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Preliminary results of surface displacement of the Elazig Sivrice region by comparing D-InSAR and SBAS methods

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Abstract

Earthquakes, which are caused by cracks in the earth's crust, are a type of natural disaster that can result in loss of life and property as well as economic damage. Earthquakes also induce ground surface displacements. In Turkey, the North Anatolian Fault Line, the East Anatolian Fault Line, and the West Anatolian Fault Line all experience continuous ground movements. The displacement caused by the earthquake that struck the Elazig-Sivrice region on the Eastern Anatolian fault line on January 24, 2020 was calculated using D-Insar (Differential Interferometric Sytntethic Apeture Radar) and SBAS (Sort Baseline Subsets) methods using Radar data from the Sentinel-1 satellite. compared and computed.

1. Introduction

Earthquakes are described as the shaking of the environment caused by the vibrations of the earth's crust breaking. Varying soils experience different deformations as a result of the earthquake effect. Surface rupture, regional collapse, slope movements, volumetric compression, liquefaction, settling and bearing failures, flow slides, lateral spreading, and sand volcanoes are some of the deformations that can occur (Onur, 2007). Since Turkey is located on the North Anatolian Fault Line, East Anatolian Fault Line, and West Anatolian Fault Zones, it is subject to earthquakes. Turkey, which is located on the Eurasian-Arab-African plate, has been subjected to destructive earthquakes throughout history due to its tectonic structure.Since the 1900s, these seismic movements in the square have been recorded with instruments. The two primary seismic network operators in Turkey are the Ministry of Interior, Disaster and Emergency Management Presidency (AFAD) and Boaziçi University Kandilli Observatory and Earthquake Research Institute (KRDAE) (Kadiriolu et al., 2018). The 1999 Gölcük and Düzce, 2011 Van, and 2020 Elaz earthquakes are among the most catastrophic earthquakes in Turkey, according to records.Elazig is a province in Turkey's Eastern Anatolia region, bordered on the north by Tunceli and on the west by Malatya. The East Anatolian Fault Zone runs across this province, with Diyarbakr in the south and Bingöl in the east. In the last hundred years, 299 earthquakes larger than 4.0 have occurred in this region, which is still on this fault line and is still quite active today (AFAD, 2020). According to AFAD statistics, the epicenter of the 6.8 magnitude earthquake that struck on January 24, 2020 at 20:55 and lasted 20.04 seconds was located in the evrimtaş village of Elazığ province, Sivrice district, around 800 meters distant. The earthquake occurred in the Sivrice-Pötürge segment of the left-lateral Eastern Anatolian Fault zone, according to the research. After the earthquake, there is expected to be a 50-55 km rupture. 41 people were killed and 1600 more were injured in this earthquake, which demolished 547 structures and badly damaged 6247 others.With technical advancements, the use of remote sensing tools in the analysis and monitoring of natural disasters has increased. Change detection analysis usually employs RADAR/SAR, LIDAR, and UAV technologies, which are commonly utilized in the field of active remote sensing. It is critical to properly and swiftly assess the changes that occur as a result of the disaster (Turker and San (2003), Turker and San (2004), Gince and San (2018)). Artificial Aperture Radar (SAR) approaches, in particular, are one of the most effective remote sensing instruments available today since they are unaffected by environmental conditions, are an active

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system, and can collect data at any period (Gunce and San, 2018).Mamolu et al. (2020) analyzed a general geodetic event that occurred in Bolvadin using the interferometry technique, and displacement time series were acquired by creating the region's velocity map (mamolu et al., 2020).The SAR image records the amplitude and phases of the reflected signals from the targets in the study region. The phase is a value that is proportional to the target's distance. The target's reflectance values are used to calculate the amplitude. Using SAR data and D-InSAR and SBAS methodologies, the displacement analysis that happened after the earthquake in the Elazig Sivrice region was carried out in this work. D-InSAR uses the phase difference of two SAR images to calculate the difference in distances between targets on the ground. The SBAS method of Berardino et al. (2002) was used, as well as the advanced D-InSAR approach. In terms of providing temporal and spatial analysis, this approach is an important and powerful tool in the analysis of disasters that occur on Earth. This method can be used to see the spatial development of the deformation, which occurs over a long period of time and develops slowly.

2. Test Site and Methods

2.1. Test Site

According to AFAD data, the epicenter of the 6.8 magnitude earthquake that struck on January 24, 2020 at 20:55 and lasted 20.04 seconds was located in the evrimtaş village of Elaz province, Sivrice district, around 800 meters distant. The earthquake occurred in the Sivrice-Pötürge segment of the left-lateral Eastern Anatolian Fault zone, according to the research. After the earthquake, there is expected to be a 50-55 km rupture.

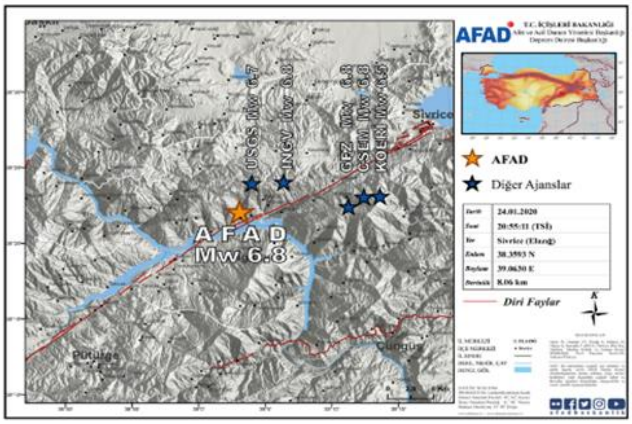

Figure 1. Sivrice (Elazig) earthquake location map (AFAD,2020)

2.2. Methods

2.2.1. D-InSAR

SAR data acquired by the Sentinel-1 satellite on the 22nd of January and the 3rd of February 2020 were used in the research. These photos are in SLC format and are stored in IW mode. An image created at an oblique range distance along the azimuth direction is stored in SLC format. Complex values (I and Q) including amplitude and phase information are used to represent each pixel in the image. SLC products are processed to produce a single view of any size that uses the entire signal bandwidth. The satellite's orbit and altitude data are used to geo-reference the images (Bourbig et al., 2016).The SAR image records the amplitude and phases of the reflected signals from the targets in the study area. The phase is a value that is proportional to the target's distance. The target's reflectance values are used to calculate the amplitude.

Based on the phase difference of two SAR images, D-InSAR is used to measure displacements in the study area with very low precision. The interferogram used in this case provides information on the target area's high difference. A one-dimensional measure of surface collapses in the satellite line of sight direction corresponds to a portion of the phase difference between the two SAR images obtained before and after the earthquake.

2.2.2. SBAS

Another method, known as the SBAS method, obtains displacement over time by stacking conventional D-InSAR interferograms (Berardino et al. 2002, Schmidt and Bürgmann 2003, 30 Hooper 2008).

When compared to D-InSAR, the SBAS approach has two distinct features. Multiple SAR images taken at different times in the same area are required to get started. Second, only stable scattering signals are extracted.

3. Results

The data from February 3, 2020 and January 22, 2020 were utilized to analyze the earthquake that occurred on January 24, 2020 in Elazig Sivrice district, and the phase difference between the data was used to create the interferogram displayed in Figure 2. The slump values in the displacement map developed varied from +25.4 cm to -17.9 cm, according to this interferogram. Figure 3 depicts the displacement map that was developed. Furthermore, the displacement map developed with the LICSBAS tool (Morishita, et al.,2020), which is a SAR interferometry time series analysis software, is consistent with the results obtained from the D-InSAR study.

The SBAS study determined that the subsidence in the Elazığ Sivrice region was between +11.73 cm and -11.92 cm, based on a displacement map developed on the same platform as the D-InSAR displacement map. Figure 4 shows the resulting displacement map.

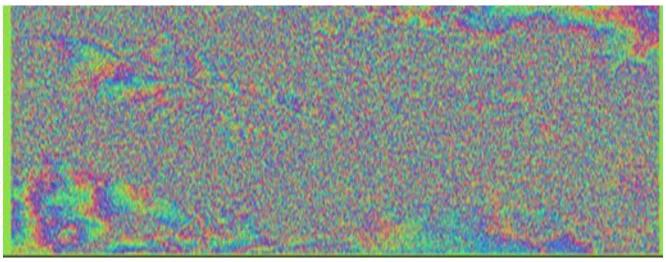

Figure 2. Interferogram

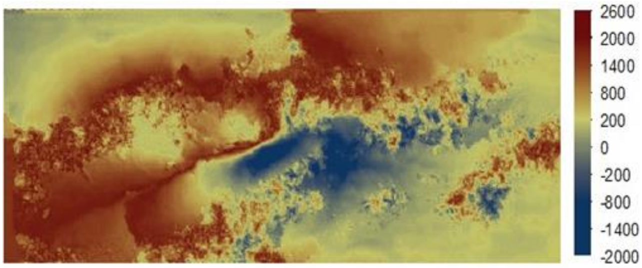

Figure 3. Displacement Map in mm (D-InSAR)

Figure 4. Displacement Map in mm (SBAS)

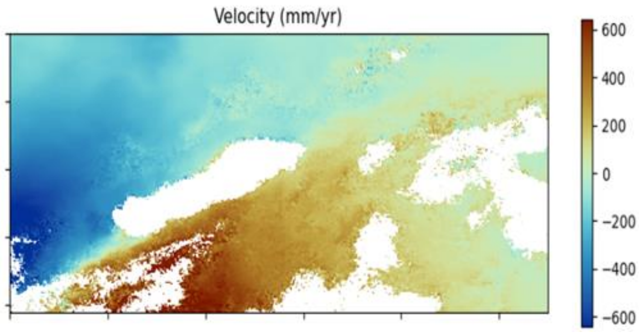

Figure 5. Displacement Map in mm (SBAS)

The minimum, maximum mean and standard deviation values of the obtained analysis results are given in Table 1.

Table 1. Values obtained as a result of analysis

	Minimum value	Maximum value	Mean value	Standard deviation
D-InSAR	-1799,979	2545,0082	-24,8119	240,8371
SBAS	-1094,050903	1173,7658	-37,8196	347,8103

4. Discussion and Conclusions

Karslıoğlu et al. determined the collapse values between +25.4 cm and -17.9 cm as a result of the earthquake that occurred in the Sivrice district of Elazig province in January 2021 as a result of the study. The earthquake-induced subsidence analysis of the Sentinel-1 satellite: Sivrice-Doğanyol-Pütürge sample agrees well with the study's collapse values, confirming the study's findings.

It has been determined that the displacement values obtained as a result of the SBAS analysis using interferogram stacks give more sensitive results than the values found by the D-InSAR method, as shown in the table 1.

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