# Understanding of processes of surface water dynamics causing storm surge flooding

Jim Kirby

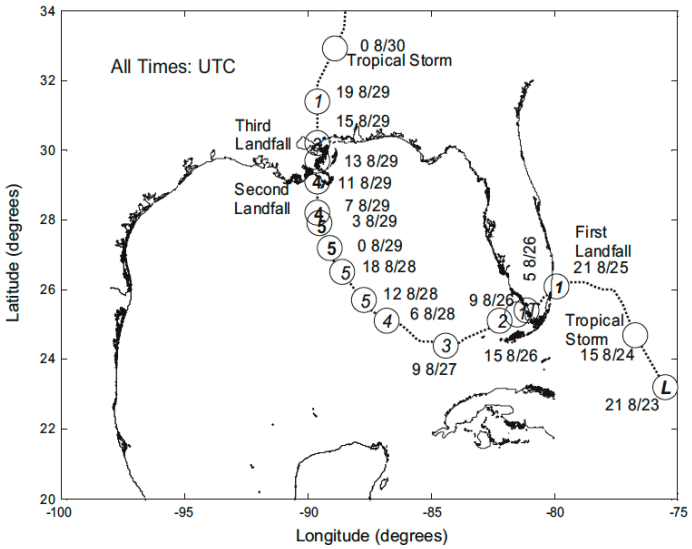
Center for Applied Coastal Research, Department of Civil and Environmental Engineering

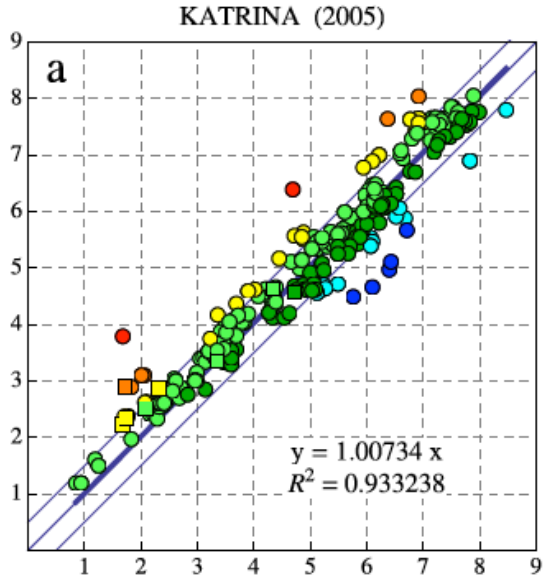
POSE, College of Earth, Ocean and Environment

UD

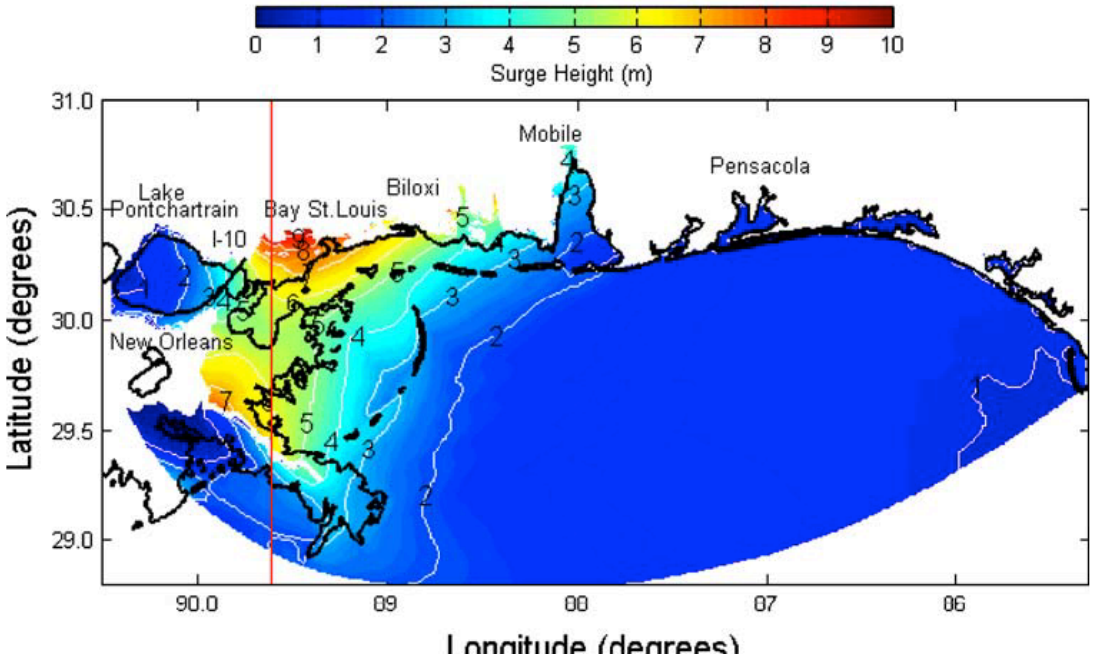
- How will SLR affect developed, undeveloped and agricultural land in the mid-Atlantic region?
- What are the dominant mechanisms and timescales of salinization of soils and groundwater due to storm surges and SLR?
  - First, can we predict SLR or storm surges in open coastal water bodies?
  - How do we go about translating these predictions into areas inundated by rising water level?
- What hydrogeological factors most affect salinization and freshening of coastal water?

# First, can we model surge events in open water?




Dietrich et al, 2012

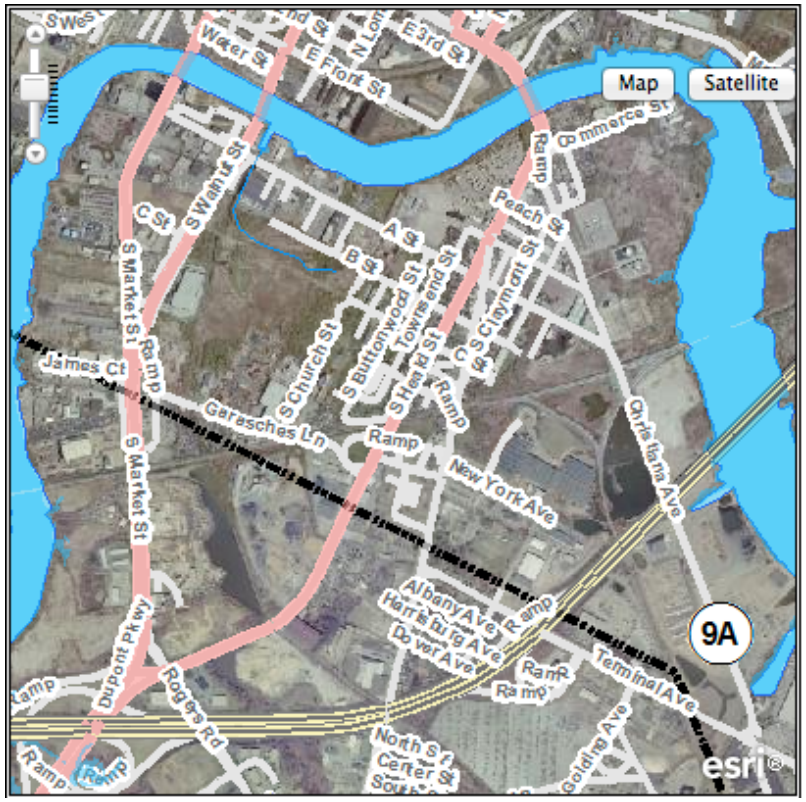



Chen et al, 2008

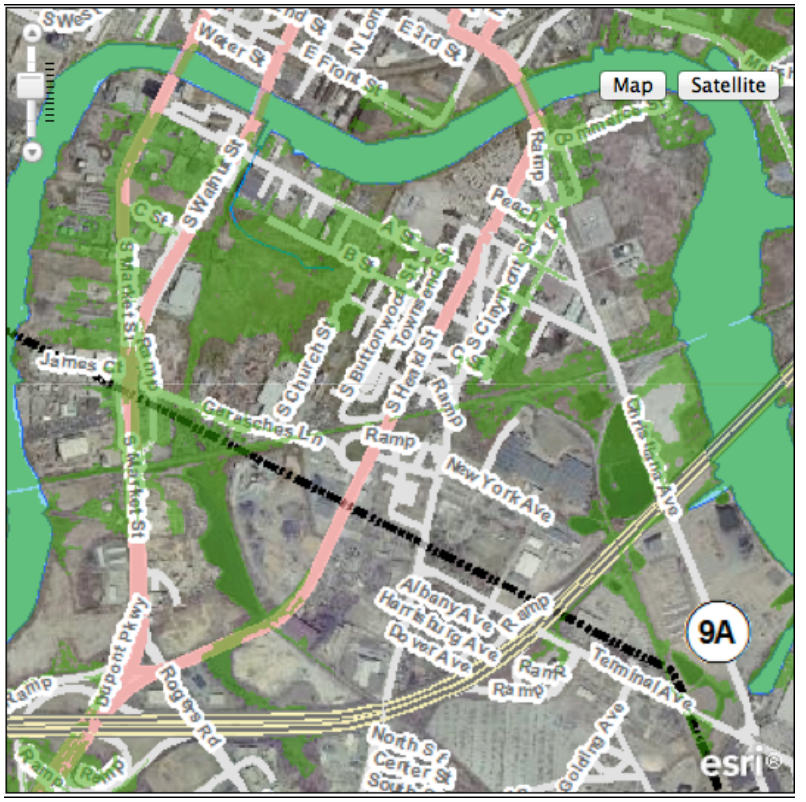
Can we translate open water results to meaningful estimates of water levels in inundated areas? What time scales are involved?

- Approach: "Bathtub" modeling
  1. Dry regions adjacent to open water are filled to same surface elevation as open water.
  2. Sophisticated applications of this method are smart enough to avoid filling enclosed or protected regions (polders)

# Wilmington, DE




Present sea level



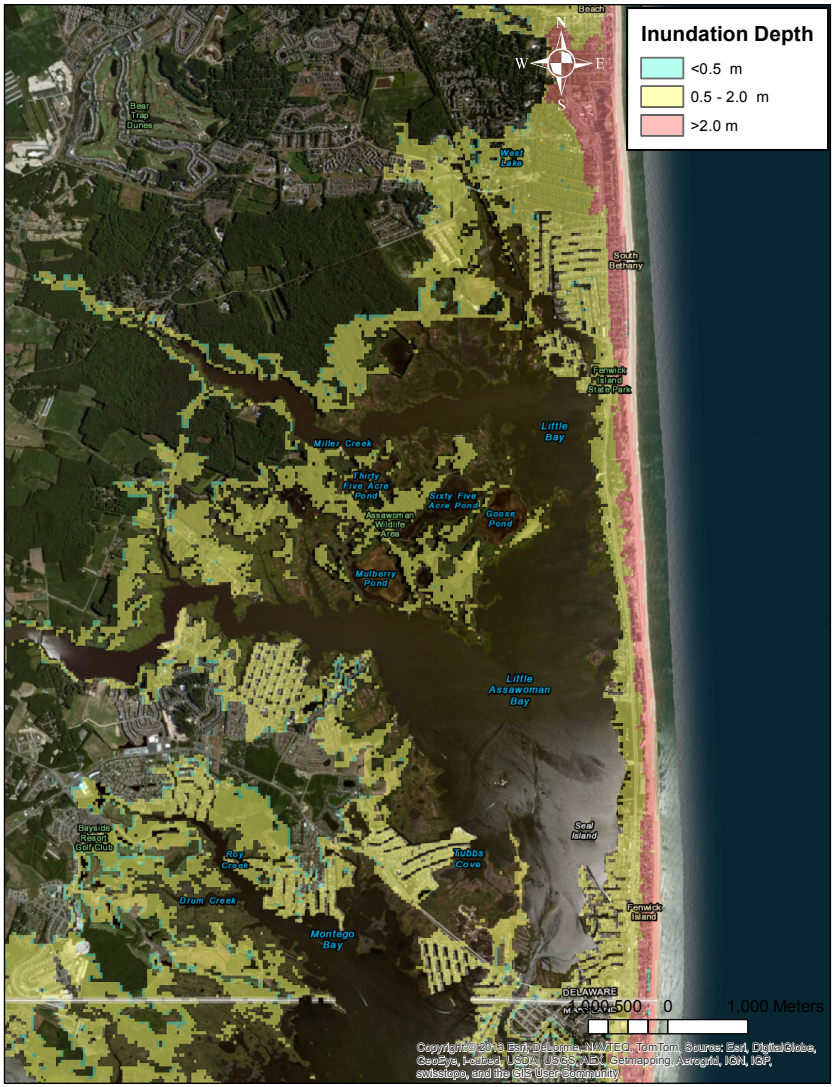

Present + 0.5 m

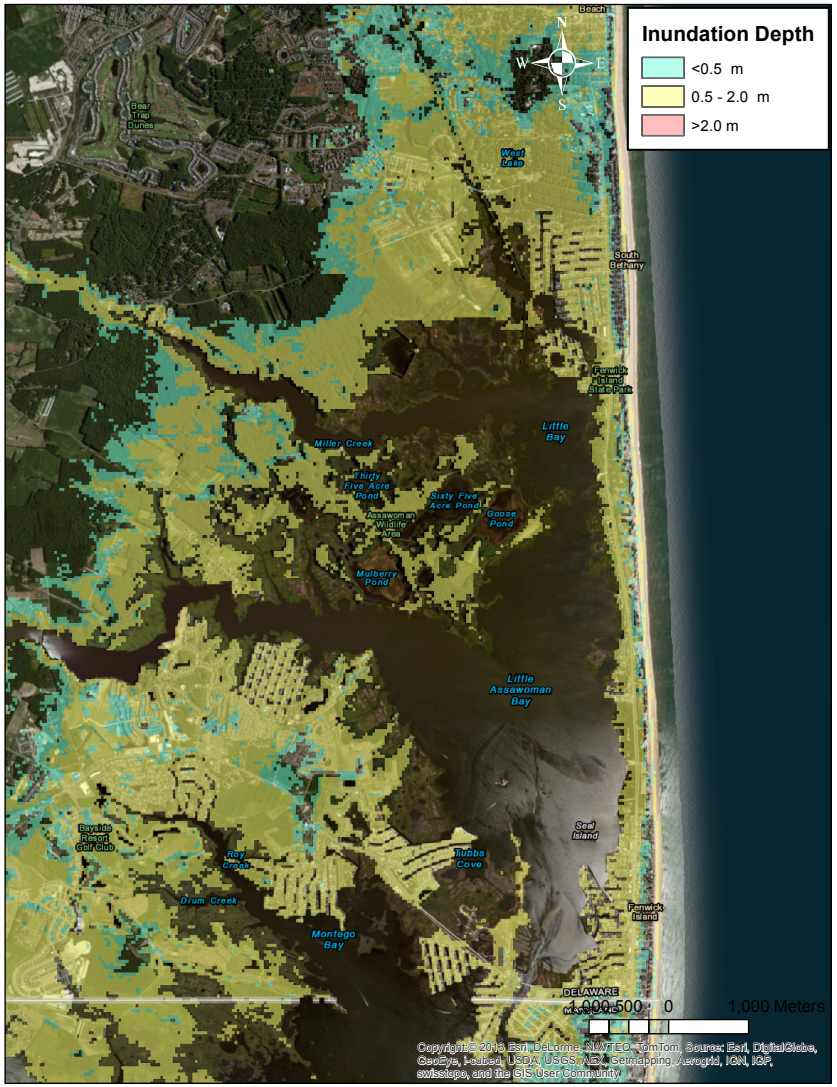
(DNREC Sea Level Rise Inundation Maps)

Is this reasonable to do for events occuring on shorter time scales? (tides, storms, tsunamis)

- Bathtub models probably provide a conservative estimate of inundation depths.
- Overdoing predictions of inundation on short time scales could lead to overestimation of scope of related transport problems.
- Bathtub models tell us nothing about dynamics
  - How are floodwaters routed?
  - What are transport pathways for sediments and mobilized contaminants?

# Comparing 2 meter bathtub surge (right) to comparable tsunami wave height (left). MD/DE border

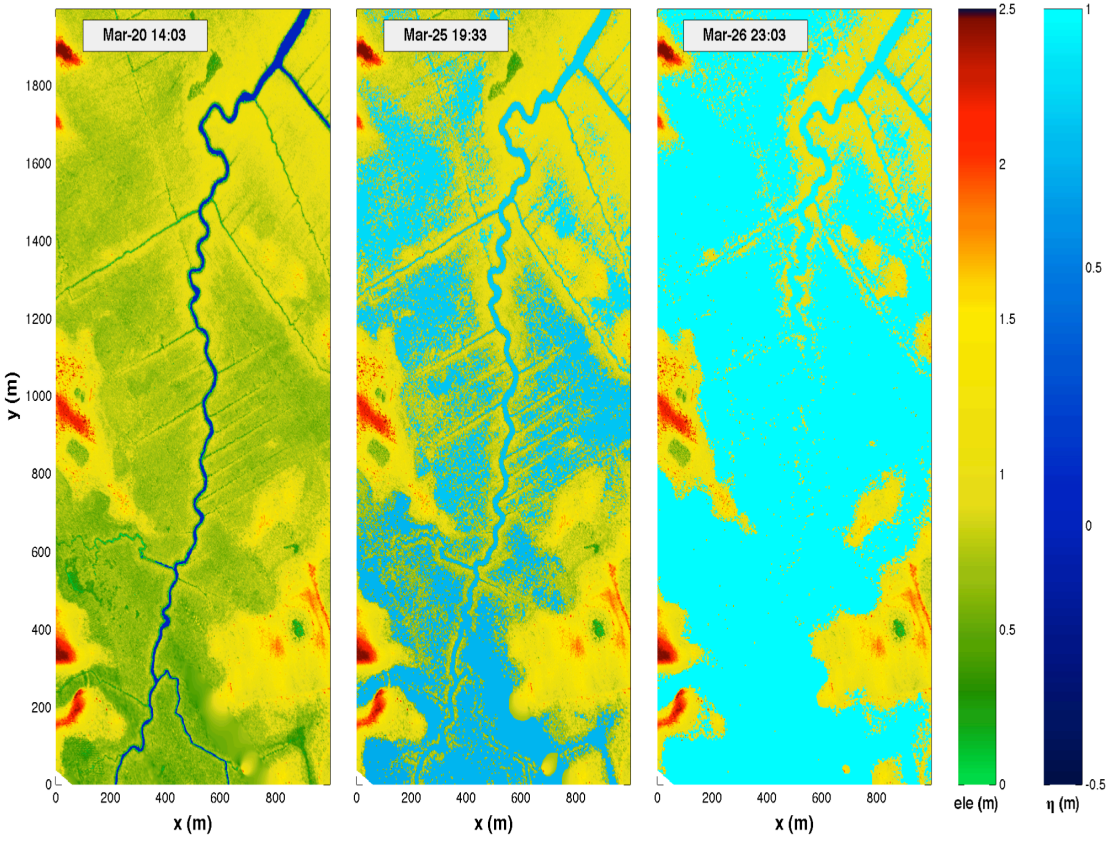



(Tehranirad et al, 2013)

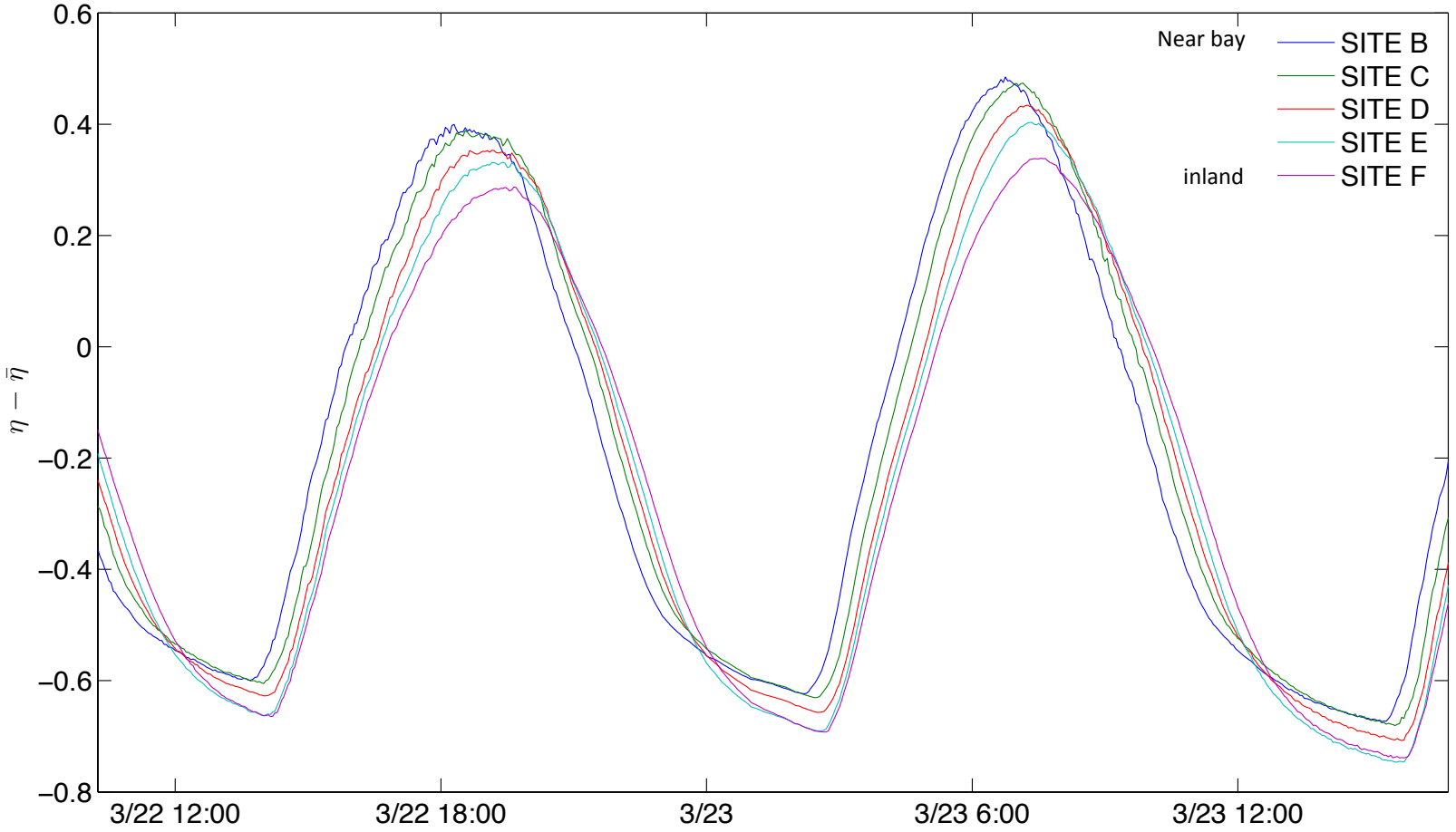
# Tidal time scales: Draining and filling of Brockonbridge Marsh, DE


Deployed instruments, March 2013




Simulated rising spring tide
(Mieras et al, 2013)

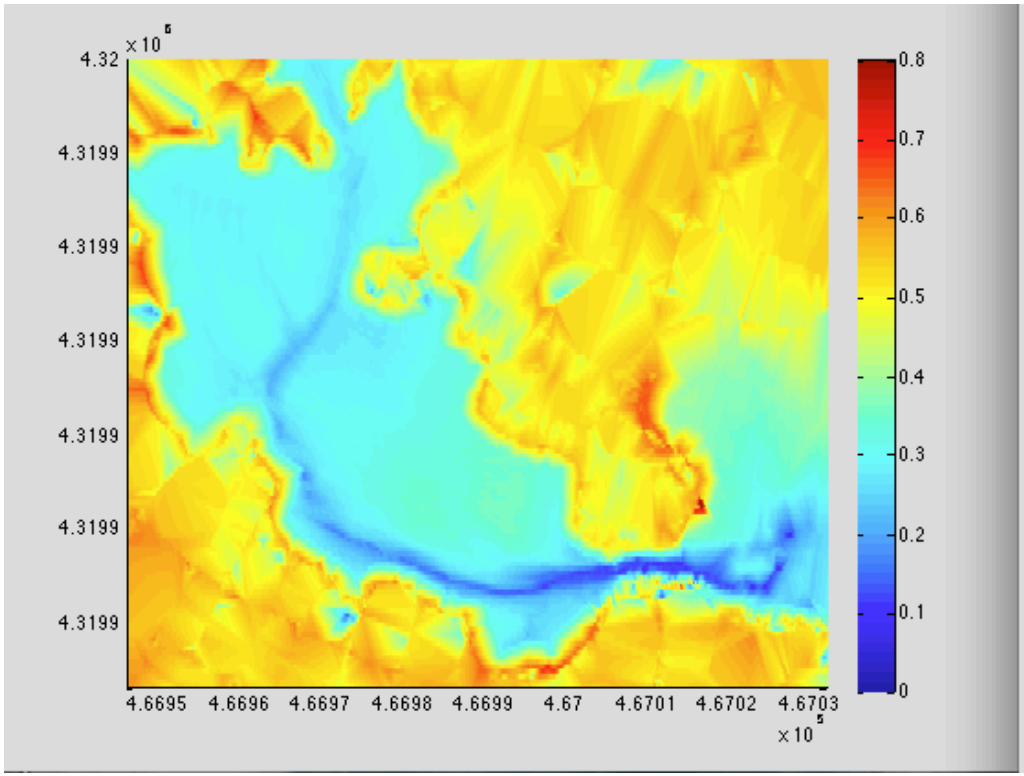
# Comparing tide gage records along marsh channel



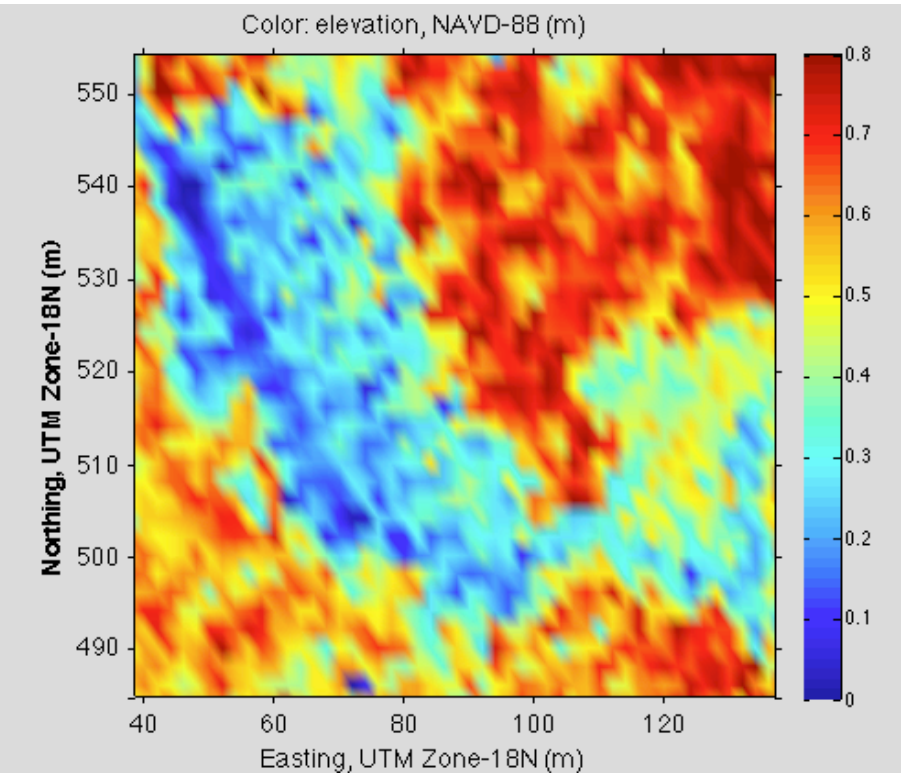

Brockonbridge Marsh, March 2013 (Mieras et al)

# Modeling appears to be warranted. What are challenges?

- Accurate/detailed enough knowledge of topography, built environment and other land-use patterns?
  - Example: biases in marsh DEM related to vegetation cover



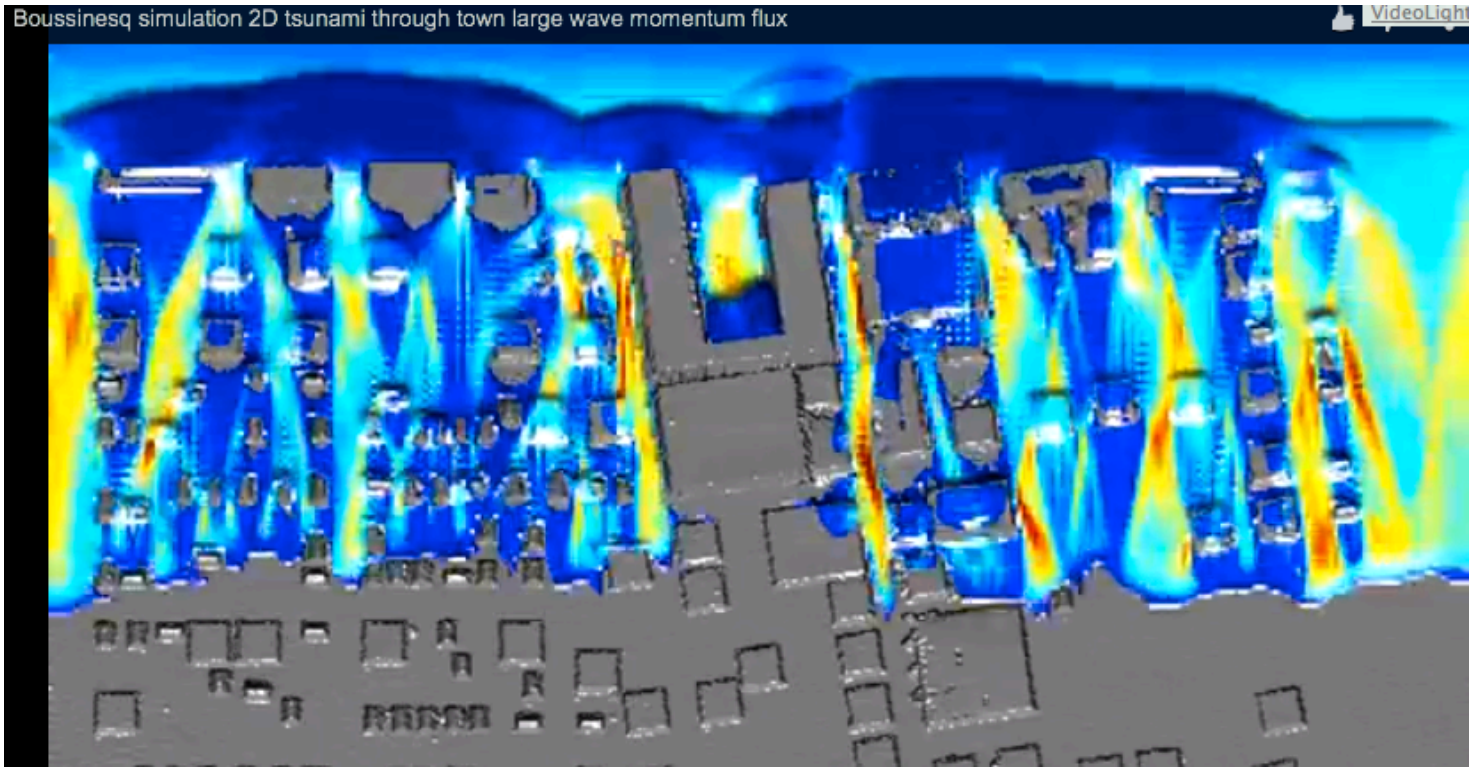

Local measurement




Airborne LIDAR

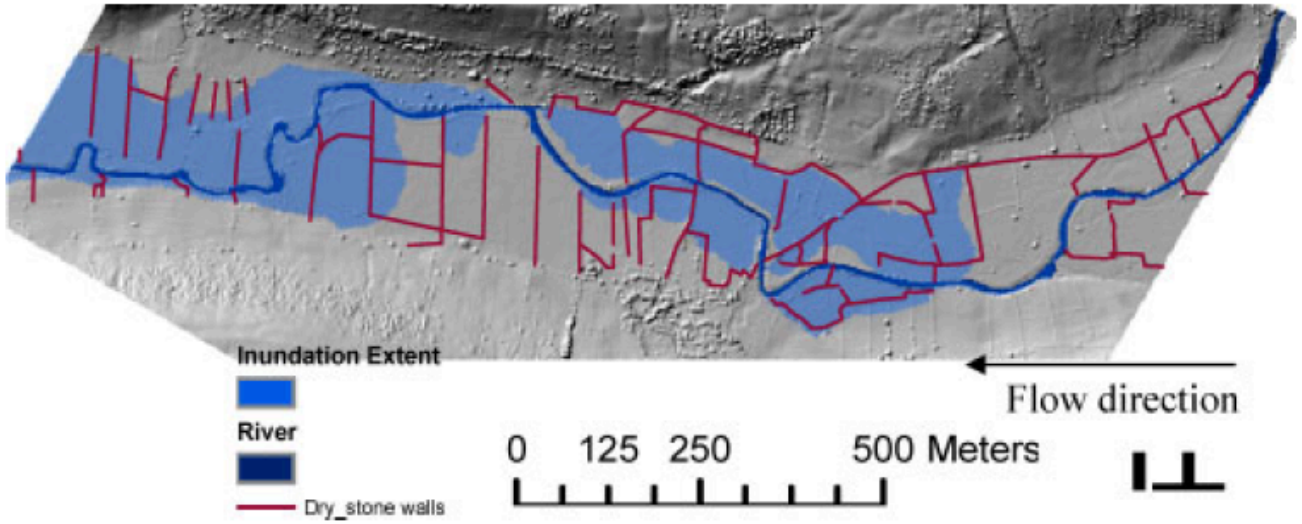
Modeling appears to be warranted. What are challenges?

- Accurate/detailed enough knowledge of topography, built environment and other land-use patterns?
- Efficient computational approaches to handle this detail?




Wave momentum flux estimates for tsunami inundation: Seaside Oregon (P. Lynett)

# Modeling subgrid features in DEM's




Yu + Lane, 2011

Figure 3. Floodplain topography (shaded DEM) with observed max inundation extent

Volp et al, 2013

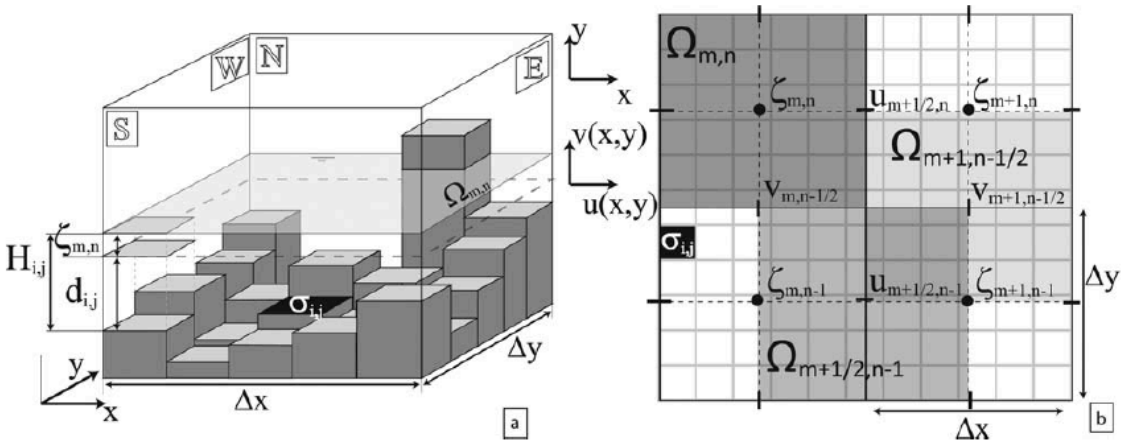



**Figure 1.** (a) A schematic view of a computation cell with an underlying subgrid, where a part of the domain is dry and (b) an overview of computation cells and domains.

# SLR: natural and anthropogenic responses to increased inundation

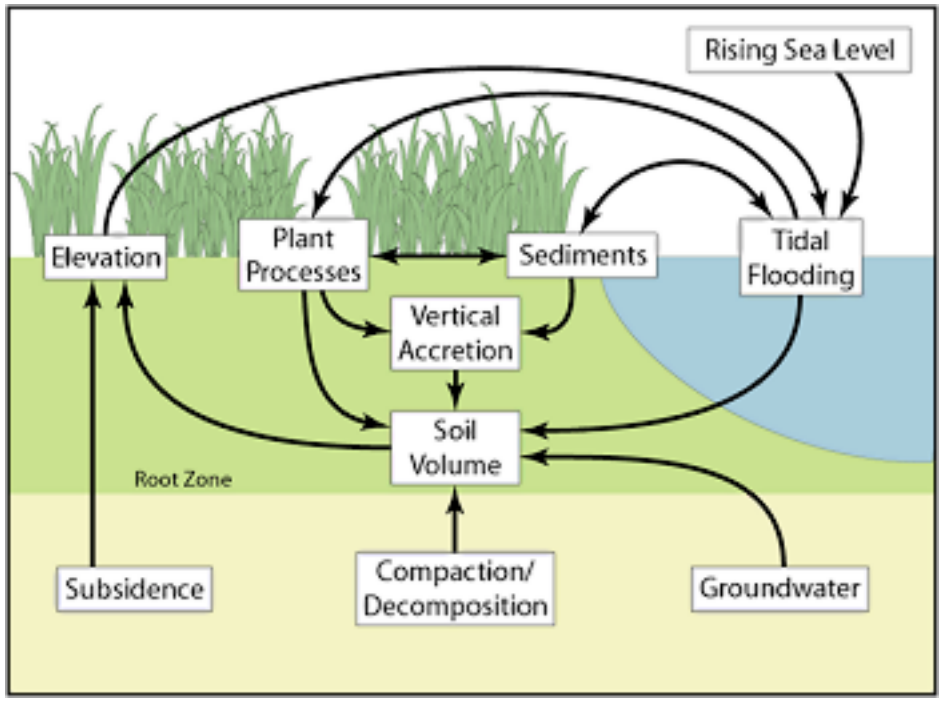
- Natural landscape responses to increasing sea level
  - Upward and landward adjustment of barrier islands through overwash processes

Sandy sand deposits and removal efforts on DE 1

(photos courtesy of Tony Pratt, DNREC)

# SLR: natural and anthropogenic responses to increased inundation

- Natural landscape responses to increasing sea level
  - Upward and landward adjustment of barrier islands through overwash processes
  - Marsh platform accretion

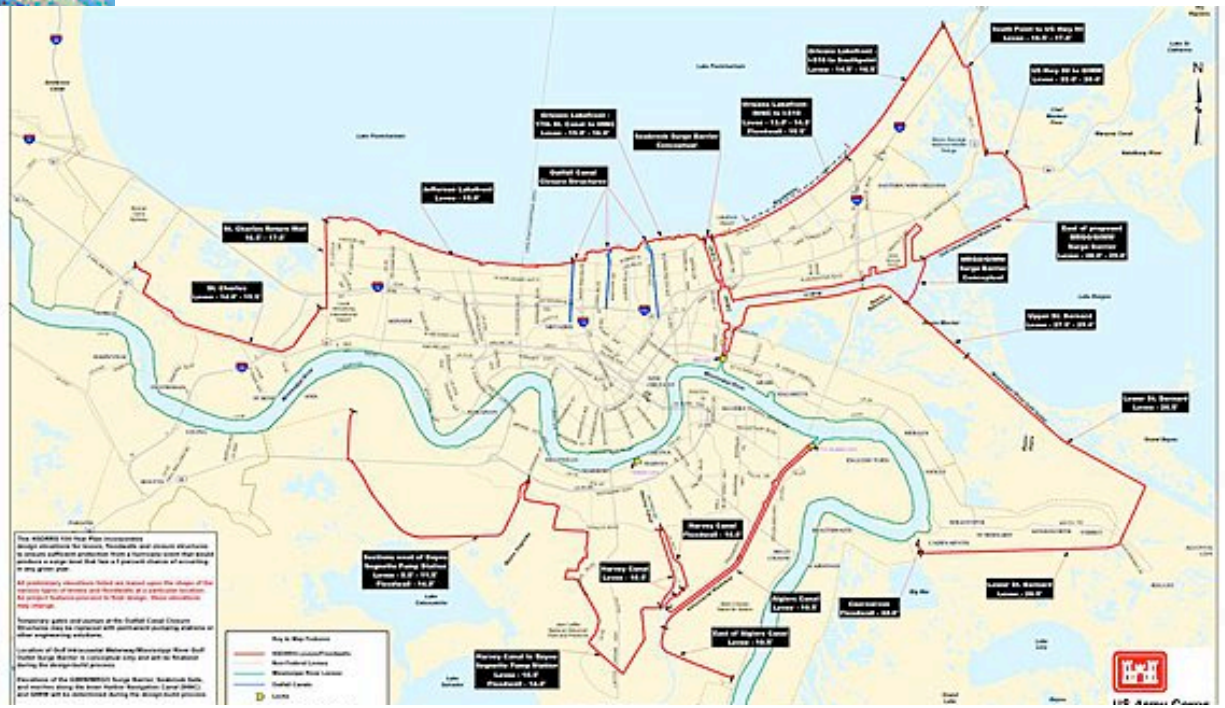



Defense Coastal/Estuarine Research Program

# SLR: natural and anthropogenic responses to increased inundation

- Man-made interventions to reduce risk of inundation (polders, etc)

New Orleans, LA



Hurricane & Storm Damage Risk Reduction System (HSDRRS):