Office of Coast Survey

OCSMesh: A Brief Introduction

Soroosh Mani[1,2], Saeed Moghimi[1], Jaime Calzada[3]

1. National Oceanic and Atmospheric Administration (NOAA)
2. Spatial Front Inc. (SFI)
3. Virginia Institute of Marine Science (VIMS)

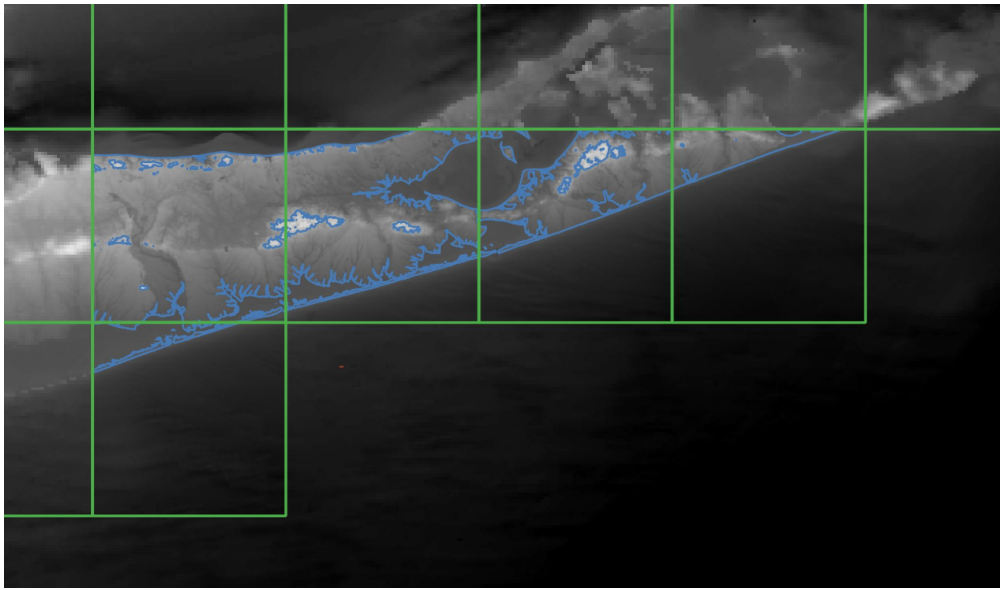
What is OCSMesh (formerly Geomesh)

- Mesh **preparation** tool
  - Define domain
  - Define size function
  - Uses a mesh engine
  - Clean up mesh
  - Interpolate elevations on mesh

Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

Processing Digital Elevation Model (DEM)

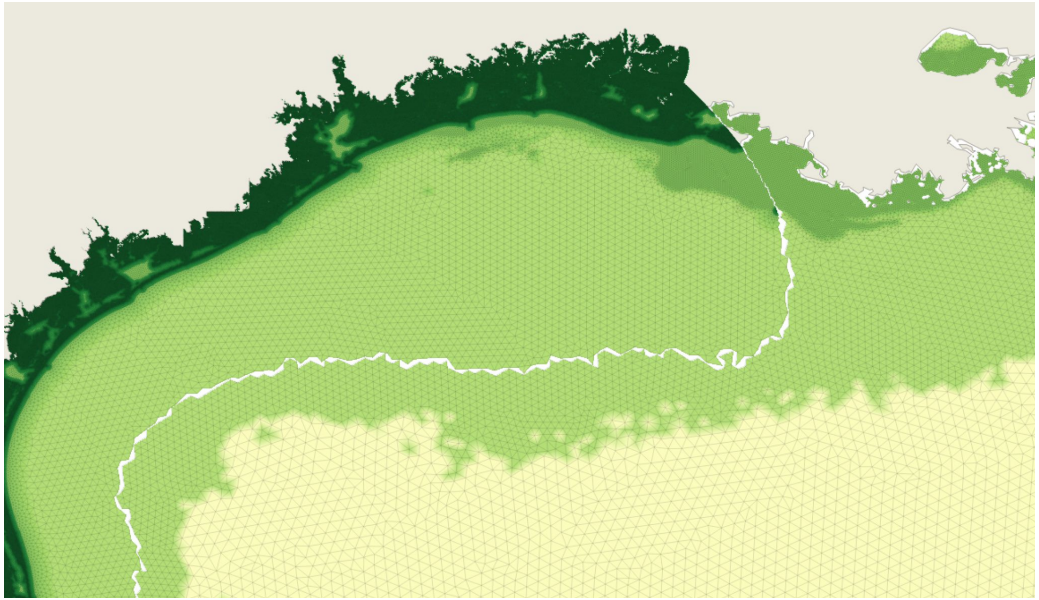
- Elevation contour extraction
- Calculate domain of meshing (geometry)
- Specify mesh size function based on elevation
- Interpolate elevations on mesh nodes
- Multi-tile Processing



Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

Size Function

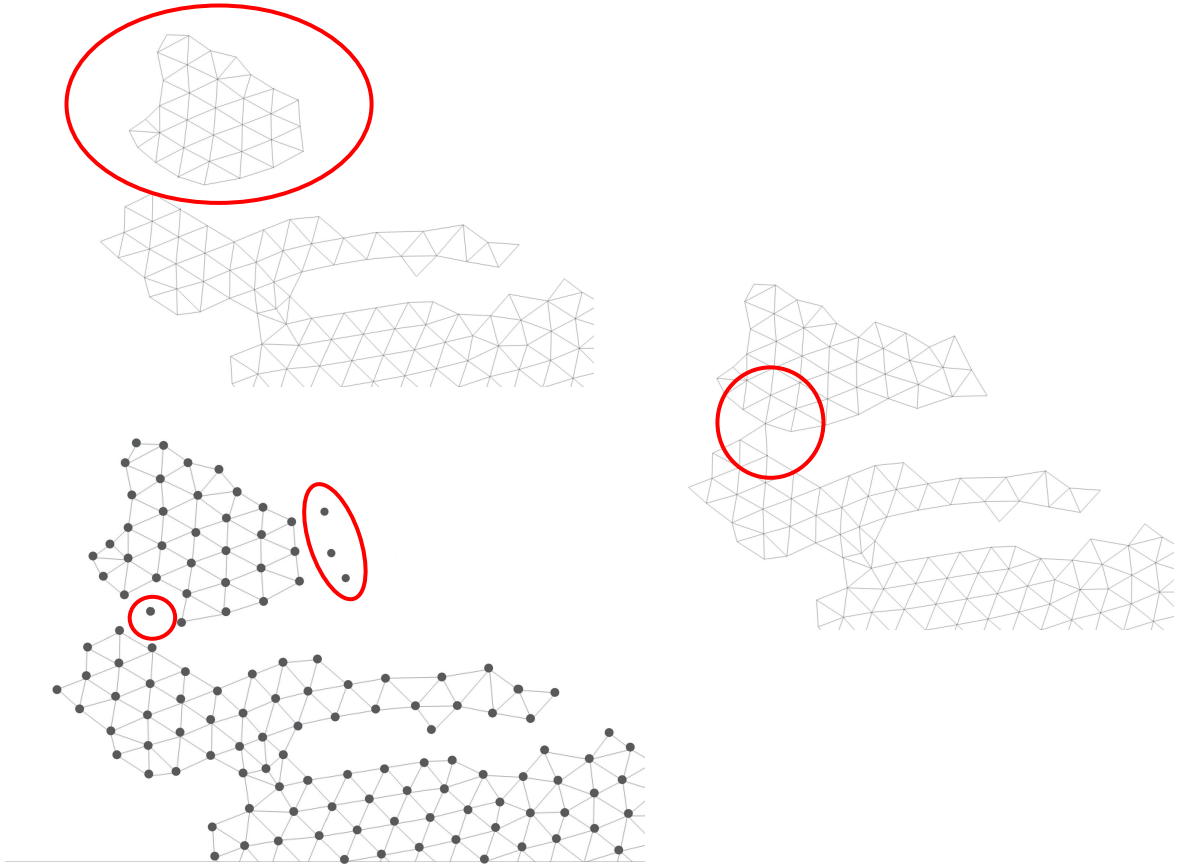
- Lazy evaluation of size function
- Size function is fully calculated before meshing
  - Not dynamically calculated during mesh generation
- Refinement based on distance from features
  - Features can be either custom input or extracted from DEM
- Define size function on an **unstructured** mesh (save memory)
- Overlapping size functions in case of multi-tile processing



Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

Mesh Clean-up

- Island patches
- Pinched nodes
- Isolate nodes



Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

A Little Deeper …

- Uses Jigsaw mesh representation for operations on mesh
- Uses Shapely and GeoPandas for operations on regions and geometry
- Calculations based on Polygon geometry
  - One surface cannot have multiple sections
- UTM transformation for meshing
  - No internal accounting for units

Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

Requirements & Suggestions

- Quad element mesh generation
- Local mesh modification
- Geometry aware of attached elements
- Size function definition strategy
  - On demand calculated size function (callback) vs predefined
- Custom mesh quality criteria during meshing
  - Quality metric
  - Local criteria
- Cleanup tools
  - Split/merge element on node(s)
- Preserving boundary edges
- Abstract mesh definition and manipulation from underlying object

Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

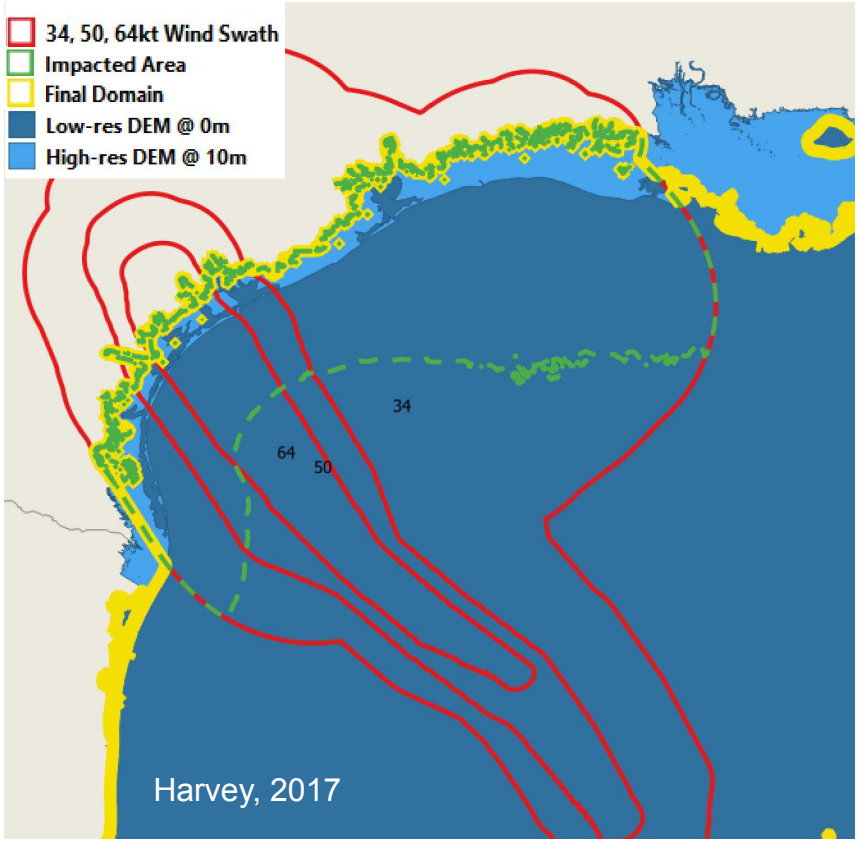
Extra slides

Meshing Domain and Regions

https://github.com/noaa-ocs-modeling/OCSMesh

- Uses **OCSMesh** developed at NOAA/NOS/OCS
  - Open source Python package
  - Automated meshing capabilities
- **2** domain shapes up to **0 (dark)** and **10 meters (light)** above mean sea level
- **Exterior** boundary of the hurricane **34kt*** wind swath **(red)**
- **Upstream** estuaries from 10m shape
- User specified **cut off** depth computed on DEMs
- **Smaller** min **element** size in **impacted region (green)**
- Runs either as
  - ECS task on a single large memory EC2 instance or
  - Slurm job on a ParallelWorks cluster

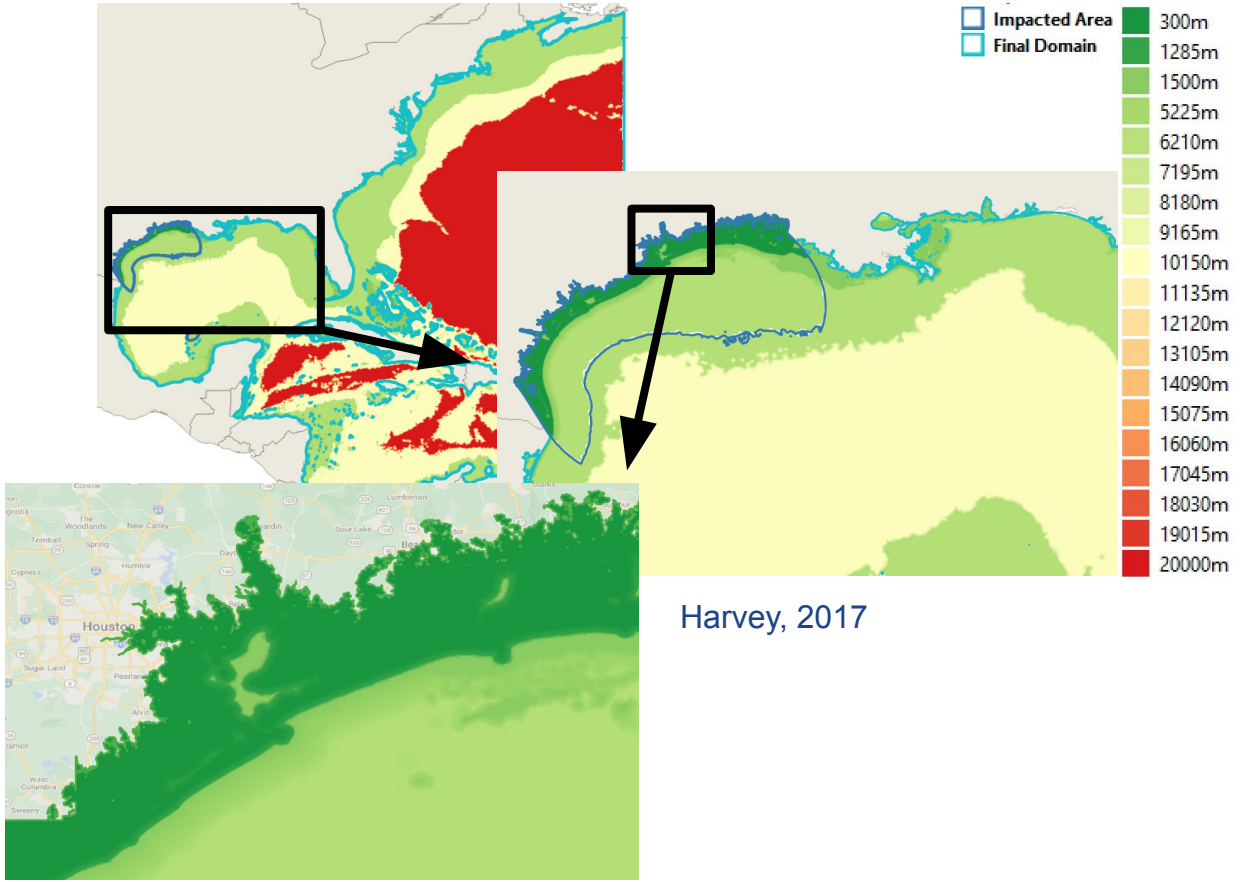
*Approach similar to Pringle et al, HSOFS mesh



Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

Mesh Size

- Stepwise refinement
  - 10km @ 4km depth
  - 6km @ 1km depth
  - 1.5km @ 10m depth
  - 300m @ 0m depth



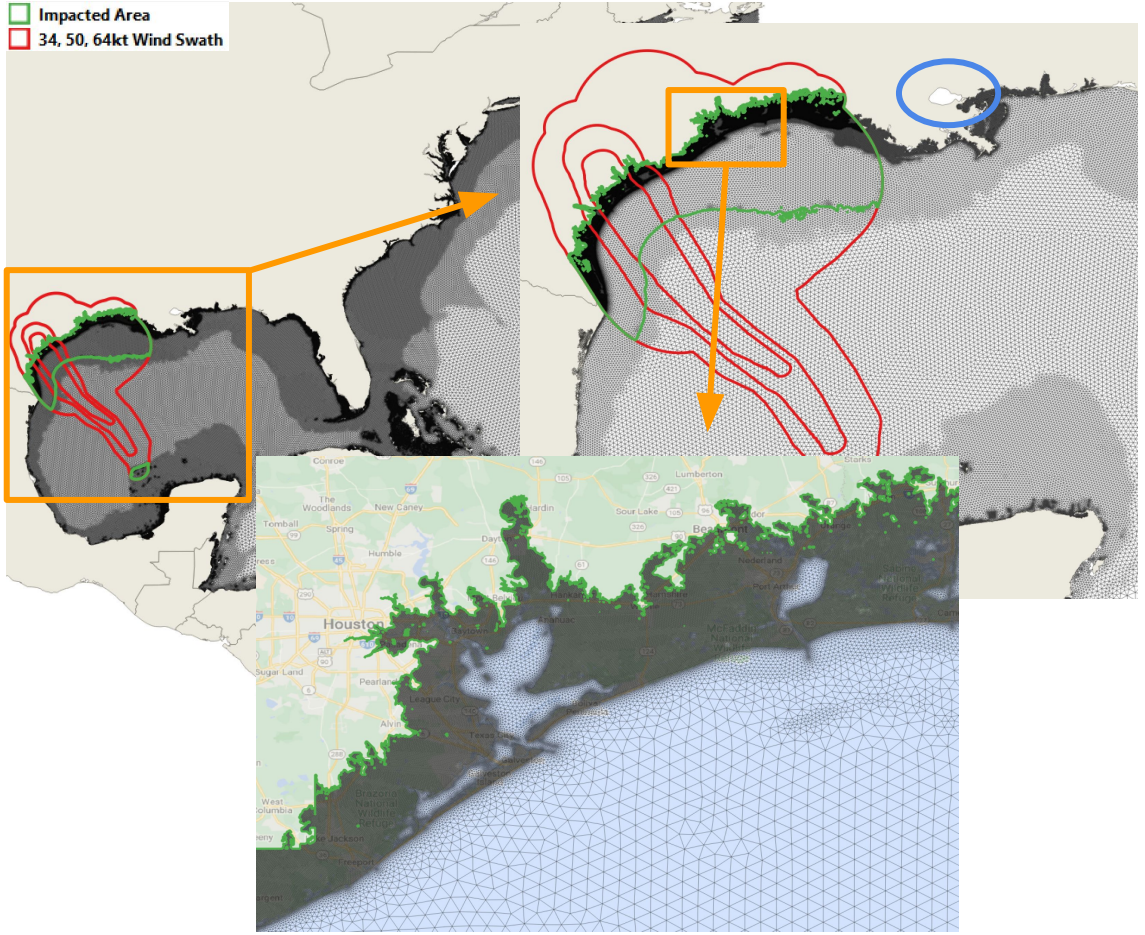
Harvey, 2017

Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

Results

Harvey 2017

- Finer coastal mesh in **Impacted Area**
- Cleaned up mesh "***patches***"

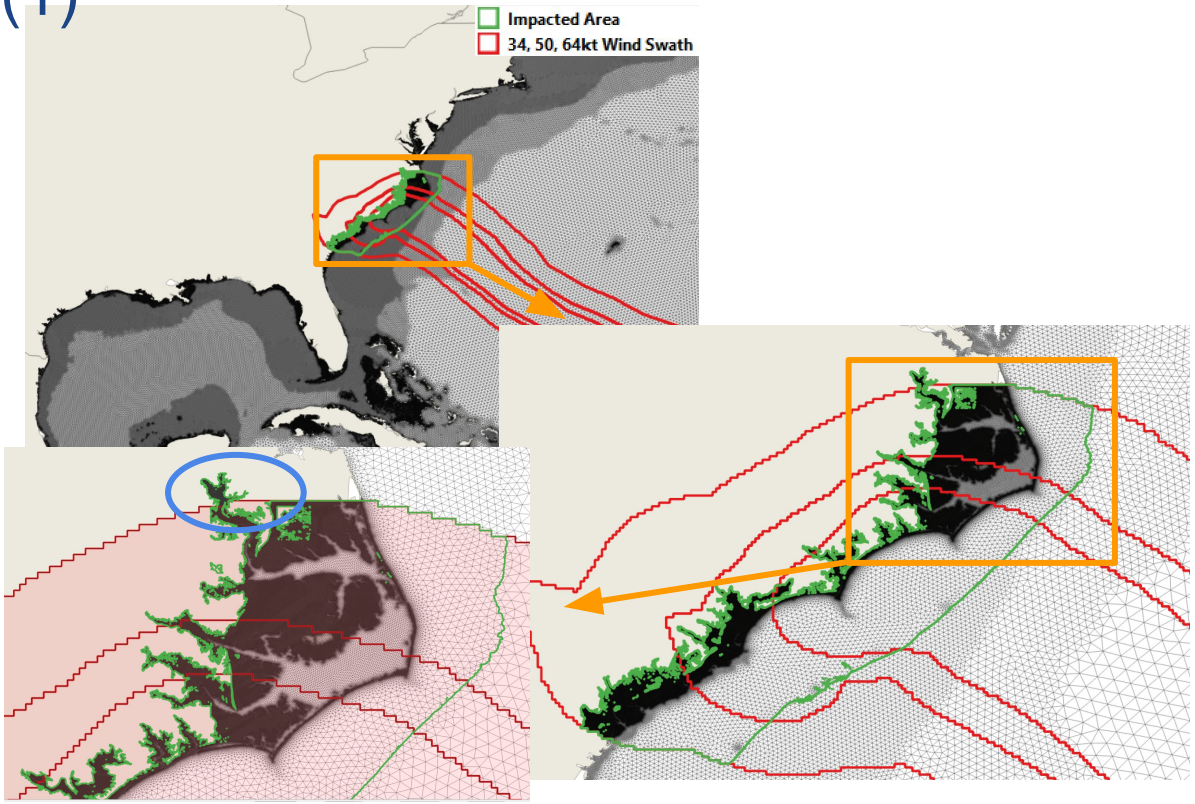


Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

More Mesh Results (1)

Florence 2018

- Notice (re)attached **upstream**

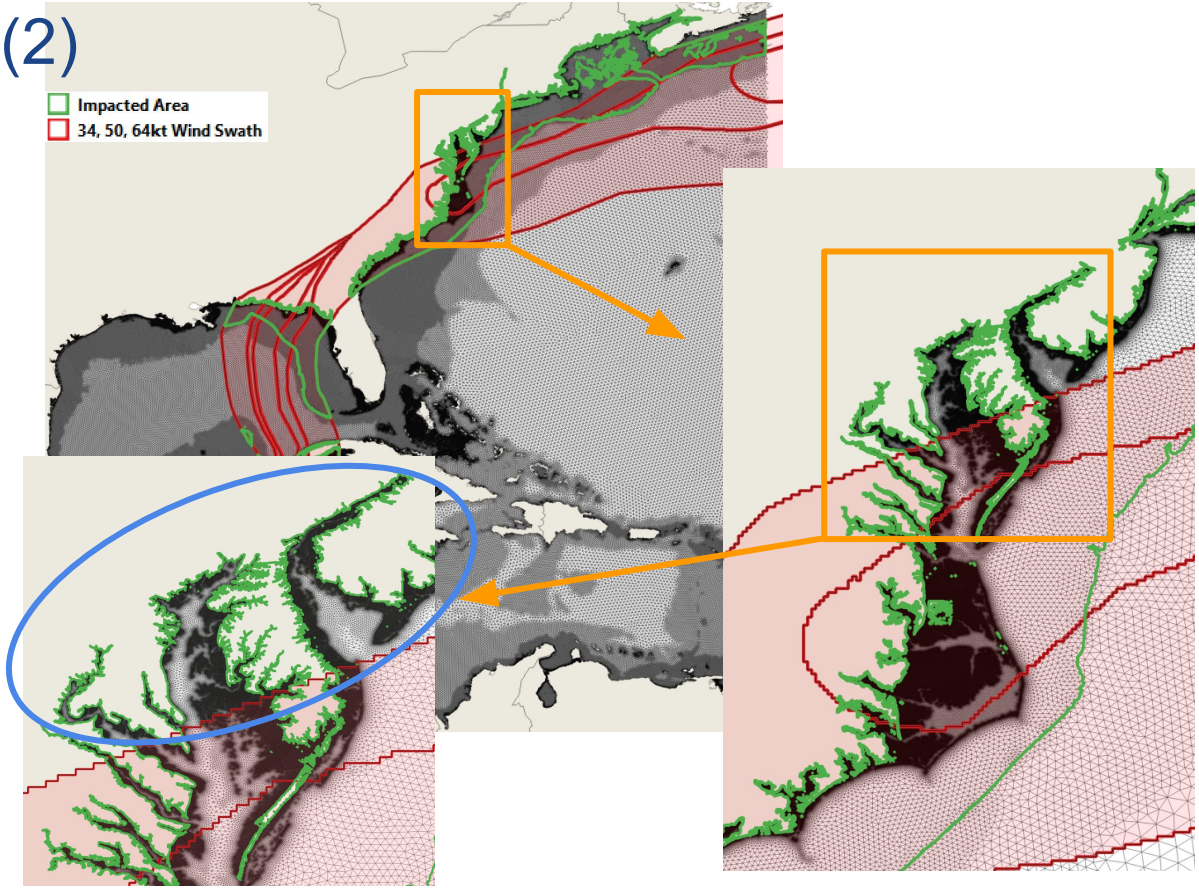


Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

More Mesh Results (2)

Michael 2018

- Large **refinement** area!
  - Use track up to US landfall
- Notice (re)attached **upstream**

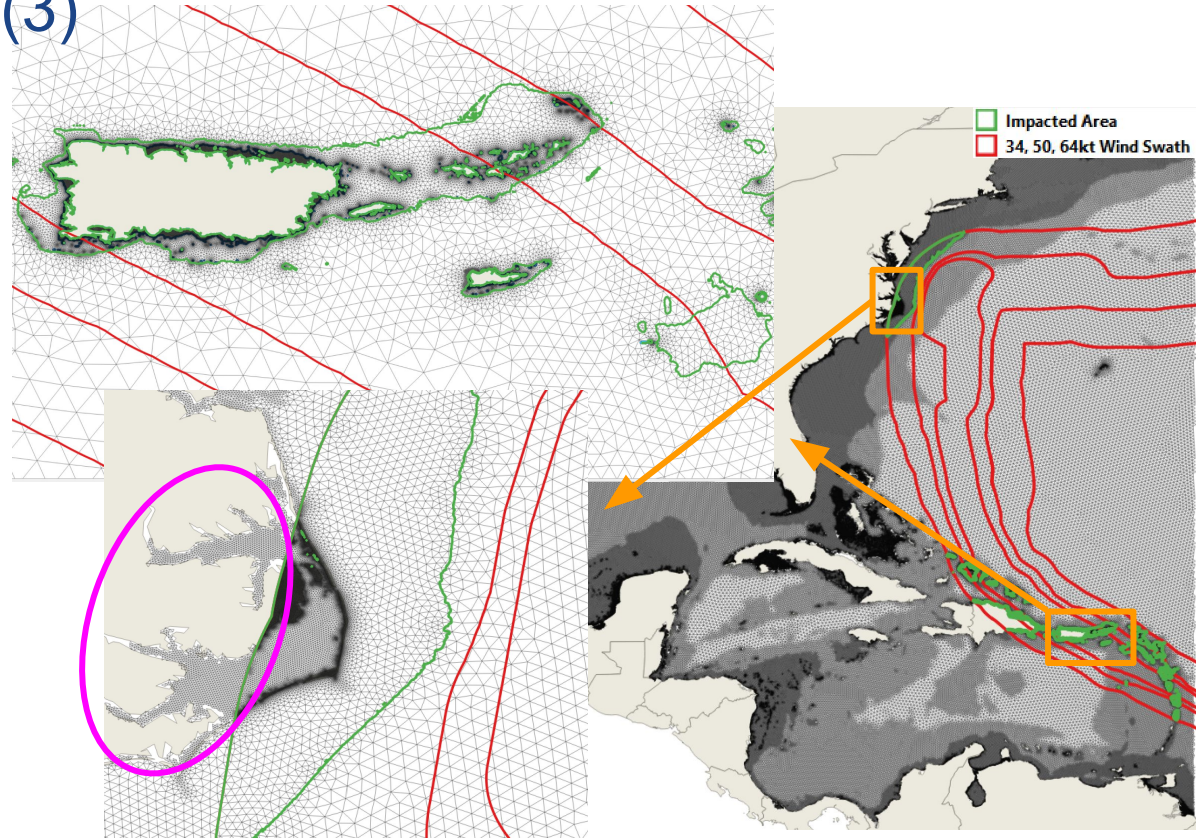


Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)

More Mesh Results (3)

Maria 2017

- **Imperfections** in detection logic!



Contacts: soroosh.mani@noaa.gov (Lead Modeler); saeed.moghimi@noaa.gov (PI)