Sediment transport and morphodynamics at salt marsh boundary in the shallow bay during cold front passages

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Abstract

Understanding the processes of wetland boundary morphodynamics is critical to evaluating the vulnerability of wetlands. Specifically, analysis of changes in sediment supply at the wetland boundary due to the effects of global sea-level rise and local subsidence provides a more comprehensive depiction of future changes in coastal wetlands. This requires analysis through numerical modeling along the wetlands area to provide predictive information for future scenarios. However, sediment transport and morphological dynamics in adjacent bays have not been incorporated into regional models of wetland evolution. The study investigates the short-term sediment transport processes in a highly resolved wetland boundary within Galveston Bay during cold front passages. In-situ measurements verified the hydrodynamic and waves conditions at the salt marsh boundary during the period of two cold front passages. The model showed that the circulation of sediment fluxes to Galveston Bay was increased during the cold front passage. In addition, extensive wetlands flooding caused by cold fronts significantly affected the sediment supply to the wetlands. The sea-level rise adaptation of the salt marsh platform was verified by comparing the baseline and relative sea level rise models.

SEDIMENT TRANSPORT AND MORPHODYNAMICS AT SALT MARSH BOUNDARY IN THE SHALLOW BAY DURING COLD FRONT PASSAGES

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Dec 14. 2021

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Salt Marsh
Sediment transport

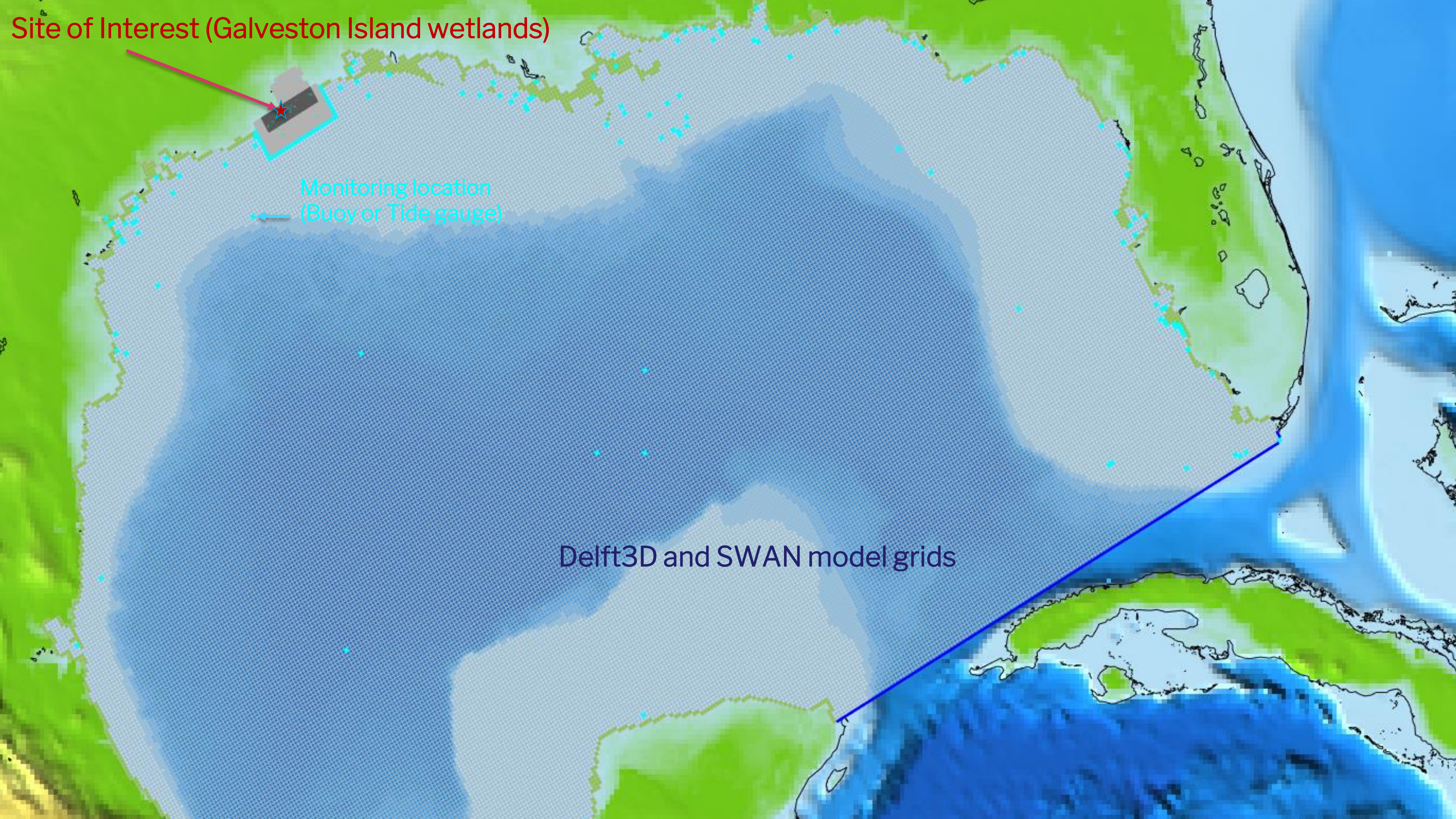

Wetland's vulnerability to the loss in response to global
sea-level rise and land subsidence

Mechanisms of coastal wetland edge’s morphodynamics

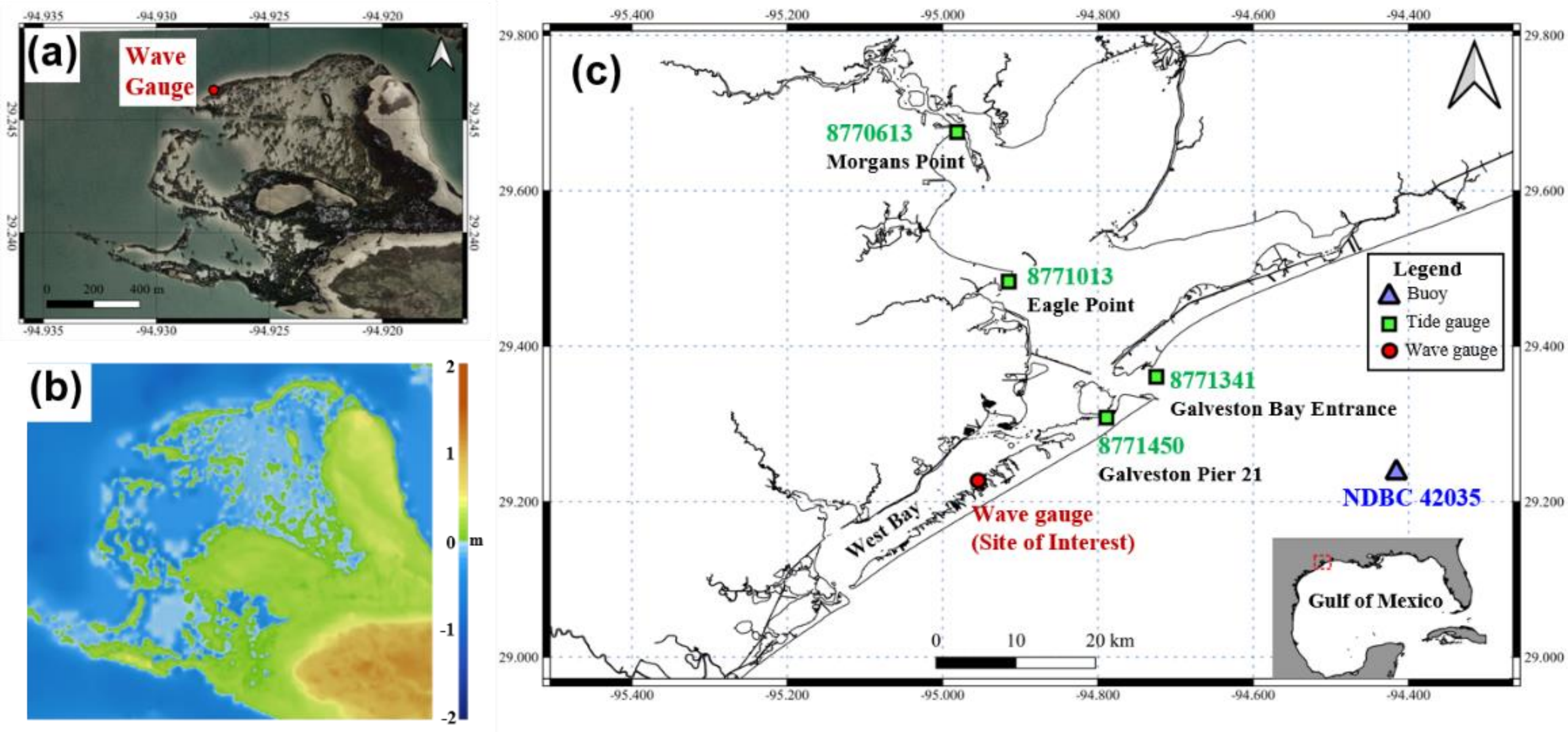
PURPOSE

- To investigate the short-term sediment transport processes during the cold front passage using numerical model

- To verify cold front induced wind's effect on salt marsh boundary accretion and erosion <u>with and without relative sea level rise</u>


Site of Interest (Galveston Island wetlands)
Monitoring location
(Buoy or Tide gauge)
Delft3D and SWAN model grids

SITE OF INTEREST



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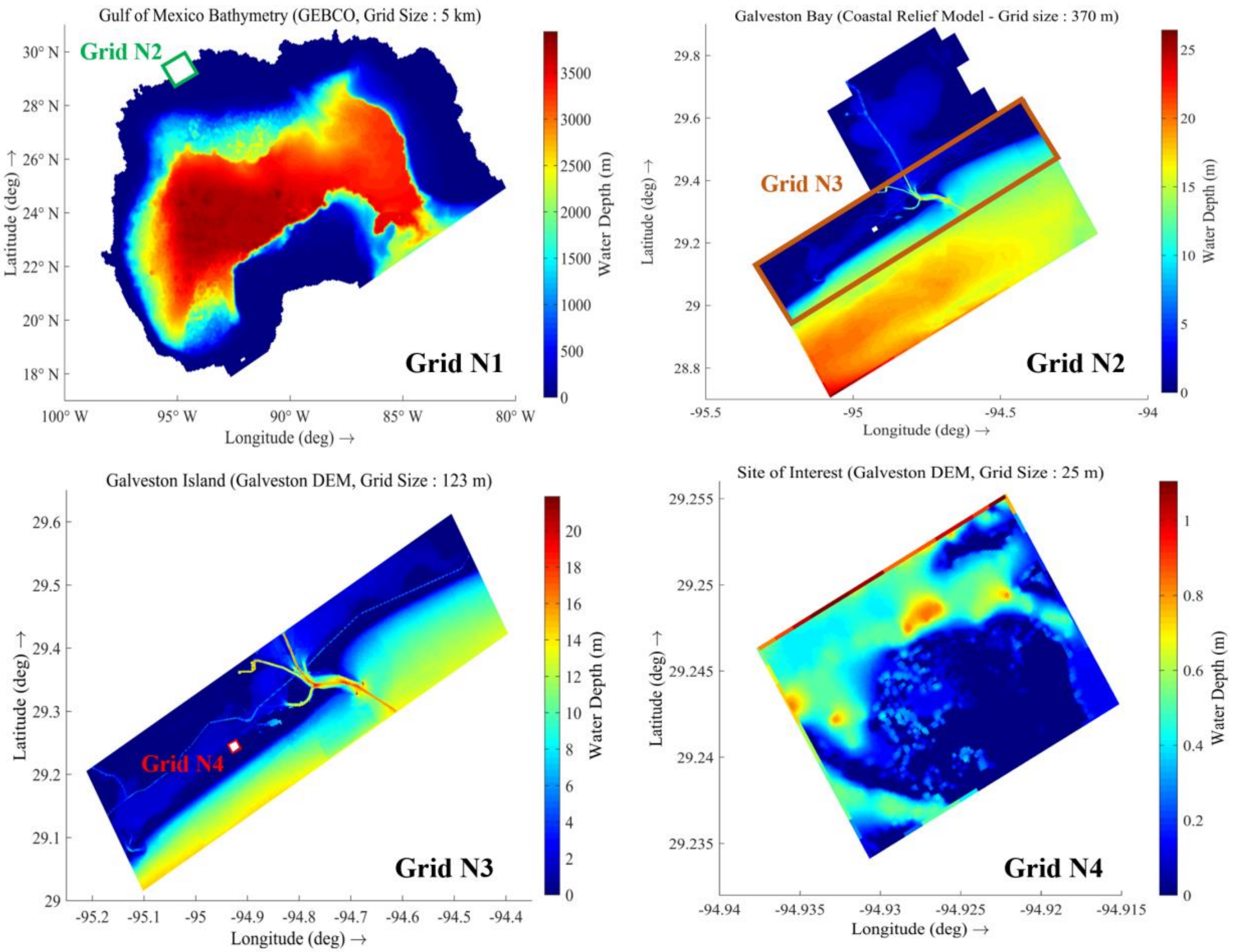
DELFT3D MODEL

- Bathymetric data: GEBCO + Coastal Relief Model (3 arcsec) + Galveston Bay DEM (1/3 arcsec)
- Tide Input: Tide constituents from TPXO 8.0 models at the Gulf of Mexico outer boundary
- Wind Input: NCEP Reanalysis wind (6 hours interval), NOAA Wind Station Records (6min interval)



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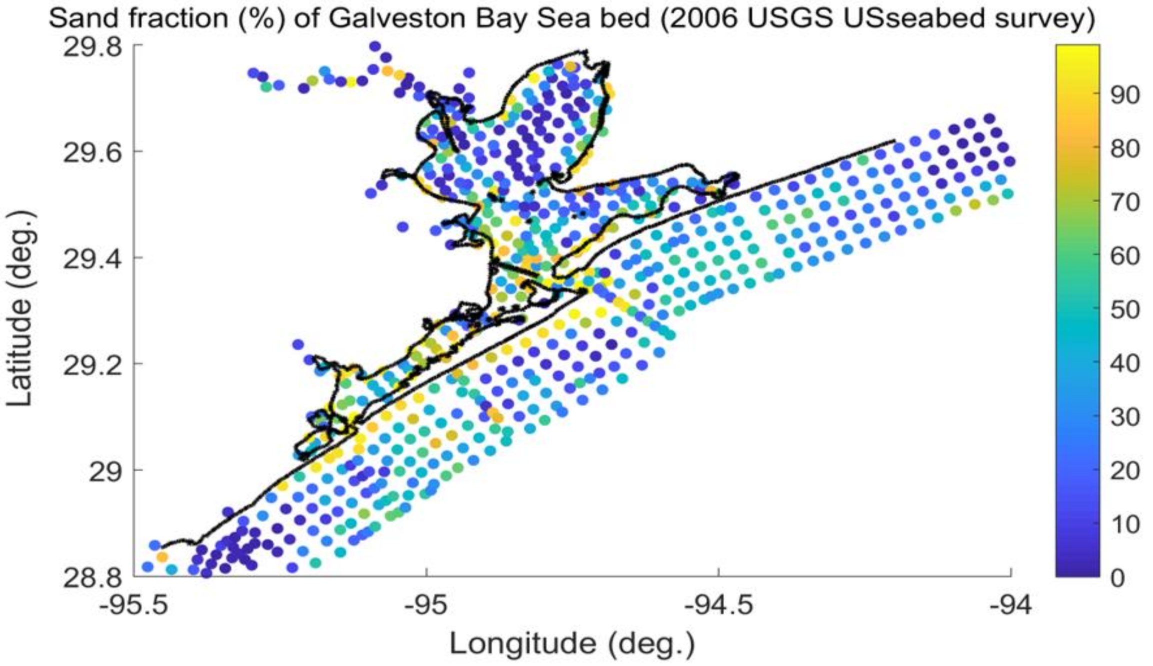
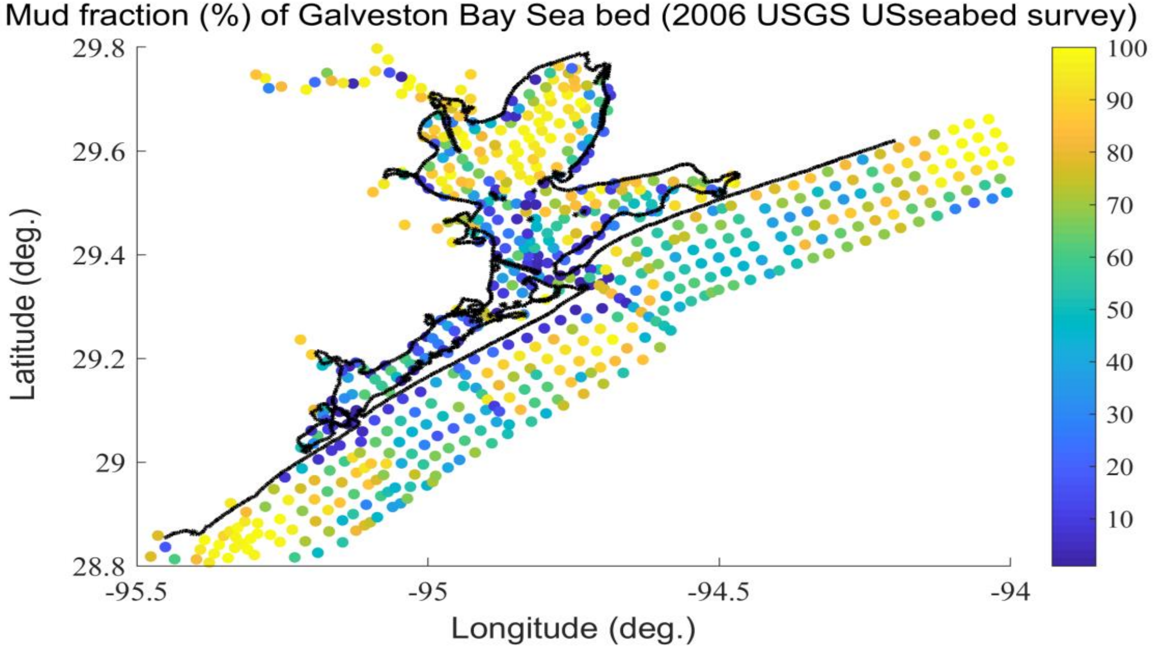
SAND AND MUD FRACTION OF GALVESTON BAY SEABED





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SEDIMENT PROPERTIES AND VEGETATION EFFECT

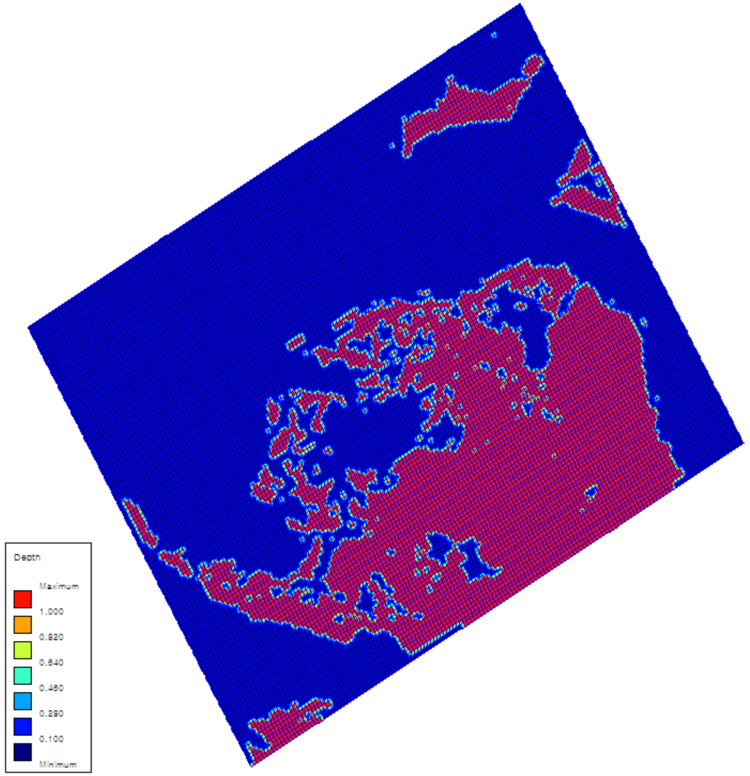
<Non-cohesive sediment parameters used in the model>

Sediment Type	Layer Thickness (m)	D50 (mm)
Sand	5	0.1

<Cohesive sediment parameters>

Sediment Type	Critical shear stress (Pa)	Layer Thickness (m)	Settling velocity (mm/s)	Erosion rate (kg/m2/s)
Mud	0.1/1.0	5	0.25	0.0001

<Critical shear stress near marsh boundary>



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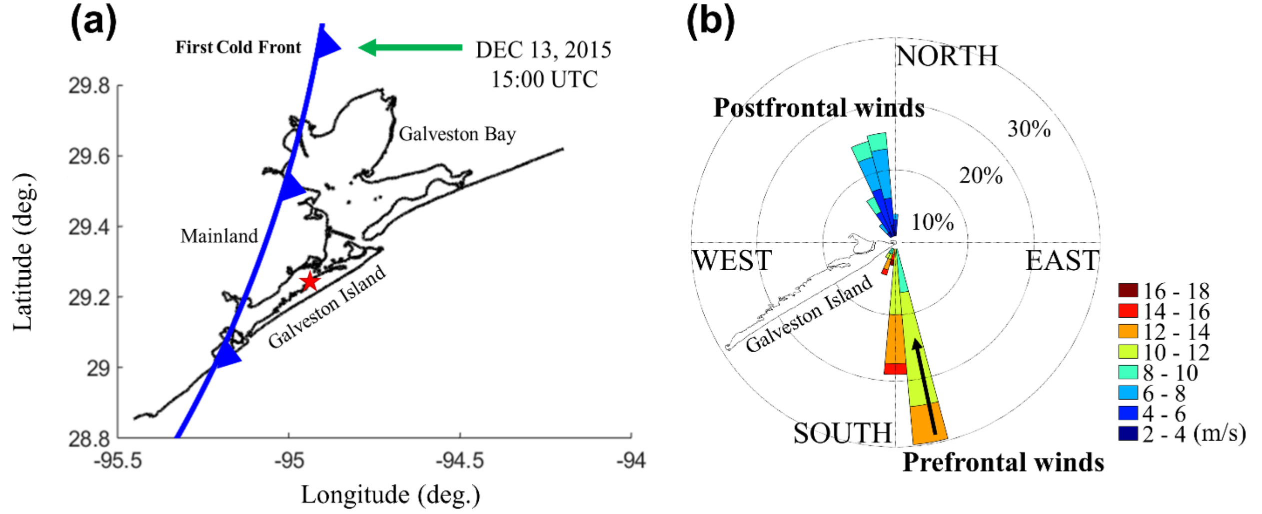
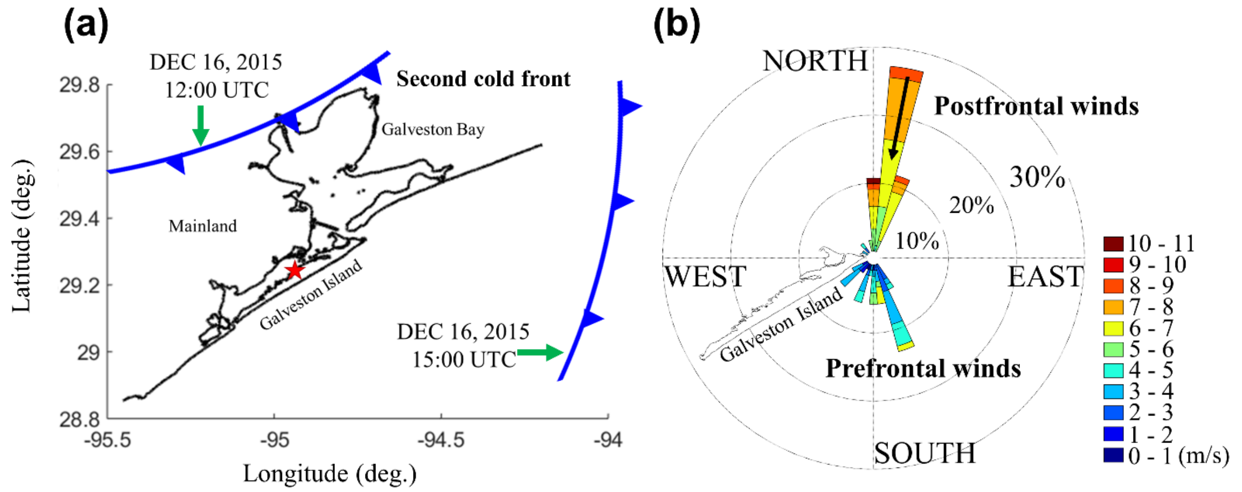
1st cold front



- Prefrontal wind prevails
- Significant water level increase
- High peak wind velocity

2nd cold front



- Postfrontal wind prevails
- Water level increase -> decrease
- Long duration of postfrontal winds

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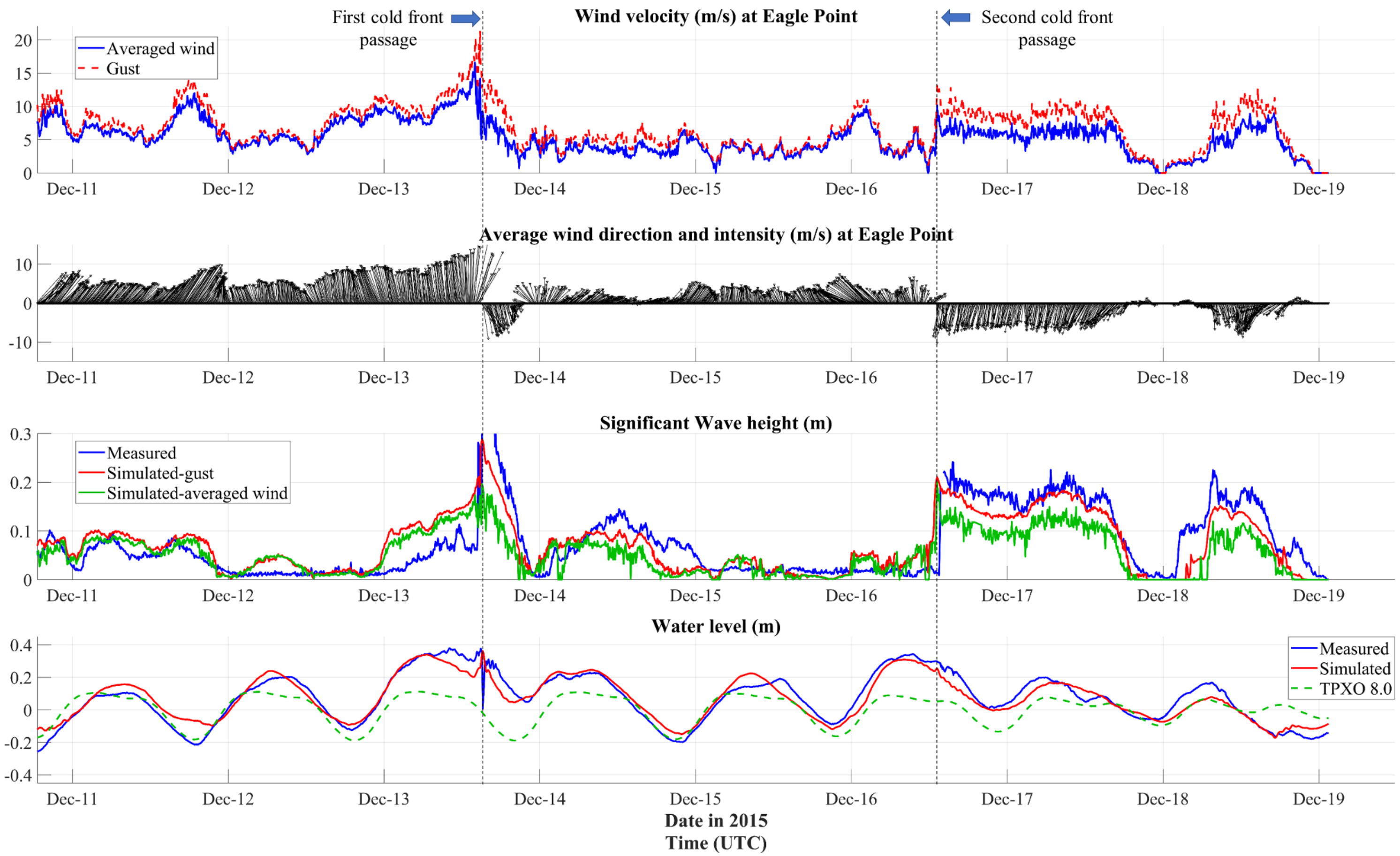
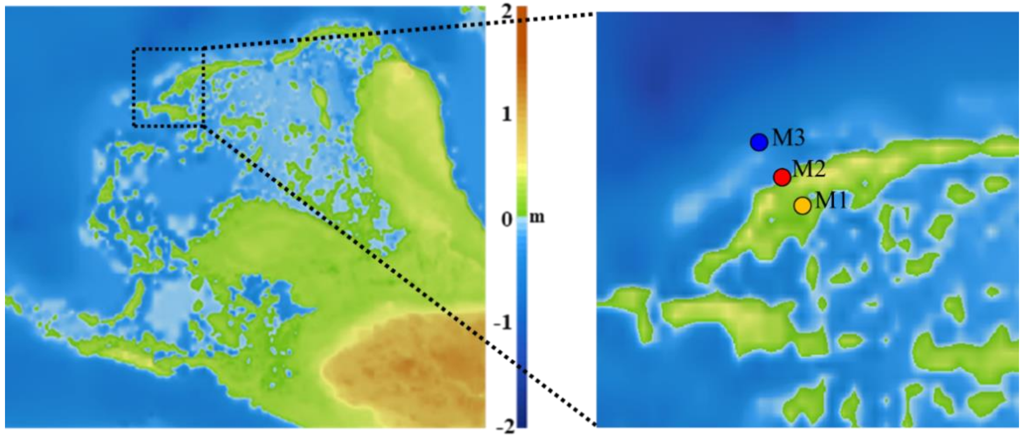
DELFT3D MODEL RESULTS



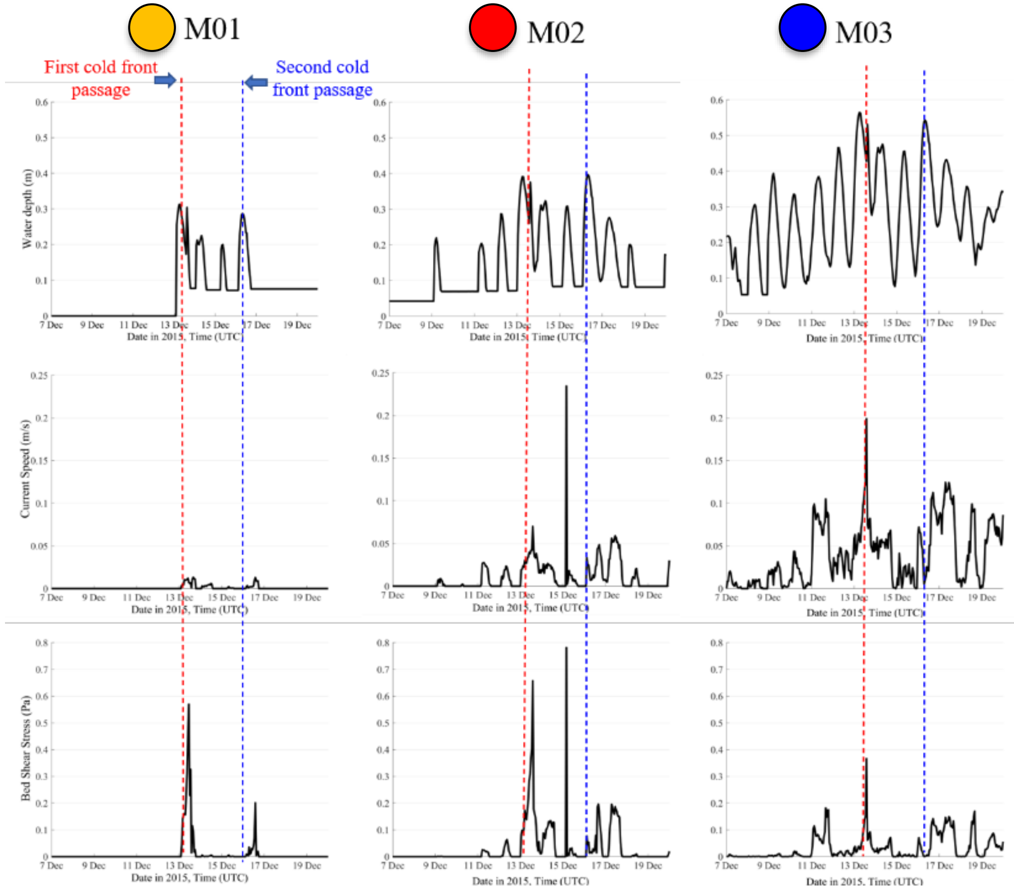
HYDRODYNAMIC RESULTS NEAR SALT MARSH



Water depth

Current speed

Bed shear stress



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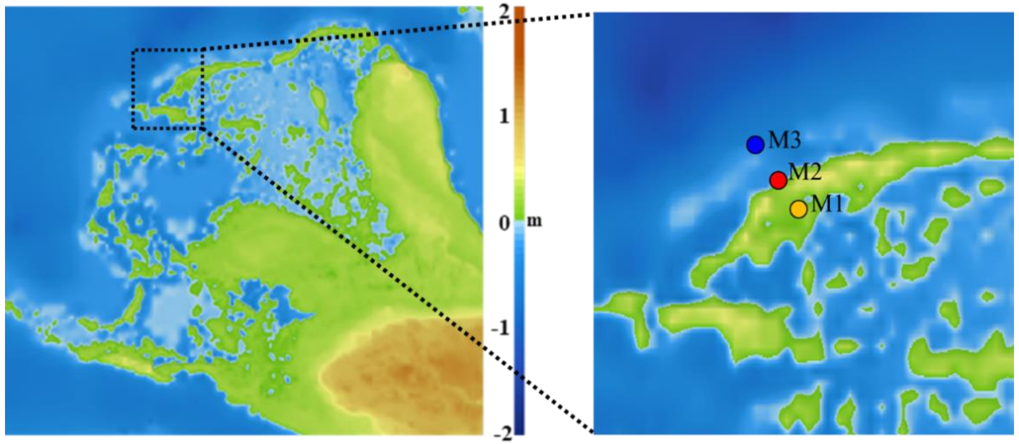
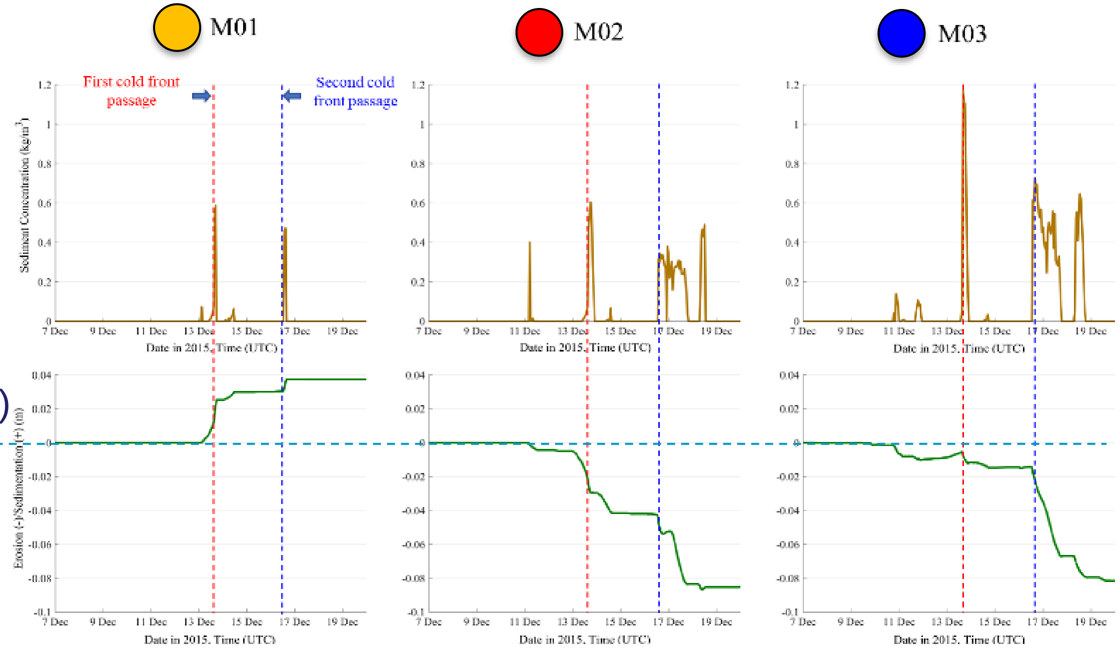
MORPHODYNAMIC RESPONSE OF SALT MARSH BOUNDARY



Sediment concentration

Sedimentation(+)

Erosion(-)



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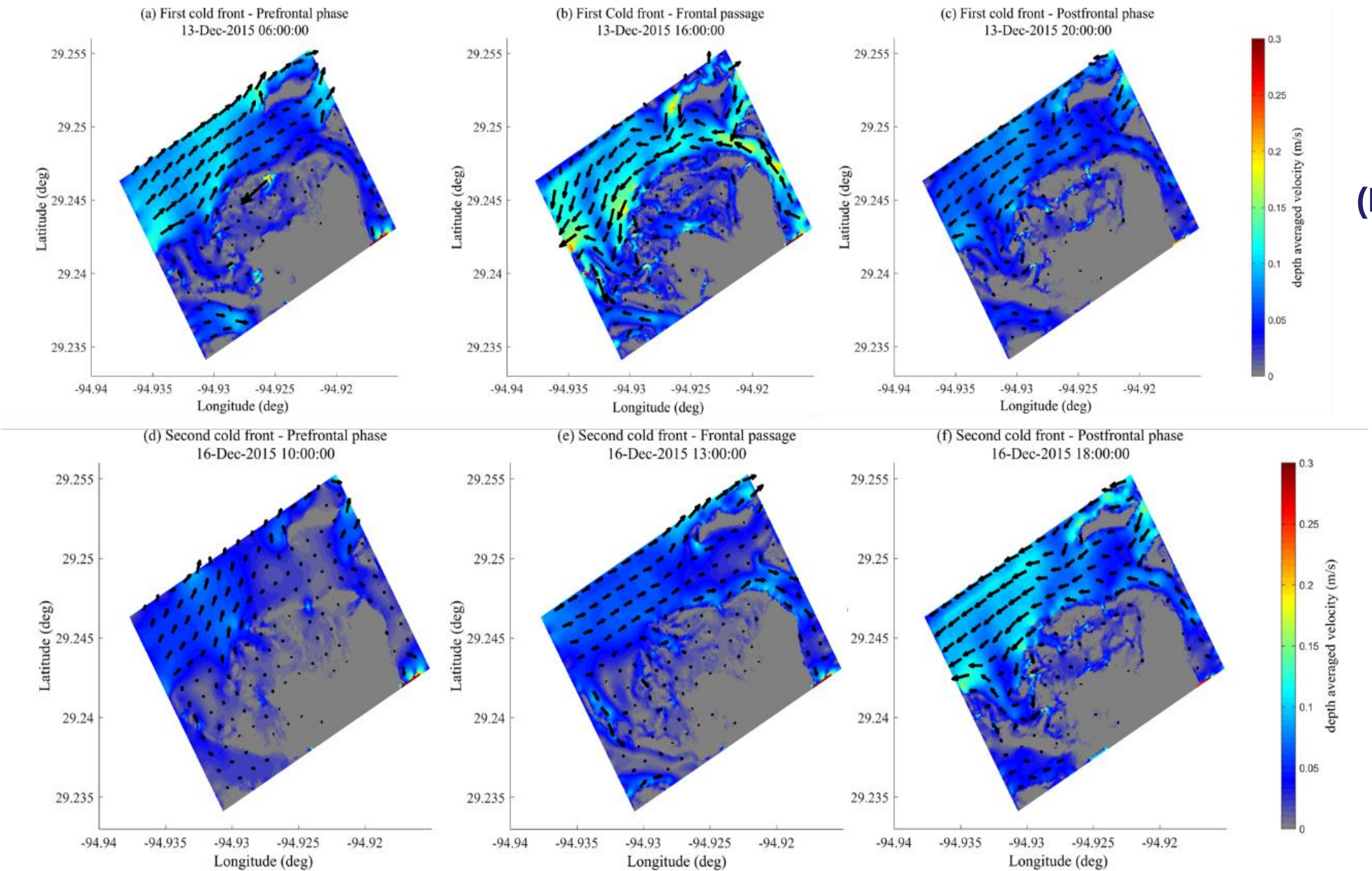
RESULTS OF COLD FRONT INDUCED CURRENTS

Prefrontal | Frontal passage | Postfrontal



(Depth averaged velocity, m/s)

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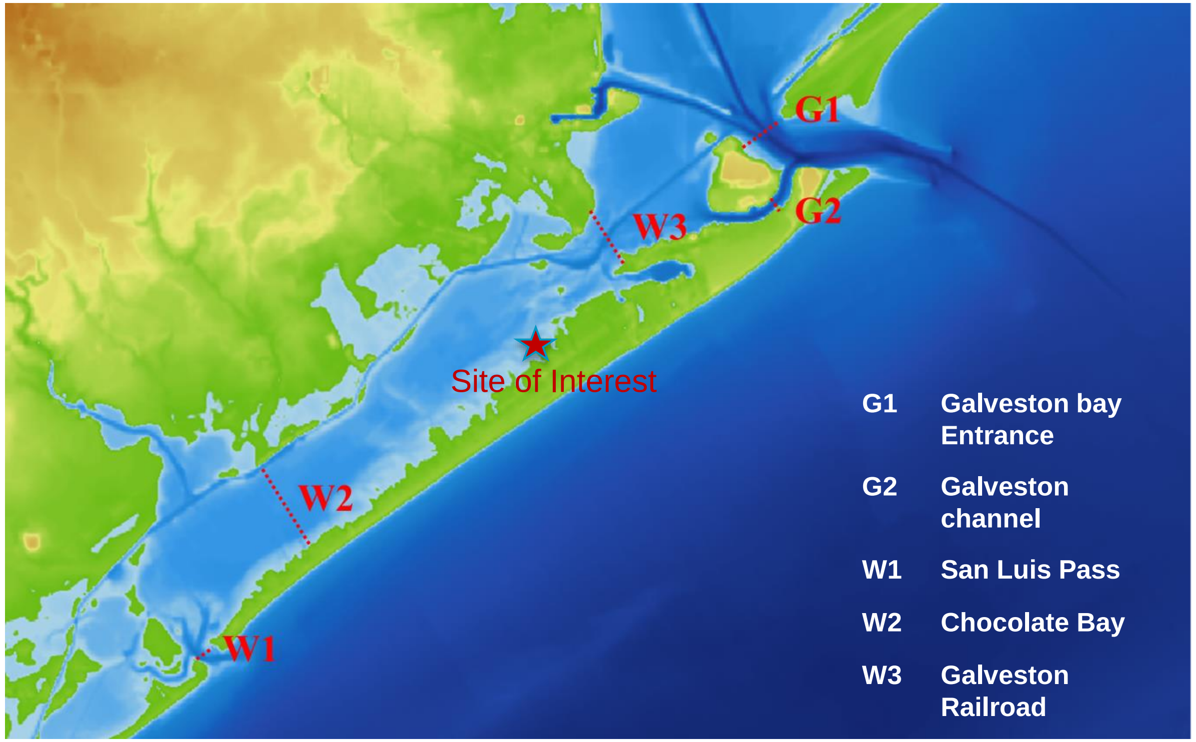
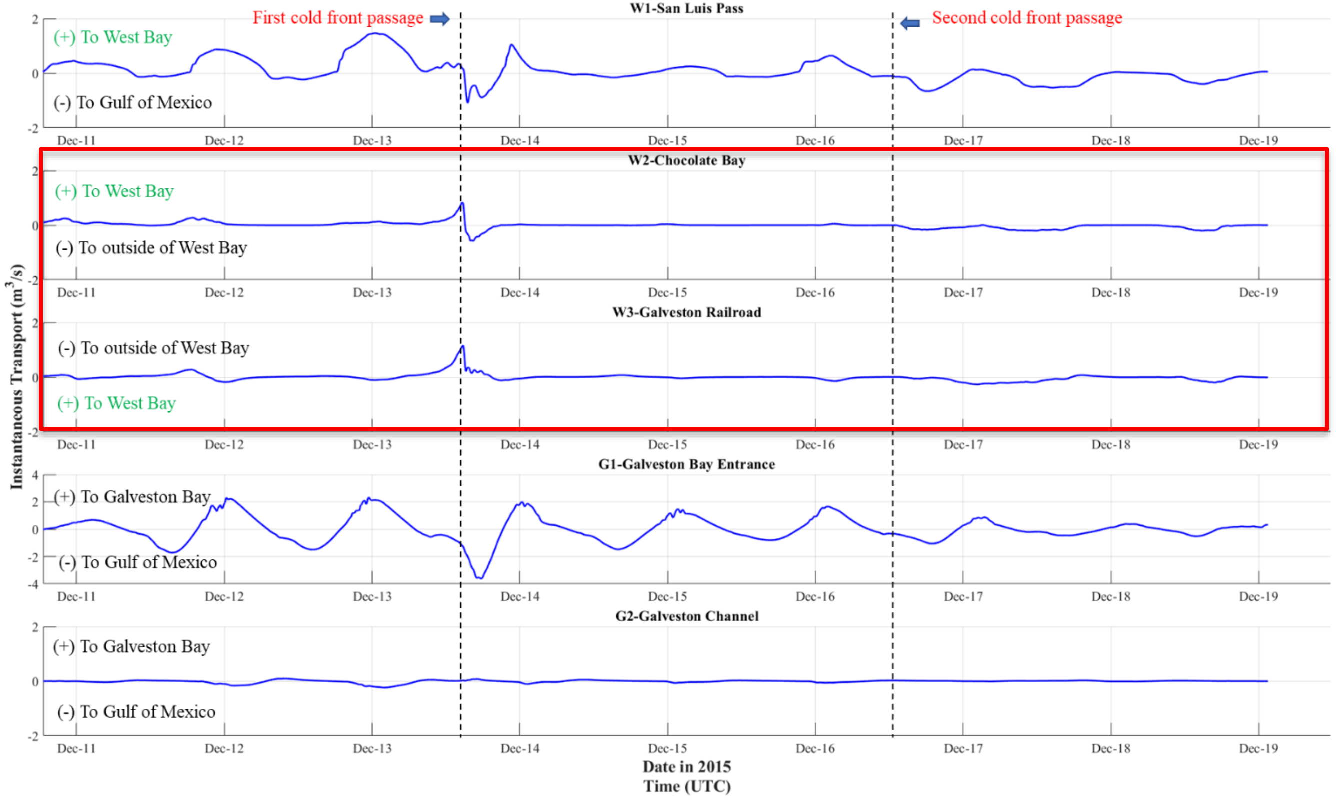
INSTANTANEOUS TRANSPORT ALONG MONITORING CROSS SECTION





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RSLR MODEL VS BASELINE MODEL

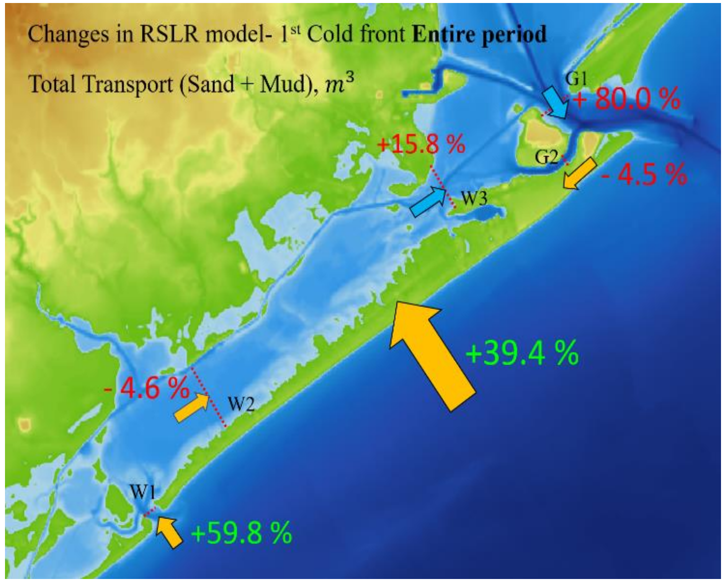
<Annual Mean Sea Level rise Calculation for Galveston, Tx>

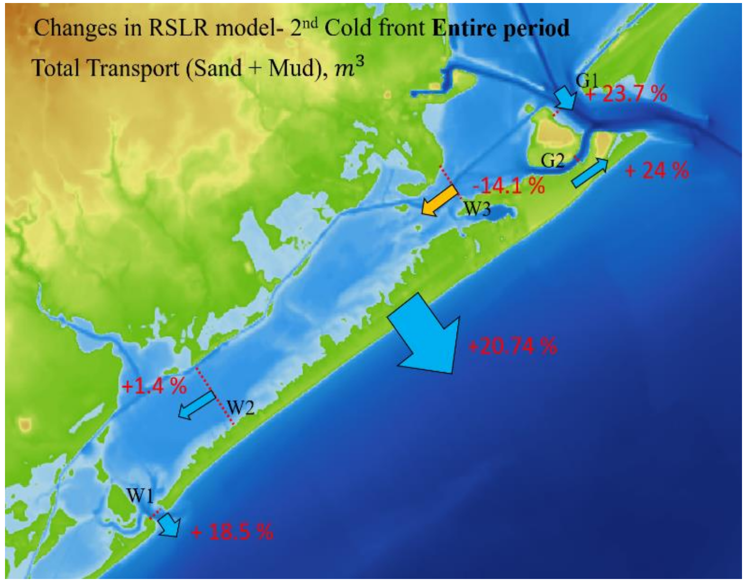
- $\mathbf{AMSL\ (mm) = 4.60t - 1877.03 + 0.1349(t - 1992)^2}$

  (Estimation from 1992 to 2018 with a regression coefficient of 0.98)

- 5 years later RSLR model: 37.5 mm local subsidence + 15 mm global sea level rise

Liu, Y., J. Li, J. Fasullo and D. L. Galloway (2020). "Land subsidence contributions to relative sea level rise at tide gauge Galveston Pier 21, Texas." *Scientific reports* **10**(1): 1-11.





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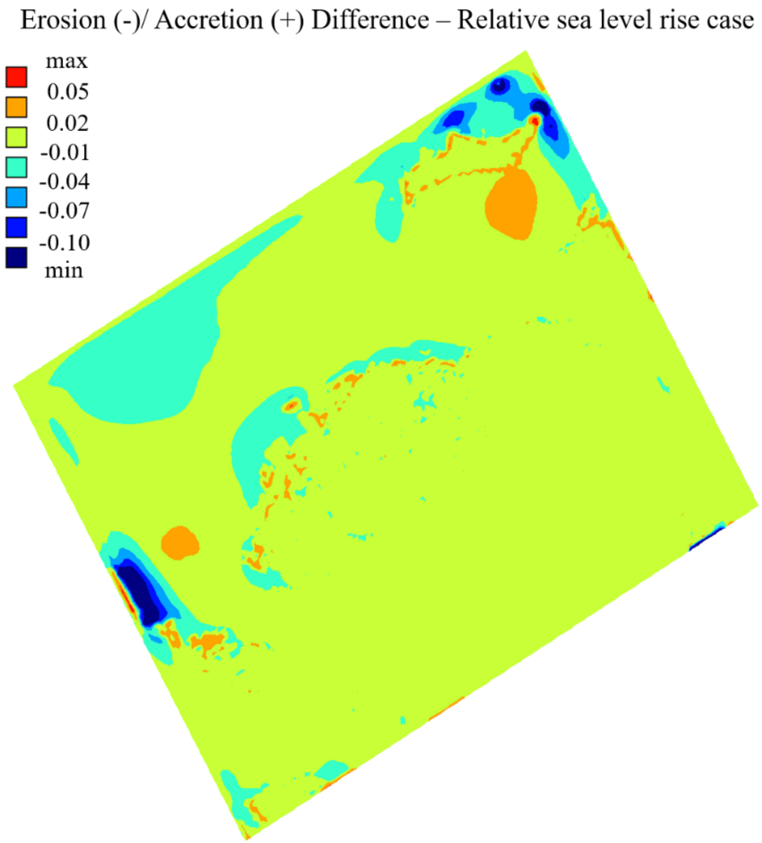
EROSION (-)/ ACCRETION (+) DIFFERENCE OF THE RSLR MODEL



- More accretion was observed along the salt marsh edge platform
- Sea level rise adaptation ?
- More erosion was observed at seabed in front of the salt marsh edge

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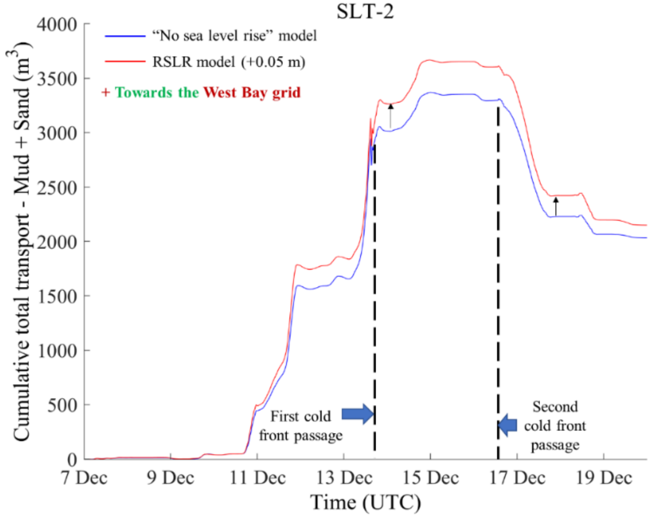
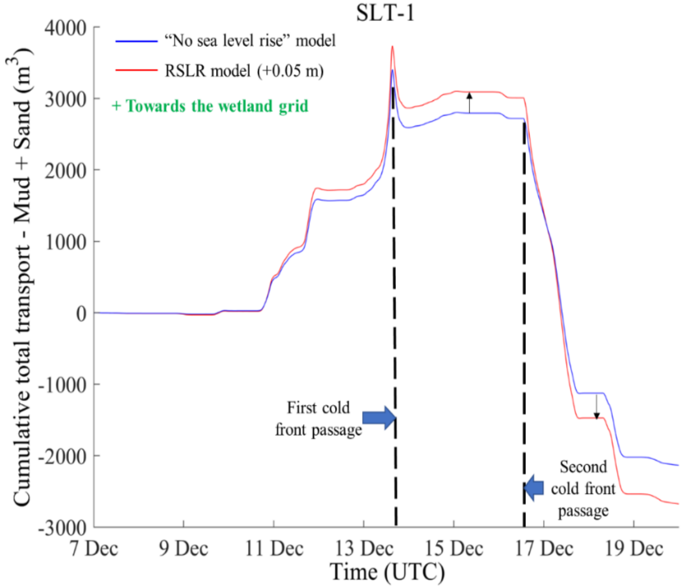
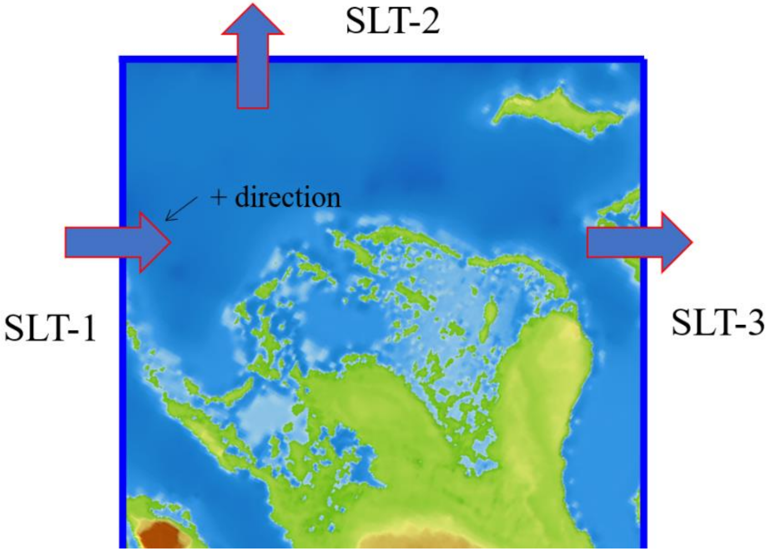
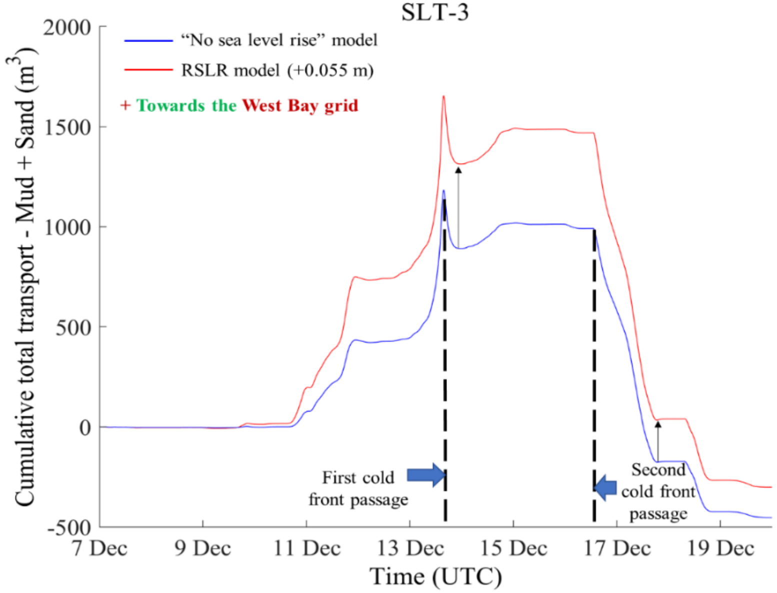
SEDIMENT TRANSPORT AT CROSS SECTIONS NEAR SALT MARSH BOUNDARY



- RSLR affected sediment fluxes near site of interest especially during cold front passages







SUMMARY AND CONCLUDING REMARKS

- The prefrontal passage increased water level in Galveston Bay, allowing additional wave growth and sediment influx to Galveston Bay
- Suspended Sediment Concentration(SSC) was high during the cold front passages due to high wind speeds
- In RSLR model, cold fronts had a negative effect in sediment supply, but additional accretion occurs along the salt marsh edges compare to baseline model

THANK YOU

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