THE CHANGE OF TIDAL SURFACE SEDIMENT FACIES USING HIGH RESOLUTION REMOTE SENSING BY GIS ANALYSIS

Jong-Kuk Choi[1], Joo-Hyung Ryu[1], and Jin Ah Eom[1]

[1] Korea Ocean Satellite Centre, Korea Ocean Research & Development Institute (jkchoi@kordi.re.kr)

1. INTRODUCTION

Remote sensing techniques have been widely used for the classification of surface sediment facies in tidal flats [1], [2], [3]. Many studies have tried to relate surficial sedimentary environments to the characteristics of satellite images [4], [5], [6]. However, studies on the spatial relationships between optical characteristics and surface sediment distribution have rarely been attempted. A quantitative estimate of the spatial distribution of sediment according to the grades of surface spectral reflectance makes it possible to grasp the characteristics of a tidal flat intuitively. It can also be helpful in detecting changes in sedimentary environments through a comparison with previous quantitative estimates.

In this study we quantitatively estimated the spatial distribution of the tidal surface sediments according to the spectral reflectance strength based on high-resolution remote sensing using a GIS-based probabilistic model. The surface sediment distribution indicated by a satellite image acquired in 2001 was compared with that discerned from a 2008 satellite image. Maps of the tidal surface sediment distribution for each timeframe were generated using an object-based classification method and each sediment map was related to the spectral reflectance. The test was carried out in the Hwang-Do tidal flat of Cheonsu Bay, Korea (Fig. 1a), which is characterized by complex tidal channels in its central part. The sediment facies are comprised of mud flats, mixed flats, and sand flats occurring from the high towards the low waterline.

2. DATABASE

To map the sediment distribution in the Hwang-Do tidal flat, we used IKONOS and KOMPSAT-2 satellite images with a spatial resolution of 4 m. The IKONOS image was acquired on the 26th of February, 2001 and was used for surface sediment classification combined with 43 grain samples (Fig. 1b) collected in March, 2004. The KOMPSAT-2 image from the Korean remote sensing system was acquired on the 8th of April, 2008, and was used for surface sediment classification combined with 28 grain samples (Fig. 1c) collected in May, 2009.

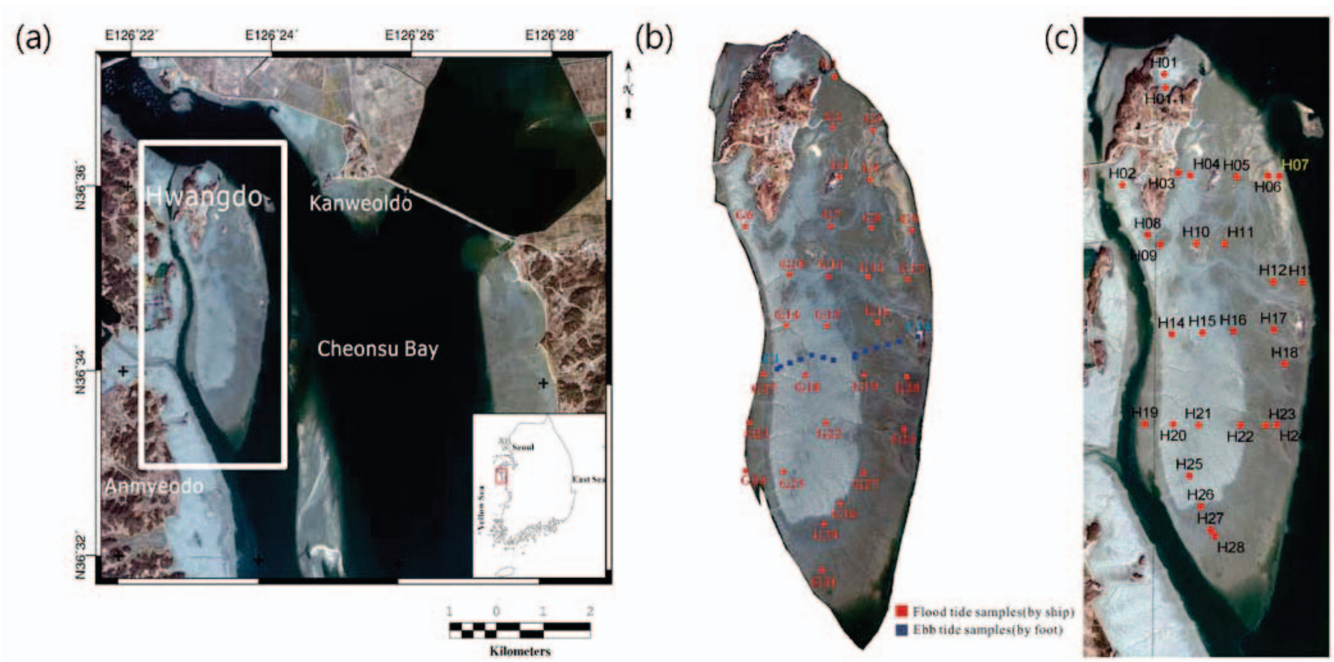

Fig. 1 (a) IKONOS image of the Cheonsu Bay and Hwang-Do tidal flat acquired on Feb. 26, 2001, and the locations of sampling positions for grain size analysis acquired on (b) early March, 2004, and (c) May, 2009.

All the grain size data at each sampling site were classified according to the percentage of grains larger than very fine sand (0.0625 mm) based on Folk's criteria [7]. We classified the samples into the three facies of sand flat (above 70%), mixed flat (30–70%), and mud flat (0–30%). Some of the grain size data were used as a training dataset for the classification and some were used for validation.

3. METHODOLOGY

Mapping of the surface sediment distribution was conducted using the object-based method used for high-resolution satellite images and realized by means of Definiens® Developer 7, commercial software developed for object-based image analysis [8]. A probabilistic frequency ratio model was applied in the quantitative estimation of the spatial relationship between the spectral reflectance of satellite image and each surface sediment facies for each data acquisition event. The model has been widely used to reveal the correlation between a geological event and the factors influencing the event [9], [10]. Based on the result of the frequency ratio model, the percentage of each surface sediment facies for ten classes of spectral reflectance was quantized. The spectral reflectance of each satellite image was represented by the digital number (DN) value.

4. RESULTS

The quantized distribution of each surface sediment facies induced by the IKONOS image and in-situ data of the early 2000s is summarized in Table 1. In the class with the top 10% of low reflectance, 91.23% of the surface sediment facies was sand flat. The percentage of sand flat decreased gradually as the spectral reflectance increased. In the class with intermediate reflectance the mud flat facies was dominant. The higher the spectral reflectance, the greater was the percentage of mud flat facies. Mixed flat also increased as the reflectance increased, but it was never dominant over other facies.

In the most recent case (Table 2), the trend for predominance of sand flat occupancies was preserved. However, mixed flat facies was most prominent within the intermediate reflectance class, and mud flat dominated only in the class belonging to the top 10% of high reflectance. These observations indicate that the percentage of grains larger than very fine sand (0.0625 mm) has increased considerably since the early 2000s. It is concluded that the greater part of the Hwangdo tidal mud flat facies has been exchanged for mixed flat facies over several years. Field work is required in the area of change from mud flat to mixed flat for verification of the sedimentary facies.

Table 1. Spatial distribution of each surface sediment facies according to the spectral reflectance estimated based upon IKONOS image and in-situ data in early 2000s.

Class		Domain	Mud flat (%)	Mixed flat (%)	Sand flat (%)	Sand shoal (%)
IKONOS Digital Number	86-170	44,321	0.37	8.40	91.23	0.00
	170-179	44,941	2.87	10.08	87.05	0.00
	179-187	46,750	9.34	15.11	75.55	0.00
	187-194	42,023	17.36	19.00	63.64	0.00
	194-201	41,284	27.33	19.21	53.47	0.00
	201-209	43,283	40.46	22.38	37.16	0.00
	209-218	39,244	50.17	26.64	23.18	0.01
	218-230	39,895	67.73	20.98	11.20	0.09
	230-246	38,540	91.32	4.47	1.58	2.63
	246-527	37,846	83.95	0.04	0.01	16.00

Table 2. Spatial distribution of each surface sediment facies according to the spectral reflectance estimated based upon KOMPSAT-2 image and in-situ data in recent years.

Class		Domain	Mud flat (%)	Mixed flat (%)	Sand flat (%)	Sand shoal (%)
KOMPSAT-2 Digital Number	0-245	44,515	0.00	0.74	95.88	0.00
	245-252	43,561	0.01	4.99	93.78	0.00
	252-258	45,952	0.10	19.05	80.48	0.01
	258-264	44,111	0.97	40.06	58.78	0.05
	264-270	49,461	4.26	53.26	42.29	0.16
	270-275	42,613	12.44	57.62	29.35	0.56
	275-280	44,022	23.48	58.51	16.76	1.24
	280-285	39,510	34.16	55.59	8.84	1.39
	285-292	35,778	45.13	48.04	5.03	1.78
	292-477	35,222	57.30	29.71	3.89	9.06

5. CONCLUSIONS

This study showed that a quantitative estimate of the spatial distribution of surface sediments according to the grades of spectral reflectance makes it possible to detect changes in sedimentary environments through a comparison with quantitative estimates made at other times. Estimates can be effectively achieved by GIS-based probabilistic models based upon high-resolution remote sensing.

6. REFERENCES

[1] M.G. Yates, A.R. Jones, S. McGrorty, and J.D. Goss-Custard, "The use of satellite imagery to determine the distribution of intertidal surface sediments of the Wash, England", *Estuarine Coastal and Shelf Science*, 36(4): 333-344, 1993.

[2] M.P. Rainey, A.N. Tyler, D.J. Gilvear, R.G. Bryant, and P. McDonald, "Mapping intertidal estuarine sediment grain size distributions through airborne remote sensing", *Remote Sensing of Environment*, 86: 480-490, 2003.

[3] R.J. Zomer, A. Trabucco, and S.L. Ustin, "Building spectral libraries for wetlands land cover classification and hyperspectral remote sensing", *Journal of Environmental Management*, 90: 2170-2177, 2009.

[4] R. Doerffer, and D. Murphy, "Factor Analysis and Classification of remotely sensed data for monitoring tidal flats", *Helgolander Meeresunters*, 43: 275-293, 1989.

[5] J.H. Ryu, Y.H. Na, J.S. Won, R. Doerffer, "A critical grain size for Landsat ETM+ investigations into intertidal sediments, A case study of the Gomso tidal flats, Korea", *Estuarine Coastal and Shelf Science*, 60 (3): 491-502, 2004.

[6] D.C. Mason, T.R. Scott, and H.J. Wang, "Extraction of tidal channel networks from airborne scanning laser altimetry", *Isprs Journal of Photogrammetry and Remote Sensing*, 61: 67-83, 2006.

[7] R.L. Folk, "A review of grain size parameters", *Sedimentology*, 6: 73-93, 1968.

[8] S.J. Walsh, A.L. McCleary, C.F. Mena, Y. Shao, J.P. Tuttle, A. Gonzalez, and R. Atkinson, "QuickBird and Hyperion data analysis of an invasive plant species in the. Galapagos Islands of Ecuador: Implications for control and land use management", *Remote Sensing of Environment*, 112(5): 1927-1941, 2008.

[9] K.D. Kim, S. Lee, H.J. Oh, J.K. Choi, and J.S. Won, "Assessment of ground subsidence hazard near an abandoned underground coal mine using GIS", *Environmental Geology*, 50: 1183-1191, 2006.

[10] S. Lee, and T. Sambath, "Landslide susceptibility mapping in the Damrei Romel area, Cambodia using frequency ratio and logistic regression models", *Environmental Geology*, 50: 847-855, 2006.