SPECTRAL SIGNATURE OF LEAVES OF AMAZON RAINFOREST TREE SPECIES

Egidio Arai[1], *Gabriel Pereira*[1], *Samuel M. C. Coura*[1], *Francielle S. Cardozo*[1], *Yosio E. Shimabukuro*[1], *Elisabete C. Moraes*[1], *Ramon M. Freitas*[1], *Fernando D. B. Espirito-Santo*[2]

National Institute for Space Research (INPE)[1]
University of New Hampshire (UNH)[2]

1. INTRODUCTION

Remote sensing is an important tool to acquire data of the dynamic of the land-use as well biophysical parameters of the vegetation. Surface objects interact with electromagnetic radiation performing different spectral responses in satellite image. These interactions vary according with physical-chemical and biological properties of the object surface. Also, objects surface interact anisotropic and isotropic with incident energy. The spectral radiance is defined as the radiometric component that describes the behavior of radiation in space and could be characterized by the relationship between spectral reflectance and incident irradiance [1].

The pigments in the leaves such as chlorophyll, carotenoids and xanthophylls act as absorbers of electromagnetic radiation in the visible spectral region (photosynthetically active radiation), providing absorption features in 425 nm, 450 nm, 480 nm, 650 nm, 675 nm and 700 nm. The reflectance peak is found in green electromagnetic region due the chlorophyll. Also, an important component of leaf that interacts with radiation is the cell structure. Some of these components are almost transparent to electromagnetic radiation in the infrared region between 700 nm to 1400 nm, such as epidermis and cuticle. Moreover, when electromagnetic energy interacts with the spongy mesophyll and with air cavities inside the leaf, the spectral reflectance in this region increases multiple scattering and refraction. In the middle-infrared the spectral response of leaves is mainly dominated by electromagnetic absorption due water content, being evident absorptions features in 1400 nm, 1900 nm and 2500 nm [2]. Although the vegetation spectral proprieties are very well known in the remote sensing literature, few ground studies have been tested in tropical areas, especially in the Amazon region. The main objective of this study is to present the spectral signature responses of common species of several forest functional types in a tropical forest area in the Amazon.

2. STUDY AREA

The radiometric data was collected in the area of the Tapajos National Forest (TNF), State of Para, Brazil . TNF is covered by two major types, as a function of geomorphologic characteristics: (1) Tropical Lowland Forests and (2) Open Rainforests. The fist forest types are found in areas with altitude less than 100 m, with short variation in slope and with large volume of high commercial timber values; and in Precambrian dissected relief, between an altitude of 100 m and 600 m. The second forest groups are frequently located in heavily dissected plateaus with slope erosion areas, narrow valleys and degraded medium texture soils [3].

3. MATERIAL AND METHODS

The ground reflectance measurements, aims to maintain same settings of orbital circumstances where these measurements could represent with high accuracy the characteristics present in satellite images. Considering the technical difficulties to obtain good measurements of spectral reflectance of a ground object, we used a ratio spectral correction, named as reflectance factor. The reflectance factor of the surface of an object is given by the ratio between the measurement of the radiance of the object and the radiance collected from an ideal Lambertian surface acquired in the same conditions of illumination and observation [1].

The reflectance factor of different tropical leaves were measured with a FieldSpec Pro FR Spectroradiometer from National Institute for Space Research (INPE), with a view of 25°, spectral range varying from 350nm to 2500nm, spectral resolution ranging from 3 to 10 nm and acquisition time of 0.1 second per spectrum. We used a lambertian Spectralon 11 plate with approximately a total irradiance to calculate the reflectance factor.

The FieldSpec spectroradiometer radiance measurements (L) can be represented by ratio of radiant flux (ϕ) per solid angle (ω), cosine of zenith angle (θ) and the area (A):

$$L = \frac{\partial\phi}{\delta\omega\,.\,\cos\theta\,.\,\delta A} \qquad [\mathrm{W.m^{-2}.sr^{-1}.\mu m^{-1}}] \qquad (1)$$

Reflectance factor (***RF***) can be expressed as a relationship between the sample radiance ($\boldsymbol{Ls}$) and field lambertian plate radiance ($\boldsymbol{Lfp}$) in the same observation ($\boldsymbol{\theta}$) and acquisition characteristics ($\boldsymbol{\phi}$). However, the lambertian plate used in the field does not have a reflectance of 100% in all electromagnetic spectrum and the spectroradiometer used in field must be calibrated. Therefore, these factors must be corrected using an ideal lambertian plate ($\boldsymbol{Lip}$) with laboratorial use only and a calibrated unit of LARAD:

$$\boldsymbol{RF}_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i)} = \frac{Ls_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i)}}{Lfp_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i)}} \cdot \frac{Lfp_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i)}}{Lip_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i)}} \cdot \frac{Lip_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i,\,Field\,Unit)}}{Lip_{(\lambda,\theta_o,\phi_o,\theta_i,\phi_i,\,Calibrated\,Unit)}} \qquad (2)$$

4. ANALYSED LEAVES CHARACTERISTICS

To describe the spectral propriety of the vegetation, we selected 12 common species of trees based the frequency distribution of trees in TNF and also litter fall samples. The tree species selected were: *Manilkara huberi, Clarisia racemosa* and *Copaifera multijuga* are large trees that reach an upper canopy or emergent position in primary forests. *Couratari guianensis* is a medium to large-sized tree that usually reaches an upper canopy or emergent position in primary forests. G*enipa americana*, *Coccoloba latifólia*, *Eschweilera sp., E. coriácea*, *Miconia guianensis* and *Cecropia palmata* are trees with medium size that attains a middle or upper canopy position, common in abandoned shifting cultivation sites or in secondary forests. The *Duguetia echinophora* is a small to medium-sized tree of primary and secondary forests that occurs in middle canopy position. The *Astrocaryum mumbaca* is a small apiny palm [4].

5. RESULTS AND DISCUSSIONS

Figure 1 shows an average reflectance factor of 30 measurements collected for each tree species in TNF site. We noticed that reflectance factor in the visible region of electromagnetic spectrum remains almost constant for all samples, varying in function of different leaf pigments concentration such as carotenoids, chlorophyll and xanthophylls.

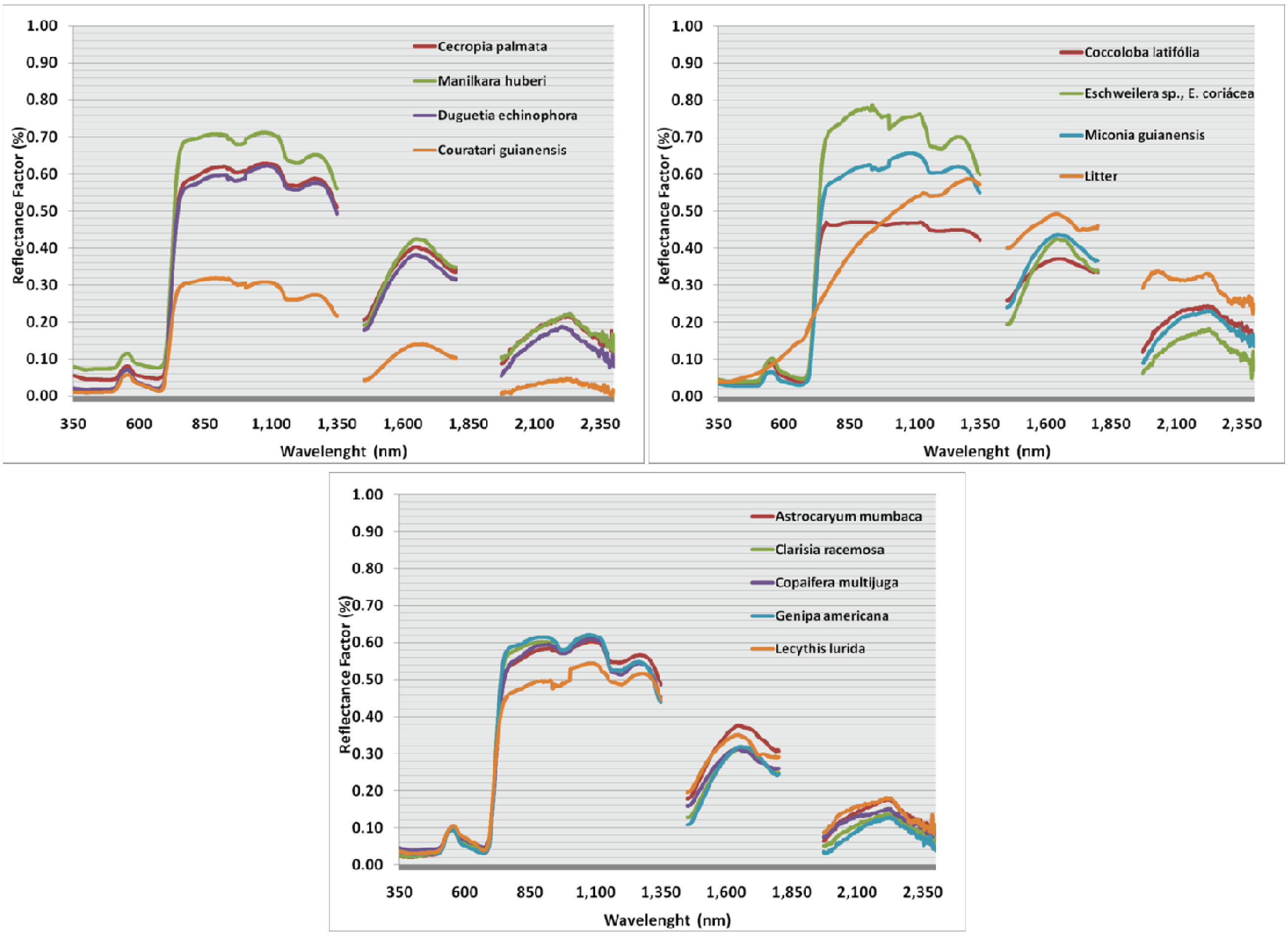

Figure 1 – Spectral reflectance of tree leaves.

In contrast with visible electromagnetic region, in shortwave infrared spectral range (700 nm – 1350nm), where the radiation interaction process are controlled mainly by leaf cell structures and tissues such as epidermis and mesophyll, the reflectance factor undergo for changes in the spectral signature due to physical-chemical and biological properties of each leaf. Species like *Cecropia palmata, Duguetia echinophora, Miconia guianensis,* *Astrocaryum mumbaca, Clarisia racemosa, Copaifera multijuga* and G*enipa americana* have similar spectral behavior along all electromagnetic solar spectrum, this fact could be associated with similar cellular structure, chemical composition and water content.

Furthermore, the following species *Manilkara huberi, Couratari guianensis, Coccoloba latifólia, Eschweilera sp.,* and *E. coriácea* yields a distinct spectral signature compared with species mentioned above. One of the possible reasons to explain this difference is related to tissue structure such as spongy mesophyll which has a significant role in the infrared radiation reflectance. Leaves that are thinner than others usually have a higher transmittance because there is less of spongy tissue and water content in its structures. Moreover, the spectral values between 1350nm-1450nm and 1850nm-1950nm intervals are not showed because this feature represents the absorption band of the electromagnetic energy by water vapor in the atmosphere.

6. CONCLUSIONS

Considering the diversity of trees species in the Amazon, we found expressive differences in the spectral signatures of tropical trees. Several studies are planed to be conducted in the tropics using hyperspectral technology such as orbital data of Hyperion or AVIRIS aircraft data. Our study could provide complementary information to understand the spectral propriety of tropical vegetation types

7. REFERENCES

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