Surface deformation analysis in Istanbul, Turkey using multi-temporal ALOS-2 data

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Abstract: Monitoring large areas can be time consuming considering megacities which have more than ten million citizens. Istanbul is one of the megacities where the population is more than fifteen million inhabitants. The city is vulnerable to various natural and human induced hazards that threaten human life. One of the biggest natural disaster is the earthquake, which has caused severe changes to the socio-economics of the region. Besides, there are also local deformations due to urbanization, ground fillings, metro constructions, and landslides which also affect human life, properties, and transportations. However, previous studies widely focused on earthquake-related deformations, and these local deformations were not studied in detail. Remotely sensed data obtained by Synthetic Aperture Radar (SAR) satellite sensors and processed with SAR Interferometry techniques can be used to monitor deformations in cities thanks to their high spatial and temporal resolutions. The purpose of this study is to determine the deformations using multi-temporal L-band SAR data applying the Persistent Scatterer InSAR (PSI) technique. L-Band data was used for the first time for the investigation of the deformation analysis over this region.

In this study, two regions of the Istanbul megacity were studied. The first one is coastlines of Golden Horn, and the second one is landslide areas of Avcilar-Beylikduzu. The Golden Horn is a natural estuary and it is located at the old city of the Istanbul, which is one of the protected sites of UNESCO. It is a natural port and connects various transportations. Because of its alluvial structure and human made ground fillings the geological structure is not very solid. The second region is located on the west of Istanbul, and it is vulnerable to slowly developing landslides due to the topography and geological structure of the region.

In the InSAR analysis, the ALOS-2 image data of the Golden Horn area was processed. 27 images belonging to the ascending mode and different acquisition times were considered, including the master image. However, 3 images were excluded from the evaluation due to low coherence and high errors in their orbits although temporal and spatial vases of them were suitable. All images were evaluated in the SARProz software. In this context, initially polarizations were defined as horizontal-

horizontal, master image was selected, co-registration was applied to master and other images, and then PSI analysis was performed. In this way, 21584 persistent scattering points were obtained and deformations of these points in the line of sight (LOS) direction were determined. The displacement values ranges between 20 mm/year to -20 mm/year. The maximum displacement was observed along the river where the coastline is filled and used for recreational areas. Additionally, a displacement is also noticed over newly constructed port that is located at the south. For the same region, 31 Sentinel-1 data was also used. The data were acquired between 2015 and 2017. Compared to L-band, C-band Sentinel-1 provided displacements over the same locations. However, lower displacement values were determined with C-band data especially over the new port and along the coastal region.

In the regions, a combination of open source SNAP and StaMPS softwares were used and PSI approach was applied. In the analysis 19 ALOS-2 data from 2016 and 2018 with HH polarization was used. Additionally, Sentinel-1 data were also analyzed from 2015 to 2020. Both dataset showed similar displacement pattern. In this region the displacement range is slower and it changes between 10 mm/year to -10 mm/year when ALOS-2 data was used. The results of Seninel-1 showed slower displacement compared to ALOS-2 data. The results of ALOS-2 data showed more PS points over the rural parts of the region that could not determine by Sentinel-1. The results indicated that most of the old landslides were reactivated and there are new locations that were not shown in the current landslide inventory. At the east part of the region a vertical accumulation is identified while the topography is decreasing. The rural part has started to urbanization, and the results showed that they are vulnerable to landslides.

In this study, the first results of the multi-temporal PSI analysis of ALOS-2 was presented over the city Istanbul. Surface subsidence and landslides were determined over the city. In both cases, the results of ALOS-2 data provided higher level values of displacement even providing lower PS points. Moreover, it provided PS displacement where C-band could not achieve due to having shorter wavelength. The results indicated that landslides are dominated by slowly developing horizontal movement. As the results of InSAR just provide displacement at LOS direction at least one descending and one ascending dataset should be used to determine 2D deformation movement. However, in this region the archived ALOS-2 data has only ascending mode data. It is expected to have more data with ALOS-4 data to monitor deformation using L-band. It is planned to combine Sentinel-1 and ALOS-2 data to achieve better results than single sensor analysis.

Keywords: Surface deformation; landslide; InSAR; ALOS-2

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