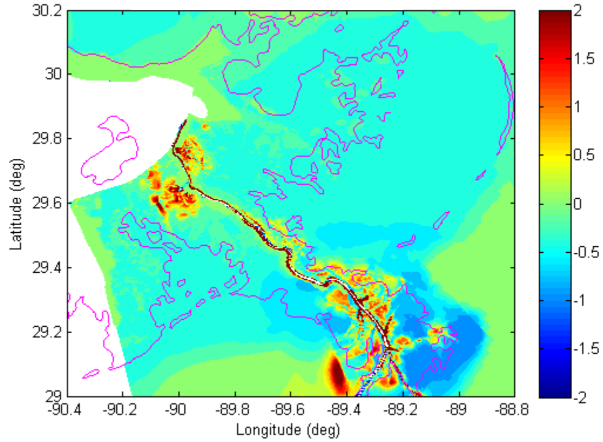
### Y2020



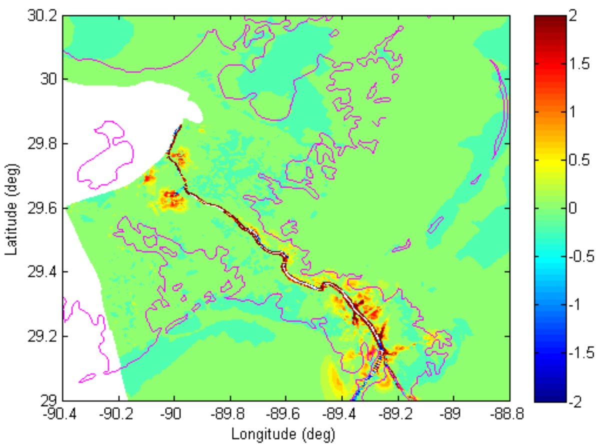

### Y2040-Y2020



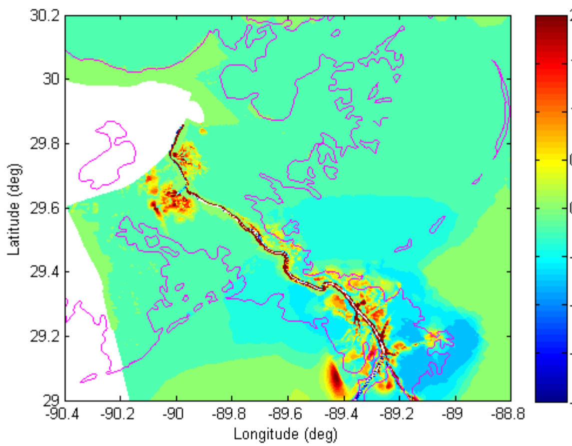

### Y2060-Y2020



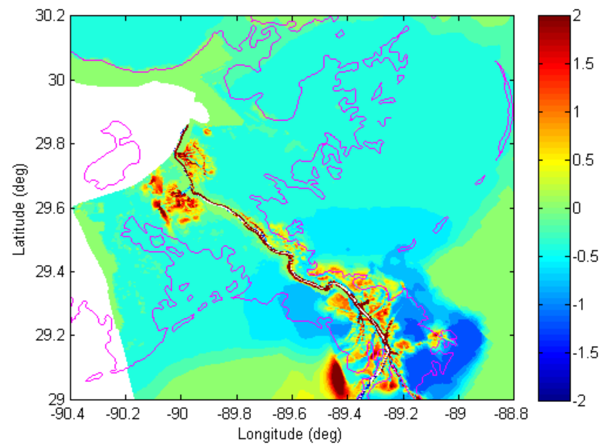

### Y2030-Y2020




### Y2050-Y2020

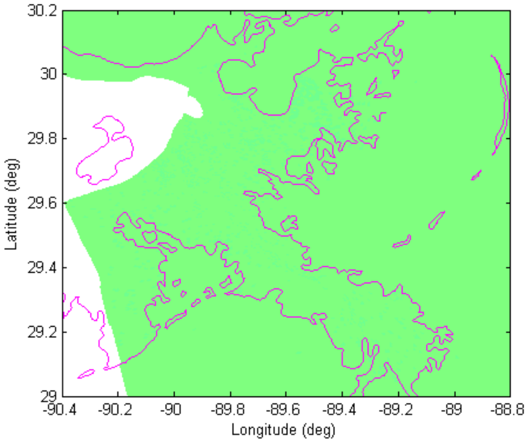



### Y2070-Y2020

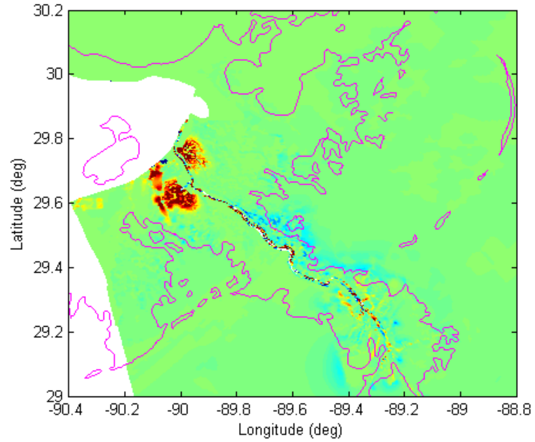


# Elevation changes (m)
# (with project – w/o project)

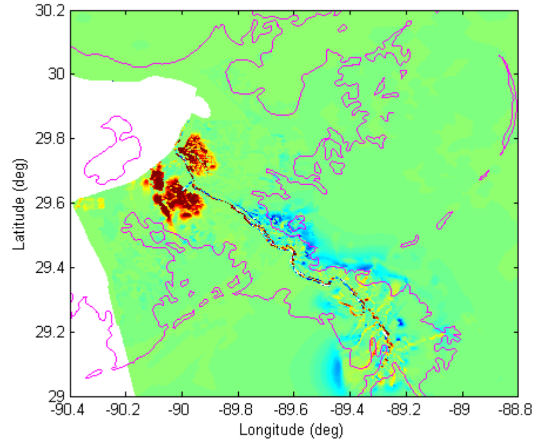
**Y2020**



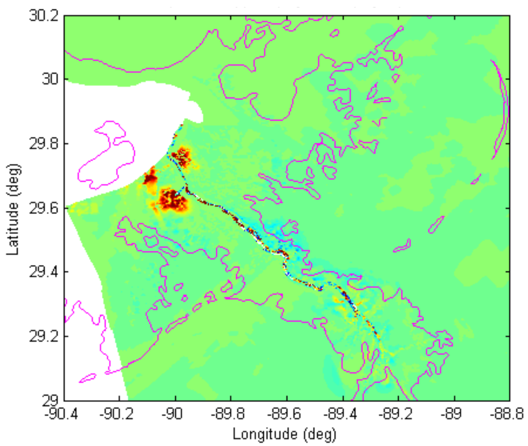

**Y2040**



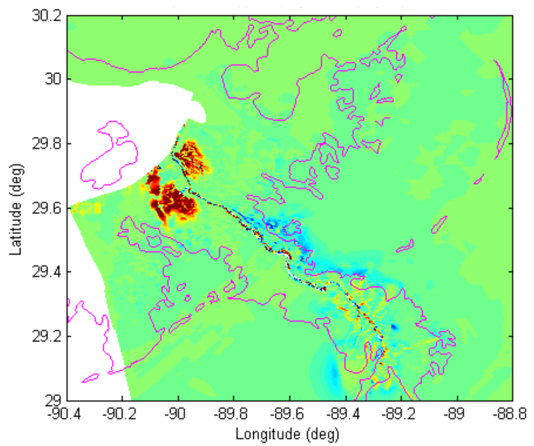

**Y2060**



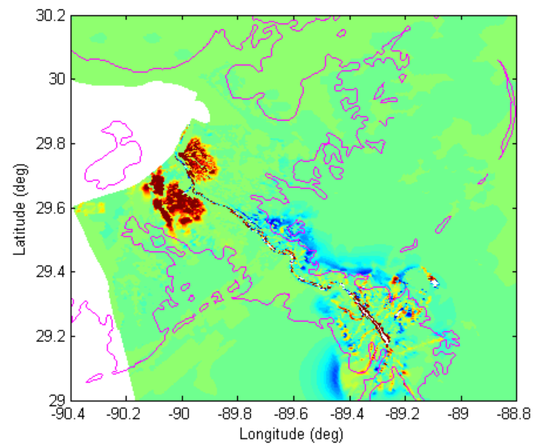

**Y2030**




**Y2050**

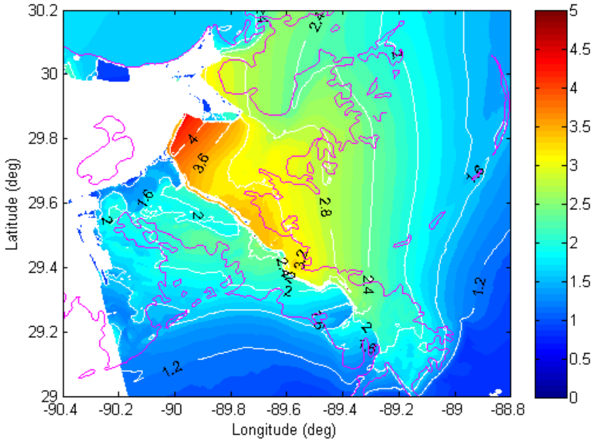



**Y2070**

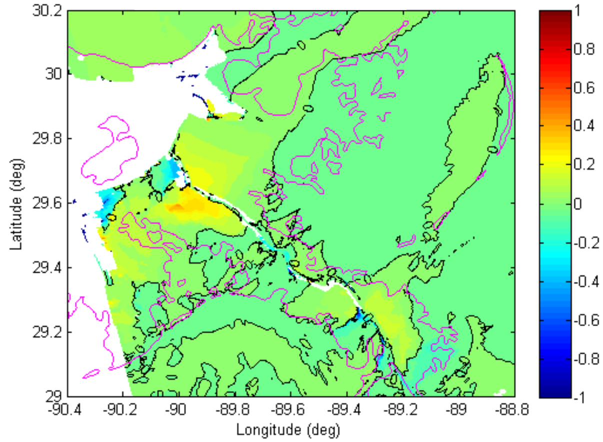


# Maximum surge and changes (in m, MSL) during Hurricane Isaac (with projects, vegetation, waves and SLR)

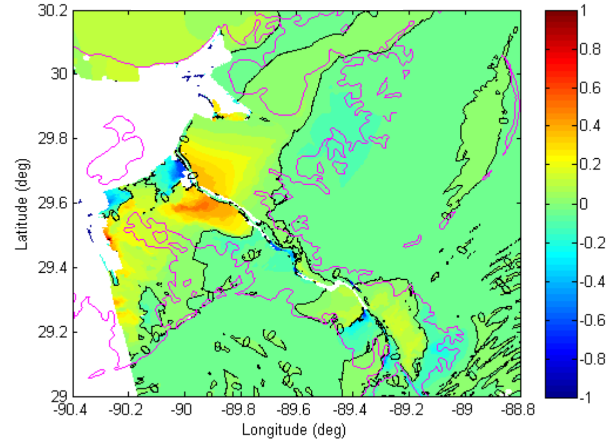
**Y2020**



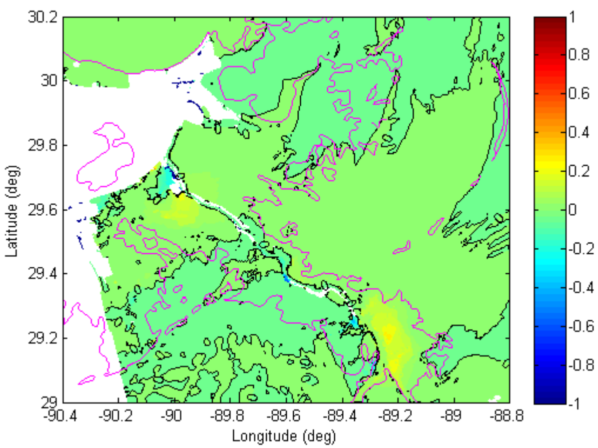

**Y2040-Y2020**



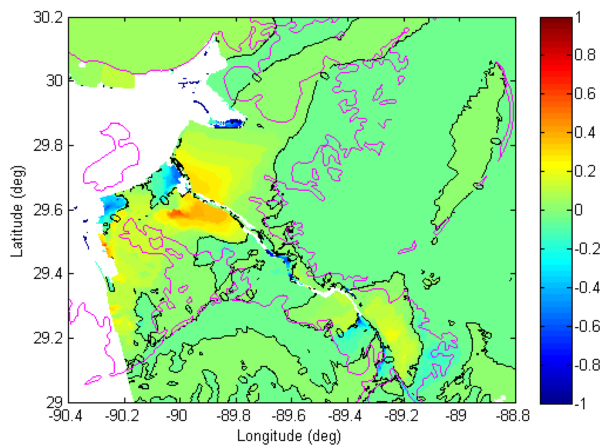

**Y2060-Y2020**



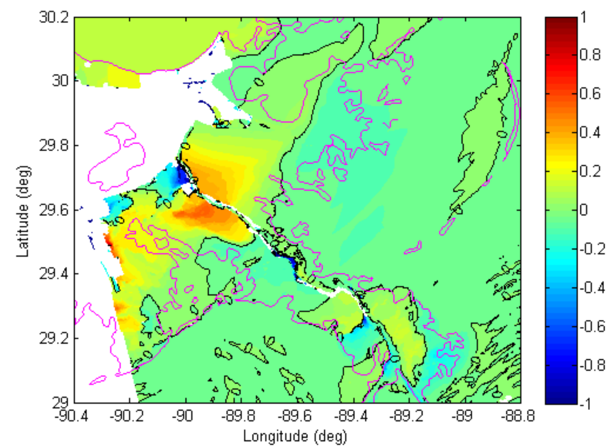

**Y2030-Y2020**




**Y2050-Y2020**

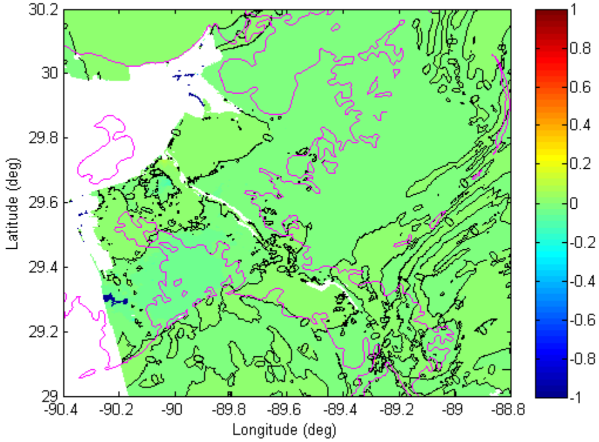



**Y2070-Y2020**

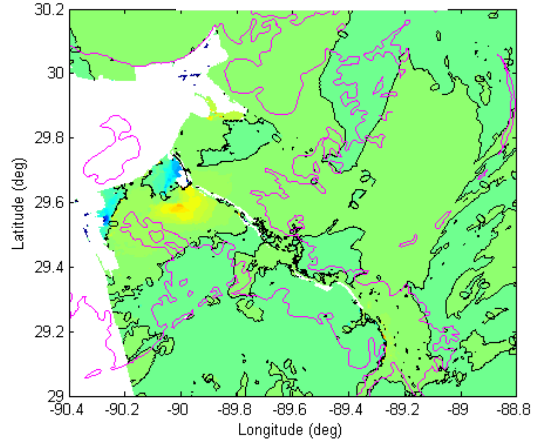


# Project effect on maximum surge (in m) (with projects – w/o projects)

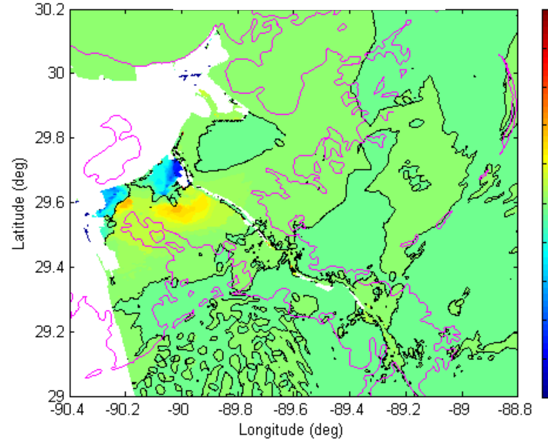
**Y2020**



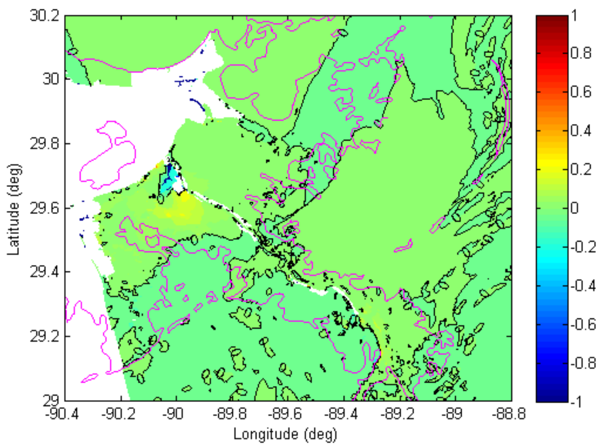

**Y2040**



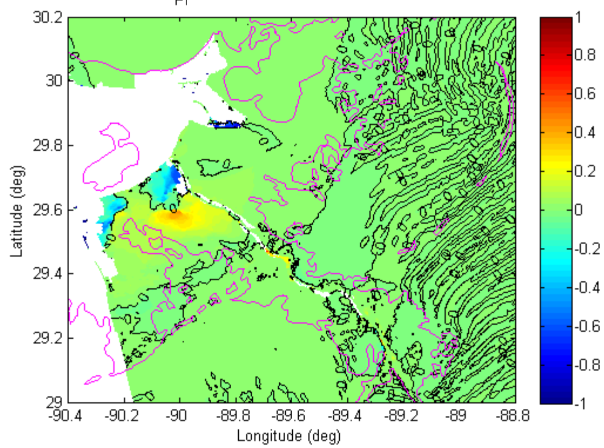

**Y2060**



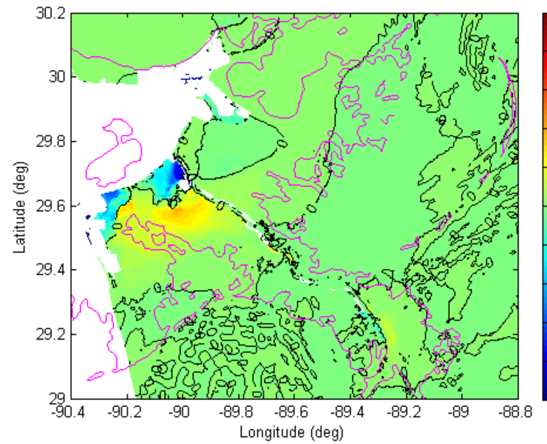

**Y2030**



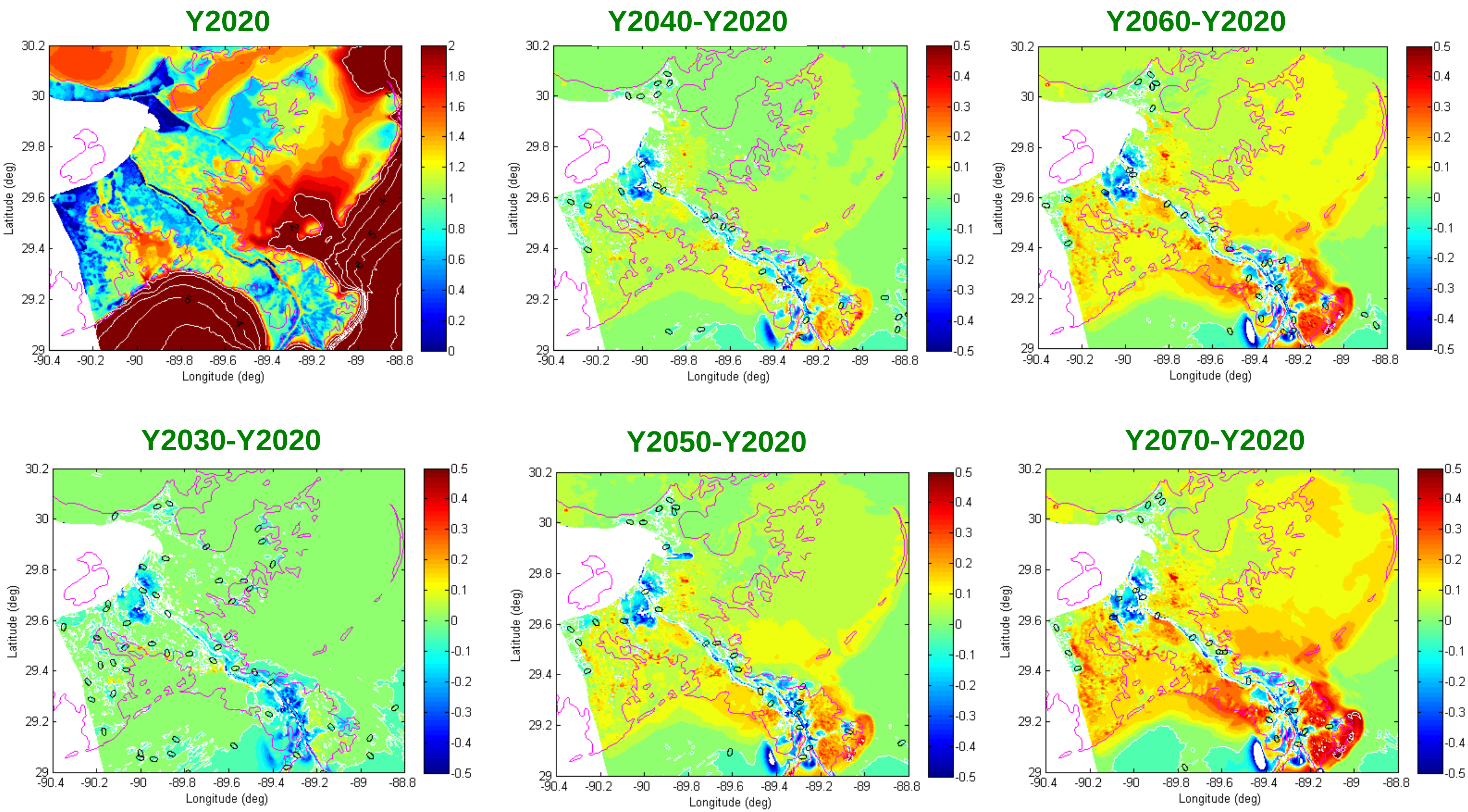

**Y2050**




**Y2070**

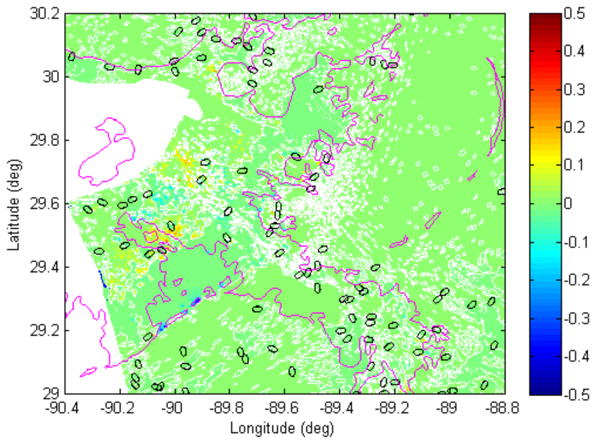


# Maximum Hs and changes (in m) during Hurricane Isaac (with projects, vegetation and SLR)

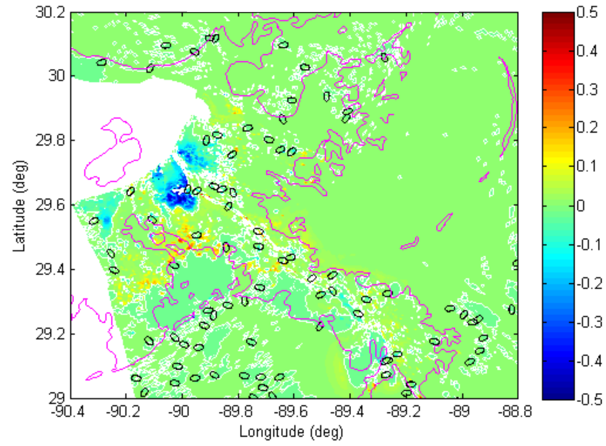


# Project effect on maximum Hs (in m) (with projects – w/o projects)

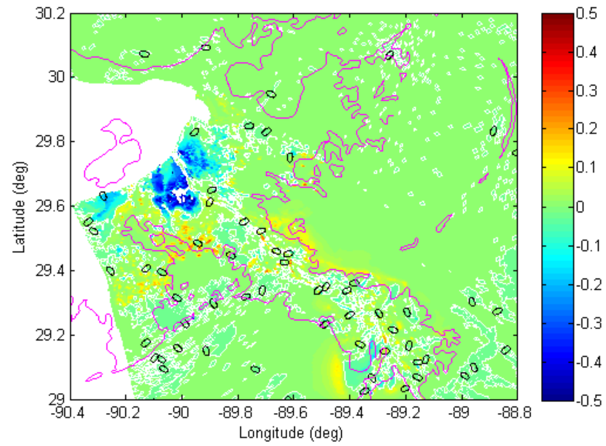
**Y2020**



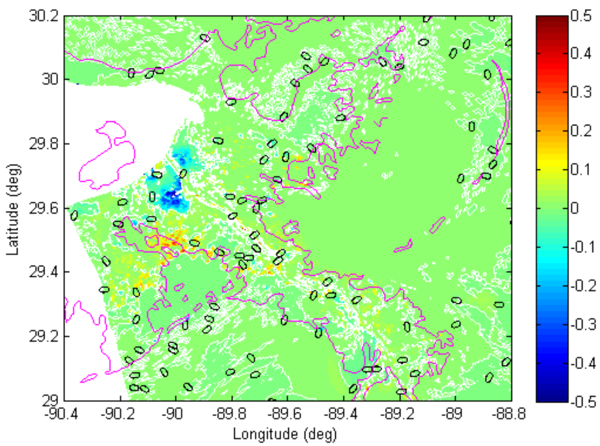

**Y2040**



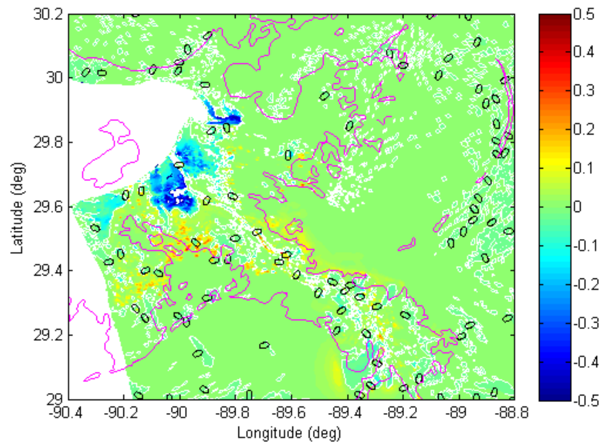

**Y2060**



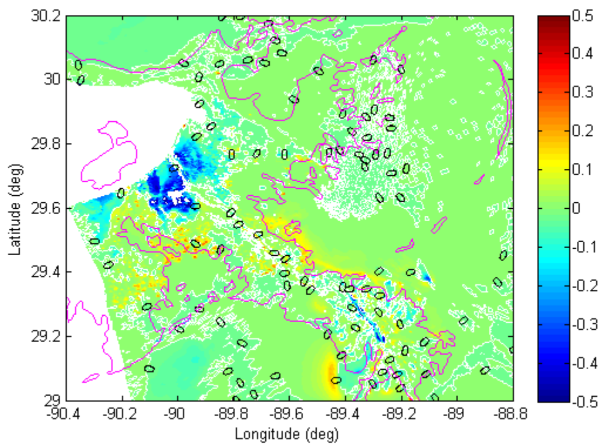

**Y2030**




**Y2050**




**Y2070**

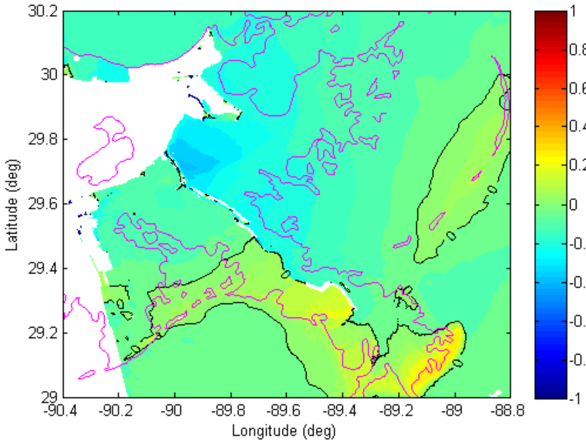


# Conclusions

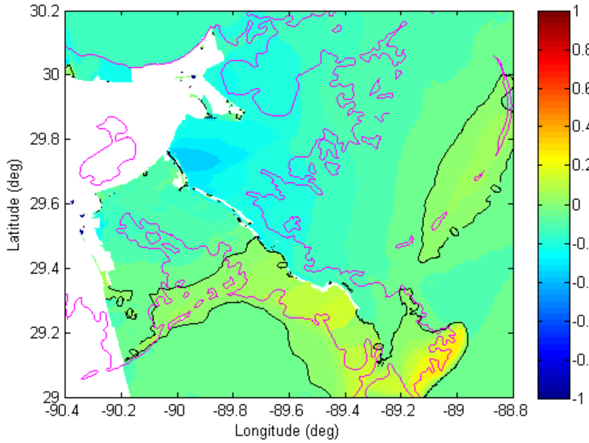
- The coupled Delft3D model was successfully applied to coastal Louisiana for storm surge and hurricane wave simulations;
- The mid-Barataria diversion project would reduce both surge and waves in construction areas, while to the south of the project, surge and waves would increase;
- The mid-Breton diversion project would reduce waves nearby, but it would have little effect on surge under Hurricane Isaac conditions because of the unique geometry of Breton Sound.

# Wave effect on maximum surge (in m) (with waves – w/o waves)

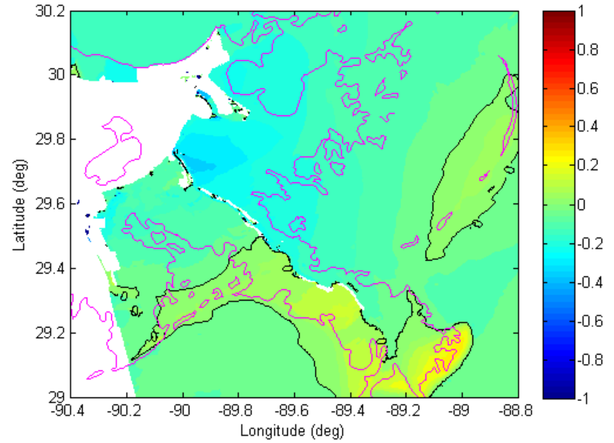
**Y2020**



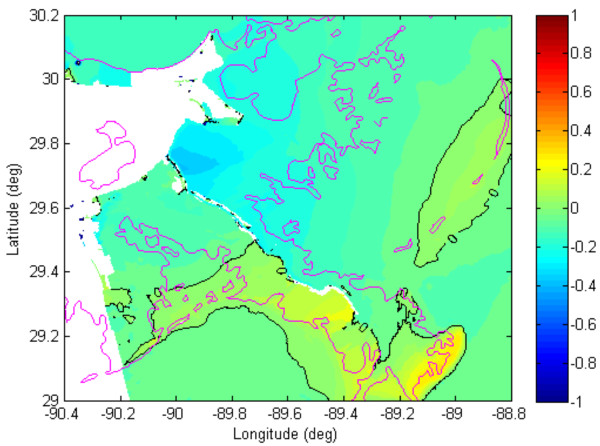

**Y2040**



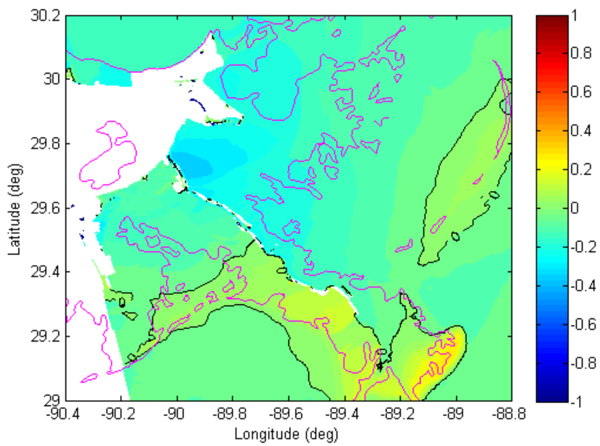

**Y2060**



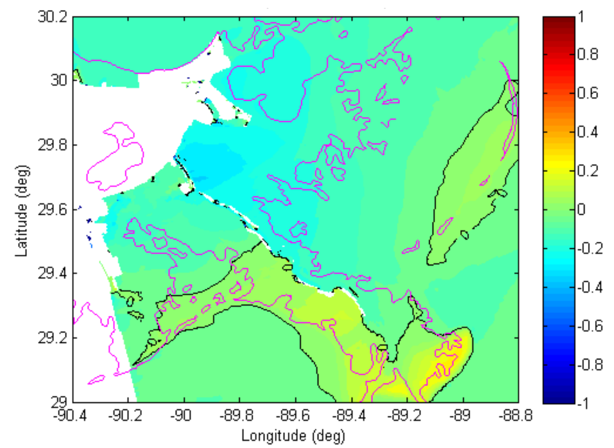

**Y2030**



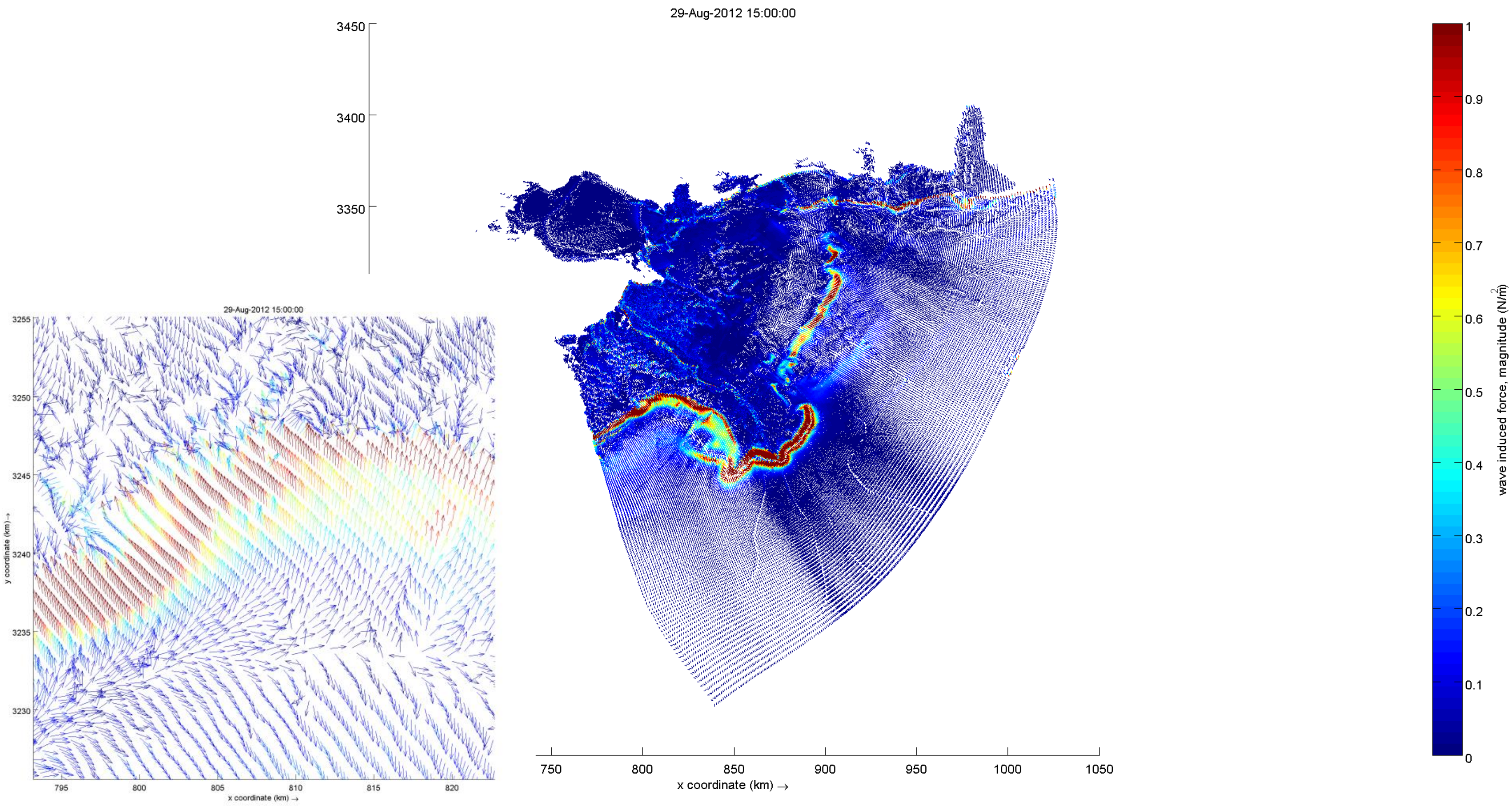

**Y2050**



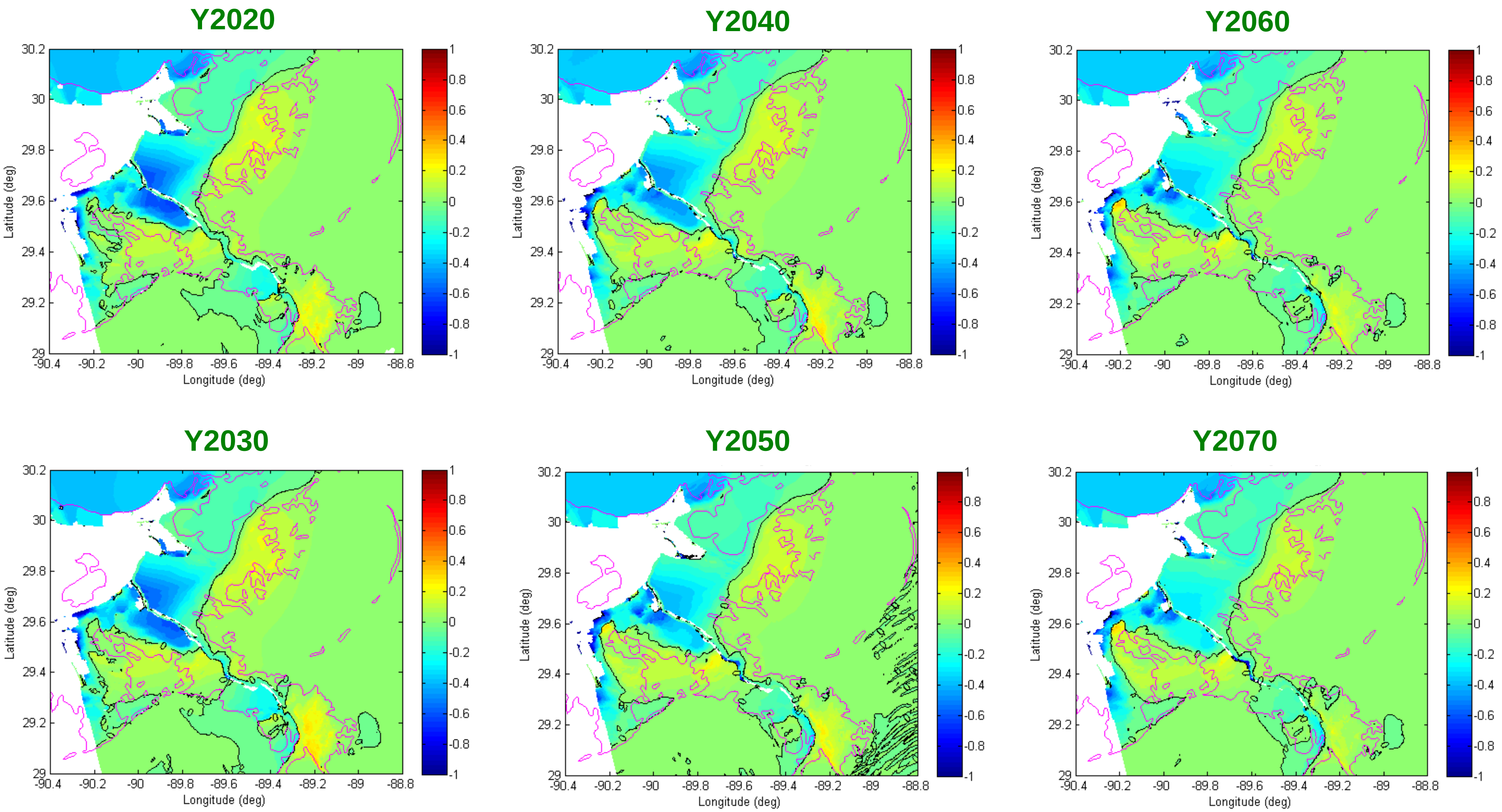

**Y2070**



# Wave-induced force

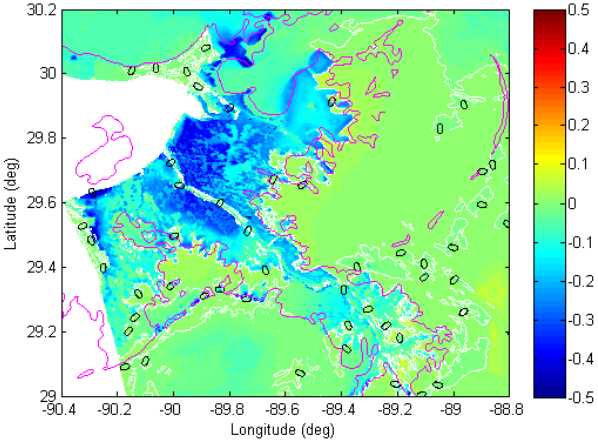


# Vegetation effect on maximum surge (in m) (with vegetation – w/o vegetation)

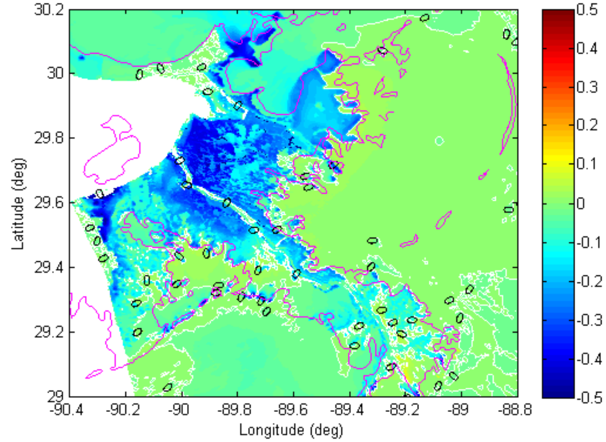


# Vegetation effect on maximum Hs (in m) (with vegetation – w/o vegetation)

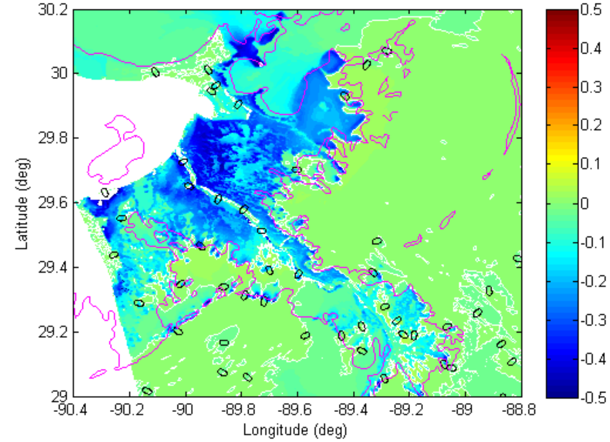
**Y2020**



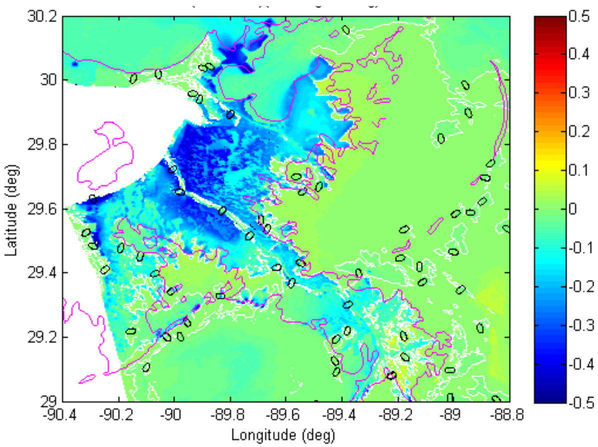

**Y2040**



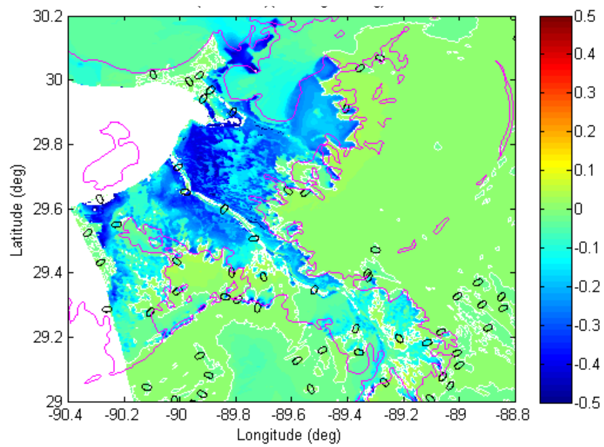

**Y2060**



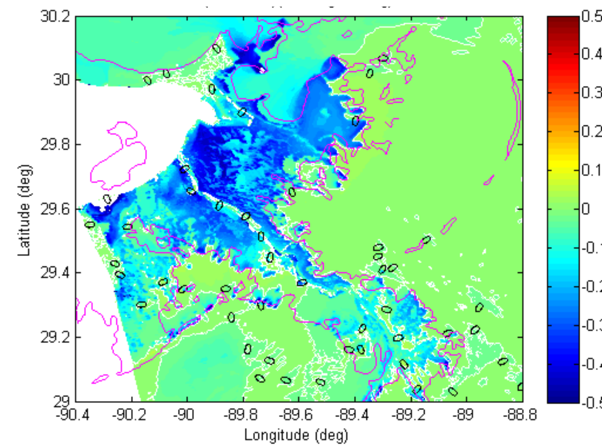

**Y2030**




**Y2050**

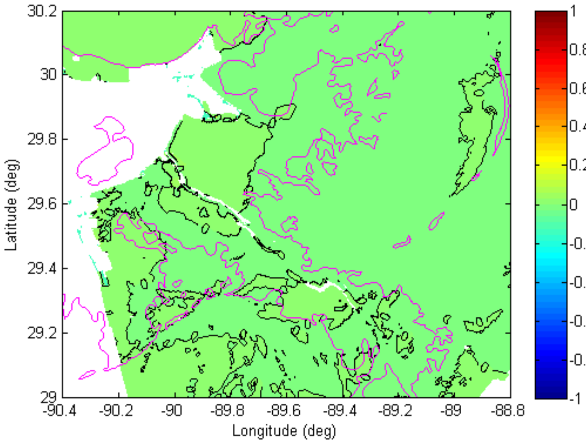



**Y2070**

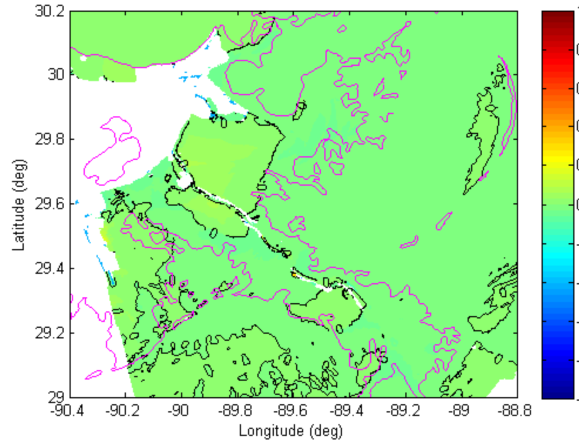


# SLR effect on maximum surge (MSL, in m) (with SLR – w/o SLR)

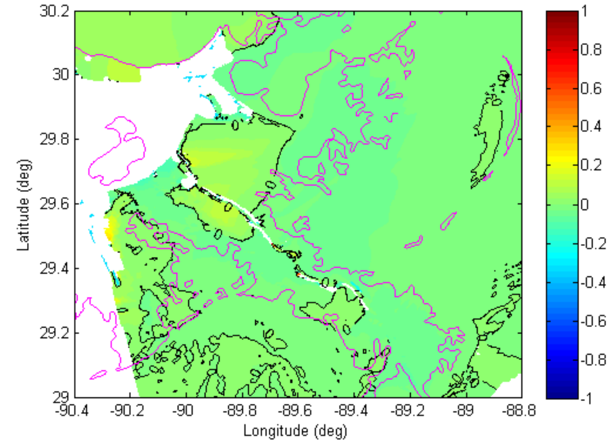
**Y2020**



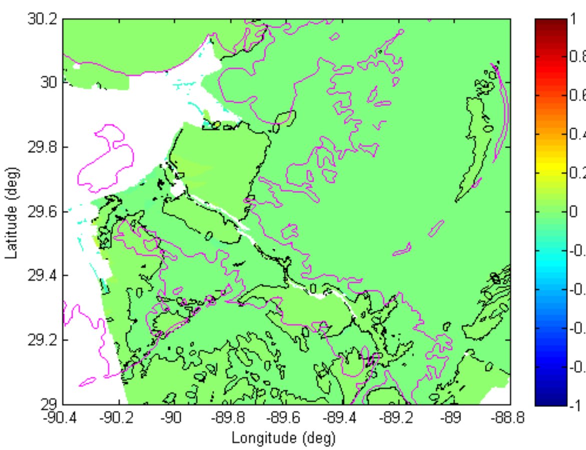

**Y2040**



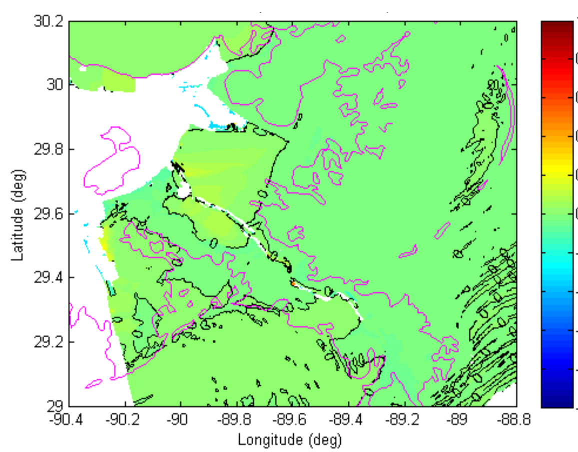

**Y2060**



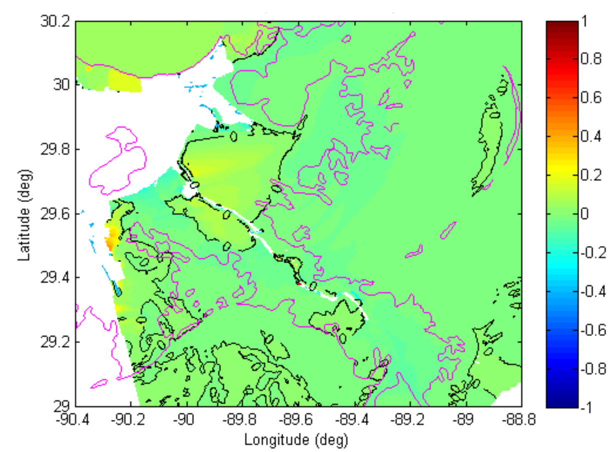

**Y2030**




**Y2050**

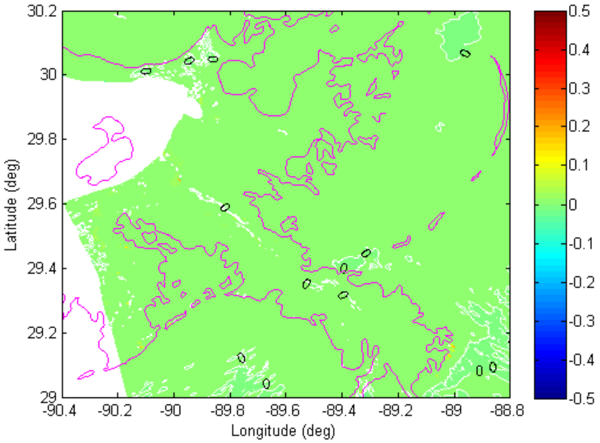



**Y2070**

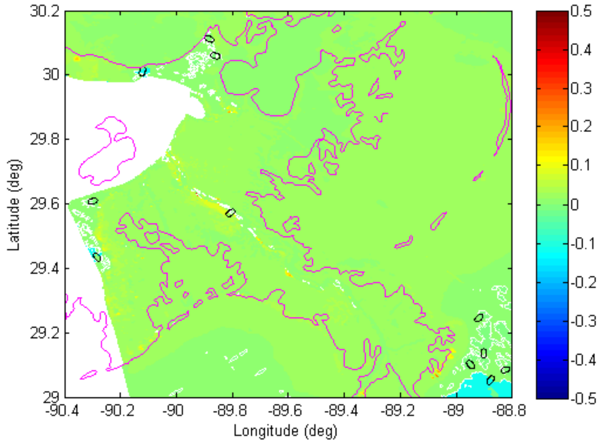


# SLR effect on maximum Hs (in m)
(with SLR – w/o SLR)

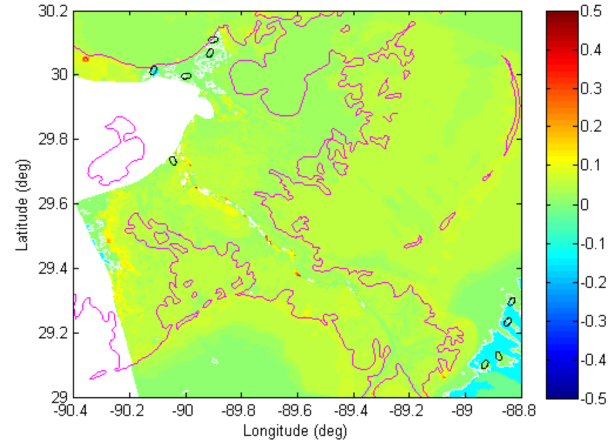
**Y2020**



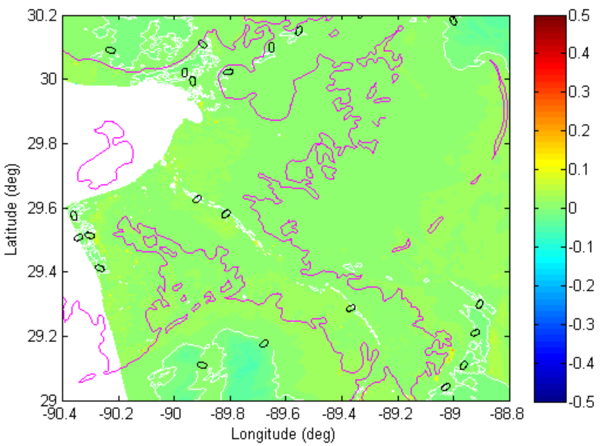

**Y2040**



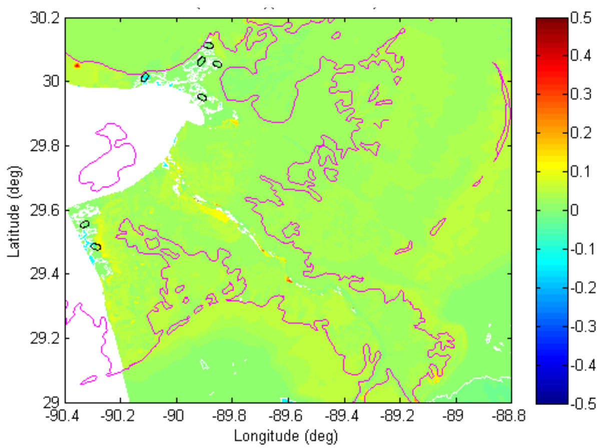

**Y2060**



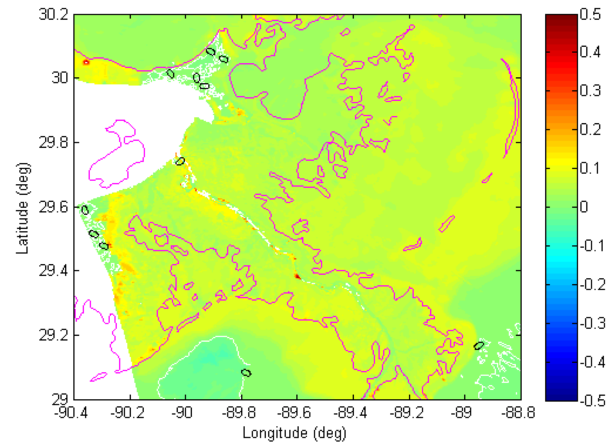

**Y2030**

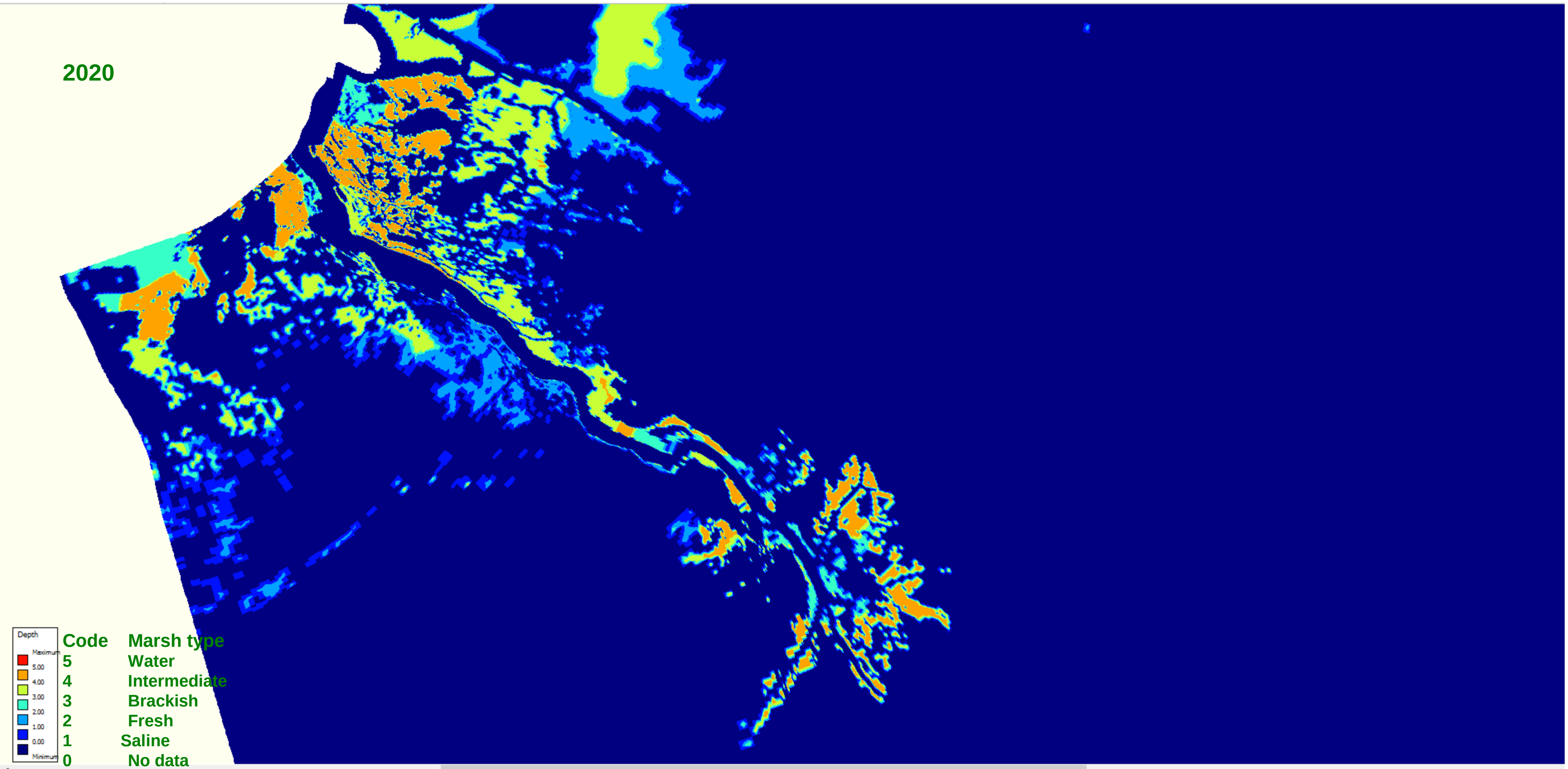


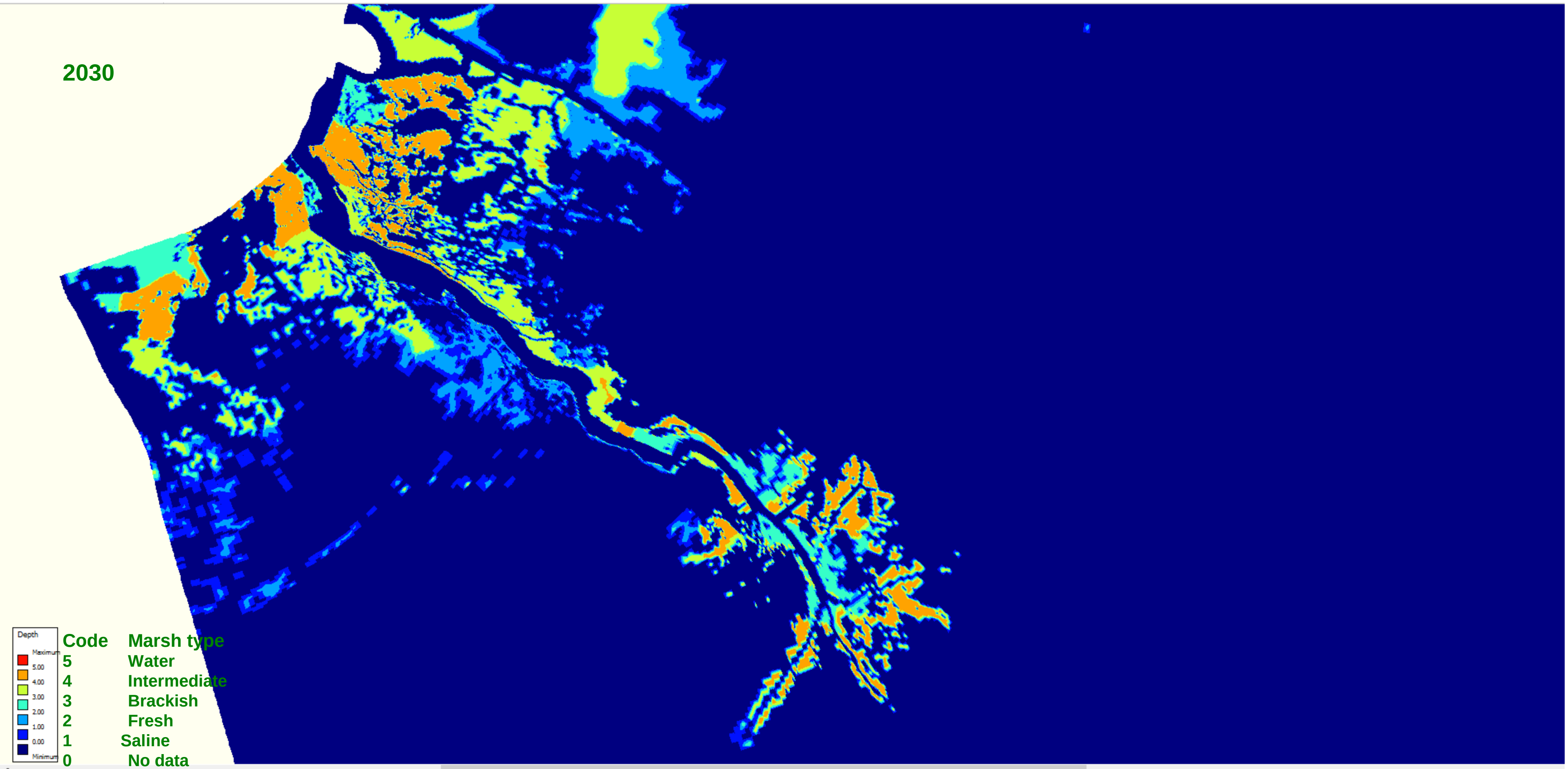

**Y2050**

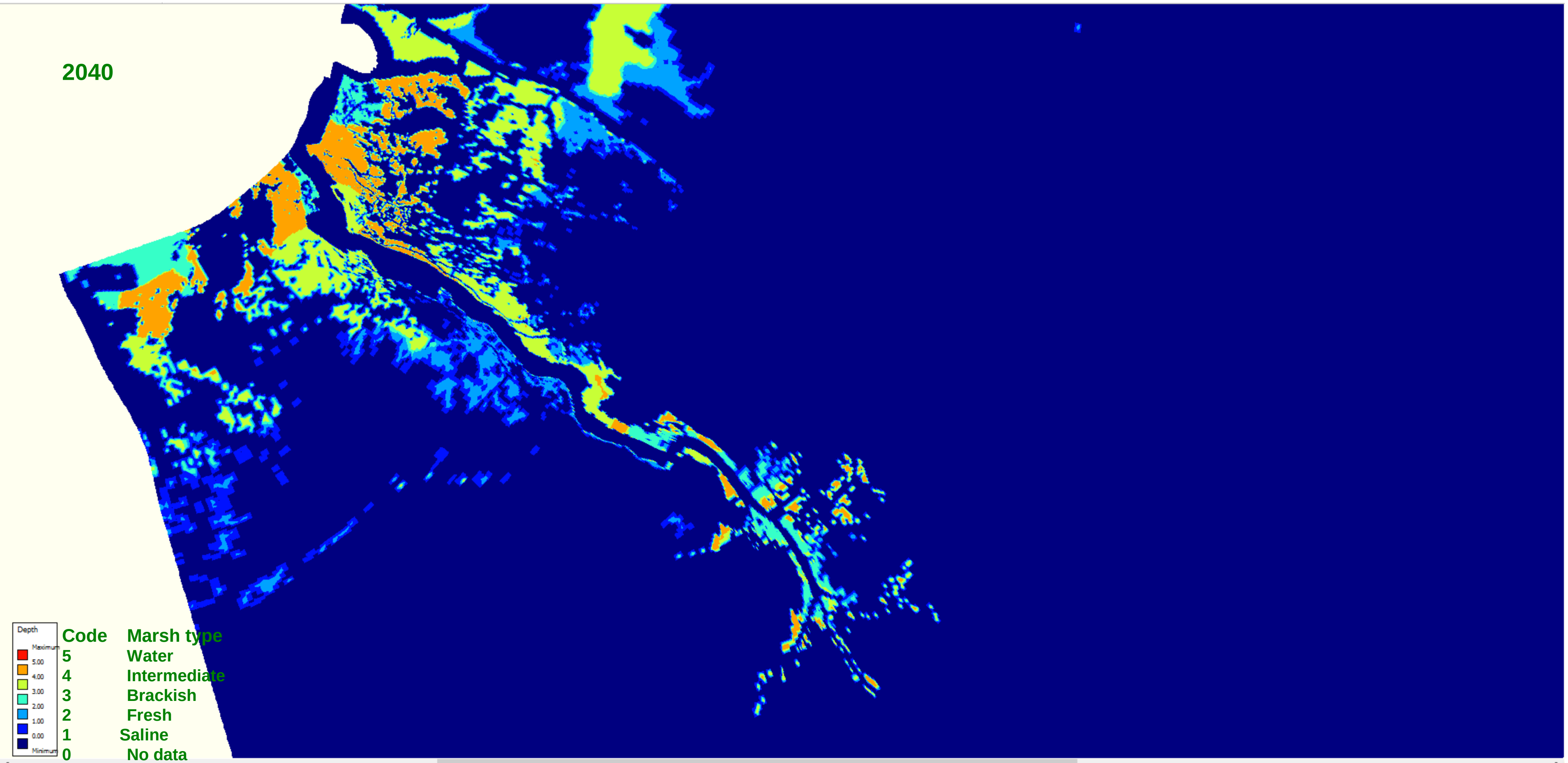



**Y2070**




2020
Depth
Maximum
5.00
4.00
3.00
2.00
1.00
0.00
Minimum
Code Marsh type
5 Water
4 Intermediate
3 Brackish
2 Fresh
1 Saline
0 No data


2030
Depth
5.00
4.00
3.00
2.00
1.00
0.00
Code Marsh type
5 Water
4 Intermediate
3 Brackish
2 Fresh
1 Saline
0 No data


2040
Code Marsh type
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4 Intermediate
3 Brackish
2 Fresh
1 Saline
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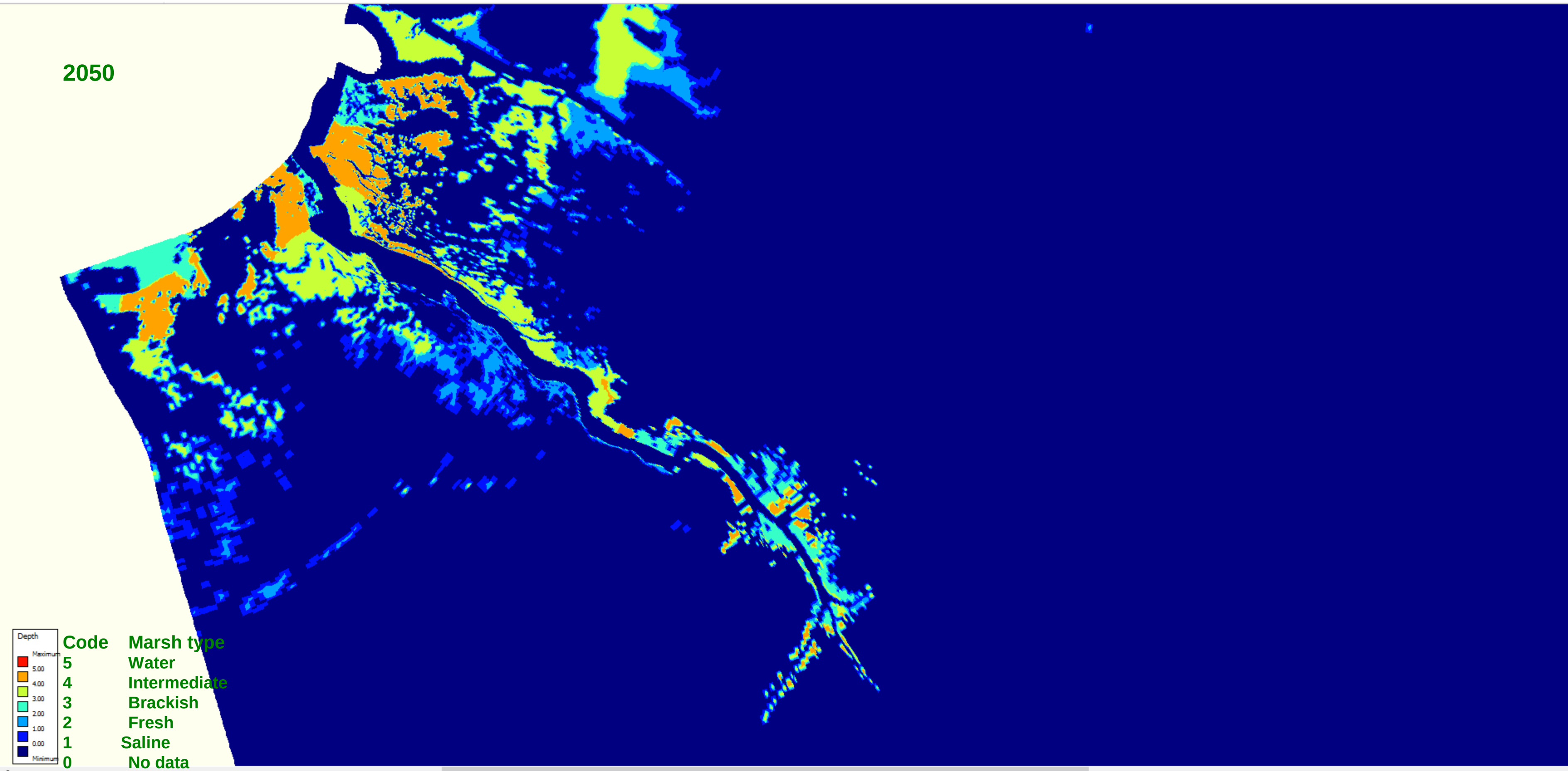
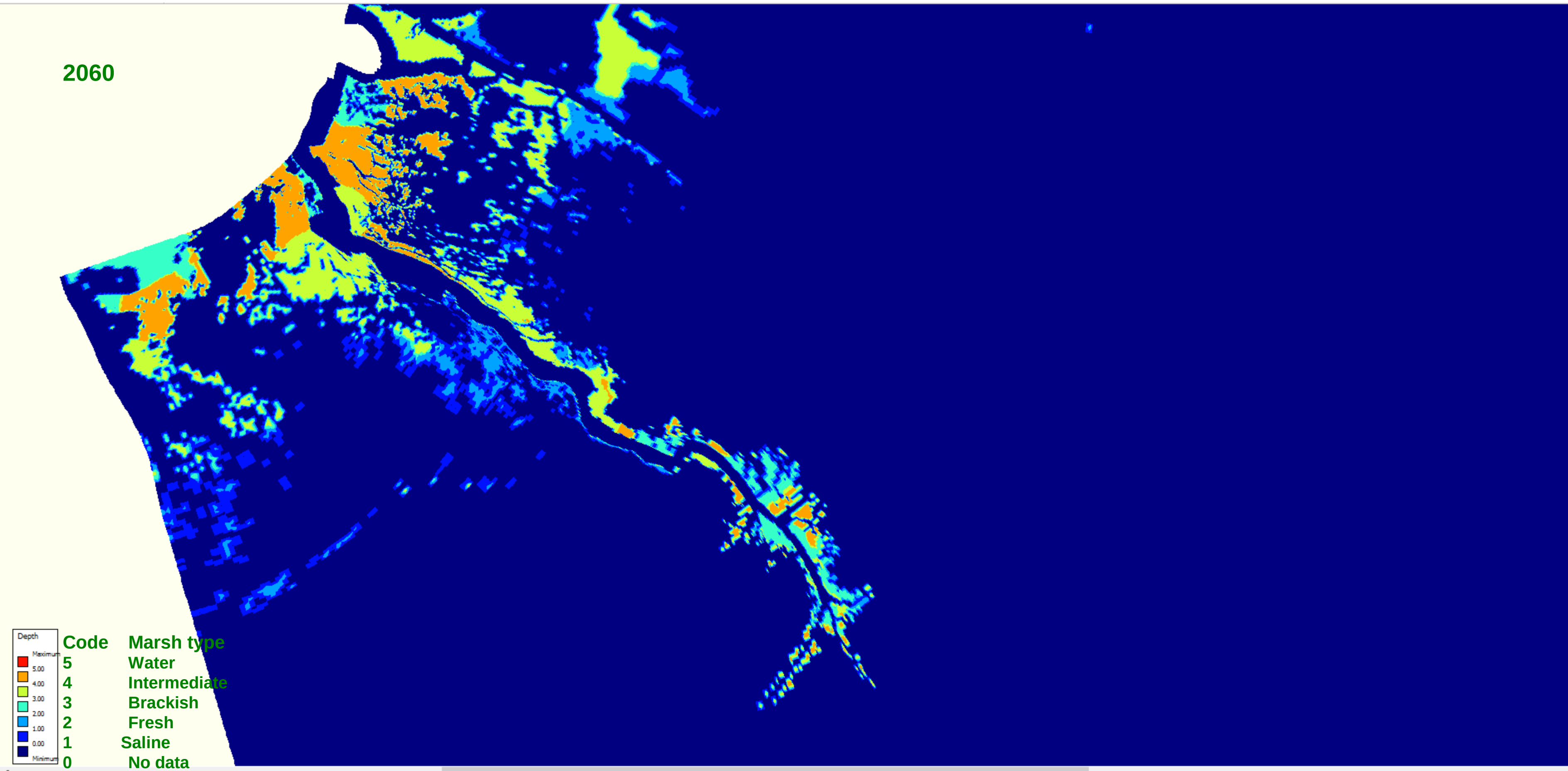

2050
Code Marsh type
5 Water
4 Intermediate
3 Brackish
2 Fresh
1 Saline
0 No data


2060
Depth
Maximum
5.00
4.00
3.00
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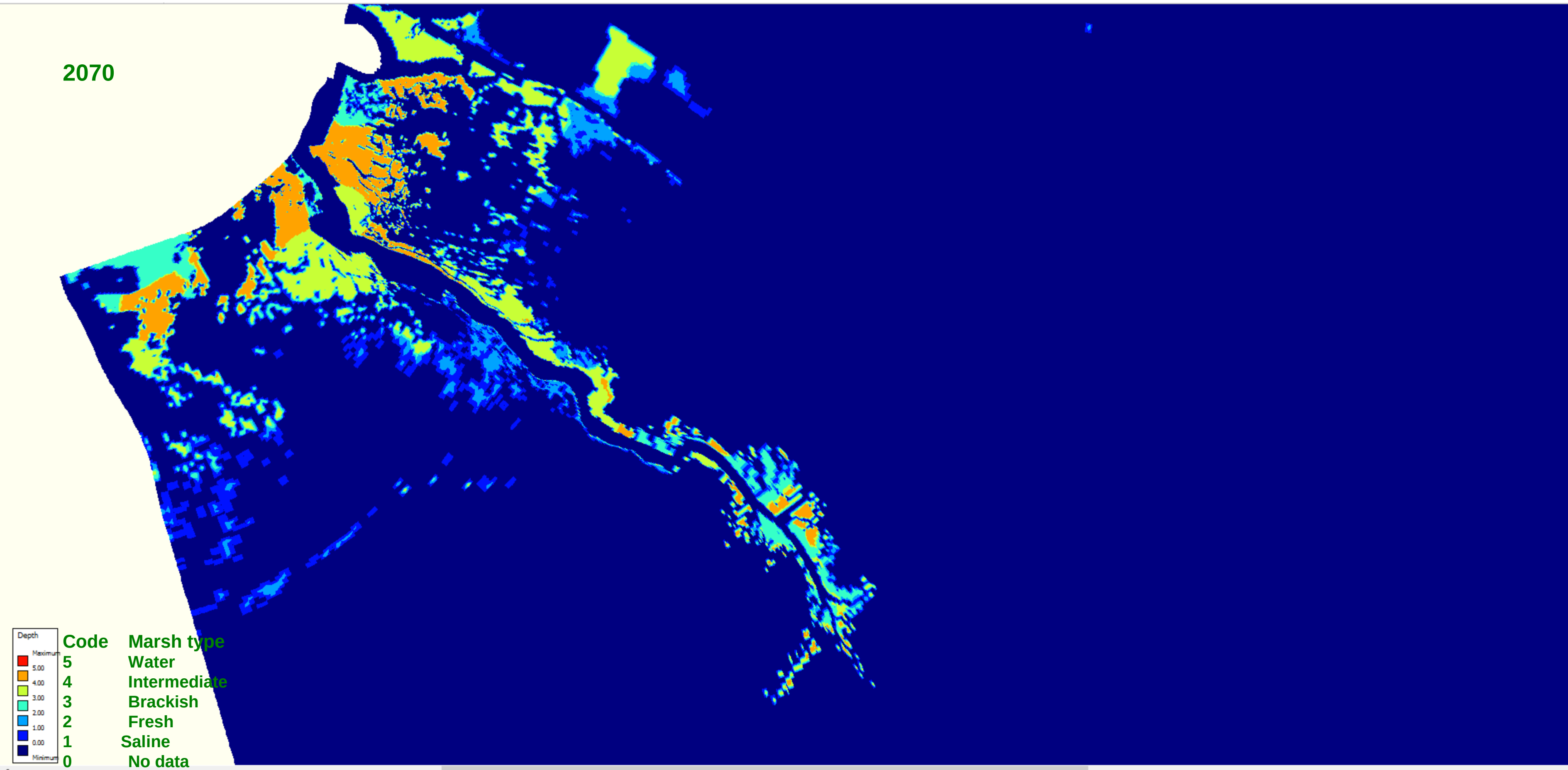
1.00
0.00
Minimum
Code Marsh type
5 Water
4 Intermediate
3 Brackish
2 Fresh
1 Saline
0 No data


2070
Depth
Maximum
5.00
4.00
3.00
2.00
1.00
0.00
Minimum
Code Marsh type
5 Water
4 Intermediate
3 Brackish
2 Fresh
1 Saline
0 No data