REMOTE SENSING IN STUDY OF HAI PHONG COASTAL ZONE

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ABSTRACT

Fusion of Spot image and aerial photo in Cat Hai enhance feature discrimination, and mapping the terrestrial objects in detail; the radar interferometry for Hai Phong give the regional additional information. Shorelines traced by using remote sensing present the coast evolution from 1927 to 2001, giving the erosion – accumulation situation in the area. Over the past seventy years (1927-2001), the south part of Cat Hai island is eroded with varying extent and rate. Period 1927-1949, Cat Hai coast is slightly deposited with 2.3 km long at the east part of Cat Hai town. From 1949 to 1965, *Cat Hai coast is strongly eroded with 6.4 km long at the south part from Hoang Chau to Ben Got. Period 1965-1988, Hoang Chau - Ben Got section is kept continuously eroding. In the same time, in Dinh Vu island coast, eroding mainly occurred in the east and southeast part with an average rate of 12-40 m/ y in period 1927-1965 and of 6-12 m/ y in period 1965-2001, and now it is still continuing to be eroded. Whereas the coast of north Dinh Vu is seawards advanced and the Cua Cam river in the south of Dinh Vu, once main access to Haiphong, is more and more narrowed but all of these changes are in non-natural way. The main reasons for erosion are the action of SE and S waves in the subsidence setting due to tectonic and global warming. The land expansion in the area is principally related to human activities such as dyke building, aquaculture, port building and related industrial activities.*

1. INTRODUCTION

Hai Phong (HP) is one of the most important port cities in Viet Nam. The economic development in the city conflicts to the tourism activity and environment protection. Coastal erosion and sediment accumulation in HP prevent sustainable development. In this paper we present the application of remote sensing in HP coastal zone, especially in Cat Hai – Dinh Vu, the most active economic region but unstable coast due to the unconsolidated-deposit foundation. Cat Hai – Dinh Vu is a low land area, composed of unconsolidated sediments. This region is characterized by moonson climate. Hydrographical network of the region belongs to Thai Binh river system. Storm wave have southeast direction and mean height of 3.5-5.0 m. Among the littoral currents, it is notable that there is a long shore current system with a direction to the south in winter and contrast direction in summer. In general, every year this system takes about 200000 tons of sediments away from Nam Trieu (Nguyen Van Cu, 1983). We used remote sensing in interpreting terrestrial objects, tracing the paleoshorelines, reconstructing shoreline evolution, analyzing the dynamic of this evolution from 1927 to 2001 and analyzing erosional and depositional risk in this area. New advanced technologies in remote sensing such as image fusion, GPS and radar interferometry are also used for improving the effectiveness of the work

2 METHODS

Our study is mainly based on following data: topographic maps 1927, 1949 and 1965, aerial photos 1952, 1992, Spot images 1988, 1994, Radasat images 1996, ERS1, ERS2 Landsat images 2001 and Ikonos images 2001, Spot 5 2004. Maps are made georeference according to co-ordinates of four corners and projection. After that, all maps are reprojected to system of UTM WGS84 (zone 48) for the comparison. Aerial photos and satellite images are made georeference with the georeferenced maps. The nature of this operation is to transform co-ordinates of the image which will be georeferenced (slave image) to co-ordinates system of the already georeferenced map (master image). This transformation demand to choose the control points in slave image and the respective ones in master image for obtaining the co-ordinates of these points in system of master image and the determining a function of transformation. The control points should be well distributed in the common zone of the two images. The transformation function must be chosen so that errors are minimum. After choosing control points, it is carried out resample interpolating to obtain the georeferenced image. Mosaic operation could be made for the gereferenced aerial photos to obtain an only single image of total area. After the georeference, it could be taken the operations such as image enhancements, classification, interpolation, etc. in order to identify the terrestrial object, define the coastline, analyze the environmental dynamic, etc. In addition, to increase effect in image analysis, some new relative remote sensing technologies are also used such as: Image fusion, Radar interferometry and GPS technique. In fusion technique, higher spatial resolution panchromatic image is combined with lower resolution multispectral image in order to create a product having the spatial resolution of panchromatic image and the characteristics of mutispectral image. Various fusion techniques are currently used such as IHS transform, principal component analysis, high-pass filter, wavelet transform, etc. (Guyenne T., 1988, Carper, W.J. et al., 1990, Grasso, D.N., 1993, Mangolini et al., 1993). Applying in Cat hai (Haiphong) coastal zone, the fusion between aerial photos of 1992 with SPOT multispectral of 1994 is made. Firstly the aerial photo is georeferenced on the bases of topographic map and control points and then the georeferences of SPOT image and aerial photo are compared by using 22 control points, measured by GPS with the accuracy of less than 1 meter. We try to find the control points at the boundary of aerial photo in order to increase the accuracy at the center of image. Radar interferometry utilises the images of microwave region, which has an advantage of penetrating the atmosphere in virtually all weather conditions, crossing cloud cover and night-time. With the technique of radar interferometry, it may be possible to obtain height information on spatial basis thereby producing DEM up to centimeter level accuracy. Due to this, the technique is applied in many studies concerning topographical features such as lithosphere movements in geology, crustal deformation studies in seismology, volcano monitoring, landslide monitoring, ice and glacial studies, etc. (Massonnet *et al.* 1996; Bilrgmann R., *et al.* 1999). Radar interferometry, applied for coastal zone of HP is based on two tandem radar images: ERS1 of April 2nd, 1996 and ERS2 of April 3rd, 1996.

3 RESULTS

3.1. Mapping from image fusion and Radar Interferometry

We use aerial photo as master image and SPOT image as slave one for geometric correction. For setting of the advantage of fusion image, we compare the SPOT multispectral with the fusion image in Hoang Chau commune, southwest Cat Hai, we can observe more detail structure of flows, sand beach and houses in village. We compare the fusion image with SPOT in southern part of Cat Hai area (Fig. 1). The distribution of vegetation cover is clear in fusion image. Comparing the fusion image with Ikonos image, we recognize that the quality of fusion image is compatible with the information from Ikonos images. In certain case, we can observe more clearly in fusion image. Using the most simple classification, we show that the advantage of fusion image for recognizing small object. We present also example of the fusion of multisensor data. We test the fusion between RADASAT image, high resolution (12.5 m) with SPOT. This procedure has advantage to combine the advantage of texture and resolution of radasat image with SPOT multispectral image. The fusion image gives some more compliment information. In same time it losses also some other information. However, fusing images are still of some limitation because of the time difference between aerial photos (1992) and Spot images (1994). Result would become better if it had no or negligibly time difference.

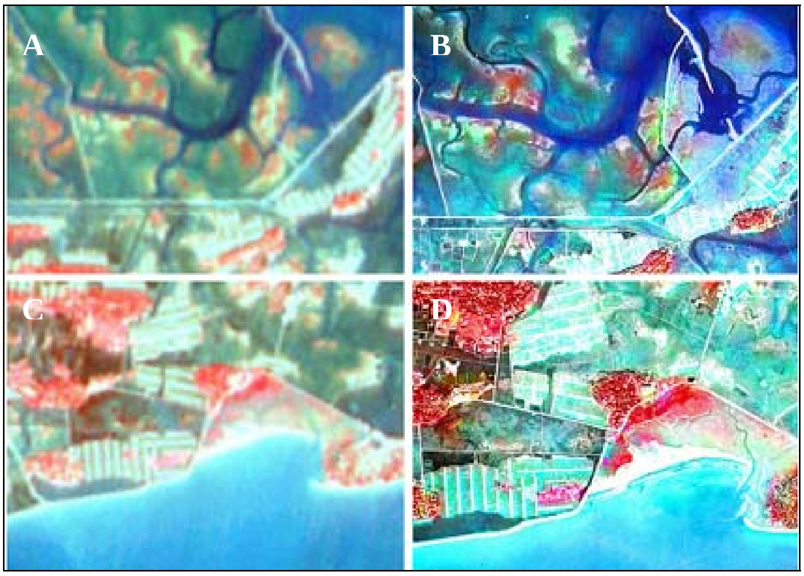

Figure 1. Comparison of SPOT image (A,C) with fusion image (B,D) in north and south of Cat Hai

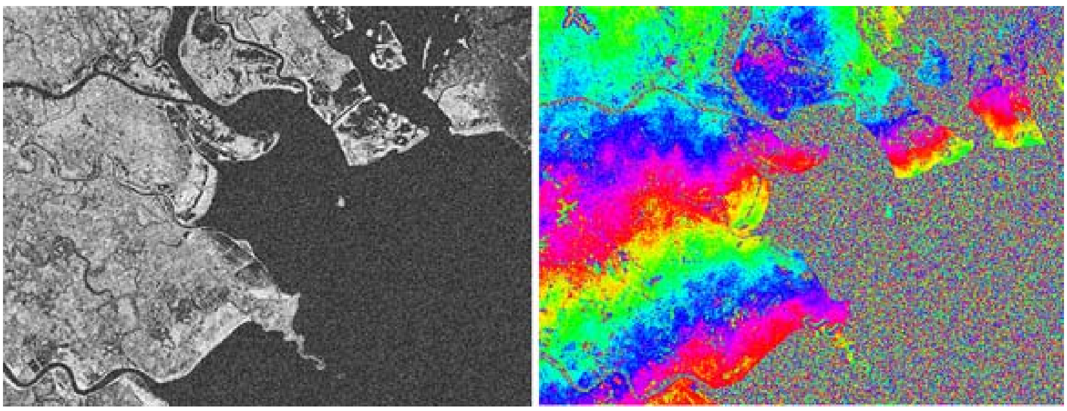

Figure 2. Coherent image (left) and interferogramme (right) of Hai Phong region

From the two tandem radar images, ERS1 of April 2^{nd},1996 and ERS2 of April 3^{rd},1996, by radar interferometry, we make coherent image and interferogramme for region of HP (Fig. 2). The coherence is an important parameter in process of phase unwrapping. In coherence image, the values vary in a range between 0 (black) and 1 (white). For plain area, the value is usually high, thus an image is expressed in light color. Dark color area in coherent image of HP implies water object or mountainous area Cat Ba due to presence of trees and steep flank. Coherence image in turn provides many compliment information for optical images. DEM made from radar interferometry portrays the regional topographic information. HP is the plain region so interferometric fringes are coarse, except the Do Son area, interferometric fringes are fine due to mountainous relief. For the water object in interferogramme, the color is regularly dispersed and no fringe is made.

3.2. Change of Haiphong coastline

Section of Cat Hai island (Fig.3). This section is characterized by a low coast, situated between the two large river mouths: Lach Huyen and the Nam Trieu. From 1927 to 1949, the

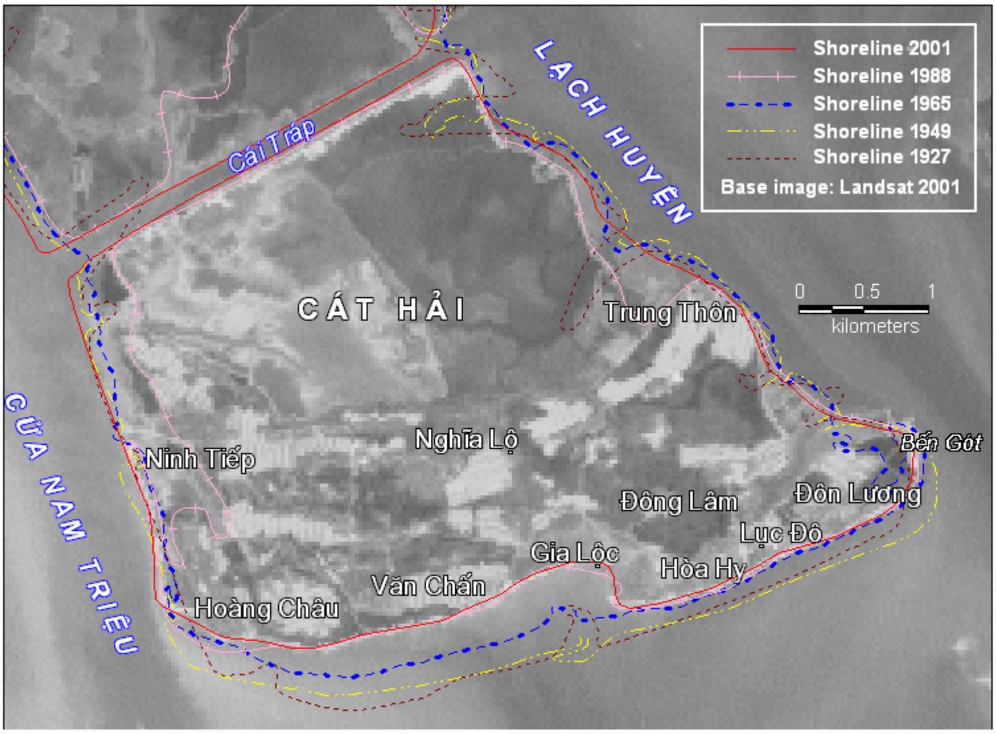

Figure 3. Change of shorelines in Cat Hai from 1927 to 2001

coast was slightly accumulated with 2.3 km long and 80-120 m wide (i.e. 2-4 m/y) in Don Luong, whereas it was eroded in the 3.2 km southwest part, from Gia Loc to Hoang Chau with the width of 80-100 m (max 200m) and rate of 4 m/y. From 1949 to 1965, Cat Hai was eroded with 6.4 km long in the southern part from Hoang Chau to Ben Got, this erosion is estimated of 80 –300m wide and trate of 5-18 m/y. From 1965 to 1988, Ben Got-Hoang Chau section, in general, was kept continuously eroding with an extent of 2.9 km long, 250 m wide (max 400m wide) and rate of 10-25 m/y; however thank to the jetty building, the erosion rate in some individual part of the section was considerably decreased. In this period the coasts along Lach Huyen and Nam Trieu mouth were also eroded with size of 2.3 km and 1.7 km long, respectively. From 1988 to 2001, the coast of Ben Got–Hoang Chau continued to be eroded but the erosional extent and rate were decreased thanks to presence of newly built jetties and seadykes. At this time, sections facing to Lach Huyen and Nam Trieu mouth were re-accumulated with a slow rate. In short, nearly over the past seventy years (1927-2001), according to general trend, the south part of Cat Hai is eroded with varying extent and rate.

Section of Dinh Vu (Fig. 4). This section prolongs 4.2 km, situated between two large rivers: Cua Cam and Nam Trieu. From 1927 to 1949, the east coast was eroded with a size of 3.8 km long, 300m wide, sometime up to 700m wide and a rate of 10-40 m/y; whereas sections facing to Cua Cam and Nam Trieu were partly deposited with length of 0.3-1.4 km, depositional rate is 5-12 m/y. In period of 1949-1965, the coast is forcefully eroded over a distance of 5.3 km; the erosion is estimated of 190m wide with the rate of 13 m/y. From 1965 to 1988, erosion occurred with the extent of 4 km long, 150m wide and the rate of 6-12 m/y. In period of 1988-2001, erosion mainly occurred at the cap of Dinh Vu island with an erosional extent of 1.9 km long and 60m wide (max 150 m); in contrast, deposition mainly occurred at the west part of the island, belonging to older Cam channel, this accumulation prolonged 7,2 km along the channel with a width of 1300m. In brief, from 1927 to 2001, in Dinh Vu island, erosion is principally found at the E and SE part with rate of 12 –40 m/y for 1927-1965, 6-12 m/y for 1965-2001; whereas in the north part next to Nam Trieu mouth, the coast is seawards advanced but in non-natural way. The Cua Cam river in the south of Dinh Vu, once main access to Haiphong, is more and more narrowed because of the exploitation for agriculture and aquaculture, and at present it exist as a small creek of some meters wide.

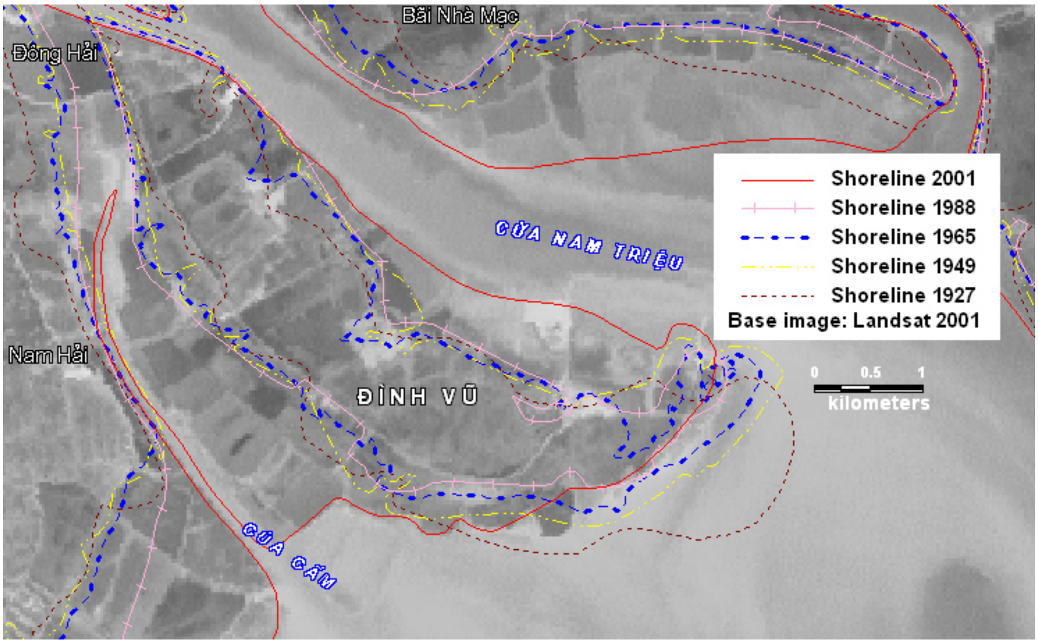

Figure 4. Change of shorelines in Dinh Vu – Cua Cam from 1927 to 2001

4. DISCUSSION

HP shoreline generally has a SE convex-bay shape and is intensively cut by channel system. There are many continuously eroded shoreline sections over years, especially in Cat Hai and Dinh Vu. However, there are some rapidly deposited sections, Cua Cam area, for example. The reasons for these events are: HP shoreline is developed on the tectonic subsiding area with the center in Bach Dang estuary. This is the most important factor deciding the trend of shoreline change process in this region. The subsidence cause rising sea level, added by global sea level rise with a rising value of 2.24 mm/y for the region (Nguyen Ngoc Thuy, 1993). Wind in this area comes from E, NE in winter and S, SE in summer creating maximum wave height of 2 m, even 4m in storms. The eroded shoreline sections in the southeast of Dinh Vu, Cat Hai are strongly affected by the S and SE waves. HP coast is dominated by diurnal tide with a large amplitude (1,5-3m) creating the strong currents which greatly influence on the sedimentary budget in the area. In summer, tide rising combine with S, SE wind and wave creating a alongshore current to transport sediment to the north. Summer wave, storm and tide are principal factors causing coastal erosion in summer. Human activities also contribute an important role to the shoreline change. The most influence is Dinh Vu channel digging by the beginning of 20th century and Dinh Vu damming in Cam river in 1980s, driving water from Cam to Nam Trieu river, causing deposition in lower section of Cam river and erosion in Hoang Chau – Cat Hai. However the erosion is significantly diminished thank to the protecting works. Dyking and landfilling for aquaculture, industry, harbor, etc influence the regional erosion – accumulation balance in provoking the land expansion in Cua Cam mouth and north of Dinh Vu.

5. CONCLUSION

The fusion of mutispectral image, higher spatial resolution panchromatic image with lower resolution multispectral image creating a product which has the spatial resolution of panchromatic image and the characteristics of mutispectral image could improve the identification of the objects on earth. Radar interferometry also provides a lot of information on topographic region, makes DEM for geological and geomorphologic research. By analyses of map, aerial photos and satellite image, we determine shoreline locality over different periods, reconstruct paleoshoreline and assessment erosional – depositional risk. HP shoreline from 1927 to 2001 changed according to main trends: eroding in south of Cat Hai island and east of Dinh Vu and depositing intensively in Cua Cam area. The reasons for these events are interactive relationship between tectonic subsidence and global warming with additionally supports from southeast and south wave in summer. The climate factor causes destruction of coastal zone and transportation of sediments apart. In Cua Cam area and the north of Dinh Vu island, rapid deposition is caused by human factors such as dyke building, ponding for aquaculture, port building and related industrial activities. This work is fulfilled by the assistant from basic Research program of M. of Sci. and Tech., International project of VN – Walonnie–Bruxelle region and project supported from Réseaux de télédétection (AUF).

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