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**The Deformation Field of the 27<sup>th</sup> May 2017 Gölarmara  
Earthquake**

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**ABSTRACT**

Gediz (Alaşehir) graben, which locates in Western Anatolia region, is divided into three collapses such as Gölarmara, Manisa and Kemalpaşa basins towards west. Gediz graben exists on Menderes massive, besides, the high and medium grades metamorphic rocks cover the basement of this area. In this area, the earthquakes occurred since ancient periods. Recently on 27<sup>th</sup> May 2017, a moderate earthquake occurred in Deynekler-Gölarmara (Manisa City) with magnitude (Mw) 5.2 and the effects of this earthquake were felt for approximately 15 days on a great region which includes high populated cities such as Manisa, Izmir, Aydın, Uşak and Balıkesir. According to Kandilli Observatory and Earthquake Research Institute (KOERI), the focal depth of the earthquake was shallow and approximately 13 km and occurred in normal fault with vertical strike. In this study, the pre-seismic, co-seismic and post-seismic deformation analysis is realized with help of the GPS time-series of the continuous stations locate in effected region by this earthquake. In this scope, the regional evaluations are executed due to the deformation type of the GNSS stations. As the general result, the vertical components of the time series were more affected related with the consistent of the fault sense of the earthquake occurred. Additionally, the existence of a lake which appeared with the regional tectonic collapse is the sign of the vertical movements in the area. Therefore, it can be said that the regional effect type of the earthquake is the vertical directional.

Keywords: 27<sup>th</sup> May 2017 Gölarmara Earthquake, GNSS, time-series, deformation.

## Introduction

Viscoelastic loosening (relaxation) mechanism, afterslip mechanism and pore fluid motion cause the post-seismic deformation. The post-seismic deformation can be affected on the wide areas and also its effects sustain for a long time (Thatcher and Pollitz, 2008). Throughout the post-seismic motions which occur with the effect of earthquakes greater stress changes occur on the stress fields close faults relative to the stress changes which are consisted of the co-seismic movements (Freed and Lin, 2001; Rydelek and Sacks, 2001; Chery et al., 2001, Casarotti et al., 2001). The effects of post-seismic motions get away relative to the effects of co-seismic motions (Pollitz et al., 1998; Freed and Lin, 2002; Nalbant and McCloskey, 2011; Sunbul et al., 2016).

In present, Global Navigation Satellite System (GNSS) measurements are used for improving the crustal deformation models (Johnson and Fukuda, 2010; Chuang and Johnson, 2011). The strain concentration is not stable and depends on the viscous flow in the lower crust and upper mantle which are taken place due to effect of the large earthquakes. The fault slip rates which are obtained by geodetic and geological data can be different. In the study of Matmon et al. (2005), the slip rates which were derived from geological data throughout Garlock fault and San Andreas Fault's Mojave segment were found two times greater than the slip rates which were derived from the geodetic data in the studies of Meade and Hager (2004) and Bird (2009). During a large earthquake the shear stresses which are taken place in the lower lithosphere and the lithosphere makes an effort to be equilibrated in stages due to the rheological features of the lower crust and upper mantle. For examining the effects of the rheological structures some rheological models were figured out. These are a model with a weak lower crust and a strong upper mantle (Freed and Lin, 2001; Pollitz and Sacks, 2002; Pollitz et al., 2008) opposite of the first model (Zeng, 2001) and the combining of the first and the second models (Lorenzo-Martin et al., 2006; Nalbant et al., 2006). Therefore, the deformation types (elastic, plastic, viscoelastic) of the tectonic structures, when a large earthquake occurs, depend on the rheological regimes of the affected area.

In this study, we investigated the post-seismic effects of moderate earthquake ( $M_w = 5.2$ ) which was effective in Western Anatolia and occurred in Deynekler-Gölmarmara (Manisa City) at 27<sup>th</sup> May 2017 by using GNSS data (Figure 1). Gediz (Alaşehir) Graben contains three collapses as Gölmarmara, Manisa and Kemalpaşa basins. Gediz graben exists on Menderes massive also the high and medium grades metamorphic rocks cover the basement. In this area, the earthquakes have occurred since ancient periods. The effects of 27<sup>th</sup> May 2017 earthquake were felt for approximately 15 days on a wide area which includes high populated cities such as Manisa, Izmir, Aydin, Uşak and Balıkesir. According to the earthquake report of Kandilli Observatory and Earthquake Research Institute (KOERI) the focal depth of the earthquake was shallow and approximately 13 km and the focal mechanism of the earthquake is normal fault with vertical strike.

Seven GNSS stations of Continuously Operating Reference Stations-Turkey (CORS-TR) namely; BALK (Balıkesir City Center), AYVL (Ayvalık City

Center), KIKA (Kirkagac, Manisa), SALH (Salihli, Manisa), IZMI (Izmir City Center), CESM (Cesme, Izmir), AYD1 (Aydin City Center) and 1 GNSS station of Dokuz Eylul University namely; DEUG (Buca, Izmir) totally 8 GNSS stations (Figure 2) were used for showing the earthquake effect area. As the result of the study, the effects of the earthquake are seen at the surroundings of the GPS stations which locate at Kirkagac, Manisa and Aydin city center.

## Methodology

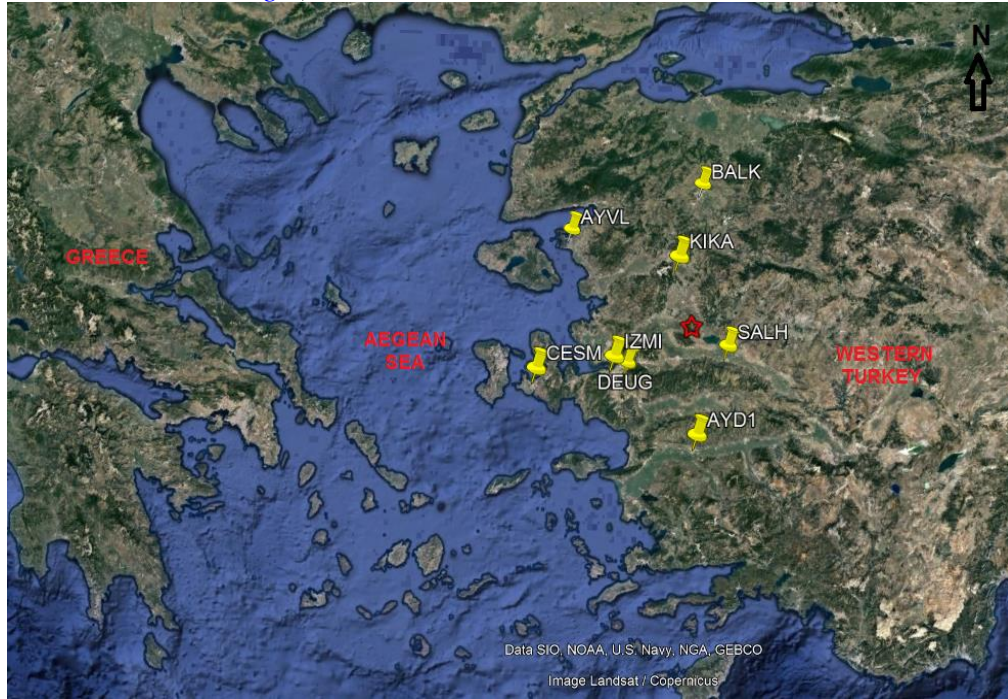
For circulating the network area and describing Eurasia fixed reference frame; 9 IGS (International GNSS Service) namely; ISTA, TUBI (Turkey), ZECK (Russia), NICO (Cyprus), MIKL (Ukraine), GLSV (Ukraine), BUCU (Romania), PENC (Hungary), WTZR (Germany) and MATE (Italy) were chosen (Figure 3). The GNSS data of 17 days which include pre-seismic, co-seismic and post-seismic movements were handling by using ITRF08 (International Terrestrial Reference Frame 2008) relative to Eurasia fixed frame. The GNSS data were processed by using GAMIT/GLOBK software (Herring et al., 2015). Consequently, the time-series which represent the horizontal (North and East component) and vertical movements (Up component) of GNSS stations were obtained.

**Figure 1.** The Location of the Study Region. Yellow Rectangular Represents the Study Region and the Red Star Represents the Epicenter of the Earthquake. This Figure is Created with the Help of Google Earth Pro, 2018 (<http://www.google.com/earth/download/ge/>)

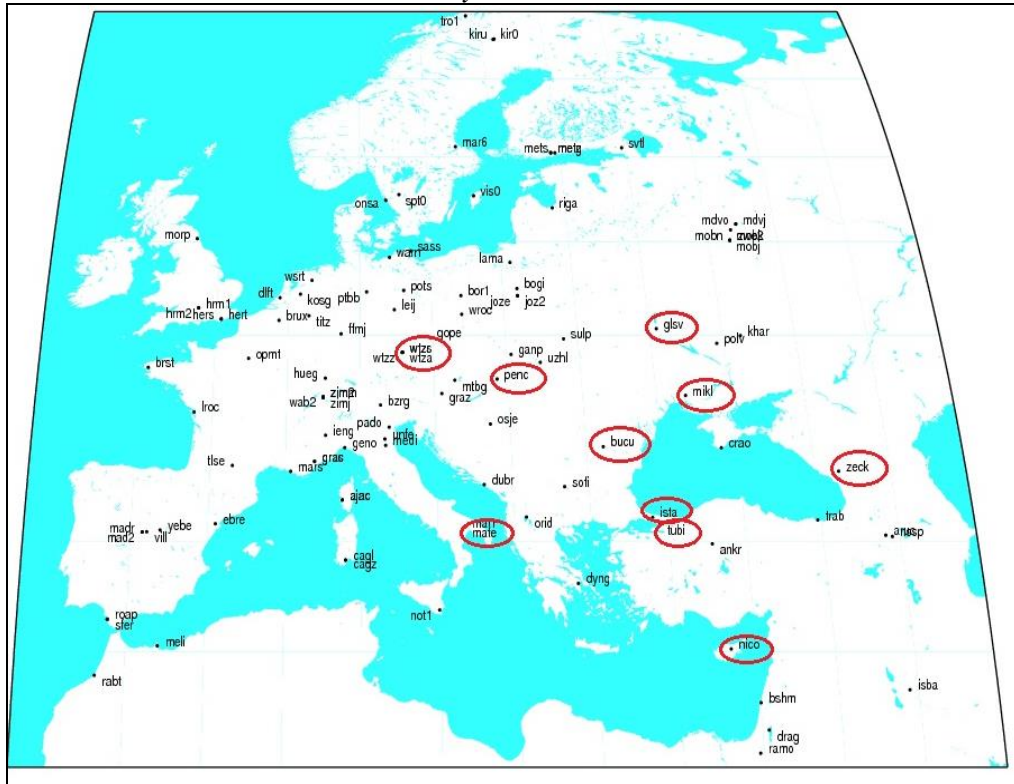




**Figure 2.** The Location of GNSS Stations and Epicenter of the Earthquake. This Figure is Created with the Help of Google Earth Pro, 2018 (<http://www.google.com/earth/download/ge/>)



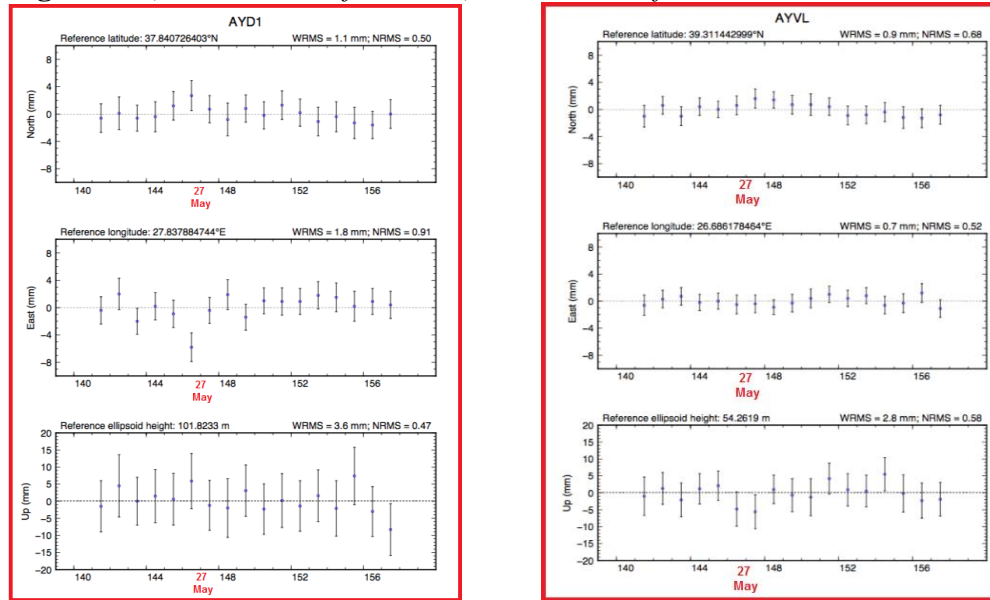
**Figure 3.** The Locations of the IGS Stations. The Red Circles Represent the IGS Stations which were used in this Study



## Conclusions

In this study, the Eurasia fixed frame solutions of GPS stations were examining for 17days which include pre-seismic, co-seismic and post-seismic periods (Figure 4a-h). In Figure 4a, it is seen that the earthquake affects only East (E) component of AYD1 station. In Figure 4b, it is seen that the deformation is not clear at vertical (North and East) components but the deformation is seen at vertical (Up) component for AYVL. In Figure 4c and 4d, it is noticed that the deformation is not clear at all (vertical and horizontal) components for BALK and CESM. For DEUG (Figure 4e) only N component is affected by the earthquake. For IZMI (Figure 4f) the deformation is not clear at all components. In Figure 4g, the deformation is seen at East and Up components for KIKA. Additionally, the earthquake which occurred at 29th May is seen at this station. For SALH (Figure 4h), the deformation is not clear for all components.

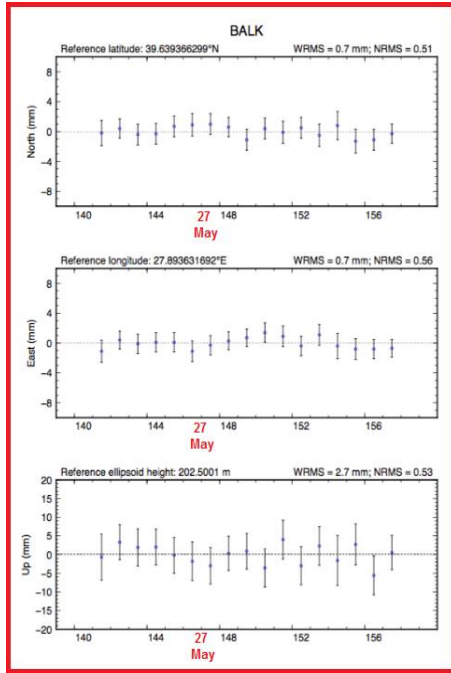
**Figure 4.** a) *Time Series of AYD1* b) *Time Series of AYVL*



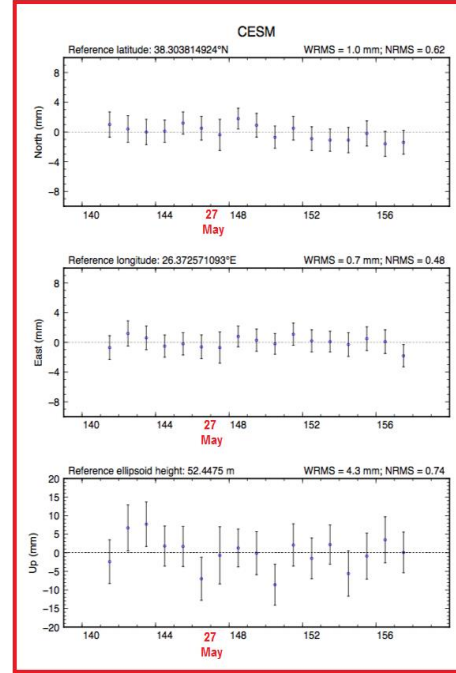
a)

b)

**Figure 4. c) Time Series of BALK d) Time Series of CESM**

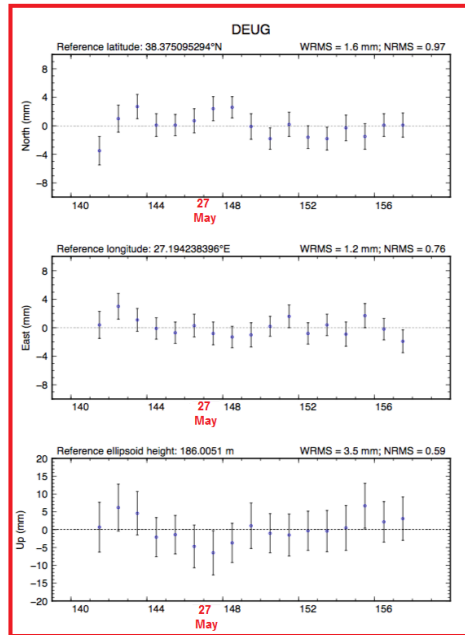


c)

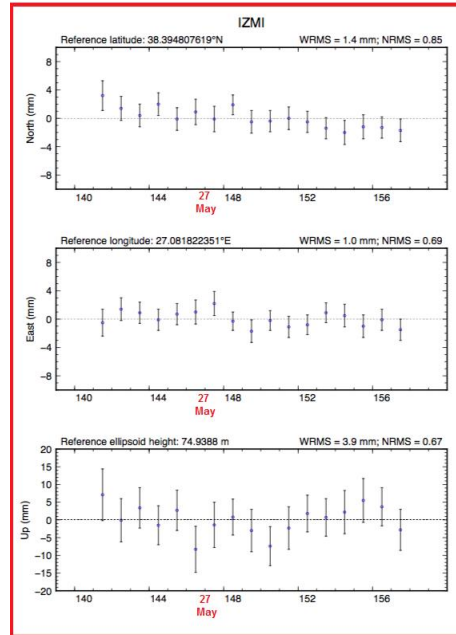


d)

**Figure 4. e) Time Series of DEUG f) Time Series of IZMI**

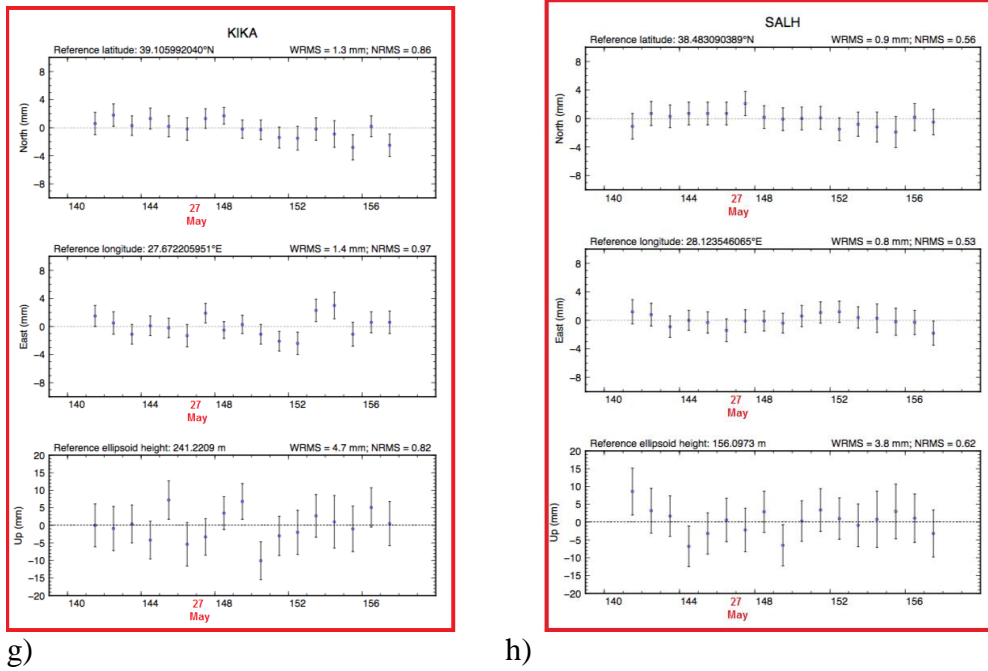


e)



f)

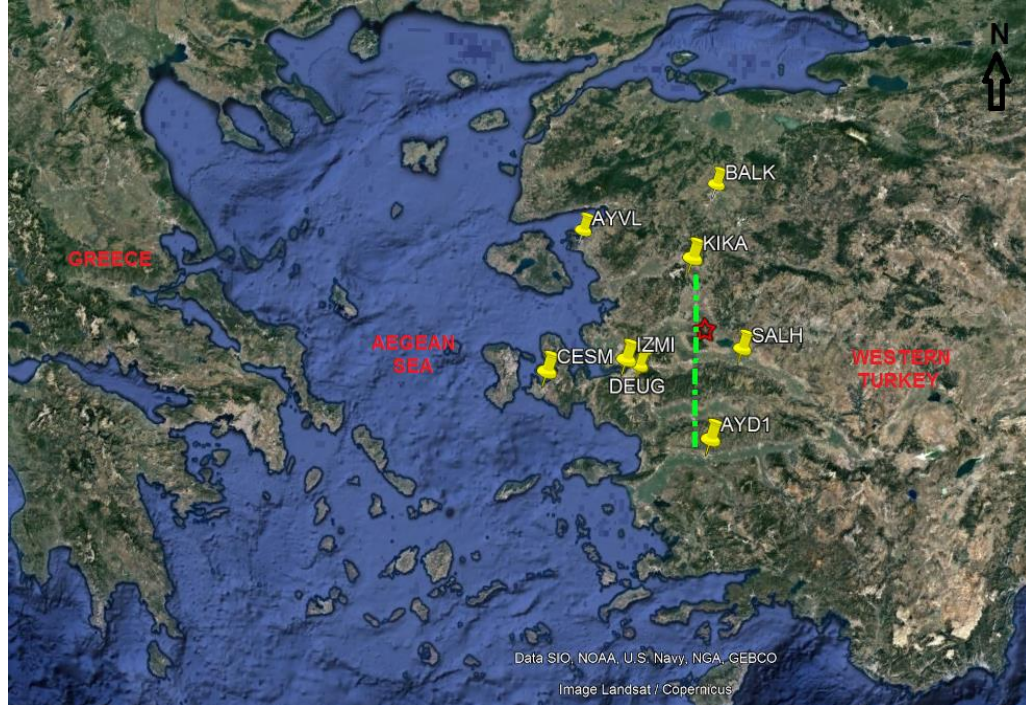
**Figure 4.** g) *Time Series of KIKA* h) *Time Series of SALH*



Consequently, the 27<sup>th</sup> May 2017 Gölarmara earthquake was felt for the wide area. But generally, the deformation effects of the earthquake was not monitored clearly at the coordinate time series of the stable continuous GNSS stations expect AYD1 (Figure 4a) and KIKA (Figure 4g). If the locations of KIKA and AYD1, it is seen that the epicenter of the earthquake and two GPS stations locate on approximately a N-S trending line. Additionally, some movements were monitored at the Up components for all stations. The existence of a lake in the region which appeared with the regional tectonic collapse may be the sign of the vertical movements in the area. As seen at Figure 5, the energy of the earthquake was widen at N-S directional.



**Figure 5.** The View of the GPS Stations and the Epicenter of the Earthquake. The N-S Trending Green Line Represents Affected Line due to the Earthquake. This Figure is Created with the Help of Google Earth Pro, 2018 (<http://www.google.com/earth/download/ge/>)



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