Monitoring of surface deformation in Changshu (China) with sentinel-1 data using Tomo-PSInSAR

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Abstract: Surface deformation is one of the most common geotechnical hazards and widespread in cities, which may result from human activities such as underground construction or groundwater extraction. Surface deformation can cause serious damage to infrastructures, tunnels, roads, bridges, and buildings, which made a huge impact to the safety of the cities. Changshu is a county-level city under the jurisdiction of Suzhou, Jiangsu province, and is part of the Yangtze River Delta in China. In this study, we utilized a Tomography-based Persistent Scatterers Interferometry (Tomo-PSInSAR) approach for monitoring the surface deformation in Changshu city. For the purpose of this study, we used 69 Sentinel-1A images spanning from January 2017 to May 2019 acquired from an ascending orbit. Considering that the study area has cloudy and rainy weather, where there is much bias when eliminating the atmospheric phase screen (APS) using spatiotemporal filtering, we applied a two-tier network strategy to detect single and double PSs with no need for preliminary removal of the atmospheric phase screen (APS) in the study area. In the first-tier network, single PS candidates were initially selected using the amplitude dispersion criterion and a Delaunay triangulation network was constructed to connect the single PS candidates. And then, we used an M-estimator for the estimation of relative parameters (height and deformation velocity) at arcs by rejecting possible phase outliers and estimated the height and deformation velocity of the true single PSs using the ridge estimator. In the second-tier network, the remaining single PS and double PS candidates were selected with a temporally averaged amplitude threshold. After that, we connected each single PS candidate to the nearest single PSs detected in the first-tier network and constructed the second-tier local star network. And then we used the M-estimator again to calculate the final parameters (height and deformation velocity) of remaining single PSs, referring to single PSs extracted from the first-tier network. Finally, we used a local maximum ratio (LMR) method for detecting double PSs. Our results using Tomo-PSInSAR are compared to those using traditional PSInSAR method. We observe that the PS spatial density after using the Tomo-PSInSAR method increased by factors of 2.4 on the same area compared to the traditional PSInSAR method, especially in densely built areas. The deformation velocity map reveals that the Changshu city is subject to a great deal of deformation due to overexploitation of groundwater. This study emphasizes the potential of the Tomo-PSInSAR solution for monitoring the deformation in cities.

Keywords: Tomo-PSInSAR, two-tier network strategy, Changshu city, overexploitation of groundwater