論 文

한강하구 뱃길 개발을 위한 하구역 퇴적상 변동 조사

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Bar Morphological Changes for Navigation Route Design with Environmental Affinity in the Han River Estuary

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요 약 : 북방한계선 주변의 한강하구는 지난 60년 동안 개발 및 이용이 금지되었기 때문에, 자연하천의 모습을 간직하고 있다. 그러나 최근 들어 경인수로를 비롯한 민간 이용을 위한 논의가 이루어지고 있으나, 한강하구의 기본적인 특성에 관한 정보가 부족한 실정이다. 본 연구에서는, 인공위성 합성개구레이더(SAR)를 이용한 하구역 퇴적상의 변동 조사를 실시하고, 퇴적상을 기반으로 한강하구 뱃길을 제안하고자 한다. 2000년부터 2005년까지의 Radarsat-1 영상을 이용하여 시계열해석한 결과에 따르면, 1) 한강 하구역은 집중호우등 에 의해 부유사가 많이 발생하며, 2) 식생역(vegetated area)은 거의 안정화단계에 있으며, 3) 퇴적상(bar)의 월 변동성은 크지 않으나, 매년 발생하는 호우등에 의해 퇴적상의 위치 변화는 상당히 컸다. 여기서 얻어진 퇴적상의 변동 특성을 기반으로, 북방한계선 이남의 한강 수역에 대한 뱃길의 설계 방향을 제시하였다. 향후, 장기간에 대한 위성 및 현장 조가를 바탕으로 자연하천의 특성을 훼손하지 않는 범위에서의 개발이 이루어져야 한다.

핵심용어 : Bar Morphological Change, Navigation Route Design, Han River Estuary, SAR, Radarsat-1

1. 서 론

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 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

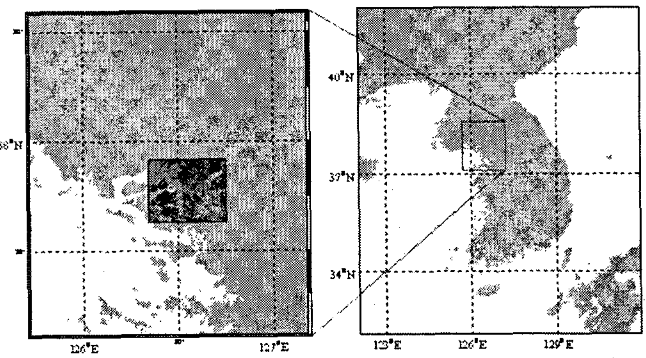

Fig. 1. Research area for the Han River Estuary, Korea. The estuary is connected to the Yellow Sea, the Yeseong River and the Imjin River. An image in the left figure is produced from SPOT-5 multispectral data.

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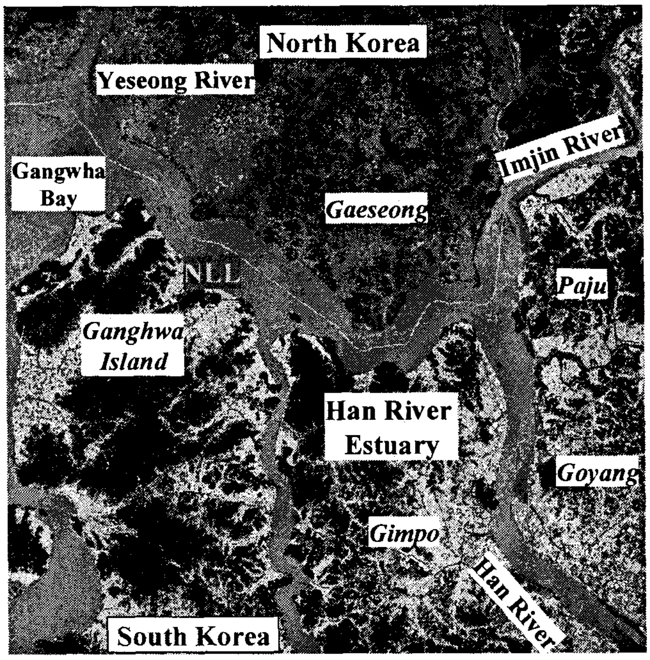

Fig. 2. SPOT-5 color composite image for the research area acquired on October 22, 2005. Northern Limit Line(NLL) represents the sea boundary between the two Koreas on the Korean Peninsula. Fresh water from rivers such as the Han, the Imjin and the Yeseong flow to the Yellow Sea through Gangwha Bay.

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

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: Ebb)
September 1, 2000	Standard	S3/Ascending	34-40°	8.7 (L->H: Flood)
June 13, 2001	Standard	S6/Descending	41-46°	4.5 (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)
September 17, 2001	Fine	F3/Descending	41-44°	8.5 (H->L)
December 25, 2003	Fine	F4/Ascending	43-46°	8.7 (L->H)
September 21, 2004	Standard	S5/Ascending	36-42°	3.9 (L(1500h:1.1)->H)
November 8, 2004	Standard	S5/Ascending	36-42°	3.7 (H(1400h:6.4)->L)
December 2, 2004	Standard	S5/Ascending	36-42°	6.9 (L(1400h:1:3)->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)

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 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.

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

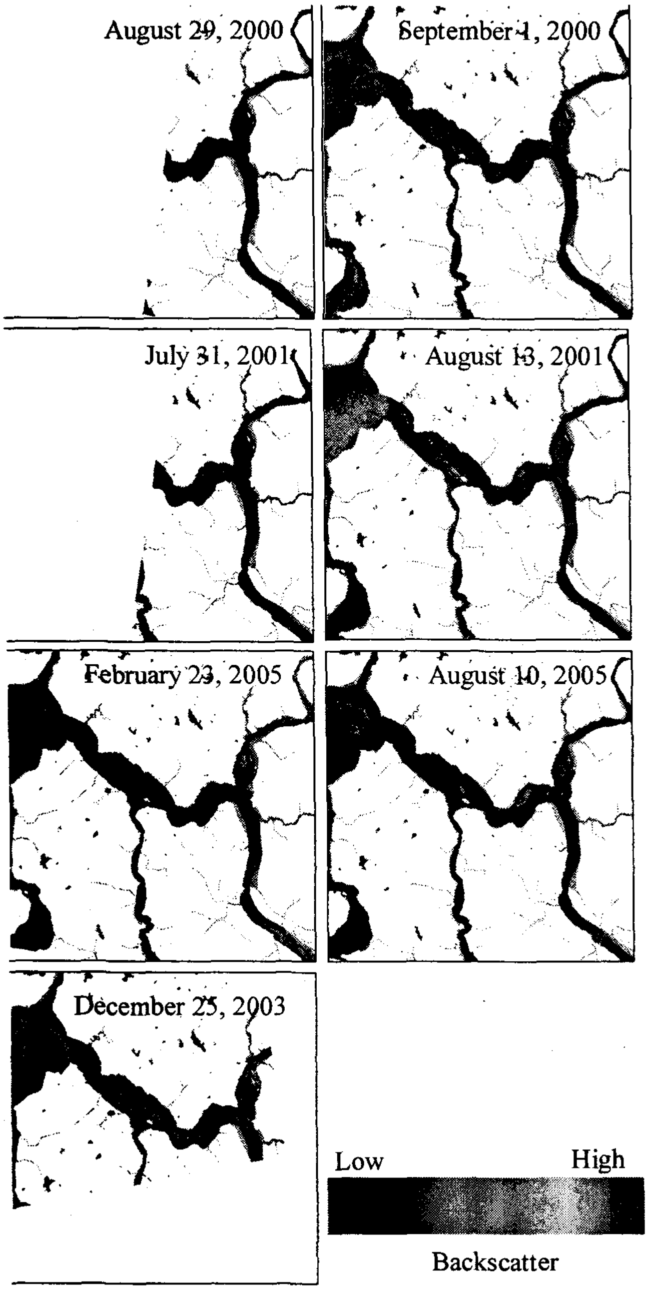

Fig. 4. Results from bascatters for Radarsat-1 SAR images listed in Table 1.

3. RESULTS

Temporal changes of bars and vegetation zones are shown in Figs. 4 to 6. 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 8.7 m to 9.0 m.

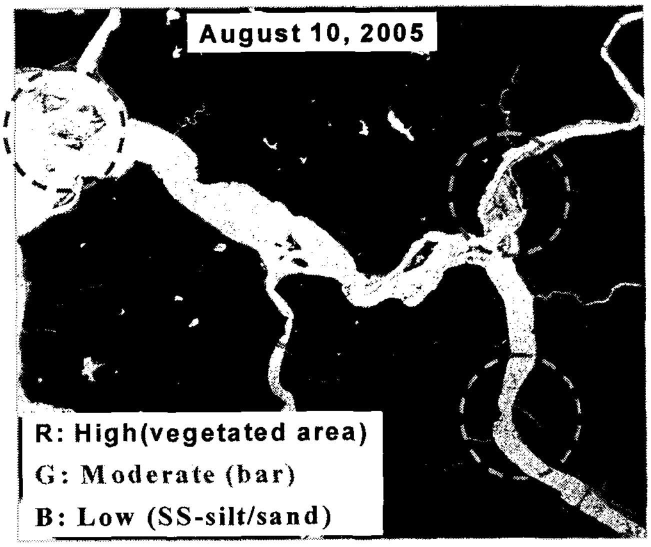

Fig. 5. Suspended-silt transportations from terrestrial runoff during the events of severe rain storm obtained from RADARSAT image on August 10, 2005. Red: High backscatter, Green: Moderate backscatter, Blue: Low backscatter.

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 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 originated from flood made very bright returns throughout all channel than the right image acquired under normal conditions.

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.

4. Summary

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.

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A navigational route could be designed with a minimum width of about 200m.

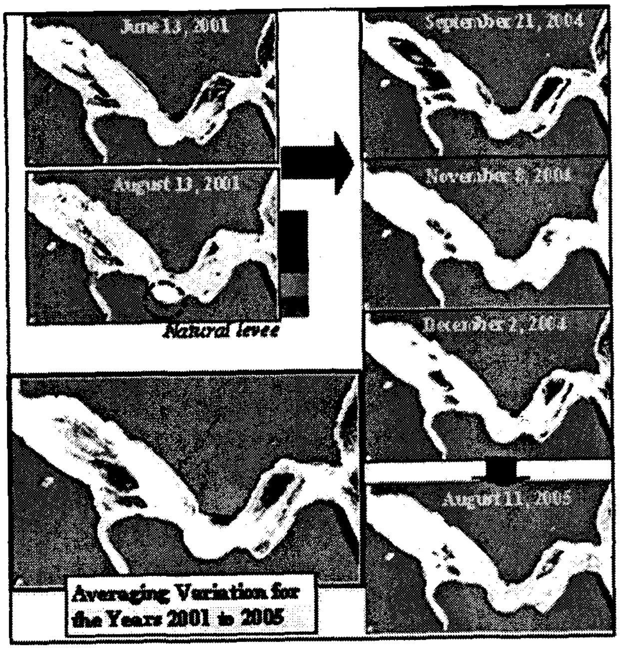

Fig. 6. Temporal distribution and averaging variation of bar morphology by RADARSAT images from June 13, 2001 to August 11, 2005.

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