

# **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**

**H. Kefelegn<sup>2</sup>, R. Gibbs<sup>2</sup>, J. Zyberman<sup>2</sup>, T. Flowers<sup>2</sup>, E.P. Clark<sup>2</sup>, H. Mashriqui<sup>1</sup>, J. Allen<sup>2</sup>, J. Ducker<sup>2</sup>, R. Grout<sup>2</sup>**

**<sup>1</sup>NOAA Office of Water Prediction, Silver Spring, MD**

**<sup>2</sup>NOAA Office of Water Prediction, National Water Center, Tuscaloosa, AL**



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# Introduction

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- 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

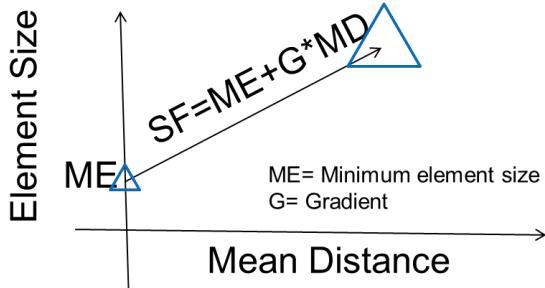
Euclidean Distance From Boundary Features (DB)

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

Size Function (SF)  
 $SF=f(MD)$

Mesh

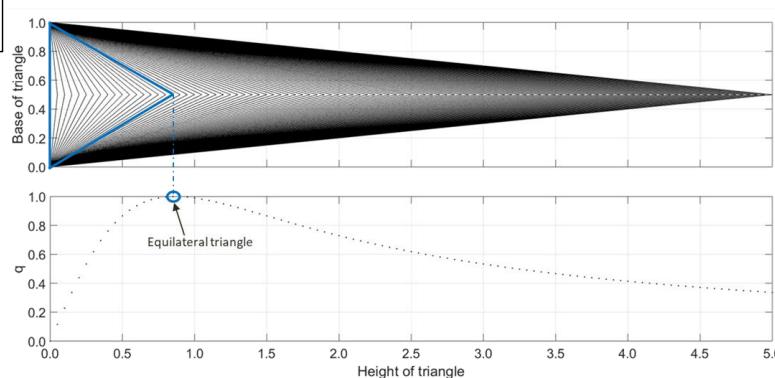
Euclidean Distance From Medial Features (DM)



Quality Assessment

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

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](https://digitalcommons.lsu.edu/gradschool_dissertations/5133)

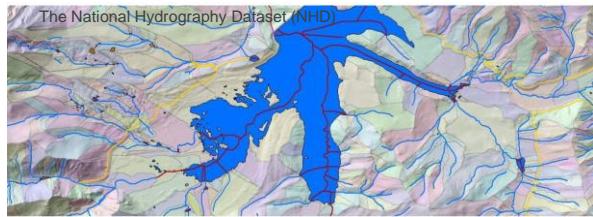


# Model Domains (~+10 m, MSL & ~-2 m, MSL)



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

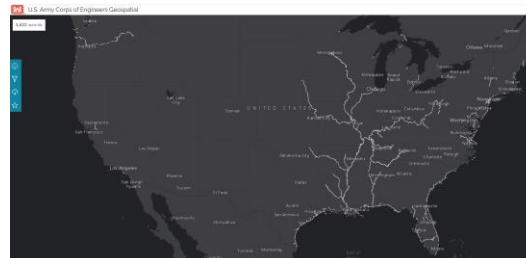
NWM Streamflow Output Points (~2.7 mil)



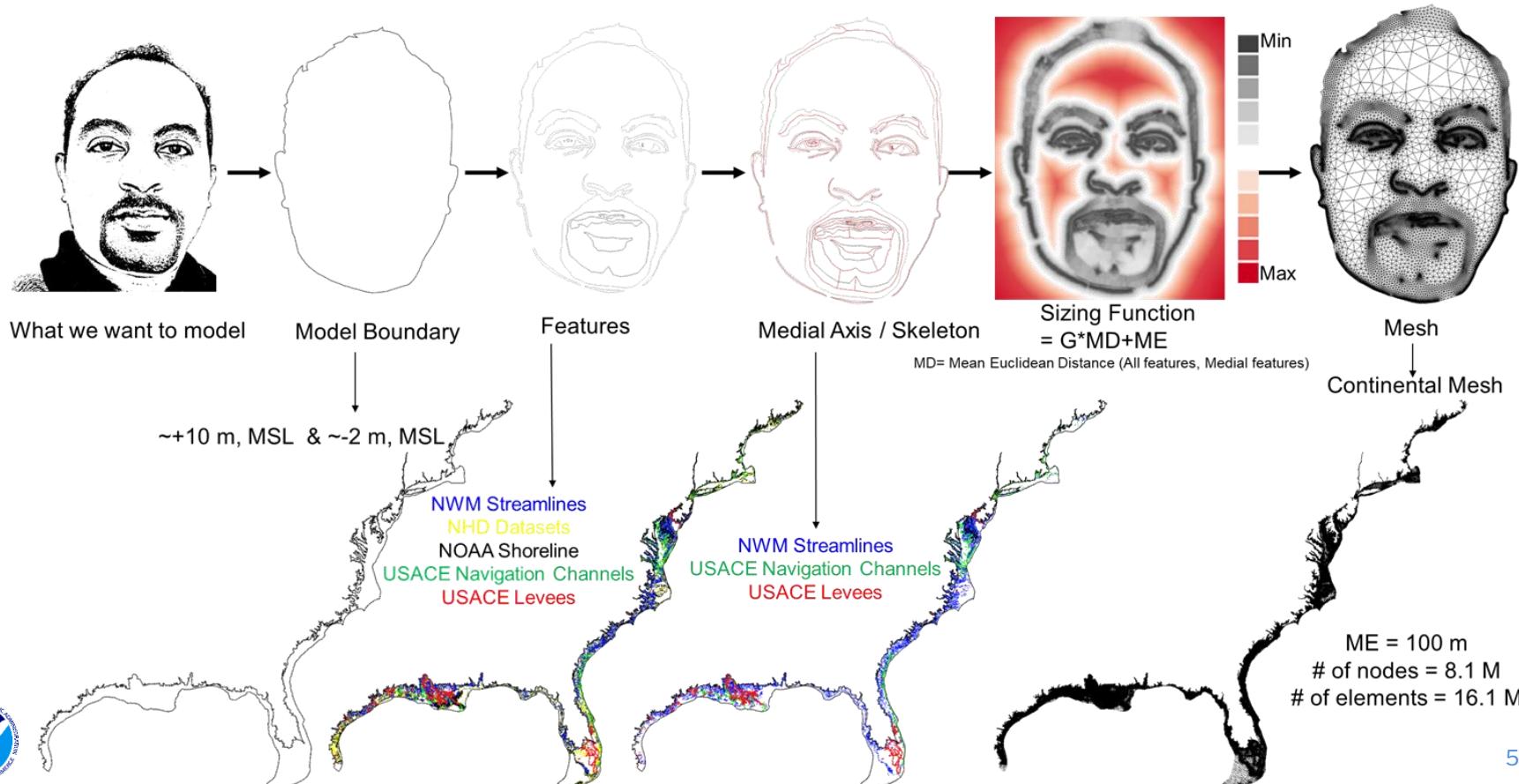
Levees of The Nation



National Channel Framework

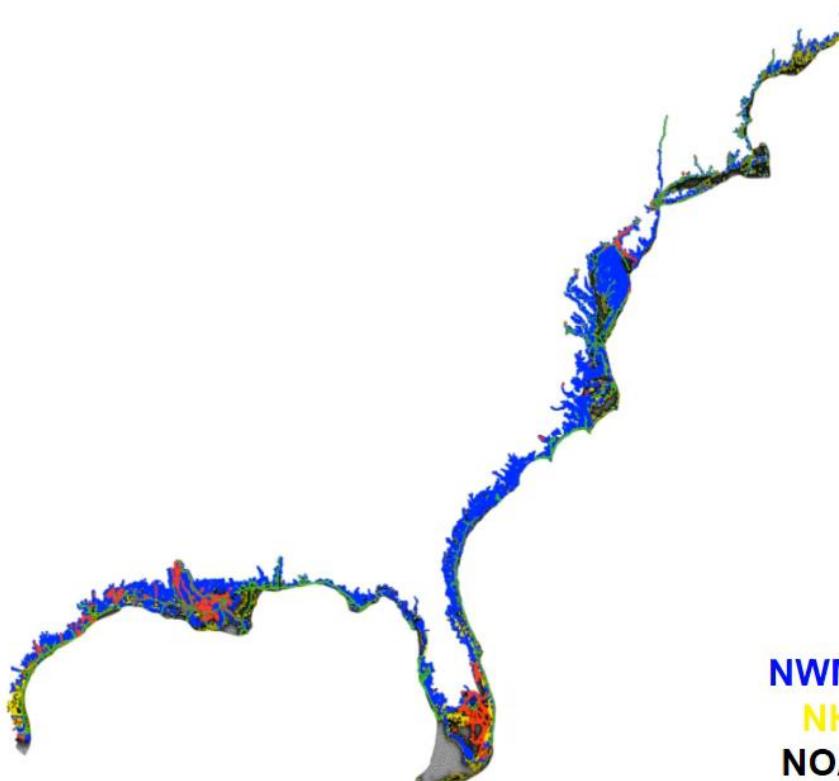


# Continental Mesh Development



# Continental-Scale Mesh (Atlantic & Gulf of Mexico)

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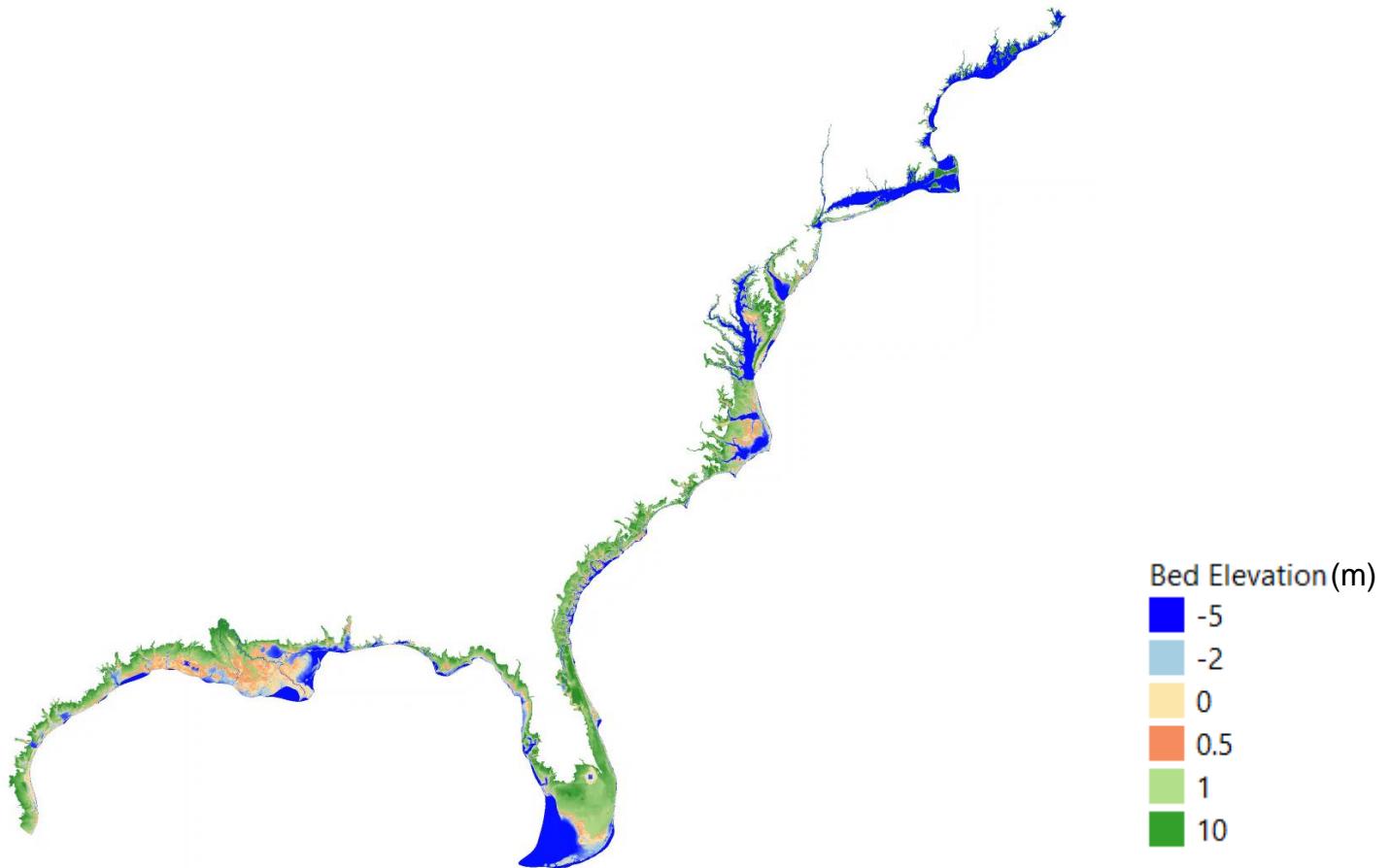


**NWM Streamlines**  
**NHD Datasets**  
**NOAA Shoreline**  
**USACE Navigation Channels**  
**USACE Levees**

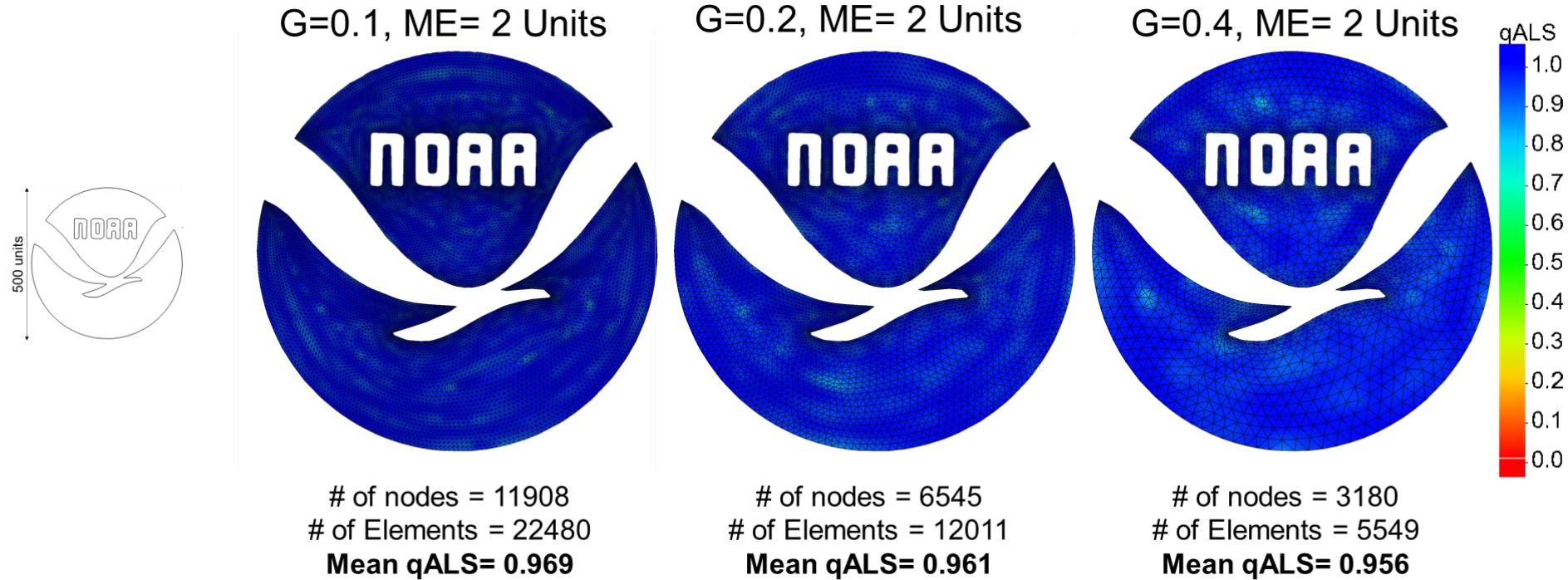


# Continental-Scale Mesh (Atlantic & Gulf of Mexico)

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# Mesh Quality Assessment



# Mesh Quality

## The US Continental Mesh

Mean qALS= 0.96 (High Quality!)

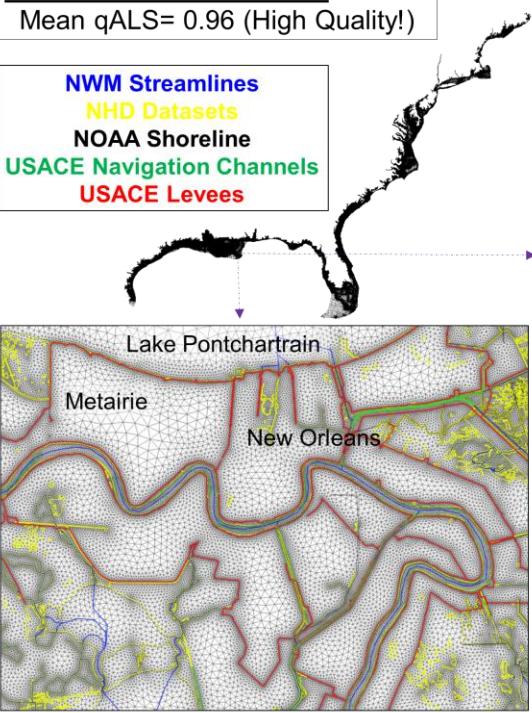
NWM Streamlines

NHD Datasets

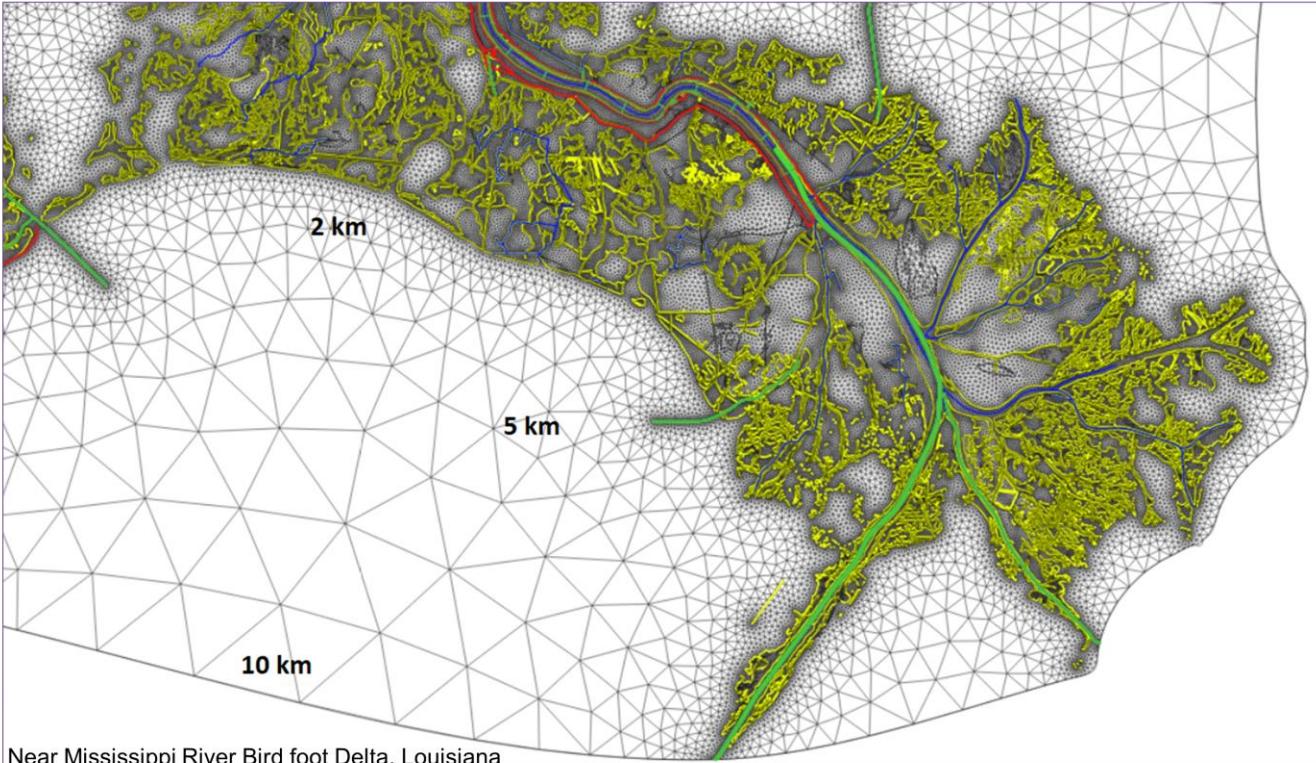
NOAA Shoreline

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!)

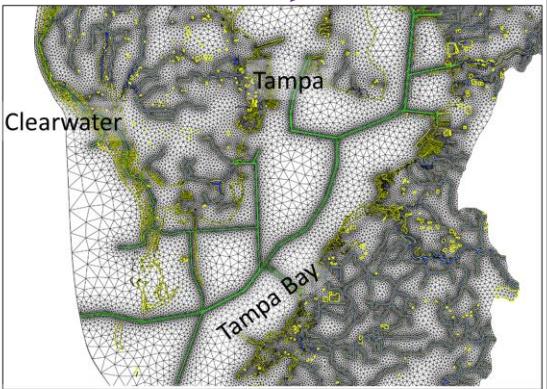
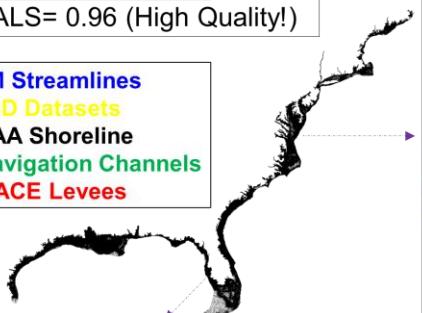
NWM Streamlines

NHD Datasets

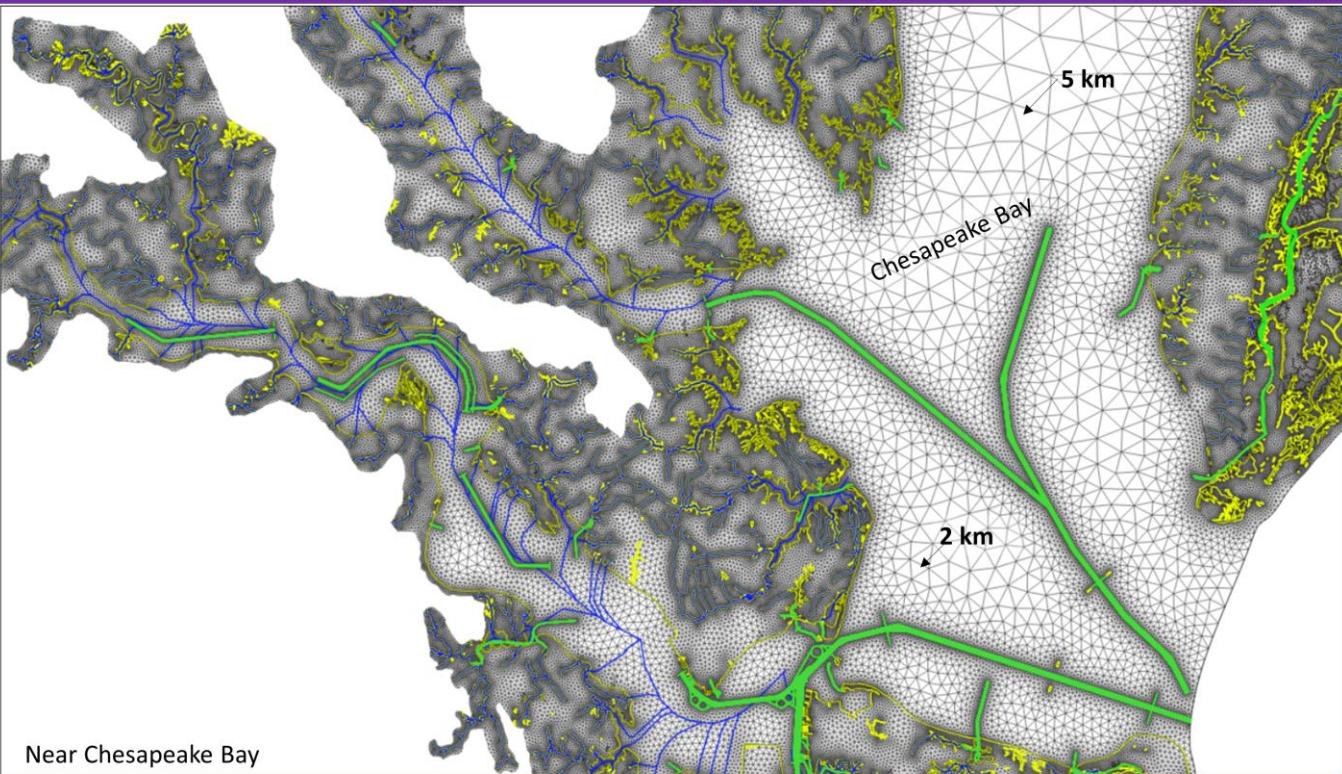
NOAA Shoreline

USACE Navigation Channels

USACE Levees

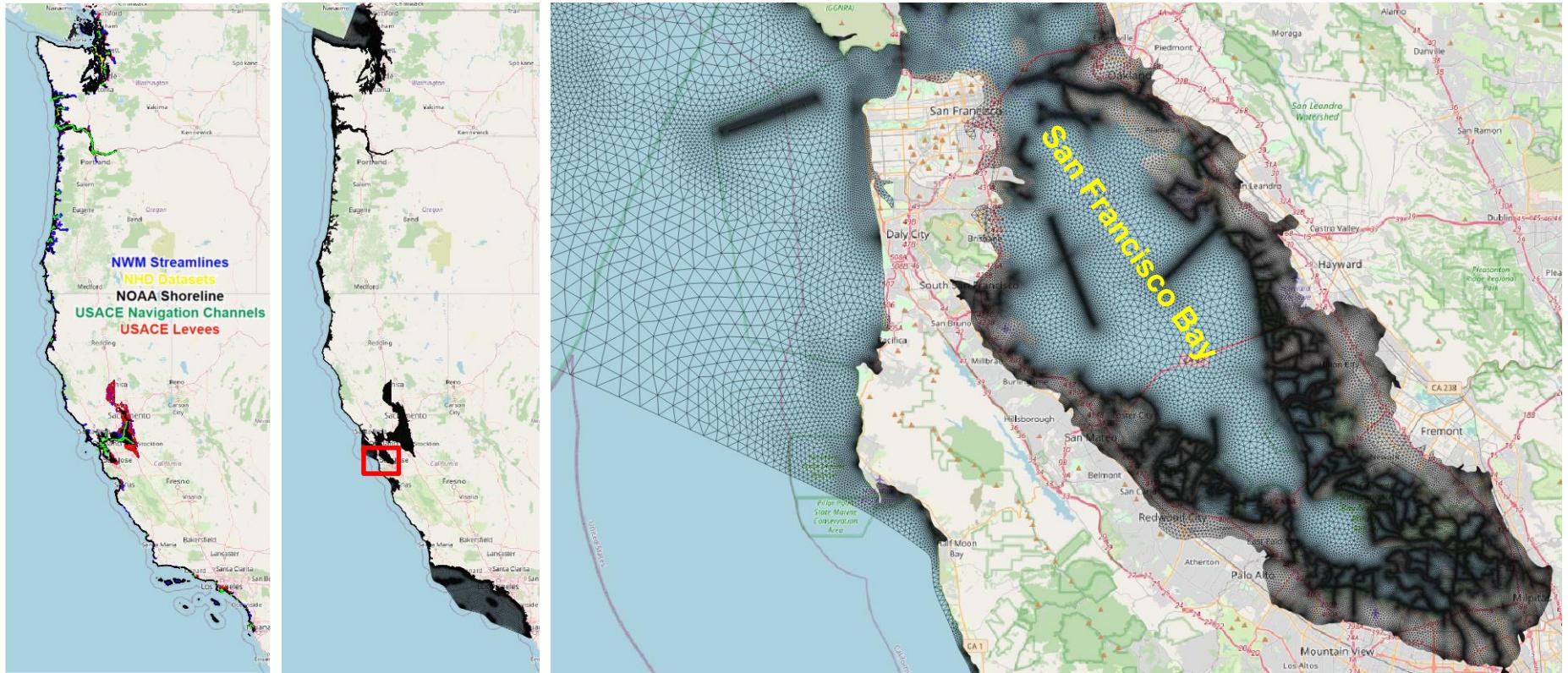


Near Tampa Bay, FL



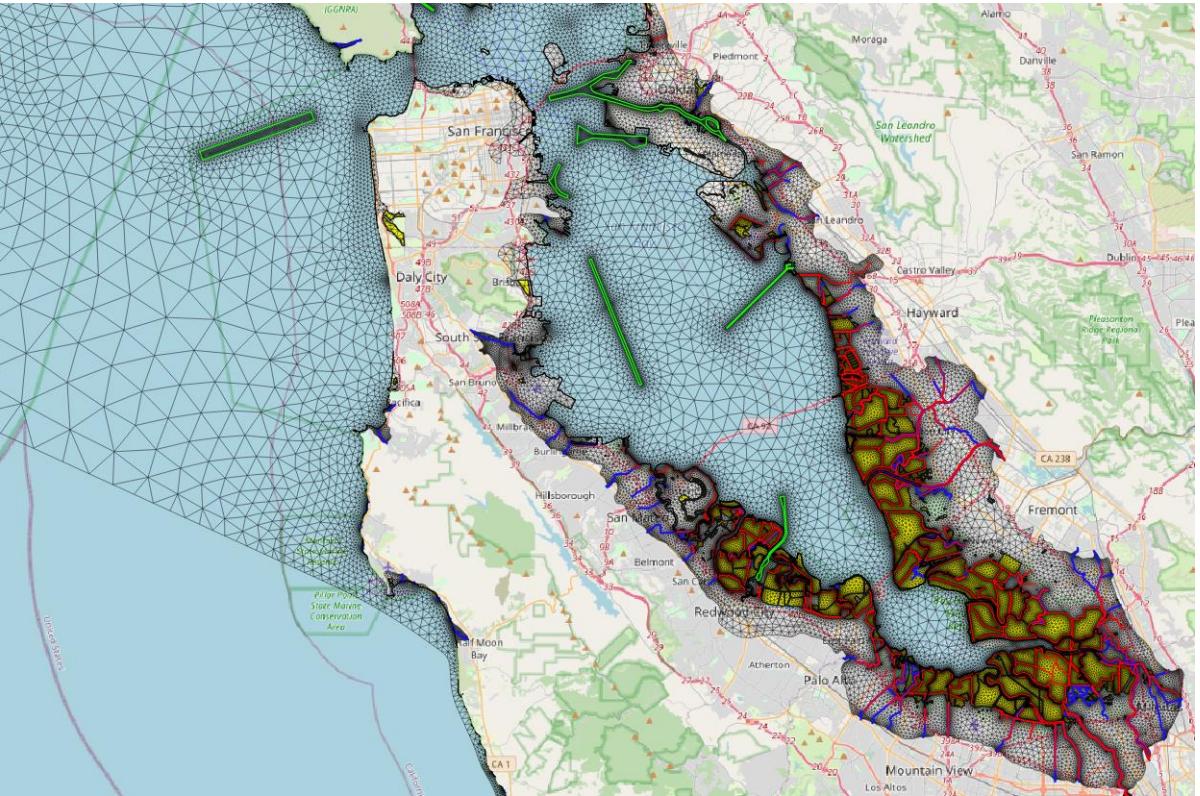
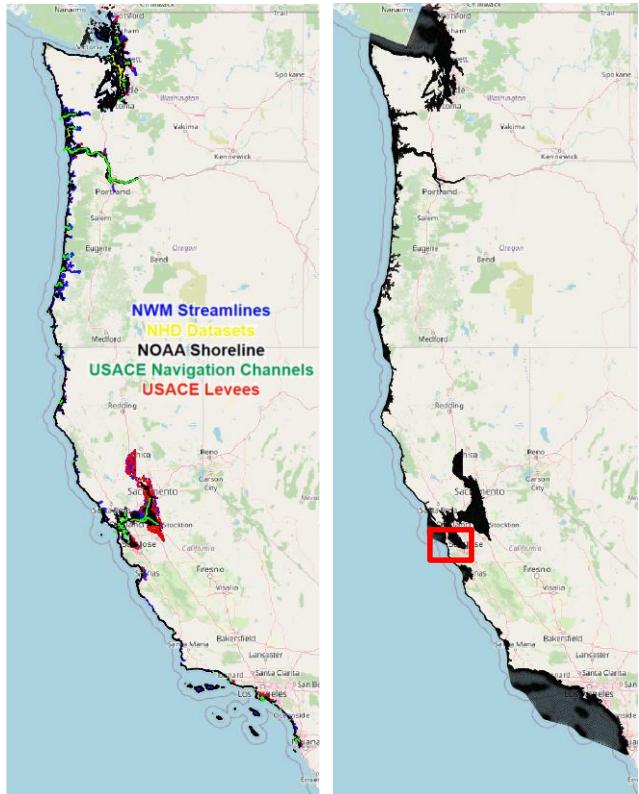
# Continental-Scale Mesh (Pacific)

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

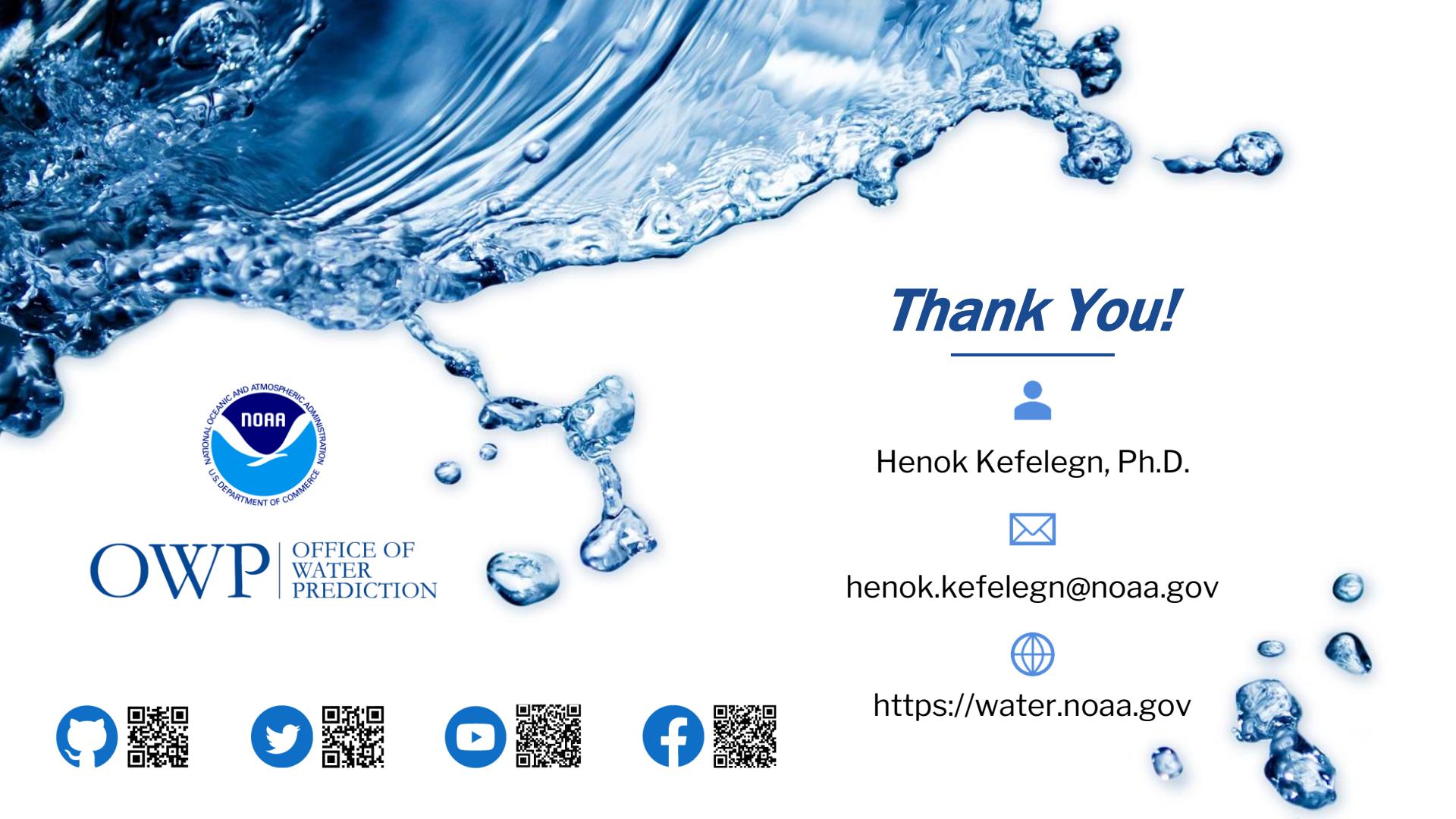


# Conclusions

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- 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.





# *Thank You!*

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Henok Kefelegn, Ph.D.



[henok.kefelegn@noaa.gov](mailto:henok.kefelegn@noaa.gov)



<https://water.noaa.gov>

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