A STUDY ON ESTIMATION OF TREES HEIGHT IN JAPANEASE CEDAR AND JAPANEASE CYPRESS IN NARA USING ALOS/PRISM SATELLITE SENSOR

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Commission VIII, Working Group VIII/8

KEY WORDS: Land, Land Use, Forestry, ALOS PRISM, DSM, DTM

ABSTRACT:

An estimation of wood's volume is very important issue for forest management, and estimating the carbon stock, and absorption of carbon from the atmosphere for global warning.To estimate wood's volume, tree height is important key parameter. ALOS satellite was launched on January 24, 2006 by Japan Aerospace Exploration Agency (JAXA). The PRISM instrument was mounted on ALOS satellite. Its spatial resolution is 2.5m, its spectral range from 0.55 to 0.77 μm, and it provides of the different directional image, nadir, backward, forward. Using the sets of different directional image, Surface height can be estimated. The surface height will be different from ground level. Focusing on this difference, we consider that the difference is trees height. In this paper, trees height was estimated from PRISM and compare with real trees height.

1. INTRODUCTION

Advanced Land Observing Satellite (ALOS) was developed from ADEOS and JERS-1. This satellite has aimed to collect by observation data of high resolution in the global areas. This satellite has three sensors, Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM), Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), Phased Array type L-band Synthetic Aperture Rader (PALSAR).

PRISM sensor observes land surface from the three difference directions. Using the structure, DSM (Digital Surface Model) is generated.

An estimation of wood's volume is very important issue. In general, it is needed to measure diameter and height of all trees to get the correct volume of woods. Meanwhile, if the area of estimation is large, its cost is very high. If the measurement of diameter and height were not precision, the volume very roughly estimate using equations.

The purpose of this study is estimating tree height of Japanese cedar and the Japanese cypress forest to large area and low cost. Finally, it will be used to calculate tree volume based on this tree height. Specially, it pays attention to Nara, Japan. Because the tree of this area is traditional and famous in Japan and this area include our university. And we would like to help to make active Nara's forestry.

2. MAKING GRAND VERIFICATION DATA

It is necessary to make the ground verification data to verify the correctness of the tree height estimated from the satellite. Here, the ground verification data made by analysing stem and the field survey is described in this section.

2.1 Study Site

Target area is Ikari management district（N34°20' 33.8″ E136°01' 33.8″）, Kawakami-village, Yoshino-country, Nara Prefecture. This place has two study sites. The elevation of the first site is about 1240～1280m with size of 80 m×80ｍ. This site is defined "site Ⅰ". On another site, the elevation is about 1110～1140m while the size is 40m×40ｍ. This site is defined "Site Ⅱ". The distance between Site Ⅰ and Site Ⅱ is about 250m. There forest type is Japanese cedar and Japanese cypress. Site Ⅰ has 1012 trees (Japanese cedar : Japanese cypress =810:202) and Site Ⅱ has 221 trees(Japanese cedar : Japanese cypress =192：29) at the time of, November 1, 2007.

2.2 Method of Stem analysis

To understand the growth process of tree height and trees volume, the tree was sawed into disks. Each disk was sampled each 0.5m length. The annual rings of each disk are measured.

2.3 Used Data to stem analysis

In this study, the data used for the stem analysis is shown in Table 1. When the kind of the tree is Japanese cedar, it is with as cedar, and Japanese cypress forest as cypress.

Sample Name	Species	Site	Height (m)	Diameter (mm)	Age
A	cedar	II	14.55	188.02	33
C	cedar	II	16.45	177.32	35
A102	cedar	I	13.94	174.54	39
A206	cedar	I	15.17	217.14	35
A306	cedar	I	11.06	129.52	36
A405	cedar	I	11.21	176.32	37
AE3	cedar	I	13	182.32	38
B	cypress	II	14.83	189.2	36
D	cypress	II	12.65	175.24	35
AE8	cypress	I	10.85	232.18	34
AE9	cypress	I	11.37	202.36	32
A404	cypress	I	8.54	162.31	36

Table1: Detail of Sample to use Stem analysis

2.4 Results of stem analysis

The growing process from stem analysis about SampleB and SampleD are showed in figure 1 and figure 2. Those figure's x-axis is diameter (mm) and y-axis is height (m).

The diameter of the annual ring was measured. Counting the annual ring of each disk, each age of the annual ring can be known. Figure1 and figure 2 are made by the diameter of each age drawing line. However, the top and the lower side are complemented using two points before that. As a result, the height at each age can be estimated.

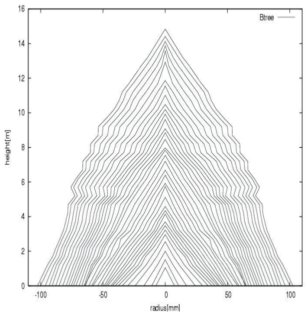

Figure 1: Sample B

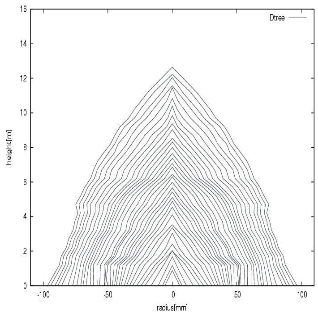

Figure 2: Sample B

2.5 Tree height estimation equation

Using the relationship between height and diameter is guiding the equation (Takahashi E. and Takeuchi N, 2001). Figure3 is related chart of the diameter and the tree height about the Japanese cedar in Site I, Figure4 is related chart of the diameter and the tree height about the Japanese cedar in Site II, and figure5 is related chart of the diameter and the tree height about the Japanese cedar. Those figure's x-axis is tree height (m) and y-axis is diameter (cm). If the figure's legend is "sample's name", that point is obtained from stem analysis. If the figure's legend is "by machine", that point is obtained from using the measuring instrument of tree height(T3 transponder and VertexIII). Fitting those points about each site, the tree height estimated equation is made. The tree height against diameter in site II is higher than site I. The reason is that the site II has hard slope and little sunshine than site I.

Using the recently data from machine, the slope of Japanese cedar growing is becoming small in Site I. So other place and other species are needed that this research is keeping.

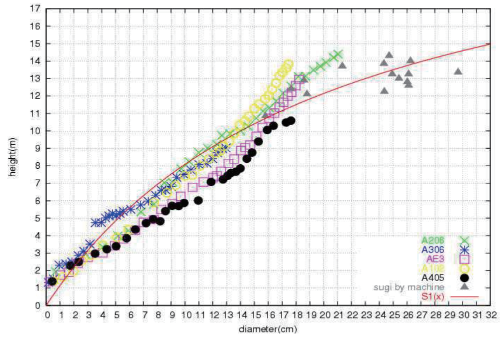

Figure 3: Relationship of diameter and tree height of Japanese cedar in Site I

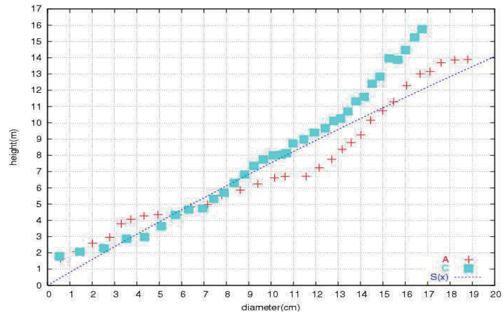

Figure 4: Relationship of diameter and tree height of Japanese cedar in Site II

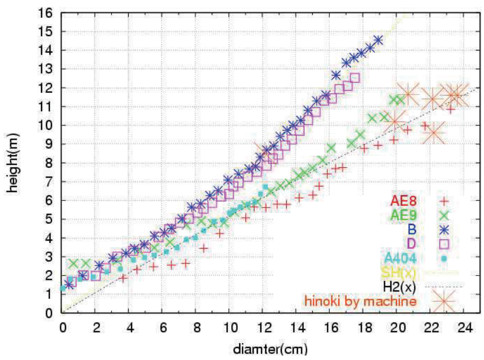

Figure 5: Relationship of diameter and tree height of Japanese cypress

$$h = \frac{d}{0.83 + 0.04 \times d} \quad (1)$$

$$h = \frac{d}{1.23 + 0.01 \times d} \quad (2)$$

$$h = \frac{d}{1.85 + 0.01 \times d} \quad (3)$$

$$h = \frac{d}{1.56 - 0.01 \times d} \quad (4)$$

where *d=diameter(cm)*
h=height(m)

Equation (1) is tree height estimating equation of Japanese cedar in Site Ⅰ, equation (2) Japanese cedar in Site Ⅱ, Equation (3) Japanese cypress forest in Site Ⅰ, equation (4) Japanese cypress forest in Site Ⅱ. The average difference between height from equation (1) and that from stem analysis is 0.99m and an average difference as the volume is 0.01m. The average difference between height from equation (2) and that from stem analysis is 1.05m and an average difference as the volume is 0.007m. The average difference between height from equation (3) and that from stem analysis is 0.55m and an average difference as the volume is 0.005m. The average difference between height from equation (4) and that from stem analysis is 0.47m and an average difference as the volume is 0.004m.

2.6 Results of making verification data

Using the tree height estimated equations(equation(1) ～(4)), the average height are calculated for each site. Using the tree volume equations (is calculation from Japanese Forestry Investigation Committee), the average volumes are calculated for each site. For Japanese cedar in Site Ⅰ, the average diameter is 20.9 ㎝, the average height is 12. 4 m and the average volume is 0.033 ㎥. For Japanese cedar in Site Ⅱ, the average diameter is 19.2 ㎝ and the average height is 9.38m and the average volume is 0.022 ㎥. For Japanese cypress forest in Site Ⅰ, the average diameter is 19.9 ㎝ and the average height is 13.8m and the average volume is 0.03 ㎥. For Japanese cypress forest in Site Ⅱ, the average diameter is 19.4 ㎝ and the average height is14.9m and the average volume is 0.030 ㎥. For all species in Site Ⅰ, the average diameter is 20.4 ㎝ and the average height is 13.1m and the average volume is0.031 ㎥. For all species Site Ⅱ, the average diameter is 19.6 ㎝ and the average height is 14.0m and the average volume is 0.023 ㎥.

3. ESTIMATION OF TREE HEIGHT FROM ALOS/PRISM DATA

In this section, tree height is estimated using DSM of ALOS/PRISM and DTM (Digital Terrain Model) by Geographical Survey Institute. And it is compared the tree height from grand verification data with the tree height from ALOS/PRISM.

3.1 Used data as DSM

ALOS/PRISM image data include study site show in Figure8 and Figure 9. It was acquired on June 13, 2008. The operation mode is OB2 with nadir (center coordinates : N34.264 E136.096) and backwards (center coordinates : N34.310 E135.949).In this study, two DSM is made from the PRISM data and is used UTM. Those spatial resolutions are 2.5m. Those axes are shown by UTM coordinates.

3.1.1 DSM from JAXA

Using the PRISM images, one of DSM was processed by JAXA. Figure 9 contour of DSM is shown. The absolute height of DSM is not same as the height above sea level. The relate height difference between DSM and the height of terrain required. Since, several control points are taken to calibrate the DSM height on the river, ponds, and road. These objects have the same height between the height above sea and the surface height from satellite. Using these control points, DSM height from satellite. Using these control points, DSM height from satellite are calibrate.

3.1.2 DSM by Soft Remote10

Soft Remote10 is made by T.Sugimura (RESTEC) for educational. This soft can make DSM and it is open to the public on Web. Figure 8 contour of DSM is shown. Using this Soft ware, DSM is calculated by myself as follows.
Using ALOS/PRISM image data sets with the different observing angle, ICP (Image Control Point) is taken. RMS of the affine conversion cannot be made within one pixel if points are not same elevation. So it is careful that all ICPs are same elevation. Using affine conversion images are registered mutually based on the nadir image. Then, DSM is estimated from the gap of the difference images. Finally, if the difference between DTM and DSM is 25m or more, it is considered the error value and it is complemented by a surrounding point. The absolute value of the height above sea level and DSM is not same each others. The relate height difference between DSM and the height of terrain required. Since, several control points are taken to calibrate the DSM height on the river, ponds, and road. These objects have the same height between the height above sea and the surface height from satellite. Using these control points, DSM height from satellite. Using these control points, DSM height from satellite are calibrate.

3.2 Used data as DTM

DTM is shown in Figure 7. DTM including study site is used through download service of basic map information on Geographical Survey Institute in Japan. That date is 10m mesh and that axis is shown by latitude and longitude coordinates. DSM spatial resolutions are 2.5m. Those are shown by UTM coordinates. So DTM was supplemented to the resolution of 2.5m with using the Bi-Linear method and that axis change UTM coordinates.

3.3 Results and Discussion

After calibrating the DSM height to DTM, the height differences are compared with each other. The result is shown in Figure 10. In Figure 10, x-axis is showed as UTM coordinates and y-axis is showed as difference height about site Ⅰ. The difference between DTM and DSM from JAXA was 8m in average for whole area of study site Ⅰ. The tree height average in Site I was 13.1m, since the difference between estimated tree height and the validation was 5.1m. The difference of 2m was seen on average as a result of comparing DTM and DSM by Soft Remote10. The tree height average in Site I was 13.1m, since the difference between estimated tree height and the validation was 11.1m. Figure 11 show the detail in direction of West-East to pass site Ⅰ and, x-tics is showed as UTM coordinates and y-tics is showed as difference height. Then, the difference of 18m was seen on average as a result of comparing DTM and DSM from JAXA. Then, the difference of 3m was seen on average as a result of comparing DTM and DSM by soft Remote10. From these results, the precision of DSM from JAXA is higher than that of DSM proceed by myself using remote10 software. It is considered that two reasons. One of reason is the condition at the supplementation that uses DTM is too tight. Another reason is that to decide relative point. In either case, the matter needs further study.

There is high possibility to estimate tree height using DSM from JAXA.

3.4 Conclusions and Future

Tree height can be estimated using DSM from JAXA. In the future, tree height is estimated about the whole area of Nara, Japan using DSM from JAXA and DTM.

4. Reference

1)Japanease Forestry Investigation Committee, 1970. Tree volume product table West Japan chapter

２）T.Sugimura（RESTEC）et al ,Soft Remote10（http://www.restec.or.jp/research/）

3) Japan Aerospace Exploration Agency (JAXA)（http://www.jaxa.jp/）

４）E,takahashi., and N,Takeuchi., 2001. The situation and guideline about old Japanese cedar man-made forest in Kamitako, Kawakami-mura, Nara, Japan. Forest Study73, pp 59-66.

5) Geographical Survey Institute. Basic map information downloads service (http://fgd.gsi.go.jp/download/)

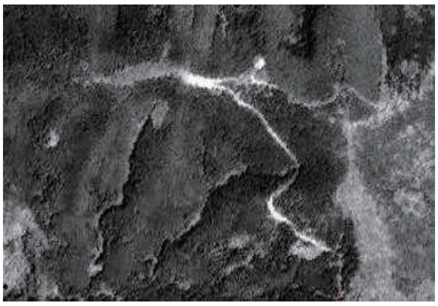

Figure 6: PRISM Image Data around Kawakami,Nara

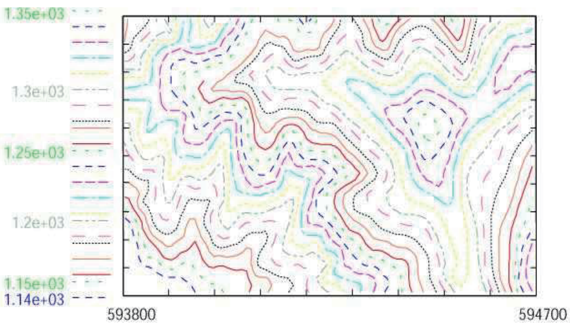

Figure 8: DSM by remote10

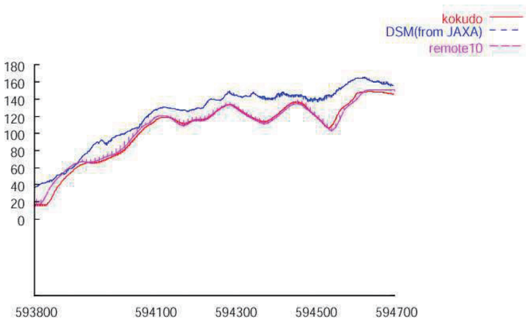

Figure 10: the difference height of DSM (from JAXA) and DSM(by Soft Remote10) and DTM in direction of West-East

5. Acknowledgements

This study site was in Nara Prefecture forest. Thanks are giving to Nara Prefecture, division of wood polities, Kawakami Forestry Association and Forestry fund in Nara, Japan. In this study, Remote10 Soft was used. This Soft was created by Dr. T.Sugimura. Special thanks are giving Dr. T.Sugimura for giving opportunity to use this Soft ware and giving useful advices. ALOS/PRISM data was provided from JAXA. Special thanks are giving to Dr. T.Tadono for giving useful comments and discuss.

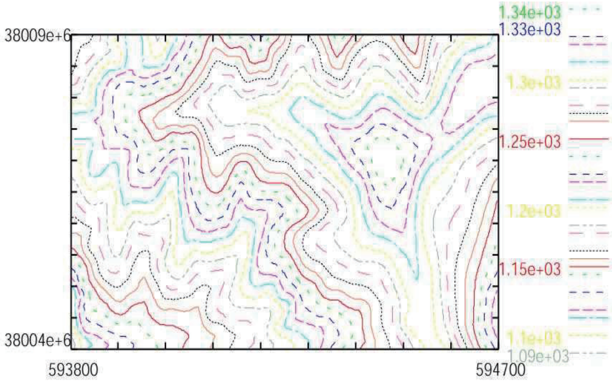

Figure 7: DTM from Geospatiotional Information Authority of Japan (GSI)

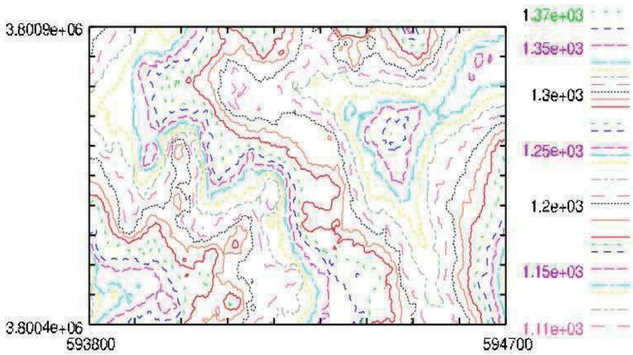

Figure 9: DSM from JAXA

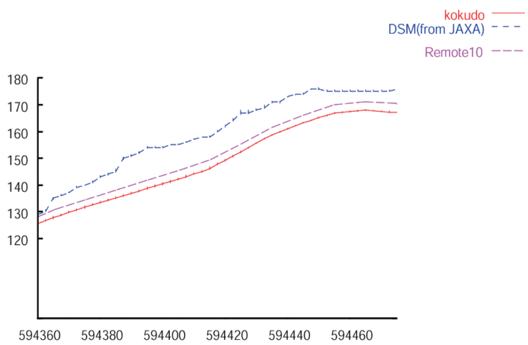

Figure 11: the difference height of DSM (from JAXA) and DSM (by Soft Remote10) and DTM in direction of West-East to pass site Ⅰ