Detection of the morphologic change on tidal flat using intertidal DEMs

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ABSTRACT: The objective of this study is to detect a inter-tidal topographic change in a decade. Waterline extraction is a one of widely used method to generate digital elevation model (DEM) of tidal flat using multi-temporal optical data. This method has been well known that it is possible to construct detailed topographic relief of tidal flat using waterlines In this study, we generated two sets of tidal flat DEM for the southern Ganghwado. The DEMs showed that the Yeongjongdo northern tidal flat is relatively high elevation with steep gradients. The Ganghwado southern tidal flat is relatively low elevation and gentle gradients. To detect the morphologic change of tidal flat during a decade, we compared between early 1990's DEM and early 2000's DEM. Erosion during a decade is dominant at the west of southern Ganghwado tidal flat, while sedimentation is dominant at the wide channel between the southern Ganghwado and Yeongjongdo tidal flats. This area has been commonly affected by high current and sedimentation energy. Although we are not able to verify the accuracy of the changes in topography and absolute volume of sediments, this result shows that DEM using waterline extraction method is an effective tool for long term topographic change estimation.

KEY WORDS: Tidal flats, DEM, Ganghwado, morphologic change, waterline method

1. INTRODUCTION

Exposure time and topographic relief are of the major controlling elements to the environment of tidal flat. Generally, tidal flats experience dynamic morphologic changes originated by high tidal energy and sediment transportation. Biological environment and surface sediment distribution change according to the morphologic change. Estimating the amount of sediment deposited or eroded can be deduced by precisely estimating topographic changes in the tidal flats (Ryu *et al.*, 2002). Remote sensing has been widely used for monitoring change of the tidal flats within a short or long time on the large area. Field survey combined with remote sensing technique has been accepted as complementary tools in geomorphology (Kevin *et al.*, 1999). The objectives of this study are: (i) to generate intertidal DEMs by the waterline method using Landsat TM/ETM+ images, and (ii) to detect a morphologic change of inter-tidal during a decade by comparison between the DEMs.

2. TEST SITE & DATA

Ganghwado tidal flat locating in the mid-western part of Korean Peninsula is an open type and one of the biggest flats on the west coast of Korea (105km^2) (Fig. 1). Substantial amount of sediments input from the Han River.

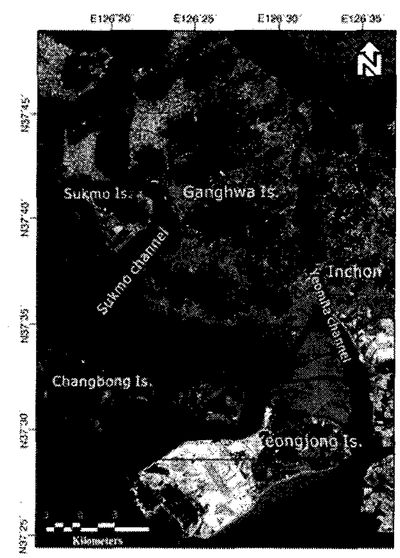

Figure 1. Landsat ETM+ image of the southern tidal flat of Ganghwado acquired on September 23, 2002.

There are two prominent tidal channels (Yeomha channel located in eastern Ganghwado: 300-1500 m wide, Sukmo channel located in western Ganghwado: 1200-3800 m wide). The tides are semi-diurnal, with a mean tidal rage of 6.5m (spring tide = 8 m, neap tide = 4 m). Mud flats are located in the eastern part of the Ganghwado tidal flat, sand flats near the western part, and the mixed flats in the broad transition zone between them (Lee *et al.*, 1992: Woo & Je, 2002: Choi and Dalrymple, 2004). Several land reclamation projects has been occurred on a large scale such as Incheon New Airport project and Choji Bridge.

We acquired a total of 12 sets of satellite images. The images are listed in Table1. Horizental accuracy of less than 0.3 pixel was achieved after geometric rectification. Tide conditions were recorded by a tide gauge during image acquisition.

Table 1. Summary of satellite images used in this study

No.	Sensor	Date	Tide(cm)
1	Landsat TM	90.01.01	731
2	Landsat TM	90.01.20	627
3	Landsat TM	90.04.10	174
4	Landsat TM	90.05.31	440
5	Landsat TM	91.10.22	472
6	Landsat TM	91.12.09	264
7	Landsat TM	99.05.21	803
8	Landsat TM	01.11.18	222
9	Landsat TM	01.12.20	483
10	Landsat TM	02.01.05	633
11	Landsat ETM+	02.01.29	6.3
12	Landsat ETM+	02.09.10	361

3. INTERTIDAL DEM CONSTRUCTION

Waterline method is a one of popularly used methods for DEM construction of tidal flat using satellite image such as Landsat TM and Landsat ETM+. The waterline method is based on three assumptions; (i) that the waterline represents an equal elevation at the moment of image acquisition; (ii) that topographic change is negligible during the period of time-series data acquisition; and (iii) that the absolute elevation of each waterline is known. The extraction of waterlines from multi-temporal satellite data and the absolute elevation assigned to the waterline produce information on the topographic relief of tidal flats.

We extracted waterlines by applying the procedures proposed by Ryu *et al.*, (2002). Tide conditions observed from the nearest station were used for the study area.

4. RESULT AND DISCUSSION

Two Ganghwado intertidal DEMs were constructured for comparison: one for early 1990 and the other from early 2000. To generate the 1990's DEM, we selected six images suitable for an intertidal DEM construction. Absolute elevation was assigned to each waterline using tide gauge data. The minimum curvature interpolation was used for two-dimensional completion. The intertidal 2000's DEM was also constructed.

The obtained DEMs (Fig.2) show that the Yeongjongdo northern tidal flat is relatively high elevation with steep gradients. This tidal flat is clay dominant with heavily developed tidal channels. The Ganghwado southern tidal flat is relatively low elevation with gentle gradients. Inner tidal flat is relatively higher than outer tidal flat. Surface topography is relatively smooth in the outer tidal flat. It is sand and mixed tidal flats and development of tidal channels relatively poor.

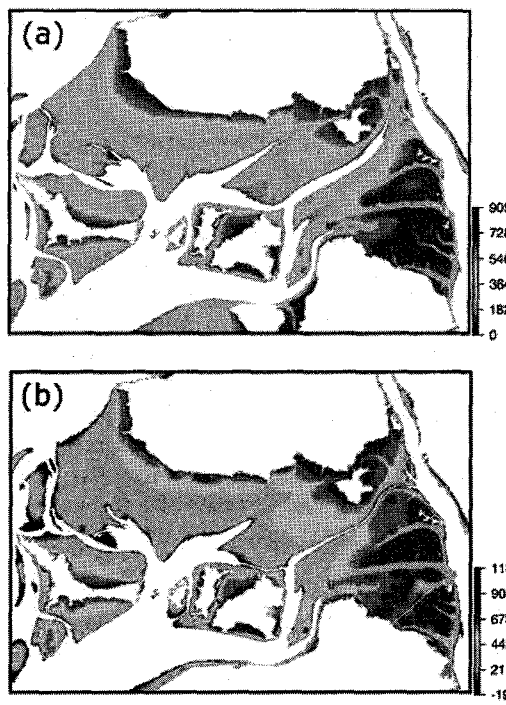

Figure 2. Intertidal DEM constructed by waterline method: (a) DEM'90 and (b) DEM'2000. Red represents relatively high topography, and blue low topography (unit in centimetre).

To detect the morphologic change during a decade, DEM'2000 was subtracted by DEM'90. The change in the Yeonjongdo tidal flat was disregarded because it was an artificial change for construction of Inchon Internatinal Airport. The result is shown in Fig.3 in which sedimentation is presented in red and erosion in blue. Erosion had been dominant during the decade specifically in the west of southern Ganghwado tidal flat. On the contrary, sedimentation had been dominant around the wide channel between the southern Ganghwado tidal flat and the Yeongjongdo tidal flat. High tidal energy and change in sediment flux from Han River could be a reason for that morphologic change. The influence of underwater dams in Jamsil and Singok are not confirmed.

Changes in tidal flat morphology are closely related with potential changes in flow regime. The Han River is a main source of sediment at the tidal inlet. Volumetric change of long-term averaged sediment flux might have affected

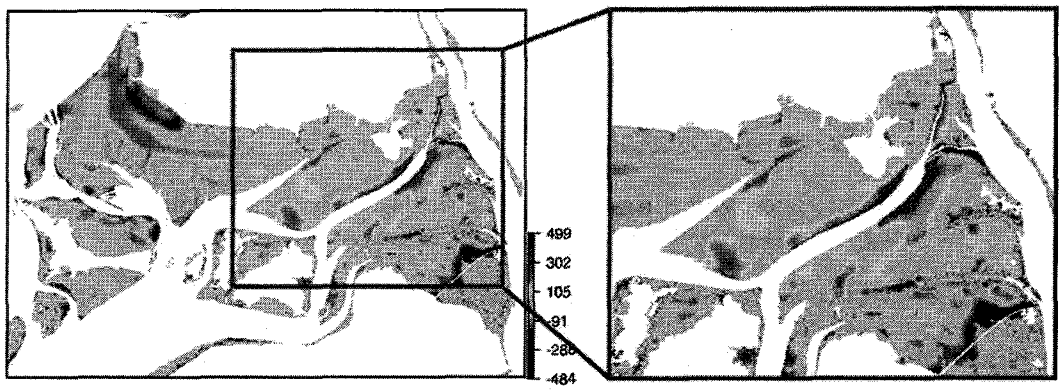

Figure 3. Geomorphologic changes during 1990-2000. Positive value (red) presents accumulation and negative (blue) erosion in centimetre.

sedimentation and erosion process in this area. Construction of the Inchon International Airport also have greatly influenced on tide dynamics in this area, which consequently contributed to changes in sedimentation and erosion rates.

If the DEMs are combined with grain size measured from field sample, one could estimate sediment budget as well as total morphologic change..

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