

APPLICATION OF HIGH-RESOLUTION SATELLITE IMAGERY FOR DETECTION OF DISASTER DAMAGES AND DISASTER MONITORING -THROUGH THE PRODUCED OF INTERPRETATION CHARACTERISTICS CARDS OF SATELLITE IMAGERIES FOR DISASTER DAMAGES-

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ABSTRACT:

Geographical Survey Institute (GSI) had the chance to interpret disaster damages using high-resolution satellite imageries, in case of the Northern Pakistan Earthquake on 2005, the Middle Java Earthquake in Indonesia on 2006, the Leyte Landslide in Philippine on 2006 and so on. Through these researches, the interpretation characteristics cards of satellite imagery for disaster damages were produced using Quick Bird, IKONOS, ALOS PRISM and SPOT5 imageries. In this paper, the authors explain the difference of interpretation characteristics of high-resolution satellite imageries, between 2.5-meter class resolution and 1-meter class, and between single imagery and stereo pair imageries. The targeted features for interpretation are collapses, damaged buildings, surface earthquake faults and so on.

Satellite SAR imagery is also useful for disaster monitoring in early disaster stage, especially night or rain condition. In this paper, the authors introduce the comparison between satellite SAR back scattering intensity imageries and high-resolution optical sensor satellite imageries in disaster damaged area. Through these researches, they discuss the possibility to detect the heavy damaged area just after the disaster occurred.

1. INTRODUCTION

For one-meter high-resolution satellite imagery, it is easy to not only analysis the identification using image processing, but also interpret information by specialist such as aerial photo. Especially, as it is possible to detect disaster information in short time using aerial photo interpretation method, it is expected to use high-resolution satellite imagery for detection of landform changes and disaster damages just after the disaster occurred, and the case of big disaster in developing countries.

Geographical Survey Institute (GSI) had the chance to interpret disaster damage using high-resolution satellite imageries, in case of the Northern Pakistan Earthquake on 2005, the Middle Java Earthquake in Indonesia on 2006, the Leyte Landslide in Philippine on 2006 and so on. Through these researches, the interpretation characteristics cards of satellite imagery for disaster damages were produced using Quick Bird, IKONOS, ALOS PRISM and SPOT5 imageries. In this paper, the authors explain the difference of interpretation characteristics of high-resolution satellite imageries, between 2.5-meter class resolution and 1-meter class, and between single imagery and stereo pair imageries. The targeted features for interpretation

are collapses, damaged buildings, surface earthquake faults and so on.

In this paper, the authors report the interpretation characteristics for disaster information of high-resolution satellite imagery, compared with the result of the interpretation characteristics of high-resolution satellite imageries for large-scale topographical mapping (Koarai et al.; 2005). In addition, the authors introduce the comparison between satellite SAR back scattering intensity imageries and high-resolution optical sensor satellite imageries in disaster damaged area.

2. CASE OF THE NORTHERN PAKISTAN EARTHQUAKE

2.1 Outline of earthquake

On October 8, 2005, the Northern Pakistan Earthquake occurred. Various high-resolution satellite imageries of the damaged area were taken and opened in the WEB site. The authors researched disaster damages distribution characteristics at the point of view as geomorphology, using satellite imageries include high-resolution satellite imageries opened at the WEB site (Sato et al.: 2006). As the results, the

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authors cleared that the distribution of collapses by the Northern Pakistan Earthquake is concentrated in northeastern side of the active faults (up lift side of reverse active faults).

Satellite imageries using the comparison of interpretation characteristics are as follows:

SPOT5 (2.5 meter resolution, panchromatic)

Stereo pair imageries taken just after earthquake
(20 Oct. 2005, 27 Oct. 2005)

Single imagery taken before earthquake (2 March 2004)

IKONOS (1meter resolution, pansharpen)

Single imagery taken before earthquake (22 Sep. 2002)

Single imagery taken just after earthquake (9 Oct. 2005)

<http://www.spaceimaging.com/gallery/AsiaEQViewer.htm>

Quick Bird (0.6m resolution, pansharpen)

Balakot, in HP of Hitachi Soft Engineering

Single imagery taken before earthquake (11 Aug. 2005)

Single imagery taken just after earthquake (19 Oct. 2005)

<http://hitachisoft.jp/News/News350.html>

For IKONOS and Quick Bird imageries, the authors used only the imageries opened in the WEB site. For the interpretation of disaster damages in wide area, the authors used SPOT5 stereo pair imageries.

2.2 Collapse

Using SPOT5 stereo pair imageries taken after earthquake, the distribution of collapses by earthquake was interpreted. The amount number of interpreted collapses was 2424. Collapses concentrated the northeastern side along the known active faults. Especially, large size collapses concentrate in the northern part of Muzaffarabad. Figure 1 shows SPOT5 stereo imageries covered the northern part of Muzaffarabad.

Using IKONOS single imagery, the authors are able to interpret shallow collapse, small-scale collapse at a cutting, collapse wall of collapse and crack, but it is impossible to be interpret them using SPOT5 stereo pair imageries. It is possible to get collect polygon information of collapse, to project the shape of collapses on ortho SPOT5 imagery. The damaged road covered by collapse soil is easy to be interpreted using SPOT5.

2.3 Damaged buildings

On the point of view about interpretation characteristics of large-scale topographical mapping, it is possible to portrait and interpreter large size building using IKONOS imagery, and it is possible to interpreter normal size building but is impossible to portrait it using IKONOS imagery (Koarai et al.: 2005).

As the results of interpretation characteristics of IKONOS imagery for disaster damages, it is possible to interpreter each buildings, but is difficult to interpreter damage of each buildings as IKONOS is single imagery.

In Muzaffarabad, damaged buildings and non-damaged buildings are mixed. In such a situation, it is possible to interpret the damages of large buildings using single imagery, but is difficult to map all damaged buildings. If possible to use

stereo pair IKONOS imageries, it is easier to interpreter the damaged buildings, as the interpretation characteristics of buildings is easy using stereo pair interpretation method.

However SPOT5 imageries are the stereo pair imageries, it is impossible to detect the damages of buildings for the resolution of SPOT5 is not so high. It is impossible not only to interpreter damages of buildings, and is difficult but also to recognize each building.

Quick Bird imagery is easy to interpret the damaged buildings, because of the difference of each resolution. This single imagery is possible to interpreter the disaster damage of each building. It is expected to be possibility that it is easy to interpreter the buildings in Balakot.

2.4 Landform deformation

Using IKONOS single imagery, it is impossible to detect the landform deformation such as surface earthquake fault, displacement of terrace and so on. However, it is cleared that the concentration zone of heavy destroyed buildings is continued in the north part of Muzaffarabad (Figure 2). In Figure 1, this heavy damaged area was shown in #5. For the interpretation of stereo pair SPOT5 imageries, the authors can recognize the existence of surface earthquake fault occurred along terrace cliff.

In Balakot, the concentration area of heavy destroyed buildings is located in the hill of old Balakot city. For the interpretation of Quick Bird imagery, as the existence of shallow area in the river that means uplifting of ground surface, the authors can recognize the hill of old Balakot is the deformation landscape due to earthquake.

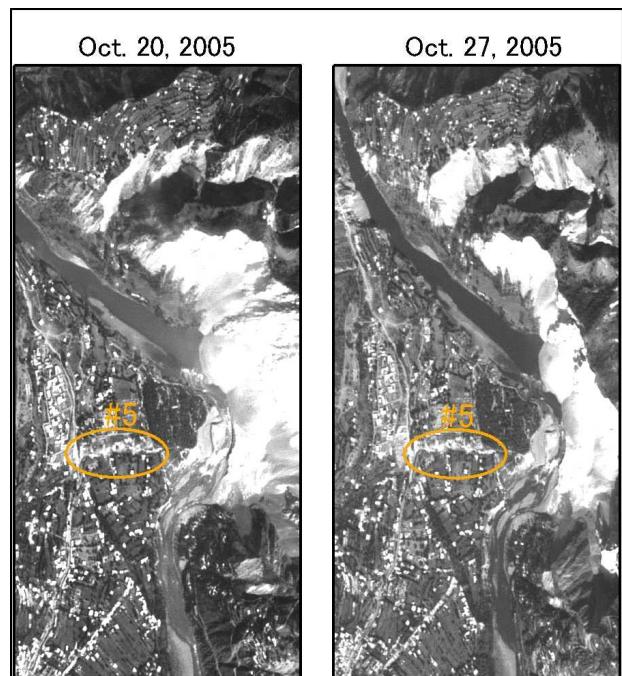


Figure 1. SPOT5 stereo pair imageries in north part of Muzaffarabad. #5 is the cliff by earthquake



Figure 2. Concentrated area of destroyed buildings (IKONOS)
(Same area as #5 in Figure1)

3. CASE OF THE MIDDLE JAVA EARTHQUAKE

JAXA had launched high-resolution satellite ALOS in January 2006. PRISM sensor of ALOS satellite has 2.5-meter resolution with three directions such as forward, nadir and backward. The Middle Java Earthquake occurred on May 27, 2006. The authors interpreted the disaster damage of buildings by this earthquake using high-resolution satellite imageries, especially IKONOS single imagery and ALOS PRISM stereo pair imageries.

Using ALOS PRISM stereo pair imageries, it is possible to interpret that large size buildings are destroyed in rural area. Using IKONOS single imagery, it is possible to interpret the damage of each small buildings and land liquefaction in rural area. In the housing concentrated area, it is possible to interpret the destroyed building concentrated area, however it is impossible to interpret the damage of each small building.

4. CASE OF LEYTE LANDSLIDE

On February 27, 2006, the Leyte landslide in Philippine occurred. Over 1600 people killed by this disaster. GSI has been trying to research about interpretation and topographic measurement using satellite imageries, in the collaboration research with National Research Institute for Fire and Disaster (FRI), and National Institute for Land and Infrastructure (NIRI). The used satellite imageries are as follows:

Quick Bird (0.6m resolution, pansharpen)

Single imagery taken after collapse
(16 April 2006, 18 April 2006)

ALOS PRISM (2.5 meter resolution, panchromatic)

Stereo pair imageries taken after collapse (10 Oct. 2006)

Using Quick Bird pansharpen imagery, it is possible to interpret the detailed landslide landform from the collar of debris deposit area. The debris disaster area is divided into three categories of collapse area, flow area and deposit area (Figure 3). However it is difficult to interpret the difference of height, it is possible to recognize the hummocks. The size of hummocks in the lower part is smaller than in the upper stream.

It is possible to interpret the damaged buildings by debris disaster.

Using ALOS PRISM stereo imageries, it is difficult to interpret the detailed landform for 2.5m resolution, however is easy to interpret the landforms such as hummocks for stereo pair imageries. In this research, GSI team try to GPS survey at GCP such as cross of road and bridges. Based on the results of GPS survey, GSI team try to measure the shape of hummocks on the geocorded ALOS PRISM imageries.

In addition, DEM generated by stereo pair satellite imageries is also useful for disaster monitoring. GSI has been trying to estimate mass movement of the Leyte landslide quantitatively using DEM generated by ALOS PRISM.

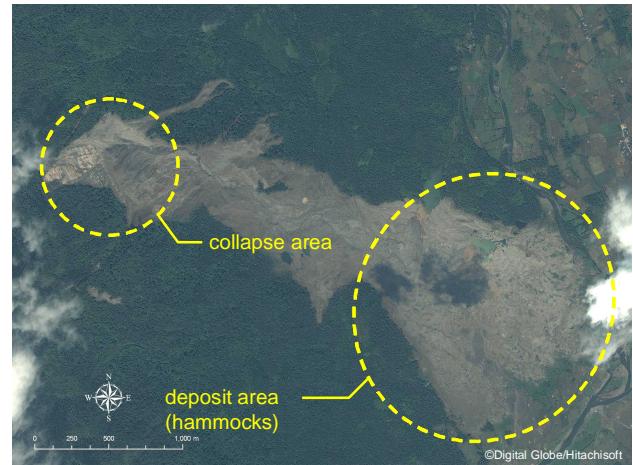


Figure 3. Leyte collapse (Quick Bird)

5. INTERPRETATION CHARACTERISTICS OF OPTICAL HIGH RESOLUTION SATELLITE IMAGERY

Using 2.5-meter resolution satellite imagery, it is possible to interpret the distribution of collapse occurred by earthquake, but impossible to interpret shallow collapse and cracks. In this case, it is necessary to use 1-meter resolution satellite imagery. As it is impossible to interpret damaged buildings using 2.5-meter resolution satellite imagery, it is necessary for interpretation of damaged buildings to use 1-meter resolution satellite imagery. If we do not prepare stereo pair imageries, it is difficult to mapping the distribution of all damaged buildings. In the area where the heavy damaged buildings concentrate, it is possible to interpret the damaged buildings using 1-meter resolution single imagery.

For the interpretation of landform deformation such as earthquake active fault, it is necessary for 1-meter resolution stereo pair satellite imageries. In the case of the Northern Pakistan Earthquake, the combine of 1-meter resolution single satellite imagery and 2.5-meter resolution stereo pair satellite imageries is useful. It means the combination of interpretation of the heavy damaged buildings concentrated zone using IKONOS or Quick Bird single imagery, and interpretation of cliff landscape using SPOT5 stereo pair satellite imageries.

6. APPLICATION OF SAR IMAGERY

Satellite SAR imagery is useful for disaster monitoring in early disaster stage, especially in the night or on the rainy day when optical sensor images are not available. The authors introduce the comparison between satellite SAR back scattering intensity imageries and high-resolution optical sensor satellite imageries in disaster damaged areas.

For the building damage detection technique, the value derived from the correlation and difference in intensities between pre- and post- event SAR imageries is used. Matsuoka et.al. (2007) proposed a new technique by using two pairs (pre-seismic and co-seismic) of SAR imageries, to identify building damage in less density built-up areas and large-scale landslides in mountainous area, in case of the 2004 Niigata-ken Chuetsu Earthquake.

In this research, the authors applied this technique to the Northern Pakistan Earthquake and compared with the interpretation results using optical satellite imageries. Figure 4 shows the detected difference areas using three Radarsat imageries before and after earthquake. Used SAR imageries are as follows:

Radarsat (Standard: 30m resolution)
(11 July 2001, 20 Jun 2005, 18 October 2005)

In Balakot, the heavy destroyed area on the old Balakot hill near active fault is detected very clearly as the detected difference area (circle A in Figure 4). Also large-scale collapses are concentrated as zone in the northeast side of active fault, these areas are detected clearly as the difference areas (area B in Figure 4). In Muzaffarabad (circle C in Figure 4), the difference area is not detected clearly, this result harmonize with the interpretation of optical satellite imageries as damaged buildings and non-damaged buildings are mixed in Muzaffarabad city area. For the reason that the concentration zone of heavy destroyed buildings in the north part of Muzaffarabad (Figure 2) is not detected clearly, it is presumed that the width of destroyed building zone is narrow compared with the pixel size (30m) of SAR imagery.

7. CONCLUSION

The interpretation characteristics of high-resolution satellite imagery and SAR imagery for disaster damage detection are summarized through the case of the Northern Pakistan Earthquake, the Middle Java Earthquake and the Leyte landslide. The results are compiled as the interpretation Characteristics cards. Sample of these cards shows Figure 5 and figure 6. Figure 6 includes SAR back scattering intensity imagery for disaster detection.

In this research, it is clear that stereo pair satellite imageries are useful for interpretation of disaster damages. Especially, the combine of 1-meter resolution single satellite imagery and 2.5-meter resolution stereo pair satellite imageries is useful for interpretation of landform deformation such as active fault. In addition, the difference of back scattering intensity of SAR imageries is useful for detection of disaster damage in early disaster stage.

Finally, it is important for the practical use of high-resolution satellite imagery to combine positioning technology and web technology. The authors hope to discuss the possibility of these technologies in remote sensing and disaster prevention field.

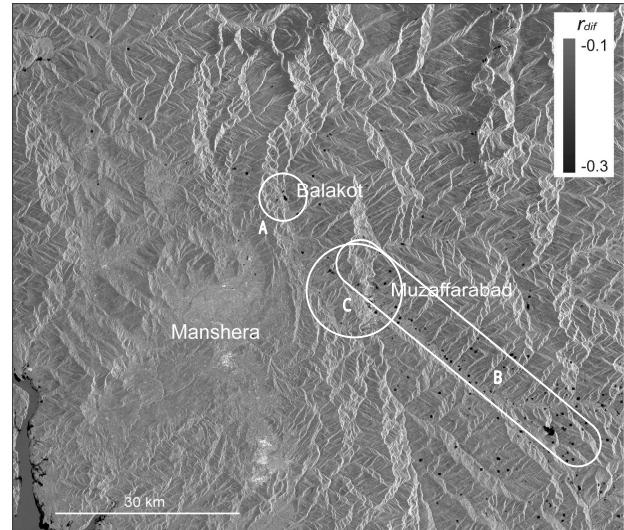


Figure 4. Difference of backscatter of SAR imageries between before and after the 2005 Northern Pakistan Earthquake

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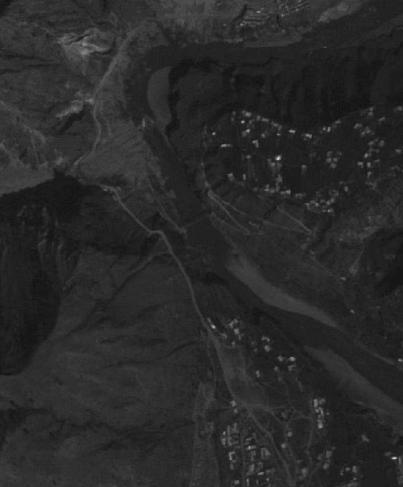
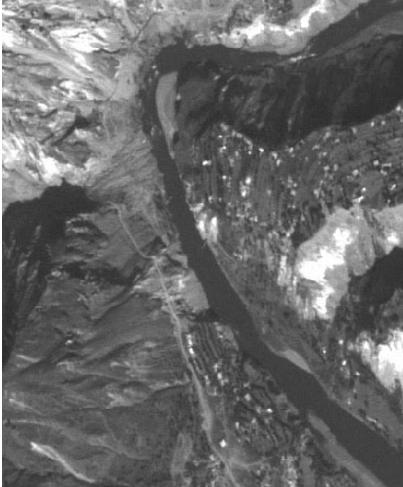
the Northern Pakistan EQ 8 Oct. 2005	Damaged bridge	
IKONOS (before EQ) 	IKONOS (before EQ) 1m resolution 	IKONOS (after EQ) 1m resolution 
22 Sept. 2002	22 Sept. 2002	9 Oct. 2005
SPOT5 (before EQ) 2.5m resolution 	SPOT5 (after EQ, left) 2.5m resolution 	SPOT5 (after EQ, right) 2.5m resolution 
Condition for interpretation	Interpretation characteristics	
IKONOS (pansharpen): P,2.5K,M,F: SPOT5 (panchromatic) P,25K,Sb,F:	<p>IKONOS single imagery: It is easy to recognize that the bridge is broken and fall in the river, to interpreter the shadow of bridge.</p> <p>SPOT5 stereo pair imageries: As the resolution is not so high, it is not easy for the interpretation of the damaged bridge. Using stereoscope interpretation method, it is possible to interpreter the bridge contacts the road only east side, to recognize the shadow of bridge exists only east side.</p>	

Figure 5. Sample of the interpretation characteristics cards of satellite imagery for disaster damage (case of damaged bridge)

Balakot

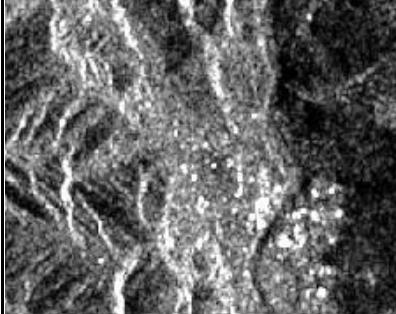
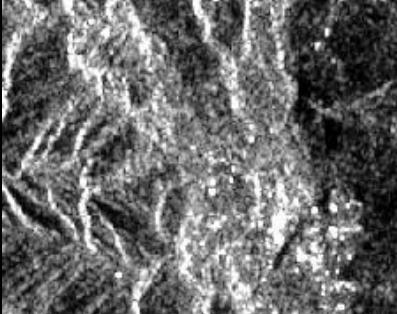
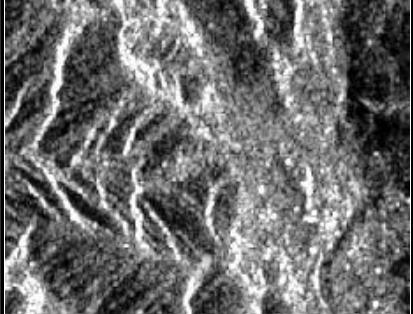
the Northern Pakistan EQ 8 Oct. 2005	building damage	
No Index Map	Quick Bird (before EQ) 0.6m resolution 	Quick Bird (after EQ) 0.6m resolution 
	11 Aug. 2005	19 Oct. 2005
SPOT5 (before EQ) 2.5m resolution 	SPOT5 (after EQ, left) 2.5m resolution 	SPOT5 (after EQ, right) 2.5m resolution 
2 Mar. 2004	20 Oct. 2005	27 Oct. 2005
Radarsat (before EQ) 30m resolution 	Radarsat (before EQ) 30m resolution 	Radarsat (after EQ) 30m resolution 
11 Jul. 2001	20 Jun. 2005	18 Oct. 2005
Condition for interpretation IKONOS (pansharpen): P,2.5K,M,F: SPOT5 (panchromatic): P,2.5K,Sb,F: RadarSat (SAR): P,25K,M,F:	Interpretation characteristics Quick Bird single imagery: It is easy to recognize that the building completely damaged area spread widely. It is possible to recognize each building was destroyed completely. Because Quick Bird imagery is single imagery, it is impossible to interpret the landform deformation such as slope of terrace by earthquake. SPOT5 stereo imageries: It is possible to recognize that many destroyed buildings are located on the deformed slope. But it is impossible to recognize the condition of each destroyed buildings. RadarSat SAR imageries: It is presumed the existence of destroyed building concentration area, because the decreasing of back scattering intensity is clear on city area of SAR imagery taken after earthquake.	

Figure 6. Sample of the interpretation characteristics cards of satellite SAR imagery for disaster damage (case of building damage)