Sequential InSAR Time Series Deformation Monitoring of Land Subsidence and Rebound in Xi'an, China

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The Xi'an, China has suffered from severe land subsidence and ground fissure hazards since the 1960s. With the progress of economic development and urbanization, groundwater was over-exploited for more than 50 years. Consequently, it had caused the formation of fourteen ground fissures accompanying land subsidence throughout the city. The maximum land subsidence rate reached 300 mm/year in 1996, and the maximum cumulative subsidence reached 3 m approximately in last 60 years, which has threatened and will continue to threaten the safety of urban artificial constructions.

InSAR time series deformation monitoring plays an important role in revealing the historical displacement of the Earth's surface. In order to study the spatiotemporal characteristics of subsidence and ground fissures, previous studies show that there existed a close spatiotemporal relationship between land subsidence and the formation of earth fissures. The degradation of the aquifer system is the one of the key factors to these typical deformations. In order to alleviate the land subsidence and ground fissures caused by over-extraction of groundwater, the pumping groundwater was restricted in 1996, meanwhile, water was supplied from Heihe River. Moreover, cumulative volume of 1552800 m3 had been recharged in Xi'an from 2009 to 2014.

In order to retrieve the history of land subsidence in Xi'an, we employed the sequential estimation method to update the time series deformation dynamically, which is an efficient InSAR tool to update the surface deformation as quickly as possible, when the SAR image is acquired one by one. In the experimental section,we take 83 Sentinel-1A images acquired from 20 June 2015 to 17 July 2019 to show the performance of the method and to analyze the evolution of land subsidence in Xi'an, China. For the sequential InSAR time series deformation processing, we divide SAR data into two groups. The first group is the archived SAR data for parameters initialization. While the second group is newly received SAR image (i.e., a new SAR acquisition) to update the new deformation parameter.

Results show three surface deformation phenomena occurred in Xi'an city from 20 June 2015 to 17 July 2019, i.e. continuous land subsidence, slow uplift and rebound after long-term subsidence, which can be explained as the response to the underground water changes in different regions. As for the response tothe artificial water injection, the rebound pattern can be further divided into immediate elastic recovery deformation and time-dependent visco-elastic recovery deformation.

Keywords: Sequential estimation; InSAR time series deformation; groundwater; land subsidence and rebound