Effect of a steep and complex-featured shelf on computed wave spectra

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Motivation

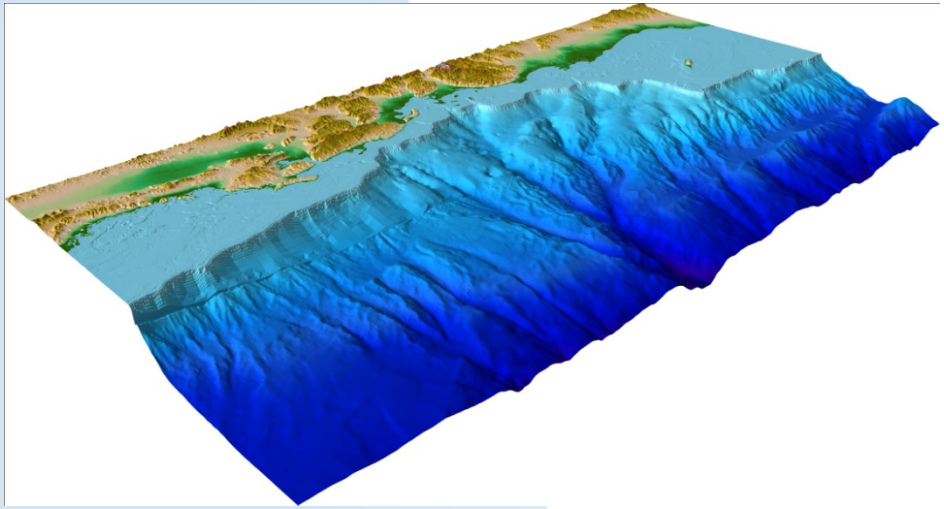
Coupling of circulation and wave models:

- Different physical scales (currents / waves)
- Both scales must be appropriately solved on same mesh
- Computational constraints

Extend SWAN+ADCIRC applications:

- Operational forecasting
- Physical phenomena at least computational cost

Islands / steep and complex bathymetry modeling



Methodology

SWAN+ADCIRC

- Wave – circulation coupled model
- Parametric winds for Hurricane Georges (1998)
- Manning's n bottom friction based on benthic coverage

Explore the effect of mesh resolution on computed wave spectra

- Original FEMA FIS 2007 mesh : ~ 800 m resolution at shelf
- CariCOOS 2011 mesh: ~ 50 m resolution at shelf
- Notre Dame 2011 mesh: ~50 m resolution at shelf, ~ 50 m resolution at coast

Compare results to high-resolution structured SWAN simulation

- 30 m resolution structured grid, nested inside a 5 km grid
- Same winds, currents, and water levels

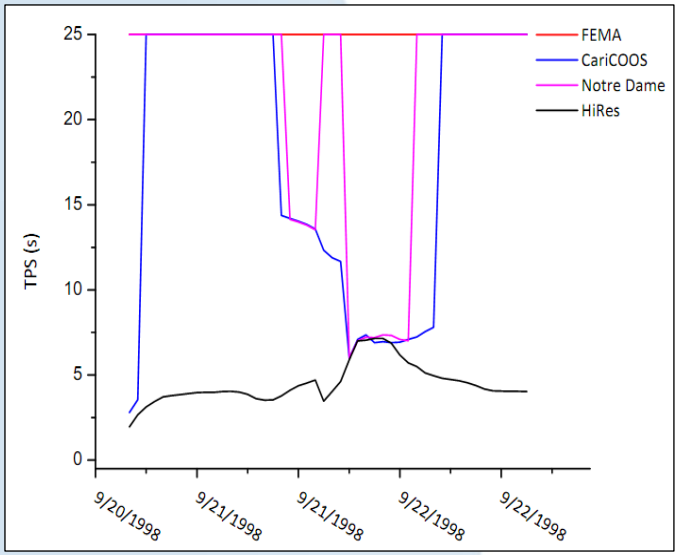
Focus on two dimensional wave spectra, peak periods and significant wave height

Conclusions

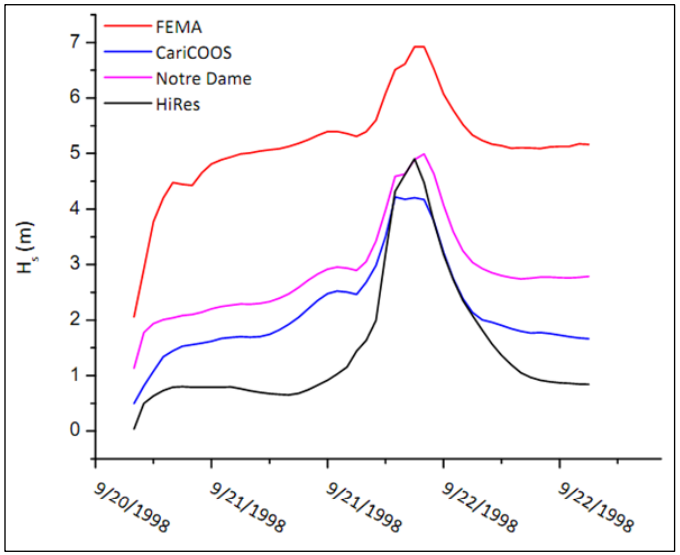
Computation of SWAN+ADCIRC wave spectra is <u>very sensitive</u> to the mesh spatial resolution

- Increasing / decreasing resolution **<u>only</u>** at the shelf break produces very different solutions
- Computed 2D wave spectrum shows higher spectral energy at low shelf resolution
- When compared to high-resolution (30 m) structured SWAN the energy of the peak spectral energy is incorrect; not in accordance with wind direction

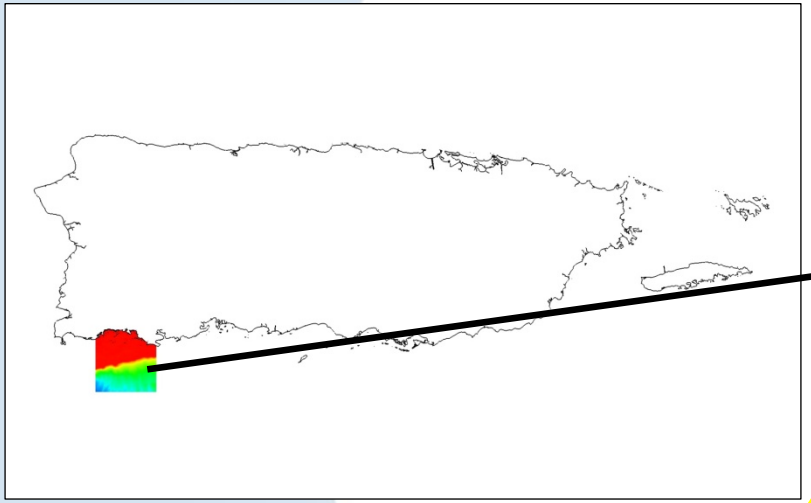
TPS (s)

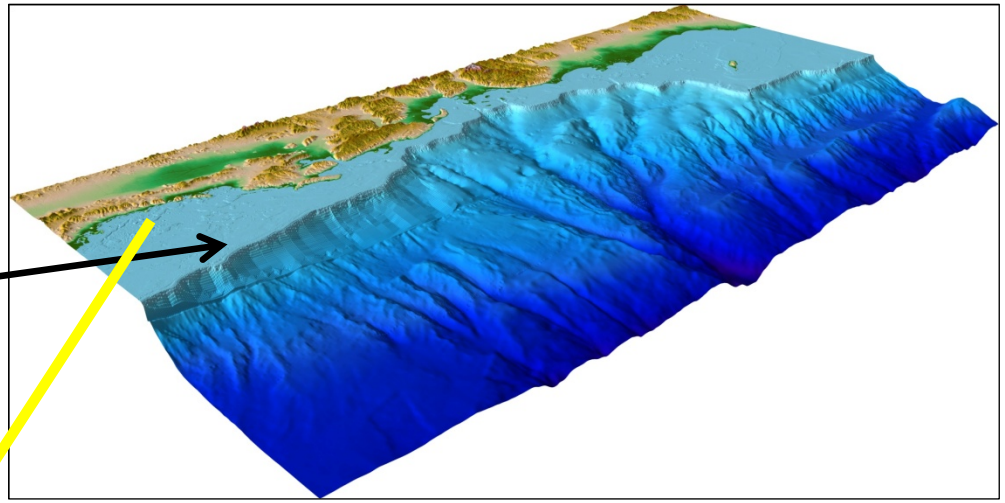


Hs (m)



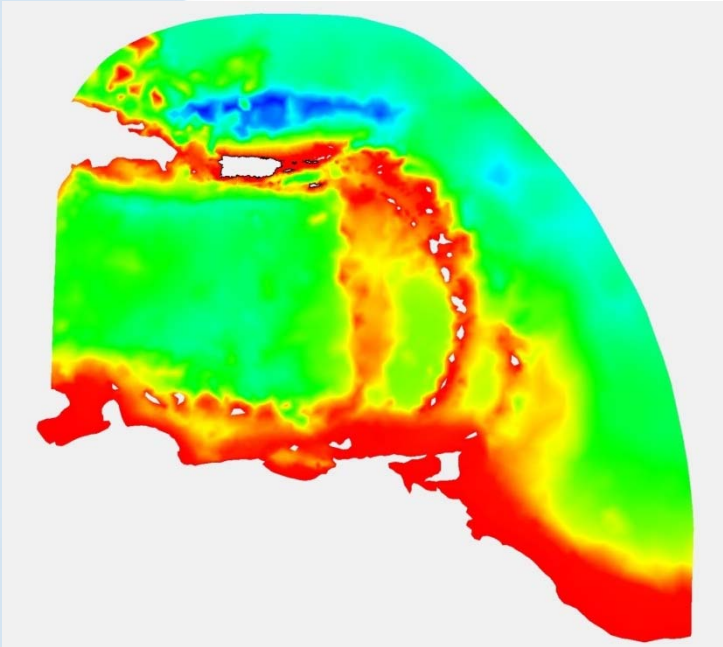
Puerto Rico Southwest Shelf



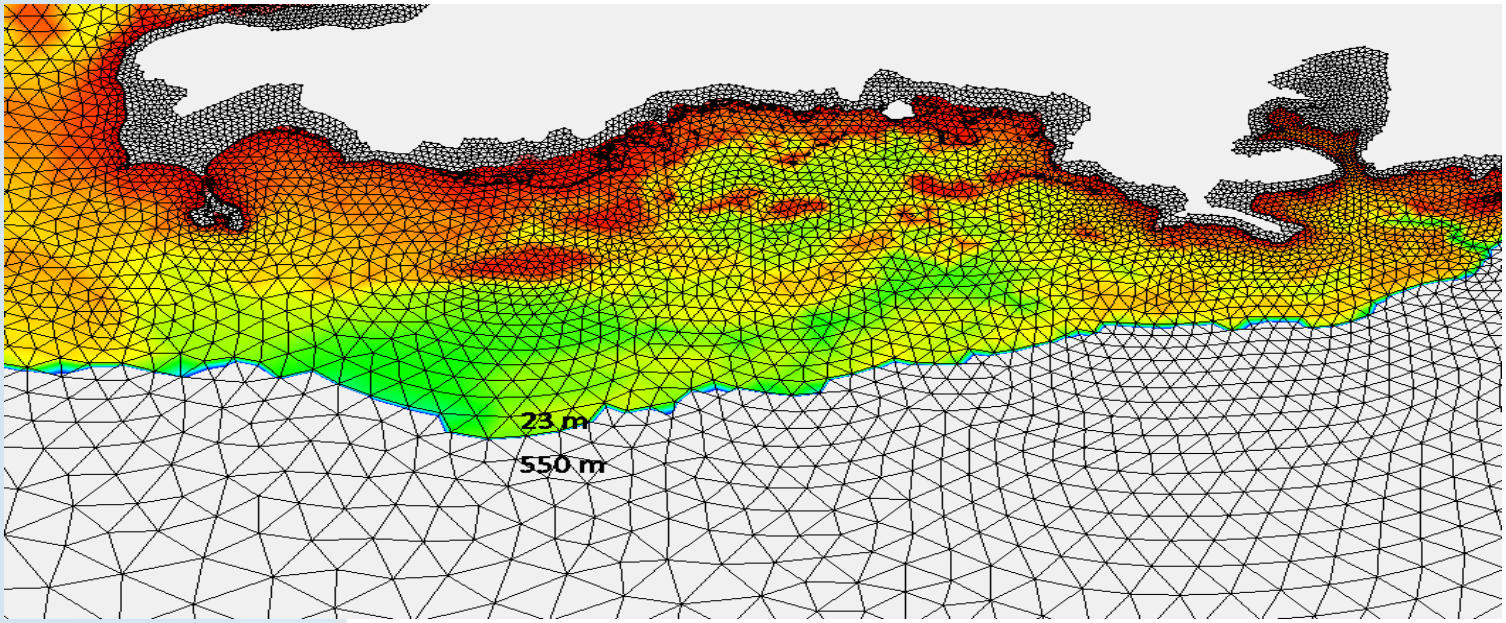


- Bathymetric slope exceeds 2:1
- Depth drops from 20 to 400 m

FEMA FIS 2007 Mesh

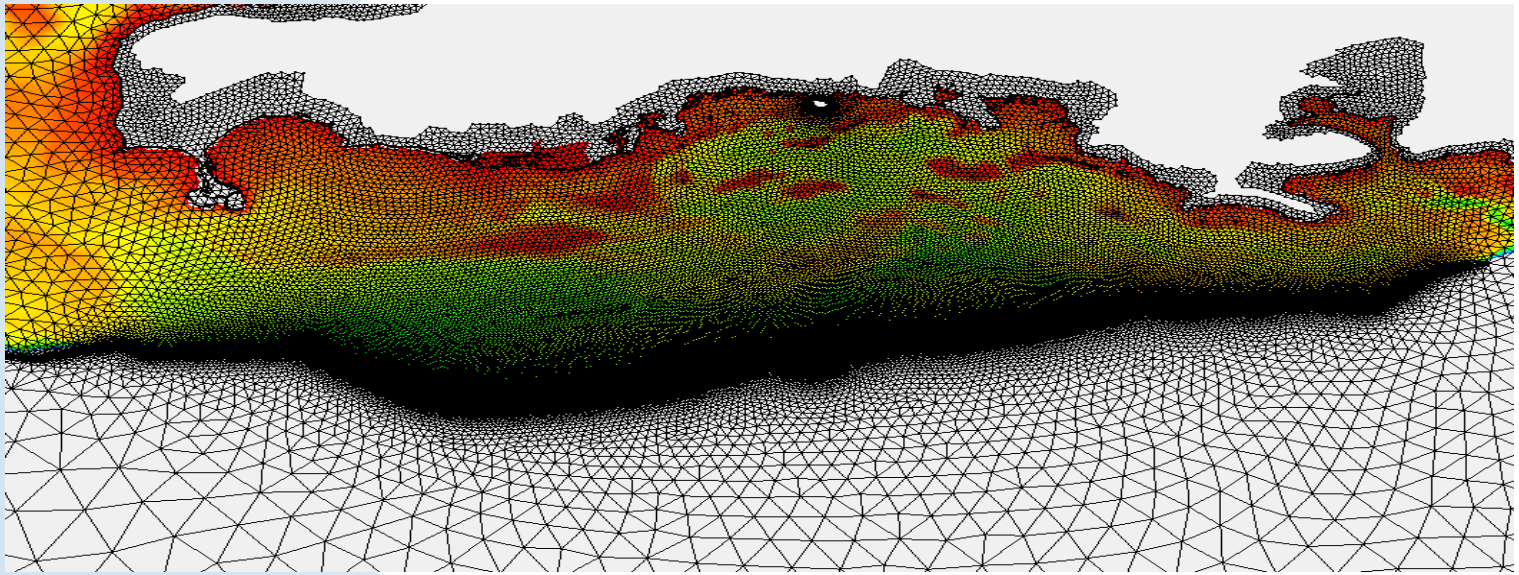


- FEMA mesh not made for wave-circulation coupling.
- 800 m resolution at shelf break
- 23 to 550 m in one element size



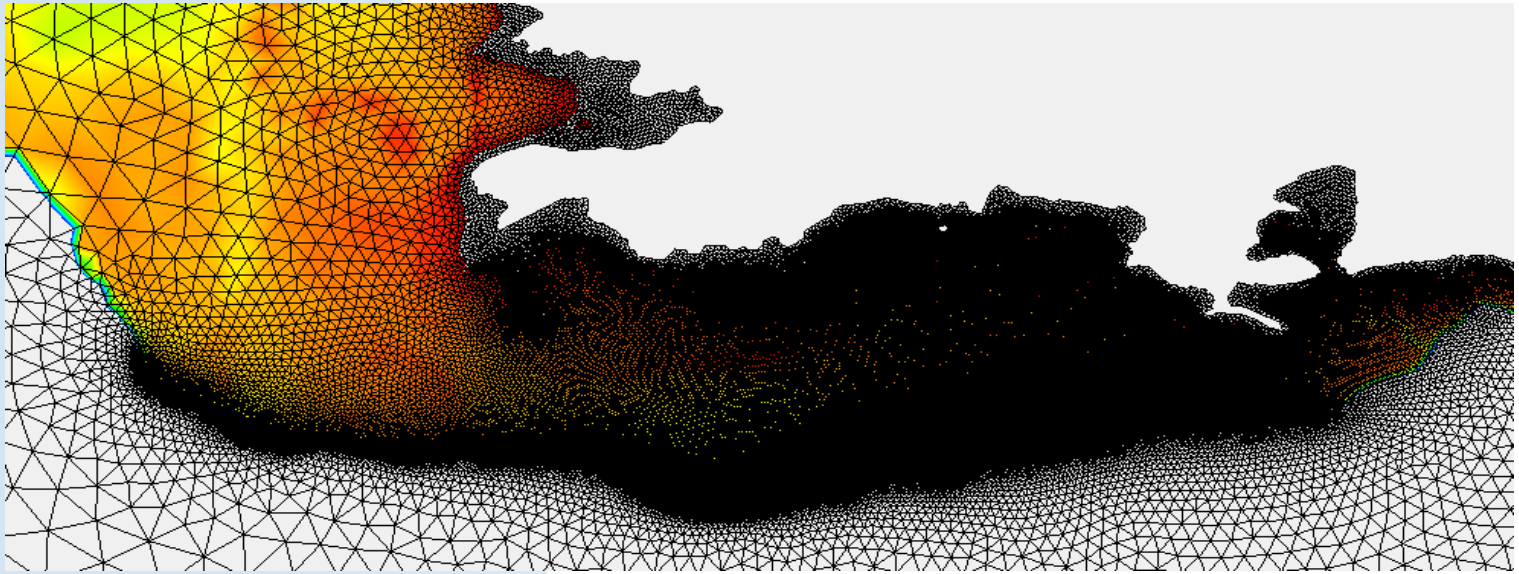
Increasing resolution at shelf

CariCOOS 2011 MESH

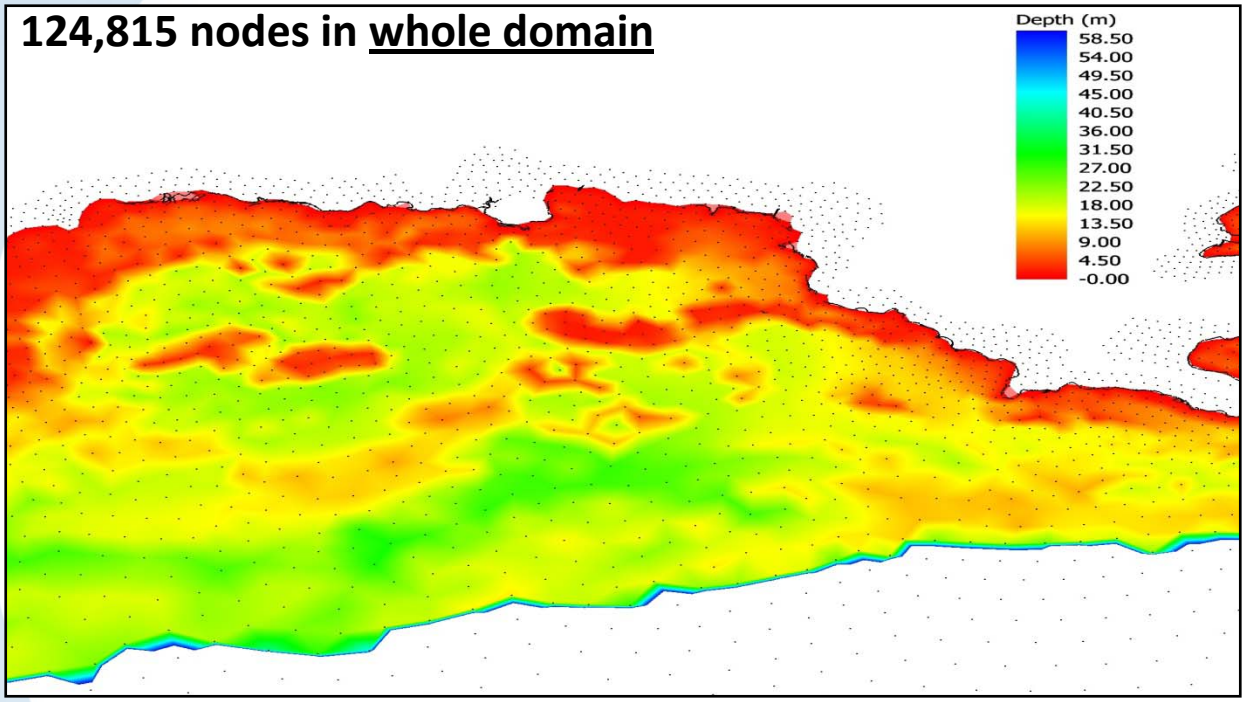


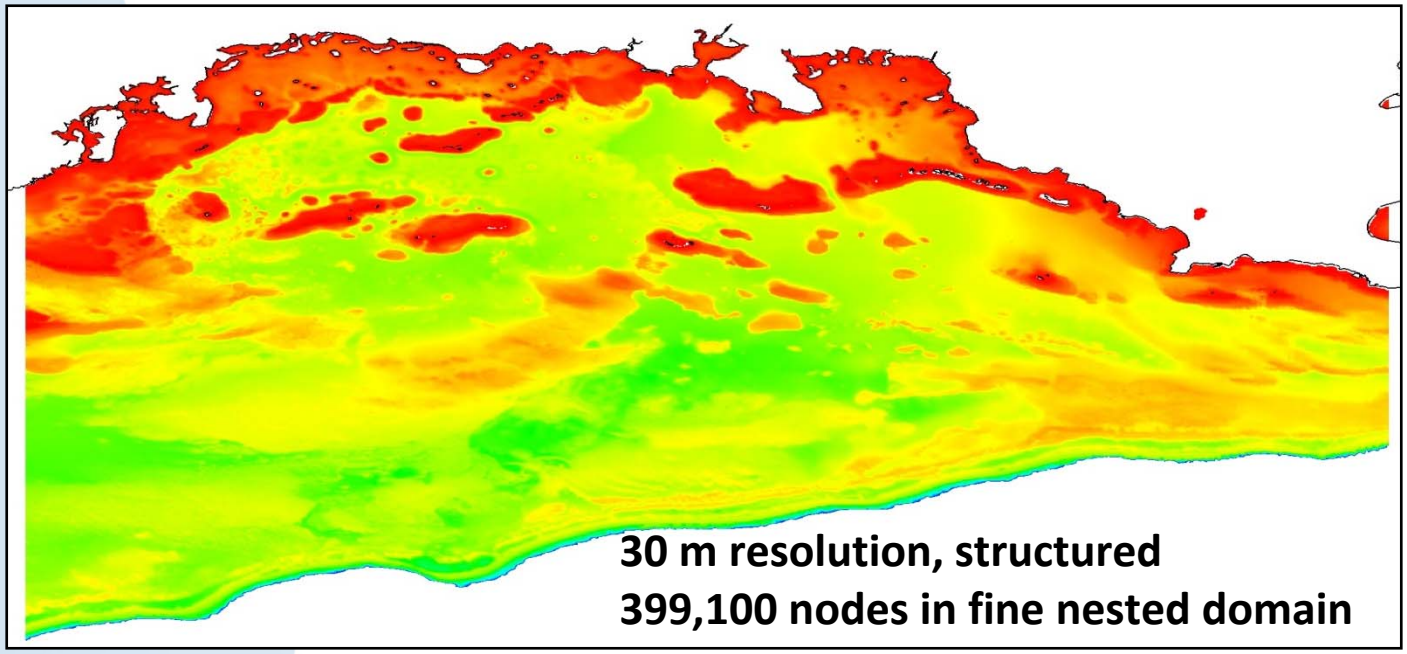
50 m resolution at shelf

Notre Dame 2011 MESH



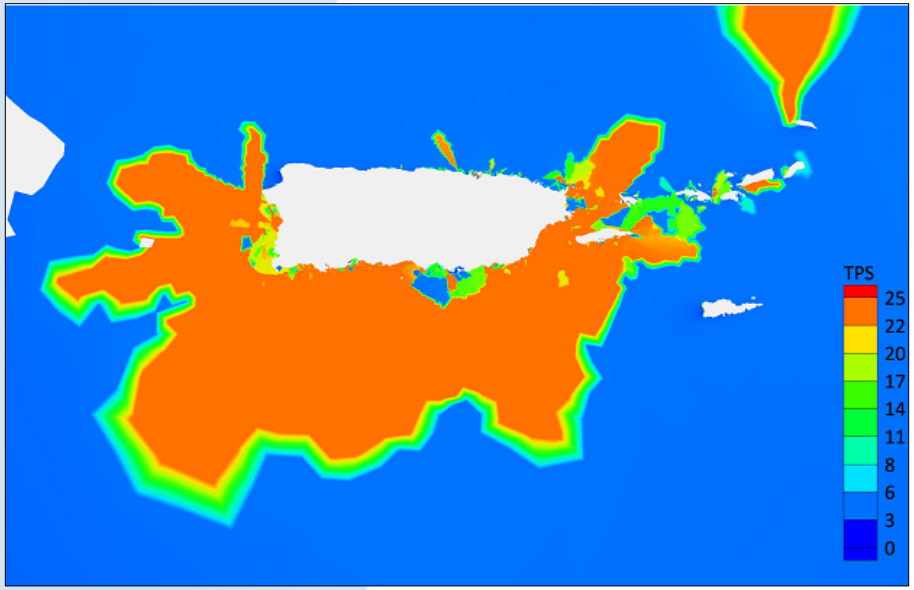
50 m resolution at shelf and coastline


124,815 nodes in whole domain
Depth (m)
58.50
54.00
49.50
45.00
40.50
36.00
31.50
27.00
22.50
18.00
13.50
9.00
4.50
-0.00

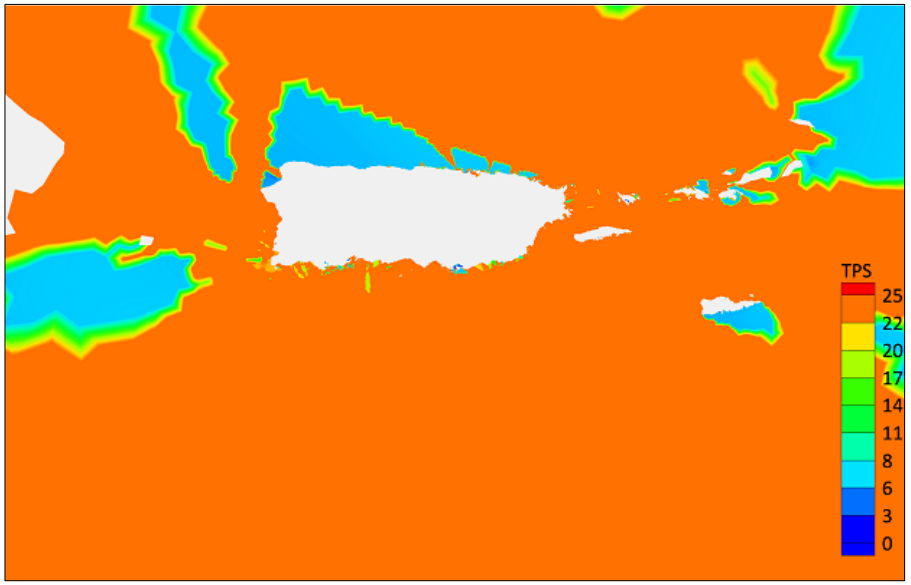

30 m resolution, structured
399,100 nodes in fine nested domain

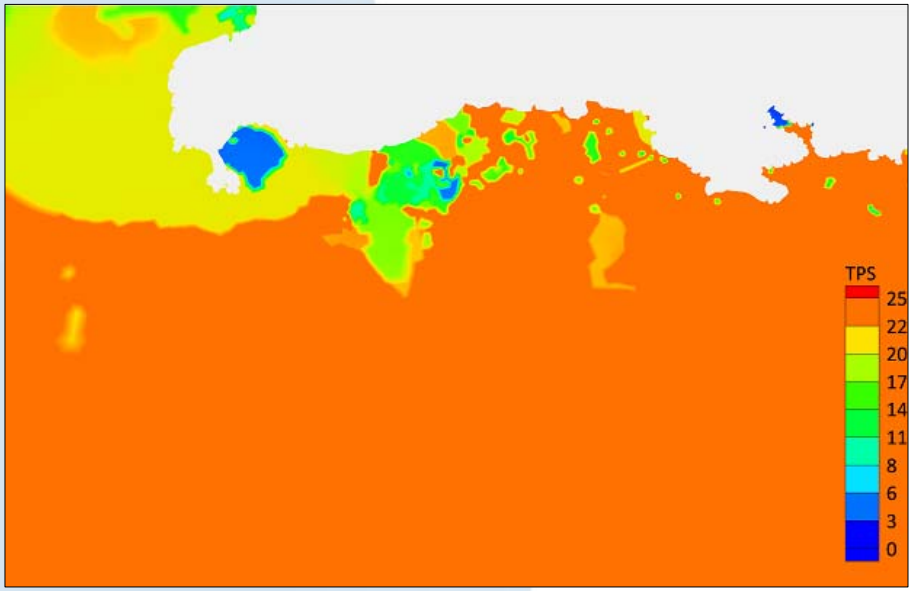
FEMA FIS 2007 Peak Periods (s)

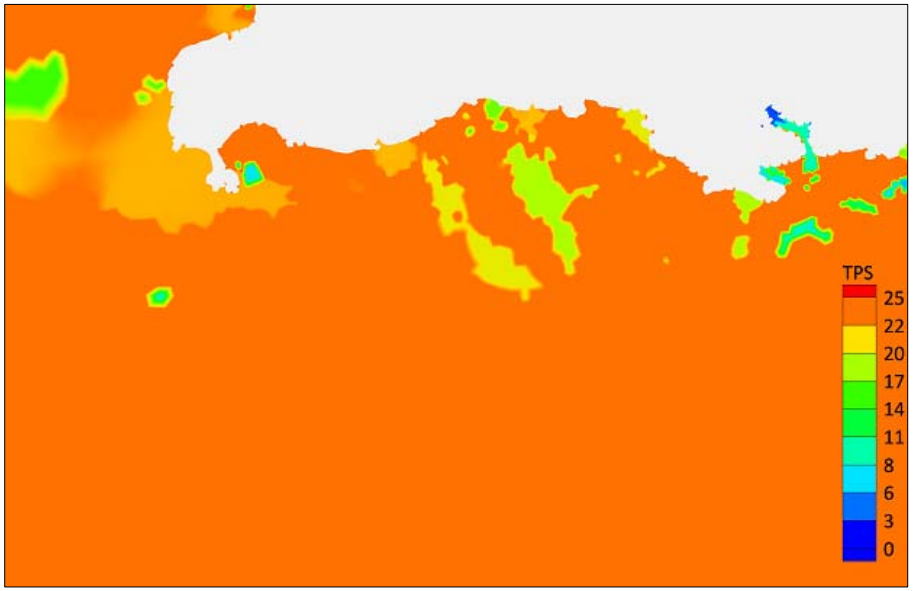
T = 1H



T = 6H







FEMA FIS 2007 HS (m)

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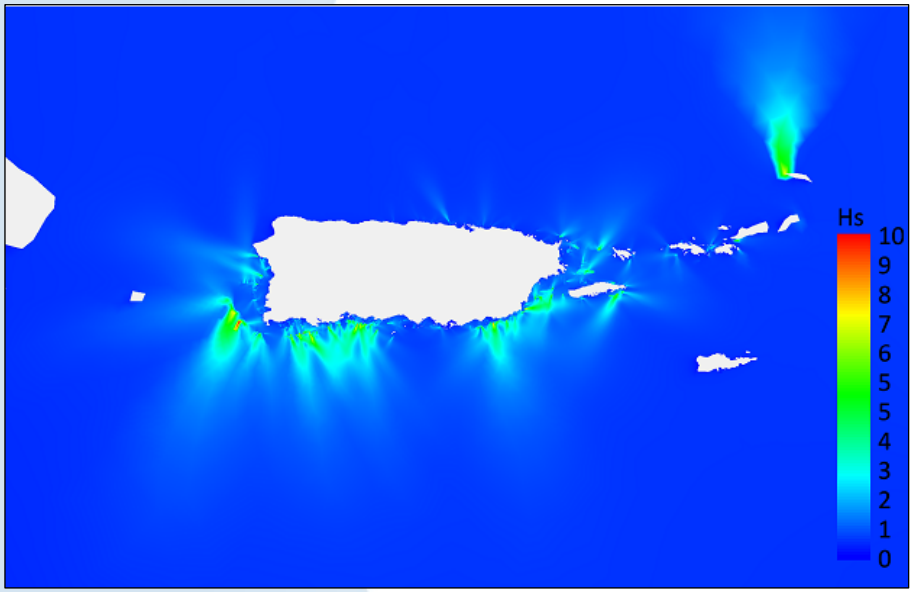

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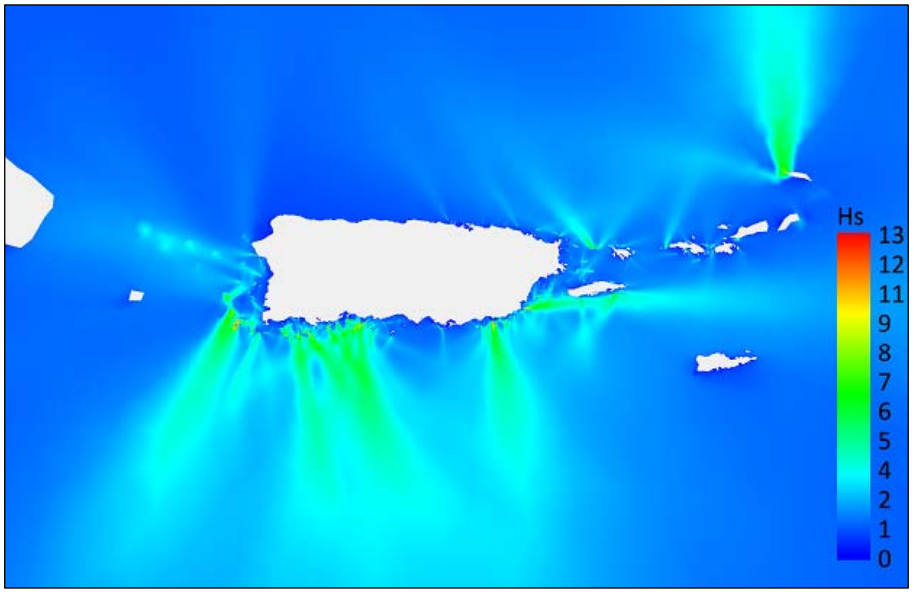
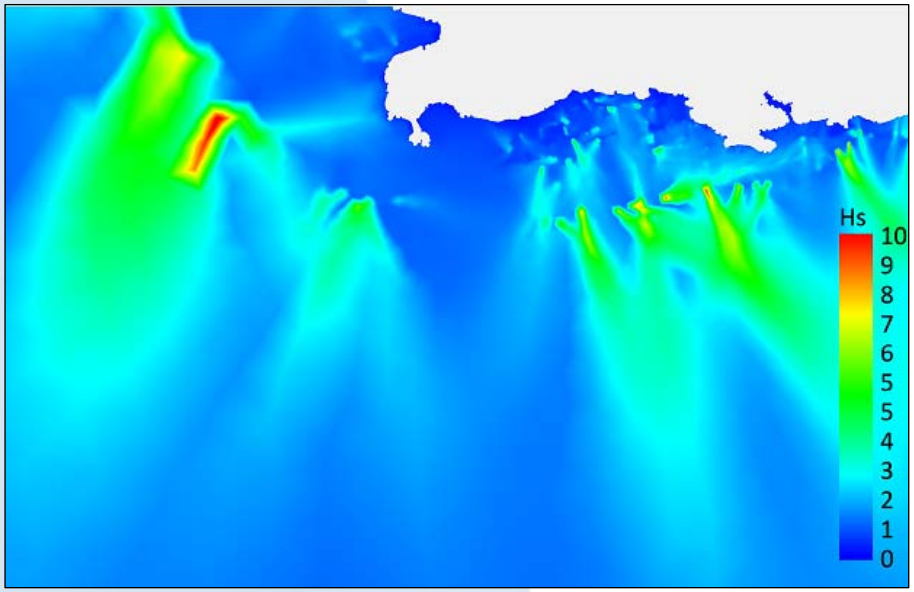
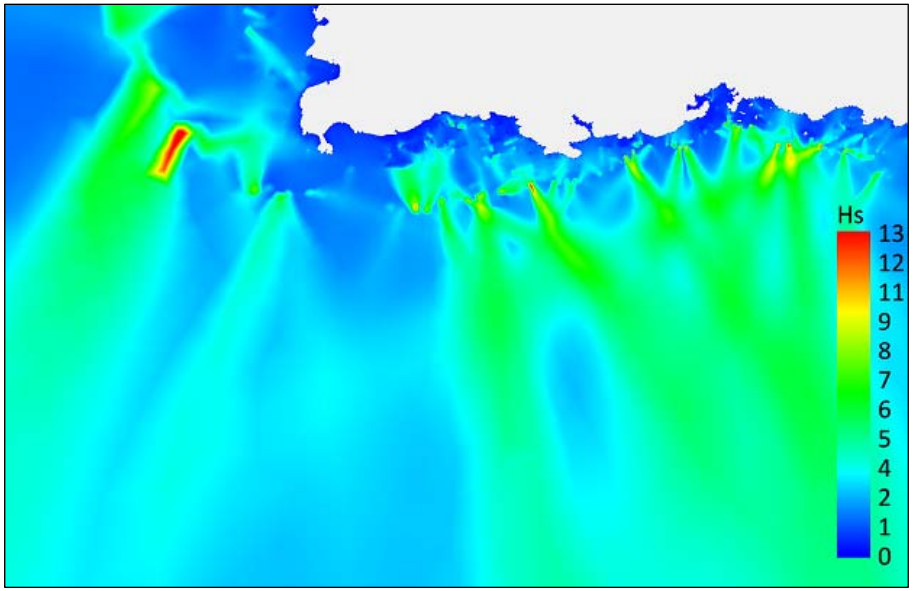


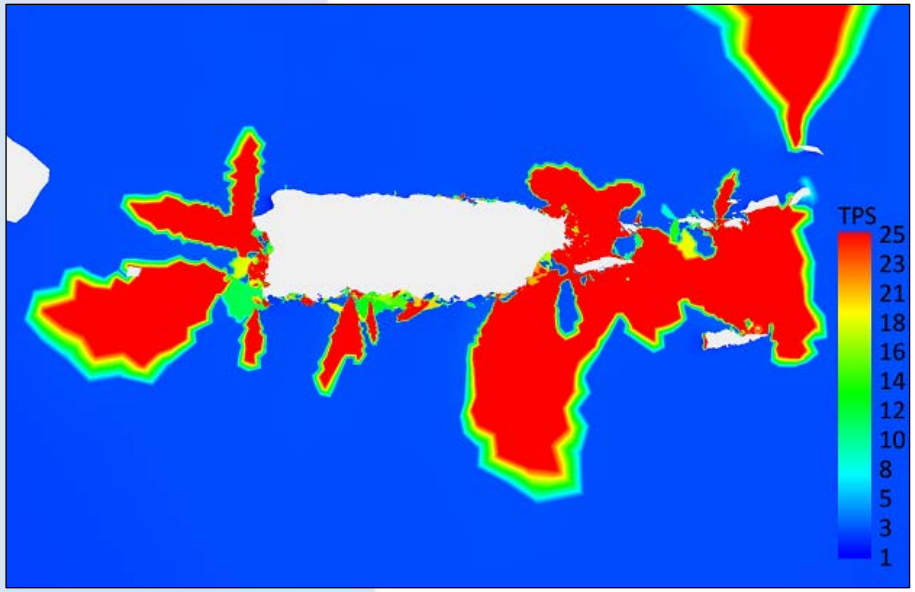


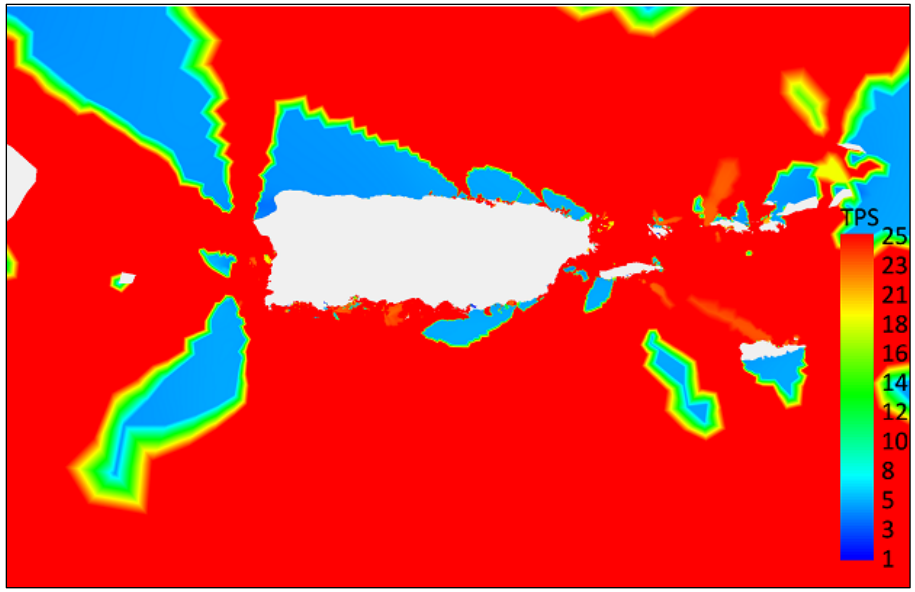


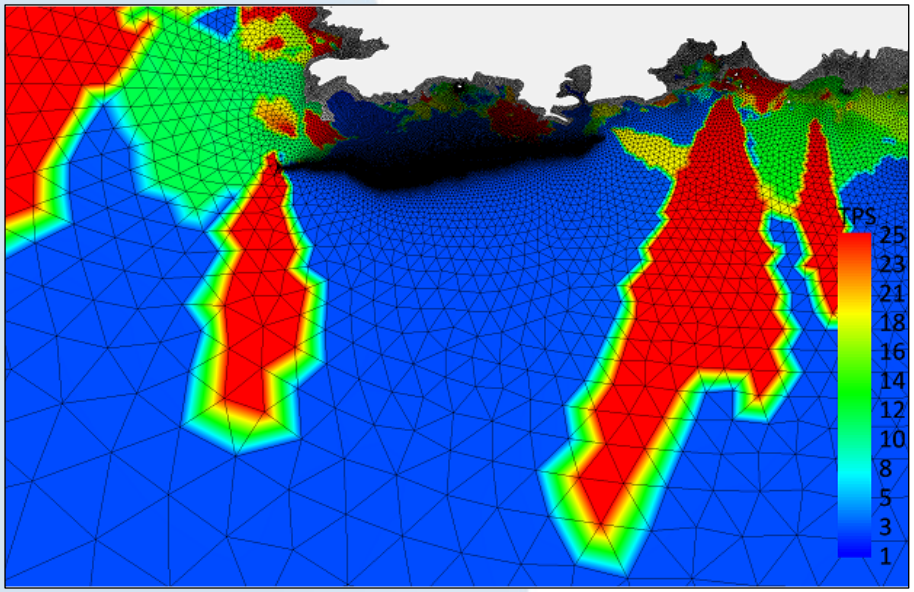
CariCOOS 2011 Peak Periods (s)

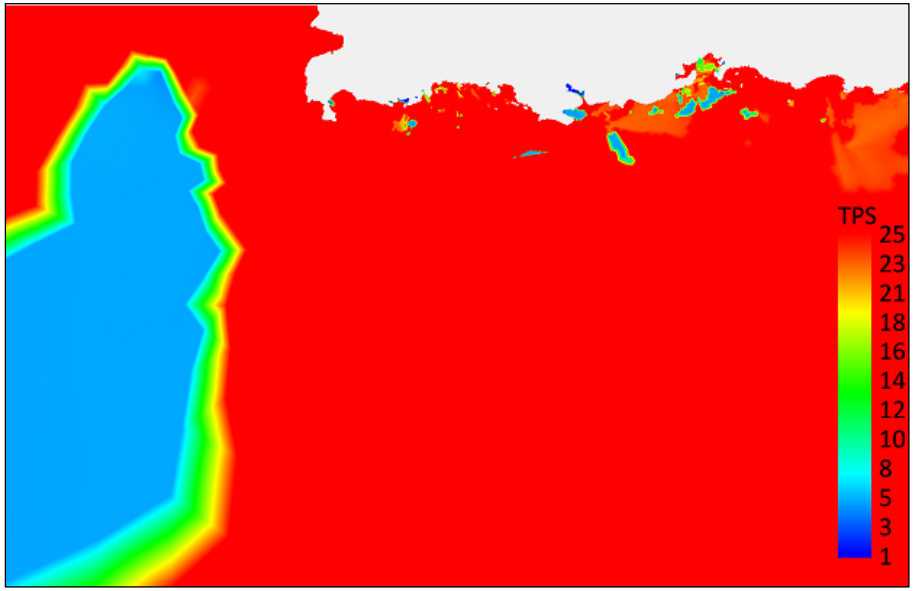
T = 1H

T = 6H



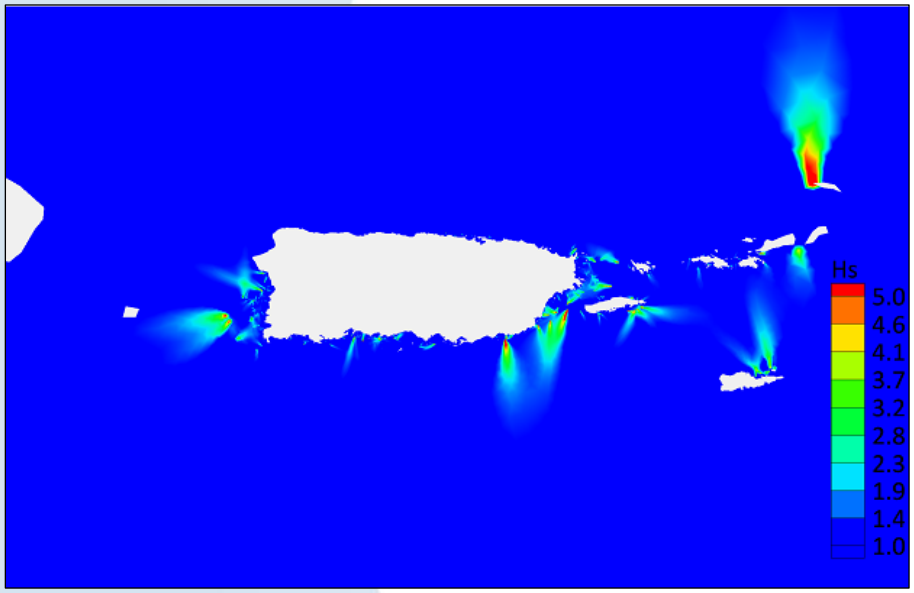






CariCOOS 2011 HS (m)

T = 1H



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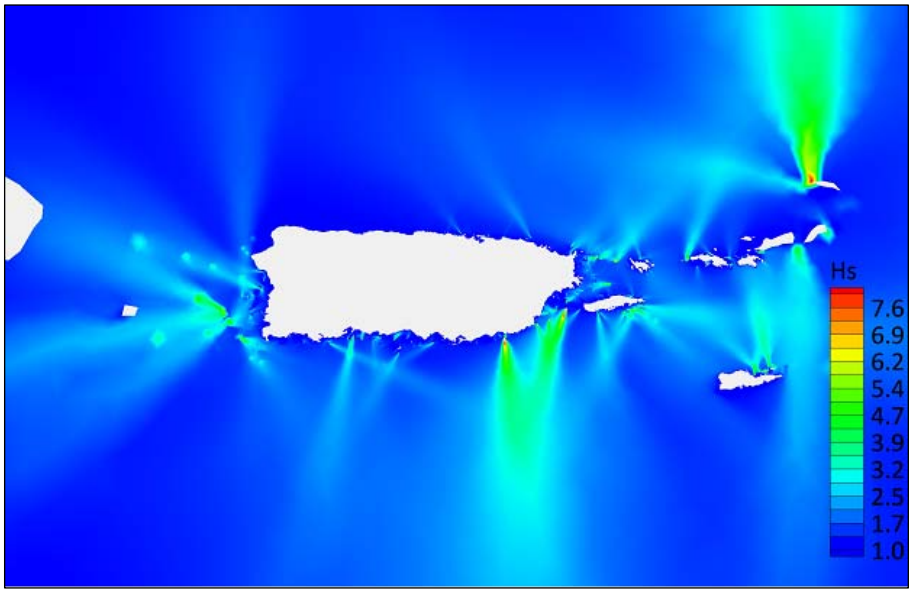
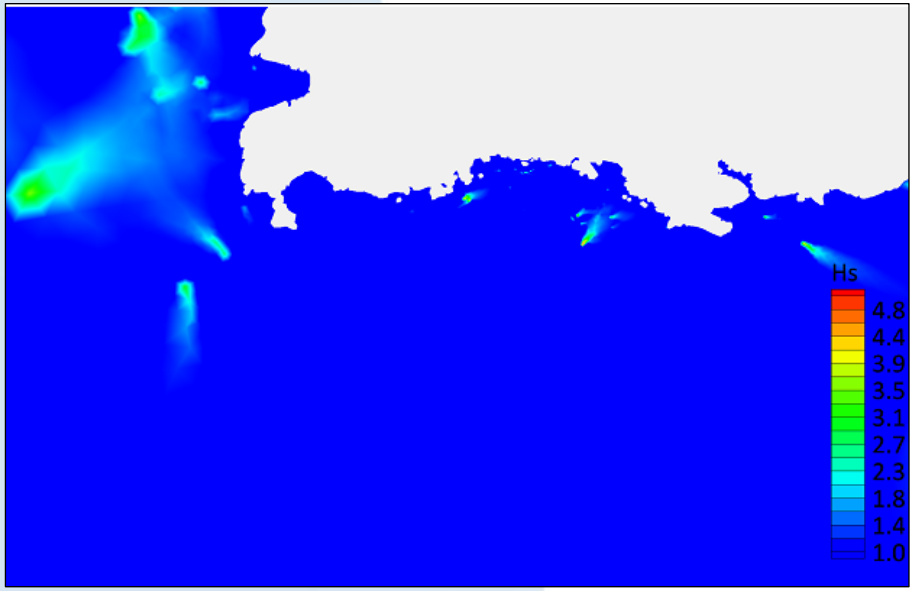
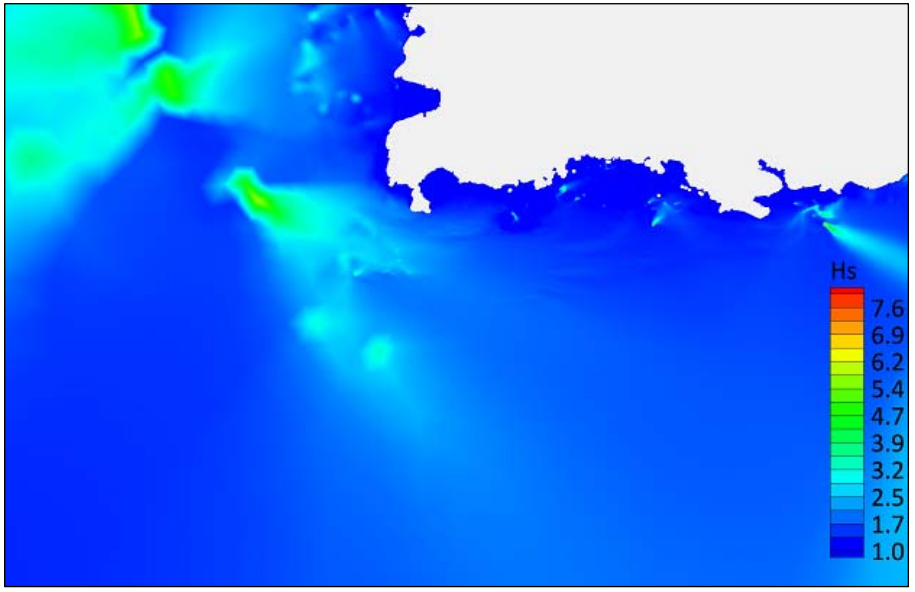
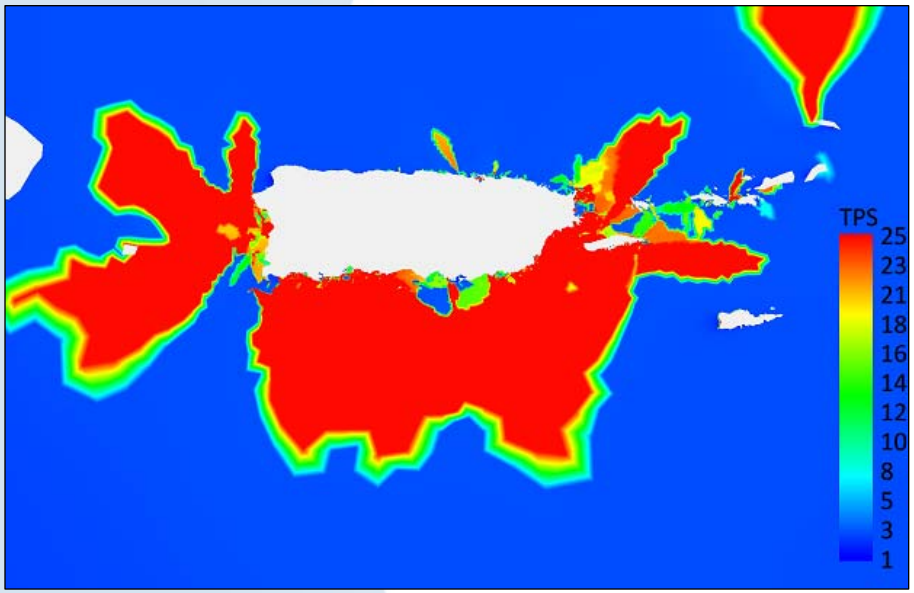




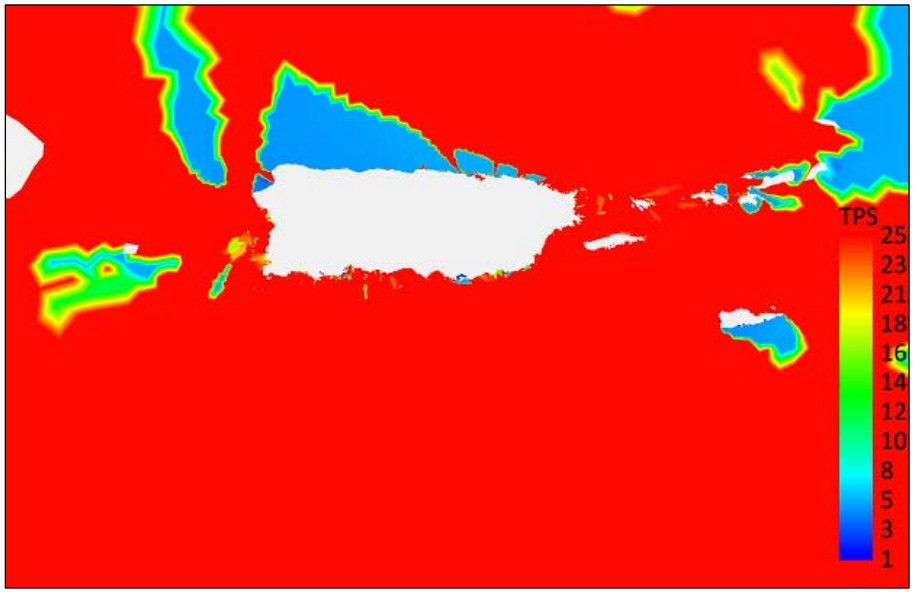


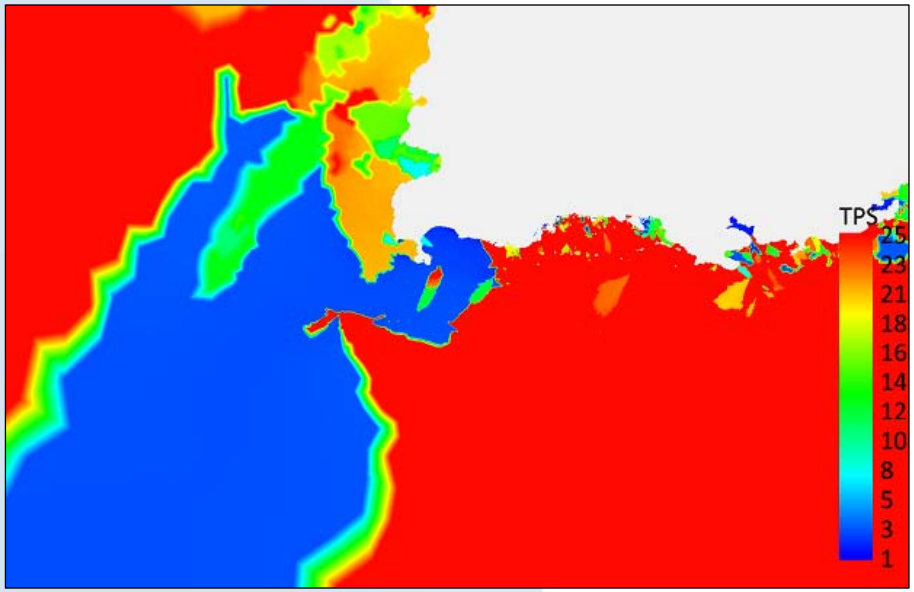
Notre Dame 2011 TPS (s)

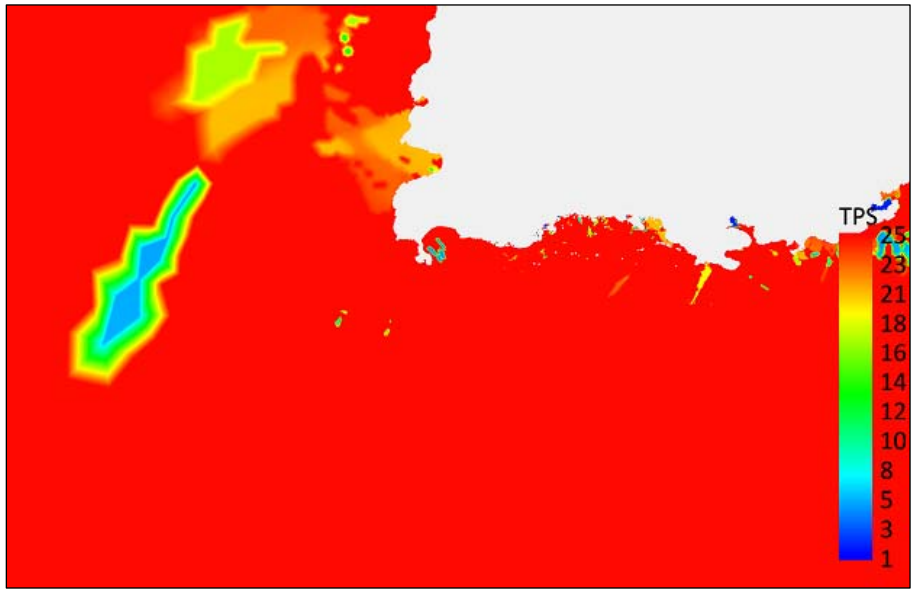
T = 1H



T = 6H

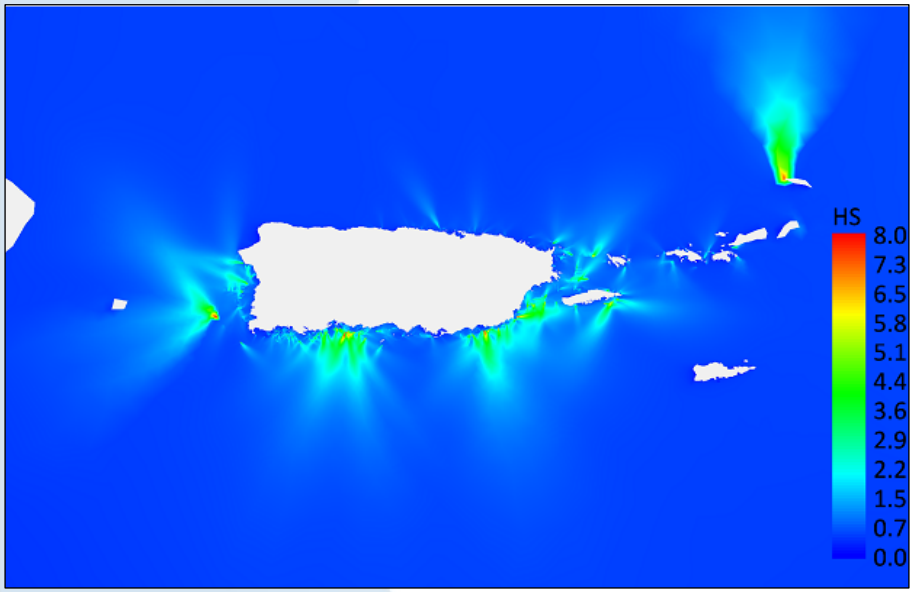






Notre Dame 2011 HS (s)

T = 1H



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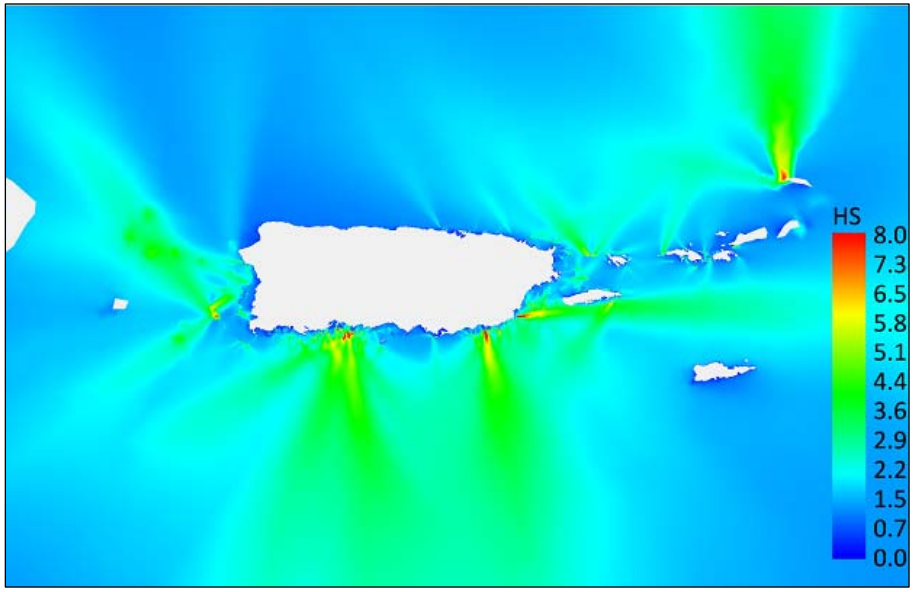
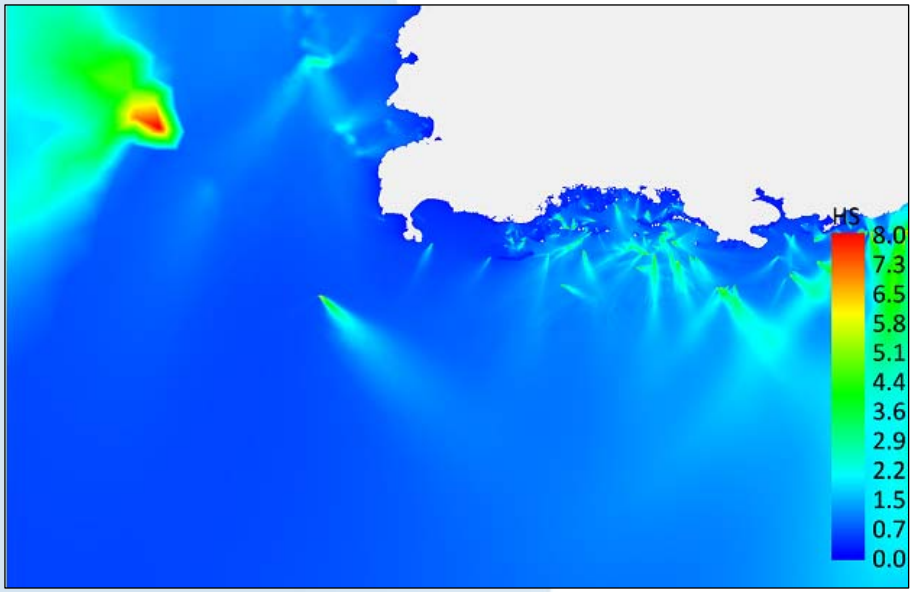
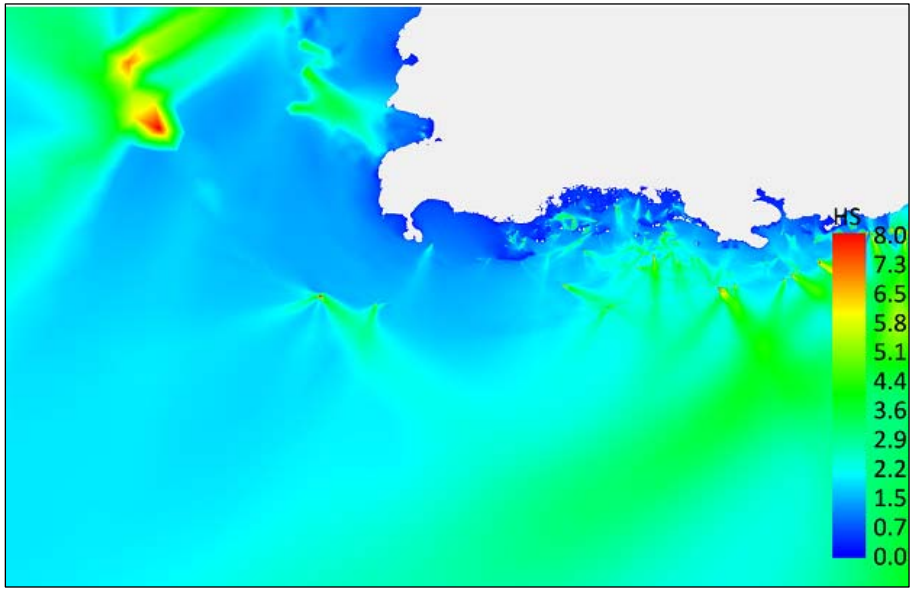
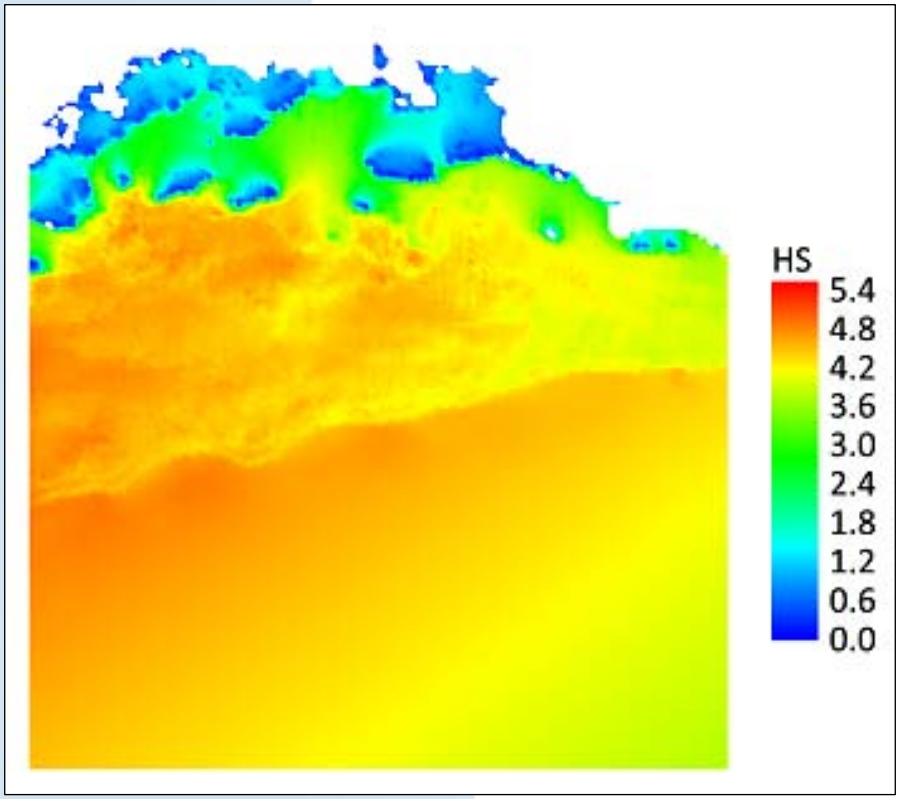


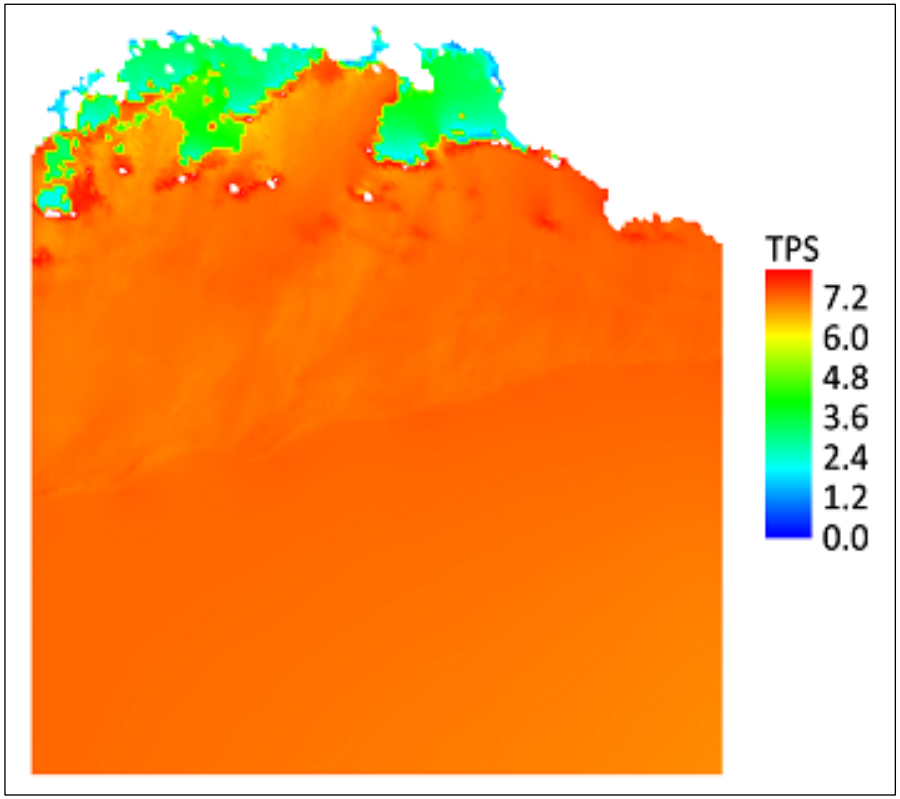




HiRes SWAN

T = Hs max

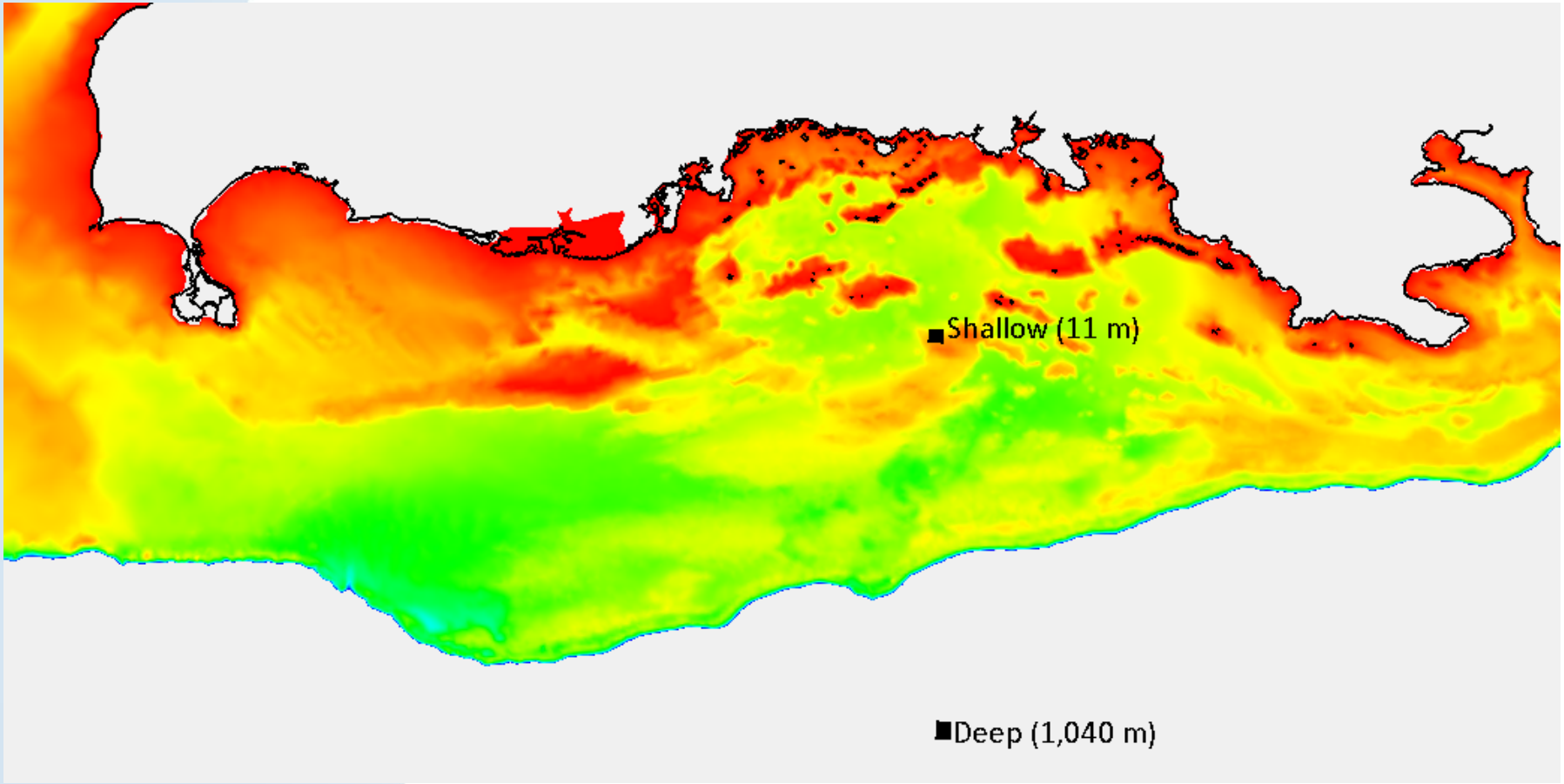




Same winds, currents, water levels

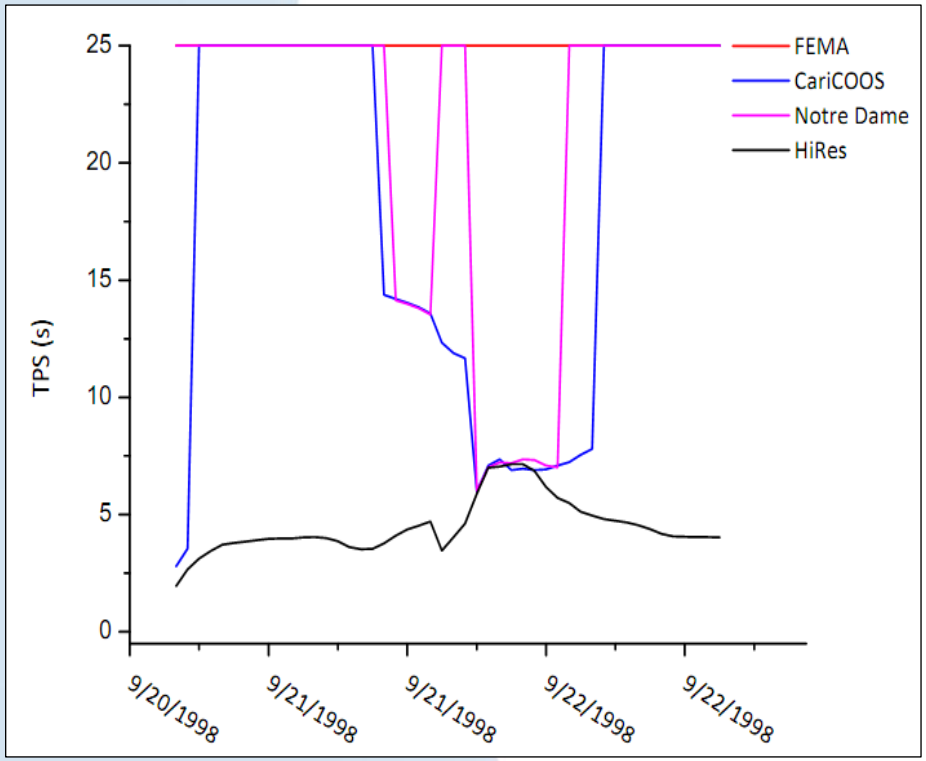
No “anomalous” peak periods or HS “rays”

HiRes SWAN

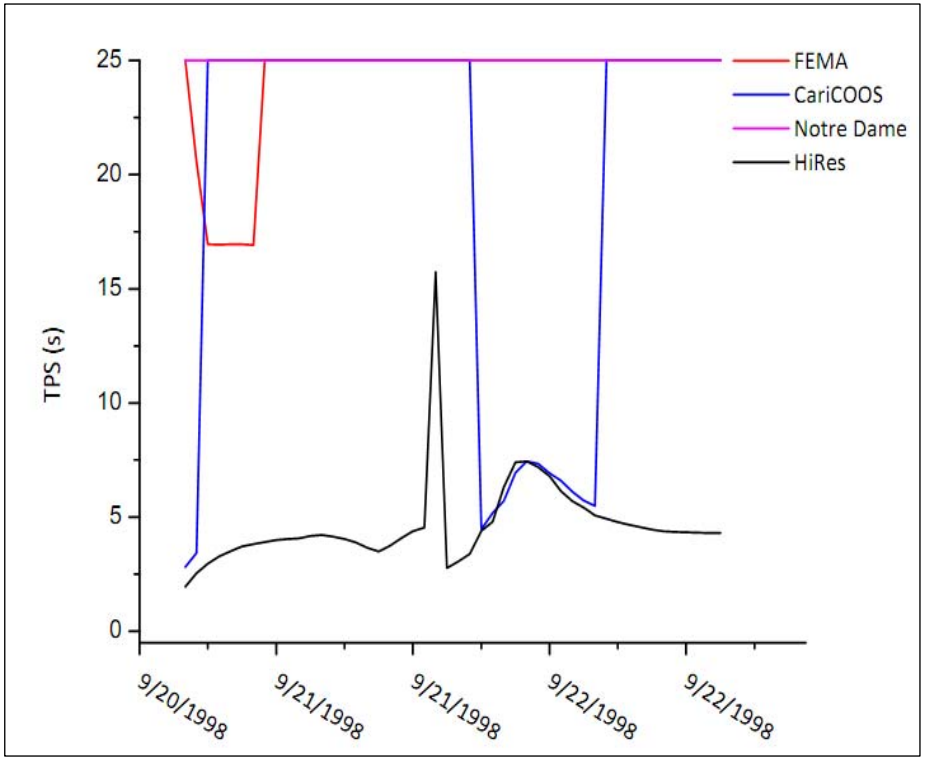


Peak Periods (s)

Deep Location

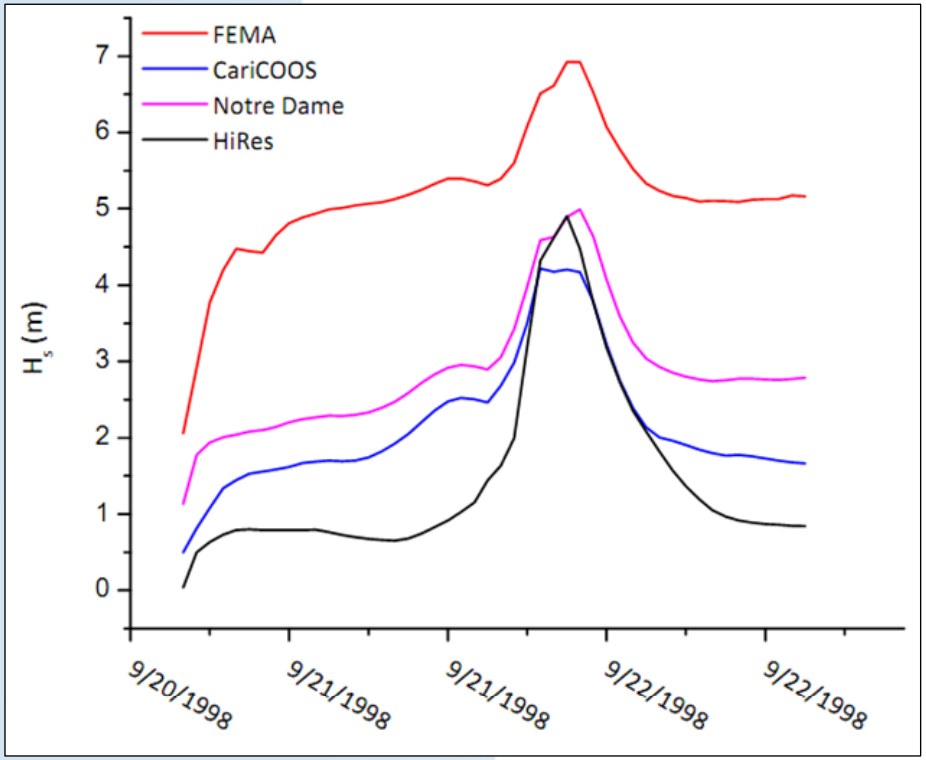


Shallow Location

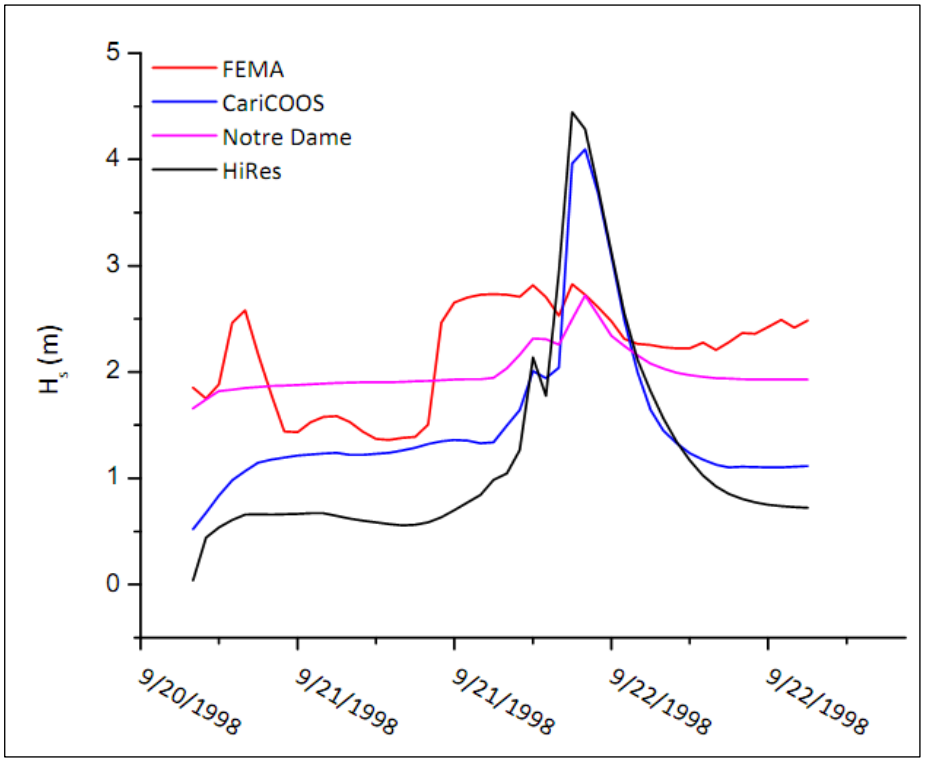


Significant Wave Heights (m)

Deep Location

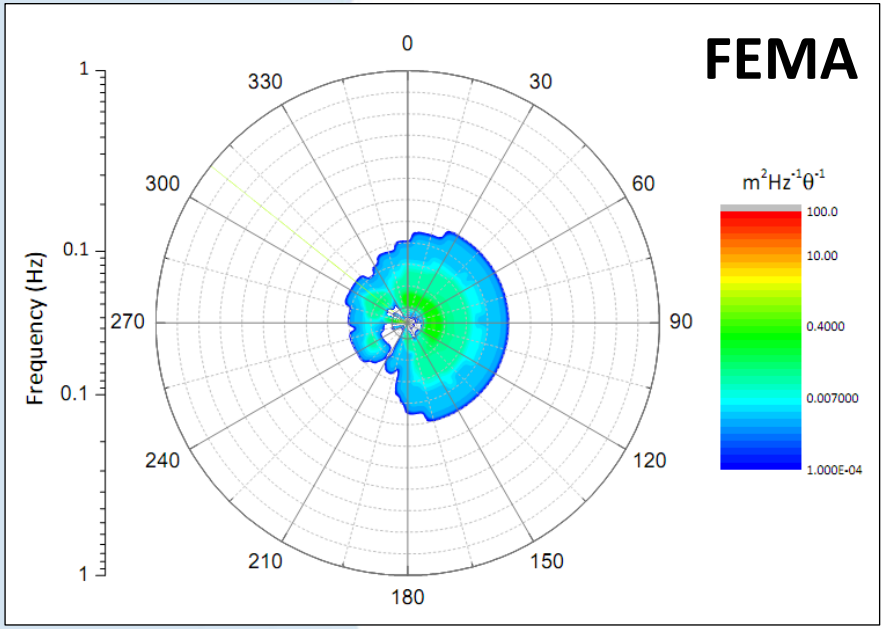


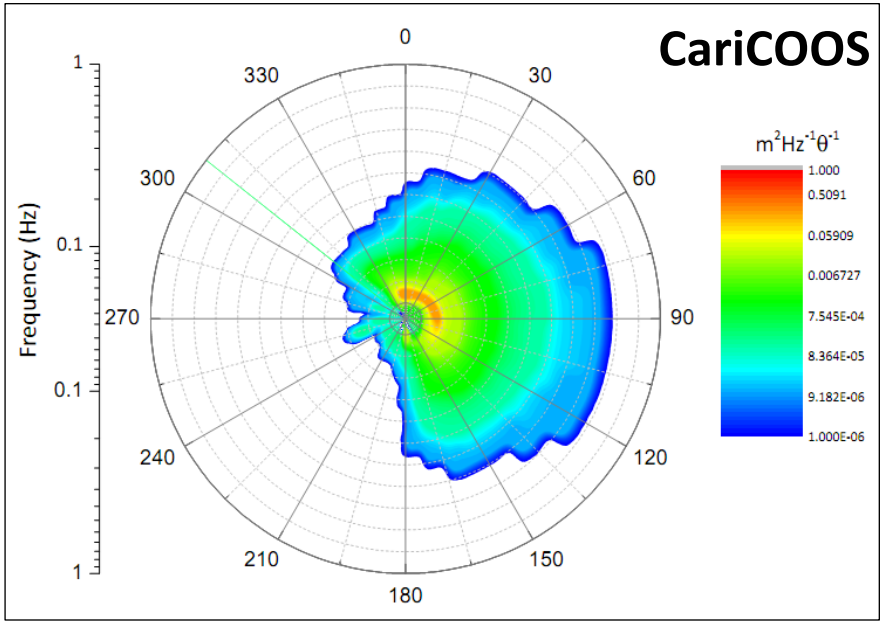
Shallow Location

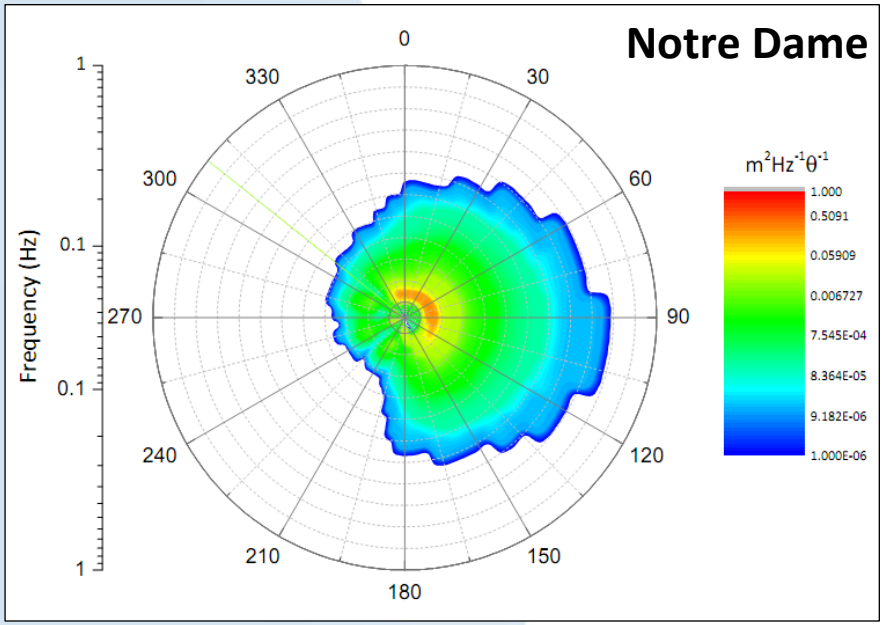


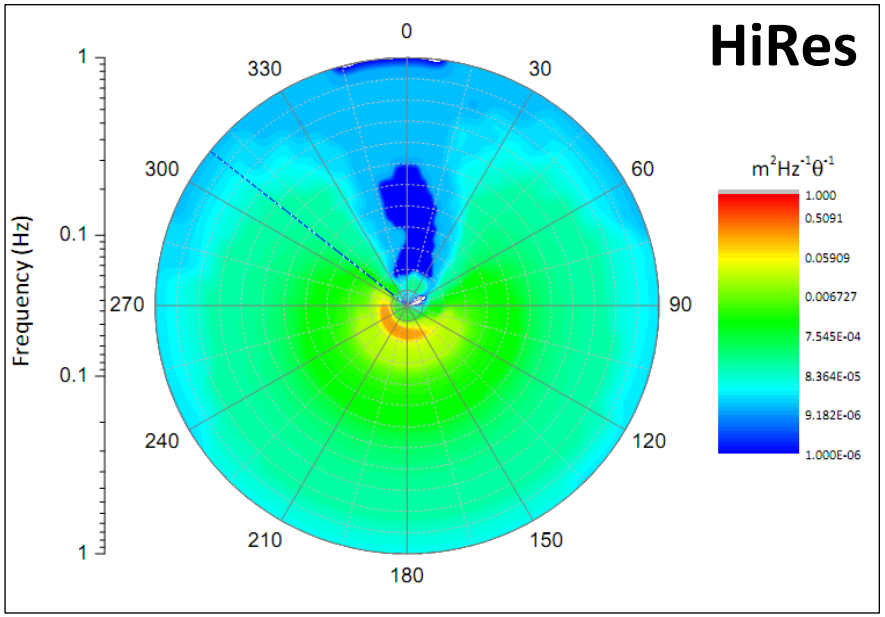
2D Spectra at Deep Location

Wind: 34 m/s SSW









Conclusions

Computation of SWAN+ADCIRC wave spectra is very sensitive to the mesh spatial resolution

- Increasing / decreasing resolution **only** at the shelf break produces very different solutions
- Computed 2D wave spectrum shows higher spectral energy at low shelf resolution
- When compared to high-resolution (30 m) structured SWAN the direction of the peak spectral energy is incorrect; not in accordance with wind direction

Acknowledgements

José Enrique Fernández fellowship

University of Notre Dame

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