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GPS Networks in Seismically Active Areas of Western Greece: The Case of Zakynthos Earthquake (Mw=6.8) of October 25, 2018

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Ground deformation studies based on satellite geodetic measurements (GPS/GNSS) have been proved a unique tool to measure ground deformation in seismically active areas aiming to study the tectonic motions associated with earthquake procedures. The Central Ionian Islands is an area of high seismicity accompanied with large ground deformation due to the intense tectonic activity occurring in the area. In order to measure pre- co- and post-seismic activity in this area several local GPS networks have been established since 2001 covering the islands of Cephalonia, Ithaca and Zakynthos. Periodic GPS campaigns provided vital information of the motions that occurred prior and after strong earthquakes, such as are the Cephalonia events in 2014, and the Lefkadian event in 2015 (Sakkas and Lagios 2015; 2017).

Late October 2018, a strong seismic event (Mw=6.8) occurred offshore ~40km SW of Zakynthos Island (Fig. 1). The post seismic activity that started that day continued for many months, comprised by several events of lower magnitude ~M5 and hundreds other smaller events. The post seismic activity that took place during the first few days after the main event was in the epicentral area, but also extended to the NE along three zones with a SW-NE extension that cross-cut the central and southern part of the island.

The October 25, 2018 Zakynthos Earthquake is a typical example of a strong event that caused intense deformation in the broader epicentral area, revealing significant tectonic structures in the island.

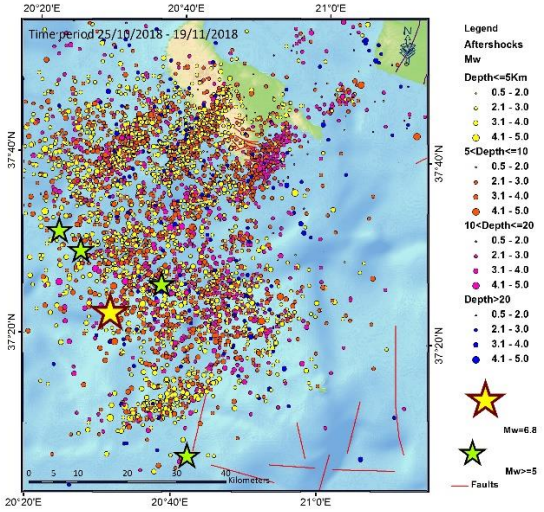

Figure 1. The October 25th, 2018 Zakynthos Earthquake and the post seismic activity during the following days.

Brief Geotectonic Setting

The Central Ionian islands in western Greece play an important role in the kinematic processes of the Eastern Mediterranean. They are situated within a very active seismotectonically complex area which is undergoing rapid and intense ground deformation. The highest seismic activity in Europe currently takes place in that region, constituting part of the Eastern Mediterranean Lithosphere that is subducting beneath the Aegean Lithosphere along the Hellenic Arc. The subduction zone terminates against the Cephallonia Transform Fault, a major strike-slip fault that links the subduction boundary to the continental collision between the Apulian microplate and the Hellenic foreland, and plays a key role in the region's geodynamic complexity (Brooks and Ferentinos, 1984).

Zakynthos Island consists of rocks of two zones, the Pre-Apulian or Paxos Zone and the Ionian Zone. Both zones lie to the west of the Pindos thrust and the boundary between them is the Ionian thrust which is generally considered to represent the most external Hellenides structure (Underhill, 1989). This thrust is not well exposed in Zakynthos, because the absence of Mesozoic carbonates and the occurrence of a thick Pliocene cover make the boundary between these zones difficult to define. The Pre-Apulian Zone is characterized by Upper Cretaceous to Miocene sediments (limestones, marly limestones etc.), whereas the Ionian zone, which appears in the southeastern part of the island, consists of limestones and evaporitic rocks of Triassic age. The post Alpine deposits are marls of Pliocene age and Quaternary marine and continental formations.

The GPS Measurements

The GPS network (14 stations) in Zakynthos was first installed in 2005 and re-measured in 2006, 2012, 2015, May 2018 and after the earthquake November 2018. Overall rms errors of about 1.0-7.0 mm and 2.0-8.1 mm for the horizontal and vertical components of displacement, respectively, were achieved for the majority of the stations (at a 90% confidence level) using the Bernese v5.2 software. Station No. 73 was chosen as a local reference station for the periods prior to 2010. Late 2013 a continuous GNSS site has been established by METRICA SA in the city of Zakynthos, and since then this site has been used as local reference station, showing a velocity vector with respect to ITRF2008 (V_{East}=12.7±1.1 mm/yr and V_{North}=-3.1±0.7 mm/yr) that is consistent with the anticipated regional motion (Hollenstein et al. 2008).

For the first re-measurement periods 2005-2015, the horizontal deformation is consistent with the anticipated southwestern motion of the area with respect to the ITRF. However, at the northern half of the island, the vectors show a westward motion (about 80 mm), while to the south a southwestern motion of the same amplitude prevails. The vertical deformation shows significant subsidence for the whole of the island. The strong differentiation in the motion between the northern and the southern parts of the island, observed mainly in the first re-measurement period (2005-2006), but also in the second period (2006-2015), highlights the different kinematic status of the two areas, as has been described also in previous works (Lagios et al. 2007).

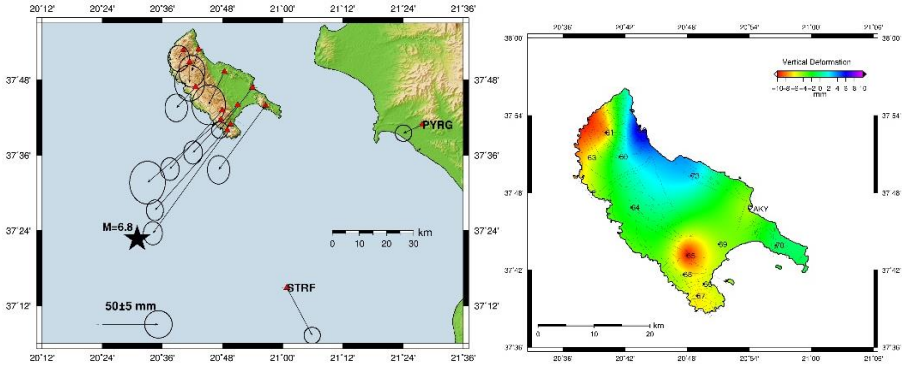

Figure 2. Horizontal (left) and Vertical (vertical) displacements (mm) of the Zakynthos GPS network observed for the period May to November 2018

The last remeasurements of the network took place during May and November 2018, before and after the strong earthquake. The deformation results of these two re-measurement periods may be considered as representing the co-seismic deformation occurred in the island (Fig. 2). The horizontal vector shows SW motion of about 110mm is the southern stations and less (~30mm) in the northern stations. Results from two other permanent stations that operate in the broader area, the PYRG station (METRICA SA) in western Peloponnese and the STRF station in Strofades islet (RING network http://ring.gm.ingv.it) show SW and SE horizontal motion, respectively. The most distinctive characteristic of the horizontal vectors is the differentiation of the motion vectors, in both amplitude and direction, between the northern and southern part of the island that has also been observed during the pre-seismic observational periods. The zone that marks the change of type of motion is across the northern line that forms the post seismic events (see Fig. 1) showing that there is a clear tectonic lineament that cross-cuts Zakynthos in its central area, and causes this different type of motion between the northern and southern part of the island.

Acknowledgements

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