Progress Report

Transition of the Coastal and Estuarine Storm Tide Model (CEST) to an Operational Model for Forecasting Storm Surges

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Acknowledgments

- The Joint Hurricane Testbed Program of NHC for supporting the project
- The storm surge unit of NHC
- The Meteorological Development Laboratory of National Weather Service

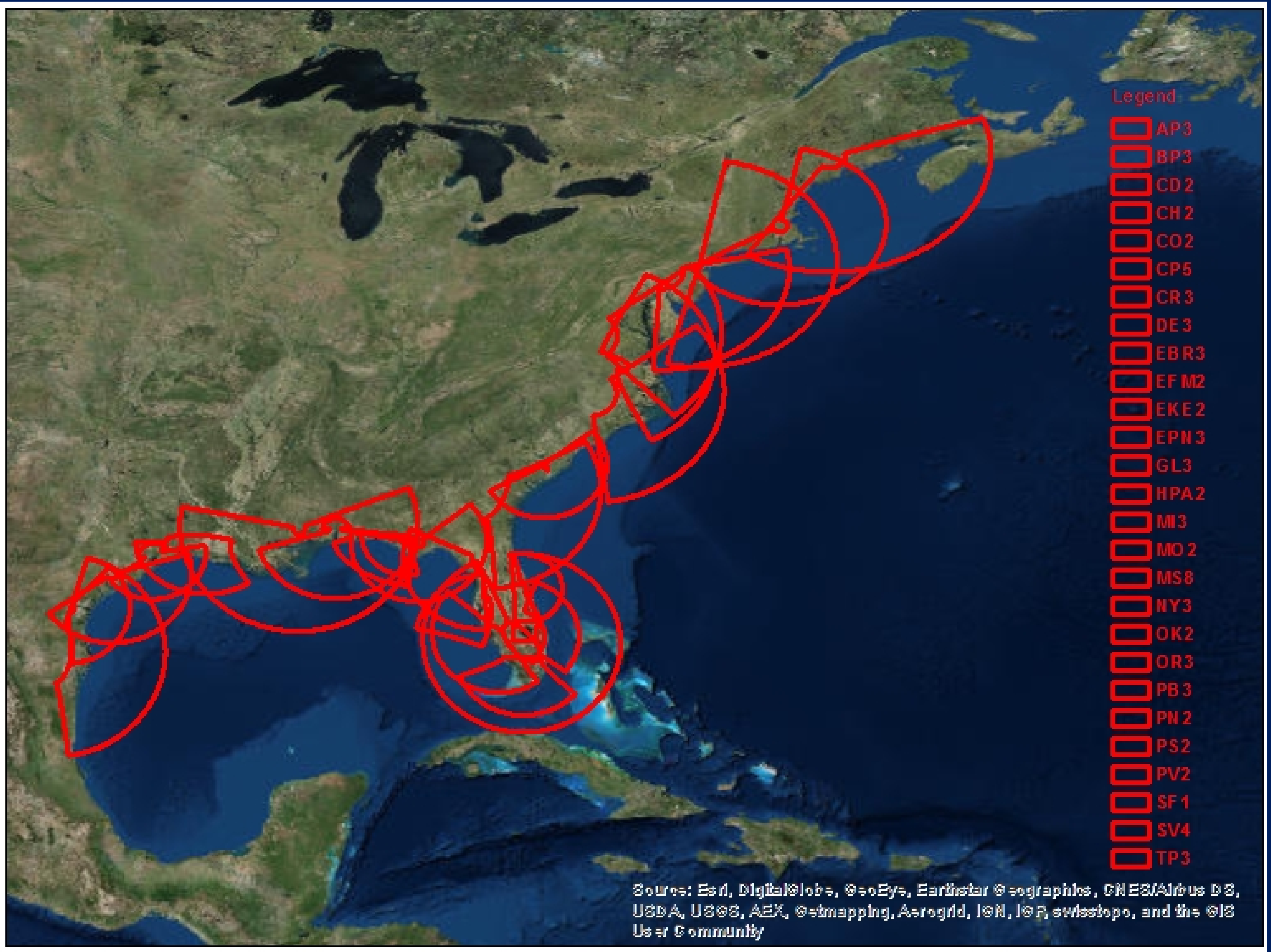
Outlines

- Introduction
- Convert SLOSH Basins into CEST Grids
- MOM (Maximum of the Maximum) Comparison
- MEOW (Maximum Envelope of Water) Comparison
- Conclusions
- Future Work

Comparison of SLOSH and CEST

Items	SLOSH	CEST
Numerical method	Finite difference	Finite difference
Numerical scheme	Explicit	Semi-implicit
Grid format	Conformal grid	Orthogonal curvilinear
Grid style	B-grid	Modified C-grid
Overland flooding	Wetting and drying based on the relationship between water flows and water level elevations of neighboring cells	Wetting and drying based on accumulated water volume in a grid cell to conserve water volume
Wind field	SLOSH Wind	SLOSH , Holland wind, H*Wind
Bottom friction	Function of total water depth	Function of water depth and type of land cover
Time step for synthetic cases	3-15 seconds	15-60 seconds

Testing CEST on existing and recently updated SLOSH basins



SLOSH Basins

- DTA Files
- Shape files
  - Grid
  - Height
  - Barrier
  - Flow
  - Cut
  - Tree
- Synthetic storm track Files

  - Category, forward speed, trajectory, and initial tide level

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Convert SLOSH Basin into CEST Grid

- Grid Coordinate
- Cell Center Depth
- Edge Depth
- Barrier Depth
- Cut Depth
- Tree Flag
- Manning's Coefficients (For model bottom stress)

Manning's Coefficients

- In CEST, Manning coefficients for grid cells over the land were estimated according to the 2011 NLCD. Then an average Manning coefficient for a land grid cell is calculated using:

$$n_a = \frac{\sum_{i=1}^{N}(n_i\alpha) + n_0\beta}{N\alpha + \beta}$$

n_i: Manning coefficient value of an NLCD pixel within a model grid cell;

α: the area of an NLCD pixel;

N: the total number of NLCD pixels within a model cell;

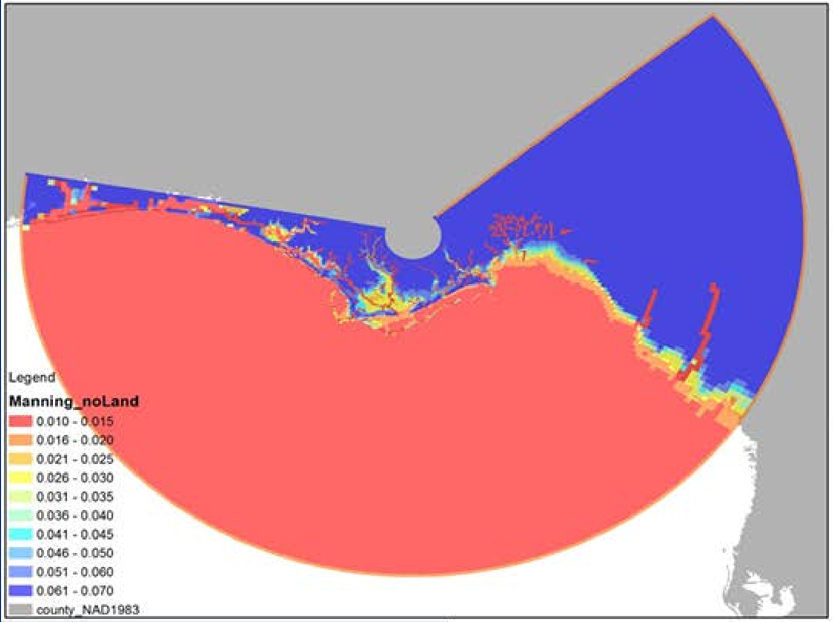
n_0: the Manning coefficient for the oceanic area;

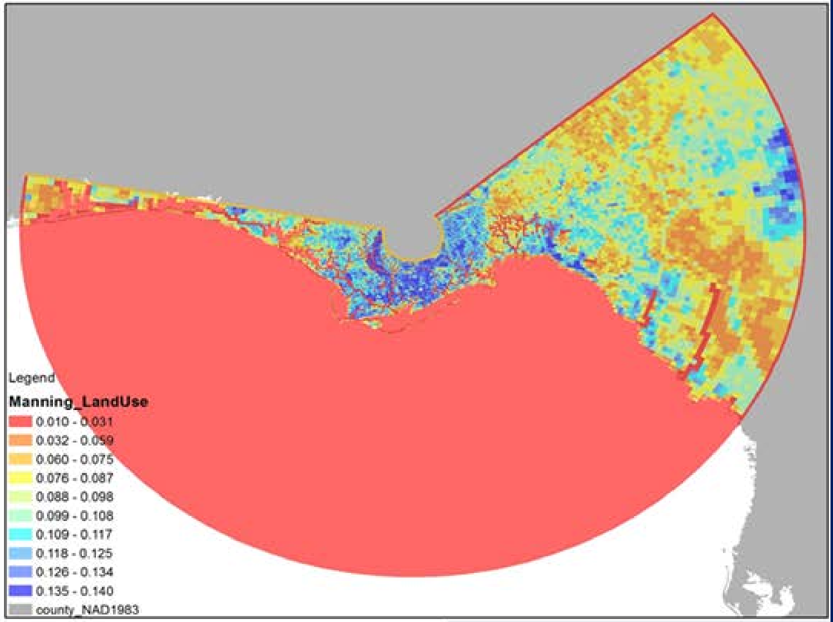
β: Oceanic area that is not covered by NLCD pixel.

References:

- Zhang, K., H. Liu, Y. Li, H. Xu, J. Shen, J. Rhome, and T. J. Smith III, 2012: The role of mangroves in attenuating storm surges. *Estuarine, Coastal, and Shelf Science*, **102-103,** 11-23.
- Zhang, K., Y. Li, H. Liu, J. Rhome, and C. Forbes, 2013: Transition of the Coastal and Estuarine Storm Tide Model into an operational storm surge forecast model: A case study of the Florida Coast. *Weather and Forecasting*, **28,** 1019-1037.

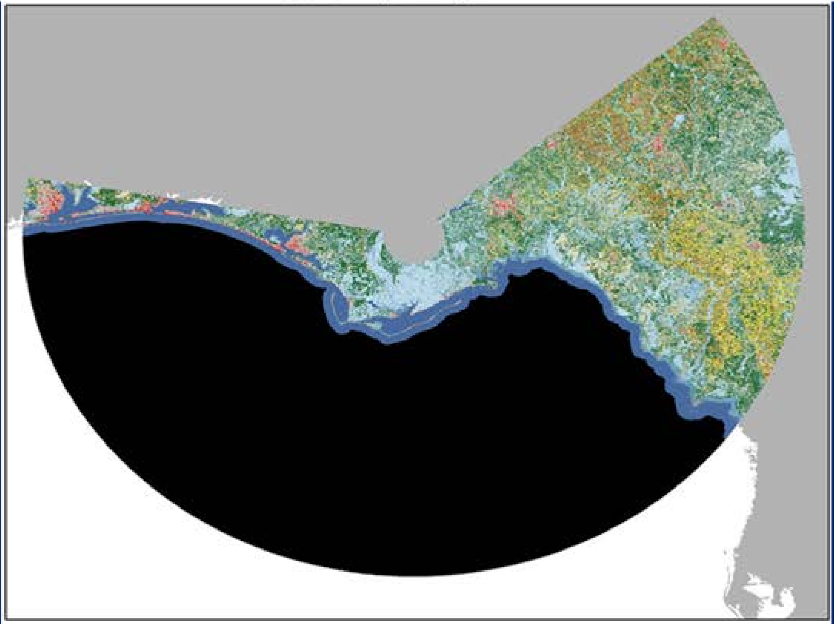
Manning's Coefficients Calculated from National Land Cover Data





Manning *n* w/o NLCD

Manning *n* w/ NLCD



Land Cover Image

11 Basins have been converted

Basins	Name	Tracks	NLCD
Apalachicola Bay	AP3	YES	YES
Cedar Key	CD2	YES	YES
Cape Canaveral	CO2	YES	YES
Delaware Bay	DE3	YES	YES
Fort Myers	FM2	YES	YES
Florida Bay	GL3	YES	YES
Biscayne Bay	HMI3	YES	YES
Mobile Bay	MO2	YES	YES
New Orleans	MS7	YES	YES
Tampa Bay	TP3	YES	YES
Norfolk	OR3	YES	YES

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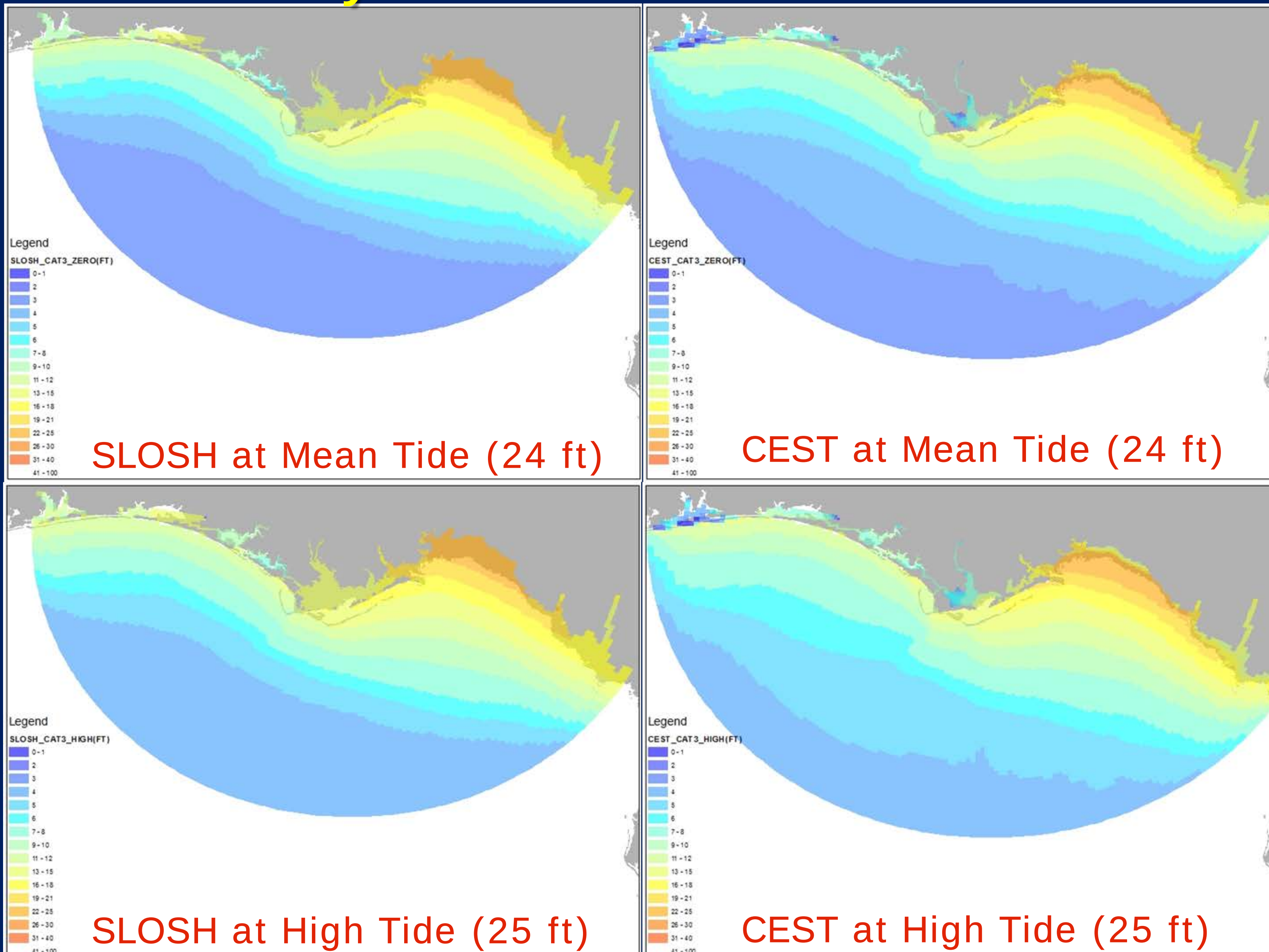
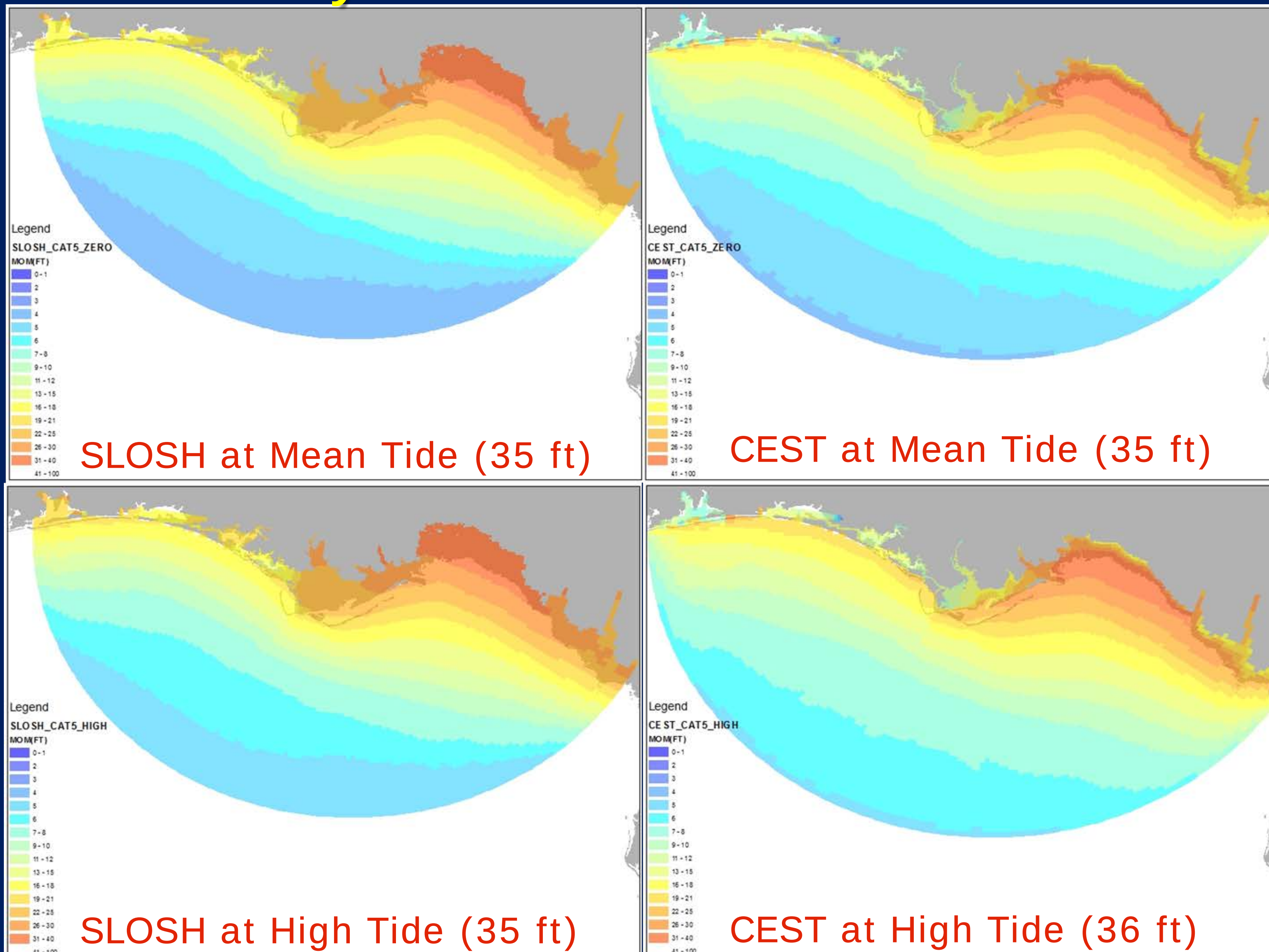
Comparison of Category 3 MOMs by SLOSH and CEST



Comparison of Category 5 MOMs by SLOSH and CEST



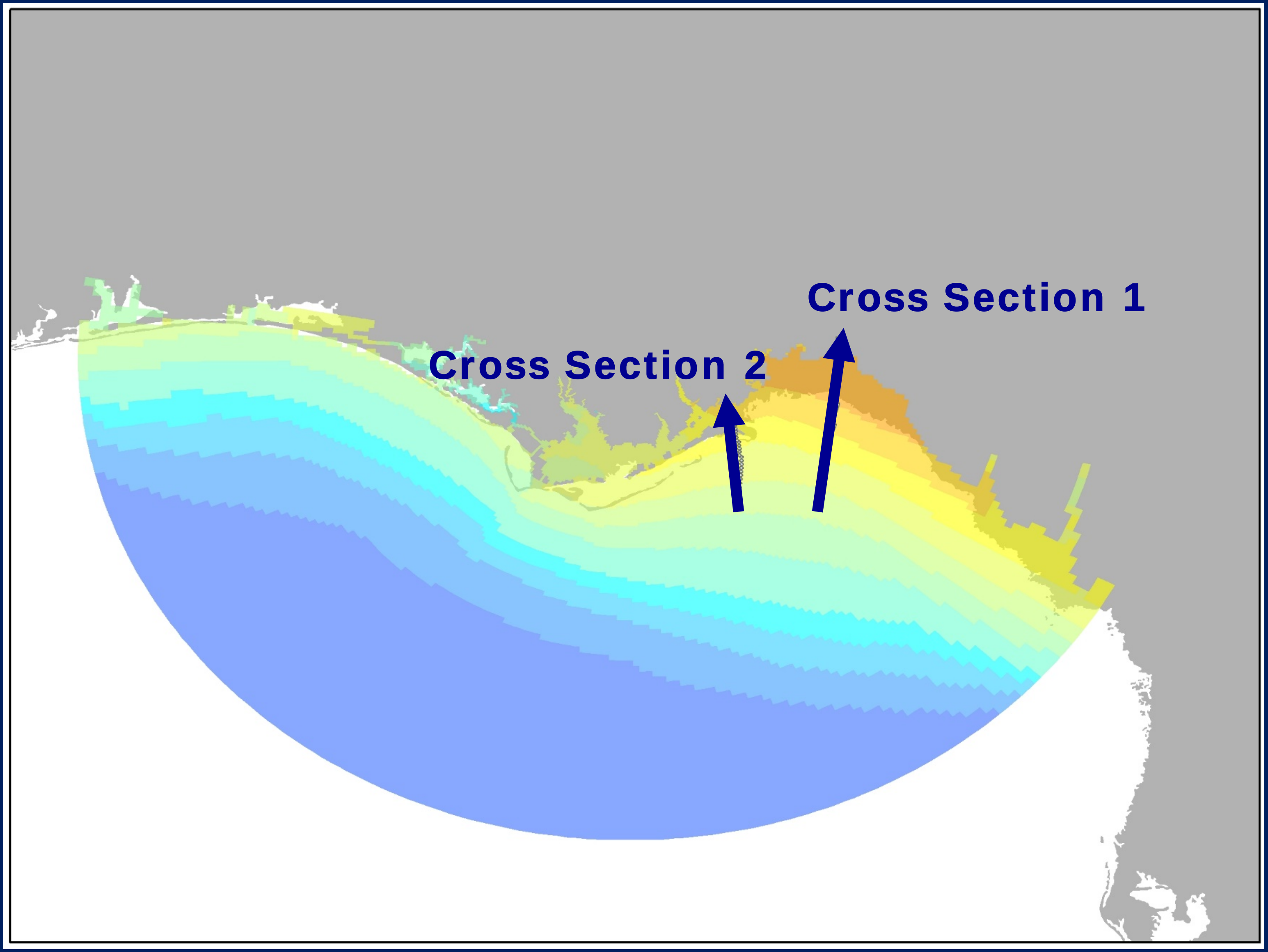
Comparison of Maximum MOMs By SLOSH and CEST

MOMs	SLOSH (mean)	CEST (mean)	SLOSH (high)	CEST (high)
Tropical Storm(ft)	6	5	7	6
Category 1(ft)	9	8	10	9
Category 2(ft)	16	16	17	17
Category 3(ft)	24	24	25	25
Category 4(ft)	30	29	31	30
Category 5(ft)	35	35	35	36

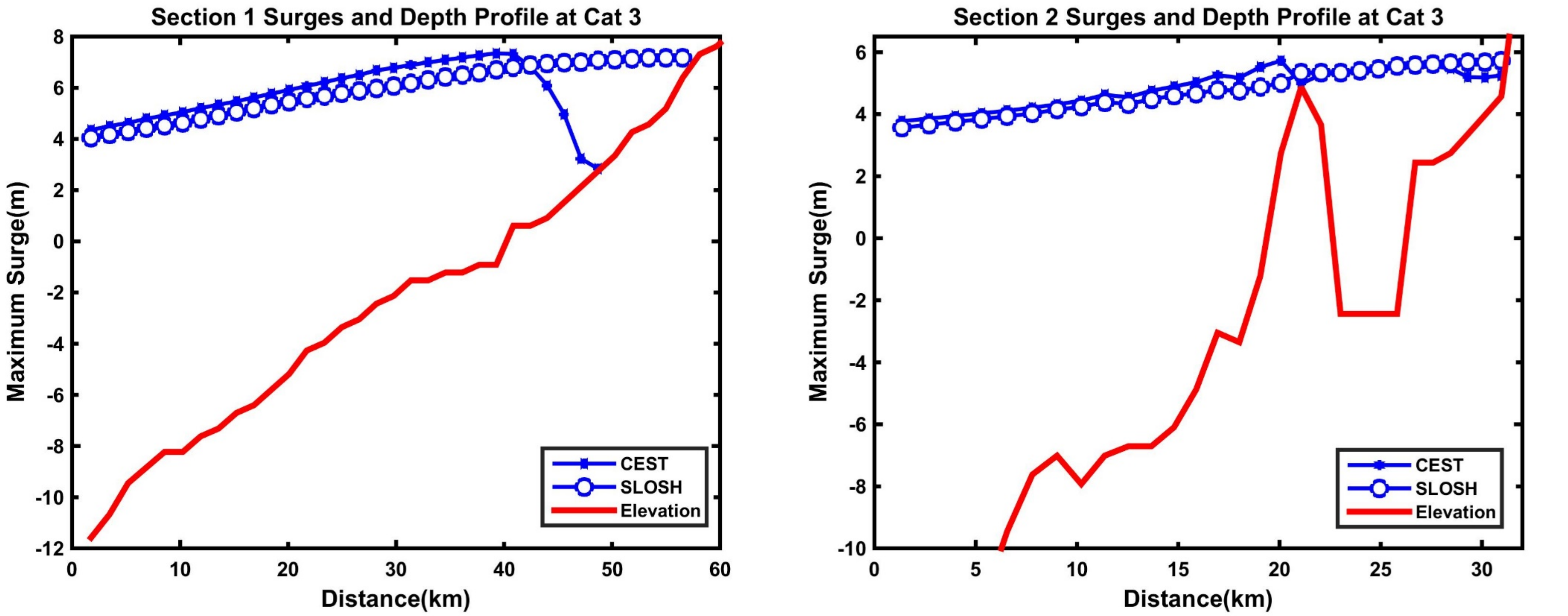
Comparison of Inundation Area By SLOSH and CEST

MOMs	SLOSH (mean)	CEST (mean)	SLOSH (high)	CEST (high)
Tropical Storm(km^2)	979	423	1387	660
Category 1(km^2)	1472	742	1785	925
Category 2(km^2)	2544	1774	2771	1989
Category 3(km^2)	3911	2641	4210	2776
Category 4(km^2)	5217	3373	5447	3526
Category 5(km^2)	6467	4091	6628	4291

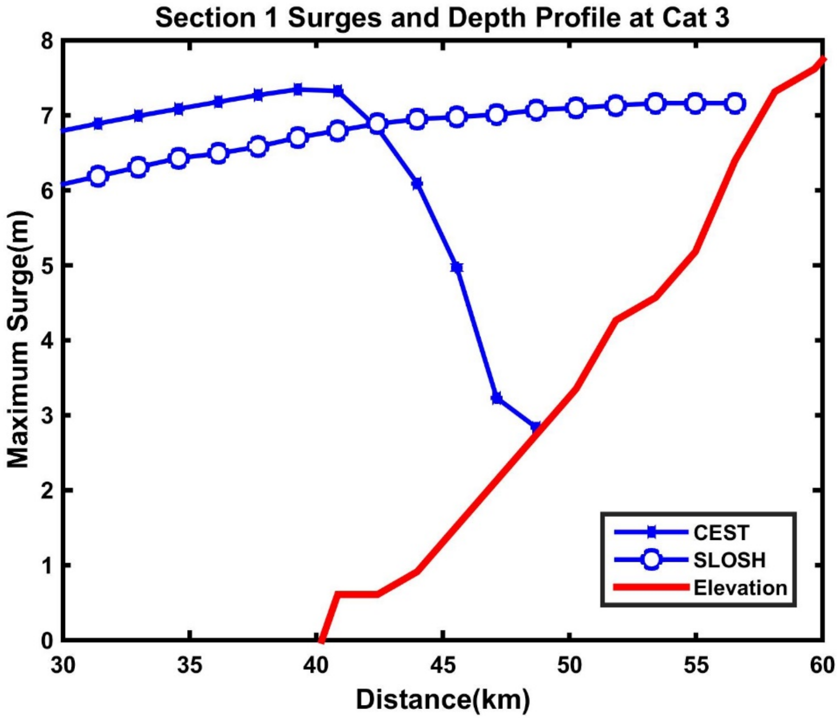
Cross Section along Coastal line

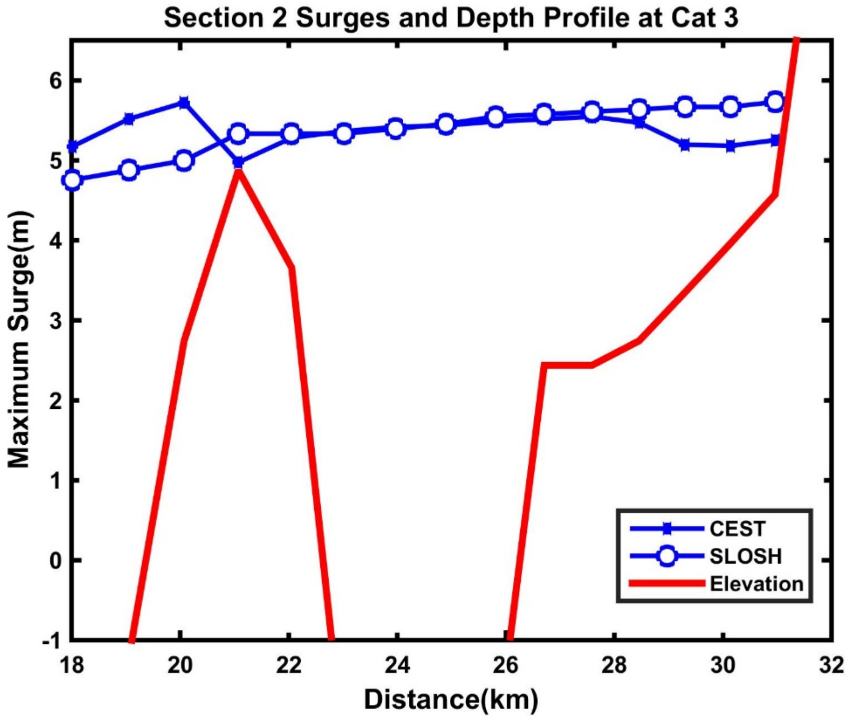


Maximum Surge of Category 3 MOM and Depth Profiles



Maximum Surge of Category 3 MOM and Depth Profiles – Zoom In





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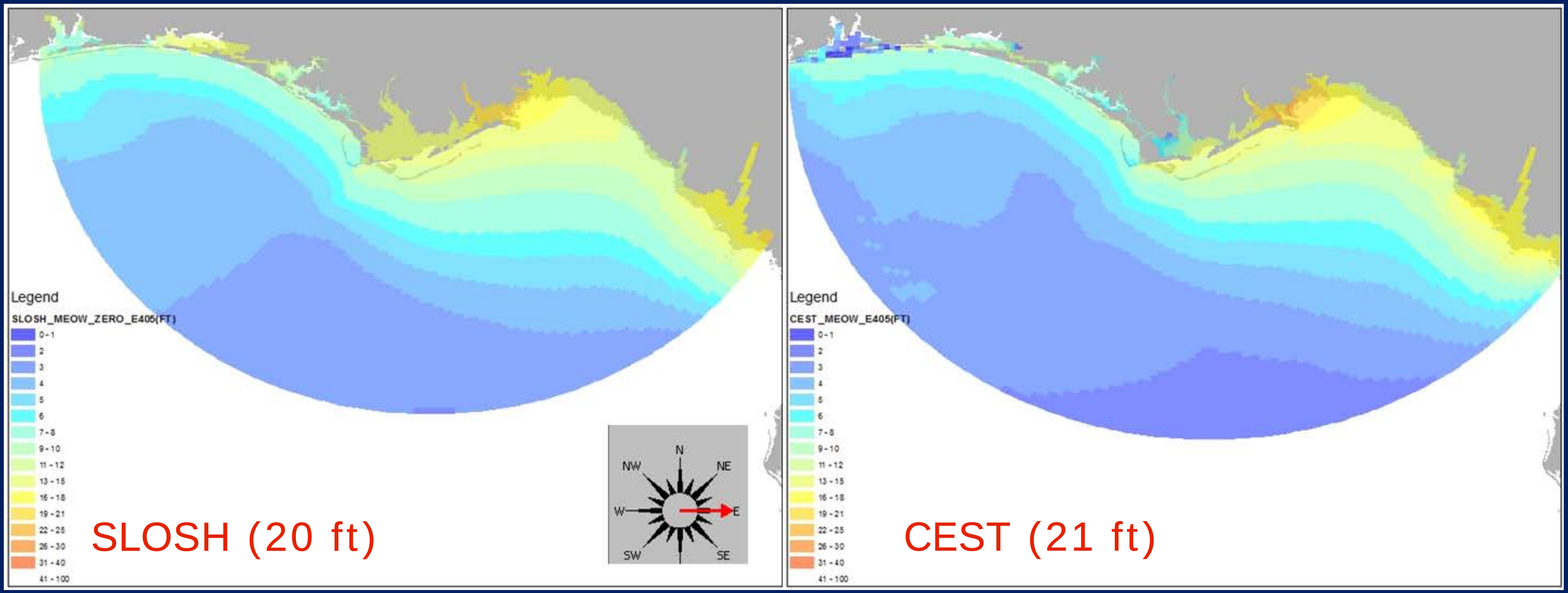
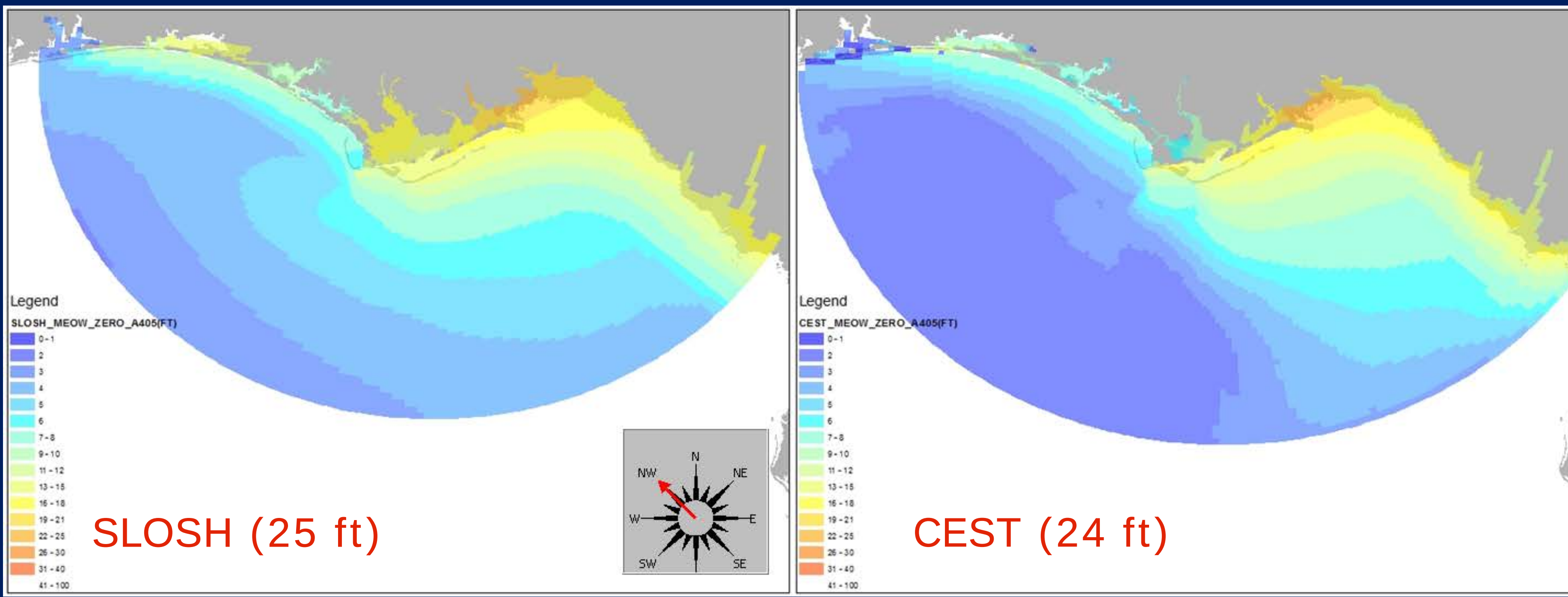
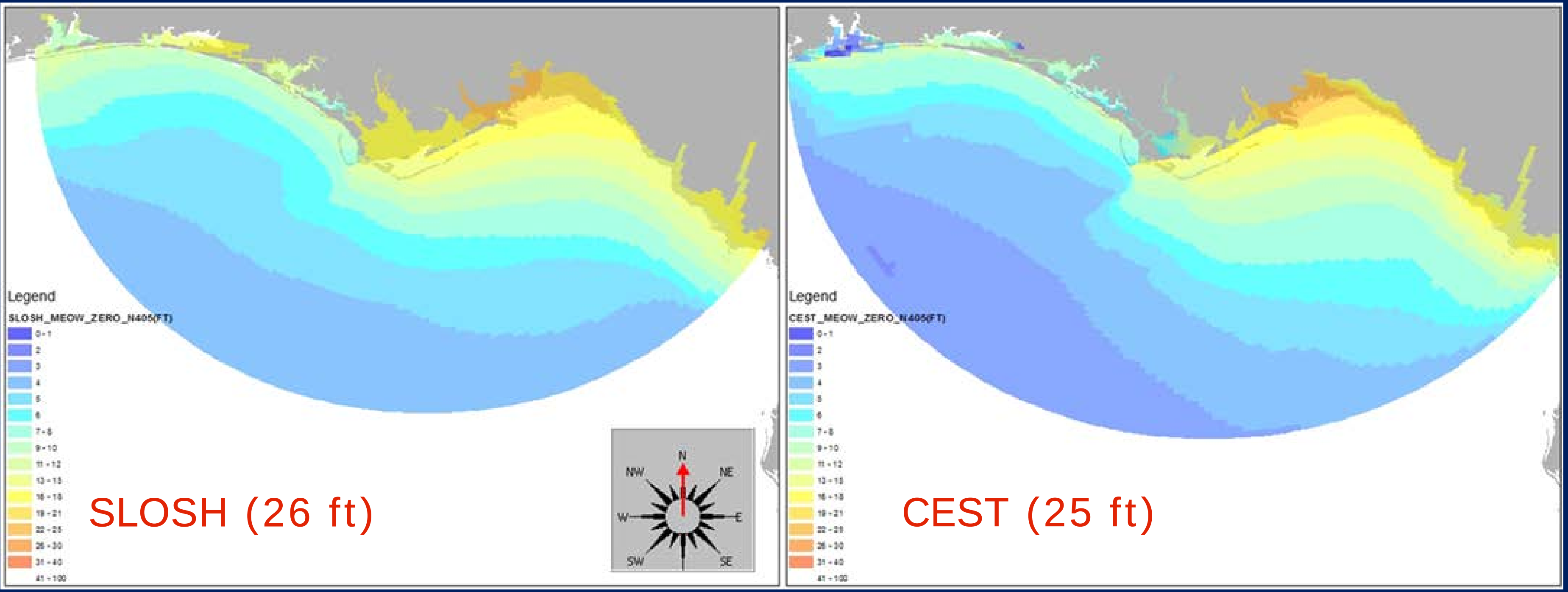
The MEOWs of e405 at mean tide (Direction=East, Category=4, Moving speed=5 mph)



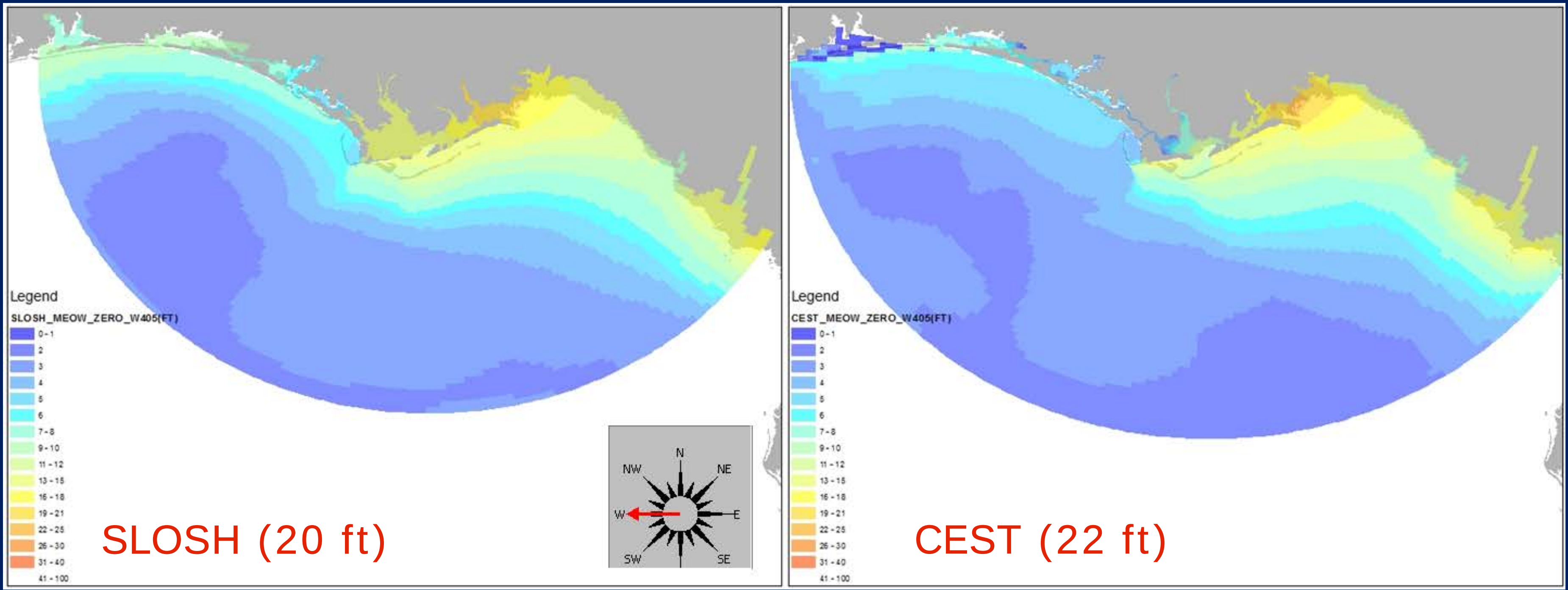
The MEOWs of a405 at mean tide (Direction=North-West, Category=4, Moving speed=5 mph)



The MEOWs of n405 at mean tide (Direction=North, Category=4, Moving speed=5 mph)



The MEOWs of w405 at mean tide (Direction=West, Category=4, Moving speed=5 mph)



Comparison of Maximum MEOWs by Category 4 hurricanes with Moving Speed of 5 mph at Mean Tide

MEOWs	SLOSH (ft)	CEST (ft)
East direct (e)	20	21
East-North-East direct (i)	21	22
North direct (n)	26	25
North-East direct (b)	21	23
North-North-East direct (c)	24	24
North-North-West (f)	26	25
North-West direct (a)	25	24
West direct (w)	20	22
West-North-East (d)	24	24

Conclusions

- CEST can run on the SLOSH Basins robustly and efficiently.
- MOMs and MEOWs comparisons indicated that CEST generated similar surge patterns and peak surges at most cases.
- Inundation area comparisons showed that CEST produced smaller inundation extent on the land even the magnitude of maximum surges is similar.

Future Work

- Continuing to convert all SLOSH basins into CEST grid;
- Replicating current operational capabilities (i.e. creation of MOMs, MEOWS, and ensemble runs);
- Examining the different inundation patterns of MOMs and MEOWs produced by CEST and SLOSH;
- Developing a prototype of CEST P-Surge.

Time Line

Tasks	Q3 (2015)	Q4	Q1 (2016)	Q2	Q3	Q4	Q1 (2017)	Q2
Task 1: Testing CEST on existing and recently developed SLOSH basins				Report on testing result				
Task 2: Developing CEST P-Surge				Initial report on P-Surge				**Final report on P-Surge**
Task 3: Conducting real-time surge forecasting during hurricane seasons	Surge maps and analysis	Surge maps and analysis			Surge maps and analysis	Surge maps and analysis		
Task 4: Porting CEST to NHC forecast environment				**CEST code, initial set up and training documents**				**Final set up and training documents and Project report**

Next step

Thanks

Questions?