

Development of 2D Unstructured Meshes Using a Sizing Function Derived from Euclidean Distances to Coastal Features for the NWM Hydrodynamic Engine (D-Flow FM) Model

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PREDICTION

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20th Symposium on the Coastal Environment
102nd Annual Meeting | Houston | Monday, January 24, 2022

Introduction

- Goal: To generate an element sizing function for construction of high-quality 2D unstructured mesh.
- Element sizing function based on proximities of coastal features from
 - ❑ National Water Model (NWM) streamlines
 - ❑ National Hydrography Dataset (NHD)
 - ❑ NOAA Medium Resolution Shoreline and
 - ❑ Bathymetric features from the United States Army Corps of Engineers (USACE).
- Finer elements for fine geometric details and coarser elsewhere.
- Input: Complex geometry of coastal features and user assigned element gradation.
- Output: High-quality mesh.

Mesh Generation Method

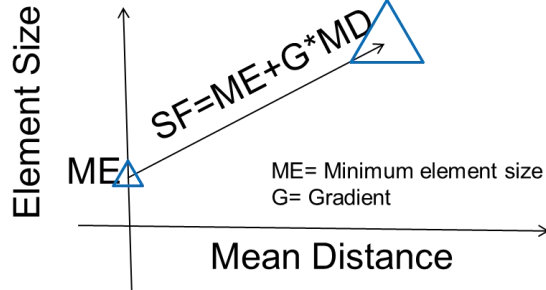
Euclidean Distance From Boundary Features (DB)

Mean Distance (MD)
MD=0.5x(DB+DM)

Size Function (SF)
SF=f(MD)

Mesh

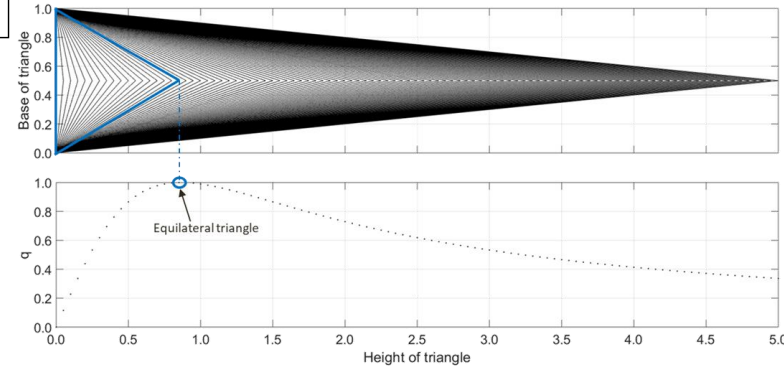
Euclidean Distance From Medial Features (DM)



Quality Assessment

$$q_{ALS} = \frac{4\sqrt{3} A}{l_1^2 + l_2^2 + l_3^2}$$

Bhatia et al 1990;
Sarrate et al 2003;
Bank et al 1997



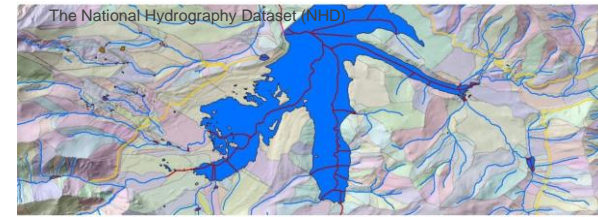
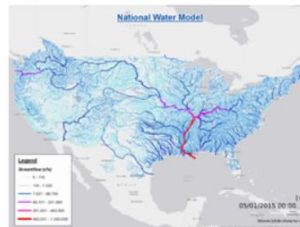
Kefelegn, Henok, "Automatic Shoreline Digitization and Mesh Element Sizing for Hydrodynamic Modeling" (2020). LSU Doctoral Dissertations. 5133.
https://digitalcommons.lsu.edu/gradschool_dissertations/5133

Model Domains (~+10 m, MSL & ~-2 m, MSL)

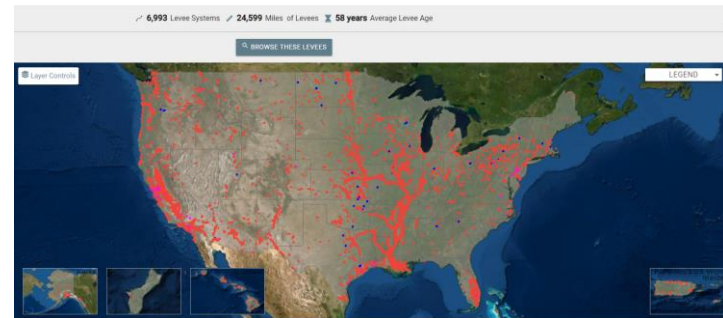


	Pacific	Gulf & Atlantic
Domain Area (km ²)	64,881	329,572
NWM Reach Length (km)	10,682	105,135
NHD Waterbody Area (km ²)	166	7,010
USACE Levee Length (km)	5,603	6,503
USACE Leveed Area (km ²)	6,076	23,343
USACE Navigation Channel Area (km ²)	159	1,525
USACE Navigation Channel Length (km)	4,093	24,691

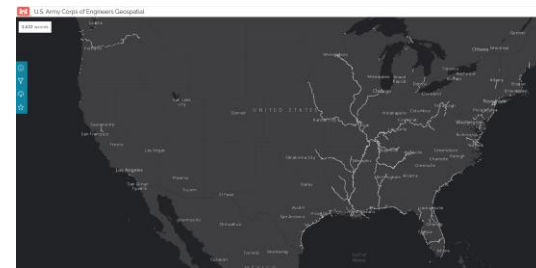
NWM Streamflow Output Points (~2.7 mil)



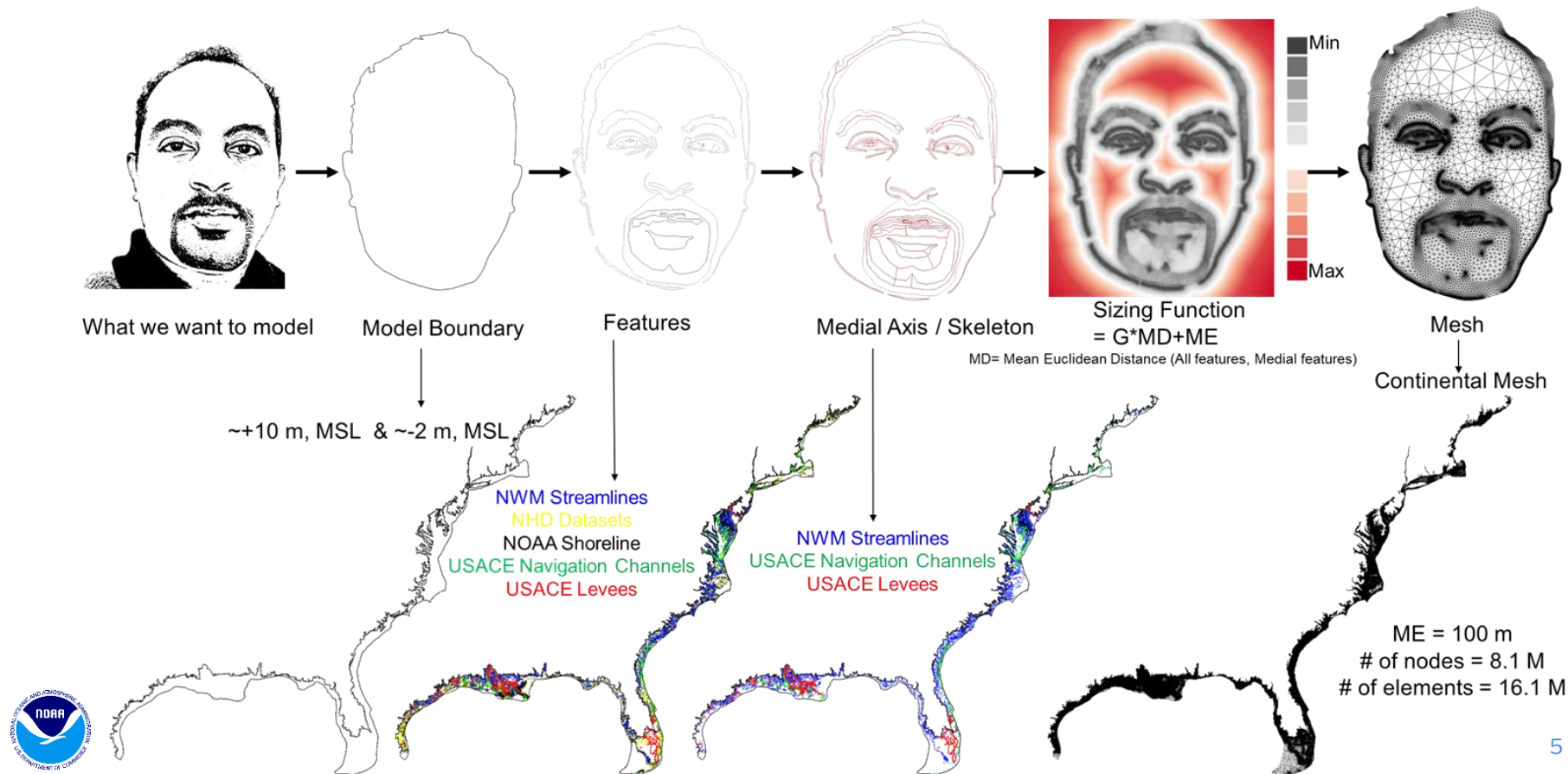
Levees of The Nation



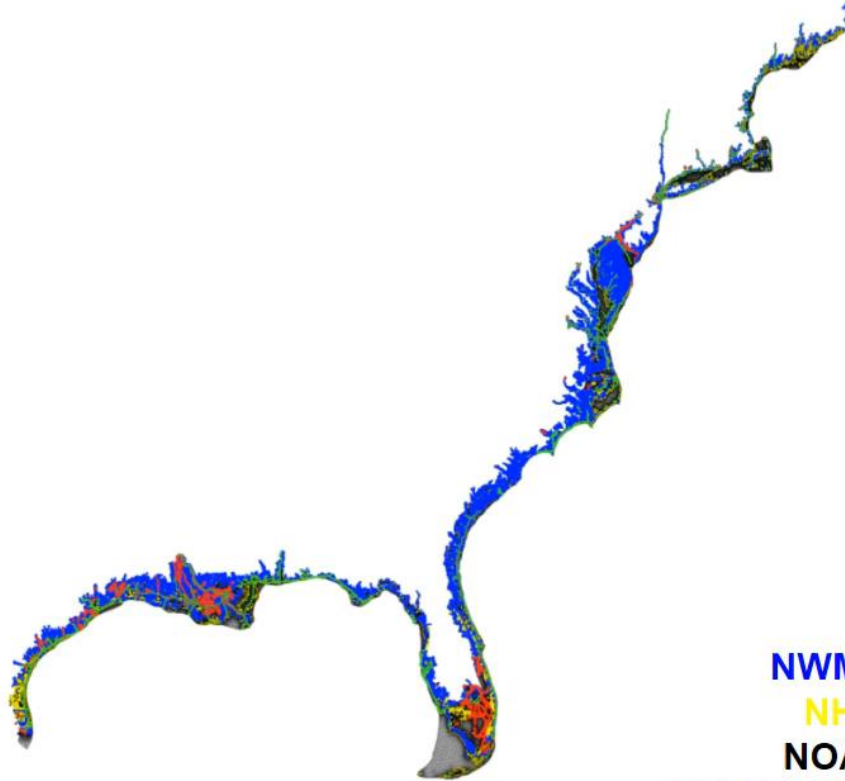
National Channel Framework



Continental Mesh Development



Continental-Scale Mesh (Atlantic & Gulf of Mexico)



NWM Streamlines

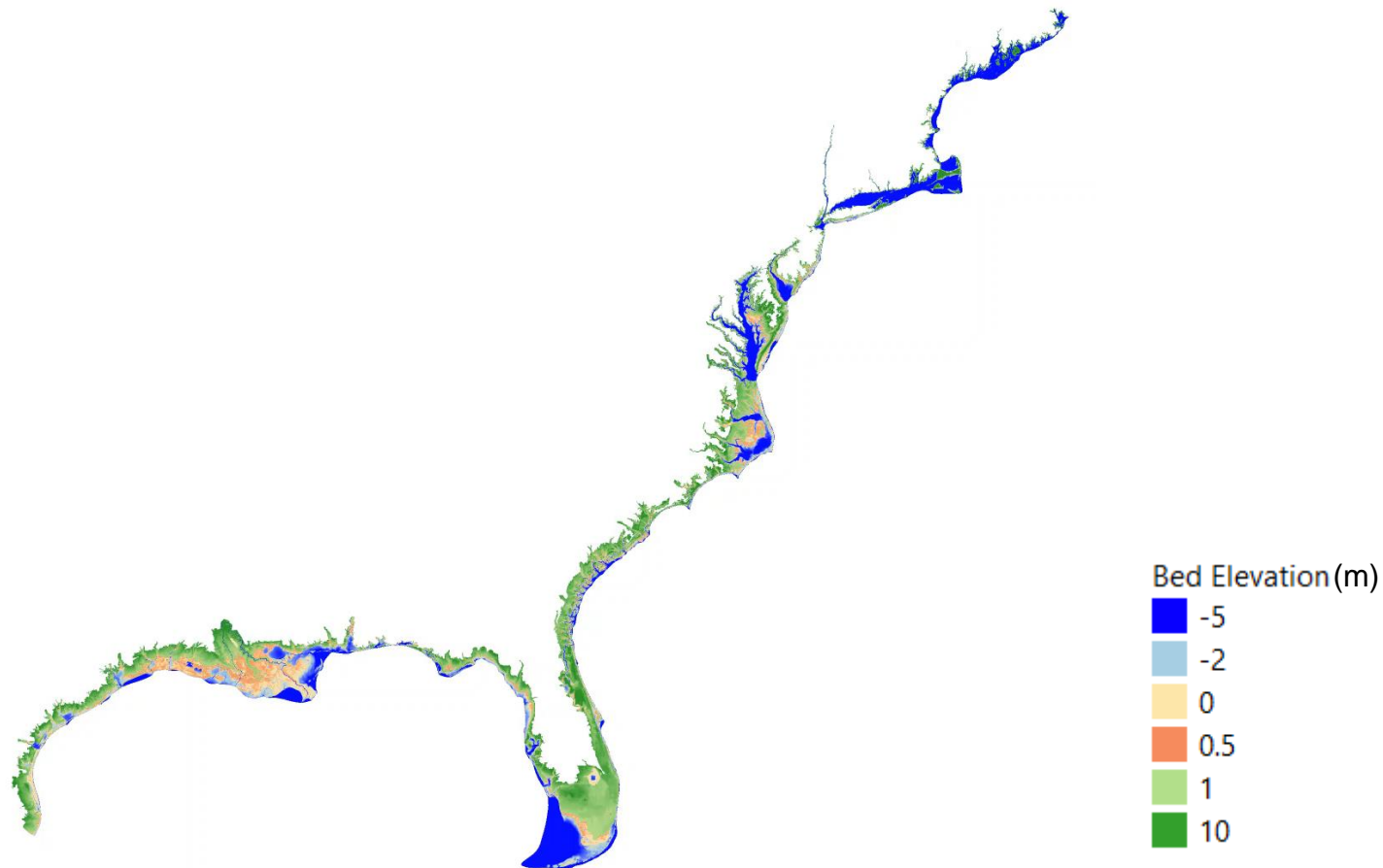
NHD Datasets

NOAA Shoreline

USACE Navigation Channels

USACE Levees

Continental-Scale Mesh (Atlantic & Gulf of Mexico)



Mesh Quality Assessment

G=0.1, ME= 2 Units



of nodes = 11908
of Elements = 22480
Mean qALS= 0.969

G=0.2, ME= 2 Units



of nodes = 6545
of Elements = 12011
Mean qALS= 0.961

G=0.4, ME= 2 Units



of nodes = 3180
of Elements = 5549
Mean qALS= 0.956

Mesh Quality

The US Continental Mesh

Mean qALS= 0.96 (High Quality!)

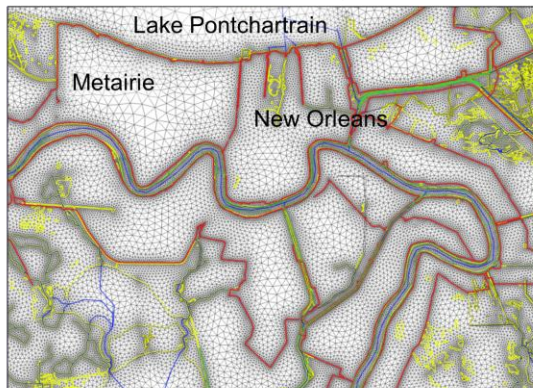
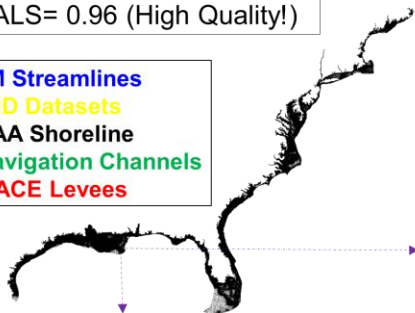
NWM Streamlines

NHD Datasets

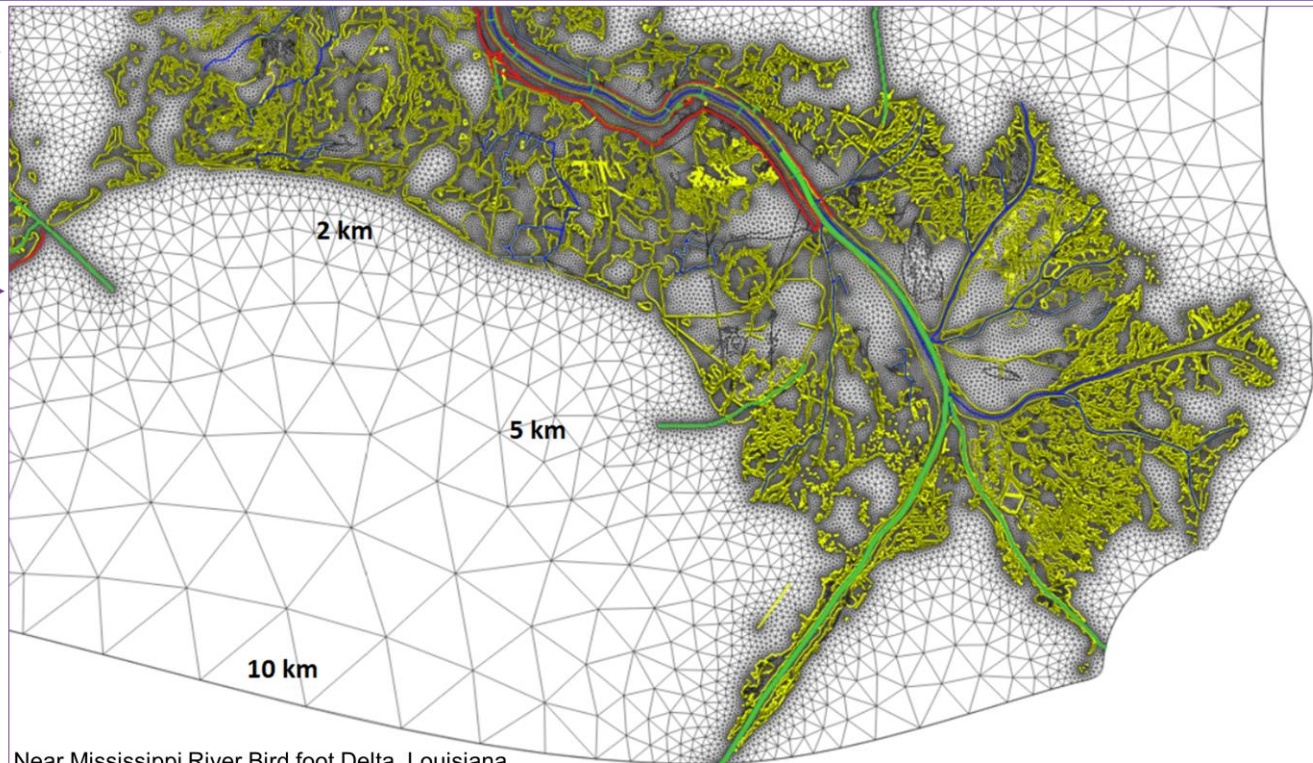
NOAA Shoreline

USACE Navigation Channels

USACE Levees



Near New Orleans, Louisiana



Near Mississippi River Bird foot Delta, Louisiana

Mesh Quality Cont.

The US Continental Mesh

Mean qALS= 0.96 (High Quality!)

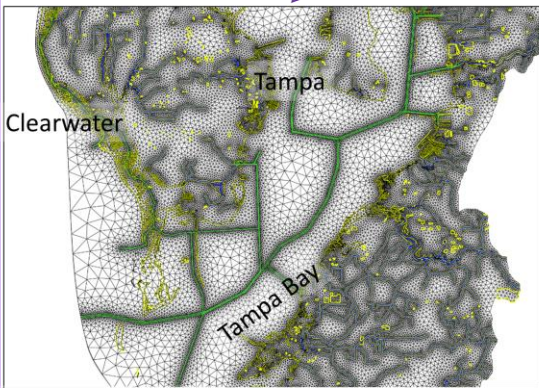
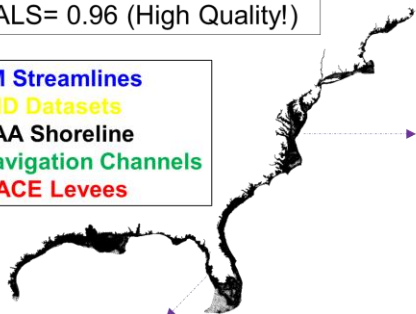
NWM Streamlines

NHD Datasets

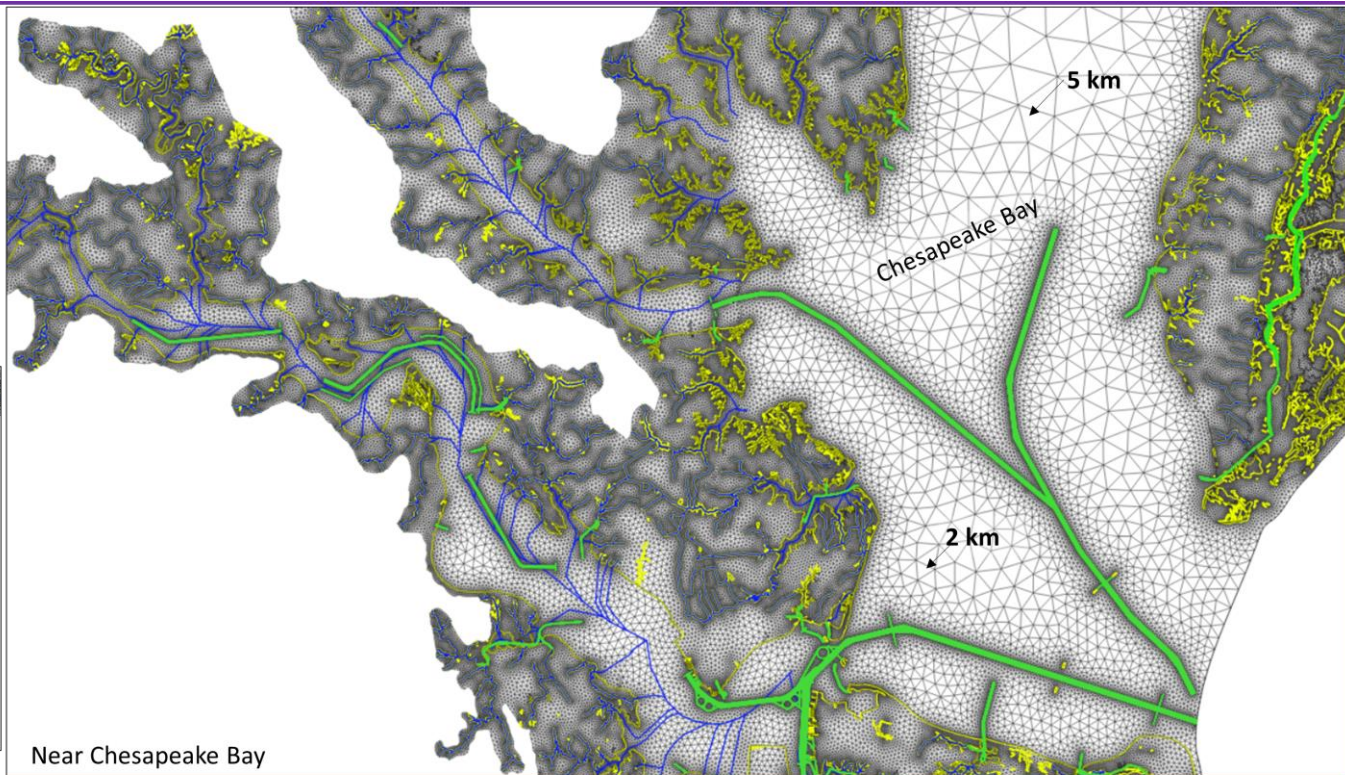
NOAA Shoreline

USACE Navigation Channels

USACE Levees



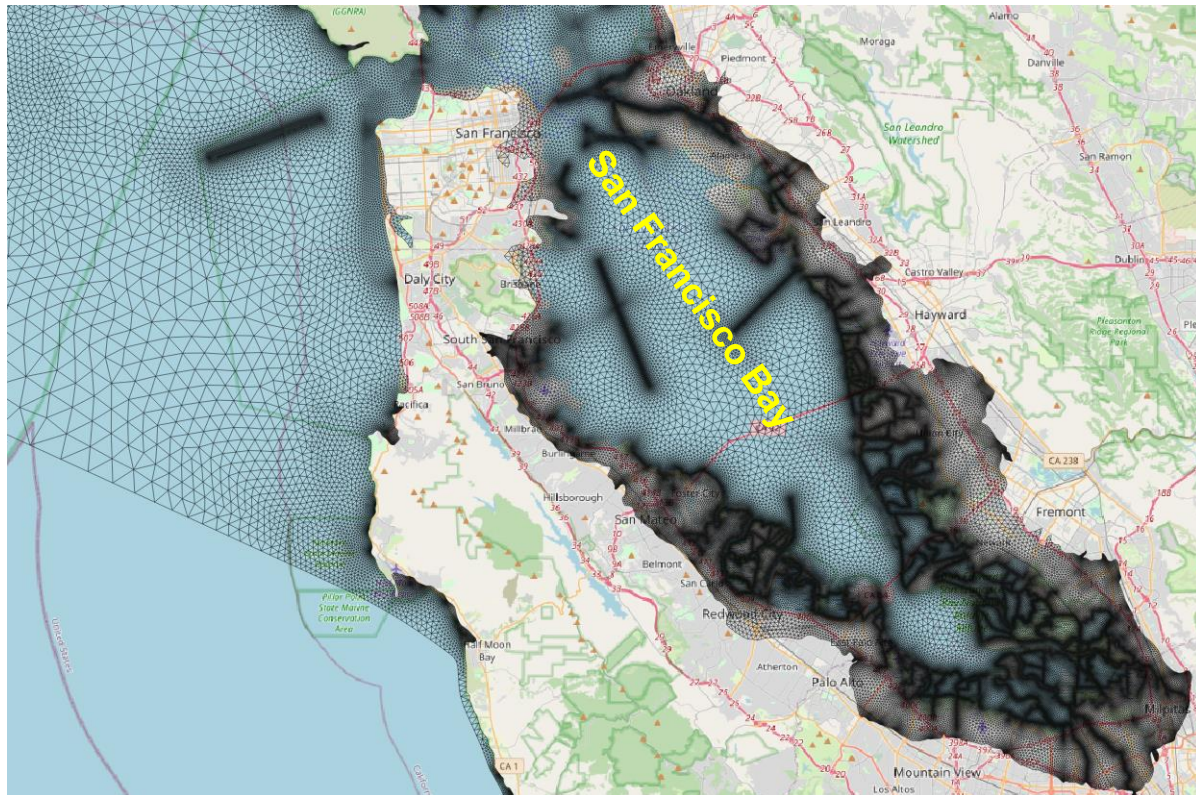
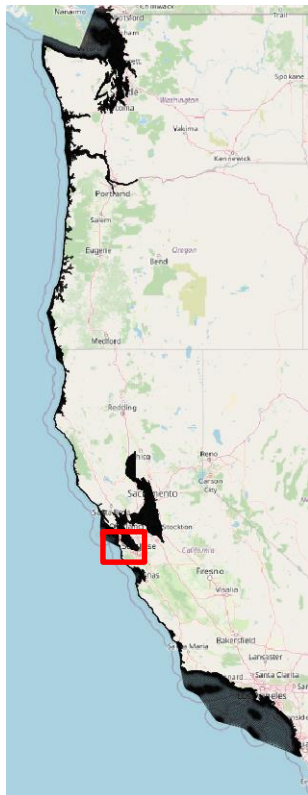
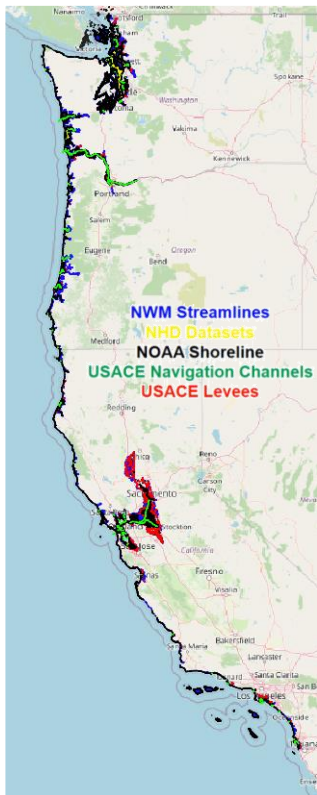
Near Tampa Bay, FL



Near Chesapeake Bay

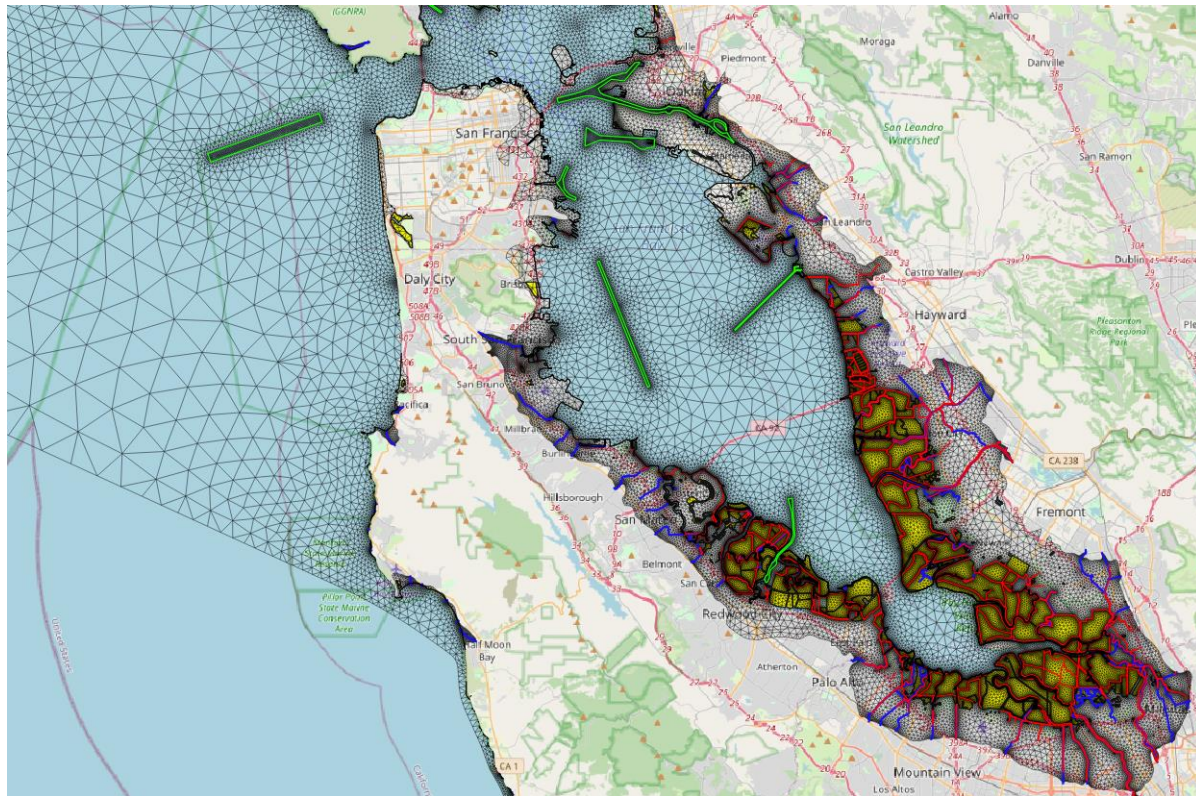
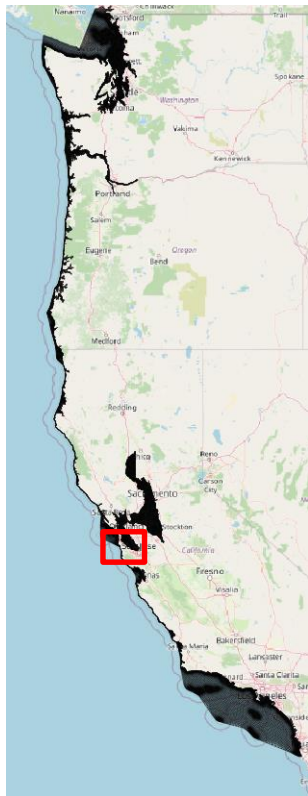
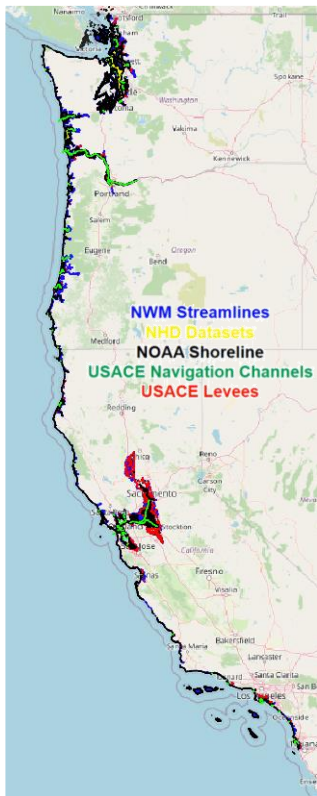
Continental-Scale Mesh (Pacific)

Mesh 1: 50 m resolution, $G = 0.2$, # of nodes: 3.2 M, # of elements: 6.3 M, $qALS = 0.963$



Continental-Scale Mesh (Pacific)

Mesh 1: 50 m resolution, $G = 0.4$, # of nodes: 1.8 M, # of elements: 3.5 M, $qALS = 0.957$



+ Levees lines + Navigation Channels + US Medium SL + NWM Streamlines + NHD Water body

Conclusions

- A new method was developed to define small elements in the region where coastal features exist and larger elements elsewhere.
- The method grants the user flexibility to adjust the gradient and avoid manual iterative procedure.
- Quality assessment shows that the new algorithm is capable of producing high quality meshes.
- Newly created continental-scale meshes on the Atlantic Ocean, Gulf of Mexico and Pacific Ocean coastlines demonstrate the application of the proposed method for automatic generation of unstructured, high-quality 2D meshes.
- The method allows improved integration of the hydrodynamic D-Flow Flexible Mesh (D-Flow FM) model into the hydrological NWM and results in an optimum number of computational points.



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Thank You!



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