Modeling Tidal Marsh Resilience

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Tidal Shoreline Management Workshop

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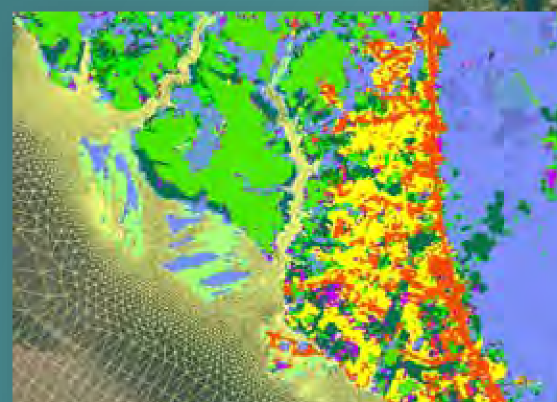
Center for Coastal Resources Management
Virginia Institute of Marine Science

VIMS | William & Mary
Virginia Institute of Marine Science

Photo Credit: Kory Angstadt

Outline

- Background and Motivation
- Tidal Marsh Model (TMM) Overview
- Project Significance

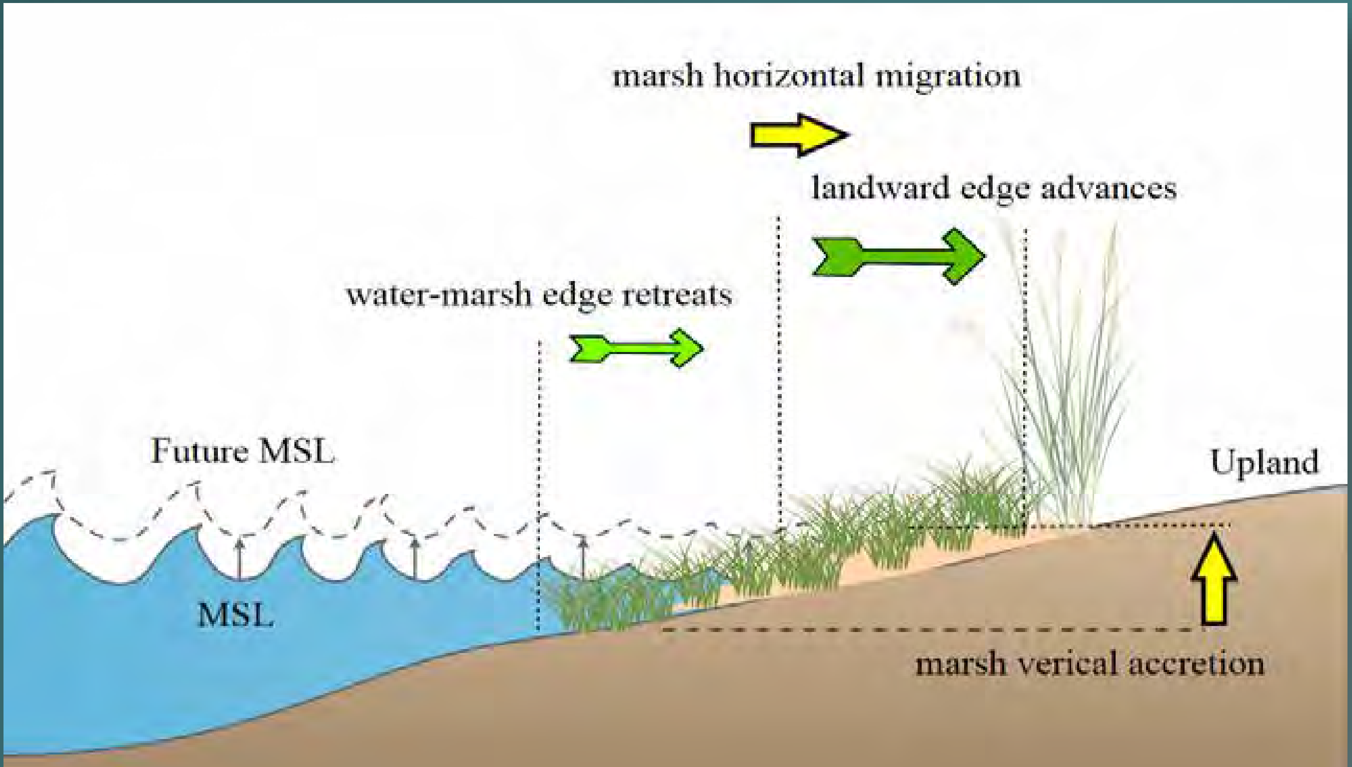


Tidal Marshes & Sea Level Rise

Coastal areas are experiencing a growing threat from sea-level rise and recurrent flooding due to changes in the global climate.

In past decades, special attention has focused on tidal marshes and how they respond to sea-level rise.

Tidal Marshes & Sea Level Rise (SLR)



Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols)

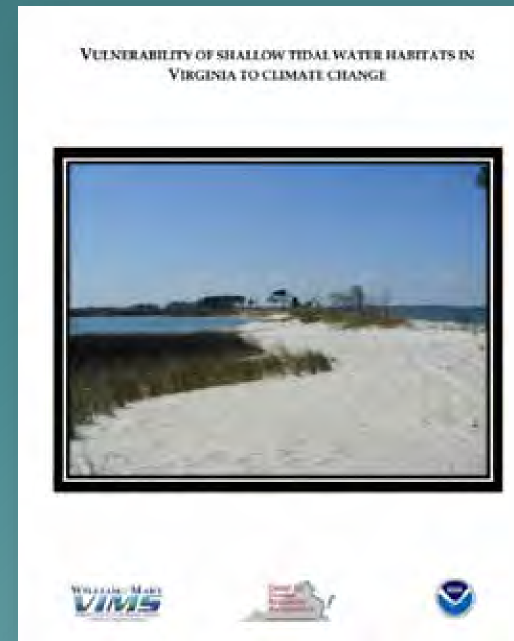
To keep pace with SLR:

- **Marshes accrete vertically**
- **Marshes migrate horizontally**

Tidal Marshes – Sea Level Rise (SLR) & Barriers to Migration

Approximately, 40% of Virginia marshes are vulnerable to SLR due to adjacent development and topography

High Risk Marsh | Low Risk Marsh



Bilkovic et al. 2009 - Vulnerability of shallow tidal water habitats in Virginia to climate change.
http://ccrm.vims.edu/research/climate_change/index.html

Current Marsh Models

Predicting future wetland sustainability

Large-scale landscape models

(e.g. SLAMM)

Site-specific models

(e.g. MEM)

Marsh Modeling – New Approach: TMM

Develop an **advanced modeling framework** that integrates:

- physical processes

- human components

simulate and assess the evolution and persistence of tidal marshes under different sea-level rise scenarios

Dynamic high-resolution model to evaluate marsh evolution:

TIDAL MARSH MODEL (TMM)

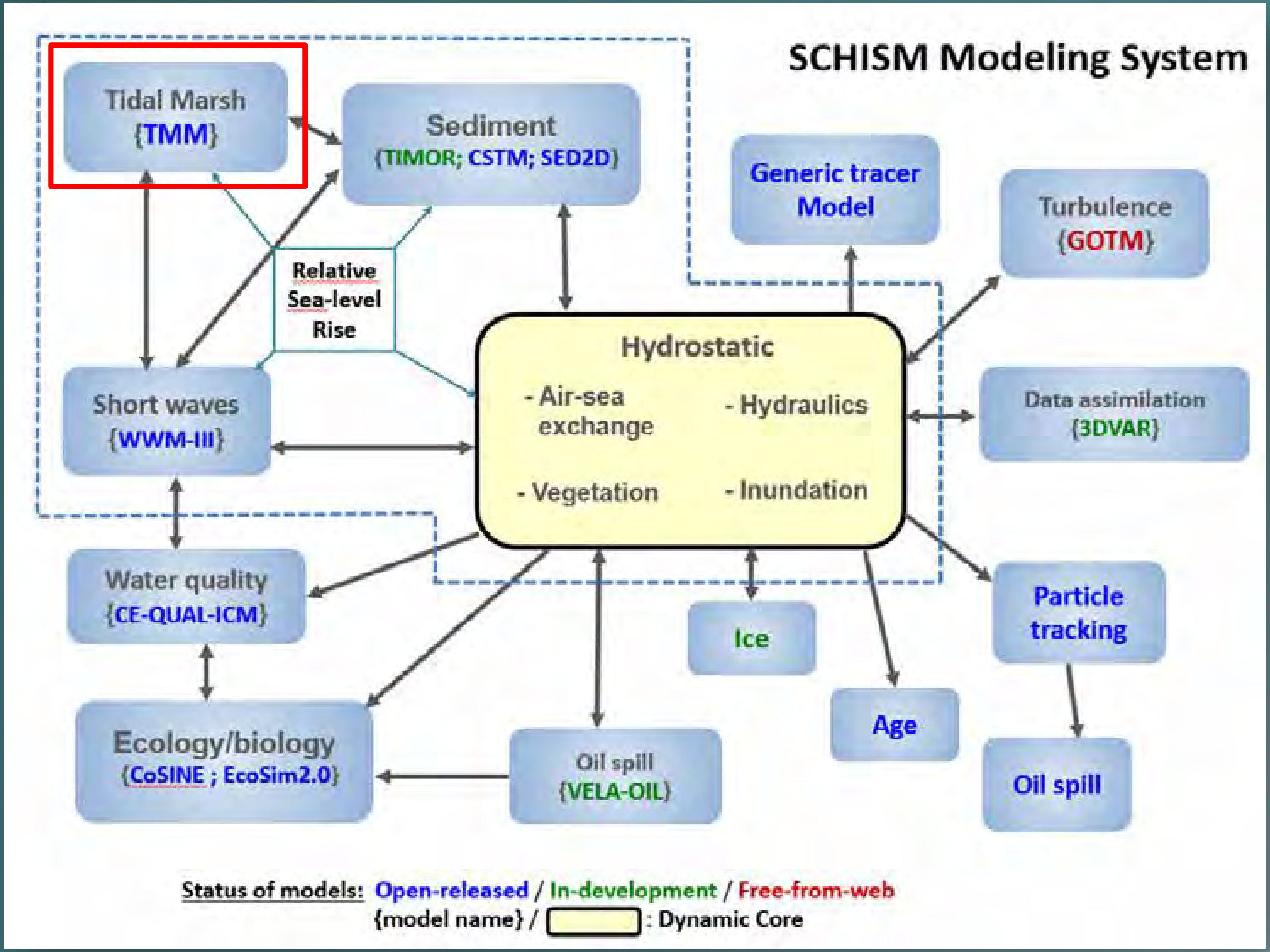
Unique Model Features

TIDAL MARSH MODEL (TMM)

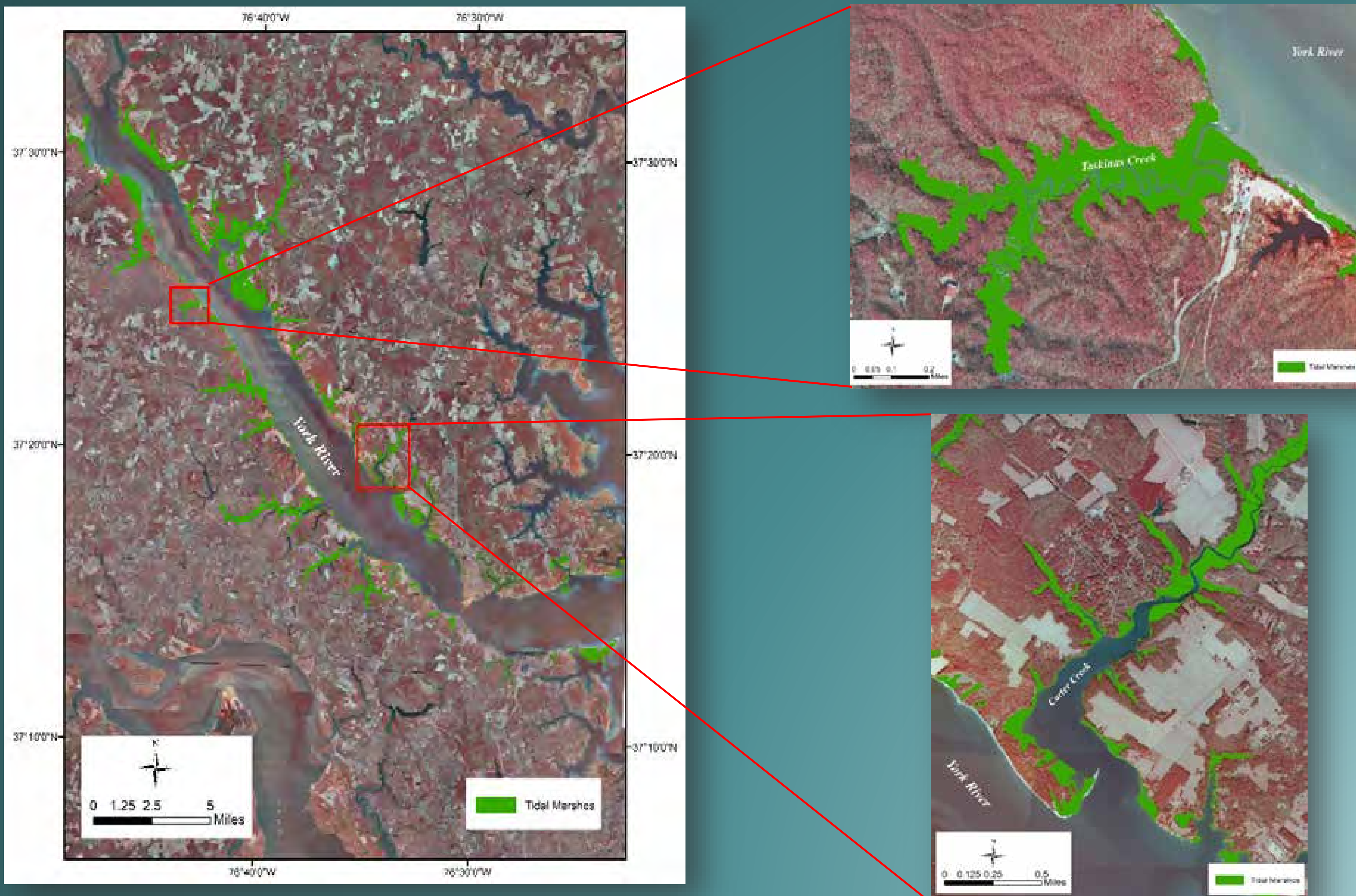
- **cross-scale model**
  - Process at one temporal (e.g. day, year) or spatial (e.g. creek, ocean) scale can interact with processes at another scale.
- **dynamic rates**
  - varying rates in space and time
- **barriers to marsh migration**
  - Shoreline erosion protection structures (e.g. bulkhead)

SCHISM

(Semi-implicit Cross-scale Hydroscience Integrated System Model)



Study Area – Carter Creek & Taskinas Creek



TMM code specifications –

Tidal Marsh
{TMM}

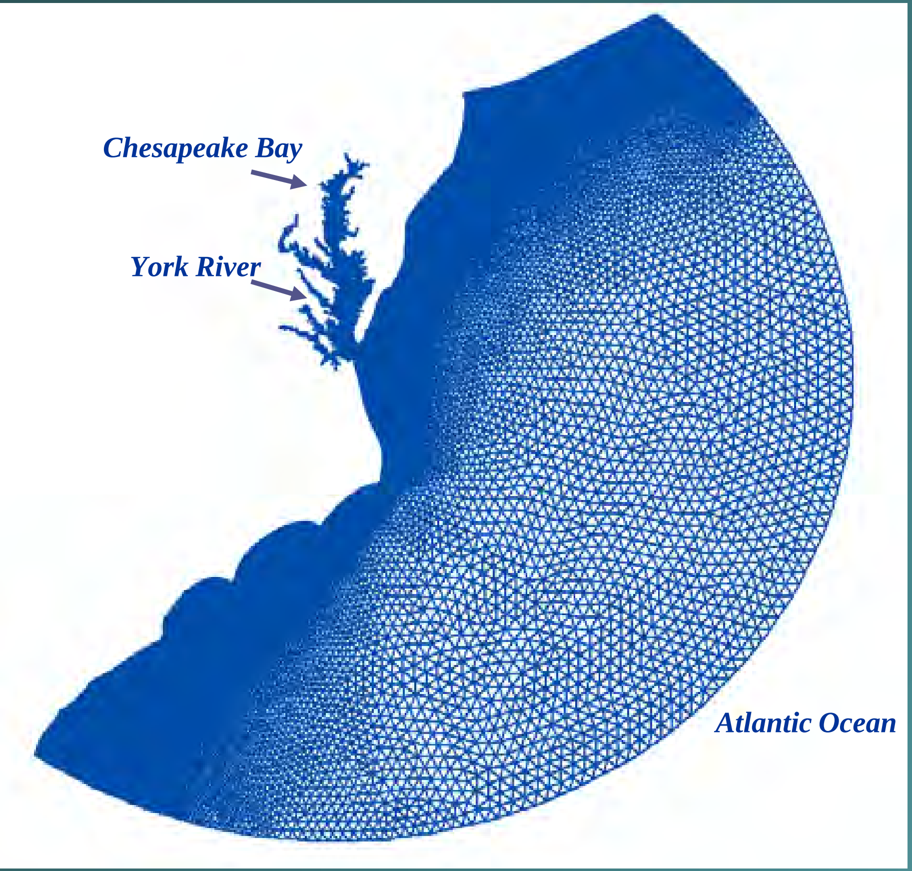
TMM simulates marsh migration under the joint influence from tides, wind waves, sediment transport, precipitation, and SLR

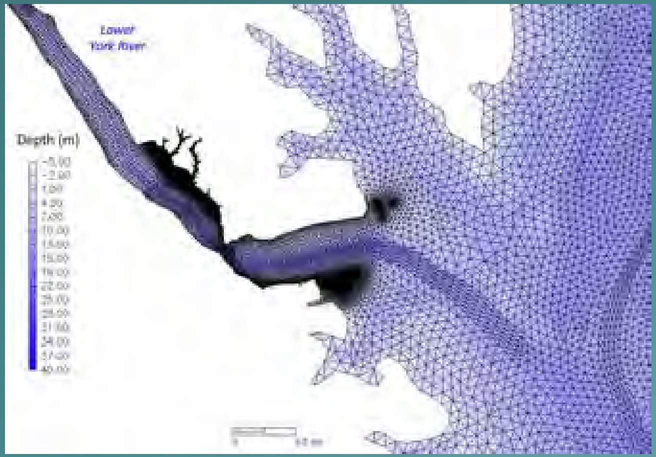
TMM accounts for:

- shoreline bank erosion (water-marsh interphase)
- upland erosion inputs at the upland-marsh edge
- marsh vertical accretion through mineral sediment deposition
- marsh landward migration under changing sea levels with constraints from physical barriers (e.g. ripraps, bulkheads, etc.)

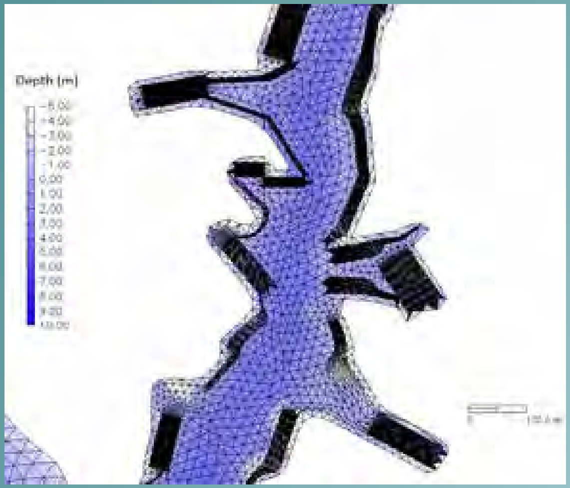
Grid Generation

Unstructured grid: uses various combinations of cell shapes and sizes, which allows better fit in areas with complex shoreline geometries





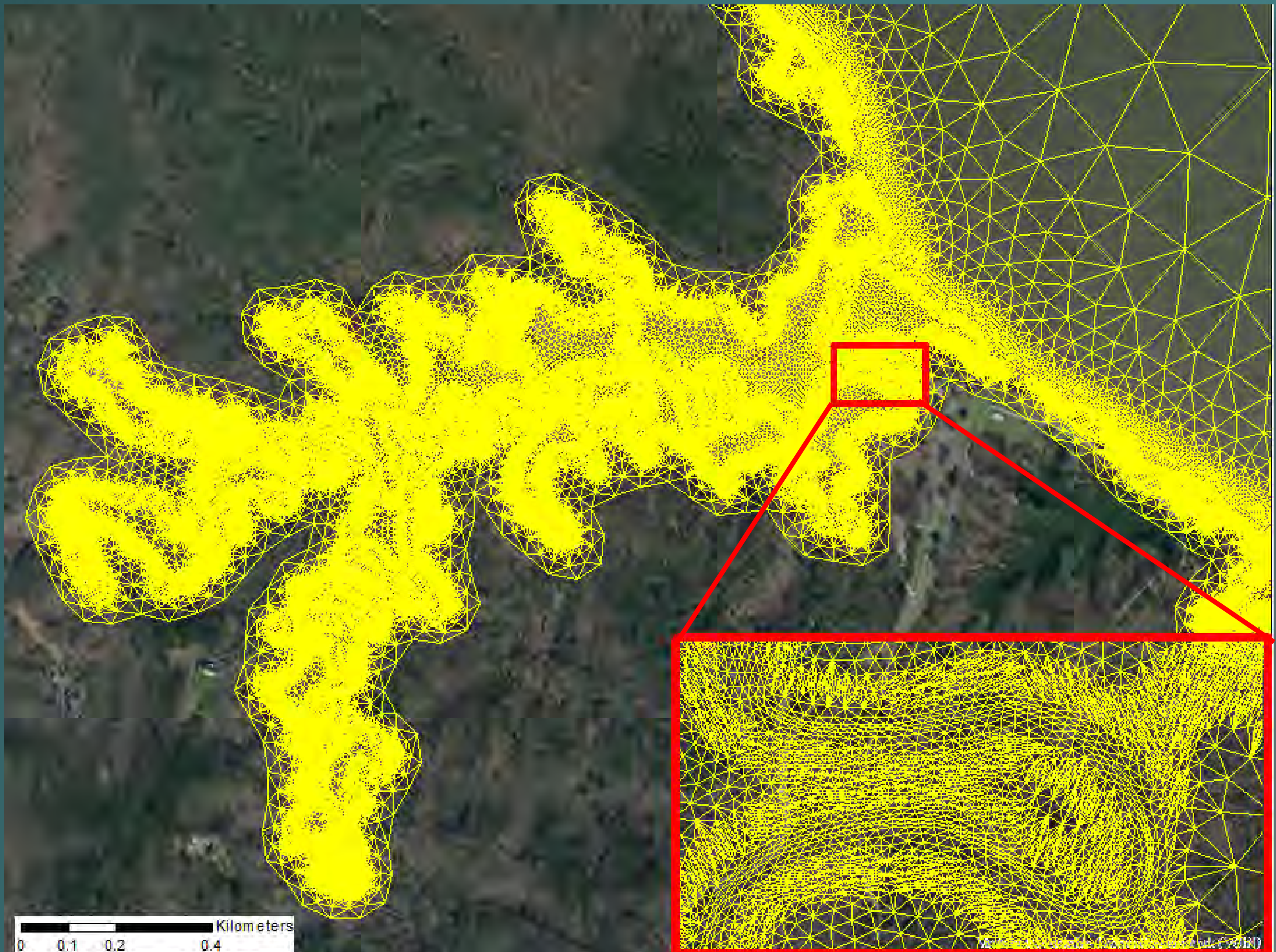
This type of grid allows higher resolution (details) where fine scales are important: **sharp transition**



Grid generation software: SMS (Surface-water Modelling System) by Aquaveo.com

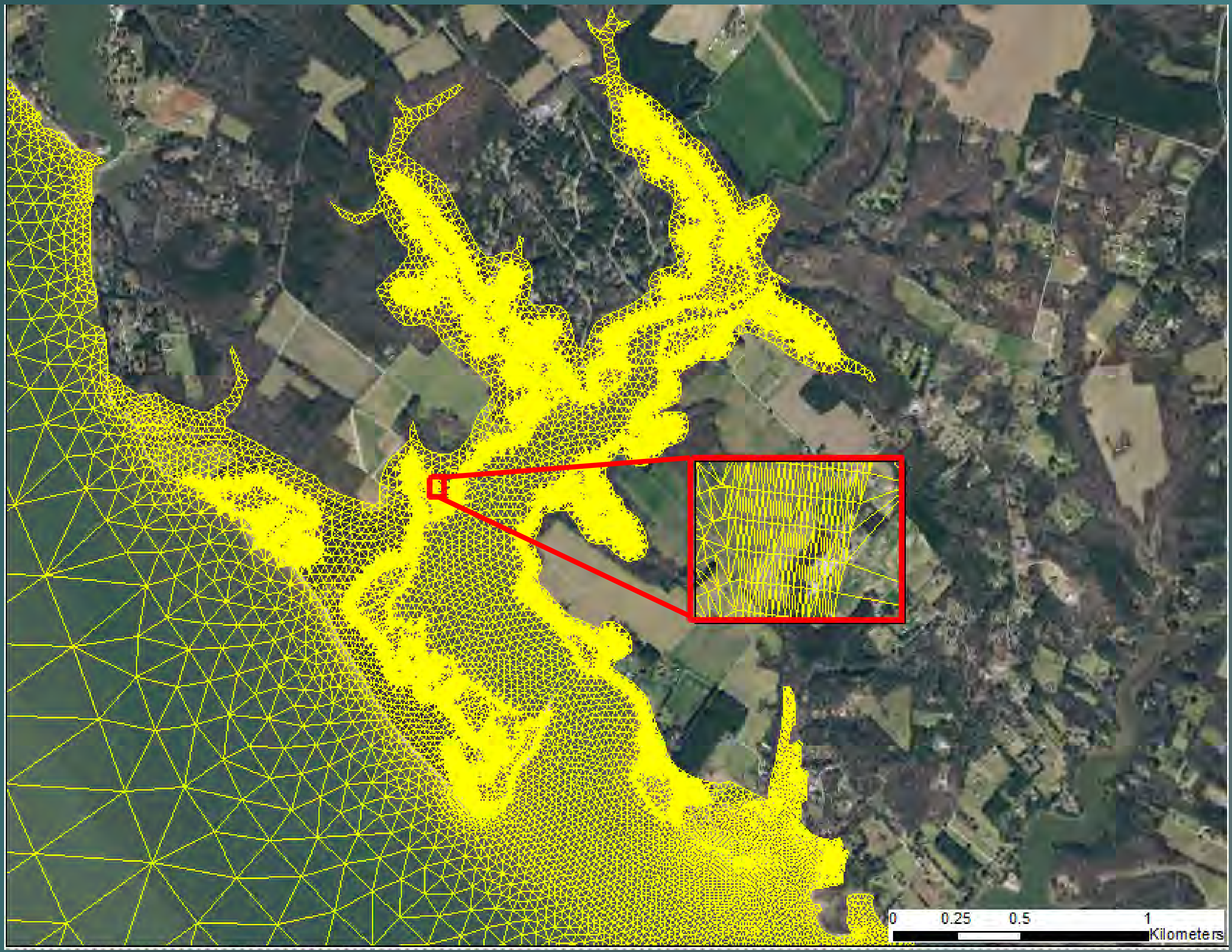
TMM – Model Evaluation

Unstructured Grid - Taskinas Creek

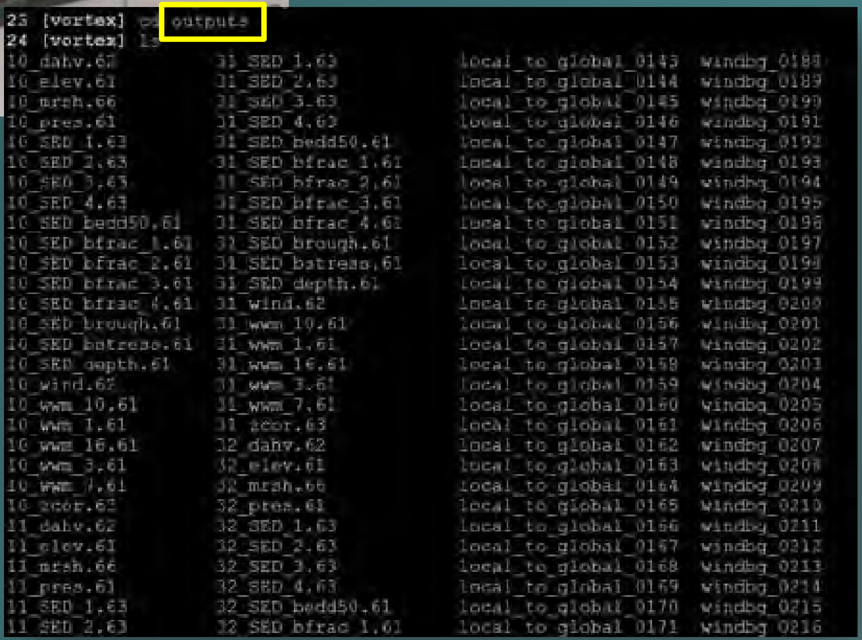


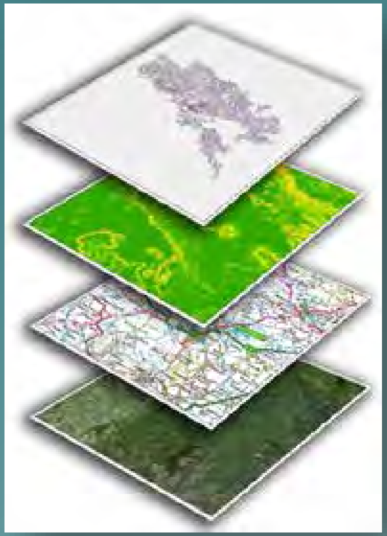
TMM – Model Evaluation

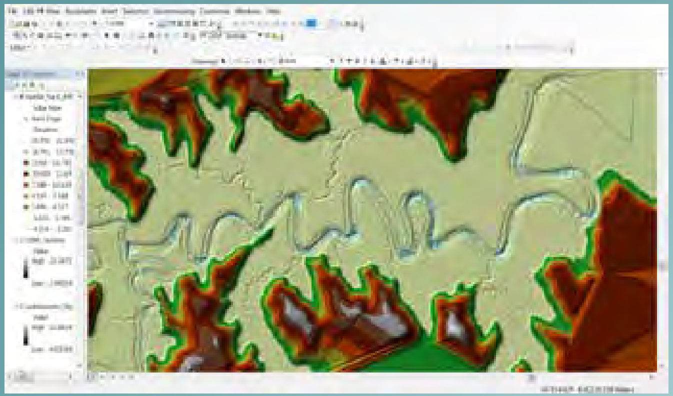
Unstructured Grid - Carter Creek



High Performance Computing (HPC) at William & Mary

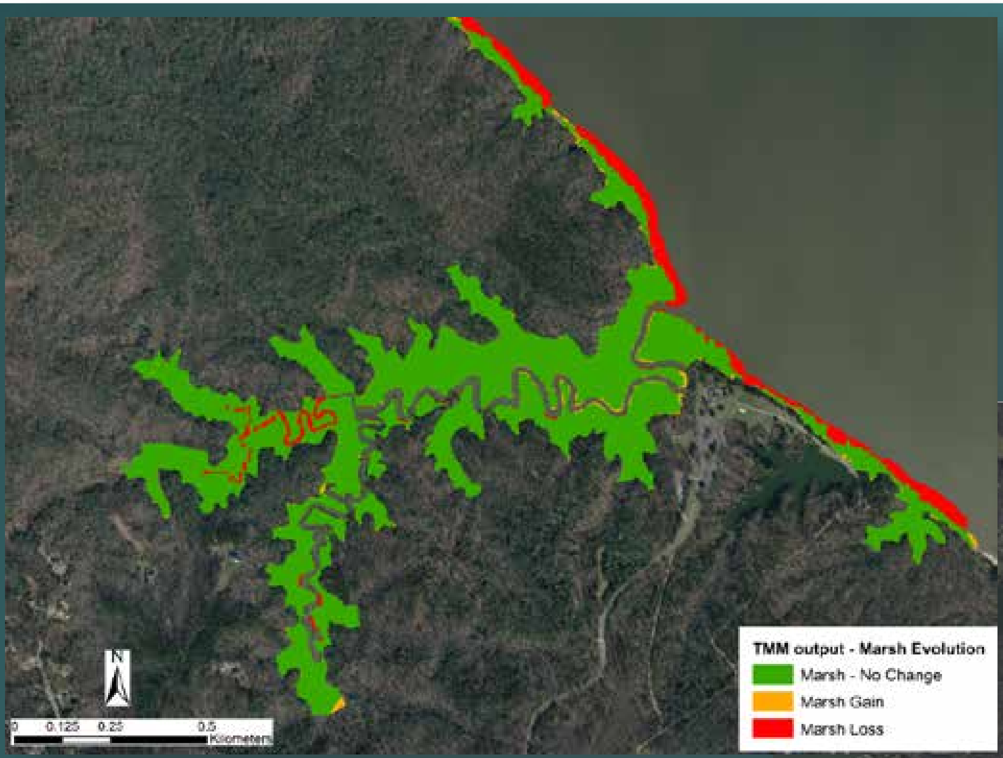






TMM outputs: files can be exported to the GIS environment for further spatial analysis and visualization (e.g. interactive map viewers).

TMM Results - Marsh Boundary Evolution



TMM Results

- Model outputs present a strong agreement with field observation
- Model results show that the TMM successfully captures processes important for marsh evolution:

  - marsh inundation frequency
  - wave energy attenuation by marsh plants
  - erosion-deposition patterns around coastal structures
  - marsh landward migration

SUMMARY - Project Significance

TMM will overcome many of the **limitations** current marsh models present:

Current Models		TMM
scaling problems	→	**"cross-scale"** model (increased resolution)
constant rates	→	**dynamic modeling** *(varying rates in space and time)*
exclusion of hardened shoreline structure impacts	→	**highly resolves marsh landward migration**

SUMMARY - Project Significance

- Build a better foundation/framework to model marsh evolution

Highly resolved outputs will allow coastal planners to more accurately identify the potential future location of marsh habitats where protection and restoration activities can be focused to increase tidal marsh resilience.

Thanks!

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