Tsunami Flood Map Development for Puerto Rico

National Tsunami Hazard/Risk Analysis
Workshop

July 25-26, 2012

Pacific Marine Environmental Laboratories
NOAA
Seattle, WA

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• Model: NOAA/Method Of Splitting Tsunamis (MOST) v 2.5 rev.912 (obtained from PMEL; hydrostatic non-linear shallow water equations)

• Topographic/bathymetry data (National Geophysical Data Center PR DEM, 2007) (10x10 meters resolution)

• Sources: For local tsunamis see: http://poseidon.uprm.edu/public/Final-Reports/huerfano/PRTWMP-Final%20Report-Task_1-Mode-of-Faulting-in-the-Local-Zone-of-Puerto-Rico.pdf by Dr. Victor Huerfano, Director, Puerto Rico Seismic Network/Department of Geology/Univ. of Puerto Rico. A total of 269 faults all around the island (see below). These are supplemented by 6 faults representing “historical” events, and suggested by different experts (published as a USGS Open File Report).

• Sources: For regional tsunamis: under discussion. For far-field tsunamis we will include the 1755 Lisbon event (several scenarios).

• Methodology: Each of the fault scenarios is modeled. Inundation outer grid has 60 arc sec resolution. Inundation intermediate grid has 9 arc sec resolution. For the inundation inner grids the island was broken down into three parts: West, Central, and East (see below). Each with a computational cell size of 1 arc second (approximately 30x30 meters). Results (see below) are output for each part, and then a mosaic is created based on joining the three parts.
For the propagation modeling:
- Bottom deformation
- Maximum Sea Surface Elevation relative to MSL all over the propagation grid.
- Movie showing the propagation in the propagation grid.

For each island part (West, Central, and East) the following is output in each inundation grid:
- Figure showing Maximum Envelope Of Highest Waters relative to MSL (MEOHW).
- Figure showing the same as above but relative to terrain elevation (called Local Water Depth (LWD)) – shown only inland of MSL shoreline.
- Maximum water particle velocity all over the computational grid
- Same as above, but just inland of MSL shoreline.
- Google Earth KMZ of LWD and Particle Velocity (just inland of MSL shoreline)
- Movie of wave propagation.

For the mosaic based on all three parts put together:
- Figure showing Maximum Sea Surface Elevation relative to MSL
- Figure showing the same as above but relative to terrain elevation (called Local Water Depth (LWD)) – shown only inland of MSL shoreline.
- Same as above but with streets overlaid on top.
- Maximum water particle velocity all over the computational grid
- Same as above, but just inland of MSL shoreline.
• Google Earth KMZ of LWD
• For each mosaic we also produce a figure showing the sea surface elevation in the surrounding areas stratified into three elevations: 0 to 0.3 m (blue), 0.3 – 1.0 m (gold - ADVISORY), and > 1 m (red - WARNING).
• Same as above (ADVISORY AND WARNING) but just for inland flooding (Local Water Depth).
• Same as above (ADVISORY AND WARNING) but in KMZ format.
• Next we go through all of the output MEOHW’s and we get the Maximum of the Maximums (MOM) to get one final map showing the inland extension, and elevations, of the tsunamis. This will be presented as KMZ and shapefiles.
• The databank of modeled tsunamis can serve as the starting set of more scenarios that can be used to make more specific real-time Advisories and Warnings.
Fig. 2a - Fault Locations: Anegada Passage. Return period estimated at 3762 years. 28 faults.

Fig. 3a - Fault Locations: Eastern Dominican Republic. Return period estimated at 807 years. 9 faults.

Fig. 4a - Fault Locations: Leeward Islands. Return period estimated at 3053 years. 11 faults.

Fig. 5a - Fault Locations: McCann faults. 31 faults.

Fig. 7a - Fault Locations: Muertos Trough. Return period estimated at 3092 years. 23 faults.

Fig. 6a - Fault Locations: Mona Canyon. Return period estimated at 2083 years. 24 faults.
Fig. 8a - Fault Locations: North 19°. Return period estimated at 3382 years. 16 faults.

Fig. 9a - Fault Locations: North Platform. Return period estimated at 2506 years. 25 faults.

Fig. 10a - Fault Locations: Puerto Rico Trench. Return period estimated at 3841 years. 28 faults.

Fig. 11a - Fault Locations: Puerto Rico West to Southeast. Return period estimated at 1823 years. 36 faults.

Fig. 12a - Fault Locations: Septentrional. Return period estimated at 705 (von Hillebrandt), or 450 (McCann) years. 14 faults.

Fig. 13a - Fault Locations: Sombrero region. Return period estimated at 1241 years. 24 faults.
Example: Mw 8.1 at the Puerto Rico Trench (Local fault: /V/PRT/f13)
Length = 174 km, Width = 50.69 km, Dip = 40, Rake = -120, Strike = 111, Slip = 3.2 m, Depth = 4 km
by
Dr. Victor Huerfano, Director, Puerto Rico Seismic Network/Department of Geology/Univ. of Puerto Rico
V_PRT_13_east: WAVE HEIGHT ABOVE MSL (M)
Maximum Elevation = 12.53 at Location (Lonc.,Lat.): (-65.3415,18.3474)
Location of Time series (triangle), Maximum Runup (pentagon)
White areas are non-flooded terrain
2011 Puerto Rico NTHMP Tsunami Flood Map
Maximum of the Maximums: Local Sources (meters above terrain elevation)
(NOAA MOST model)
ADDITIONAL WORK AS PART OF NTHMP:
• We have already had two weeks of training by Dr. Juan Horrillo on the use of the coupled models TSUNAMI-3D and NEOWAVE for modeling landslide tsunamis. Tested with what could be a submarine landslide that occurred as a consequence of the 1918 Puerto Rico earthquake. The USGS has identified additional slides along the Puerto Rico Trench, and also along the south coast (in cooperation with Spanish scientists). This is the next phase of work.

FUTURE WORK:
• Must include variable roughness, especially along coastlines protected by fringing reefs, mangrove forests, and very dense vegetation.
• Include the built infrastructure
• Improve bathymetry and topography once the geoid in Puerto Rico is upgraded
• Include dispersive effects