A STUDY OF TIDAL CHANNEL INFLUENCE UPON SURFICIAL SEDIMENT DISTRIBUTION IN THE GANGHWA-DO SOUTHERN TIDAL FLAT

Jin Ah Eom[1,2], Jong-Kuk Choi[1], Joo-Hyung Ryu[1] and Joong-Sun Won[2]

[1] Korea Ocean Satellite Center, Korea Ocean Research & Development Institute (jina9003@kordi.re.kr)
[2] Department of Earth System Sciences, Yonsei University

1. INTRODUCTION

It is well known that a tidal flat environment has a very close relation to tidal channel development, which is influenced by sedimentation type, grain size, composition, and current energy. However, quantitative analyses of tidal channels based on remotely sensed data have rarely been carried out. Many researchers have applied a fractal-based method to their studies on coastlines or national frontiers [2], [7], [9]. Classifications of drainage networks or single channels have also been attempted based upon fractal analysis [3], [4].

In this study, we examined the spatial relationship between the tidal channel pattern and the surface sediment facies. To this end, we quantified tidal channels in terms of fractal dimension, tidal channel density, and relative distances. These factors indicating the distribution of tidal channels in the study area were compared with surface sediment facies for a quantitative estimation of the relation. We also compared the tidal channel pattern with a digital elevation model (DEM) and the spectral reflectance of high-resolution satellite images. The test was carried out in the Ganghwa-Do southern tidal flat, Korea (Fig. 1).

2. STUDY AREA AND DATA

The Yellow Sea has a great tidal range, consequently the tidal flats are wide. The Ganghwa-Do tidal flat, located in the mid-western part of the Korean Peninsula, is open to the sea and is one of the largest such features on the west coast, covering 105 km^2. Substantial amounts of sediment are deposited from the Han River. The study area represents a variety of environments due to the influences of the Han River mainstream and a tributary [5]. To extract tidal channel data from the study area, we used IKONOS and KOMPSAT-2 images that were acquired on March 28, 2001 and February 16, 2007, respectively.

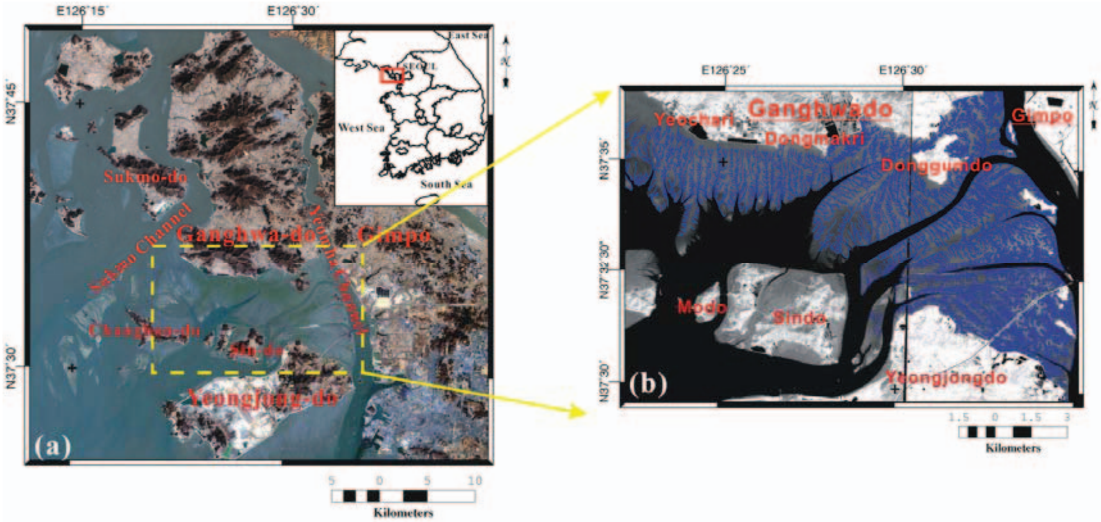

Fig. 1 (a) The location map and (b) the IKONOS satellite image of the study area acquired at Mar. 28, 2001

3. METHODOLOGY

3.1. Estimation of fractal dimension

Fractals are means of describing complicated, irregular features of variation. Fractal geometry was introduced and popularized by Mandelbrot [8], [9] to describe highly complex forms that are characteristic of natural phenomena such as coastlines and landscapes. A popular box-counting method of fractal analysis was used in this study. This approach has been successfully applied to several studies on streams, coastlines, and other linear features [10]. A series of grids with a uniform side length (S) were created. Each grid was independently superimposed on the channels extracted from satellite images. The number of boxes (N) with a certain size that contained a channel was recorded. The value of the fractal dimension (D) is described as follows:

$$D = \lim_{s \to \infty} \frac{\log N(S)}{\log(S)} \qquad (1)$$

3.2. DEM generation

The waterline method exploits the different tide conditions that are rendered in each image as a topographic contour line. The principal tactic in the waterline method is to collect as many images as possible, since the tidal conditions are different in almost all of them. The tidal flat DEM can be generated by stacking all the waterlines acquired over a given short period [6]. The accuracy of the resulting DEM from the waterline method largely depends on the accuracy of the waterline extracted from a given image, and of the absolute elevation assigned to it [1].

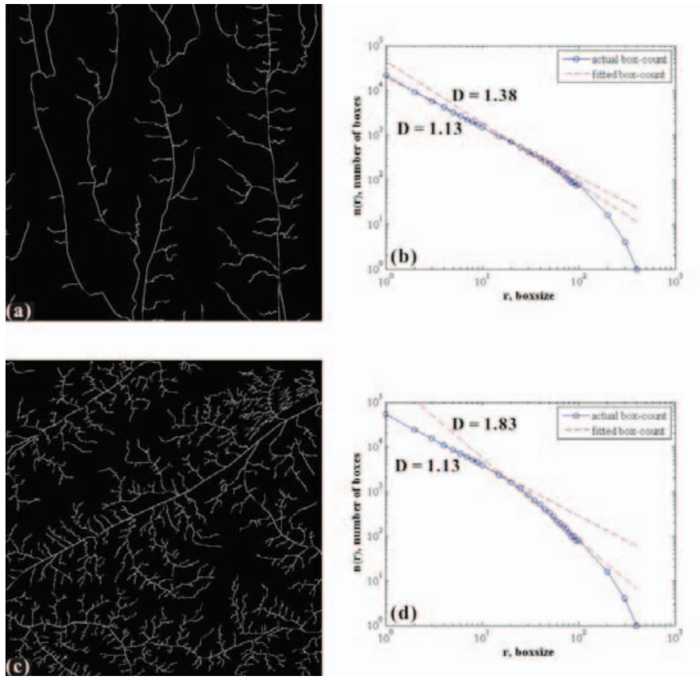

Fig. 2 The fractal dimension (D) estimated for subarea (site 1 and 2 of IKONOS image (a) and (c): Size of subarea in site 1 and site 2 is 1000 m × 1000 m (b) and (d): fractal dimension at each site.

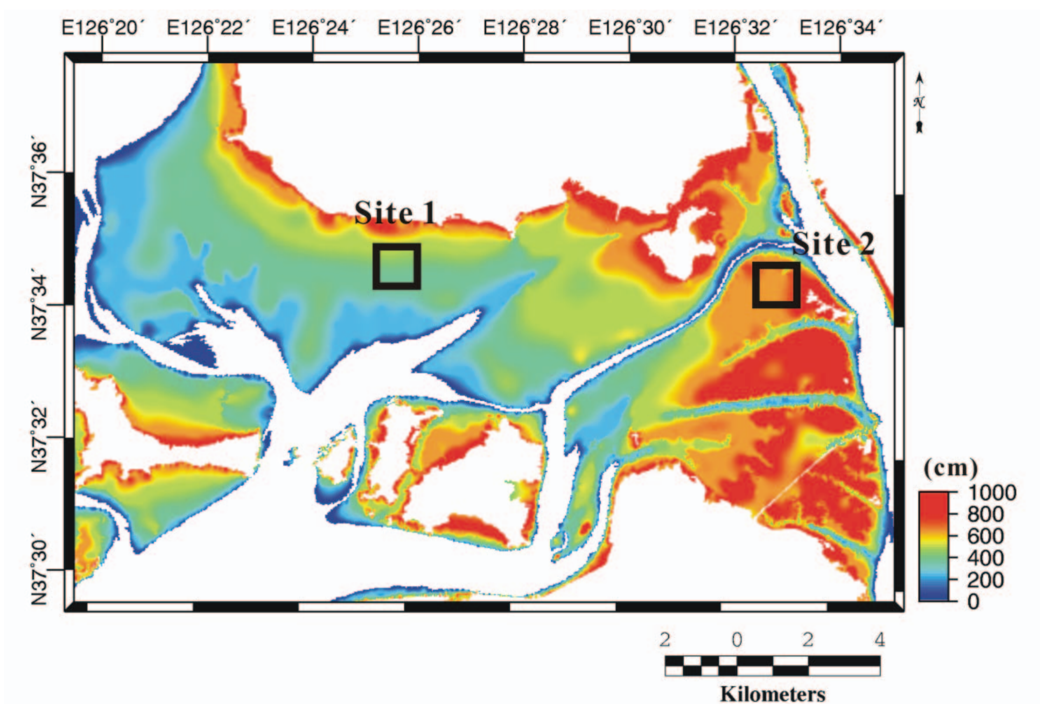

Fig. 3 Intertidal DEMs of the Southern part of the Ganghwa-do

4. RESULTS

Two sub-regions were selected in the study area. Site 1 was located in front of Yeochari where the tidal channel has a simple pattern. Site 2 was located offshore of Yeonjongdo where there is a complex, meandering channel pattern (Fig. 2).

Site 1 was found to be characterized by linear tidal channel patterns of relatively low density and elevation (Fig. 3). Consequently, it showed a low fractal dimension value. By contrast, site 2 showed a dendritic pattern with a relatively high channel density (Fig. 3), and therefore had a high D value. These observations imply that the more complicated the channel pattern, the higher is the fractal dimension. Furthermore, the difference in the fractal dimensions, of about 0.5 between the two test sites, is a relatively large enough difference to be used as an index for tidal channel classification.

We will estimate the tidal channel density and relevant distances from a channel. We will then compare these measurements with a DEM, surface sediment facies, and spectral reflectance. Finally, a comparative study of the fractal dimensions will be the focus of future work.

5. REFERENCES

[1] B. Lohani and D.C. Mason, "Construction of a digital elevation model of the holderness coast using the waterline method and airborne thematic mapper data", *International Journal of Remote Sensing*, 20(3), 593-607, 1999.

[2] B. B. Mandelbrot, "How long is the coast of Britain? Statistical self-similarity and fractional dimension", *Science*, 156, pp.636-638, 1967.

[3] C. Jelmer and P. Q. Albert, "The fractal geometry of tidal-chaanel systems in the Dutch Wadden Sea", *Geologie en Mijibouw*, 78, pp.21-30, 1999.

[4] D. L. Turcotte, "Fractals in geology and geophysics", *Pure and Applied Geophysics*, 131, pp.171-196, 1989.

[5] H. J. Woo and J. G. Je, "Changes of sedimentary environments in the Southern Tidal Flat of Kanghwa Island", *Ocean and Polar Research*, 24, pp. 331-343, 2002.

[6] J. H. Ryu, C. H. Kim, Y. K. Lee, J. S. Won, S. S. Chun and S. Lee, "Detecting the intertidal morphologic change using satellite data", *Estuarine, Coastal and Shelf Science*, 78, pp. 623-632, 2008.

[7] Z. Xiaohua, C. Yunlong and Y. Xiuchun, "On Fractal Dimension of China's Coastlines, Mathematical", *Geology*, 36, pp. 447-461, 2004.

[8] Mandelbrot, B. B., *Fractals: Form, Chance and Dimension*, San Francisco, Freeman, 1977.

[9] Mandelbrot, B. B., *The fractal geometry of nature*, New York, Freeman, 1983.

[10] Turcotte, D. L., *Fractals and Chaos in Geology and Geophysics*, Cambridge Univ. Press, Cambridge. pp. 2-193, 1992.