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Ground Deformation from GNSS Data Following Strong Ionian Sea Earthquakes in 2014 and 2015: Co-seismic Offsets and Station Baseline Changes

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Extended abstract

In this study we used geodetic data from two Greek GNSS networks, operating during the 2014-2015 period when three (3) strong and shallow seismic events occurred in the central Ionian islands, Greece. The earthquakes occurred on 26 January 2014 13:55 UTC (moment magnitude M_w=6.1; Fig. 1), 3 February 2014 03:08 UTC (M_w=5.9) and 17 November 2015 07:10 UTC (M_w=6.4). The 2014 events occurred onshore Cephalonia (Fig. 1; e.g. Karastathis et al. 2015), while the 2015 event occurred onshore south Lefkada (Ganas et al. 2016). To study the ground deformation due to the three events we used daily observations from the GPS satellite constellation sampled at 30-s intervals. The daily data are provided by the network operators in the form of rinex version 2.11 files. The stations are equipped with dual-frequency geodetic receivers and belong to NOANET (Ganas et al., 2008; 2013), HxGN SmartNet Greece, EUREF and NKUA networks (Sakkas and Lagios, 2015, 2017). The GNSS data are processed using the Bernese 5.1 software following the double-difference approach. Details of the processing can be found in Sakkas and Lagios (2017). For each station we obtained daily estimates of IGb08 positions (X, Y, Z). We then converted the positions in EGSA 1987 (Greek national projection) coordinates using the Leica Geo-office software. We normalized the position data dividing each component by the mean position of all the years (for example, for station VLSM the data coverage is 2009-2018; see station location in Fig. 1). Then, we took the mean value (and its standard deviation) of the normalized position one week before and one week after the event (in all components), and we calculated the offset and the quadratic error of the offset. We found that cm-size co-seismic horizontal offsets were recorded by the continuous GPS stations operating at both Cephalonia and Lefkada islands, in agreement with previous studies. Mm-size offsets were detected in stations located in western Peloponnese and Akarnania regions. In Table 1 we present the offsets due to the 26 January 2014 M_w=6.1 event (see Fig. 1 for vector plots).

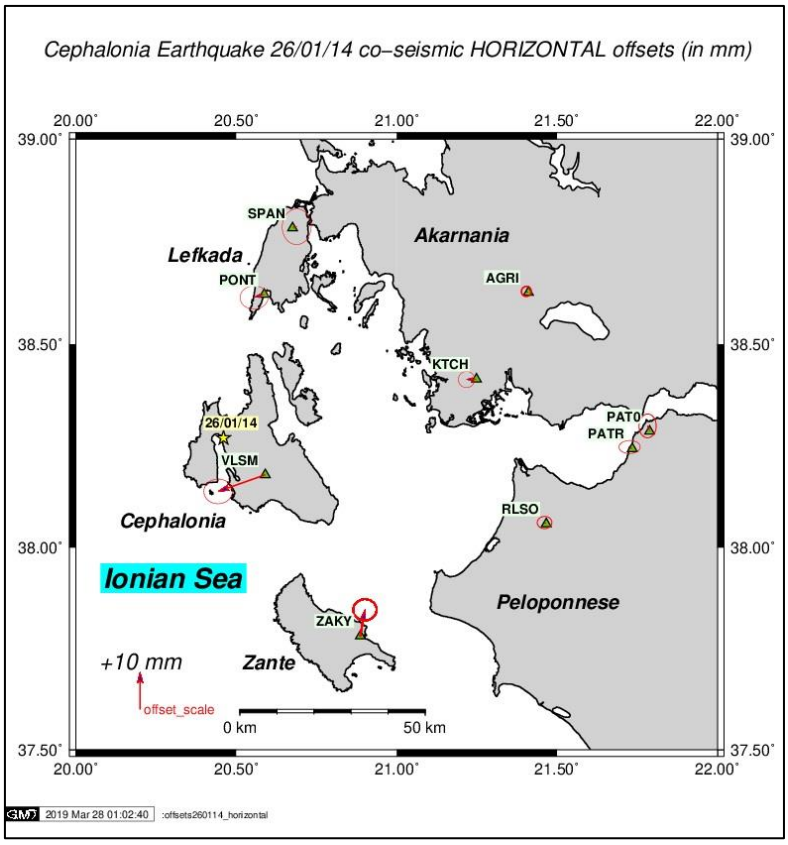

Figure 1. Map of central Ionian Islands and western Greece showing the location of GNSS stations (green triangles) that recorded the January 26, 2014 earthquake (yellow star). The co-seismic offsets are shown as vectors with error ellipses. The map was done with GMT software v5.0 (Wessel et al. 2013).

We also studied the change of station baselines with time, i.e. we calculated a) the baseline (horizontal distance) between all stations within our network and b) how this distance varies over the study period (2006-2018). It is expected that station baselines will change after the occurrence of a strong earthquake as station positions change. In addition, after the earthquake the baseline may show a delay before obtaining a stable trend because of post-seismic motions that may affect the GNSS station. It is of interest to study if baseline changes can be detected before strong earthquakes, so that the GNSS data may be used for earthquake forecasting. The Ionian Sea is a region with high seismic activity due to the occurrence of the Cephalonia strike-slip fault, a transform fault between the Eurasia and African tectonic plates so the GNSS data are crucial for monitoring ground motions before, during and after earthquakes.

Table 1. List of GNSS stations that recorded the 26 January 2014 earthquake (M=6.1) and their co-seismic offsets. Lon, LAT indicates station location in decimal degrees longitude, latitude, respectively. A_E, A_N & A_{UP} indicate East-West, North-South and Up-Down offsets, respectively. Stations are depicted in Fig. 1.

Station	Network	LON	LAT	26/01/2014 Mw=6.1		
				A_E mm	A_N mm	A_{UP} mm
AGRI	HxGN	21.410664	38.626618	-0.56 ± 0.97	0.26 ± 0.99	2.92 ± 4.52
KTCH	PPGNET	21.248555	38.414210	-2.66 ± 1.60	-0.09 ± 1.60	0.82 ± 3.57
PAT0	EUREF	21.788366	38.286275	-0.52 ± 1.70	1.44 ± 2.35	0.98 ± 4.55
PATR	HxGN	21.734591	38.243478	-0.73 ± 2.09	0.45 ± 1.29	2.84 ± 5.67
PONT	NOANET	21.781232	38.370106	-2.69 ± 2.76	-0.81 ± 2.28	4.75 ± 6.84
RLSO	NOANET	20.586785	38.621631	-0.46 ± 1.44	0.37 ± 1.21	6.1 ± 6.24
SPAN	NOANET	21.466366	38.058459	1.11 ± 2.86	0.33 ± 3.52	3.44 ± 8.33
VLSM	NOANET	20.590243	38.179464	-12.58 ± 2.82	-4.44 ± 2.44	-3.77 ± 2.68
ZAKY	HxGN	20.886645	37.781794	3.59 ± 2.31	1.2 ± 2.10	6.98 ± 7.16

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