Investigation of deep-seated slope gravitational deformation from TCP-InSAR techniques with ALOS/PALSAR images in the Lushan area, Taiwan

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INTRODUCTION

After 2009 Typhoon Morakot, a catastrophic Hsiaolin landslide that caused 450 casualties, how to identify potential sites of deep-seated landslides and evaluate their activity and susceptibility become an important issue for natural hazard mitigation of the island. In the past few years, our research team has processed many slope failures that have caused considerable damages by using airborne LiDAR Digital Elevation Model (DEM), and implemented related analyses for the goal of deep-seated landslide (Lin et al., 2013). In this study, we focused on the TCP-InSAR techniques of available L-band SAR data were acquired, which could penetrate dense vegetation and used to estimate more ground deformation information to evaluate the activity and susceptibility of Deep-Seated Gravitational Slope Deformation (DSGSD) which has potential transfer to catastrophic landslide in the mountain region.

METHODS

Space-borne Synthetic Aperture Radar Interferometry (InSAR) is a widely used remote sensing technique to get surface deformation measurements with high precision over large areas. It is based on the phase comparison of SAR images, gathered simultaneously or at different times with slightly different looking angles from space or airborne platforms. TCP-InSAR includes algorithms for identifying and co-registering coherent points that are not necessarily to be coherent during the whole time span of observations and to develop an efficient algorithm to estimate the deformation parameters with no need of phase unwrapping. The increased density of TCPs can reflect more deformation details especially in areas that undergo fast development and mountain areas. This approach had been applied to assess the earthquake hazards for metropolitan Los Angeles, and deformation rate estimation on changing landscapes (Zhang et al., 2011, 2012). The results obtained are in good agreement with GPS and leveling measurements, indicating the effectiveness of the TCP-InSAR in retrieving deformation signals from multi-temporal SAR data (Haung, 2013).

RESULTS

Lushan in Nantou County is well known as one of the three high altitude agriculture area in Taiwan. It is suffering from landslides as a result of several typhoons every year and overdevelopment of the land. In this study, we using the Phased Array L-band Synthetic Aperture Radar (PALSAR), carried by the Advanced Land Observing Satellite (ALOS), providing observation data during 2006 to 2011 with a recurrence cycle of 46 days. Lushan area is covered by PALSAR 445-460 (path-row) scene, totally 14 ascending orbit images are acquired during the ALOS mission period from 2007 to 2010. This method largely increases the accuracy of the estimated displacements and also make it applicable in area with widely varying deformation gradients. Although there are 91 possible image-pair combinations from available images, only 10 image-pairs with sufficient coherent interferometry condition in the mountain area are selected for the TCP estimation to keep desirable TCP density and avoiding potential phase unwrapping error. The TCP-InSAR analysis shows a significant subsidence pattern around the Lushan. Comparing the TCPs and the field investigation records of DSGSD area, several imperceptible deep-seated landslide locations are found and the boundaries can be identified as well as the spatial distribution of instability to them. The deposition pattern also implies different landslide development types on the slopes. This case study shows the great potential of TCP-InSAR evaluating the slope activities and deformation in the vegetated mountain area. Combined with

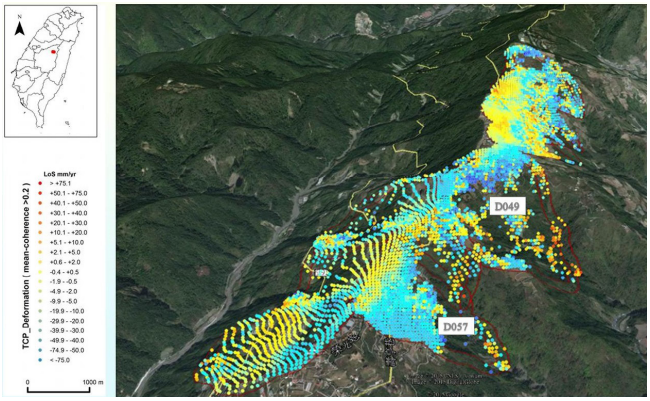

Figure 1. The TCP-InSAR is a relative fast and economics approach to evaluate the activity of potential large scale landslide comparing to traditional landslide monitoring system. Green to blue colors in the figures representing the area is moving downward, and the yellow to red color representing the area is uplifted. Therefore, the moving downward annual displacement rate of each potential large scale landslides can be used as an indicator of its activity.

topography signatures from high-resolution digital elevation model data, it will be an effective way to determine the stability of slopes and potential hazard locations over a large area.

CONCLUSION

The precise measurement of the present day ground displacements by using TCP-InSAR and GPS at the scale of the whole Taiwan Island has been proposed or applied in researches of different earth surface processes such as crustal deformation, earthquake hazard assessment, land subsidence and active mountain uplift. However, such kind of technique has not been used to evaluate the activity and susceptibility of DSGSD and potential catastrophic landslides. On the basis of LiDAR derived DEM, we believe that TCP-InSAR interfermotry will provide the unique opportunity to precisely continuous monitoring the activity and its susceptibility of DSGSD in Taiwan (Figure1). The study results will help scientific community to better understand the triggering threshold and the mechanism of catastrophic landslides, and also help the government making hazard mitigation plan.

REFERENCES

- Huang D.R. (2013) Detection of Land Subsidence by Temporarily Coherent Point SAR Interferometry in Changhua, Yunlin, and Chiayi. Master Thesis, Department of Civil Engineering, National Chiao Tung University, Taiwan. 86 pages.
- Lin C.W., Tseng C.M., Tseng Y.H., Fei L-Y., Hsieh Y.C., Tarolli P. (2013). Recognition of large scale deep-seated landslides in forest areas of Taiwan using high resolution topography. J. Asian Earth Sci. 62, 389-400.
- Zhang L., Ding X., Lu Z. (2011). Ground settlement monitoring based on temporarily coherent points between two SAR acquisitions. ISPRS J. Photogramm. Remote Sens. 66, 146-152.
- Zhang L., Lu Z., Ding X., Jung H., Feng G., Lee C.W. (2012). Mapping ground surface deformation using temporarily coherent point SAR interferometry: Application to Los Angeles Basin. Remote Sensing of Environment, 117, 429-439. doi:10.1016/j.rse.2011.10.020

KEYWORDS

TCP-InSAR techniques, Deep-Seated Slope Gravitational Deformation, ALOS/PALSAR images, Taiwan

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