Geophysical Research Abstracts
Vol. 21, EGU2019-13017-1, 2019
EGU General Assembly 2019

Landslide detection with satellite radar observations: challenges and solutions

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Satellite radar imagery can record surface deformation over a wide range in both phase and amplitude formats, with Interferometric Synthetic Aperture Radar (InSAR) achieving millimetre accuracy. Based on these satellite radar observations, landslide detection at a large scale can be enhanced, which is beneficial to landslide risk assessment and disaster mitigation. However, there are still several challenges in the landslide detection with satellite radar observations. This talk presents an automated SAR-based landslide detection system under development which addresses the five main challenges of conventional InSAR for landslide detection.

The first challenge is dense vegetation that affects the coherence of SAR data. The effects can be weakened by use of SAR imagery with a long wavelength (e.g. S-band or L-band), a short temporal resolution, and/or a high spatial resolution (e.g. 1 m or even higher), and/or advanced InSAR time series. The second challenge is to deal with landslides with large deformation gradients, which can be addressed by SAR offset tracking and range split-spectrum interferometry (RSSI) methods with relatively low precision. We have developed an integrated approach to combine the RSSI and conventional InSAR to capture the large surface displacements of fast-moving landslides more precisely. Atmospheric effects represent another challenge of conventional InSAR for landslide detection, especially in mountain areas. The Generic Atmospheric Correction Online Service (GACOS) developed at Newcastle University is used to reduce atmospheric effects on radar observations and simplify the following time series analysis.

The fourth challenge is the impacts of SAR geometry such as shadow and layover. The impacts can be pre-analysed using a high-resolution external DEM. Since very high-resolution (VHR) DEMs are often not available whilst processing VHR radar images (e.g. 1m or higher TerraSAR-X), a machine learning approach has been developed to identify water bodies, shadow and layover areas. The geometry impacts can be weakened with the joint use of descending and ascending tracks, different tracks with different incidence angles, or radar images from different radar missions. The fifth challenge is topographic effects in areas with high buildings or steep slopes, which could easily lead to phase unwrapping errors. A baseline linear combination approach has been developed to address it.

In our automated SAR-based landslide detection system under development, the GACOS-assisted InSAR time series technique is employed to delimit deformation acceleration zones and detect extremely-slow-to-slow moving landslides. SAR offset tracking and RSSI are used in parallel to capture large displacements and detect moderate-to-fast moving landslides. Machine learning algorithms are developed to automatically map post-event landslides triggered by earthquakes or heavy rains.