



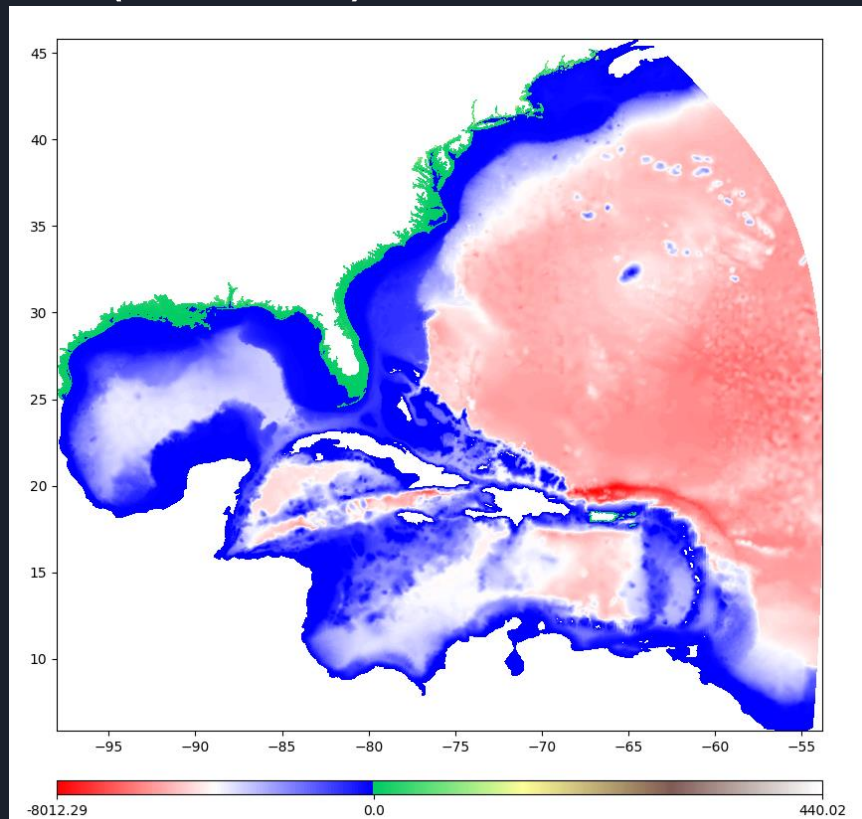
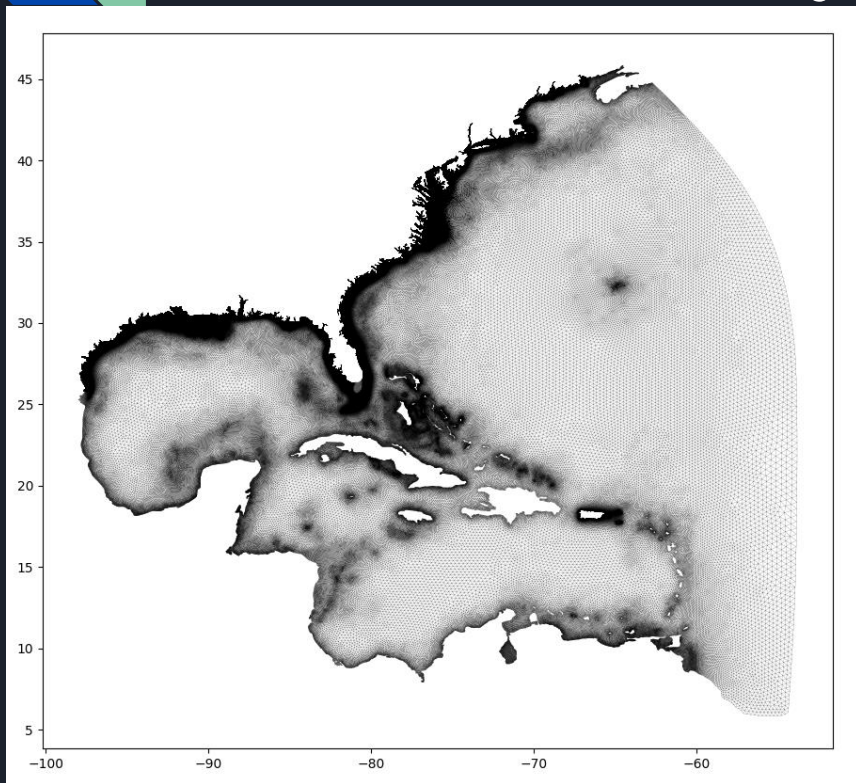
# Data driven geophysical unstructured mesh generation

Jaime R Calzada<sup>1,2</sup>, Ed Myers<sup>1</sup>, Sergey Vinogradov<sup>1</sup> and Saeed Moghimi<sup>1,2</sup>

<sup>1</sup>Coastal Survey and Development Lab, NOAA

<sup>2</sup>University Center for Atmospheric Research (UCAR)

# Current operational mesh Hurricane Storm-Surge On-Demand Forecast System (HSOFS)



# HSOFS mesh source data

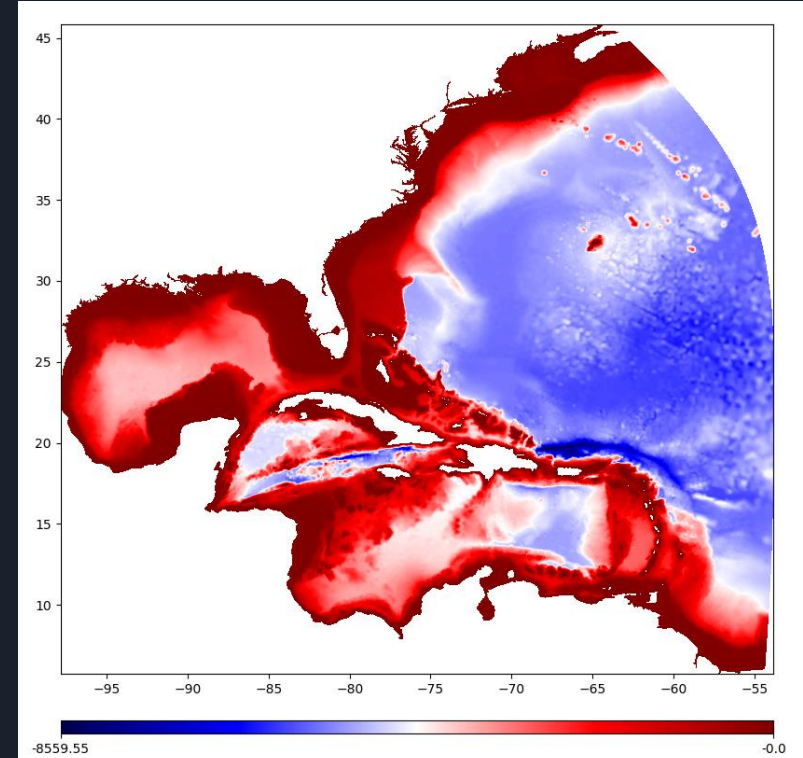
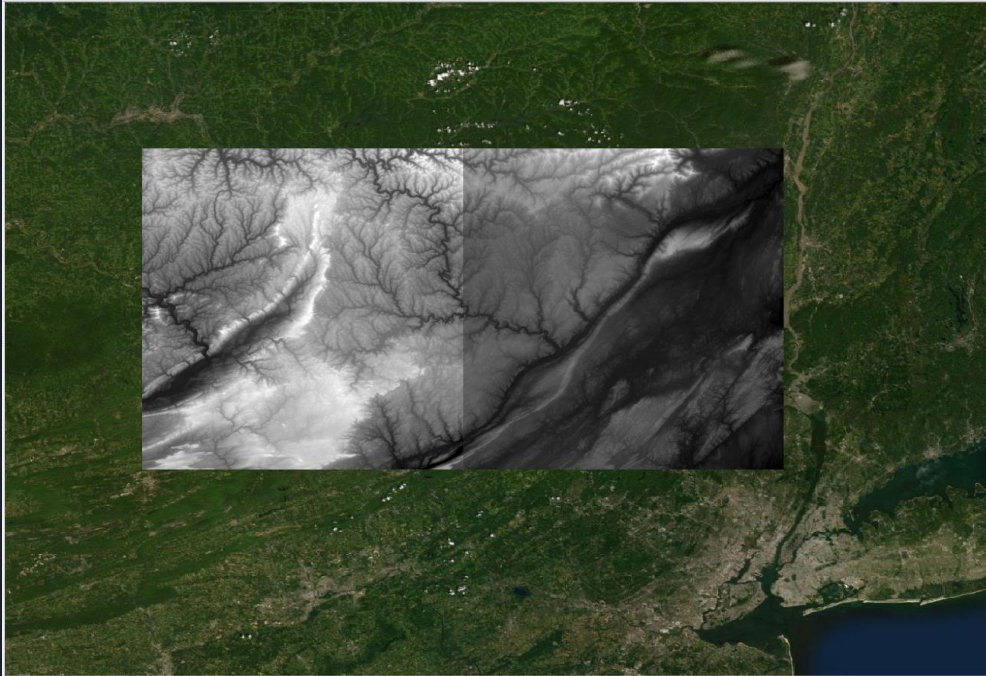
USGS NED DEM

+

EC2012 mesh

Contains dry nodes only

Contains wet nodes only



# Digital Elevation Model data comparison

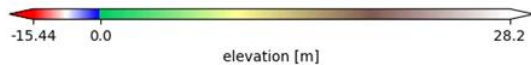
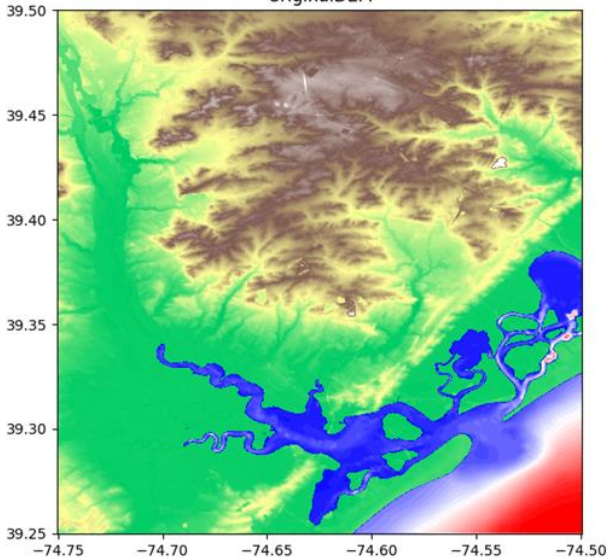
## Ocean City Inlet, NJ

USGS+EC2012  
(old DEM)

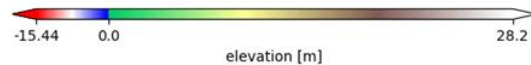
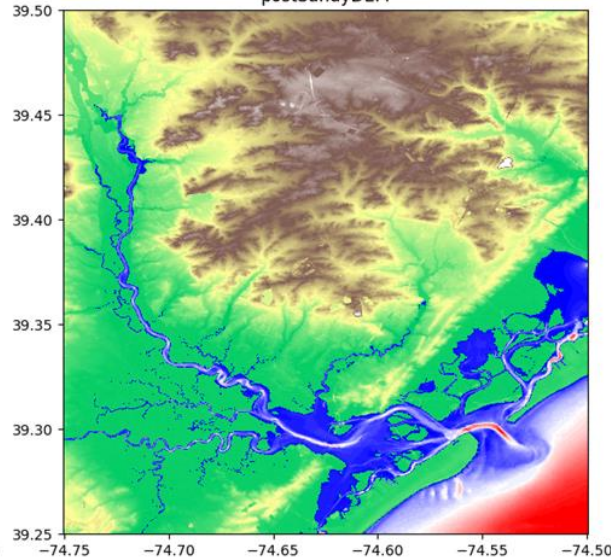
NCEI post Sandy (2012)  
(new DEM)

difference

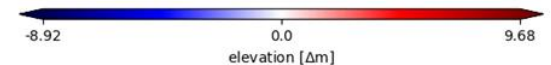
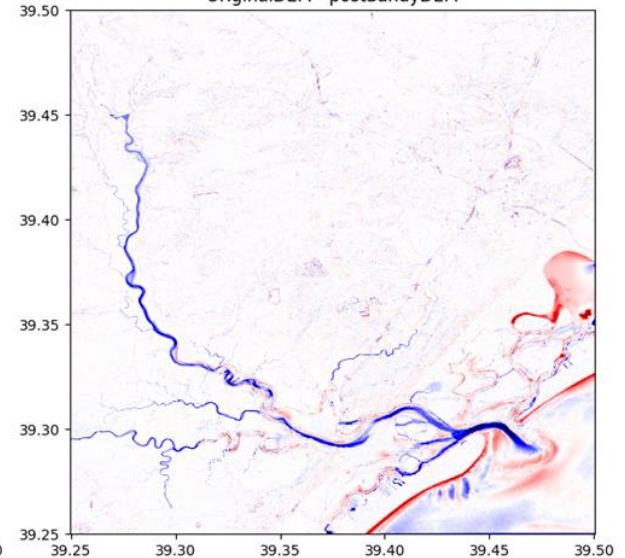
OriginalDEM



postSandyDEM



OriginalDEM - postSandyDEM

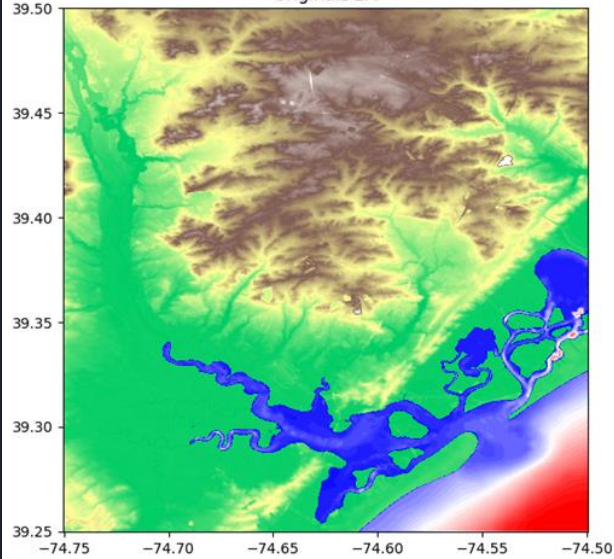


# Digital Elevation Model data comparison

## Ocean City Inlet, NJ

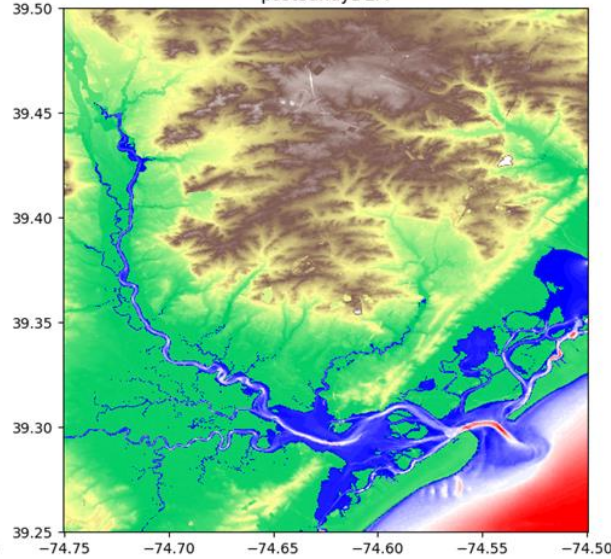
USGS+EC2012

OriginalDEM

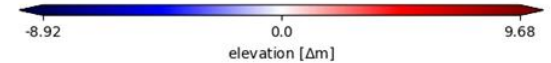
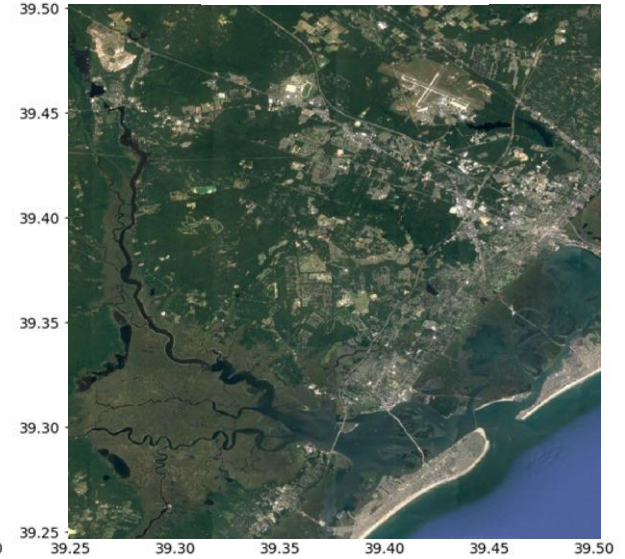


NCEI post Sandy (2012)

postSandyDEM



satellite

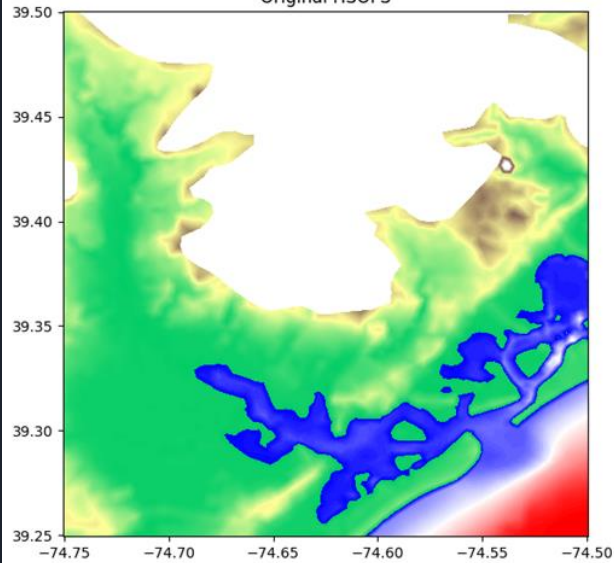


# HSOFS - DEM interpolation

## Ocean City Inlet, NJ

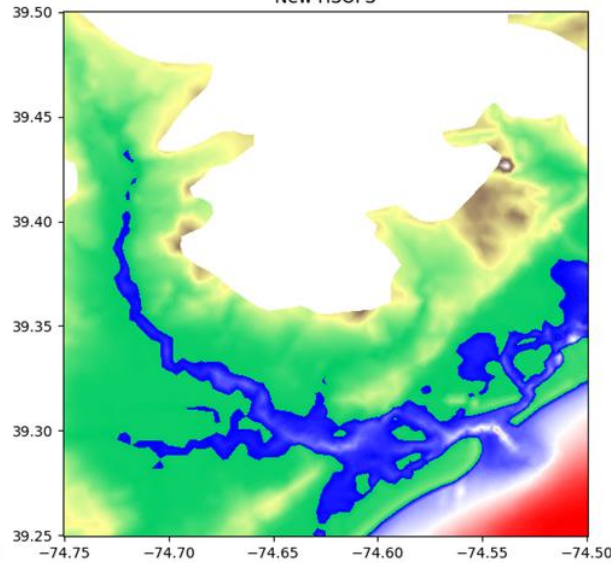
USGS+EC2012

Original HSOFS

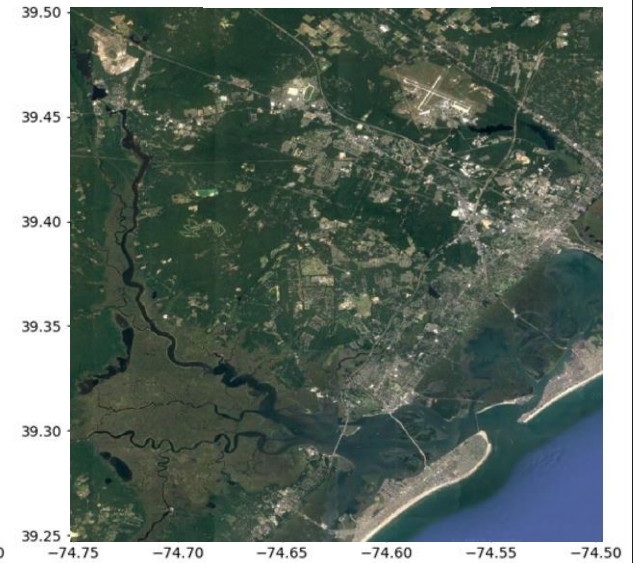


NCEI post Sandy (2012)

New HSOFS



satellite

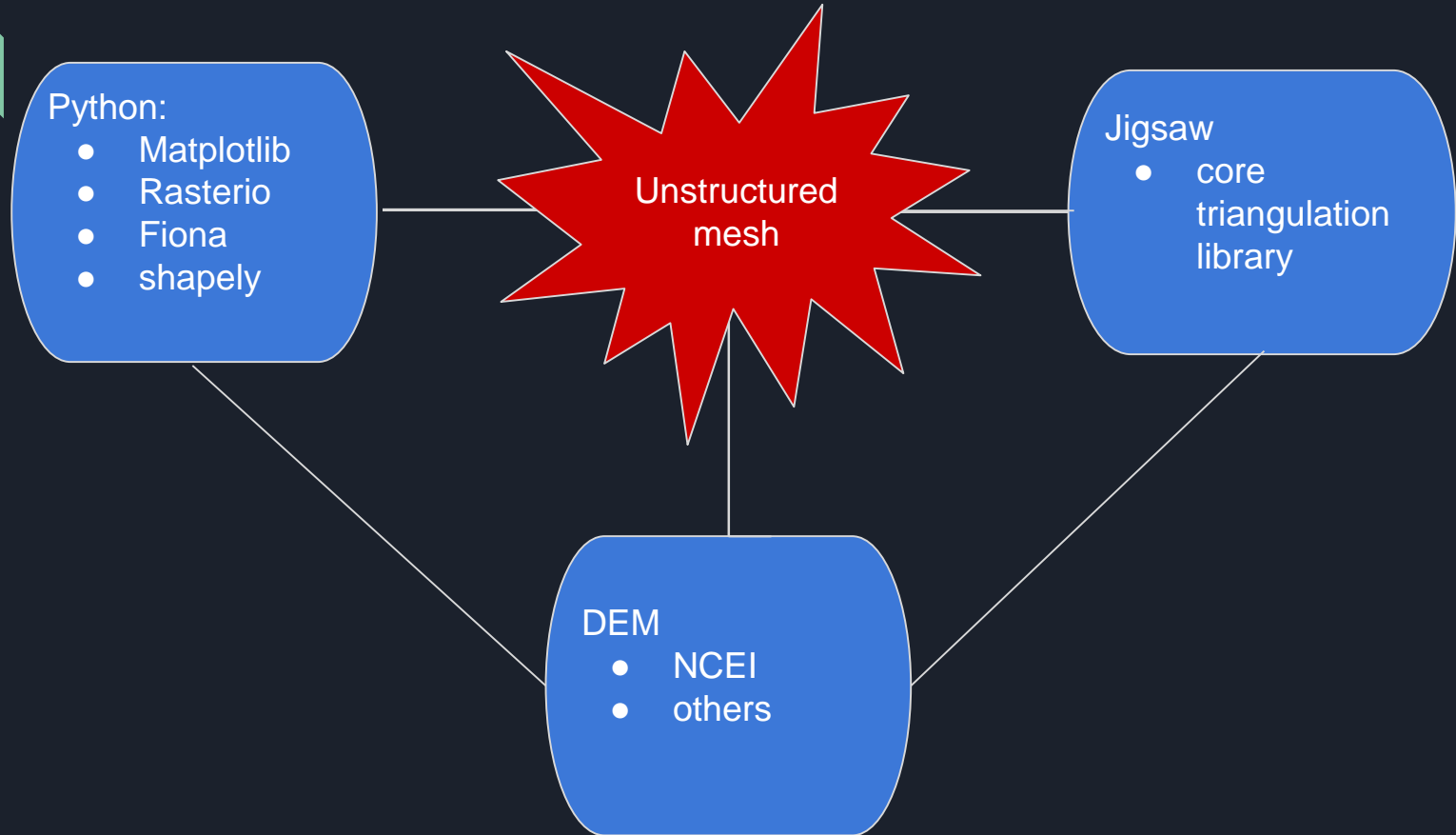


-15.44 0.0 28.2  
elevation [m]

-15.44 0.0 28.2  
elevation [m]

-8.92 0.0 9.68  
elevation [ $\Delta$  m]

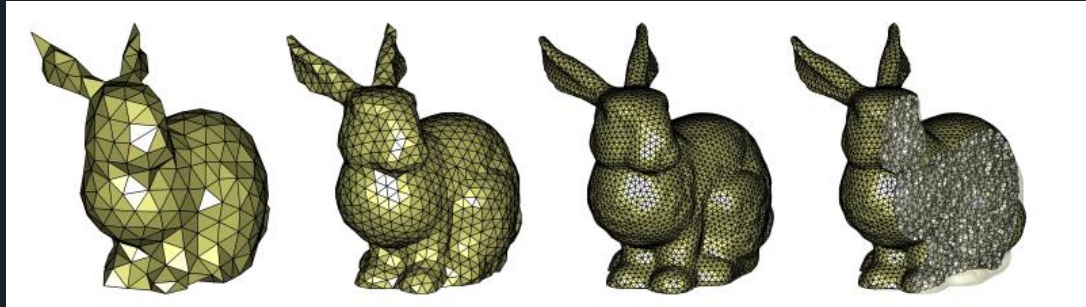
# New meshing paradigm



# The Jigsaw library

From the Jigsaw documentation:

JIGSAW is a computational library for unstructured mesh generation and tessellation; designed to generate high-quality triangulations and polyhedral decompositions of general planar, surface and volumetric domains. JIGSAW includes refinement-based algorithms for the construction of new meshes, optimisation-driven techniques for the improvement of existing grids, as well as routines to assemble (restricted) Delaunay tessellations, Voronoi complexes and Power diagrams.



Darren Engwirda: Generalised primal-dual grids for unstructured co-volume schemes, *J. Comp. Phys.*, 375, pp. 155-176, <https://doi.org/10.1016/j.jcp.2018.07.025>, 2018.

<https://github.com/dengwirda/jigsaw>





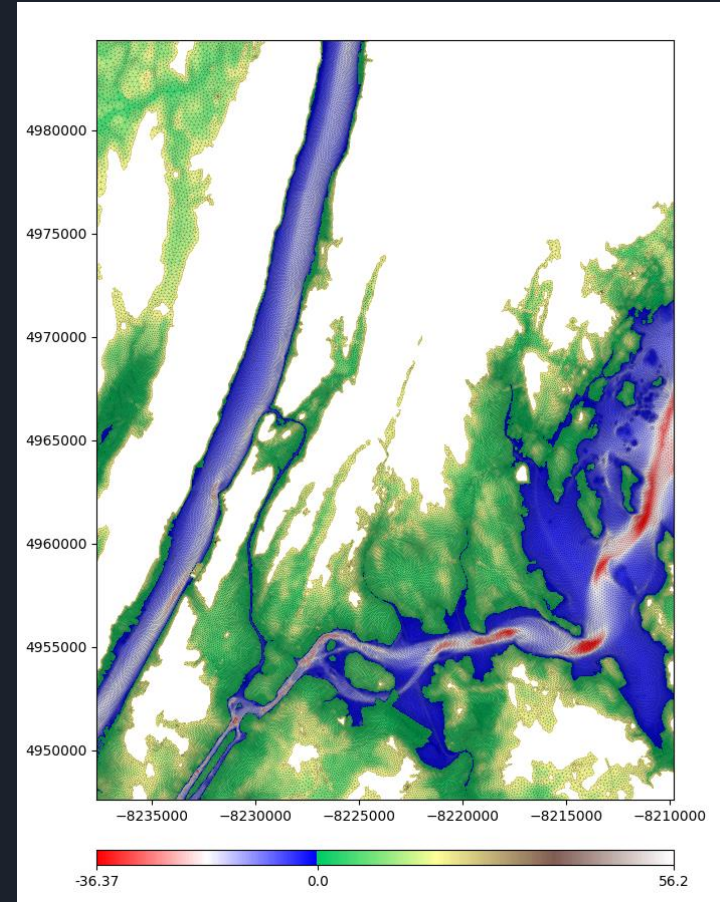
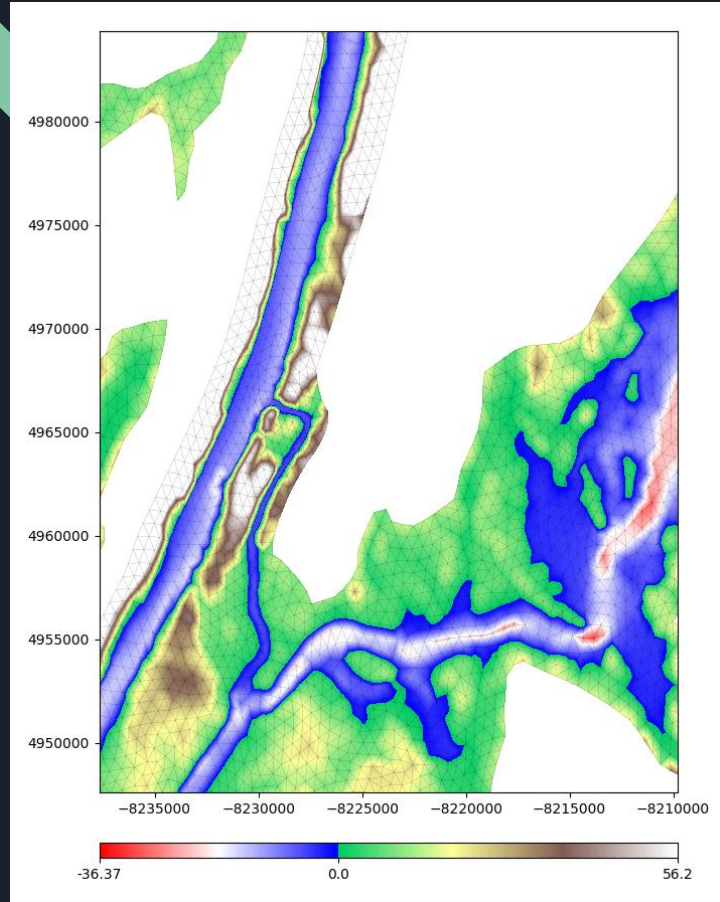
# Mesh generation process overview

- 1) Select DEM's to be included in mesh.
  - a) These should have already passed QA/QC process.
- 2) Compute planar straight line graph (PSLG)
  - a) Optional zmin and zmax (can be unbounded)
- 3) Compute size function
  - a) Linear Distance to shoreline
  - b) Subtidal flow limiter
  - c) Optional min and max sizes
    - i) No smaller than DEM size, but usually bounded to 30-50 meters.
- 4) Pass Size function or PSLG to Jigsaw to generate mesh.

# New meshing algorithm

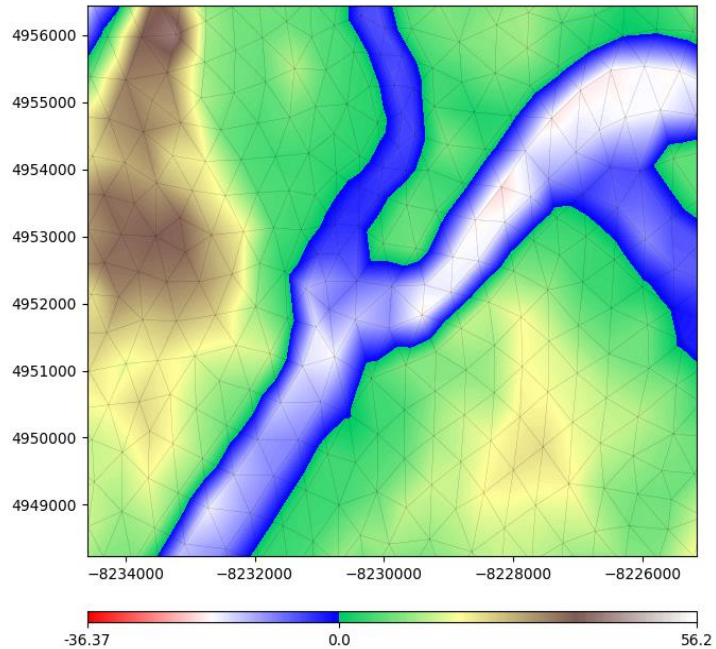
before

after

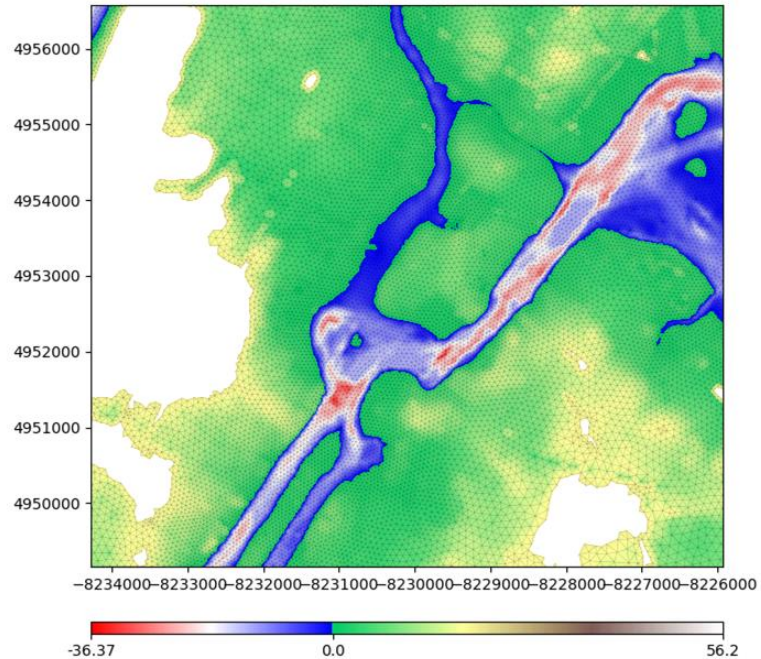


# New meshing algorithm

before



after

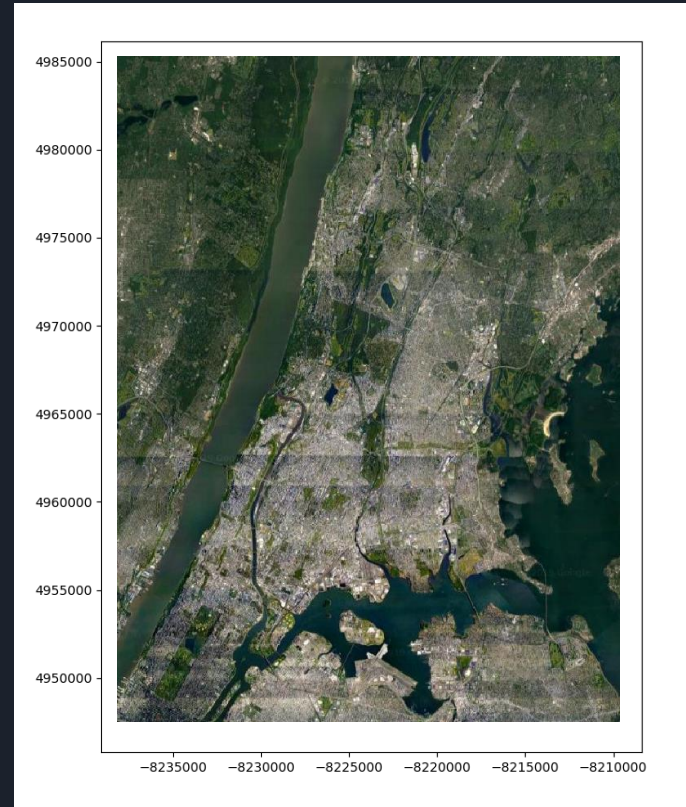
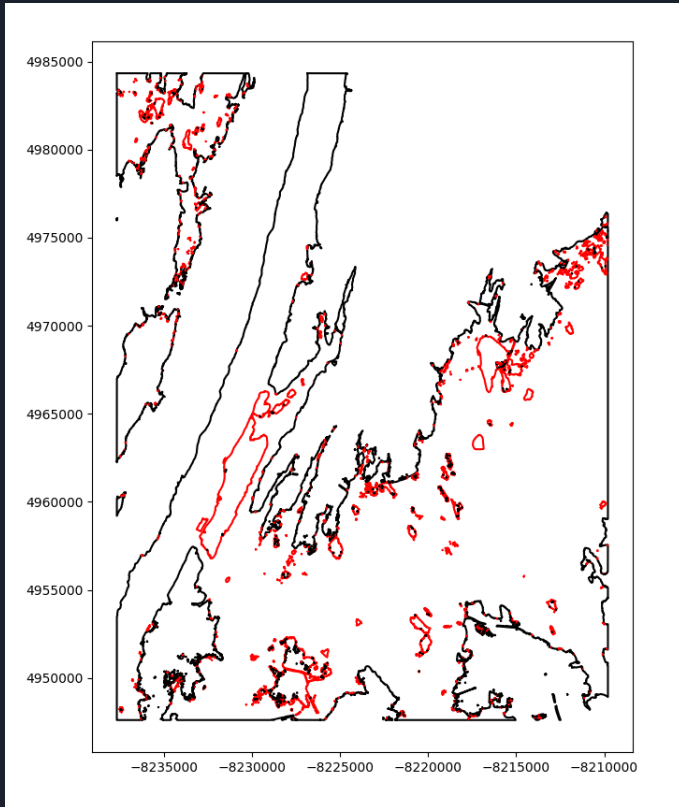


# Planar straight line graph

Multi-polygon that defines the extent of the meshing domain.

Hudson River Estuary, NY

$z_{\max} = 15$  [m]



# Size function

Linear distance to shoreline



$$\text{size\_at\_pixel} = \text{expansion\_rate} * \text{target\_size} * \text{distance\_to\_nearest\_shoreline\_point} + \text{target\_size}$$

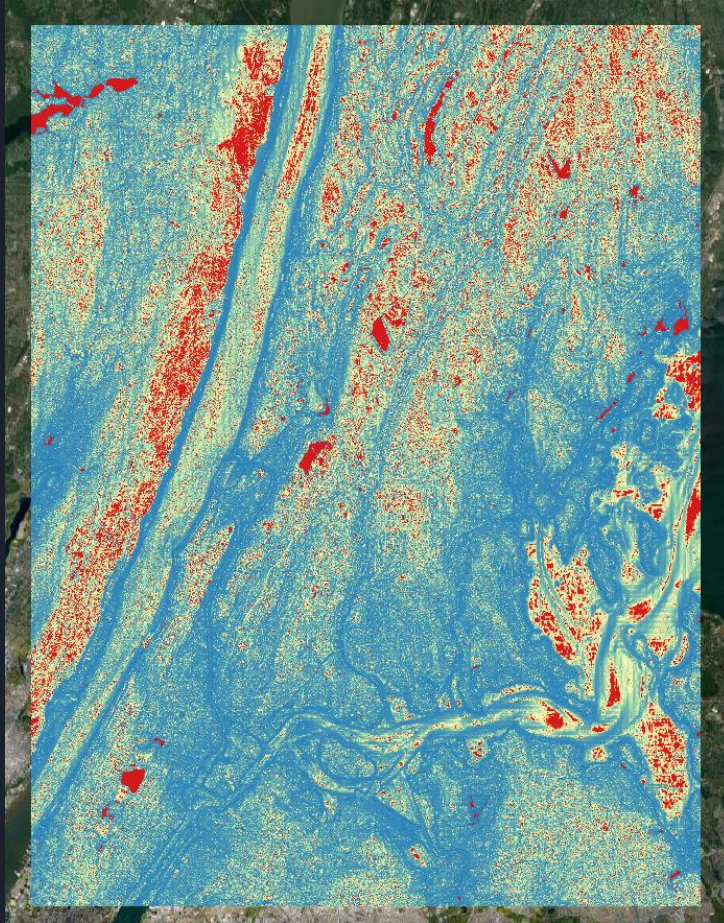
For the present example:

$$\text{expansion\_rate} = 0.001 \text{ [meters/meter]}$$

$$\text{target\_size} = 50. \text{ [meters]}$$

# Size function

Subtidal flow limiter

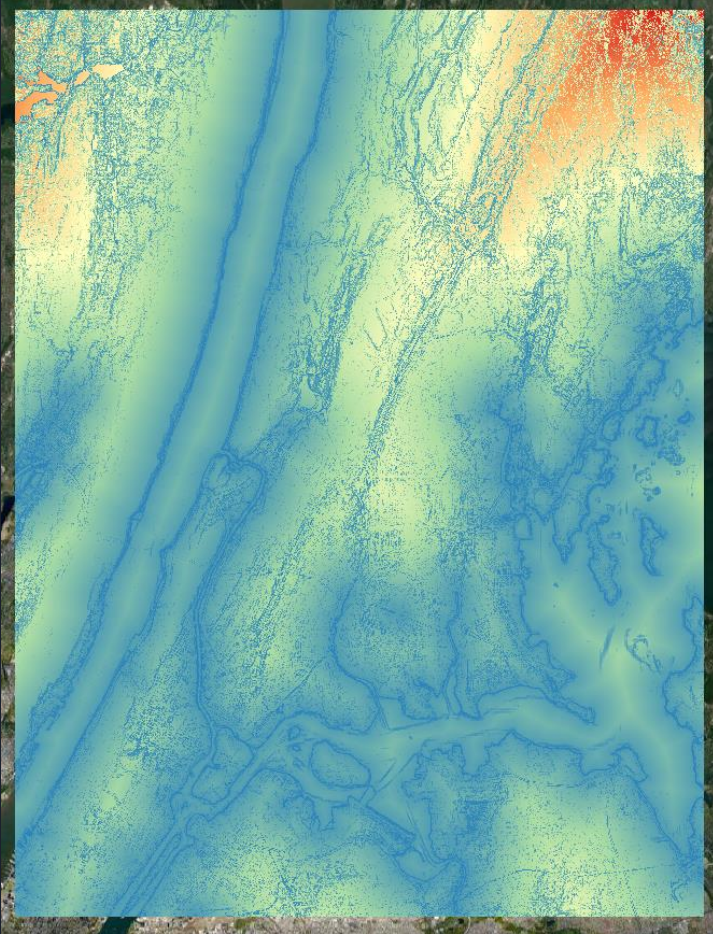


$$\text{size\_at\_pixel} = |(1./3.) * (h/dh)|$$

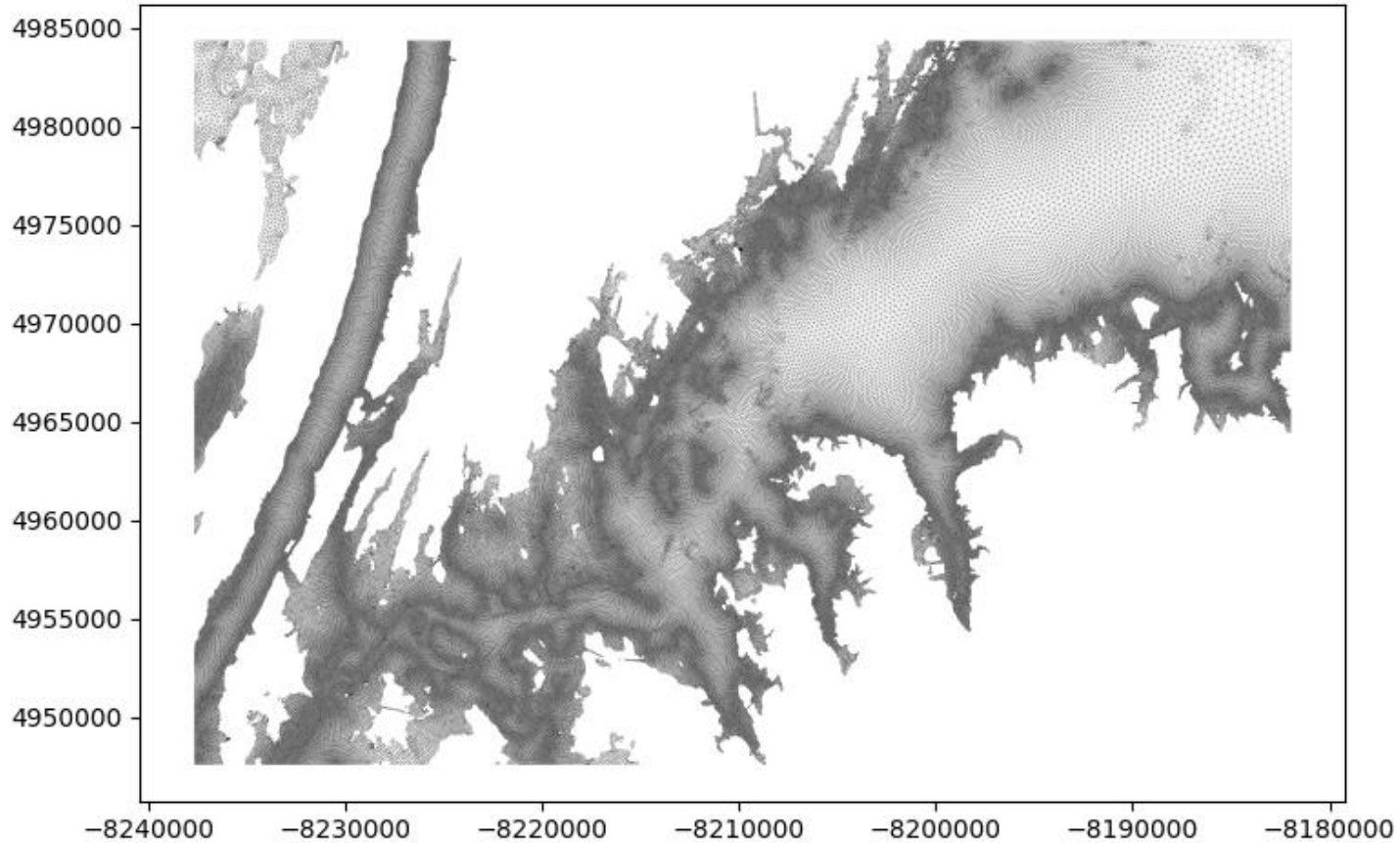
[https://wiki.fvcom.pml.ac.uk/doku.php?id=configuration%3Agrid\\_scale\\_considerations](https://wiki.fvcom.pml.ac.uk/doku.php?id=configuration%3Agrid_scale_considerations)

# Size function

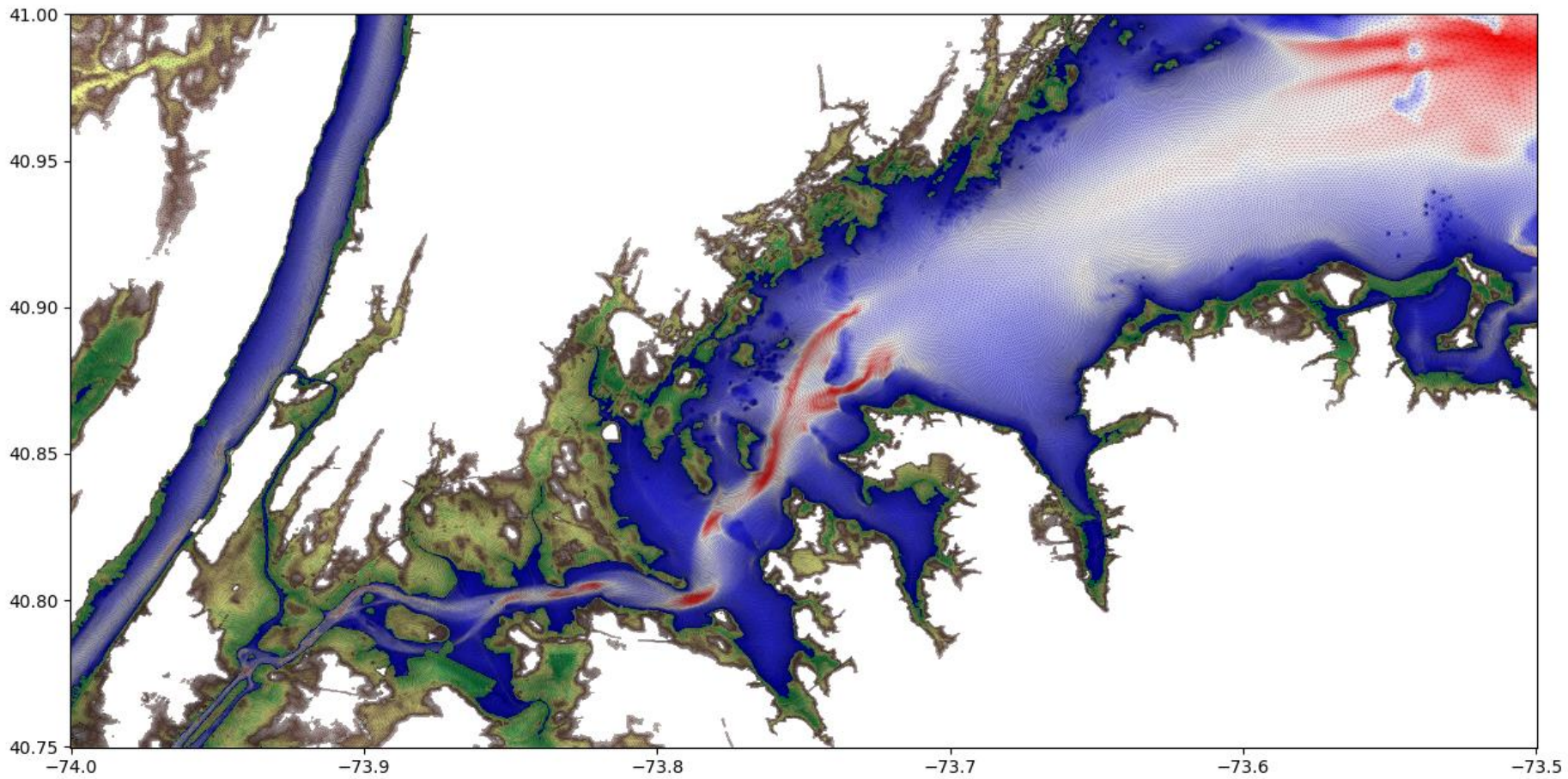
Combined size function



Minimum of all size functions is passed to jigsaw along with the planar straight line graph defining the domain.







-37.41

0.0

17.23

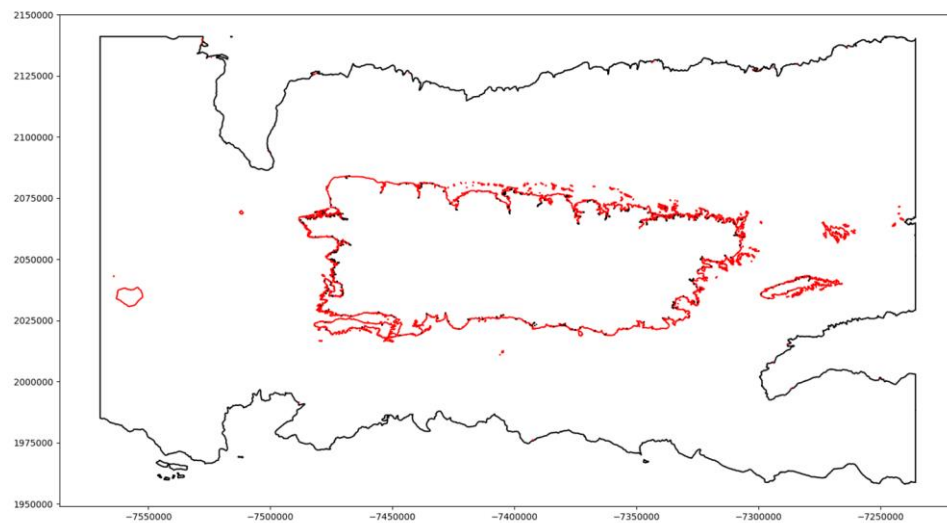
# Planar straight line graph

Examples of two different PSLGs

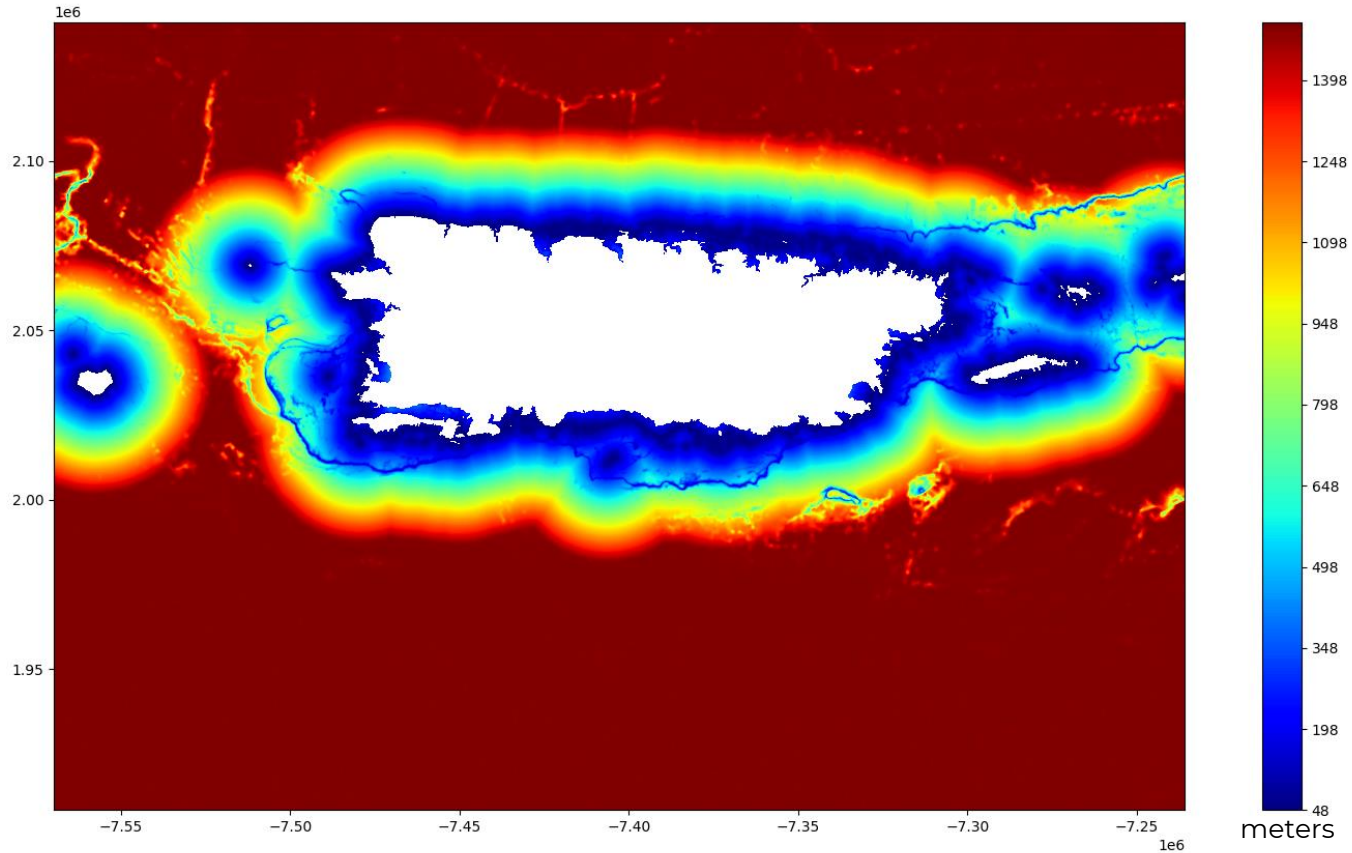
$z_{\max}=15$

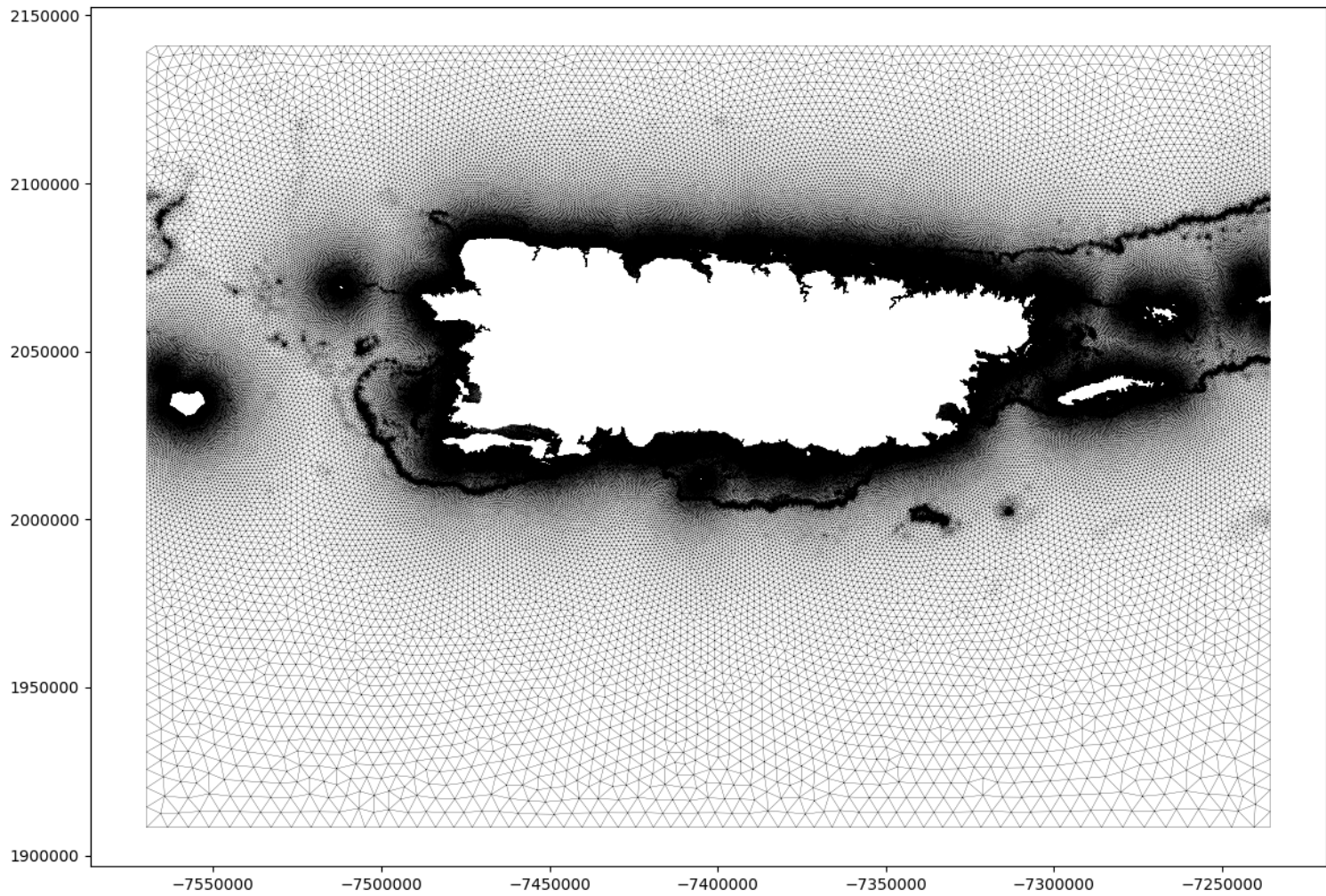


$z_{\min}=-3000, z_{\max}=15$

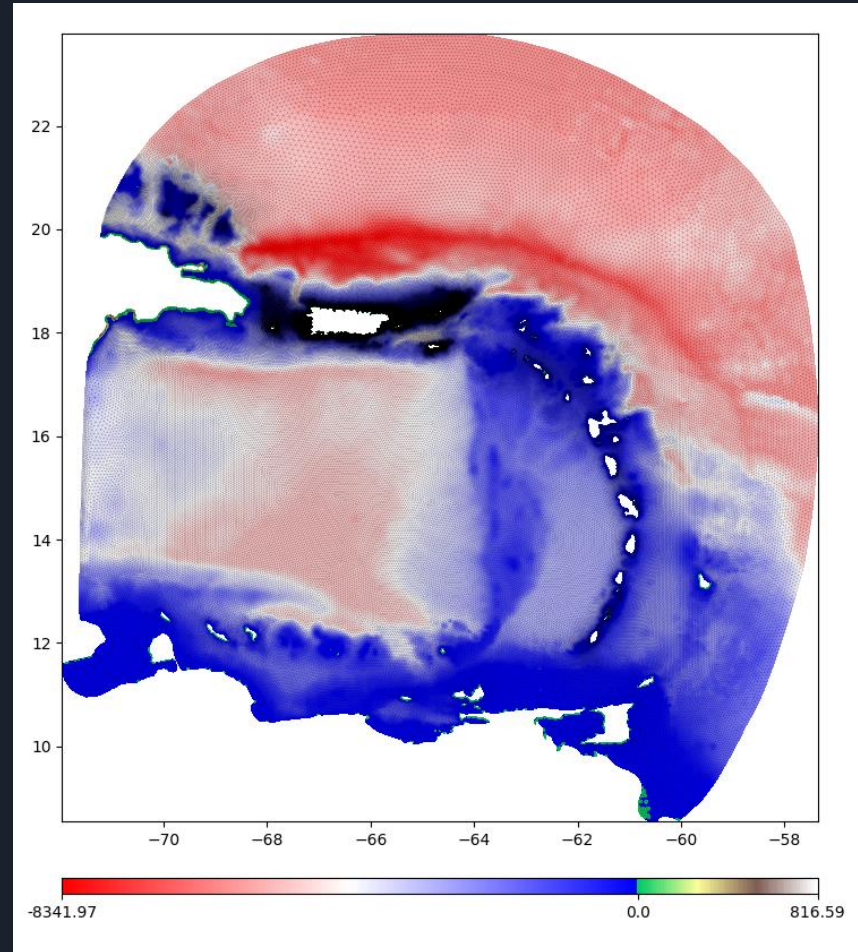


# Size function

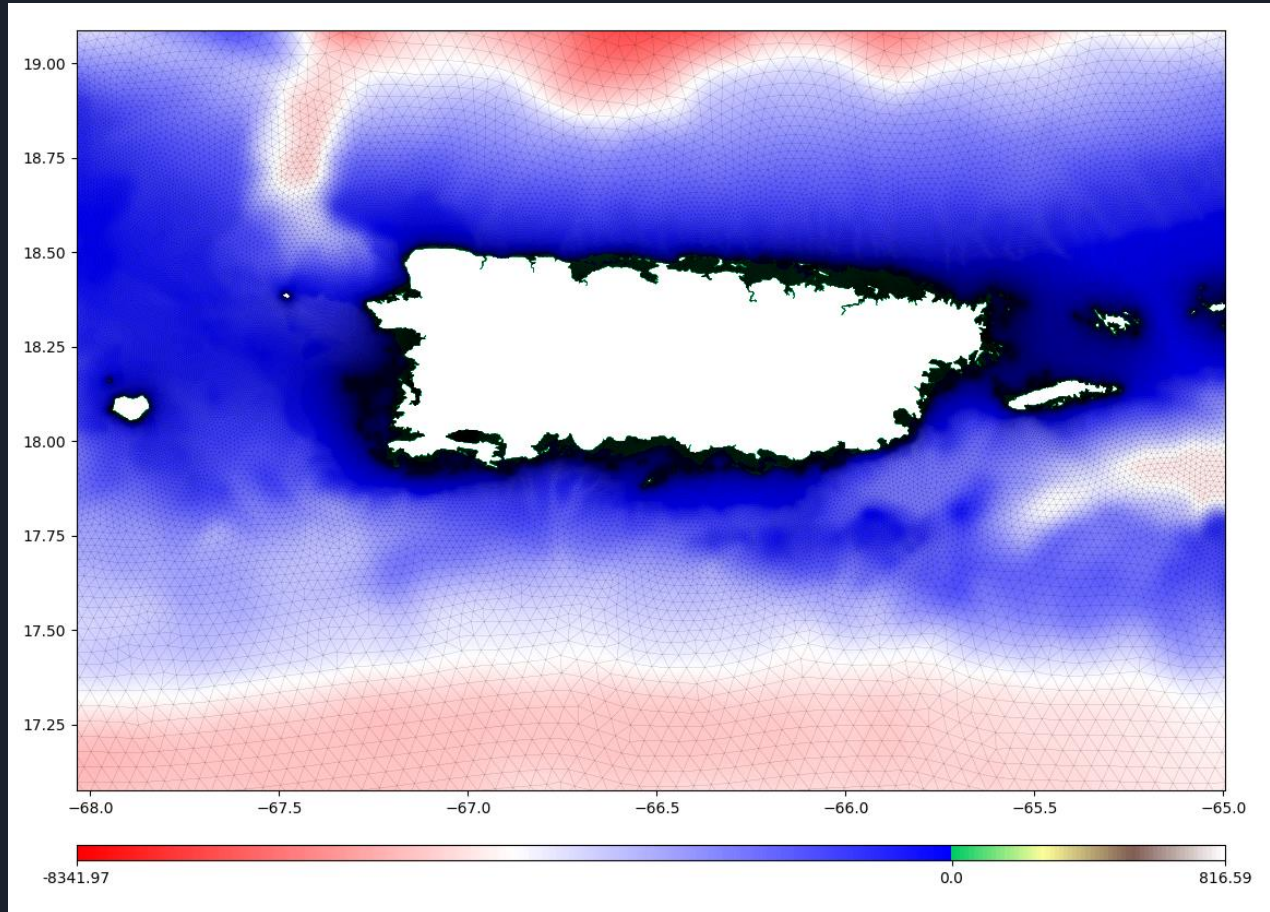




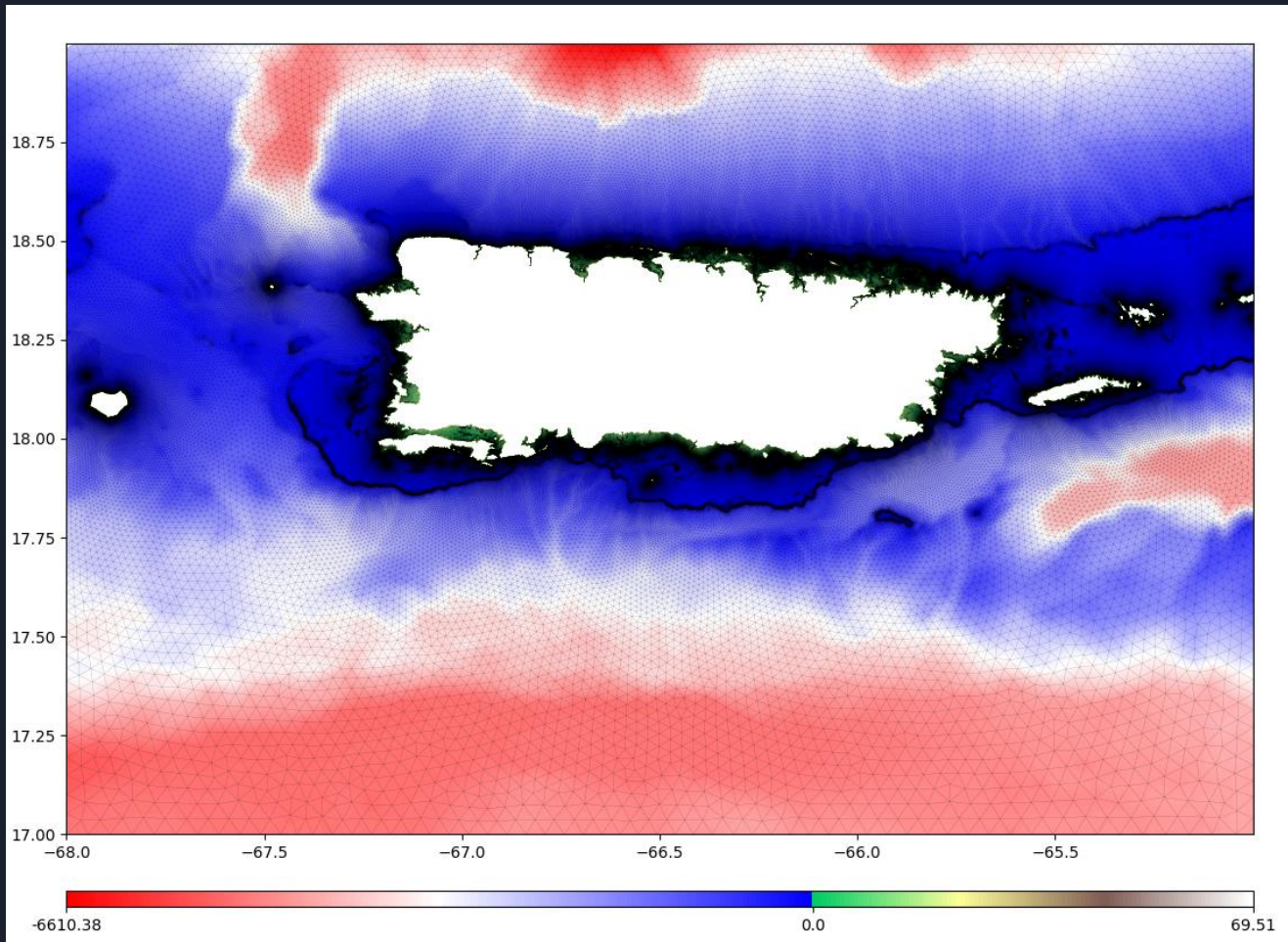
# Previous Puerto Rico mesh



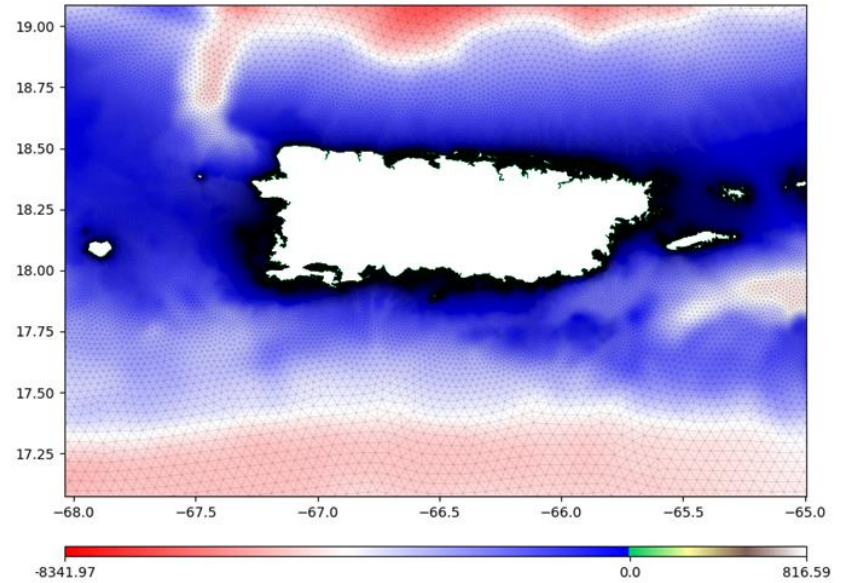
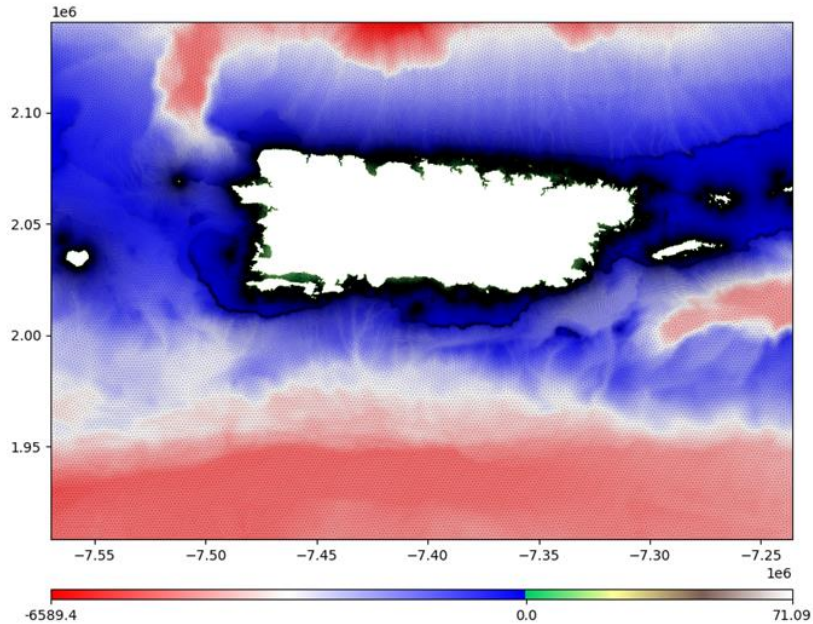
# Previous Puerto Rico mesh



# New Puerto Rico mesh

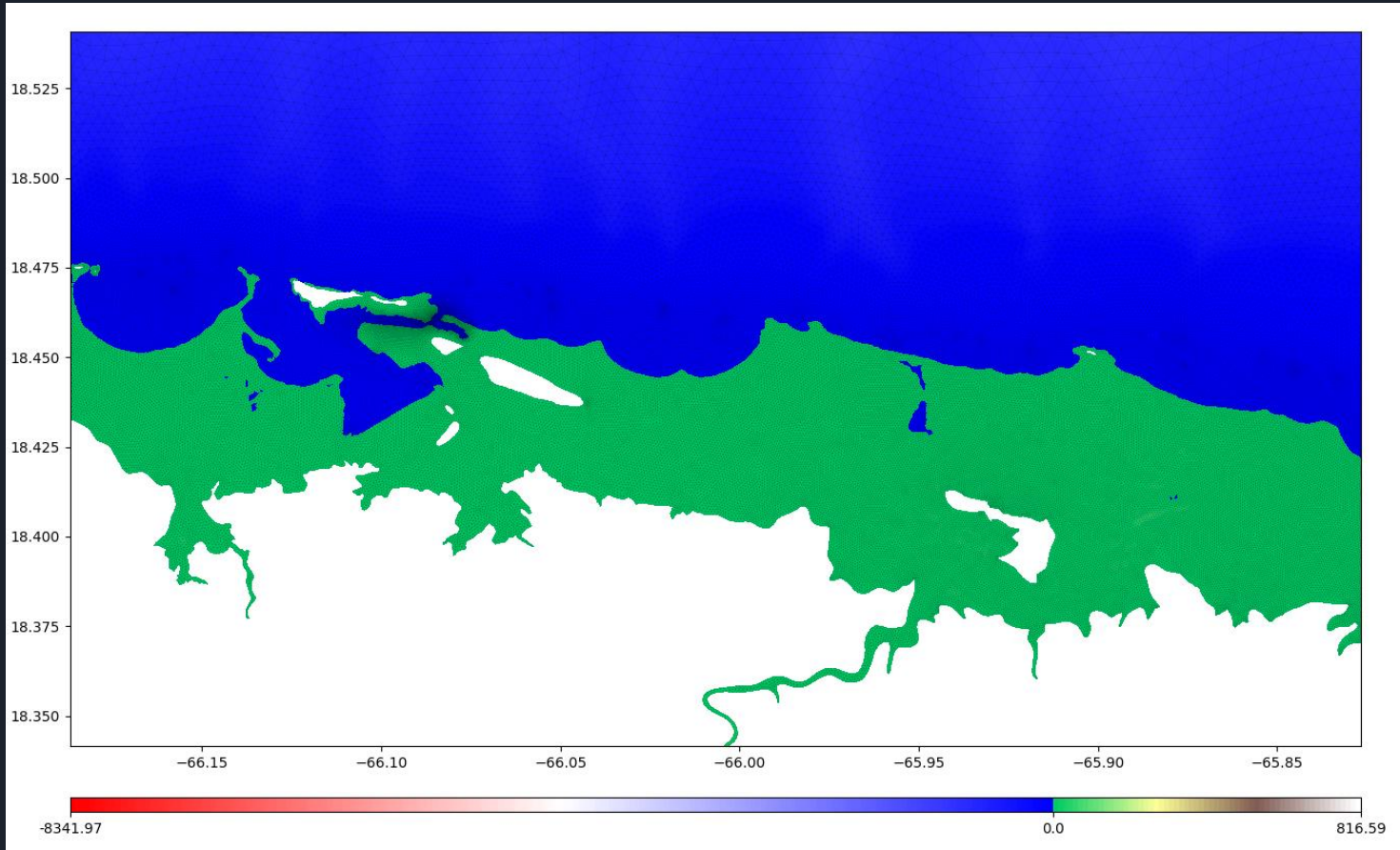


# New mesh vs previous mesh

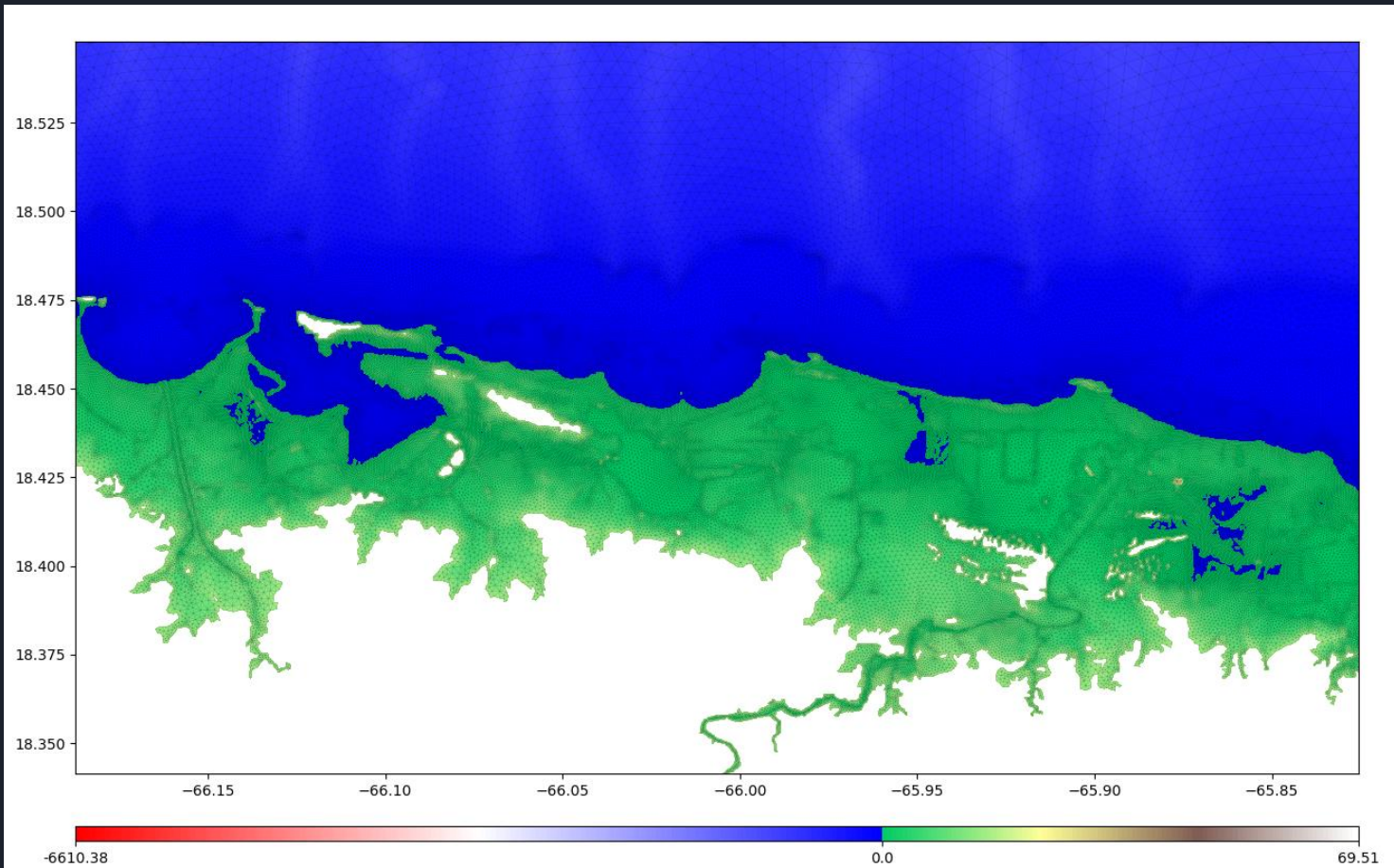


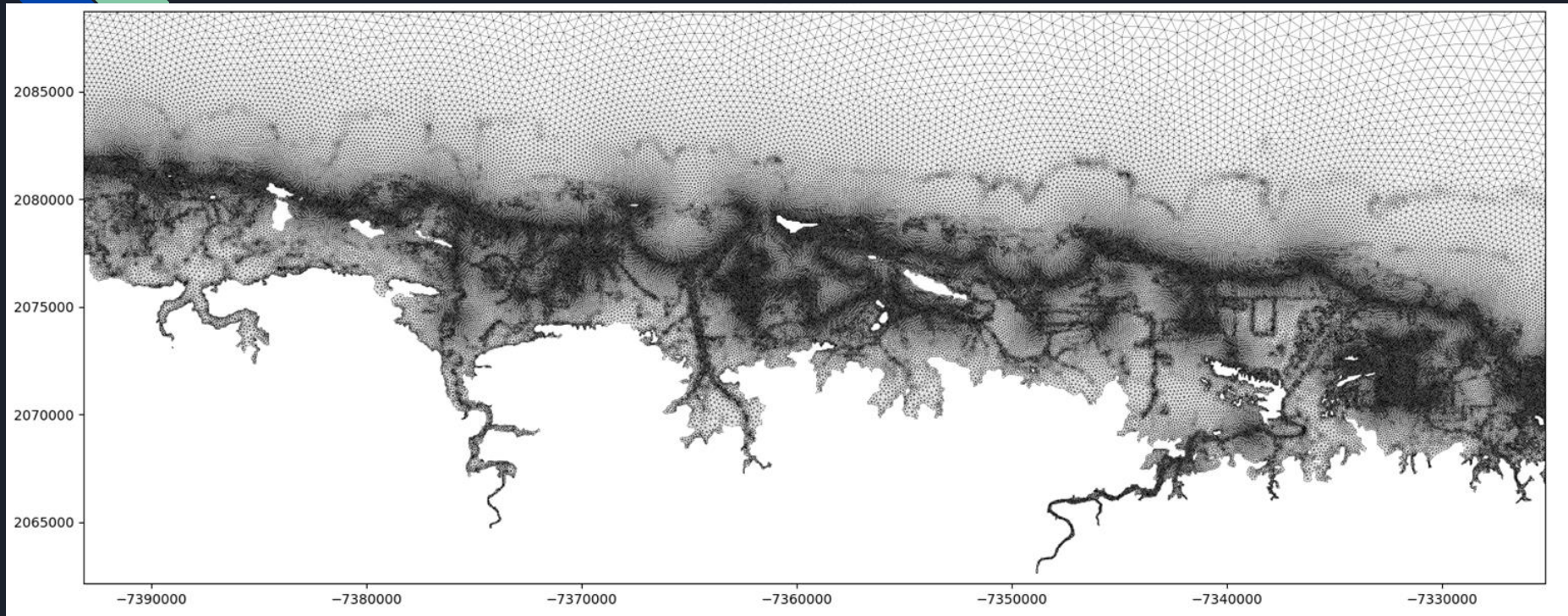


# Previous Puerto Rico mesh



# New Puerto Rico mesh







# Future work

Add size function criteria for watershed delineation using [pysheds](#).

Add additional size function criteria.

Auto assign boundaries for direct mesh-to-model bootstrapping.

Test with different (coupled) models: ADCIRC/WWIII and [SCHISM/WWM](#)

Implement support for quadrilateral geometries (this is natively supported by jigsaw).

Add support for 3D meshes (for baroclinic modelling).



# Questions

[github.com/jreniel/geomesh](https://github.com/jreniel/geomesh)