

## Appendix: NECIA Coastal Impacts analysis

### Additional technical background

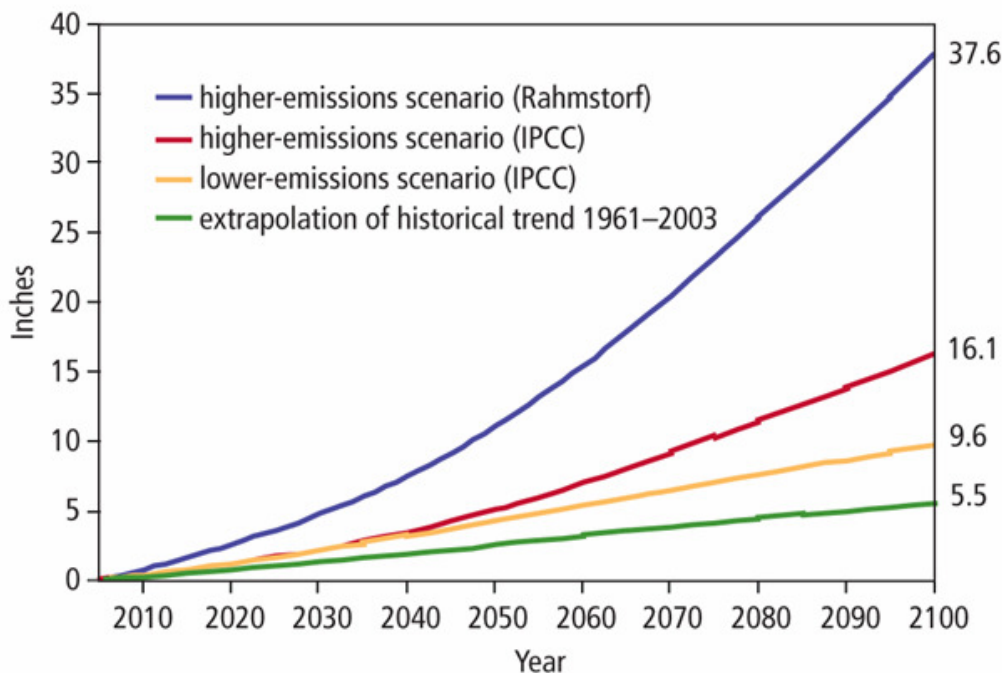
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The NECIA coastal flooding findings, presented in *Confronting Climate Change in the U.S. Northeast, Science Impacts and Solutions* (NECIA, 2007) is based on the analysis of the NECIA coastal flooding team (Kirshen et al. 2008, in press; available at [www.northeastclimateimpacts.org](http://www.northeastclimateimpacts.org)). This analysis was updated in early 2007 using the newly-released IPCC sea-level rise projections.

Members of the NECIA coastal impacts team projected both the change in recurrence intervals of today's 100-year coastal flooding event in five locations (Atlantic City, Boston, New London, CT, New York and Woods Hole, MA), as well as the floodwater heights associated with future 100-year flood events, by mid- and late-century, using the following series of sea-level rise projections:

- (1) a linear extension of historical global SLR rates of 0.18 mm/yr (1961 to 2003) (IPCC 2007),
- (2) the mid-range of the IPCC AR4 projections under the lower-emissions scenario (IPCC 2007),
- (3) the mid-range of the IPCC AR4 projections under the higher-emissions scenario (IPCC 2007),
- (4) the mid-range of a new set of projections (Rahmstorf 2007) under the higher-emissions scenario.



**Projected flood elevations:**

All projected coastal flood elevations are relative to the North American Vertical Datum of 1988 (NAVD). In Boston, for example, NAVD is approximately four inches (~0.3 feet) above mean sea level. Projected coastal flood elevations also assume that the storm surge occurs during an average higher high tide (i.e., the long-term average of the highest daily tides). This does not include the height of any additional wave action associated with a coastal storm, which could be significant along the coast.

Estimated flood elevations for 2005, 2050 and 2100 for each site are shown in Table 1.

**Table 1: Changing storm surge (coastal flood) elevations**

Station	Scenario	100-yr Storm Surge Elevation at MHHW (feet NAVD)		
		2005	2050	2100
Boston	Extrapolating 1961-2003 obs trend	9.7	10.5	11.5
	B1 (mid-range)	9.7	10.7	11.8
	A1FI (mid-range)	9.7	10.7	12.3
	Rahmstorf (mid-range)	9.7	11.2	14.1
Woods Hole	Extrapolating 1961-2003 obs trend	10.0	10.3	10.7
	B1 (mid-range)	10.0	10.5	11.1
	A1FI (mid-range)	10.0	10.5	11.6
	Rahmstorf (mid-range)	10.0	11.0	13.4
New London	Extrapolating 1961-2003 obs trend	7.4	7.6	8.0
	B1 (mid-range)	7.4	7.8	8.3
	A1FI (mid-range)	7.4	7.8	8.9
	Rahmstorf (mid-range)	7.4	8.3	10.6
New York City	Extrapolating 1961-2003 obs trend	9.0	9.4	9.8
	B1 (mid-range)	9.0	9.5	10.2
	A1FI (mid-range)	9.0	9.6	10.7
	Rahmstorf (mid-range)	9.0	10.1	12.5
Atlantic City	Extrapolating 1961-2003 obs trend	7.7	9.4	11.2
	B1 (mid-range)	7.7	9.5	11.6
	A1FI (mid-range)	7.7	9.6	12.1
	Rahmstorf (mid-range)	7.7	10.1	13.9

**Projected flood frequencies:**

Table 2 shows the recurrence intervals in 2050 and 2100 for the 2005 100-year storm surge elevation.

**Table 2: Changing Flood Frequency**

Station	Scenario	Recurrence Interval of 2005 100-yr Anomaly (years)	
		2050	2100
Boston	Extrapolating 1961-2003 obs trend	3	<<2
	B1 (mid-range)	3	<<2
	A1FI (mid-range)	2	<<2
	Rahmstorf (mid-range)	<2	<<2
Woods Hole	Extrapolating 1961-2003 obs trend	61	34
	B1 (mid-range)	51	21
	A1FI (mid-range)	46	9
	Rahmstorf (mid-range)	22	<<2
New London	Extrapolating 1961-2003 obs trend	72	49
	B1 (mid-range)	61	32
	A1FI (mid-range)	56	17
	Rahmstorf (mid-range)	31	2
New York City	Extrapolating 1961-2003 obs trend	60	34
	B1 (mid-range)	50	22
	A1FI (mid-range)	46	11
	Rahmstorf (mid-range)	24	<2
Atlantic City	Extrapolating 1961-2003 obs trend	5	<<2
	B1 (mid-range)	4	<<2
	A1FI (mid-range)	4	<<2
	Rahmstorf (mid-range)	<2	<<2

The increased flooding frequencies in Boston and Atlantic City relative to the other three (New York City, New London, and Woods Hole) are likely due to differences in the physical location of the tide gauges at each site as well as the hydraulic influences measured during a coastal flooding event. In Boston and Atlantic City, the tide gauges are located such that only oceanic storm responses are measured during coastal flooding events. Sea-level rise, therefore, is the major factor influencing the projected increases in coastal flooding frequencies.

At the other three sites (New York City, New London, and Woods Hole) oceanic storm surges are not the only measured component of coastal flooding. Rain associated with coastal storms generates a large volume of fresh water flowing in the Hudson River in New York, and the Thames River in New London. Because of their location at the mouths of these major rivers, the tide gauges measure the combination of storm surge and increased river flow during coastal flooding events. In Woods Hole, the strong and complex tides and currents, from which the “Hole” gets its name, likely have a strong influence on the water levels measured during coastal flooding events. Thus, in these three cases, oceanic storm surges are not the only factor in coastal flooding; increases in sea level have a relatively smaller direct influence on the associated increases in coastal flooding frequencies than in the other locations. In addition, during the NECIA analysis, statistically significant trends in the coastal flood event time series were identified at both Boston and Atlantic City. The presence of these trends required additional analysis and affected the shape of the frequency curves relative to the other three sites.

### **Mapping methods:**

**Boston:** The Boston inundation maps were created using data available from Commonwealth of Massachusetts Executive Office of Environmental Affairs' Office of Geographic and Environmental Information (MassGIS). The blue shading indicates areas that are likely to be inundated in the year 2100 by a 100-year coastal flood under the A1 fi mid scenario. The blue shading is shown over aerial photographs for reference. The areas of dark blue hatching also shown on these maps represent areas currently designated by the Federal Emergency Management Agency (FEMA) as 100-year flood zones.

The inundation areas (blue shading) are based on a digital elevation model (DEM) derived from LIDAR<sup>1</sup> data obtained by MassGIS in 2002. These inundation areas were created by shading the specific areas (pixels) within the DEM that were located at or below the target elevation for the specific coastal flood. In addition, shading was removed from areas where buildings are located. As indicated in Table 1, the NECIA study determined that the estimated elevation of this future flooding event in Boston is 12.3 feet.

**Atlantic City/NYC/New London:** The AC/NYC/NL inundation maps were created using data available from Federal Emergency Management Agency (FEMA). The blue shading indicates both tidal waters as well as land areas that are currently designated by the Federal Emergency Management Agency (FEMA) as 100-year flood zones. The blue shading is shown over aerial photographs for reference. These maps were provided courtesy of Applied Science Associates, Inc.

The FEMA flood maps represent the approximate area that would be flooded with increasing frequency based on the NECIA (Kirshen et al., 2008 in press) analysis. It should be noted, however, that the elevations of the NECIA 100-year flood in 2005 are slightly higher than the FEMA flood elevations. Thus, the FEMA maps may be a conservative representation of the area that is projected to be flooded at increased frequency. Limitations in coastal elevation data prevented mapping of the 2005 100-year flood zone at these three locations.

### **References:**

Kirshen, P., C. Watson, E. Douglas, A. Gontz, J. Lee, and Y. Tian. 2008. Coastal flooding in the northeastern United States due to climate change. *Mitigation and Adaptation Strategies for Global Change*. In press.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: The Scientific Basis*, Summary for Policy Makers. Cambridge, UK: Cambridge University Press. In press. Online at <http://www.ipcc.ch/SPM2feb07.pdf>.

Rahmstorf, S. 2007. A semi-empirical approach to projecting future sea-level rise. *Science* 315(5810):368-370.

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<sup>1</sup> LIDAR (an acronym for LIght Detection And Ranging) uses the same principle as RADAR. The LIDAR instrument transmits light out to a target and some of this light is reflected/scattered back to the instrument where it is analyzed. (<http://www.mass.gov/mgis/lidarbuildingfp2d.htm>, January 2005; accessed June 2007)