Feasibility Studies of DInSAR in the Northeastern Kyungsang Basin, Korea

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Abstract: This study focuses on examing the feasibility of differential SAR interferometry (DInSAR) in the Northeastern Kyungsang Basin, Korea. Major faults in the Kyungsang Basin such as Yangsan fault, Dongrae fault, and Ulsan fault had developed during Cretaceous, and the activeness of these faults is still controversial in Korean geology community. We attempt to measure displacements in the study area by applying DInSAR techniques to JERS-1 SAR data sets. Some surface displacements are recognized by DInSAR method at Young-il Bay in which the POSCO Company locates, although the displacements may not be directly associated with geologic structures. We also discuss atmospheric effects for the techniques used.
Keywords: DInSAR, Displacements, Atmospheric effects, Kyusngsang Basin.

1. Introduction

SAR interferometry using spaceborne Synthetic Aperture Radar (SAR) has proven to be an effective tool for detecting surface changes caused by earthquakes, subsidence, volcanic activities, mining and ground water pumping, etc. SAR Interferomety has shown a great deal of potential in detecting displacements of sub-centimeter accuracy in several geophysically important applications such as earthquake co-seismic dislocations and strain accumulation investigations, glacier motion studies, and subsidence monitoring of a wide range region [A. Refice et al., 2001: Zebker et al., 1994]. Here, we use the differential interferometry (DInSAR) method to examine potentials of ground deformation around the Northeastern Kyungsang Basin, Korea. We should consider phase distortions in radar interferograms due mostly to variations in atmospheric water vapor. The effects of vapor result in a nearly constant time delay of the radar signal (independent of frequency at microwave wavelengths) [Zebker et al, 1997]. Consequently, DInSAR has not become an operational technique because of the presence of measurement biases due to atmospheric propagation effects that seriously degrade the accuracy of DInSAR-only results [Linlin et al, 2002].

2. Data and Analysis

1) DInSAR Pairs and DEM

We used JERS-1 L-band SAR data obtained from 1993 to 1998 and processed 42 DInSAR pairs (Fig. 1) that have relatively short interferometric baselines (< 1 km). We adopted 2-pass method using digital elevation model (DEM) from 1:25,000 digital map by National Geographic Information Institute (NGII).

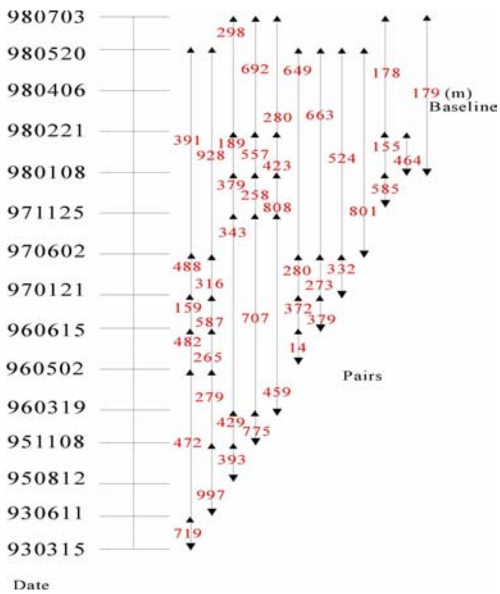

Fig 1. JERS-1 SAR data sets obtained from 1993 to 1998 and used in this study. All pairs have shorter perpendicular baseline than 1 km.

2) Optic Images

Optic images are also used to examine the cloud coverage on the day of SAR data acquisition. Fortunately, we found SPOT-2 HRV (Fig. 2 (B)) and LANDSAT-5 TM (Fig. 2 (C)) images. Those were recorded in the same day and similar time to SAR data acquisition on 11:10 a.m. 2 May 1996 and 11:16 a.m. 20 May 1998 by NASDA.

3) DInSAR and Atmospheric Effects

There are major faults in the Kyungsng Basin (Fig. 2 (A)) and it is still controversial for the activeness of the faults in Korean Geology community. An earthquake with the magnitude of 4.3 (MW) was measured at east region of Kyung-Ju city (Fig. 2 (a)) on 26 June 1997, but fault displacement was not reported.

We constructed 19 interferograms using JERS-1 SAR data sets obtained before and after the earthquake. Two interferograms out of 19 are shown in (Fig. 3) It was clear sky without cloud components confirmed by optic images (Fig. 2(B) and (C)) in study area. It may, however, still contain measurement biases due to atmospheric propagation effects such as ground temperature, humidity and pressure, etc. By applying DInSAR methods, line-of-sight (LOS) ground displacements was estimated to be 4.7 cm (one fringe of L-band JERS-1 SAR is 11.75 cm) in 960502_980520 pair. We cannot exactly distinguish ground displacement from atmospheric effects by only DInSAR method. For more precise results, GPS data are required because atmospheric corrections components can be derived from GPS measurements. GPS precise point positioning has an important contributor to the atmospheric heterogeneities and obvious choice for generating atmospheric corrections for DInSAR [Linlin et al, 2002]. Otherwise, we can use Permanent Scatterers Interferometry (PSInSAR) method for removal Atmospheric Phase Screen (APS). As an example for atmospheric effects, we can present in rectangular area of 970602_980520 pair (Fig. 3 (B)). Temporal period of 970602_980520 pair (Fig. 3 (B)) is shorter than 960502_980520 pair (Fig. 3 (A)). That means all ground displacements of 970602_980520 pair (Fig. 3 (B)) must be included in ground displacements of 960502_980520 pair (Fig. 3 (A)). In 960502_980520 pair (Fig. 3 (A)), we cannot see any fringe patterns within the rectangle. On the contrary, the 970602_980520 pair (Fig. 3 (B)) produced fringes about 0.26-0.46 cycles (3.05-5.40 cm). This fringe pattern may be caused by atmospheric effects not by ground displacement.

4) Subsidence

The first step was the selection of a suitable pair of SAR images for estimation of ground displacement at Young-il Bay in which the POSCO Company locates. To minimize atmospheric effects, we used all available interferograms. We found six interferograms out of forty-two interferograms. Three of them showed consistent fringes (Fig. 4 (A), (B) and (C)), but the others did not produce fringes (Fig. 4 (D), (E) and (F)). From the interferograms, we measured ground displacement from March 1993 to May 1998. The interferogram of 930315_960615 pair (Fig. 4 (A)), 930315_970121 pair (Fig. 4 (B)), and 930315_980520 pair (Fig. 4 (C)) have fringes of about 0.33-0.40 cycles (3.88-4.70 cm), 0.67-0.73 cycles (7.83-8.62 cm), and 0.87-0.93 cycles (10.18-10.97 cm), respectively. No ground displacement in Young-il Bay from was measured between 25 November 1997 and 21 February 1998 (Fig. 4 (D), (E) and (F)). These phase pattern of 930315_960615, 930315_970121 and 930315_980520 pairs (Fig. 4 (A), (B), and (C)) had increased to the same direction. We do understand these displacements are ground subsidence by line-of-sight (LOS).

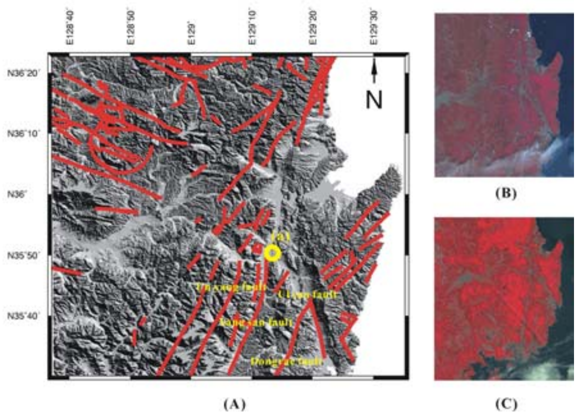

Fig 2. (A) Major faults in the kyungsang Basin: Unyang, Yangsan, Dongrae, and Ulsan faults from left to right. Circle (a) represents epicenter. (B) SPOT-2 HRV quick look image acquired at 11:05 2 May 1996. (C) LANDSAT-5 TM quick look image at 10:36 20 May 1998.

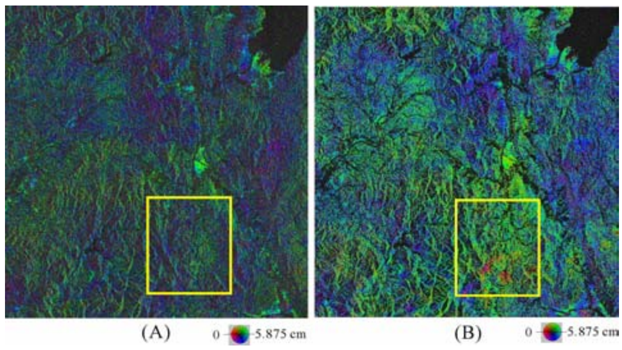

Fig 3. Differential interferograms derived from JERS pairs of (A) 960502_980520 and (B) 970602_980520.

Land subsidence quantities measured by DInSAR were 3.88-4.70 cm from 15 March 1993 to 15 June 1996, 3.92-3.95 cm from 15 June 1996 to 21 January 1997, 2.35 cm from 21 January 1997 to 20 May 1998.

3. Conclusions

We constructed differential interferograms by using JERS-1 SAR data sets and DEM before and after the earthquake at Yangsan fault zone. Displacements associated with the fault movement were not conclusive. Line-of-sight ground displacements of 4.7 cm measured by 960502_980520 pair might be caused by atmospheric effects.

Land subsidence quantities measured by DInSAR were 3.88-4.70 cm from 930315 to 960615, 3.92-3.95 cm from 960615 to 970121, and 2.35 cm from 970121 to 980520 at Young-il Bay in which the POSCO Company locates.

However, GPS data or PSInSAR techniques with a series of qualified data sets must need to draw final conclusions.

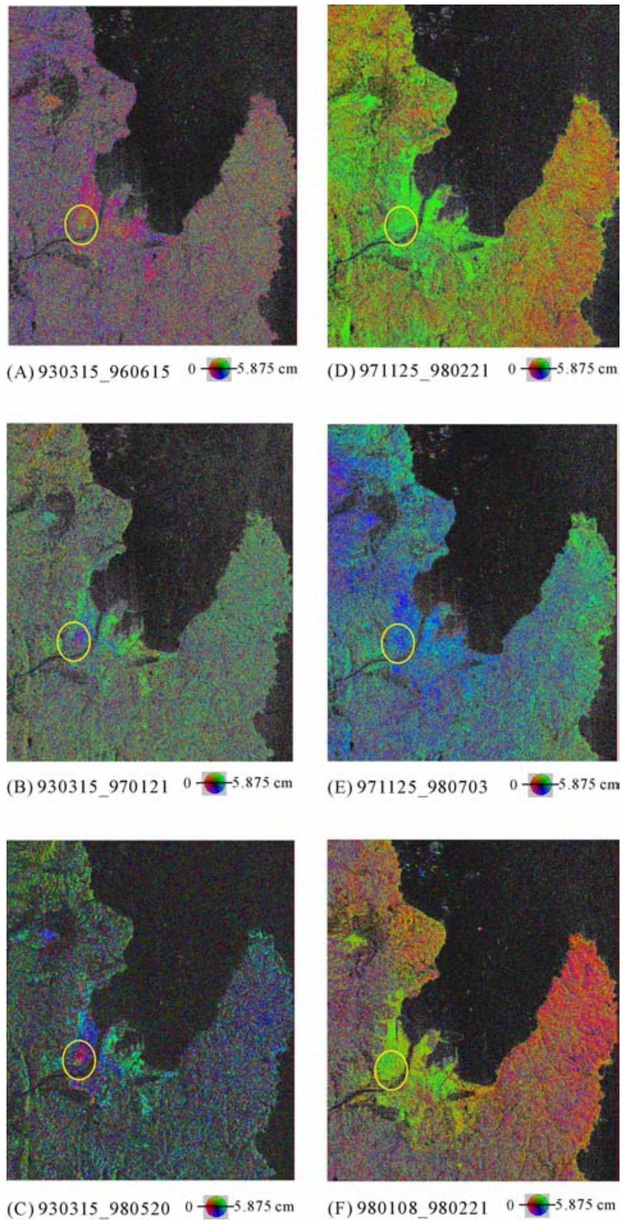

Fig 4. Fringe has produced in case of (A),(B) and (C), has not produced in case of (D), (E) and (F) at Young-il Bay.

References

[1] Massonnet, D., M. Rossi, C. Carmona, F. Adragna, G. Peltzer, K. Feigl, and T. Rabaute, 1993. The displacement field of the Landers earthquake mapped by radar interferometry, *Nature,* 364: 138-142.

[2] Klinger, Y., R. Michel and J. P. Avouac, 2000. Co-seismic deformation during the Mw 7.3 Aqaba earthquake (1995) from ERS-SAR interferometry, *Geophysical Research Letters,* 27(22): 3651-3654.

[3] Delacourt, C., P. Briole and J. Achache, 1998. Tropospheric corrections of SAR interferograms with strong topography. Application to Etna, *Geophysical Research Letters,* 25(15): 2849-2852.

[4] Zebker, H. A., P. A. Rosen and S. Hensley, 1997. Atmospheric effects in interferometric synthetic aperture radar surface deformation and topographic maps, *Journal of Geophysical Research,* 102(B4): 7547-7563.

[5] Beauducel, F., P. Briole and J. L. Froger, 2000. Volcano-wide fringes in ERS synthetic aperture radar interferograms of Etna (1992-1998): *Journal of Geophysical Research.*

[6] Ge, L., T. Tsujii and C. Rizos, 2002. Tropospheric Heterogeneities Corrections in Differential Radar Interferometry.

[7] Yonezawa, C. and S. Takeuchi, 2003. Effect of clouds on ERS SAR interferograms applied to land subsidence detection, *International Journal of Remote Sensing,* 24(1): 169-174.

[8] Hirose, K., Y. Maruyama, D. Murdohardono, A. Effendi and H. Z. Abidin, 2001. Land Subsidence detection using JERS-1 SAR Interferometry, *Astan Conference on Remote Sensing,* 5(9).

[9] Mora, O., J. J. Mallorqui, J. Duro and A. Broquetas, and H. Z. Abidin, 2001. Long-term subsidence monitoring of urban areas using differential interferometric SAR techniques, *IEEE,* 1104-1106.

[10] Rigo, A. and D. Massonnet, 1999. Investigating the 1996 Pyrenean earthquake (France) with SAR Interferograms heavily distorted by atmosphere, *Geophysical Research Letters,* 26(21): 3217-3220.