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BRF MEASUREMENT OF RAINFOREST CANOPY BY CRANE OBSERVATION

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ABSTRACT: This paper describes bi-directional reflectance effects of rainforest canopy. To obtain the spectral information such as Bi-directional Reflectance Distribution Function (BRDF) has been getting more important in the advanced satellite sensor's technology. The bi-directional reflectance effects of canopy surface have not discussed in both of the ecological analysis and the application of remote sensing because there is the problem to access to over the canopy. For its solution, the canopy crane that is 80m height with the arm length of 75m was established in Borneo Malaysia in 2001. In this way, every researcher can access to over the rainforest canopy.
From the mentioned background, we developed measurement system called 'Multi- Point Accessible Spectro-Radiometer' in order to obtain Bi-directional Reflectance Factors (BRF) on the mentioned canopy crane. In this paper, the method how to measure BRF of rainforest canopy efficiently was discussed and its BRF effects were summarized as the results.

1. INTRODUCTION

Tropical Rainforests have huge biomass and biodiversity. In order to understand the ecological processes and functions of rainforest, the remote sensing technology is one of the most powerful tools. Recently, various sensors for example high resolution, hyperspectral and multi-pointing have been developed in advanced remote sensing technology, so that many kinds of satellite image have begun to be used in various application fields.
Therefore Bi-directional Reflectance Distribution Function (BRDF) and Bi- directional Reflectance Factors (BRF), which are based on the observation geometry of sun incident angles and sensor viewing angles is getting more important to understand the relationship between satellite imageries and physical phenomena.
As the beginning of our research, we developed the measurement system and discussed the method how to measure BRF of rainforest canopy using this measurement system on canopy crane. This measurement system can take many samples from different sensor viewing angles in short time. The objectives of this study are to obtain BRF data set efficiently and to examine its BRF effects by different sensor viewing angles and sun incident angles.

2. STUDY SITE AND CANOPY CRANE

Figure 1 shows the study site where is located in Lambir Hills National Park, Sarawak, Borneo Malaysia. Here is covered with natural rainforest. The average of tree height is approximately 50 meters.
The canopy crane shown in figure 2 is used as our measurement platform. This canopy crane has 85 meters tower height with the arm length of 75 meters. It is equipped with the gondola, observation stages at four levels and the trolley that moves on the arm. The canopy crane provides us to access three- dimensionally to 2.3 ha of cylinder area freely.

Figure 1. Study Site

Figure 2. Canopy Crane

3. MEASUREMENT SYSTEM AND METHOD

3.1 System Configuration

We developed the BRF measurement system called 'Multi- Point Accessible Spectro-Radiometer' shown in figure 3. This system is mounted on the trolley that moves on the crane arm. This system consists of 10 points viewing sensor units, two white reference units, spectro-radiometer, optical channel changer, PC for system control and data store, GPS, and digital cameras. The sensor viewing angles can be changed at 5 degrees interval from forward 60 to backward 60 degrees. Each measurement time and position are identified by GPS, and recorded with original measurement data files. The measured wavelength range is from 500 to 850 nm that corresponds to visible green, red and near infrared regions. The FOV of the sensor is about 22 degrees. This system can take different 10 samples with different sensor viewing angles and two white references at the same time.

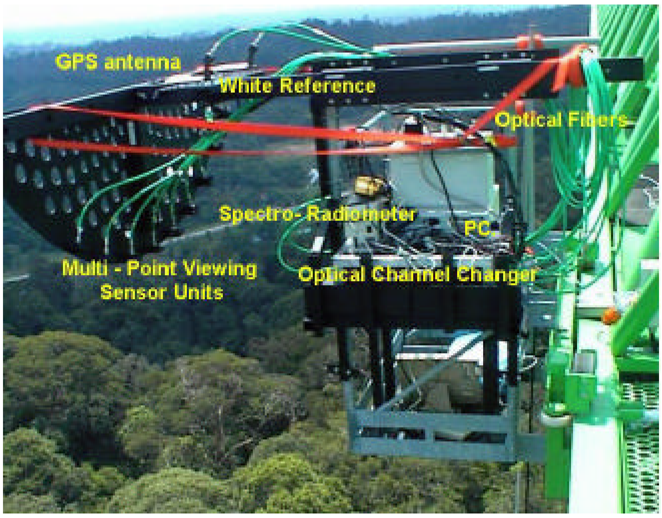

Figure 3. Overview of BRF Measurement System

3.2 Observation Method Using Canopy Crane

Here, the observation method how to take samples using the measurement system and canopy crane is explained and illustrated in figure 4.
The target of BRF measurement is selected on conditions that are; 1) to cover the crown in sensor's viewing area, 2) to be located at the point where the crown can be viewed from many different sensor viewing angles and 3) not to be influenced by shadow of crane own during the observation time. We inspected around crane site and selected the target crown. Therefore, 174° direction from magnetic north was decided for our measurement.

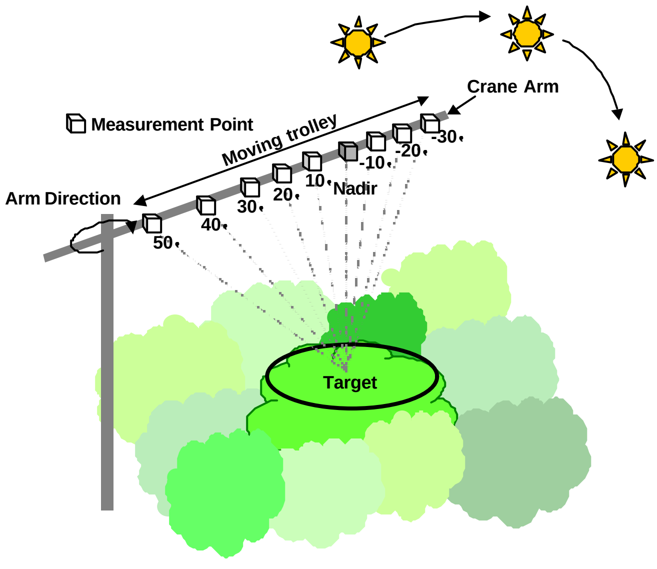

Figure 4. Concept of Observation Method

After selecting the target and fixing the arm direction, then we decide several measurement points on the arm. The measurement target is stood just under the point on the arm at 52 meters from the crane tower. This point is defined as nadir point. The distance from nadir point to the target is about 40 meters. The other measurement points on the arm are introduced by moving distances of trolley from nadir point to next measurement point. In this case, 9 measurement points are decided totally. The target can be viewed from each measurement point at every 10 degrees interval of sensor angles from forward 50 to backward 30 degrees.

3.3 Observation

Here, one observation is defined as to take all of the samples at 9 different measurement points on the arm. In short, 90 samples are taken during one observation.
According to the mentioned observation method, the observations were performed during the time from 10am to 14pm on Feb. 21st and 22ed in 2001. The observation needs the conditions of the clear sky and to finish in short time during when the sun incident angles do not almost change. This BRF measurement system can take 10 different samples in less than one minute so that one observation should be finished during from 20 to 30 minutes.
In this time, three observations had been done under the perfect conditions. The times of three observations were around 11 am, 12 pm and 14 pm for two days. The sun azimuth for the crane arm were irradiated from52 degrees eas t at 11 am, 20 degrees east at 12 pm and 64 degrees west at 14 pm. The angles of sun altitude at 11 am, 12 pm and 14 pm were 63 degrees, 74 degrees as the peak and 61 degrees respectively.

3.4 Calculation of BRF and Its Data Set Construction

Figure 5 shows the relationship between the target crown and sensor viewing angles from 9 different measurement points.
The calculation procedure of bi-directional reflectance factors of the target crown and the construction of BRF data set are explained as follows.

1) 9 samples aimed at the same target area (yellow circle) are selected from 90 samples taken at 9 different measurement points during one observation (red lines).
2) Each bi- directional reflectance factor data is calculated from selected 9 samples by using white references taken at the same measurement point as the standard.
3) One BRF data set, which was observed under a certain condition of sun incident angles, is composed by 9 reflectance factors data.

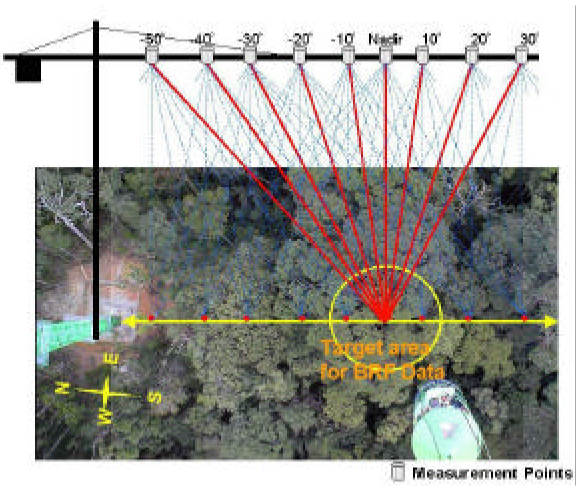

Fig.5 Target Area and Measured Samples

In this way, three BRF data sets were obtained. However, some samples were not taken so that one BRF data set was composed by 7 or 8 reflectance factors data.

4. RESULTS

Three graphs shown in figure 6 are each calculated BRF at different sensor viewing angles in wavelength in order from the left at observation time of 11 am, 12 pm, and 14 pm.

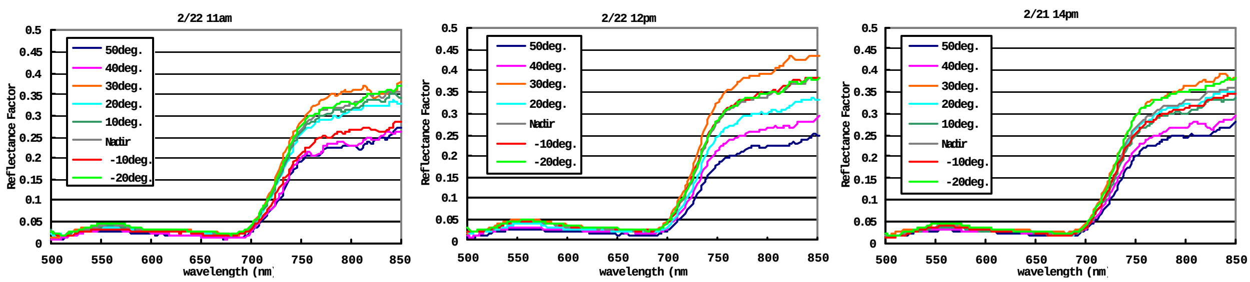

Figure 6. Three BRF graphs shown at different viewing angles in wavelength

These graphs show the typical pattern of vegetation spectral reflection. When it is seen by the sensor viewing angles in three graphs, high reflectance factors are shown at 30 degrees, and low reflectance factors are shown in the conditions with the sensor angle 40 and 50 degrees. In the middle graph of BRF which was observed around 12 pm when sun altitude was highest in three observations and the sun azimuth looked nearly the arm direction, the differences at each reflectance factors are bigger than the other two BRF graphs. The BRF effects are also seen by different sun incident angles.

Here, the BRF effects caused by sun incident angles are examined. Figure 7 shows the graphs of bi-directional reflectance factor distribution at sensor viewing angles observed at three different times, that are sun incident angles, in three wavelength regions in order from the left in visible green, red and near infrared.

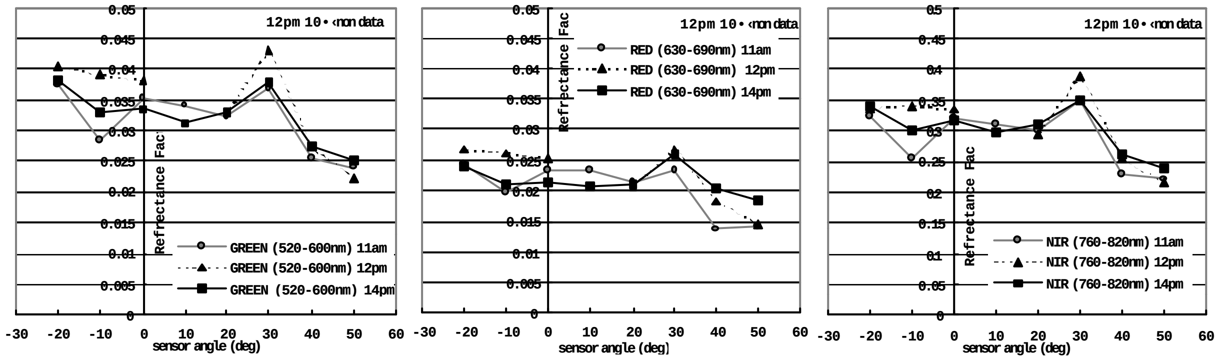

Figure 7. BRF distribution at sensor viewing angles observed at three different times in three wavelength regions

Reflectance factors measured at 20 degrees are almost same values at three observation times in three wavelength regions. On the other hand, the different reflectance factors at -10 degrees are shown at three observation times in three wavelength regions. In all of graphs, reflectance factors are getting lower in order f rom 12 pm, 14 pm and 11 am. These BRF effects shown at different sensor viewing angles and observation times could be caused by the complex structure of canopy surface.

5. CONCLUSIONS

In this paper, the development of our BRF measurement system was introduced and the method how to obtain BRF data sets was discussed. Through the actual observations on the canopy crane, our measurement system that can take many samples in short time and its observation method were confirmed to be efficient. As the results of BRF data set construction, some BRF effects were shown at different conditions of sensor viewing angles and sun incident angles. As the future works, the followings are necessary.

1) to continue the BRF measurement and accumulate multi- temporal BRF data sets observed under the conditions of various sun incident angles
2) to clarify the relationship between BRF effects and the canopy structure that has been measured in the same study site

Through the above works, the Sun- Canopy Reflectance Model is going to be developed in order to estimate BRDF of rainforest canopy and some ecological functions for instance the amount of photosynthesis.

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