BIOMASS ESTIMATION OF PINUS RADIATA (D. DON) STANDS IN NORTHWESTERN SPAIN BY UNMIXING CCD CBERS DATA

Eva Sevillano-Marco[1], Alfonso Fernández-Manso[1], Carmen Quintano[2], Yosio Edemir Shimabukuro[3]

[1]Universidad de León
Departamento de Ingeniería y Ciencias Agrarias, Escuela Superior y Técnica de Ingeniería Agraria, Avda. de Astorga SN, 24400 Ponferrada, Spain
evadevanos@gmail.com, alfonso@unileon.es

[2]Universidad de Valladolid
Departamento Tecnología Electrónica, Escuela Universitaria Politécnica, Francisco Mendizábal, 1, 47014 –Valladolid, España
menchu@tele.uva.es

[3]INPE- Instituto Nacional de Pesquisas Espaciais
Av. dos Astronautas, 1758 12.227-010 São José dos Campos – SP, Brasil
yosio@dsr.inpe.br,

1. INTRODUCTION

Information from satellite imagery is an important data source to forest management. Remote sensing techniques provide information about volume, biomass and other biophysical parameters of forest stands. The estimation of biomass by satellite remote sensing has been tested considering a wide range of spatial scales and environments [1] [2] [3]. Chinese-Brazilian Earth Resources Satellite (CBERS) data had not been used in Europe yet. In this work, we examined the potential of CBERS CCD data for estimating radiata pine stand attributes, especially biomass, in a Northwestern Spain region.

2. MATERIAL AND METHOD

The study area was El Bierzo, in the Northwestern Spain. Climate and decline of agriculture have favoured the establishment of extensive commercial forest plantations in the study area. Even if relatively recently introduced in the region of El Bierzo, radiata pine currently occupies an area of approximately 150 km^2 [4] .

Data from field inventory carried out during the summer of 2003 in 45 permanent sample plots of the network established by the University of León (Spain) in pure radiata pine plantations were employed. Concerning remote sensed data, a CBERS image (20 x 20 m) acquired on November 5th, by the high resolution Charge-Coupled Device (CCD) sensor was used. CBERS CCD images have 5 spectral bands: blue, green, red, infrared, and panchromatic.

The applied methodology had the following steps:
1.-Preprocessing the field inventory data: the following variables were considered: stand volume (V, m^3ha^{-1}), stand aboveground biomass (W, $t{\cdot}ha^{-1}$), stand stem biomass (Ws, $t{\cdot}ha^{-1}$), carbon pools in stand aboveground biomass (C, $t{\cdot}ha^{-1}$), carbon pools in stem biomass (Cs, $t{\cdot}ha^{-1}$), age (t, years), dominant height (H, m), stand basal area (G, m^2ha^{-1}), quadratic mean diameter (Dg, cm), dominant diameter (Do, cm), mean height (Hm, m), number of stems per hectare (N), and Site Index (SI, m).
2.-Preprocessing the CBERS CCD image: as fraction images from spectral unmixing show biophysics properties more easily than original bands (they represent physical aspects of ground covers), Spectral Mixture Analysis (SMA) was applied to the original image [5] .

3.-Work database formation: an average 3x3 filter was applied to the image as a previous step to the extraction of the digital values that corresponded to the considered field plots. These values were stored together with the field inventory information in order to form the work database.
4.-Statistical analysis of the work database: the statistical relationships were performed using correlation analysis, whereas predictive linear and non-linear regression models were consequently selected for estimation trials. The regression models tested in this study were mainly the proposed by [2] [3] [6] [7] . Comparison of the different fitted models was based on numerical analyses. Three statistical criteria obtained from the residuals were examined: the coefficient of determination (R^2), showing the proportion of the total variance of the dependent variable explained by the model; the root mean square error (RMSE), which states the accuracy of the estimates for basal area and stand volume; and the mean percent standard error (S%), that indicates the size of error as a percentage of the mean of the estimated variable distribution.

3. RESULTS AND DISCUSSION

The correlation analysis showed that both the original band infrared and the shade fraction images were significantly correlated to W and C (Pearson correlation coefficient equal 0.53 and 0.55, respectively, p-value = 0.01). This result was not surprising; different authors ([8] and [9] , among others) stated that the shade fraction image was the best band to estimate forest biophysical stand variables. The non-linear regression model described by [3] showed the best performance considering the randomly defined training plots. This model was validated using the remained plots.

4. CONCLUSION

The preliminary results showed that CBERS CCD data can be used to estimate biophysical forest stand variables, concretely biomass and carbon pools. Using SMA allowed obtaining a regression model statistically significant that can help forest management.

5. REFERENCES

[1] E. Tomppo, M. Nilsson, M. Rosengren, P. Aalto and P. Kennedy, "Simultaneous use of Landsat-TM and IRS-1c WiFs data in estimating large area tree stem volume and aboveground biomass", *Remote Sensing of Environment*, vol. 82, pp. 156-171, 2002.

[2] Q. Meng, C.J. Cieszewski, M. Madden and B. Borders, "A linear mixed-effects model of biomass and volume of trees using Landsat ETM+ images", *Forest Ecology and Management*, vol. 244, pp. 93–101, 2007.

[3] P. Muukkonen and J. Heiskanen, "Biomass estimation over a large area based on standwise forest inventory data and ASTER and MODIS satellite data: A possibility to verify carbon inventories", *Remote Sensing of Environment*, vol. 107, pp. 617–624, 2007.

[4] A. Fernández-Manso, J.M. González and J. Ramírez, "Radiata pine in El Bierzo county: situation and management proposals", *Proceedings of III Spanish Forestry Congress*, Granada, vol. 5, pp. 766-771, 2001.

[5] Y.E. Shimabukuro and J. Smith, "The Least-Squares Mixing Models to Generate Fraction Images Derived from Remote Sensing Multispectral Data", *IEEE Transactions on Geoscience and Remote Sensing*. vol. 29, pp. 16-21, 1991.

[6] J. Heiskanen, "Estimating aboveground tree biomass and leaf area index in a mountain birch forest using ASTER satellite data", *International Journal of Remote Sensing*, vol. 27, pp. 1135–1158, 2006.

[7] S. Labrecque, R.A. Fournier, J.E. Luther and D. Piercey, "A comparison of four methods to map biomass from Landsat-TM and inventory data in western Newfoundland", *Forest Ecology and Management*, vol. 226, pp. 129–144, 2006.

[8] F.G. Hall, D.R. Peddle and E.F. LeDrew, "Remote sensing of biophysical variables in boreal stands of Picea mariana". *Proceedings of International Geoscience and Remote Sensing Symposium (IGARSS),* Italy, vol. 2, pp. 976-977, 1995.

[9] D.R. Peddle and R.L. Johnson. "Spectral mixture analysis of airborne remote sensing imagery for improved prediction of Leaf Area Index in mountainous terrain, Kananoskis Alberta", *Canadian Journal of Remote Sensing*, vol. 26, pp. 177-188, 2000.