DEVELOPMENT OF A TSUNAMI FORECAST MODEL FOR MONTAUK, NEW YORK

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Development of a Tsunami Forecast Model for Montauk, New York

W.E. Schmidt

Abstract

This report describes the development of a Standby Inundation Model (SIM) for Montauk, New York, as a component of the NOAA SIFT system. The optimized MOST model can obtain accurate amplitude of first waves and reasonable inundation limit within 10 minutes for the study area upon receiving the information of the earthquake source determined from real-time data assimilation and inversion. The model is validated using numerical results from a high-resolution MOST reference model since there are no historical tsunami records for the island. The developed SIM is tested against the scenario of a large virtual tsunami numerically generated from the Puerto Rico Trench subduction zone.

1.0 Background and Objectives

The NOAA Center for Tsunami Research (NCTR) at NOAA Pacific Marine Environmental Laboratory (PMEL) is developing a tsunami forecasting tool known as Short-term Inundation Forecasting for Tsunamis (SIFT) for NOAA Tsunami Warning Centers The primary goal of the system is to provide NOAA Tsunami Warning Centers with operational tools that combine real-time deep-ocean Bottom Pressure Recorder (BPR) recordings from the DART tsunameter network and seismic data with a suite of numerical codes, Method of Splitting Tsunami (MOST) (Titov and Synolakis, 1998; Titov and González, 1997), to produce efficient forecasts of tsunami arrival time, heights and inundation. To achieve accurate and detailed information on the likely impact of incoming tsunami on specific coastal communities within certain time limits and to reduce false alarms, Tsunami Forecast models are being developed and integrated as crucial components of SIFT for a limited number of 75 US coastal cities and territories that are potentially at most risk.

The primary objective of the present study is to develop and test a SIM for real-time forecast of tsunami waves and inundation at the city of Montauk on the island of Long Island, New York. Figure 1 shows the North Atlantic Ocean and the island of Long Island, New York. Also shown is the approximate location of the city of Montauk, the location of the SIM.

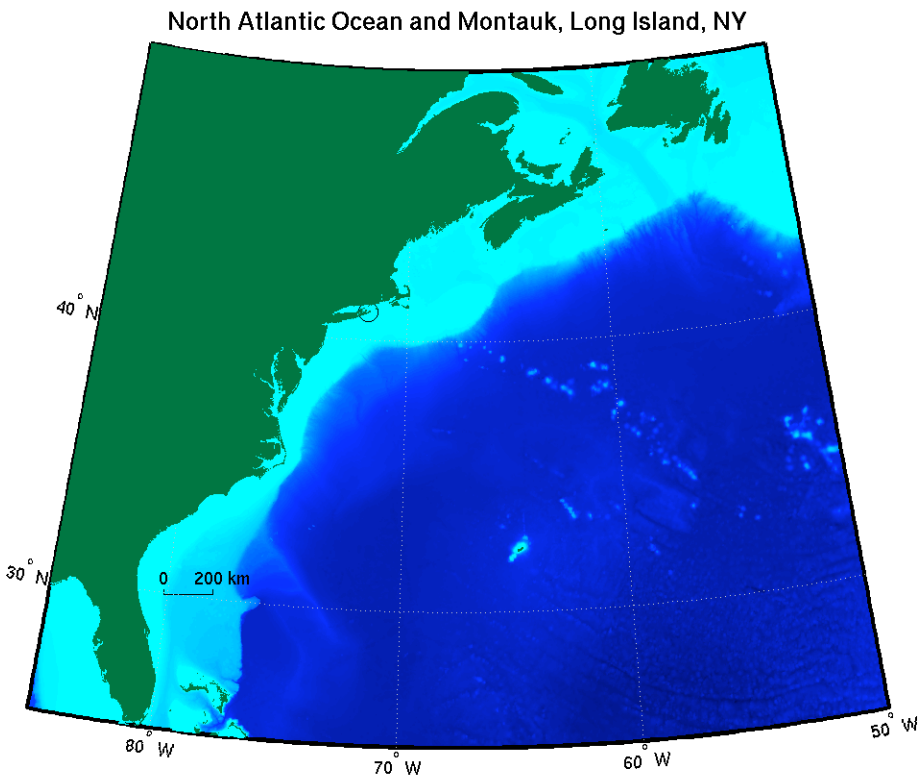


Figure 1 North Atlantic Ocean, Long Island, and Montauk, New York (black circle).

2.0 Forecast Methodology

2.1 Tsunami Model

MOST (Titov and Synolakis, 1998; Titov and González, 1997) is a 2D finite-differences numerical model based on the nonlinear long-wave approximation. It uses a splitting scheme to separate the original two-dimensional problem into two sequential one-dimensional problems.

The MOST model accommodates a base level grid (0), for wave transoceanic propagation and three levels of telescoping grids (A, B, and C) with increasing spatial and temporal resolution for simulation of wave inundation onto dry land. The linear solution is evaluated at the base level while the nonlinear are calculated at the next three. Grid 0 is not dynamically couple with the other three, which is more efficient since it can provide multiple sets of boundary conditions for subsequent detailed calculations at different locations.

The numerical solution is obtained by an explicit finite-differences scheme with a second-order approximation in space and first order in time. The MOST model uses a Neumann-type technique to determine the waterline position through the computed flow velocity.

2.2.1 Data Assimilation and Inversion

Besides seismic and coastal tide gauges, real-time deep ocean bottom pressure data from the National Tsunami Hazard Mitigation Program (NTHMP) tsunameter network, Deep-ocean Assessment and Reporting of Tsunamis (DART), is used as a primary data source since it can provide rapid tsunami observation without harbor and instrument responses. The linearity of wave dynamics of tsunami propagation in the deep ocean allows for applications of inversion schemes to construct a tsunami scenario based on the best fit to given tsunameter data. Details of the inversion method can be found in Titov *et al*. (2003) and Wei *et al*. (2003).

PMEL has developed a linear propagation model database for unit sources in the Atlantic and Caribbean Sea, with each unit source a typical Mw = 7.5 subduction zone earthquake. Based on a sensitivity study of far-field tsunami characteristics (Titov *et al*., 1999), the parameters of the unit sources are: length = 100 km, width = 50 km, dip = 15°, rake = 90°, depth = 5 km, slip = 1 m. The strike of each source is aligned with the local orientation of the subduction zone. Details of the fault parameters for each subduction zone will be published in an upcoming NOAA Technical Memorandum. The model simulation results for each unit solution, including amplitudes and velocities, are stored in a database. The database also provides the offshore forecast of tsunami amplitudes and all other wave parameters around the Caribbean Sea and North Atlantic Ocean immediately once the data assimilation is complete. The inversion algorithm, which combines real-time tsunami-meter data of offshore amplitude with the propagation database, provides an accurate offshore tsunami scenario without additional time-consuming model runs.

The locations of the unit sources for the Caribbean region are shown in Fig. 2. Table 1 presents the combination of unit sources from the forecast model database used for the optimization process in this report. At each subduction zone, two lines of sources (A – top; B – bottom) are placed next to each other. The unit sources corresponding to segments A and B were used (Mw = 9.0, Puerto Rico Trench). This corresponds to an extreme earthquake with maximum estimated magnitude possible for this seismic zone.

Source Location	Unit Sources	Slip for each unit source (m)	Mw
Puerto Rico Trench	48 through 55 Rows A and B	11	9.0

Table 1 Caribbean source used in testing the Montauk SIM and RIM.

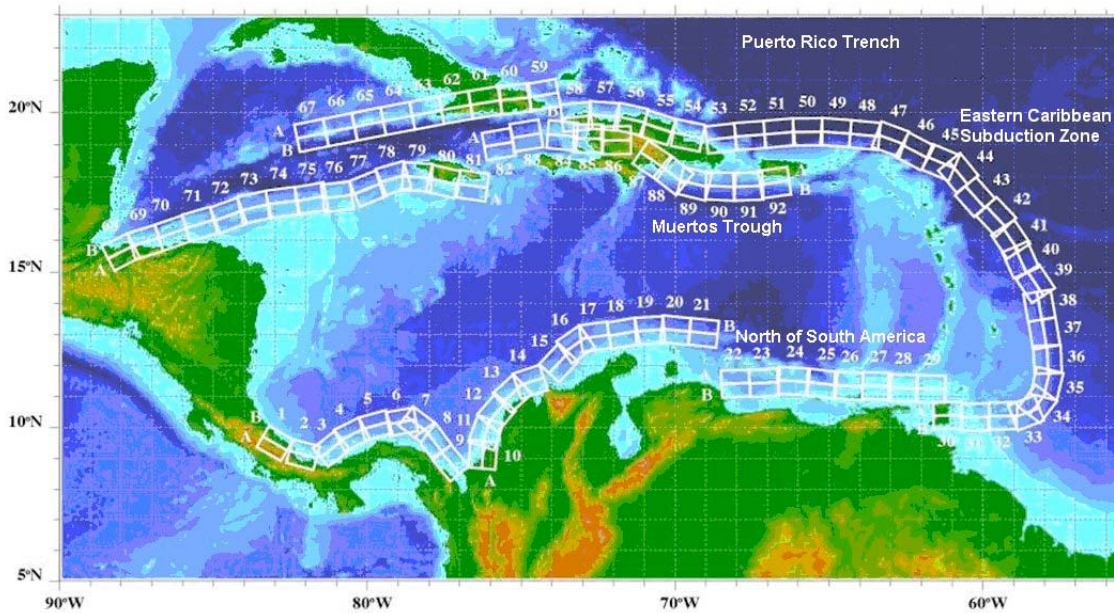


Figure 2 Location of unit sources in the Caribbean Sea region. Sources 48-55, A and B (Puerto Rico Trench) were used in this study.

2.2.2 Standby Inundation Model (SIM) Forecasting

A SIM applies the non-linear components of the MOST model using three nested grids (A, B, and C), with increasing resolution to telescope into the inundation forecasting area. The inundation area (grid C) generally includes the highest concentration of population in the coastal communities, and the National Weather Service so-called Warning Points (WP).

To provide site-specific forecasting for rapid, critical decision-making in emergency management, SIMs are implemented and optimized for both speed and accuracy. First, a SIM utilizes the pre-computed time series of offshore wave height and depth-averaged velocity from the database as the boundary and initial conditions once the offshore scenario is defined. Second, by reducing the calculation areas and grid resolutions, the optimized setup can provide forecasting results within 10 minutes (for a minimum of 4 hours of simulation time), which allows larger time steps without violations of the CFL conditions. Finally, to insure forecasting accuracy, results from the optimized runs are validated with historical tsunami tide gauge records (if available) as well as a reference model run made with higher resolutions and larger calculation domains.

3.0 SIM Set up for Montauk, Long Island, New York

3.1 Study Area

A tsunami forecast model is being prepared for Montauk, Long Island, New York. The Montauk area is exposed to events propagating from primarily the south and east. While there is no historical evidence of any significant tsunami impacting the Montauk area, the growth of population in the coastal areas potentially exposed to tsunamis has been very large. Montauk beaches are filled with tourists almost year-round.

The bathymetry offshore of Montauk is relatively complicated. To the south, shallow waters are found close to shore, but in Long Island Sound there exist a number of small islands, with very irregular bathymetry due to the presence and shoals. This complicates the task of obtaining an optimized grid for Montauk.

3.2 Bathymetry and Topography: NGDC Grids

For this study the National Geophysical Data Center (NGDC) provided high-resolution gridded data based on recent shallow water LIDAR topographic and bathymetric surveys and multi-beam surveys for deeper waters. A 9 arc second grid was supplied that covered the North Atlantic Ocean, as shown in Figure 3. Note that no topography was included in this data set, rather sub-aerial values were replaced by -9999 m. For this study, the -9999 m "sub-aerial" values were replaced by 15 m. NGDC also created a 1/3 arc second merged bathy/topo DEM for the Montauk area that was used to build the Reference and Optimized B and C grids. Table 2 lists the parameters for both grids.

Table 2 Grid parameters for the NGDC source grids for Montauk.

	9 second	**1/3 arc second**
Lat	25-50	40.6-41.4
Long	50.0025-85.000	71.5000-72.6000
ncols	14000	11881
nrows	10000	8641
Cellsize (arc sec)	1	1/3
X Grid spacing (degree)	0.0025	9.26098×10^{-5}
Y Grid spacing (degree)	0.0025	9.26053×10^{-5}
Zmin (m)	-7619.68	-118.5
Zmax (m)	15	162.58

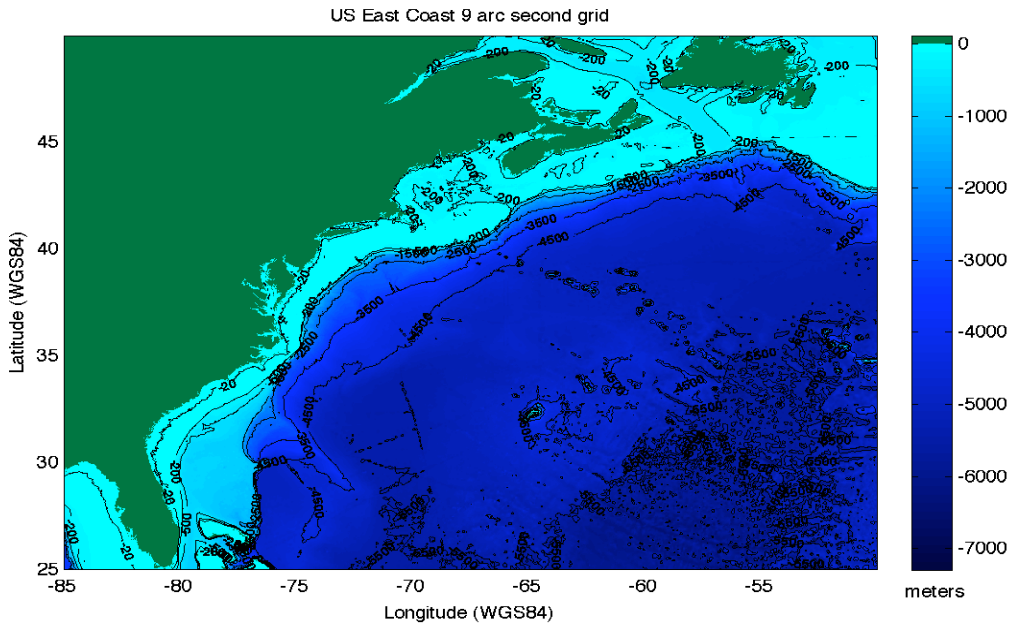


Figure 3 Depth contour plot of the North Atlantic Ocean 9-second grid supplied by NGDC. Note the varying shelf width.

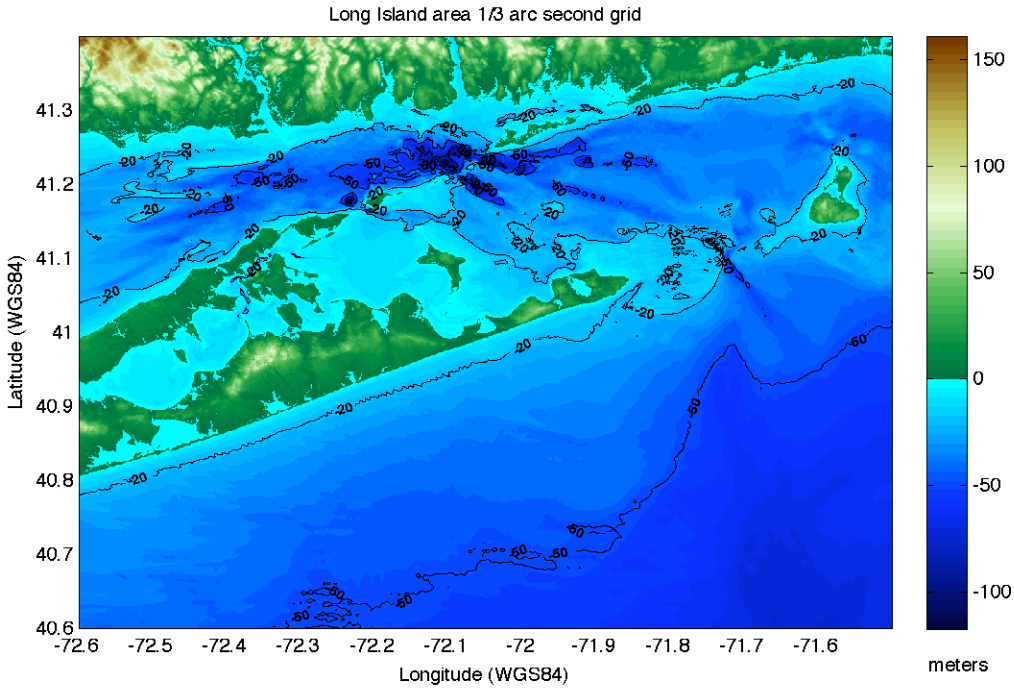


Figure 4 Depth contour plot of the high resolution (1/3 arc second) grid supplied by NGDC for the Montauk metropolitan area. Note numerous islands and varying shelf width.

3.3 Historical Events

There is no historical tide gage data for Montauk, so simulated events were used to test the forecast model.

3.4. Tide gages/Water level data

While there is no historical tide gage data available for Montauk, however, the tide gauge serves as the warning point for modeling purposes. The Montauk tide station was established in1947 and upgraded to its present installation in 1989. The tide house is located near a residential development pier on Fort Pond Bay. The GPS location of the tide gauge is 41 2.9′ N and 71 57.6′ W. The mean tide range in the vicinity is about 2.07 feet and the diurnal range is 2.53 feet. Mean high water is 5.10 feet.

3.5 Reference Grids

There is no historical tsunami tide-gauge data for Montauk. Therefore it is important to maximize the accuracy of the reference grids by maintaining high resolution. Due to the complex bathymetry and extremely large tsunami source employed, the resulting simulation was prone to instabilities. The instabilities were of two types: 1) those resulting in incomplete simulations (i.e., "crashing"); and 2) those that did not

prematurely terminate the simulation, but resulting in an unphysical harmonic feedback (i.e., "ringing") of wave heights along the coast. Both situations responded well to judicious use of the Fortran routine 'bathcorr.f', as outlined in "Method of Splitting Tsunami (MOST) Software Manual" (need reference for this – as MOST manual is not published).

3.5.1 Montauk Reference Grid A

Selected to cover the entire North Atlantic Ocean, the 9 arc second resolution grid was re-sampled to 12 arc second resolution and cropped to focus on the New York Bight and Long Island using Matlab (The Mathworks), as shown in Figure 5. Figure 5 also shows the outlines of Montauk reference grids B and C. Note again that no sub-aerial elevations were supplied in the original data set and all sub-aerial locations were set to 15 m elevation.

The 1/3 arc sec NGDC grid for eastern Long Island, New York was re-sampled to 6 arc sec and cropped to focus on eastern Long Island using Matlab. Figure 6 shows the resulting reference Grid B for Montauk. Also shown is an outline of the reference Grid C for Montauk.

To generate the reference grid C for Montauk, the 1/3 arc sec NGDC data for eastern Long Island, New York was re-sampled to 1 arc sec and cropped to focus on the Montauk, New York area using Matlab. Figure 7 shows the resulting M1s_pass9.dat, or C (reference; 1 s). Table 3 lists all the parameters for the Reference Grids.

	A	B	C
Lat	38.000-41.500	40.800-41.200	40.910-41.0900
Long	75.000-71.000	71.800-72.2000	71.9100-72.0900
ncols	1201	721	1945
nrows	1051	721	1945
Cellsize (arc sec)	12	6	1
X Grid spacing (degree)	0.00333325	0.00055555254221	0.000092592090368271
Y Grid spacing (degree)	0.00333325	0.00055555254221	0.000092592090368271
Zmin (m)	-3494.96	-108.10	-34.82
Zmax (m)	15	59.57	60.38
Final file name	M12s_pass1.dat	M6s_pass13.da	M1s_pass9.dat

Table 3 Grid parameters for Reference Grids for Montauk, NY.

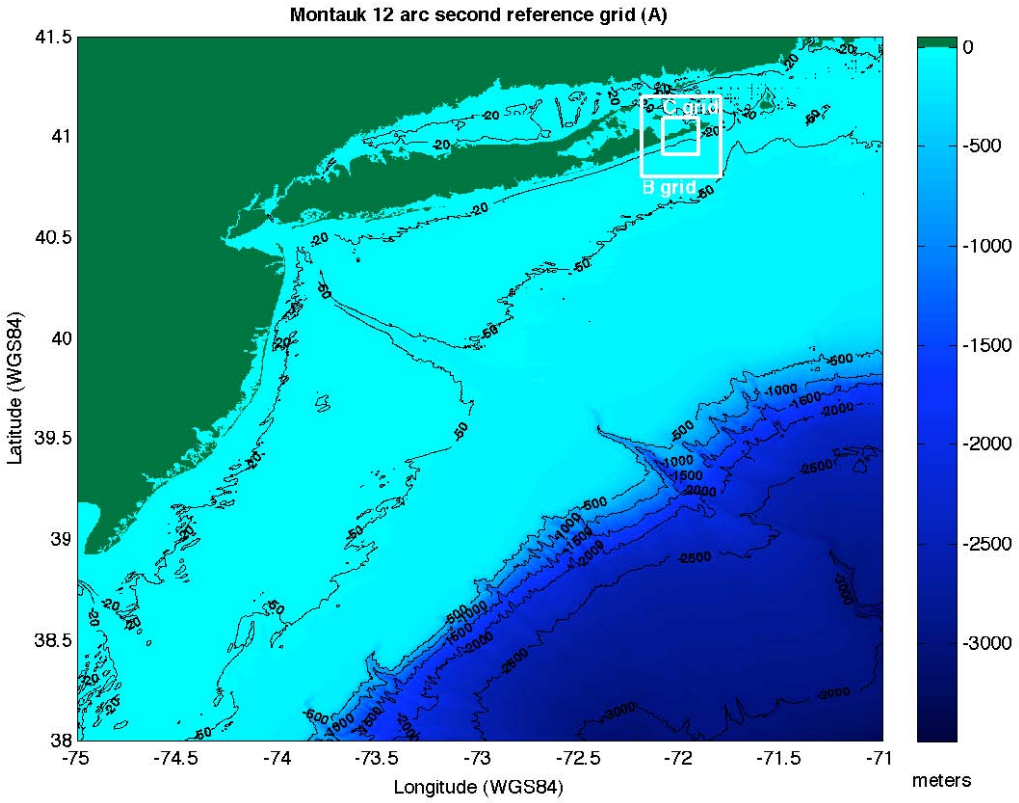


Figure 5 Depth contour plot of the common reference grid A (12 arc second) to be used for Montauk. Reference grids B and C are superimposed in white.

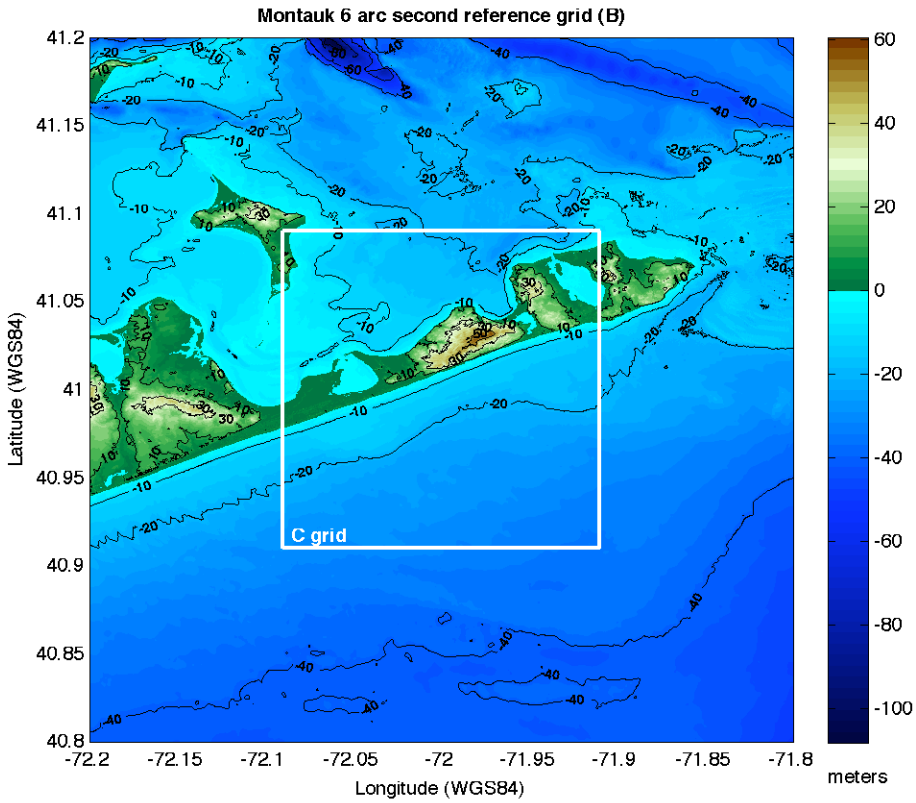


Figure 6 Depth contour plot of 6 arc second reference grid B, Montauk. Reference grid C is superimposed in white.

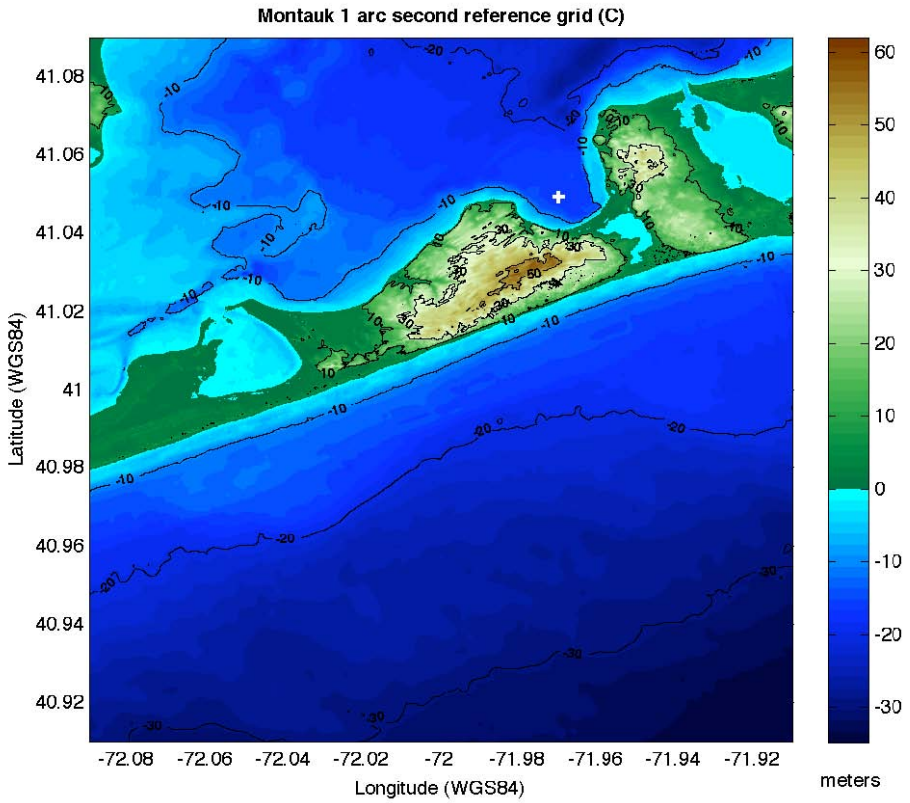


Figure 7 Depth contour plot of reference grid C, Montauk. The white cross denotes warning point location. Note complex bathymetry and local shoaling near warning point.

The Montauk warning point is located at -71.97 W and 41.049 S. The warning points will be used to compare tsunami time series of the reference versus optimized grids. Figure 8 shows the approximate location of Montauk grid C in Google Earth.

Figure 8 Montauk, NY on the eastern end of Long Island. (Google Maps

3.6 Montauk Optimized Grids

All computer simulations were run on a workstation with two AMD/Opteron 64-bit dual core CPU's and 8 GB of RAM. The operating system employed is Red Hat Enterprise Linux, and the 64-bit Fortran compiler is from the Portland Group.

The Montauk grids were tested against Puerto Rico Trench sources south of Long Island, (Figure 2 and Table 1). Approximately 40 grid optimization attempts were made, with different versions of the optimized grids. Table 4 shows the different grid versions that ran successfully and the CFL condition-based minimum time step for each. An arrow indicates the final time step utilized in Grid C.

GRID A	DESCRIPTION	Δt (s)
M12s_pass1.dat	12 arc sec reference grid A	1.5911
M24s_pass1.dat	24 arc sec version of reference grid A	3.1822
M24s_c1_pass1.dat	Cropped version of 24 arc sec grid A	3.6539
M36s_pass1.dat	36 arc sec version of reference grid A	4.7889
M48s_pass1.dat	48 arc sec version of reference grid A	6.3894
M60s_pass1.dat	60 arc sec version of reference grid A	8.0166
M120s_pass1.dat	120 arc sec version of reference grid A	16.063
GRID B		
M6s_pass13.dat	6 arc sec reference grid B	1.4297
B12s_pass1.dat	12 arc sec version of reference grid B	2.8686
B18s_pass1.dat	18 arc sec version of reference grid B	4.3200
B36s_pass1.dat	36 arc sec version of reference grid B	8.7496
GRID C		
M1s_pass9.dat	1 arc sec reference grid C	0.4217 → 0.3
C3s_pass3.dat	3 arc sec version of the reference grid C	1.2652 → 1.0
C3s_c1_pass2.dat	Cropped version of 3 arc sec grid C	1.3199 → 1.0
C6s_c1_pass2.dat	6 arc sec version of cropped 3 arc sec grid C	2.7975 → 2.0

Table 4 Grids used during optimization attempts for Montauk.

Snapshots were written to hard disk for all attempts, at a time interval of approximately 30 seconds. Also, a friction coefficient (n**2) of 0.0009 was used to reduce numerical instability in these worst-case scenarios.

The attempts simulated 4 hours for the goal of < 10 min CPU time per simulation. A quantitative method to assess the "goodness-of-fit" between the reference and optimized warning points time series, the root-mean-square (rms) difference, was computed. Although other combinations of grid resolution reduction and additional smoothing did result in optimized simulations that satisfied the goal of < 10 min CPU time, their resemblance to the reference simulation was unsatisfactory, as judged visually and/or by rms difference. The ultimate solution

in this case proved to be maintaining the A and B grid aerial extent with reduced resolution (48 and 18 arc seconds, respectively), and a cropped version of the original C reference grid, also with reduced resolution (6 arc seconds).

The resulting optimized grids then are:

A – (48 s) – M48s_pass1.dat

B – (18 s) – B18s_pass1.dat

C – (6 s) – C6s_c1_pass2.dat

Figures 9 through 12 show the optimized grids and their respective reference grid, where applicable. Basic details of the grids are given in Table**5.**

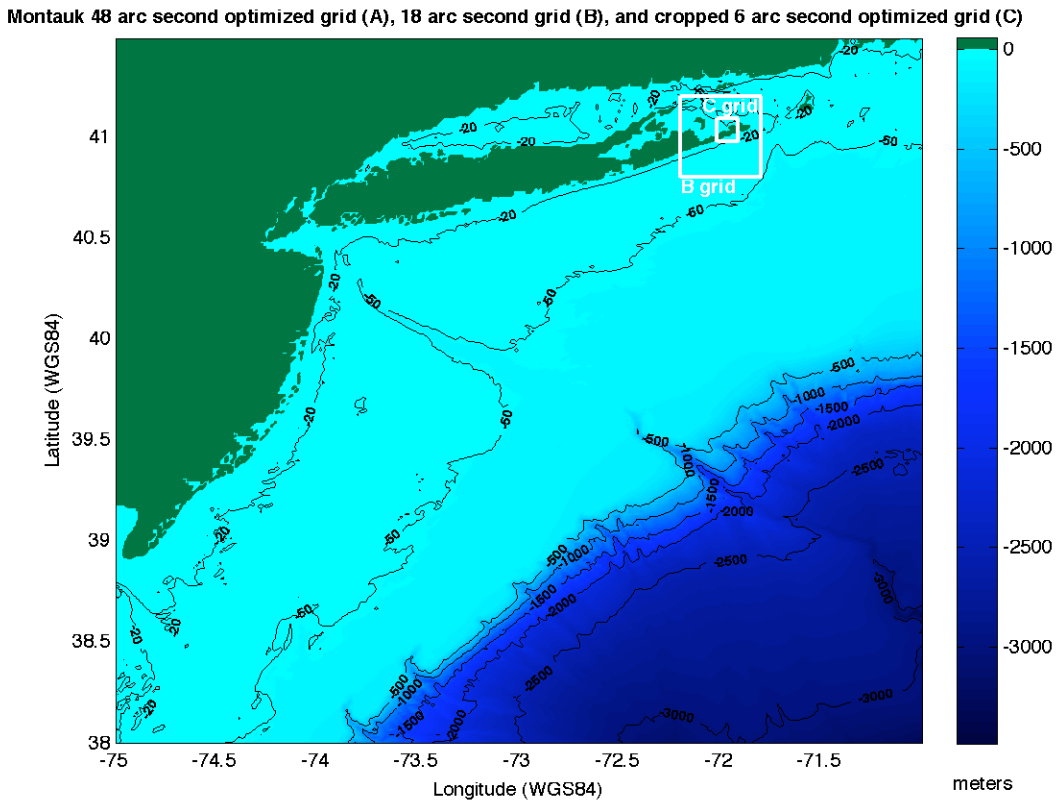


Figure 9 Depth contour plot of Long Island, New York 48 arc second optimized grid A with extent of optimized Montauk B and C (19 and 6 arc second respectively) grid superimposed in white.

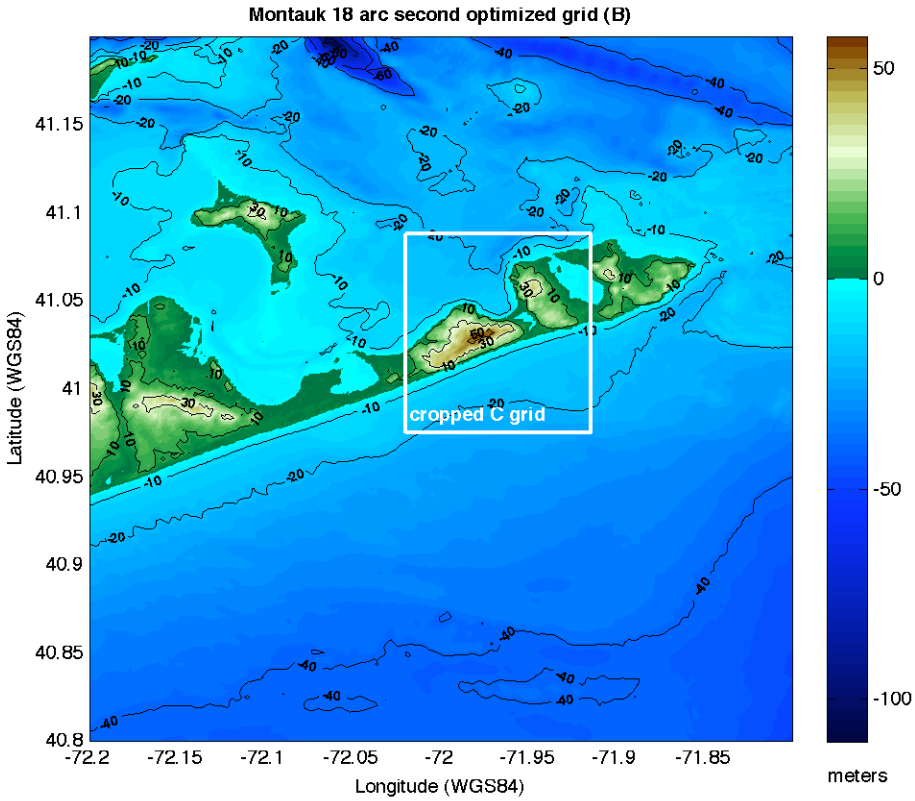


Figure 10 Depth contour plot of Montauk 18 arc second optimized grid B with extent of cropped Montauk 6 arc second optimized grid C superimposed in white.

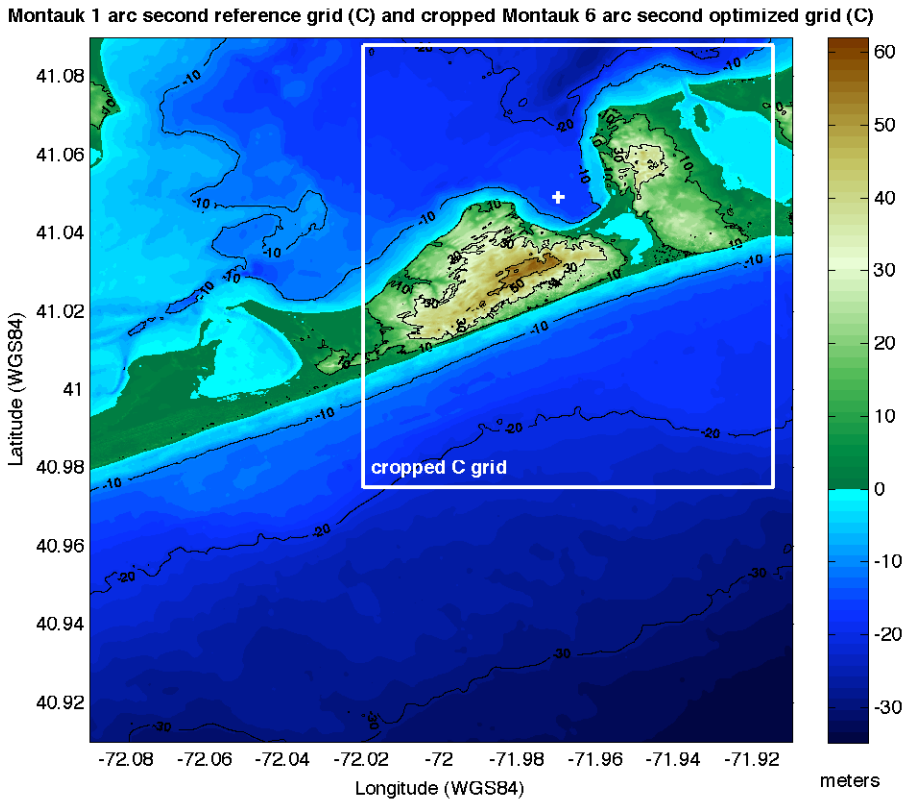
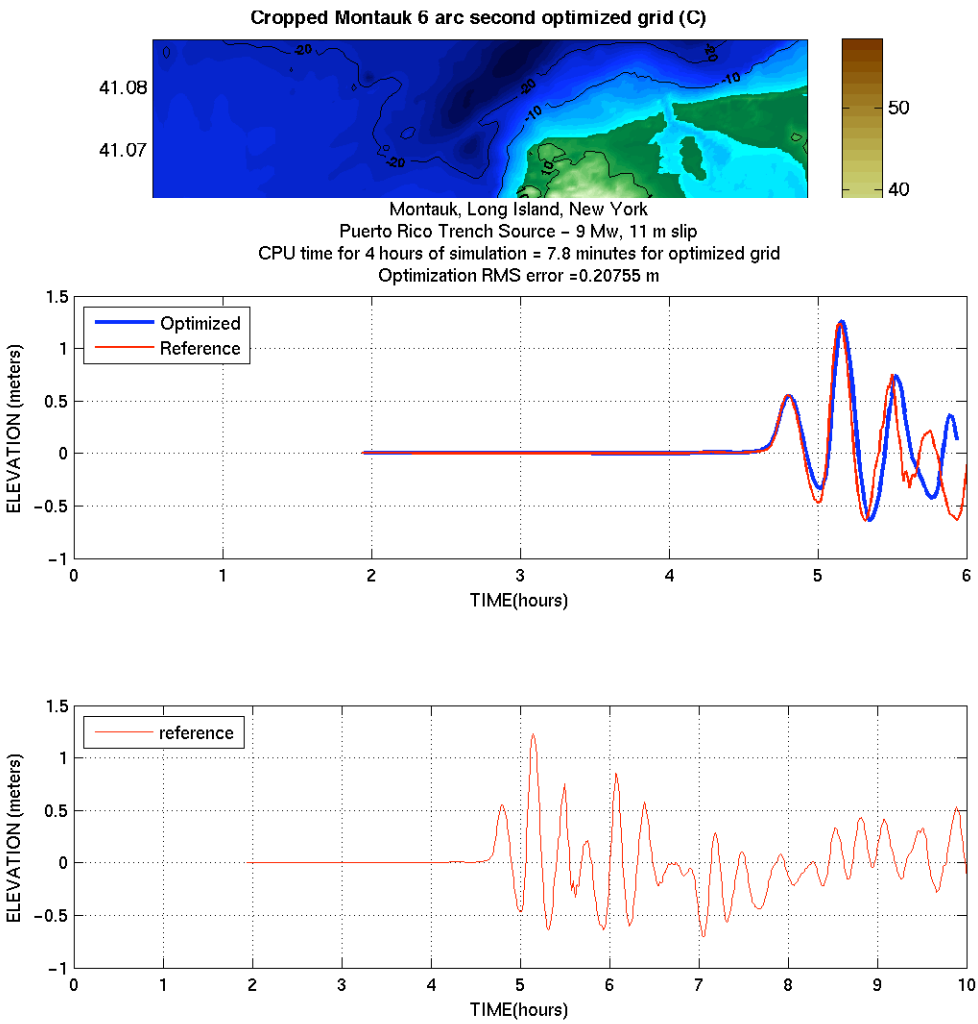


Figure 11 Depth contour plot of Montauk 1 arc second reference grid C with extent of cropped Montauk 6 arc second optimized grid C superimposed in white. White cross denotes warning point location.


Cropped Montauk 6 arc second optimized grid (C)
41.08
41.07
50
40
Montauk, Long Island, New York
Puerto Rico Trench Source – 9 Mw, 11 m slip
CPU time for 4 hours of simulation = 7.8 minutes for optimized grid
Optimization RMS error =0.20755 m
Optimized
Reference
ELEVATION (meters)
TIME(hours)
reference
ELEVATION (meters)
TIME(hours)

ig

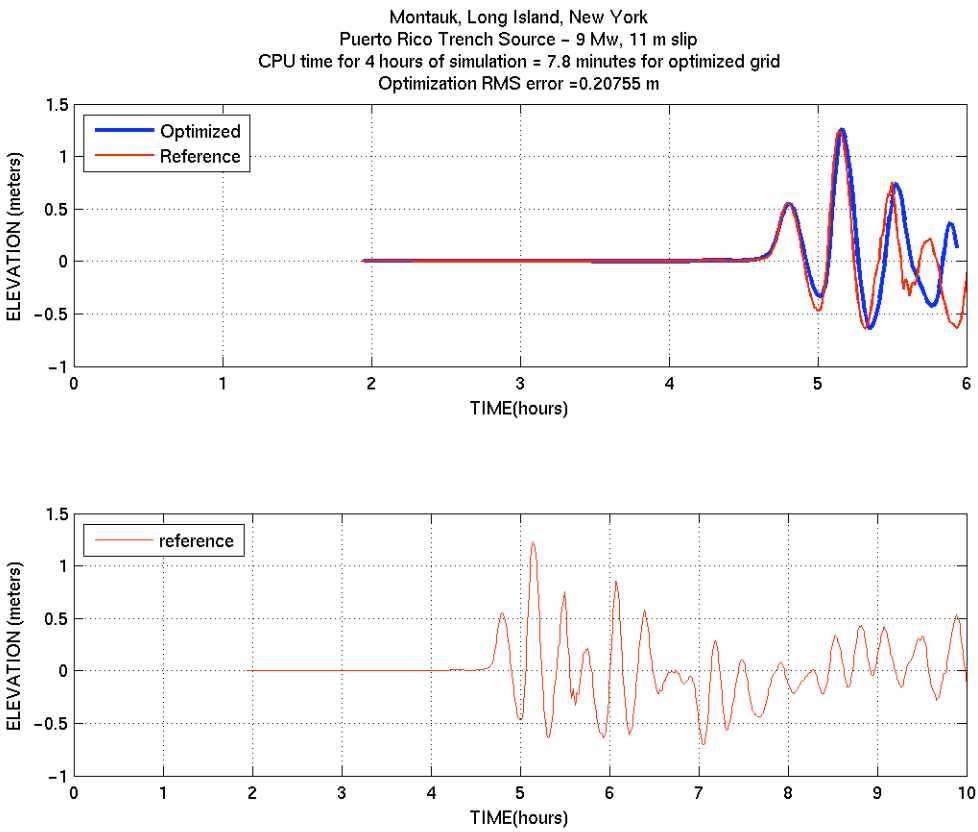


Figure 13 Time series at warning point, Montauk, for Puerto Rico Trench source. Red line is for reference grids. Blue line is for optimized grids. Top: Comparison, for 4 hours of simulation. Bottom: 10 hours of simulation, reference only.

Figure 14 compares maximum sea-surface elevation (MSSE) in both the reference and optimized grid C for the Puerto Rico Trench source. It can be concluded that, as expected, a large tsunami generated at the Puerto Rico Trench offers a threat to Montauk and the southern coast of Long Island. From the equivalent figures for grids B and A (Figures 15 and 16 respectively), it can also be concluded that this threats exists along much of the New York Bight.

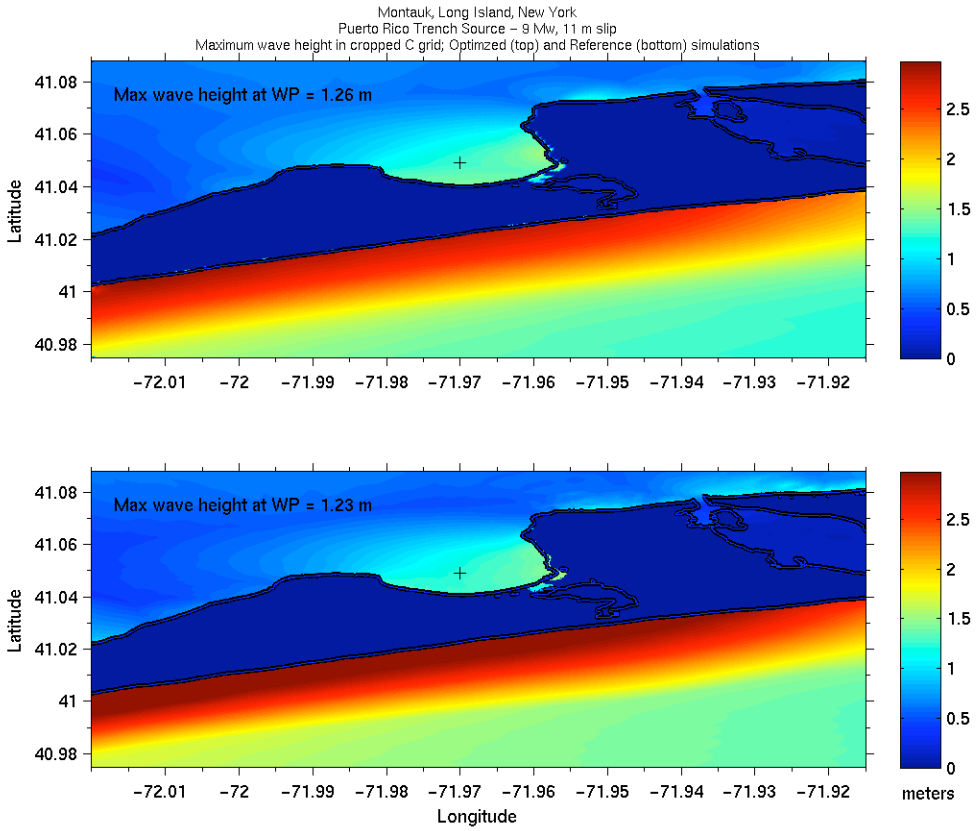


Figure 14 Maximum sea surface elevation for Montauk optimized grid C (top) vs. reference grid C (bottom), Puerto Rico Trench source. Simulation time for optimized grid, 4 hours; reference grid, 10 hours. Black cross denotes location of warning point.

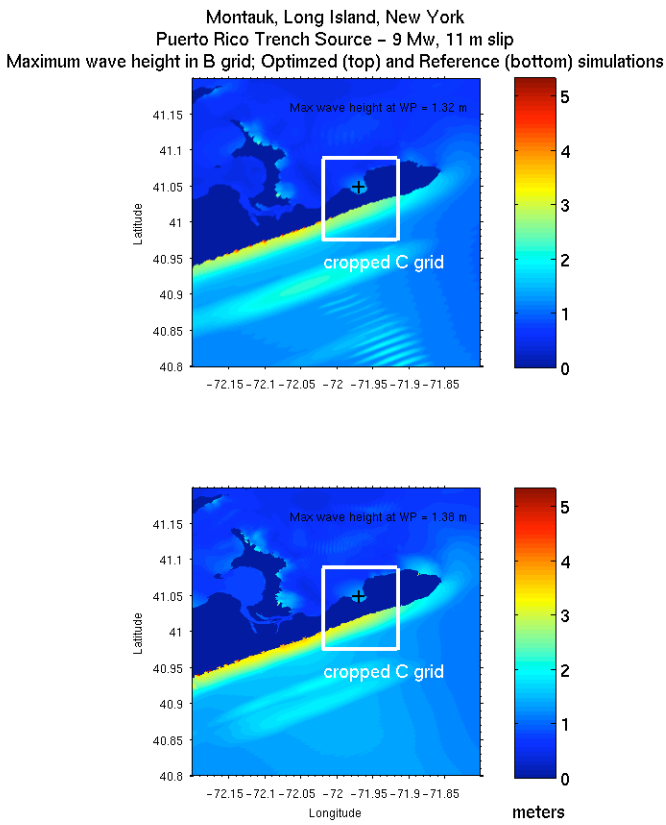


Figure 15 Maximum sea surface elevation for Montauk optimized grid B (top) versus reference grid B (bottom), Puerto Rico Trench source. Simulation time for optimized grid, 4 hours; reference grid 10 hours. Optimized cropped C grid superimposed in white. Black cross denotes location of warning point.

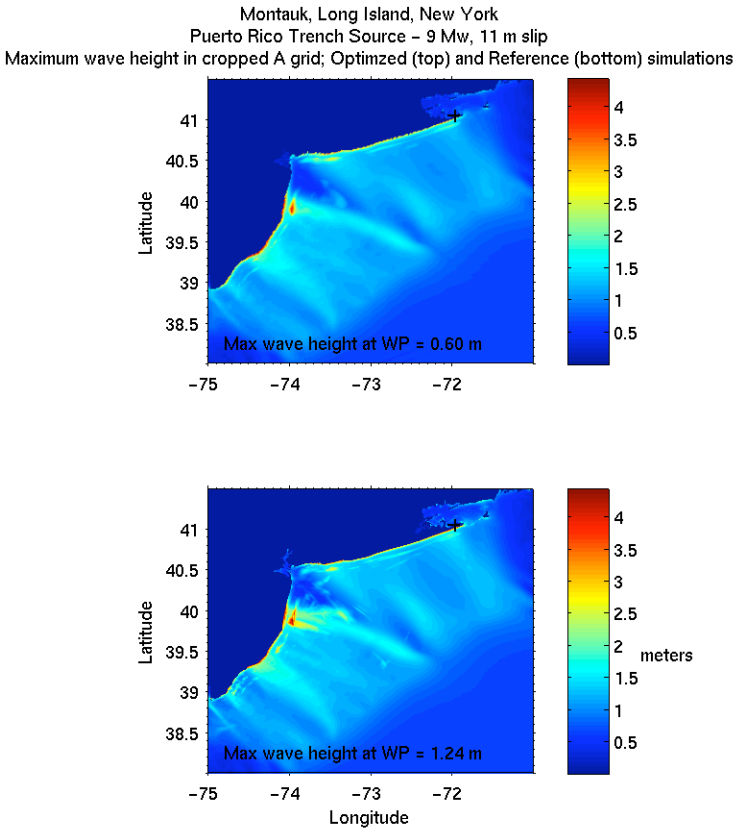


Figure 16 Maximum sea surface elevation for Montauk optimized grid A (top) versus reference grid A (bottom), Puerto Rico Trench source. Simulation time for optimized grid, 4 hours; reference grid 10 hours. Optimized cropped C grid superimposed in white. Black cross denotes location of warning point.

Grid	Region	Reference Inundation Model (RIM)				Stand-by Inundation Model (SIM)		
		Coverage	Cell	Time		Coverage	Cell	Time
		Lon. [°E]	Size	Step		Lon. [°E]	Size	Step
		Lat. [°N]	["]	[sec]		Lat. [°N]	["]	[sec]
A	New York Bight	41.49991250-38.000 71.000-75.000	12	1.591		17.654-18.731 67.947-65.066 (1)	48	6.1678
			(1201x1051)				(301x263)	
B	Eastern Long Island	41.200 - 40.8000 72.2000 -71.8000	6	1.4297		41.1999978 40.8000 72.200 -71.8000	18	4.320
			(721x721)				(241x241)	
C	Montauk	41.0900-40.9100	1	0.4217		41.0877772 -40.97500	6	2.7975
		72.0900 -71.91000	(1945x1945)			72.0200000 – 71.9150006		
Minimum offshore depth [m]			5			5		
Water depth for dry land [m]			0.1			0.1		
Manning coefficient			0.0009			0.0009		
CPU time for a 4-hour simulation			> 4544 min			**8 minutes**		

Table 5 MOST setup of reference and optimized models for Montauk

The optimized grid A is the reference grid A that has been re-gridded to 48 arc sec.

The optimized grid B is the reference grid B that has been re-gridded to 18 arc sec.

The optimized grid C is the reference grid C that has been re-gridded to 6 arc sec and cropped on all sides.

4.0 Conclusions

A Standby Inundation Models (SIM) was developed for the city of Montauk on the island of Long Island, New York. The results presented show that the city and surrounding area is vulnerable to tsunamis originating in the Puerto Rico Trench, south of the island.

Appendix A shows sample *.in and *.lis files for Montauk (both for the reference and optimized runs).

5.0 Acknowledgments

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7.0 Appendix A

7.1 Montauk Reference Grids *.in file

0.001 Minimum amplitude of input offshore wave (m):
5 Input minimum depth for offshore (m)
0.1 Input "dry land" depth for inundation (m)
0.0009 Input friction coefficient (n**2)
1 let a and b run up
200.0 max eta before blow up (m)
0.3 Input time step (sec)
120000 Input amount of steps
4 Compute "A" arrays every n-th time step, n=
4 Compute "B" arrays every n-th time step, n=
100 Input number of steps between snapshots (30 sec)
0 ...Starting from
1 ...Saving grid every n-th node, n=
M12s_pass1.dat
M6s_pass13.dat
M1s_pass9.dat

7.2 Montauk Reference Grids *.lis file

```
12-11-2007 15:06:21.342
Site: 1M_PRT_10hr_r
Input prefix: 2213
Input Directory: ./
Read Computational parameters: ./most3_facts_nc.in
Minimum amplitude of input offshore wave (m): 1.0000000000000000E-003
Input minimum depth for offshore (m): 5.000000000000000
Input "dry land" depth for inundation (m): 0.1000000000000000
Input friction coefficient (n**2): 9.0000000000000000E-004
Input runup switch (0 - runup only in gridC, 1 - runup in all grids): 1
Max allowed eta (m): 200.0000
Input time step (sec): 0.3000000000000000
Input amount of steps: 120000
Compute "A" arrays every n-th time step, n= 4
Compute "B" arrays every n-th time step, n= 4
Input number of steps between snapshots (should be a multiple of A,B and C time steps) : 100
...Starting from: 0
...Saving grid every n-th node, n= 1
Reading Bathymetry
1-ST LEVEL:
Bathymetry: ./M12s_pass1.dat
2-ND LEVEL:
Bathymetry: ./M6s_pass13.dat
3-RD LEVEL:
Bathymetry: ./M1s_pass9.dat
DODS URL: /home/wschmidt/Montauk/ZSources/
Input FACTS files:
zonal U: /home/wschmidt/Montauk/ZSources/2213u.nc
meridial V: /home/wschmidt/Montauk/ZSources/2213v.nc
amplitudes H: /home/wschmidt/Montauk/ZSources/2213h.nc
size of input array: 24 16 1441
Longitude: 284.8999666666667 to 291.0333000000000
Latitude: 37.96666411873842 to 41.96666402597404
Time: 0.000000000000000 to 86400.00000000000
NetCDF array size for grid C: 1945 1945
NetCDF array size for grid B: 721 721
```

```
NetCDF array size for grid A: 1201 1051
input 117 wave detected at 6960.000000000000 amp:
0.1061357185244560 cm at 288.8999666666667 ,
38.23333077922079
Initial surface is read at t= 6960.000000000000
elapsed secs: 272553.4 , user: 272033.6 , sys: 519.8200
clock sec: 272670 , minutes: 4544.500
```

7.3 Montauk Optimized *.in file

0.001 Minimum amplitude of input offshore wave (m):
5 Input minimum depth for offshore (m)
0.1 Input "dry land" depth for inundation (m)
0.0009 Input friction coefficient (n**2)
0 let a and b run up
200.0 max eta before blow up (m)
2.0 Input time step (sec)
7200 Input amount of steps
2 Compute "A" arrays every n-th time step, n=
1 Compute "B" arrays every n-th time step, n=
30 Input number of steps between snapshots (60 sec)
0 ...Starting from
1 ...Saving grid every n-th node, n=

7.4 Montauk Optimized *.lis file

```
1-28-2008 16:16:03.644
Site: 2M_PRT_4hr_o
Input prefix: 2213
Input Directory: ./
Read Computational parameters: ./most3_facts_nc.in
Minimum amplitude of input offshore wave (m): 1.0000000000000000E-003
Input minimum depth for offshore (m): 5.000000000000000
Input "dry land" depth for inundation (m): 0.1000000000000000
Input friction coefficient (n**2): 9.0000000000000000E-004
Input runup switch (0 - runup only in gridC, 1 - runup in all grids): 0
Max allowed eta (m): 200.0000
Input time step (sec): 2.000000000000000
Input amount of steps: 7200
Compute "A" arrays every n-th time step, n= 2
Compute "B" arrays every n-th time step, n= 1
Input number of steps between snapshots (should be a multiple of A,B and C time steps) : 30
...Starting from: 0
...Saving grid every n-th node, n= 1

size of input array: 24 16 1441
Longitude: 284.8999666666667 to 291.0333000000000
Latitude: 37.96666411873842 to 41.96666402597404
Time: 0.000000000000000 to 86400.00000000000
NetCDF array size for grid C: 190 204
NetCDF array size for grid B: 241 241
NetCDF array size for grid A: 301 263
netCDF output:
input 117 wave detected at 6960.000000000000 amp:
0.1061357185244560 cm at 288.8999666666667 ,
38.23333077922079
Initial surface is read at t= 6960.000000000000
Run finished
1-28-2008 16:23:50.761
elapsed secs: 466.3000 , user: 463.4400 , sys: 2.860000
clock sec: 467 , minutes: 7.783334
```

8.0 Appendix B

Since the initial development of the Montauk, NY SIM , the parameters for the input file for running the SIM and RIM in MOST have been changed to reflect changes to the MOST model code. The following appendix lists the new input files for Montauk.

8.1 RIM *.in files for Montauk, NY – updated for 2009

```
0.001   Minimum amplitude of input offshore wave (m):
5       Input minimum depth for offshore (m)
0.1     Input "dry land" depth for inundation (m)
0.0009  Input friction coefficient (n**2)
1       let a and b run up
200.0   max eta before blow up (m)
0.3     Input time step (sec)
120000  Input amount of steps
4       Compute "A" arrays every n-th time step, n=
4       Compute "B" arrays every n-th time step, n=
100     Input number of steps between snapshots (30 sec)
0       ...Starting from
1       ...Saving grid every n-th node, n=
M12s_pass1.dat
M6s_pass13.dat
M1s_pass9.dat
```

8.2 SIM *.in file for Montauk, NY updated for 2009

```
0.0001 Minimum amplitude of input offshore wave (m):
5      Input minimum depth for offshore (m)
0.1    Input "dry land" depth for inundation (m)
0.0009 Input friction coefficient (n**2)
0      let a and b run up
300.0  max eta before blow up (m)
2.0    Input time step (sec)
10800  Input amount of steps
2      Compute "A" arrays every n-th time step, n=
2      Compute "B" arrays every n-th time step, n=
30     Input number of steps between snapshots (60 sec)
0      ...Starting from
1      ...Saving grid every n-th node, n=
```