Geophysical Research Abstracts
Vol. 20, EGU2018-12517-1, 2018
EGU General Assembly 2018

Monitoring of local topographic hazards in densely populated urban environments using high/ultra-high resolution time-series SAR Interferometry

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Local-scale topographic hazards caused by structural failures, sink holes and localized ground subsidence have been frequently reported over densely populated urban areas. The technical difficulties to identify or even predict local topographic hazard elements are not very well addressable throughout conventional in-suite survey techniques as well as contemporary Inferferometric SAR observations. In this study we attempt to address topographic hazard management issues over densely populated urban environments based on high (1-5 m) and ultra high (0.25 m) resolution time-series SAR Interferometry. Target areas were established over three main test sites covering local zones of subsidence in Taipei City, highly densified housing area in Rio de Janeiro, Brazil and Gangneung City in Korea. Staring and spotlight mode TerraSAR-X images together with Sentinel-2 data were employed.

For instance, in the case of local subsidence in Taipei City, an area along an elevated track section of the Mass Rapid Transit (MRT) system was found to subside with a velocity of 1-3 cm per year. Another local subsidence occurred near the intersection of two congested roads with a maximum magnitude of 118 mm. Yet another ground subsidence has constantly been observed over the construction site of the Taipei Dome since 2013. The reasons causing these ground surface displacements often remain unclear, however, all local subsidence cases have the potential to cause significant damage as they occurred in highly populated areas. Therefore a continuous detection of surface displacement spots over the city is essential. To achieve this, we propose to introduce a time-series Synthetic Aperture Radar (SAR) interferometric analysis to conduct a two-stage monitoring and detecting task. Firstly, for the purpose of observing surface stability, the interferograms and the unwrapped products used to identify the surface displacement were generated. In addition, the Persistent Scatterer Interferometry (PSI) approach combining a set of unwrapped D-InSAR interferograms was also employed to derive displacement velocities over a long-term period. Based on the derived products, we then applied an automatic pattern recognition algorithm to identify deformed areas over the city. Through the proposed workflow, we expect to establish the first corner stone towards systematically monitoring local topographic changes and hazards occurring in urban areas. A similar approach is being applied for Gangneung City, Korea and in parts of Rio de Janeiro, Brazil with a coverage of Sentinel-1 and Staring mode TerraSAR-X data to demonstrate the feasibility of the proposed method.