



# PUERTO RICO GEOPHYSICAL NETWORKS

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

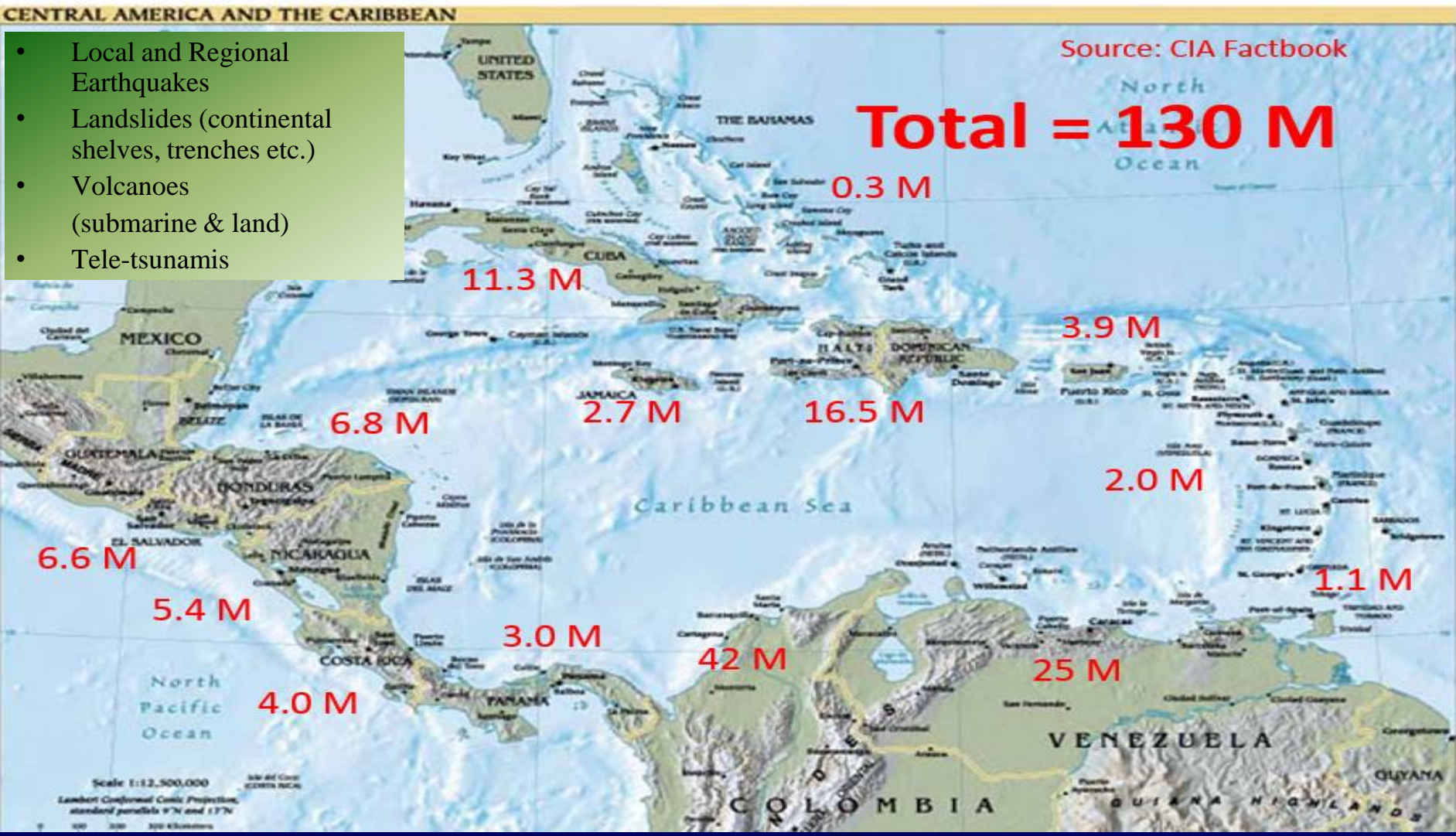
Civil Engineering and Surveying Department  
Puerto Rico Strong Motion Program

# Population at Risk for Natural Hazards

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

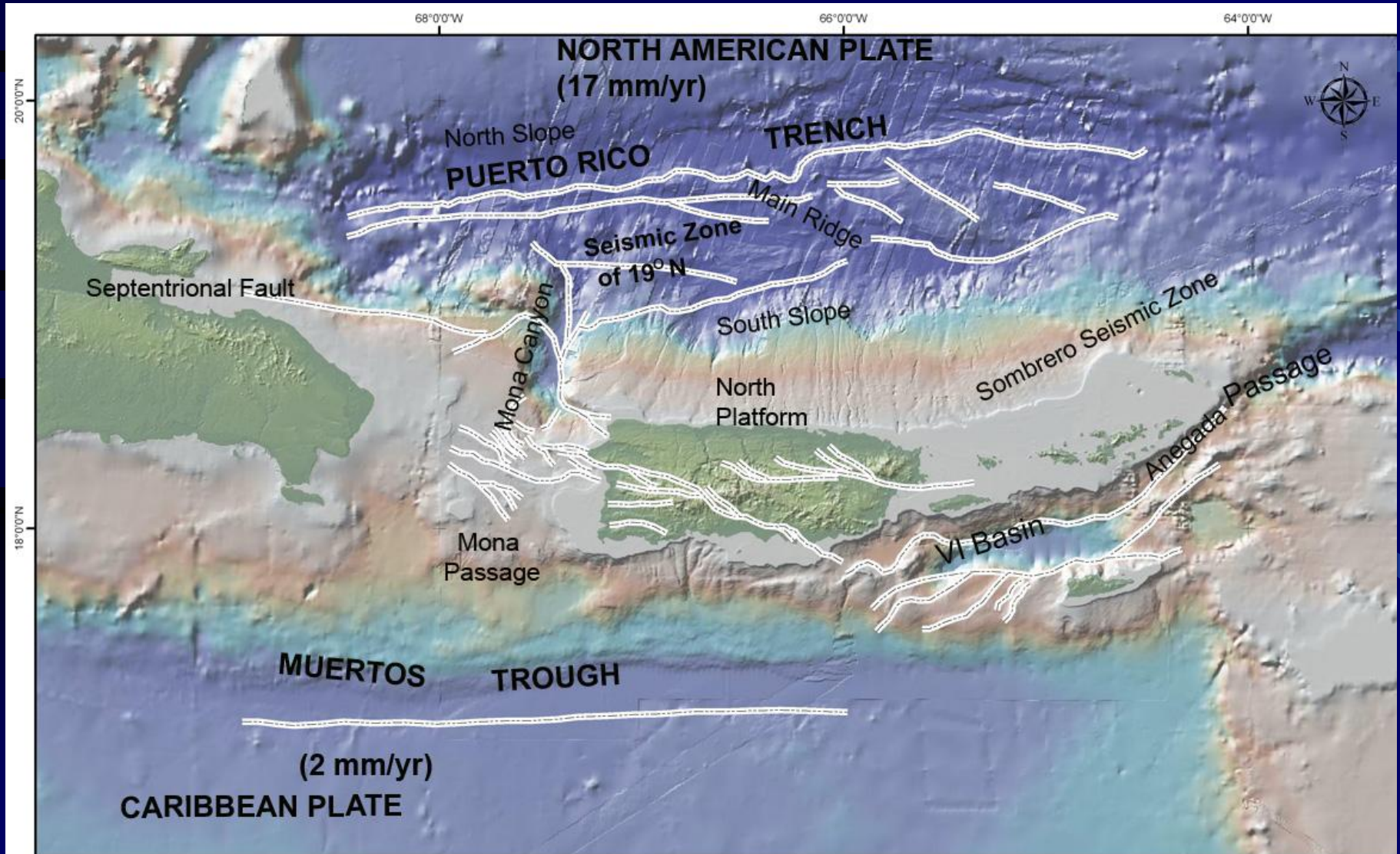
Source: CIA Factbook

**Total = 130 M**



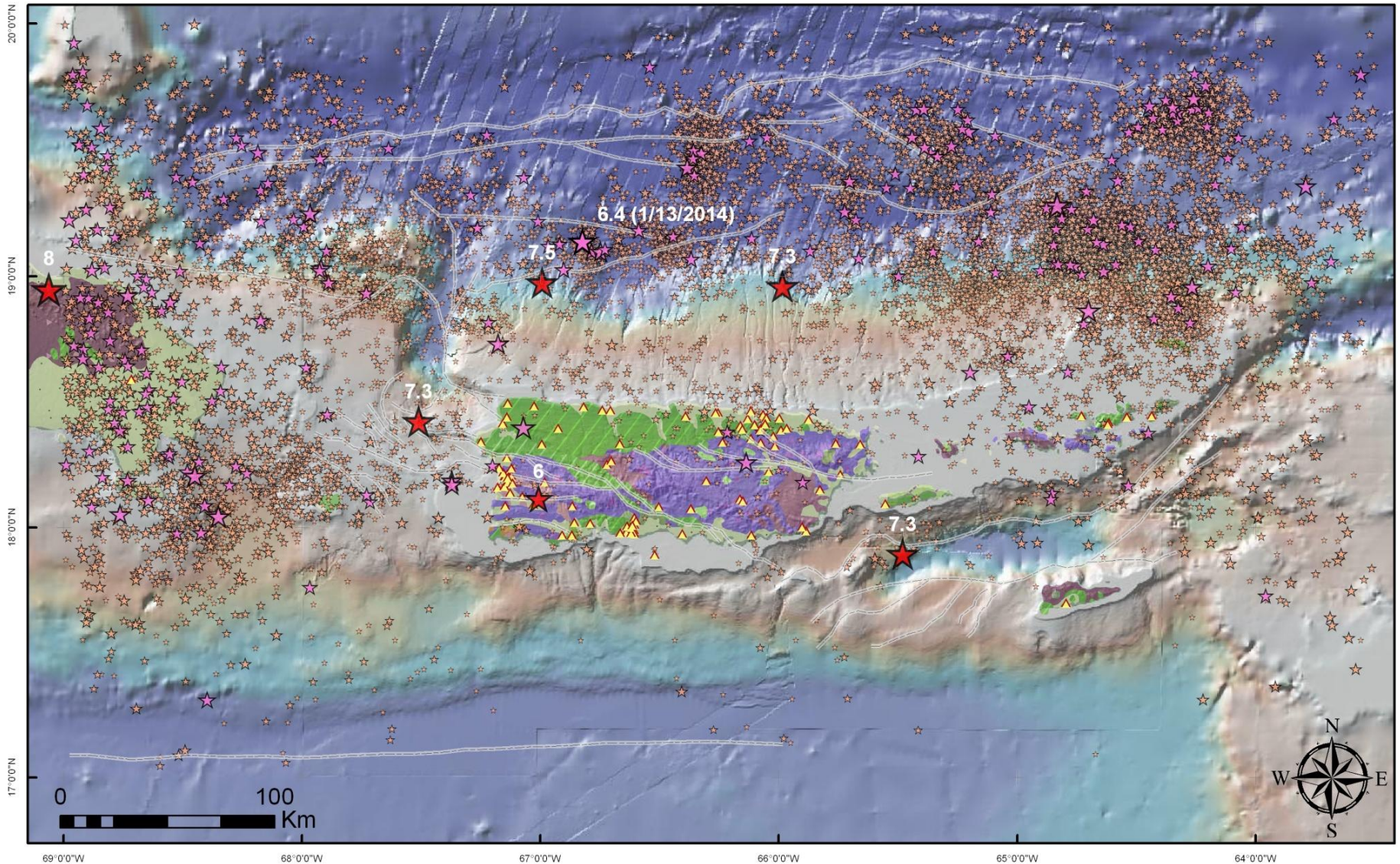


# Puerto Rico and North-east Caribbean Tectonic-frame





# Caribbean and Puerto Rico Region





## □ 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/Horizontal Datum



# Working Groups

## PRSN:

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

## PRSN-CTWC:

Crista vonHillebrandt.	-CTWC Director
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## PRSMP:

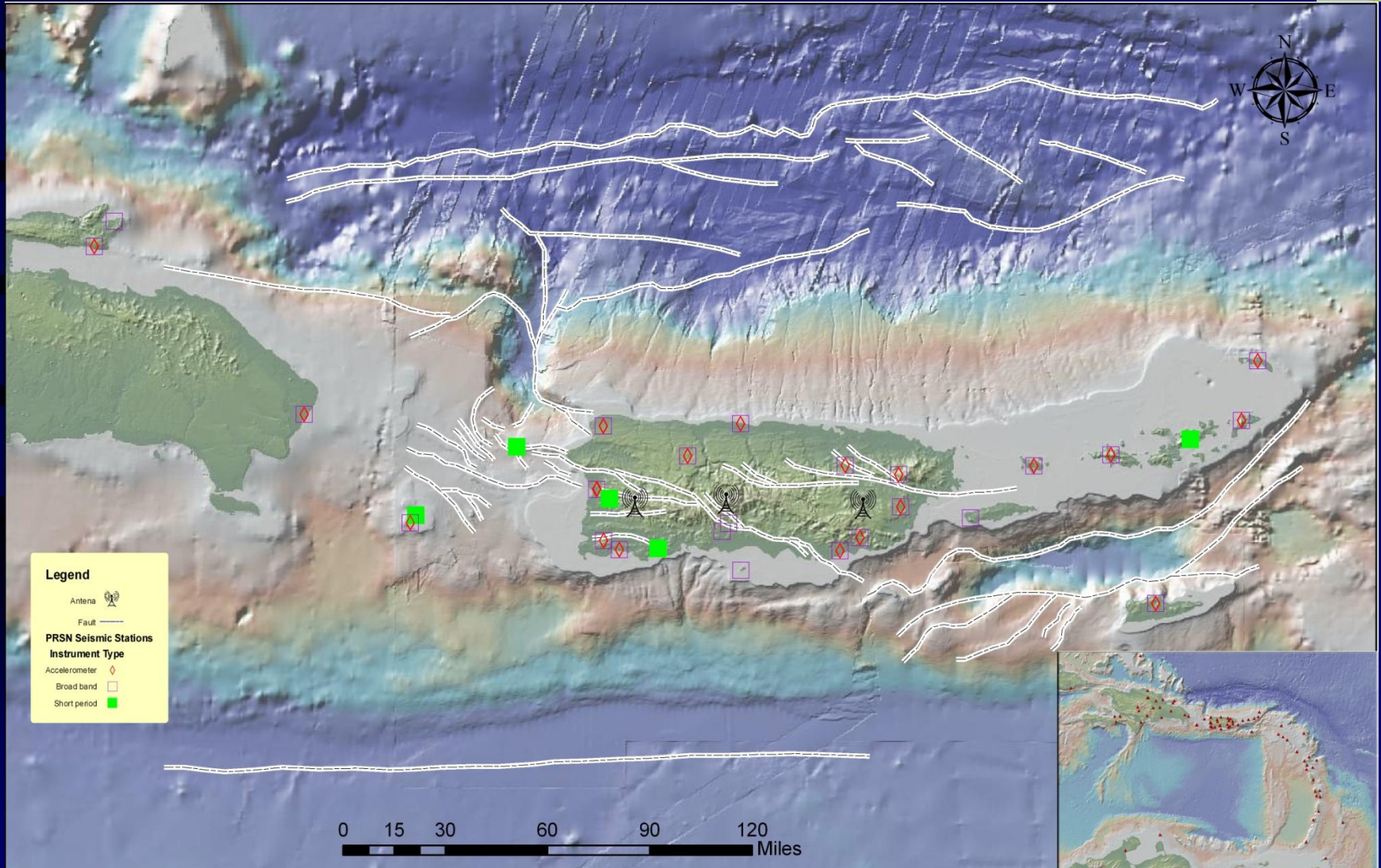
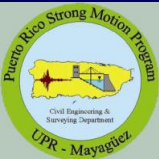
José A. Martínez-Cruzado.	-PRSMP Director
Carlos I. Huerta-López.	-Seismologist

## Engineering surveying/Geodesy:

Linda A. Velez.	Group-leader
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# PUERTO RICO SEISMIC NETWORK (PRSN)



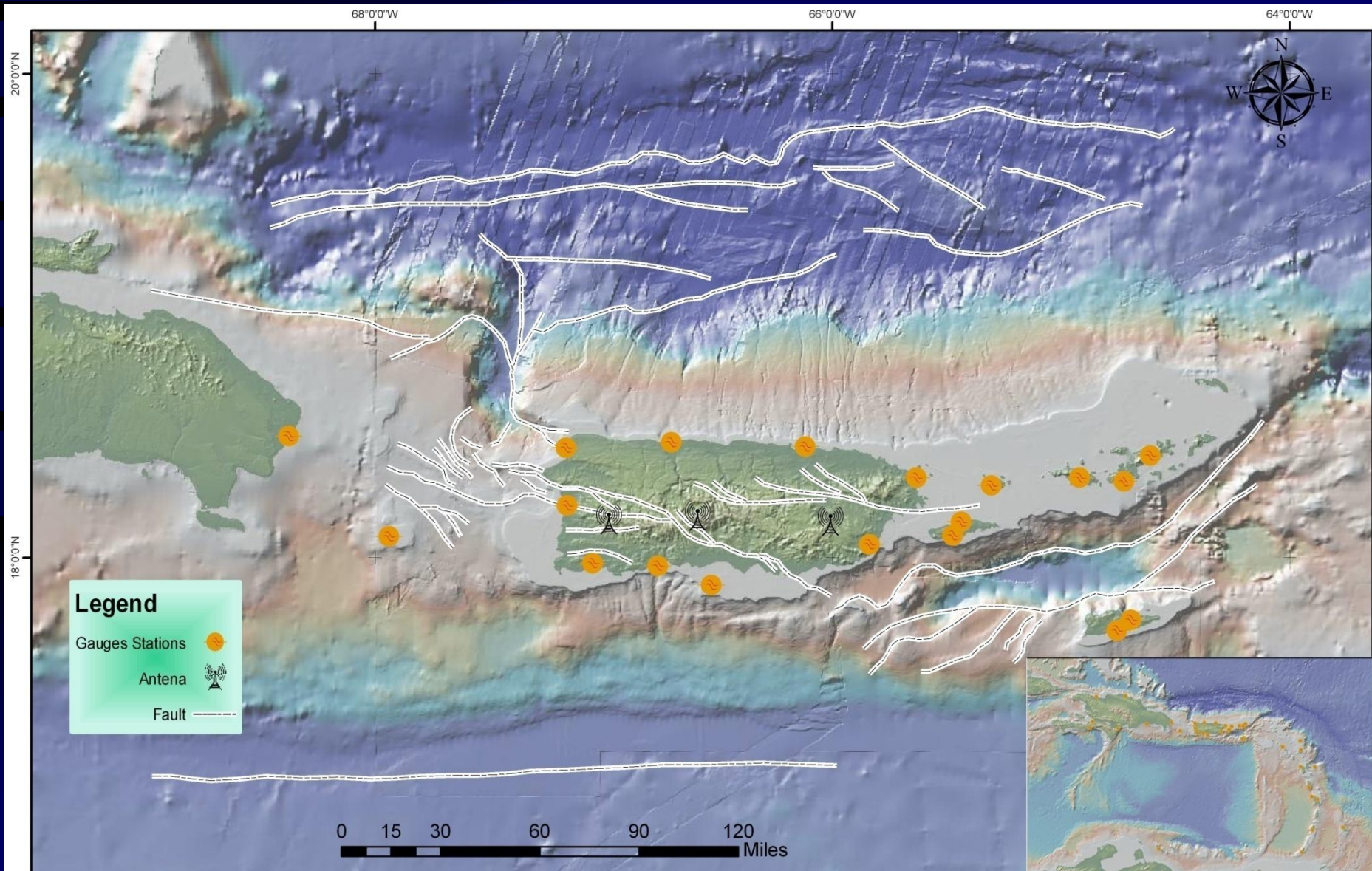


# PRSN/GPS/TG

## □ PUERTO RICO SEISMIC NETWORK (PRSN)

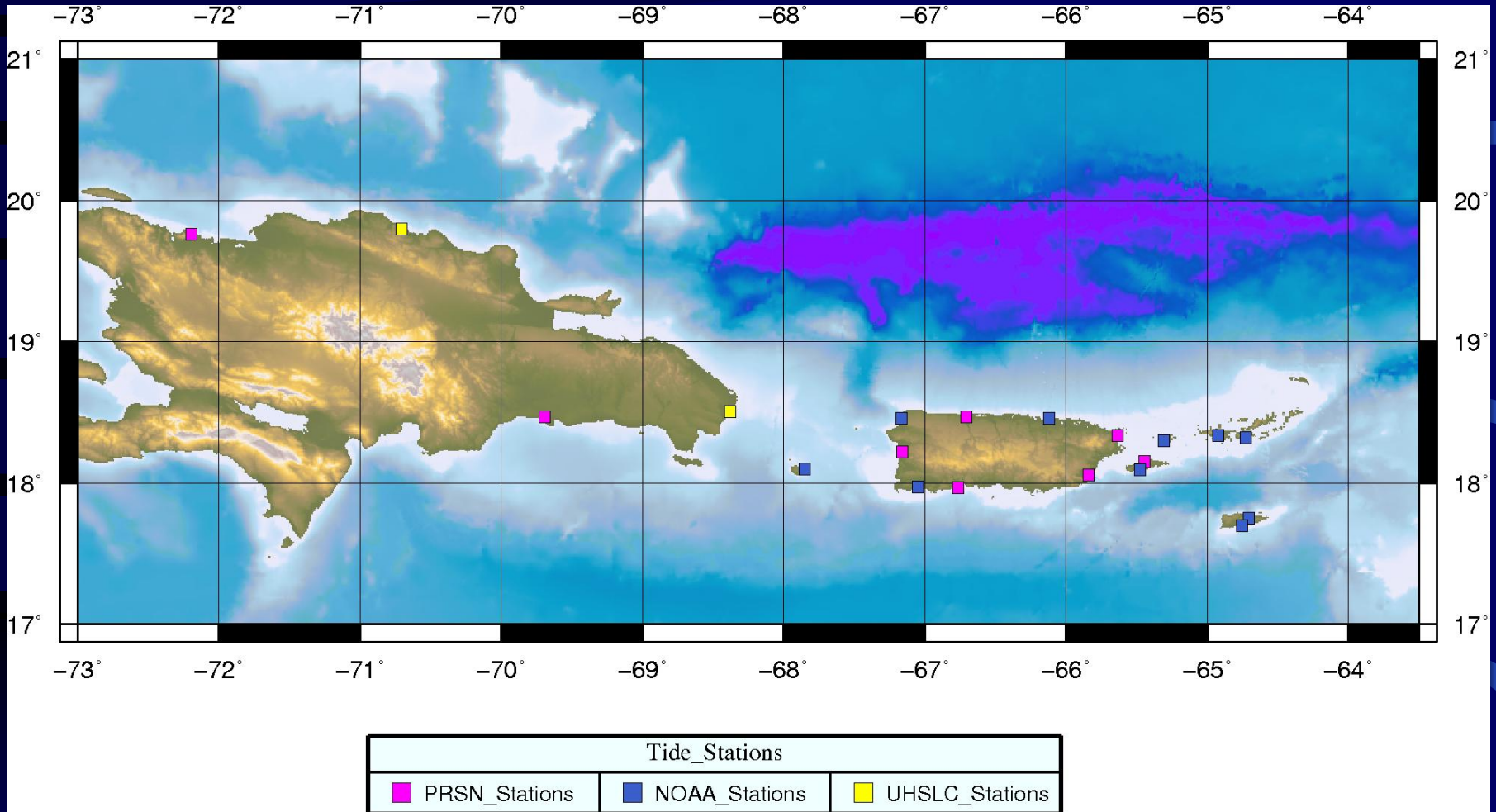
- Provides earthquake parameters in the Puerto Rico and Virgin Islands (PRVI), Area of Responsibility, AOR (17.0N-20.0N, 63.5W-69.0W).
- The mission is to monitor (24/7) and rapidly determine/disseminate earthquake parameters (local, regional, or tele-seismic), and support National Tsunami Warning Center (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.

# PRSN - Tide-gauge





# PRSN Sea-Level Monitoring Stations



- Tide Gauges for Tsunami monitoring system
- Over 15 Installed locally and thru the Virgin Island
- Reference points for the ETAS

# CTWC

“Providing regional service, strengthening local capabilities...”

- 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 1st 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



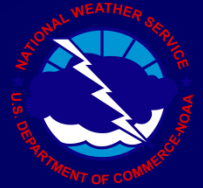




# Caribbean Sea Level Monitoring Stations

NOAA NWS Caribbean Tsunami Warning Program

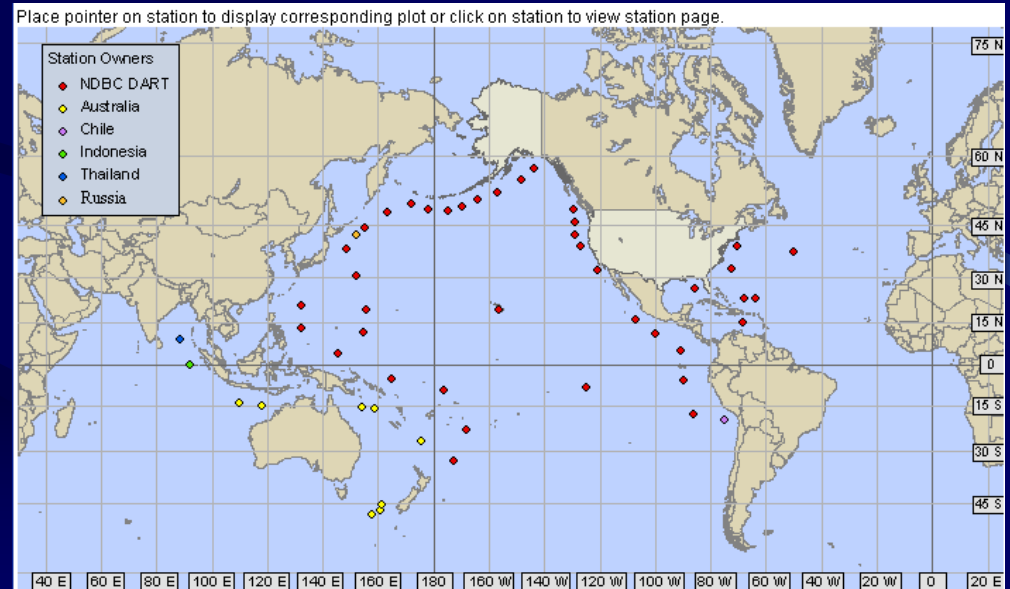
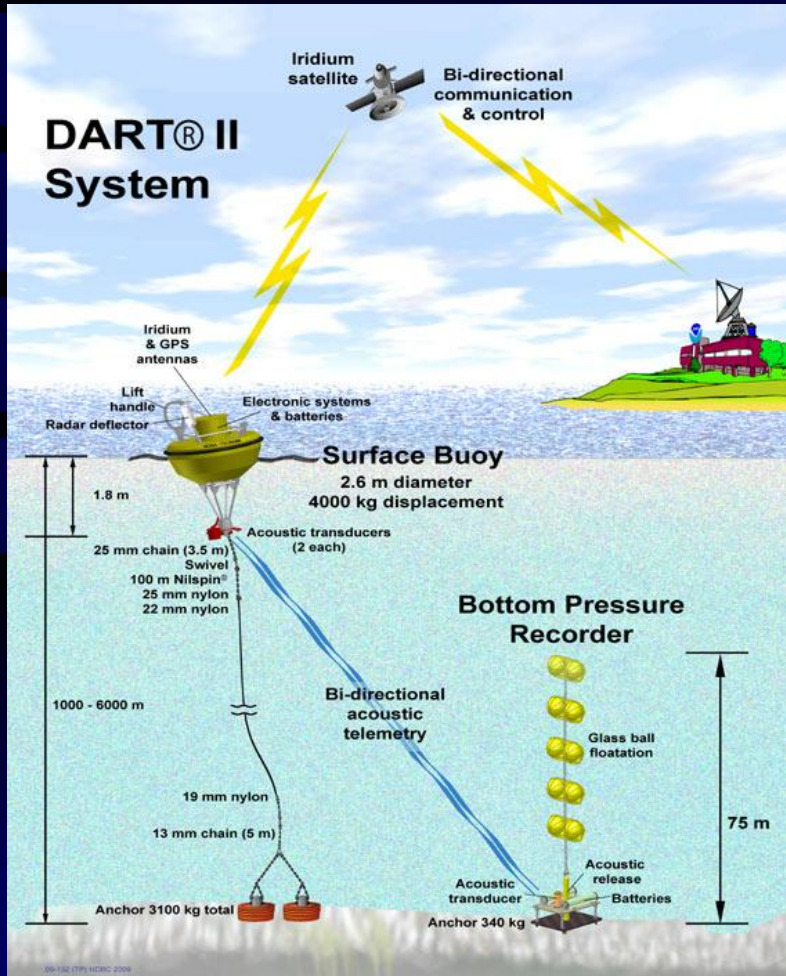
<http://www.srh.noaa.gov/srh/ctwp/>



● Contributing, ● Contributing RTX (DART), ● Existing, ● Gap, ● Planned, ● Non Operational/Unknown

# DART<sup>®</sup>

## Deep-Ocean Assessment and Reporting of Tsunamis





# NOAA Tides & Currents

NOAA NOS/CO-OPS ODIN Observational Data Interactive Navigation

Search for station (Prelim. Data)

Zoom to region: All East Coast

Require data type: Prelim. Data

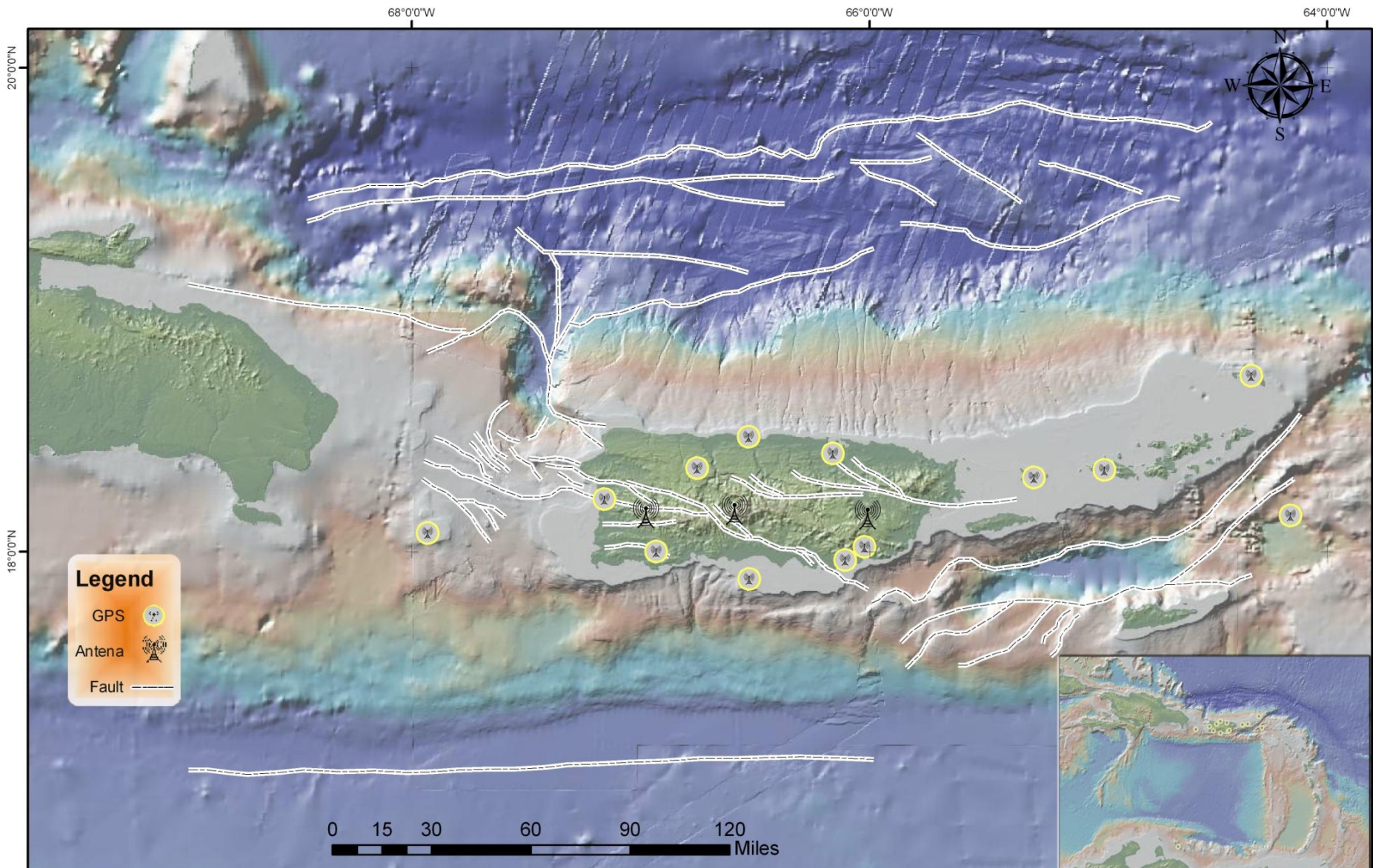
East Coast Gulf Coast West Coast Alaska Pacific Great Lakes Caribbean

Name	ID
Bermuda Esso Pier	2695540
XML	WL VER WL PRED MET OBS
Sewells Point	8638610
XML	WL VER WL PRED MET OBS
Chesapeake Bay Bridge...	8638863
XML	WL VER WL PRED MET OBS
Money Point	8639348
XML	WL VER WL PRED MET OBS
Duck	8651370
XML	WL VER WL PRED MET OBS
Oregon Inlet Marina	8652587
XML	WL VER WL PRED MET OBS
Uscg Station Hatteras	8654467
XML	WL VER WL PRED MET OBS
Beaufort	8656483
XML	WL VER WL PRED MET OBS
Wilmington	8658120
XML	WL VER WL PRED MET OBS
Wrightsville Beach	8658163
XML	WL VER WL PRED MET OBS
Springmaid Pier	8661070
XML	WL VER WL PRED MET OBS
Oyster Landing (N. In...	8662245
XML	WL VER WL PRED MET OBS
Charleston	8665530
XML	WL VER WL PRED MET OBS
Ciarendon Plantation	8667633
XML	WL VER WL PRED MET OBS
Fort Pulaski	8670870
XML	WL VER WL PRED MET OBS

Web site owner: Center for Operational Oceanographic Products & Services (CO-OPS) | National Ocean Service (NOS)  
National Oceanic and Atmospheric Administration | U.S. Department of Commerce | Privacy Policy  
Metadata : Water Level | Metadata : Sea Level Trends | Metadata : Currents

[http://tidesandcurrents.noaa.gov/station\\_retrieve.shtml?type=Tide+Data](http://tidesandcurrents.noaa.gov/station_retrieve.shtml?type=Tide+Data)

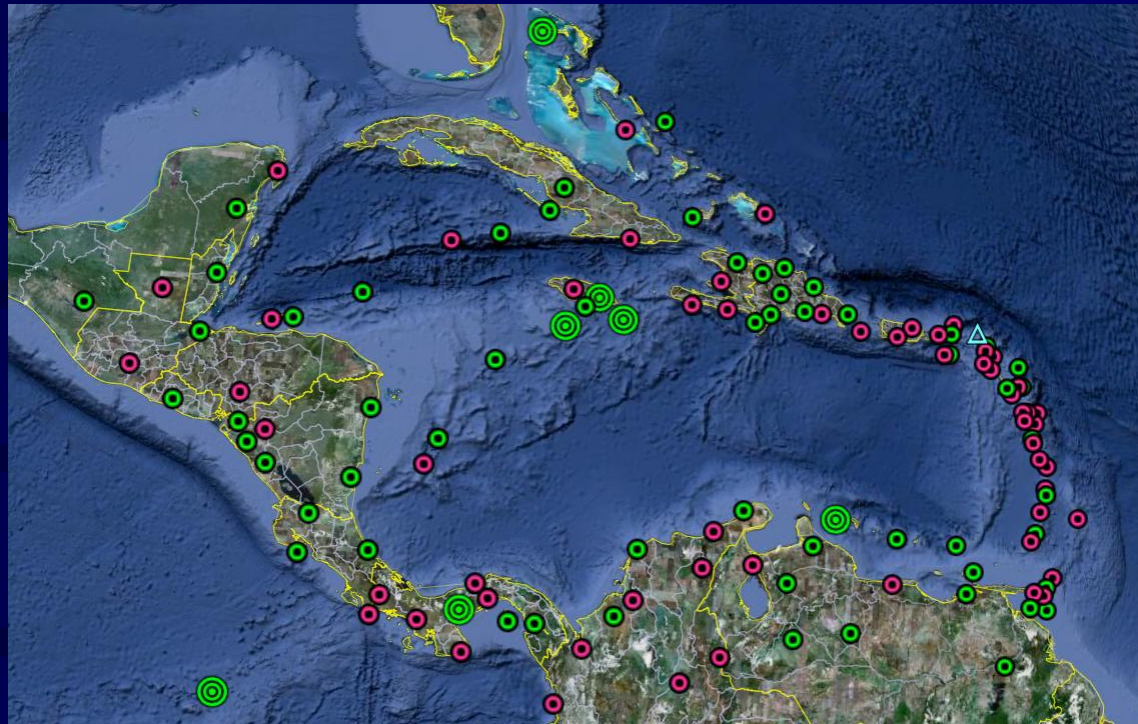
# PRSN - GPS





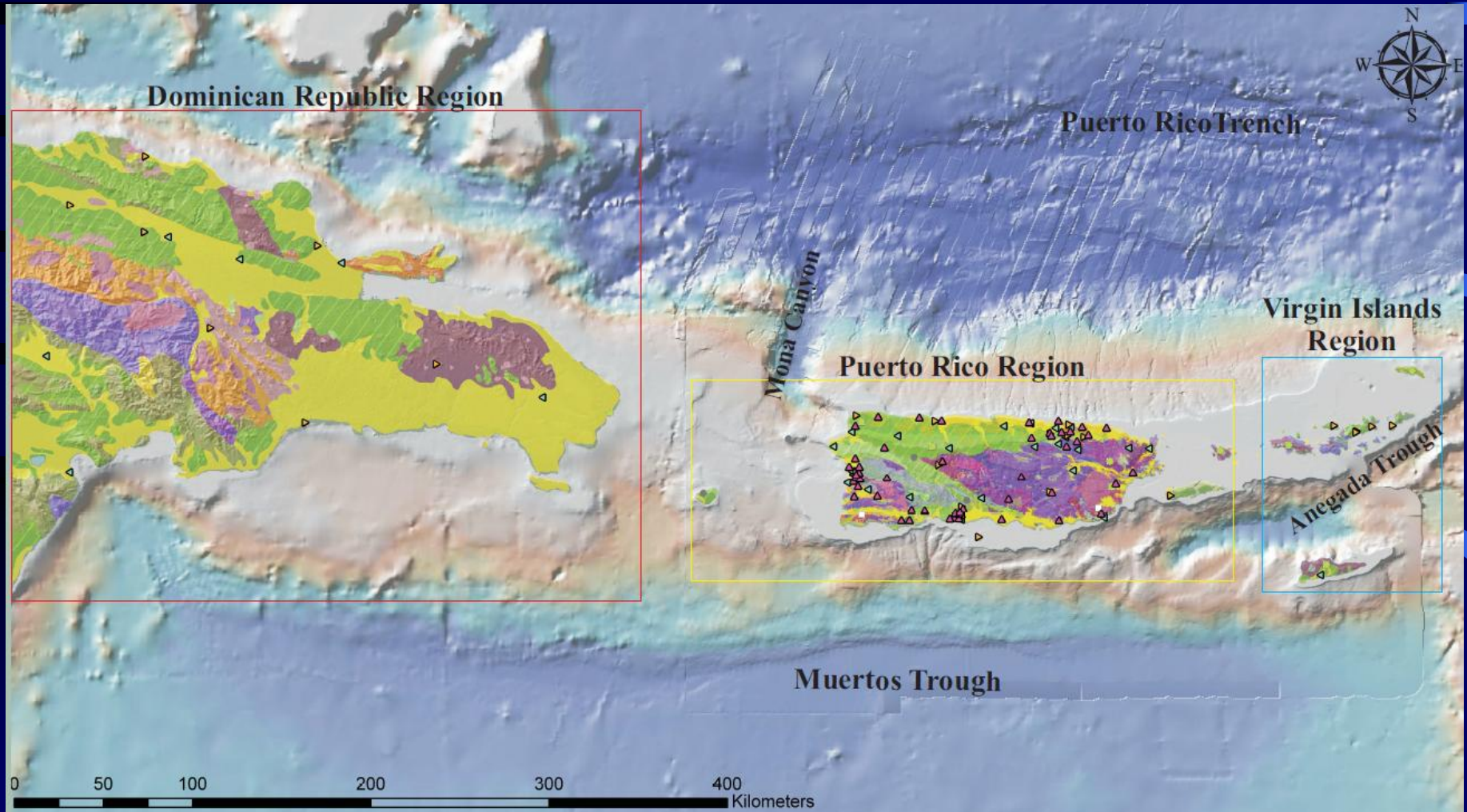
# COCONet Project NSF/UNAVCO/2.5 M US\$

- 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 Sombbrero Island. Large green dots represent the seven completed COCONet stations to date.

# PUERTO RICO STRONG MOTION SEISMIC NETWORK (PRSMMP)





# PRSMMP

- ❑ THE PUERTO RICO STRONG MOTION SEISMIC NETWORK (ACTUALLY PUERTO RICO STRONG MOTION PROGRAM, PRSMMP) has grown since 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.

# PRSMMP

- ❑ 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.

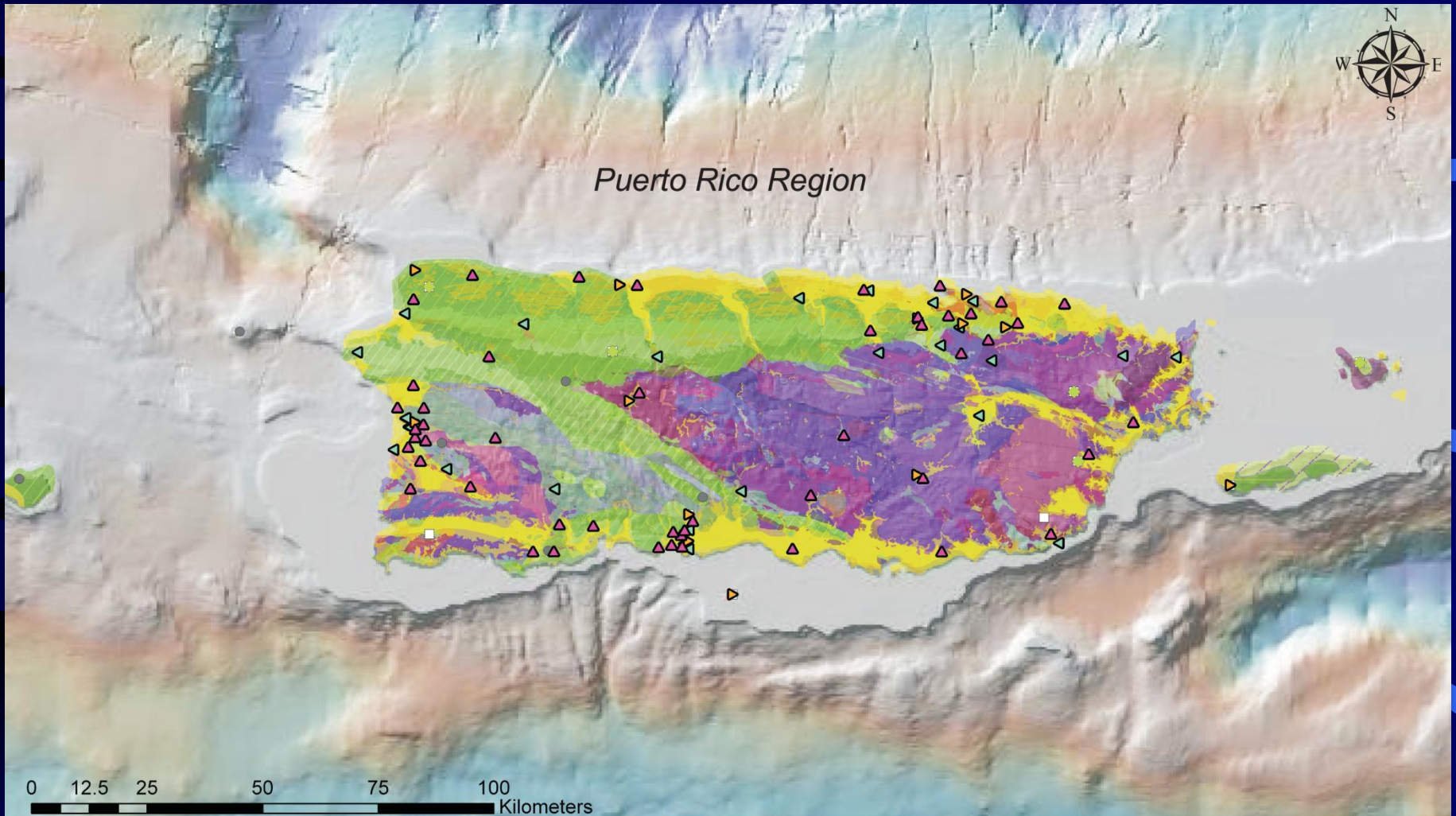


## □ PRSMP STATUS:

- 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 Stations**

- ▲ Stand-Alone
- ▶ IP
- ◀ Stand-Alone

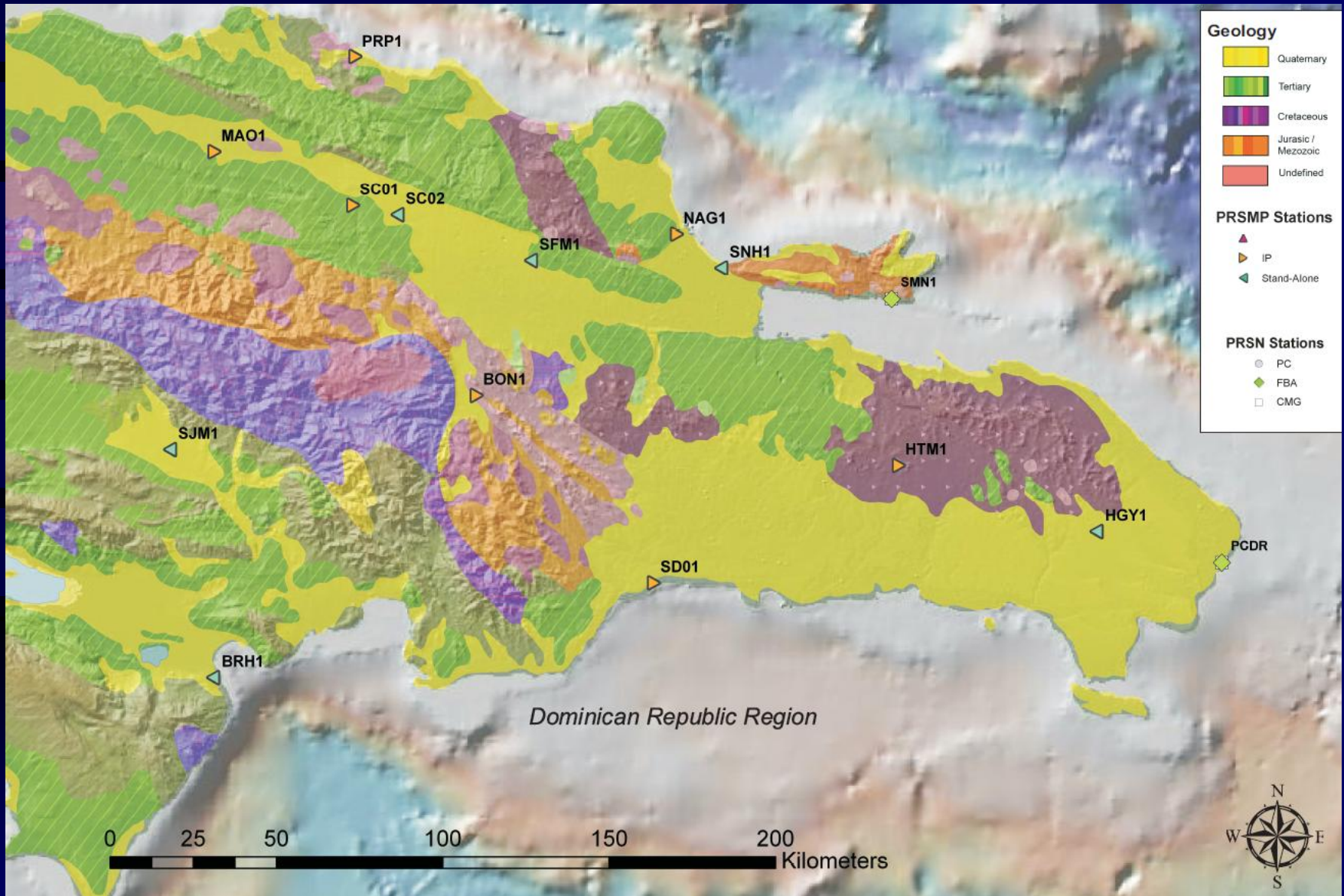
**PRSN Stations**

- PC
- ◆ FBA
- CMG

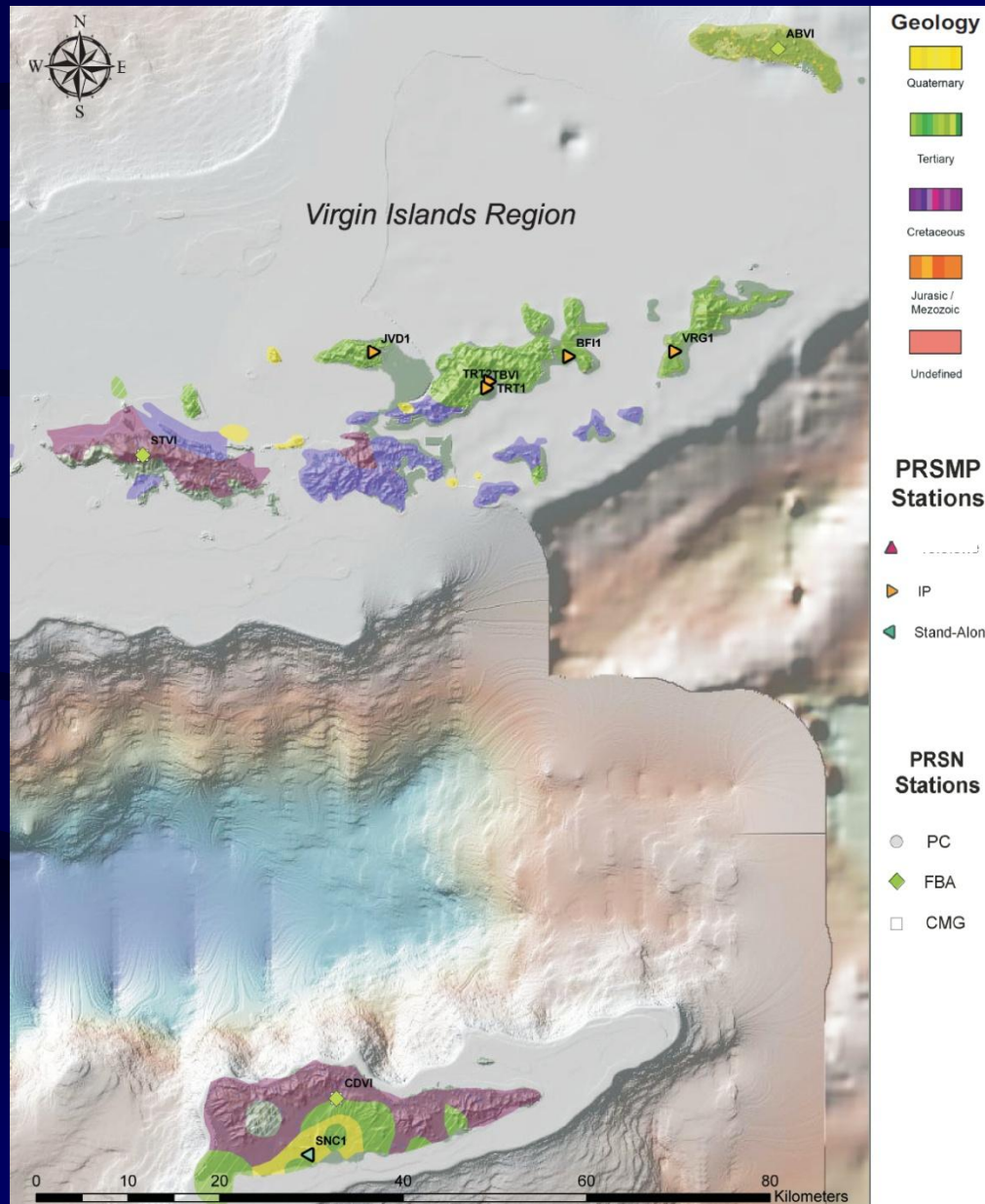
**Geology**

- |  |   |  |
|--|---|--|
| <span style="background-color: yellow; width: 15px; height: 10px; display: inline-block;"></span> Quaternary | <span style="background-color: purple; width: 15px; height: 10px; display: inline-block;"></span> Cretaceous          | <span style="background-color: red; width: 15px; height: 10px; display: inline-block;"></span> Undefined |
| <span style="background-color: green; width: 15px; height: 10px; display: inline-block;"></span> Tertiary    | <span style="background-color: orange; width: 15px; height: 10px; display: inline-block;"></span> Jurassic / Mesozoic |  |















# PRISMP NETWORK ADMINISTRATOR

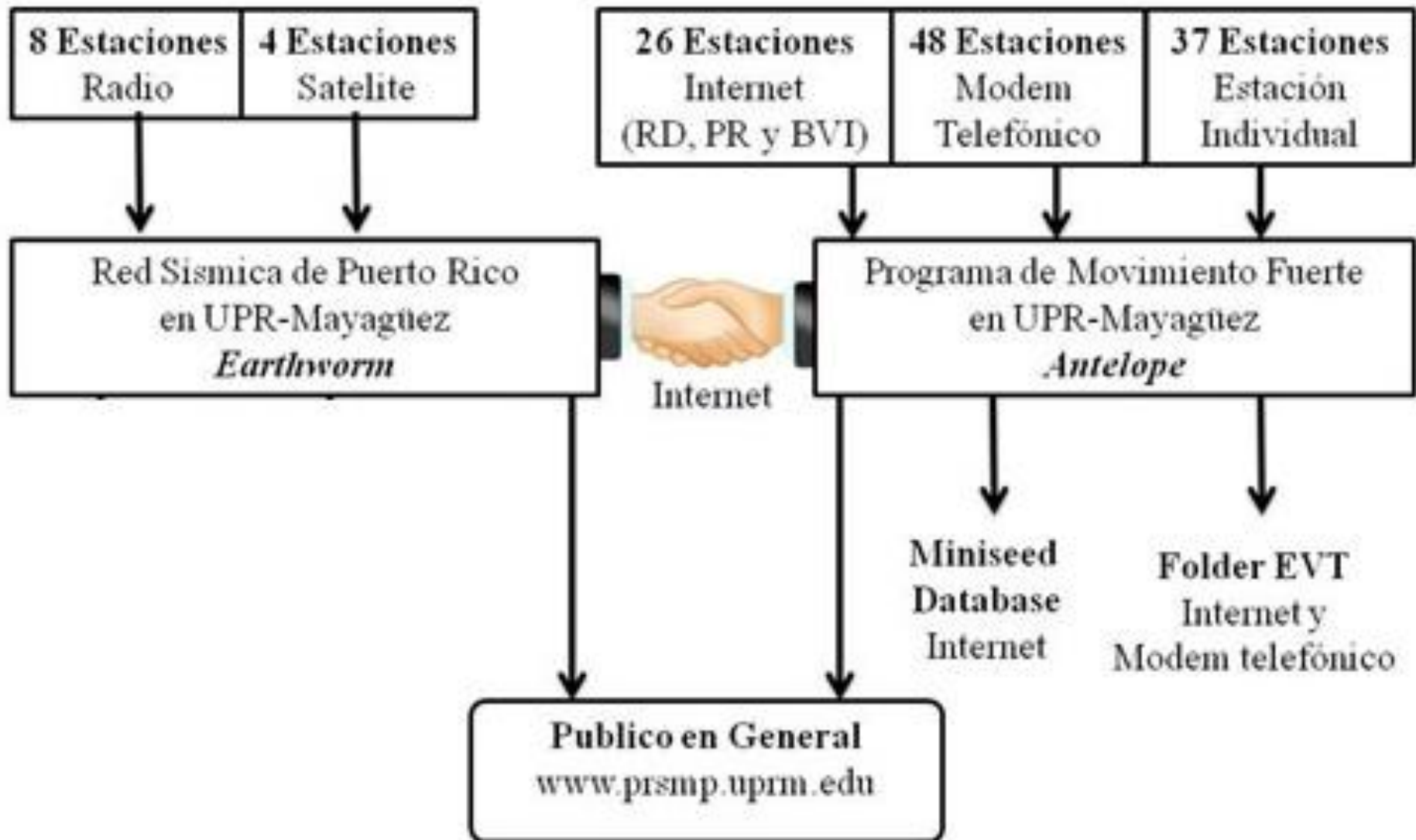
- ❑ ANTELOPE 5.3 (BRTT. Three nodes license)
  - Run in Dell/PowerEdge servers (At: UPRM/PRISMP)
  - Operative System, CentOS 6.2
  - UPRM Internet Communication/PRISMP sector: 136:145:117:
  - Firewalls: UPRM, PRISMP, Servers
  - Automatic power generator backup
  
- ❑ EARTHWORM 7.7 (Public domain)
  - Run in Dell/PowerEdge servers (At: UPRM/PRISMP)
  - Run in Dell/Precision Workstations (At: BVI, AEE)
  - Operative System, CentOS 6.2
  - UPRM Internet Communication/PRISMP sector: 136:145:117:
  - Firewalls : UPRM, PRISMP, Servers
  - Automatic power generator backup

# STATION/DATA COMMUNICATION

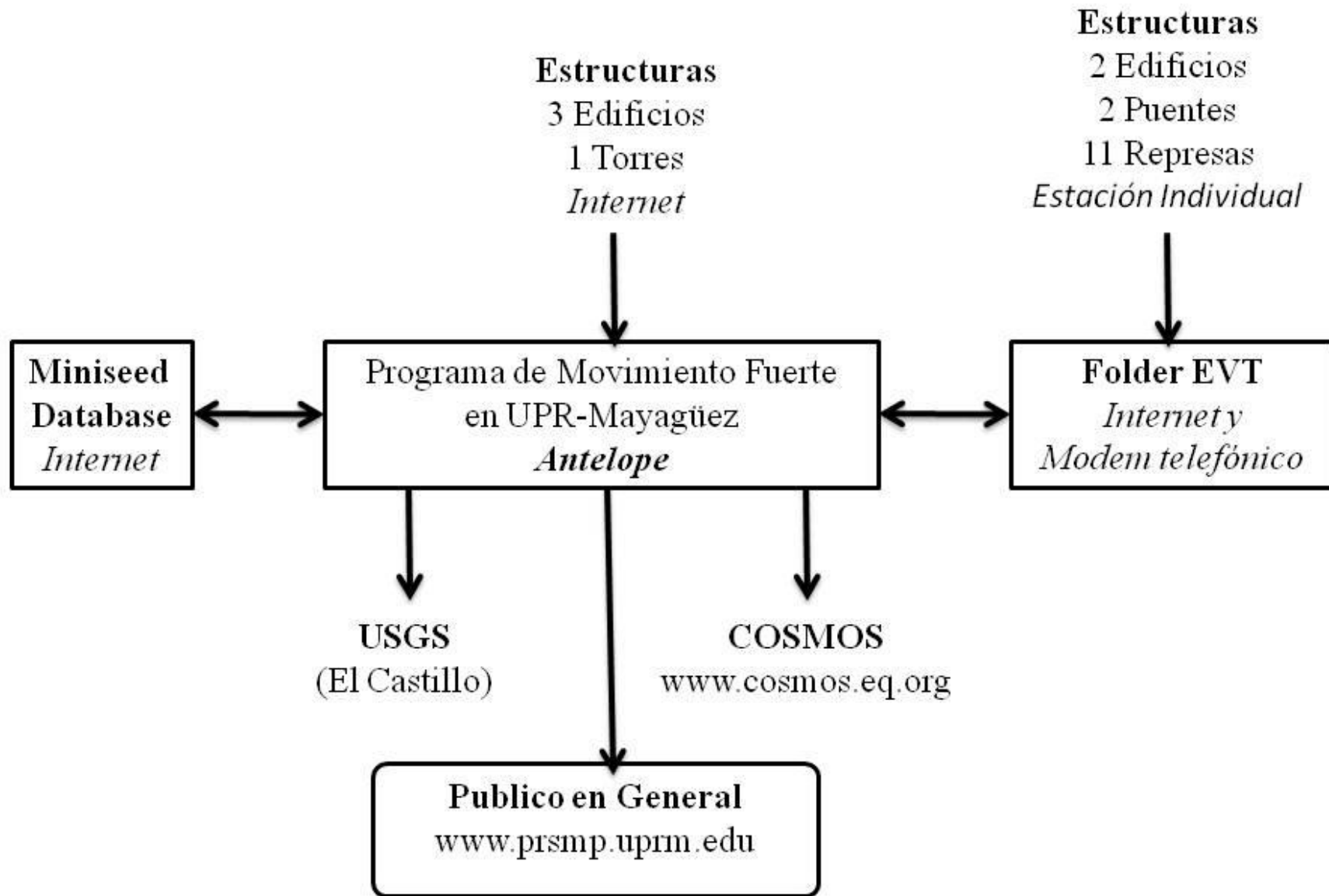
- ❑ ANTELOPE (PRSMP-PRI. FREE FIELD, FF & STRUCT. ST)
  - Via Internet/IP Lantronix, ETNA/K2 (10-IP FF)
  - Telephone Line/Modem (49-DU FF)
  - Stand Alone (27-SA FF)
  - Structures (16-SA ST)
  
- ❑ EARTHWORM (PRSMP-BVI: FREE FIELD, FF & STRUCT. ST)
  - Via Internet/IP Lantronix ETNA (5-IP FF)
  - Via 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)



# FREE-FIELD STATIONS

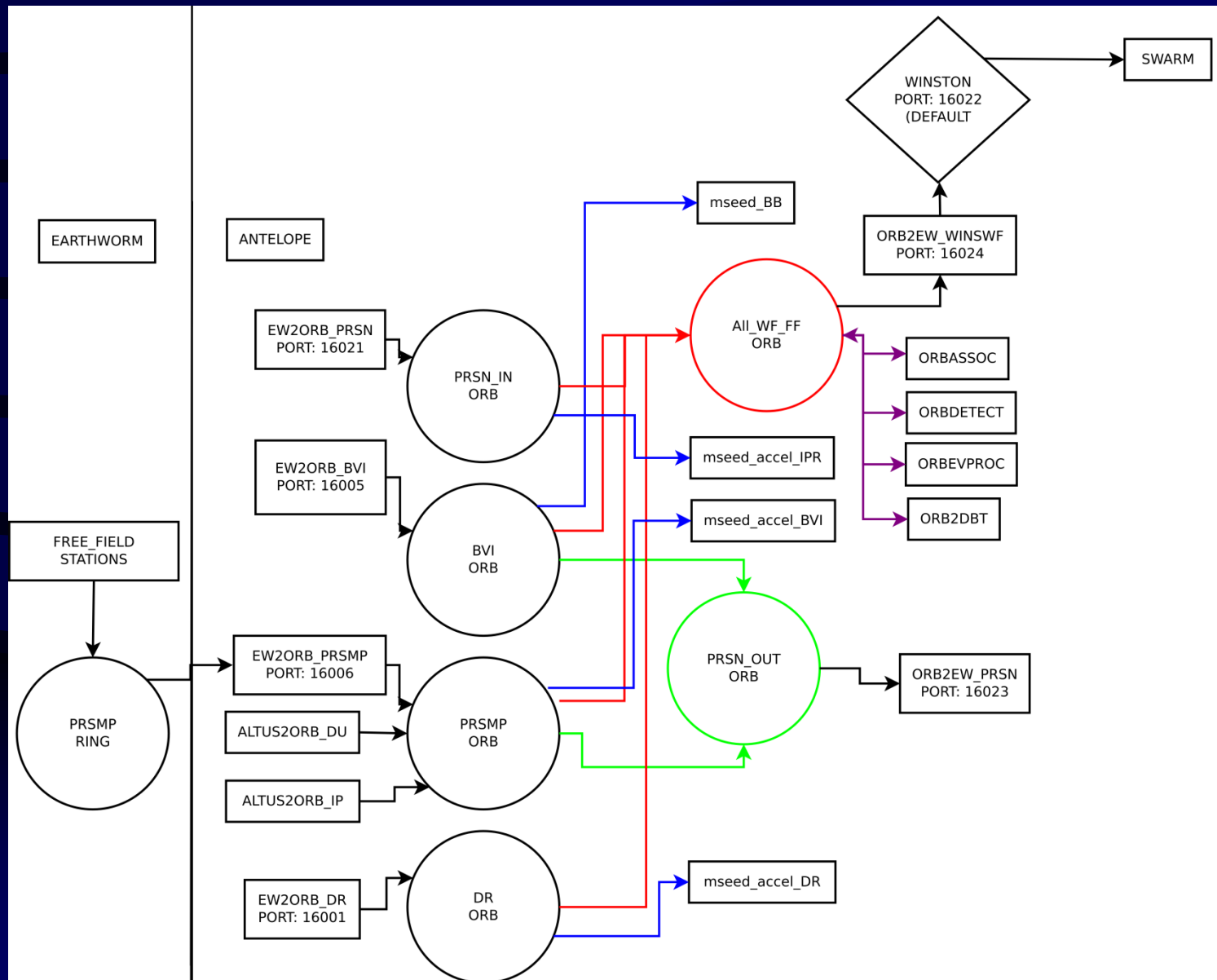


# STRUCTURES





# DATA PROCESSING



# STRONG MOTION DATA PROCESSING

- ❑ Standard strong motion signal processing (SMA-Kinematics 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.



# UNIVERSITY OF PUERTO RICO

## 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](mailto: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)**

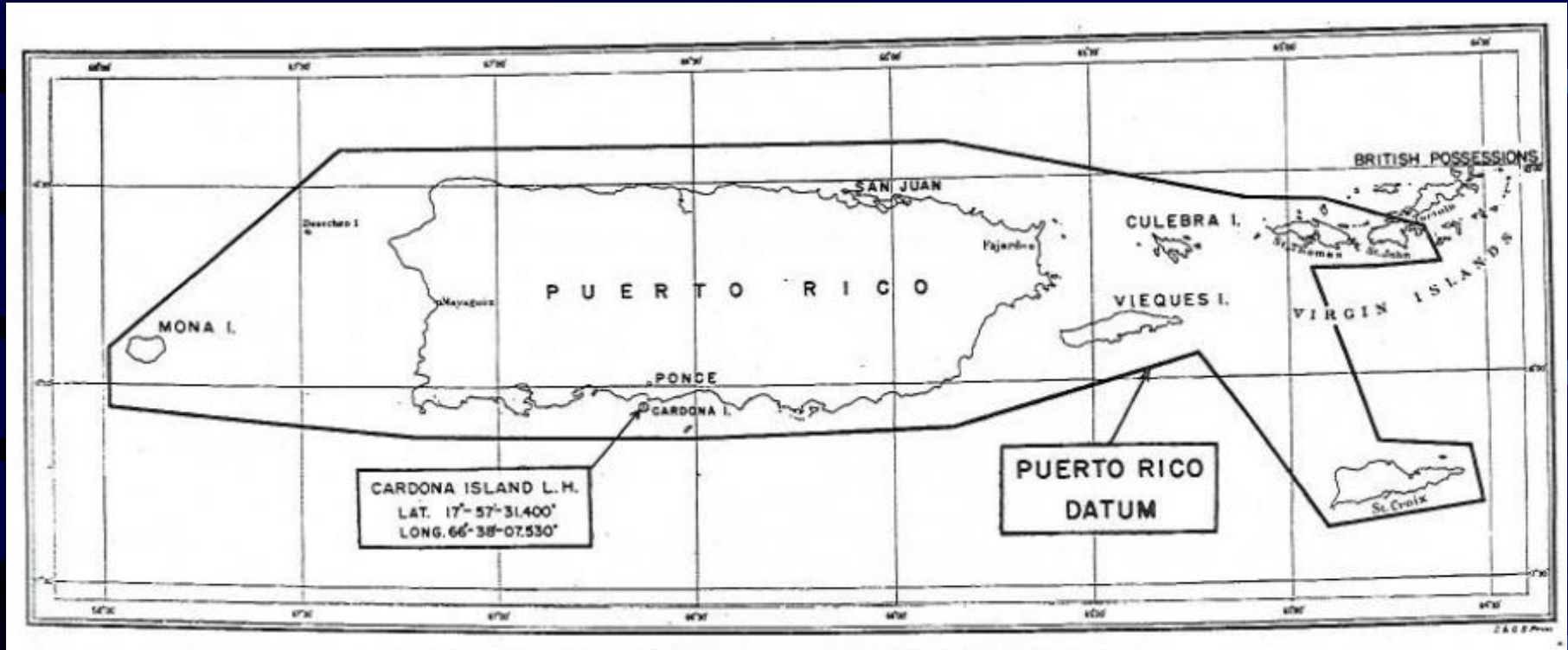
**Epoch 2010.0 – Elipsoide GRS80**

**Puerto Rico Vertical Datum of 2002 – Origen  
en La Puntilla, Viejo San Juan**





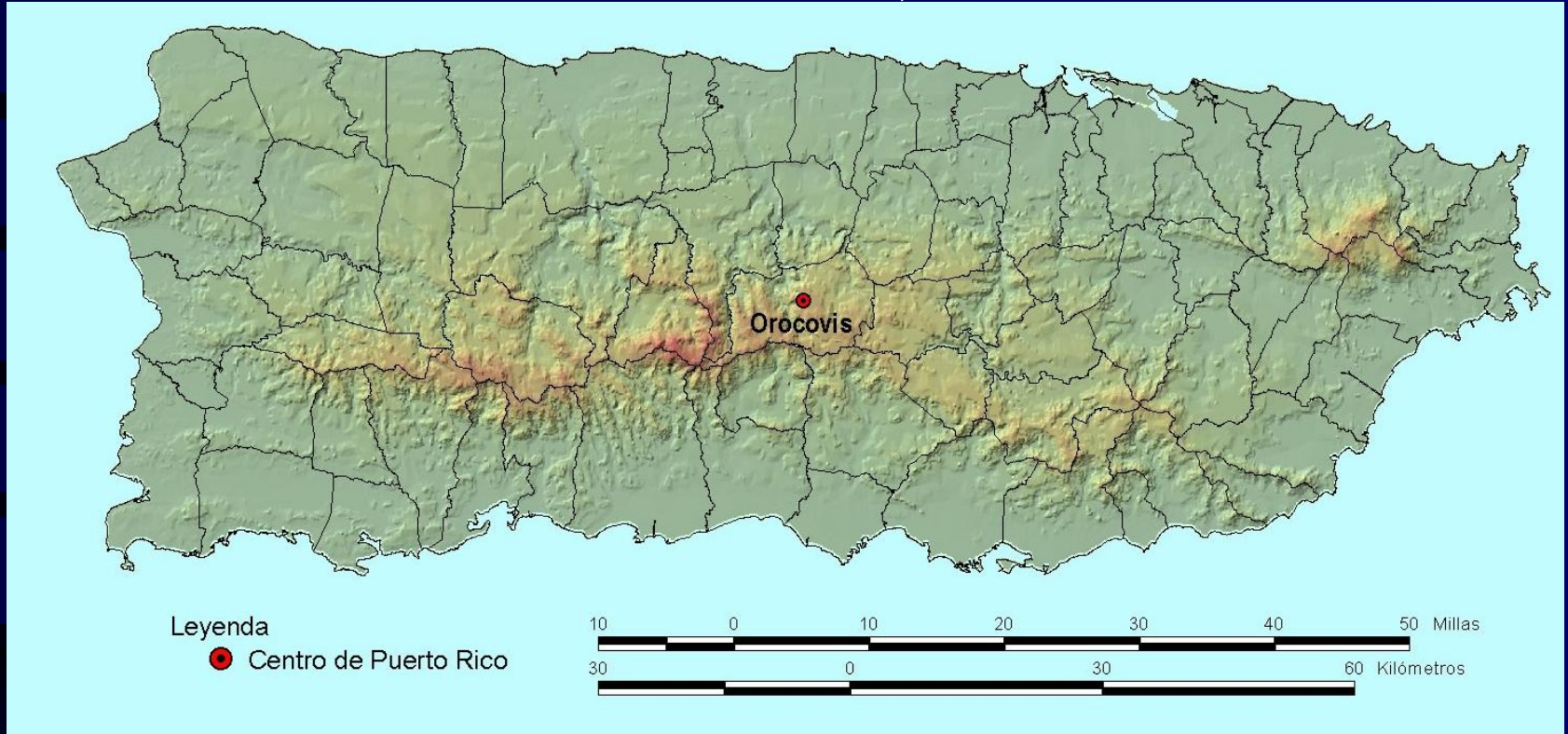
# Puerto Rico Datum del 1901



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, Estacin Damian



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





# Puerto Rico Vertical Datum of 2002

## National Oceanic and Atmospheric Administration

### Affirmation of Vertical Datum for Surveying and Mapping Activities for the Territory of Puerto Rico

**AGENCY:** National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration, Commerce.

**ACTION:** Notice.

**SUMMARY:** This Notice announces a decision by the Federal Geographic Data Committee's Federal Geodetic Control Subcommittee in accordance with the Office of Management and Budget, Circular A-16 (<http://www.whitehouse.gov/omb/circulars/a016/a016.html>), to affirm the Puerto Rico Vertical Datum of 2002 (PRVD02) as the official civilian vertical datum for surveying and mapping activities for the islands of Puerto Rico, Culebra, Mona and Vieques of the Commonwealth of Puerto Rico and to the extent practicable, legally allowable and feasible, require that all Federal agencies, with the exception of those with specific military related applications, using or producing vertical height information undertake an orderly transition to PRVD02.

physiological effects. For pinnipeds, the absence of any major rookeries and only a few isolated and opportunistic haul-out areas near or adjacent to the project site means that potential takes by disturbance would have an insignificant short-term effect on individuals and would not result in population-level impacts. Similarly, for cetacean species the absence of any known rookery occurrence adjacent to the project site means that potential takes by disturbance would have an insignificant short-term effect on individuals and would not result in population-level impacts. Due to the nature, degree, and context of behavioral harassment anticipated, the activity is not expected to impact rates of recruitment or survival.

While the number of marine mammals potentially incidentally harassed would depend on the distribution and abundance of marine mammals in the vicinity of the survey activity, the number of potential harassment takings is estimated to be small relative to regional stock or population number, and has been mitigated to the lowest level practicable through incorporation of the mitigation and monitoring measures mentioned previously in this document. This activity is expected to result in a negligible impact on the affected species or stocks.

Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the mitigation and monitoring measures, NMFS finds that the proposed wharf construction project would result in the incidental take of small numbers of marine mammals, by Level B harassment only, and that the total taking from the activity would have a negligible impact on the affected species or stocks.

**Impact on Availability of Affected Species or Stock for Taking for Subsistence Uses**  
No tribal subsistence hunts are held in the vicinity of the project area; thus, temporary behavioral impacts to individual animals would not affect any subsistence activity. Further, no population or stock level impacts to marine mammals are anticipated or authorized. As a result, no impacts to the availability of the species or stock to the Pacific Northwest treaty tribes are expected as a result of the activities. Therefore, no relevant subsistence uses of marine mammals are implicated by this action.

**Determinations**  
We have determined that the impact of conducting the specific activities described in this notice and in the IHA request in the specific geographic region in the Hood Canal, Washington may result, at worst, in a temporary modification in behavior (Level B harassment) of small numbers of marine mammals. Further, this activity is expected to result in a negligible impact on the affected species or stocks of marine mammals. The provision requiring that the activity not have an unmitigable impact on the availability of the affected species or stock of marine mammals for subsistence uses is not implicated for this action.

#### Endangered Species Act (ESA)

There are two ESA-listed marine mammal species with known occurrences in the project area: the eastern DPS of the Steller sea lion, listed as threatened, and the humpback whale, listed as endangered. Because of the potential presence of these species, the Navy requested a formal consultation with the NMFS Northwest Regional Office under section 7 of the ESA. NMFS' Office of Protected Resources also initiated formal consultation on its authorization of incidental take of Steller sea lions. These consultations are complete, with the determination that these activities are not likely to jeopardize the continued existence of the threatened Steller sea lion and are not likely to adversely affect humpback whales. These species do not have critical habitat in the action area.

#### National Environmental Policy Act (NEPA)

In compliance with the National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.), as implemented by the regulations published by the Council on Environmental Quality (40 CFR parts 1500-1508), and NOAA Administrative Order 216-6, the Navy prepared an Environmental Assessment (EA) to consider the direct, indirect and cumulative effects to the human environment resulting from the pile replacement project. We adopted that EA in order to assess the impacts to the human environment of issuance of an IHA to the Navy and signed a Finding of No Significant Impact (FONSI) on May 17, 2011. On the basis of new information related to the occurrence of marine mammals in the Hood Canal, the Navy prepared a supplement to that EA. We have adopted that supplemental EA and signed a new FONSI on July 11, 2012.

**Determinations**  
We have determined that the impact of conducting the specific activities described in this notice and in the IHA request in the specific geographic region in the Hood Canal, Washington may result, at worst, in a temporary modification in behavior (Level B harassment) of small numbers of marine mammals. Further, this activity is expected to result in a negligible impact on the affected species or stocks of marine mammals. The provision requiring that the activity not have an unmitigable impact on the availability of the affected species or stock of marine mammals for subsistence uses is not implicated for this action.

#### Authorization

As a result of these determinations, we have issued an IHA to the Navy to conduct the described activities in the Hood Canal from the period of July 16, 2012, through February 15, 2013, provided the previously described mitigation, monitoring, and reporting requirements are incorporated.

Dated: July 23, 2012.

**Heidi M. Gade,**  
Acting Director, Office of Protected Resources,  
National Marine Fisheries Service.  
(PR) (66) 2012-17038 (1007 7-20-12; 8:45 am)  
BILLING CODE 8010-01-P

#### DEPARTMENT OF COMMERCE

##### National Oceanic and Atmospheric Administration

##### Affirmation of Vertical Datum for Surveying and Mapping Activities for the Territory of Puerto Rico

**AGENCY:** National Geodetic Survey (NGS), National Ocean Service (NOS), National Oceanic and Atmospheric Administration, Commerce.

#### ACTION:

**NOTICE:**  
**SUMMARY:** This Notice announces a decision by the Federal Geographic Data Committee's Federal Geodetic Control Subcommittee in accordance with the Office of Management and Budget, Circular A-16 (<http://www.whitehouse.gov/omb/circulars/a016/a016.html>), to affirm the Puerto Rico Vertical Datum of 2002 (PRVD02) as the official civilian vertical datum for the Territory of Puerto Rico, Culebra, Mona and Vieques of the Commonwealth of Puerto Rico and to the extent practicable, legally allowable and feasible, require that all Federal agencies, with the exception of those with specific military related applications, using or producing vertical height information undertake an orderly transition to PRVD02.

**DATES:** Individuals or organizations wishing to submit comments on the adoption of PRVD02 as the official civilian vertical datum for the Territory of Puerto Rico, which includes the islands of Puerto Rico, Culebra, Vieques, and Mona, should do so by August 22, 2012.  
**ADDRESSES:** Written comments should be sent to the attention of David Doyle, Chief Geodetic Surveyor, Office of the National Geodetic Survey, National Ocean Service (NOS), 1315 East-West Highway, #6815, Silver Spring, Maryland, 20910, fax 301-713-4324, or via email [Dave.Doyle@noaa.gov](mailto:Dave.Doyle@noaa.gov).

**FOR FURTHER INFORMATION CONTACT:**  
Requests for additional information should be directed to David Doyle, Chief Geodetic Surveyor, National Geodetic Survey (NOS), 1315 East-West Highway, #6815, Silver Spring, MD, 20910; Phone: (301) 713-3178.

**SUPPLEMENTARY INFORMATION:** The National Ocean Service (NOS), National Geodetic Survey (NGS), has completed the definition and implementation of PRVD02. PRVD02 supersedes all previously published height systems determined by other Federal surveying and mapping agencies on Puerto Rico, Culebra, Vieques and Mona, with the exception of those specifically related to tidal datums and/or military applications. PRVD02 heights are the result of a mathematical least squares general adjustment of the vertical control position of the National Spatial Reference System (NSRS) and are derived from approximately 700 km of Double-Run, 1st-Order, Class II geodetic leveling observations (650 km on Puerto Rico, 5 km on Culebra and 45 km on Vieques) undertaken specifically for this project. The basis for all PRVD02 heights is Local Mean Sea Level, for the National Tidal Datum Epoch 1983-2001, as determined by the NOS Center for Operational Oceanographic Products and Services (CO-OPS), and published as part of the National Water Level Observation Network (NWLON) for bench marks designated 975 5271 A TIDAL (PD 171513) (1,324 meters), located at La Panilla, San Juan Puerto Rico, 975 2235 D (PD 1D8624) (0,972 meters), located on Culebra Island, 975 2655 A (PD 1D8535) (1,962 meters), located at Esperanza, Vieques Island, and 975 9938 A (1,158 meters) (PD 1D8596) on Mona Island. No leveling is planned for Mona Island; however this value serves as the datum definition for any further geodetic surveying that may be conducted there.

PRVD02 height information for individual geodetic control monuments is available in digital form, from the NOS Web site: <http://www.nos.noaa.gov/cgi-bin/datsheet.pl>.  
Dated: July 10, 2012.  
**Juliana P. Blackwell,**  
Director, Office of National Geodetic Survey,  
National Ocean Service, National Oceanic and Atmospheric Administration  
(PR) (DC) 2012-17040 (1007 7-20-12; 8:45 am)  
1 11 N O C O. 2012 8 P

#### COMMODITY FUTURES TRADING COMMISSION

##### Meeting, Technology Adv Committee

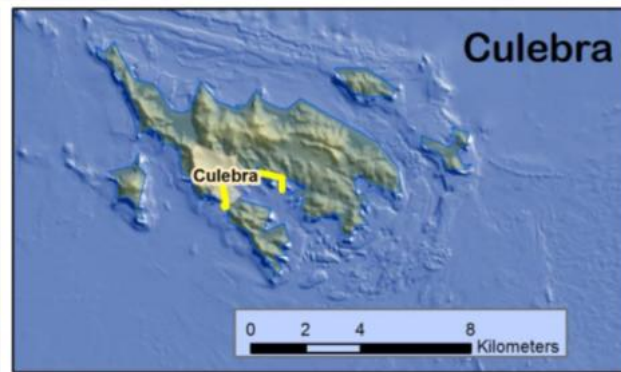
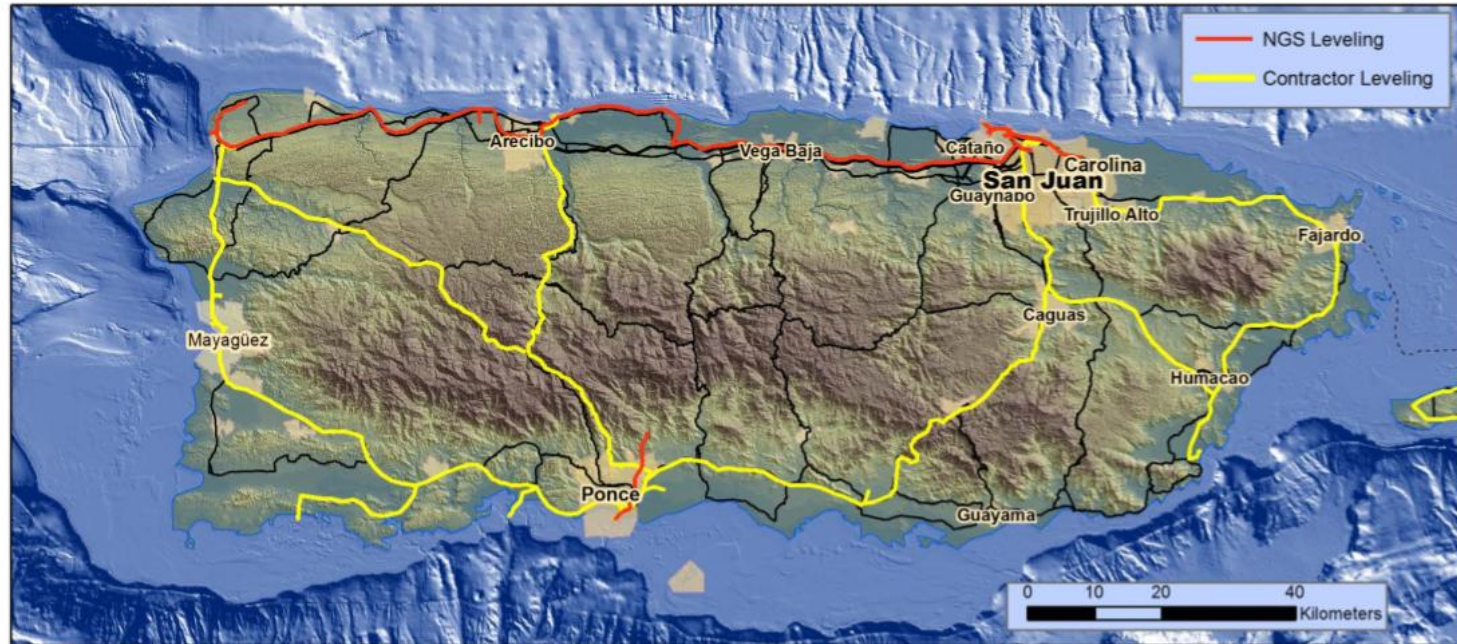
**AGENCY:** Commodity Futures Trading Commission (CFTC).

**ACTION:** Notice of emergency technology advisory committee meeting. The CFTC announces Thursday, July 26, 2012, at Technology Advisory Committee (TAC) will hold an emergency meeting at the CFTC's Was headquarters, from 10:00 a.m. to 12:00 p.m. The TAC will focus on technology solutions to, on things, enable futures commission merchant customers, self-organizations and the CFTI near real-time the accuracy amount of funds held in segregated accounts.

**DATES:** The meeting will be held on Thursday, July 26, 2012, from 10:00 a.m. to 12:00 p.m. Members of the public who wish to submit written statements with the meeting should do so by July 19, 2012.

**ADDRESSES:** The meeting will be held in the Conference Center at headquarters, Three Lafayette Square, 1155 21st Street NW, Washington, DC 20581. Written statements submitted to: Commodity Futures Trading Commission, Three Lafayette Square, 1155 21st Street NW, Washington, DC 20581, attention: Technology Advisory Committee. Any statements submitted with the committee meeting made available to the public for FURTHER INFORMATION (Lynn Cardy, Commodity Futures Trading Commission, Three Lafayette Square, 1155 21st Street NW, Washington, DC 20581, (202) 418-7200. **SUPPLEMENTARY INFORMATION:** Emergency meeting of the CFTC held in response to the July 10, 2012 complaint by Foreign Financial Group registered futures commission (FCM), and its owner, Russ Wansford, Sr., alleging his misappropriation of customer funds, and making false state financial statements filed a complaint. The filing of this complaint by the CFTC is earlier this month which is despite PFC's representative

# Puerto Rico Vertical Datum of 2002





# PRVD 2002 – VÉLEZ

## VERT ORDER - FIRST CLASS II



HORZ ORDER - B  
NAD 83(2002)-  
 $\phi=18\ 26' 41.28060''$  N  
 $\lambda=67\ 08' 48.93357''$  W



NAD 83(2011) Epoch 2010.00-  
 $\phi=18\ 26' 41.28162''$  N  
 $\lambda=67\ 08' 48.92893''$  W



PRVD02 - 134.320meters  
440.68feet





**Daniel Winester, Geodesta del National Geodetic Survey, y  
Juan A. Rodriguez.**

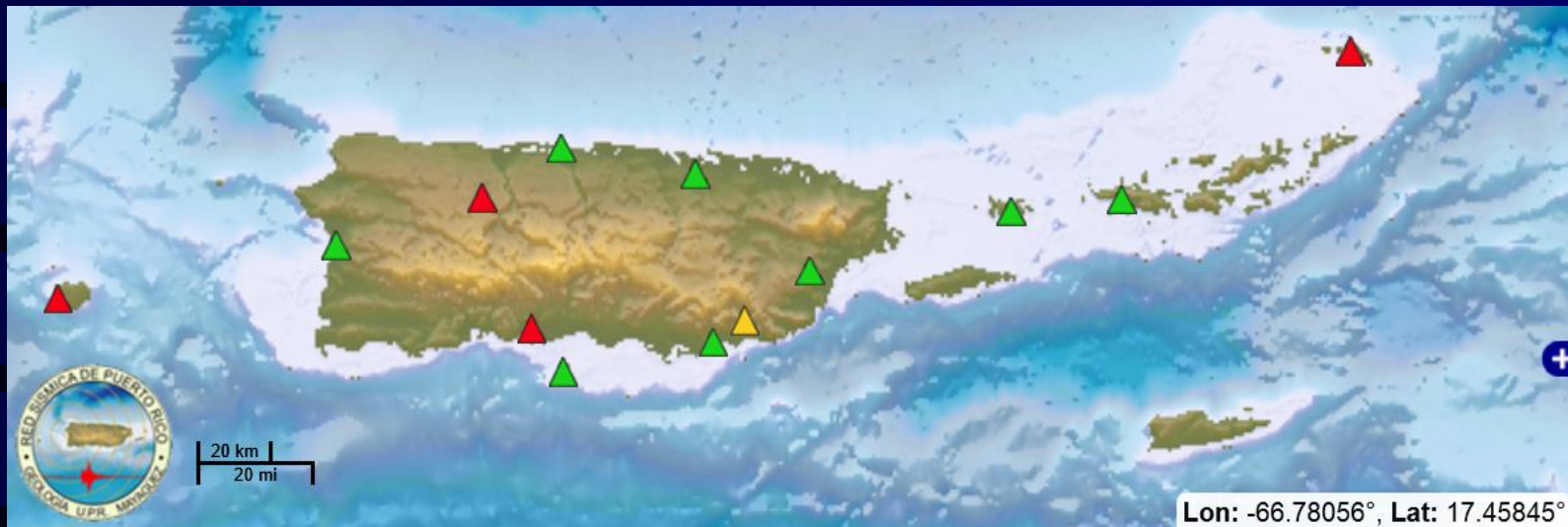
**Monumentando estación Mayagüez AA 2008, salón CI-019-RUM.  
Se realizarón observaciones por 48 horas de Gravedad absoluta**





# COCOnet: Continuously Operating Caribbean Observational GPS Network

<http://coconet.unavco.org/>



## Escala:

▲ Gap 10 - 60 minutos

▲ Gap 12 - 18 horas

▲ Gap < 5 minutos

▲ Gap 1 - 3 horas

▲ Sin datos

▲ Gap 5 - 10 minutos

▲ Gap 3 - 12 horas



# CORS: Continuously Operating Reference Station

[http://www.ngs.noaa.gov/CORS\\_Map/](http://www.ngs.noaa.gov/CORS_Map/)

250 km radius

\*\* To filter sites click on icons \*\*

GPS	GNSS	All
		<a href="#">1 sec rate</a>
		<a href="#">5 sec rate</a>
		<a href="#">15 sec rate</a>
		<a href="#">30 sec rate</a>
		<a href="#">All Active</a>
		<a href="#">All Non-Operational</a>
		Decommissioned

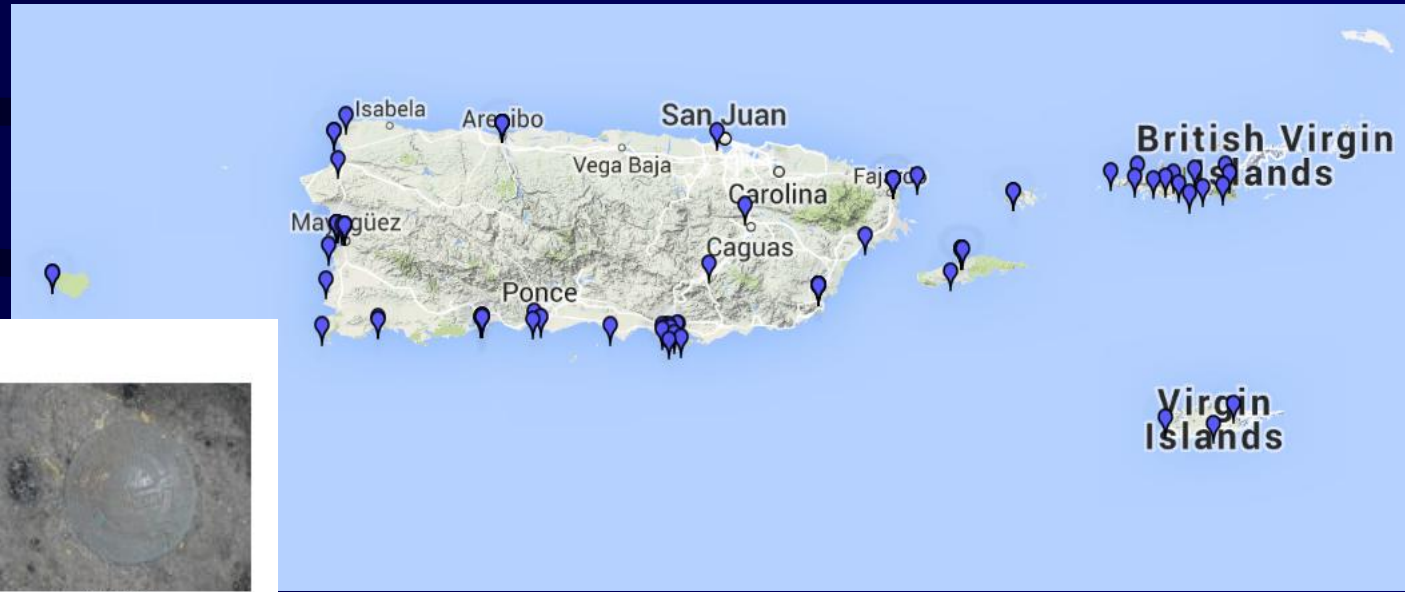
[Download CORS KMZ](#)





# OPUS SHARED: Online Positioning User Service

<http://www.ngs.noaa.gov/OPUS/showMarks.jsp>



## Shared Solution

PID: DK7450  
 Designation: 975 9394 MHPR 1 TIDAL  
 Stamping: MHPR 1 1971  
 Stability: Monument will probably hold position well  
 Setting: Abutment or pier of large bridges  
 Mark Condition: G  
 Description: The existing description at the DataSheet is good.  
 Observed: 2006-10-30T10:57:00Z See Also [2003-02-02](#)  
 Source: OPUS - page5 1209.04



Close-up View

REF_FRAME: NAD_83(2011) EPOCH: 2010.0000 SOURCE: H = h-N (N = GEOD12A HGT) UNITS: m SET PROFILE DETAILS	
LAT: 18° 13' 3.84158" ± 0.006 m	UTM 19 SPC 5200(PRVT)
LLN: -67° 9' 32.34259" ± 0.003 m	NORTHING: 2015253.090m 242697.882m
ELL HT: -39.463 ± 0.018 m	EASTING: 694681.320m 123245.504m
X: 2352490.710 ± 0.007 m	CONVERGENCE: 0.57573690° -0.22704754°
Y: -5585158.822 ± 0.014 m	POINT SCALE: 1.0000858 0.99999398
Z: 1981277.566 ± 0.011 m	COMBINED FACTOR: 1.00007478 1.00000018
ORTHO HT: 1.599 ± 0.030 m	

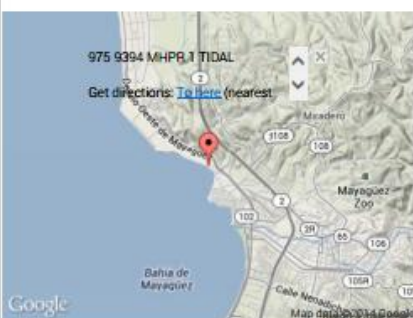
REF\_FRAME: NAD\_83(2011) EPOCH: 2010.0000

### CONTRIBUTED BY

[linda.velez](#)  
 University of Puerto Rico, Mayagüez



Horizon View



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

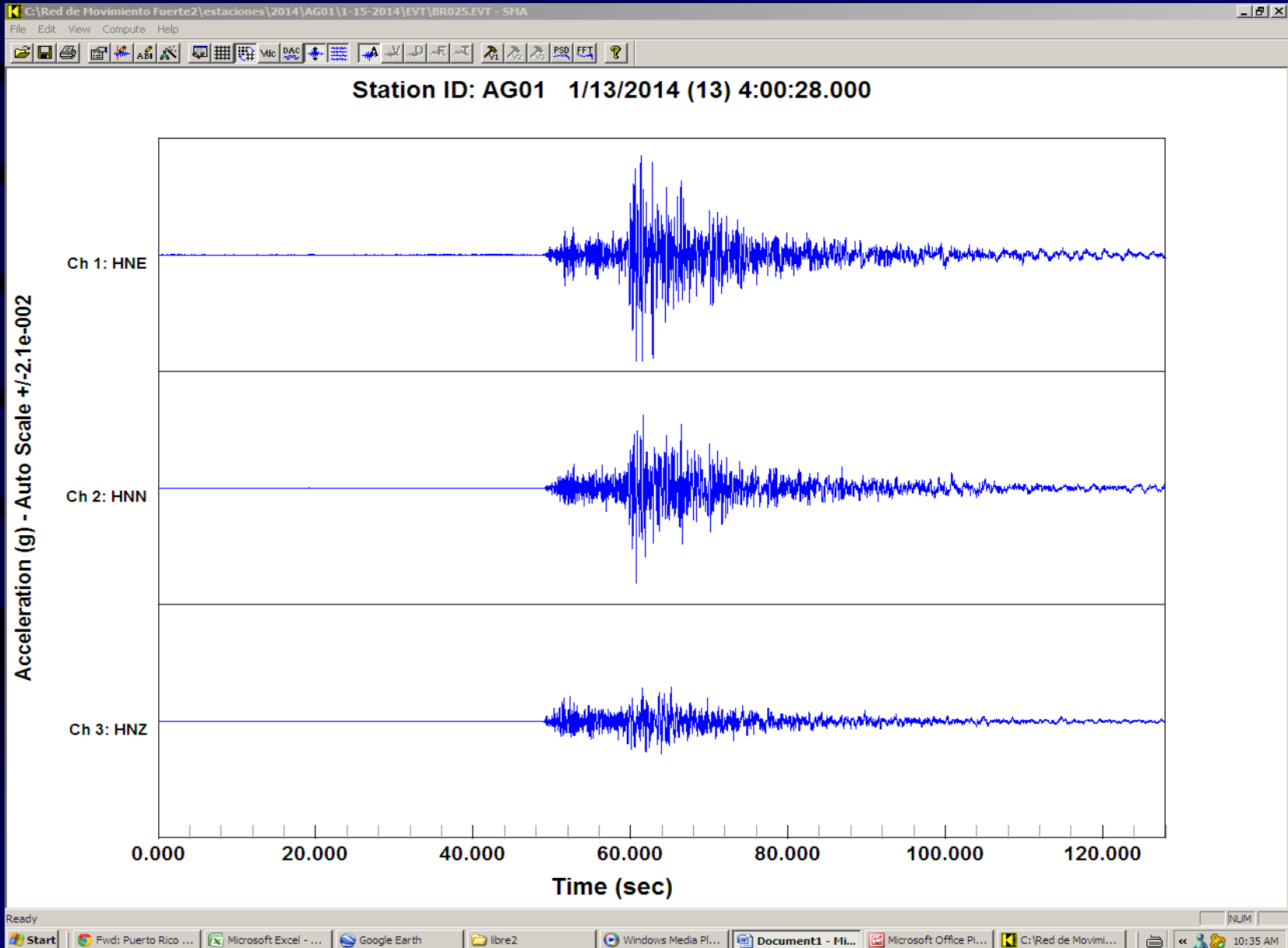
<http://www.caricoos.org/drupal/>





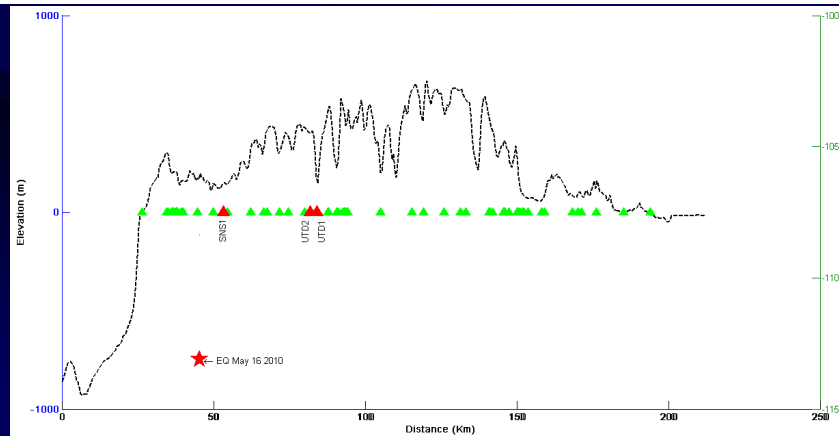
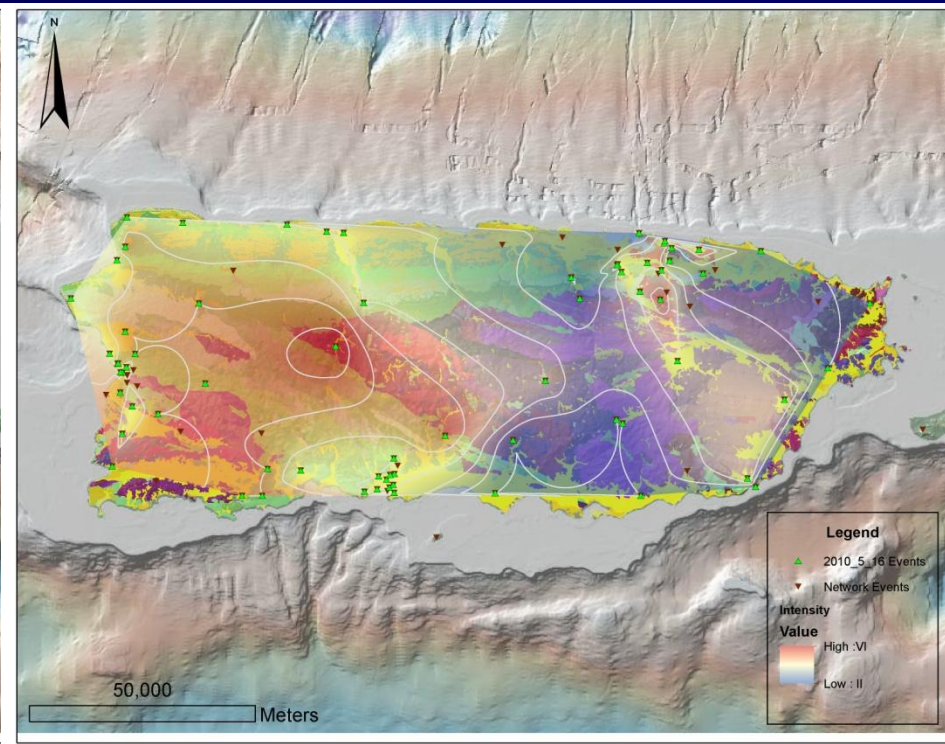
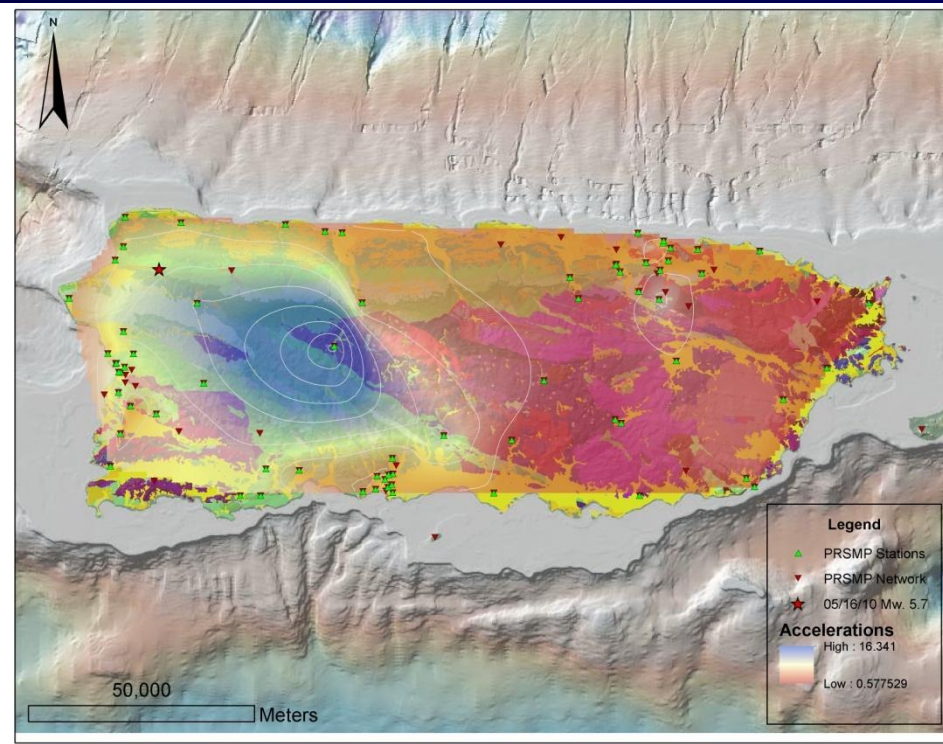
Thanks,

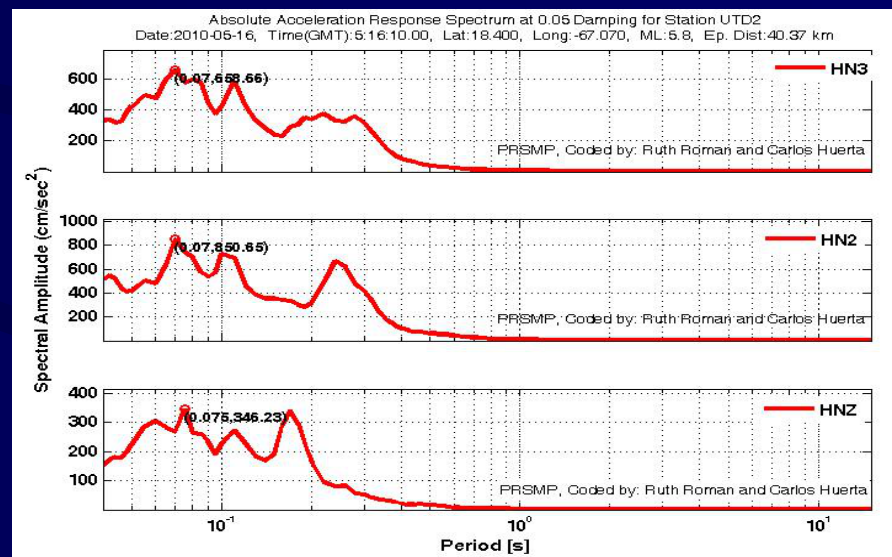
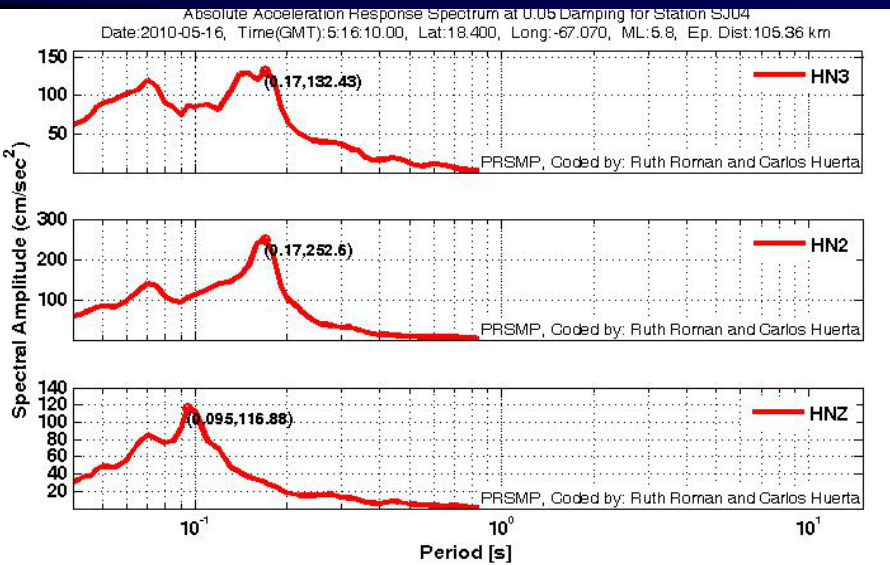
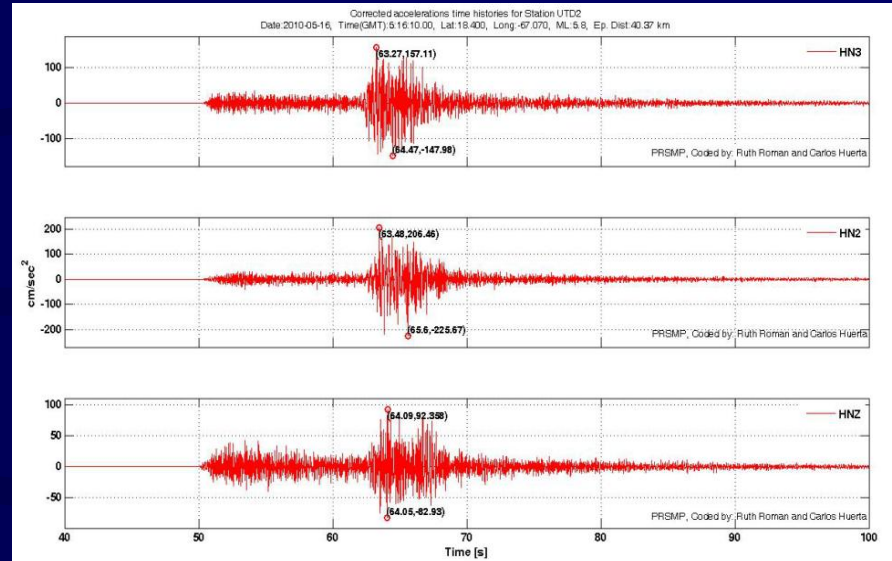
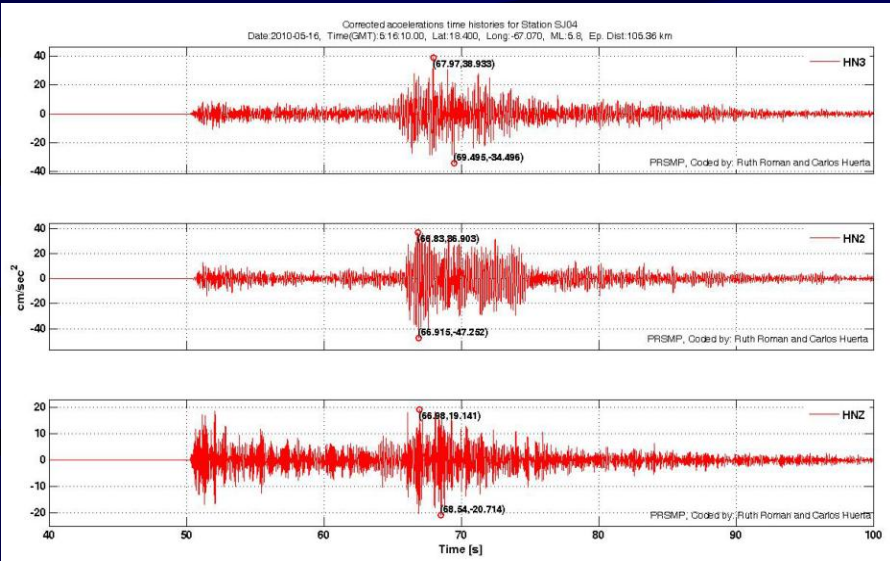
# STRONG MOTION DATA PROCESSING





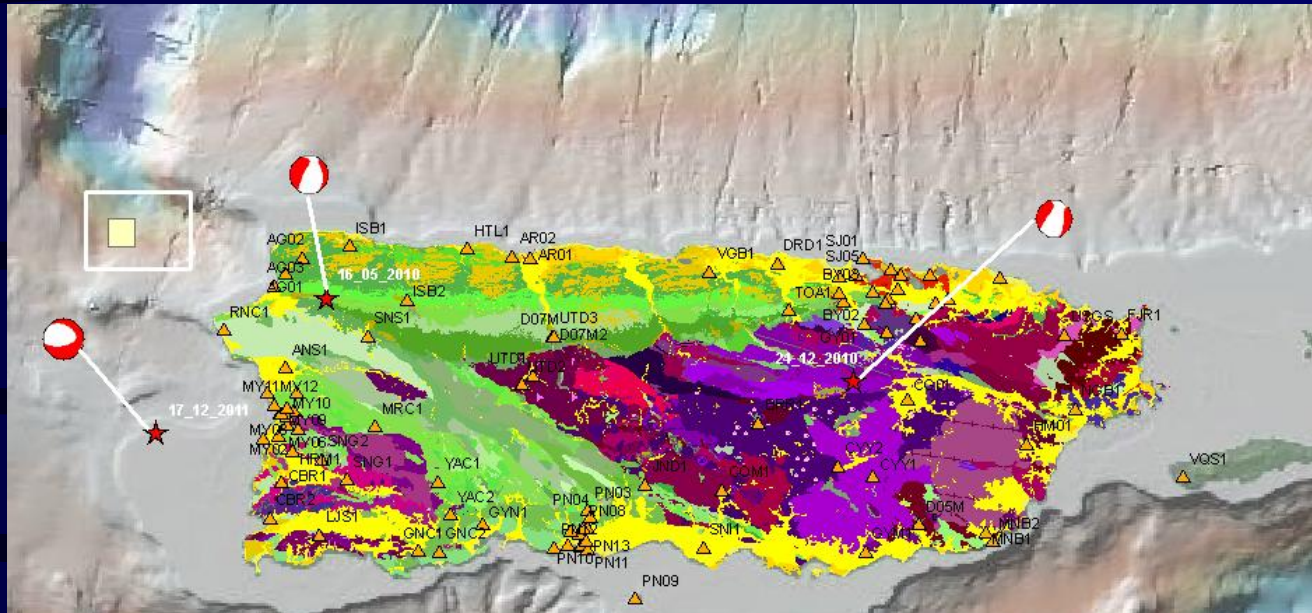
# May 16, 2010 Earthquake: Study case





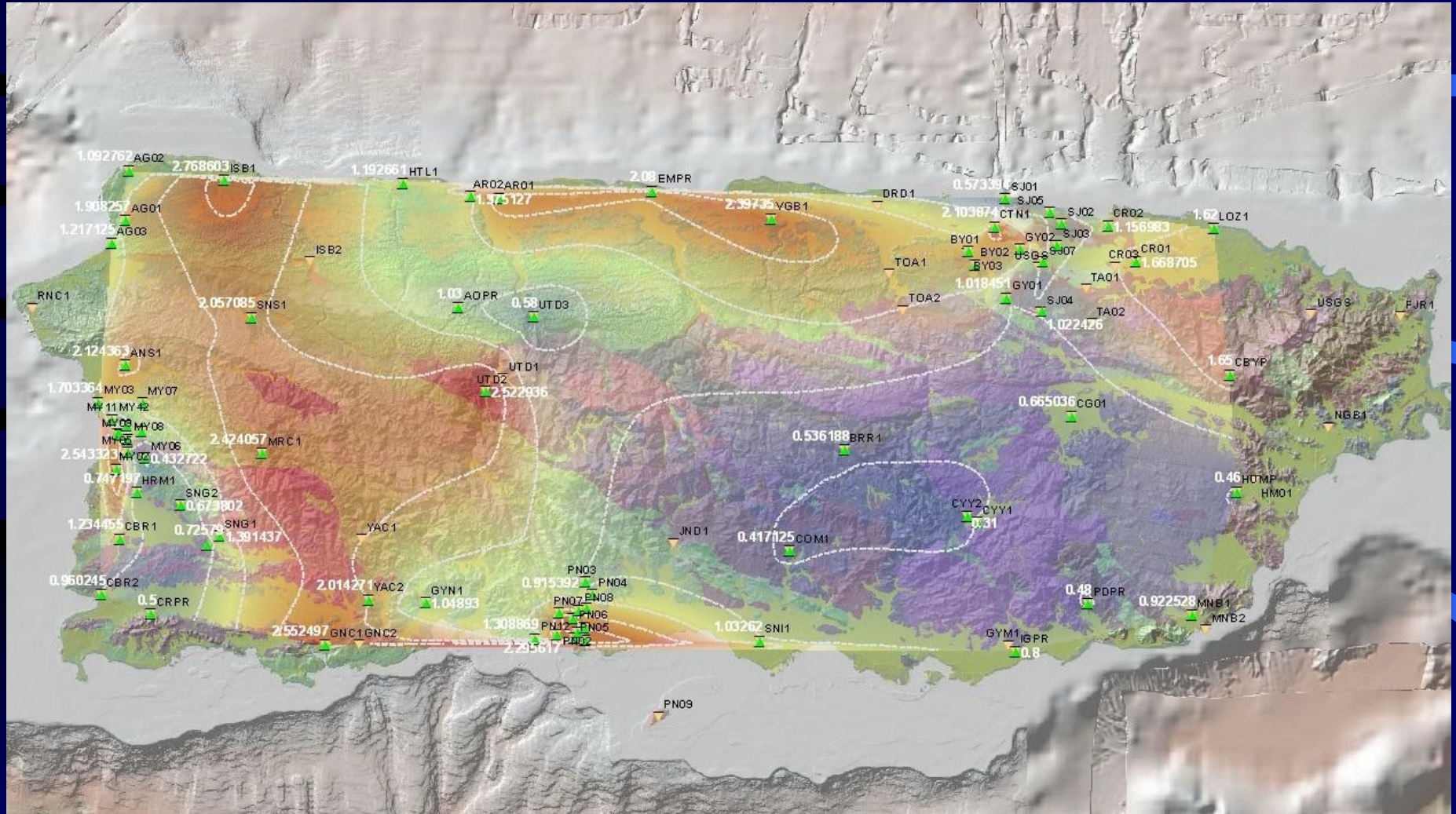


# 05/16/-, 12/24/2010, 12/17/2011, 02/26/2013 Eqks: Study case



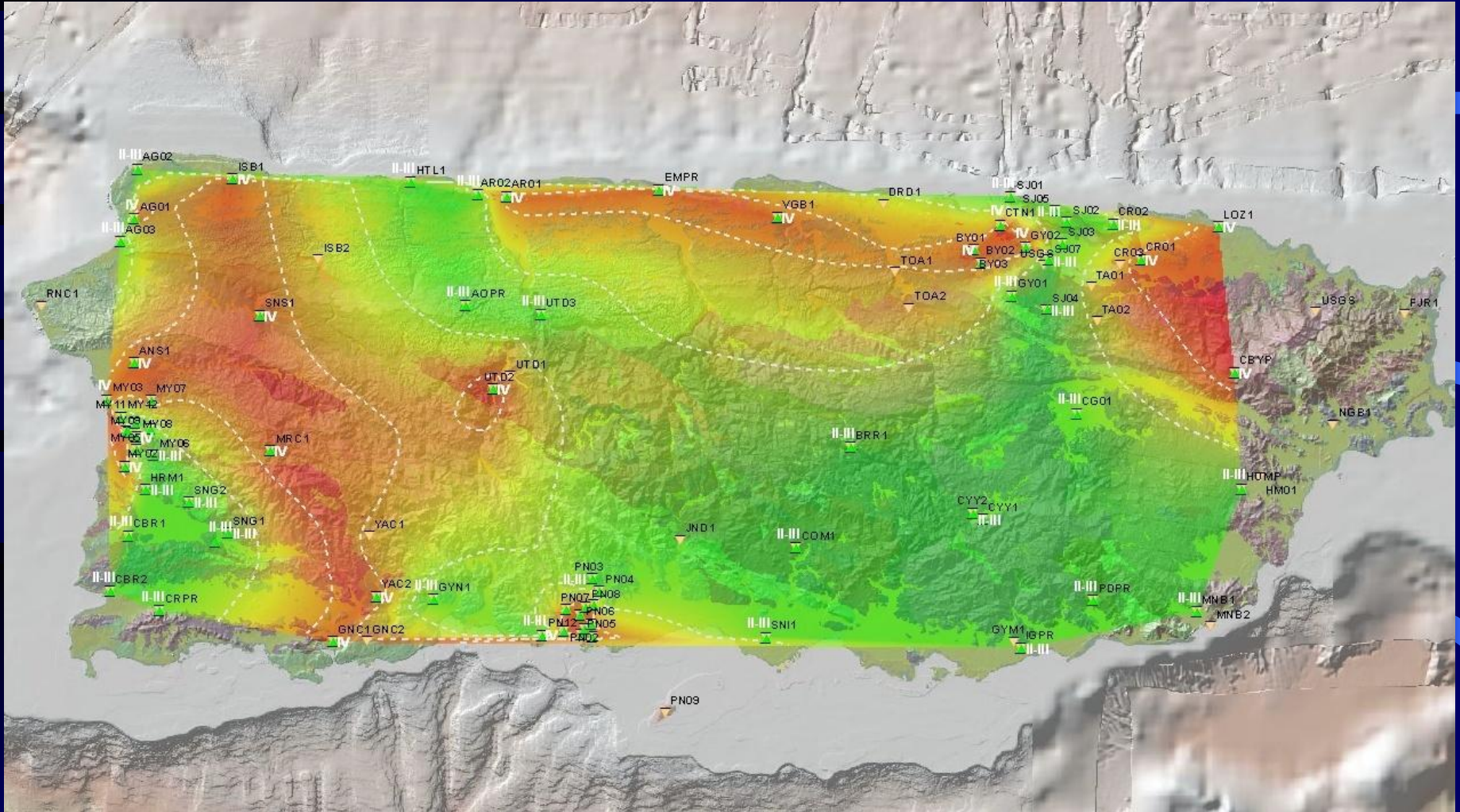
Event date	Max_PGA (cm/s <sup>2</sup> )	Station	Distance (Km)	Max_PGA (cm/s <sup>2</sup> )	Station	Distance (Km)
May-16-2010 (5.8)	23.01	UTD2	E=40.17 H=120.02	2.04	AG02	E=13.03 H=113.84
Dec-24-2010 (5.1)	14.15	HM01	E=34.01 H=108.54	12.13	CG01	E=10.06 H=103.44
Dec-17-2011 (5.3)	11.30	MY12	E=23.38 H=29.01	4.08	UTD2	E=69.3 H=71.3
Feb-26-2013 (5.1)	0.78	UTD2	E=171.5 H=171.7	0.45	AG02	E=120.72 H=120.99

# January 13, 2014 Earthquake: Study case





# January 13, 2014 Earthquake: Study case







2011 Annual Meeting  
13-15 April  
Memphis, Tennessee

# THE PUERTO RICO 5.8 MW EARTHQUAKE OF MAY 16, 2010 and the Distribution of Peak Ground Motion in the Puerto Rico Island

<sup>1,2</sup>Carlos I. Huerta-López, <sup>3</sup>Jonas De Dios De Basabe-Delgado, <sup>4</sup>Ruth E. Román-Batista, <sup>1</sup>José A. Martínez-Cruzado, <sup>1</sup>Jorge Andrés Caro-Cortes, and <sup>1</sup>Luis E. Suárez-Colche

<sup>1</sup>University of Puerto Rico Mayagüez, Department of Civil Engineering and Sciences, Puerto Rico Strong Motion Program (PRSM), Mayagüez, Puerto Rico; <sup>2</sup>University of Puerto Rico Mayagüez, Department of Civil Engineering and Sciences, Mayagüez, Puerto Rico; <sup>3</sup>University of Puerto Rico Mayagüez, Department of Civil Engineering and Sciences, Mayagüez, Puerto Rico; <sup>4</sup>University of Puerto Rico Mayagüez, Department of Civil Engineering and Sciences, Mayagüez, Puerto Rico; <sup>5</sup>University of Puerto Rico Mayagüez, Department of Civil Engineering and Sciences, Mayagüez, Puerto Rico



**ABSTRACT.** An earthquake of  $M_w 5.8$  occurred in the northwest region of Puerto Rico Island (18.4° Lat., 67.47° Lon., and focal depth 13.1 km) at 03:18:10 UTC on May 16, 2010. An inventory and distribution of peak ground motion is presented with the aim to explore the nonuniform distribution of peak ground motion that may be associated not only by local site effects due to dispersion of seismic waves.

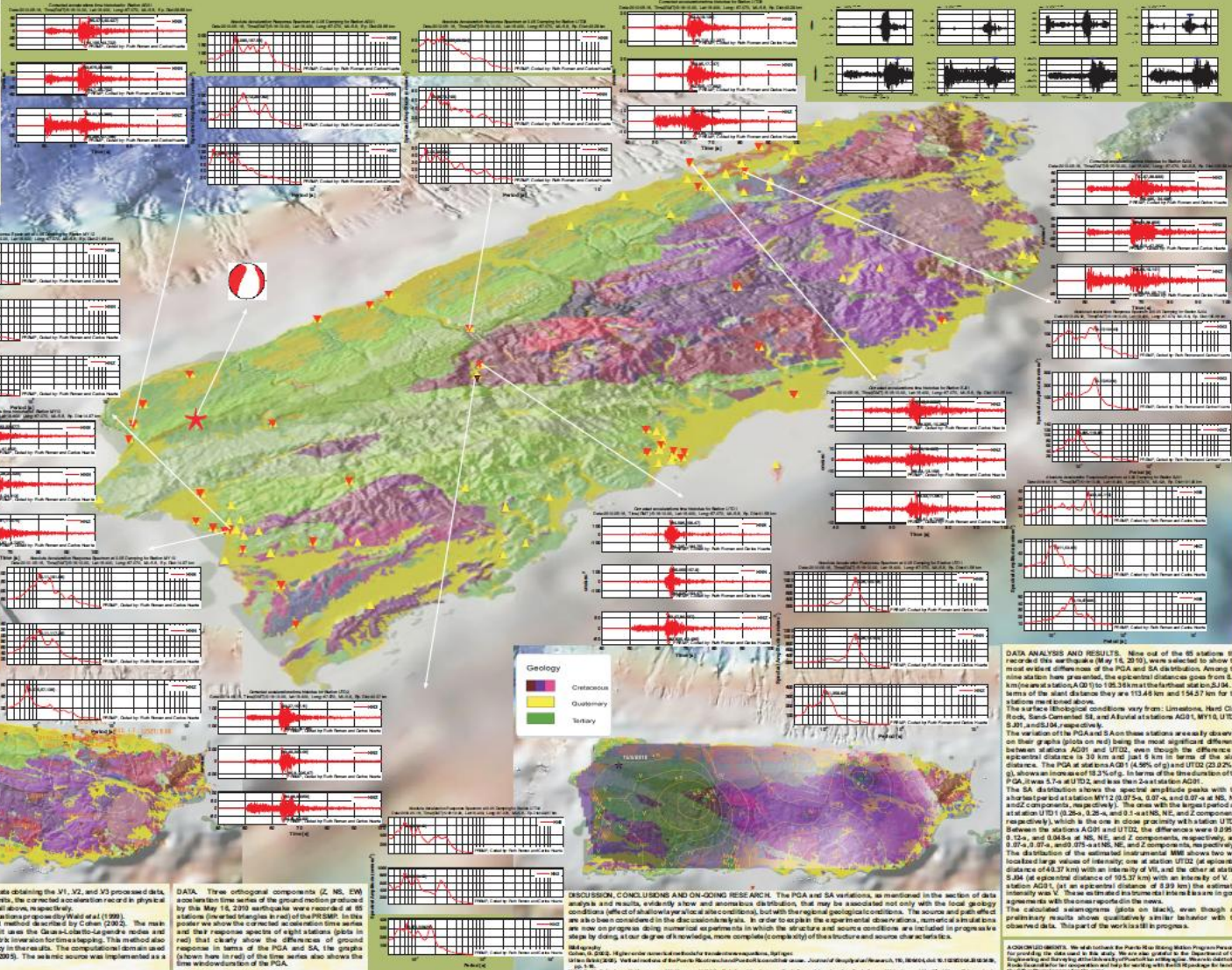
In the city of Aguadilla, which is located at approximately at 10 Km from the epicenter, an intensity (MM) of V was reported, while in some cases hardly reach the value of III at similar epicentral distances. An instrumental intensity of VII was estimated in the area of Utuadidown located roughly at 40 Km from the epicenter. The observed maximum peak ground acceleration was (i) 0.365  $g$  at Aguadilla (AGI) station, located at an epicentral distance of 8.39 km from station, and (ii) 0.231  $g$  at station UTU, located at an epicentral distance of 41.56 km from station. The instrumental intensity (MM) estimated by Wald et al. (1999) relationship to  $M_w$  and  $M$ , respectively for the two previous locations are III and V, respectively. This earthquake was widely felt in Puerto Rico, the eastern Dominican Republic, and the Virgin Islands. It was recorded also by 59 stations of the Puerto Rico Strong Motion Program (PRSM) providing a unique set of color acceleration records distributed around the island. According to the USGS Centroid Moment Tensor solution, the earthquake occurred in an inclined seismic zone that dips south from the Puerto Rico Trench and that consists of subducted lithosphere of the North America plate. Earthquakes that have focal depths between 70- and 300-km, are commonly termed "intermediate depth" earthquakes and typically cause less damage on the ground surface above the foci than shallower magnitude 5.0-6.0 shallow earthquakes. Also, larger intermediate depth earthquakes may be felt at great distance from their epicenters.

**INTRODUCTION.** The Puerto Rico Strong Motion Program (PRSM) is dedicated to obtain reliable and precise strong motion records generated by earthquakes affecting the Puerto Rico region. The PRSM has 191 free-field stations (194 total), and 10 instrumented structures and dams. Among the free-field stations 27 are stand alone, 68 have telephone data communication, 94 are connected through the internet and 12 shared with the Puerto Rico Seismic Network. The stations of that network are located in 11 island areas, and 4 have internet communication. All the stations are distributed around Puerto Rico, the US and the Virgin Islands, and the Dominican Republic, and are equipped with digital accelerometers and digital data recorder using a sampling frequency of 100 Hz. The Puerto Rico  $M_w 5.8$  (05/16/2010) earthquake is of special interest because of the peak ground motion (PGA) and the spectral amplitude (SA) distribution within the island is relatively irregular with respect to the expected decay of the PGA and the SA as the distance increases. Local site conditions (LSC) as well as path effects are here discussed in order to explain the observed behavior.

Beyond the observational evidence obtained after processing the recorded acceleration records, we have computed isoseismograms for comparison purposes, using the second-order spectral moment method. The computational domain we used is a 2D rectangle divided into horizontal layers. As a first approach, we used the regional model proposed by Brink (2005). The seismic source was implemented as a point source in space and a Richter wavelet in time with a peak frequency of 10 Hz. The computed results are preliminary and do not include topography, neither the shallow conditions of the stations (local models) available for the considered stations.

Standard strong motion processing was applied to the recorded data, obtaining the  $V_L$ ,  $V_H$ , and  $V_V$  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 of all above, respectively. The instrumental intensity (MM) was estimated using the equation proposed by Wald et al. (1999). The synthetic waveforms were computed using the second-order spectral moment method described by Cohen (2002). The main differences between this method and that used in the Centroid Moment Tensor (CMT) solution are that in this method, an increase in efficiency allows not to require any  $M_w$  inversion for times tapering. This method also allows using a different tapering function to obtain higher-order spectra in the analysis. The computational domain used is a 2D rectangle divided into horizontal layers, using the regional model of Brink (2005). The seismic source was implemented as a point source in space and a Richter wavelet in time with a peak frequency of 10 Hz.

**DATA.** Three orthogonal components (Z, NE, EW) acceleration time series of the ground motion generated by the May 16, 2010 earthquake were recorded at 59 stations. Colored triangles in red in the PRSM. In this poster we show the corrected acceleration time series and their response spectra of eight stations (plots in red) that clearly show the differences of ground response in terms of the PGA and SA. The graphs (shown here in red) of the PGA and SA, also show the time window duration of the PGA.



**DATA ANALYSIS AND RESULTS.** Five out of the 59 stations that recorded this earthquake (May 16, 2010) were selected to show the most evident differences of the PGA and SA distribution. Among the nine stations here presented, the epicentral distances range from 8.39 km (near station AGI) to 105.36 km at the furthest station UTU. In terms of the station distances they are 13.4 km, and 134.57 km for the stations NE and UTU, respectively.

The variation of the PGA and SA from these stations were by observed on their graphs (plots in red) being the most significant difference between stations AGI and UTU, even though the difference in epicentral distance is 39 km and just 8 km in terms of the station distance. The PGA at station AGI (0.365  $g$ ) and UTU (0.232  $g$ ) of  $g$ , shows an increase of 57.3% of  $g$ . In terms of the SA distribution of the PGA, the SA at station AGI (0.365  $g$ ) and UTU (0.232  $g$ ) of  $g$ , shows an increase of 57.3% of  $g$ . The SA distribution shows the spectral amplitude peaks with the shortest period at station MY12 (0.37 s, 0.07 s, and 0.07 s at NE, NE, and Z components, respectively). The one with the longest period are at station UTU (0.28 s, 0.26 s, and 0.3 s at NS, NE, and Z components, respectively), which is the one in closer proximity with station UTU. Between the stations AGI and UTU, the differences were 0.09 s, 0.12 s, and 0.04 s at NS, NE, and Z components, respectively, and 0.27 s, 0.17 s, and 0.15 s at NS, NE, and Z components, respectively. The distribution of the estimated instrumental MM shows two well focused large values of intensity only at station UTU (at epicentral distance of 43.37 km) with an intensity of VII, and the other at station AGI (at an epicentral distance of 8.39 km) the estimated intensity was V. The estimated instrumental intensity here is in good agreement with the observed data. The calculated isoseismograms (plots on black), even though are preliminary results allow qualitatively a better behavior with the observed data. This part of the work is still in progress.

**ACKNOWLEDGMENTS.** We wish to thank the Puerto Rico Strong Motion Program for providing the data used in this study. We are also grateful to the Department of Civil Engineering and Sciences, University of Puerto Rico Mayagüez, for providing the facilities and equipment for carrying out this research.





# Peak ground acceleration response of three moderate magnitude earthquakes and their implication to local site effects in the Puerto Rico Island

By:

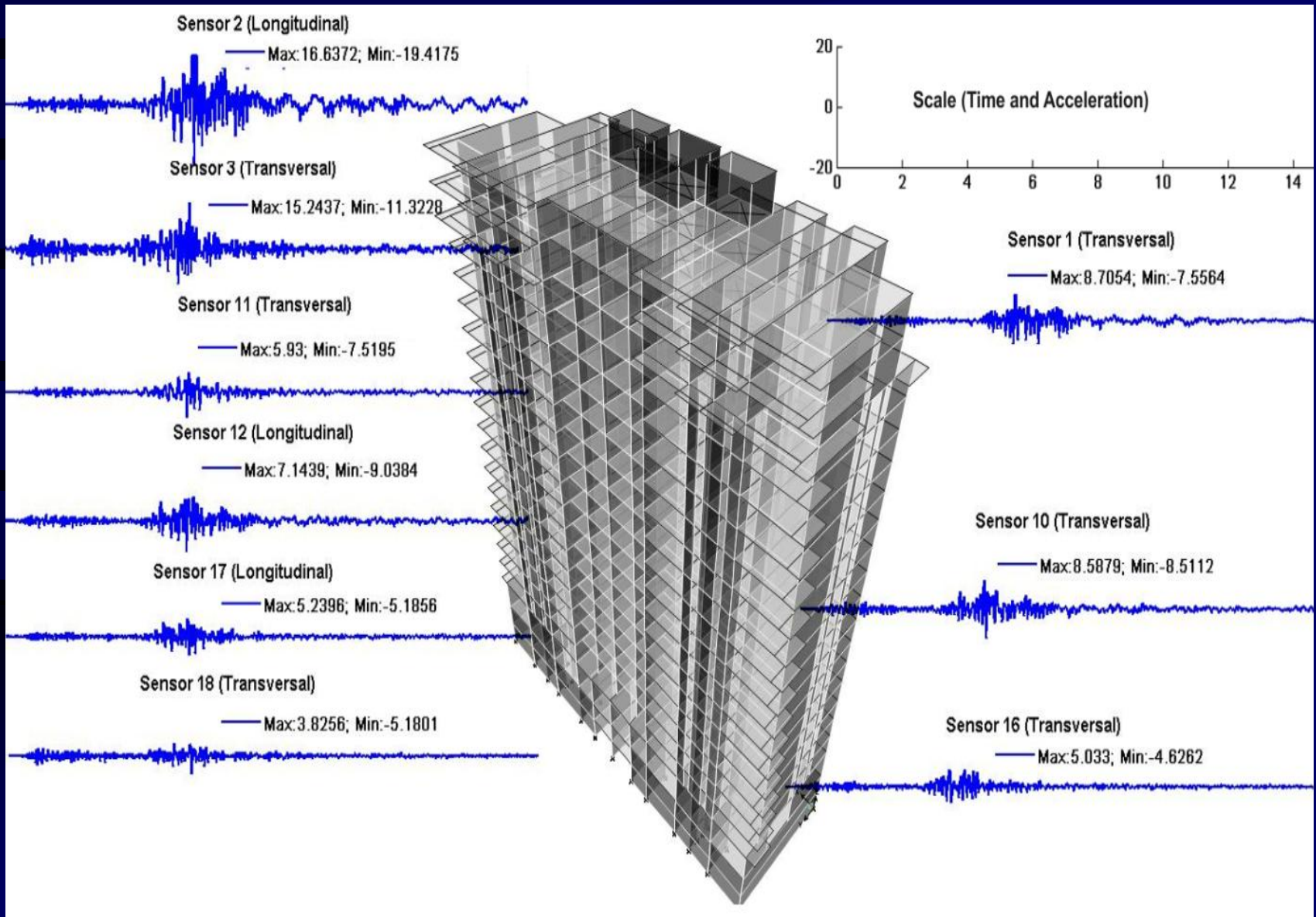
Carlos I. Huerta-López, Ph.D

José A. Martínez-Cruzado, Ph.D

Fabio M. Upegui-Botero, Grad. Stud.

Luis E. Suarez-Colche, Ph.D.

# El Castillo Building. M5.3 Eqk.





[prsmg.uprm.edu](http://prsmg.uprm.edu)

# PRSMG WEB PAGE DATA DISSEMINATION

Thanks,