Study on the Minimum Representative Area on a Test Site

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Abstract

It is necessary to use the ground observational data to calculate physical value in a wide survey unit (1km×1km) in order to verify the reliability of the algorithm for speculating physical variable from 1km satellite data. Since it is difficult to conduct the ground observation within whole wide area survey unit in short time, the minimal survey area which can represent a wide survey unit has to be determined. The objective of this study is to find the minimal representing area of a wide survey unit through the car survey and radio-controlled helicopter survey we developed in Mongolian grassland. As a result, it can be said that these systems used in the research are a good way to calculate the minimal representing area of a wide survey unit.

1. Introduction

In Earth System Science(1984) proposed by NASA, various information on earth is gathered during first decade and it is made some models for various phenomena arised on earth during second decade. Especially, in recent years, it is interested in estimating vegetation amount quantitatively from satellite data which has the characteristics of lower spatial resolution and higher time-frequency. Global quantitative analysis using satellite data is very important for understanding water and energy flow in the arid and semiarid region.

It is necessary to understand relation between spectral reflectance and physical parameter of the objects because satellite sensor fundamentally obtain only reflected spectral radiance energy. But each pixels of satellite data have not only ground reflectance but also atmospheric information. Therefore atmospheric correction is often conducted on satellite image processing, and ground data for verification are needed for global quantitative land analysis using satellite data .

Generaly, it is often tried to get the ground truth data, which should be satisfied with condition of scale as same as satellite data and condition of simultaneity for satellite data. But it is difficult to collect the ground truth data in the short time in the area which is the same as low spatial resolution of satellite sensor (ex. NOAA AVHRR, ADEOS OCTS, in future ADEOS-II GLI, EOS-AM MODIS data). If the study area looks like very homogeneous area, it is needed to confirm whether the site is actually uniform area or not. For example, in sparse vegetated area, it cannot be regarded as homogeneous area in small scale because ground may vary the condition of some objects at each observation units. Therefore, it is needed to clarify how large the area can be regarded as one unit.

2. Objective

The aim of this study is to estimate the minimum representative area in Mongolian grassland, which is very flat and homogeneous area, and to verify data obtained by the system we developed.

3. Methods and Results

In this study, we tried to obtain spectral information and video images by our two developed system. One is car survey system (Figure 1.) and the other is Radio-Controled Helicopter (RC Heli) survey system (Figure 2.). Both can get so many video images and spectral information in the short time. The detailed statement of these system is explained in section 3.1 and 3.2.

The study area where we observed is Mongolian grassland, which is located at about N47.3 deg E106.3 deg , and which is very homogenous and flat area. The terrain type is almost gravel or sandy, and vegetation density is thin, plant height is from about 1.0cm to about 22.5cm. The distribution of measurement point is shown in the Figure 3 . The measurement was conducted in 14 Aug. 1996 and 15 Aug. 1996(Table 1.). Both systems are able to obtain spectral information and video images at the same time. In this study, there may have possibility of difference of change for spectral information affected by difference of siol condition (soil moisture content etc.) between car survey and RC-heli survey, because each measurement date is different. Therefore this study does not compare spectral refrectance directly, but compare minimum area using vegetation coverage ratio derived from each measurements.

3.1 Measurement using Car Survey System

The arm of this system juts from the roof of car and move with car, and it observes the gound condition quickly. CCD camera, multichannel spectrometer S2320(Soma Optics, Ltd.), GPS receiver, and GPS Camera (made by Konica) are mounted on the tip of the observation tower all together. GPS Camera can save information (date,time, longitude and latitude, and azimuth and observation angle) in the upper side of the photograph. Before optical fiber, there is a diaphragm, which can be set the sensor's field of view (FOV) continuously. FOV in this video image is the same as sensor looking position and the sensor's FOV. The center of sensor is coincident with the optical center of sensor. White standard reference board we used is barium sulphate panel. This panel is made by baraita paper plus $BaSO_4$, which is superior cost performance, geometric dependancy. This system can avoid shadow of measurement system itself by the revolving stand on the car-top. This system can obtain one data every one minute, and in this study, we measured 100 points in 1km×2.5km area(Figure 2.).

Figure 4 depicts vegetation coverage ratio (VCR) of 100 measurement points. VCR is derived from video images obtained by the above system. This diagram shows that the virtical axis is vegetation coverage ratio and the horizontal axis is measurement number. it can be seen that grassland which looks like homogeneous area has big variability. For this figure, Figure 5. is shown moving averaged VCR from 5 points to 35 points. It has become smaller variability over about 25 points. Figure 6 is shown diagram for the variance and standard deviation of moving averaged VCR each moving averaged number. From over 25 moving averaged number for measurement points, standard deviation and variance become small and practically constant value. Therefore it is clear that the set of 25 measurement points removes the variability. The measurement area S for one measurement point is expressed by FOV and observation height of spectrometer and CCD camera:

$$S = \pi \times 2.16^2[m^2] \times \tan^2(\frac{22^\circ}{2}) \cong 0.554[m^2] \quad (1)$$

The set of 5×5 measurement points which put out the variety is represented as approximately satellite ground spatial resolution 1km×1km(in this study, NOAA AVHRR), therefore the minimum representative area S' derived from car survey measuremet is shown below:

$$S' = 0.554[m^2] \times 5 \times 5 \cong 13.9[m^2] \quad (2)$$

3.2 Measurement Using Radio-controled Helicopter

We developed the radio-controled helicopter (RC-heli) measurement system. This system has spectrometer, GPS receiver, CCD camera and micro-computer, and it can change the observation height from about 1m to 150m. In this study, the measurement height of RC-heli is about 55m. The result of section 3.1 occasionally may measure the only same gound condition. Therefore we observed the wide range of ground condition using RC-heli system in 30 measurement points. The area S' measured by spectrometer and CCD camera mounted on RC-Heli is calculated with measurement condition:

$$S = \pi \times 55^2[m^2] \times \tan^2(\frac{22^\circ}{2}) \cong 359[m^2] \quad (3)$$

By using this, the variety of measurement value is confirmed whether about 359m^2 area is regarded as one unit or not. CCD camera mounted on RC-Heli takes ground condition such like the car survey system, but it is difficult to calculate vegetation coverage ratio directly because video image has many noise and unclearness in one pixel. Therefore, at first, we conducted simple regression analysis between NDVI and VCR obtained by car survey, and then NDVI obtained RC-Heli survey is substituted for relationship between VCR and NDVI obtained car survey. Calculated simple regression equation is the following:

$$VCR = 1.3537 \cdot NDVI - 0.24867 \quad (4)$$

VCR :Vegetation Coverage Ratio

NDVI:Normarized Difference Vegetation Index

NDVI value obtained by RC-heli system is substituted for the above equation and then we calculated VCR at each points. Figure 6 depicts defference of VCR at each measurement points. Vertical axis shows VCR and horizontal axis shows measurement point number. This diagram expresses small variabirity of VCR at each measurement points. In this case, variance is 0.0006 and standard deviation is 0.024. Therefore, we could confirm that the area measured by RC-heli system in this study is regarded as one unit area. Observed variety of VCR observed by RC-Heli is smaller than that of VCR observed by car survey.

4. Discussion

When we try to get ground data using car survey system with the same variance measured by RC-Heli survey system, the moving averaged number of data should be 31 (see Figure 6.).

$$S' = 0.554[m^2] \times 31 \cong 17.2[m^2] \quad (5)$$

$$359[m^2] \div 17.2[m^2] \cong 21 \quad (6)$$

This result shows that the measurement area of spectrometer and CCD camera mounted on RC-heli is about the 21 times as large as the area measured by car survey. It is better that the area 17.2km^2 which dose not cause vriety is identified as the minimum representative area than 25 measurement points of car survey. Therefore it is said that the minimum representative area for the wide area (1km$\times$ 1km) is about 17.2km^2. And the result of section 4.2 indicates that RC-heli survey system is very useful tool because it can be measured objects which has large variety in the large area all at once.

5. Conclusion

In this study, we could calculate minimum representative area, which is about 17.2km^2 in flat and homogeneous wide grassland in Mongolia (1km$\times$1km), by using car and RC-heli system. The car survey system which has high efficiency of observation needs about two hours for 100 points measurement, but RC-heli system needs 5 minutes for 30 points measurement. It is evident that RC-heli survey is very useful for changeability of incident solor radiance and so on. This system is conducted ground truth efficiently because this system can estimate minimum representative area in the short time by changing observation height. When ground observation and satellite observation are conducted at the same time without changing solor incident radiance, it is very important to shorten the total time of observation. From this point of view, it is also said that RC-heli is very useful tool. Data obtained by using these systems we developed in this study can be used as verification data after atmospheric correction for satellite data.

In future, it is thought to obtain some samples of biomass etc. in the minimum representative area calculated by using method we developed in this study. Moreover, it is also needed to prove representativity of minimum area derived from some vegetation indeces (NDVI etc.) statistically. In order to prove this, it is important to develop the method of acquisition of biomass etc. in small error.

6. References

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Table 1. Measurement Condition

Date	14 Aug. 1996	15 Aug. 1996
Time	15:44～17:30	12:05～12:10
Accumulation Count	10	10
Integration Time	0.08 sec	0.16 sec
The Numberof	1024ch	512ch
Spectral Resolution	0.68nm/ch	1.37nm/ch
Observation Angle	Nadir	Nadir
Field of View	Approx. 22 deg	Approx. 22 deg
Sensor Height	2m16cm	Approx. 55m
The Numberof	100 points	30 points

Figure 1. The Appeararance of Car Survey System

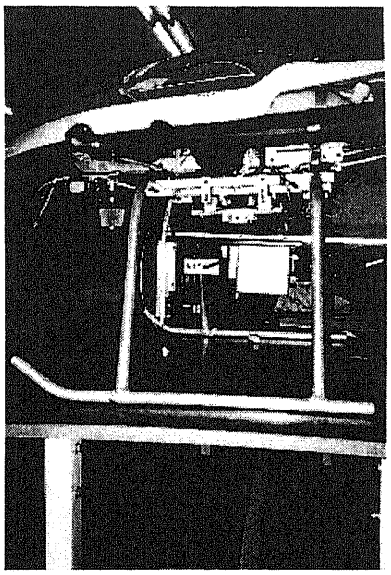

Figure 2 The Appearance of Radio-controled Helicopter System

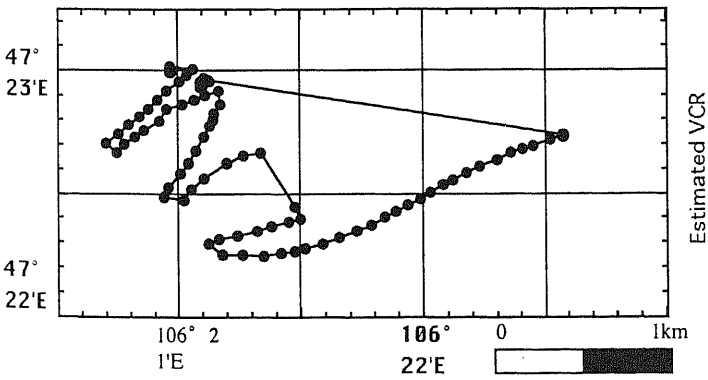

Figure 3. Distribution of Measurement Points by Car Survey

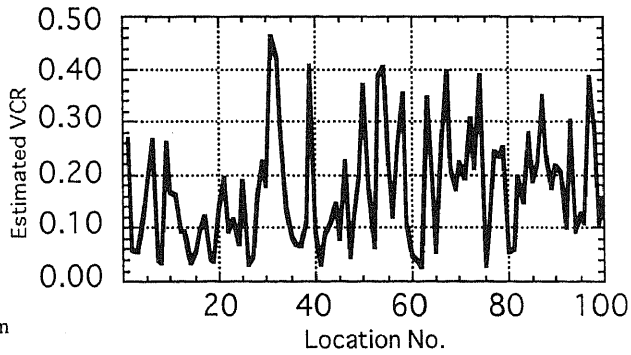

Figure 4. Difference of VCR obtained by car survey

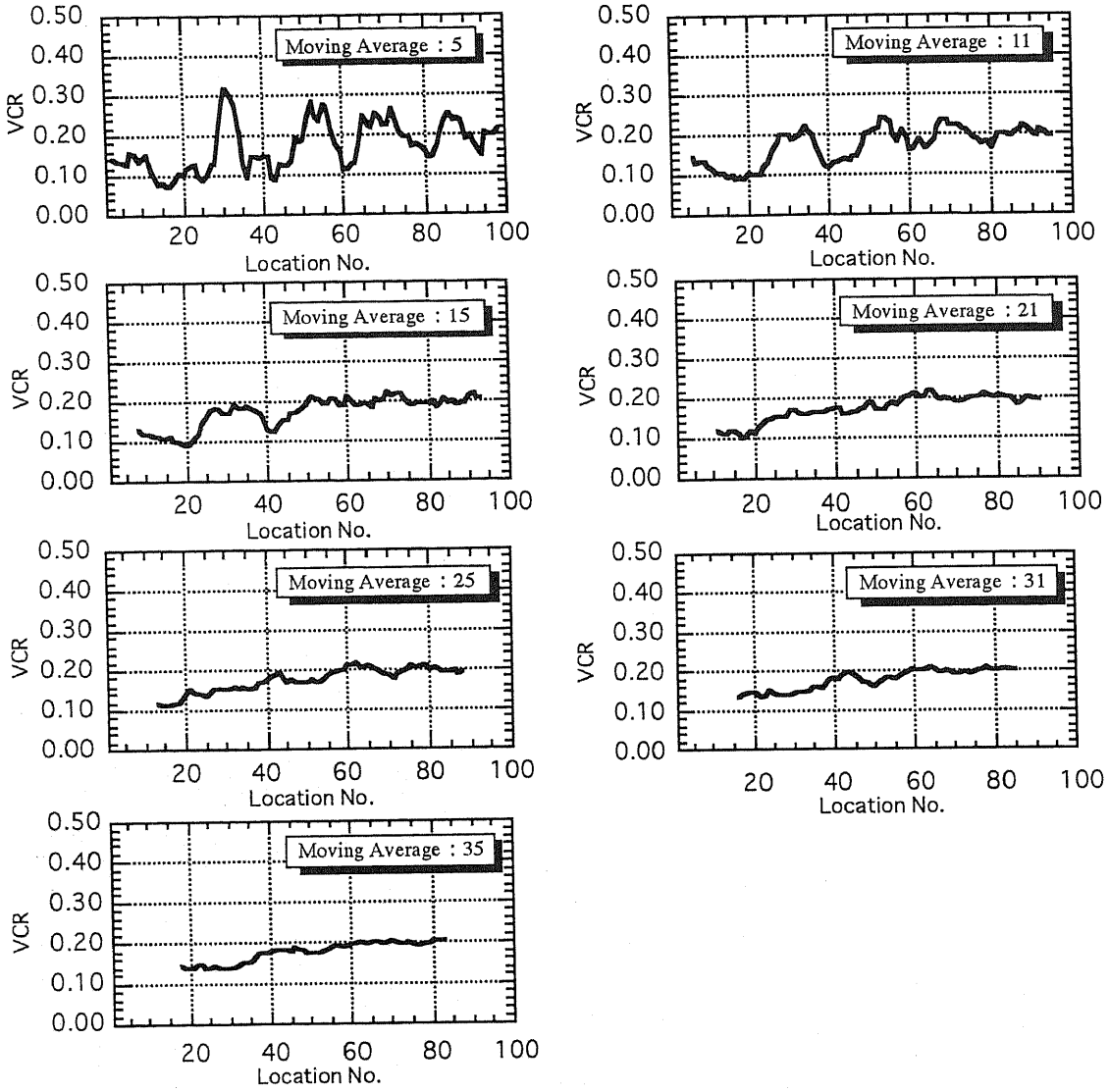

Figure 5. Difference of Moving Averaged VCR

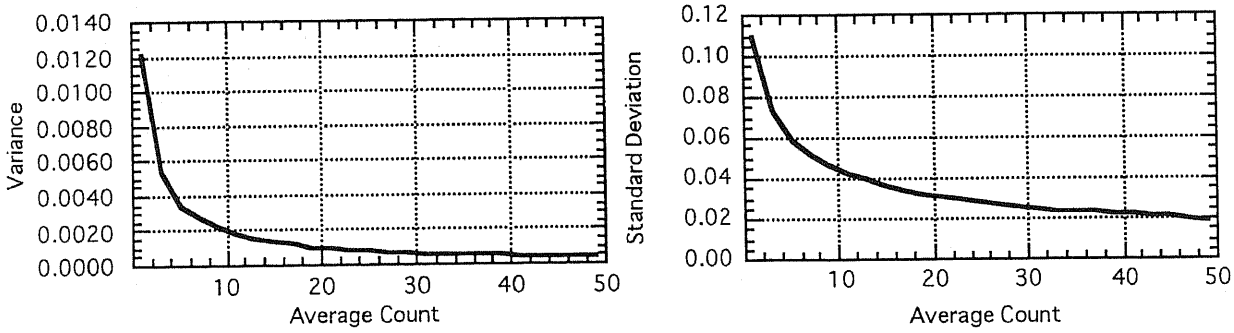

Figure 6. Variance and Standard Deviation of Moving Averaged VCR

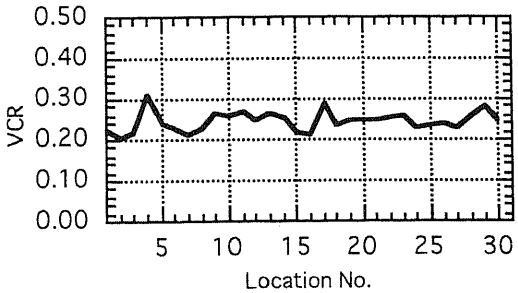

Figure 7. Difference of VCR Obtained by RC-heli survey