Analysis and Evaluation of Flooding Predictions in the Transition Zone Using a State of the Art Coupled Hydrologic/Hydrodynamic Modeling System

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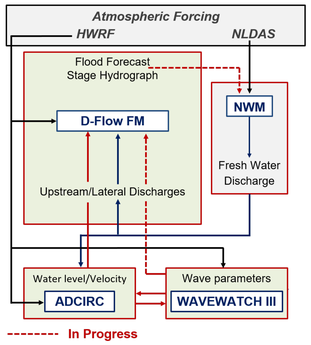
Problem Definition and Objectives

- A ***tropical storm*** that comes ashore brings ***strong winds***, and ***heavy rainfall*** followed by ***flooding*** that can cause ***serious destruction of life*** and ***substantial property damages***.
- ***Total flooding damages*** refer to the ***combined effects*** of hydrologic drivers such as ***rainfall runoff*** and ***river discharge*** and oceanographic drivers such as ***tides***, ***storm surge*** and ***waves***. The combination of these flooding events is referred to as ***compound flooding***.
- ***Forecasting compound flooding*** requires a modeling system that, integrates the interacting ***atmospheric***, ***hydrologic***, ***hydraulic***, and ***coastal hydrodynamic processes***.
- To ***predict compound flooding***, a ***state of the art modeling system*** is introduced for an ***end-to-end modeling solution***.
- The ***modeling approach*** represents an area of ***emerging research*** that allows us to address the ***coupled impacts of extreme storm events*** such as hurricanes on ***coastal and inland areas***.

Methods, Domain, and Site Selection

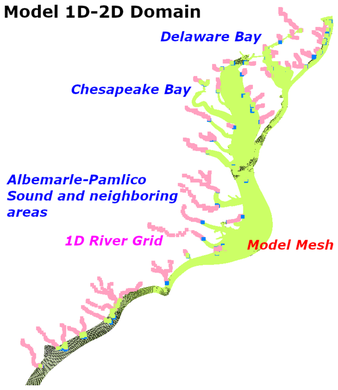
The system consists of the:

- ***National Water Model (NWM)*** - *Hydrology*
- ***DFlow Flexible Mesh (DFlow FM, Deltares)*** – *Hydraulics and Hydrodynamics*
- Storm surge/wave system ***ADCIRC/WAVEWATCH III*** – Hydrodynamics and Waves.
- High resolution ***Hurricane Weather Forecast System (HWRF)*** – Atmospheric forcings for all models.

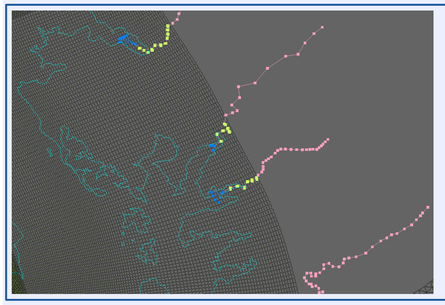


Application: Hurricane Florence

Model 1D-2D Domain



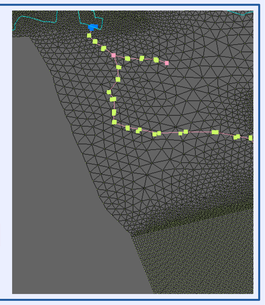
Two-Way coupling between the ***inland hydraulics*** (1D riverine modeling and hydraulic routing) and the ***coastal processes*** at the transition zone (2D estuarine hydrodynamics) ***improve the accuracy*** of total water level and flood inundation predictions.

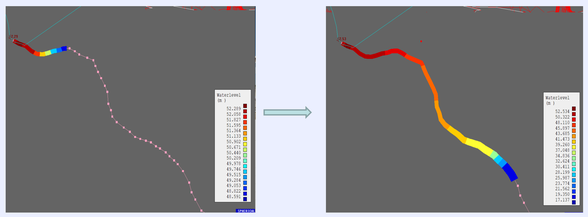


Linked 1D grids and 2D domain mesh

Two-way coupling approaches used in the modeling system

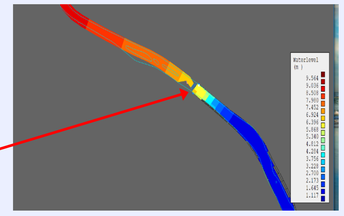
Embedded 1D riverine grid into the 2D domain mesh

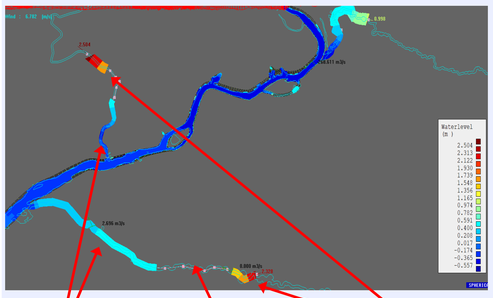




Flow propagation in 1D tributaries

Transition between 1D and 2D calculations



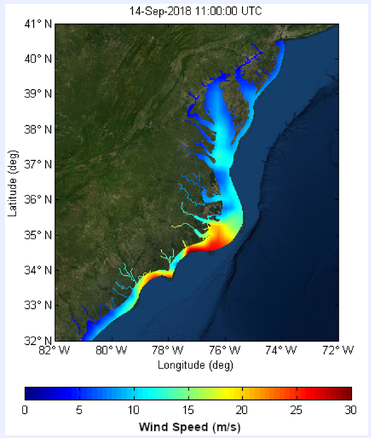


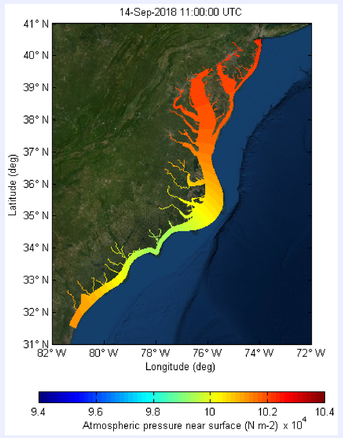
Backwater **Initially dry** **Inflow**

At the beginning of the simulation rivers are dry. Flow rate time series are supplied by NWM

Atmospheric Forcing (GFS Forecasts - Florence)

Atmospheric fields during landfall





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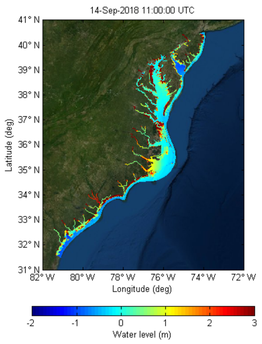
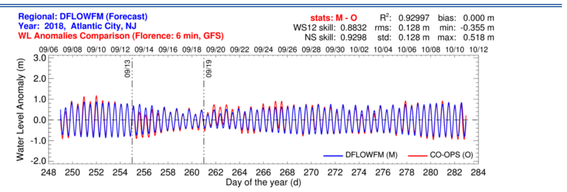
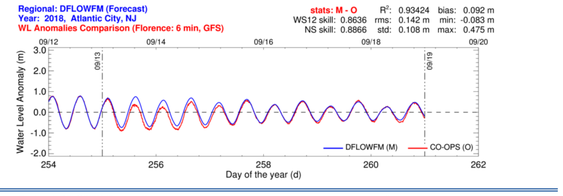
Results and Discussion



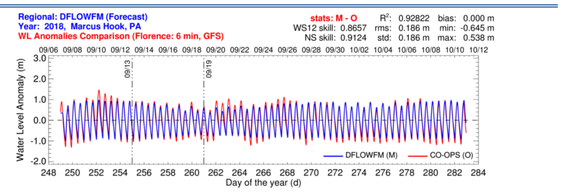
Hurricane Florence **Landfall near Wrightsville Beach, NC on 09/14/2018. Model run in forecasting mode forced by GFS atmospheric fields and by ESTOFS water levels at the open ocean boundary. Fresh water discharges were supplied by NWM 2.0.**

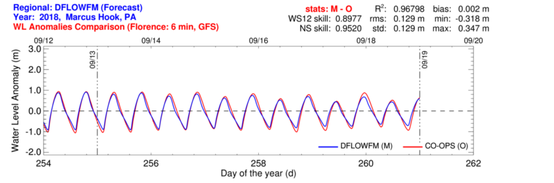
Coastal Zone



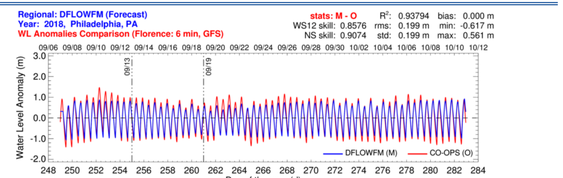


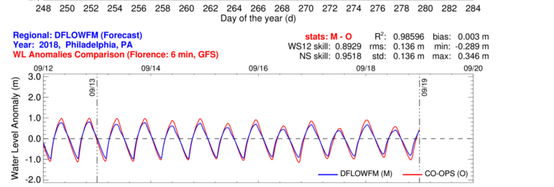
Delaware River: Inland





Delaware River: Further Inland





Conclusions

- Prediction of total water levels and flood inundation is improved when using the two-way coupling between riverine and coastal processes (1D-2D model configuration).
- Water level predictions were about 90% accurate in both their phases and peaks at the costal areas.
- Water level predictions in the riverine areas appear to be less accurate mainly due to lack of quality bathymetry and bottom roughness data (1D riverine modeling partially remedies the problem).

On-going and Future Work

- We are currently working to expand the modeling domain in the whole Atlantic region (Main to Florida's Atlantic coast).
- Implement the modeling system to the Northern Gulf of Mexico Region and inland areas.
- Finalize the two-way model coupling to couple inland and coastal processes.