Geophysical Research Abstracts
Vol. 13, EGU2011-9597, 2011
EGU General Assembly 2011

Monitoring of Land Deformation around Active Fault in the Metro Manila, the Philippines

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The Republic of the Philippines lies across the boundary between the Eurasian plate and the Philippine Sea plate, an area ridden with active faults and frequent earthquakes. The Manila metropolitan area is the nation's center of politics, economy, and culture. Over the last several decades it has rapidly grown into an overcrowded mega city with an economically active population of at least 10 million. The Valley fault, running from north to south along the eastern edge of the Manila metropolitan, is a right-lateral active fault with two to four activities recorded over the past 1400 years; the estimated recurrence cycle translates to 200 to 400 years. Creep deformation along the southern part of the fault has produced some cracks running in a north-south or northeast-southwest direction. As a result, roads and ground structures near the fault exhibit vertical displacements. According to recent studies, the last activity of the fault took place on August 19, 1658. In consideration of the estimated recurrence cycle, the region now faces a high risk of a devastating earthquake with a magnitude of 7 or higher. The government therefore needs to quickly establish a system for monitoring changes in active faults in the region, as there have been no actual long-term observations of land deformation around the Valley fault as of today. Some researchers from the Philippine Institute of Volcanology and Seismology (PHIVOLCS) are engaged in their own studies concerning GPS-based land deformation observation, but time and cost constraints have limited the measurement frequency of their observations and the planar coverage of their measurement points. Consequently, they hope to use space-borne measuring techniques to create a monitoring system capable of efficiently capturing changes around the Valley fault.

In this study we measured land deformations around the Valley fault along the eastern edge of the Manila metropolitan area, by means of InSAR time series analysis using ENVISAT data and DInSAR based on TerraSAR-X data. DInSAR is an unique application technique of synthetic aperture radar (SAR) and is now drawing attention as a methodology capable of measuring subtle surface deformation over a wide area with a high spatial resolution. InSAR time series analysis can synthesize long-term land deformations from individual DInSAR results, enabling measurement of temporal changes in surface deformation in pixels. It proves capable of ascertaining land deformation characteristics in time domein, this makes it very effective for visualizing temporal and spatial deformations over wide areas.

According to our InSAR time series analysis using ENVISAT data, several phase anomalies were detected in the Manila. Most of them could be found a strong correlation with the vertical movements of the groundwater levels, the deformation at each location progresses monotonically. The maximum average deformation velocity was measured 91 mm a year. Meanwhile, some of the land deformations are independent of the groundwater levels in the surrounding of the Valley fault. The difference in measurement times may partially explain this discrepancy, but we cannot deny the possibility that it resulted from creep deformation around the Valley fault, as the spatial geometry of the surface deformation runs in parallel with the fault and sites in the eastern part of the Valley fault stopped subsiding and began moving upward in around 2007.

Though the availability of the TerraSAR-X data is limited to acquisitions in and after 2008 and there are only three acquisitions over the target area on July 8, 2008, January 29, 2009, and March 27, 2010, the DInSAR using TerraSAR-X data identified uplifts in the eastern part of the Valley fault. Because phase differences from DInSAR indicative of ground subsidence or atmospheric phase delays generally tend to be smooth over wide areas, thus, by detecting a sudden spatial change in phases, a site of creep deformation can be identified and this leads to determine if the phase difference around the site results from the creep deformation. In this study, we applied the first differentiation in east-west direction to the TerraSAR-X DInSAR results to detect a steep gradient of interferometric phases. As a result, a segment was detected in the direction parallel with the Valley fault. A further examination of the link between the steep gradients of phases and creep deformation of the Valley fault will require InSAR time series analysis using TerraSAR-X data, detailed field survey, ground-based measurements, and tectonic investigation based on geophysical exploration techniques. This will be our next research theme.