Observations of sparsely vegetated areas using optical sensor

MURAMATSU Kanako[1], Xiong Yan[1], FURUMI Shinobu[1] and KAIHOTSU Ichirow[2]

1 *KYOUSEI* Science Center for Life and Nature, Nara Women's University, 630-8506, Japan
2 Department of Natural Environmental Sciences, Hiroshima University, 739-8521, Japan

Key words: water cycle, floral change, wetness, monitoring, plant coverage

Introduction

On December 14, 2002, the Japan Aerospace Exploration Agency (JAXA) launched the Advanced Earth Observing Satellite II (ADEOS-II); Advanced Microwave Scanning Radiometer (AMSR) and Global imager (GLI) sensors were included on board. Algorithms to estimate soil moisture using AMSR data and experiments to validate of the algorithms have been developend. Since estimations of soil moisture using AMSR data are affected by vegetation moisture content, determination of the quantity and distribution of vegetation is necessary.

A variety of information can be obtained simultaneously using optical sensor such as GLI; for example, information on vegetation coverage, depth, and activity. Many scientists have attempted to develop an estimation method for these vegetation parameters using vegetation indices such as the Normalized Difference Vegetation Index (NDVI). Because of the wavelength range of optical sensors, light can not easily penetrate a thick vegetation canopy, and the sensitivity of vegetation indices to the vegetation coverage is better than that to vegetation depth. Photosynthesis is

In this study, vegetation information such as vegetation coverage, net primary production of vegetation and plant water content is extracted using optical sensor data . In this paper, how to estimate vegetation coverage and plant water content is reported.

Study area and field survey

The experimental area was located in one of the validation sites of the soil moisture algorithms based on ADEOS-II / AMSR and Aqua / Advancedd Microwave Scanning Radiometer -EOS (AMSR-E). data. It is a semiarid sparsely vegetated area approximately 235 km south-southwest of Ulaanbaatar, the capital of Mongolia. The dominant vegetation types are short and long grasses, such as *Achnatherum splendens* and shrubs such as *Caragana microphylla* and *C. pygmaea.*

The area is 60 x 60 km starting in Mandalgobi (M.G.) city, which is the most southwest. A field survey was carried out at each grid point, at intervals of 10 km.

Field survey data analysis

Sensitivity of the vegetation index to vegetation coverage is better than that to biomass. If related to vegetation coverage, estimations of plant water content should be possible using the vegetation index observed with the GLI sensor. For this reason, the relationships among vegetation coverage, biomass and plant water content were studied. Biomass and plant water content showed an almost linear relationship defined as:

$WC(g/m^2)= 0.84\ (\pm\ 0.03) \times DM\ (g/m^2)$. (1) The experimental linear-correlation coefficient was 0.81.

Next, Relationship between vegetation coverage and biomass was studied for two vegetation types, short grasses, and long grasses and shrubs using field survey data, since it is difficult to directly estimates biomass using optical sensor data. The short grass data indicated linear relationship. If sufficient data is available, the relationship between vegetation coverage and biomass of each species should be determined; however in this study, the number of long grass and shrub samples was insufficient for them to be divided into species. The relationships between the biomass and plant water content of short grasses, and shrubs and long grasses were respectively determined from

$DM(g/m^2)= 1.75(\pm 0.08)\times VC(\%)$, (2)

$DM(g/m^2)= 4.55\ (\pm 0.35) \times VC(\%)$. (3)

Satellite data and Analysis method

ADEOS-II/GLI has 30 bands of 1km spatial resolution and 6 bands of 250m spatial resolution in the VNIR(Visible and near-infrared region), SWIR(Short-wave length infrared region.) and

MTIR(Middle and thermal infrared region.) Global mosaic of GLI data has 12 bands for the VNIR and SWIR, 5 bands for MTIR and a spatial resolution of 1km. We used 9 bands in VNIR and SWIR for global mosaic data analysis.

The spectral reflectance data measured with GLI sensor were analyzed using the universal pattern decomposition method (UPDM) (L.F.Zhang et al., 2004), which is based on the pattern decomposition method (PDM)(Fujiwara et al., 1996, Muramatsu et al. 2000, Daigo et al., 2003). In the PDM framework, the normalization of standard patterns depends on how many bands and which wavelengths the sensor detects. As a result, the obtained pattern decomposition coefficients might differ between sensors such as TM and GLI, even when observing the same sample. However, with UPDM the same normalized spectral patterns are used for all sensors, and therefore, the same coefficient values are obtained even when using different sensor. The spectral reflectance values (R_1, R_2, ・・・, R_n) of n bands of a pixel are transformed into four coefficients, water (uC_w), vegetation (uC_v), soil (uC_s) and supplementary of a yellow-leaf (uC_4), with four standard spectral patterns. Of these four patterns, three correspond to typical ground objects, water (uP_{iw}), vegetation (uP_{iv}) and soil (uP_{is}), and one represents the supplementary standard pattern (uP_{i4}). Here, i is represents band number. The general equation of UPDM is as follows:

$$R_i \to uC_w uP_{iw} + uC_v uP_{iv} + uC_s uP_{is} + uC_4 uP_{i4} \quad (4)$$

The modified vegetation index based on UPDM was determined as follows:

$$MVIUPD= (uC_v-0.2uC_s-uC_4-uC_w) / (uC_w+uC_v+uC_s) \quad (5)$$

A linear relationship with vegetation cover and the quantity of photosynthesis was assumed (XIONG Yan 2005, L.F.Zhang et al., 2004) . Using this index, net primary production of vegetation is estimated and vegetation coverage is estimated. Using the information of vegetation coverage and vegetation type, plant water is estimated.

Estimation of vegetation coverage

Using the data obtained on August 13 2003, the vegetation index MVIUPD of all grid points was calculated and compared with the field survey results of vegetation coverage from August 7 to 10 2003. The relationship with NDVI is also shown in Figure 3. The sensitivity of MVIUPD to vegetation coverage was better than that to NDVI and it showed a linear relationship as follows:

$$VC(\%)= 100.1\ (\pm\ 6.1) \times MVIUPD. \quad (6)$$

The experimental linear-correlation coefficient was 0.94. The results of vegetation coverage obtained using equation(3).

Estimation of plant water content

If short grasses and shrubs are classified, separately, plant water content can be estimated using the relationships in Eq. (2), (3) , (1) and (6). To classify these two types of vegetation separately, seasonal changes in MVIUPD were examined at each grid point.

The seasonal patterns in MVIUPD for short grasses and shrubs, respectively, were only slightly different. The seasonal peak of MVIUPD of short grasses is faster than that of shurbs.

In this study, the criteria was determined as follows: on August 13 2003, MVIUPD was less than 0.18 for the short grasses and more than 0.18 for the shrubs. The percentage of miss-classification was also studied for each grid, and it determined as 38 %. Although the accuracy of this vegetation classification is debatable, estimates of plant water content were nevertheless attempted using the obtained result.

The estimation result of plant water content and net primary production of vegetation will present at the workshop.

References

K. Muramatsu, S. Furumi, A. Hayashi, N.Fujiwara, M. Daigo,and F. Ochiai, ``Pattern decomposition method in the albedo space for landsat/TM and MSS data analysis'', *Int. J. Remote Sensing*, **21**,99-119(2000)

K. Muramatsu, S. Furumi, A.Hayashi, Y. Shiono, N. Fujiwara, M. Daigo, and F. Ochiai, ``Pattern Decomposition Method and a new vegetation index for hyper-multispectral satellite data analysis'', *Adv. Space Res.*, **26,** 1137-1140(2000)

L.F.Zhang, S.Furumi, K.Muramatsu, N.Fujiwara, M.Daigo, L.P.Zhang, ``Sensor-independent analysis method for hyper-multispectral data based on the pattern decomposition method'', accepted to *Int. J. of Remote Sensing*

M.Daigo, A. Ono, N. Fujiwara, R. Urabe, ``Pattern decomposition method for hyper-multispectral data analysis'', Int. J. of Remote Sensing, **25(6)**,1153-1166

Y. Xiong, ``A study of algorithm for estimation of global terrestrial net primary production using satellite sensor data'', *Doctoral thesis*, 2005 Nara Women's Univ.