Temporal variation of shoreline positions on Cua Dai beach, Vietnam

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Abstract: Severe erosion has been observed on Cua Dai Beach, Hoi An City, Quang Nam Province, central part of Vietnam. The erosion is getting more and more serious. This study discusses the volume change rate through the analysis of shoreline positions at a selected region of coasts extended from Cua Dai River mouth. The predomination of the long shore sediment transport is recognized and the movement towards the south of the sediment is also observed.

1. Introduction

Along 3,300km coastline of Vietnam, severe erosions have been observed at many locations in the recent years. Cua Dai River mouth, which is located in the central part of the country is also one of such erosion locations. Cua Dai Beach is one of the best beach resorts of Vietnam located on the left bank of Thu Bon River estuary (usually known as Cua Dai River mouth) which is 6km from Hoi An City in Quang Nam Province, the central province of Vietnam (Figure 1). Ancient town had been formed in Hoi An City during the 16th century under strong effects of Japanese culture owing to a busy international trading port at the Cua Dai River mouth. However, large amount of sediment supply from Thu Bon River had been recognized as the main factor causing loss of function of this market since the 19th century.

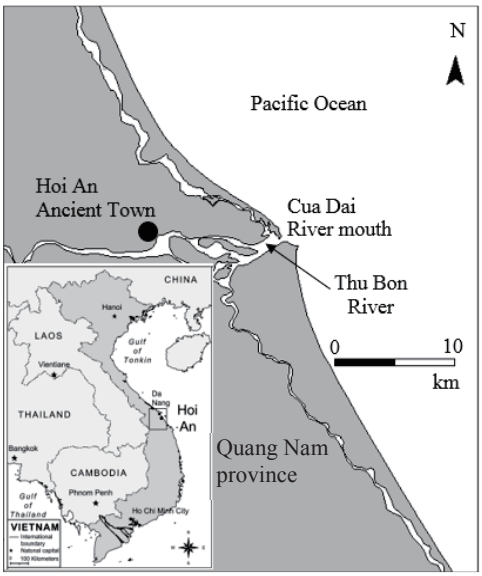

Figure 1. Location map of study area

Due to severe erosions observed at the Cua Dai River mouth in the recent years, some studies about the erosions at this river mouth have been carried out. Viet et al. (2015) investigated the morphological change on Cua Dai Beach through image analysis. Hoang et al. (2015) performed a theoretical analysis on the erosion of shoreline around the Cua Dai River mouth using analytical solutions of one-line model. Tanaka et al. (2015) pointed out the erosion mechanism at the Cua Dai River mouth. Tanaka et al. (2016) also discussed the interrelationship between serious shoreline retreat and sand terrace formation on Cua Dai Beach using Landsat images.

Although studies about erosion at the Cua Dai River mouth have been done, these studies focused only on the area around the river mouth. Therefore, the objective of this study is to extend the study area to the southern and northern parts from the Cua Dai River mouth in order to make discussion on the volume change rate of sediment in this area.

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2. Study area and data collection

This study focuses on the Cua Dai River mouth (Hoi An City, Quang Nam Province, central part of Vietnam) and the two coastlines extended to 20km and 40km in the northern and southern parts, respectively, from the river mouth (Figure 2). Cua Dai River mouth is where the Thu Bon River flows into the Pacific Ocean. The Thu Bon River (152km in length) has the average annual discharge of about 327m^3/s (Viet et al., 2015).

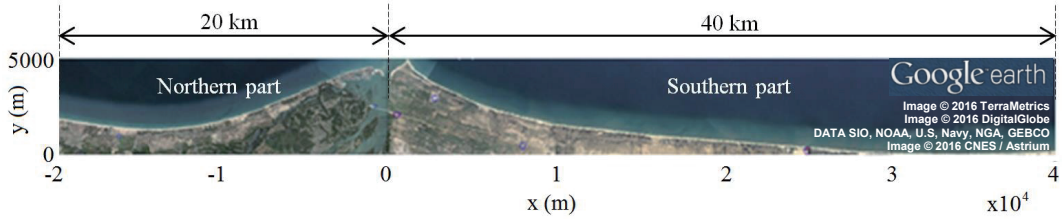

Figure 2. Extended coastlines from the river mouth

Google Earth images available in 2001, 2002, 2004, 2009, 2010, 2011, 2012, 2013, 2014 and 2015 are used for the analysis of this study. However, not all images are captured for the whole study area. Concerning the rectification process, all images are re-rectified to the World Geodetic System – 84 (WGS-84) using a line with the direction of 144.94 degree counter clockwise from the north and an original point (x=0) with the coordinates 217289.08 E and 1754078.07 N on WGS-84. Shoreline positions are extracted from rectified images at 5m intervals along the coast. Moving averaging method is applied to reduce the effect of beach cusps. Tidal correction has not been made in this study due to the lack of capturing time.

3. Results and discussion

3.1 Temporal variation of shoreline positions

Various shoreline mapping methods have been developed over the past decades. Moore (2000) provided a survey of existing methods and summarized a list of considerations to be made when selecting a shoreline mapping technique. Elizabeth and Ian (2005) gave a review on shoreline definition and detection and came to the conclusion that temporal consideration of the "shoreline" obtained from imagery has been improved by analyzing the time-averaged images. In this study, the shoreline mapping method utilized by Pradjoko and Tanaka (2010) is applied.

Because of the wide study area, detected shoreline positions (y-axis) are shown only at some locations along the coastlines (x-axis) in Figures 3 for the northern part (upper diagrams) and the southern part (lower diagrams). All shoreline position diagrams are plotted with the same length scale in the y-direction. As can be seen from the upper diagram in Figure 3, shoreline retreated significantly (about 180m from 2004 to 2015) at locations closed to the river mouth and advanced at locations far from the river mouth. Concerning the shoreline positions plotted in the lower diagram in Figure 3, it can be seen that the shoreline advanced at locations closed to the river mouth with the advance magnitude observed to be about 10m from 2011 to 2014. At locations far from the river mouth, shorelines retreated with a small magnitude (about 6m from 2001 to 2014). Based on the results obtained from the diagrams, it can be said that the shoreline variations at regions around the river mouth are more significant than at regions far from the river mouth.

In order to have a general view on the retreat and advance of the shoreline positions, the shoreline change (Δy) diagrams are plotted in Figure 4. However, due to the different initial years, the shoreline changes are separated into two diagrams with the same length scale in the vertical direction (Δy) for the

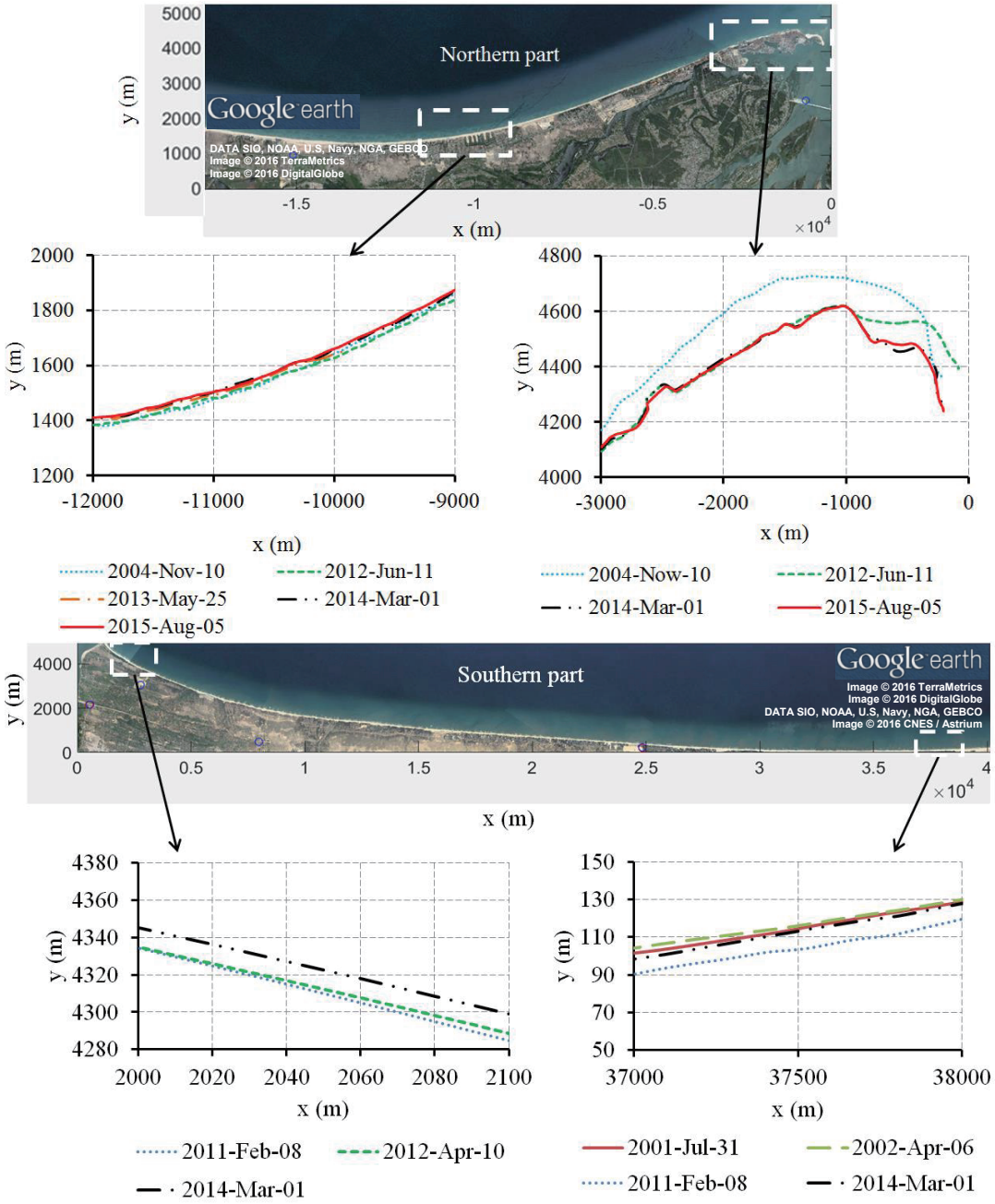

Figure 3. Detected shoreline positions at some locations in the study area

purpose of making comparison between the northern and southern parts. From the upper diagram, it can be easily recognized that the shoreline near the river mouth retreated significantly while advanced parallel to each other in a major part of the northern area. Specifically, the erosion zone expands to about 5km from the river mouth. At about 5km from the river mouth, the shoreline starts to advance downcoast. On the other hand, shoreline in the southern part advanced near the river mouth and

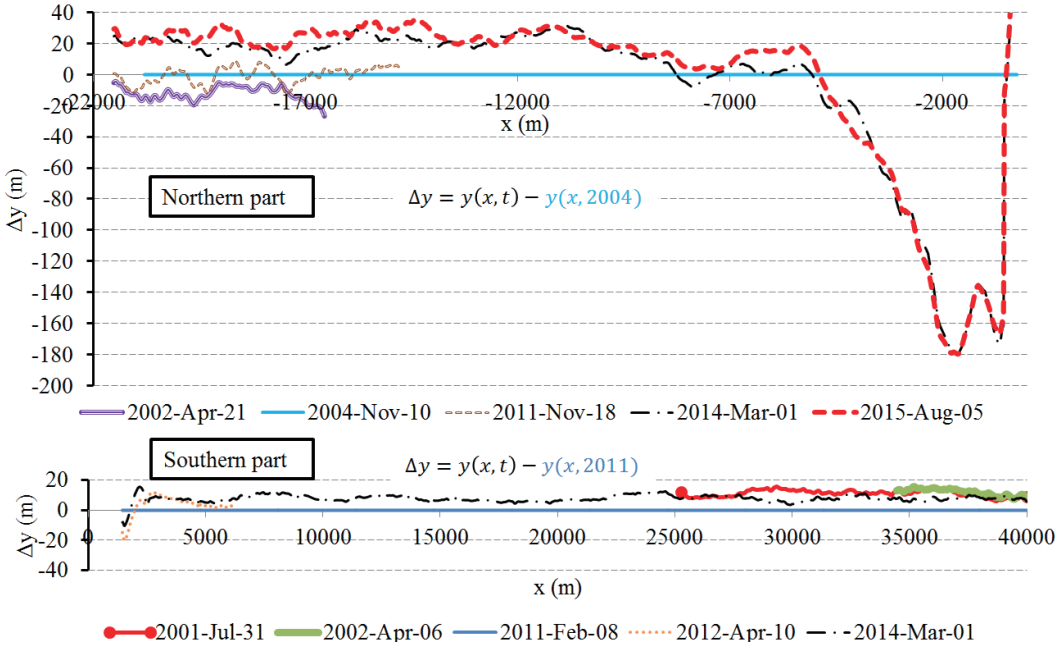

Figure 4. Shoreline changes in northern part (upper diagram) and southern part (lower diagram)

retreated at locations far from the river mouth. In general, variation of shoreline position in the northern part is much greater than in the southern part.

3.2 Shoreline change rate

Rosati (2005) reviewed the sediment budget concepts and expressed that volume change rate magnitudes may be estimated using shoreline position data or shoreline change rate which is denoted by *a* (m/y) in Figure 6. Therefore, shoreline change rate will be determined to facilitate the discussion on sediment budget. In order to determine the shoreline change rate values along the coastlines, the temporal variations of the detected shorelines will be plotted at every 1,000m intervals along the coastlines. The slope of the trend line associated with the temporal variation of the shoreline at each section is considered to be the shoreline change rate at this section. Temporal variations of shoreline positions at some locations are presented in Figure 5 with the shoreline positions and the temporal scale presented in the y and x-axes, respectively. All values of shoreline change rates are plotted in Figure 6. From Figure 6, it can be concluded that longshore sediment movement is predominant in this area and sediment is moving to the north.

4. Conclusions

In this study, google images have been used to analyze the temporal variation of shoreline positions on a large area from the Cua Dai River mouth. On the northern part, the shoreline retreated significantly at locations near the river mouth and advanced parallel to each other in a wide area of this part. The shoreline changes in the south represent a small variation during the survey period from 2001 to 2014. It is also observed that longshore sediment movement is predominant in this area and the sediment is moving to the north. Based on this conclusion, one-line model can be applied to find a solution of morphological change for a finite region at Cua Dai River mouth.

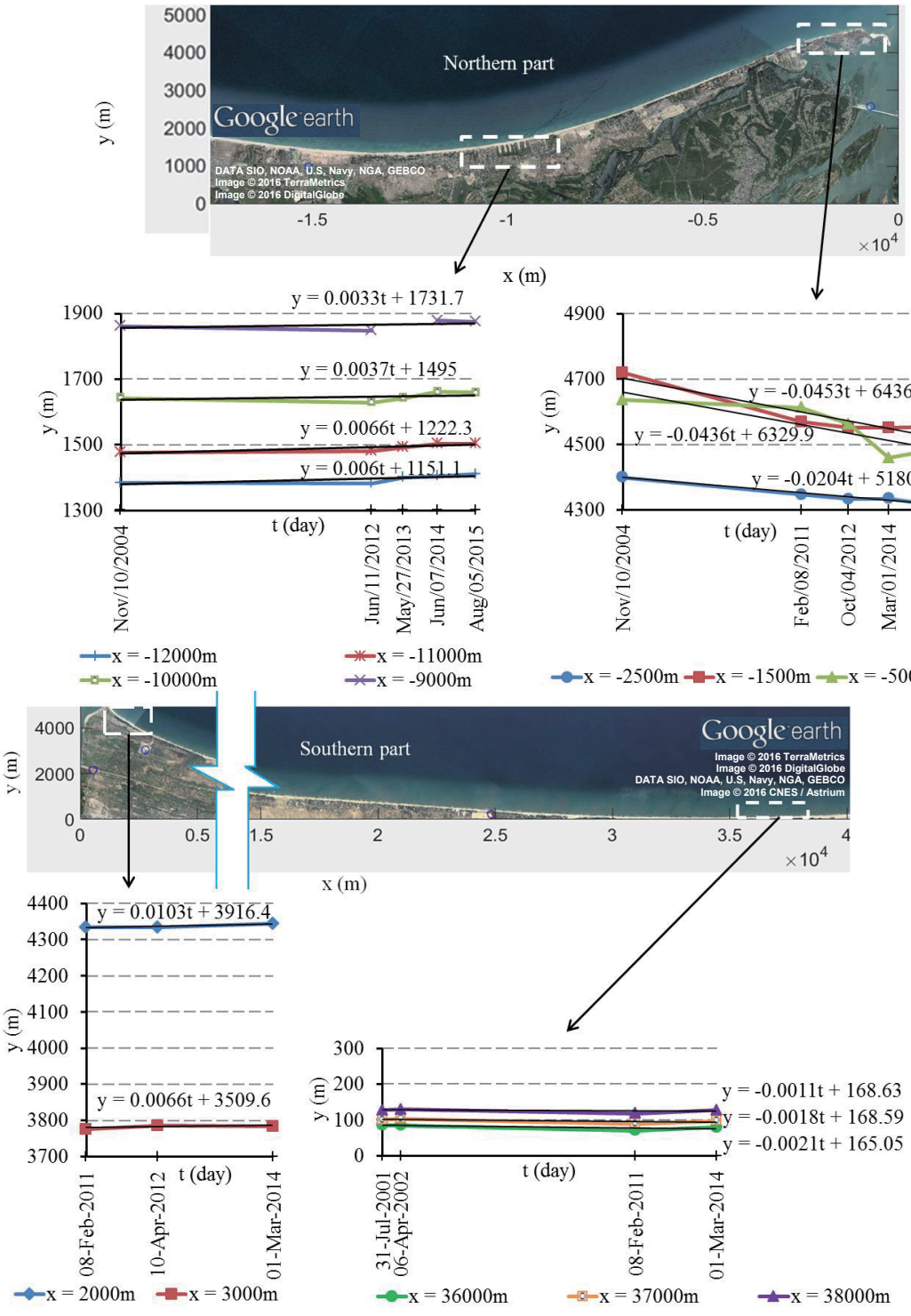

Figure 5. Temporal variation of shoreline positions at some locations

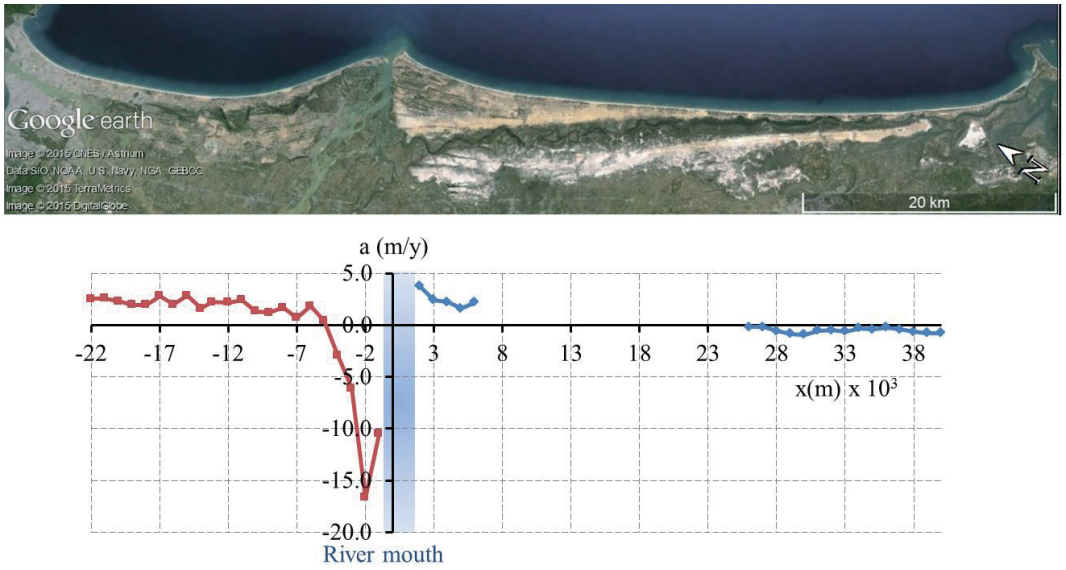

Figure 6. Shoreline change rate in the study area

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