# Land Subsidence Analysis Using PAZ and Sentinel-1 Data on the Karstic Region of Konya Basin, Turkey

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## Introduction

Groundwater lowering due to excessive pumping, drought, and climate change; causes severe and long-term effects on the Earth's surface. Due to the increasing demand for food, dense agricultural activities have been carried out over the study area of Konya Closed Basin (Figure 1) (Calò et al., 2017). The underground water used for irrigation increased mainly due to overpumping from unregistered wells. The lithology of the study area is composed of clay, limestone, silt, sandstone, and its characteristics play an essential role in forming karstic depressions, often resulting in sinkholes (Ozdemir, 2015, Bayari et al., 2009). These human-induced and naturally developed phenomena affect the region and have threatened people heavily for the last thirty years. A previous study showed the spatial distribution of surface deformation using a small baseline Interferometric SAR (InSAR) approach on using Envisat data (2002-2010). The maximum observed subsidence rate was 15 mm/yr (Calò et al., 2015). A recent study carried out over the region using both Cosmo-SkyMed (2016-2017) and Sentinel-1 (2014-2018) found Line of Sight (LOS) deformation velocity ranging between -70 and 10 mm/yr in the area, while GNSS indicated 25 mm/yr (Orhan et al., 2021). Abdikan et al (2020) studied the performance of the PAZ satellite over the region and detected a 200 m sinkhole. The high-resolution PAZ based analysis pointed out the contribution of high-resolution X-band SAR for the extraction of small-scale sinkholes that may be harder to detect using Sentinel-1. Previously, the potential of PAZ for surface movement and scattering characterization was also explored over the Netherlands with co-polarized multi-temporal data (Chang & Stein, 2021). Abdikan et al. (2022) showed the contribution of the PAZ data over the study area using sequential interferograms with small-scale sinkhole shaped surface displacement.

The main contributions of this study are as follows:

- We produce a new map of subsidence rate due to groundwater levels declining in an agriculture dominated region.
- We evaluate the performance of PAZ data based on a Persistent Scatterer Interferometry (PSI) analysis over the karstic region.

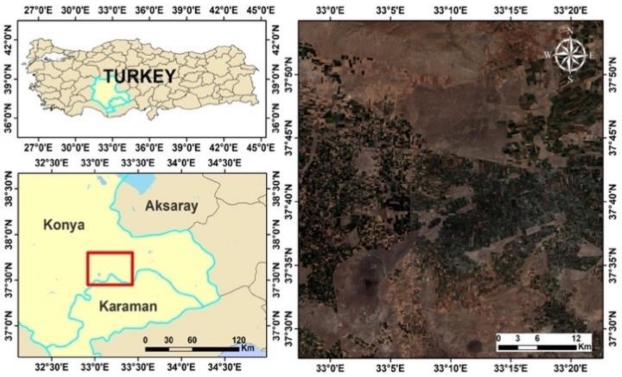


*Figure 1 The study area*

## Methods and data

This study determines the surface deformation pattern using the Persistent Scatterer Interferometry (PSI) method. Freely available Sentinel-1A images from the European Space Agency (ESA) were used for this application. Image preprocessing was performed with the Open-Source Sentinel Application Platform (SNAP) software. For the following steps, the open-source StaMPS (Stanford Method for Persistent Scatterers) software was used (Hooper et al., 2010). With this software, processing steps such as PS selection, DEM error correction, and unwrapping of interferograms were carried out. Interferograms were generated in primary and secondary geometry. In total, 76 images of Sentinel-1A acquired along descending orbit are used and 75 interferograms are obtained between 2016 and 2021. One arc-second SRTM (30 m x 30 m) DEM was used to eliminate the topographic phase effect. For the PAZ analysis, 38 high resolution (1m) StripMap data (2019 Oct - 2021 Oct) were analyzed and 37 interferograms were generated. The stripmap mode PAZ data is also acquired in descending orbit and in VV polarization. All processing steps for Sentinel-1 are given in Figure 2. In the processing of PAZ data, interferograms are created using the software DORIS and the PSI is applied in the StaMPS (Figure 2). In the previous studies, the analysis indicates that the surface deformation is mainly developed along the vertical direction due to underground water depletion (Calò et al., 2017, Orhan et al., 2021). In this study, the results are extracted along the LOS direction.

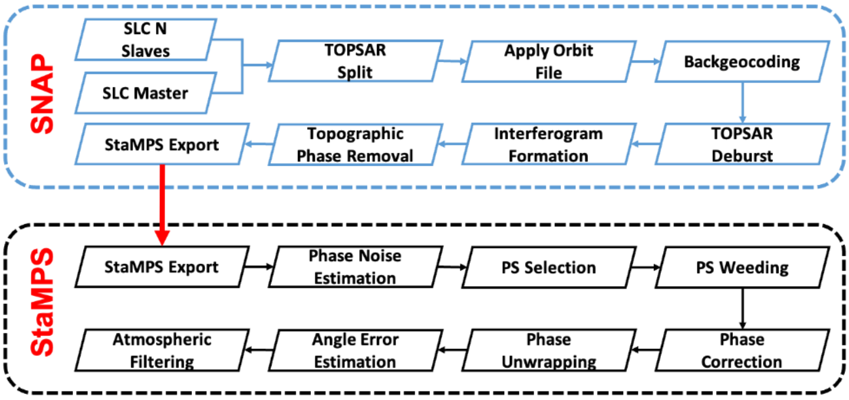


*Figure 2 Flowchart of data processing for Sentinel-1 data*

## Results and discussions

The spatial distribution of surface deformation detected from the PSI analysis of Sentinel-1 data is shown in Figure 3. The maximum velocity of displacements reaches up to about -20 mm/yr (±1mm/yr) during the observed period (2016-2021). This points out that the deformation continues at an increasing rate. The subsidence pattern has similarities to the previous studies (Calò et al., 2017, Orhan et al., 2021). Furthermore, as we used the PSI approach in this study, we also extracted deformation over man-made structures; see the white boxes in Figure 3.

Moreover, the agriculture fields are highly decorrelated areas. However, we detected measurement points over the utility poles (i.e., electricity and telecommunication) developed within the agricultural fields, see linear infrastructural features visible in Figures 3b, 3c. In the eastern part of the region, we noticed the high density of points with high displacement rates located over the city of Karapinar (Figure 3d). Finally, an additional preliminary analysis is conducted using data acquired by the new generation X-band PAZ satellite mission. The maximum displacement obtained from PAZ results is about 20-25 mm/yr ($\pm$2 mm/yr) in the LOS direction (Figure 4). Even though the results of PAZ data provided denser point distribution than the results of Sentinel-1, it has also obtained an additional displacement pattern over bare lands that is not present in the Sentinel-1 analysis. The maximum displacement areas indicated by the red points in Figure 4a are could not determine in the long-term Sentinel-1 product. The agricultural activities and the change of plants over time have caused a decorrelation. As a common result, PS points could not be obtained with both satellite images in vegetated areas.

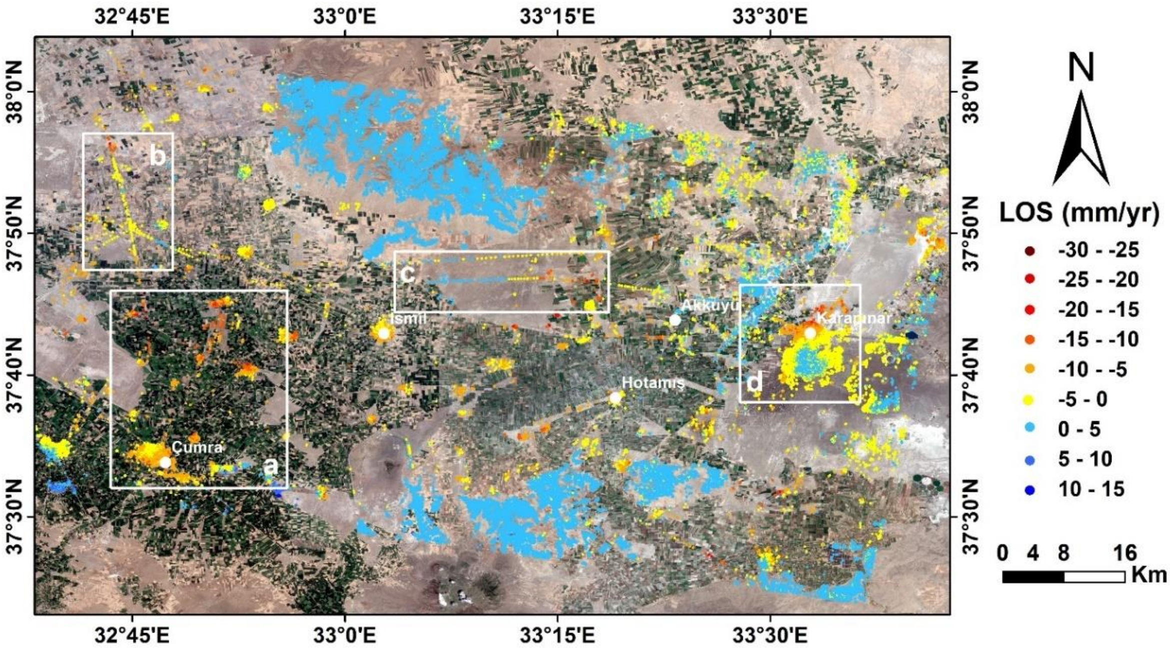


*Figure 3 PSI results of Sentinel-1*

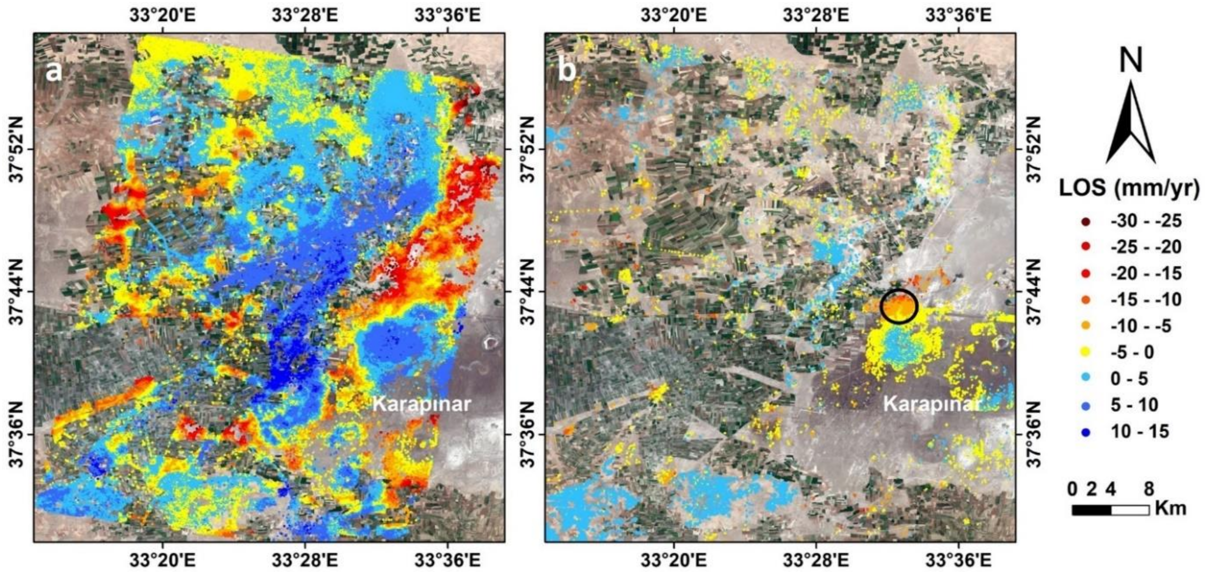


*Figure 4 PAZ (a) and Sentinel-1 (b) descending LOS results of Karapınar (black circle) and its surroundings.*

## Conclusion

The study examines the current ground stability over the Konya Closed Basin study area located in central Turkey. Sentinel-1 has had a high impact on long-term monitoring with its large amount of archived data since 2014. On the other hand, the stripmap mode PAZ data cover a smaller area compared to Sentinel-1. The study showed that, along with the settlements (cities and villages), linear infrastructures were also determined. The PAZ results belong to a two-year analysis which obtained higher persistent scatterer points compared to Sentinel-1 analysis based on a five-year dataset. As further perspectives, since the region is dominated by agriculture, a small baseline approach will be applied to enhance the spatial distribution of surface displacement. We will also acquire and process ascending orbit Sentinel-1 dataset and extract both vertical and horizontal deformation for the first time over the study area. The results will be integrated with ground water level measurement data, and geospatial analysis will be performed to get deeper insights into the subsidence risk affecting the Konya region.

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