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Exploring and Testing Satellite Imagery to Historical Geography*

Eunmi Chang* · Kyeong Park**

위성영상의 문화역사지리학적 활용 가능성에 대한 탐색*

장은미* · 박 경**

Abstract : Both Geographic Information System and Remote Sensing fields have been nearly neglected or ignored by historical geographers. This paper intends to show the potentiality of satellite images of various spatial resolutions to explore and to express themes of historical geography. Old Chinese maps and atlas were also used to relate the digital values and historical factors. Advanced Very High Resolution Radiometer data might be used as a real image for a continental scale to show changes in coastal shoreline. Landsat Thematic Mapper Imagery of Beijing showed some of boundaries of old palaces. Finally IKONOS images of one meter resolution showed detailed information of landcover and landuse of the City, Beijing. The potential capability and limitation to apply satellite imagery in application of historical geography are also discussed.

Key Words : satellite imagery, historical geography, china, detection, analysis, integration

요약 : 문화역사지리학회지의 논문을 총괄해 보면, 지리정보시스템과 원격탐사 분야에 대한 전통적인 역사지리학자들의 입장은 크게 학문적인 발전 도구로서 인정하려는 경향과 더불어 적극적인 수용 입장을 보이지 않은 것으로 보인다. 역사지리학적 사실을 탐구하거나 그 결과물을 표현하는 방식으로서 위성영상의 활용방안에 대한 다양한 접근을 시도해 본 결과, 상이한 공간해상도를 갖는 위성영상이 여러 수준의 정보를 포함할 수 있다는 것과 축척의 개념을 역사지리의 내용으로 활용할 수 있었다. 역사지리지도집의 내용과 AVHRR 기상위성 자료의 시기별 중첩을 통해 중국의 상하이 지역 해안선의 변화에 대한 이해를 명확히 할 수 있으며, 전문적인 위성영상의 분석과정을 생략하고도 많은 정보를 전달할 수 있는 매개체로 활용할 수 있음을 확인할 수 있다. 본 연구에서는 Landsat Thematic Mapper와 IKONOS 영상과 옛 성곽의 경계를 중첩한 결과를 상호 분석하였다. 고고학에서 적극 수용하는 정보기술의 활용에 관한 활발한 논의에 기초하여 역사지리학에서 위성영상과 지리정보시스템을 활용할 때 기대할 수 있는 활용성과 발생할 수 있는 문제점을 논의하였다.

주요어 : 원격탐사, 지리정보시스템, 문화역사지리, 중국, 탐사, 분석, 종합

1. Preface

1) Background

If we assume the distance between historical geography and cultural geography is less than 5 unit over one hundred units, it will be over fifty or near ninety to apply the distance between historical geography and geographic information system including remotely sensed data. It will be cautious to apply new technologies to historical geography, even in spite of long argument and efforts to extract the common identity of geography. In the side of historical or traditional geographers tend to consider GIS as a tool to handle or express data. On the other hands, GIS experts consider that geographic information system should be considered not only as a methodology but also as a field of science, that is to say geographic information science. The tendency of convergence among the disciplines has been strengthened but the gaps between the sub field of geographers become wide.

There was a good trial for a GIS expert to cite the

* CTO, 3G Core, Inc.
** Senior Research Scientist, National Park Research Team, Korean National Parks Authority

Bible and literature. Michael Goodchild (2000) made a presentation of the role of geographic information system to understand digital earth in the age of information technology. It will be a trial to fuse themes historical geography, remotely sensed data and GIS by reviewing the number of articles to merge the themes in four journals such as Annals of Korean Cultural and Historical Geography, Journal of Historical Geography, Photogrammetric Engineering and Remote Sensing, International Journal of Remote Sensing.

2) Purposes

This article aims to overview the current interactive status of two sides: historical geographers and GIS including satellite images. The fusion of both sides might extends the knowledge of geography and enhance the quality of geographical contents in education. The second aim is to apply satellite images with different spatial resolutions to compare the level of information which may be utilized by historical geographers. The final purposeis to discuss the potentiality and limitations of satellite imagery.

3) Methods

(1) Processing of Satellite Imagery and Geographic Information System

Spatial resolution is the actual distance in the earth that one pixel represents. Each pixel in an image corresponds to a small area of that image; ideally, we would choose the area to be small enough so that a single measurement of brightness is enough to pleasingly represent that region of the image to the viewer. This process of breaking a continuous image into a grid of pixels is sometimes called pixelization, sampling, scanning or spatial quantization. Sensors equipped to satellite have different pixelization schemes. High spatial resolution data covers smaller areas than lower resolution data when the size of the data is the same. We chose three levels of satellite data, AVHRR(Advanced Very High Resolution Radiometer), TM(Thematic Mapper), IKONOS. The degree of conciseness and precisions of remotely sensed data in historical geography might be less strict than that of geodesy or geometric engineeing, preprocessing of AVHRR data was omitted. Geometric correction was done for the data of TM and IKONOS, based on topographic maps using Imagine (Erdas, 2000).

(2) Digitizing of Historical Maps

Coastal lines of Zhangsui Province north to City of Shanghai was headup digitized which was archived in Chinese Historical Atlas with the 1: 500,000 scale. Han, Wuhan, Sui, Tang, Ming, Ching, and current coastal line overlaid respectively with data of stretched AVHRR. Coastal lines of Chungmin Islands east to Shanghai spanning 1900 to 1986 were digitized. TM data in the Beijing areas were composited in false colors overlayed with old boundaries of capital city of Beijing, Wuan, Ming, Ching, current to explore whether there is any signals of old boundaries of the past. With one-meter resolutions of IKONOS data were also compared with TM data and the vector data.

(3) Counting and Categorizing of the Articles

The Annals of Korean Cultural and Historical Geographers from 1993 to 1999 were reviewed whether they included satellite images or geographic information system. Journal of Historical Geography published by International Congress of Historical Geographers were reviewed at the same way. To compare Korean situation with international view, we set the extent of period to start in 1993 when the first volume of Annals of Korean Cultural and Historical Geographers was published. Journal of Korean Geographic Information System is a representative journal with the longest history in GIS and Journal of Korean Society of Remote Sensing is

one of the interdisciplinary journal covering remote sensing which publish the most articles and short reports since 1985. Photogrammetric Engineering and Remote Sensing, and International Journal of Remote Sensing were chosen each for the members of each society rank first and second in the field. Annals of Korean Historical Geography and Journal of Historical Geography were chosen as domestic journal and as international journal in the field of historical geography.

2. Bodies

1) GIS and RS in the aspect of historical geography

(1) GIS and Remotely Sensed data in Historical Geography

Table 1 and Table 2 showed that the interaction between historical geographers and GIS experts is a small portion of in both sides (1.56 percent) whether domestic academy of Korea or internal society.

The Aerial Archaeology Research Group (AARG) provides a forum for the exchange of ideas and information for all those actively involved in aerial photography, photo interpretation, field archaeology and landscape history. This also includes the use of aerial photography in defining preservation policies for archaeological sites and landscapes.

(2) Historical themes in fields of GIS and Remote Sensing

Remote Sensing was more actively adopted by archaeologists than historical geographers.

The categories of historical themes can be grouped in three types of technical approach, theoretical approach and descriptive approaches.

① Technical approach with experimental scheme:

The Spaceborne Imaging Radar- C/X -band Synthetic Aperture Radar(SIR-C/X-SAR) mission was a cooperative endeavor of the United States, Germany, and Italy. The SIR-C/X-SAR scientific research program was a large international cooperative program of radar for Earth observation

Table 1. The comparison of the numbers of articles between historical geography and GIS

Journal	published years	the total numbers of articles	the number of articles including GIS and Remotely Sensed Data
Annals of Korean Cultural and Historical Geography	1993	8	0
	1994	9	0
	1995	7	0
	1996	10	0
	1997	10	0
	1998	6	0
	1999	9	0
	2000	9	0
	Total	68	0
Journal of Historical Geography	1993	25	0
	1994	31	1
	1995	12	1
	1996	27	0
	1997	31	0
	1998	26	0
	1999	50	1
	2000	54	1
	Total	256	4

Table 2. The Number of Historical Themes in Journal of GIS and RS

Journal	year of publish	the total number of articles		the number of articles with themes of Historical Geography
Journal of Korean Geographic Information System + Journal Korean Society of Remote Sensing	1993	8	10	0
	1994	19	10	0
	1995	17	15	0
	1996	14	22	0
	1997	15	18	0
	1998	17	26	0
	1999	22	29	0
	2000	-		0
	Total	241		0
Photogrammetric Engineering and Remote Sensing + International Journal of Remote Sensing	1993	-	-	
	1994	76	-	0
	1995	77	-	3
	1996	84	-	1
	1997	83	300	0
	1998	64	267	1
	1999	94	247	0
	2000	70	183	2
	Total	1545		7

in which 13 countries participated, including China. SIR-C/X-SAR, with the ability to acquire polarimetric SAR and interferometric SAR data, was the first spaceborne radar to operate simultaneously at several frequencies and polarizations, representing the most advanced civilian SAR system for Earth observation. This paper presented some results of the SIR-C/X-SAR program made in China. The emphasis was placed on aerial and ground synchronous experiments with SIR-C/X-SAR overpasses, SAR penetration studies for dry sands, and SIR-C/X-SAR data applications in relevant fields and different areas, for example, discovering the volcanoes of the Kunlun Mountains, detecting geological features underneath vegetation canopies, and revealing the Great Wall segments of the Ming and Sui dynasties (SIR-C/X-SAR mission, Guo 2000).

② Theoretical approach to reconstruct Paleofacts

Paleo-drainage directions in the Selima Sand Sheet (centered on 22.5° N, 29° E) were determined using high-resolution, multi-wavelength, multi-polarization Spaceborne Imaging Radar (SIR-C) data and the Global Land One-km Base Elevation (GLOBE) Project Digital Elevation Model (DEM). The combined use of these two data sets shows that both large flood features and later superimposed drainage channels of variable morphology all drain NE and ENE from northwest Sudan toward the Kharga depression in southern Egypt. This is supported by drainage directions deduced from the USGS Global Topography DEM. These directions are opposite to those of the Trans-African Drainage System model in which the large flood features are considered to flow southwest across northeastern Africa into the Chad Basin. Another example of this approach is that Postwar satellite images were correlated with prewar maps within a GIS to identify changed surface features in Kuwait's desert (Magaly Koch and Farouk El-Baz 2000).

③ Descriptive approach

Historical data was mainly used and satellite data and aerial photography were additionally provided for better understanding. Overlaying methods are more frequently used. It is easier to

approach the transient part between waterbodies and lands, because reflectance values(digital number) are sensitive to moisture(Cox 1992).

2) Spatial Resolution and Depth of Information

Though many applications of images from Radarsat and airborne sensors have been made in other countries, the data are not available without purchasing, which means that quickview images are not allowed to the public before ordering. From AVHRR with 1.1 km spatial resolution to IKONOS with one meter spatial resolution, extractable the information is varied. With a specific purpose of studies, further trial of application might be introduced.

3) Application of AVHRR data

At first, each dynasty of Chinese history had their own national boundaries with different physical environments. It might be a good trial to have students draw the boundaries of each dynasty over the AVHRR images. The true color or false color composite of AVHRR data showed the

Table 3. The Comparison of satellite images with different resolutions

name of satellite	name of sensor	spatial resolution	temporal resolution	spectral resolution	Radiometric resolution	application to historical geography
NOAA	AVHRR (Advanced Very High Resolution Radiometer)	1.1 km	12 hour	6 1 0.58 - 0.68 2 0.725 - 1.00 3a 1.58 - 1.64 3b 3.55 - 3.93 4 10.30 - 11.30 5 11.50 - 12.50	12 hour	-comparisons of location of capital cities -changes in coastal lines and islands -explanation of place of historical events (diffusion theory)
Landsat	TM (Thematic Mapper)	30 m	17 day	7 1 0.45 - 0.53 2 0.52 - 0.60 3 0.63 - 0.69 4 0.76 - 0.90 5 1.55 - 1.75 6 10.40 - 12.5 7 2.08 - 2.35	512	-overlay of historical maps -prediction direction of landuse, city expansion and its rates
SPOT	HRVIR (Haute Resolution Visible Infrarouge)	20 m 10 m	15 day	4 1 0.05 - 0.53 2 0.61 - 0.68 3 0.79 - 0.89 4 1.58 - 1.75 1	12 hour	-changes in urban expansion -management and development of coastal areas
IRS 1D	PAN	5.9 m	6 day	1(0.5-0.75)	12 hour	-distribution maps of residential areas with various densities
IKONOS	PAN, multi	1 m- 4 m	3 day	1 0.50 - 0.59 2 0.61 - 0.68 3 0.79 - 0.89 4 1.58 - 1.75	12 hour	-inner structure of old castles -comparison of historical events such as Olypimcs - map for management of historical heritage

characteristics of physical environments.

The second application of AVHRR data is to use background data of geomorphological trends and to trace climatic events such as hurricanes and typhoons. Historical maps and topographic maps were overlaid over linearly-stretched images, the lands which were under the sea visually presented in Fig 1, Fig 2 and Fig 3. All the figures show that deposition from the Zhang River near shorelines continues.

Without satellite images, the coastal lines of Chungming Island overlaid gradually in Fig 4. The changes in sea levels can be a topic of historical

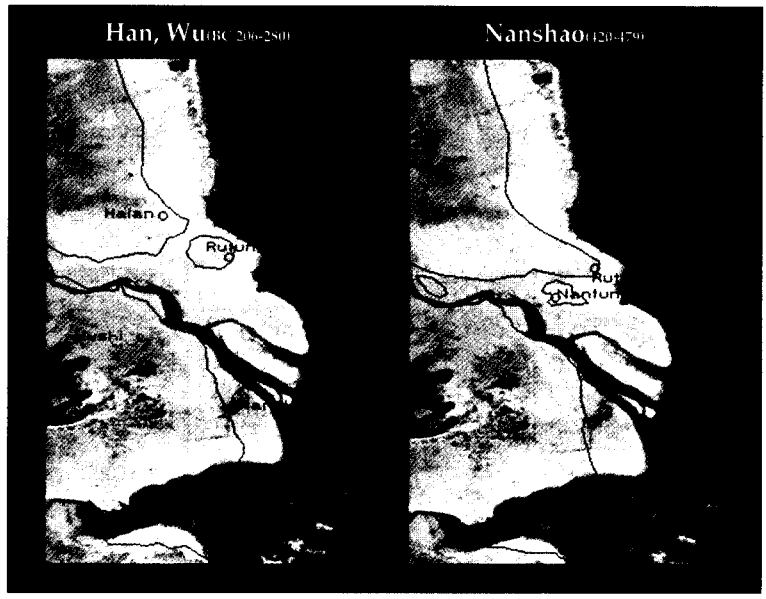

Figure 1. The coastal line of Han, Wu and Nanchao based on AVHRR satellite data

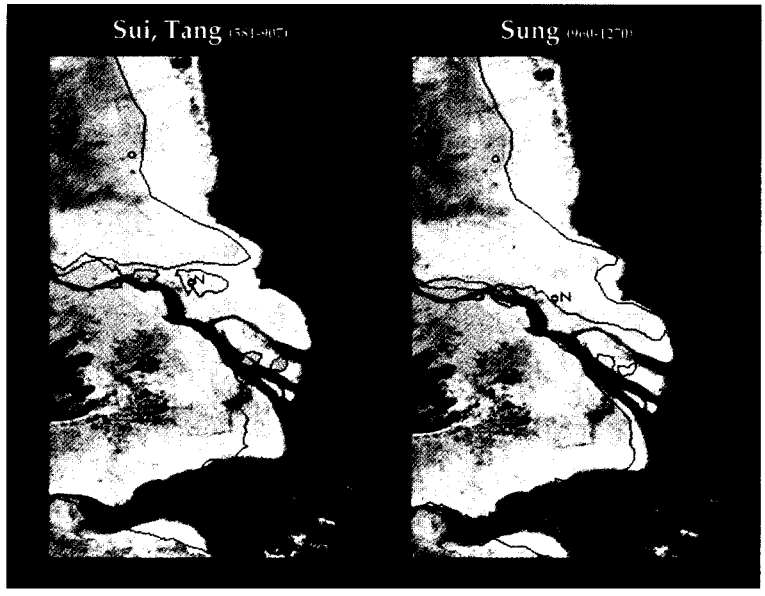

Figure 2. The coastal line of Sui and Tang based on AVHRR satellite data

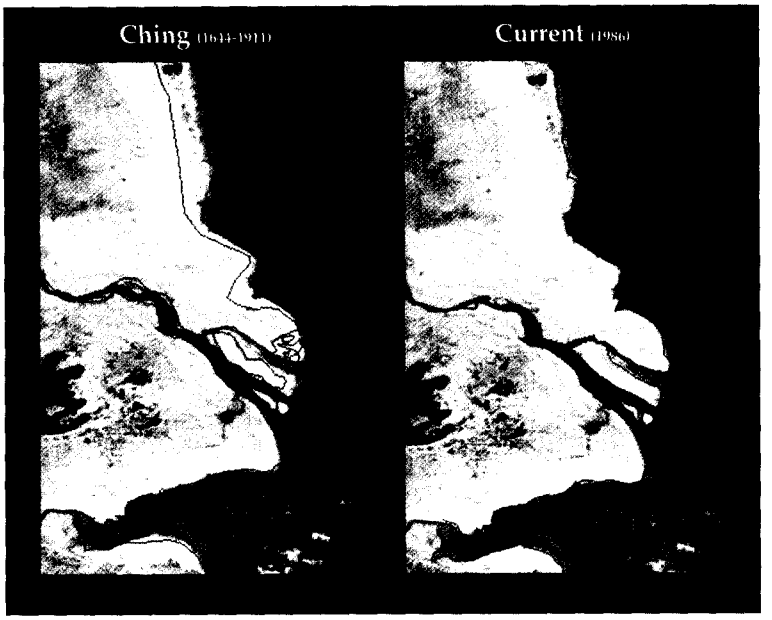

Figure 3. The coastal line of Ching and Modern China based on AVHRR satellite data

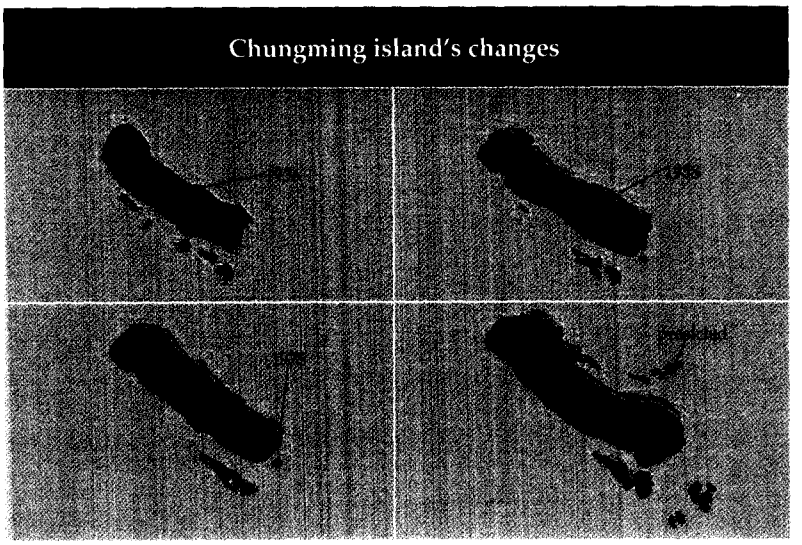

Figure 4. The coastal line of Chungming island based on AVHRR satellite data in modern china

geography as well as physical geography with the use of overlay functions of GIS.

4) Application of TM images

The City of Beijing in 1990 was analyzed in false color composit (4:3:2 = R:G:B) and overlaid with vector maps in History of Beijing as a capital cities.

5) Application of IKONOS images

As IKONOS images have 1 meter spatial

Figure 5. Beijing City in the era of Wuan, Ming and Ching dynasties overlaid on Landsat TM data

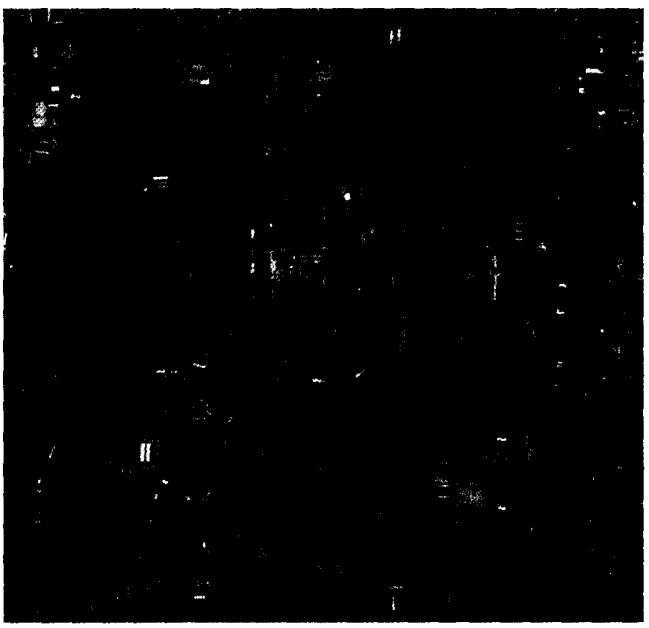

Figure 6. IKONOS Images near Tienanwian of Beijing

resolution, the application can be extended as a tool of management of historical heritages. General classification will not work on high resolution images, so it is not necessary to classify the images but to just use pan-sharpened images directly. With the expansion of world wide web and internet users, tourism site using satellite images might be a spot to apply the concept of management of historical sites with pinpointing their locations.

3. Discussions

The use of Geographic Information Systems in the study of ancient landscapes and features related to ancient land use with its references to the three

goals-detection, analysis, and integration(Peterson 1998). The applications mentioned in the field of archeology were as follows: first, Cultural Resource Management is one of the applications such as handling large data sets, rapid queries, sorting and presentation of results, site registers, urban historical datasets, mapping features, testing distribution hypotheses, unification of data sets.

Second category of application in Landscape archaeology is the subject of mapping, study of historical maps, predictive modeling, combining different scales, symbols and legends, and speed and accuracy. Especially predictive modelling is a key aspect of scientific archaeology including site location, probability, density, archaeological sensitivity, analysing the physical and cultural landscape.

Third application of GIS is for the site catchment analysis such as view-shed analysis, inter-visibility, territorial control, access to communication routes: networks, patterns and grids (for example, Roman centuriation, ancient alignments). Last application of GIS is the subject of landscape visualization including 3-dimension landscape display, simulation of landscape evolution, and view-shed visualization. Potential of GIS in landscape studies was summarized as useful integrating technology, streamline data collection and storage, direct and realistic presentation, speed of analysis.

Why does the discipline of historical geography have less opportunity to use satellite data and GIS than the discipline of archaeology even though the methodologies have developed in the same discipline? Is the tendency of divergency in the field of geography too strong in the last three decades in the name of scientific methodology? Or is the aggressive adoption of new methods by archaeologist faster than geographers? The review of this phenomenon is not explained with such simple question; however, it is necessary for geographers to find more logical background of use of satellite images and GIS.

At first, historical geographers have closer temporal scheme to the satellite data than archaeologists do. Reconstruction of the past is the common goal, it might be approached with ease with less time gaps. Secondly, historical geographers are able to be provided with more materials such as historical literature, books, gazetters and maps even for building hypothesis.

4. Conclusions

The satellite images with different spatial resolutions were applied to some parts of China. The applications of satellite data and GIS are not limited under the name of geography any more with the advent of GIE(Geographic Information Engineering, Hoeschele 2000) or new dimension of GIS, so called Geographic Information Science (Wright et al. 1997). The synergy effect in the same discipline should be considered in both historical geographers and GIS experts. Effective visualization, modeling and management of national international heritages will be tried by expanding the interaction within as well as above the discipline, Geography.

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