2ND ANNUAL CAPE COASTAL CONFERENCE

Linking Science with Local Solutions and Decision-Making

JUNE 6, 2014

Preparing for Sea Level Rise and Climate Change at a Community and Individual Asset Scale

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Climate Change Preparation

1. Sea Level Rise and Storm Surge Risk – What is the real risk?
2. Vulnerability Assessment – How do we determine what is vulnerable?
3. Preparedness Planning and Adaptations – What should the plan be?

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Background on Sea Level Rise

- Sea Level Rise (SLR)
  - Thermal expansion of ocean water
  - Increased water input from land-based sources

- Northeast and Mid-Atlantic SLR is higher than global average
  - 1.75 mm/yr (Maine) to 6.05 mm/yr (Virginia)
  - Changes in ocean circulation (Yin et al., 2009, 2010)

- People live on the coast
  - 80% within 60 miles
  - ¾ of the cities
  - In the U.S. – 40% in 2010, 50% in 2020

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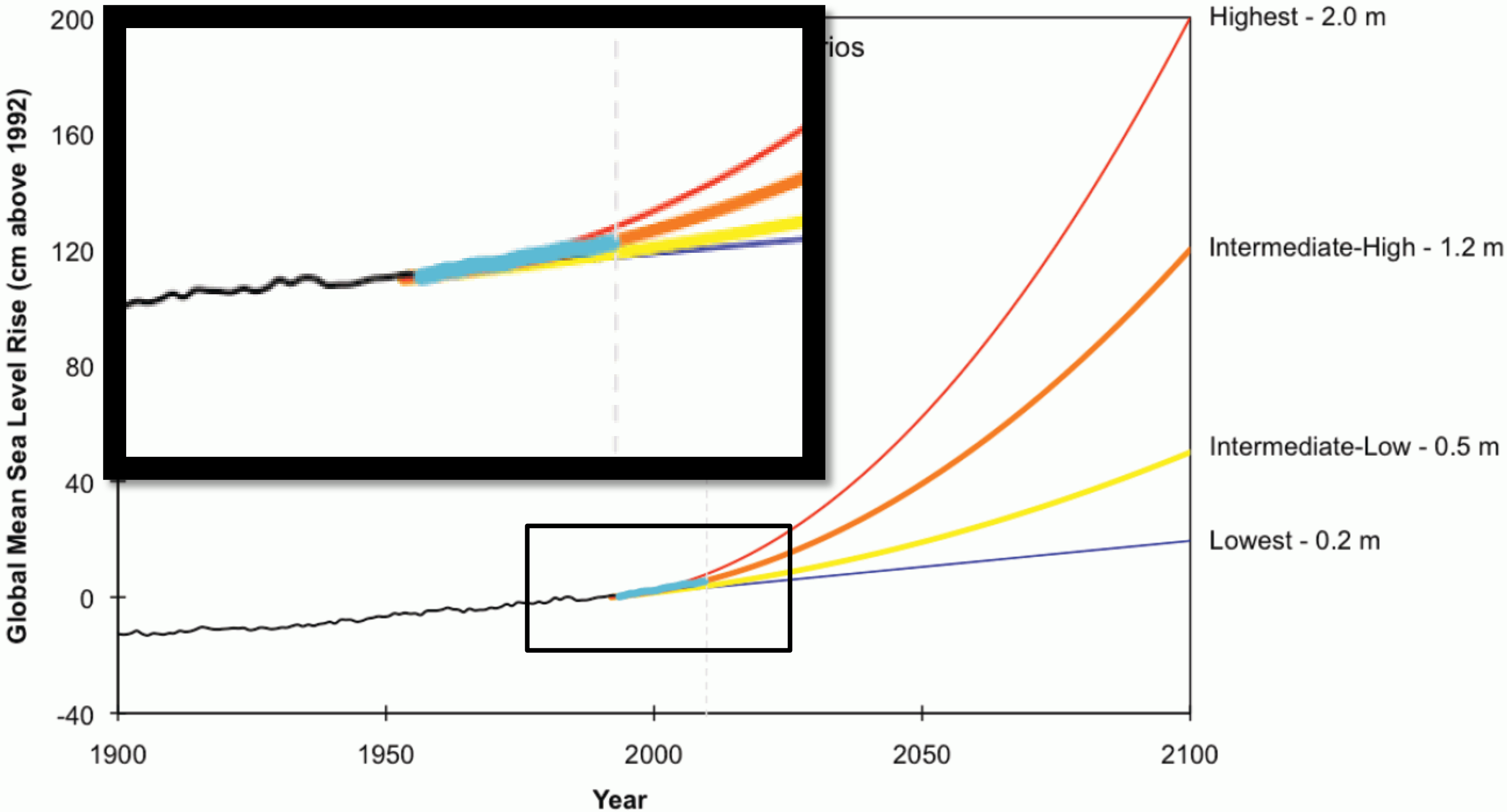
Wide Range of Projections



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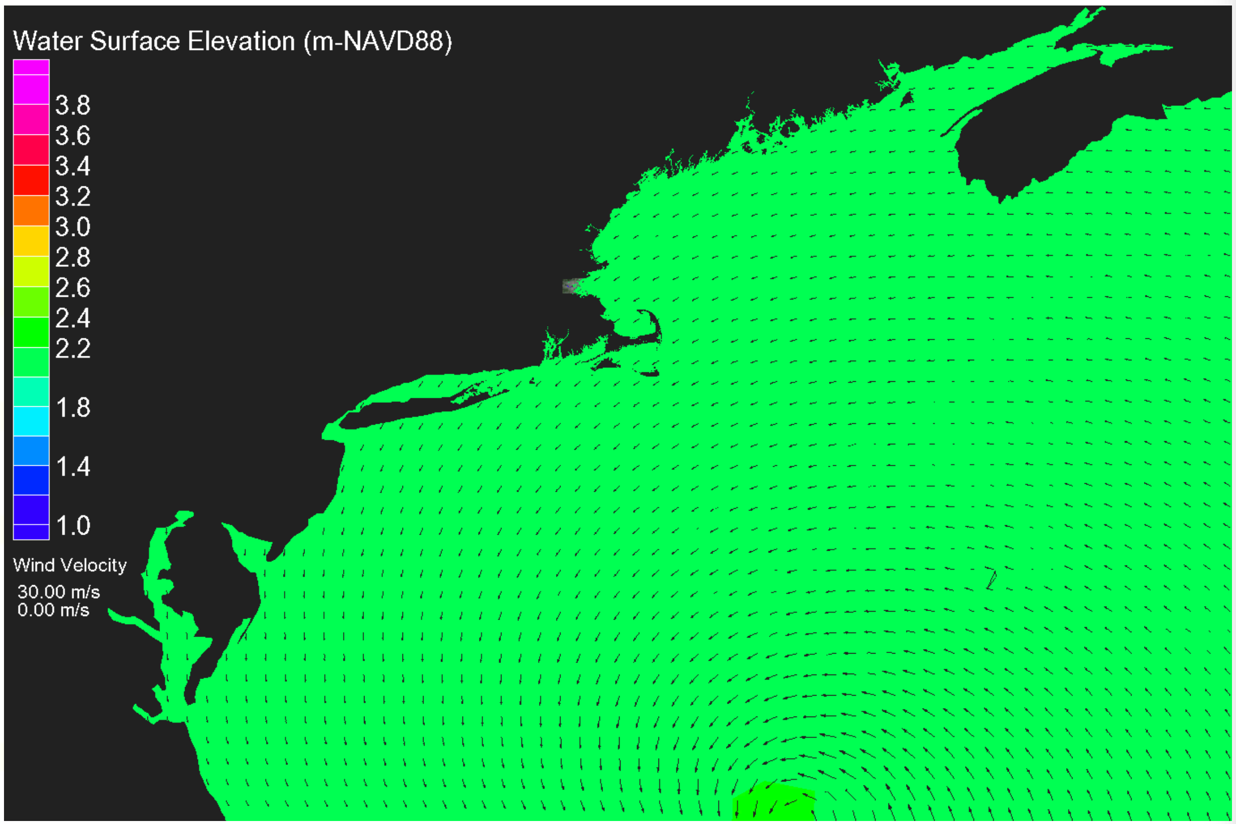
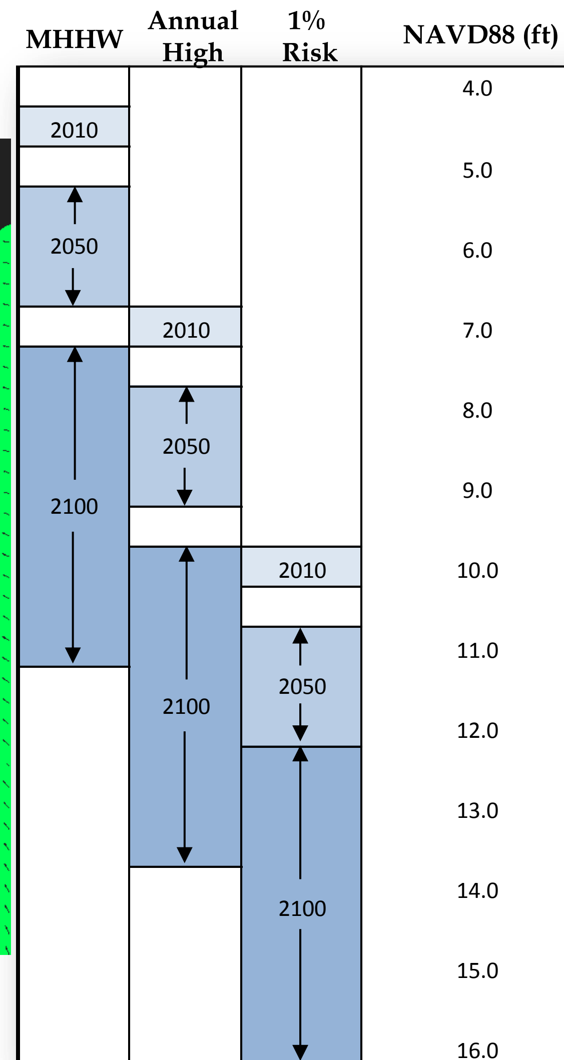
Importance of Storms





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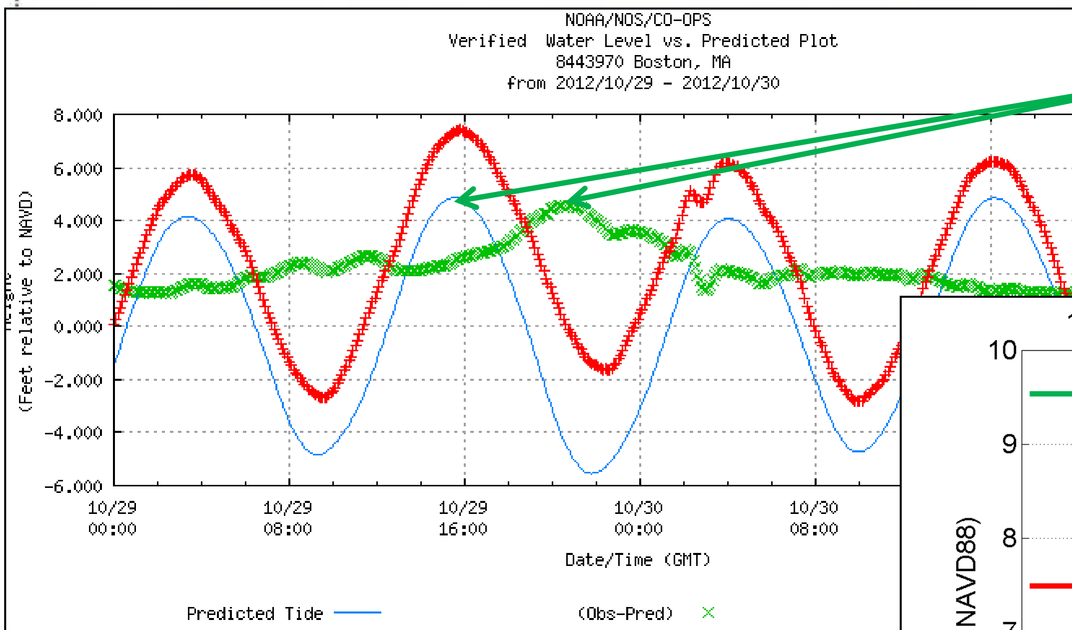
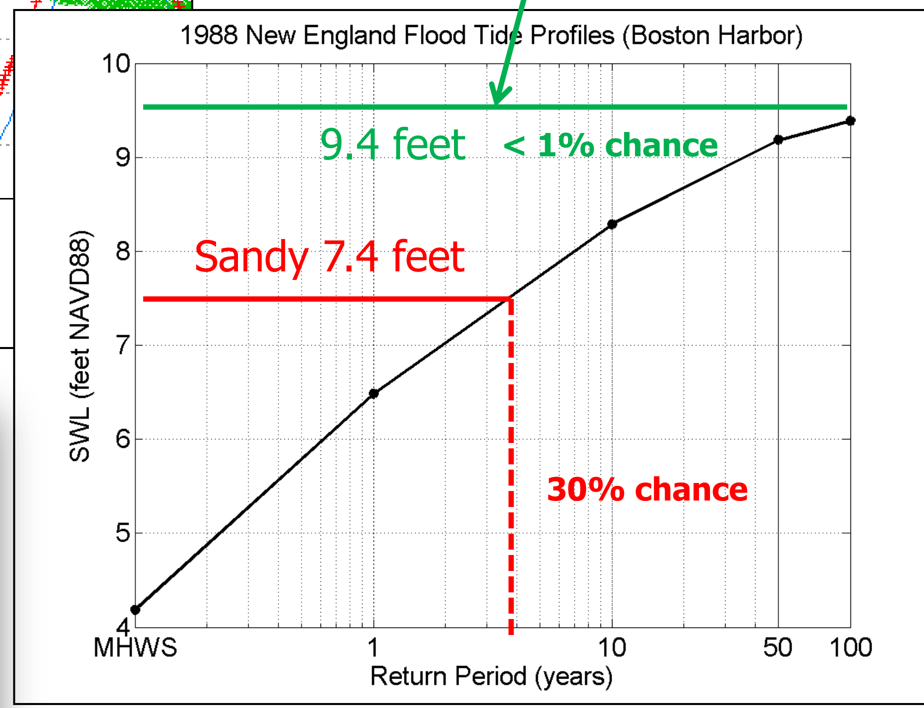
Assessing Risk

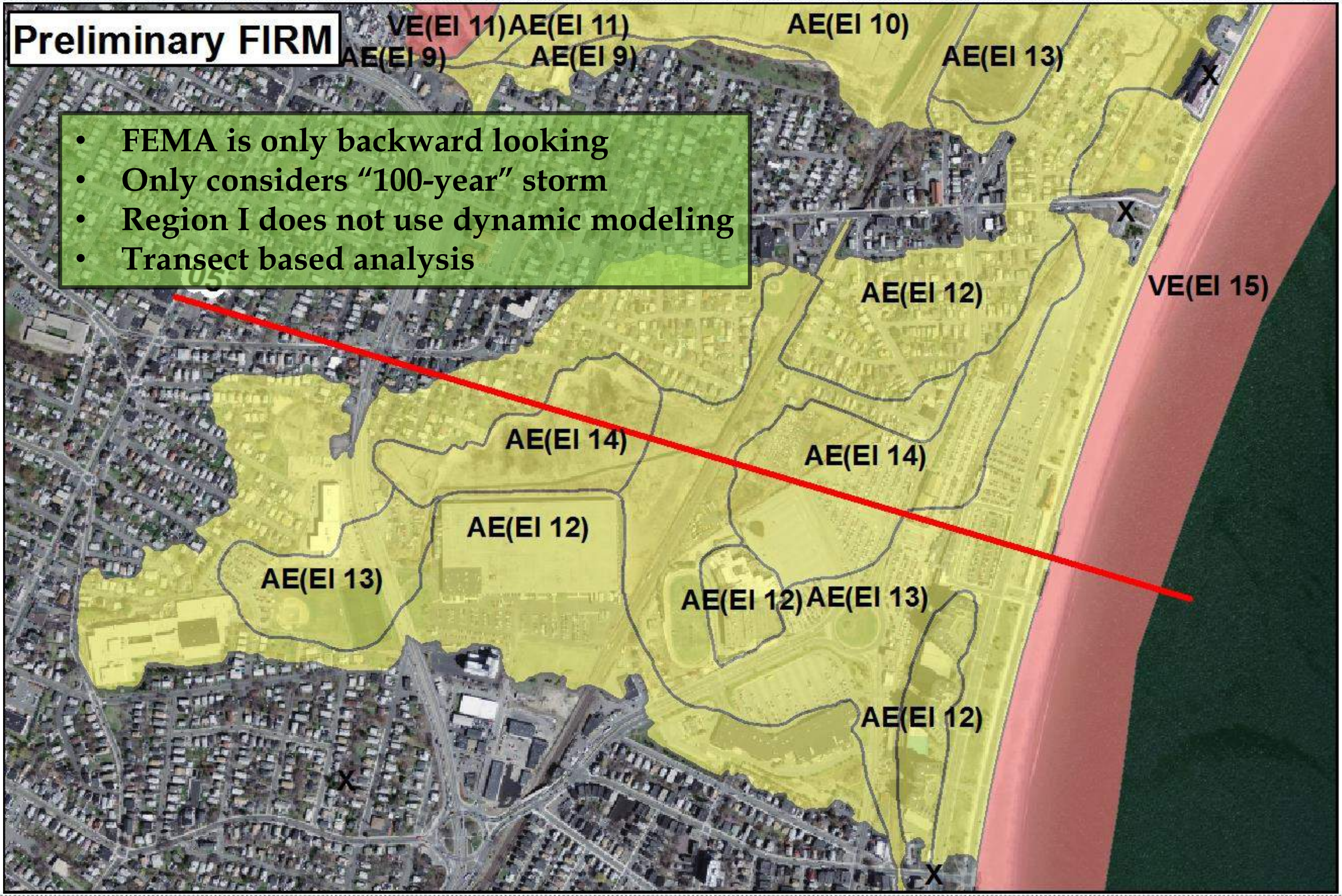
If peaks were simultaneous…





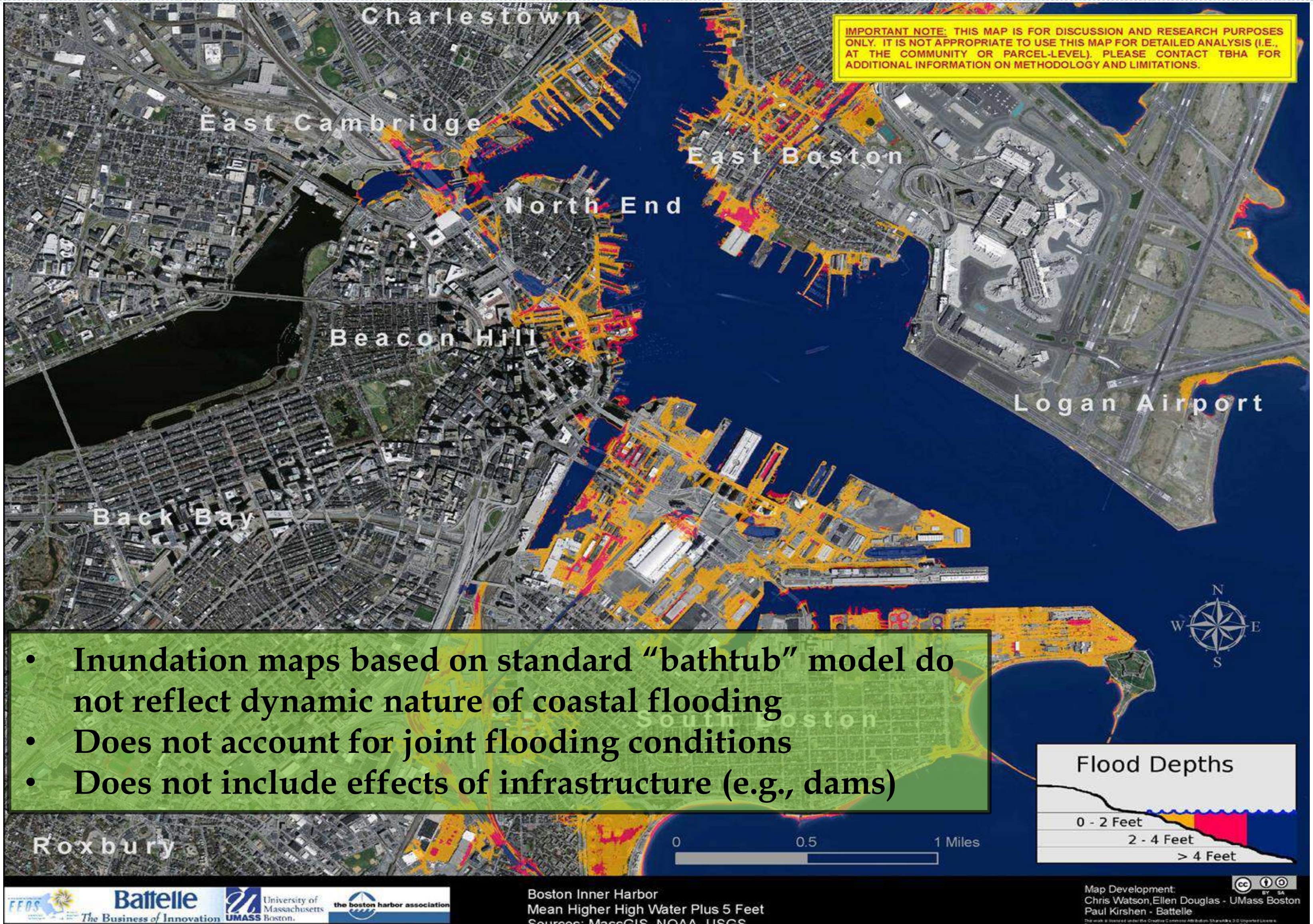
$50 billion damages in NYC

So how do we determine what is vulnerable?



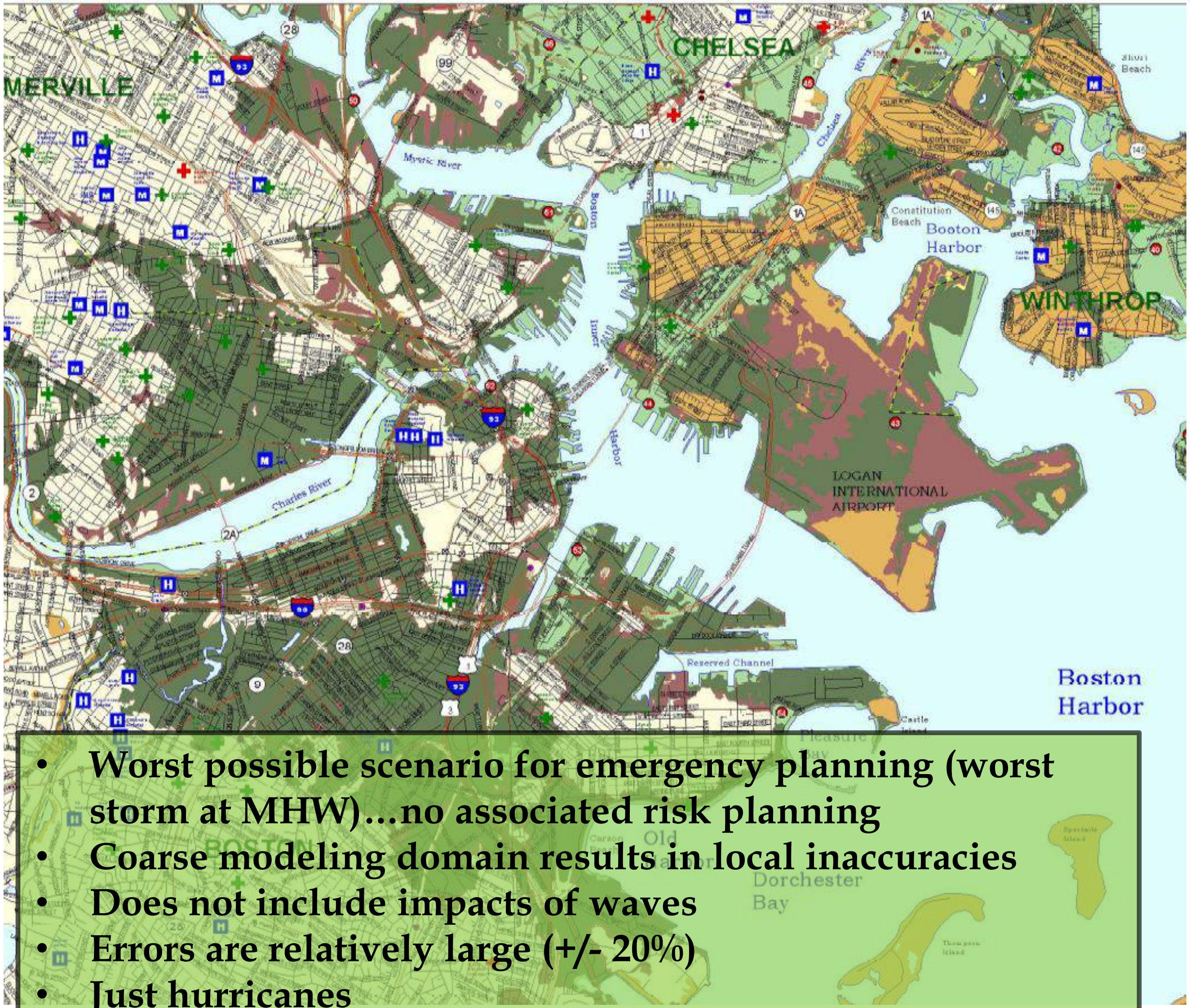
- FEMA is only backward looking
- Only considers "100-year" storm
- Region I does not use dynamic modeling
- Transect based analysis

So how do we determine what is vulnerable?



- **Inundation maps based on standard "bathtub" model do not reflect dynamic nature of coastal flooding**
- **Does not account for joint flooding conditions**
- **Does not include effects of infrastructure (e.g., dams)**

So how do we determine what is vulnerable?



- Worst possible scenario for emergency planning (worst storm at MHW)…no associated risk planning
- Coarse modeling domain results in local inaccuracies
- Does not include impacts of waves
- Errors are relatively large (+/- 20%)
- Just hurricanes

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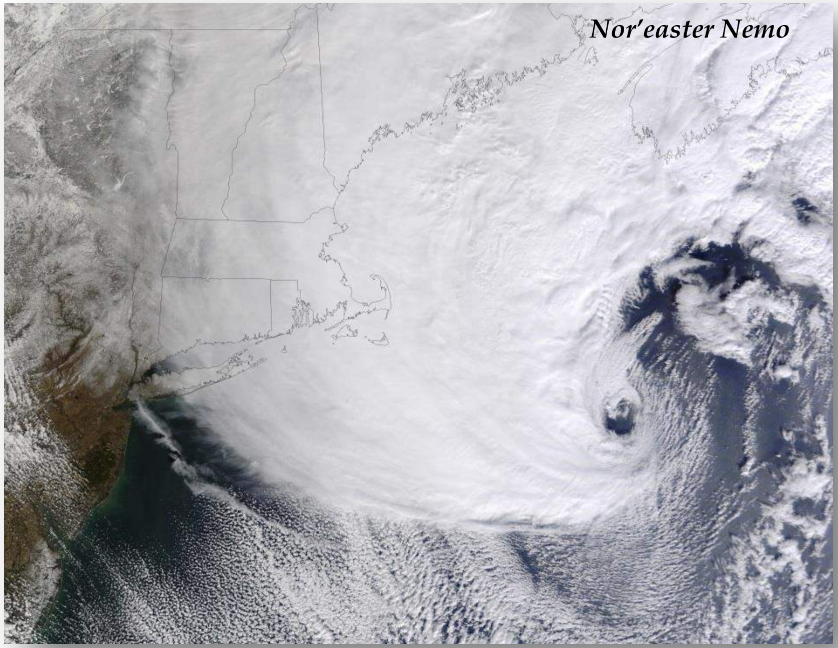
High-Resolution Hydrodynamic Modeling

- Includes relevant physical processes (tides, storm surge, wind, waves, wave setup, river discharge, sea level rise, future climate scenarios, infrastructure effects)
- Covers a larger physical area to correctly represent the storm dynamics



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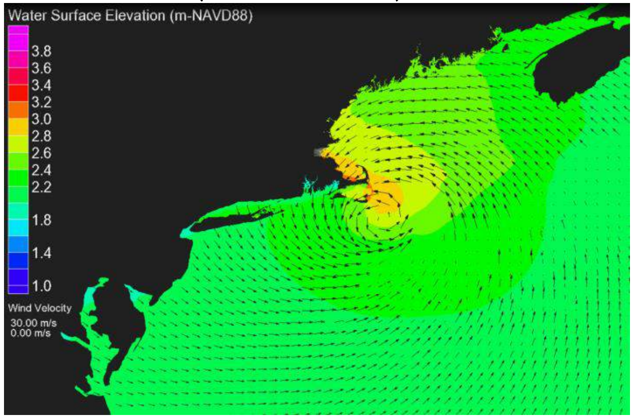
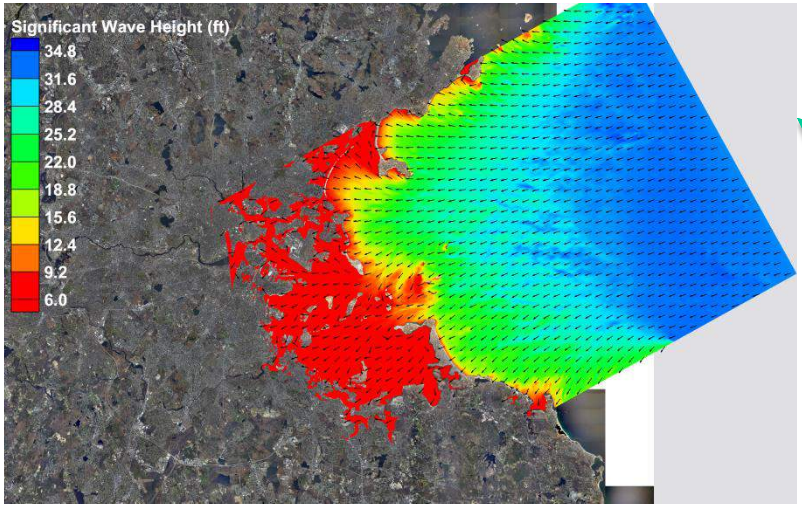
BH-FRM Modules

- Advanced Circulation Model for Oceanic, Coastal, and Estuarine Waters (ADCIRC)



- Currents
- Storm Surge
- Tides
- Water Levels
- Winds
- SLR
- Discharge

- Simulating WAves Nearshore (SWAN)



- Waves
- Wave Setup

Tightly Coupled

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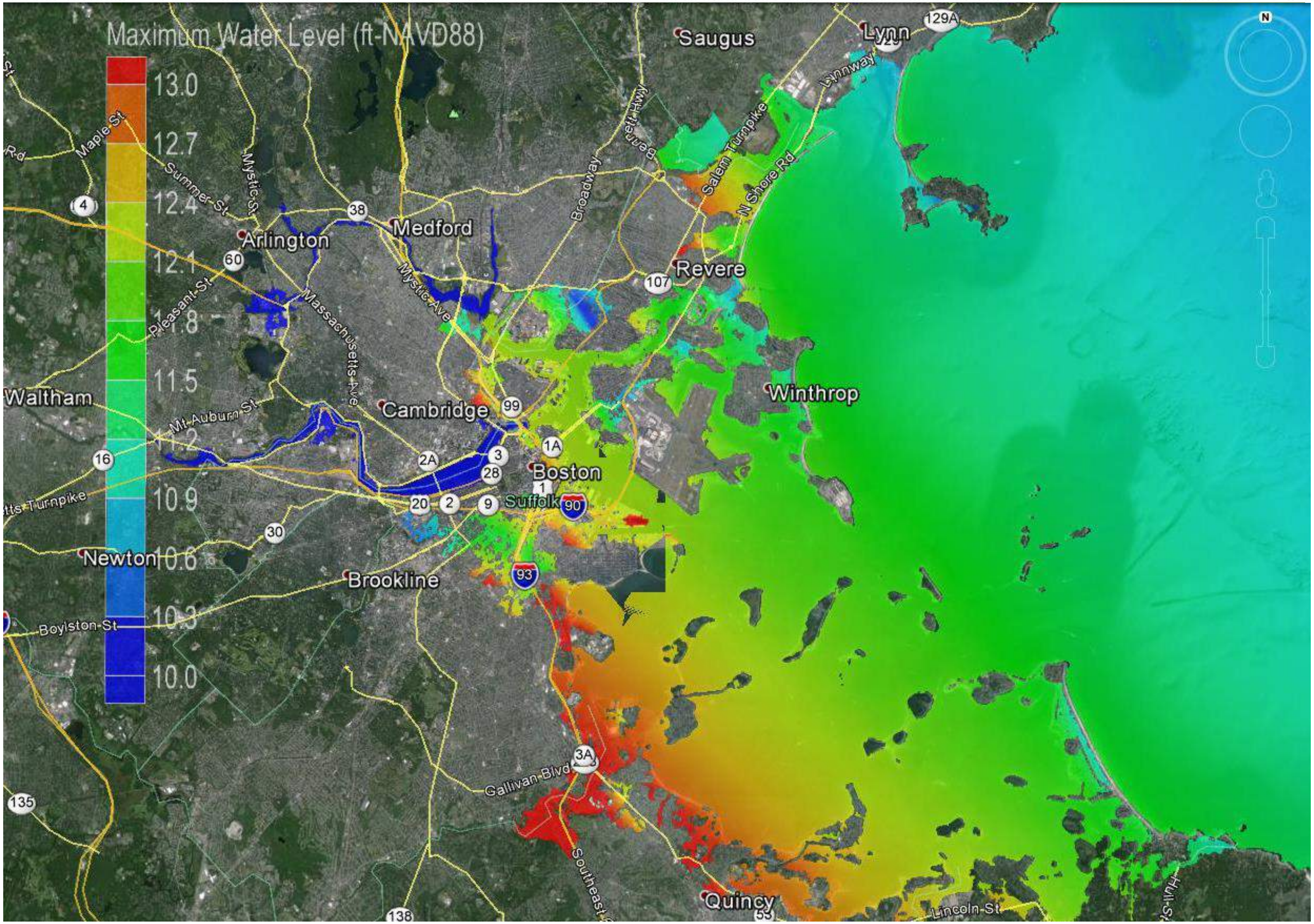
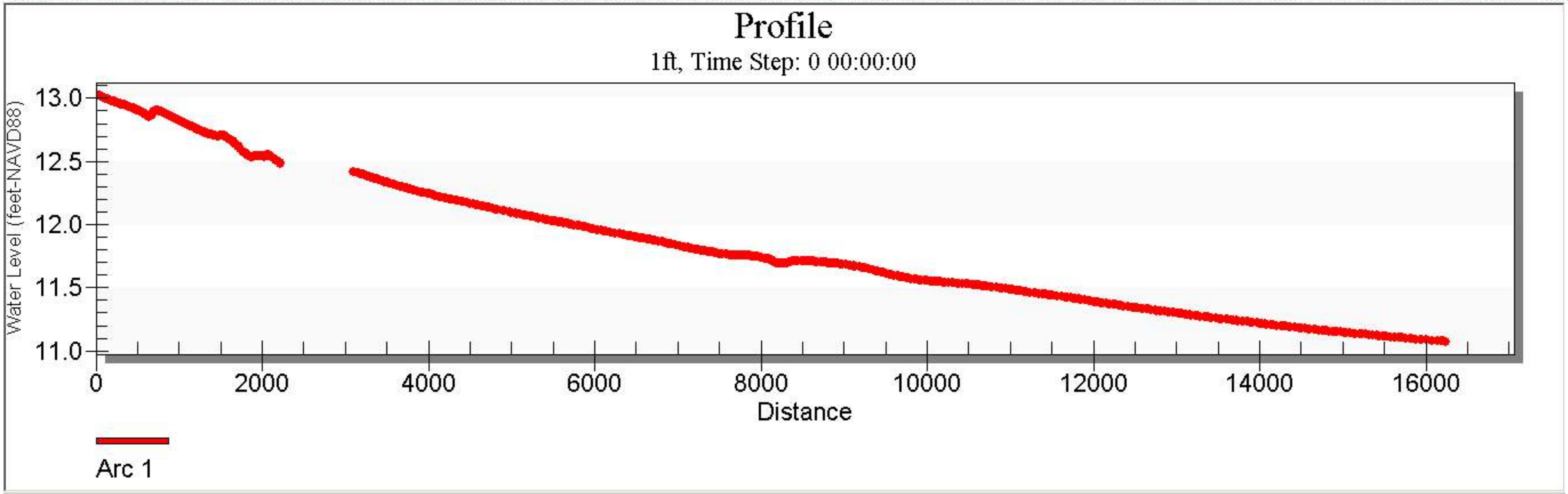
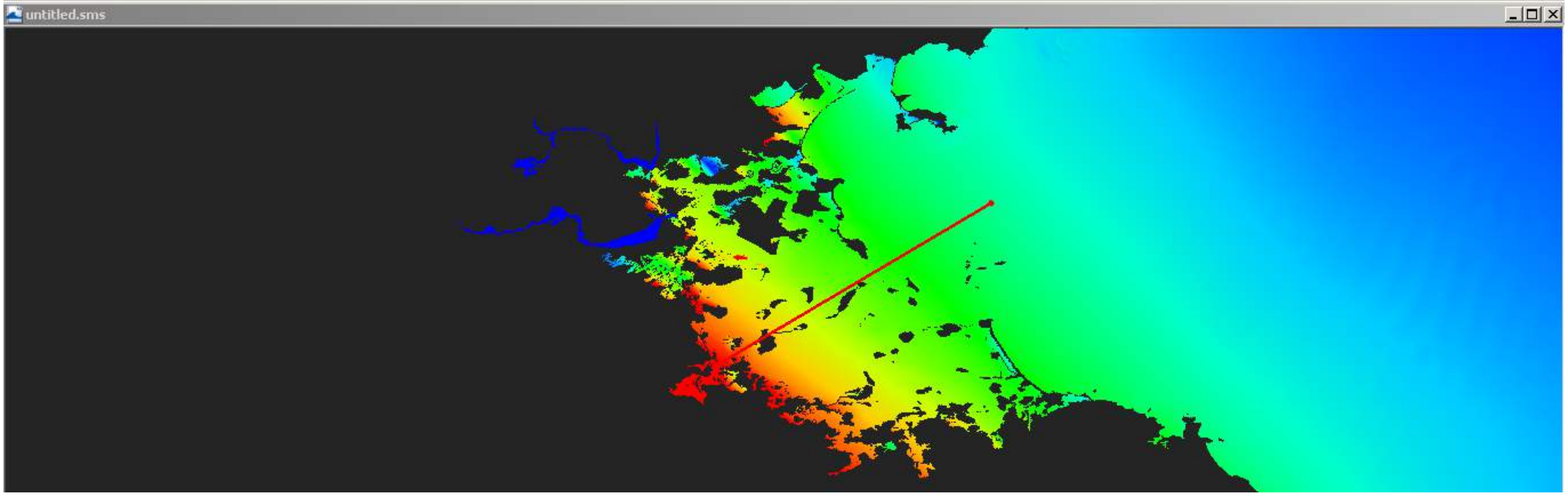
Why existing maps are not good enough



Dynamic modeling





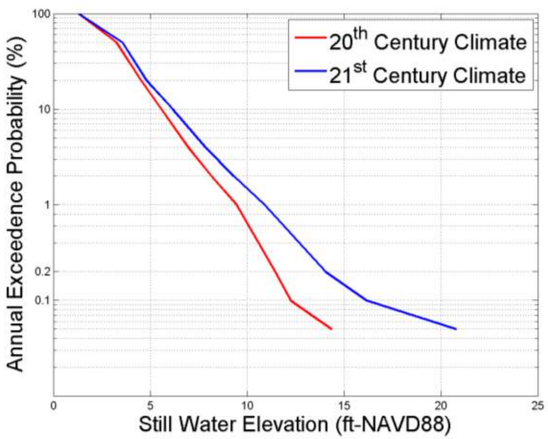
Why do we need a sophisticated approach?

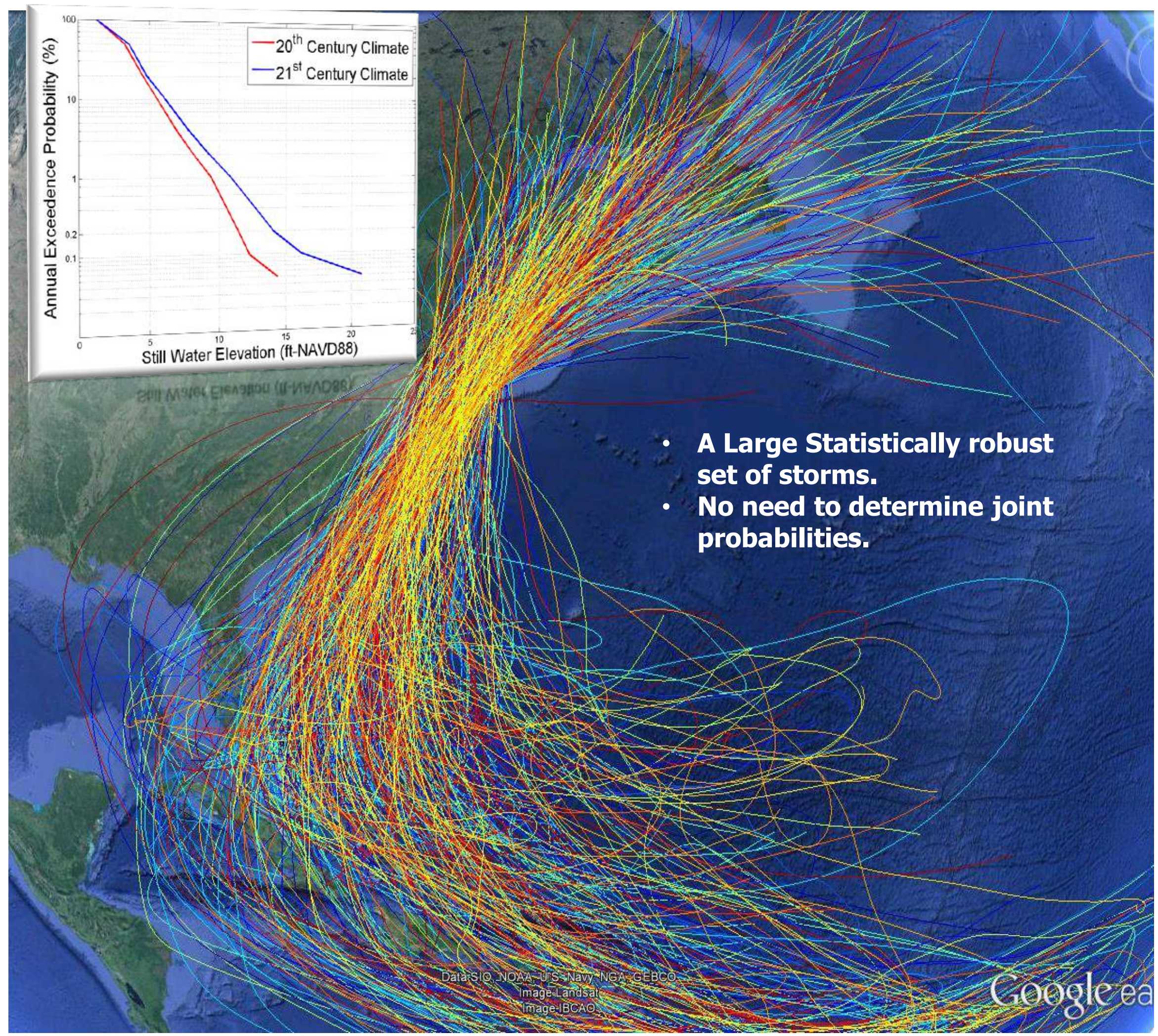
- The risk is high
- There are a lot of important factors
  - Bathymetric effects
    - Storm types and parameters
    - Coastline geometry
    - Infrastructure
    - Frictional effects
  - Coastal processes (waves, tides, etc.)

- Dynamic model answers a number of additional questions
  - Flooding pathways can be significantly influenced by dynamic processes
  - Achieve more detailed results to answer what is causing the flooding (e.g., increased river discharge, waves, winds, etc.)
  - Determine length and volume of flooding
  - Test performance of engineering adaptations

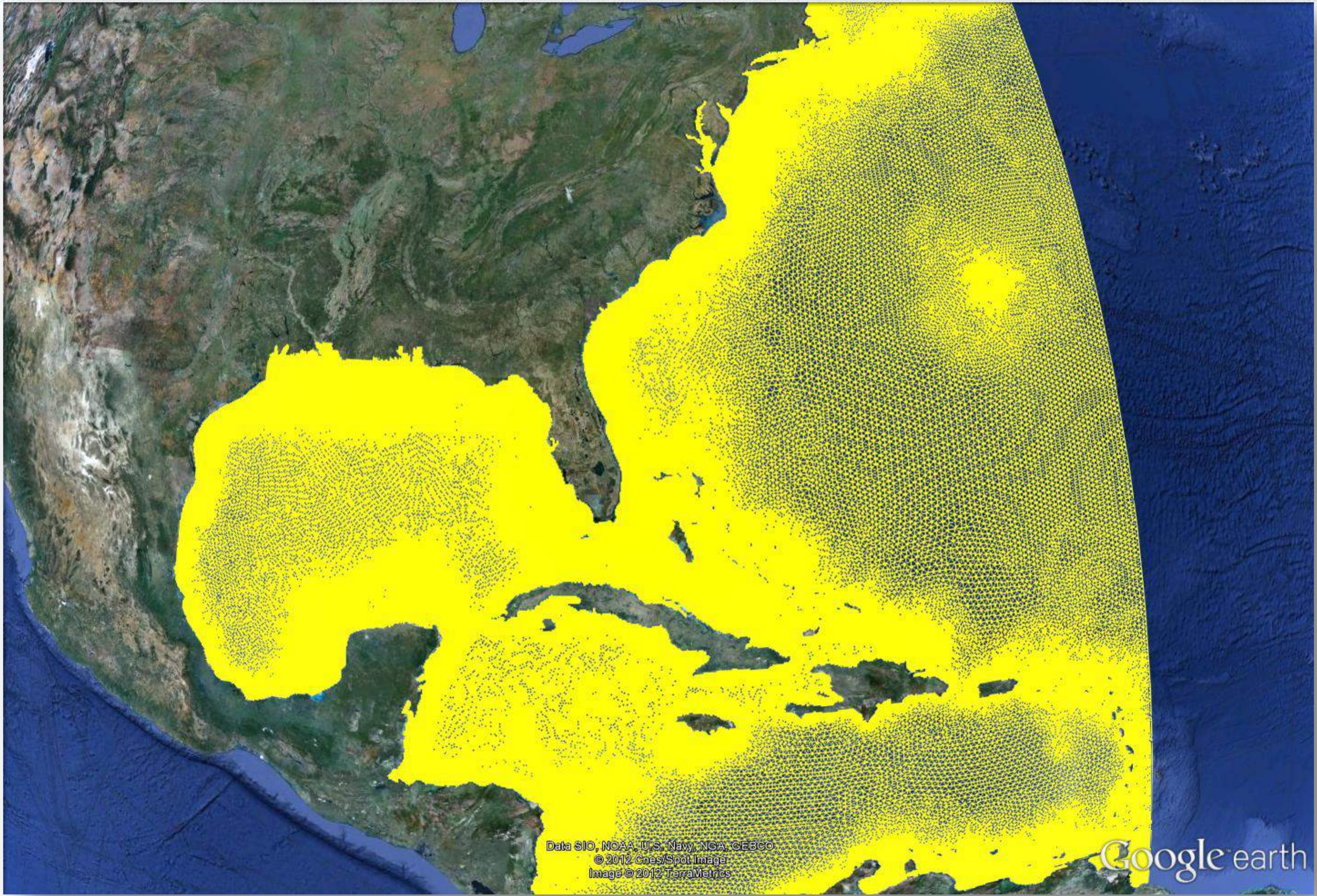
Vulnerability Assessment in BH-FRM

– Simulation Scenarios
  - Monte Carlo simulations, using a large statistically robust set of storms (Emanuel, et al., 2006) and a physics based approach
  - Present and future climate change scenarios
  - Simulates both hurricane and nor'easter conditions combined with SLR and precipitation

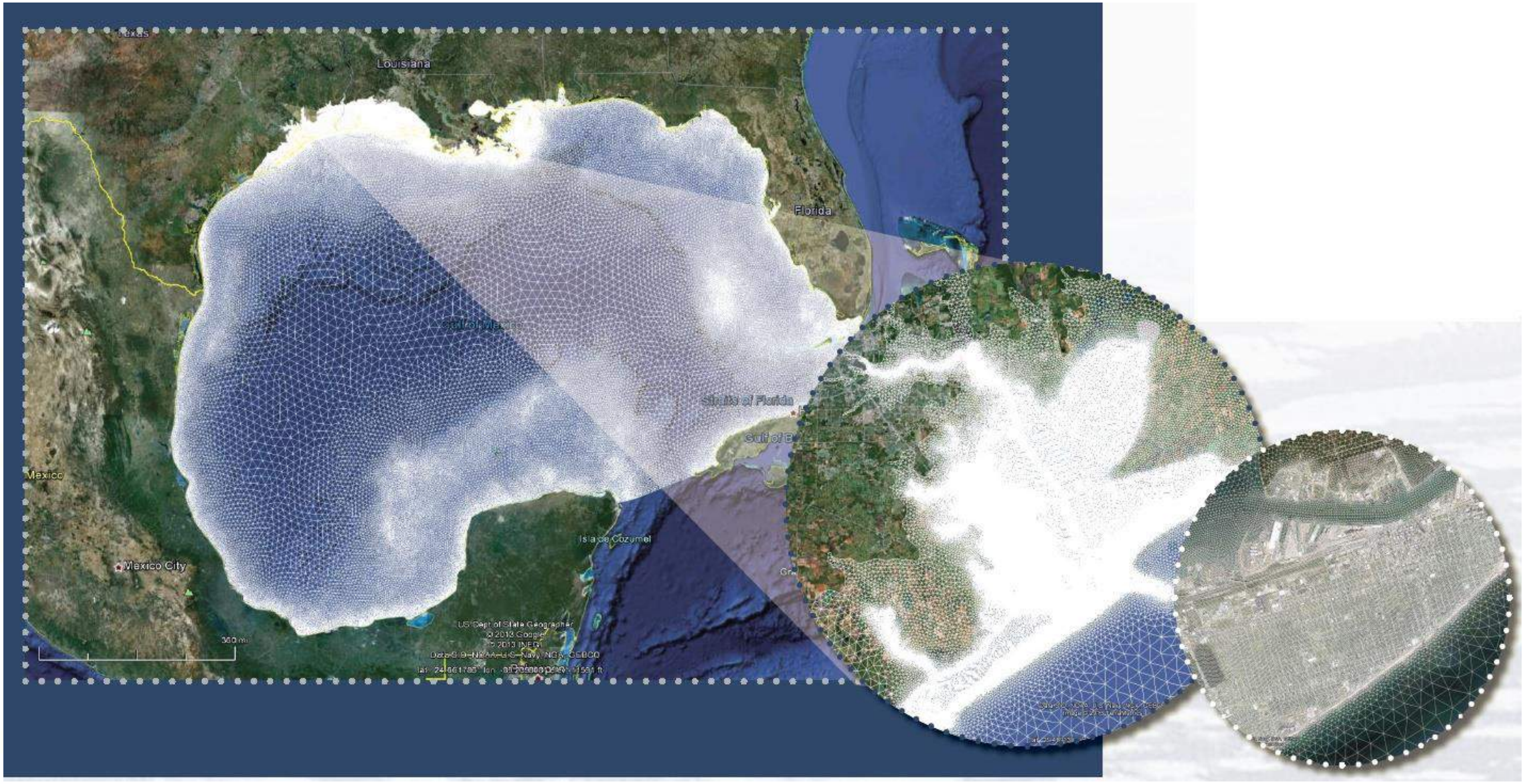




Regional Grid Requirements



Unstructured Grid



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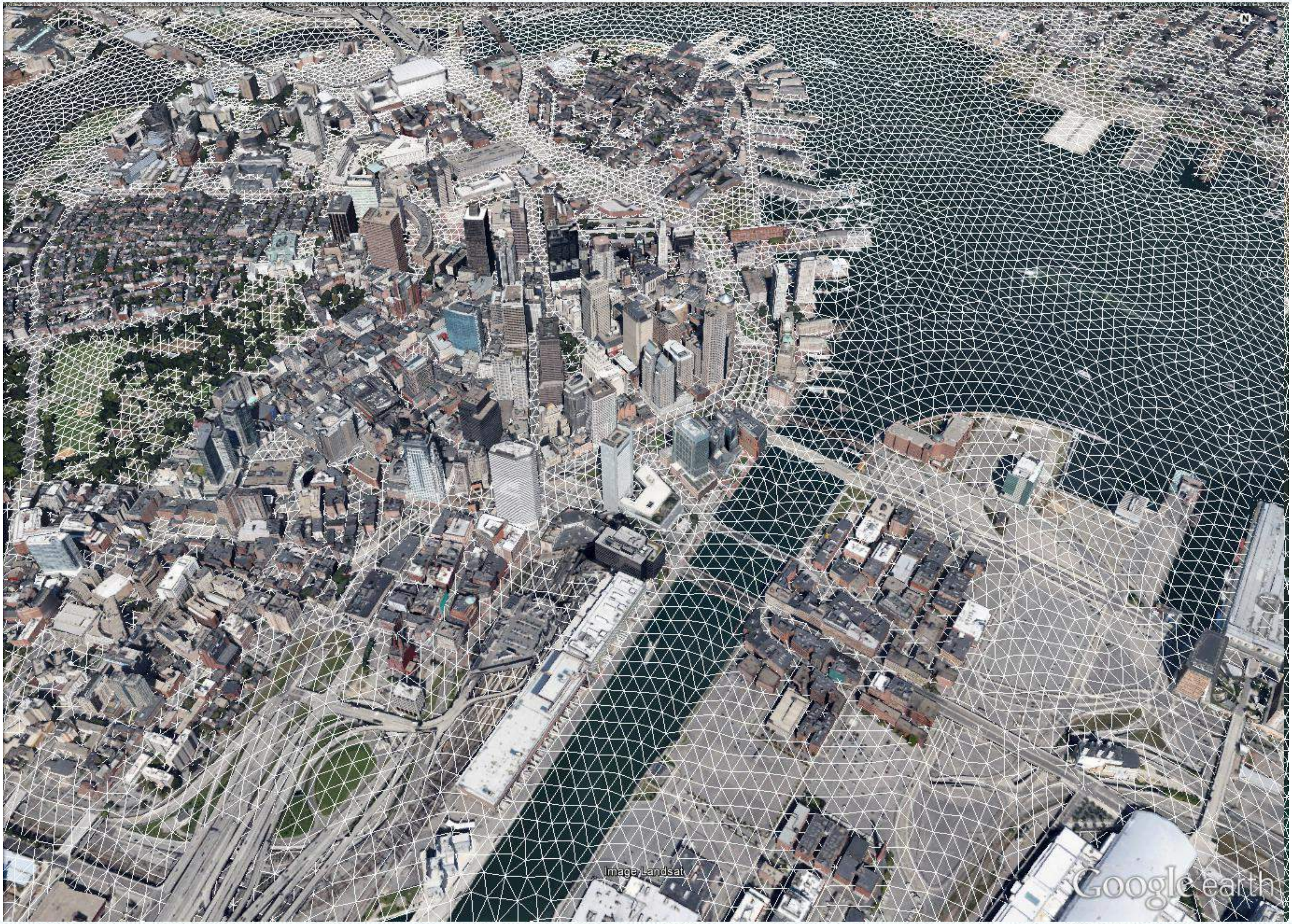
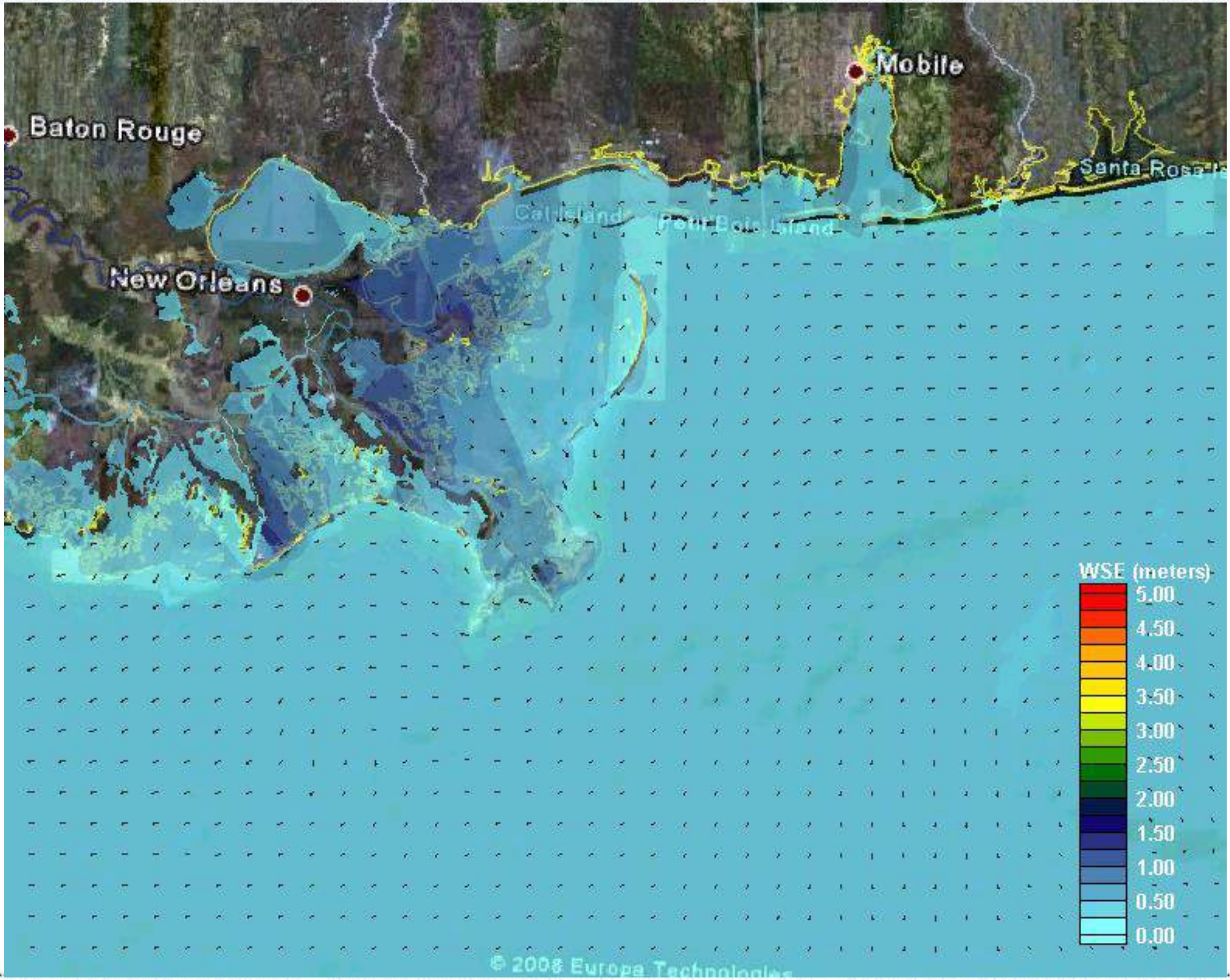
BH-FRM: Boston Grid

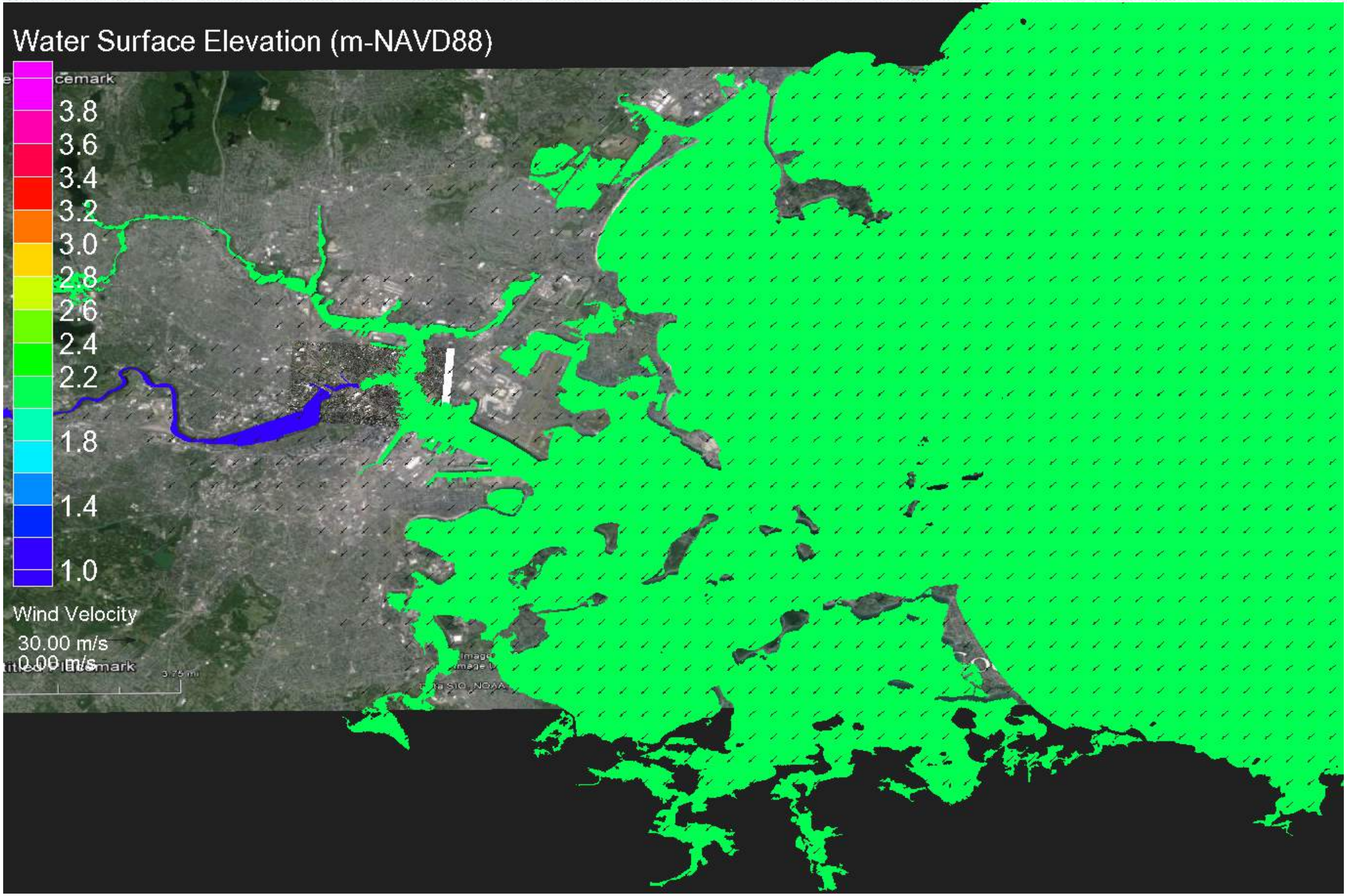


BH-FRM: Boston Grid

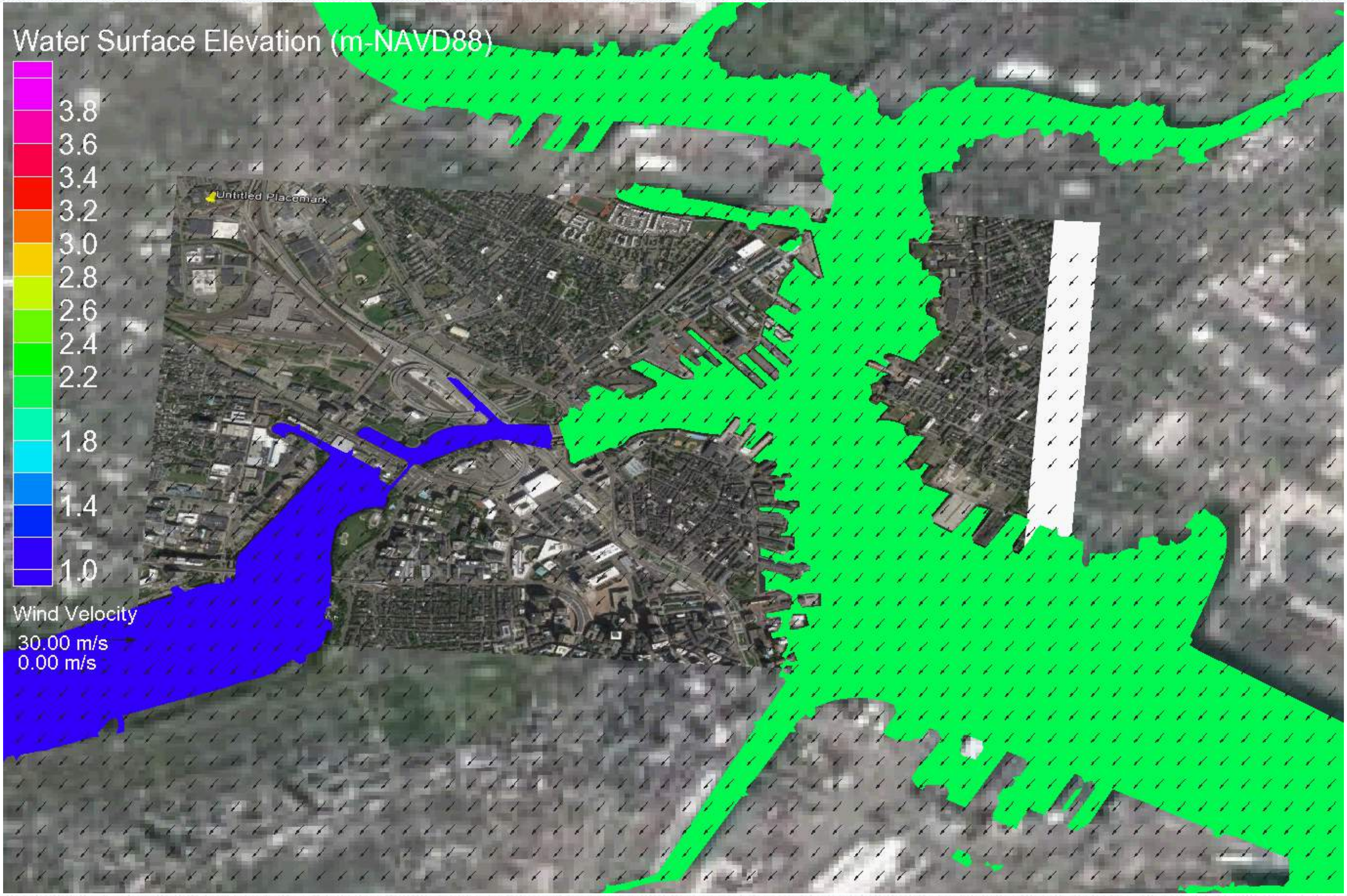
Storm Surge Simulation - Calibration



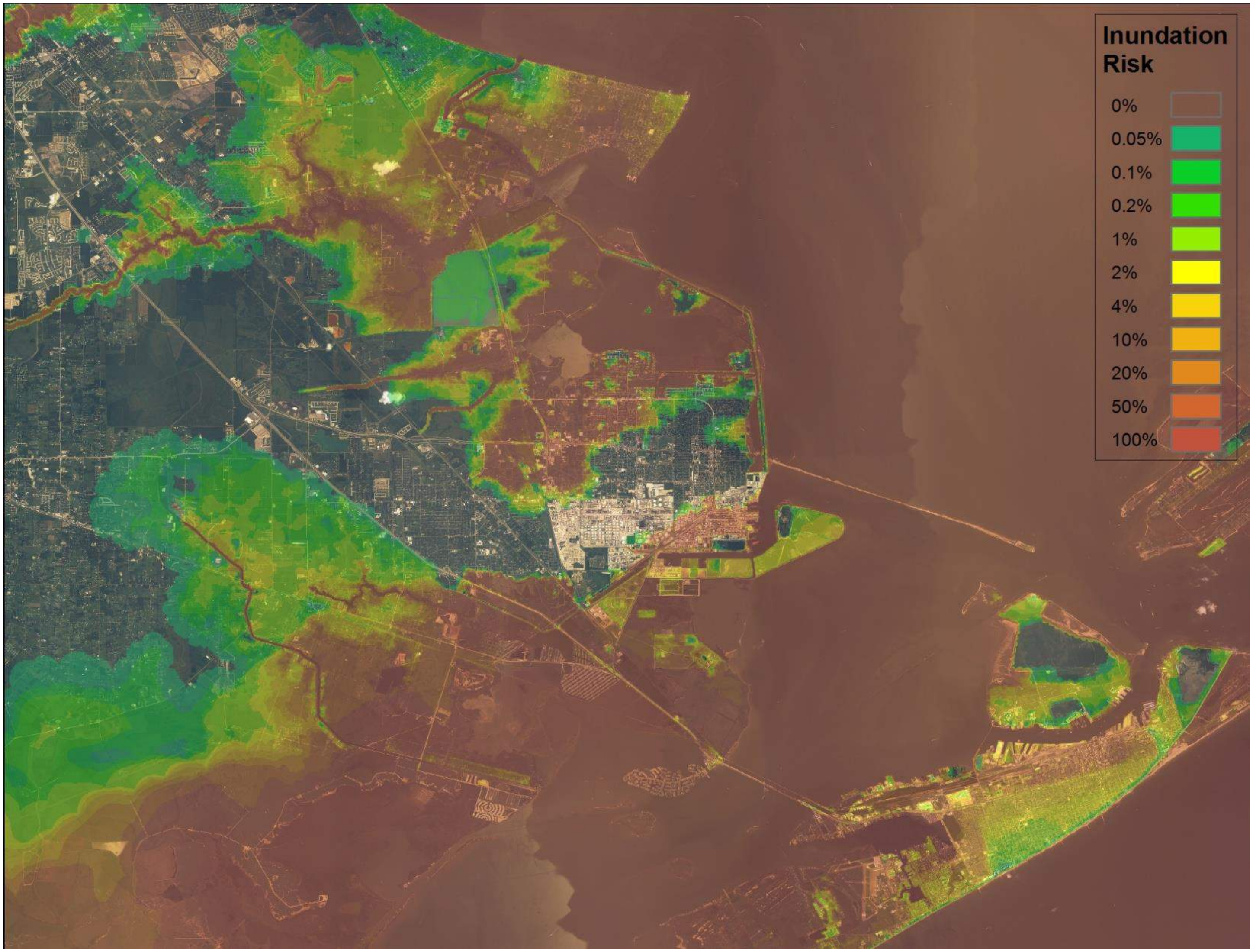
BH-FRM: Examples



BH-FRM: Examples



Flooding Risk Results



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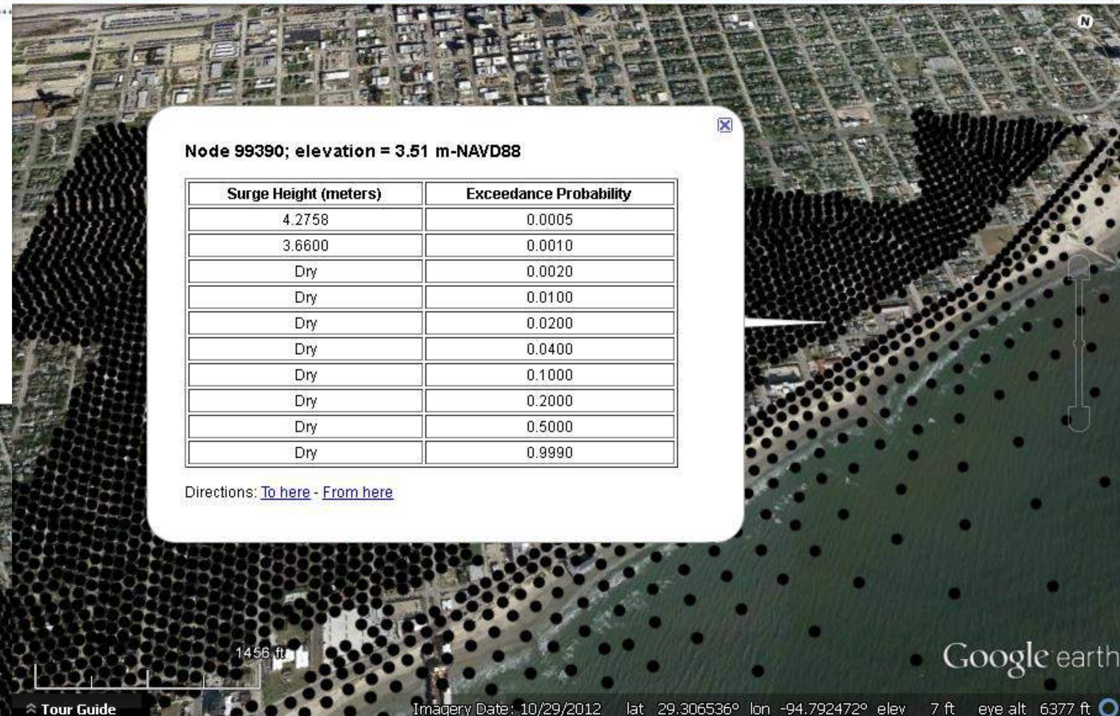
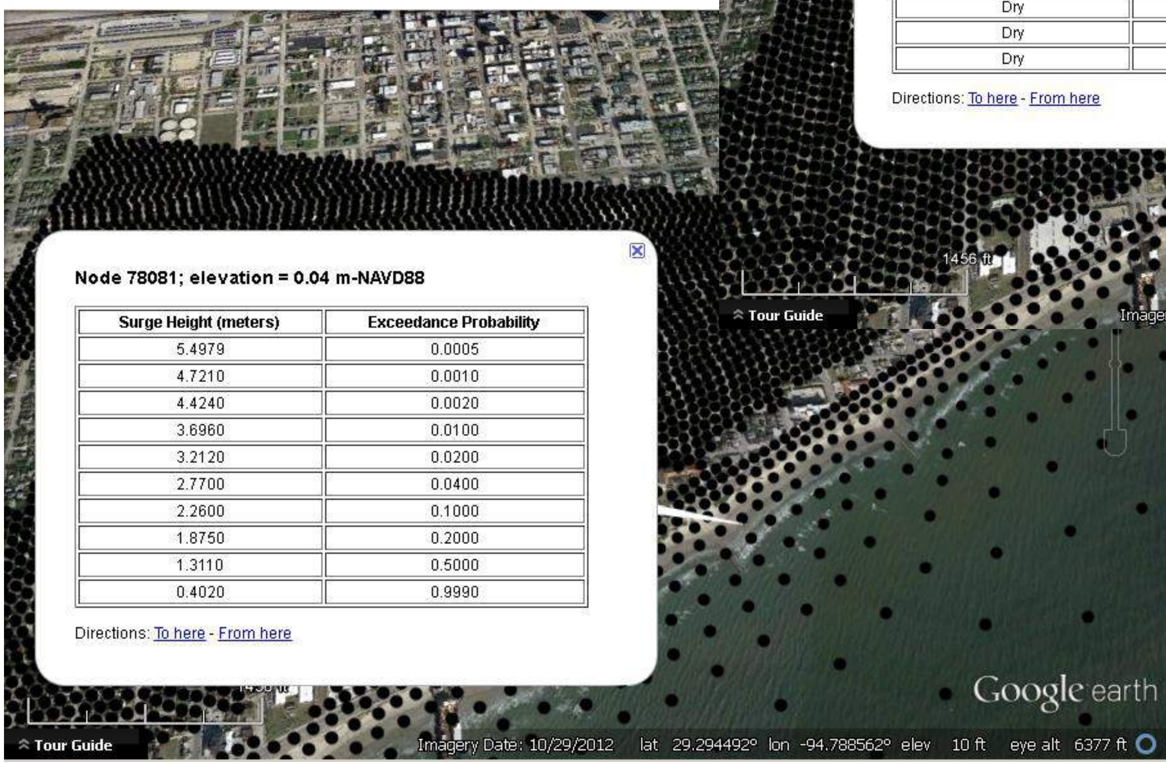
Flooding Risk Results



Node 99390; elevation = 3.51 m-NAVD88

Surge Height (meters)	Exceedance Probability
4.2758	0.0005
3.6600	0.0010
Dry	0.0020
Dry	0.0100
Dry	0.0200
Dry	0.0400
Dry	0.1000
Dry	0.2000
Dry	0.5000
Dry	0.9990

Directions: To here - From here

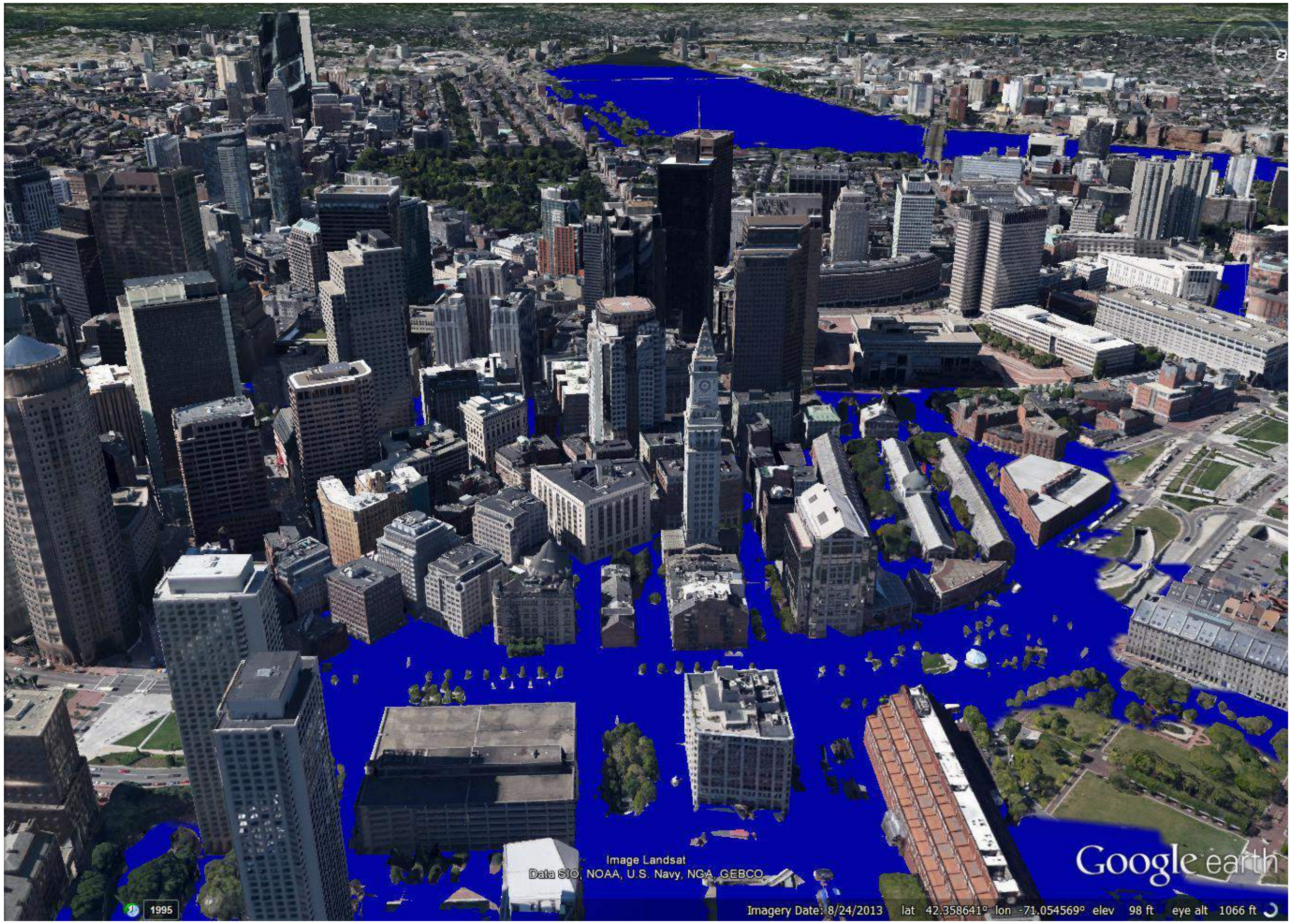


Node 78081; elevation = 0.04 m-NAVD88

Surge Height (meters)	Exceedance Probability
5.4979	0.0005
4.7210	0.0010
4.4240	0.0020
3.6960	0.0100
3.2120	0.0200
2.7700	0.0400
2.2600	0.1000
1.8750	0.2000
1.3110	0.5000
0.4020	0.9990

Directions: To here - From here

BH-FRM: Results



Climate Change Preparedness

1. Vulnerability Assessment
   - Physics based modeling includes all important factors and processes
   - Risk based approach is important
   - High-resolution results are critical to assess pathways and evaluate asset risk
   - Dynamic components may influence decision making (e.g., volume of water)

2. Develop Preparedness Plan over Time and Scale
   - Multiple scales: Regional down to individual buildings
   - Times to re-act: Actions now and into the future
   - Identify adaptation options based on risk tolerance
     1. No Action
     2. Accommodate (“Living with water”)
     3. Protect (“Keep water out”)
     4. Retreat

Range of adaptation options

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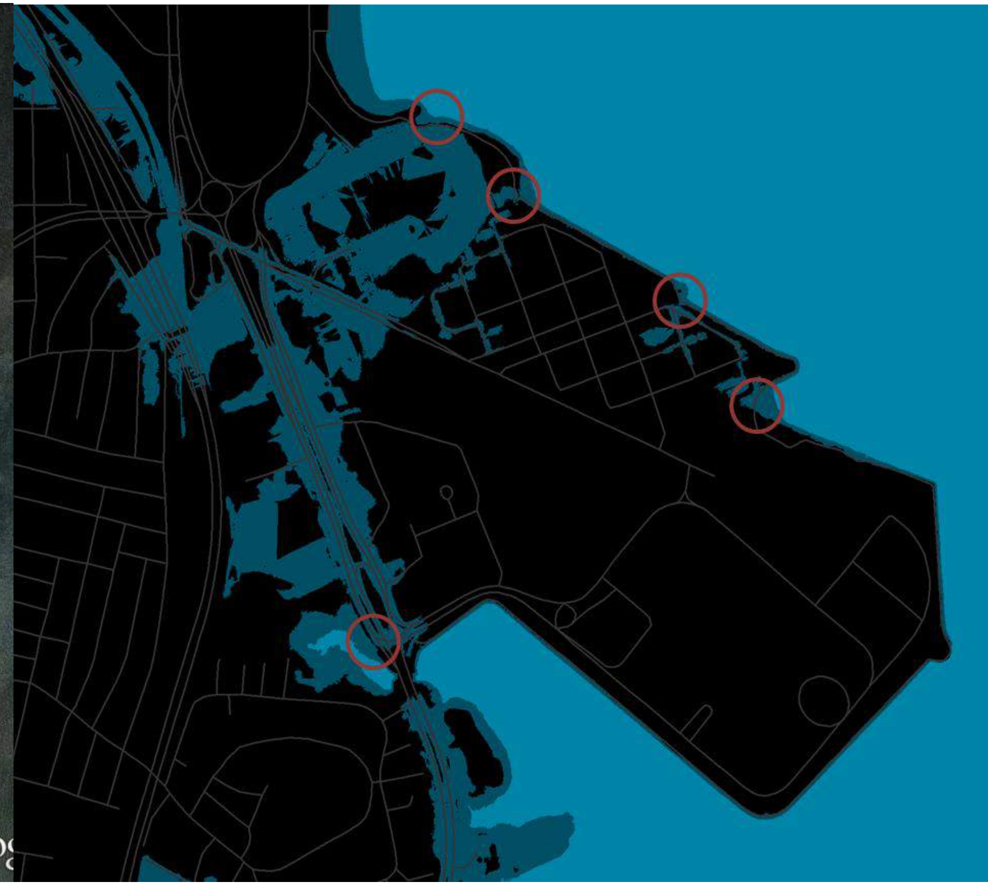
Example – UMass Boston

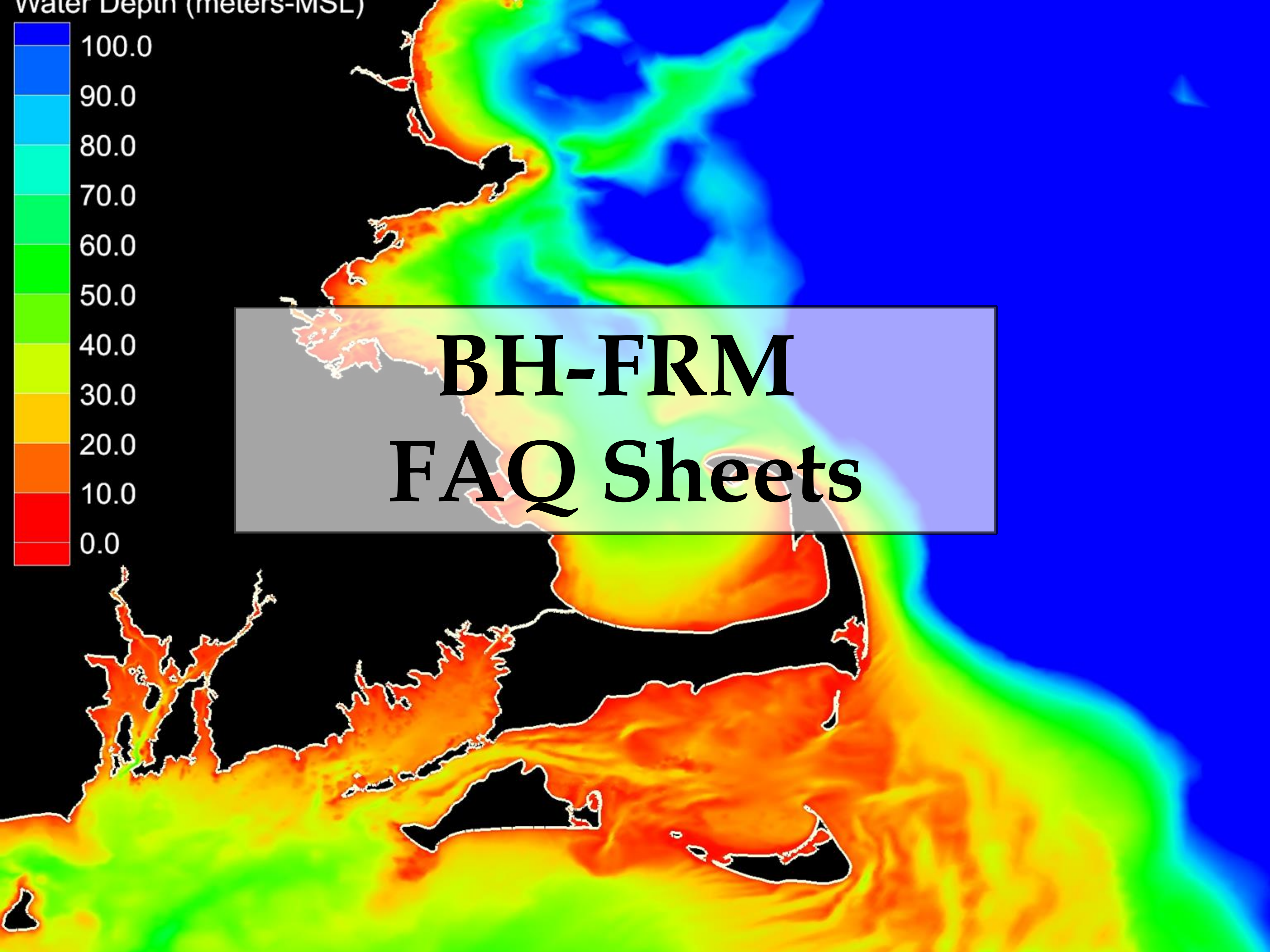
Sometimes regional problems can be solved by minor projects



Mean Higher High Water (MHHW) Timeline	Annual (1-year) Storm Surge Timeline	100-year Storm Surge Timeline	Approximate Maximum Water Surface Elevation (ft, NAVD88)	Upland Flooding Potential	Recommended Engineering Adaptations	Estimated Adaptation Cost*	Upland Flooding Potential	Recommended Engineering Adaptations	Estimated Adaptation Cost*
2010			4.0	No Flooding Expected	No Action Required	N/A	Poor Drainage of Bayside Expo Parking areas during heavy rainfall events. No Flooding of areas from Dorchester Bay waters.	Minor flood proofing of structures. Installation of a pump house and pumped based-drainage system for parking area[+]	Capital Cost: $ 2.0 Million. Annual Maintenance Costs: $ 10,000
			5.0						
2050			6.0						
	2010		7.0	Flooding of Morrissey Blvd. approximately 1/4 mile south of campus entrance. No flooding of campus entrance or campus facilities					
	2050		8.0						
2100			9.0						
		2010	10.0	Flooding of campus entrance. Initially from Patten's Cove (tidal pond to the west of entrance), and subsequently from Savin Hill Cove.	Tidal control structure installation at entrance to Patten's Cove. Soft solution (beach nourishment and vegetation enhancement) along Savin Hill Cove.	Capital Cost: $500-750,000. Annual Maintenance Costs: $10,000	Flooding of Bayside Expo areas from Dorchester Bay. Water overtops harbor walk in places.	Modular seawall installation at critical locations along Harbor walk. Seawall extension along Harbor walk as needed	Capital Cost[#]: $1.0-1.5 million (1,000 foot length). Annual Maintenance Costs: $15,000
	2100	2050	11.0						
			12.0						
			13.0	Widespread flooding of UMASS Boston Campus, Morrisey Blvd. and surrounding areas	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing	Widespread flooding of UMASS Boston Campus, Morrisey Blvd. and surrounding areas	In addition to adaptations above, additional flood proofing and elevation of critical infrastructure. Evacuate during storm event and return.	Capital Cost: $20 per square foot of building for wet flood proofing
		2100	14.0						
			15.0						
			16.0						

Conclusions

- Climate change related coastal flooding is a reality, and predicted to increase
- Detailed modeling is required to capture all the important physical processes that create spatial variability in flooding and accurately define risk and vulnerability
- This is attainable for individual communities!
- Climate change preparedness plans:
  - Involve multiple activities from building-specific through regional scales
  - Involve implementing phased plans to lower cost over time
  - Require coordinated efforts among all sectors of individual communities


Water Depth (meters-MSL)
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
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FAQ Sheets