SESSION C: COASTAL RISK 2

ROLE OF STORM MOTION AND ENVIRONMENT FLOW FOR SURGE RISK ASSESSMENT

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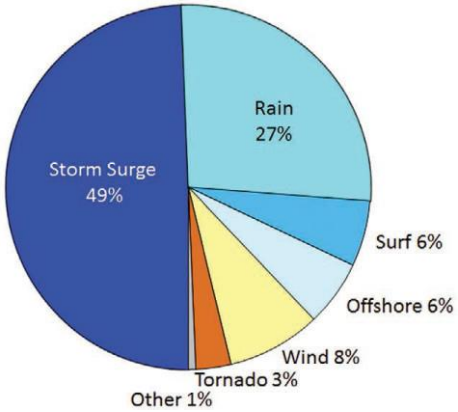
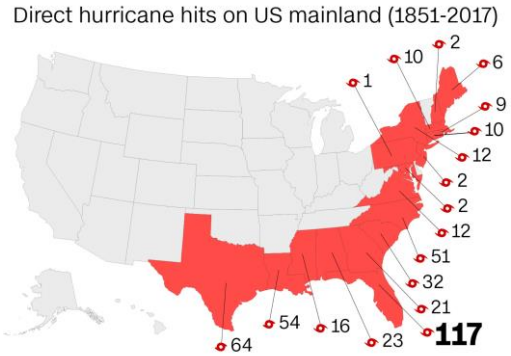
3rd International Workshop on Waves, Storm Surges, and Coastal Hazards Incorporating the 17th International Waves Workshop

SURGE INDUCED BY HURRICANES
POSE GREAT RISK TO COASTAL COMMUNITIES AND PROPERTIES



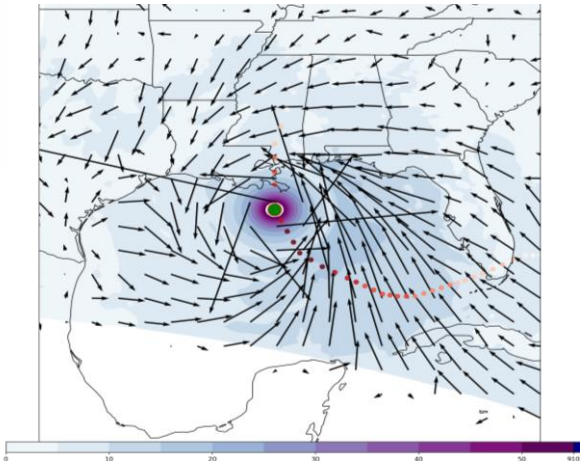
50-year records (1963–2012)
Rappaport 2014

1. Lack of historical data complicate risk assessment



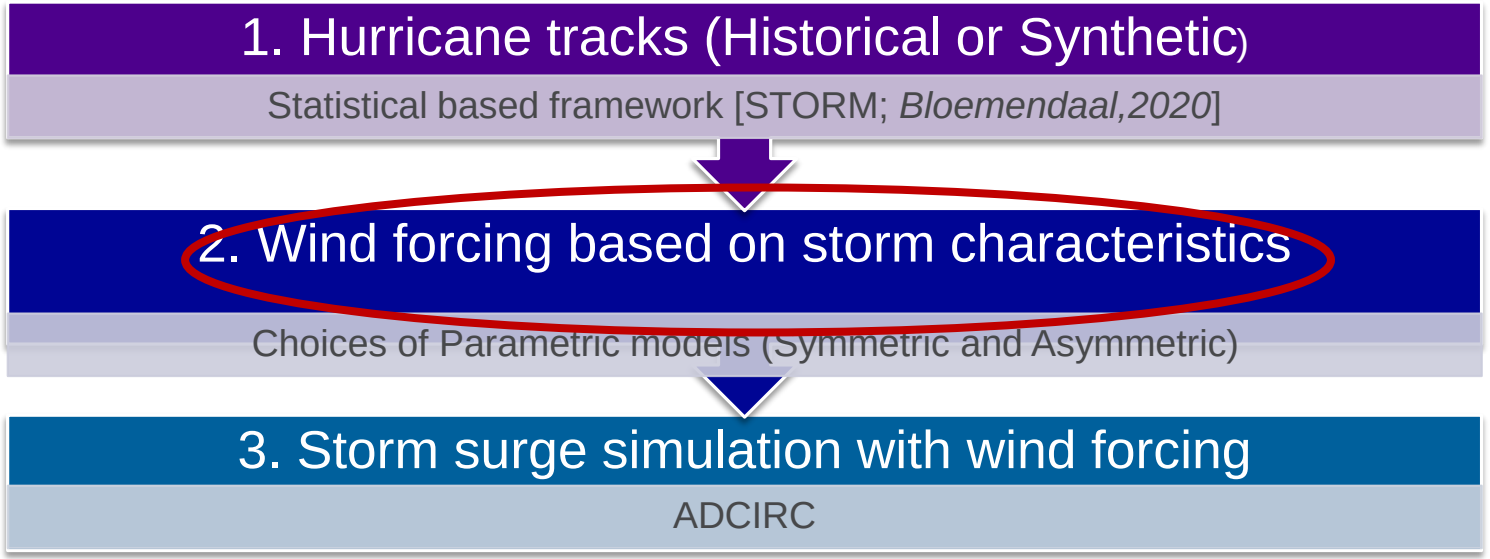
Historical landfalling events count:
NOAA (1851-2017)

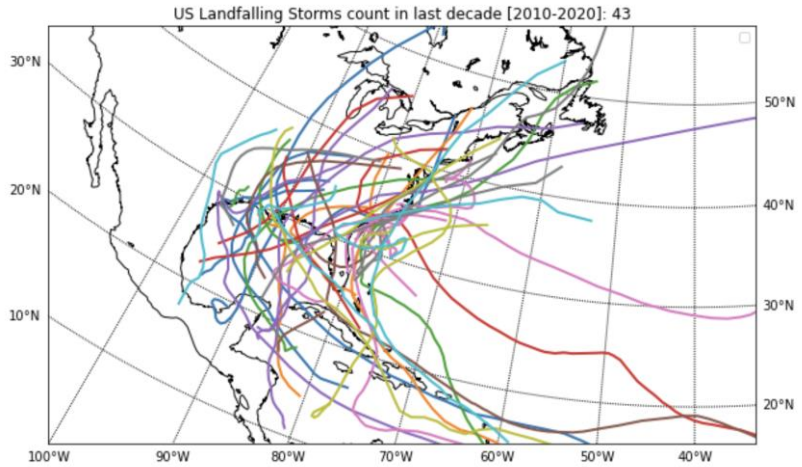
2. Another challenge: choice of wind field modeling

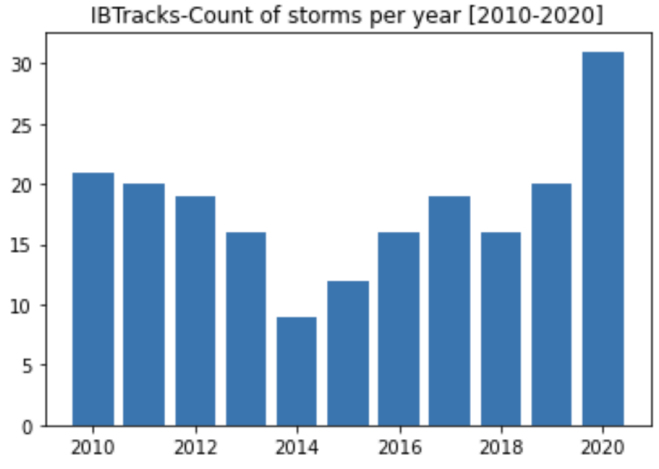


Storm surge risk assessment is required for building resiliency in coastal communities

MODEL BASED FRAMEWORK FOR STORM SURGE





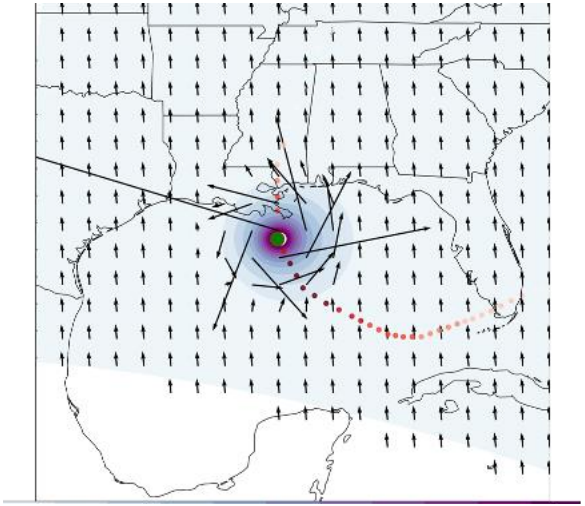


ROLE OF STORM MOTION AND ENVIRONMENT FLOW ON DIFFERENT PARAMETRIC TROPICAL CYCLONE FORCING FOR MODELED STORM TIDE

PARAMETRIC WIND PROFILE

Parametric models: Vortex + background wind field

- **Mean radial profiles based on cyclostrophic or gradient wind**



A snapshot of parametric wind spatial structure with LC12 background wind field model

Background winds as function of forward speed, *Vs*

Popular parametric representation of Background wind $V_b(r)$

Constant factor=1

- $|V_s|$ (Powell et al., 2005; Mattocks and Forbes, 2008; Vickery et al., 2009b)

Radially varying factor

- $\frac{R_{max}r}{R^2_{max}+r^2}|V_s|$ (SLOSH; Jelesnianski et al 1992)

Varying factor with radial wind fraction

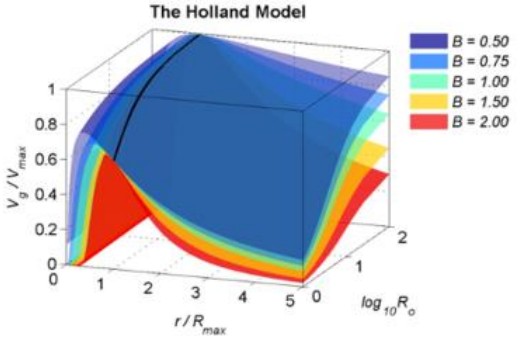
- $\frac{V_r}{V_{max}}|V_s|$ (ADCIRC; Luettich & Westerink, 2004)

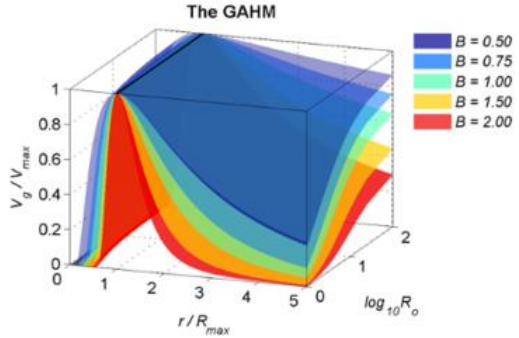
Empirically derived constant reduction factor with angle 20 deg counter-clockwise

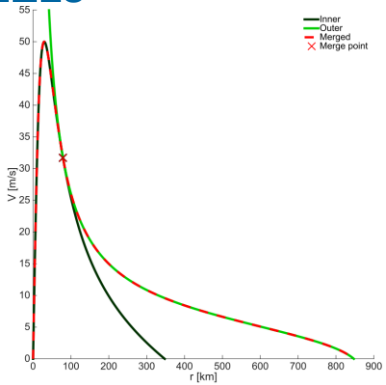
- $.55|V_s|$ (LC12; Chavas and Lin, 2012)

CHOICE OF PARAMETRIC VORTEX MODELS

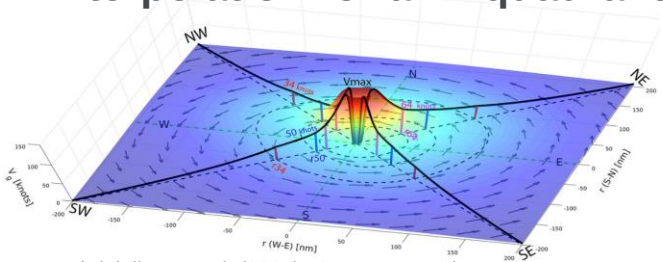
Holland (1980), Generalized Asymmetric Holland (GAHM), CLE15







GAHM uses multiple isotach interpolation for all 4 quadrants



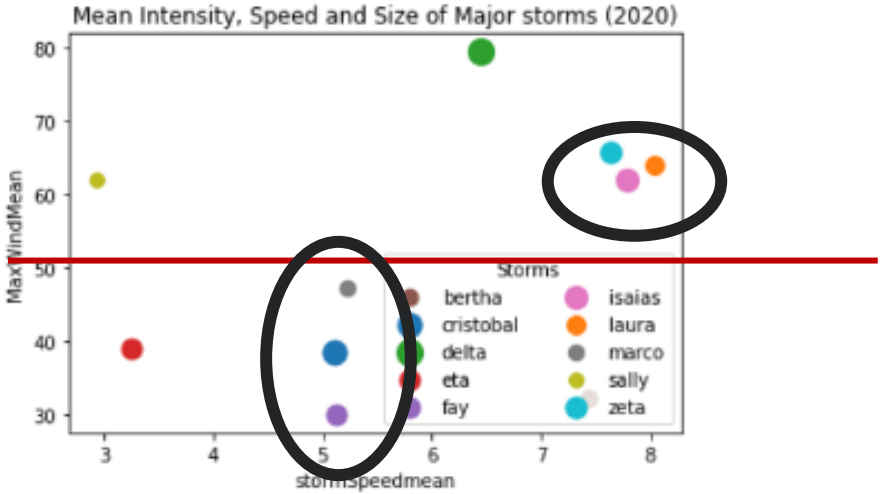
Abdolali, A., et al. (2021). *Ocean Dynamics*, https://doi.org/10.1007/s10236-020-01426-9

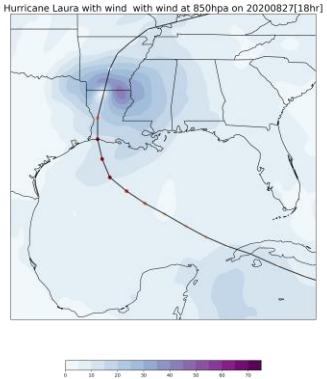
CLE15 is a simple full physics theoretical model merged inner core from Emanuel and Rotunno (2011) and outer core from Emanuel (2004)

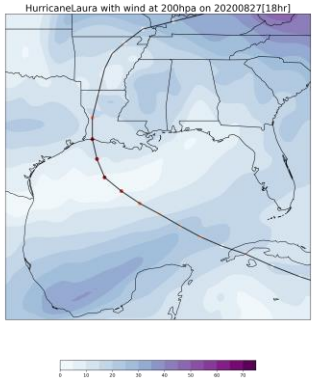
Chavas, Daniel R., Ning Lin, and Kerry Emanuel. 2015. "A Model for the Complete Radial Structure of the Tropical Cyclone Wind Field. Part I: Comparison with Observed Structure." *Journal of the Atmospheric Sciences* 72 (9): 3647–62. https://doi.org/10.1175/JAS-D-15-0014.1.

STORM CHARACTERISTICS

- Weaker and slower storms: example Sally, Eta, **Cristobal**, Fay, Bertha
- Intense and faster storms: example hurricane **Laura**, Zeta, Isaias

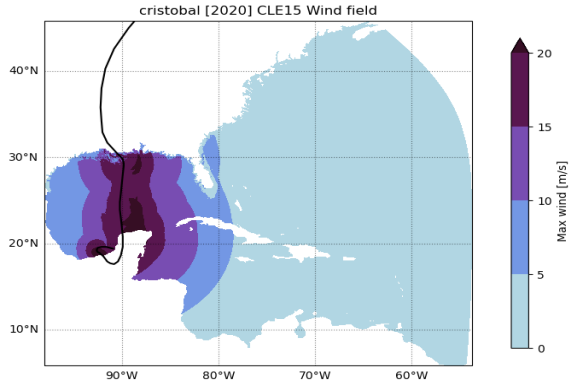


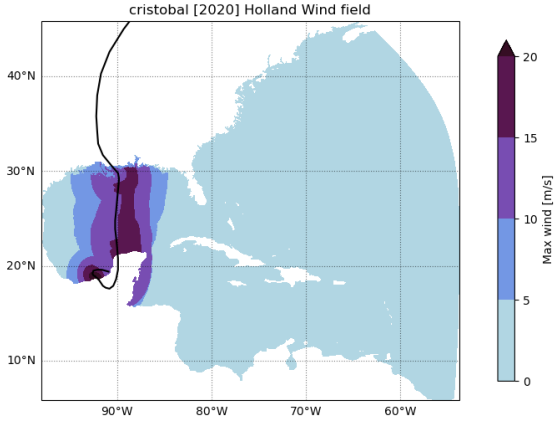


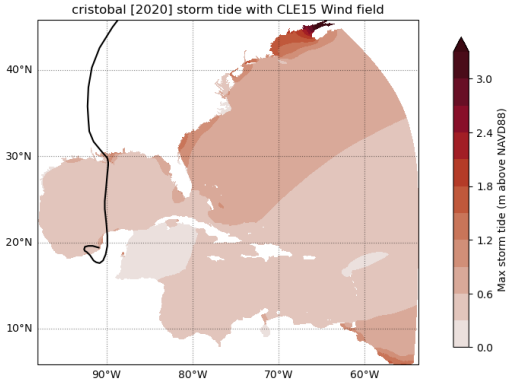


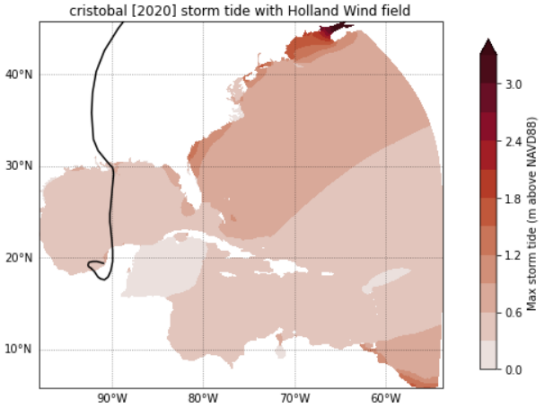
Year 2020 significant landfalling events

CRISTOBAL (2020)

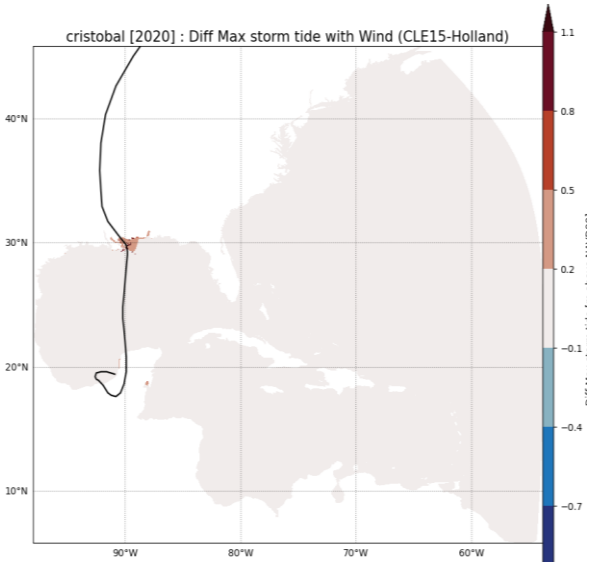






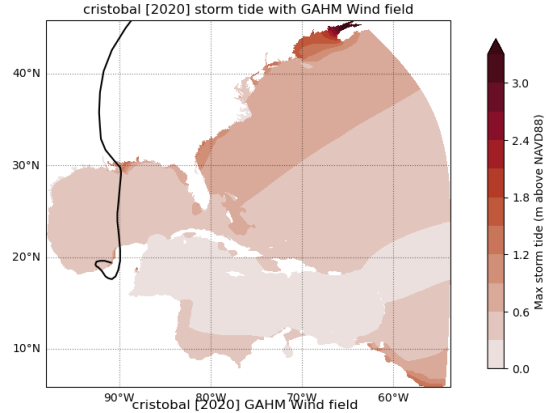


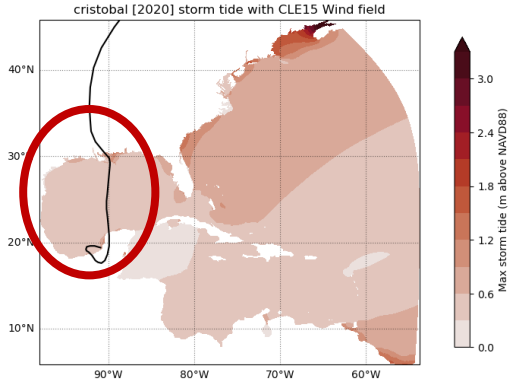
Higher storm peak tide in CLE15 compared to Holland

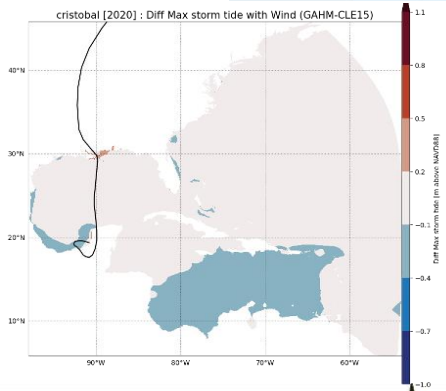


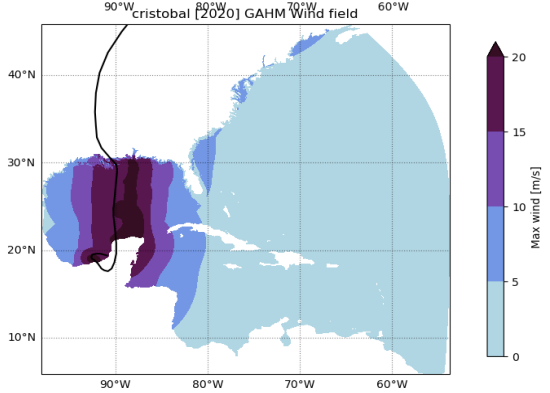
CRISTOBAL (2020)

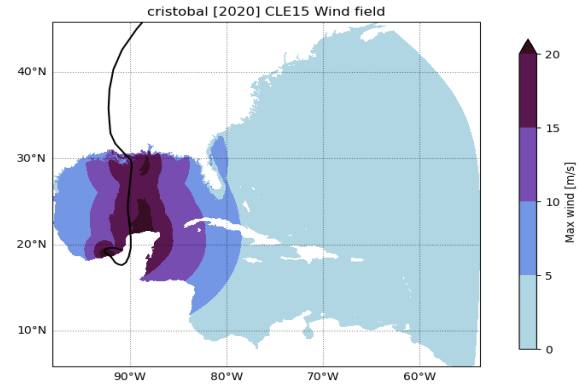
Higher storm peak tide in GAHM compared to CLE15

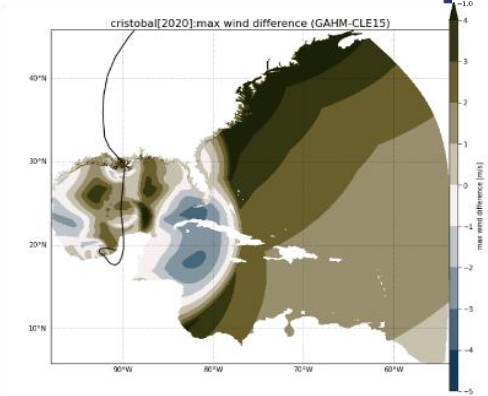








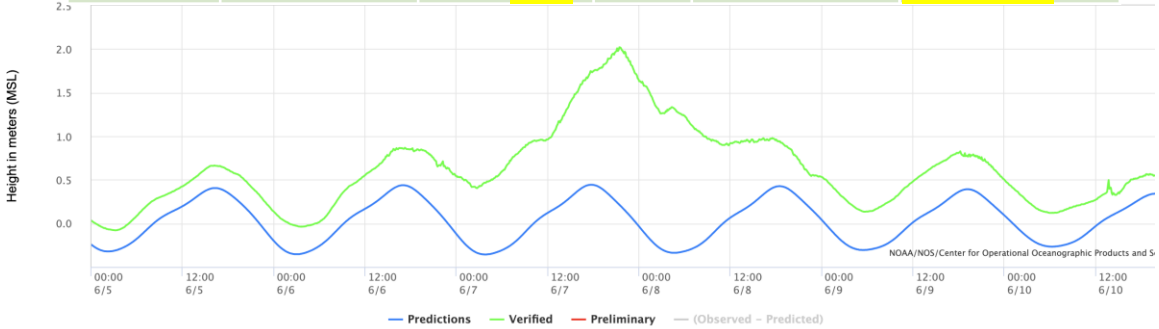




STORM TIDE TIME SERIES

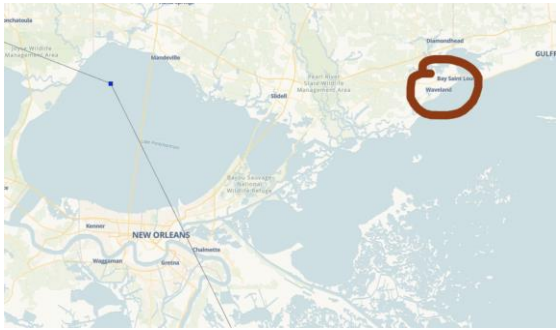
Tide gauge station on right side of storm

HWM	CLE15+T	GAHM+T	H+T	CLE15+LC12	GAHM+LC12
2.02	1.15	**1.48**	NAN	1.19	**1.47**



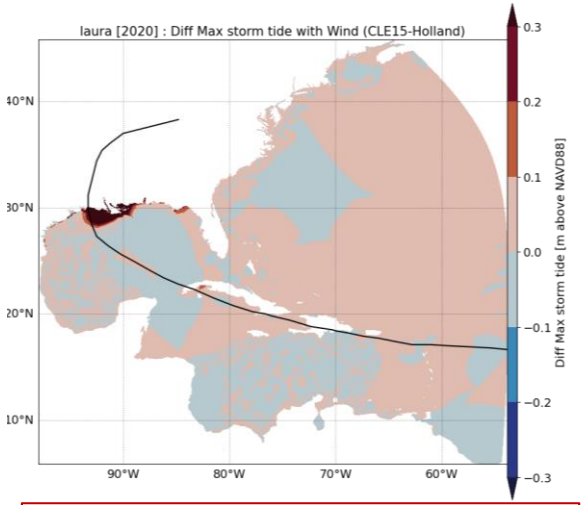
Bay Waveland Yacht Club, MS

RMax=90km; ROCI=270km
Station is inside ROCI (150km away from storm)



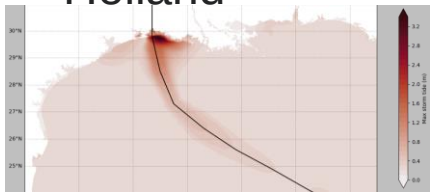
LAURA: PEAK STORM TIDE AND DIFFERENCE

With different Vortex model and same ADCIRC default background

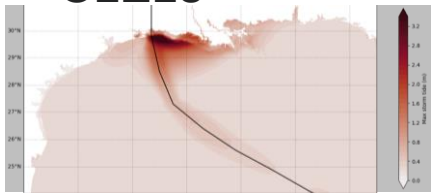


CLE15 -Holland:
CLE15 > Holland dominated in inner core

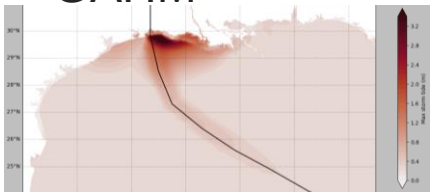
- Holland



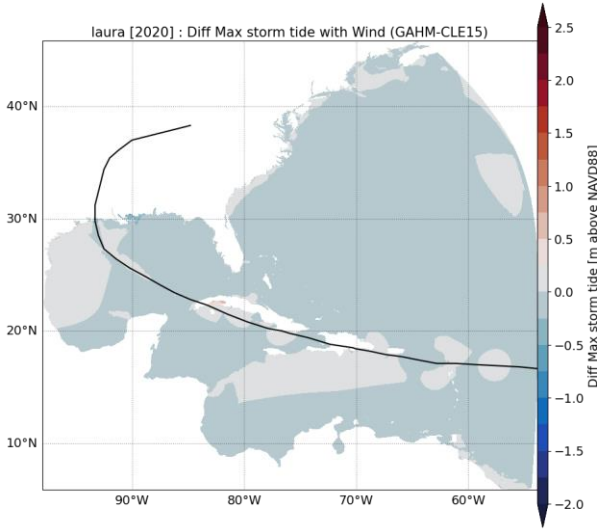
- CLE15



- GAHM

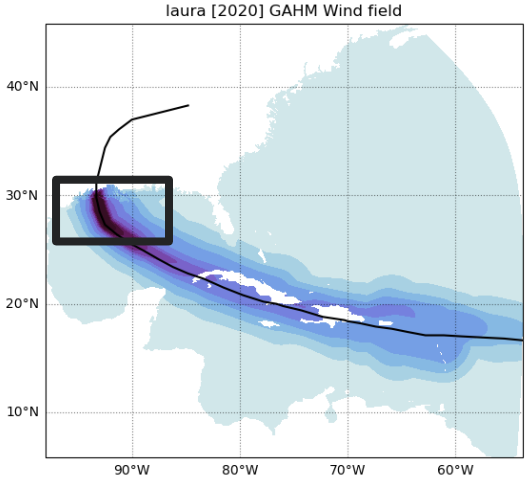


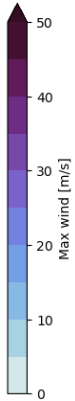
Peak storm tide difference:
CLE15 > GAHM dominated mostly on right in outer region

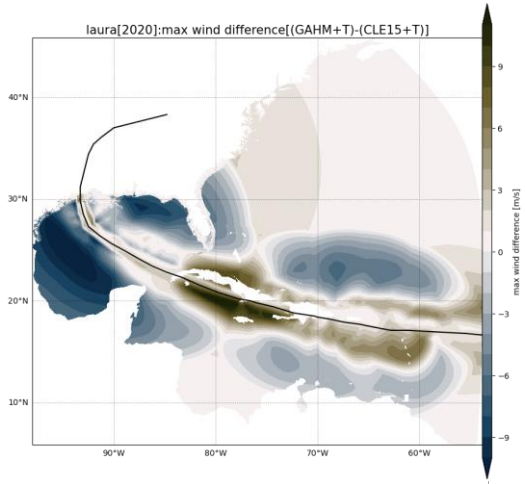


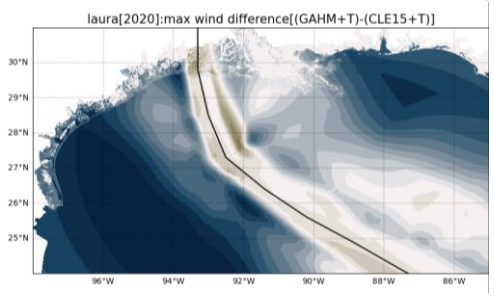
LAURA (2020) WIND FIELD

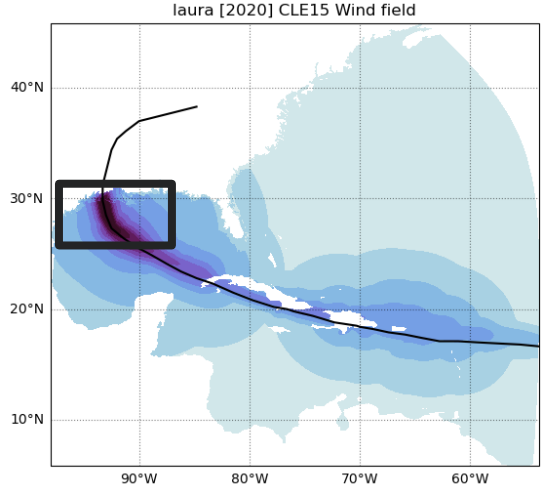
With same ADCIRC default background field

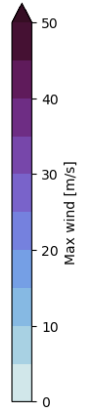










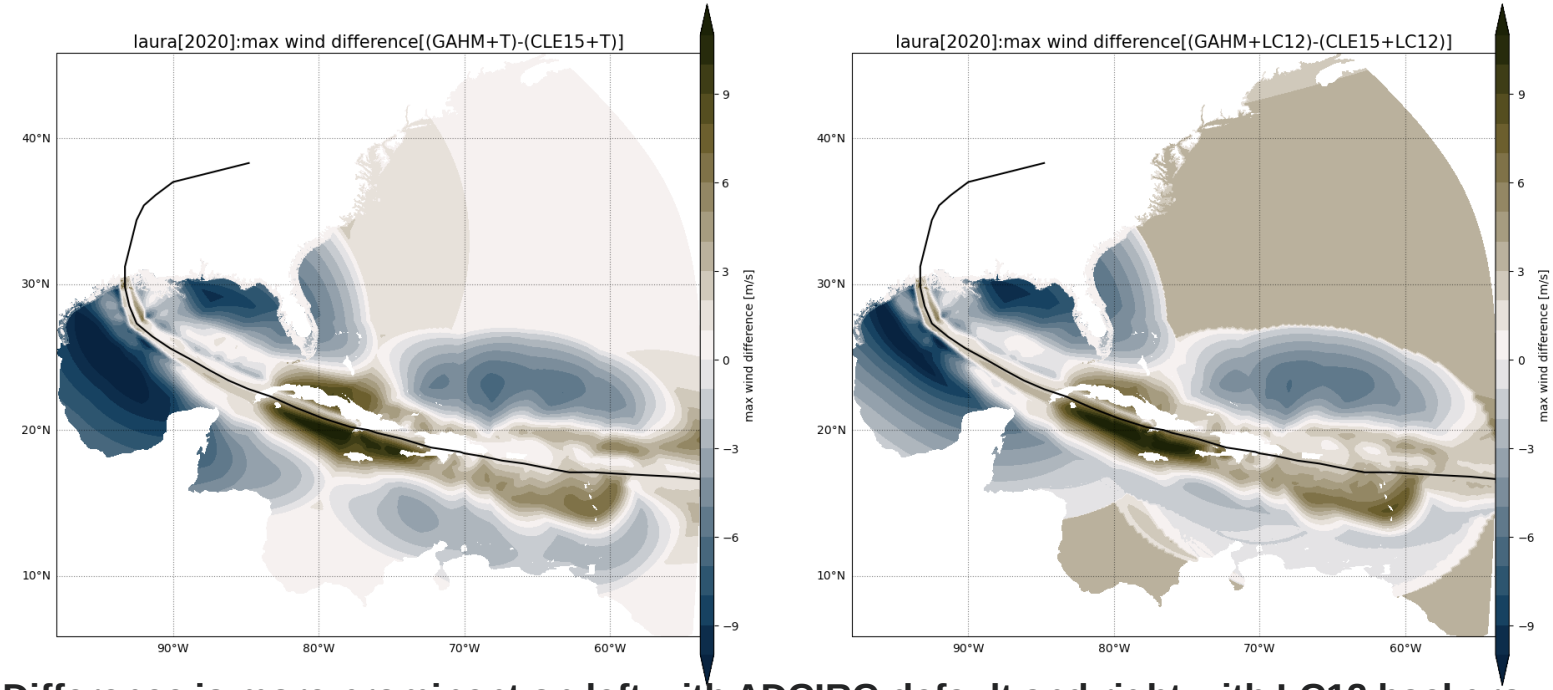


GAHM > CLE15 in inner core

Outer region wind field is enhanced in CLE15 compared to GAHM

WIND FORCING DIFFERENCE

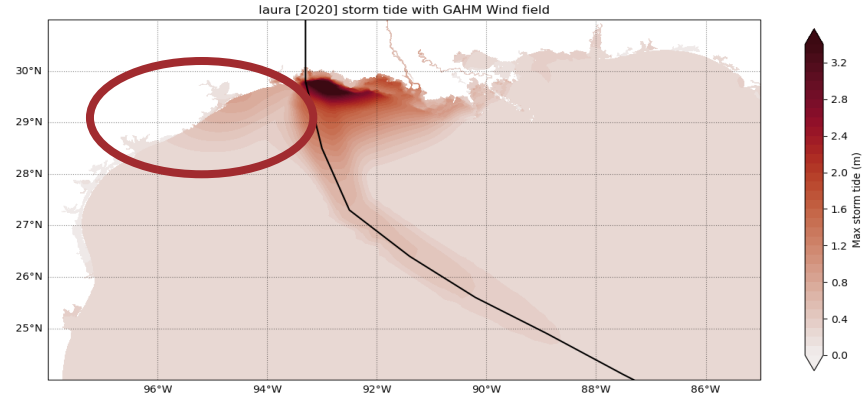
GAHM-CLE15 with different background wind field

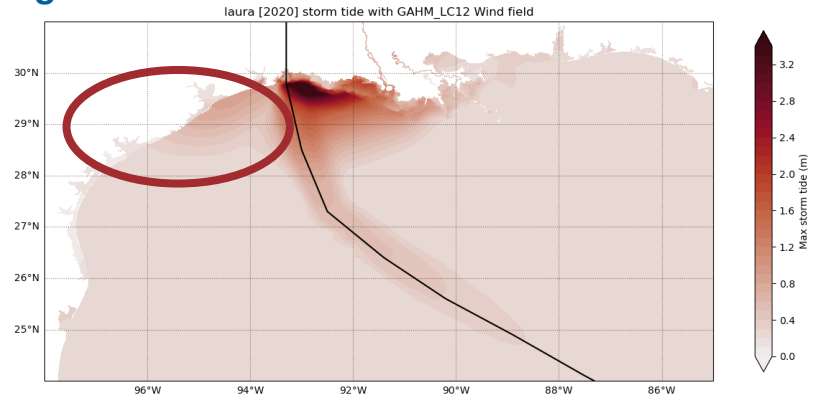


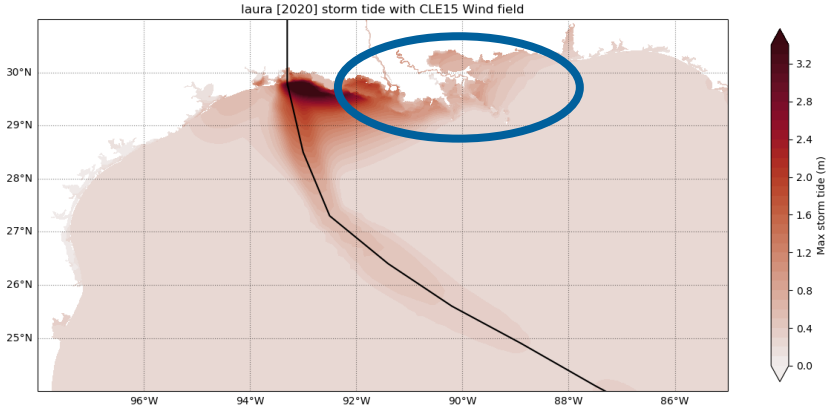
Difference is more prominent on left with ADCIRC default and right with LC12 background

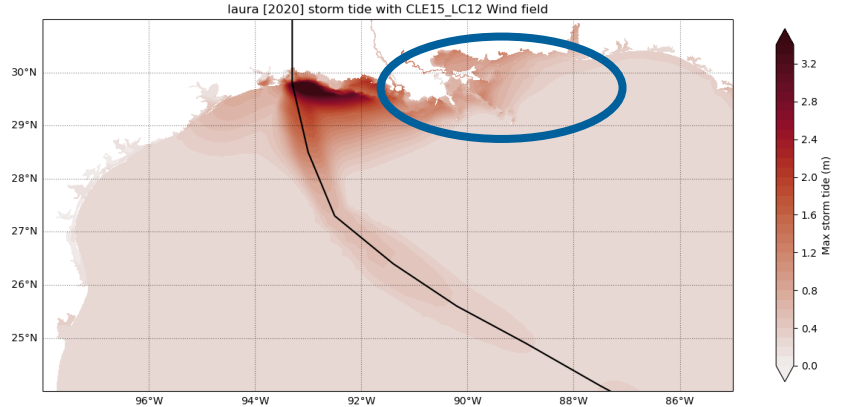
LAURA WITH DIFFERENT WIND FORCING

GAHM and CLE with ADCIRC default and LC12 background flow



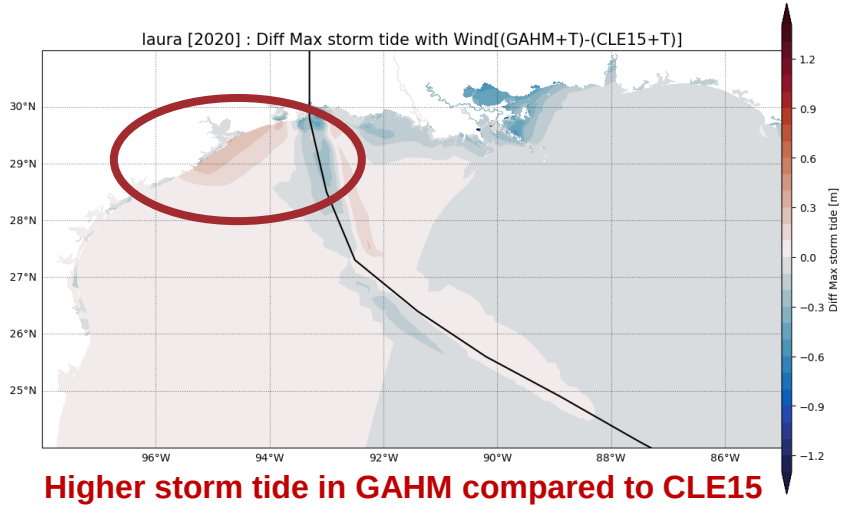




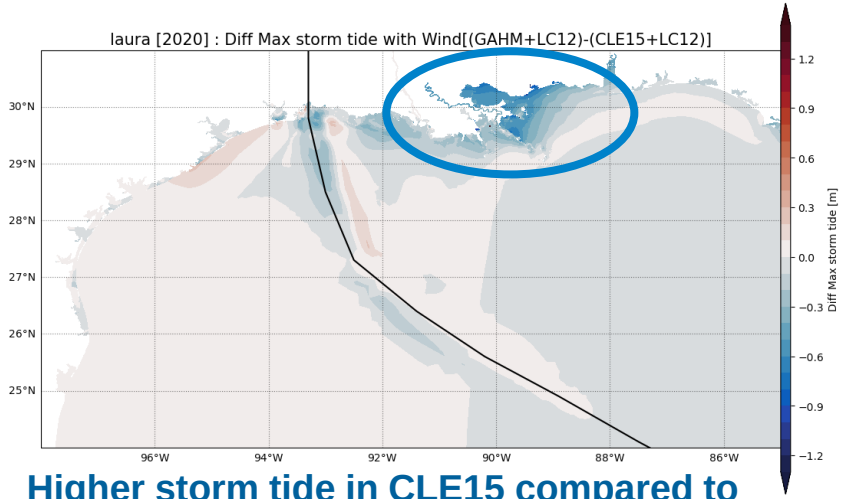


SENSITIVITY OF VORTEX MODEL

With different background wind models



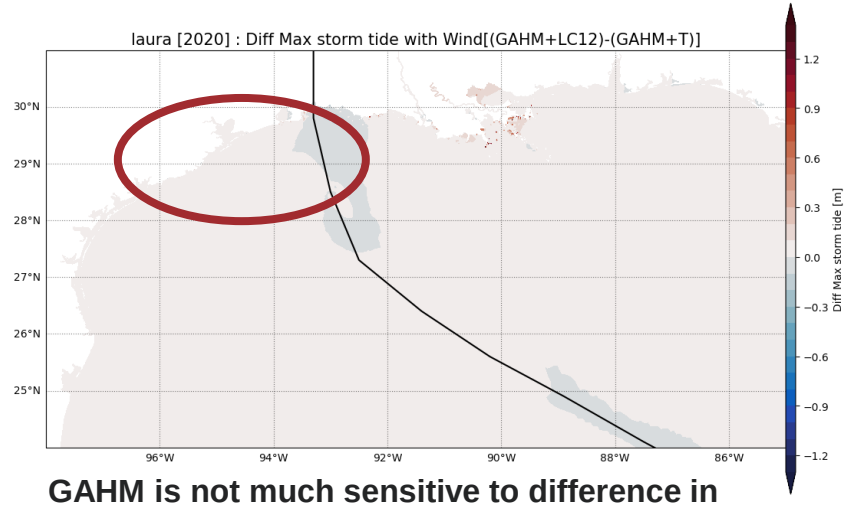
Higher storm tide in GAHM compared to CLE15 on left inner region of storm



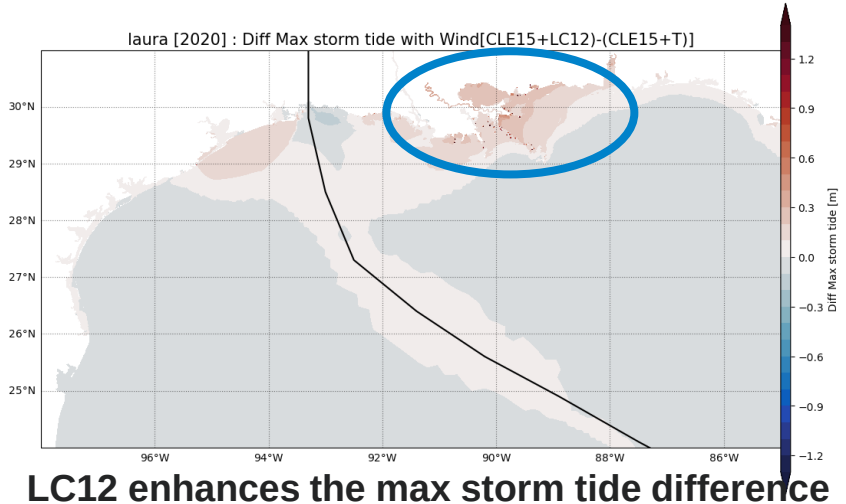
Higher storm tide in CLE15 compared to GAHM on outer right region of the storm

SENSITIVITY OF BACKGROUND MODEL

With different vortex models



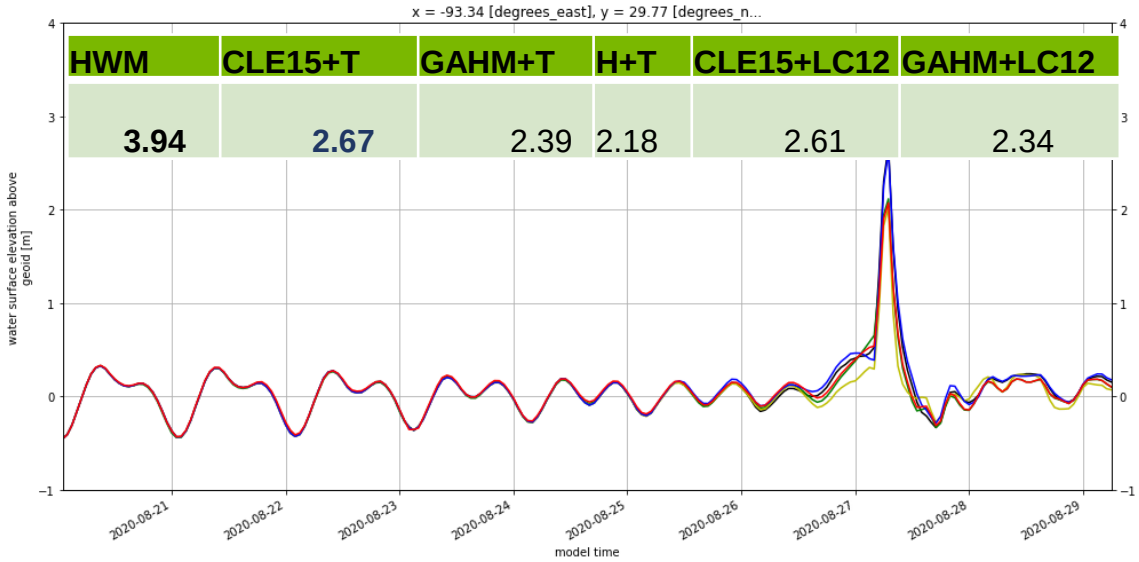
GAHM is not much sensitive to difference in background wind model (LC12 and T)



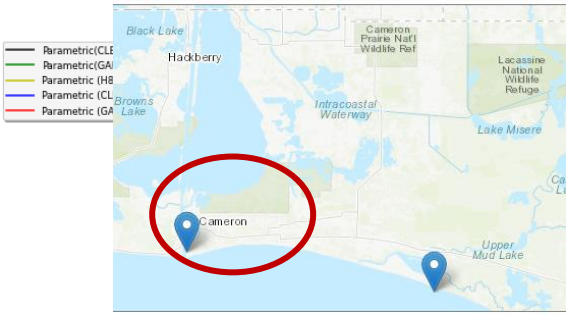
LC12 enhances the max storm tide difference more for CLE15 vortex

STORM TIDE TIME SERIES

HWM close to inner core



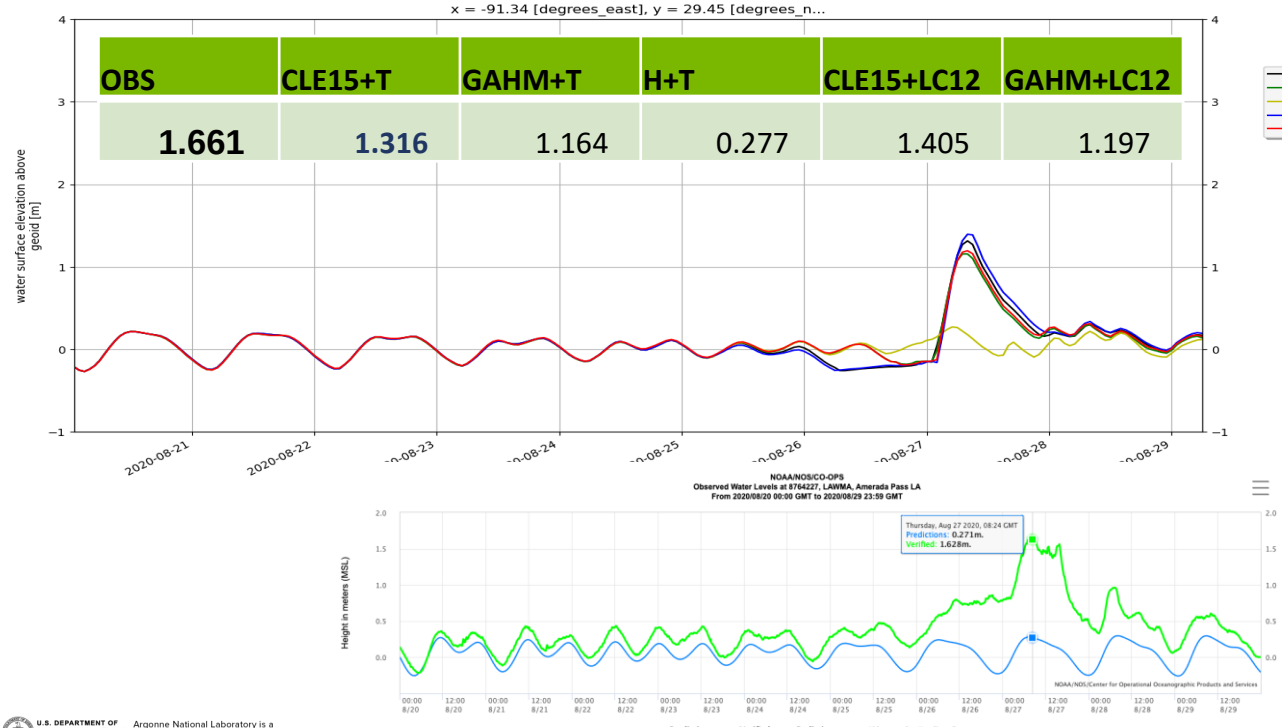
Calcasieu Pass, LA -
HWM ID: 8768094
(1.08 m above MSL)

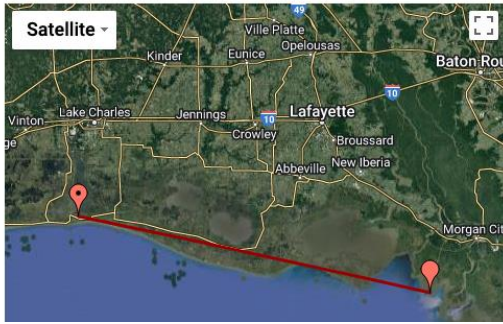


- Location was close to inner core on left side of the storm

STORM TIDE TIME SERIES

Station away from inner core





- Station was 43 km away from radius of outer closed isobar

SUMMARY

- Overall CLE15 is better than Holland for capturing wind and storm tide both as supported by previous study as well (Wang et al 2022)
- For weaker and slower storms such as Cristobal, GAHM seem to give higher peak storm tide as compared to CLE15
- For faster and intense storms, example : Laura, CLE15+LC12 seem to give higher storm tide and wind forcing

Ongoing work

- Investigating more storms for different year background flow and events
- Application in offshore wind energy project