Incorporating Hurricane Parameters to Enhance the Storm Surge Reconstruction and Extreme Events Analysis along the US East Coast by Data-Driven Method

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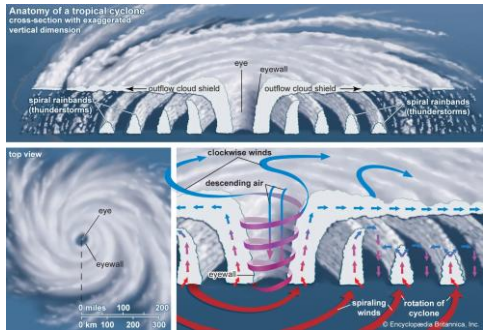
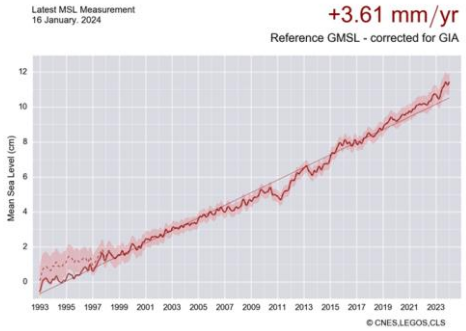
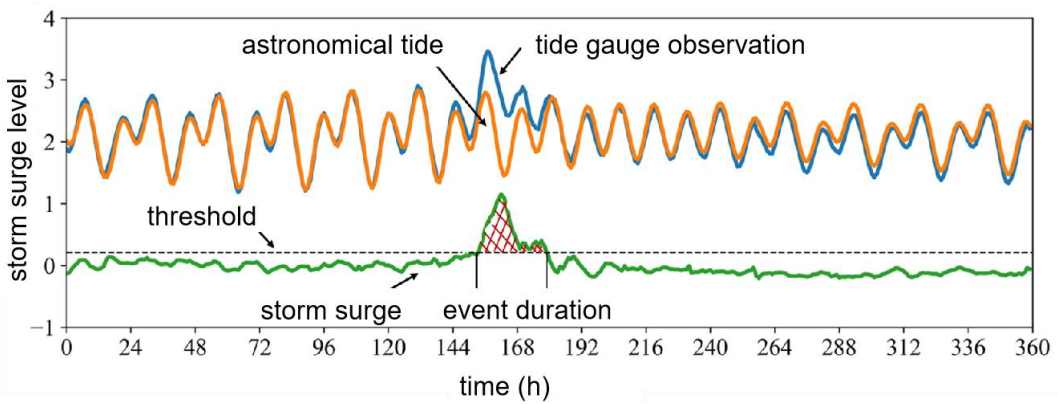
1 Background

☐ hurricanes and extreme events

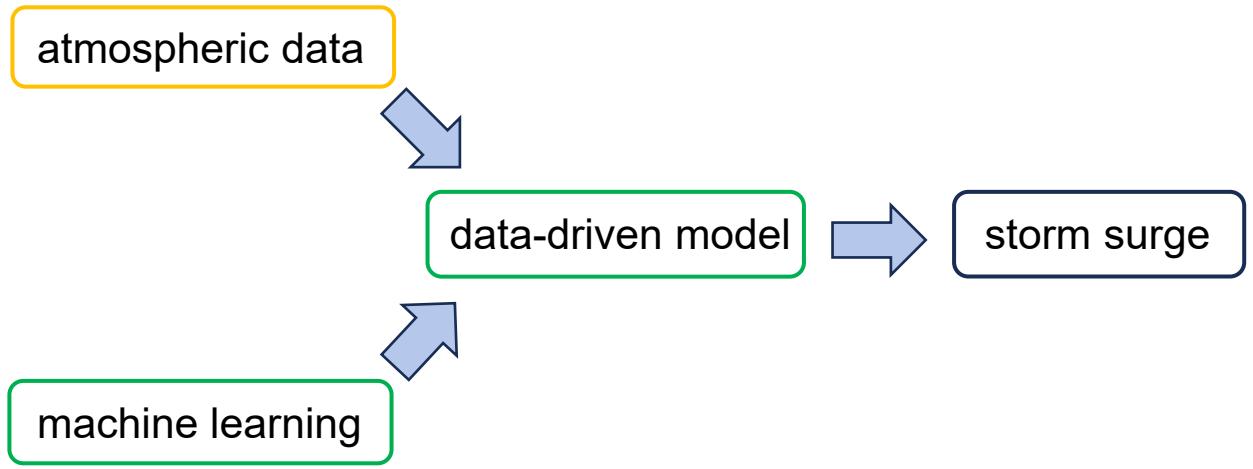






✓ Reconstructing hurricane-induced storm surge with high spatiotemporal resolution and precision is critical.

☐ data-driven method



2 Methods

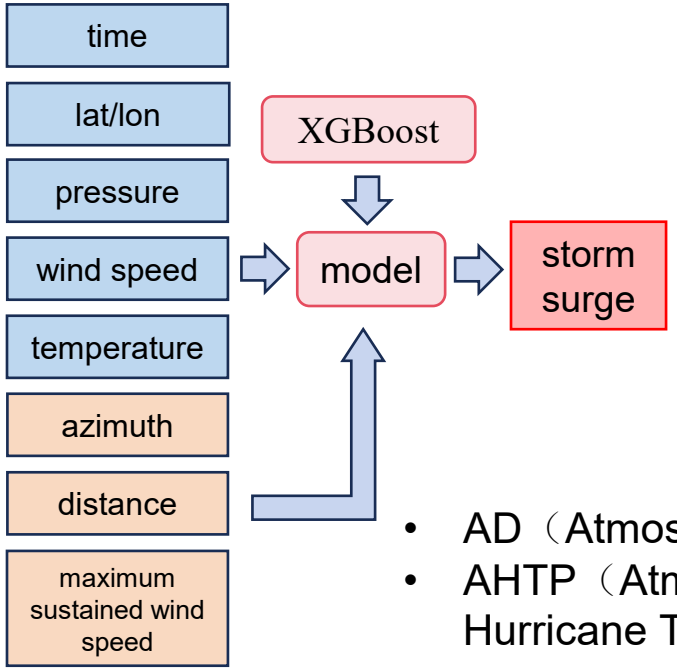
☐ incorporating hurricane parameters

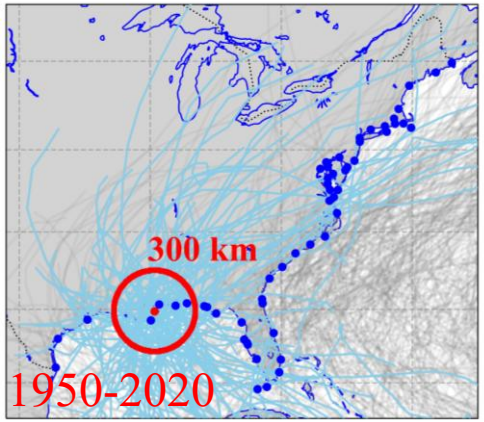
problems

Using only atmospheric data leads to an underestimation of peak storm surge levels.

research focus

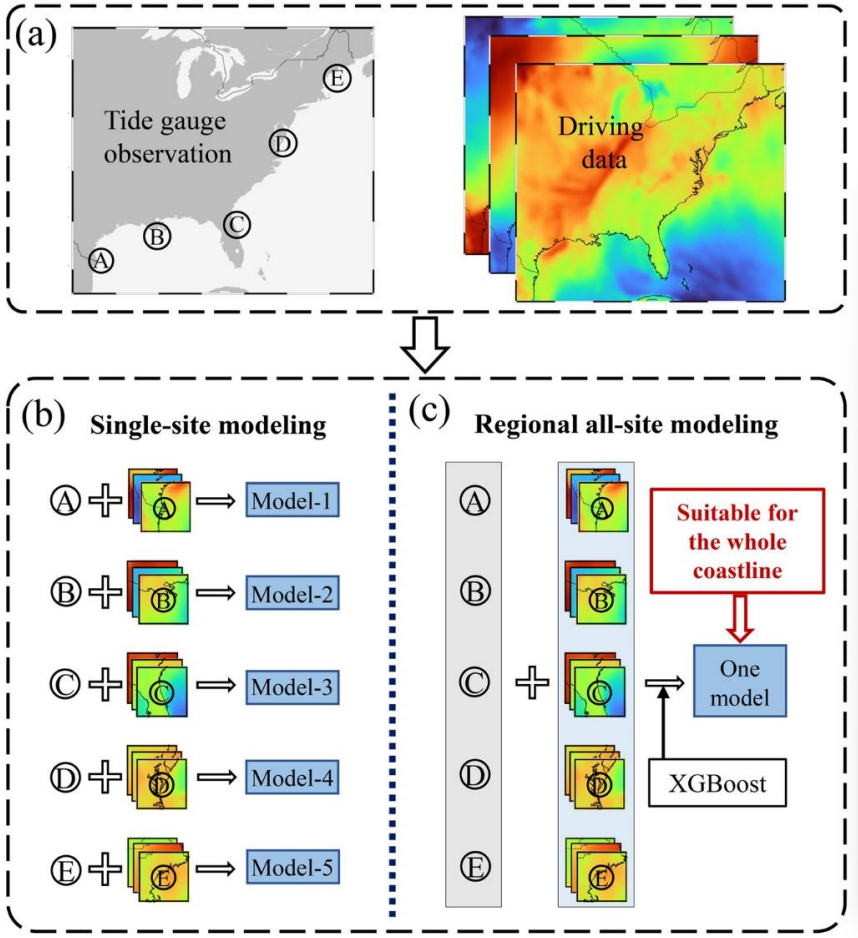
Hurricane parameters are incorporated in addition to atmospheric parameters to enhance the reconstruction of storm surge for hurricane events





- AD（Atmospheric Data）
- AHTP（Atmospheric data with Hurricane Time information and Parameters）

the all-site modeling framework (Yang et al., 2023)



Yang, L., Jin, T., Xiao, M., Gao, X., Jiang, W., & Li, J. (2023). Extreme events and probability analysis along the United States east coast based on high spatial-coverage reconstructed storm surges. Geophysical Research Letters, 50, e2023GL103492. https://doi. org/10.1029/2023GL103492

3 Results

☐ model evaluation at tide gauge scale

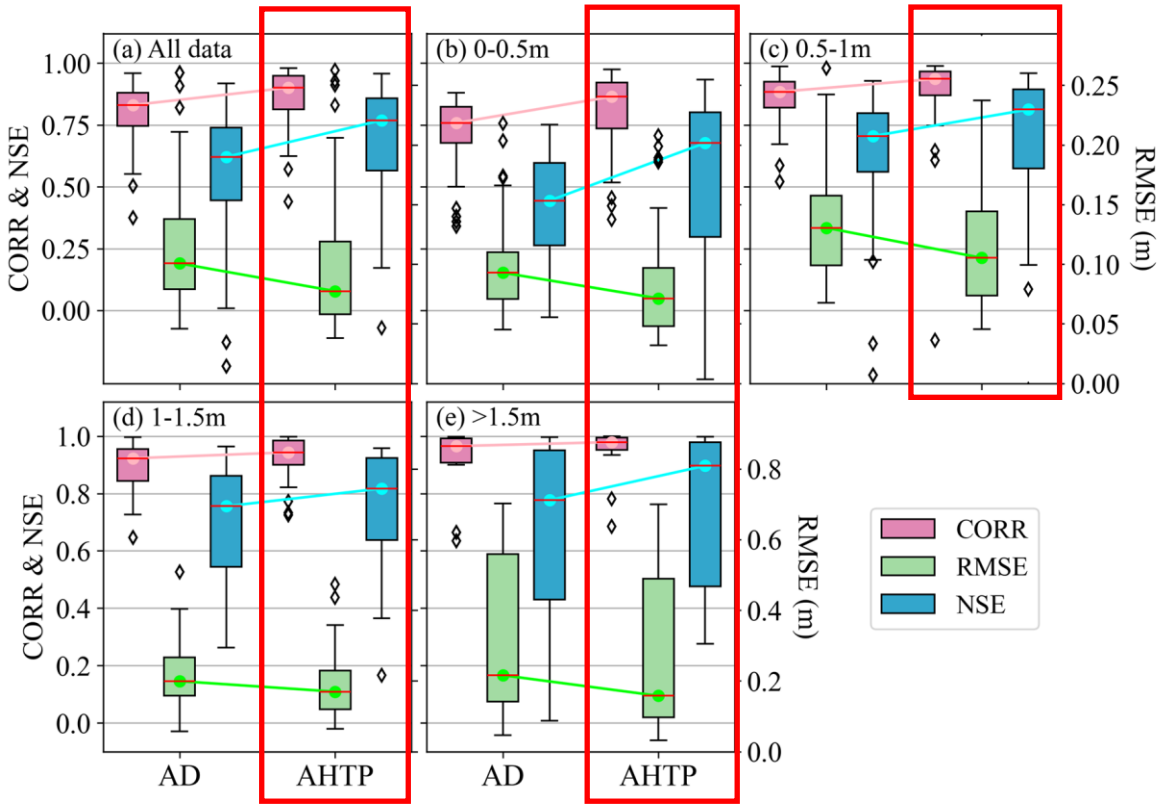


Figure 1. Model evaluation for hourly storm surge (SS) levels at tide gauges. SS evaluation for all SS events (a), and events with peak SS levels of 0-0.5 m (b), 0.5-1.0 m (c), 1.0-1.5 m (d), above 1.5 m (e); Spatial distribution of AD (f-h) and AHTP (i-k) SS evaluation for all SS events.

table 1. improvents across intervals

intervals	CORR	RMSE	NSE
All-data	8%	23%	24%
0-0.5 m	14%	23%	52%
0.5-1 m	6%	20%	15%
1-1.5 m	2%	15%	8%
>1.5 m	1%	27%	16%

✓ Incorporating hurricane parameters can improve the reconstruction precision of storm surge events for hurricanes of all intervals, with more significant improvements observed for both high and low storm surge levels.

3 Results

☐model evaluation at coastal scale

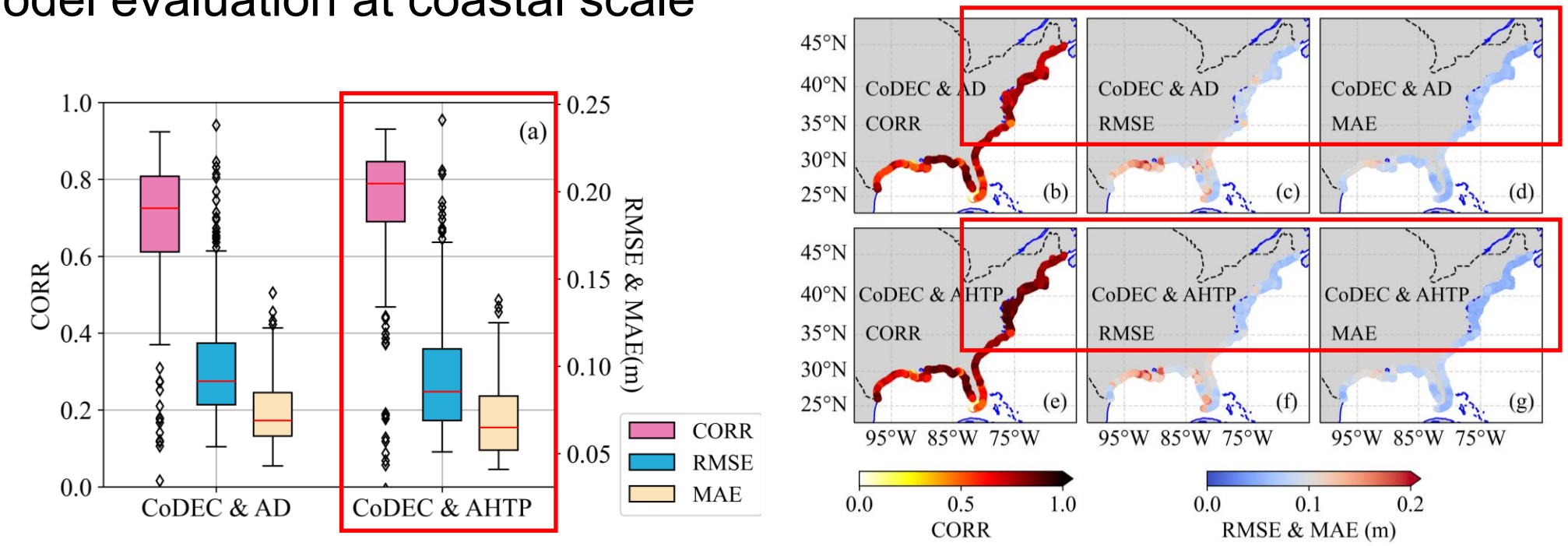
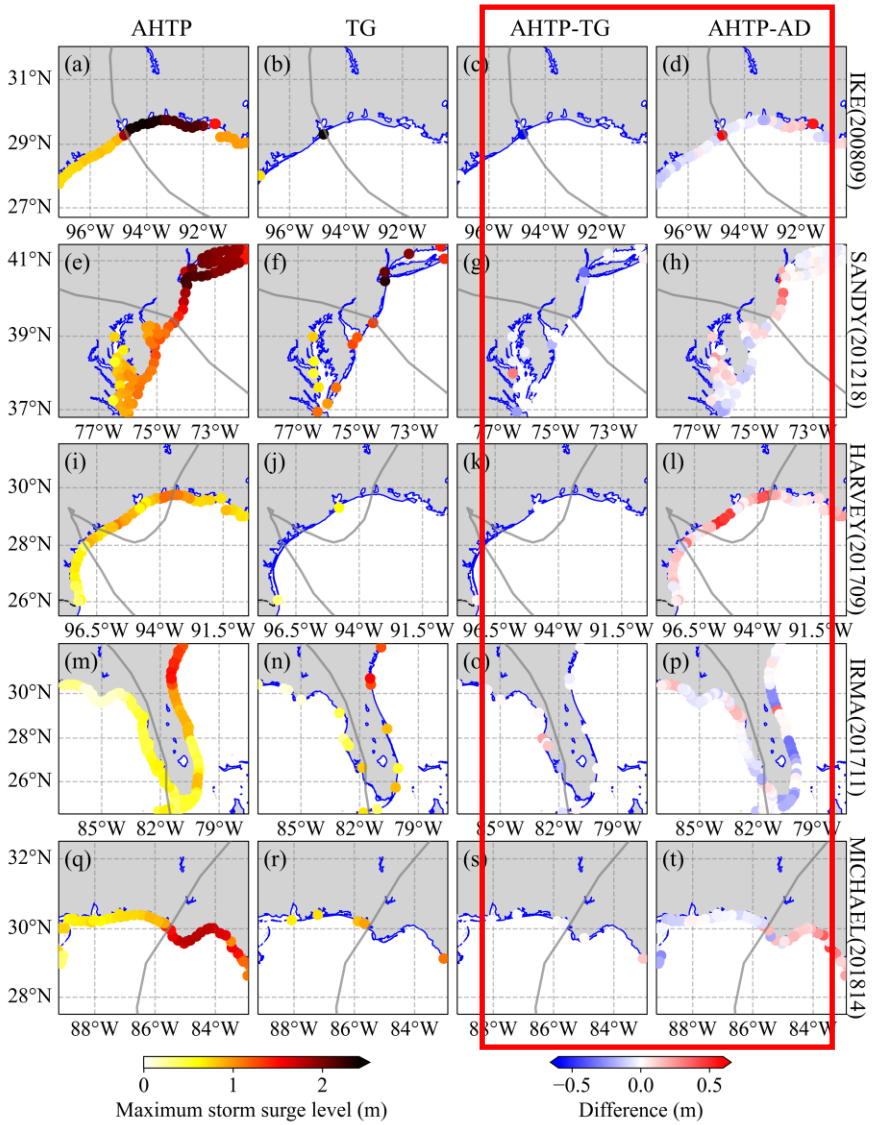


Figure 2. Comparison of hurricane storm surge levels from AD and AHTP with those from CoDEC across the entire coastline. (a) Boxplot of CORR, RMSE, STD, MAE for model evaluation; (b-e) AD compared with CoDEC; (f-i) AHTP compared with CoDEC.

- ✓ Incorporating hurricane parameters can improve the reconstruction precision of hurricane-induced storm surges along the entire coastline.
- ✓ The regions with the largest improvements are mainly located along the coastline north of 35° N.

3 Results

☐model evaluation at historical extreme hurricane events



- ✓ Incorporating hurricane parameters partially addresses the underestimation of peak storm surge when using only atmospheric parameters.

Figure 3. Maximum storm surge levels during hurricanes Ike (a-d), Sandy (e-h), Harvey (i-l), Irma (m-p), and Michael (q-t) on the US East Coast. The hurricane's track is shown as the grey line.

3 Results

☐ feature importance analysis of hurricane parameters

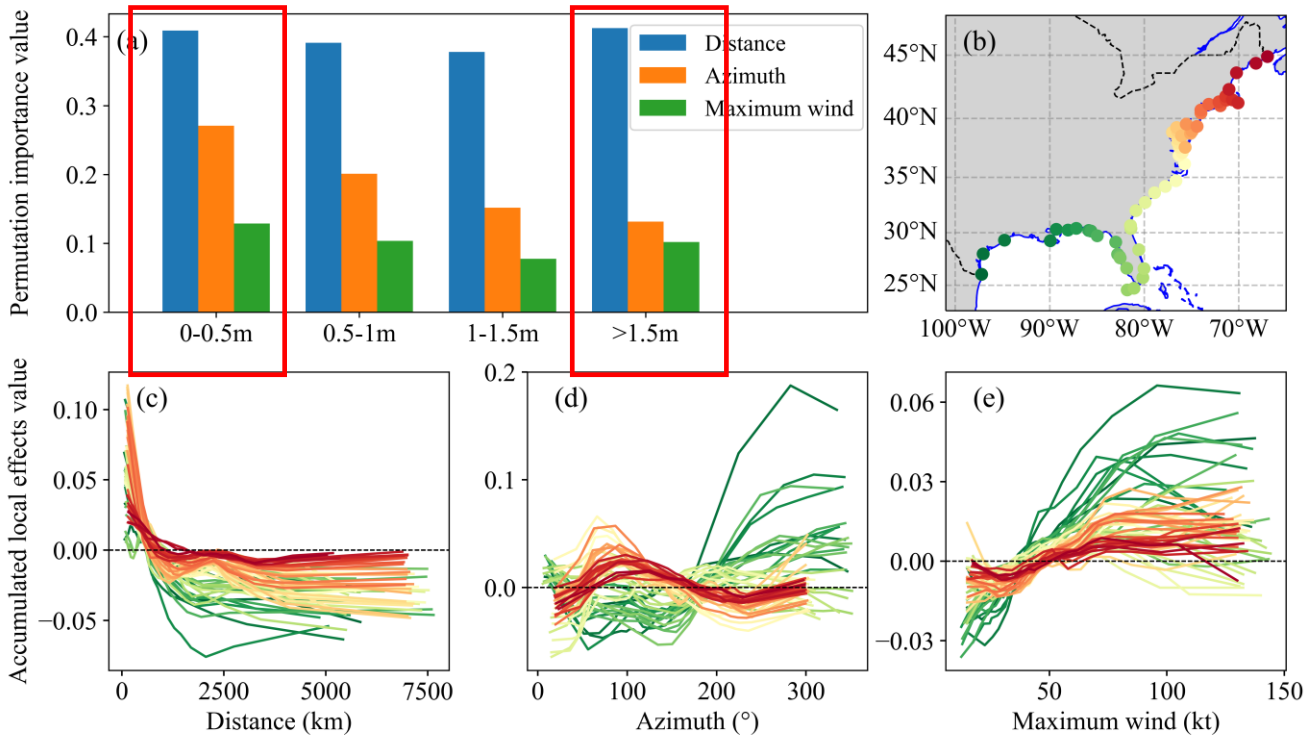
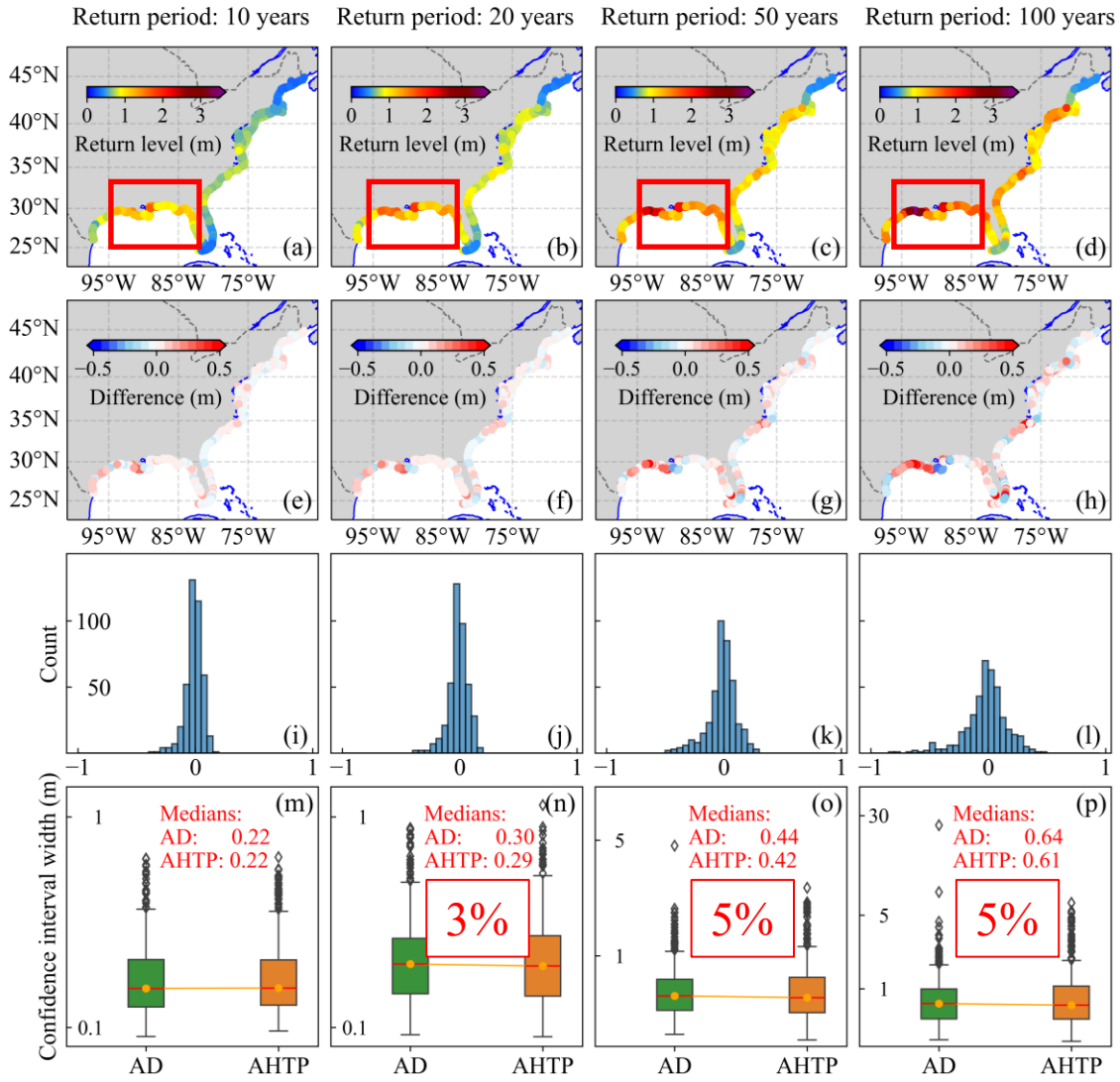


Figure 4. (a) Feature importance of different storm surge ranges and the accumulated local effects plots at tide gauges: (c) Distance, (d) azimuth, and (e) maximum sustained wind speed, different colors in (b) represent the results at the corresponding tide gauge stations.

- ✓ Distance is the dominant hurricane parameter for storm surge, followed by azimuth and maximum sustained wind speed.
- ✓ Both distance and maximum sustained wind speed contribute more significantly to low- and high-level storm surge events.
- ✓ The response of storm surge to hurricane parameters varies significantly across regions.

3 Results

☐ hurricane events probability analysis



- ✓ Higher return levels are observed along the northern coastline of the Gulf of Mexico, with 100-year values exceeding 1.5 m across much of the region and peaking above 3.5 m.
- ✓ Incorporating hurricane parameters can reduce the uncertainty in extreme events probability analysis, enabling more reliable return level estimates.

Figure 5. (a-d) The return levels of storm surge during hurricanes from 1950 to 2020 at four return periods by the AHTP model. (e-h) Spatial difference maps of return levels between AD and AHTP models (AHTP-AD). (i-l) Statistical plots of differences in return levels between AD and AHTP models. (m-p) Box plots of confidence interval widths for AD and AHTP models.

Thanks for your attention!

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