DAMAGE ASSESSMENT OF INFRASTRUCTURES IN YANGON, MYANMAR BASED ON INSAR ANALYSIS

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ABSTRACT: This study tries to improve the feasibility of applying satellite imagery to monitoring for infrastructures such as railways, roads and dams. Synthetic Aperture Radar (SAR) provides clear advantages over optical satellite imagery as its acquisition is largely illumination and weather independent. This study focuses Yangon city, Myanmar, where some elevated roads have been built rapidly. We try to analyze the SAR images with interferometric technique and detect subsidence and damages of trucks or roads. Also, demand for water becomes high with the number of population is increases. We expects that the dams which have been built recently can be observed using satellite images which are acquire on a long-term basis. We prepare the reference data in order to discuss the causes of the damages such as decrease of ground water level. The demand of ground water has become higher and higher because high-rise buildings have been built and population is concentrating in Yangon city. We can consider that it probably causes the ground subsidence.

1. INTRODUCTION

1.1 Background

Yangon is well known as the largest city in Myanmar. According to the census report conducted in 2014 which is published by department of population, ministry of immigration and population and, the number of population is 7.4 million in Yangon city. The population has been grown drastically in the last 30 years since its number was 2.5 million in 1983.

In YCDC (Yangon City Development Committee) area, the piped water is provided but amount is not enough. Thus the people have made their own tube-wells and the coordination policy about the groundwater is not satisfied (JICA, 2001). However, only few studies exist on the assessment of land subsidence due to excess extraction of groundwater especially in this area. Anuphao et al. (2014) studied detection of displacement based on InSAR time series analysis using 15 Radarsat-2 images. They detect that vertical displacement rates are between +55 and -74 mm/year.

Recently, the number of vehicles has been increasing with population growth. Traffic congestion becomes social issue in Yangon City. In order to solve this problem, some flyovers have been constructed as shown in the **Figure 1 (a)**. Here, if the land subsidence occurred, the damages at some parts such as a tilting. At the same time, Myanmar Railways and Yangon Circle Line are running (**Figure 1 (b)**), thus Yangon City is an important position for land transport. Therefore, the diagnosis based on satellite is useful, efficient and economical compared with visual inspection.

In order to avoid the accidents and provide emergency response such as repair quickly after damages are occurred, the extraction of damaged parts in wide area at an early stage is significant. Satellite remote sensing technology has an advantage of observing a wide area periodically. In addition, compared with optical sensors, Synthetic Aperture Radar (SAR) does not suffer from the limitation of sunlight, weather conditions, and fire smoke. Thereby, periodical observation using SAR images is useful in infrastructure monitoring continuously. Authors' previous study tried the extraction of bridge damages due to tsunamis using TerraSAR-X intensity images (Inoue et al, 2015). It found that the parts of large damages can be detected from calculations of difference and correlation coefficient. However, it cannot detect the small damages and vertical changes such as bumps of pavement developed by the subsidence of the river embankment, and we concluded that analysis with InSAR method is needed.

Figure 1. (a) A flyover in Yangon City. (Source: Myanmar Business Today) (b) Yangon Circular Train. (Source: Builma.com).

Conventional interferometry SAR method cannot detect slight changes since the measurement accuracy is several centimeter. Also its results are included noises due to changes of electronic density distribution and steam distribution, and decrease of interferometry caused by change of scattering characteristics. Thus, detection of small deformation is difficult. These noises can be decreased using many data since they are independent on each data. One of the method is InSAR time-series analysis which can improve the accuracy of measurement of changes by means of statistic estimation and remove.

For example, Chaussard et al. (2014) set the entire central Mexico region as target area, used InSAR images acquired between 2007 and 2011 and carried out time-series analysis of ALOS data in order to resolve land subsidence. They identified land subsidence in 21 areas including 17 cities, and linear vertical rates over 30 cm/year are observed in Mexico City, while in the other locations rates of 5 to 10 cm/year are detected. Mexico City is also suffer from massive groundwater extraction. It causes land subsidence and this situation is similar to the target place of this study.

1.2 Objective

The objective of this research is to examine InSAR images to detect damages of infrastructures due to land subsidence. We also aim to prepare for InSAR time series analysis which has a merit which can do diagnosis for not point-like but whole area.

2. METHODOLOGY

2.1 Imagery data

The SAR images which we used are ALOS / PALSAR data including the flyovers and Yangon Circular Train as shown in the **Figure 1** and covering the YCDC area, and acquired from both ascending and descending orbit direction (**Table 1**). These data were recorded as signature data with slant range and were level 1.0 product without imaging. These were acquired with FBD (Fine Beam Dual) mode.

Table 1. PALSAR data which we used. All the images have dual polarization (HH and HV).

Data (YYYYMMDD)	Operation Mode
20070806	FBD
20080808	FBD
20090926	FBD
20100814	FBD

2.2 Method

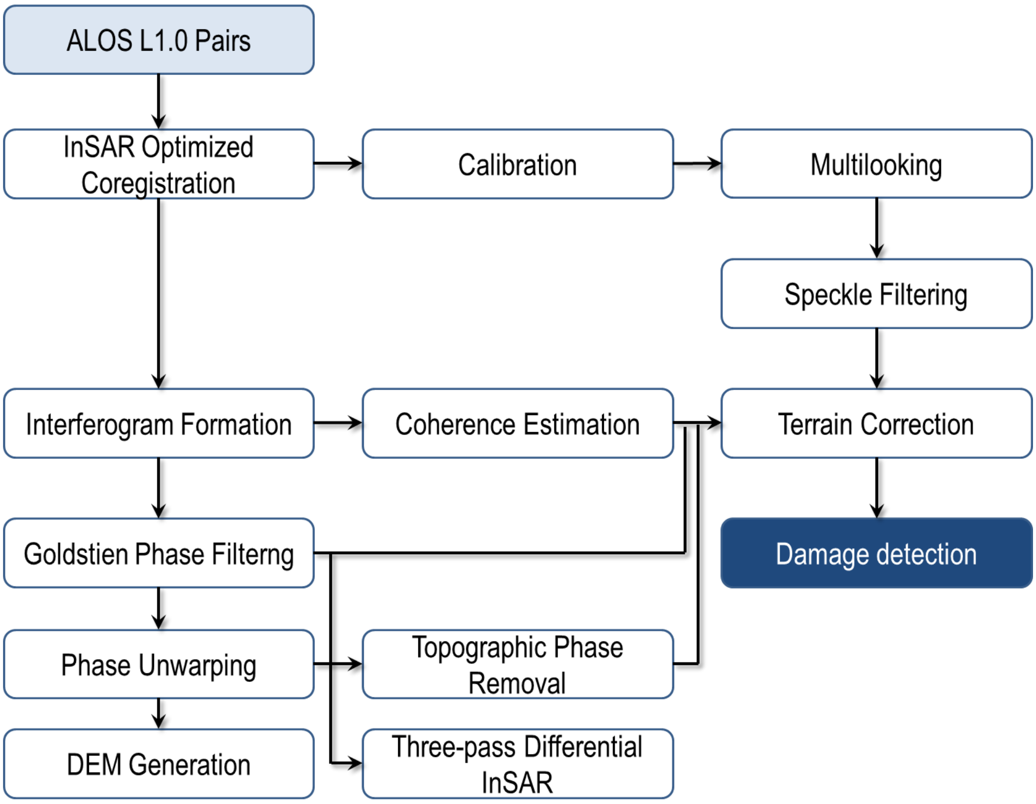


Figure 2. The flowchart of this study.

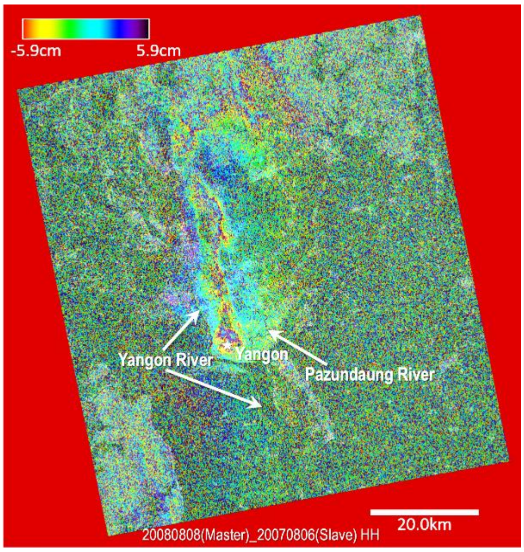
Figure 2 shows the flowchart of this study. We made a SLC image, did the coregistration between master and slave images, made the images interferogram formation, did the matching between DEM and intensity images, estimated baseline, and did the geocording. The raw SAR data were processed using the JAXA/SIGMA-SAR (Shimada, 1999).

3. RESULTS AND DISCUSSIONS

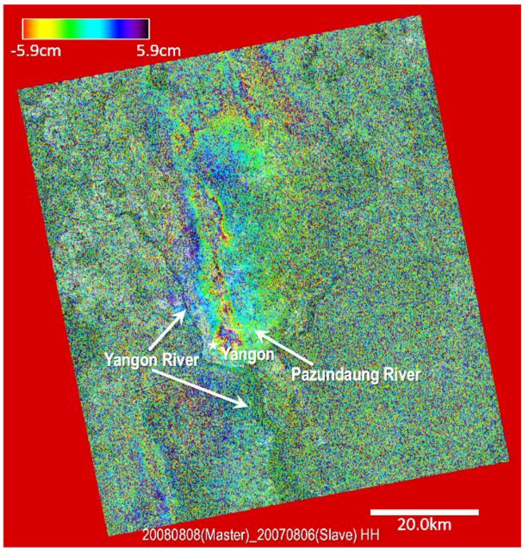
3.1 Result

In this paper, we gave all the images name “YYYYMMDD”. The result of the pair of 20080808 (Master) – 20070806 (Slave) can be obtained. Similarly, the result of 20090926 (Master) – 20070806 (Slave) and 20100814 (Master) 20070806 (Slave) can be obtained on this process. On the other hand, the pairs of 20090926 (Master) – 20080808 (Slave), 20100814 (Master) - 20090926 (Slave) and 20100814 (Master) – 20080806 (Slave) were not obtained.

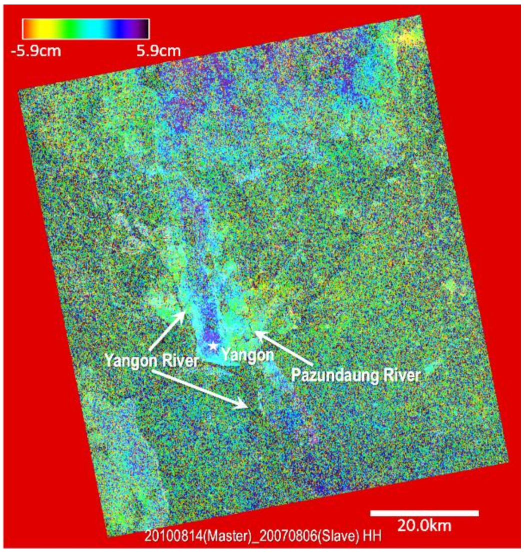
Figure 3 shows the results which were obtained in this study. Each result is shown as interferogram image and intensity image. In order to make visual interpretation easier, the interferogram value were plotted by superposing on the master’s intensity image as shown in **Figure 4**.



(a)

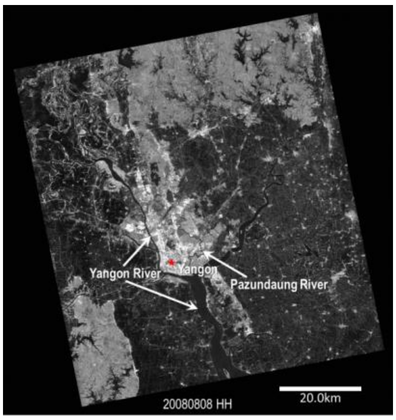


(b)



(c)

Figure 3. Interferogram image after geocording. (a) is a pair of 20080808_20070806, (b) is a pair of 20090926_20070806, and (c) is a pair of 20100814_20070806.



(a)

(b)

(c)

Figure 4. Intensity image after geocording. (a) is 20080808, (b) is 20090926 and (c) is 20100814.

3.2 Discussion

Figure 3 (a), (b) and (c) show the InSAR analysis results which master image set as around one year, two years and three years after image and slave image was set 20070806 image. We can see from these images that south west area of Yangon City surrounded by Pazundaung River and Yangon River is severally displacement occurred. This trend is match with the results analyzed in Aobpaet et al. (2014). The Yangon Circular Train runs in this place. Thus we estimate that it has been damaged probably and we need to examine in detail with InSAR time series analysis.

The image acquired in 2009 is only September though other images are August. Thus it can be estimated that **Figure 3 (b)** shows different trend from **(a)**, and **(c)**.

It can be considered that three pairs cannot be processed since the base line is too long so these are not proper for InSAR analysis and the Sigma SAR software did not processed.

As shown in Figure 5, we draw the profile between A and B and made the graph as shown in Figure 6. (a) and (b) is needed to apply filter since we think some noises exist. But (c) shows proper results and upward area can be seen near the point A.

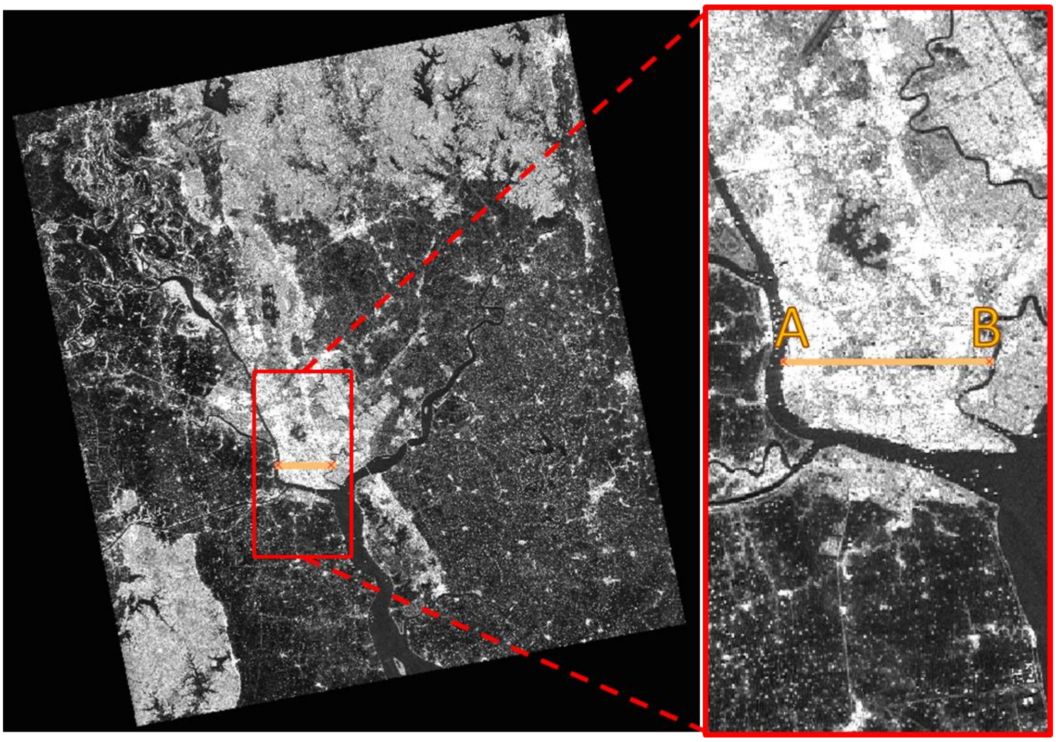
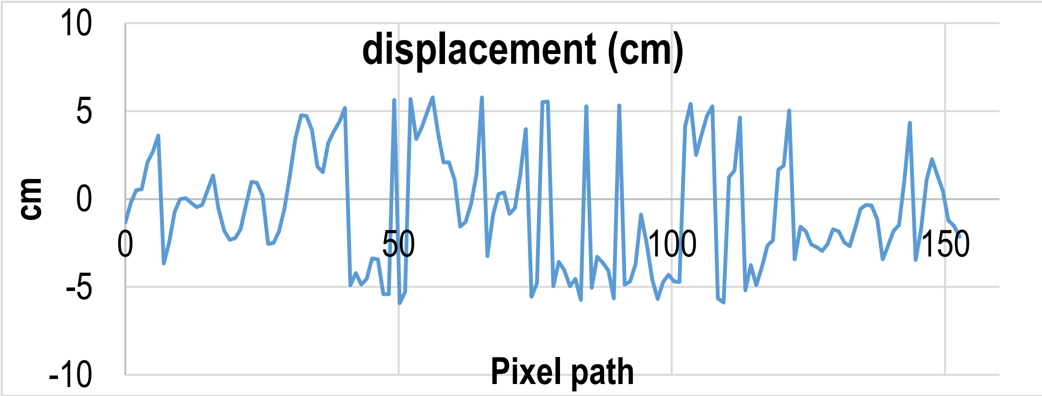
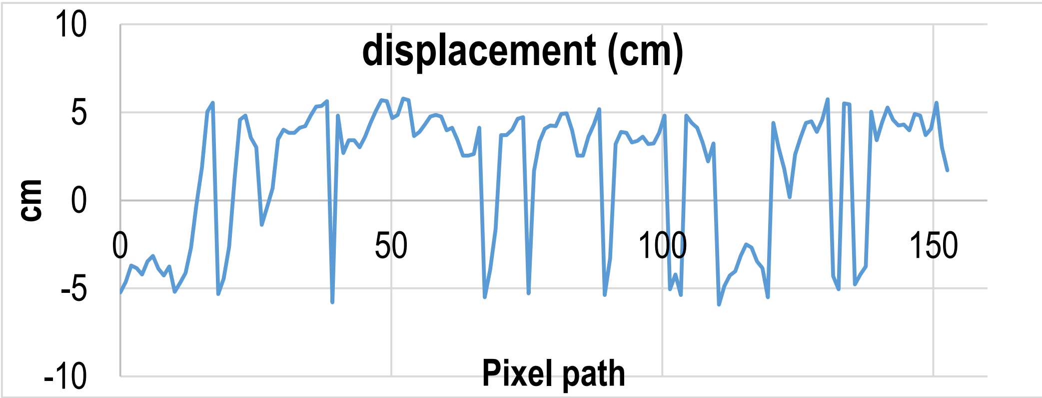


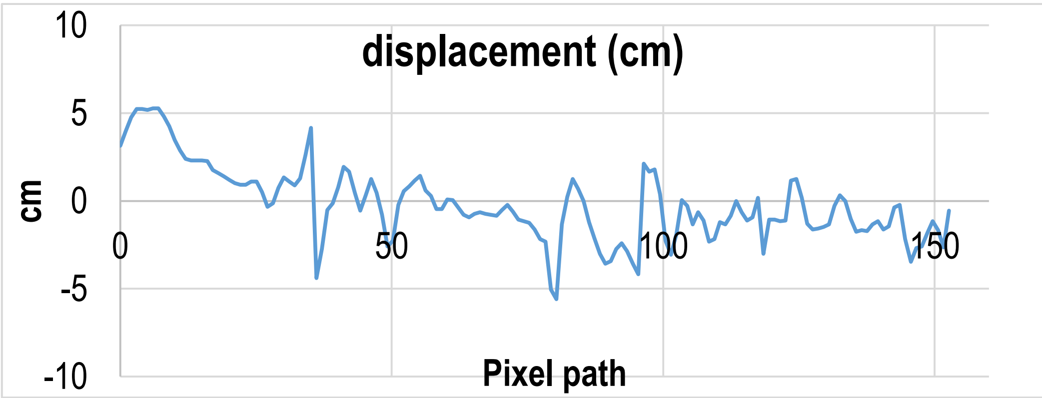
Figure 5. Profile of interferogram for comparison between three images.



(a)



(b)



(c)

Figure 6. Each profile graph.

4. CONCLUDING REMARKS

In this study, Yangon City, Myanmar was set as study area and InSAR method was carried out in order to extract for land subsidence due to excess extraction of groundwater with population growth. This process is progress for carrying out the InSAR time series method.

As future works, we will carry out the InSAR time series analysis and will build the screening system for damages and deformation of infrastructures such as elevated roads, railway trucks, bridges and dams due to deterioration or disasters. Therefore long-term SAR images which have HH and HV polarization and acquired from ascending and descending orbit direction will be prepared

Then we need to prepare the reference data and carry out validation. There is no available validation data since the scientific study which research the groundwater in this site is first phase at present.

We also need to carry out about HV image such as similar to this study and will compare the results with HH images. We expect that the interferogram results of suburb areas will be different from HH polarization images.

In addition we will analyze the images acquired from other orbit path because of consideration of looking direction. We still need to accumulate validation data until a solid conclusion is drawn.

REFERENCES

Aobpaet A., Trisirisatayawong I., Aung H., Maksin P., 2014, Yangon surface disp;acement as detected by InSAR time series analysis, Asian Conference on Remote Sensing, Proc, pp. 646-651.

Chaussard E., Wdowinski S., Cabral-Cano E., Amelung F., 2014, Land subsidence in central Mexico detected by ALOS InSAR time-series, Remote Sensing of Environment 140, pp. 94-106.

Inoue K., Liu W., Wieland M., Yamazaki F., 2015, Analysis and evaluation of bridge damages using high-resolution SAR imagery, Proc. Asian Conference on Remote Sensing, 9p.

JICA (Japan International Corporation Agency), 2001-2002, “The Study on Improvement of water supply System in Yangon City in The Union of Myanmar”, Final Report.

Shimada M., Verification processor for SAR calibration and interferometry, 1999, Adv. Space Res. Vol. 23, No. 8, pp. 1477-1486.