

MONITORING OF BAR TRANSFORMATION IN THE HAN RIVER ESTUARY USING RADARSAT/SAR IMAGES

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ABSTRACT In river with bar, the characteristics of its physical conditions have a close relationship with bar morphology. In this paper, a monitoring approach of bar transformation in the Han River Estuary is presented using RADARSAT/SAR Images. The estuary is divided into North and South Korea and its area is blocked by CCL(Civil Control Line). Satellite remote sensing, therefore, is uniquely suited to monitoring bar transformation. Based on SAR signatures for bars, bar transformation is investigated from 2000 to 2005, and monitoring of suspended-silt transportations from terrestrial runoff is tried to understand the morphology during the events of severe rain storm. SAR data did not reveal clearly the bar locations because of most of data acquisitions during high tides from 6.8 m to 9.0 m. Even though the problem, it could be said that in the estuary vegetated area and natural levees are developed well, but bars are shifted after an event like a flood. It is also showed that suspended solids such as silt transported through the estuary could contribute highly to a sedimentation environment around Incheon.

KEY WORDS: Han river, Estuary, Bar transformation, SAR, Radarsat-1

1. INTRODUCTION

The Korean Peninsula is divided to South Korea on the southern half and North Korea to the north with 238 km of border running along the Demilitarized Zone (DMZ). The DMZ is a 4,000-meter-wide strip of land that runs

along the line from the east to the west coasts for a distance of 241 km. However, the sea boundary with North Korea is NLL (Northern Limit Line) as shown in Fig. 1.

The Han River located in South Korea, is the confluence of the South Han River, which originates in

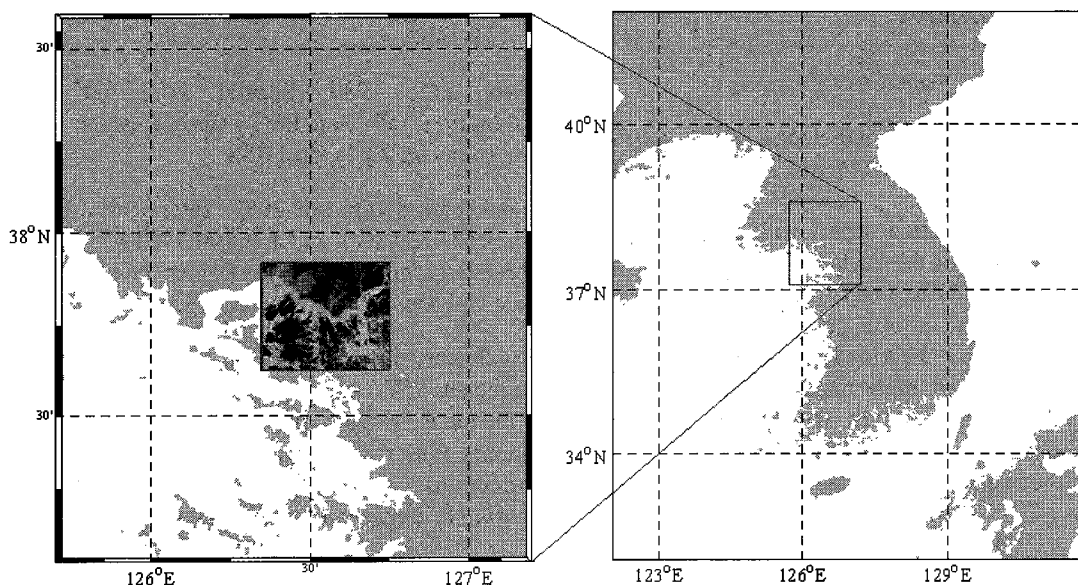


Figure 1. Research area for the Han River Estuary, Korea. The estuary is connected to the Yellow Sea, the Yeseong River and the Imjin River. An image in the left figure is produced from SPOT-5 multispectral data.

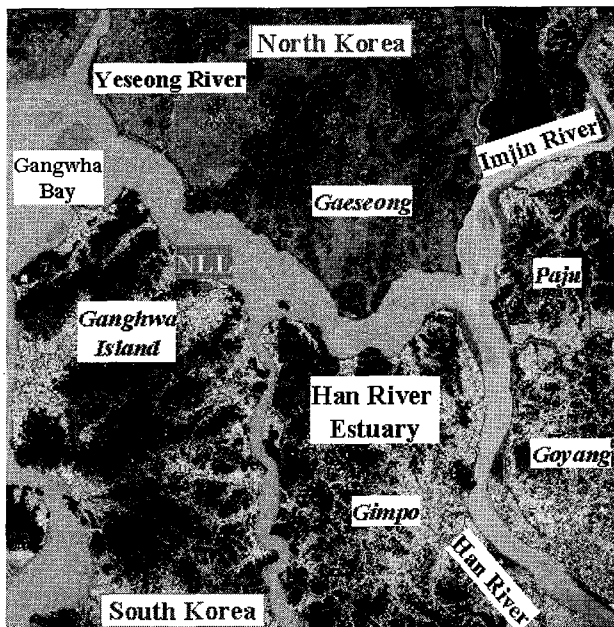


Figure 2. SPOT-5 color composite image for the research area acquired on October 22, 2005. Northern Limit Line(NLL) represents the sea boundary between the two Koreas on the Korean Peninsula. Fresh water from rivers such as the Han, the Imjin and the Yeseong flow to the Yellow Sea through Gangwha Bay.

Mount Daedeok (Samcheok, Gangwon Province), and the North Han, which originates in Mount Geumgang (Gangwon Province). The Han River flows through Seoul to empty into the Yellow Sea. The total distance of the Han River is 481.7 km. Although it is not a long river, the lower Han is remarkably broad for such a relatively short river. Within Seoul limits, the river is more than 1 km wide. The Imjin River, a tributary of the Han flows through both North Korea and South Korea and forms an estuary with the Han River. The major rivers flow north to south or east to west and empty into the Yellow Sea or the Korea Strait. They tend to be broad and shallow and to have wide seasonal variations in water flow.

The Han River Estuary (Figs. 1 and 2) has a free connection with the Yellow Sea and within which seawater mixes with fresh water from the Han River. The estuary encompasses the Yellow Sea to the west, the Yeseong River flowing to the south and the Imjin River, a tributary of the Han River. The key feature in the waters is that the typical tidal range is about 8 to 10 m and then a tide is a force to maintain a dynamic relationship at the meeting between the two waters. The estuary is often characterized by sedimentation of silt carried in from terrestrial runoff. About two-thirds of the annual precipitation occurs between June and September.

For the past half century, the Han River Estuary has preserved because its area is blocked by CCL(Civil Control Line) or NLL as shown in Fig. 2. In this paper, bar transformation and silt transportation in a natural

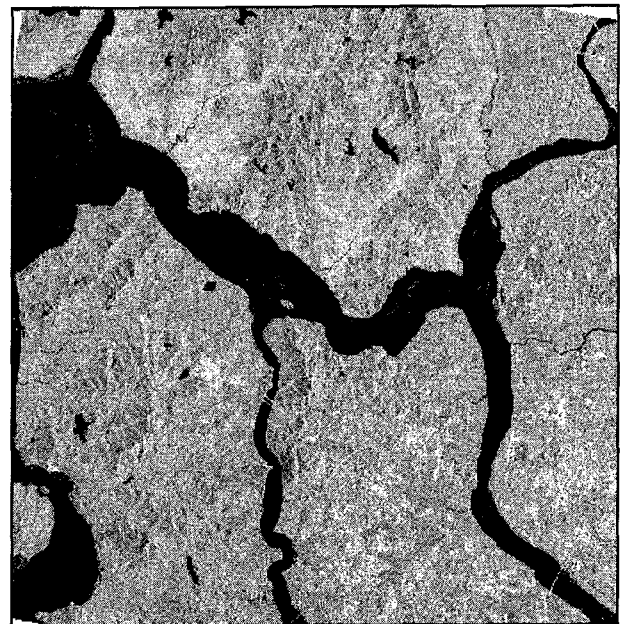


Figure 3. Radarsat-1 SAR image for the research area acquired on August 10, 2005.

river are investigated from 2000 to 2005 using Radarsat-1 SAR imagery.

2. SAR IMAGE DATA: FINE AND STANDARD MODE

RADARSAT-1 satellite SAR data were acquired and processed at the Korea Earth Observation Center (KEOC) as shown in Table 1. SAR image is calibrated to geophysical (sigma naught) values of radar cross section (RCS) even if data numbers (DN) on these detected images can be viewed as indicating relative radar backscatter intensities.

Incheon with a tidal level measurement site has a large tidal range, which amounts to over 9 meters in height. Rainfall is on an average 103 days a year, the rainy season starts in July and tapers off in August. The heights of tide at each data acquisition are listed in Table 1.

Table 1. Radarsat-1 SAR data and tidal conditions

Date	Mode	Beam	Incidence Angle	Height of Tide (m)
August 29, 2000	Standard	S5/Descending	41-46°	9.0 (H->L)
September 1, 2000	Standard	S3/Ascending	34-40°	8.7 (L->H)
July 31, 2001	Fine	F2/Descending	39-42°	5.1 (H->L)
August 13, 2001	Standard	S6/Ascending	45-49°	3.5 (L->H)
December 25, 2003	Fine	F4/Ascending	43-46°	8.7 (L->H)
February 23, 2005	Standard	S7/Descending	39-42°	6.8 (H->L)
August 10, 2005	Standard	S7/Descending	39-42°	6.9 (L->H)

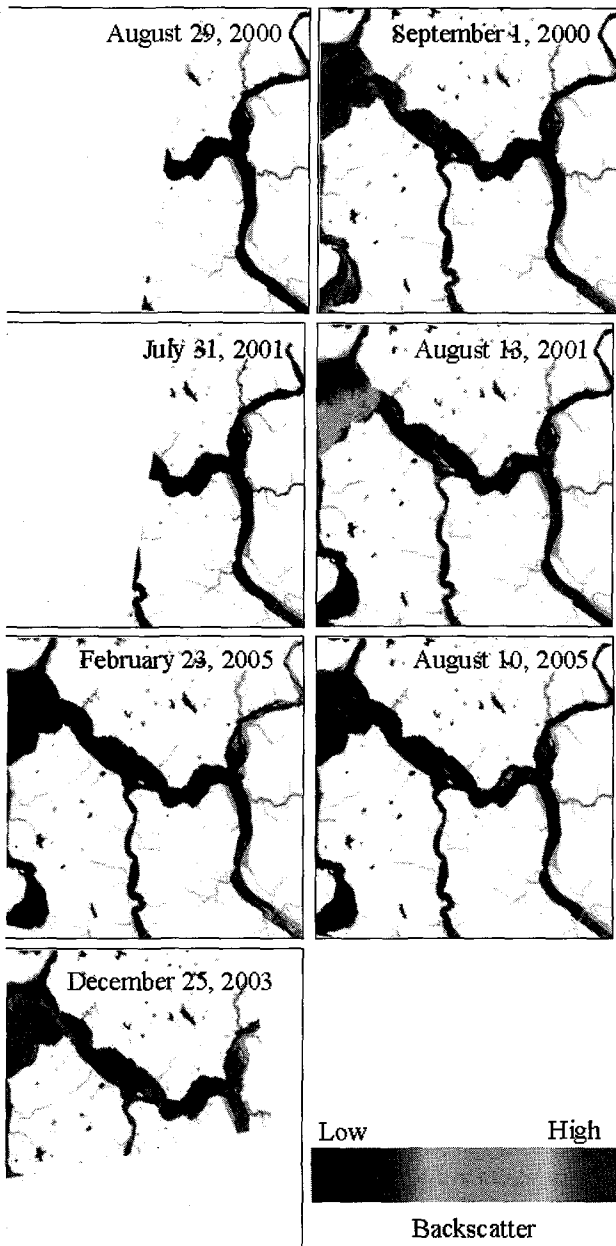


Figure 4. Results from backscatters for Radarsat-1 SAR images listed in Table 1.

Figure 3 shows Radarsat-1 SAR image for the research area acquired on August 10, 2005.

3. RESULTS

Temporal changes of bars and vegetation zones are shown in Figs. 4 to 7. Since the heights of tide at the time of the SAR overpass are more than 3.5 m with an average height of 7.0 m, silt or mud bars do not appear distinctly different from vegetated areas.

August to September 2000: Daily flows during the period of SAR acquisition are 2 to 4 times as high as daily means. In addition to that, tidal heights range from

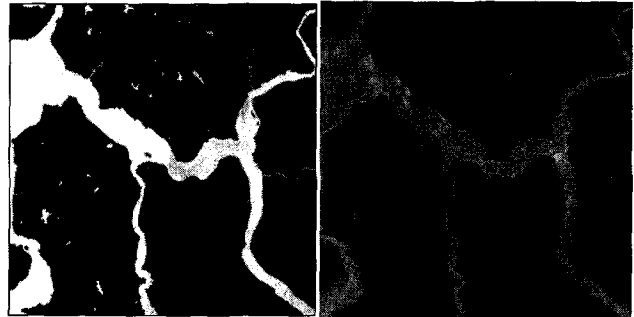


Figure 5. Classification of silt and its bar by RADARSAT images: August 29, 2000 (left) and September 1, 2000 (right). Red: High backscatter, Green: Moderate backscatter, Blue: Low backscatter.

8.7 m to 9.0 m. But the measurement site is located more than 50 km away from the center of research area. Masked images were used to generate four different values as follows:

- Vegetated area: high reflectance
- Sand or silt bar: medium reflectance
- Suspended substance or flowing silts: low reflectance
- Water area

The left image of Fig. 5 shows comparatively low values under a high tide, while the right one explains morphology of the Han River Estuary just after several days of heavy rains.

August 2001: Heavy rains (about 173 mm) from July 30 to August 1 caused floods and mudslides. Waters (left figure of Fig. 6) originated from flood made very bright returns throughout all channel than the right image acquired under normal conditions.

Multi-temporal color composite of Radarsat-1 SAR imagery is shown in Fig. 6 using the following images: Red: August 10, 2005, Green: August 13, 2001, Blue: September 1, 2000.

Based on SAR signatures for bars, bar transformation is investigated from 2000 to 2005, and monitoring of suspended-silt transportations from terrestrial runoff is tried to understand the morphology during the events of severe rain storm. SAR data did not reveal clearly the bar locations because of most of data acquisitions during high tides from 6.8 m to 9.0 m. Even though the problem, it could be said that in the estuary vegetated area and natural levees are developed well, but bars are shifted after an event like a flood. It is also showed that suspended solids such as silt transported through the estuary could contribute highly to a sedimentation environment around Incheon.

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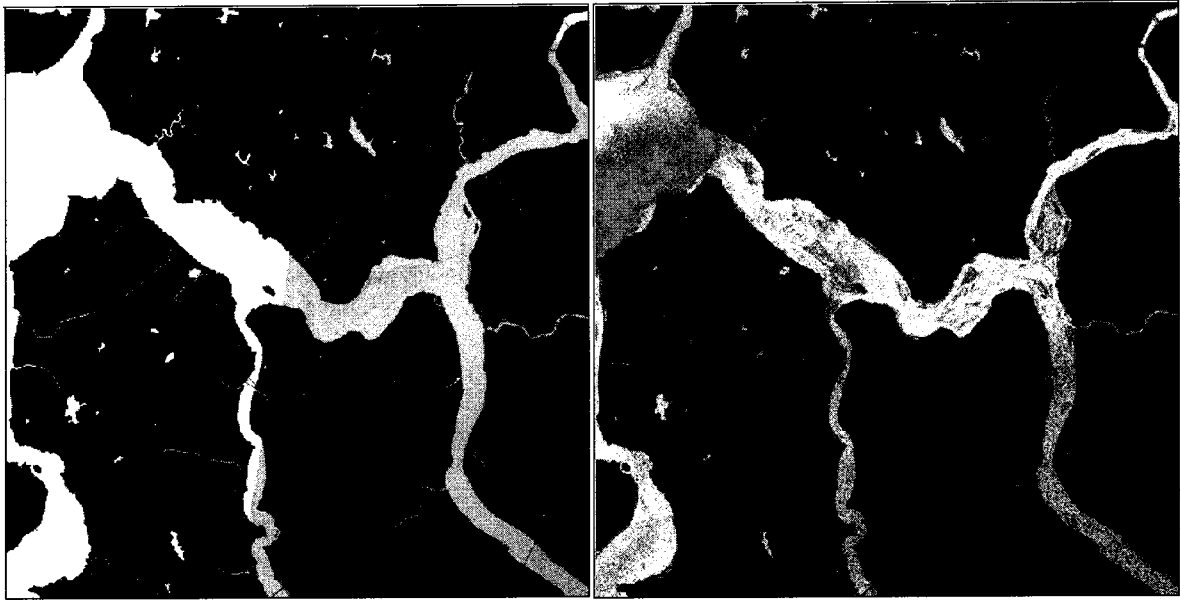


Figure 6. Classification of silt and its bar by RADARSAT images: July 31, 2001 (left) and August 13, 2001 (right). Red: High backscatter, Green: Moderate backscatter, Blue: Low backscatter.

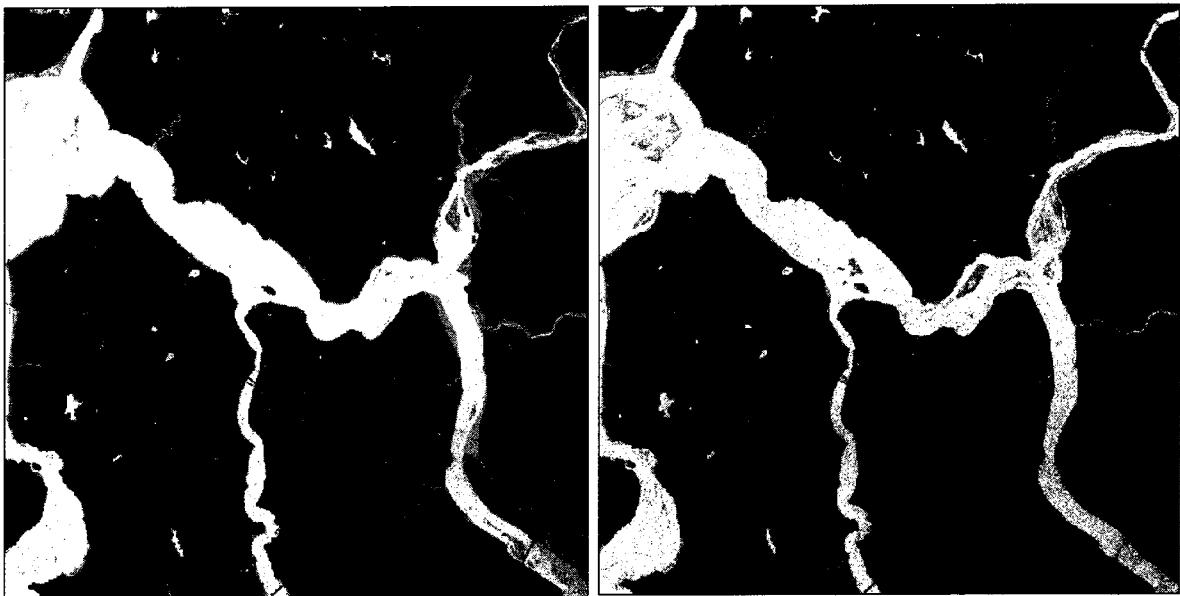


Figure 7. Classification of silt and its bar by RADARSAT images: February 24, 2005 (left) and August 10, 2005 (right). Red: High backscatter, Green: Moderate backscatter, Blue: Low backscatter.