Characteristics of SAR intensity images for the affected areas of the 2008 Iwate-Miyagi, Japan, earthquake

Fumio Yamazaki
Graduate School of Engineering, Chiba University, Japan
Hisamitsu Inoue
Faculty of Engineering, Chiba University, Japan

ABSTRACT: As a first step to extract damages due to the 2008 Iwate-Miyagi, Japan, earthquake, ALOS/PALSAR images obtained before and after the event were compared. Using the post-event backscattering intensity and its change before and after the event, the filled areas of the dam lake due the landslide were extracted properly. The post-event TerraSAR-X images were also compared with the PALSAR and aerial images.

1 Introduction

Synthetic aperture radar (SAR) has the remarkable ability to examine the Earth's surface, regardless of weather or sunlight conditions. A SAR-based remote sensing system can assess the damages due to large-scale disasters at an early stage. Thus, SAR images obtained before and after an event are considered to be useful for emergency response and recovery planning. Recently, the spatial resolutions of SAR systems have been improved significantly; e.g. ALOS/PALSAR (L-band, 6.25 m) and TerraSAR-X (X-band, 1.0 m). In this paper SAR intensity images acquired before and after the 2008 Iwate-Miyagi earthquake are employed to investigate the radar backscattering characteristics for various acquisition and surface conditions and to extract the damages caused by the event.

2 2008 Iwate-Miyagi earthquake and satellite SAR images

A magnitude 7.2 earthquake hit an inland region near the border of Iwate and Miyagi prefectures in the northern Japan on June 14, 2008. Since the epicenter is located in a mountainous region, the most roads in the affected areas were blocked by slope failures/landslides and many villages were isolated. Hence, airborne and satellite remote sensing technologies were employed to obtain damage distribution in this event (GSI, 2008). As one of satellites, ALOS (The Advanced Land Observing Satellite: JAXA, 2008) captured the affected areas both before and after the earthquake by its PALSAR sensor with high-resolution (FBS) mode as shown in Fig. 1.

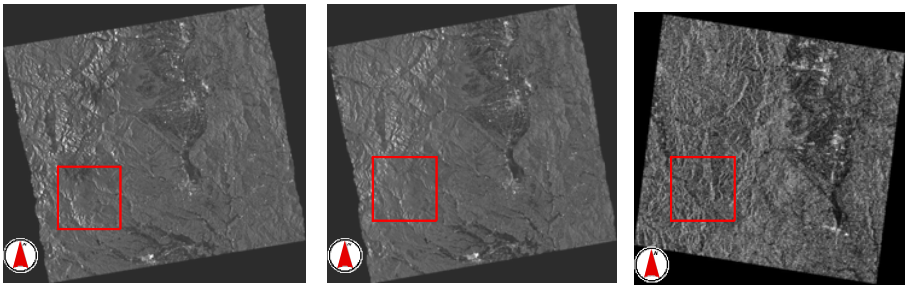
TerraSAR-X (DLR, 2009) also observed the affected areas at three time instants after the event by high-resolution SpotLight mode with incidence angle 49.3 degrees. These SAR intensity images were investigated from the viewpoint of microwave frequency (L- or X-band), satellite path (ascending or descending), radar incidence angle. Since the study area is mountainous and topographic effects are considered to be significant, we used orthorectified products for TerraSAR-X images and the effect of orthorectification was investigated for PARSAR images.

3 Change detection using PALSAR images

ALOS/PALSAR images of the affected areas were acquired both before and after the earthquake with the same radar conditions. After co-registering the two SAR images, each image was filtered using a Lee filter with a 5 x 5 pixel window. As one of the significant changes due to the earthquake, the increase and decrease of water body were extracted. Figure 2 shows the extracted pixels near Aratozawa Dam, where a large-scale landslide occurred in the upstream of the dam lake. Comparing with the post-event AVNIR-2 image, the extracted pixels are in good agreement with the filled area by the landslide and the floating objects on the dam lake. The small noises seen in Fig. 2 (d) could be filtered out by applying an open-and-close filter (Vu et al., 2007).

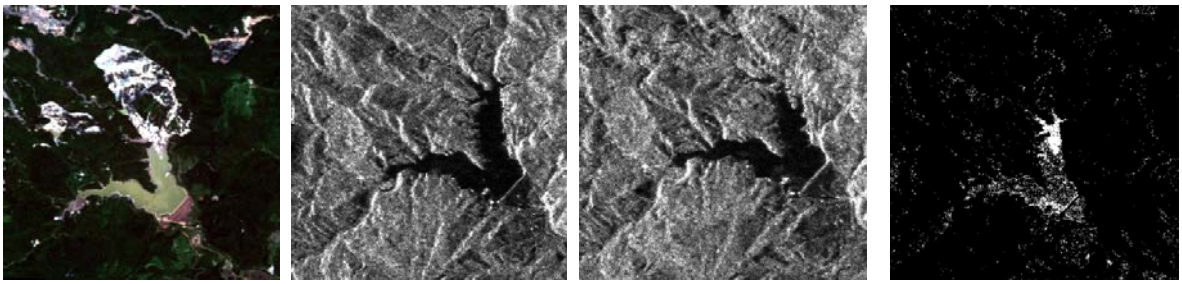
4 Effects of radar illumination direction, frequency and resolution

The same area was also observed from the descending path with the same off-nadir angle. Thus, comparing the two post-event SAR images, the effects of different radar illumination direction were examined. It is seen that radar shadows seen in the ascending path image do not exist in the descending path image. Since the ground surface of the scene is not flat, the backscattering intensity was



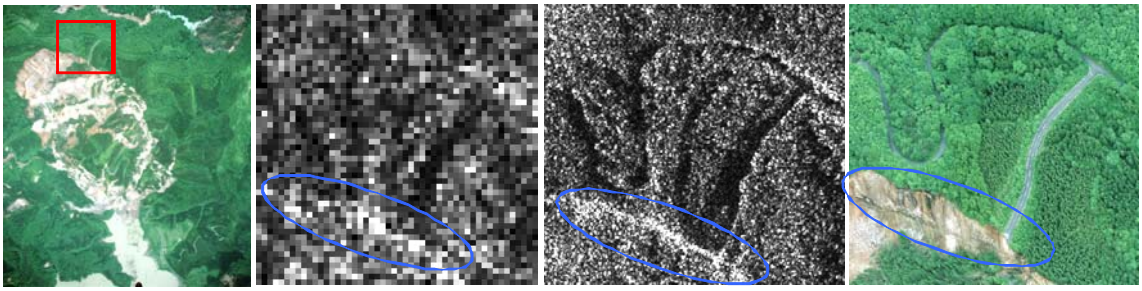
(a) 2008/03/23 21:58 (Ascending, 34.3°) (b) 2008/06/23 21:58 (Ascending, 34.3°) (c) 2008/07/16 10:06 (Descending, 34.3°)

Fig. 1 ALOS/PALSAR images of the affected area of the 2008 Iwate-Miyagi earthquake.



(a) AVNIR-2 on 2008/7/2 (b) PALSAR on 2008/3/2 (c) PALSAR on 2008/6/23 (d) Extracted filled area

Fig. 2 ALOS/AVNIR-2 and PALSAR images including Aratozawa Dam. The filled area of water body (d) was extracted comparing the pre-event (b) and post-event (c) SAR images.



Aerial Photo of Aratozawa PALSAR TerraSAR-X Aerial Photograph (GSI)

Fig. 3 Comparison of PALSAR and TerraSAR-X images with the aerial photograph (GSI, 2008)

affected by the orientation of slopes, typically seen at the dam embankment.

The SAR intensity images obtained by TerraSAR-X were also compared with those by ALOS/PALSAR. Figure 3 compares the two SAR images of the upstream of Aratozawa Dam. Since the spatial resolution of TerraSAR-X is 1.0 m, much more details can be recognized from the TerraSAR image than from the PALSAR image with 6.25 m resolution. The cliff generated by the large-scale landslide exhibits strong backscattering while small roads in the trees show small backscattering.

5 Acknowledgement

The TerraSAR-X images used in this study were provided by PASCO Co., Tokyo, Japan.

6 References

JAXA (2008), http://www.eorc.jaxa.jp/ALOS/img_up/jdis_iwatemiyagi_eq_080702.htm

DLR (2009), http://www.dlr.de/en/desktopdefault.aspx/tabid-4219/

Geographical Survey Institute (2008), http://cais.gsi.go.jp/Research/topics/topic080625/index.html

Midorikawa, S. & Miura, H. (2008), Damage and High-Resolution SAR Image in the 2008 Iwate-Miyagi-Nairiku, Japan Earthquake, *6th International Workshop on Remote Sensing for Disaster Applications*, Pavia, Italy.

Vu, T.T., Matsuoka, M. & Yamazaki, F. (2007), Dual-scale Approach for Detection of Tsunami-affected Areas using Optical Satellite Images, *International Journal of Remote Sensing*, 28(13-14), 2995-3011.