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The Investigation of Halabjah / Iraq Earthquakes Effects from Turkish National Permanent GNSS Network Data



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INTRODUCTION

It is an important issue to determine the crustal movements and effects of earthquakes in order to continue engineering projects with their quality. The studies on determination of crust and structural deformations have been increasing day by day. Especially, before the major engineering projects accomplish, the feasibility studies have great importance.

GNSS technique which is widely used, with high sensitivity positioning facilitates the monitoring of fault lines. Thanks to the availability of highly accurate location data from the CORS - TR system, these data have been made available for pre and post processing analysis of the earthquake.

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INTRODUCTION

The purpose of this study is to determine the movements of earthquake-induced displacements with the help of Turkish National Permanent GNSS Network (TNPNGN).

In this study, 10 TNPNGN stations were selected in the southeast of Turkey. The rinex data collected from 10 TNPNGN stations were processed and the results are presented. The data of the TNPNGN stations were analyzed on 5 days before and after Halabjah/ Iraq earthquake time to determine tectonic deformations.

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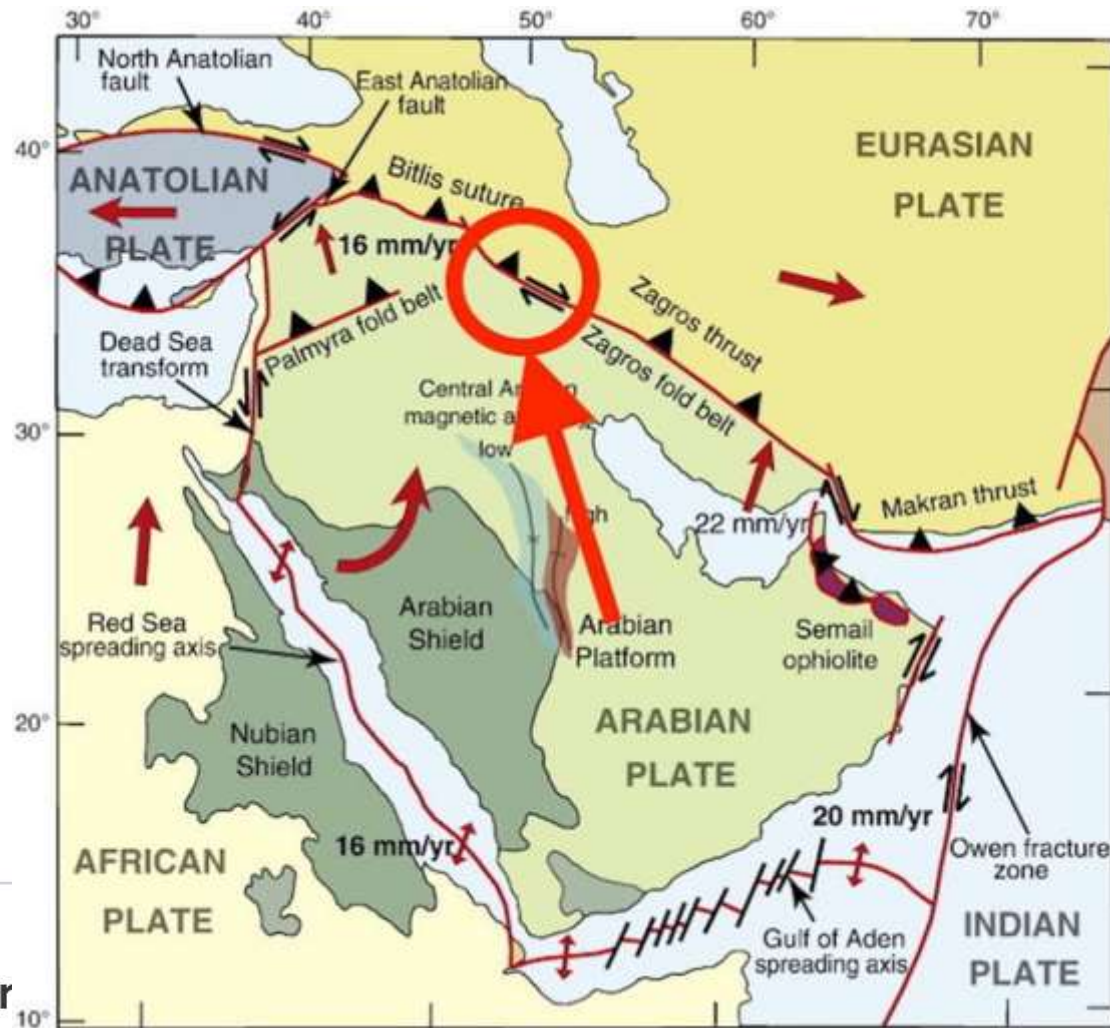


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SEISMIC STRUCTURE OF THE HALEBJAH EARTHQUAKE REGION

In the region where the earthquake occurred, the two crustal plates are slipping against one another. The Arabian plate is moving northwards by one or two centimeters per year. The Plate is colliding into the Eurasian plate and raising the Zagros Mountains. This collision between two continental plates switches from a subduction to a strike-slip setting depending on particular positioning.



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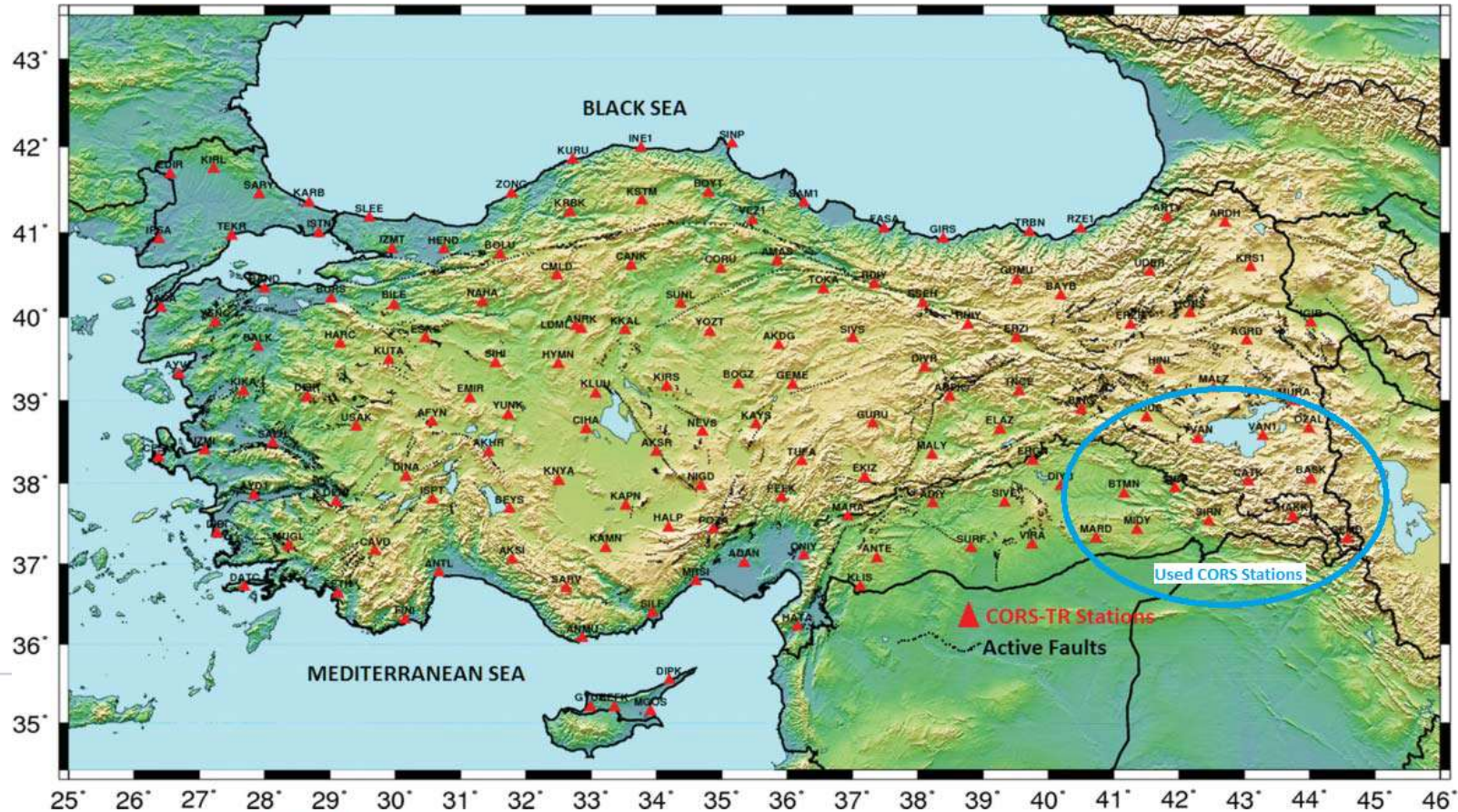
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TURKISH NATIONAL PERMANENT GNSS SYSTEM (CORS – TR)

TNPGN picks up data from all of the stations at one-second intervals for 24 hours. The system has been actively working since 2009. There are 146 constant measuring stations on the GNSS network in Turkey.



Distribution of the TNPGN-Active stations on the Map

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CALCULATIONS OF STATION DISPLACEMENTS

The rinex data of **10 stations** which are established at Eastern Anatolia Region were processed by AUSPOS Online GNSS Processing Service with Bernese v5.2 GNSS software and calculated the displacements of the CORS-TR Stations. AUSPOS Online GNSS Processing is used in point-position calculations. This service has used IGS products to compute precise coordinates (ITRF) anywhere on Earth. The service was setted to process only dual frequency GPS phase data.

User Stations (CORS – TR)	Reference Stations (IGS)
BASK, BTMN, CATK, HAK1, MARD, MUR1, OZAL, SEMD, SIR1, TVA2	ANKR, ARTU, BHR3, BUCU, CRAO, GLSV, ISER, ISNA, JOZ2, MAT1, MDVJ, NOT1, POLV, SOFI





CALCULATIONS OF STATION DISPLACEMENTS

These stations are thought to be affected by the Halebjah / Iraq earthquake.

To examine the movements in the TNP GN stations near the earthquake epicenter, we used data from 14 IGS stations on the Eurasian plate and Arabian plate.



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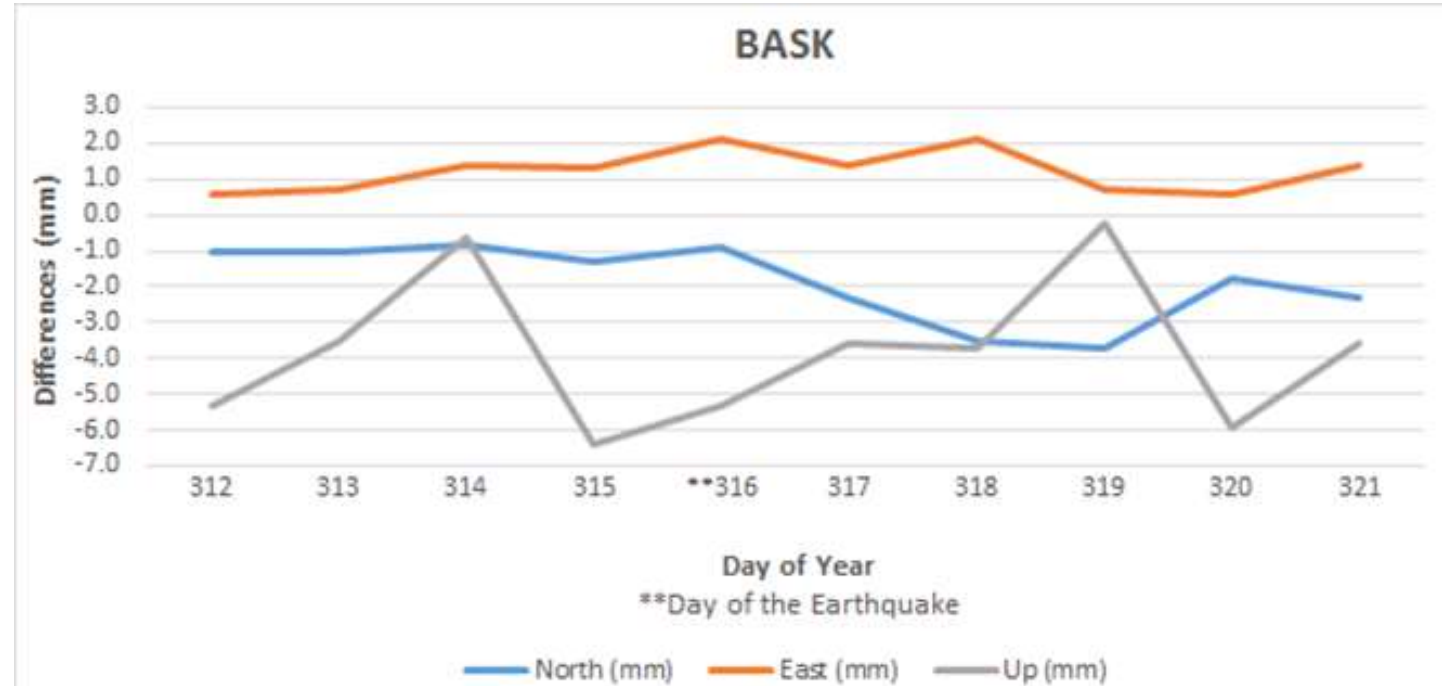
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HALABJAH EARTHQUAKE FINDINGS

At the processing elevation mask angle is 7 degree, sampling rate of 30 seconds. Global Mapping Functions (GMF) has been used for tropospheric model. For eliminating of first-order ionospheric effect, L3 combination has been chosen also, second and third effect model has been applied.



BAŞKALE station displacements.

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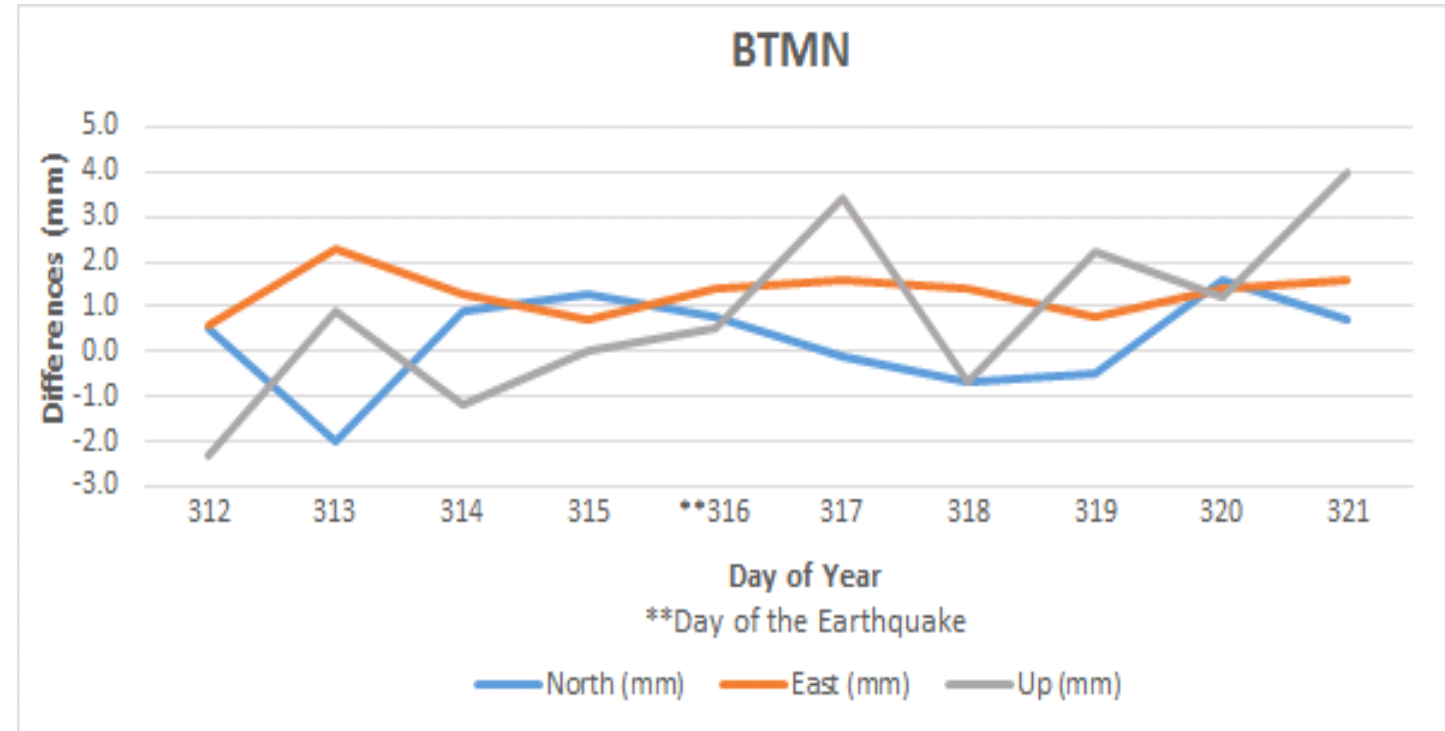
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HALABJAH EARTHQUAKE FINDINGS

The rinex data of stations has been obtained from the TNPGN center on 5 days before and after the earthquake between 07 and 17 November 2017 to determine tectonic deformations and then this data has been forwarded to AUSPOS.



BATMAN station displacements.

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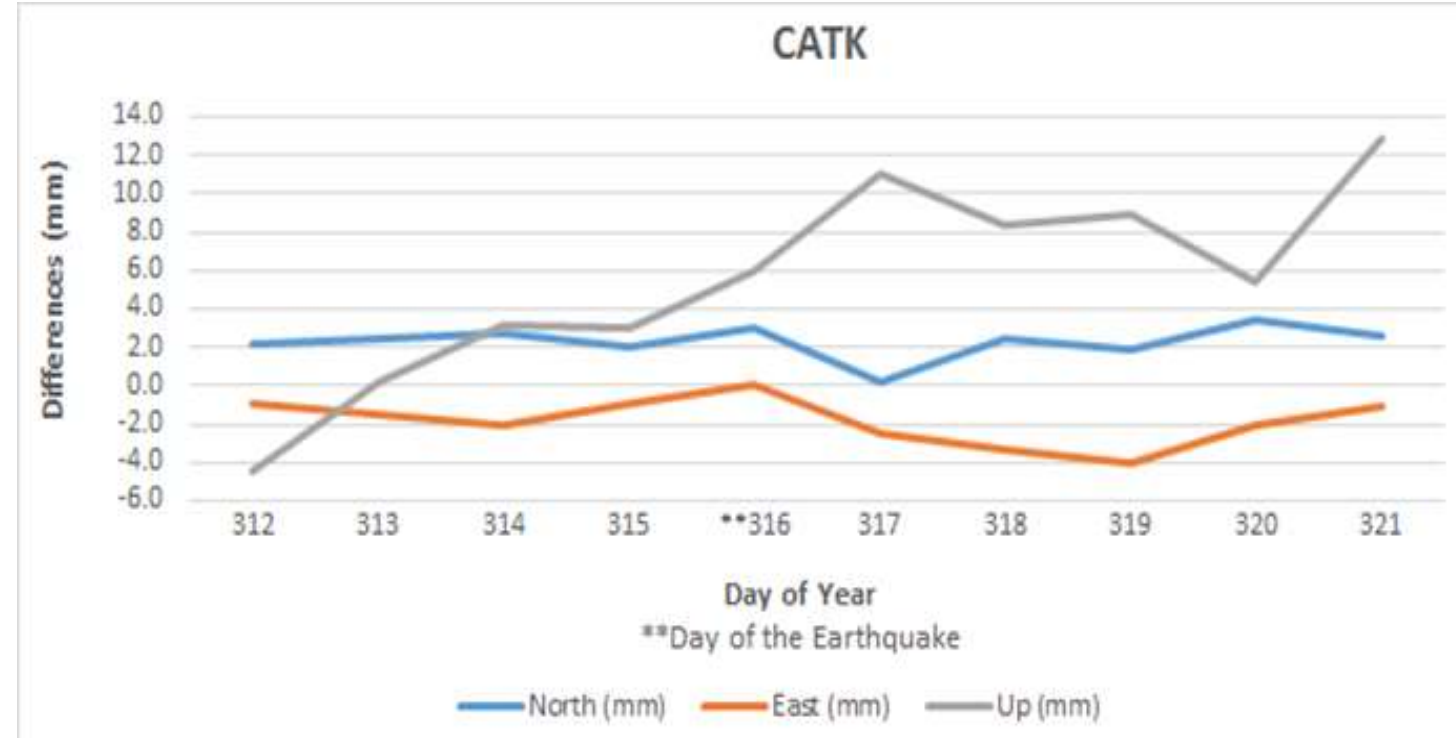
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HALABJAH EARTHQUAKE FINDINGS

The coordinates obtained from the AUSPOS Service on 07 November 2017 were considered fixed for the calculation of the displacements.



ÇATAK station displacements.

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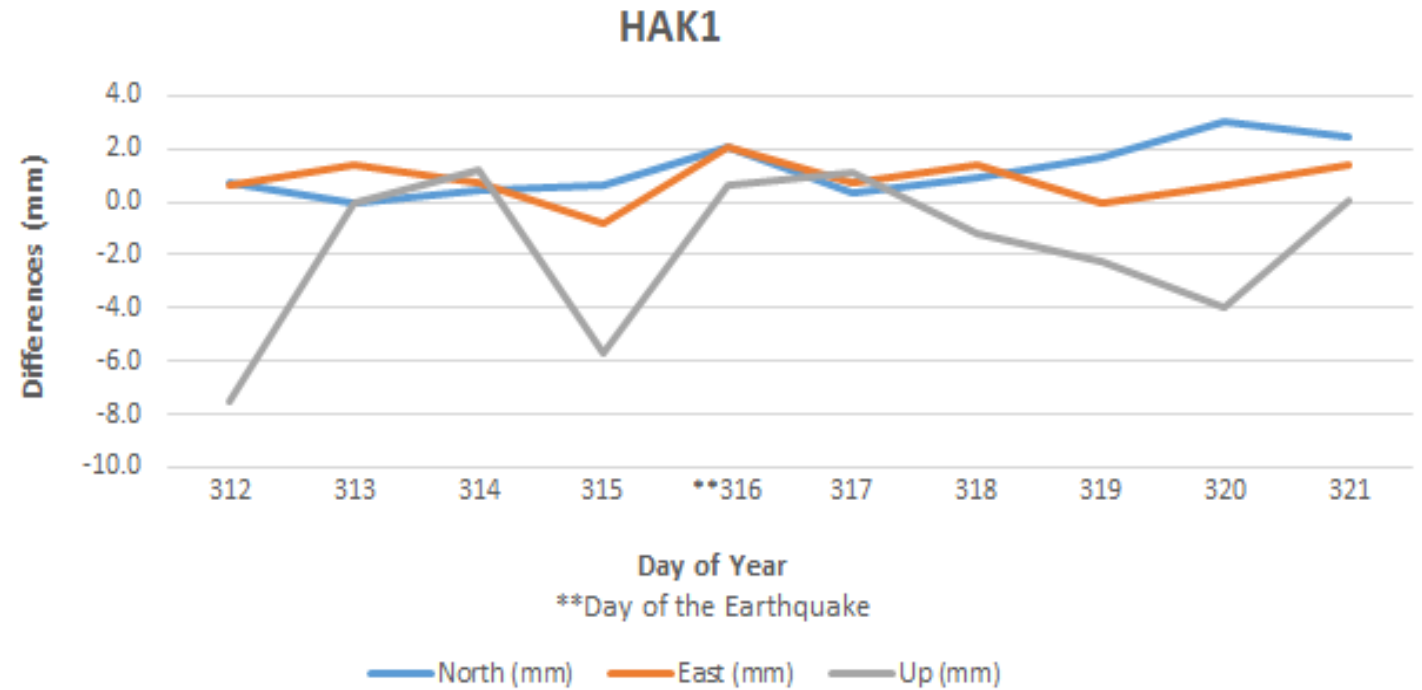
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HALABJAH EARTHQUAKE FINDINGS

The differences between the coordinates of the other days and coordinates of the day (07 Nov 11) were calculated for chart of the displacements. The Cartesian coordinates differences were transformed to topocentric coordinates north, east, up.



HAKKARİ station displacements.

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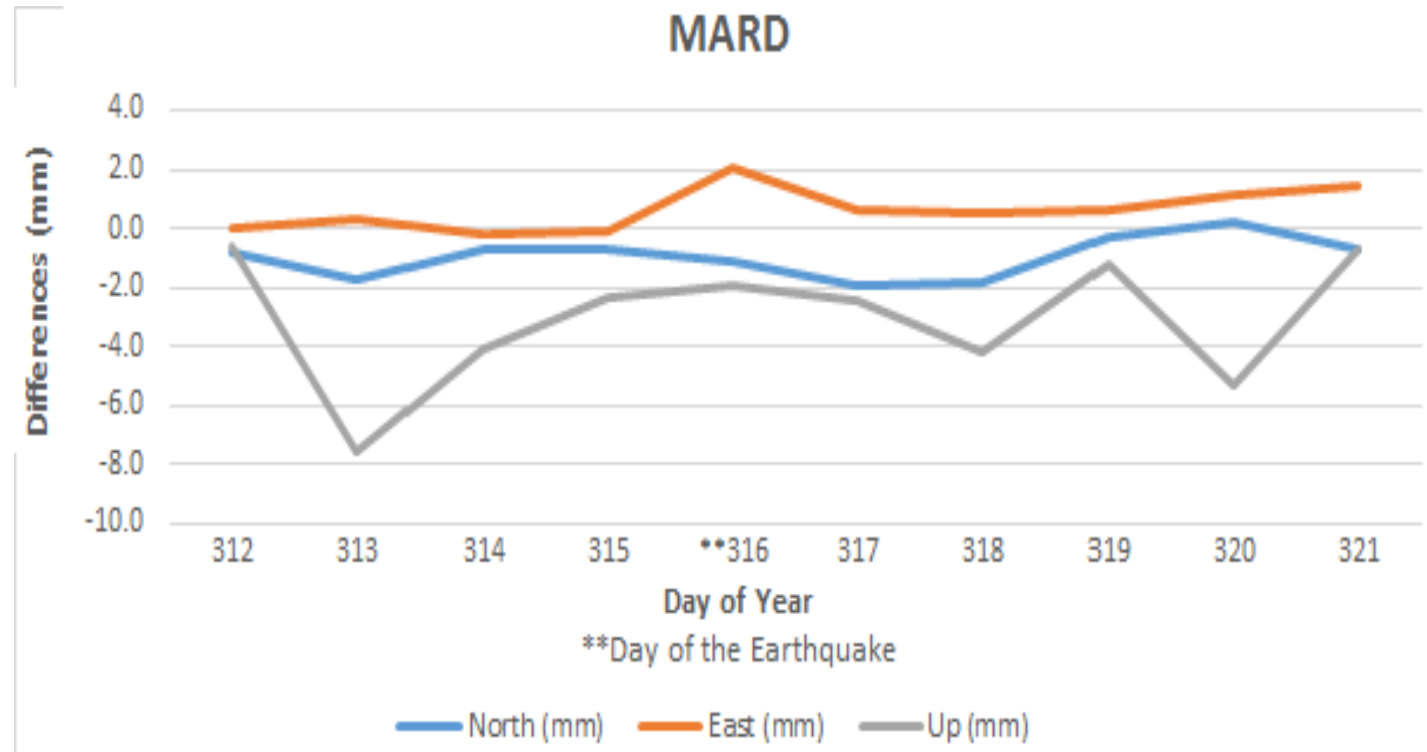
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HALABJAH EARTHQUAKE FINDINGS

The graph of displacements for each TNPNG stations were prepared and drawn in MS Office Excel and MATLAB software. The results are shown in figures on the right side.



MARDİN station displacements.

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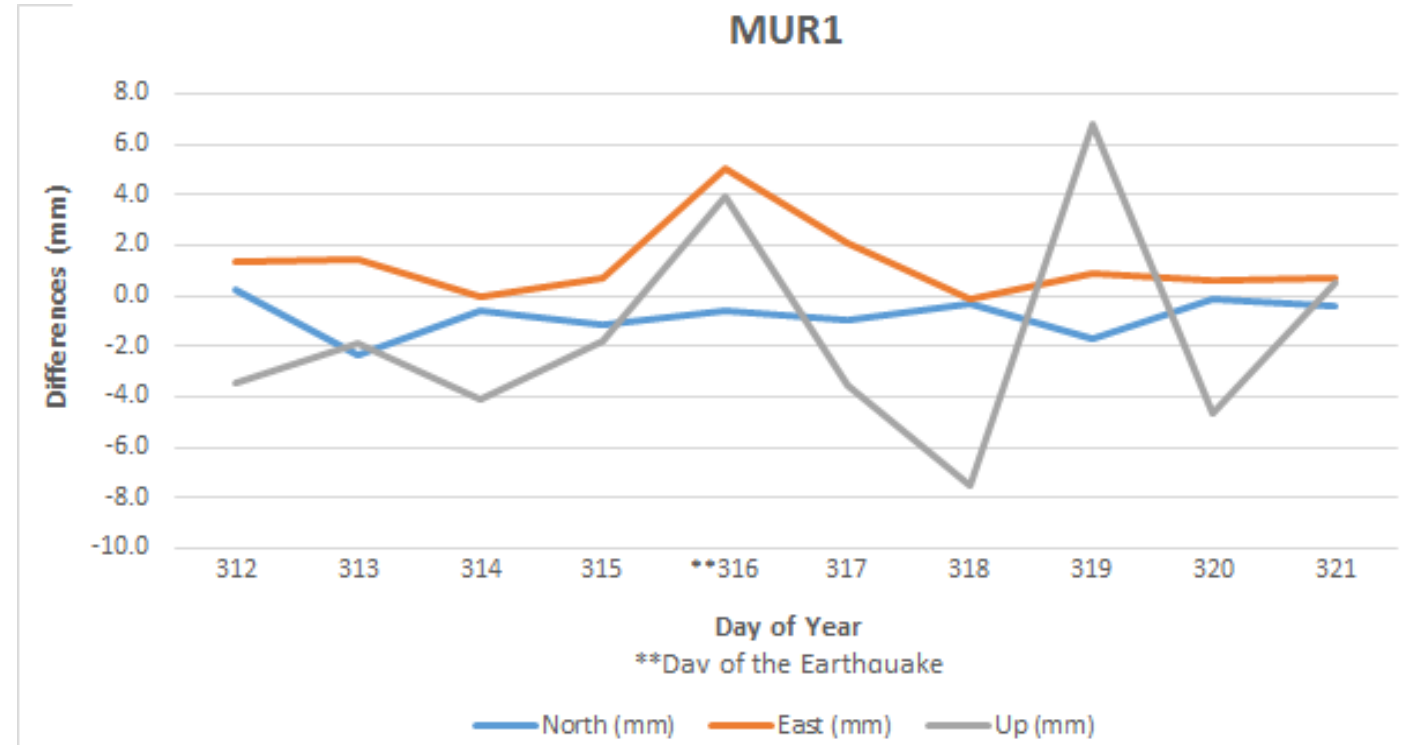
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HALABJAH EARTHQUAKE FINDINGS

The graph of the all TNPNGN stations shows that the variations before and after of the earthquake are appeared the same.



MURADIYE station displacements.

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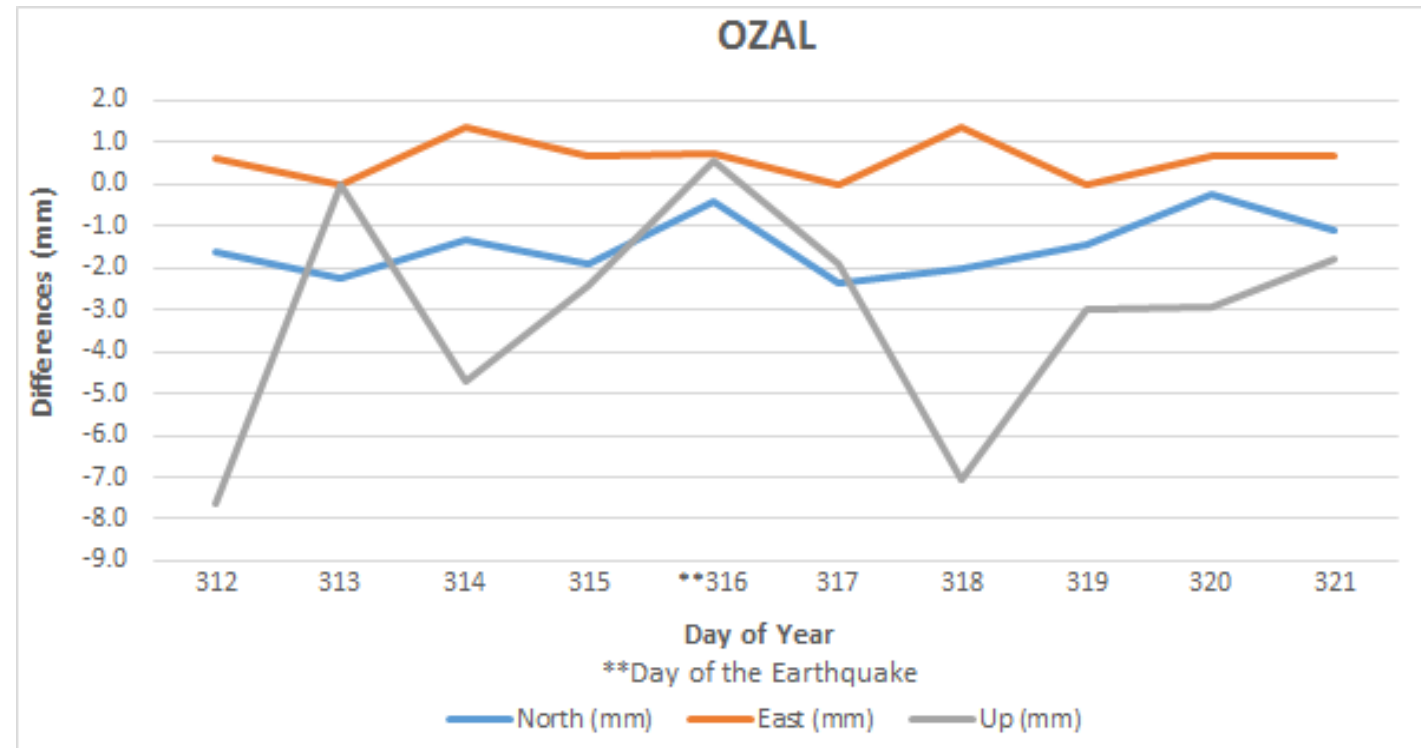
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HALABJAH EARTHQUAKE FINDINGS

So, there is no significant difference between the before fifth day and the after days. Because the displacement values are lower than three times values of rms.



ÖZALP station displacements.

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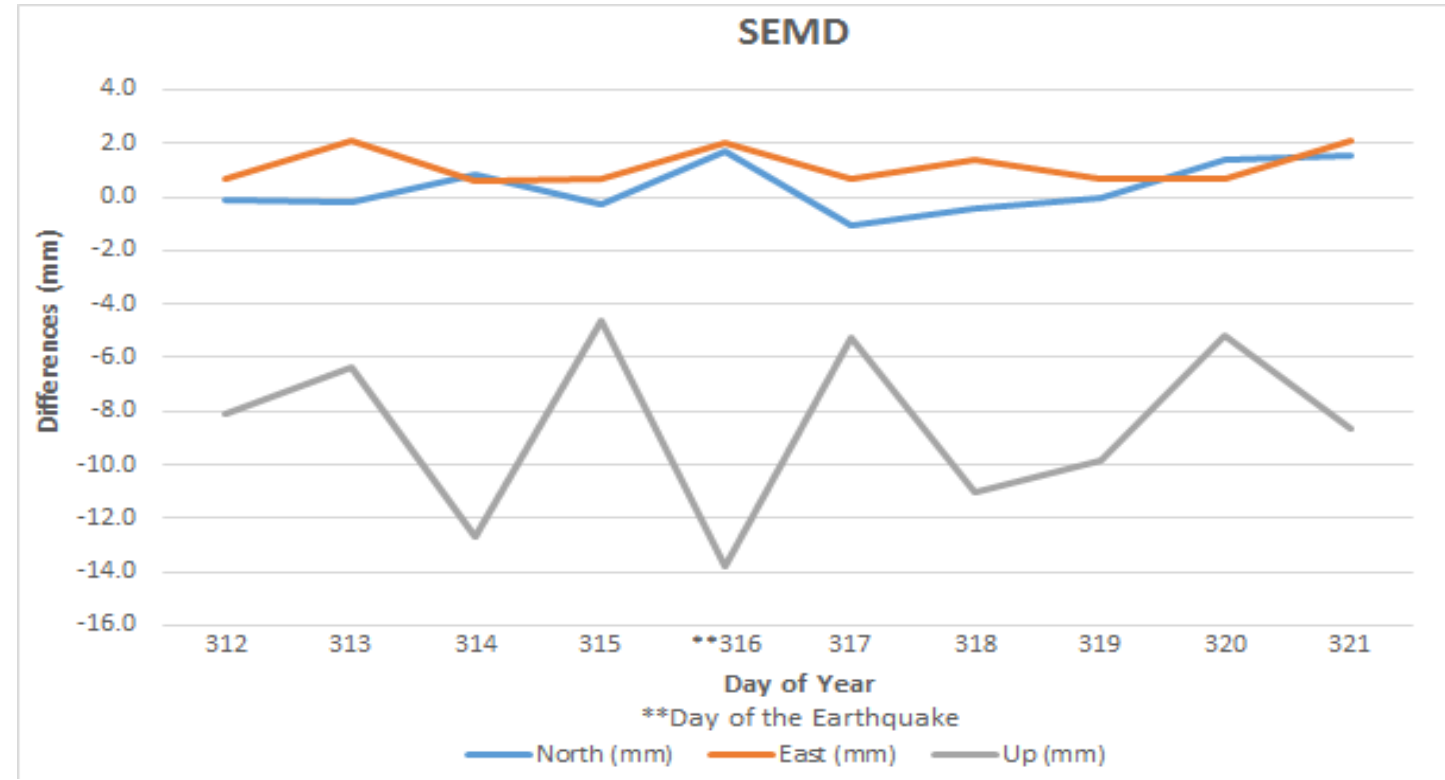
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HALABJAH EARTHQUAKE FINDINGS

When the above charts of horizontal and vertical displacements are examined, the positional displacements are not exceeded the standard deviations.



ŞEMĐİNLİ station displacements.

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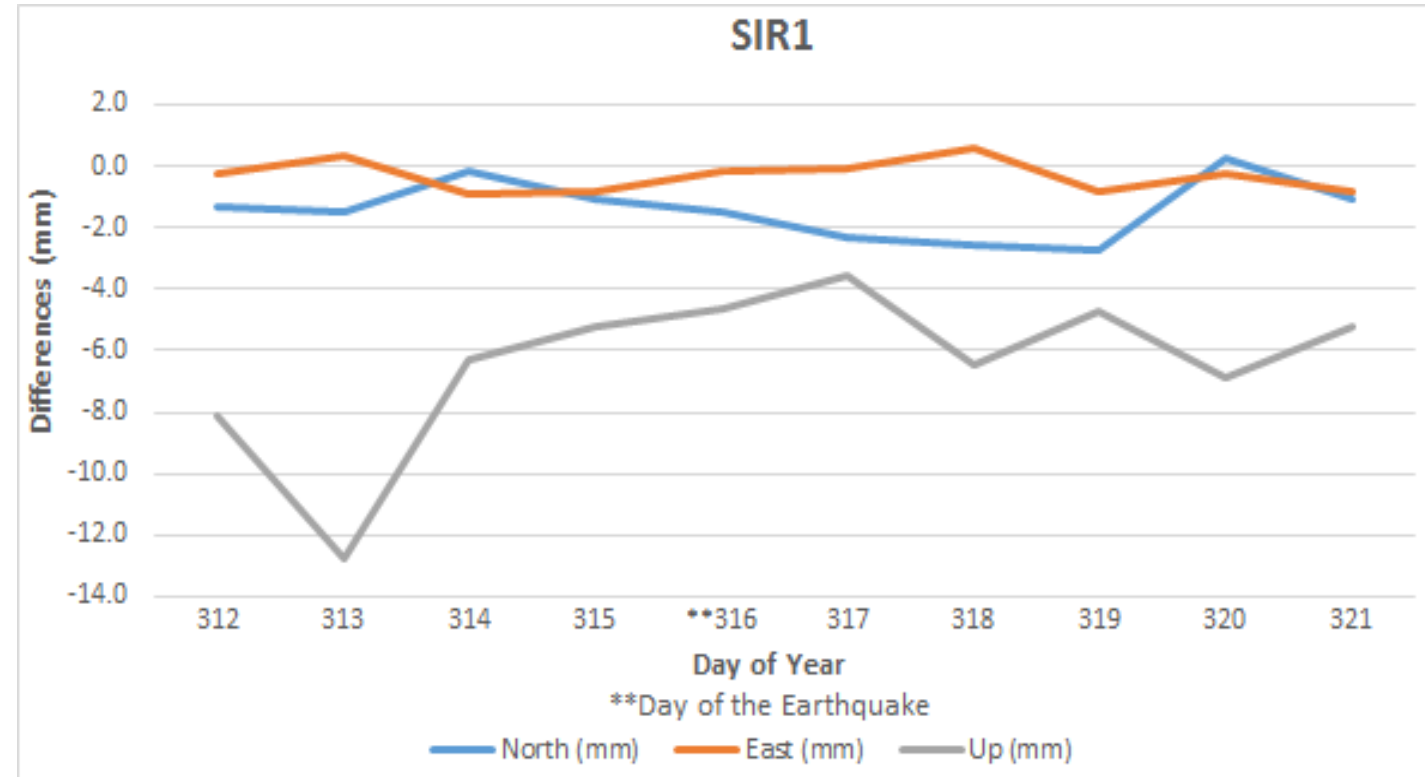
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HALABJAH EARTHQUAKE FINDINGS

They are seen in the evaluation of 5 days before and 5 days after data charts.



ŞIRNAK station displacements.

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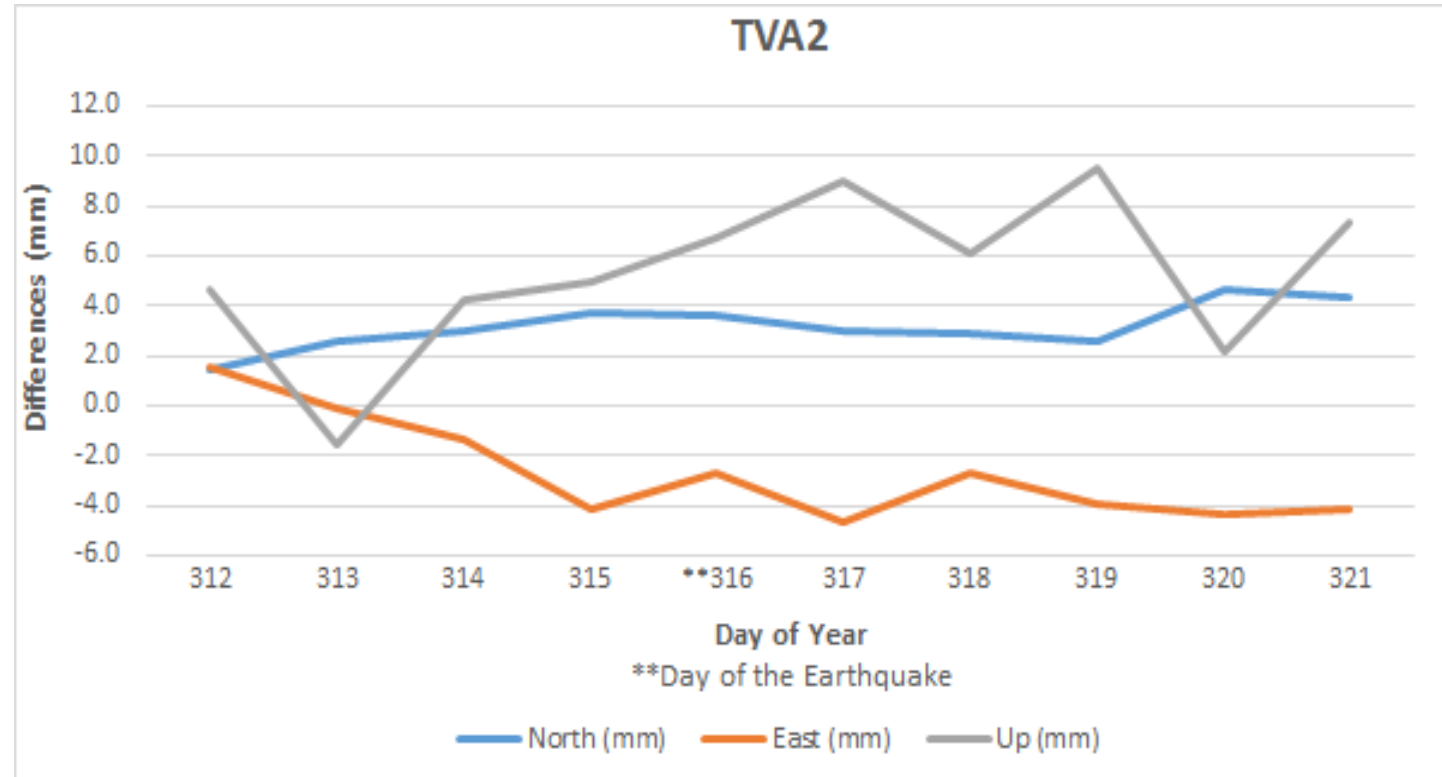
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HALABJAH EARTHQUAKE FINDINGS

So it can be said that the Southeastern Anatolian region was not affected by the Halabjah earthquake and the aftershocks.



TATVAN station displacements.

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HALABJAH EARTHQUAKE FINDINGS

The Root Mean Square (RMS) values calculated in this study are shown in the table on the side.

Station ID	Root Mean Square			Distance From Earthquake Epicenter (km)
	East (mm)	North (mm)	Up (mm)	
BASK	2.1	1.3	4.3	389
BTMN	1.1	1.4	2.1	541
CATK	2.4	2.2	7.4	431
HAK1	1.6	1.1	3.4	357
MARD	1.2	0.9	3.7	541
MUR1	1.1	1.9	4.3	493
OZAL	1.6	0.8	4.0	451
SEMD	1.0	1.3	9.1	293
SIR1	1.7	0.6	6.9	428
TVA2	3.3	3.3	6.2	518

The RMS values of TNP GN stations displacements

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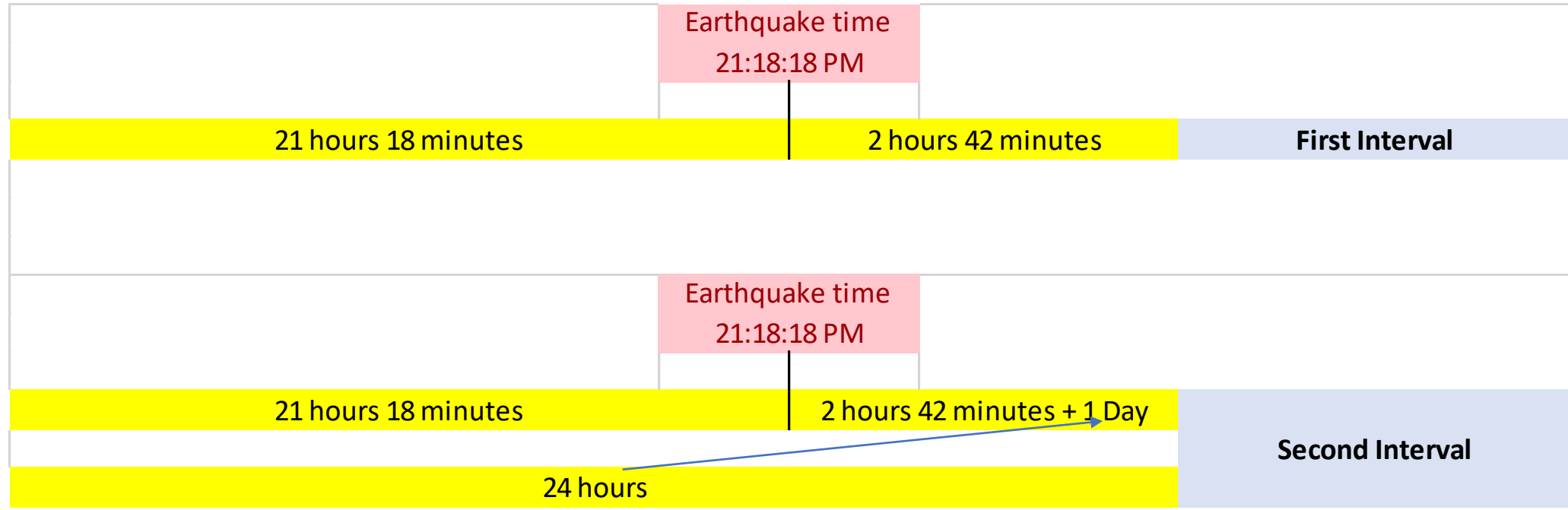


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HALABJAH EARTHQUAKE FINDINGS



For better understanding, the intervals are shown in the figure.

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HALABJAH EARTHQUAKE FINDINGS

In addition to this study, the observations of these stations were divided into two before and after at 09:18:18 PM (November 12). For first interval, the time of observations is 21 hours 18 minutes before earthquake and 2 hours 42 minutes after earthquake.

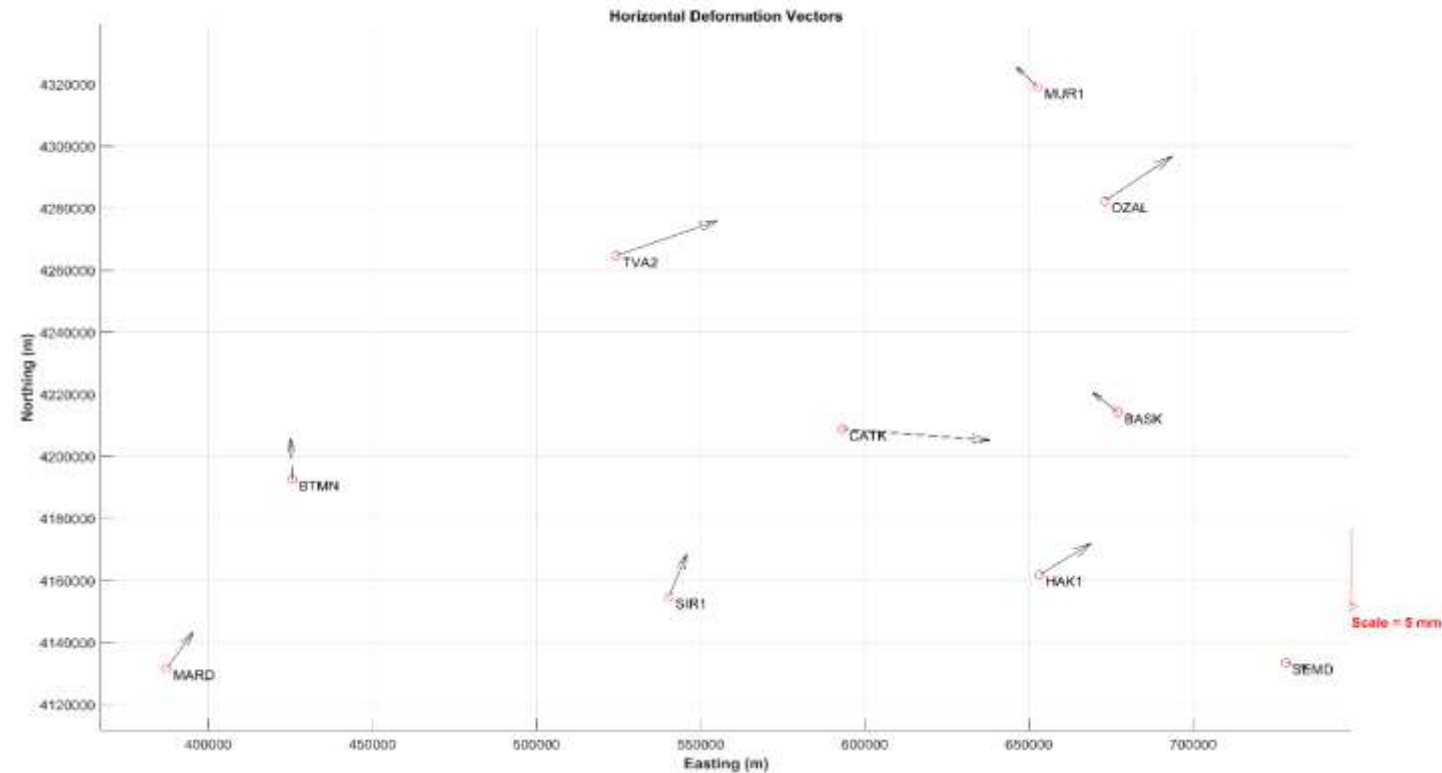


Figure 5 (a). Horizontal movements of first interval

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HALABJAH EARTHQUAKE FINDINGS

Vertical movements of first interval is shown on the chart.

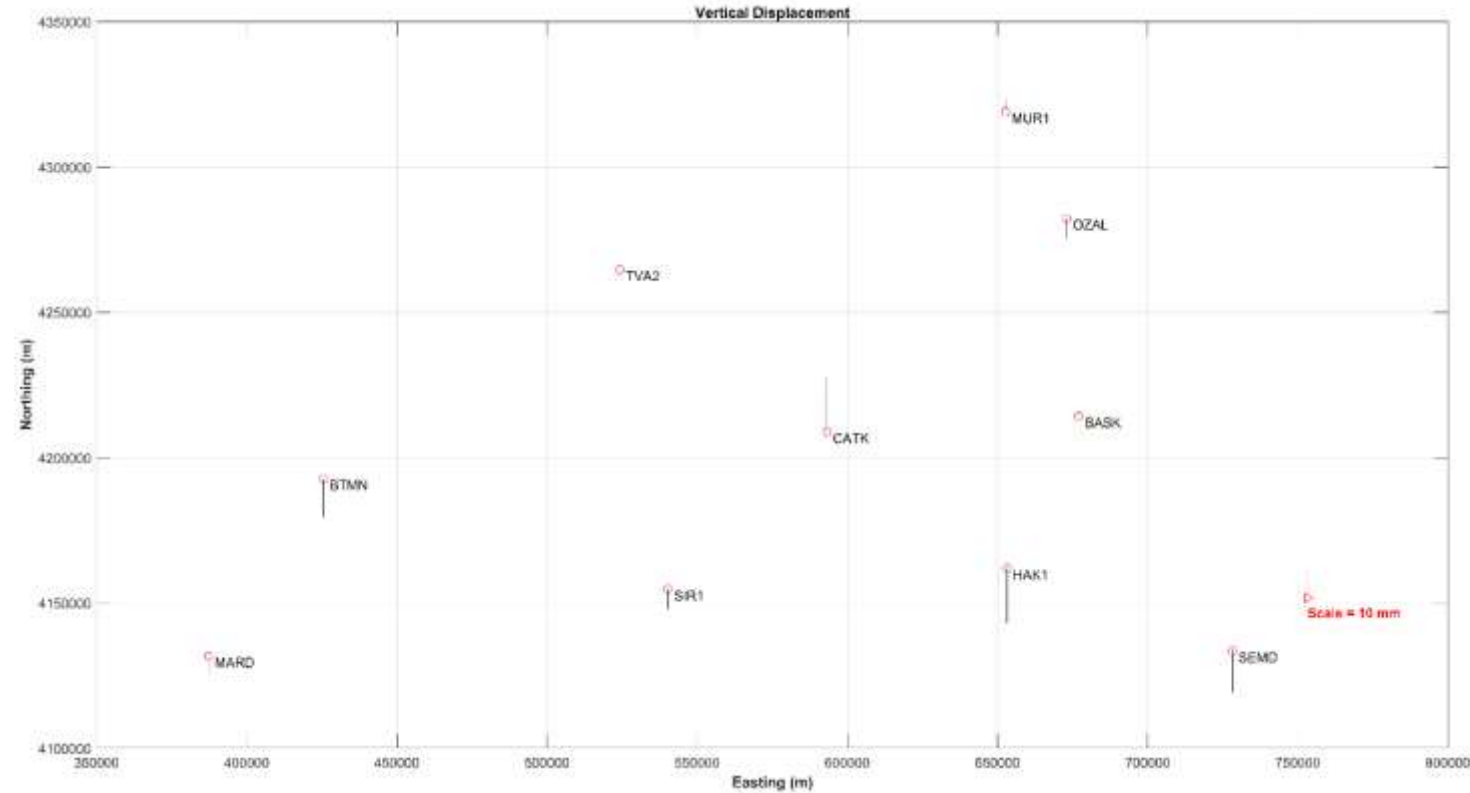


Figure 5 (b). Vertical movements of first interval

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HALABJAH EARTHQUAKE FINDINGS

The second interval the time of observations is 21 hours 18 minutes before earthquake and 26 hours 42 minutes after earthquake. The all observations were processed by AUSPOS Service.

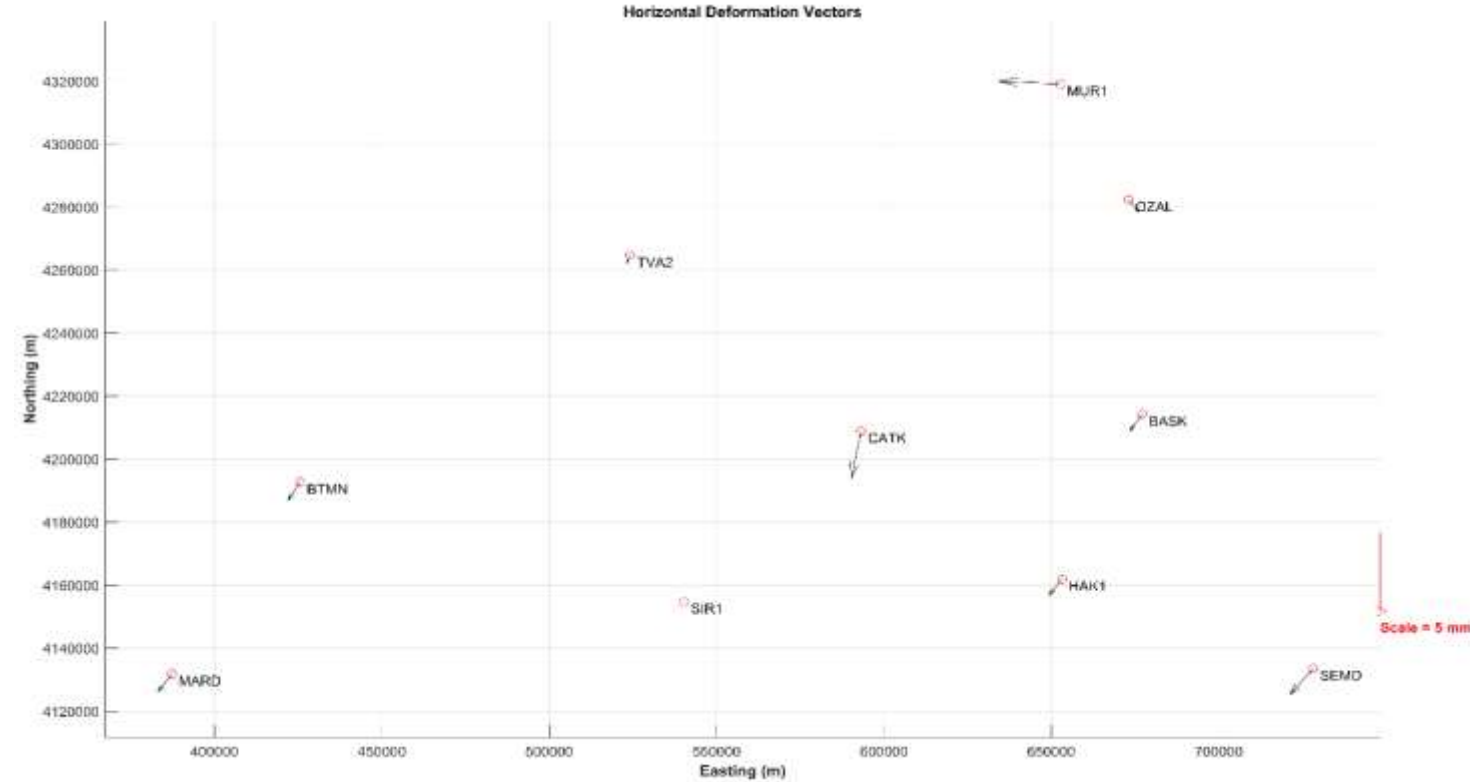


Figure 6 (a). The Horizontal movements of second interval

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HALABJAH EARTHQUAKE FINDINGS

The differences between coordinates of before the earthquake time and coordinates of after the earthquake time were calculated. The results and displacements of first interval are drawn *figure 5(a)* and *5(b)*. The results and displacements of second interval are drawn *figure 6(a)* and *6(b)*.

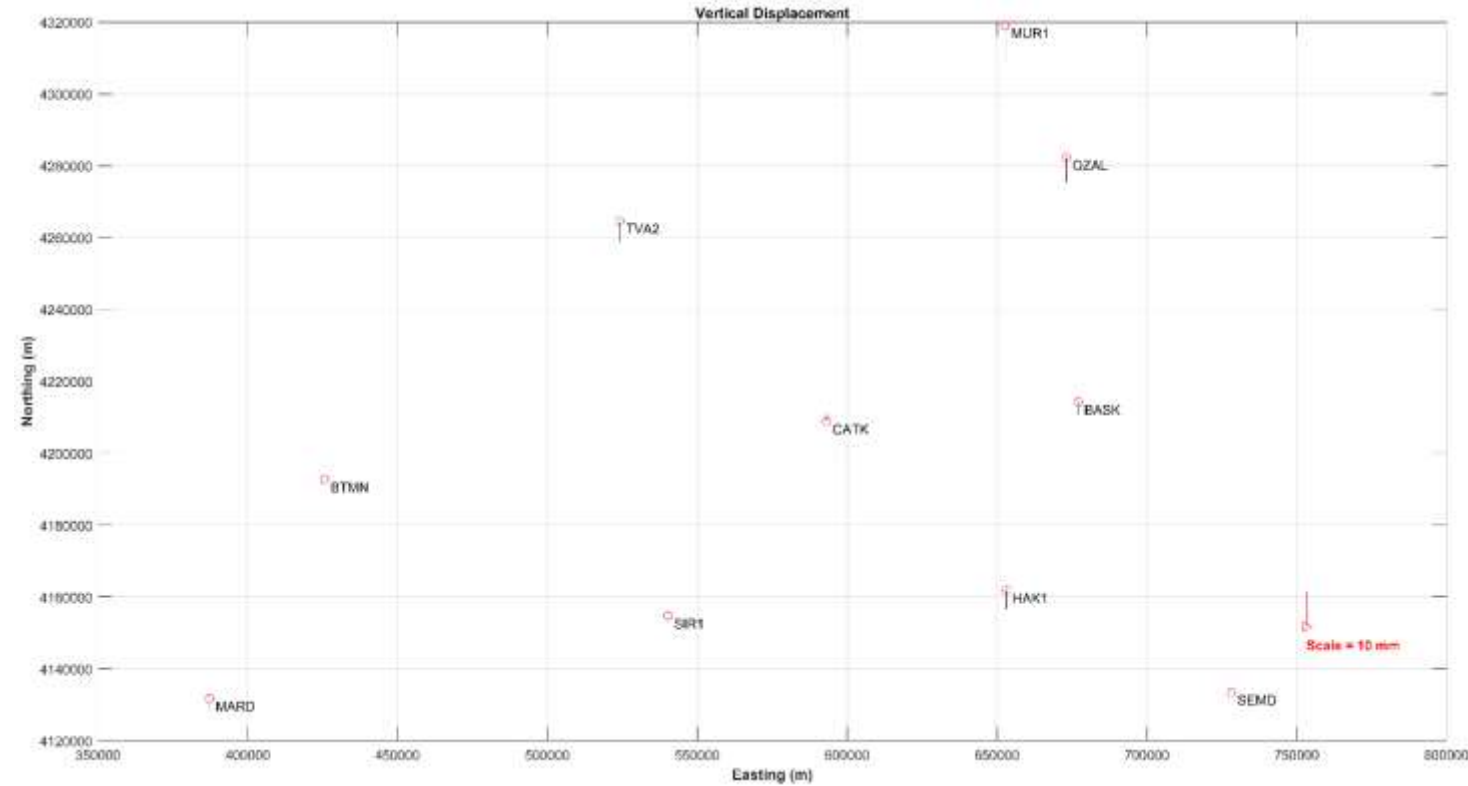


Figure 6 (b). The Vertical movements of second

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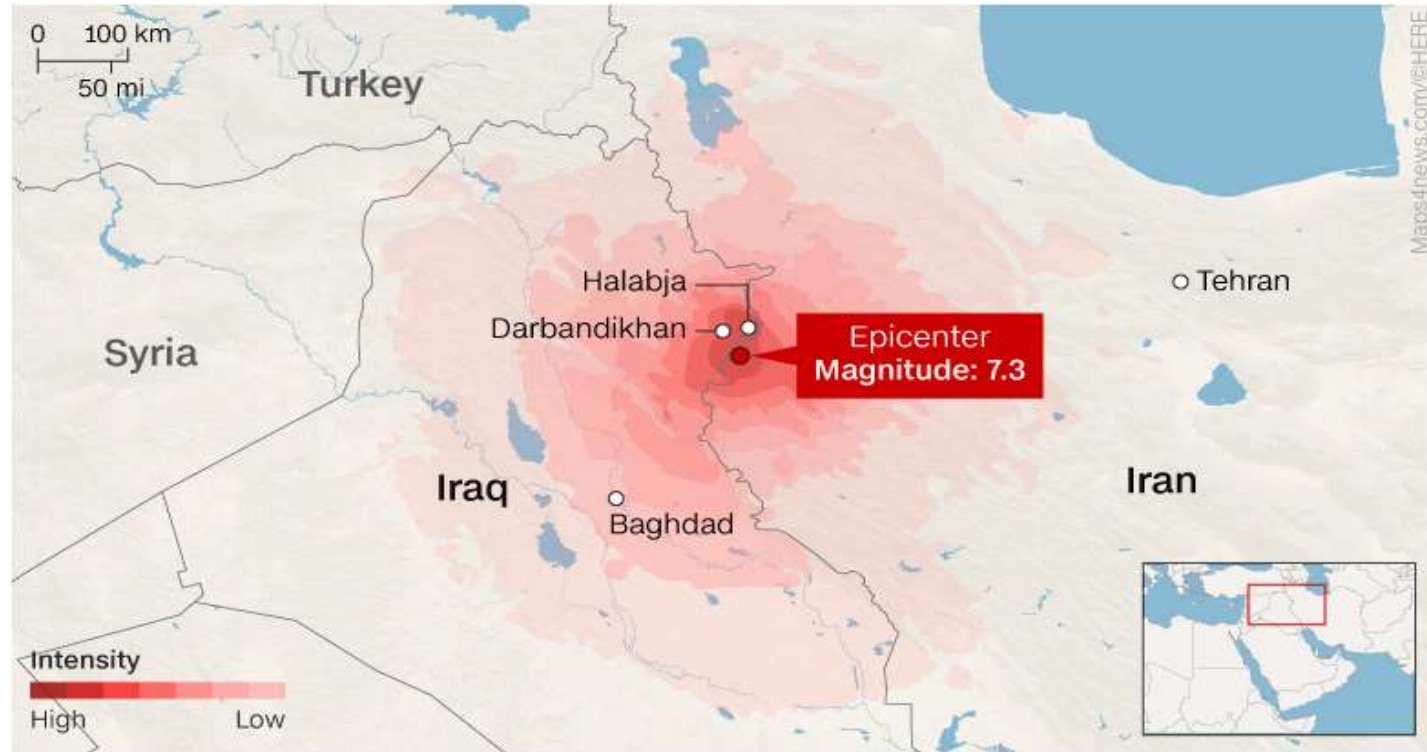
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CONCLUSION

There are no changes in positions determined as a result of the earthquake. The intensity of effect is shown from the epicenter of earthquake to outward in the thematic map with red color. As it can be seen, the red area of the earthquake effect is not included territory of Turkey.



Demonstration of the effects of the Halabjah Earthquake

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Thanks for your attention... 😊

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