A NEW GPS – DERIVED DATABASE FOR CO – SEISMIC DISPLACEMENTS IN THE AEGEAN AREA AND ITS GEODYNAMIC SIGNIFICANCE

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Introduction

Global Navigation Satellite System (GNSS) data measurements contribute in

- Quantification of **ground deformation** following strong earthquakes,
- Determination of the **geometry and kinematics of the seismic fault** in case of "blind" ruptures
- **Fault inversion models.**

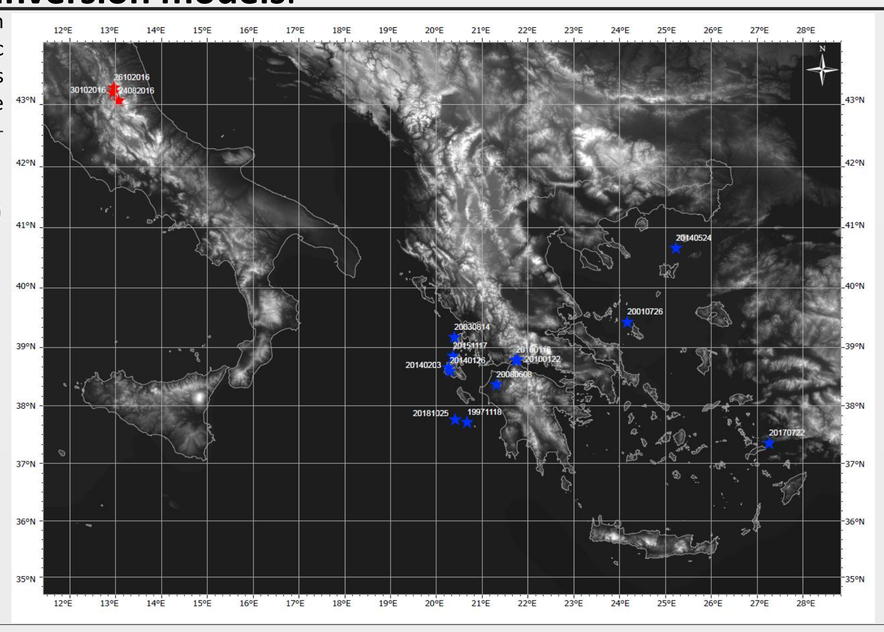


Fig.1. Location map of the seismic events used in this study from Greece and Italy (Multi-Directional Hillshade Map/USGS– NASA)

Data & Methods

The dataset consists of GNSS horizontal displacements for 12 (≥M5.5) earthquakes. The majority of the recordings are collected by NOA at 1Hz as raw observations and they are subsampled to 30-s and translated to RINEX format. Users of the data have published offsets in the literature from where we selected 64 data points for further analysis.

Date	Lat	Long	D (km)	Mw (GCMT)	Ref
19971118	37.4800	20.6900	10.0	6.6	1
20010726	39.0500	24.3500	19.0	6.4	2
20030814	38.8300	20.6400	6.8	6.2	3
20080608	37.9400	21.4780	18.0	6.4	4
20100118	38.3962	21.9039	8.5	5.5	5
20100122	38.4075	21.9422	5.1	5.4	6
20140126	38.2102	20.4614	16.5	6.1	7
20140203	38.2734	20.4310	4.6	6.0	8
20140524	40.2900	25.4000	14.0	6.9	9
20151117	38.6755	20.5930	9.6	6.5	10
20170720	36.9553	27.4484	9.2	6.6	11
20181025	37.3768	20.5805	11.5	6.7	12

Table 1. The data comprise GPS static offsets (measured on the horizontal components, N-S and E-W) regarding the earthquakes

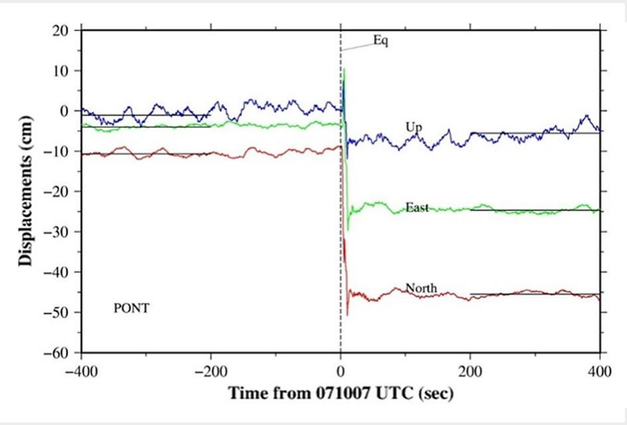


Fig.2. Graph showing co-seismic offsets on GNSS waveforms from station PONT (south Lefkada, Greece), following the 17/11/2015 M6.5 earthquake. This data was used to calculate PGD and PGD-S respectively for this station and earthquake.

PGD scaling relationships for Aegean earthquakes

The static offsets are named **PGD** (Peak ground displacement) and **PGD-S** (PGD-squared) offsets, respectively.

A_{N-S} and A_{E-W} components of ground displacement

Quantity PGD (Peak Ground Displacement)

$$PGD = (|AN{-}S| + |AE{-}W|)/2$$

where PGD = mean value of the absolute horizontal displacement in two orthogonal directions (cm)

Quantity PGD-S (Peak Ground Displacement-Squared)

$$PGD - S = (AN{-}S^2 + AE{-}W^2)\,1/2$$

where PGD-S = resultant horizontal displacement (cm)

$$LOG(x) = A + B * Mw + C * Mw * LOGR$$

where x = either PGD or PGD-S, Mw = magnitude of the earthquake event, R = hypocentral distance of the GPS station to the earthquake's epicenter

The **correlation of M_w and LOGR with PGD and PGD-S** occurs with the use of L1-norm minimization regression. This regression is a **least squares method** with a penalty of the L1-norm form multiplied by a factor λ. The regression for PGD-S minimizes the Mean Square Error in comparison to PGD, so we expect it to show a better fit.

$$\boldsymbol{LOG(PGD) = -8.2849 + 1.6810 * Mw - 0.2453 * Mw * LOGR}$$

$$\boldsymbol{LOG(PGD - S) = -8.0839 + 1.6793 * Mw - 0.2447 * Mw * LOGR}$$

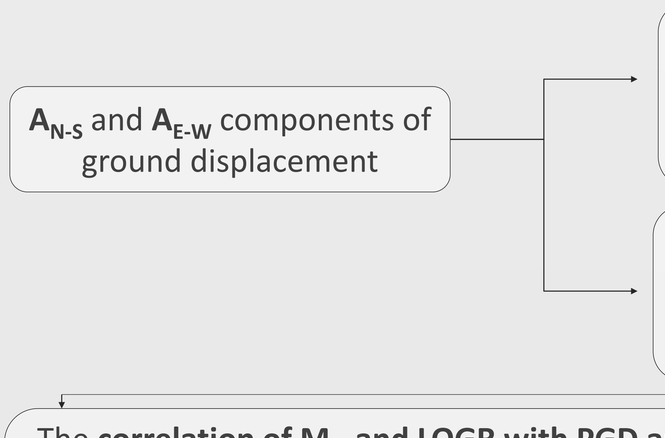
GNSS Magnitude (estimated) vs real Magnitude

The main aim is to develop a set of relationships which may be used for the rapid estimation of the earthquake magnitude in near real-time.

We calculated the standard deviation for our GNSS estimated magnitudes (Mw) for each seismic event for PGD and PGD-S approach.

$$\boldsymbol{Mw^{PGD} = [LOG(PGD) + 8.2849] / (1.6810 - 0.2453 * LOGR)}$$

$$\boldsymbol{Mw^{PGD-S} = [LOG(PGD - S) + 8.0839] / (1.6793 - 0.2447 * LOGR)}$$



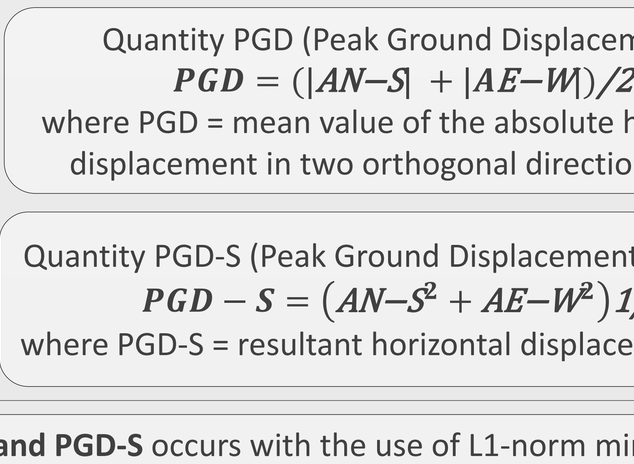
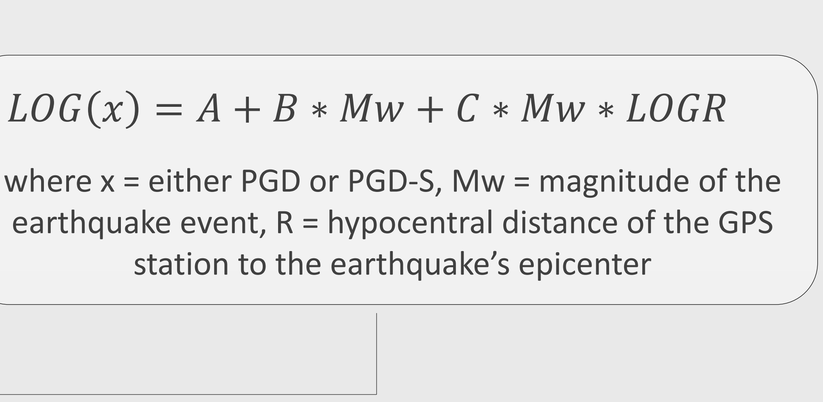
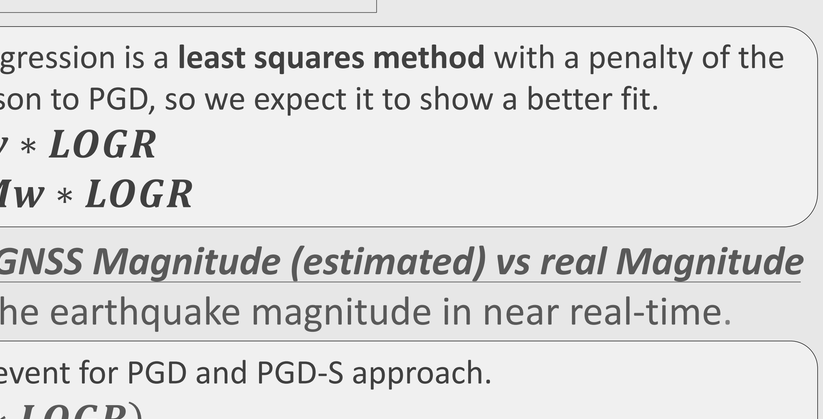


Fig.3. (Left) Scatter plots showing the decrease of PGD/PGD-S with hypocentral distance (km) in the magnitude range 5.5-7. (Right) Scatter plots showing of PGD/PGD-S (cm) with hypocentral distance (km) in the magnitude range 5.9-6.5 (3 events from central Italy, period 24/8/2016-30/10/2016).





Conclusions

- -We find coefficients that are well fit over the magnitude and distance ranges used (PGD data plot 0.3).
- -A validation of our estimated (GNSS) magnitude in the case of the 2018 Zakynthos earthquake showed that the magnitude difference with real magnitude is less than 0.1 magnitude units.

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