Impact of Sea Level Rise on Future Storm-induced Coastal Inundation

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Outline

- Sources of storm-induced coastal inundation;
- Observed evidences of sea level rise (SLR) in the New England region;
- Impacts of SLR on future storm-induced coastal inundation:
  - Northeast Coastal Ocean Forecast System (NECOFS);
  - Case study 1: Hurricane;
  - Case study 2: Nor’easter storms.
Super Typhoon Soudelor, August 7, 2015
Overwash of a Seawall (Scituate, MA) During January 2015 Storm

From Tony Mignone at NOAA
Storm-induced Hazards along the New England Coast

Hurricanes/Tropic Storms

Extratropic Storms/Nor’easters

Coastal Inundation
Infrastructure damages
Human safety
Coastal Inundation

- Splashing over
- or overtopping

- Wave runup
- Storm surge
- Tidal elevation
- Total water level

MEDM Lab Marine Ecosystem Dynamics Modeling
Future Challenge: Impacts of the Sea Level Rise

IPCC temperature projection for three emission scenarios (B1, A2 and A1F1). Figure is downloaded from Vermeer and Rahmstorf (2009).
Tidal gauge stations

- Eastport
- Halifax
- Portland
- Boston
- New London
- Newport
- Montauk
- Nantucket
- Woods Hole
- New York
### Boston

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean Elevation Projection (m)</th>
<th>SLR (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1927</td>
<td>2.49</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>2.76</td>
<td>0.27</td>
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<tr>
<td>2100</td>
<td>2.97</td>
<td>0.21</td>
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### New York

<table>
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<tr>
<th>Year</th>
<th>Mean Elevation Projection (m)</th>
<th>SLR (m)</th>
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</thead>
<tbody>
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<tr>
<td>2012</td>
<td>1.88</td>
<td>0.31</td>
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<tr>
<td>2100</td>
<td>2.12</td>
<td>0.21</td>
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</table>
Arctic Ocean Sea Ice

Observation

FVCOM

Sept. 1978

Sept. 2007

Sept. 2012
Northeast Coastal Ocean Forecast System (NECOFS)

North American Meso-scale (NAM) Weather Model

Local Weather Model (WRF)

Satellite SST
Buoy Winds
Insolation

Satellite SST, SSH
Buoy or Survey
T,S,U,V

MASS Coastal FVCOM
(up to 10 m)

Regional FVCOM
(GOM-FVCOM: 0.3-15 km)

Surface Wave Model
(FVCOM-SWAVE)

Heat Flux
P-E

Wind Stress
U,V

Wind Stress

Global-FVCOM
(tides, currents, T and S)

River discharges

Groundwater

Mass Bay/Boston Harbor

Hampton River, NH

Saco, ME

Scituate, MA

Assimilation

Inundation Models

BC’s

Storm Surge (hurricanes, Nor’easter)

BC’s

Products:
Weather: winds, air temperature, air humidity, air pressure, heat flux, E-P
Oceans: sea level, currents, T, S, wave heights, wave frequencies, icing
Lands: inundation areas

KEY

Existing Models

Data

Products
Global-FVCOM
(2-50 km)

GOM-FVCOM (0.3-15 km)

Mass-Coastal FVCOM
(10 m-5 km)

Scituate, MA (up to 10 m)  Boston Harbor, MA (up to 10 m)  Hampton, NH (up to 10 m)  Saco Bay (up to 10 m)
The August 19 1991 Hurricane Bob
Differences (meters) with 0.5 m SLR

**Significant Wave Height**

**Surface Elevation**
Inundation in the northern region of Boston

Flooded by 0.5-m sea level rise

Hurricane-induced flooding
Flooded by 0.5-m sea level rise

Hurricane-induced flooding

Southern Region of Boston
Scituate, MA

The Test Site: 44013 Tide gauge station
Days (Dec., 2010)

**Barometric pressure**

**Significant wave height**

**Wind vectors at Scituate Harbor (SH)**
Maps of surface wave height (m) and direction (arrows) at Dec. 27 08 GMT
Wave Runup Produced Splashing Discharge

- 0.61 m³/s, ~36%
- 0.53 m³/s, ~18%
- 0.45 m³/s

Dec. 27, 2010
Summary

As a result of the mean sea level rise, for a given same storm as before, the surface wave height could be significant increased, and thus the sea level. We will face a greater threat from the wave runup inundation during hurricanes and nor’easter storms.