DISATER MONITORING BY MULTI-TEMPORAL AND MULTI-SOURCE DATA FOR THE GREAT EAST JAPAN EARTHQUAKE AND TSUNAMI

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ABSTRACT: A massive earthquake of 9.0 magnitude hit off the coast of Tohoku, Japan on March 11, and following tsunami caused devastating damages over wide areas of the East Japan, particularly along with the coastline of the Pacific Ocean. PASCO has contributed to the disaster monitoring for mitigating by remote-sensing technologies. Varieties of image data include satellites, airborne, helicopters, vehicles and ships.
Satellite images were utilized to obtain the information of the wide areas. Specifically, TerraSAR-X captured a series of images from March 13 through April 4 over the affected tsunami areas. Automatic extraction of inundation areas from the satellite images was effective (Takagishi, 2011a, b, Yoshikawa, 2011, Okajima, 2011). Oblique images of our sensor plat formed on the helicopter were also collected to observe the specific areas of the severely damaged regions. Mobile Mapping Systems and Sonar were also used to comprehend the conditions of damaged sites.

1. CONCEPT FOR THE MONITORING

Concept for the disaster monitoring and mitigation is as follows: 1) Observing wide area information and creating three dimension data, 2) Speedy day and night observation, 3) Narrow area with higher accuracy, 4) Quick analysis of acquired data from various sensors, its visualization and supply. 5) Data relay and immediate processing in the areas of disaster.
Our goal is to develop integrated social system and providing information within three hours. To realize this concept, global disaster monitoring has been put into practice since 2008 (PASCO, 2011).

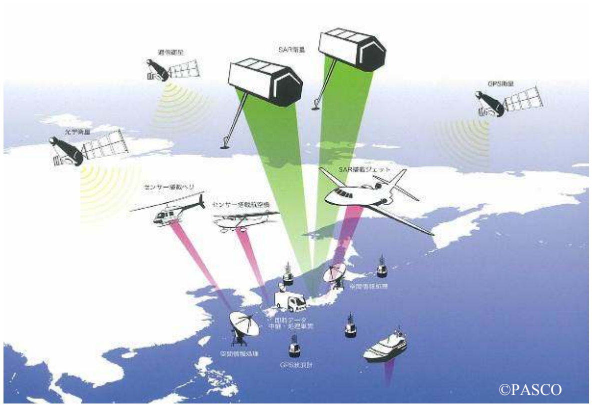

Fig.1 Concept for the Disaster Monitoring

2. ACTION FOR THE GREAT EAST JAPAN EARTHQUAKE

2.1 Planning for the Disaster Monitoring

It was essential to make an entire plan for acquisition, processing, analysis and providing of data in the same day of earthquake on March 11th (Fig.2).

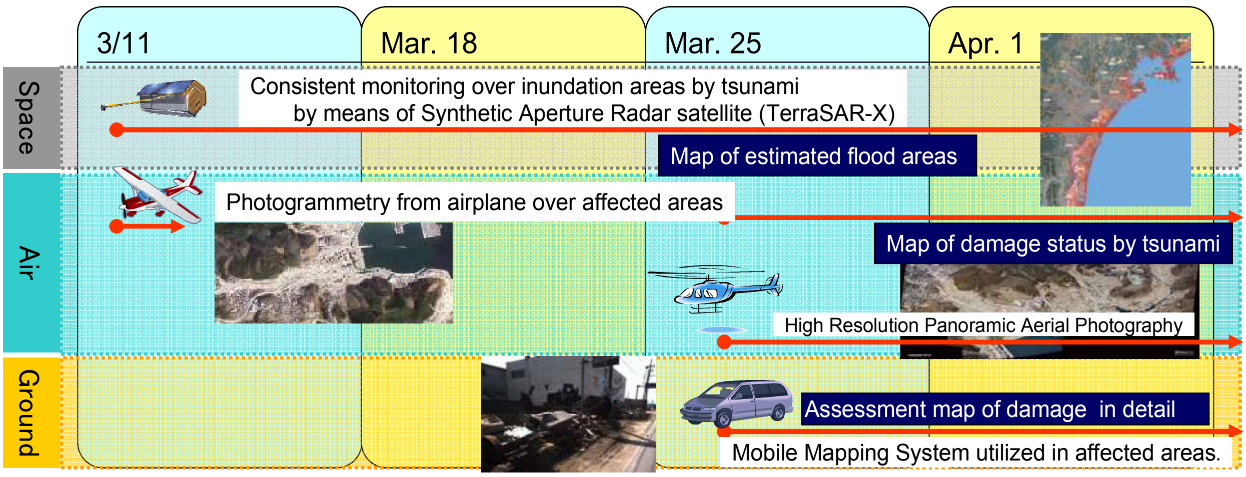

Fig2. Actions taken in a month after the Great East Japan Earthquake

The action plan was developed with the following three phases: first 72 hours with detailed schedule of SAR data acquisition, processing, analysis and delivery to concerned agencies as well as collection of other geospatial information and related statistics; after one week with data acquisition from airborne data; and after one month with repetitive observations by all possible multiple sources.
TerraSAR-X is the most suitable option as an emergency mean to grasp the disaster situation since its SAR sensor is independent of weather conditions and daylight. TerraSAR-X is also useful for monitoring activity, considering its revisit cycle is 11 days. Airborne photogrammetric digital camera images were acquired over severely affected and important areas such as harbors and cities and coast lines. High resolution panoramic aerial images from helicopter covered the areas, where damage was serious, for reconstruction plans. All of optical sensors depend on weather and it is best-effort basis.
Mobile Mapping System (MMS) was utilized in affected areas for road management. The system consists of laser scanners and digital video scanners.

2.2 Satellite Date

Satellite images for interpretation of flood areas from March 12th to 18th were total of 194 scenes by multi-temporal and multi-source covered about 560,000 km^2. TerraSAR-X images were 40 scenes. ALOS images were 44 scenes including PRISM, AVNIR-2 and PALSAR. WorldView-1, 2, SPOT-5 and RapidEye were 61, 9 and 40 respectively.

2.3 Rapid Mapping for the Flooded Area by Tsunami

The topographic change map was created after tsunami around the Sendai city utilizing superimposed TerraSAR-X images acquired on October 21, 2010 (before the disaster) and March 13, 2011 (after the disaster). This map indicates the change of the ground surface roughness utilizing the characteristic of TerraSAR-X images (Fig.3). In fig3., the yellow area of the map is estimated flooded areas using photogrammetric method. The analyzed data was showing that the tsunami reached approximately 6 km inland.

2.4 Maps of Flooded Areas for 500 km Coastline

The estimated flooded areas along the East Japan coast were visually interpreted from pre- and post-disaster satellite images with topographic maps (PFM*) overplayed. Target area was 500 kilometers long from Aomori Pref. to Ibaraki Pref. A total of 50 technical experts went into this project from March 12th to March 18th.
Images from AVNIR-2(ALOS), RapidEye, WorldView and SPOT were contributed and useful. The 2.5m pan-sharpened color image from ALOS（PSO**）acquired before the earthquake was utilized as reference. On March 23rd, the maps were updated with finer photogrammetric orthoimages.

Fig3.Rapid mapping of flood by TerraSAR-X

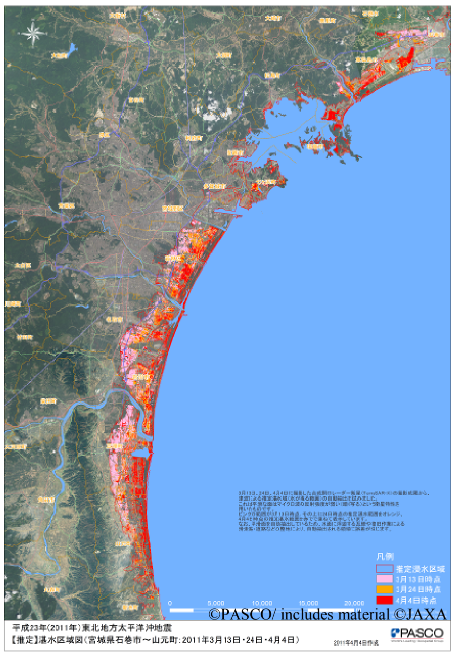

Fig.4 Inundation monitoring by TerraSAR-X

*PFM (Pasco Fresh Map) is 25,000 scale vector map including river, road, boundary etc.
**PSO (PASCO Satellite Ortho) is 25,000 scale cloud free satellite color image

2.5 Change Detection of Inundated Areas

Daily reporting of inundated areas was requested by Ministry of Land, Infrastructure, Transport and Tourism for their drainage efforts.
To this end, TerraSAR-X images acquired on March 13th, March 24th and April 4th were utilized. This automatic change detection method utilizes the characteristics of weak microwave reflection at the smooth surface (Fig.4). In Fig.4, pink, orange and red areas indicate estimated flooded areas on March 13th, 24th and April 4th respectively. The 2.5m pan-sharpened color image from ALOS（PSO）, acquired before the earthquake was utilized as the background reference.

2.6 High Resolution Panoramic Oblique Photo

Using a special device handy digital camera on the helicopter, over 20,000 oblique photos were taken within several days and combined to make the panoramic images by each districts. Its resolution is sub centimeter, so these panoramic images are useful for damage estimation of houses, buildings, roads and any other properties. These oblique image archives would be valuable as well as orthoimages for reconstruction planning by local governments, ministries and academics.

Fig.5 Panoramic oblique photo (Onagawa city, Miyagi Pref.)

3. QUICK DELIVERY

The maps have been delivered to the ministries and local governments directly hand-carry within a few hours or within a day. Publishing the information on the PASCO website as free access has been ongoing. These contents and analyses data were feature in major papers, magazines and other media.

4. CONCLUSION

Disaster Monitoring were provided within the shortest period of time, which could help to supply better disaster mitigation and restoration during the early stage of the huge disaster. Multi-source and multi-temporal data were essential to monitor the wide areas in detail. To urgent processing of data, automatic change detection method was effective. Also, photogrammetry, field survey and visual check ensure the accuracy. Quick delivery to disaster management organization was important by any means through website, FTP and hand-carry within a few hours or within a day. We believe that , those maps and analyses would be useful for planning the reconstruction of damaged areas and recovery from the disaster even more.

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