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Atmospheric correction evaluation in the mapping of forest stands with OLI/Landsat 8 images

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ABSTRACT

Background: The remote detection of the vegetation characteristics in spatial scale is of fundamental importance for maximizing the productivity of commercial forest plantations, but in the atmosphere, there numerous components that can interfere in the signal stored by the sensor, requiring studies to evaluate the influence of these elements for each sensor. The Landsat 8 satellite began operating in 2013, generating multispectral images from the OLI and TIR sensors, corresponding the one important font of data of observation of earth. **Objective:** This work aims to evaluate the importance of the atmospheric correction in the obtain of information about the forest´s yeld using Landsat 8 images. **Material and Methods:** The forest inventory has allocated 38 plotsin *E. grandis* stands, being collected the dendrometric variables. The association of physical parameters of vegetation with data of remote sensing require the use of reflectance values, thus, was used for atmospheric correction of Landsat 8 images the DOS method. So, the spectral response and data collected in the field were related by regression analysis, being assessed the efficiency of the spectral variable in estimating the volume using the determination coefficient (R^2). **Results:** The best correlation was obtained from the surface reflectance by the blue band (B2), explaining 72% of the variability of volume (m^3). The apparent reflectance, based on the band 3, responded to 64% of the variability **Conclusion:** The surface reflectance showed better fit when compared with the apparent reflectance, evidencing the importance of correction of the attenuation atmospheric to study the response of the vegetation as a means of estimates the variables of field when used this satellite.

INTRODUCTION

The forest sector in Brazil along the last decades has shown great expansion throughout the national territory. This context, the *Eucalyptus* is presented as the main genus responsible of supply the demand for raw materials from the forest sector. Are used countless species of this genus, but due the silvicultural properties, ease in adaptation and quality of wood, the *Eucalyptus grandis* stands out in this scenario. Knowledge of dendrometric variables of a forest is extremely important to guide appropriate actions and interventions in a forest stand, supporting management techniques and planning of exploration.

This growing demand for forest products makes the productive sector seek technologies that provide more information on the characteristics of stands, once these areas require periodic monitoring in order to have a quality product. Studies have prioritized maximizing methods of forest production field (Bonete *et al.*, 2016;

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Trevisan *et al*., 2016) and their identification by remote sensors (Goergen, *et al*., 2016; Dube & Mutanga, 2015; Tillack *et al*., 2014; Berra *et al*., 2014).

The remote sensing through orbital images and their applications provide detailed information on the structure and productivity of vegetation, reducing the measurement`s cost of field characteristic sand maximizing productivity. The discrimination of targets in the environment it´s based on the use of radiation received by the sensor to characterize its properties. From orbital images, this ratio, normally, it is expresso by reflectance values, which consists of a physical variable which allows spectral data relate to the parameters located within the field (Ponzoni *et al*., 2012). Currently, there are numerous systems sensors with spatial characteristics, temporal and spectral differentiated. However, images with a higher level of detail at high cost and smaller width of covering the tracks, which restricts their use in analysis of extension areas that require periodicity.

In this sense, the spectral response obtained by the Landsat series products have represented a source data of acquisition easy and free. Numerous surveys successfully relate these multispectral images with the characteristics of canopies using sensors TM/Landsat 5, ETM+/Landsat 7 and OLI/Landsat 8 (Ponzoni *et al*., 2015; Dube & Mutanga, 2015). However, this new satellite (Landsat 8) features changes, highlighting the increased radiometric resolution and the number of spectral bands. The change in the 8-bit radiometric resolution to 16 bits provides the distribution of gray levels on a larger scale (Dube & Mutanga, 2015), directly relating with the ability to differentiate the targets on the earth's surface.

This interaction has limitations, since the atmosphere interacts with the electromagnetic radiation, changing the radiant flux from the target (Kauffman, 1989). Lower brightness and the loss of neatness, especially in smaller spectral regions constitutes some of the interference effects of atmospheric factors in orbital images (Latorre *et al*., 2002).

So, uses models of atmospheric correction to eliminate the effects of the components present in the atmosphere, obtained surface reflectance. The models can be divided into physical, based on radiative transfer theory, or empirical, which takes the interference from the atmosphere as an additive (Mather, 1999). The empirical model of atmospheric correction most widely used is the based on the subtraction of the dark pixel, called DOS (Dark Object Subtraction) (Chavez, 1988).This method has been widely used due to the simplicity of the process and good results.

Thus, to obtain the surface reflectance is required establish procedures for the atmospheric correction and after this step, develop models that describe the conditions of parameters of the target located in earth surface (Berra *et al*., 2014). The effects of atmospheric correction were demonstrated in several studies including changes in land use and land cover (Kolis & Stylios, 2013; Lin *et al*., 2015), estimate of forest volume (Berra *et al*.; 2014), surface temperature (Ghosh & Joshi, 2014; Wu *et al*., 2015). However, studies describing the possible differences of the use of surface reflectance or apparent (without atmospheric correction) with date Landsat 8 remain undefined.

Front to technological advances encompassed by OLI/Landsat 8 images, it is necessary studies showing the degree of interference of the atmosphere components in the spectral response of the vegetation, relating these factors with the accuracy of estimates of biophysical characteristics of vegetation obtained with this images.

This study aims to evaluate the influence of atmospheric correction in obtaining information about the stand's characteristics of *Eucalyptus grandis* by using satellite images Landsat 8, based on observations of surface and apparent reflectance.

MATERIAL AND METHODS

Location of the study area:

The Landsat 8 image acquired to cover an area of approximately 200 ha, corresponding to a commercial plantation of *Eucalyptus grandis*, occupying a narrow strip of coastal plain of Rio Grande do Sul, south of the city of Rio Grande (Figure 1).

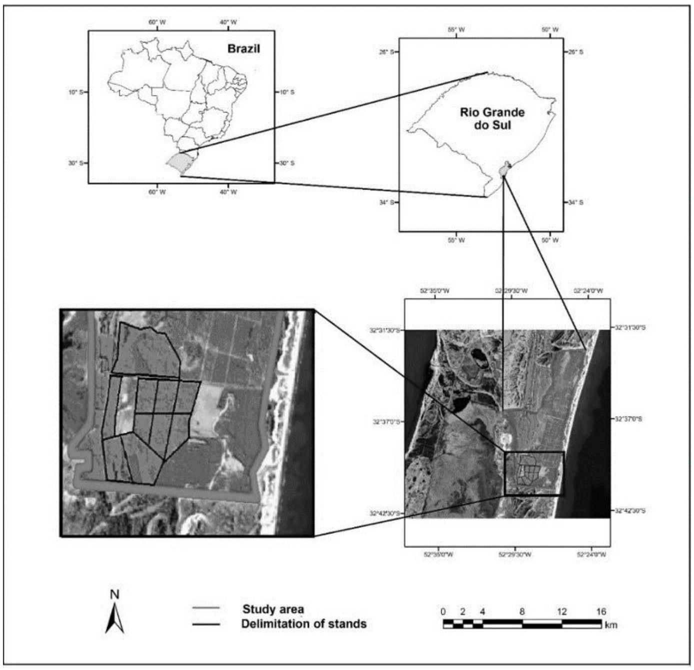

Fig. 1: Location map of the study area

According to Koppen`s classification the climate is Cfa1 with an average annual temperature of 16.5 ° C to 18.0 ° C. The soils had Quaternary sediments source type quartzarenico neosoil, with predominantly sandy characteristics, poor drainage and composing a relief plan to the fullest extent, rising just a few meters from the sea level.

Database:

The forest inventory was performed with systematic allocation of an sample plot every 5 hectares, and the GARMIN GPS Etrex Legend® was used for the location of the samples in the UTM coordinate system datum SIRGAS-2000, the accuracy was less than 10 m. Coordinated was taken in the center of the plot, totaling 38 samples with 420 m²

In each sample point were taken diameter at breast height, total height and geographic coordinates. Participated in this study individuals had diameter at breast height greater than 10 cm, being obtained with the dendrometric caliper and the height with Sunnto hypsometer. For the correlation of these field data, was selected a Landsat 8 image on orbit-point 221/083 dated August 30, 2013, which coincides with the date of the forest inventory, being used all multispectral bands present in this sensor (1-7 and 9).

Digital processing and statistical analysis:

The pre-processing of the original images started by the conversion of the digital level values in reflectance values in atmosphere top, as shown by Equation 1.In order to obtain real values of canopy reflectance was applied the DOS atmospheric correction through Software Grass Gis.

$$\rho=\frac{M_\rho * ND+A_\rho}{\mathrm{Sin}\,(\Theta_{SE})} \quad (1)$$

where: ρ = reflectance of the Top of the Atmosphere; $M\rho$ = multiplicative factor of resizing; $A\rho$ = factor resizing additive; Qcal = quantized value calibrated by pixel;Θ_{SE} = solar elevation angle.

Each pixel containing the sample plot, was identified and the surface reflectance values on the top atmosphere for the multispectral1-7 and 9 by performing linear regression in which the volume of wood is the dependent variable and the spectral responses as independent variables, and evaluated based on the coefficient of determination (R^2) demonstrated through graphics the best correlations. Statistical analysis was developed in R Software.

RESULTS AND DISCUSSION

Based on the mean reflectance values from multispectral bands from each plot, was held the descriptive analysis of the data (Table 1 and 2). Was observed that a greater variation is associated with spectral response without atmospheric correction (0,288).

Table 1: Average values of surface reflectance of multispectral bands in stands of *E. grandis*.

Spectral bands	Mean	Standard Deviation	Minimum	Máximum	Interval
BAND 1 (0,43-0,45)	0,012	0,001	0,01	0,016	0,006
BAND 2 (0,45-0,51)	0,013	0,002	0,011	0,017	0,006
BAND 3 (0,53-0,59)	0,030	0,038	0,019	0,260	0,241
BAND 4 (0,64-0,67)	0,023	0,003	0,019	0,033	0,014
BAND 5 (0,85-0,88)	0,304	0,028	0,212	0,344	0,132
BAND 6 (1,57-1,65)	0,082	0,011	0,06	0,110	0,050
BAND 7 (2,11-2,29)	0,034	0,004	0,029	0,048	0,019
BAND 9 (1,36-1,38)	0,016	0,0003	0,011	0,012	0,001

Table 2: Average values of apparent reflectance of multispectral bands in stands of *E. grandis*.

Spectral bands	Mean	Standard Deviation	Minimum	Máximum	Interval
BAND 1 (0,43-0,45)	0,109	0,005	0,100	0,120	0,020
BAND 2 (0,45-0,51)	0,089	0,032	0,067	0,279	0,212
BAND 3 (0,53-0,59)	0,058	0,003	0,053	0,065	0,012
BAND 4 (0,64-0,67)	0,043	0,043	0,004	0,291	0,288
BAND 5 (0,85-0,88)	0,305	0,305	0,209	0,360	0,151
BAND 6 (1,57-1,65)	0,074	0,074	0,056	0,099	0,043
BAND 7 (2,11-2,29)	0,023	0,024	0,018	0,038	0,019
BAND 9 (1,36-1,38)	0,001	0,002	0,001	0,008	0,008

Bands 3, 5 and 6 corresponding to green, near and medium infrared, show a wiser interval, and band 1, 2 and 9 from the specter present a lower variation when studied the response after DOS correction in *E grandis* stands. The reflectance values without atmospheric correction, it can be noticed that higher variability is on bands 2 and 4 (green and cirrus).

Comparing the two methods, the stand´s canopy spectral response, when DOS correction is applied the values of reflectance are minimum on the visible spectrum, (bands 1, 2, 3 and 4) and maximal on infrared (bands 6, 7 and 9). Information acquired, show similar behavior with the literature existing, when studied TM/Landsat 5 images by Berra *et al*. (2012) and Sanches *et al*. (2011). In the near infrared region (Band 5), values were similar in both compared methods (Figure2).

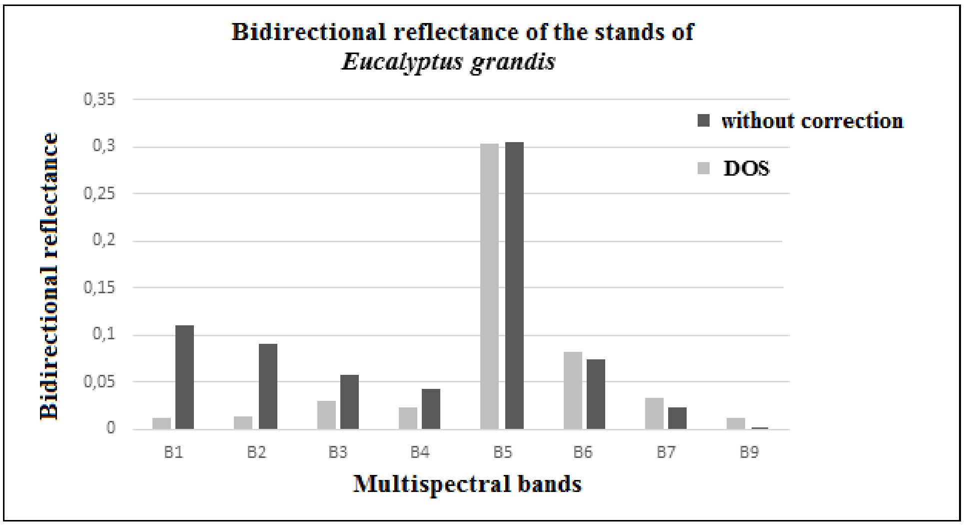

Fig. 2: Bidirectional reflectance of stands of *E. grandis* from Landsat 8/OLI image.

Figure 3 shows the volume plots and residual from the multispectral bands reflectance, which had significant correlation exceeding 0.50 under the influence of the DOS correction method. The blue band (2) has a higher correlation with the sampled field variable when analyzing the multispectral bands with OLI sensor system by simple linear regression. In this way, the volume is inversely proportional, increasing as the reflectance decreases, at this wavelength, the greater coefficient of determination to 0.72 (Figure 3). The major residues ($V_{Observed}$ -$V_{Predicted}$) are associated with volume values around 30 m³, as shown in Figure 3b.

The dependent variable in the green band (3) is concentrated in the reflectance range between 0.020 and 0.030 microns, with a regression that explains 61% of the total variance of the data. The residual plot show a higher error when the estimated volume is greater than 25 cubic meters (Figure 3c, d).

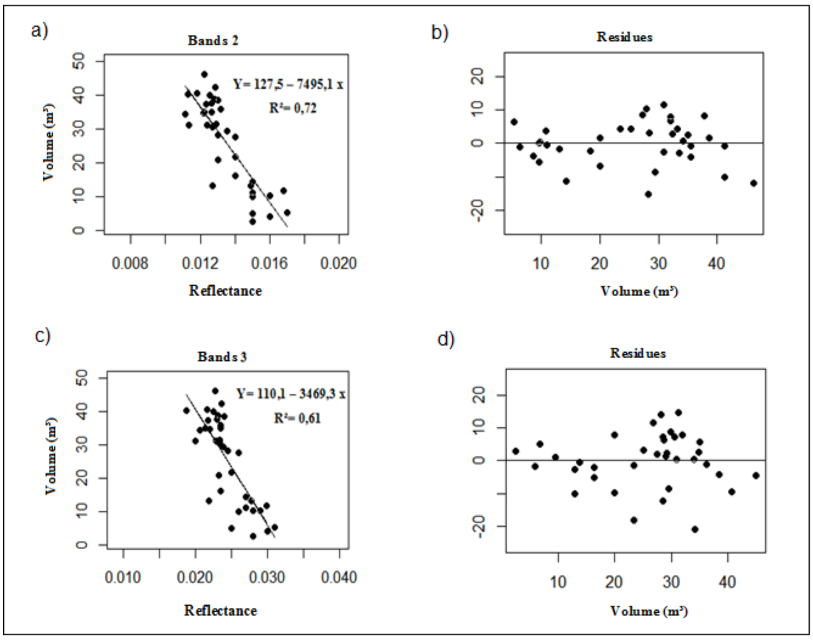

Fig. 3: Plots and residues of regression analysis of bands 2 and 3 (a, b, c and d) by DOS method

When the regression analysis is done with the apparent reflectance values (without correction), the bands 3 and 7 had a higher correlation with wood volume in *E grandis* stands. Only the band Green presented superior results than 0.5 in the regression analysis for this treatment.

The apparent reflectance on the wavelengths of 0.53 to 0.59 microns, comprised of the green band (3) is presented as the most precise variable for volume, accounting approximately 64% of the total change of volume data (Figure 4 and b). The band 7 had a lower coefficient of determination (R^2) 0.47, and residue with larger error between 25 and 27 cubic meters (Figure 4c, d).

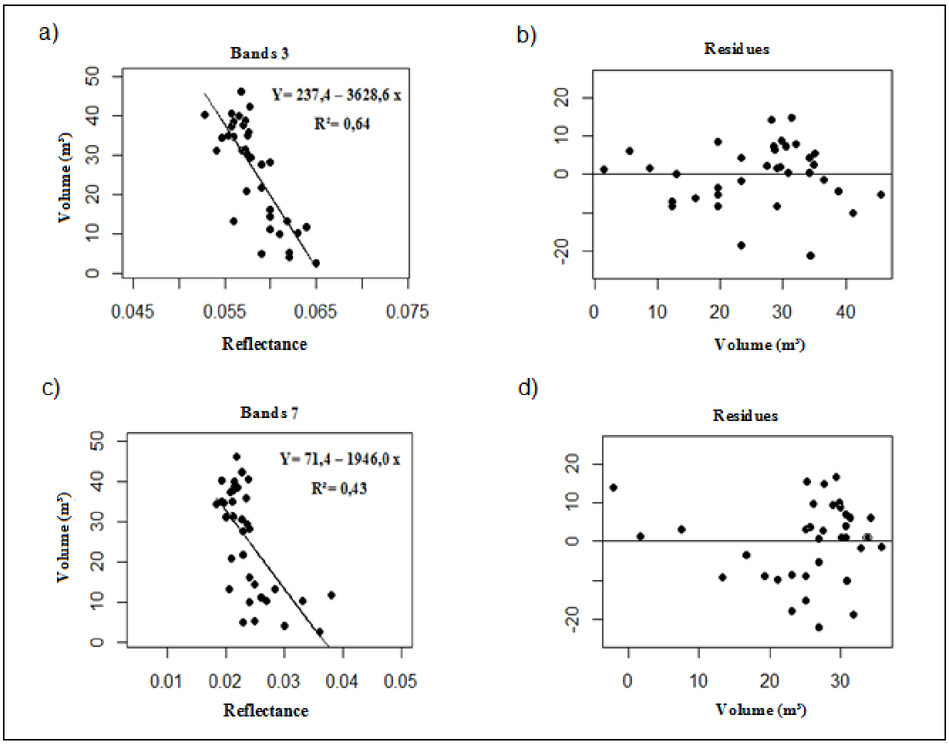

Fig. 4: Plots and residues of regression analysis from apparent reflectance values of the bands 3e7 (a, b, c and d).

The results found in this study were higher when compared with the Landsat 5 satellite, as described by Berra *et al*. (2012) modeling volume equations for *Eucalyptus*, using stepwise methods, selected the simples ratio index and band 2 as explaining variables, having a less precise model (R^2= 0,68). Orué (2002) find band 5 having a determination coefficient of 0.45 for wood volume in *Pinus* stands.

Berra *et al*. (2014) evaluated different methods of atmospheric correction in estimative of forest volume of *Pinus elliottii* with TM/Landsat 5, showing that the atmospheric correction methods have similar results, showing R^2 between 0.50 and 0.60. In mapping of changes in land use and land cover, using low spatial resolution images, the atmospheric correction can generate an improvement in classification, achieving greater accuracy, greater than 80% (Lin *et al*., 2015).

Agapiou *et al*. (2011) highlights the influence of atmospheric effects in the application of NDVI and satellite image interpretation in archaeological studies. Because of the importance of atmospheric correction on data stored by orbital sensors, the implementation of algorithms related to this theme has been developed, as is the case study of Jaelami *et al*., (2015) which developed an atmospheric correction algorithm for MERIS data applied to observation of turbid waters.

Conclusions:

To analyze the spectral response of the bands and the influence of atmospheric correction in determine stand`s wood volume, can be concluded that the atmospheric effects over the reflectance presented by species *E. grandis* have influence in spectral and spacial characteristics of the structure. The best regression lines for atmospheric correction were obtained with multispectral bands.

The images of LANDSAT 8´s sensor OLI show strong correlation when evaluated specialization the structure of stand of *E. grandis*, demonstrating that the changes of this satellite allowed obtain more precise data for that kind of study. Residues` behavior show that volumes higher than 25m³ trend to have greater error, thus, young stands show a tendency to a greater correlation with reflectance in differences wavelengths.

REFERENCES

Agapiou, A., D.G. Hadjimitsis, C. Papoutsa, D.D. Alexakis, G. Papadavid, 2011. The Importance of Accounting for Atmospheric Effects in the Application of NDVI and Interpretation of Satellite Imagery Supporting Archaeological Research: The Case Studies of Palaepaphos and Nea Paphos Sites in Cyprus. Remote Sensing, 3: 2605-2629.

Berra, E.F., C. Brandelero, R.S. Pereira, E. Sebem, L.C.G. Goergen, A.C.P. Benedetti, 2012. Estimativa do volume total de madeira em espécies de eucalipto a partir de imagens de satélite Landsat. Ciência Florestal, 22: 853-864.

Berra, E.F., D.C. Fontana, R.S. Pereira, 2014. Accuracy of forest stem volume estimation by TM/Landsat Imagery with different geometric and atmospheric correction methods.Journal of Applied Science and Technology, 4(3): 108-116.

Bonete I.P., K.H.P. Deus, C.C. Benin, A.T.A. Garrett, A.N. Dias, L.F. Watzlawick, 2016. Identity of hypsometric and volumetric models for *Eucalyptus benthamii* grouped by planting spacings.Australian Journal of Basic and Applied Sciences, 10(13): 101-107.

Chavez, P.S., 1988. An improved dark-object subtraction technique for atmospheric scattering correction of multispectral data. Remote Sensing of Environment, 24: 59-479.

Dube, T. and O. Mutanga, 2015. Evaluating the utility of medium-spatial resolution Landsat 8 multispectral sensor in quantifying aboveground biomass in uMgeni Catchment, South Africa. Journal of Photogrammetry and Remote Sensing, 101: 36-46.

Ghosh, A. and P.K. Joshi, 2014. Hyperspectral imagery for disaggregation of land surface temperature with selected regression algorithms over different land use land cover scenes. ISPRS J Photogram Remote Sensing, 96: 76-93.

Goergen, L.C.G., R.V. Kilca, I.S. Narvaes, M.N. Silva, E.A. Silva, R.S. Pereira, M. Adami, 2016. Distinção de espécies de eucalipto de diferentes idades por meio de imagens TM/Landsat 5. Pesquisa Agropecuária Brasileira, 51(1): 53-60.

Jaelani, L.M., B. Matsushita, W. Yang, T. Fukushima, 2015. An improved atmospheric correction algorithm for applying MERIS data to very turbid inland waters. International Journal of Applied Earth Observation and Geoinformation, 39: 128-141.

Latorre, M., O.A. Júnior Carvalho, A.P.F. Carvalho, Y.E. Shimbukuro, 2002. Correção atmosférica: conceitos e fundamentos. Espaço & Geografia, 5: 153-178.

Lin, C., C.C. Wu, K. Tsogt, Y.C. Ouyang, C.I. Chang, 2015. Effects of atmospheric correction and pansharpening on LULC classification accuracy using WorldView-2 imagery. Information Processing in Agriculture, 2: 25-36.

Kauffman, J.Y., 1989. The atmospheric effect on remote sensing and its correction, In: Asrar, G. ed. Theory and applications of optical remote sensing. New York: Willey, pp: 336-428.

Kolios S., and C.D. Stylios, 2013. Identification of land cover/land use changes in the greater area of the Preveza peninsula in Greece using Landsat satellite data. Applied Geography, 40: 150-60.

Orué, N.E., 2002. Estimativa de volume de povoamentos de *Pinus spp*, utilizando dados do satélite Landsat 7. Thesis (Master), Universidade Federal do Paraná, Curitiba, Brasil.

Sanches, I.D.A., R.G. Andrade, C.F. Quartaroli, C.A.G. Rodrigues,2011. Análise comparativa de três métodos de correção atmosférica de imagens Landsat 5- TM para obtenção da reflectância de superfície e NDVI, Simpósio Brasileiro de Sensoriamento Remoto, Instituto de pesquisas Nacional de Pesquisas Espaciais, Curitiba, pp: 7564-7571.

Tillack, A., A. Clasen, B. Kleinschmit, M. Förster, 2014. Estimation of the seasonal leaf area index in an alluvial forest using high-resolution satellite-based vegetation indices. Remote Sensing of Environment, 141: 52-64.

Trevisan, R., C.R. Haselein, E. Eloy, B.O. Caron, R. Balbinot, 2016. Dendrometric characteristics of *Eucalyptus grandis* submitted to thinning. Australian Journal of Basic and Applied Sciences, 10(10): 45-51.

Wu P., H. Shen, L. Zhang, F.M. Göttsche, 2015. Integrated fusion of multi-scale polar-orbiting and geostationary satellite observations for the mapping of high spatial and temporal resolution land surface temperature. Remote Sensing Environment, 156: 169-81.