

Flood Monitoring Using ALOS/PALSAR Imagery

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SUMMARY

Flood in Red River Delta of Vietnam in November 2008 has reached historical record since 1984. Heavy rains battered Hanoi capital with falls of up to 450mm in major streets and roads. Hanoi has been seriously flooded, some areas in sub-urban were 3 meters under water and damages were very heavy. Therefore needs of monitoring and rapid statistical report of the damage as well as the distribution of flooded areas have become a matter of concern to decision making managers. Space technology has brought the capability to observe quickly and precisely the earth surface. As radar remote sensing can provide images during day or night and presence of clouds, it is really useful for flood monitoring and damage assessment. In this paper, the authors present the methodology and steps to process and analyze the radar image for this purpose. A set of ALOS/PALSAR data including three dates observed on the flood area has been used, in there one date was taken on Sept 22, 2008 (before flood) and another ones were taken on Nov 5 and 7, 2008 (after flood). Firstly, preprocessing and reduce of speckle in PALSAR image need to be done then identification and mapping of flood inundated areas. The image of Sept 22 was executed to extract permanent water body. Processing and classification of multi-temporal image (after flood) then overlay two-date to define the flooded areas and analyze the flood movement. A field work trip was also realized to verify and select ground truth samples. The results have shown the possibility to apply ALOS/PALSAR data for flood mapping and monitoring.

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1. INTRODUCTION

Flood is very serious natural disaster. Every year, Vietnam has to face to the flood, typhoon, flash flood which creating tremendous economic loss including immense casualties and destruction of infrastructures, houses, crops... From 30th october to 1st november, 2008 the heavy rain covering in Red river delta for an unprecedented period of time, a large area was dumped in water. Hanoi capital with falls of up to 450mm in major streets and roads, it has reached historical record since 1984. Many of markets, schools, offices have to close, the communications, transport routes in the city have been prevented from flood, at some place, people have to travel by small boat. The rains submerged 45,000ha of subsidiary crops and 9,000ha of aquatic breeding acreage. Total material losses were estimated at VND3,000 billion, according to initial reports from the Municipal People's Committee.

Vietnam is a member of Sentinel Asia project. That is "voluntary and best-efforts-basic initiatives" led by Asian Pacific Regional Space Agent Forum (APRSAP) to share the disaster information on the Digital Asia (Web-GIS) platform and to make the best use of earth observation satellites data for disaster management in Asia-Pacific region. After the flood happened, the Emergency Observation request has activated and PALSAR imagery was selected for flood monitoring. PALSAR is an active sensor, therefore it is not affected by weather conditions including cloud, rain and fog, operating at L-band. In addition to its all-weather observation regardless of day and night, PALSAR has incorporated many highly advanced observation technologies, and is expected to contribute greatly in environmental monitoring on earth and monitoring of natural disasters. It features enhanced capability in terms of coverage, range of incidence angles, polarization and modes of operation. These characteristics of PALSAR are very important in flood monitoring.

In this study, authors used ALOS/PALSAR data to extract the flooded areas for establish thematic map and analyze the change of flood by using multi temporal image.

2. STUDY AREA AND METHODOLOGY

2.1 Study area

The study area belongs almost to Red river delta, north of Vietnam which has very high density of population including Hanoi capital and many big cities and towns. The terrain is quite flat, the elevation is from 0.4 m to 12 m compared to sea level and 56% area is lower than 2m. The climate is divided into two seasons: dry season from November to April and raining season from May to October. Air temperature averaged approximately from 22,5-23,5°C and average rainfall in 1400-2000 mm. Nearly 90% of the precipitation occurs during the summer.

Location of study area is shown on figure 1.

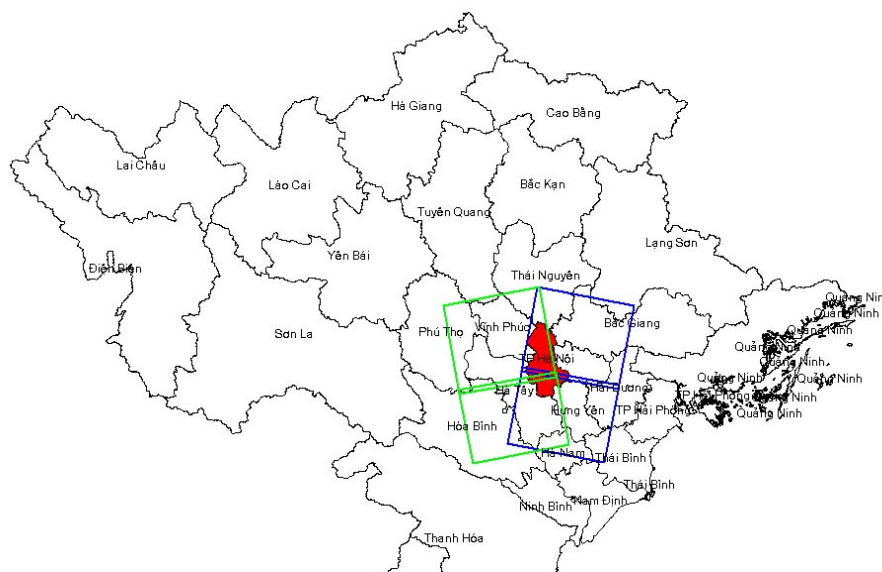


Figure 1. Location of study area in north of Vietnam

2.2 Data used

Six ALOS/PALSAR scenes were used in the study with two acquisitions before and after the flood happened, in there two scenes were taken on Sep. 22, 2008 (before flood) and the other one were taken on Nov. 5, 2008 and Nov. 7, 2008 (after flood). The PALSAR data and its characteristics are shown in Table 1.

Observation date	Sept 22, 2008	Nov 05, 2008	Nov 07, 2008
Observation mode	Fine mode, Ascending	Fine mode, Descending	Fine mode, Ascending
Resolution	12.5 m	6.25 m	12.5m
Swath Width	70 km	70 km	70 km
Polarization	HH + HV	HH	HH + HV
Off-nadir angle	34.3 deg	34.3 deg	34.3 deg
Incidence angle	8 ~ 60 deg	8 ~ 60 deg	8 ~ 60 deg
Processing level	1.5	1.5	1.5
Format	CEOS	CEOS	CEOS
Projection	UTM, zone 48 North	UTM, zone 48 North	UTM, zone 48 North

Table 1: Technical specifications of ALOS/PALSAR

A set of topographical maps 1:50,000 in UTM projection were used to geometric correction and integrate for flood assessment . PALSAR imagerys were at first mosaicked together then geo-rectified using selected GCP. GIS layers that were used to overlap image classification are hydrographical network, road network, residential areas, administrative boundaries...

2.3 Methodology

The methodology was processed by following steps:

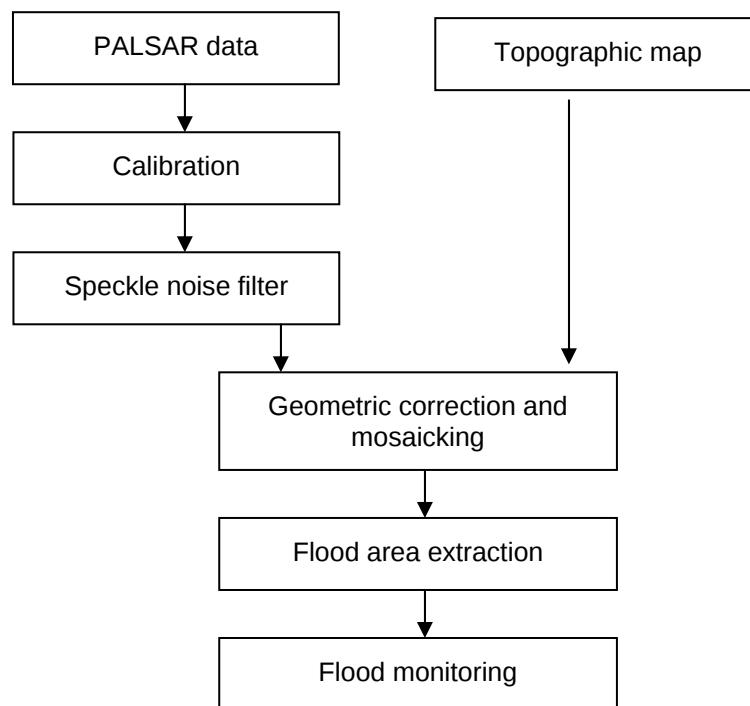


Figure 2: Methodology to estimate the flooded areas

There are ascending and descending observation mode of PALSAR and differences in backscattering therefore the image calibration need to be done. In SAR image, the speckle noise is also one of obstacles to be overcome in data processing, so it is necessary to take effective methods to filter the image. Several filter algorithms have been experiment and Lee filter was applied to reduce speckle noise.

The next step is geometric correction. After taking ground control points (GCP) from topographic map, 1:50,000, the base image, that is PALSAR (taken on Sept 22, 2008) was georectified by using first order nearest neighbour method. The other imageries were registered with base image by same technique and resampled to the same resolution. Mosaic for each dated data were created also.

Flood mapping is based on the fact that water body will normally appear dark tones on the image because it usually has minimum radar echo. By using threshold method, the flood area was classified quite easy. Both the pre-event and post-event images are used for analysis, from the Sept. 22 PALSAR the areal coverall of permanent water body was extracted, while Nov. 5 and Nov. 7 images used to extract the flooded areas. Then, the flood movement was

estimated by overlaying. Topographical map layers were also integrated to analyze and make the thematic maps.

RESULT AND DISCUSSION

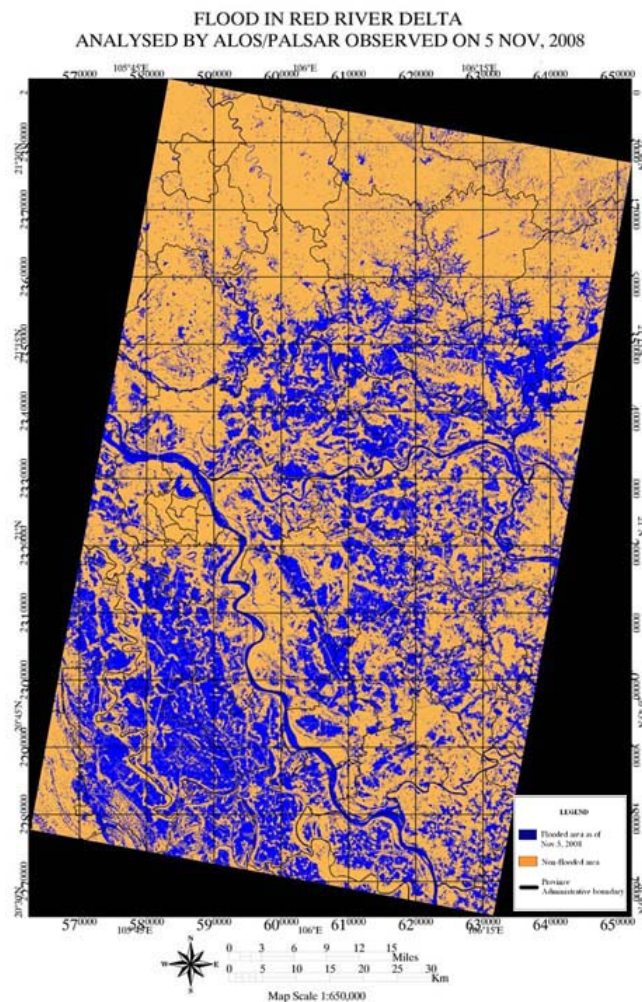


Figure 3: Flood area analysed by ALOS/PALR (Nov 05, 2009)

The PALSAR images show quite clear distinction between water body and land or other objectives due to a higher incidence angle. Therefore, it is easy to detect the flooded area by simply applying a threshold. After processing, the flood area had been obtained. Figure 3 shows the distribution of flood in study area on Nov 05, 2008. This image was mosaiced by two scenes with the area is appromixately 70km x 140 km and covered on 7 provinces in Red river delta.

In this classification, the orange color represent the non-flood areas, the blue color indicates a flooded and permanent water body zone. We can find the effect of flood is highest in low and flat land and lowest in upland. In the north of study area the terrain is mountain and hilly therefore it is not affect while in the south very large area under the water, some provinces were seriously affected such as Hanoi, Ha Tay, Ha Nam, Hung Yen, Bac Ninh... with almost are rice land, cultivation and crop land. The flood also had affected of many urban and residential areas, however because of the observation principle in SAR

image and the complex structure of residential areas consist of houses, buidings and infrastructure therefore it has a limitation in detection flood in these places. Anyhow, by the simple method, the rapid flood map can be establish very quickly. The flood-affected area also can calculate for each province to make the rapid report of flood damage.

Flood monitoring is the change detection before and after inundation. This change can be detected by overlaying of classified imagery to find out the exposed land difference of two dates. By this way, we can analyze submerged range of study area according to series of

extraction results obtained at different time. The topographical map also was overlaid to the analysis result.

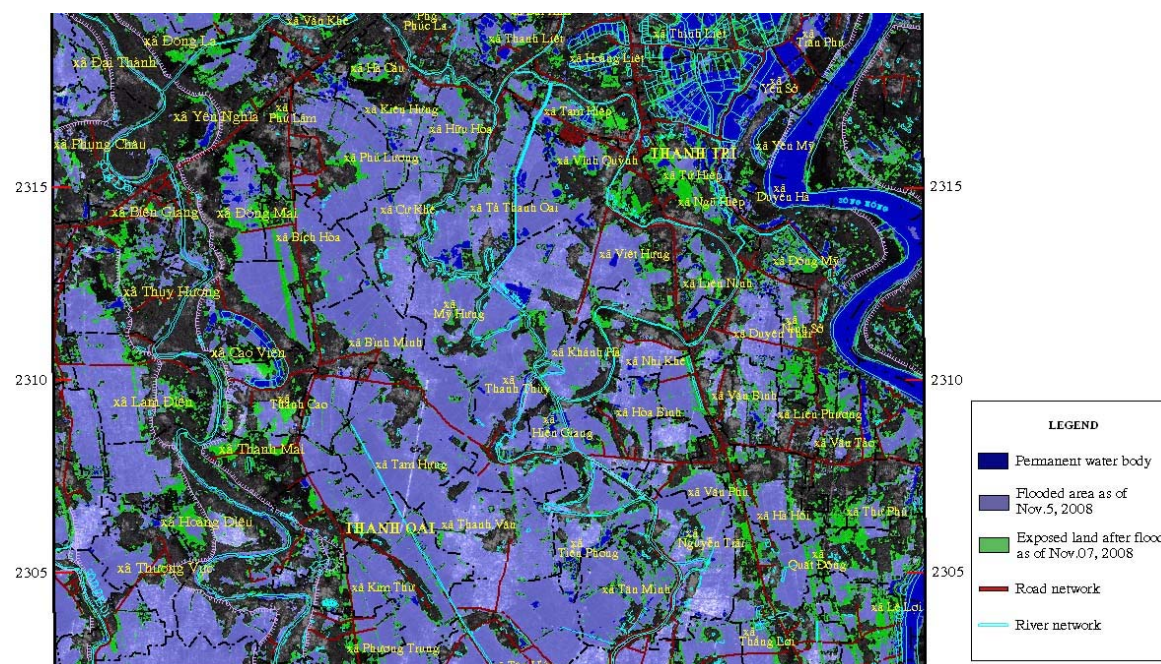


Figure 4: Analysis result overlaid on topographical map

Figure 4 displays analysis of flood movement using multi-temporal images in the south of Hanoi capital. The blue color represents the permanent water body, dark blue shows the flood area of Nov 05, 2008, the light green presents the exposed land from Nov. 5 to 7, 2008.

To verify the result, a field work trip has been implemented after the flood. The survey route following the flood analysis result and indicates in composite PALSAR image. The method to inspect the groundtruth is interview the local inhabitant and vestiges of flood for each point has been selected. Some highway in Hanoi such as Pham Hung Rd., Huynh Thuc Khang Rd., Giai Phong Rd.,... were submerge seriously, special points 1,5 m under water and it has prevented all the traffic on the roads. Some other points have validated near the Red river and low land zone in south of Hanoi such as Tam Hung, Binh Minh communes, Thanh Oai district where flood happened in very large area, some places were deep 3 meters under water. The flood has done this area very serious damage.

In this study, ALOS PALSAR data provided before and during flood is useful for understanding overall situation. Multi-temporal images were used to extract flooded areas and to compare, analyze the movement of the flood. The results can provide quickly useful information for prevention and reduction of flooding damage, specially support for decision making. It is strongly recommended to continue observation in longer time in case of flooding. Such an information is needed to understand flood mechanism and to better develop water discharge and flood prevention system.

3. ACKNOWLEDGEMENT

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