Preliminary Results of Persistent Scatterers Interferometry in and Around the Tatun Volcano Group, Northern Taiwan

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Abstrct

The northwest part of Taipei basin is covered by lahar originated from Tatun volcano group and its thickness reaches over eighty meters in the very northwest corner of the basin. If the distribution of the population and building in Taipei basin stay in a similar pattern, it would cause inconceivable casualty and damage to property if the volcano erupted.

We set out to investigate the surface deformation of Tatun volcano group between 2003 and 2007 using the archived radar images acquired by Envisat satellite that was launched by ESA. We plan to use Persistent Scatterers Interferometric Sythetic Aperture Radar (PSInSAR) to extract the deformation signal. Since the region of Tatun volcano group is covered with varying vegetations over different seasons, therefore the noise of DInSAR interferograms are often too high to see surface deformation. The atmospheric disturbance can be reduced by using PSInSAR, so that we can acquire the information of crustal deformation effectively. Aside from natural PS, we erected man-made corner reflectors in our study area of Tatun volcano group. These corner reflectors will appear in radar image as apparent spots, which could be easily recognized and regarded as surface control points. Some of our corner reflectors were erected nearby GPS stations set out by other agencies.

Introduction

The Unzen volcano of Kyushu in Japan was erupted on May, 1991; the Pinatubo Mountain of the middle of the Luzon Island was erupted on August in the same year. The Tatun volcano group of northern Taiwan is located the ring of fire of Pacific Rim, like Unzen and Pinatubo Mountain. Consequently, it is worried that the Tatun volcano could erupt. Besides, the northwest part of Taipei basin, according to the geologic circumstance, is covered by lahar originated from Tatun volcano group and its thickness reaches over eighty meters in the very northwest corner of the basin. It is revealed that the former has repeatedly Tatun volcanic eruption. If the distribution of the population and building in Taipei basin stay in a similar pattern, it would cause inconceivable casualty and damage to property if the volcano erupted. Therefore, whether the Tatun volcano group could erupt, like Unzen and Pinatubo Mountain, has

become an important issue to people living in Taipei basin. We plan to use Persistent Scatterers Interferometric Sythetic Aperture Radar (PSInSAR) to extract the deformation signal, so that we can acquire the information of crustal deformation effectively. However, applying PSInSAR to estimate deformation on volcanoes is more challenging because a) the majority of volcanoes are not urbanized and therefore lack the man-made structures which are recognized by the PS algorithm, and b) deformation tends to proceed at an irregular rate. Therefore, aside from natural PS, we erected man-made corner reflectors in our study area of Tatun volcano group, and these will appear in radar image as apparent spots, which could be easily recognized and regarded as surface control points. Consequently, corner reflectors installing is the major work that we need to do now. Presently we have set three corner reflectors in the region of Tatun mountain, and the number of corner reflector is expect to reach twenty in about a year.

Background

The Tatun volcano group is distributed in the northern tip of Taiwan. The Ryukyu arc system is formed, from north to south, of back-arc basin (the Okinawa trough), inner volcanic arc, outer sedimentary arc and trench (the Ryukyu trench). It is generally accepted that the Philippine Sea plate is subducting along the Ryukyu trench under the Asiatic plate and that the Tatun volcano group occupies the western end of the inner volcanic arc of the Ryukyu arc system.

The Tatun volcano group is interpreted to be one of the youngest volcano components in Taiwan. Its volcanic activities can be divided into two periods according to the results of radiometric dating. The Tatun volcano group began to erupt in 2.8~2.5 Ma, then ceased about one million years, and resurged in 1.5 Ma and lasted until 0.2 Ma. Thus, it was usually identified as an extinct volcano due to no historically documented eruption. Recent data of seismicity, hydrothermal activity, volcanic gases and helium isotope, however, suggest that there is probably an active magma chamber underneath the volcano group, implying that it may be dormant but a potentially active volcano based on the phenomenological definition.

Method

Synthetic Aperture Radar (SAR) is a powerful remote sensing system, enabling observations of the Earth's surface day or night, in all weather conditions from airborne platforms and from space. In many cases, the coherent phase information transmitted by a SAR satellite or aircraft is reflected from the surface back to the sensor with the phase more or less intact. A subsequent satellite pass, several days to several years after the initial pass, may also retain the phase information. A phase comparison of the two images via interferometric techniques may reveal subtle shifts in the position of the Earth's surface (closer to or farther from the satellite). This

technique is known as Interferometrtic SAR (InSAR). It can be done from either aircraft or spacecraft, but for most scientific applications, space-based platforms are preffered

While InSAR is a powerful technique for measuring changes in the Earth's surface, it does have limitations. These include temporal and spatial decorrelation (low signal to noise ratio in the phase change estimate), and variable tropospheric water vapor, which can generate variable phase delay due to the impact of water vapor on the propagation speed of microwave signals. The corresponding phase changes can be misinterpreted as surface change. The effects can be quite large, especially in tropical and sub-tropical regions. In tropical regions, up to 10 cm of variable path delay over several weeks has been observed.

Persistent scatterer analysis of InSAR data is a very sensitive technique for measuring steady or functionally-simple deformation with time when applied to urban areas. Applying these methods to estimate deformation on volcanoes is, however, more challenging because a) the majority of volcanoes are not urbanized and therefore lack the man-made structures which are recognized by the PS algorithm, and b) deformation tends to proceed at an irregular rate. Therefore, we erected man-made corner reflectors in our study area of Tatun volcano group. These corner reflectors will appear in radar image as apparent spots, which could be easily recognized and regarded as surface control points. Corner reflectors (figure 1) are simple trihedrals of aluminium that strongly reflect the radar signal back to the satellite.

Result

In order to be able to validate our result from PSInSAR in the key area in the future, deploying an array of corner reflectors in our study area is planned in this study. In order to obtain effective information from corner reflector, there world be several prerequisite of the plan sites. Sites that will be co-located with GPS stations set up by Sinica Academia around the Tatun volcano group were analyzed in this study (Figure 2). The time series of these points (Figure 3) showed that point B and D are brighter and point A and C are darker. Point B also has the highest variation in their brightness among all the poits analyzed. It is easy to compare deformation signal with GPS data if corner reflectors installed near GPS station. Furthermore, locations near GPS station are easy to reach and more spacious to fit corner reflector settings. We will use similar way to find desirable place and install corner reflectors continued.

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Figure 1. Trihedral corner reflector with 1.6 meter sides, whose response to an incident signal is returned in its direction (a feature making them treatable as point targets).

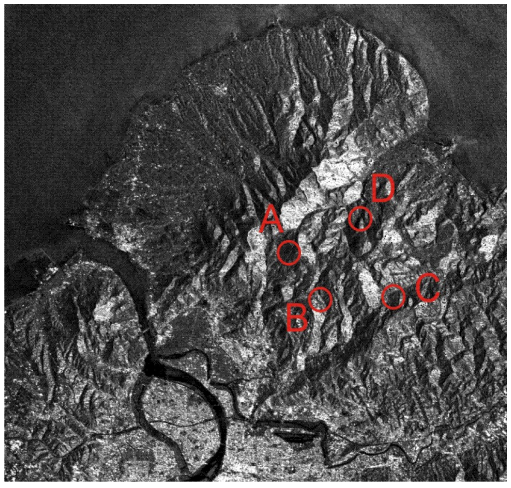

Figure 2. Illustration reveals the position of GPS station on SAR image.

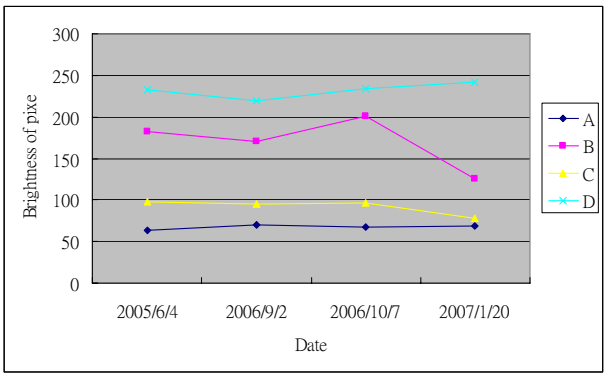

Figure 3. Brightness of pixel near GPS station from the SAR images in two years