

Integrating of Microwave Remote Sensing and WebGIS in Flooding Detection and Web-mapping

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Key words: Envisat ASAR, image processing, flooding detection, MapServer

SUMMARY

Flood usually happens in Vietnam. To detect flooding areas after storms, there were some methods, among them remote sensing is one of the solution for reducing budget and field works. There are various of remote sensing data with different resolutions which is including aerial photos, satellite images... Recently the invention of Radar satellite is the great step in remote sensing technology, it overcame the disadvantages of optical images that is bad weather influence. The research used Envisat ASAR multi temporal to detect the flooding area rapidly. Beside that, in order to publish the results on internet, the research utilized free open sources WEBGIS software Mapserver to web-mapping.

A flowchart of image processing and data publishing was proposed. It is the gathering of Radar image processing by BEST software, image processing by ERDAS IMAGINE and MapServer – Maplab for data publishing. The experimental areas were Daklak-Daknong provinces where had food in August 2007. The result proved that using Envisat ASAR for inundation detection is suitable to Vietnam condition. In addition utilization of open sources GIS and remote sensing software helps the researcher in fund saving.

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1. INTRODUCTION

Vietnam is a country located in the tropical monsoon, so natural disasters and floods occur frequently with difficult anticipating. There are many causes of floods such as: due to the heavy rain in the upstream, deforestation... Floods have caused damage several billion US dollar to the economy every year.

The research and flooding survey were examined by some institutes, but it has not achieved expectative results. Remote Sensing is a solution has been selected for the monitoring of flooding regions and its impact assessment that helps the rescue centers have quick decision to protect people and reduce damage from the disaster. However, because of weather influence, clouds, precipitation, the use of optical images to identify flooding areas is usually very limited.

The Synthetic Aperture Radar (SAR) sensor that mounted on Radar satellites can acquire images in all weather conditions and penetrate clouds and rain. As the large tract of the Radar images, it is a very effective tool for monitoring regional flooding.

Before, the use of Radar such as Radarsat or ERS1 / 2 has been tested in several places, example: Hue city... With the high price of a scene, Radarsat becomes too difficult for applications in Vietnamese condition, thus the experiment is gradually being forgotten and not be able to applications. In 2002, the more advanced satellite ENVISAT was launched. The SAR on board on ENVISAT (ASAR) can continue the success of the remote sensing mission of the ERS satellites and preserve or even increase the value of the archived ERS data. Envisat is very flexible in collecting the images and a factor more important that is lower price than the other Radar systems.

2. OVERVIEW OF ENVISAT ASAR AND IMPLEMENTATION STEPS

2.1 Envisat ASAR

ASAR (Advanced Synthetic Aperture Radar) is a sensor on Envisat satellite. ASAR is the improvement of the ERS1 / 2 Synthetic Aperture Radar system. ASAR uses active phased array antenna with incidence angles between 15 and 45 degrees. ASAR image is divided into 5 modes:

- Image mode (IM): Polarization images: VV or HH with the tract width from 56km to 100km. Pixel size is approximately 30 m
- Alternating Polarization mode (AP): It is a type that two images are acquired at the same time and they can be classified into the following categories: HH / VV, HH / HV or VV/ VH. Pixel size of this type is approximately 30m

- Wide swath mode (WSM): Image swath is large which is from 200km to 400km. Pixel size is average from 75m to 150m.
- Global mode (GM): This type has low resolution, pixel size is 1000m. The swath width is very large for monitoring on the wide areas.
- Wave mode (WM): Image with small size from 5km to 10km. Images can be acquired anywhere in the IM. The image is also HH or VV. This kind of image is usually converted into spectra for ocean monitoring.

2.2 Data Collections

Preparing the data before and after the flooding is the first step to determine the flooding areas. It includes images which are very closing time with the flood, and a map of study areas. The purpose of map or images collection is to determine the location of the rivers, streams, or reservoirs where floods occur easily. Base on these maps we can order images in the appropriate areas. In addition, based on the static water level in a river, the extent of change can be known and then the damage by flooding is assessed [2].

2.3 Quick determination of flooding area

Floods usually occur very quickly, the happening is difficult prediction therefore the first thing is needed to do that image searching as quick as possible. Currently, in Remote Sensing Center - Ministry of Natural Resources and Environment has ground receiving stations which is able to acquire Envisat ASAR, image order in there is completely alright. In addition, the images can be ordered from European Space Agency (ESA). If the order succeeds, images are downloadable within 8 hours after the image acquisition.

In order to identify the flooding areas, the back scattering characteristics of water will be extracted which is dark color tone on SAR images. In special circumstances such as wind or water with much chlorophyll, the back scatterings are very strong making the brighter tone image. The information extraction and image processing was done by BEST v4.1 software, ERDAS Imagine. To publish the result on internet, another software was used that is MapServer.

BEST is ESA software which is created to process Envisat ASAR. It can be downloaded free at the ESA website. ERDAS IMAGINE 9.1 software is image processing software of LEICA, it is a powerful commercial software to process all kinds of images. MapServer is an Open Source platform for publishing spatial data and interactive mapping applications to the web. Originally developed in the mid-1990's at the University of Minnesota. Below is a flow chart of images process using ERDAS Imagine, BEST and MapServer (figure 1).

2.3.1 Header file analyzing

Envisat ASAR image which has been received can not be viewed. Images are usually processed in two different levels. The lowest level is 0 that is raw processing, to read this kind

of image; it must have specific software by ESA. The second processing type is level 1b which is processed to form different products such as IM, AP, WSM, WM and GM.

For all products at 1b level, the header file will be created when they are read in BEST. Because the header file is in ASCII format so you can read it, view it with any software that can read the txt file. The first step of processing is extremely important, it helps us know the image information such as image mode, the processing level, coordinates of 4 image corners, pixel size, and a parameter must be recorded that is calibration constant (K). This constant is used for back scattering image generation (step 4th).

2.3.2 Import image and extract area of interest (AOI)

This processing step creates the image with the same spatial resolution as the original image as well as has the format of BEST. The images can be processed on the overall scene or can be cut to small area (AOI). To AOI creating, four coordinate corners must be provided. The coordinates can be the image coordinates, that is the number of rows and columns, or we can cut image by geographic coordinates i.e. latitude and longitude.

2.3.3 Amplitude to Power Conversion

With Radar image, the pixel sizes in the range and azimuth are different that mean Radar image has rectangle pixels. For the convenient processing, the pixels will be squared as well as convert pixel values into floating point that is equivalent to the value of intensity image.

2.3.4 Backscattering Image Generation

The backscattering image generation is used to convert a power image into an image of backscattering intensity. Each pixel is calculated by the equation below:

$$\sigma_0 = \frac{(DN)^2}{K} \sin i \quad (1)$$

where:

σ_0 : The backscattering coefficient

DN : Digital number

i : Incident angle at the swath center

K : Calibration constant

The output image may have either a linear or decibel (dB) scale. Equation 2

$$\sigma_0 (dB) = 10 \times \log_{10}(\sigma_0 \text{ _linear}) \quad (2)$$

2.3.5 Image co-registration

As already knew, the temporal satellite images is the set of image scenes that are acquired in the same area at different times. These images are not always 100% overlay. So to work with this set of scenes, the images must be fit to each other. That mean the objects on the scenes should be matched to each other, thus after co-registration the images might be displaced to the left, right or up, down.

The co-registration function will co-register one or more slave images to a master image. The function is fully automatic, in the sense that it does not require the user to manually select 'tie points' from the master and slave images.

The co-registration is performed in 3 steps.

- An initial registration step is performed using the satellite orbit parameters.
- By default, a coarse registration is carried out using a cross-correlation operation on a series of 'cells' defined across the images. This step may be disabled by changing the flag parameter 'Image Coarse Reg'.
- By default (for complex data), a further fine registration is carried out by the maximization of the complex coherence between the images for a series of 'cells' defined across the images, thereby allowing a further improvement on the cross-correlation function. This step can be executed only if the coarse registration (step 2) has been performed.

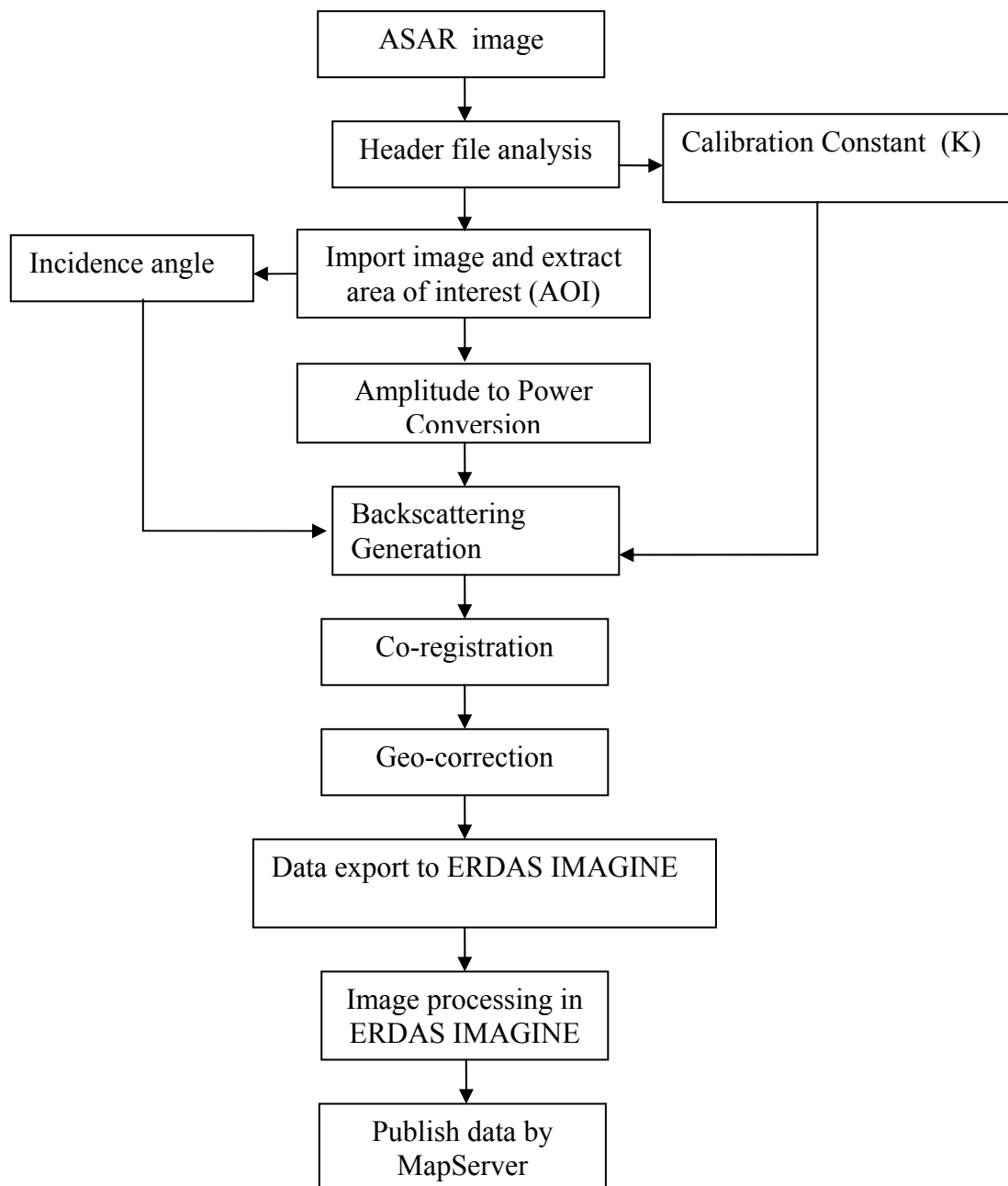


Figure 1: The flow chart of images process using BEST, ERDAS Imagine and MapServer

2.3.6 Image geo-correction

The geo-correction tool performs a geocoding process to georeference input ASAR images. It uses the Geolocation Annotation in the product header to reproject the data to a flat earth ellipsoid (no kind of terrain relief is considered for such operation). The output image is hence distorted so that its vertical and horizontal axes are aligned to the North and East axes of the selected cartographic projection (UTM).

The Geocorrection is based on the following steps:

- Creation of a regular grid in the selected cartographic reference system, having a spacing between the nodes equal to the input pixel and line spacing.
- Transformation of the grid nodes from cartographic into input image coordinates (row,col).
- Interpolation of the input image to generate the output image, using the previously generated grid.

2.3.7 Data export to ERDAS IMAGINE

Because BEST is tool for professional image processing of Radar SAR, it still lacks many functions in more image processing. To do that work, the images need to be transfer to a specific software. There are some options for the export format: GEOTIFF, tiff, BIL, RGB. ERDAS IMAGINE software can read most of such formats of BEST, so it is convenient for the next image processing.

2.3.8 Image processing in ERDAS IMAGINE

Images, after importing to ERDAS can be filtered to remove the noise. For Radar images, the Adaptive filter function with the kernels from 7x7 or 11x11 is suitable. The images are able to display in panchromatic or multi-spectral form. In the multi-spectral form, the composition of 1-2-1 channels is good. (1: before floods, 2: after floods), so the floods are prominently displayed. If the image is in panchromatic form, the images can be changed to dB and classed by threshold to extract the water layers. After extracting the water class, the images can be converted into vector form for area calculation and uploading easily.

2.3.9 Input to MapServer

- MapServer is a popular Open Source project whose purpose is to display dynamic spatial maps over the Internet. Some of its major features include:
- Support for display and querying of hundreds of raster, vector, and database formats
- Support for popular scripting languages and development environments (PHP, Python, Perl, Ruby, Java, .NET)
- High quality rendering
- Fully customizable application output

In its most basic form, MapServer is a CGI (Common Gateway Interface) program that sits inactive on your Web server. When a request is sent to MapServer, it uses information passed in the request URL and the Mapfile to create an image of the requested map. The request may also return images for legends, scale bars, reference maps, and values passed as CGI variables. The figure 2 below shows the flow chart of MapServer operation. MapServer is like a heart and many applications around are the parts of the body. Maplab is an application which was chosen for this research. Maplab help us making and fixing the scripts more easily

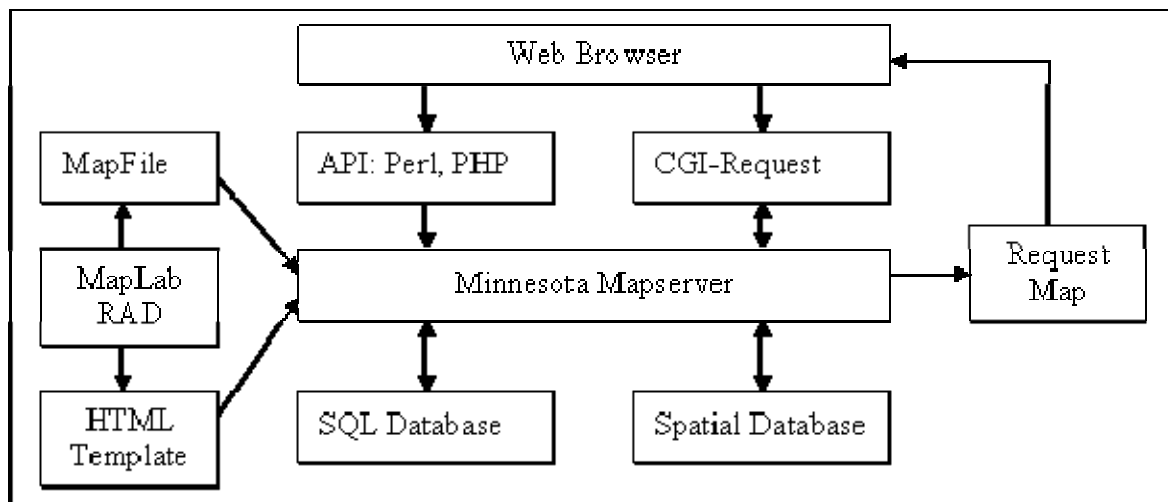


Figure 2: MapServer operating system

3. EXPERIMENT OF FLOODING DETERMINATION AT DAKLAK-DAKNONG PROVINCES IN 2007

3.1 Overview of study areas and information of storm in 2007

Daklak and Daknong is located in the Central Highlands, north of the border with Gia Lai, the southern borders with Lam Dong, the east borders with Phu Yen and Khanh Hoa, the western border with the Kingdom of Cambodia.

With the provinces in Central and West Highland, every year there are some storms and flooding is unavoidable after storms. In 2007 a big storm names 2nd was happened on 3rd and 4th August caused damage to all provinces from Quang Binh, Hue and Daklak, Daknong, Gialai ... According to Vietnamnet- Electronic, flood has swept away and flooded in the Krong Nang and Krong Ana district. The flood water rose up fast, 368 of houses was inundated in Lak, Ea Sup, Chu M'ga, Krong Ana and Ea H'leo. There were 331 households had to move. There was 10,528 ha of crop suffered flooding.

3.2 Data

- - Daklak and Daknong geographical map 1:50.000
- - Envisat ASAR WSM images were supported by ESA (table 1). Position of the image is performed on the Vietnam map and Envisat ASAR images on 5/8/2007 (Figure 3)

Table 1: List of images and the acquisition times

No	Date of acquisition	Type	Resolution	The situation of study areas
1	11/2/2007	WSM	75m	normal
2	27/5/2007	WSM	75m	normal
3	01/07/2007	WSM	75m	normal
4	05/08/2007	WSM	75m	After raining
5	09/09/2007	WSM	75m	water withdrawal

3.3 Image processing

According to the image processing flow chart described above, five images were processed. The rainy day were on 3rd and 4th August, as shown in the table 1 the nearest images with the rainy time were number 3 and 4 (table 1). Two times of images could be used to extract the flooding information by using the composite method with two images 01/07/2007 and 05/08/2007.

To highlight the water areas we assigned the red for image 01/07/2007, green for image 05/08/2007 and blue for image 01/07/2007. After done so, the magenta color areas were the difference between the two periods of time (Figure 4). Similarly with such color composite, two images number 3 and 5 (01/07/2007 and 09/09/2007) could be utilized to determine the change of the water (Figure 5).

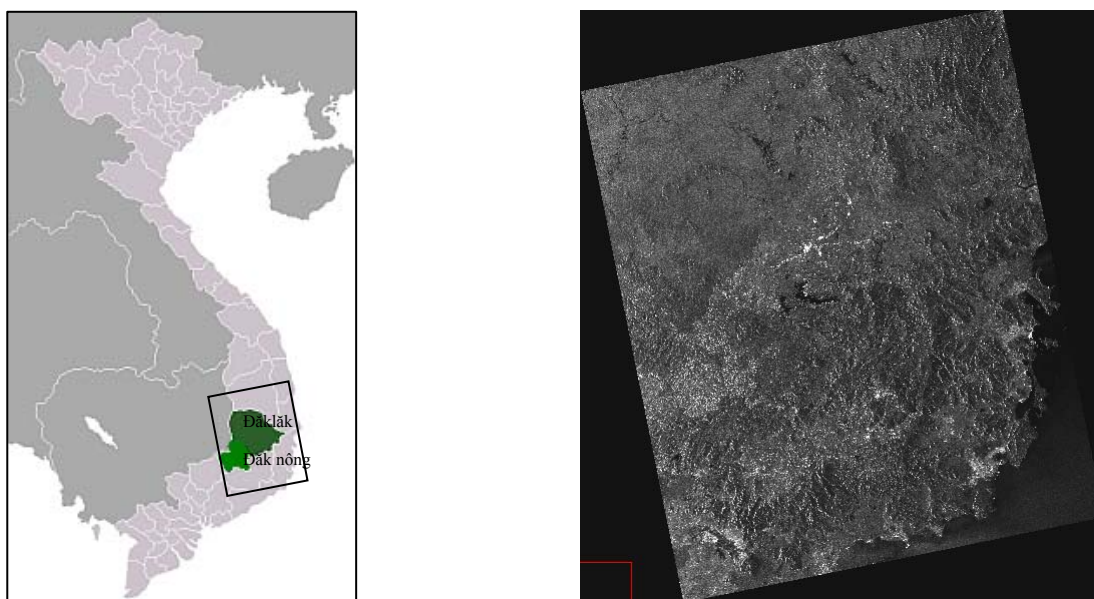


Figure 3: Position of Đăklăk-Đăknông and Envisat ASAR frame on August 5th 2007

Look at the figure 5; it is clearly that the water was withdrawn compared with the figure 4. In Easup area, the bright tone was dry land.

To observe more clearly the distribution of water which base on backscattering power from satellite acquisition, the images were transferred to dB in two periods of time (before and after the rain). Then spectral sections were created at the points of the inundated suspect. The sections showed that the spectral reflections have varied differently at the times after and before storm (Figure 6). It presented that at some places which had water after storm; the spectral reflectance was low whereas it was high before storm. Beside that the places of permanent water like ponds or river, two spectral lines were not change at all.

For calculating statistic purposes flooding regions, the maximum likelihood classification method was used to extract the flooding areas. Then the only flooding class was converted to vector form for calculating area and for the next step to query easily the flood areas on internet.

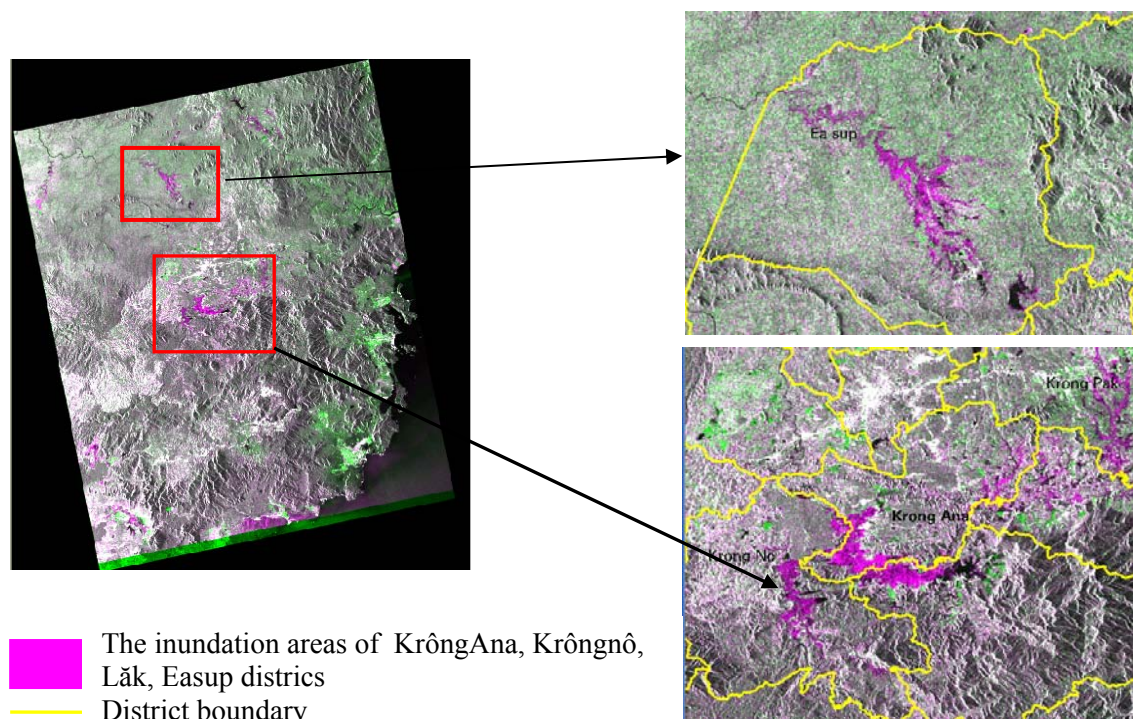
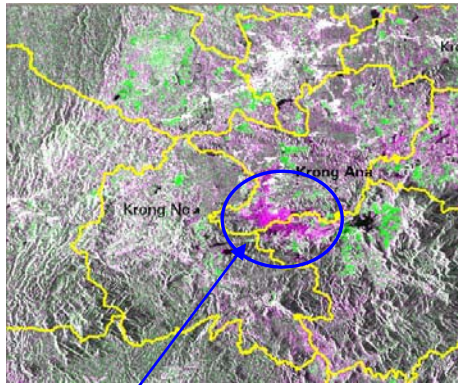
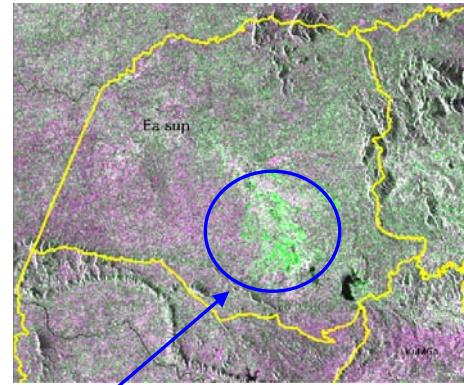


Figure 4: Image composite of two scenes were acquired on 01/07/2007 and 05/08/2007 overlaid with district boundary.

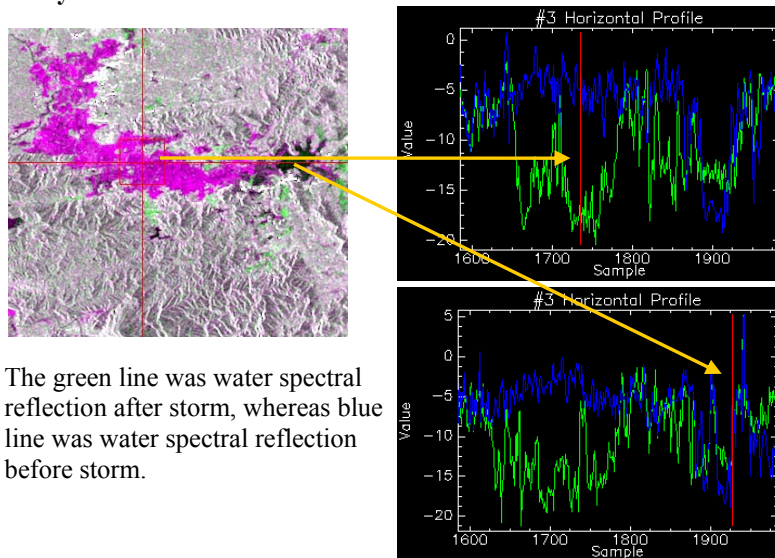


Water was existed in Krông Ana



Water was withdrawn in Easup and Krông Nô

Figure 5: Image composite of two scenes were acquired on 01/07/2007 and 09/09/2007 overlaid with district boundary.



The green line was water spectral reflection after storm, whereas blue line was water spectral reflection before storm.

Figure 6: The spectral sections at two sites, these are flooding area and permanent water areas.

3.4 Publishing data by MapServer

As explained above, the Mapfile is the heart of MapServer. It defines the relationships between objects, points MapServer to where data are located and defines how things are to be drawn. The Mapfile has a hierarchical structure, with the MAP object being the “root”. All other objects fall under this one.

In our case of Daklak-Daknong, flooding areas were extracted and saved in shape format, the digital topographical maps of Daklak-Daknong in 1:50000 shape format also and Envisat ASAR images which processed before were gathered. The Mapfile named daklak.map was created. In Mapfile, there are many objects such as: Map, Projection, Layer, Class... Each object need to be defined and pointed according to the type and the location of the data

respectively. Figure 7 is the example of extraction of daklak Mapfile, the part shows Envisat image and river scripts

```
LAYER
  NAME 'Envisat_ASAR'
  TYPE RASTER
  DATA "3bandnew_nan.tif"
  METADATA
    'wms_title' 'Envisat_ASAR'
  END
  STATUS ON
  TRANSPARENCY 100
  PROJECTION
    'proj=utm'
    'ellps=WGS84'
    'datum=WGS84'
    'no_defs'
  ''
END
LAYER
  NAME 'River_polyline'
  TYPE LINE
  DATA "Song1net_polyline.shp"
  METADATA
    'wms_title' 'River_polyline'
  END
  STATUS DEFAULT
  TRANSPARENCY 100
  PROJECTION
    'proj=utm'
```

Figure 7: the example of extraction of daklak Mapfile

The Mapfile after correcting was open by MapBrowser on MapServer base. Figure 8(a) shows the interface of Daklak Map. This place was zoom in to the Krong Ana district, the flooding areas (magenta color) on the image could be recognized very clearly. You can also see the river (green lines) overlaid with image. On the left corner of the web, four layers were displayed excepted flooding areas layer (shape file) which was converted into vector type before. To query the inundation areas, the flooding areas layer was active. Figure 8(b) illustrates the querying of flooding areas at Krong Ana district.

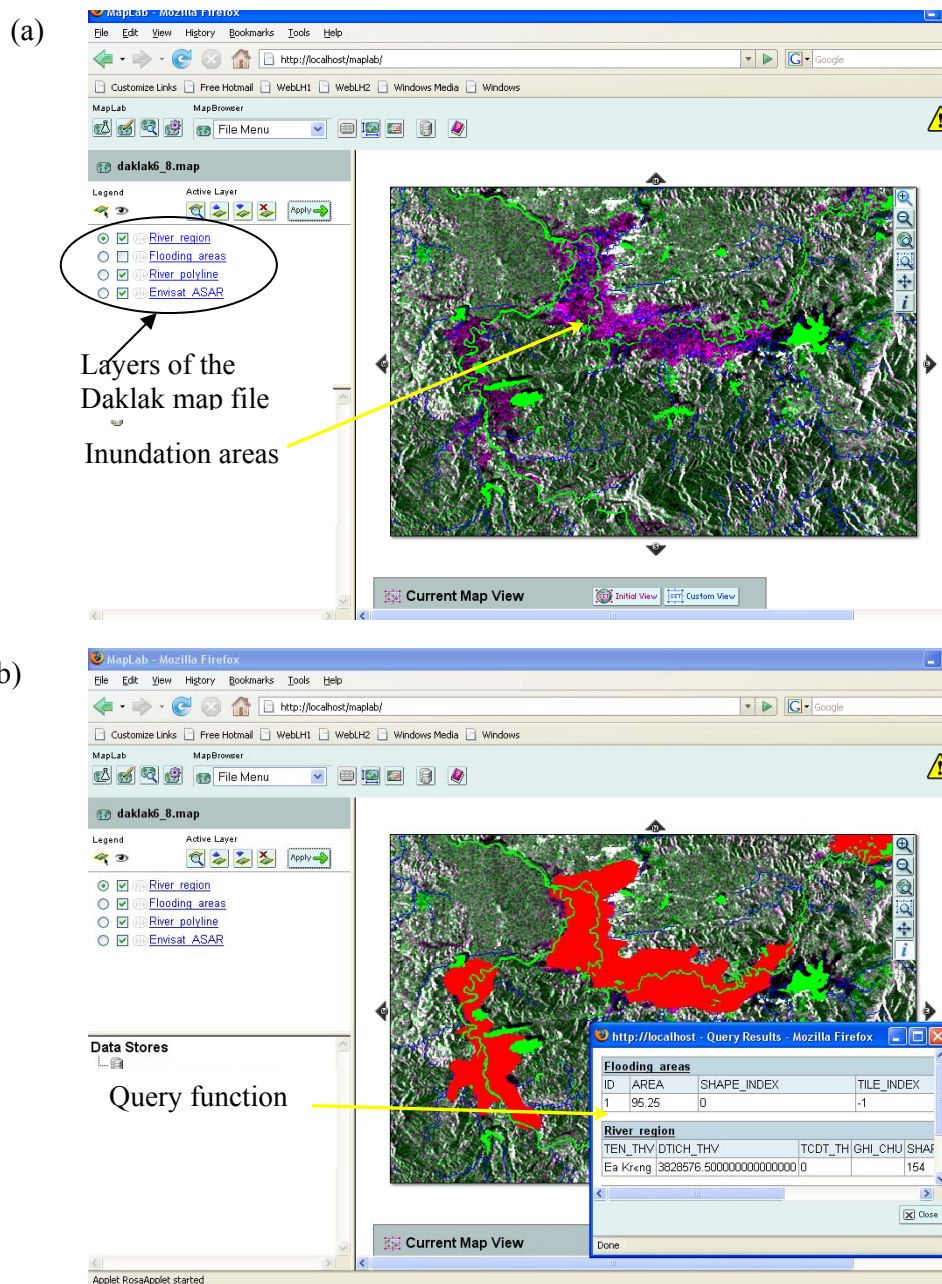


Figure 8: Interface of Daklak Map

4. CONCLUSIONS

Through the experience of two provinces Daklak and Daknong, the Envisat ASAR WSM images demonstrated their abilities. With the medium resolution and image acquirable in all weather conditions, Envisat ASAR is an optimal solution for quick detection of inundation areas.

The rapid determination of flooding areas based on some color composite methods of temporal images to extract the water characteristics of Radar images was very effective.

The integrating of open sources GIS and remote sensing software for data processing and publishing are not only save money but also enhance the capabilities of data analysis and more flexible development in many other applications.

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