

Development and application of a continental scale compound flood modeling system in a complex coastal flood plains

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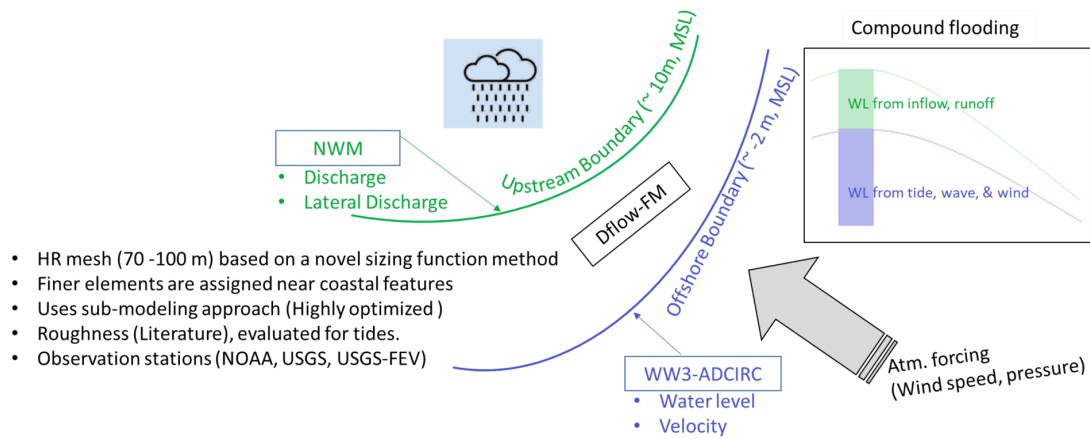
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WATER
PREDICTION

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INTRODUCTION

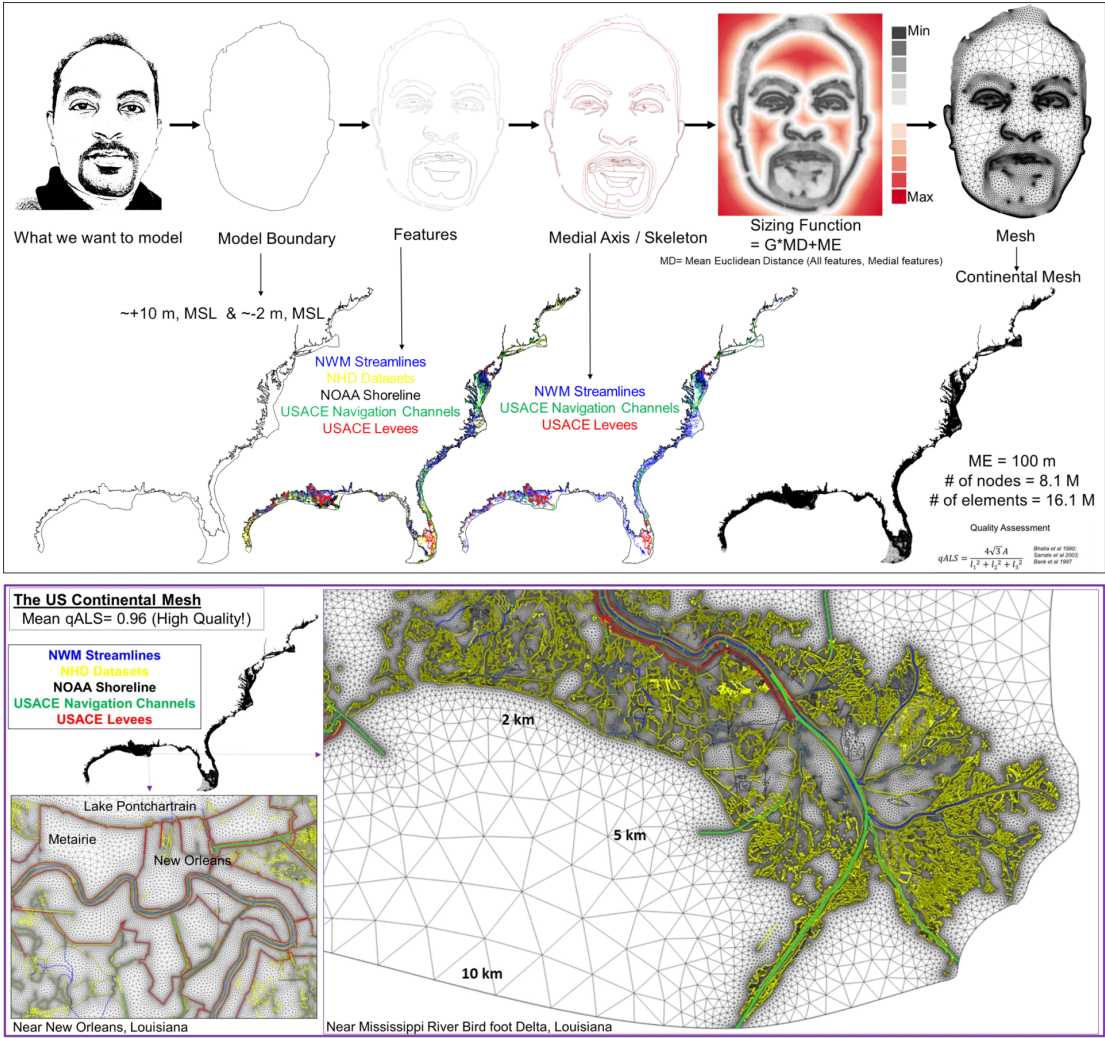
Compound flooding happens when two or more extreme events occurring simultaneously or successively.



This study investigates the compound effect of inflow from rivers, rainfall runoff and oceanic surge for four named storms (Irma, Florence, Ike, and Sandy)

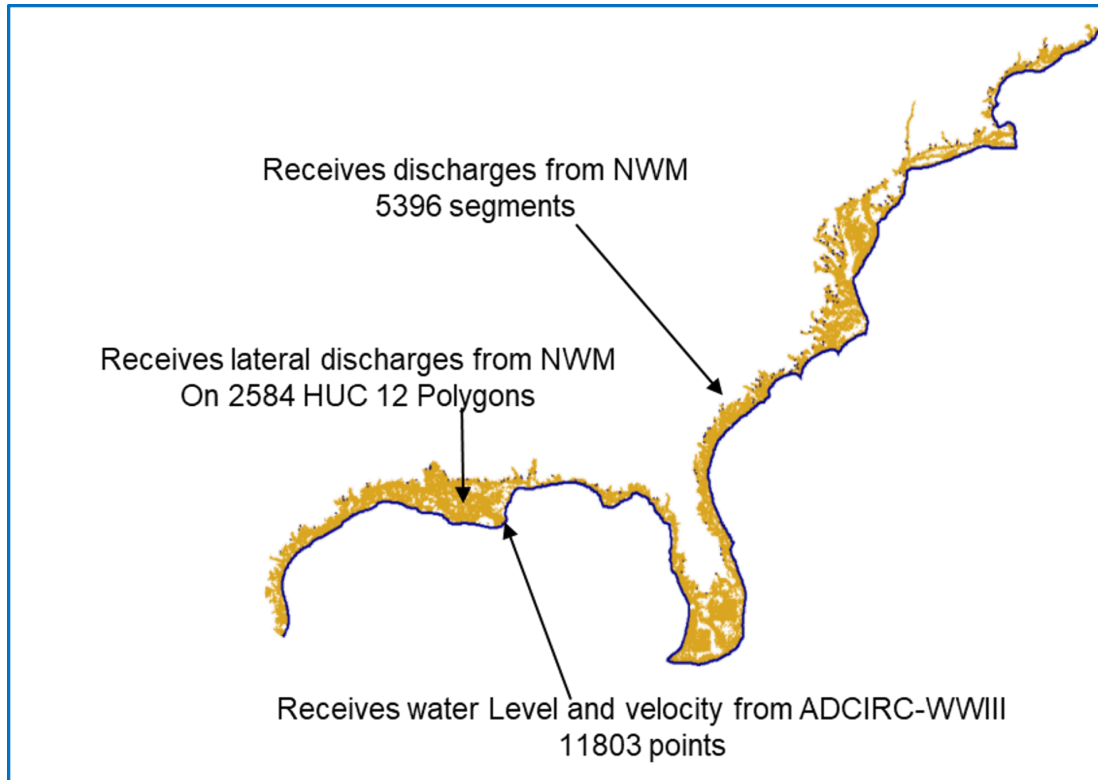
GULF-ATLANTIC CONT. MESH

Methodology for the mesh development



MODEL FEATURES

Boundary conditions



Model allows sub-setting approach

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1654648958/agu/39-68-4A-5E-96-42-4D-11-3D-20-F3-FA-54-1B-FE-70/Video/Subsetting_animation_uq63zv.mp4

Levees are represented with polylines

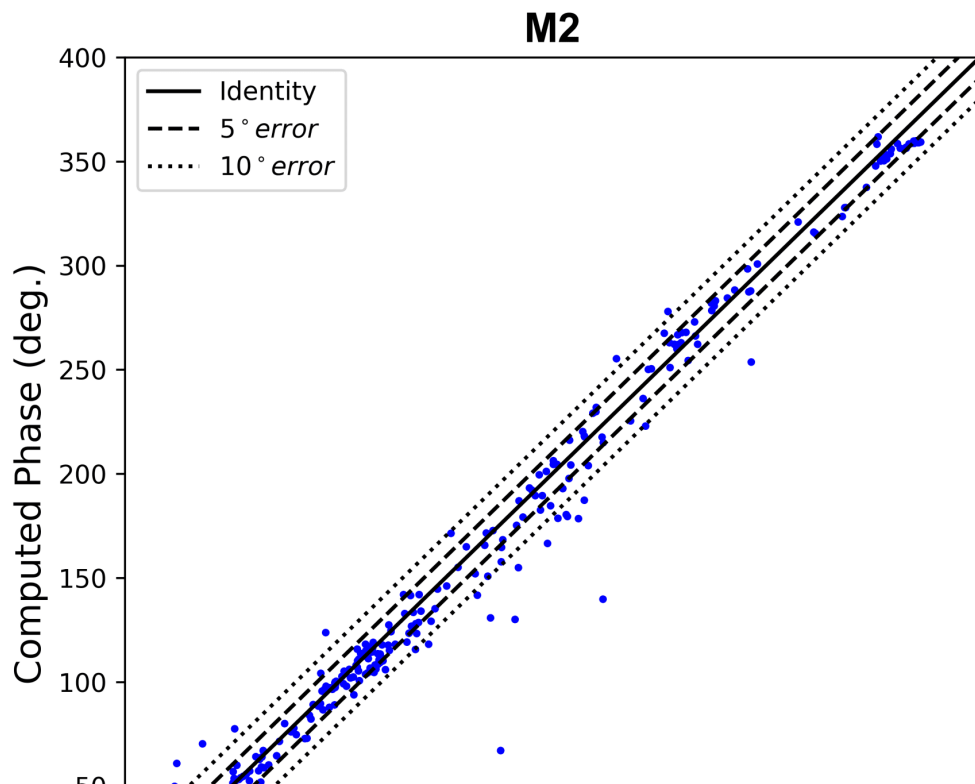
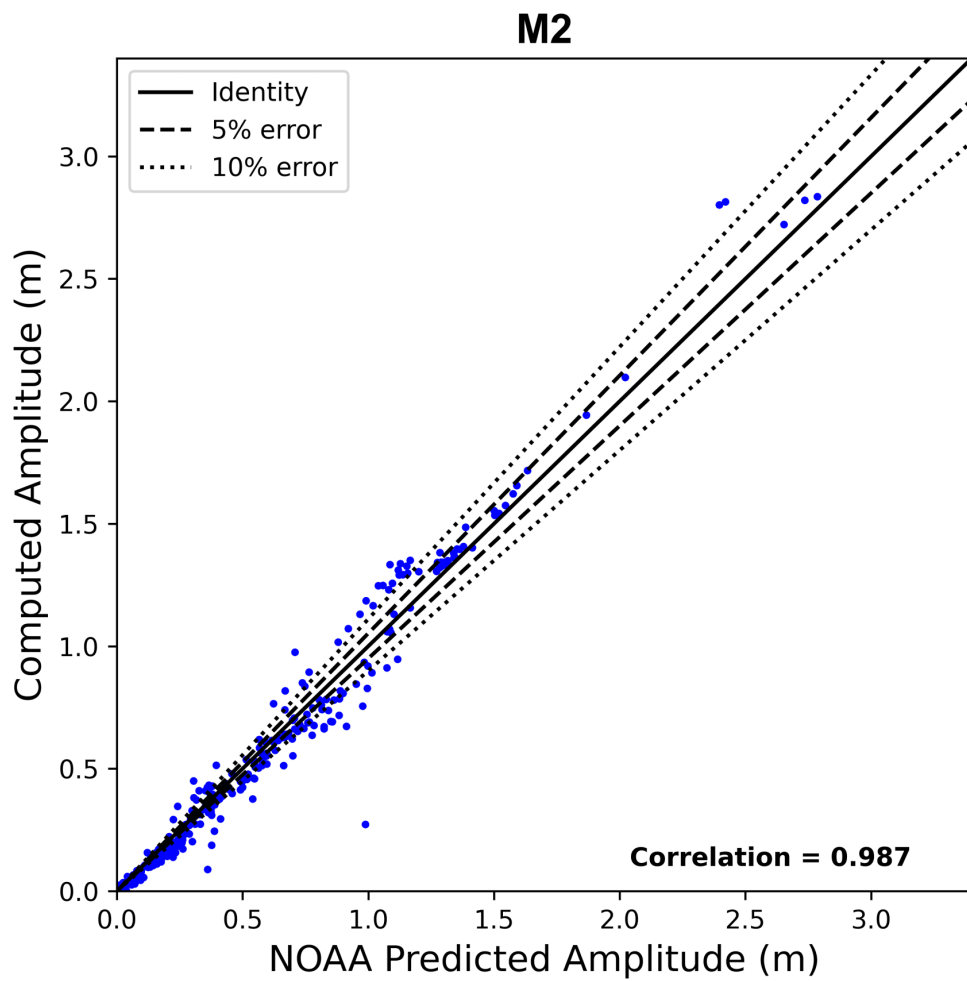
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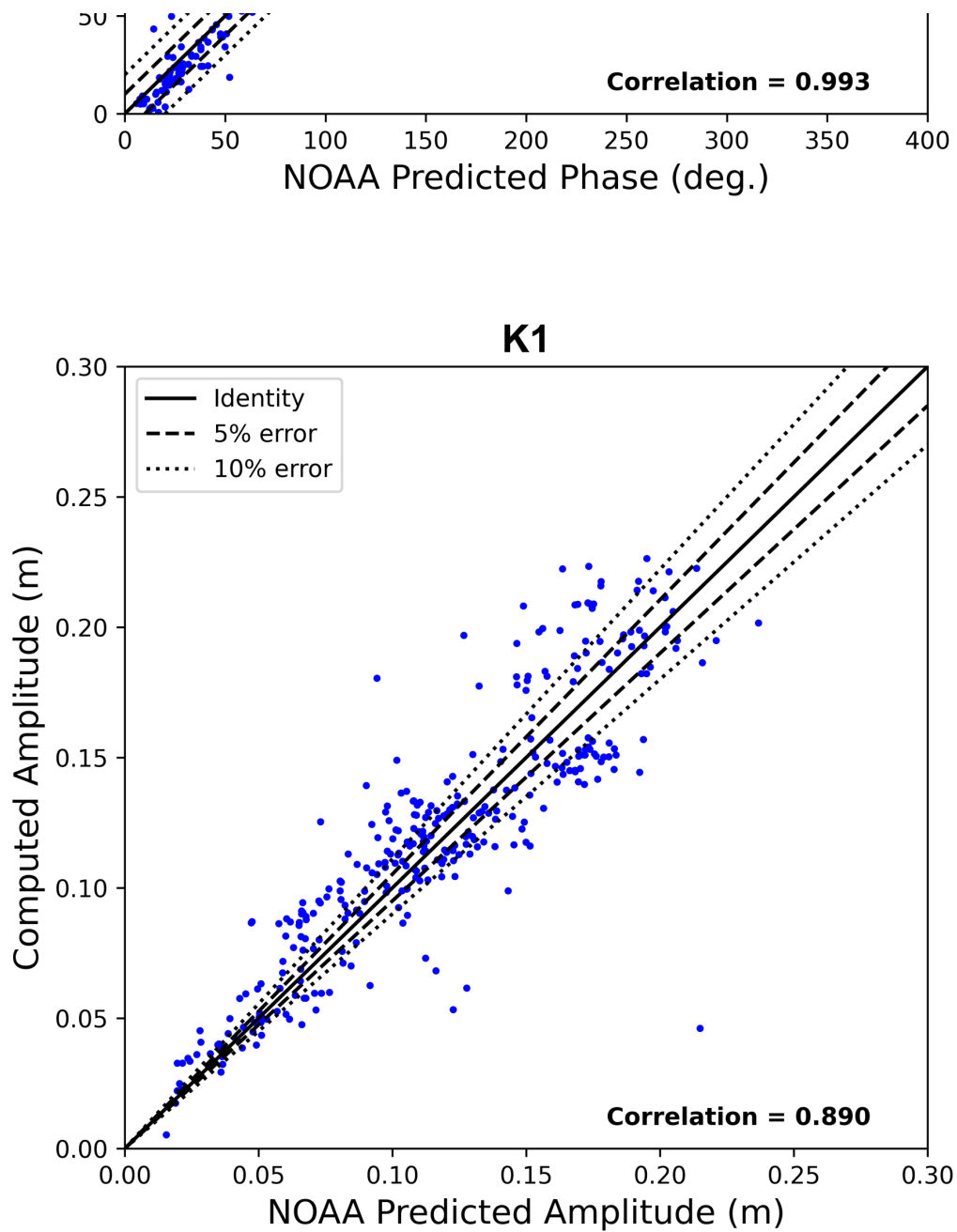
Channels are represented with finer elements

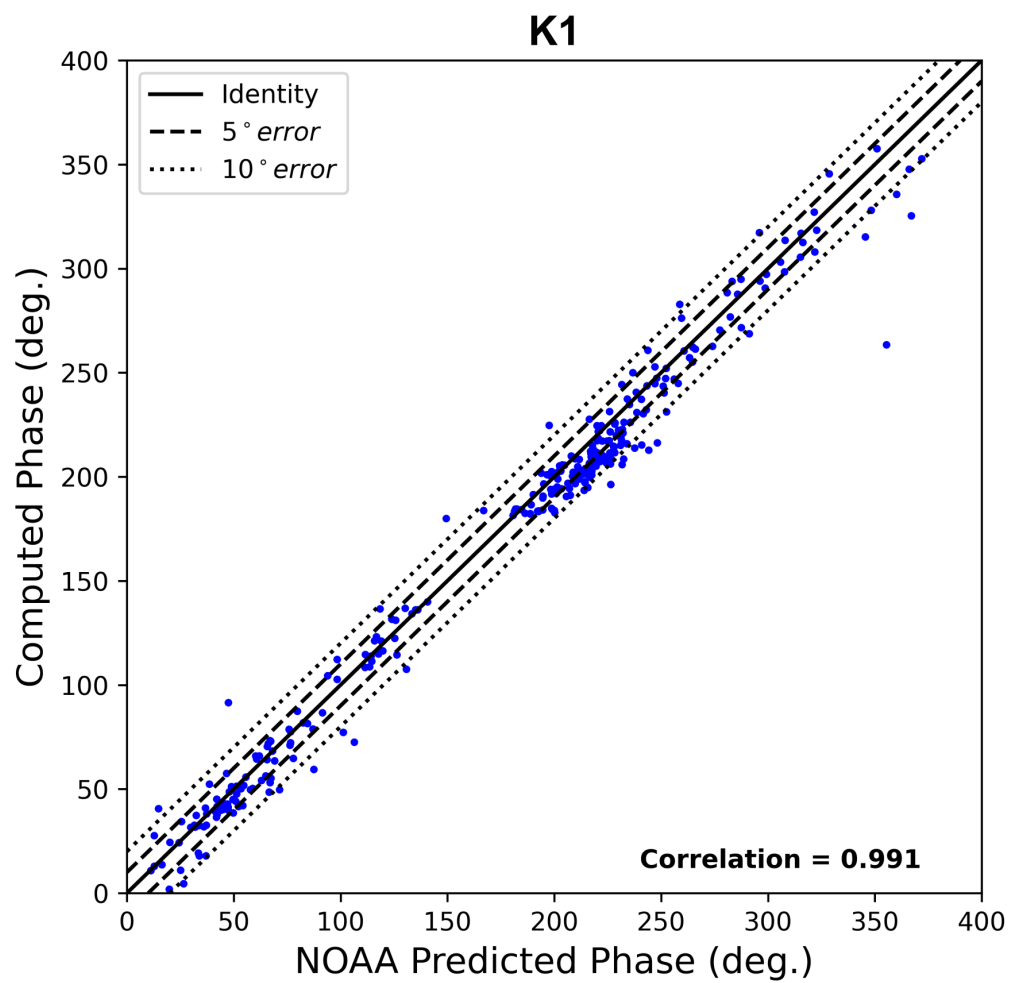
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TIDAL EVALUATION

Model was evaluated at 320 NOAA tidal stations.







CONTRIBUTION OF RAINFALL RUNOFF AND INFLOW TO THE TOTAL WATER LEVEL

IRMA

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1654667091/agu/39-68-4A-5E-96-42-4D-11-3D-20-F3-FA-54-1B-FE-70/Video/Irma_Surge_Inflow_Runoff_vs_Oceanic_Surge_wl_diff_video_kxv9bo.mp4

FLORENCE

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1654667198/agu/39-68-4A-5E-96-42-4D-11-3D-20-F3-FA-54-1B-FE-70/Video/Florence_Surge_Inflow_Runoff_vs_Oceanic_Surge_wl_diff_video_azmeo9.mp4

IKE

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1654699912/agu/39-68-4A-5E-96-42-4D-11-3D-20-F3-FA-54-1B-FE-70/Video/Ike_wl_diff_gxxgoc.mp4

FLORENCE

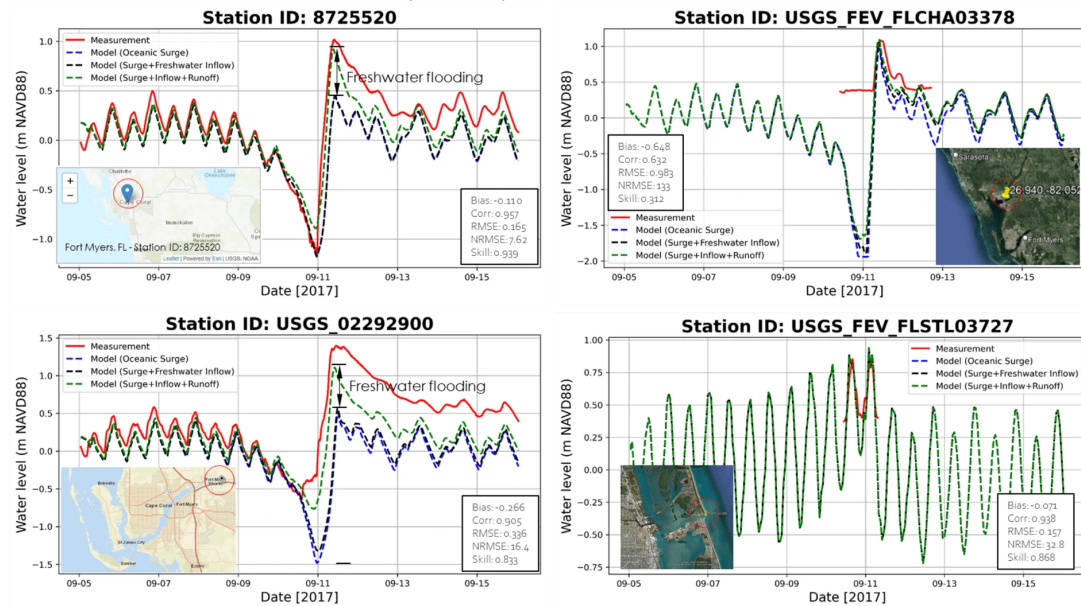
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SANDY

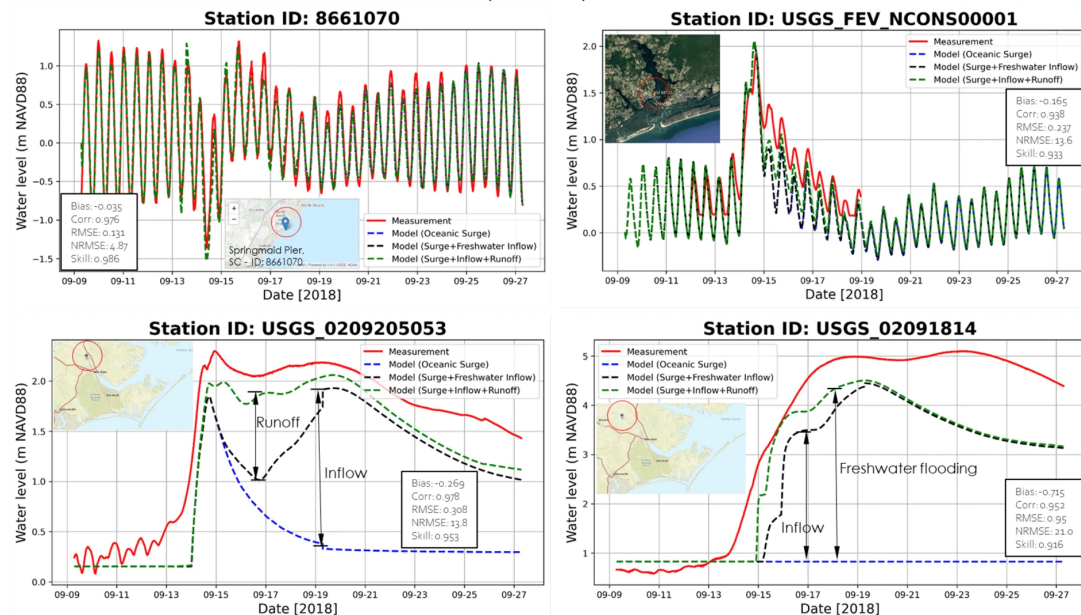
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INCLUDING THE COMPOUND EFFECTS OF RIVER-INFLOW, RAINFALL-RUNOFF AND SURGE IS CRUCIAL FOR ACCURATE DETERMINATION OF COASTAL FLOODING!

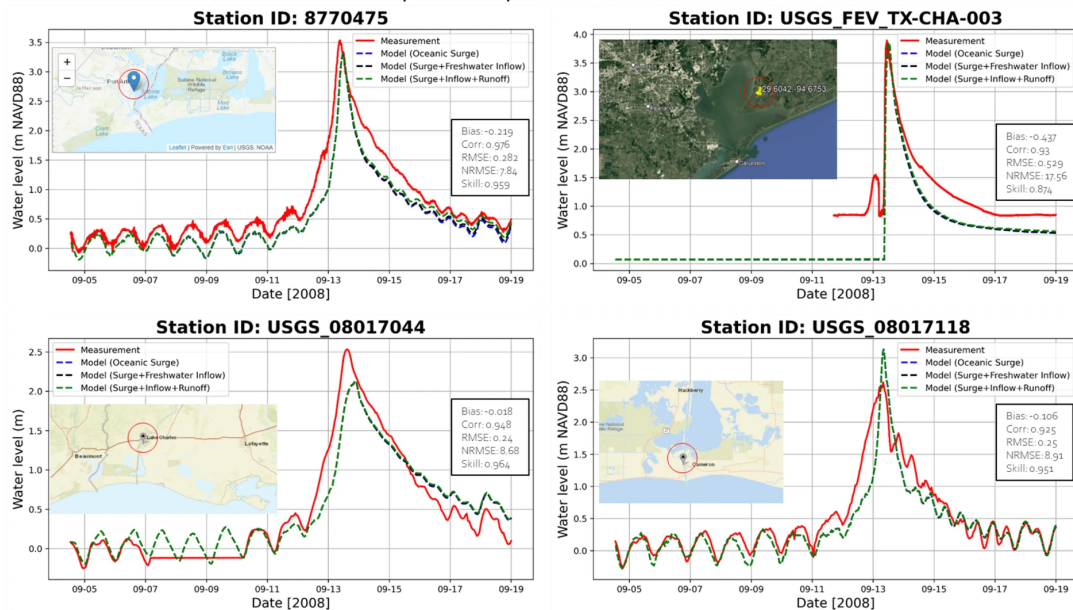
IRMA EVALUATION @ NOAA, USGS, AND USGS-FEV STATIONS



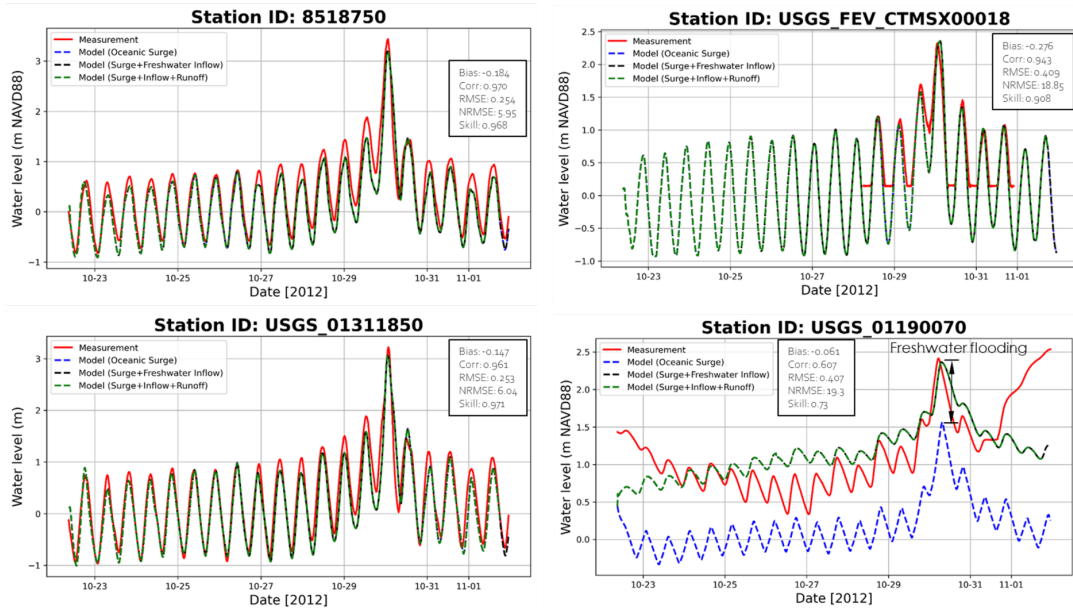
FLORENCE EVALUATION @ NOAA, USGS, AND USGS-FEV STATIONS



IKE EVALUATION @ NOAA, USGS, AND USGS-FEV STATIONS



SANDY EVALUATION @ NOAA, USGS, AND USGS-FEV STATIONS



CONCLUSION

Including the effect of compound flooding is crucial for accurate determination of coastal flooding.

The effect of compound flooding is more prone in the inland region of coastal areas where the hydrologic flood intersects the oceanic surge.

Not all storms exhibit the compound effects of storm surge, inflow and runoff. In our study Ike and Sandy lacks the compound effect from inflow and runoff in contrast, Irma and Florence can be considered compound flood events.

ABSTRACT

We present a high-resolution continental-scale compound flood modeling system. It aims to quantify inland flooding resulting from the composite effects of riverine discharge and surface runoff and storm surge, in the inland-coastal zone during significant riverine and coastal storm events. This is achieved by coupling three continental models: the National Water Model (NWM) for the hydrology component, the Advanced Circulation Ocean Model for the coastal storm surge component, and the WAVEWATCH III model for the surface wave component with a detailed inland-coastal inundation model as the mediator between coastal and inland hydrology module.

The inundation model, Delft3D FM, D-Flow Flexible Mesh (D-Flow FM), uses a high quality 2D unstructured grid with high-resolution (~100 m) near coastal features and lower-resolution in other areas to resolve the geometry of the study area. The coastal features are collected from NWM streamlines, National Hydrography Dataset, US medium shorelines and bathymetric features from the United States Army Corps of Engineers . The D-Flow FM model is forced by time-varying water levels and riverine discharges applied at its offshore and inland boundaries, respectively, by spatially- and time-varying wind and pressure fields and incorporates the contributions of surface and subsurface runoff to the total discharge in rivers, channels and streams.

We conducted model validations for the following four major flooding events across the US coast: Hurricanes Ike (2008), Sandy (2012), Irma (2017), and Florence (2018). The results highlight the importance of including composite effects of compound flooding to accurately predict water levels during combined river flooding and extreme storm surge events.

