Preliminary result of land subsidence from radar interferometry in the Yunlin County of Central Taiwan

Yu-Fang Lu1, Cheinway Hwang1, Chung-Pai Chang2, Jiu-Yee Yen2, and Wei-Chia Hung1,3

1 Department of Civil Engineering, National Chiao Tung University, Chungli, Taiwan
2 Center for Space and Remote Sensing, National Central University, Chungli, Taiwan,
3 Energy & Resource Laboratories, Industrial Technology Research Institute, Hsinchu, Taiwan

Abstract

The Taiwan High Speed Rail (THSR), which is due to start operation in early 2007, is one of the most important infrastructures in Taiwan. In the Yunlin County of central Taiwan, a section of the THSR rail passes through an area with large subsidence rate that has been reported by previous studies (maximum 10 cm/yr). The aforementioned land deformation, under certain circumstances, could lead to failures of the foundations of rail structures and damages of rail tracks. In order to monitor and prevent regional subsidence, our team uses Differential SAR Interferometry (DInSAR) to monitor this area with centimeter accuracy.

Because the Yunlin County is covered with varying vegetations over different seasons, the noise of DInSAR results are often too high to extract the real surface deformation. Persistent Scatterers (PSInSAR) may overcome this difficulty and. Persistent Scatterers can provide long-term stability of the scattering characteristics and high radar signal coherence in the multi-image analyses. PS can estimate and then reduce the effect of atmospheric disturbance, spatial and temporal decorrelation. By applying PSInSAR, it is possible to extract deformation signals from the study area in Yunlin County. Compared to, PSInSAR can provide geodetic information with high spatial density and mm-level accuracy. The resulting subsidence information could be compared to the GPS and leveling results and improves our understanding in regional deformation.

Introduction

The Taiwan High Speed Rail (THSR), which is due to start operation in early 2007, is one of the most important infrastructures in Taiwan. In the Yunlin County of central Taiwan, a section of the THSR passes through an area with large subsidence rate that has been reported by previous study (up to 10 cm/yr). Because the Yunlin County is covered with varying vegetations over different seasons, the noise of DInSAR results are often too high to extract the real surface deformation. We have
not been satisfied with the results of DInSAR. So we employed the Persistent Scatterers (PSInSAR) approach to this study. This research will focus on DInSAR and PS_InSAR along Taiwan High Speed Rail in an area near Tukiu township and Yuanchang Country.

**Status of land subsidence**

Recent reports indicate that the subsidence rate of DaCheng country of ChangHua sinks more than 10cm per year. The center of subsidence in Yunlin has moved toward Tuku and Yuanchang. The problem of subsidence continues despite of governmental measure to stop it. The average subsidence rate of Tuku township and Yuanchang country achieves 10cm/ year, which might endanger the operation of the Taiwan High Speed Rail (THSR); see Figure 1.

**SAR images and processing**

For our Differential SAR Interferometry (DInSAR) research, the SAR images are from the ERS2 mission over the zones “track:232” and “frame:3123”, which cover central and the southern parts of Taiwan. We use the program “DIAPASON_Version4.1” to process the images. ERS2 images from 1995 to Sep 21, 1999 are acquired, together with the SRTM 40 m × 40 m DEM in the same area. As an example, we selected the image acquired on July 10, 1997 as the master image and generated interferograms using the following pairs of images: (a)1997/07/10 and 1997/06/05. The resulting interferograms are shown in figure 2. Since it is difficult to obtain realistic interferograms from phase images, we perform a quantization analysis using interferograms; see Figure 3.

The large uncertainties in phases imply that the DINSAR results are not satisfactory. We then experiment with the Persistent Scatterers (PSInSAR) technique. Persistent Scatterers can provide long-term stability of the scattering characteristics and high radar signal coherence in the multi-image analyses. Using this approach, it is possible to estimate and then reduce the effect of atmospheric disturbance, spatial and temporal decorrelation. By applying PSInSAR, it is possible to extract deformation signals from the study area in Yunlin County.

**Recent progress**

Based on DInSAR technology and filter, we select two interferograms that have smaller perpendicular baselines and differences between master and slave images. Because there are no apparent interferograms for Yunlin from DInSAR, and it shows relative movement. We can analyze this region by PS_InSAR. There are three steps of PS_InSAR: planning, interferogram, and post-processing.
1. Planning: First we form N single-look interferograms from N + 1 images with respect to one “master” image. A “master” image is one that minimizes the sum of decorrelations and maximizes the sum of correlations of all interferograms.

2. Interferogram: Using Diapason_v41, we get 33 interferograms at a 3500 pixel * 3500 pixel resolution, overlapped with a 40mX40m DEM.

3. Post-processing: For post-processing, we first select the PS stable positions, and then eliminate DEM error, atmospheric effect, and other errors in phase images to obtain real deformation. The stable PS positions (Figure 5) can be obtained via the two steps. After checking the stable PS positions, the next is to perform temporal and spatial unwraps (Figure 6).

References
Andrew John Hooper, 2006, Persistent Scatterer Radar Interferometry for crustal deformation studies and modeling of volcanic deformation.

Figure 1. A spot image of Yunlin County with THSR (blue line)

Figure 2. An interferogram of 1997/07/10-1997/06/05
Figure 3. A profile on pair 1997/07/10 - 1997/06/05 for quantization analysis.

Figure 4. Quantization analysis of 1997/07/10-1997/05/06: Horizontal axis is the distance, and vertical axis is gray value (0~255) which represents the phase variation of $2\pi$. The white line varies from 200 to 150, equivalent to 0.56 cm of variation.

Figure 5. The PS positions in Yunlin (white points).

Figure 6. The two master images with spatial unwrap obtained on 1997/07/10 and 1997/08/14. The horizontal axis is the size of image based on pixel, and the vertical axis is the distribution region of the points.