УДК 528.854.2

*Trinh Le Hung*

# REMOTE SENSING TECHNIQUES FOR FLOOD MONITORING USING ENVISAT ASAR DATA

*Flooding is the most common natural disaster and can occur anywhere. Flash floods may be caused by heavy rainfall, levee breaches or dam failures. For the extraction of data of flooded areas, pre and post event ENVISAT ASAR satellite images were analyzed. This work may be helpful to policy makers for immediate assessment of flood risk and damage.*

***Keywords***: *flood, remote sensing, ENVISAT, SAR, classification, damage.*

## I. INTRODUCTION

Floods are one of the most wide spread natural disasters. They regularly cause large numbers of casualties with increasing economic losses. Remote sensing data has been widely used for flood mapping and monitoring. If optical data's utility in flood detection depends on cloud cover, active remote sensing with all weather monitoring capability and its large coverage is an important tool in flood monitoring. Data from the ENVISAT ASAR instrument supports many industries such as fishing, shipping, agriculture, oil and gas exploration and the military. Especially in cloudy and rainy environments, ENVISAT ASAR has a wide application prospect when spectral remote sensing cannot be effective [1–3]. The article discusses the contribution of multi-temporal ENVISAT ASAR Wide Swath Mode data in monitoring flooding events in areas of the Delta of the Meghna's river, in Bangladesh.

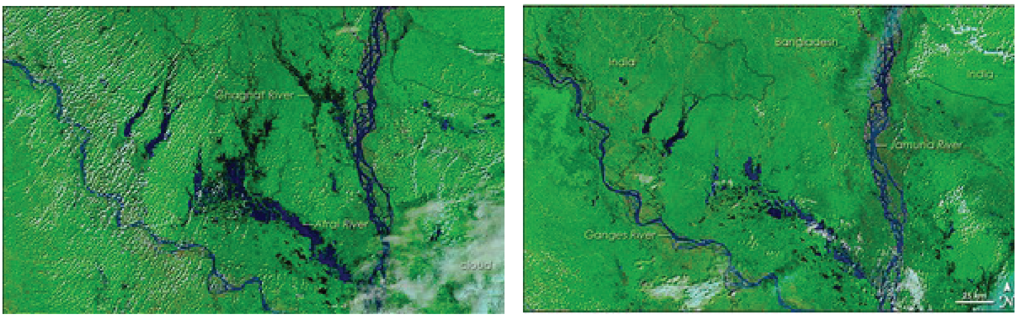
## II. METHODS AND RESULTS

### 2.1 Study area

Flooding is a natural annual phenomenon in Bangladesh. The rivers are large by international standards, and can inundate over 30 % of the land mass. The coastal flooding coupled with the flooding of Bangladesh's river is common and severely affects the landscape and Bangladeshi society. 75 % of Bangladesh is less than 10 m above sea level and 80 % is flood plain, therefore rendering Bangladesh a nation which has a huge risk of further widespread damage.

Each year in Bangladesh about 26000 km$^2$, (around 18 %) of the country is flooded, killing over 5000 people and destroying 7 million homes. During severe floods the affected area may exceed 75 % of the country, as was seen in 1998. This volume is 95 % of the total annual inflow. By comparison, only about 187000 million m$^3$, of stream flow is generated by rainfall inside the country during the same period. The floods have caused devastation in Bangladesh throughout history, especially during the years 1966, 1987, 1988 and 1998. The 2007 South Asian floods also affected a large portion of Bangladesh [7].

To extract and map flooded areas, we used multi-temporal ENVISAT ASAR images: one acquired on 27 July 2007 (post-flooding) and another on 12 April 2007 (pre-flooding) — see fig. 2. The ENVISAT ASAR image with medium spatial resolution (150 m) can be used effectively for extracting and mapping flooded areas in the region study.

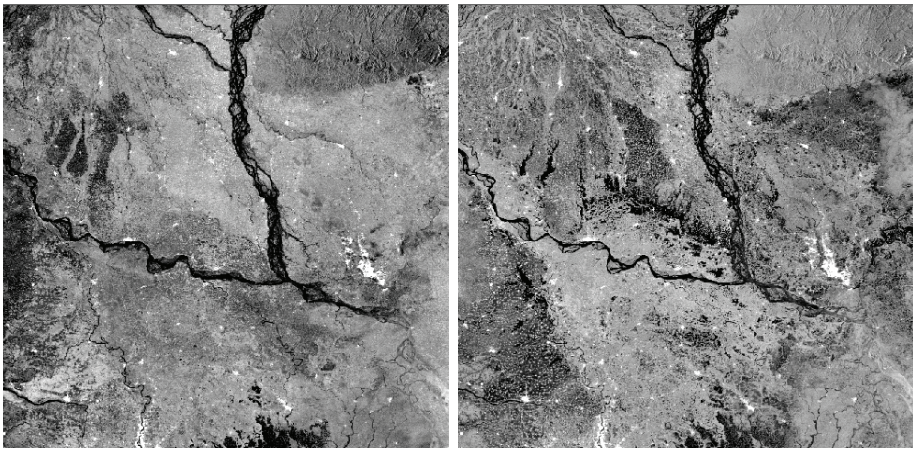



09.2005 10.2005

**Fig. 1**. The difference in river flooding in Bangladesh from satellite image

### 2.2 Methodology

One of the major advantages of using ENVISAT ASAR images corresponds to the ease of distinguishing between water and other classes, given by the high contrast. Water bodies act as a mirror reflecting surface, their response is low (low backscatter coefficient in SAR images) and then looks like a dark area. The earth, for its part, gives a much greater amount of radar energy due to example to the surface roughness and this generates the high contrast between surfaces: soil and water [1–6].



a) b)

**Fig. 2**. ENVISAT ASAR image pre- (a, 12.04.2007) and post-flooding (b, 27.07.2007)

### a. Pre-processing ENVISAT ASAR data

Pre-processing consists of the calibration and orthorectification of ENVISAT ASAR image. The antenna pattern was corrected and data ware converted in to linear backscattering values to the following equation:

$$\sigma_j^0 = \frac{DN^2}{K} \cdot \left(\frac{Rd}{Rref}\right)^4 \cdot \left(\frac{1}{G^2}\right) . \sin\left(I_j\right) \quad (1)$$

,

where K is the absolute calibration constant,

$DN^2$ is the pixel intensity,

$G^2$ is two — way antenna gain at distributed target look angle,

Rd is distributed target slant range distance,

Rref is reference slant range distance and Ij is incidence angle at each pixel location.

**b. Filtering**

The homogeneous areas on ENVISAT data were enhanced using iterative processing with a growing window size relying on the alternate calculation of two sub-filters based on a moving median filter 7 x 7 window size.

**c. Changing detection calculation**

A ratio method was preferred to extracting flooded areas (fig. 3). Band rationing is a useful method of preprocessing the satellite image, especially in areas where topographic effects are important. The reason for this is twofold: one is that differences between the spectral reflectance curves of surface types can be brought out. The second is that illumination and consequently radiance may vary the ratio between an illuminated and an unilluminated area of the same surface type will be the same. The ratio image is applied to homogenized data resulting from following equation:

$$R = \frac{I_{pre-flooding}}{I_{post-flooding}}, \quad (2)$$

where $I_{pre-flooding}$ is calibrated backscattering value on the texturally filtered image at a time pre — flooding and $I_{post-flooding}$ is calibrated backscattering value on the texturally filtered image at a time post-flooding.

**d. RGB color composite**

A color composite is elaborated to enhance flood changes with the aim of facilitating their representation and interpretation with the post-flooding image, the pre-flooding image and the change detection ratio image R in RGB. This color composite highlights permanent water between the two dates in dark blue, infilling or submersion of land surfaces in light blue, and the positive changes such as land surface in red (fig. 4b).

**e. Supervised classification**

Change extraction flooded areas performed by supervised classification to the color composite elaborated above. The most powerful classifier in common use is that of Maximum Likelihood. Based on statistics (mean; variance/covariance), a (Bayesian) probability function is calculated from the inputs for classes established from training sites. Each pixel is then judged as to the class to which it most probably belongs. The result of classification flooded areas showed in fig. 5.

## III. CONCLUSIONS

Satellite remote sensing images are useful data sources to detect, determine and estimate the flood extent, damage and its impact. The analysis of this study showed that extraction of flooded areas was focused on plain flood recognition using ENVISAT ASAR Wide Swath Mode data which appears highly adapted to large sensitive area monitoring. SAR data has the advantage of penetrating through cloud cover and forest canopies, but they are costly.

This result can be used for a quick response plan and allows to move swiftly to take appropriate remedial measures. It can help the residents in the flood affected areas to visualize and assess the amount of flooding and the lost of their property. The effectiveness of the remote sensing imagery for flood mapping has been amply demonstrated for many recent flood events.

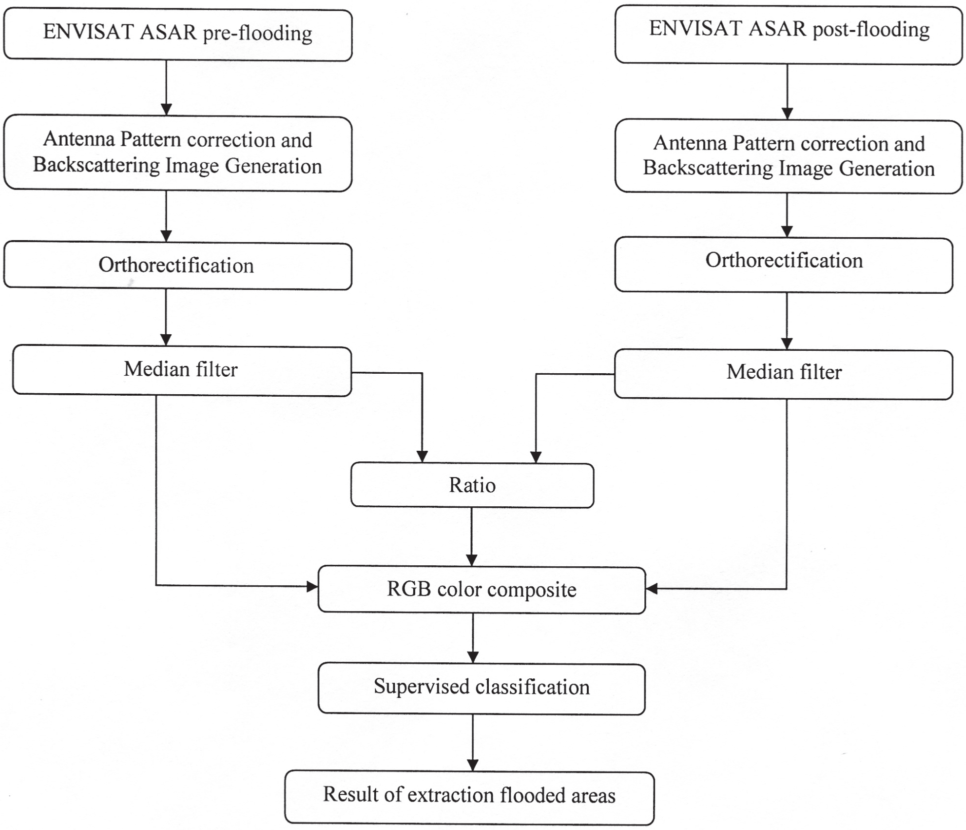
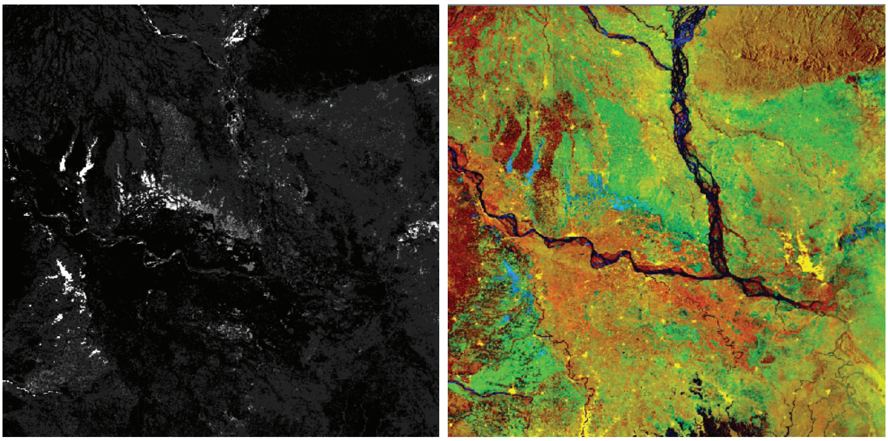
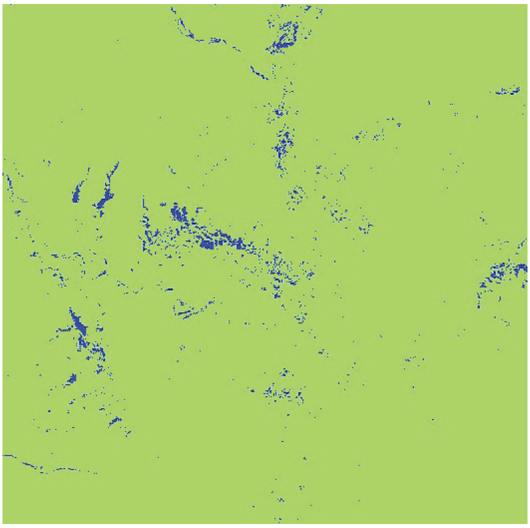



**Fig. 3**. Method of extraction and mapping flooded areas



*a)* *b)*

**Fig. 4**. Band ratio image (*a*) and result RGB combination (*b*)



*Flooded areas*

**Fig. 5**. Result of classification of flooded areas

**References**


1. Ormbsy J. P., Blanchard J. P. and Blanchard A. J. Detection of lowland flooding using active microwave systems // Photogrammetric Engineering and Remote Sensing. 1985. V. 51. P. 317–328.
2. Takeuchi S., Konishi T. and Suga Y. Comparative study for flood detection using JERS-1 SAR and LANDSAT-TM data, Geoscience and Remote Sensing Symposium // IGARSS'99 Proceedings, IEEE International. (1999. V. 2. P. 873–875.
3. Lee K. S. and Lee S. I. Assessment of post-flooding conditions of rice fields with multi-temporal SAR data // International journal of Remote sensing. 2003. V. 24(17). P. 3457–3465.
4. Andreoli R. and Yesou H. Change detection analysis dedicated to flood monitoring using ENVISAT wide swath mode data // Proc. «ENVISAT symposium 2007», Monteux, Switzerland, 2007.
5. Vilches Juan Piedra. Detection of areas affected by flooding river using SAR images. Master in Space applications for emergency early warning and response, 2003. 40 pp.
6. Ho L. T. K., Umitsu M. and Yamaguchi Y. Flood hazard mapping by satellite images and SRTM DEM in the Vu Gia — Thu Bon alluvial plain, central Vietnam // International archives of the Photogrammetry, Remote Sensing and Spatial Information Science. V. XXXVIII. Part 8. Kyoto, Japan, 2010.
7. *Bangladesh flooding, www.coolgeography.co.uk*



*Чинь Ле Хунг*


## КОСМИЧЕСКИЙ МОНИТОРИНГ НАВОДНЕНИЯ ПО ДАННЫМ РАДИОЛОКАЦИОНЫХ ИЗОБРАЖЕНИЙ ENVISAT ASAR


*Наводнение является наиболее распространенным стихийным бедствием и может произойти в любом месте. Основными причинами наводнений являются интенсивные дожди, прорывы дамб и плотин. Для определения затопленных районов были использованы разновременные изображения ENVISAT ASAR до и после наводнения. Полученные результаты могут использоваться для оценки риска и ущерба от наводнений.*



***Ключевые слова***: *наводнение, дистанционное зондирование, ENVISAT, SAR, классификация, ущерб.*