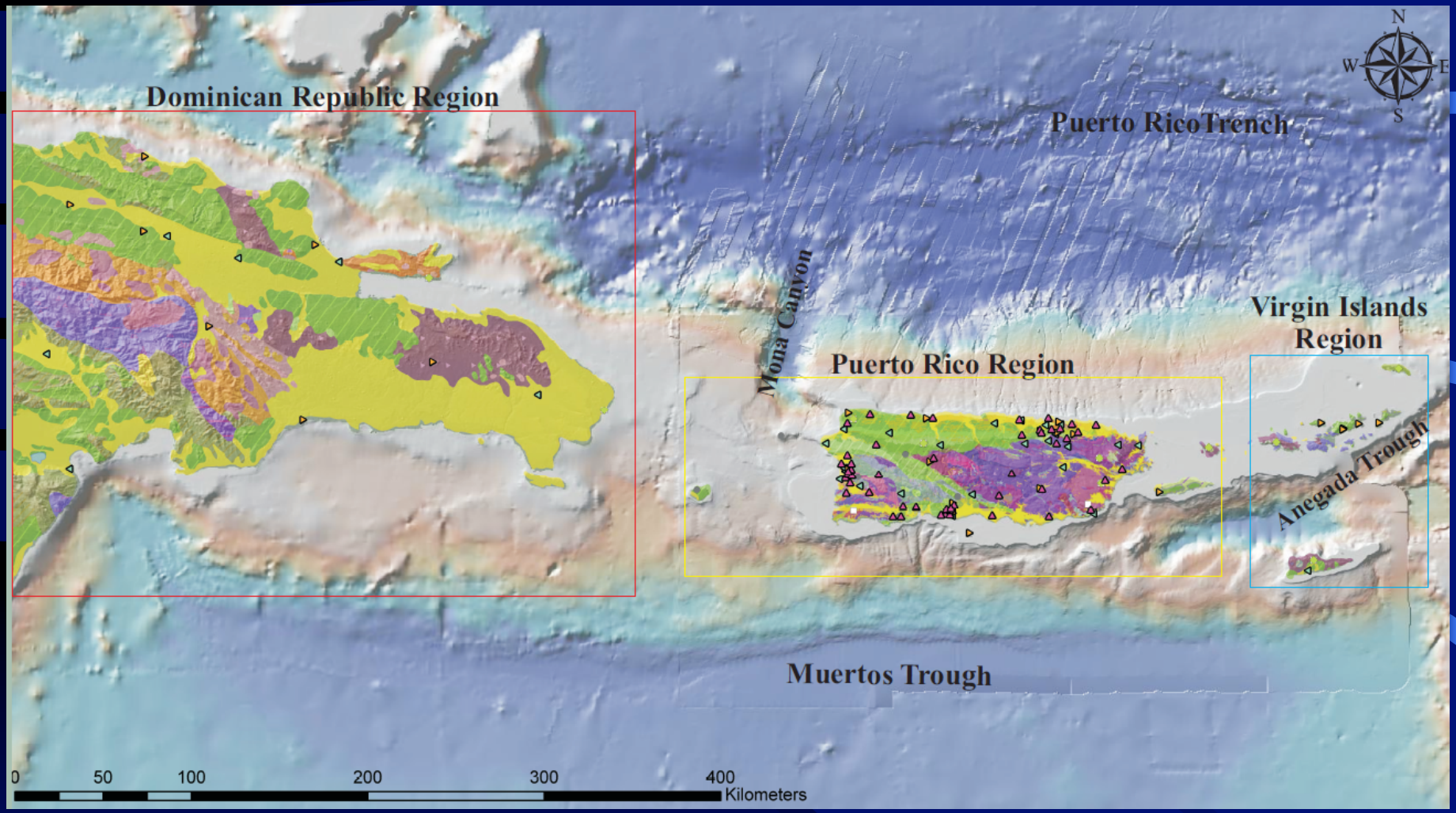
Puerto Rico Strong Motion Program

Civil Engineering and Surveying Department
University of Puerto Rico at Mayagüez



Presented by: Carlos I. Huerta López

PRSMP

GOALS:

- 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,

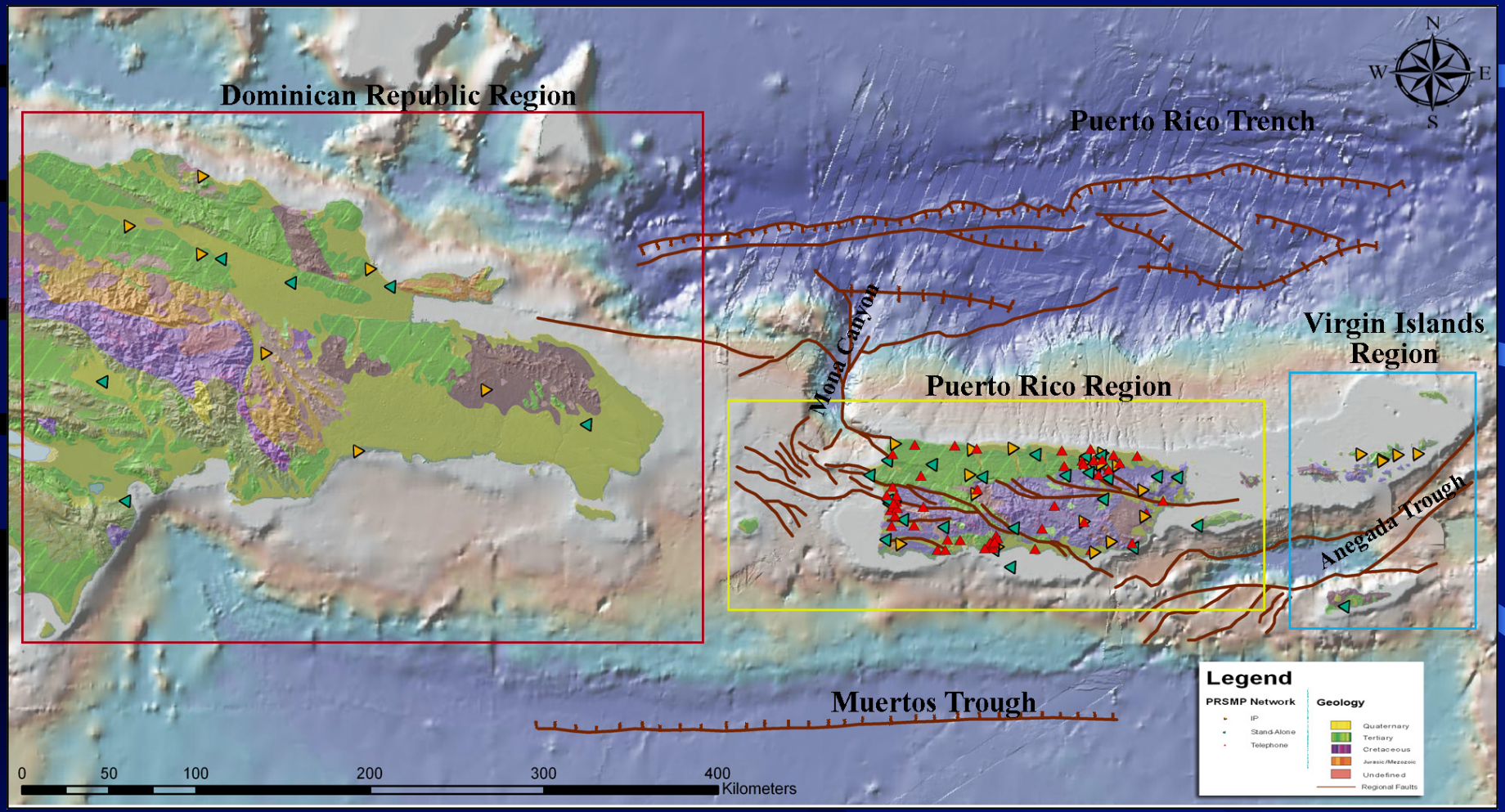
  -(ii) objectively identify and characterize the ground response, as well as the civil infrastructure response upon seismic loads.
- Mitigate both human and economical losses during high-intensity earthquakes through accurate and reliable seismic records.
- Identify in an objective manner damaged after an earthquake.

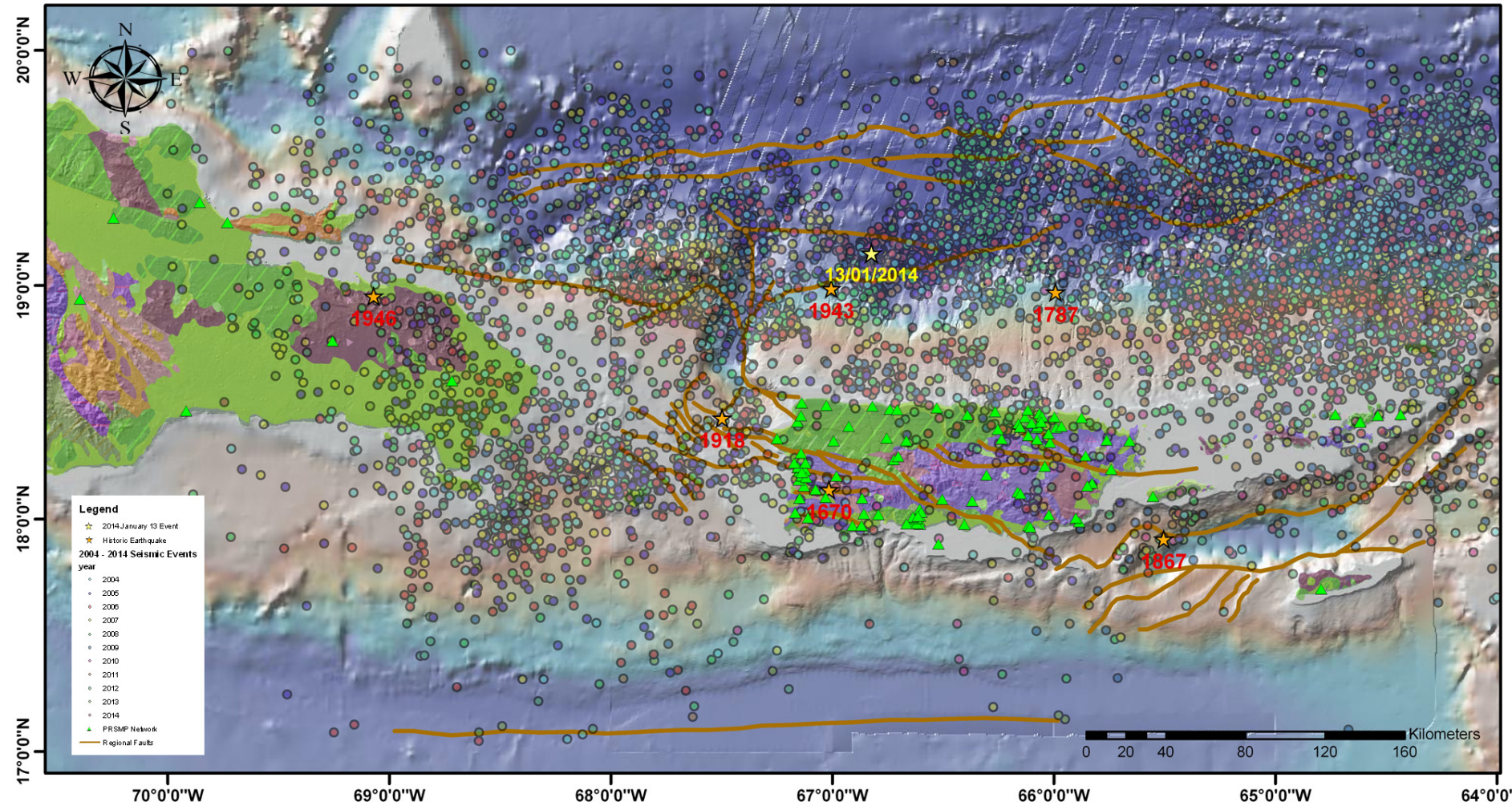
Duties:

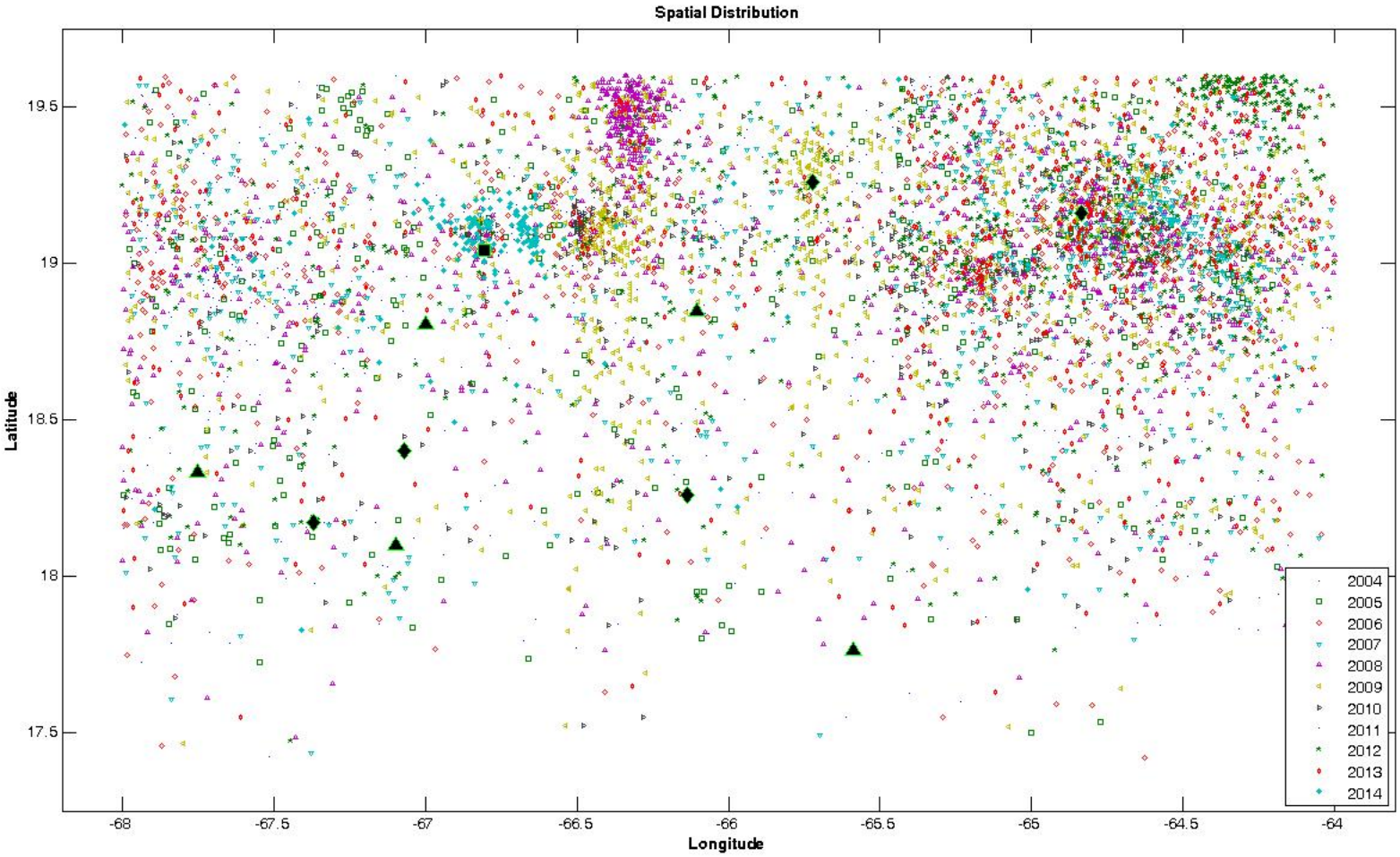
- (i) deploying/operation seismic instrumentation for monitoring strong ground motions as well as civil structures in the Puerto Rico Island (PRI) and the Caribbean region,
- (ii) Applied seismology/geophysics/geology in Civil Engineering,
- (iii) Application of seismic/geophysical methods for site characterization/local site effects/seismic zonation, and seismic risk studies.

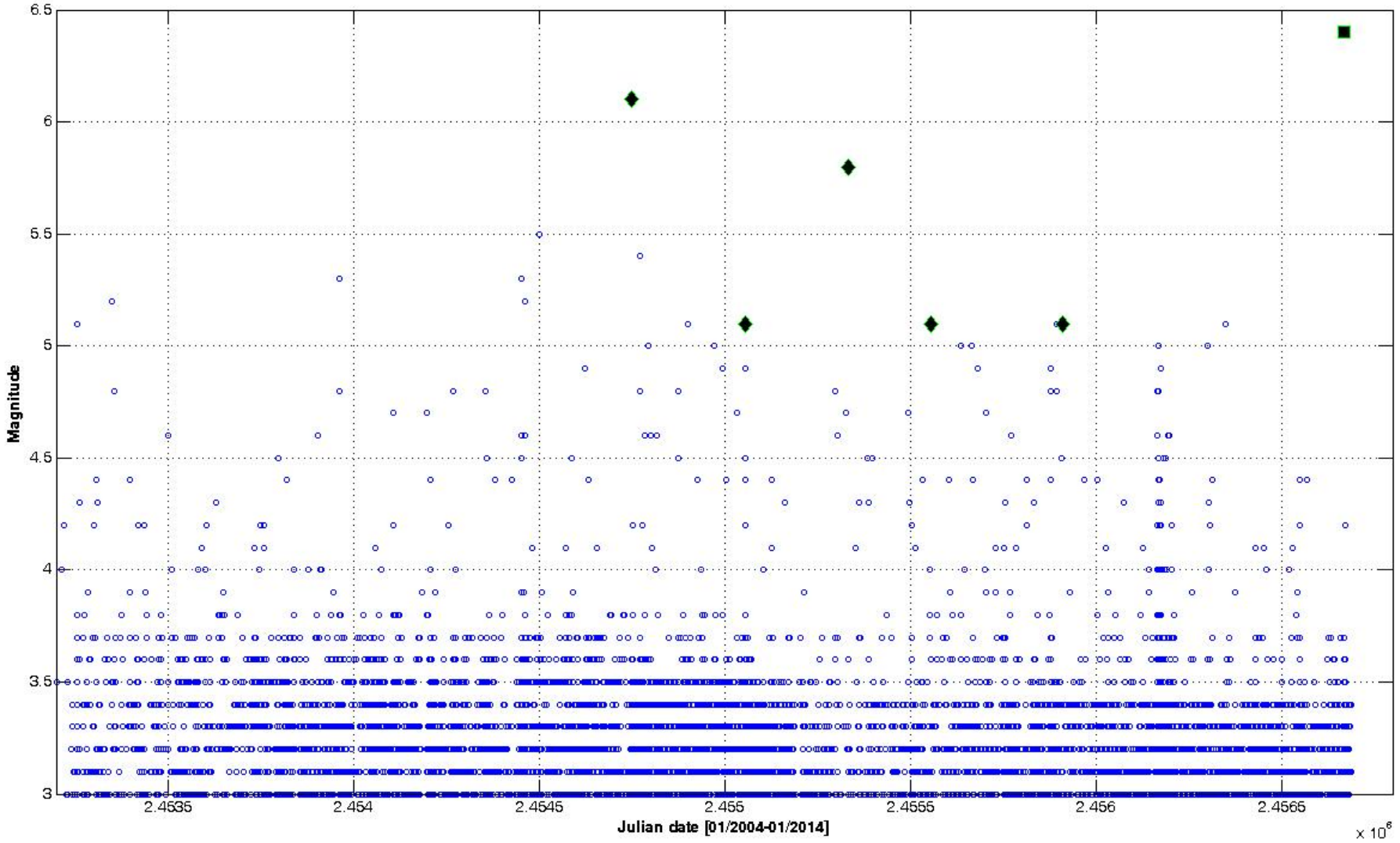
PRSMP Personnel

- José A. Martínez-Cruzado. -PRSMP Director
- Carlos I. Huerta-López. -Seismologist
- Jaffet Martínez-Pagan, Erick Santana-Torres.
  -Technical Support, Network Operation /Maintenance, Communication, Data Processing/Archiving.
- Graduate Students: Francisco Hernández, Denny Mariana Torres Ortíz.
  -Earthworm/Antelope/Communication, Data Archives (Earthquake Catalog, EVT, wf, mseed), GIS Data Archives .
- Undergraduate student. Sergio Cardona. -Data processing, GIS.
- Glorimer Torres-Batista. -Clerical/Administrative support


Dominican Republic Region
Puerto Rico Trench
Mona Canyon
Puerto Rico Region
Virgin Islands Region
Anegada Trough
Muertos Trough
N
W
E
S
0
50
100
200
300
400
Kilometers
Legend
PRSMP Network
IP
Stand-Alone
Telephone
Geology
Quaternary
Tertiary
Cretaceous
Jurassic/Mezozoic
Undefined
Regional Faults


N
W
E
S
13/01/2014
1946
1943
1787
1918
1670
1867
Legend
2014 January 13 Event
Historic Earthquake
2004 - 2014 Seismic Events
year
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
PRSMP Network
Regional Faults
Kilometers
0 20 40 80 120 160
20°0'0"N
19°0'0"N
18°0'0"N
17°0'0"N
70°0'0"W
69°0'0"W
68°0'0"W
67°0'0"W
66°0'0"W
65°0'0"W
64°0'0"W


Spatial Distribution
Latitude
Longitude
19.5
19
18.5
18
17.5
-68
-67.5
-67
-66.5
-66
-65.5
-65
-64.5
-64
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014


6.5
6
5.5
5
4.5
4
3.5
3
Magnitude
2.4535
2.454
2.4545
2.455
2.4555
2.456
2.4565
Julian date [01/2004-01/2014]
x 10^6

OUTLINE

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

PRSMP History (Short)

- 1970's. Eng. José L. Capacete asked to several agencies to contribute for buying accelerographs. The Electrical Power Authority (AEE), the Aqueduct and Wastewater Authority, and the Association of Architects, Engineers and Surveyor provided money to buy nine Accelerographs (SMA-1).

  -The United States Geological Survey was contacted to provide the expertise in installing and maintaining strong motion stations (SMS).

  -Seven free field (FF) stations were established and the Government Minillas (north) building was instrumented.

- 1987, PRSM Network passed to the Civil Engineering Department of the University of Puerto Rico at Mayagüez (UPRM).

  -Prof. Rafael Jiménez, (in charge of the network) obtained a grant from National Science Foundation to install additional eight SMS (SSA-2). Prof. Jiménez leave the university and Prof. Milton R. Martínez-Delgado became in charge of the network. The instruments were bought, and installed in January of 1994. Prof. M. Martínez was responsible for the instrumentation with 15 sensors of the Plaza Inmaculada Building, a 26-story structure with an aspect ratio greater than seven.

PRSMP History (Short)

- 1995 Prof. José A. Martínez-Cruzado took over the network.

  -Since then two main grants have been obtained from the Federal Emergency Management Agency, four main projects were carried out:

  -The first one, all the free field stations with SMA-1 installed during the 70's were substitute for ETNA's. The instrumentation of Minillas Government Building was replaced with a six-channel K2,

  -The second project was to install 13 strong motion FF stations in the San Juan Metropolitan Area,

  -The third project was to install a local strong motion network of nine instruments in the city of Mayagüez,

  -The fourth project was to install six joint stations with the Puerto Rico Seismic Network (PRSN). These joint stations include an FBA-23 triaxial sensor and a Broadband Seismometer. The PRSN is actually obtaining the data via telemetry.

- The second main grant includes several other projects. Some of them are:

  -The establishment of fourteen additional FF station around the Island,

  -A local strong motion network in the city of Ponce,

PRSMP History (Short)

-The instrumentation of the Lucchetti concrete dam in the town of Yauco, and

-The seismic instrumentation of two bridges.

- 2002, Law 106

  -To consign in the General Budget of Expenditure of the Commonwealth of Puerto Rico the annual assignment of one million dollars to the University of Puerto Rico at Mayagüez, from which the amount of $440k will be transferred to the PRSN and the amount of $560k will be transferred to the SMN to be spent in operation and to authorize matching of the assigned funds.

- 2003-2004,……2013

  -To install GPS in all strong motion stations, and to replace the SSA-2 with ETNAs

  -To establish modem communication with most stations: 48 with dialog telephone lines & 10 with Internet.

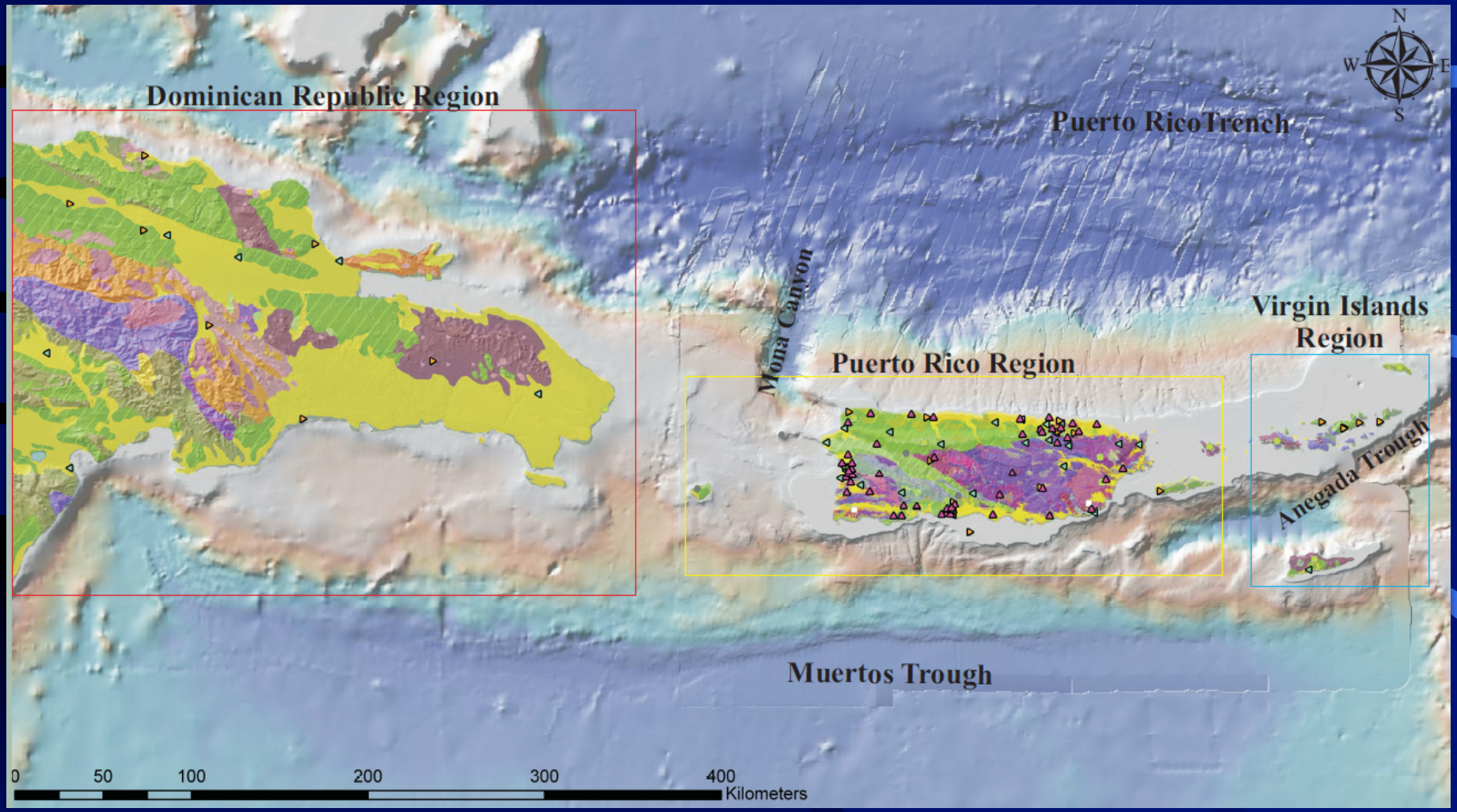
  -Installation/operation of Network Administrator/ANTELOPE

  -Hire a strong motion seismologist

PRSMP History (end)

- In conclusion:

  THE PUERTO RICO STRONG MOTION NETWORK (ACTUALLY PUERTO RICO STRONG MOTION PROGRAM, PRSMP) has grow 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 Satnd Alone stations.


Dominican Republic Region
Puerto RicoTrench
N
W
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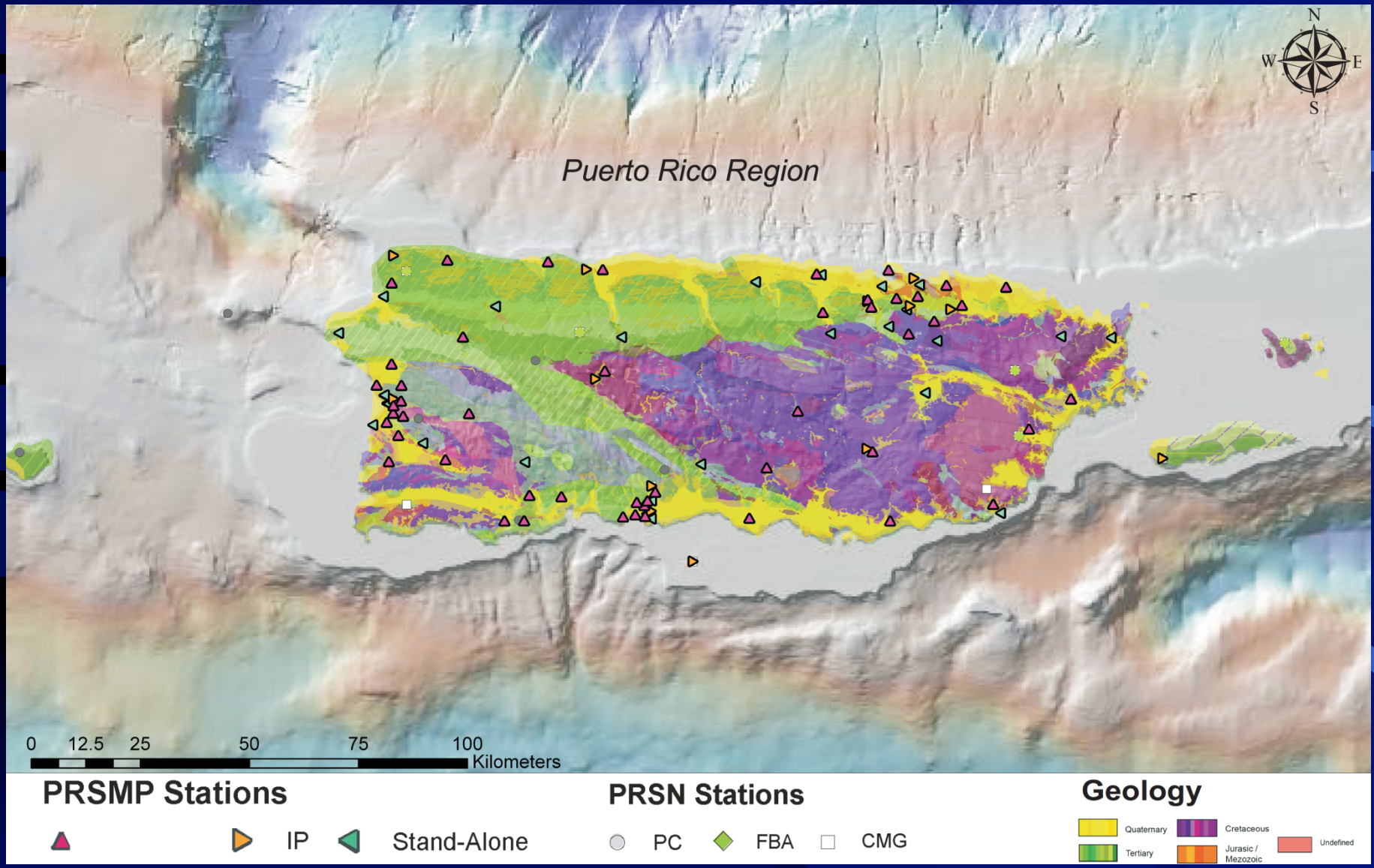
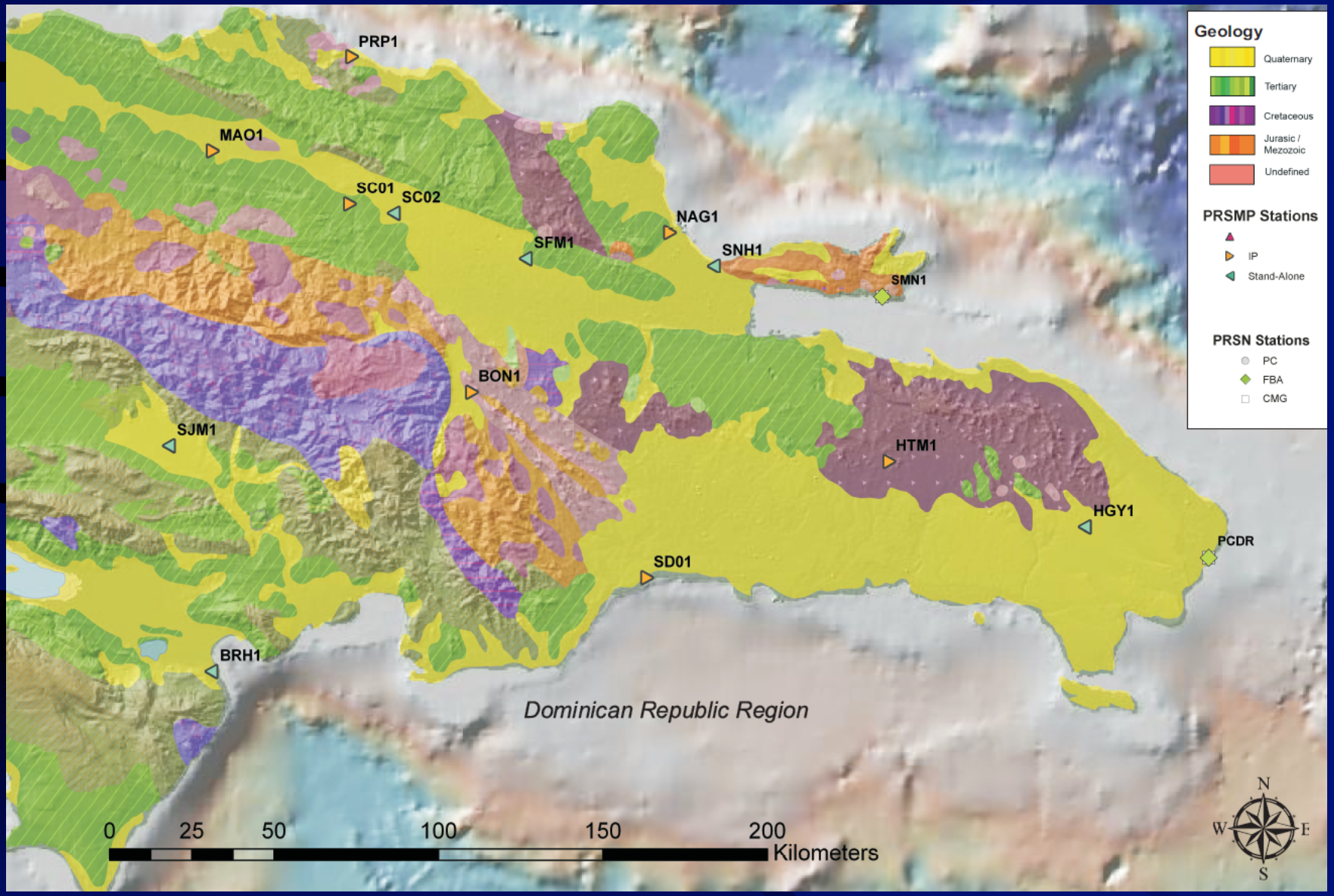
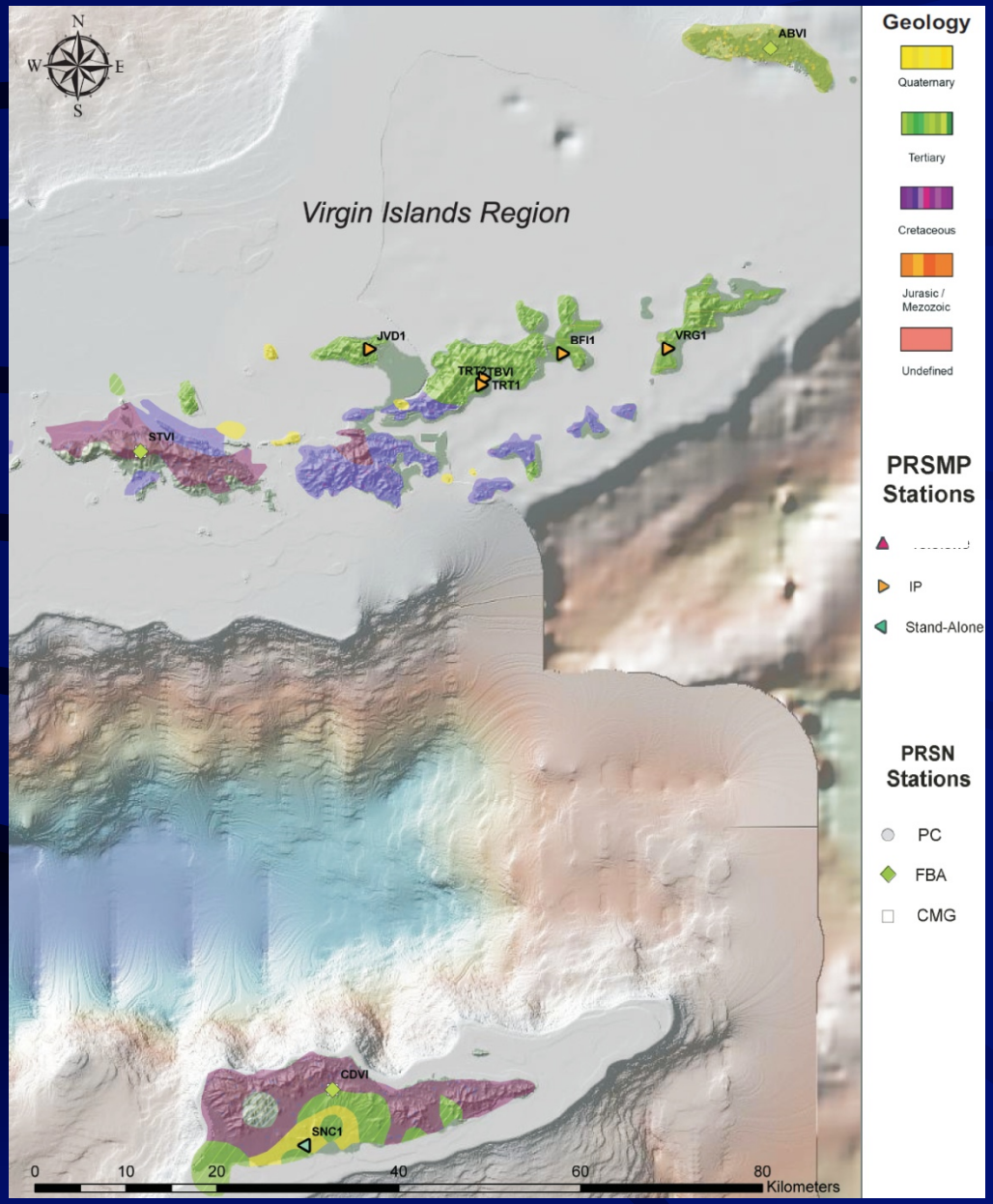
Mona Canyon
Virgin Islands Region
Puerto Rico Region
Anegada Trough
Muertos Trough
0
50
100
200
300
400
Kilometers


Puerto Rico Region
N
W
E
S
0 12.5 25 50 75 100
Kilometers
PRSMP Stations
IP
Stand-Alone
PRSN Stations
PC
FBA
CMG
Geology
Quaternary
Tertiary
Cretaceous
Jurasic / Mezozoic
Undefined


PRP1
MAO1
SC01
SC02
NAG1
SFM1
SNH1
SMN1
BON1
SJM1
HTM1
HGY1
PCDR
SD01
BRH1
Dominican Republic Region
0
25
50
100
150
200
Kilometers
N
W
E
S
Geology
Quaternary
Tertiary
Cretaceous
Jurasic / Mezozoic
Undefined
PRSMP Stations
IP
Stand-Alone
PRSN Stations
PC
FBA
CMG


N
W
E
S
Virgin Islands Region
ABVI
JVD1
BFI1
VRG1
TRT2
TBVI
TRT1
STVI
CDVI
SNC1
0
10
20
40
60
80
Kilometers
Geology
Quaternary
Tertiary
Cretaceous
Jurasic / Mezozoic
Undefined
PRSMP Stations
IP
Stand-Alone
PRSN Stations
PC
FBA
CMG


MY03
MY07
MY11
MY10
MY04
MY01
MY09
MY08
MY05
MY06
MY02
N
Legend
Mayaguez Geology
SOIL_TYPE
Jse
Kmr
Ksg
Ky
Qal
TKab
TKhp
TKpa
TKpaa
TKpb
0 30 15 0 0.3 0.6 0.9 1.2
Kilometers


PN03
PN04
PN08
PN01
PN07
PN06
PN13
PN10
PN02
PN12
PN05
PN11

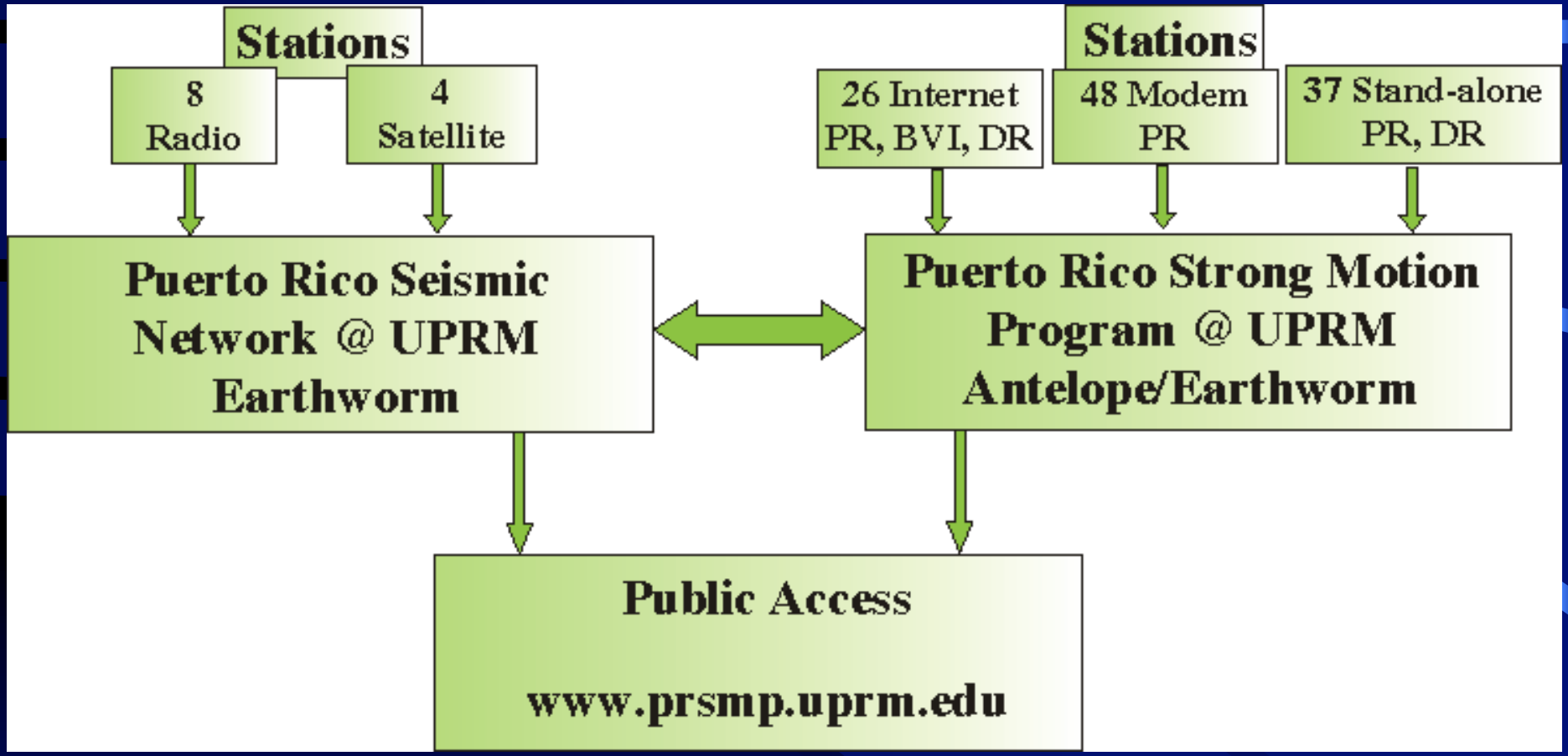
PRSMP NETWORK ADMINISTRARTOR

- ANTELOPE 5.4 (BRTT. Three nodes license)
  - -Run in Dell/PowerEdge servers (At: UPRM/PRSMP)
  - -Operative System, CentOS 6.5
  - -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

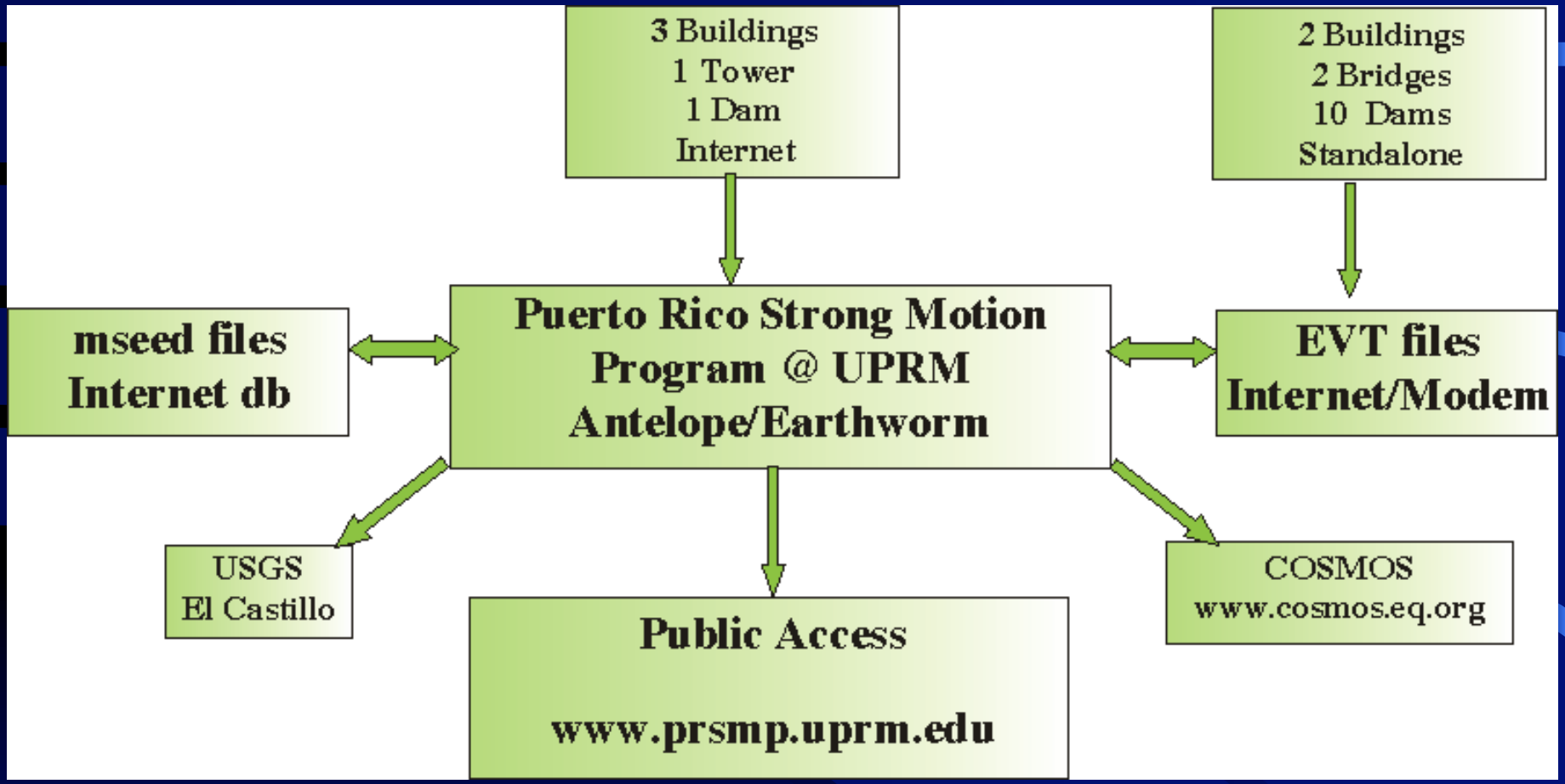
STATION/DATA COMMUNICATION

- 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)

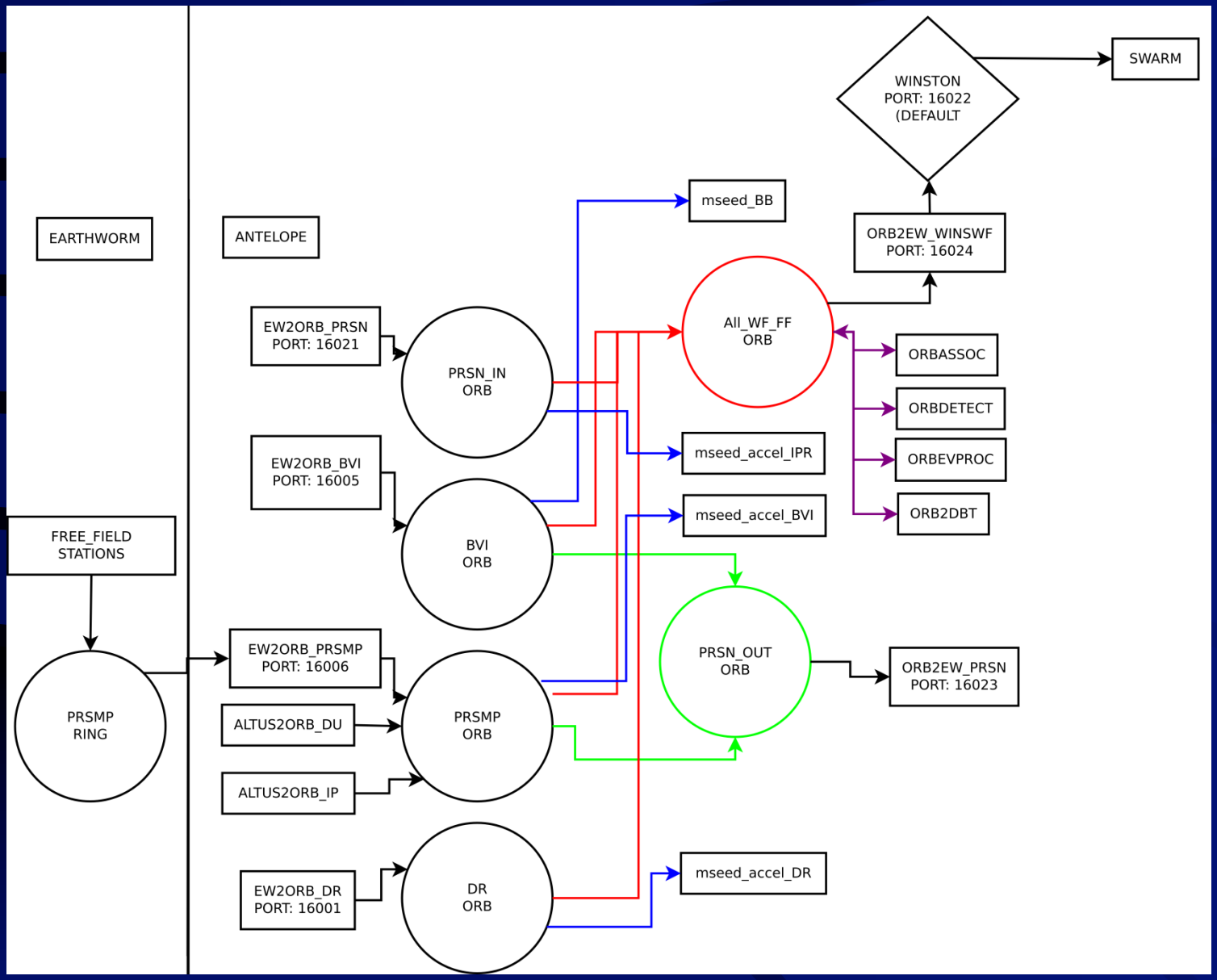
FREE FIELD STATIONS



STRUCTURES


3 Buildings
1 Tower
1 Dam
Internet
2 Buildings
2 Bridges
10 Dams
Standalone
mseed files
Internet db
Puerto Rico Strong Motion
Program @ UPRM
Antelope/Earthworm
EVT files
Internet/Modem
USGS
El Castillo
Public Access
www.prsmp.uprm.edu
COSMOS
www.cosmos.eq.org

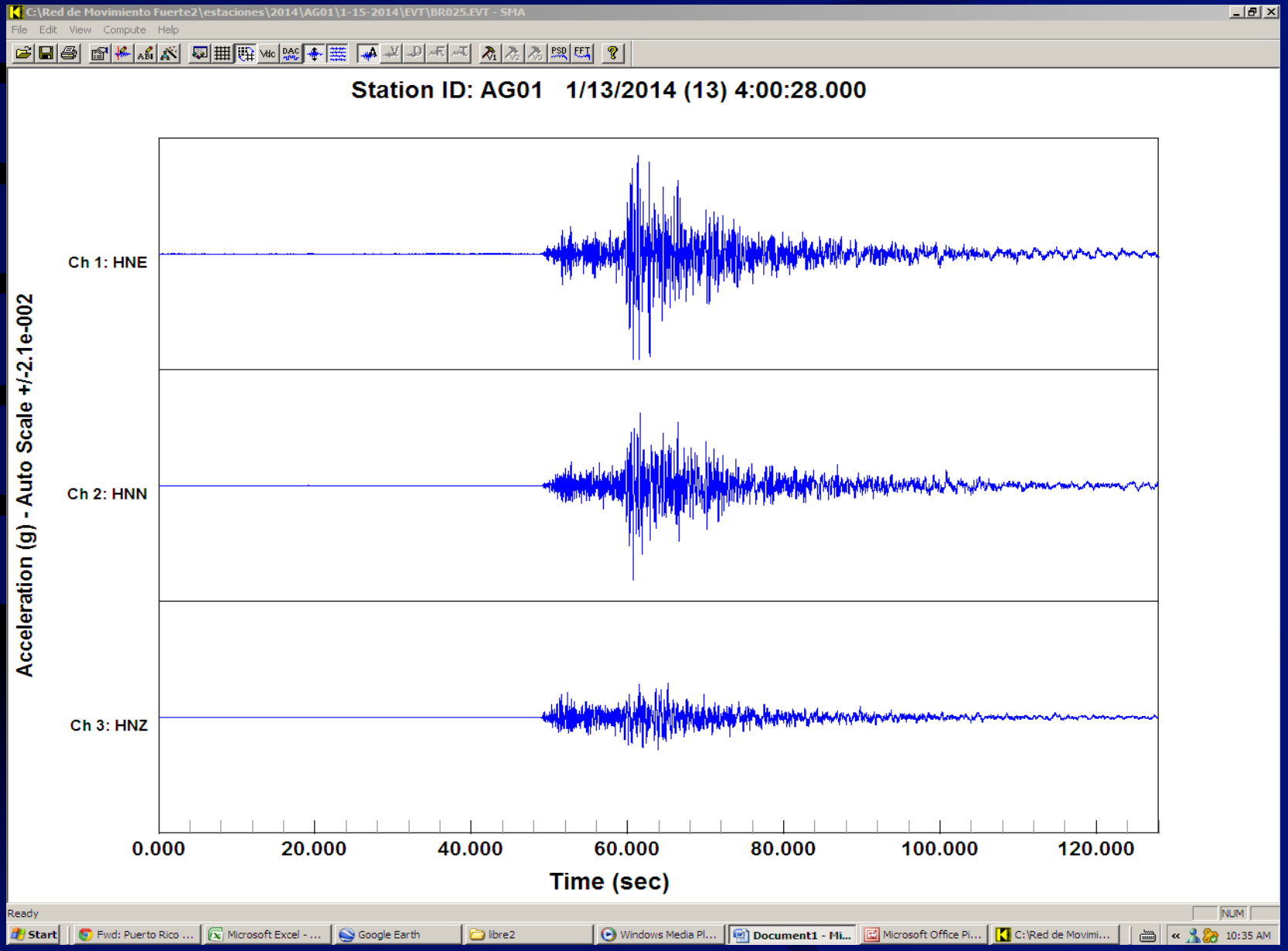
DATA PROCESSING



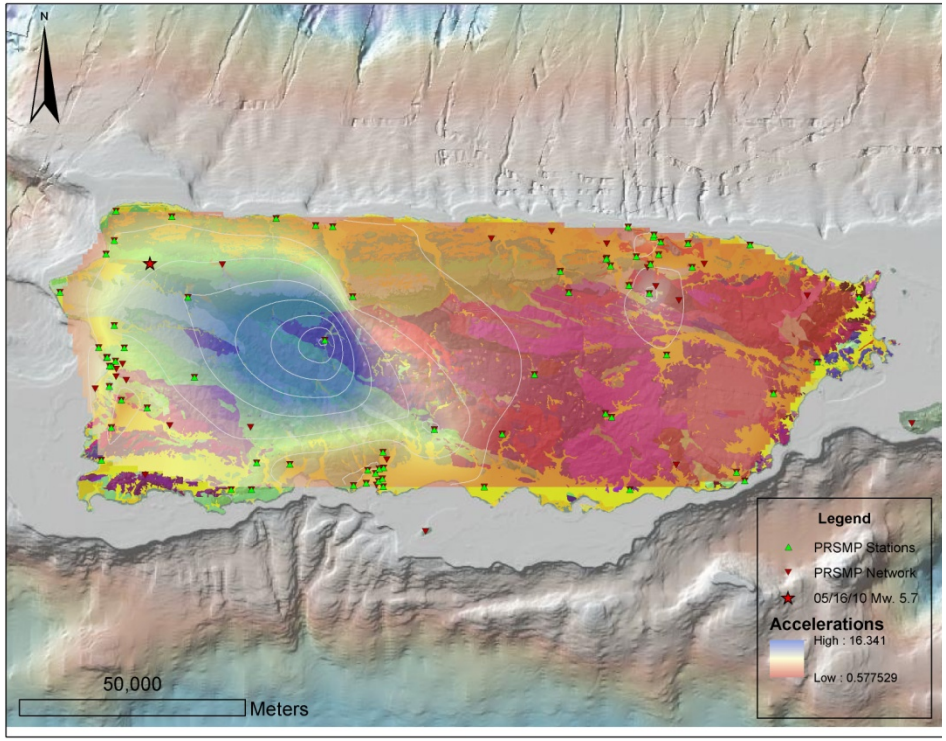
STRONG MOTION DATA PROCESSING

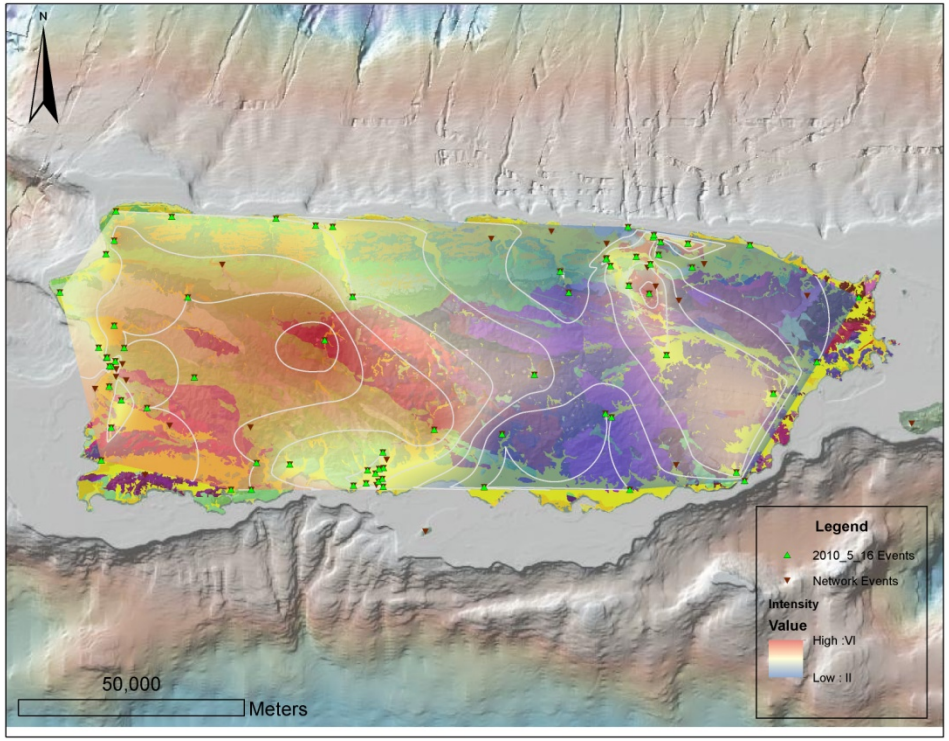
- Standard strong motion signal processing (SMA-Kinemetrics and MatLab codes) is used to the recorded data obtaining the .V1, .V2, and .V3 processed data, which correspond to the uncorrected acceleration records converted to physical units, the corrected acceleration record in physical units of acceleration,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

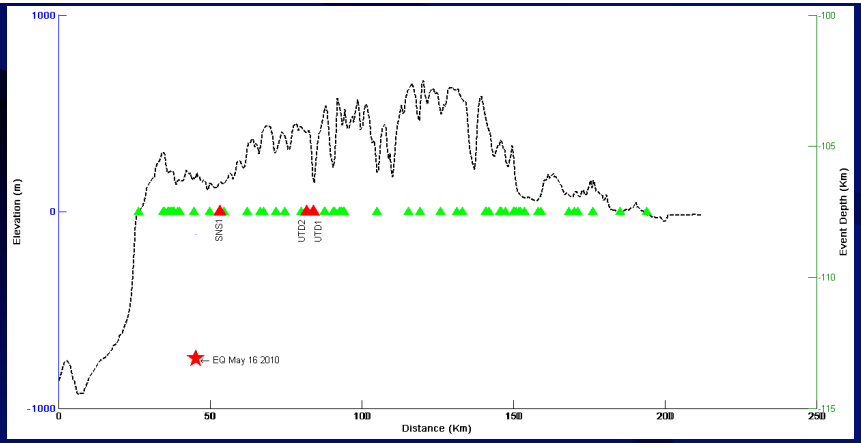
STRONG MOTION DATA PROCESSING

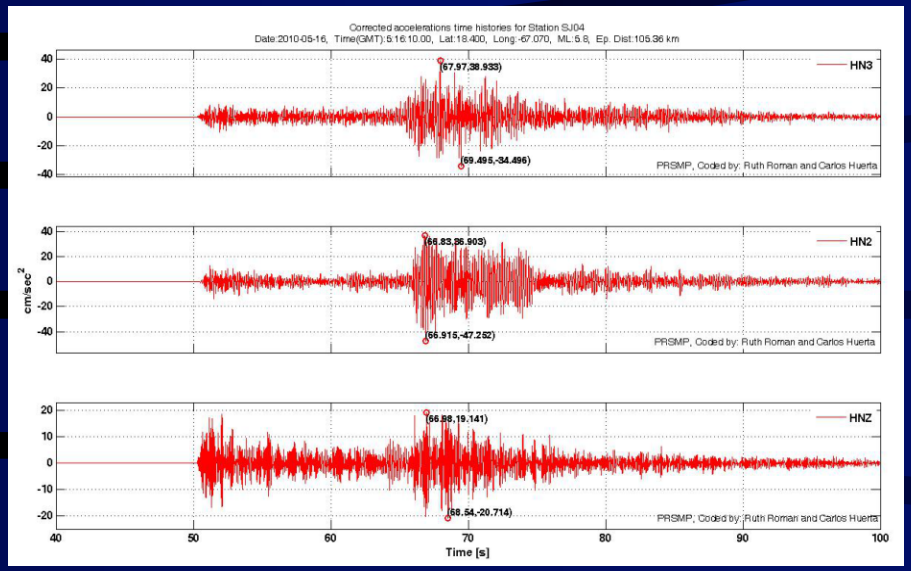


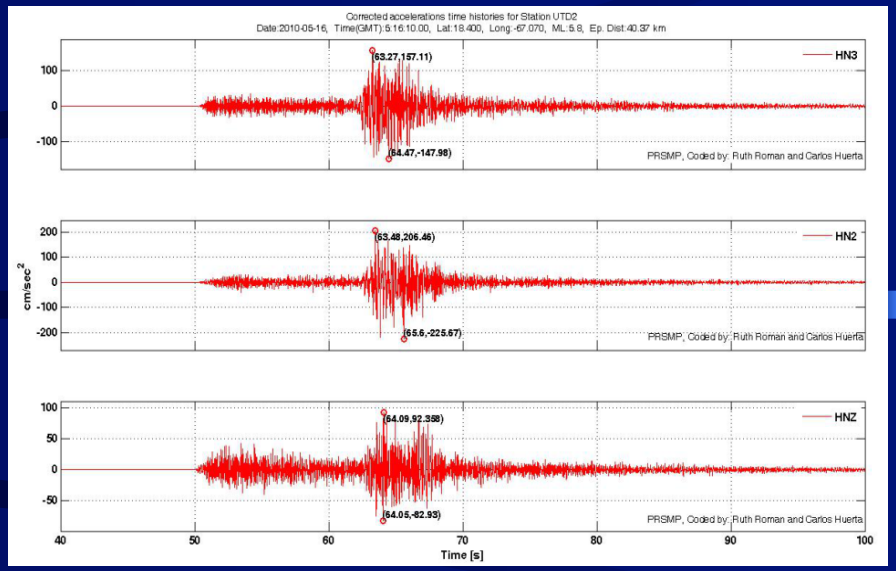
May 16, 2010 Earthquake: Study case

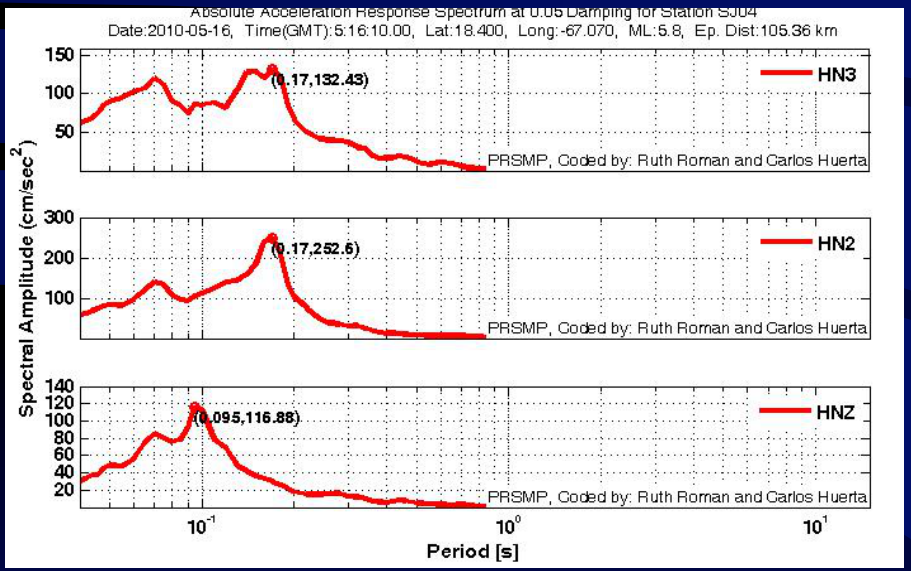


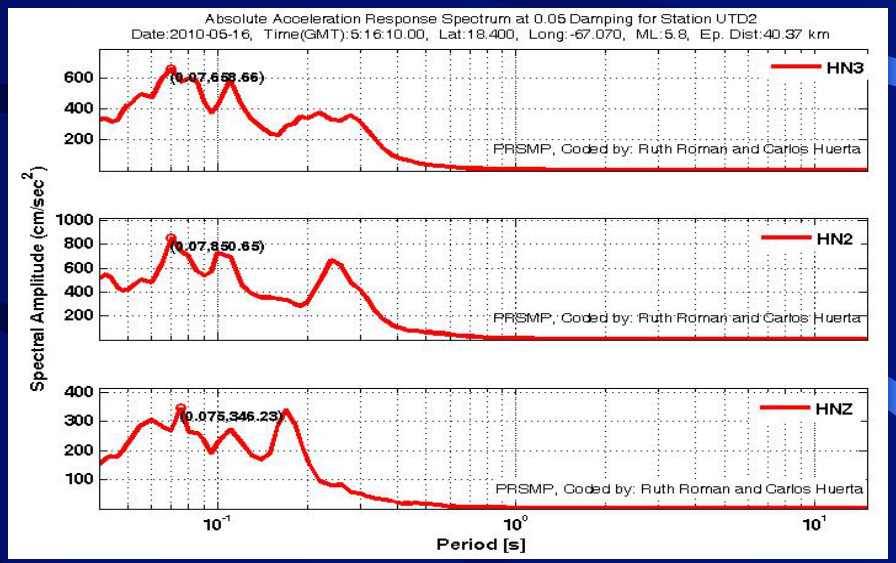




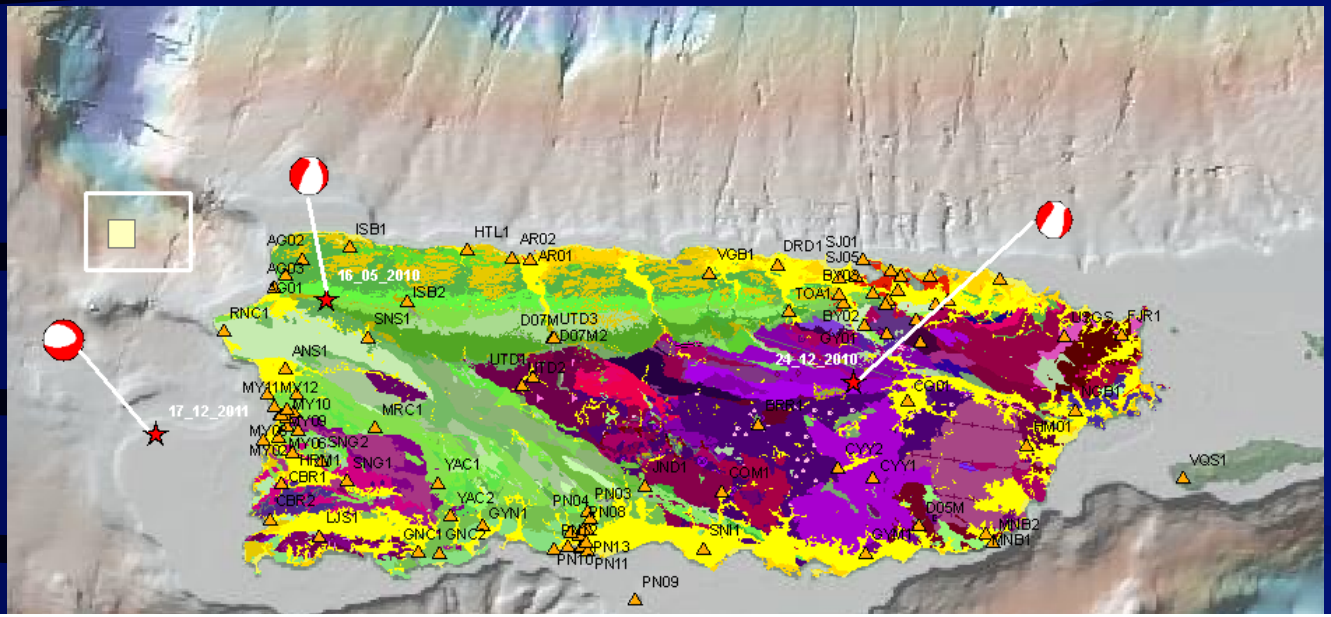

Corrected accelerations time histories for Station SJ04
Date:2010-05-16, Time(GMT):5:16:10.00, Lat:18.400, Long:-67.070, ML:5.8, Ep. Dist:105.36 km
HN3
(67.97,38.933)
(69.495,-34.496)
HN2
(66.83,36.903)
(66.915,-47.252)
HNZ
(66.88,19.141)
(68.54,-20.714)
PRSMP, Coded by: Ruth Roman and Carlos Huerta
cm/sec2
Time [s]


Corrected accelerations time histories for Station UTD2
Date:2010-05-16, Time(GMT):5:16:10.00, Lat:18.400, Long:-67.070, ML:5.8, Ep. Dist:40.37 km
HN3
(63.27,157.11)
(64.47,-147.98)
HN2
(63.48,206.46)
(65.6,-225.67)
HNZ
(64.09,92.358)
(64.05,-82.93)
PRSMP, Coded by: Ruth Roman and Carlos Huerta
cm/sec2
Time [s]


Absolute Acceleration Response Spectrum at 0.05 Damping for Station SJ04
Date:2010-05-16, Time(GMT):5:16:10.00, Lat:18.400, Long:-67.070, ML:5.8, Ep. Dist:105.36 km
HN3
(0.17,132.43)
HN2
(0.17,252.6)
HNZ
(0.095,116.88)
PRSMP, Coded by: Ruth Roman and Carlos Huerta
Spectral Amplitude (cm/sec2)
Period [s]

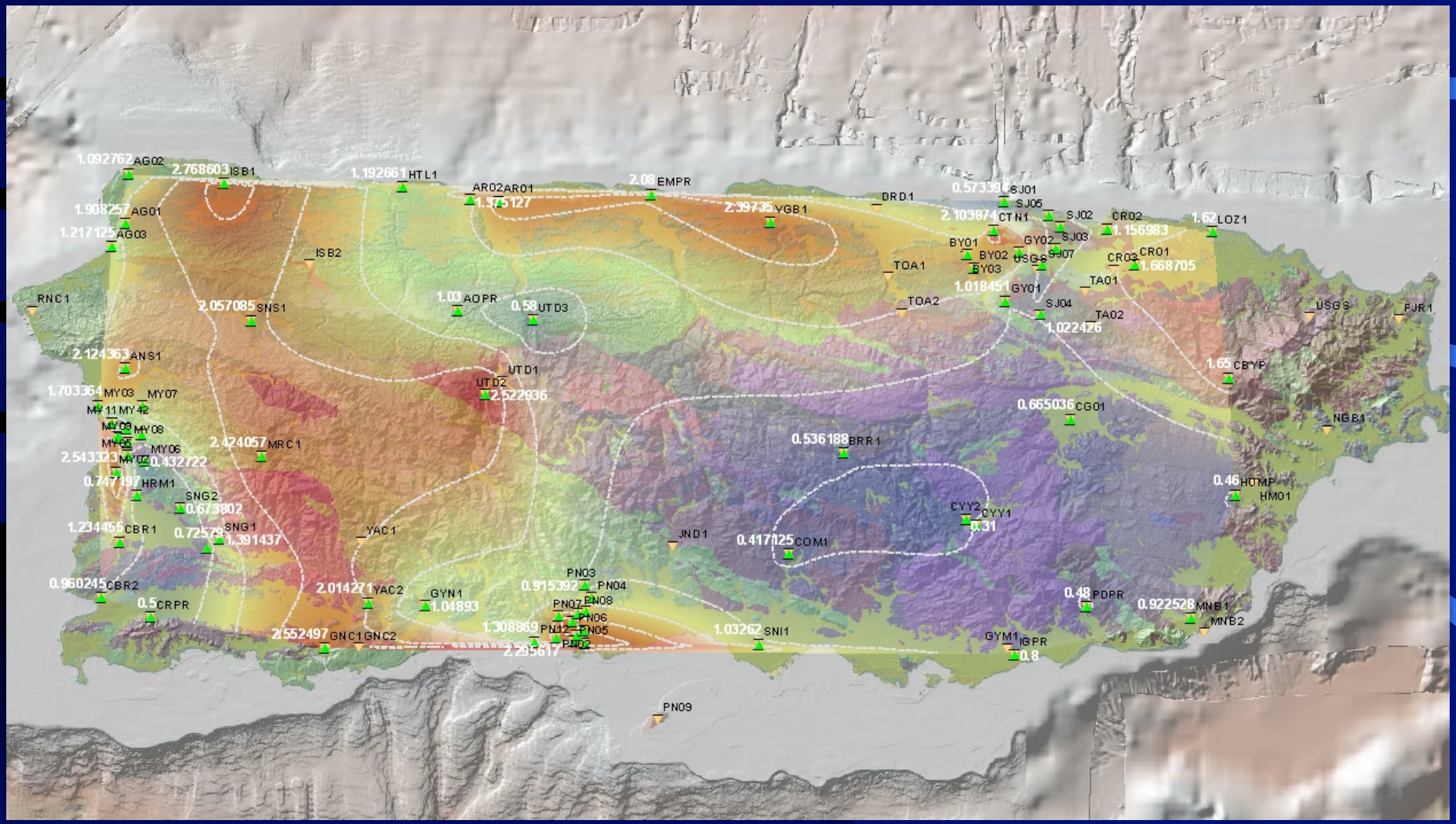

Absolute Acceleration Response Spectrum at 0.05 Damping for Station UTD2
Date:2010-05-16, Time(GMT):5:16:10.00, Lat:18.400, Long:-67.070, ML:5.8, Ep. Dist:40.37 km
HN3
(0.07,658.66)
HN2
(0.07,850.65)
HNZ
(0.075,346.23)
PRSMP, Coded by: Ruth Roman and Carlos Huerta
Spectral Amplitude (cm/sec2)
Period [s]

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

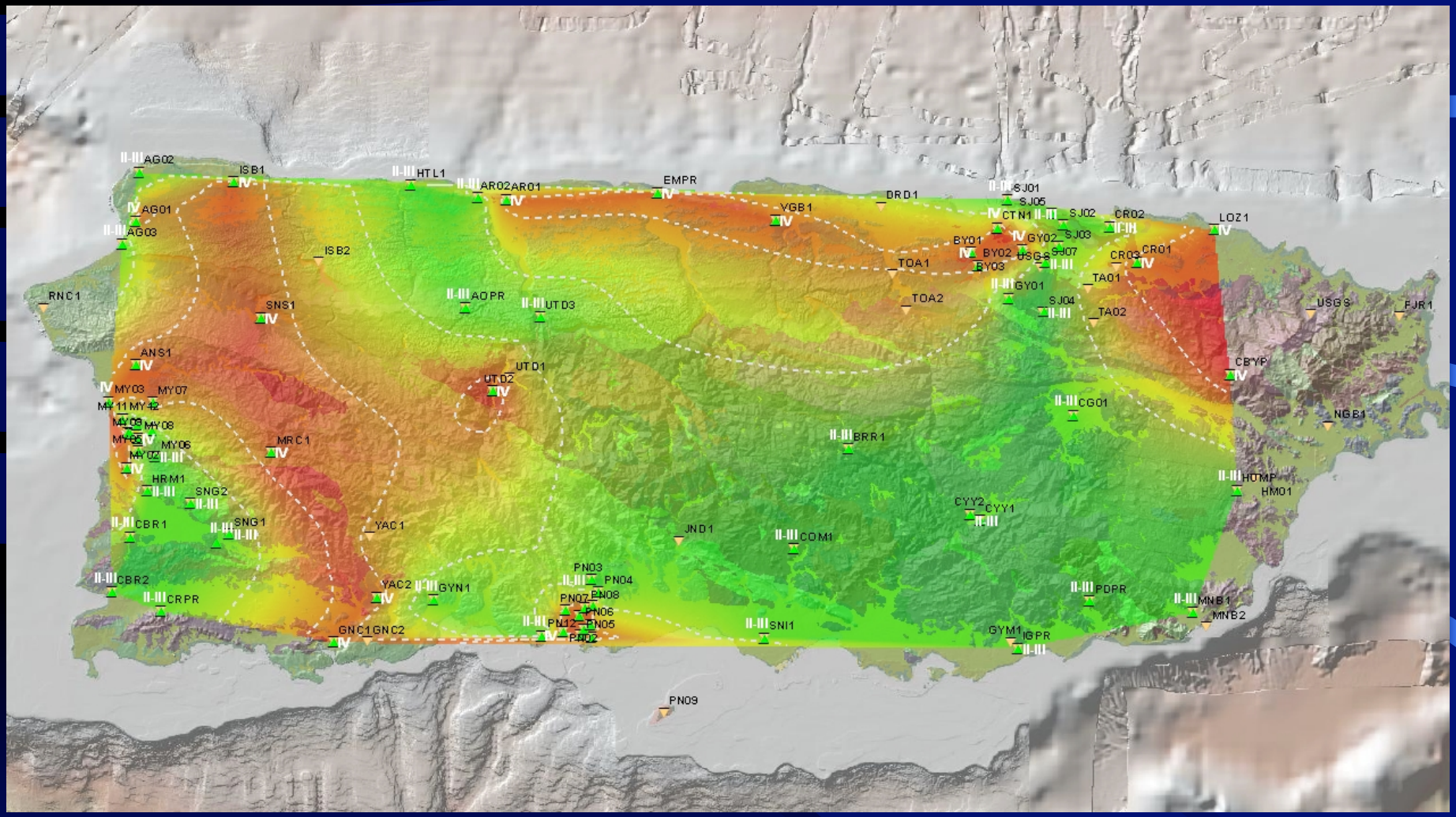


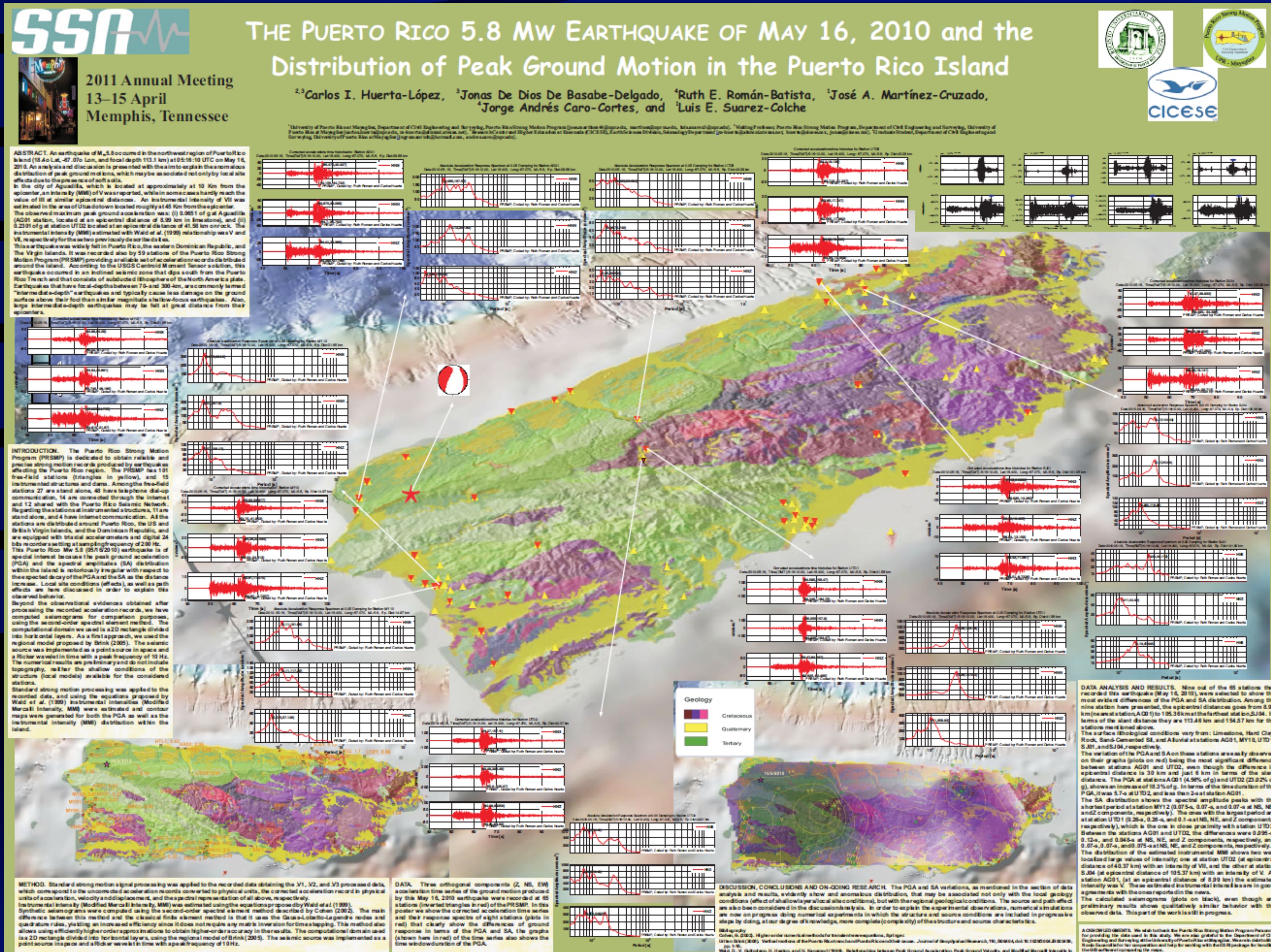
Event date	Max_PGA (cm/s^2)	Station	Distance (Km)	Max_PGA (cm/s^2)	Station	Distance (Km)
May-16-2010 (5.8)	23.01	UTD2	E=40.17 H=120.02	2.04	AG02	E=13.03 H=113.84
Dec-24-2010 (5.1)	14.15	HM01	E=34.01 H=108.54	12.13	CG01	E=10.06 H=103.44
Dec-17-2011 (5.3)	11.30	MY12	E=23.38 H=29.01	4.08	UTD2	E=69.3 H=71.3
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





AUG. San Diego, CA. 01/2015

PRSMP

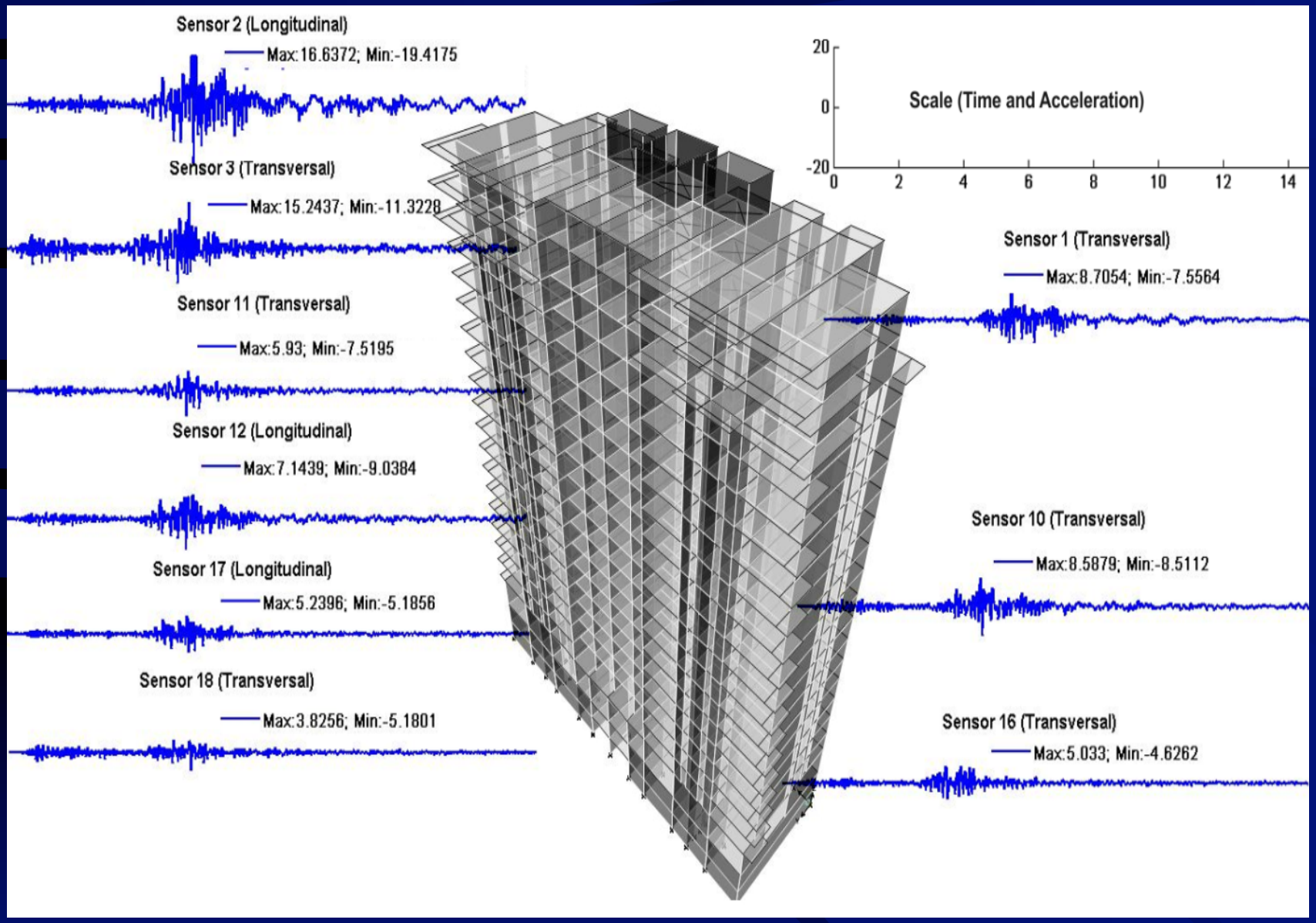
PUERTO RICO STRONG MOTION PROGRAM

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.

AUG. San Diego, CA. 01/2015

El Castillo Building. M5.3 Eqk.



go_prsmp_webpage

PRSMP WEB PAGE DATA DISSEMINATION

Thanks,