Land Use Classification of Morioka City and its Environs based on Airborne Multispectral Sensor Data

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Norio HASEGAWA, Jun NISHIHARA, Toshifumi IMAIZUMI and Hideaki MATSUMOTO

Preface

In geographical study, the urban land use classification is an important subject. However, the units of urban land use are very small, and the land use is actively changing. Therefore, land use data are collected at the cost of many surveyors and long time. The introduction of the technology of remote sensing to land use classification has a possibility to solve this problem, and makes it easy to collect the land use data of a city in different times over and over again, or the contemporary data of many cities on an equal basis.

The sun throws the solar electromagnetic waves on the surface of the earth. The objects on the ground reflect and radiate the electromagnetic waves of wider wavelength band than that of the visible rays. There are particular combinations in responses of the various electromagnetic waves radiating from the objects on the surface of the earth, in accordance with their physical and electronical properties. Remote sensing is the technology to identify and analyse the objects and the phenomena by dint of their individualities in the electromagnetic waves radiating from them.

In this paper, the authors attempt to discriminate and classify the land use pattern in urban area and its vicinity, exemplified from Morioka city, by airborne multispectral sensor data, and to assess the potential utility of remote sensing for urban land use analysis. If the desirable results are obtained successfully by this study, the technology of remote sensing will contribute greatly to the study on urban geography in Japan.

Data processing and procedure

The multispectral sensor (MSS) data measured by the Japan Foundation of Shipbuilding Advancement (JAFSA) were analysed in the Digital Data Processing System (JAFSA Remote Sensing System) in this study.

At 10:40 a.m. of September 26 in 1976, the MSS data of Morioka were collected by the sensor of DS 1250 at the altitude of 9170 feet. The sensor of DS 1250 is able to collect the MSS data as eleven portions of electromagnetic spectrum. Therefore, the MSS data consist of eleven channels, and the electromagnetic wavelength of each channel is shown in Table 1. The 7th, 9th and 11th channels are selected in this

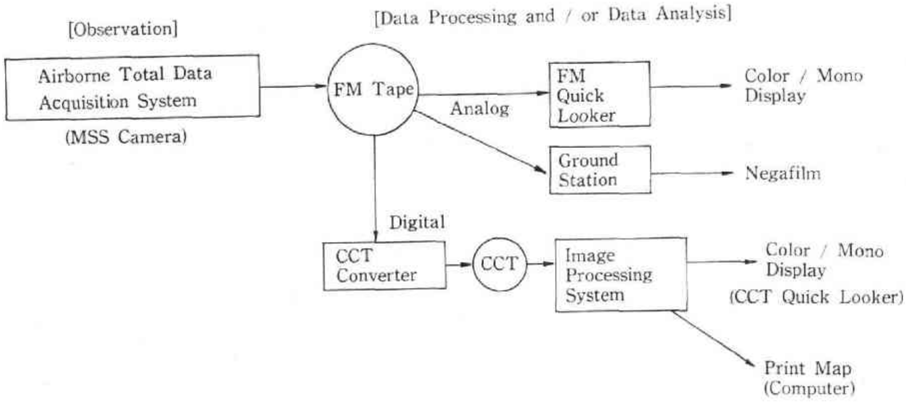

Figure 1 JAFSA remote sensing system.
(after, PROJECT REPORT-II 1977 Related to Environmental and Resources, p. 69 Figure 3.1, Japan Research Committee of Environmental Remote Sensing, JAFSA)

Table 1 Wavelength band designation of the MSS data (Sensor: DS 1250)

Channel	Wavelength (μm)		
1	0.38- 0.42	blue	visible
2	0.42- 0.45		
3	0.45- 0.50	green	
4	0.50- 0.55		
5	0.55- 0.60		
6	0.60- 0.65	red	
7	0.65- 0.69		
8	0.70- 0.79		
9	0.80- 0.89	near infrared	
10	0.92- 1.10		
11	9.5 -12.0	far infrared	

case. The format of MSS data of the training area is converted to the Computer Compatible Tape (CCT), and put into a Quick Looker. The MSS data were displayed into the color characteristic imagery using sixteen magnitude levels of electromagnetic responses of every channel in the training area.

Next, the training area is divided into smaller areas of six classes (I to VI class), according to the imagery of electromagnetic responses of every channel. Where the greatest responses of electromagnetic waves are identified, the areas are classified as the I class areas. The smaller the responses of electromagnetic waves are, the lower the class order becomes.

Finally, after the ground survey of land use, in comparison with actual land use classification map of Morioka (Fig. 2), the authors discriminated land use types in the areas of six classes, which had been decided from the MSS data.

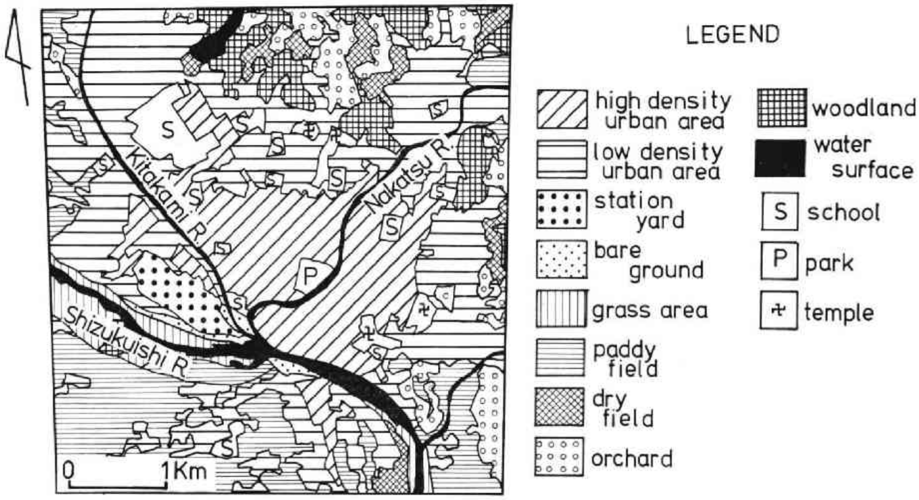

Figure 2 Land use classification of Morioka city by ground survey

Land use classification and its interpretation

The 11th channel has the wavelength band of far infrared. Therefore, the distribution of radiating responses in this channel shows the distribution pattern of surface temperature in the training area.

The I class areas in Fig. 3 correspond to the urban built areas with high density *i.e.* "high density urban areas" in Fig. 2, where the highest surface temperatures appear to emit in the training area, resulting the greatest responses of far infrared in the I class areas. The II class areas surrounding the I class areas are equivalent to the urban built areas with low density *i.e.* "low density urban areas", which are residential areas developed after the World War II. Some other II class areas are "rural settlements", which appear in rows or dispersed in the IV class areas. In both cases of the II class, the surface temperature is lower than in the high density urban areas. The difference may be caused by the low density of building and rich vegetation cover in the II class areas.

Most of the III class areas are identified in low density urban areas, and their small cells are recognized also in high density urban areas. However, they are too small to be shown in Fig. 3. Their scattered dots correspond to the school grounds in Fig. 2, and their relatively wide areas in low density urban areas are the extensive bare grounds under the construction of residential estates.

The IV class areas with relatively low surface temperature extend on flood plain of the Shizukuishi and Kitakami Rivers and on hilly land at the north and east of Morioka. The former on flood plain corresponds to "paddy field", and the latter

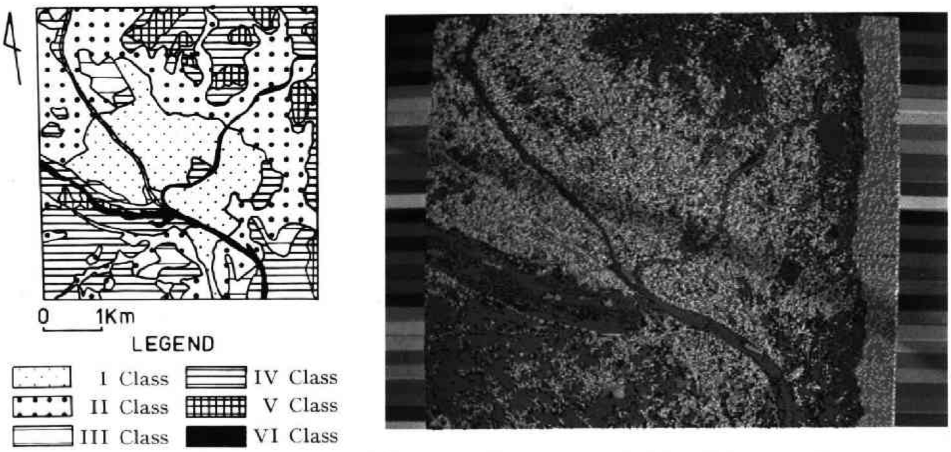

Figure 3 Color display and land use classification by the 11th channel

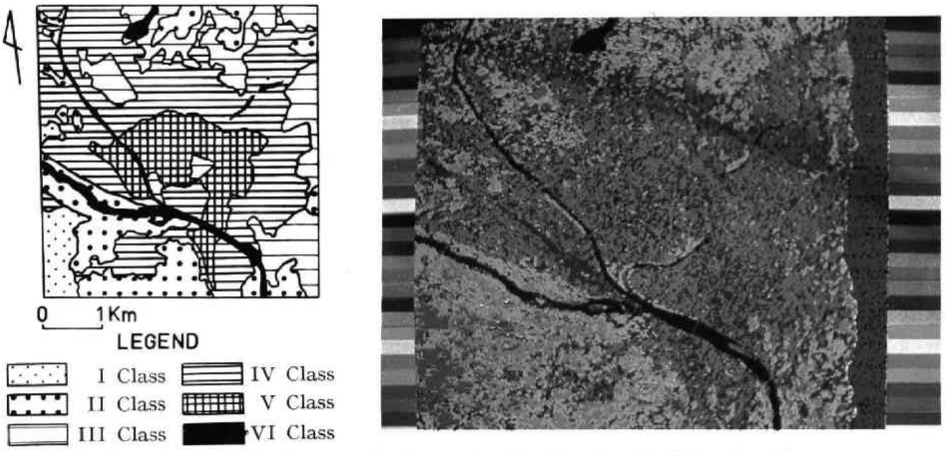

Figure 4 Color display and land use classification by the 9th channel

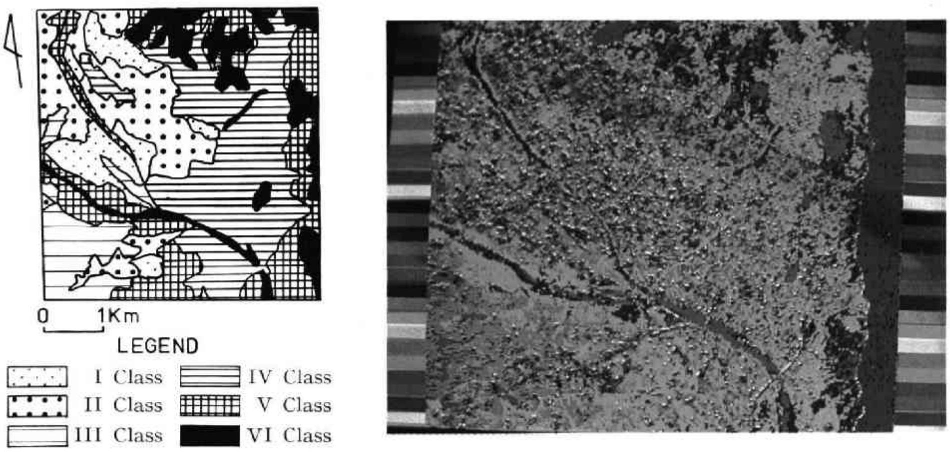

Figure 5 Color display and land use classification by the 7th channel

on hilly land are "dry-field" or "orchard". Their cells scattering in urban areas are the "green areas" in parks and temples.

The V class areas correspond to the "woodland" on hilly land or along river channel in Fig. 2, where the vegetation cover is richer than in dry-fields, orchards or parks. The VI class areas and some part of the V class areas are equivalent to the "water surface" of rivers and ponds. As the heat capacity of water is greatest, the surface temperature of water is lowest in the training area.

Thus, based on the areal difference of surface temperature estimated by radiated responses in the 11th channel, the classification of the training area is supported by the land use classification in Fig. 2. Also, the radiated responses of each land use area are similar to the results on heat radiation measured in Suginami, Tokyo (Nakamura, I. 1974).

The 9th channel has the wavelength band of near infrared. Vegetation is remarked in high-ratio reflection on near infrared, compared to other objects. In Fig. 4, the I class areas with the greatest reflected responses in the 9th channel appear in paddy fields near the Shizukuishi River in Fig. 2. The II class areas with great reflected responses of near infrared, correspond to paddy field on the flood plain or the grass land on the river valleys of the Shizukuishi and Kitakami Rivers. They also appear in dry-fields, orchards and woodlands on hilly land around the built-up areas.

The III class areas are equivalent to dry-field, orchard and woodland on hilly land, and to green areas of urban parks. All the I-III class areas in Fig. 4 are rich in vegetation cover, such as paddy field, dry-field, orchard, woodland and grass land. The electromagnetic responses of the 9th channel have a special character to distinguish species, type, vitality and distribution density of vegetation. Therefore, this channel is useful for land use classification, so far as vegetation is concerned.

The distribution patterns of the IV and V class areas in the 9th channel are similar to those of the II and I class areas in the 11th channel respectively. But in the imagery of the 9th channel, the boundaries between residential and green areas are not so clear as in that of the 11th channel. The rural settlements on flood plain of the Shizukuishi River and the green areas scattered in urban areas, which are displayed in the 11th channel's imagery, could not be discriminated in the imagery of the 9th channel. The VI class areas with the weakest responses correspond to the water surface of rivers and ponds. But some part of the Nakatsu River could not be identified in the 9th channel's imagery.

The 7th channel has the wavelength band of visible red. The VI class areas in Fig. 5 correspond to woodland and orchard on hilly land in Fig. 2. The V class areas are equivalent to dry-field on hilly land. In other parts of the training area, the pattern of electromagnetic responses could not be recognized as the reflection of

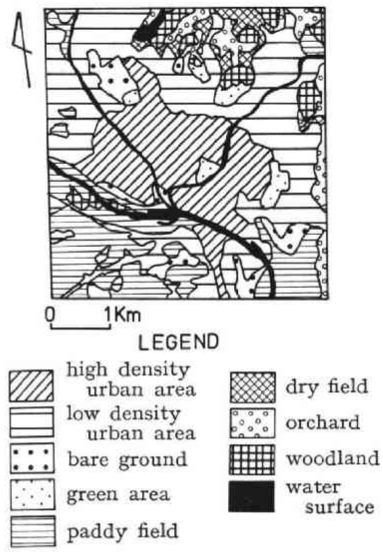

Figure 6 Land use classification by the analysing of the MSS data

particular land use in Fig. 2.

Conclusion

On the basis of the data of electromagnetic responses of the 7th, 9th and 11th channels, the training area is classified into 9 types of land use shown in Fig. 6. The surface temperature indicated by the electromagnetic responses of the 11th channel varies sensitively in accordance with the ground features. Using the data of the 11th channel, the authors tentatively classified the training area into 5 categories such as "high density urban area", "low density urban area and rural settlement", "green area of parks and temples", "paddy field" and "bare ground".

On hilly land, at first, woodland is distinguished from orchard and dry-field by the imagery of the 11th channel. Thereafter, by dint of imagery of 7th channel, orchard is distinguished from dry-field, though orchard and woodland have the same imagery in the 7th channel. Thus, the land use on hilly land is classified into three, *i.e.* "woodland", "orchard" and "dry-field"

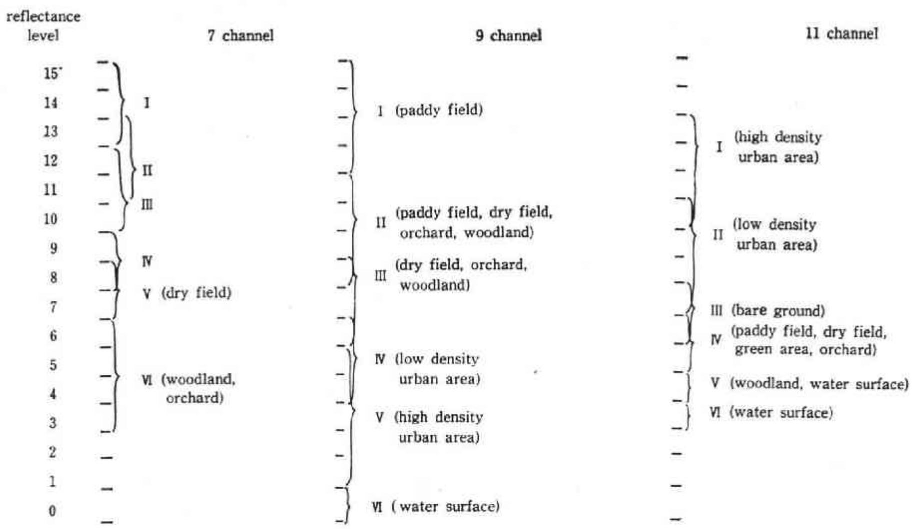

Figure 7 Relation between the class areas and land use types in three channels

by the MSS data of the 11th and 7th channels. The "water surface" is discriminated by the electromagnetic responses of the 9th channel, except the Nakatsu River confirmed by the 11th channel's imagery, not by the 9th channel.

If an area with particular magnitude in electromagnetic responses of each channel is identified with an area of particular land use type justified by ground truth, the extension and boundary of the area can be easily measured, and the land use type can be discriminated. This will lead to the application on other unknown areas, and to establishing the method of land use classification.

In this study, the authors discriminated the land use types in a training area by analysing the MSS data. However, further effort is needed to discriminate and classify the urban land use more precisely. Some problems are still remained in the application of remote sensing to urban geographical study. One of them is to establish the categories and bases in order to classify an urban area into some sub-areas. Each sub-area in general consists of various land use types which have peculiar electromagnetic properties. Even in the case of residential area as a land use type, many elements such as houses, gardens bare or green, and roads paved or not coexist with each other, and they have different electromagnetic reaction. As the pixel (the minimum unit of the MSS imagery) is so large (a pixel in this study has the area of 38.4 m^2 on the ground), that the imagery of a residential area may consist of pixels as complex having various magnitudes of the electromagnetic responses. Therefore, it is necessary to develop the statistical method of identifying the complex scene consisting of various pixels, as well as identifying an unit pixel itself.

Acknowledgement

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