Nearshore Wave Simulation in a Coupled Hydrodynamic and Wave Model System to Evaluate Storm Surge in Coastal Louisiana

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Motivation for Study

- Improve and test MORPHOS technology for hurricane wave and surge modeling
- Estimate storm surge in coastal Louisiana for alternative design and FEMA mapping
- Estimate wave conditions to define the coastal wave setup, runup, and overtopping
- Couple time-dependent, 2-dimensional meteorology, hydrodynamics, and wave forcing
- Provide boundary conditions and performance measures for levee designs and coastal restoration alternatives

Methodology for Study

- Modeling Methodology:
  – Wind modeling (H*wind blended w/ NCEP using IOKA)
  – Gulf of Mexico- and regional-scale wave modeling (WAM)
  – Surge modeling (ADCIRC)
  – Nearshore wave modeling (STWAVE)
  – One-way and two-way (for nearshore waves and surge) interactions
- Nearshore wave modeling applied several nearshore grids to encompass coastal area
- Employ half-plane and full-plane STWAVE models to provide required resolution and grid orientation

Initial Summary and Conclusions

- Coupled wave and surge modeling was significant step forward for FEMA and Corps hurricane surge estimation
- In spite of large domains, high resolution, and heavy computation load, storms suites were executed efficiently
- Future:
  - Improve efficiency and resolution
  - Validation (setup and frictional losses)
  - Tighter coupling
  - Texas coast

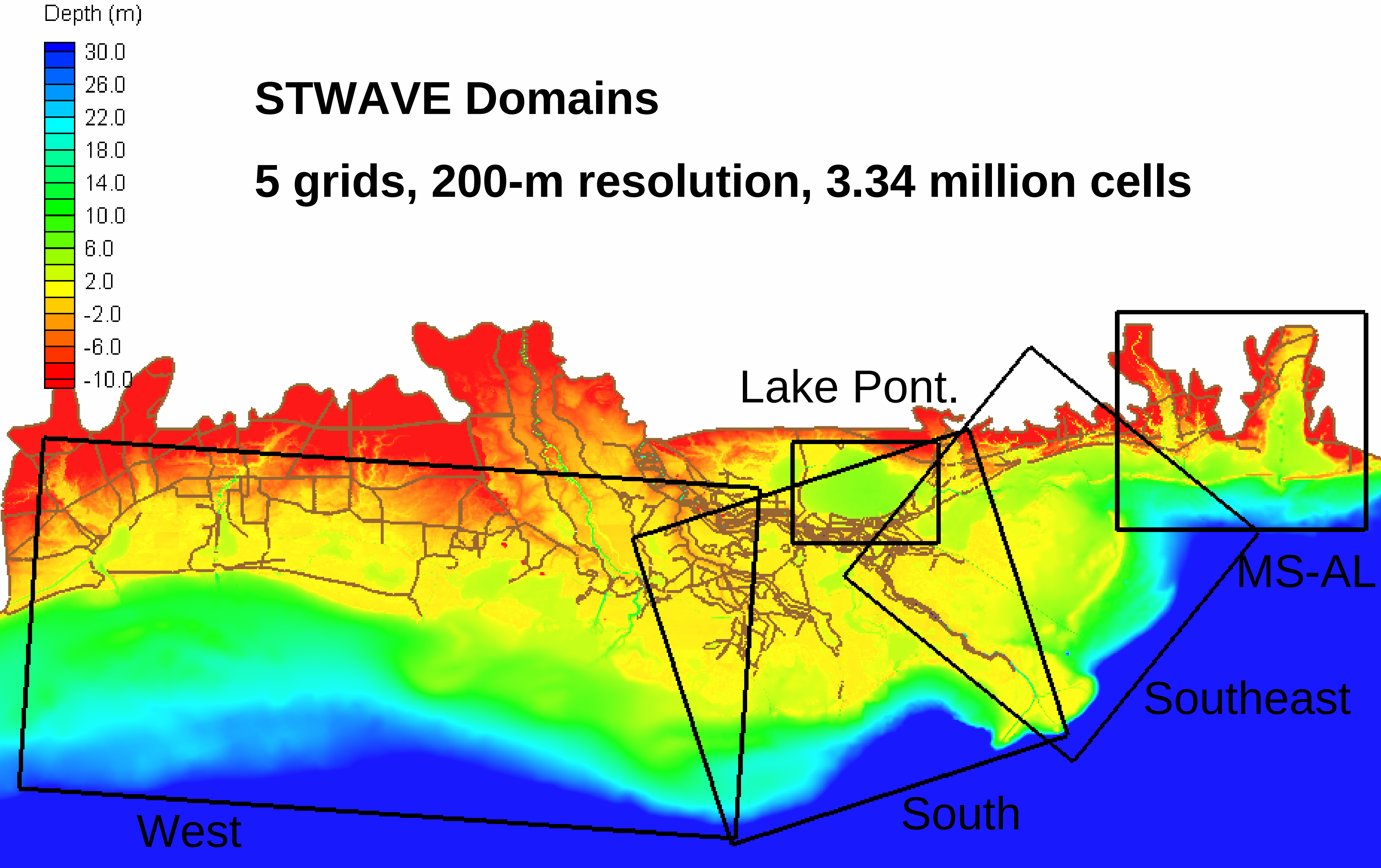
Detailed STWAVE Methodology

- Spatial and temporal nesting from regional wave model (WAM) to STWAVE grids with 200-m resolution
- Bathymetry and friction coefficients interpolated from ADCIRC
- Surge and wind interpolated from ADCIRC at every time snap
- STWAVE simulated nearshore waves at half-hourly intervals (93 time steps per hypothetical storm, approximately 500 storms)
- Gradients of radiation stress interpolated from STWAVE onto the ADCIRC mesh to drive spatial and temporal variation of wave-induced water level change and currents in ADCIRC

Detailed Methodology

STWAVE Domains

5 grids, 200-m resolution, 3.34 million cells



Study Challenges

- Study domain: large area with low-lying coastal marshes, complex nearshore features, levees and Mississippi River-related features
- Storm forcing conditions: extreme wind speeds, rapidly evolving winds, and large surge levels require robust models and coupling mechanism
- Lack of field data to validate waves and wave setup in study domain
- Study timeline, study domain, and model resolution required execution on parallel-computing platforms and resulted in enormous file sizes

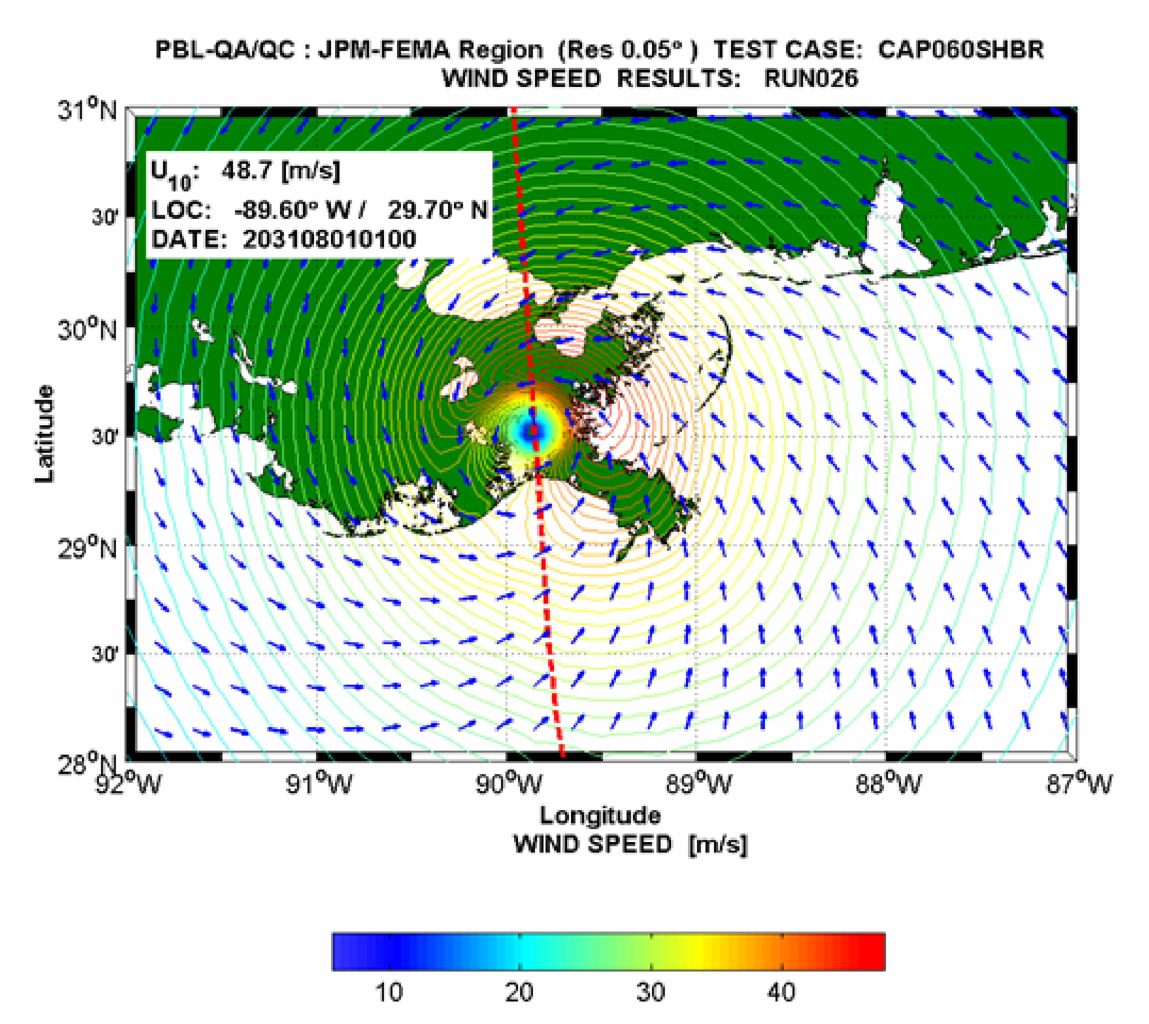
STWAVE Additions and Improvements

- **Study parameters require advancements in STWAVE model**
  - Variable wind forcing
  - Variable storm surge levels
  - Development of several formulations to account for bottom friction-induced wave dissipation
  - Application of interpolation algorithms to develop coarse grid offshore spectra to nearshore grid
  - Parallel processing capability
  - Calculation and output of low-frequency weighted mean wave period for design

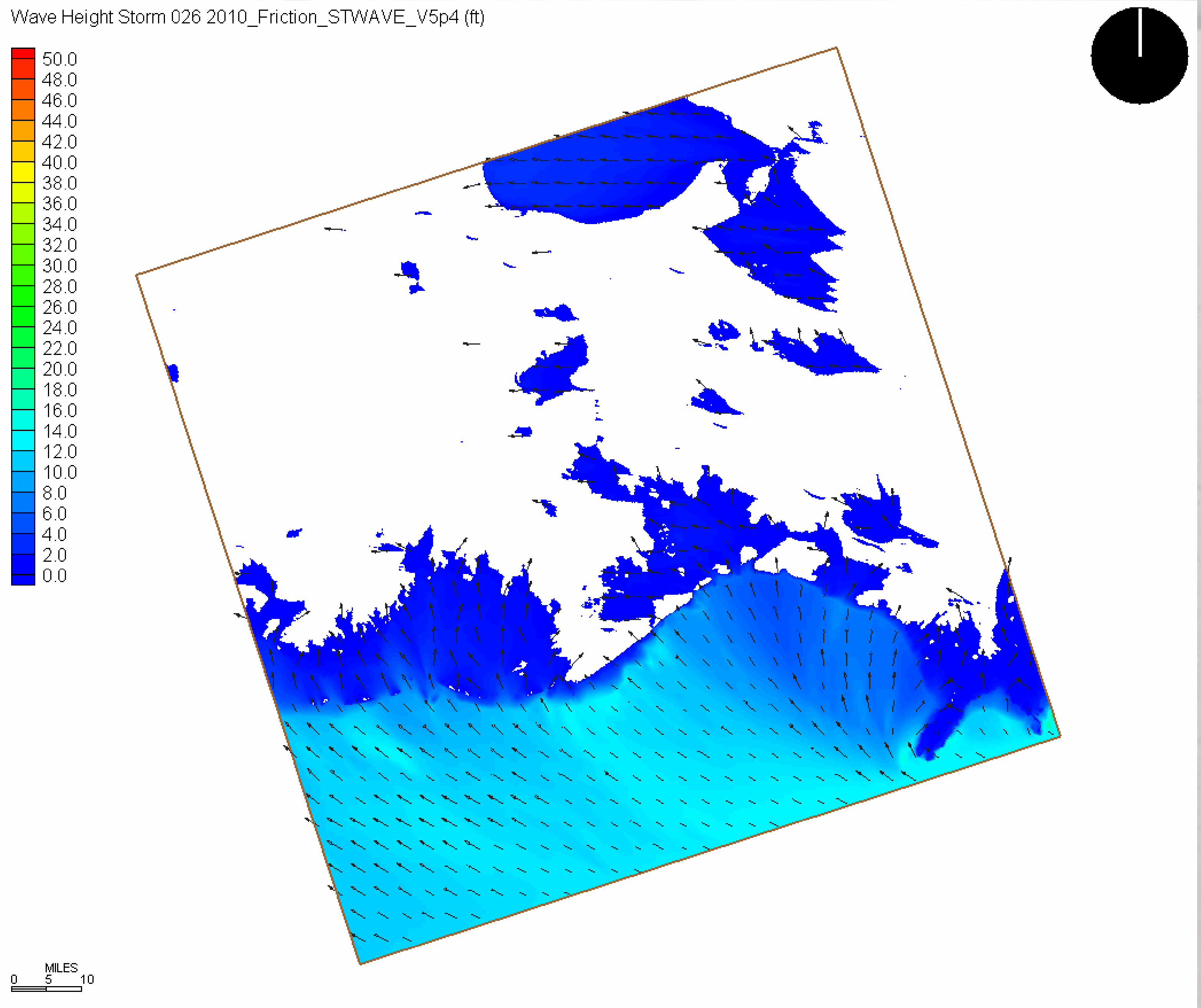
Results: Wave Animations

- Storm 026 in 152-storm suite, Katrina-like path

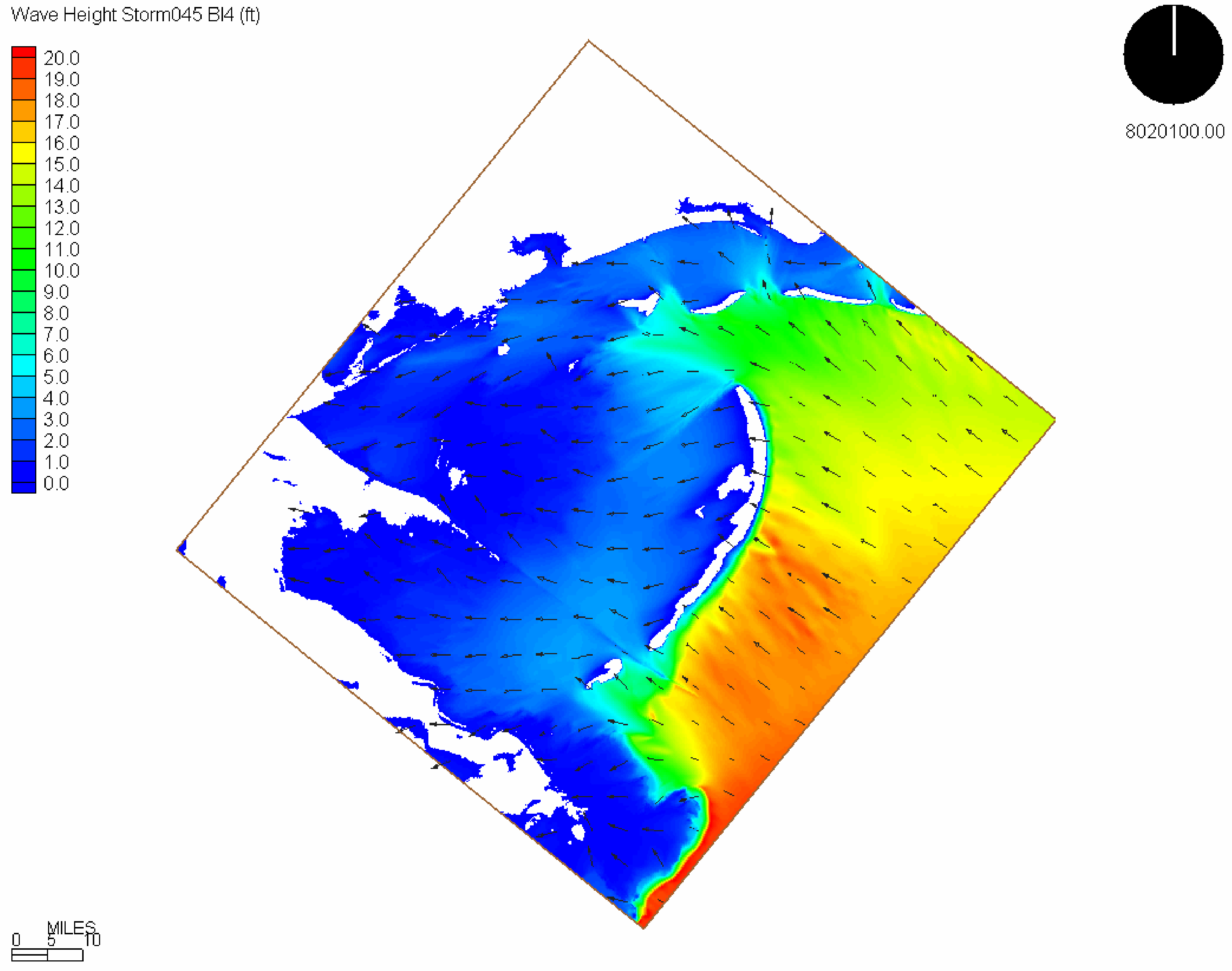
- Min Press. = 900 mb
- Radius = 14.9 nm
- Forw. Velocity = 11 kt
- Holland B = 1.27



Results: Wave Animations; Storm026, Hmo

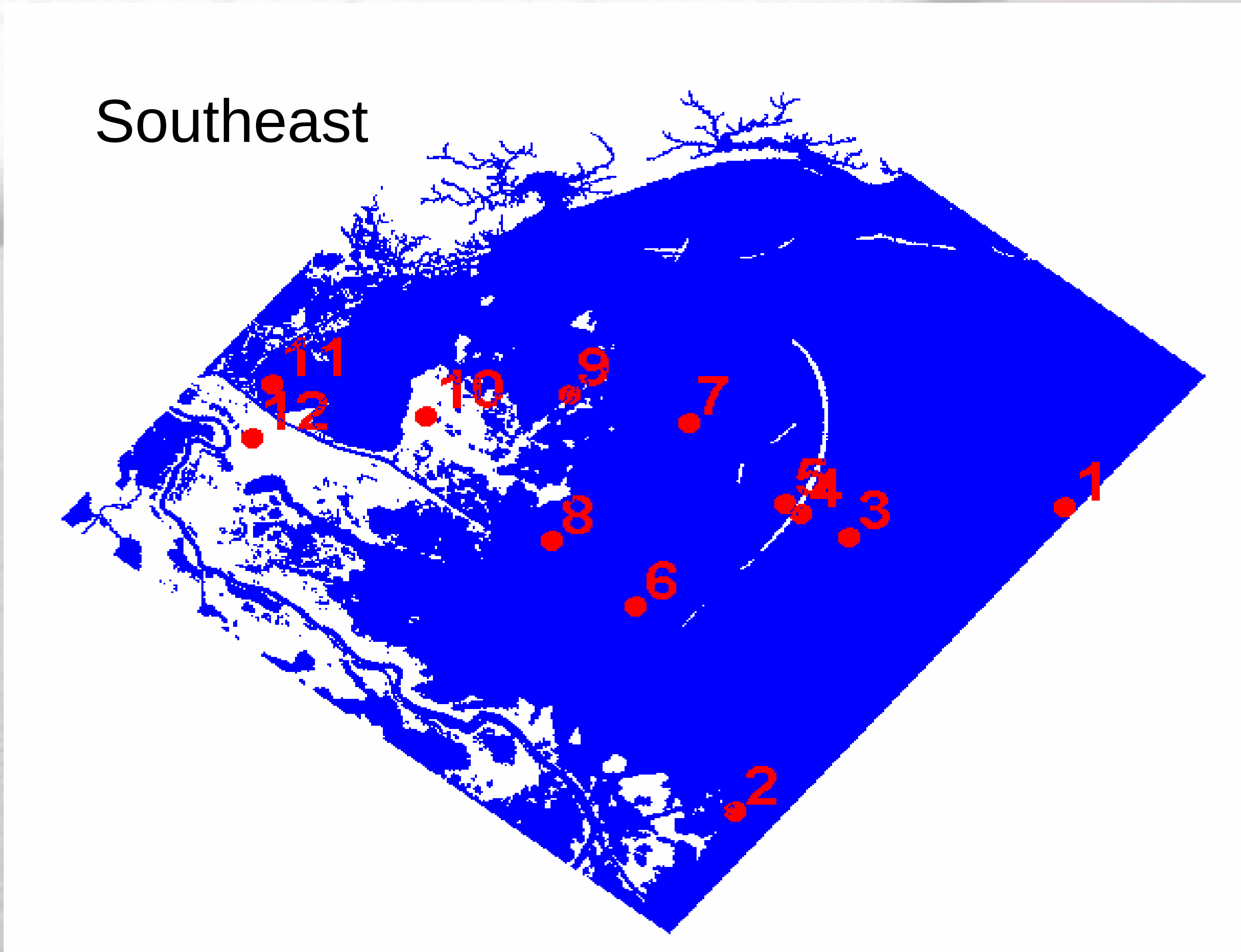


Results: Wave Animations; Storm045, Hmo



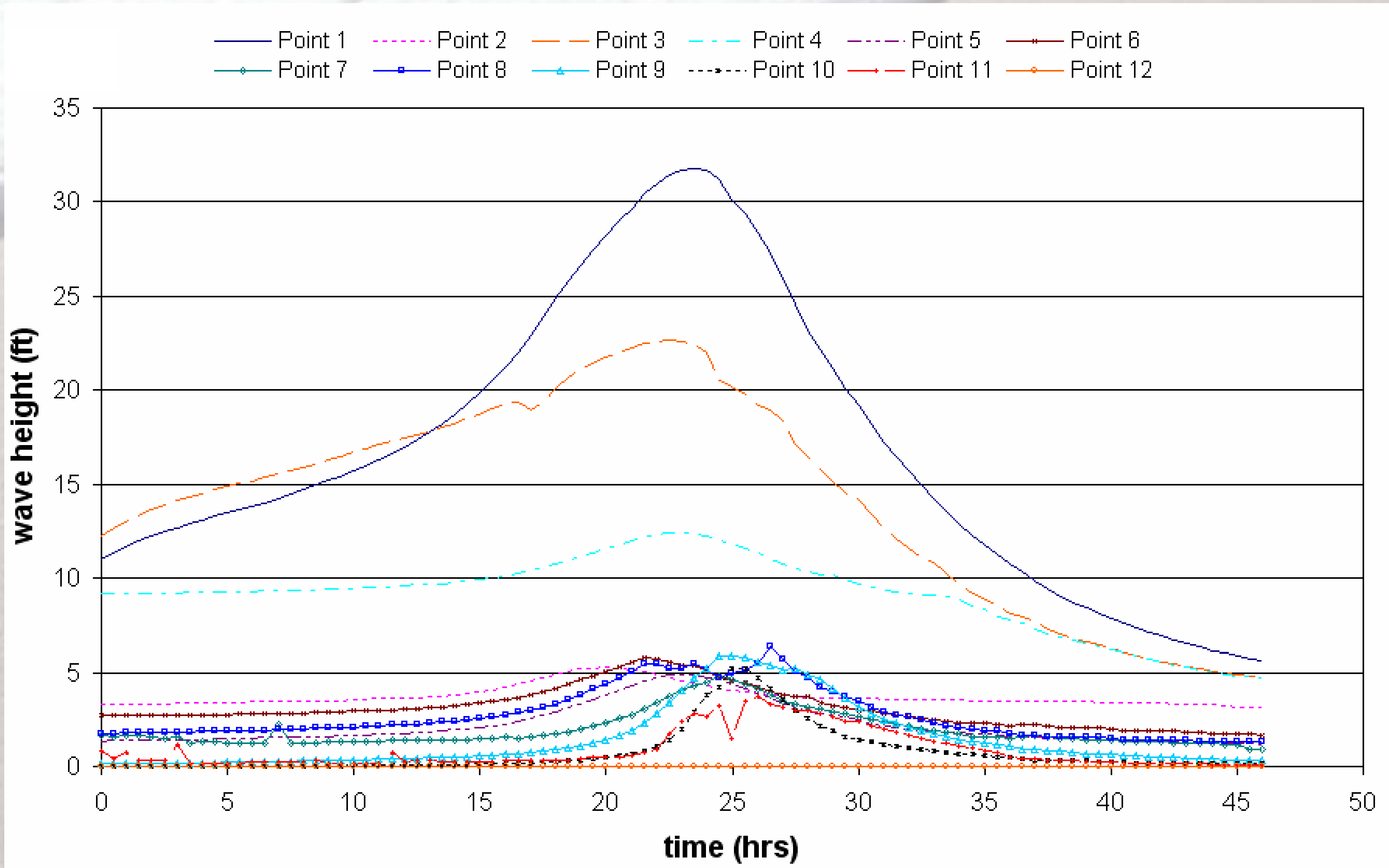
Results: Wave Time Series

- Extract results for certain points in grid

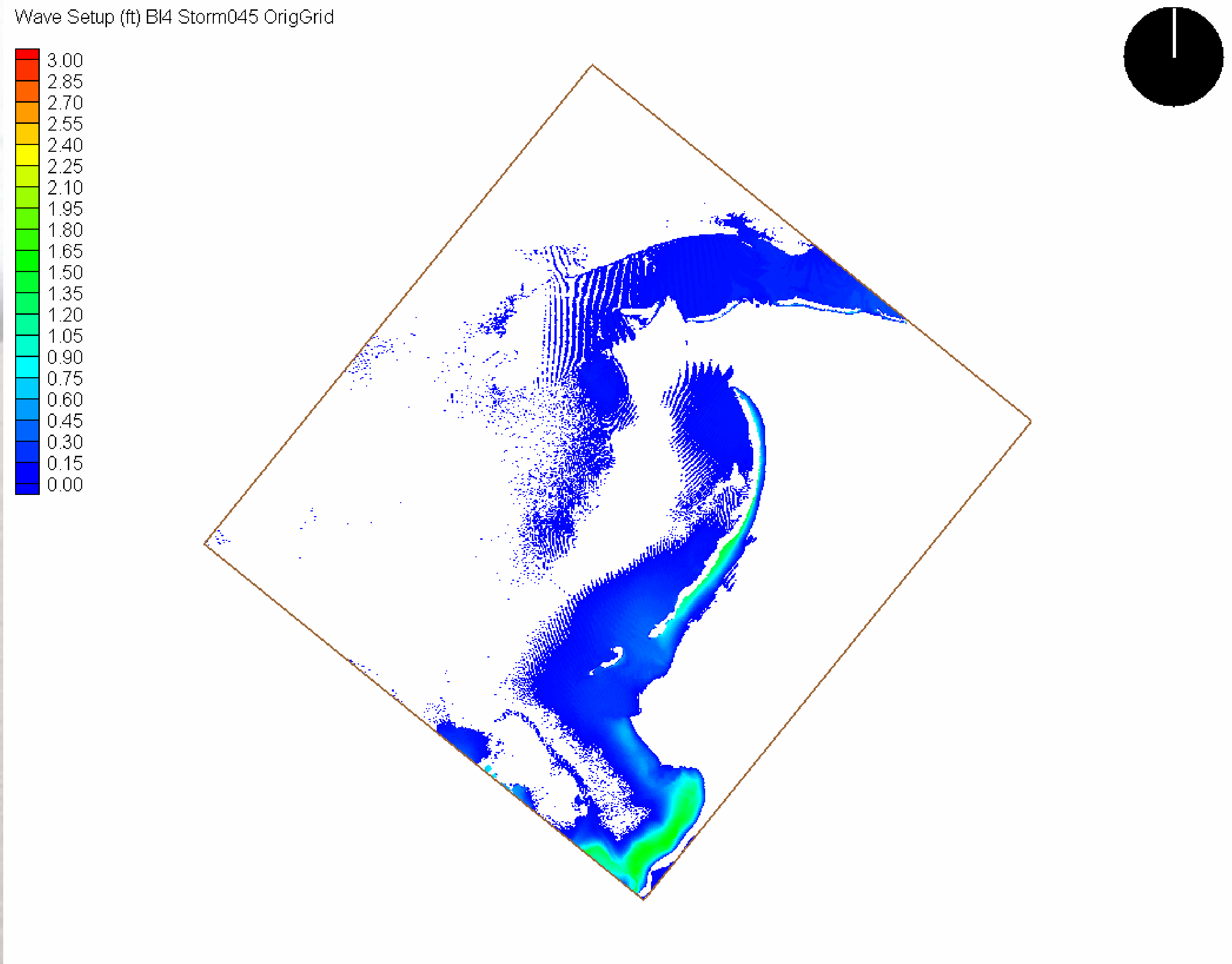


Results: Wave Time Series

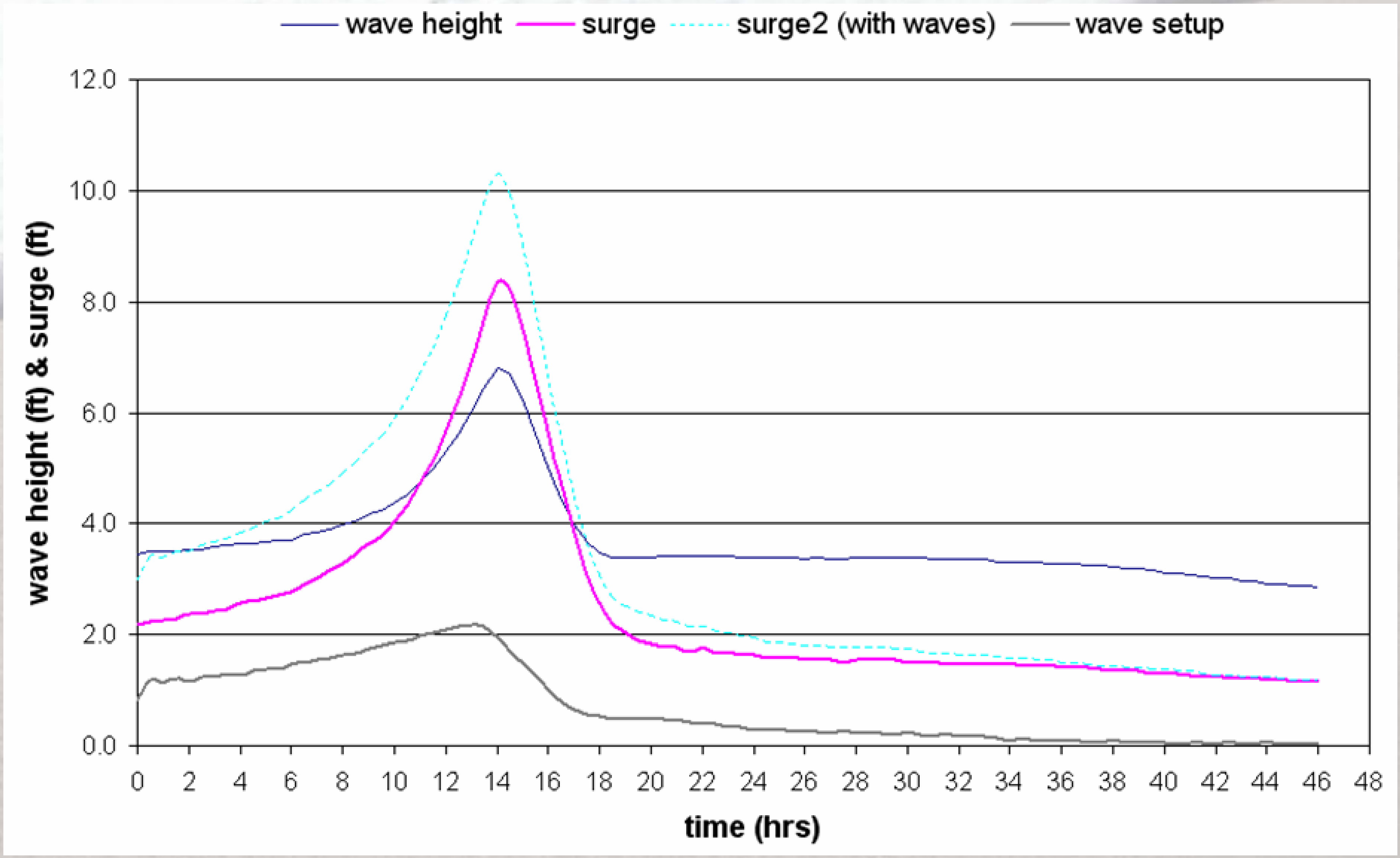
- Time series shows progression of waves



Results: Wave Animations; Storm045, Wave Setup

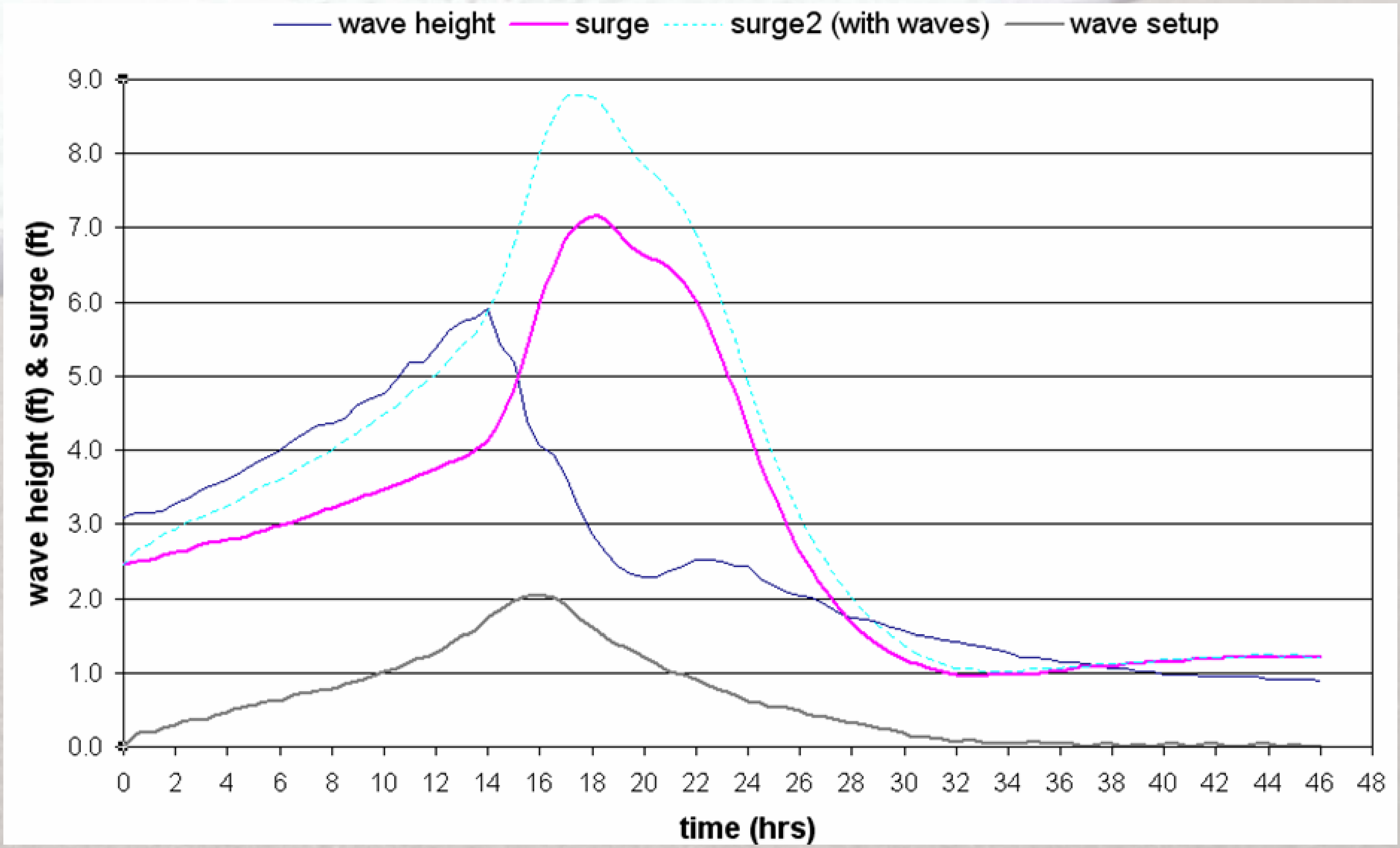


Results: Wave Time Series inc. Setup



Point 2: near MS delta near offshore boundary

Results: Wave Time Series inc. Setup



Point 6: landward of Barrier Islands

Results: Applications

- STWAVE data provide radiation stress gradients necessary to develop wave-driven water level increase (wave setup) and currents in ADCIRC
- Analysis of STWAVE data provides statistical definition of wave values in study area (.i.e. 100-year wave height)
- STWAVE with new functionality allows model calibration to surge, vegetation, and bottom friction effects when field data available

Conclusions and Future Work

- Coupled wave and surge modeling was significant step forward for FEMA and Corps hurricane surge estimation
- In spite of large domains, high resolution, and heavy computation load, storms suites were executed efficiently
- Future:
  - Improve efficiency and resolution
  - Validation (setup and frictional losses)
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