ESTIMATION ON TREE COVER PERCENTAGE USING TERRA/ASTER DATA WITH AIRBORNE LASER SCANNING DATA

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ABSTRACT:

It is expected that the remote sensing techniques will play a major role in establishing the carbon sink assessment system to meet the need of the Kyoto Protocol. Tree cover percentage is one of the useful parameters in estimating CO_2 absorption. Purpose of this study is to investigate the correlation between tree cover percentage and 15-30 m resolution TERRA/Advanced Spaceborne Thermal Emission and Reflection radiometer (ASTER) optical sensor data. First, airborne laser scanning data – better known as airborne light detection and ranging (LIDAR) sensor data, are obtained in the forest of 1 km^2 in area, Japan. The forest as the study area is classified into five kinds of landform such as 1) crest slope, 2) head hollow, 3) slope facing east, 4) slope facing west and 5) valley. Tree cover percentage in each landform is calculated by the LIDAR data. The tree cover percentage is overlapped on the TERRA/ASTER data, and the relation between them is investigated. As a result, an adequate correlation is estimated between the tree cover percentage and TERRA/ASTER data in the crest slope and the valley. In order to estimate global level tree cover percentage, there is the possibility to adopt this correlation to 1 km resolution SPOT/VEGETATION data. But more investigation will be needed in the future study.

1. INTRODUCTION

The Kyoto Protocol was adopted in 1997 in Kyoto, at the third Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). In the Protocol Japan makes an effort to meet its 6% CO_2 emissions reduction target. It is necessary to research and monitor carbon sinks such as forest to meet the target, and tree cover percentage is one of the useful parameters to estimate the volume of CO_2 absorption.

Tree cover percentage is also important parameter to make global land cover classification map. The classification system, for example, Land Cover Classification System (LCCS) of Food and Agricultural Organization (FAO), often needs tree cover percentage.

Tree cover percentage is efficiently and objectively calculated through airborne laser scanning data – better known as airborne light detection and ranging (LIDAR) sensor data. It needs high costs to obtain the LIDAR data in the wide area, but the satellite optical sensor data is more reasonable and cover wider area than the LIDAR data. Purpose of this study is to investigate the correlation between the tree cover percentage and the 15–30 m resolution satellite sensor data. Furthermore, the possibility to estimate the tree cover percentage using 1 km resolution the Systeme pour l'Observation de la Terra (SPOT)/VEGETATION (VGT) data is described.

2. STUDY AREA

The study area that covers 1 km^2 in area is Hachioji, near Tokyo, Japan (Figure 1). The hilly area is extended in wide area around Tokyo, and study area is located in the typical hilly area.

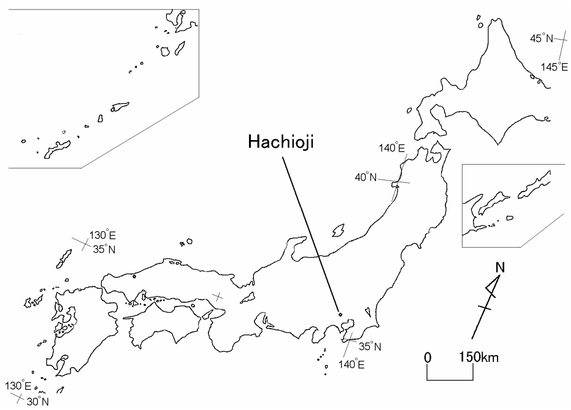

Figure 1. Study area

Landform has an effect on the distribution of the trees in the hilly area. The study area was classified into five landforms such as crest slope, head hollow, slope facing east, slope facing west and valley (Figure 2). In the crest slope and the valley soil are dry and wet, respectively. The head hollow is susceptible to landslide. Hill slopes were classified into two types; slope facing east and slope facing west. This is the reason why these differences may appear in the satellite optical sensor data. The Table 1 shows the kinds of trees in each landform.

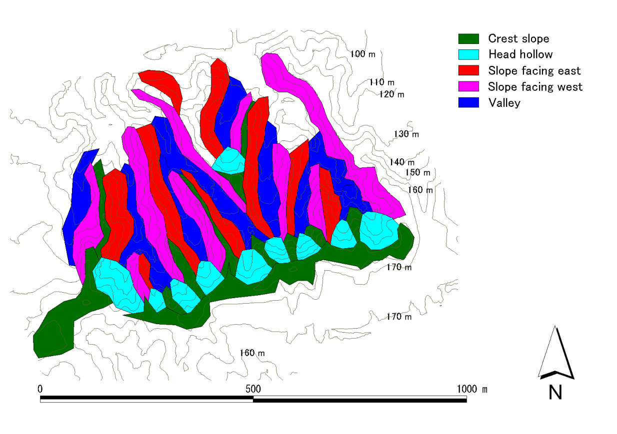

Figure 2. Landforms in the study area

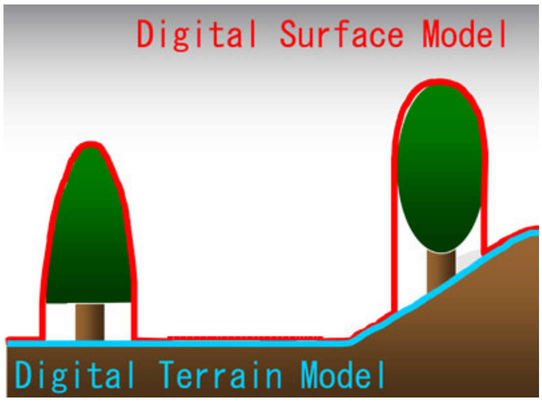

Figure 3. DSM and DTM (Masaharu et al., 2001, revised)

Landform	Typical trees
Crest slope	*Quercus serrata, Prunus jamasakura*
Head hollow	*Quercus serrata,Quercus acutissima, Carpinus tschonoskii*
Slope facing east and west	*Magnolia obovata*
Valley	*Alnus japonica*

Table 1. Landforms and typical trees (Matsui et al. (eds), 1990, revised)

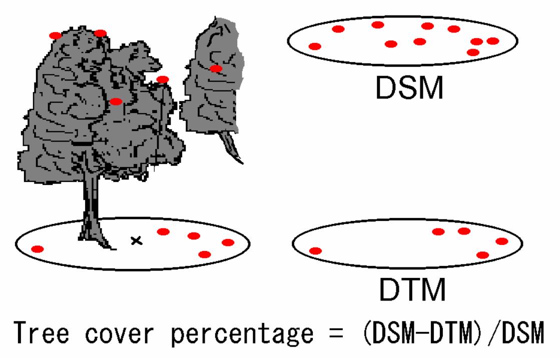

Figure 4. Tree cover percentage

3. METHOD

3.1 Airborne LIDAR sensor data

Airborne LIDAR sensor data were obtained in the study area in August 2002. In this season trees are in leaf. A canopy Digital Surface Model (DSM) was generated from the first pulse data of LIDAR sensor data, and the Digital Surface Model (DTM) was generated from the other pulse data of the LIDAR sensor data (Figure 3).

The tree cover percentage was calculated in each landform. The percentage was calculated as follows (Figure 4); first, the number of the reflected points on DSM was counted, next, the number of the reflected points on DTM was counted, finally, the number of DSM reflected points minus the number of DTM reflected points was divided the number of DSM reflected points.

3.2 Satellite optical sensor data

In this study TERRA/Advanced Spaceborne Thermal Emission and Reflection radiometer (ASTER) data in September 2002 were used in the study area. In this season trees are in leaf. Calculated tree cover percentage data were overlapped on the TERRA/ASTER data, and the correlation between this two information was investigated.

TERRA/ASTER is the high efficiency optical sensor, which covers a wide spectral region from the visible to the thermal infrared by 14 spectral bands. Resolution of the near infrared (NIR) band and two visible bands data is 15 m, and resolution of the six shortwave infrared (SWIR) bands data is 30 m. Visible bands are green (520–600 nm) and red (630–690 nm). NIR band is 760–860 nm. SWIR bands are 1,600–1,700 nm, 2,145–2,185 nm, 2,185–2,225 nm, 2,235–2,285 nm, 2,295–2,365 nm, and 2,360–2,430 nm.

Band	TERRA/ASTER (nm)	SPOT/VGT (nm)
Blue/Green	520-600 [15 m]	430-470 [1 km]
Red	630-690 [15 m]	610-680 [1 km]
NIR	760-860 [15 m]	780-890 [1 km]
SWIR	1,600-1,700 [30 m]	1,580-1,750 [1 km]

2,145-2,185 [30 m]
2,185-2,225 [30 m]
2,235-2,285 [30 m]
2,295-2,365 [30 m]
2,360-2,430 [30 m]

Table 2. Comparative table of the two sensors ([ ]: resolution)

In order to search the possibility of this study's adoption to SPOT/VGT data, four spectral bands of green, red, NIR and SWIR bands (1,600–1,700) of TERRA/ASTER data were used. If SPOT/VGT data can be used to estimate tree cover percentage, global level tree cover percentage may be efficiently estimated. Comparative table between two sensors' spectral bands are shown in Table 2.

4. RESULT

Figures 5 shows the relation between tree cover percentage and each band's digital number of TERRA/ASTER data. In the two landforms of crest slope and valley, an adequate correlation is estimated from the two bands of green and SWIR bands. Linear regression lines were calculated as shown in Figure 5. Considering the R^2 values, SWIR band gave better correlation than green band. Using the obtained regression line, tree cover percentage will be estimated only in the two landforms.

But it is difficult to find correlation in case of the other three landforms of head hollow, slope facing east and west, because tree cover percentage are not dependent on the digital number.

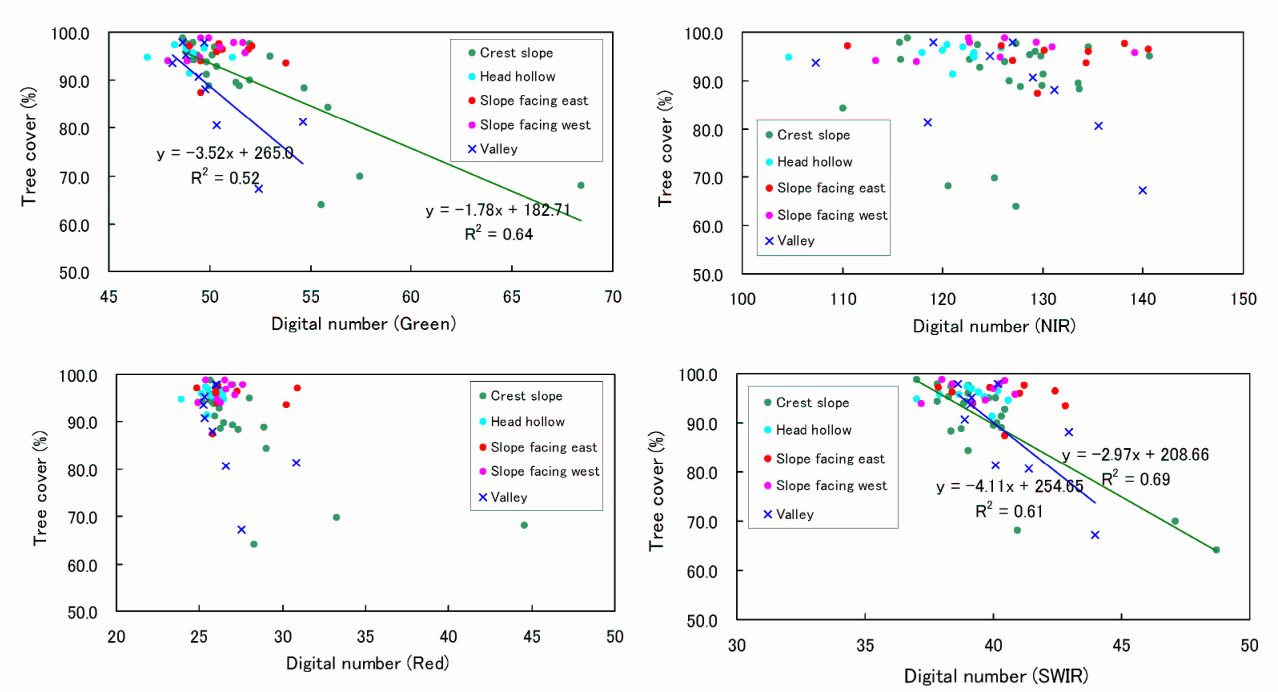

Figure 5. Tree cover percentage and digital number in each band

5. DISCUSSION

Almost all of the tree cover percentages are more than 90 % in the three landforms of head hollow, slope facing east and west. As a result, even if there is a wide distribution of digital numbers in near infrared band, tree cover percentages seem to be constant in Figure 5. It may be necessary to improve the calculation method of tree cover percentage, because DSM reflected points may include not only canopy surface but also undergrowth surface under the canopy, namely, tree cover percentage in this study may be overestimated.

In the Figure 5, when digital numbers in red band are between 24 and 27, tree cover has the tendency of more than 90 %. In other words, it is difficult to find the correlation between tree cover percentage and digital numbers in red band. The normalized difference vegetation index (NDVI) is calculated from both of NIR and red bands digital number. Here, the correlation between tree cover percentage and NDVI was investigated. The result is shown in Figure 6. NDVI in the figure is converted into the integer of 0–255. In the figure, it is also difficult to find the correlation between tree cover percentage and NDVI.

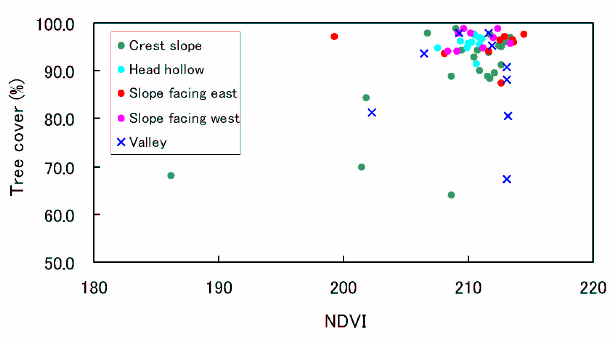

Figure 6. Tree cover percentage and NDVI

For mapping the tree cover percentage by the TERRA/ASTER data, the following method is proposed.

1) Red band digital number in the forest is investigated. When the red band digital number is between 24 and 27, tree cover percentage is decided as more than 90%.

2) When the red band digital number is less than 24, tree cover percentage is not estimated.

3) When the red band digital number is more than 27, the tree cover percentages in crest slope and valley is estimated by the regression lines in SWIR band in the Figure 5, respectively.

If this processing is improved in the future study, it is the starting points for global tree cover percentage mapping by the SPOT/VGT. But in this case it will be necessary to classify landforms in advance.

5. CONCLUSION

The possibility of the tree cover percentage by red and SWIR bands data is shown in this study. If tree cover percentage where trees sparsely grow is calculated by this study's method, the correlation between tree cover percentage and TERRA/ASTER data may be clearly found. Furthermore, for mapping the tree cover in the wider area by SPOT/VGT data, it is necessary to investigate between TERRA/ASTER data and SPOT/VGT data.

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