A study on analysis to time series data by using vegetation surface roughness index

Asako KONDA
Japan Science and Technology Corporation
1-33, Yayoi-cho, Inage-ku, Chiba, Japan
konda@cr.chiba-u.ac.jp

Koji KAJIWARA
Center for Environmental Remote Sensing, Chiba University
1-33, Yayoi-cho, Inage-ku, Chiba, Japan
kaji@cr.chiba-u.ac.jp

Yoshiaki HONDA
Center for Environmental Remote Sensing, Chiba University
1-33, Yayoi-cho, Inage-ku, Chiba, Japan
yhonda@cr.chiba-u.ac.jp

Abstracts: Index for difference of vegetation surface roughness (BSI: Bi-directional reflectance factor structure Index) was proposed in our laboratory (Konda et al., 2000). It is thought that BSI is useful vegetation index for vegetation monitoring. If it can be applied for global covered satellite data, detailed monitoring of global vegetation can be expected. However, in order to apply BSI to global satellite data, there are some problems to be solved. In this study, in order to make global data set of BSI, it arranged about processing of the global satellite data for making BSI data sets.
Keywords: Vegetation Index, BRF, Vegetation monitoring, Time series data

1. Introduction

A satellite remote sensing is useful for vegetation monitoring. But it has some problem. One of these, it is difficult to find a difference of vegetation surface roughness only using method of usual satellite remote sensing. If vegetation cover ratio on appearance is same, usual vegetation indices have a character to take a similar value. Therefore, between vegetation of different type with near vegetation cover ratio on appearance, it is difficult to classify only using usual vegetation indices. However each vegetation community has unique surface roughness by each vegetation type with near vegetation cover ratio, for example, broad leaf forest, needle leaf forest and grassland. If difference of vegetation surface roughness can be detected by satellite, difference of constitution of vegetation community can be understood in global scale. Difference of vegetation surface roughness can be detected by satellite multiangular observation. And index of vegetation surface roughness using multiangular observation was proposed in our laboratory (BSI: Bi-directional reflectance factor (BRF) structure Index). BSI can be detected vegetation surface roughness using satellite remote sensing data.

In order to analyze on global scale in time series, it is necessary to use global and time series satellite data set like PAL data set. However, in order to apply to BSI for global satellite data, there are some problems. Because BSI is based on BRF property, it is influenced of solar incident angle and of topography. Moreover, in order to use data with two different observation angles for calculation of BSI, footprint, Atmospheric correction, composite algorithm, etc. are problem. In order to make global data set of BSI, it is necessary to solve these problems.

2. Objective

The objective of this study is to make global and time series satellite data sets of detailed vegetation monitoring using BSI data sets. Therefore, in this paper, in order to make global BSI data set, it is examined about composite algorithm.

3. BSI

Fig. 1 (left figure) shows outline of BRF property in satellite data of visual and near infrared channel. BRF property of cross-principal plane in these regions can be described by linear regression equation. Each vegetation type which has different canopy surface roughness and cover ratio has different slope and offset especially in near infrared region. A set of red and NIR observation data obtained on a particular sensor zenith angle, and the intercepts of regression lines delineate a trapezoid (see right figure in Fig. 1). This trapezoid can be divided into two areas, named S_{sq} and S_{tr} in the figure.

Part of S_{sq} has relationship with Vegetation cover ratio. Because difference of near-infrared band reflectance and red band reflectance are used for calculate NDVI. Part of S_{tr} has relationship with BRF. BRF has relationship with vegetation surface and vegetation cover ratio. Therefore, it is thought that the ratio of S_{tr} and S_{sq} expresses the difference between each vegetation surface roughness.
The formula obtained from the ratio of S_{tr} and S_{sq} is BSI

(eq.(1)).

$$BSI = \frac{N_o - R_o}{N_n - R_n} \tag{1}$$

N_o : Near Infrared Reflectance data of off nadir
N_n : Near Infrared Reflectance data of off nadir
R_o : Red Reflectance data of off nadir
R_n : Red Reflectance data of off nadir

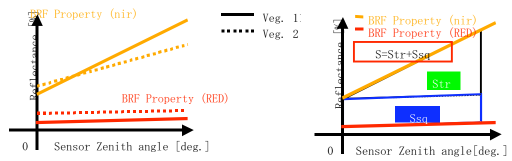

Fig. 1. Outline of BRF property of satellite observation data

4. Outline of data processing for BSI data set

In this study, NOAA AVHRR GAC data was used. In CEReS, Chiba Univ., there is GAC parallel processing system from i. to v. in Fig. 2. In order to make BSI data set, GAC parallel processing system is used.

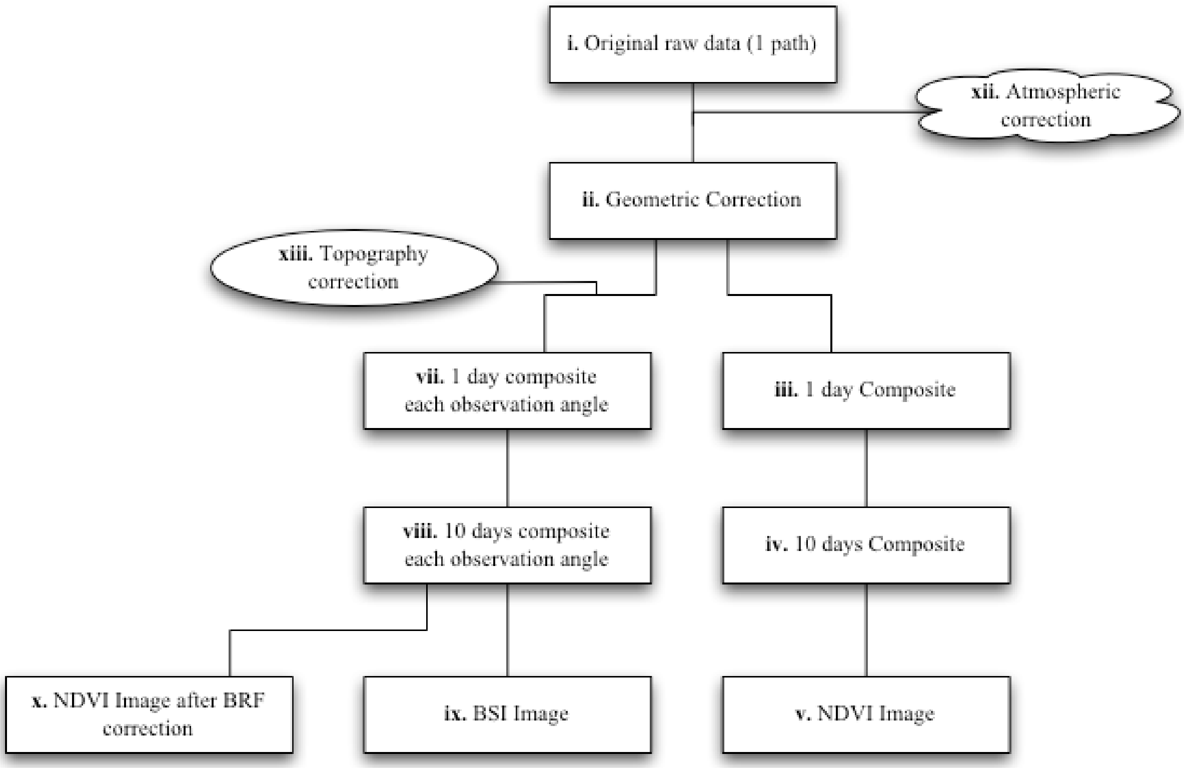

Fig. 2 Outline of data processing

Not only BSI but also NDVI is used for detailed vegetation monitoring. Therefore, NDVI data set generation procedure is also performed together with BSI data set making procedure. In this study, the conventional NDVI data (v. in Fig. 2), NDVI data (vi. in Fig. 2), which controlled the topographic effect, and the NDVI data with correction of BRF effect (x. in Fig. 2), are made.

Processing is divided into two flows after geometric correction. In order to make BSI data set, new composite algorithm is required.

1) Composite algorithm for BSI data set (1)

Since BSI based on which BRF property is shown expressed liner regression equation, for calculating of BSI, two sets of red and NIR data with different observation angles.

Satellite can detect BRF on vertical plane. Fig. 3 shows BRF property on vertical plane. In practice, it dose not become similar figure as shown in Fig. 3. It is because solar incidence conditions differ on an observation angle. Therefore, the values of BSI also differ on the right and the left. Then the data set for calculating BSI was divided into three on observation angle (Nadir, right off-nadir and Left off-nadir). This is called three directions composite. However, three directions composite has problem. Suppose that the data with which four observation angles differ at a local point as shown in Fig. 3 was acquired by satellite data. If data1 and data2 are used, the right side BRF property can be acquired from a liner regression equation. It can be said just the same to left side. In three directions composite, data2 and data3 are contained in the same direction group. Therefore, the data2 or data3 will be lost in composite process. Supposing data2 is lost, the right liner regression equation will not be obtained from data1 and data3. Therefore, BSI in a local point cannot be obtained from data1 and data3. Supposing data3 is lost, the right liner regression equation will not be obtained from data2 and data4. In order to lose such an error, it is necessary to divide the data of the Nadir direction into two parts. That should be divided into the four directions before the composite process. This is called four directions composite.

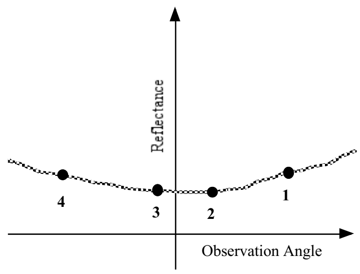

Fig. 3. BRF Property on vertical plane

2) Composite algorithm for BSI data set (2)

As described previously (3.1) the data acquired in a satellite dose not become a candidate for right and left like the BRF property of Fig. 3. Therefore, calculation of BSI is divided on the right and left. Fig. 4 shows BRF property on vertical plane of one side. A dashed line in Fig. 4 shows the observation angle that divides the data of nadir and off-nadir. Therefore, nadir data are data4 and data5, off-nadir data are data1, data2 and data3. The liner regression equation obtained from data2 and data4 is almost the same as the liner regression equation from data3 and data4. However, the liner regression equation obtained from data3 and data4 can be considered it will have big error. Therefore, it is thought that an error is included also in BSI. It is because the observation angle is too near. When making a composite, it is necessary to take into consideration the difference of the observation angle of nadir and off-nadir. The observation angle of off-nadir should not necessarily be just large. It is because it becomes impossible for a BRF property to express with the liner regression equation by data with a large observation angle. On the processing of off-nadir composite, it is required to use the data in the range that can be expressed with a liner regression.

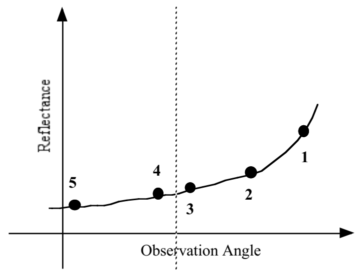

Fig. 4. BRF Property on vertical plane of one side

4. Conclusion

This paper has described only the composite algorithm for making a BSI data set. However, there are many problems that must be considered when making a BSI data set. The composite explained by the last session 3 is also one of them. There are a problem footprint, topographic effect, atmospheric correction, and influence of solar incident angle. The footprints of data differ in nadir and off-nadir. Therefore, how to fix a footprint with the data of off-nadir of bigger footprint can be considered. Control of topographic effect has taken in normalized method (2000, Ono et., al.). Atmospheric correction must be taken in the method in consideration of path length that is adapted for off-nadir data. It has two influences of a solar incidence angle. One is solar zenith angle. Another is a solar azimuth angle. Solar zenith angle affects BSI greatly than a solar direction angle. The influence of solar zenith angle is considered in a possibility that it can correct by the liner regression equation. In future study, processing also in consideration of problems other than a composite is proposed, and global data set is making, and it is used for global vegetation monitoring.

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