USING LANDSAT DATA TO DETECT LONG-TERM MORPHODYNAMIC BEHAVIOR OF ESTUARIES: A CASE STUDY IN THE XIAOQINGHE RIVER ESTUARY, CHINA

Yanxia Liu[a, b, c], *Haijun Huang*[b], *Jun Yan*[b]

[a]Yantai Institute of Coastal Zone Research, Chinese Academy of Sciences, Yantai, 264000, China;
[b]Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, 266071, China;
[c]Graduate School of the Chinese Academy of Sciences, Beijing, 100049, China.

liuyanxia@qdio.ac.cn

1. INTRODUCTION

Estuaries and tidal bays are complex dynamic systems subject to marine and terrestrial influences [1]. Ecosystems of high value and relative uniqueness were formed there, and many estuaries are important to human as places of navigation, recreation and commerce as well as being extensive and diverse habitats for wildlife. Understanding the character of estuarine landforms is important because they play a key-role in natural coastal defense, navigation and as resources for marine aggregates. Meanwhile, it can provide important theoretical bases for managements to predict the morphological response of these systems to human activities and environmental changes.

2. STUDY AREA

The Xiaoqinghe estuary is located on the southwestern margin of the Laizhou Bay and the south of the current Yellow River mouth in China. The sediment types of the offshore seabed are predominantly sandy silt and very fine sand with grain size between .002mm to 0.125mm. The mouth and route of Yellow River changed frequently. Up to 1953, the Yellow River has shifted its course three times (about 19a) to the southwest of Laizhou Bay, and it also has flowed into Bohai Sea through the Xiaoqinghe River mouth five times. Dramatic sediment accumulation has happened in the Xiaoqinghe mouth and adjacent area. Based on such deposited sediment, an estuarine shoal of NW-SE direction about -1m depth were formed around the mouth area, as well as the sand spit and sandbar on the northern side of the mouth.

3. DATA AND METHODS

Landsat MSS/TM/ETM+ images in 1973 and 1976-2007 one image per year were used to characterize and formulate the historic morphodynamic behavior model of the Xiaoqinghe estuary. According to the cycles of erosion and deposition on neighboring shorelines are often linked to phases of growth and decay of ebb-tidal shoals and to switches in ebb-and flood-channel position. This study presents the morphodynamic evolution using the waterline and bathymetry by remote sensing from 1973 to 2007.

All images are geometrically processed in order to be compatible with a WGS84 datum and the projection UTM zone 21N, and the spatial error is estimated to be a half pixel. For atmospheric correction of images for bathymetry retrieval, the Second Simulation of the Satellite Signal in the Solar Spectrum (6S) model is used. The MLS or MLW standard atmospheric model is selected. Here correlative parameters have been obtained from head files of satellite products and local meteorological data. The lowest normal low water has been selected as datum plane for waterline extraction and bathymetry retrieval in order to analyze comparatively on different spatial data. The process procedure is summarized as follows: (1) Single band density slicing method is used to extract waterline. The remnant water scattered on the tidal flat surface after exposure and the effect of grain size is considered, Landsat MSS band 7 and TM/ETM+ band 5 are used to delineate the waterline. The effect of turbid water on selected bands can be reduced by a subtraction between them and the other visible bands. (2) Correlation is analyzed between the real measurement water depth data on March 2007 and the atmospheric corrected image on April 2007. Single band method, ratio method are respectively applied to relativity analysis. Furthermore, linear, exponential, logarithmic and quadratic linear regression models are established between the water depth and single band or band combination of the strong relativity. The accuracy of models is evaluated by using correlation coefficient, root mean square error and statistic test value. Meanwhile the reflection spectrum of water influenced by suspended matter in a water body is considered. (3) The retrieved waterline and bathymetry to the lowest normal low water are corrected. Based on the hourly tidal level data (1976-1998) and high and low tidal level data (1999-2007) at Yangjiaogou observation station, the tidal level of all images was computed by using spline interpolation method. The relationship between mean sea level and lowest normal low water is obtained from the statistical analysis of the hourly tidal level data from 1953 to 1998 at Yangjiaogou station. (4) Terrain gradient correction is carried out for the extracted waterlines from images. Due to a long span of time, terrain data can not meet our requirement. So here we suppose that the terrain of two nearest images has no change at same year. Because the tide level is different in these two images, the place of waterline is different. The tangent value of gradient can be obtained by the distance of two extracted waterlines is divided by the tide range of these two images [2]. (5) The accuracy of the result is estimated by water depth and coastline data from the chart in 1976 and 1985 respectively and the field measurement data in 2007.

4. RESULTS

According to the processing method, we retrieved the waterline and bathymetry around the Xiaoqinghe estuary in 1973 and 1976-2007 respectively (Fig.1). Then the digital elevation models of submarine topography are built each year. On the basis of these long-term series data, the relationship between the erosion or deposition of shorelines and the morphodynamic evolution of estuarine sandbar, as well as sand spit is identified. Finally, we formulated a conceptual model for the morphodynamics evolution of the estuarine sandbar and sand spit at Xiaoqinghe estuary in the past 30 years, referring to the 'ebb delta breaching' model [3].

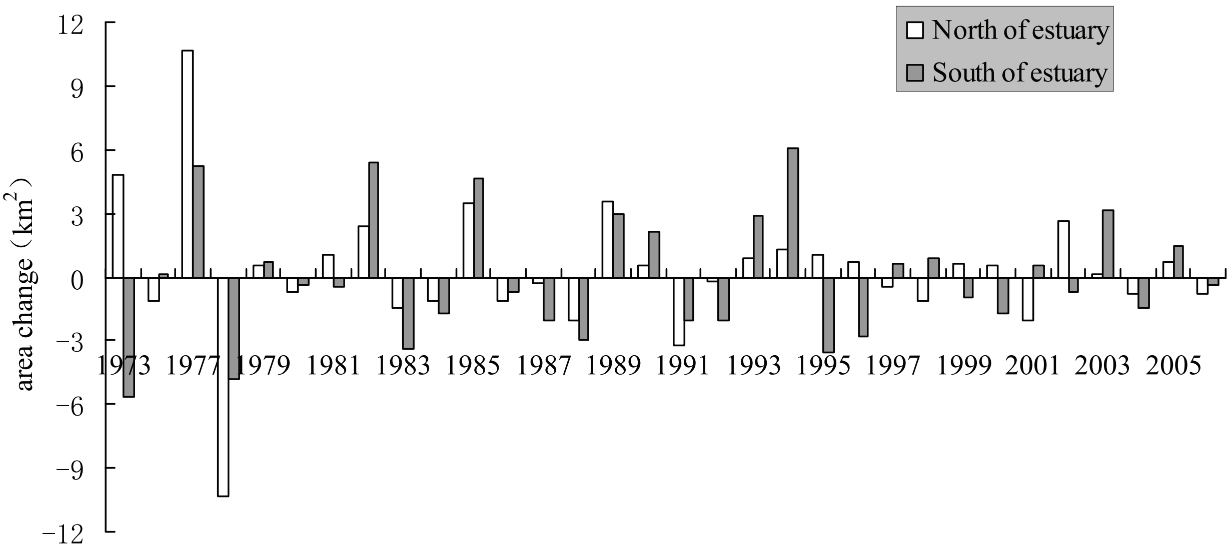

Fig.1 waterline change of retrieved from images at the north and south region of Xiaoqingeh estuary

5. REFERENCES

[1] Rowena D. Moore, Judith Wolf, Alejandro J. Souza, Stephen S. Flint, "Morphological evolution of the Dee Estuary, Eastern Irish Sea, UK: A tidal asymmetry approach", *Geomorphology*, vol. 103, no. 4, pp. 588-596, Feb. 2009.

[2] Huang Haijun, Li Chengzhi, Guo Jianjun, "Application of Landsat images to the studies of the shoreline changes of the Huanghe River delta", *Marine geology & Quaternary geology*, vol. 14, no. 2, pp. 29-37, Jun. 1994. (in Chinese with English abstract)

[3] Helene Burningham, Jon French, "Morphodynamic behavior of a mixed sand-gravel ebb-tidal delta: Deben estuary, Suffolk, UK", *Marine Geology*, vol. 225, no.1-4, pp. 23-44, Jan. 2006.