Earthquakes Detection, Sea-Level Monitoring, Global Positioning System, Geodesy

Operated by Departments of:
Civil Engineering, Geology, and Oceanography at University of Puerto Rico at Mayagüez

Carlos I. Huerta López
Civil Engineering and Surveying Department
Puerto Rico Strong Motion Program
Population at Risk for Natural Hazards

- Local and Regional Earthquakes
- Landslides (continental shelves, trenches etc.)
- Volcanoes (submarine & land)
- Tele-tsunamis

Total = 130 M

0.3 M

Source: CIA Factbook
Puerto Rico and North-east Caribbean Tectonic-frame
Monitoring/Detection of Earthquakes:
- PRSN: Puerto Rico Seismic Network,
- PRSMP: Puerto Rico Strong Motion Seismic Network.

Monitoring of Sea-Level, and Geodetic Control
[Ground displacement Vs Sea-Level changes over short time term (earthquake/tsunami) and long term]:
- PRSN: Global Positioning System (GPS)
- PRSN-Caribbean Tsunami Warning Center,
  CTWC: Tide-gauge (TG)

Engineering surveying and Geodesy:
- Geographic Coordinate System,
- Vertical/Horizonatal Datum
Working Groups

**PRSNS**:  
Victor A. Huerfano Moreno. - PRSN Director  
Gisela Baez. - Seismologist  
E. Vanacore. - Seismologist

**PRSNS-CTWC**:  
Crista vonHillebrandt. - CTWC Director

**PRSMP**:  
José A. Martínez-Cruzado. - PRSMP Director  
Carlos I. Huerta-López. - Seismologist

**Engineering surveying/Geodesy**:  
Linda A. Velez. - Group-leader
PUERTO RICO SEISMIC NETWORK (PRSN)
PUERTO RICO SEISMIC NETWORK (PRSN)

- Provides earthquake parameters in the Puerto Rico and Virgin Islands (PRVI), Area of Responsibility, AOR (17.0N-20.0N, 63.5W-69.0W).
- The mission is to monitor (24/7) and rapidly determine/disseminate earthquake parameters (local, regional, or tele-seismic), and support National Tsunami Warning Center (NTWC) to determine the Tsunami alert level in the AOR. Also to agencies, scientists, and general public.
- PRSN compiles and maintains an extensive seismic database of earthquake parameters, continuous waveforms (Earthquakes, GPS and Sea-Level) for world-wide, the Caribbean and Puerto Rico basic and applied earth science/oceanography research.
PRSNA - Tide-gauge
Tide Gauges for Tsunami monitoring system
Over 15 Installed locally and thru the Virgin Island
Reference points for the ETAS

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• NOAA NWS established in February 1, 2010 the Caribbean Tsunami Warning Program, jointly located at the Puerto Rico Seismic Network at the University of Puerto Rico at Mayagüez as a 1rst step of the U.S. towards the establishment of a Caribbean Tsunami Warning Centre.
• Endorsed by UNESCO/IOC/CARIBE EWS
• Funds are yet to be identified for full implementation of Center
• Currently supports and monitors all sea level stations in the Caribbean using Tide Tool.
• Co-Organizer of June 2011 CARIBE EWS sea level network operator workshop in Mexico
• Received special funding of $80,000 to develop tools for integration of sea level data into Caribbean and Western Atlantic Hydromet Offices and Tsunami Warning Focal Points
Caribbean Sea Level Monitoring Stations
NOAA NWS Caribbean Tsunami Warning Program
http://www.srh.noaa.gov/srh/ctwp/
DART®
Deep-Ocean Assessment and Reporting of Tsunamis

DART® II System

Surface Buoy
2.6 m diameter
4000 kg displacement

Bottom Pressure Recorder

Bi-directional acoustic telemetry

Acoustic transducer

Glass ball flotation

Anchor 3100 kg total

19 mm nylon

25 mm chain (5 m)

100 m Nylspun®
25 mm nylon
22 mm nylon

Bi-directional communication & control

Iridium satellite

Iridium & GPS antennas

LIF handle

Radar deflector

Electronic systems & batteries

Anchor 548 kg

Station Owners
- NDBC DART
- Australia
- Chile
- Indonesia
- Thailand
- Russia

Place pointer on station to display corresponding plot or click on station to view station page.

IRIS-Workshop, 05/2015
http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Tide+Data

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PRSN - GPS
To be able to get better geodetic control and address the issue of ground displacement vs sea level changes over short time term (earthquake/tsunami) and long term (sea level), efforts are being made to collocate some of the COCONet GPS stations within 1 km of existing or proposed sea level stations.

The final COCONet siting plan. Green dots represent new (50) or refurbished stations (15), red dots represent existing stations (61), and the blue triangle represents one alternate site on Sombrero Island. Large green dots represent the seven completed COCONet stations to date.
PUERTO RICO STRONG MOTION SEISMIC NETWORK (PRSMP)
THE PUERTO RICO STRONG MOTION SEISMIC NETWORK (ACTUALLY PUERTO RICO STRONG MOTION PROGRAM, PRSMP) has grown since the 1970's from 7 FF strong motion stations and one instrumented building with analog accelerographs to 111 strong motion stations and 16 instrumented buildings with digital accelerographs:

- PRI: 88 FF, 16 Struct., DOMINICAN REPUBLIC (DR): 13 FF, BRITISH VIRGIN ISLANDS (BVI): 5 FF, 2 Struct. Collecting data via IP (Internet), DU (telephone), and Stand Alone stations.
Obtain and provide strong motion data to the scientific/academic/engineering communities for:

-(i) Performing seismic analysis, earthquake resistant designs, enhance the regulations of the construction codes, improving land use, and support the seismic engineering investigation,

-(ii) objectively identify and characterize the ground response, as well as the civil infrastructure response upon seismic loads.

Mitigate both human and economical losses during high-intensity earthquakes through accurate and reliable seismic records.

Identify in an objective manner damaged after an earthquake.

Duties:

(i) deploying/operation seismic instrumentation for monitoring strong ground motions as well as civil structures in the Puerto Rico Island (PRI) and the Caribbean region,

(ii) Applied seismology/geophysics/geology in Civil Engineering,

(iii) Application of seismic/geophysical methods for site characterization/local site effects/seismic zonation, and seismic risk studies.
PRSMP STATUS:

- INSTRUMENTATION
- NETWORK ADMINISTRATOR
  - ANTELOPE
  - EARTHWORM
- COMMUNICATION
- DATA PROCESSING/ARCHIVING/DISSEMINATION
- MAPS OF EARTHQUAKES PGA/MMI DISTRIBUTION
- PUBLICATIONS/THESIS: STRUCTURAL ANALYSIS/SOIL-SITE CHARACTERIZATION-RESPONSE
- EARTHQUAKES CATALOG
- PRSMP WEB-PAGE
PRSMP NETWORK ADMINISTRATOR

- ANTELOPE 5.3 (BRTT. Three nodes license)
  - Run in Dell/PowerEdge servers (At: UPRM/PRSMP)
  - Operative System, CentOS 6.2
  - UPRM Internet Communication/PRSMP sector: 136:145:117:
  - Firewalls: UPRM, PRSMP, Servers
  - Automatic power generator backup

- EARTHWORM 7.7 (Public domain)
  - Run in Dell/PowerEdge servers (At: UPRM/PRSMP)
  - Run in Dell/Precision Workstations (At: BVI, AEE)
  - Operative System, CentOS 6.2
  - UPRM Internet Communication/PRSMP sector: 136:145:117:
  - Firewalls: UPRM, PRSMP, Servers
  - Automatic power generator backup

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STATION/DATA COMMUNICATION

- ANTELOPE (PRSMP-PRI. FREE FIELD, FF & STRUCT. ST)
  - Via Internet/IP Lantronix, ETNA/K2 (10-IP FF)
  - Telephone Line/Modem (49-DU FF)
  - Stand Alone (27-SA FF)
  - Structures (16-SA ST)

- EARTHWORM (PRSMP-BVI: FREE FIELD, FF & STRUCT. ST)
  - Via Internet/IP Lantronix ETNA (5-IP FF)
  - Via Internet/IP Lantronix (ETNA/6 Chann., and Granite/12 Chann. ST)

- EARTHWORM (PRSMP-DR. FREE FIELD, FF & STAND ALONE, SA)
  - Via Internet/IP Lantronix, Stand Alone ETNA (6-IP FF, 7-SA)

- EARTHWORM (PRSMP-AEE/PRI): FREE FIELD, FF & STRUCT. ST)
  - Via Internet/IP Lantronix ETNA/K2 (1-IP FF, 5 Patillas Dam, ST)

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FREE-FIELD STATIONS

8 Estaciones Radio
4 Estaciones Satelite

Red Sismica de Puerto Rico en UPR-Mayagüez
Earthworm

26 Estaciones Internet (RD, PR y BVI)
48 Estaciones Modem Telefónico
37 Estaciones Estación Individual

Programa de Movimiento Fuerte en UPR-Mayagüez
Antelope

Internet

Miniseed Database Internet
Folder EVT Internet y Modem telefónico

Publico en General
www.prsmp.uprm.edu

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Estructuras
3 Edificios
1 Torres
Internet

Minisear
Database
Internet

Programa de Movimiento Fuerte en UPR-Mayagüez
Antelope

USGS
(El Castillo)

COSMOS
www.cosmos.eq.org

Publico en General
www.prsmp.uprm.edu

Estructuras
2 Edificios
2 Puentes
11 Represas
Estación Individual

Folder EVT
Internet y Modem telefónico
STRONG MOTION DATA PROCESSING

- Standard strong motion signal processing (SMA-Kinemetrics and MatLab codes) is used to the recorded data obtaining the .V1, .V2, and .V3 processed data, which correspond to the uncorrected acceleration records converted to physical units, the corrected acceleration record in physical units of acceleration, velocity and displacement, and the spectral representation of all above, respectively.

- Instrument calibration sheet, PDCC

- PSD analysis

- Instrumental intensity (Modified Mercalli Intensity, MMI) using the Wald et al. (1999) equations.
Horizontal and Vertical Datum
Contribution to the Geographic Coordinate System in Puerto Rico

Surveying and Geodesy Group
Civil Engineering Department of UPR at Mayaguez Campus

Linda L. Vélez-Rodríguez, MS, PE, PLS
Catedrática

Email: linda.velez@upr.edu
Tels. 787-265-5405 Ofic.
787-313-4740 Cel.
Marcos de Referencia Horizontales y Verticales:

Puerto Rico Datum del 1901 – origen Faro Cayo Cardona en Ponce - Elipsoide Clarke 1866
Puerto Rico Datum 1940 – origen Estación Damian en Orocovis - Elipsoide Clarke 1866
North American Datum of 1983 (2011)
Epoch 2010.0 – Elipsoide GRS80

Puerto Rico Vertical Datum of 2002 – Origen en La Puntilla, Viejo San Juan
Por estar el Cayo Cardona en el municipio de Ponce, tenemos que PONCE: Genesis de un Puerto Rico espacialmente dotado
Investigación sobre el Centro de Puerto Rico localizado en Orocovis, Estación Damian

X = 200,322.93 metros & Y = 243,047.21 metros

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null
Puerto Rico Vertical Datum of 2002
PRVD 2002 – VÉLEZ
VERT ORDER - FIRST CLASS II

HORZ ORDER - B
NAD 83(2002)-
φ = 18  26’ 41.28060” N
λ = 67  08’ 48.93357” W

NAD 83(2011) Epoch 2010.00-
φ = 18  26’ 41.28162” N
λ = 67  08’ 48.92893” W

PRVD02 - 134.320meters
440.68feet

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Daniel Winester, Geodesista del National Geodetic Survey, y Juan A. Rodríguez.

Monumentando estación Mayagüez AA 2008, salón CI-019-RUM.

Se realizarán observaciones por 48 horas de Gravedad absoluta.
COCOnet: Continuously Operating Caribbean Observational GPS Network

http://coconet.unavco.org/
CORS: Continuously Operating Reference Station
http://www.ngs.noaa.gov/CORS_Map/
OPUS SHARED: Online Positioning User Service
http://www.ngs.noaa.gov/OPUS/showMarks.jsp

Shared Solution

PIB: DK7550
Designation: 5753934 USNPR 1 TIDAL
Stlying: NPS 1 1071
Stability: Monument will probably hold position well
Settled: Monument or piece of large bridge
Mark Condition: 0
Description: The existing description at the Distance is good.
Observed: 2006-11-27T03:57:05Z
See Also: 2006-11-27T03:57:05Z
Source: OPUS - page 1 299.04

LAT: 19° 17' 38.472" N ± 0.006 m
LON: 62° 33' 34.580" W ± 0.005 m
ELL: 437.16 ± 0.006 m
X: 2325496.710 ± 0.007 m
Y: 2898512.622 ± 0.004 m
Z: 1918277.566 ± 0.006 m
ORTH: 1.398 ± 0.006 m

REF_FRAME: NAD_83(2011) EPOCH: 2010.0000

CONTRIBUTED BY

University of Puerto Rico, Magüey

The numerical values for this position solution have satisfied the quality control criteria of the National Geodetic Survey. The contributor has verified that the information submitted is accurate and complete.
CariCOOs: Caribbean Coastal Observing System

http://www.caricoos.org/drupal/
Thanks,
May 16, 2010 Earthquake: Study case
<table>
<thead>
<tr>
<th>Event date</th>
<th>Max_PGA (cm/s²)</th>
<th>Station</th>
<th>Distance (Km)</th>
<th>Max_PGA (cm/s²)</th>
<th>Station</th>
<th>Distance (Km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May-16-2010 (5.8)</td>
<td>23.01</td>
<td>UTD2</td>
<td>E=40.17</td>
<td>2.04</td>
<td>AG02</td>
<td>E=13.03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>H=120.02</td>
<td></td>
<td></td>
<td>H=113.84</td>
</tr>
<tr>
<td>Dec-24-2010 (5.1)</td>
<td>14.15</td>
<td>HM01</td>
<td>E=34.01</td>
<td>12.13</td>
<td>CG01</td>
<td>E=10.06</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>H=108.54</td>
<td></td>
<td></td>
<td>H=103.44</td>
</tr>
<tr>
<td>Dec-17-2011 (5.3)</td>
<td>11.30</td>
<td>MY12</td>
<td>E=23.38</td>
<td>4.08</td>
<td>UTD2</td>
<td>E=69.3</td>
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<td></td>
<td>H=29.01</td>
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<td></td>
<td>H=71.3</td>
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<tr>
<td>Feb-26-2013 (5.1)</td>
<td>0.78</td>
<td>UTD2</td>
<td>E=171.5</td>
<td>0.45</td>
<td>AG02</td>
<td>E=120.72</td>
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<td></td>
<td>H=171.7</td>
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<td></td>
<td>H=120.99</td>
</tr>
</tbody>
</table>
January 13, 2014 Earthquake: Study case
January 13, 2014 Earthquake: Study case
Peak ground acceleration response of three moderate magnitude earthquakes and their implication to local site effects in the Puerto Rico Island

By:
Carlos I. Huerta-López, Ph.D
José A. Martínez-Cruzado, Ph.D
Fabio M. Upegui-Botero, Grad. Stud.
Luis E. Suarez-Colche, Ph.D.
El Castillo Building. M5.3 Eqk.
Thanks,