TRACEING THE SLOW MOVEMENT BEFORE AND AFTER HONG KONG LANTAU ISLAND LANDSLIDE IN JUNE 2008 WITH A SBAS-INSAR METHOD

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ABSTRACT: Hong Kong is susceptible to landslide risks due to the high mountain slope and frequent rainy weather. Landslide poses a huge threat to infrastructure and residential areas nearby, and even leads to irreparable loss of the civilian lives and properties. It is therefore urgent to explore advanced technologies to study the mechanisms of landslide dynamics for risk mitigation. In this paper, we use the satellite synthetic aperture radar interferometry (InSAR) method to trace the slow movement before and after Hong Kong Lantau Island landslide in June 2008. A comparison analysis between precipitation and slope movement suggests that rainfall has a significant impact on the slope failure in the research area.

1. INTRODUCTION

Landslides result in enormous property damage and human casualties in mountain region all over the world, with average yearly economic losses amounting to billions of US dollars (e.g., Japan, India, Italy, USA) to millions in countries like Canada, Nepal, Sweden (Metternicht et al. 2005). The landslide incidents can be due to the gravitational force and other factors such as rainfall, earthquakes and human activities. Among these factors, rainfall plays an important role in triggering landslides and often used for predicting slope failures (Bai et al. 2014; Sun et al. 2015).

Synthetic Aperture Radar Interferometry (InSAR) is an established method for the detection and monitoring of earth surface processes. During the last decades, many efforts have been made to improve the applicability of InSAR measurement, one of which is the multi-temporal InSAR (MTInSAR) that exploits solutions based on time series of SAR acquisitions, such as the Persistent Scatterers (PS)(Ferretti et al. 2000, 2001; Hooper et al. 2007; Kampes and Hanssen 2004), small baseline (SB)(Berardino et al. 2002; Lanari et al. 2004). In 2008, Hooper proposed the StaMPS-SB method, which can identify more pixels in the natural terrain and increased the Signal-to-Noise Ratio(SNR) of the selected pixels (Hooper 2008).

By forming interferograms between SAR images separated by a short time interval and with the small difference in look and squint angle, decorrelation is minimized. As a result, the small baseline method is more suitable for the investigating the landslides that are mostly taking place over natural terrains (Sun et al. 2015). In this paper, we applied the small baseline subset InSAR method to trace the slow movement before and after Hong Kong Lantau Island landslide in June 2008. A comparison analysis between precipitation and slope movement suggests that rainfall has a significant impact on the slope failure in the research area.

2. STUDY AREA AND DATA PROCESSING

2.1 Study Area

Hong Kong is located at the mouth of the Pearl River Delta in Southern China. The climate of Hong Kong is sub-tropical and monsoon, typified by mild, dry winters, and hot, humid summers. The mean annual rainfall reaches about 2400 mm, about 80% of which falls during the rainy season from May to September (Zhou et al. 2002). In 2008, a total of 868 landslide incidents were reported to the Geotechnical Engineering Office(GEO) of the Hong Kong Government Departments which resulted in a total of 888 facilities breakdown and 2 deaths. A landslide cluster occurred on the natural hillside of Lantau Island, following the heavy rainfall on the morning of 7 June 208. Figure 1 shows the maximum rolling 24-hour rainfall distribution for the period between 6 June (00:00) and 9 June 2008 (24:00) and location of landslides on Lantau Island of Hong Kong (The data is from Geotechnical Engineering Office

of Hong Kong). The Hong Kong airport is situated in the middle-west coastal zone of the island.

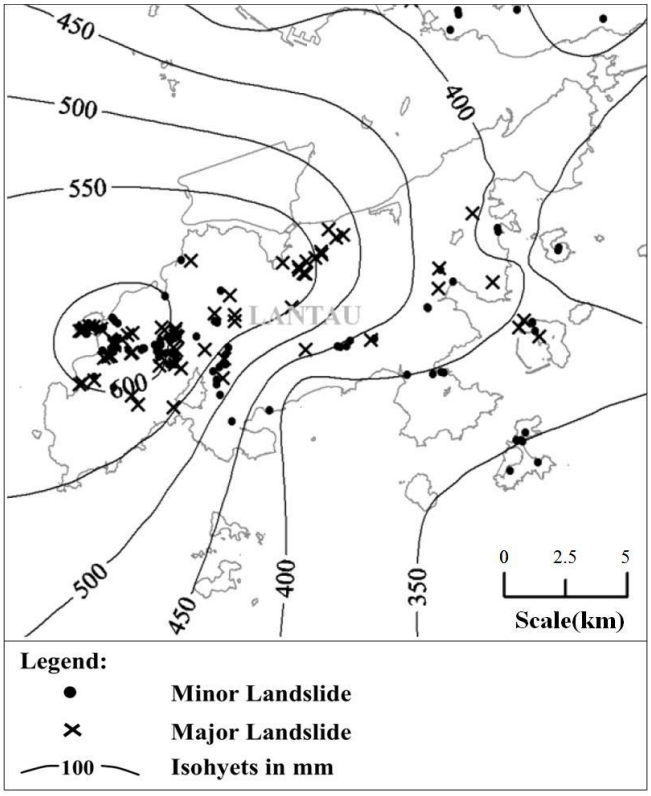

Figure 1. Maximum Rolling 24-hour Rainfall Distribution for the Period between 6 June (00:00) and 9 June 2008 (24:00) and Location of Landslides

2.2 Datasets Used and InSAR Processing Method

In this study, 21 L-Band ALOS1-PALSAR scenes data which hold well correlation over vegetated area and a Small BAseline Subset (SBAS) differential interferometry method are used to monitor the slope deformation on Lantau Island, Hong Kong during June 2007 to January 2011. SRTM (Shuttle Radar Topography Mission) DEM with a resolution of 30 m is used to remove the topographic phase. The rainfall data from the Hong Kong Observatory is used to analyze the correlation between slope movement and precipitation.

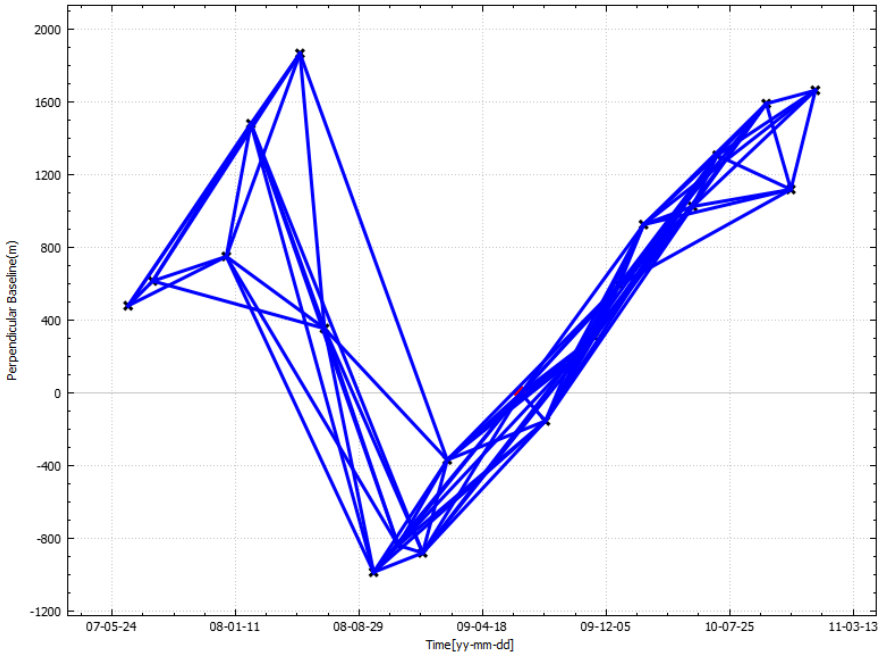

Figure 2. Temporal and Perpendicular Baseline Distribution of the Small Baseline Subset

In order to minimize the temporal and spatial decorrelation, interferometric pairs with small temporal and perpendicular baselines are selected to generate interferograms. As a result,86 InSAR pairs are generated from 21 SAR images with the critical temporal baseline 365 days and the critical perpendicular baselines 2500m. Differential InSAR processing is applied to each small baseline InSAR pair respectively.

Because of the correlation between the spatial baseline and temporal baseline of ALOS PALSAR data, topographic correction is implemented before standard SBAS algorithm to correct the topographic residual which may disturb the deformation velocity measurement. 40,767 pixels are selected to measure the surface deformation of the Lantau Island. SVD decomposition is finally used for the solution of the time series deformation which reflects the deformation history in that period.

3. PROCESSING RESULT

The line-of-sight deformation velocity map is presented in Figure 3. The range of the detected linear deformation velocity is from -19.9mm/yr to 21.2mm/yr. Because of the dense vegetation covered over the island, the distribution of the displacement velocity seems noisy rather than smooth distribution. However, from the perspective of spatial distribution, it is consistent with the spatial distribution of the landslide incidents. On the western of the island (the left side of the figure), there are more landslides happened. Similarly, the displacement velocity of the western areas is more significant than the eastern areas.

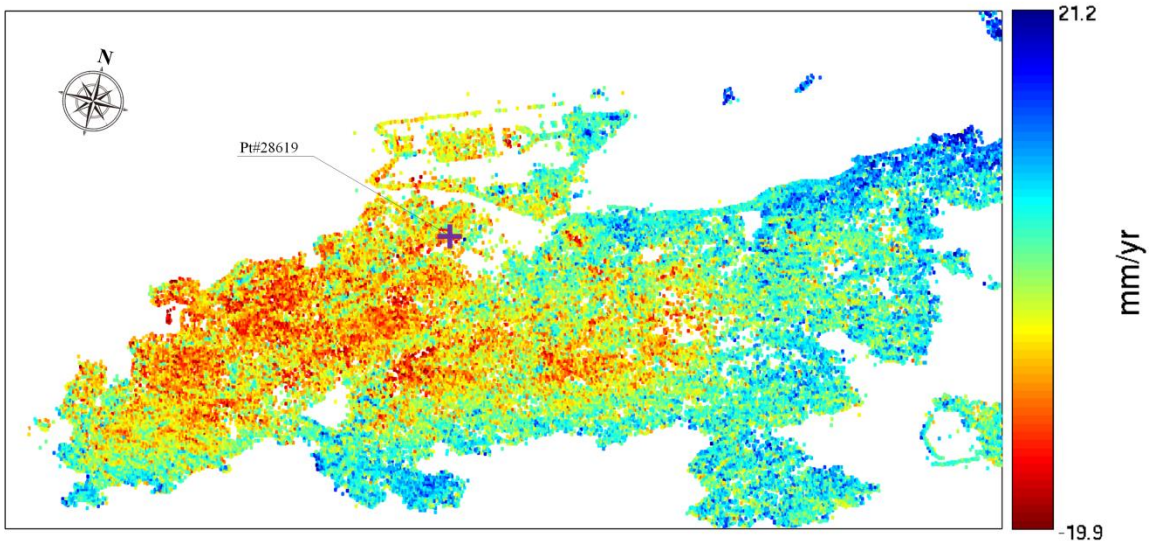

Figure 3. The deformation velocity map of Lantau Island, Hong Kong

Most pixels show nonlinear seasonal deformation history. The displacement time series line of Point No. 28619 is drawn with red line in Figure 4. The blue monthly precipitation bar chart is under the Figure. By comparing the cumulative deformation of SBAS-InSAR measurement with the monthly precipitation obtained from Hong Kong Observatory, the high correlation is concluded that the increase of rainfall may cause the displacement of the land surface. To be specific, the frequent rain in summer can cause obvious movement of the slope surface with little time lag. In June 2008, the monthly precipitation is 1346.1mm and there is a large displacement, which indicates that the precipitation may be the primary driving force of the instant landslide in this month.

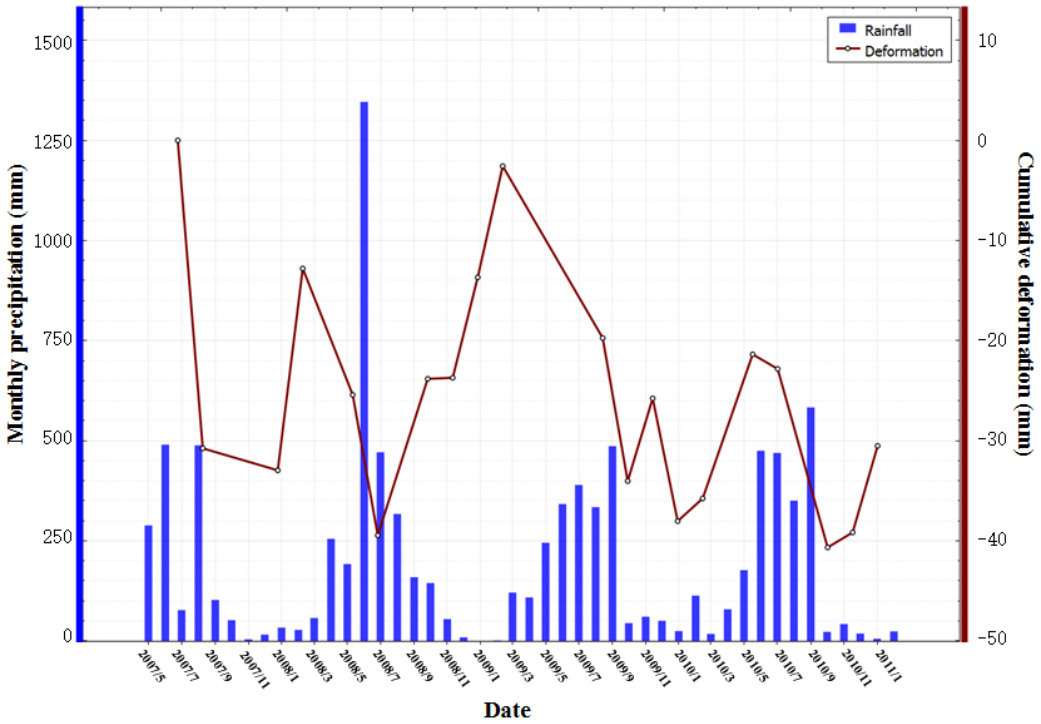

Figure 4. The relationship between the cumulative deformation (at Point No.28619) and the monthly precipitation obtained from Hong Kong Observatory

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