ГОДИШНИК НА МИННО-ГЕОЛОЖКИЯ УНИВЕРСИТЕТ "СВ. ИВАН РИЛСКИ", Том 53, Св. I, Геология и геофизика, 2010
ANNUAL OF THE UNIVERSITY OF MINING AND GEOLOGY "ST. IVAN RILSKI", Vol. 53, Part I, Geology and Geophysics, 2010

DOMINANT WAVELENGTH IN ASSESSMENT OF GREEN VEGETATION COVER

Rumiana Kancheva, Denitsa Borisova

Solar-Terrestrial Influences Laboratory, Bulgarian Academy of Sciences, 1113 Sofia; rumik@abv.bg

ABSTRACT. To a big extent the implementation of remote sensing in environmental studies concerns soil-vegetation ecosystems. The availability of means for vegetation monitoring, stress detection and state assessment is of great importance. A significant amount of research has been performed to develop efficient methods for monitoring of vegetation dynamics. A prevailing part of the works is devoted to the use of multispectral data transformations (vegetation indices) such as spectral bands ratios and linear combinations in order to estimate vegetation parameters. The dependence of vegetation spectral features in the visible and near infrared bands on plant biomass, chlorophyll content, canopy cover, etc. lies at the root of the approach. In this paper we report some results of the colorimetric analysis of vegetation spectral data. The work was conducted in order to reveal the effects of plant growth and soil background on vegetation reflectance, and respectively on color features. One of the goals of the study was to evaluate the potential of using the dominant wavelength of soil-vegetation systems for assessment of vegetation parameters.

ДОМИНАНТНАТА ДЪЛЖИНА НА ВЪЛНАТА ЗА ХАРАКТЕРИЗИРАНЕ НА РАСТИТЕЛНАТА ПОКРИВКА

Румяна Кънчева**, **Деница Борисова
ИСЗВ- БАН, 1113 София; rumik@abv.bg

РЕЗЮМЕ. Дистанционните изследвания са един основен инструмент в изучаването на околната среда. При системата почва-растителност това е свързано с периодичното наблюдение, откриването на стресови състояния и оценка на състоянието й. Множество изследвания са насочени към разработването на ефективни методи за проследяване на динамиката на растителната покривка. Преобладаваща част от публикациите са посветени на използването на спектрални преобразувания (вегетационни индекси), представляващи отношения или линейни комбинации на измерваните данни в различни спектрални диапазони, целящи оценка на параметрите на растителността. Такива параметри са биомасата, хлорофилното съдържание, проективното покритие и др. Настоящата работа показва някои резултати от колориметричния анализ на многоспектрални данни за системата почва-растителност, като една от целите е да се изследва използването на доминантната дължина на вълната като характеристики за оценка на системата почва-растителност.

Introduction

Crop monitoring by remote sensing is mainly associated with vegetation amount estimates. A basic problem in data processing is spectral mixture decomposition in order to provide quantification of vegetative and non-vegetative components of soil-plant targets. That is why vegetation canopy cover (plant relative portion in the mixture) is an operationally significant parameter all the more that it is a plant growth parameter and also a factor of measured soil-vegetation reflectance.

The objective of this study is to perform colorimetric analysis of spectral reflectance data gathered over different cultivars and to interpret crop color features in terms of vegetation canopy cover. At least two are the reasons for such investigation. First, vegetation cover p_v (called also ground cover ratio) is of particular interest because it is a bioindicator of plant development (normal or stress impacted) and directly contributes to biomass amount and to potential yield. Second, vegetation colorimetric analysis has not been a subject of many studies. The work has been conducted in order to reveal plant growth effects and the impact of the soil background on vegetation reflectance.

Materials and methods

Reflectance measured over partially vegetated canopies depends on the soil and plant spectral properties, and the proportions of these two classes (Mishev, 1991):

$$r_\Sigma(\lambda) = \sum_i p_i r_i(\lambda) \quad (1)$$

where $r_\Sigma(\lambda)$ are the resulting spectral reflectance signatures of the mixed class, $r_i(\lambda)$ - the reflectance of the components (classes) composing the mixture, p_i - components relative amounts.

In the case of soil and green vegetation, for instance, considering that $\sum_i p_i = 1$:

$$r_{sv} = p_v r_v + (1 - p_v) r_s \quad (2)$$

$$r_{sv} = p_v(r_v - r_s) + r_s \quad (3)$$

Field and greenhouse reflectance measurements of various species with dark and light soil background were carried out with a multichannel radiometer in the visible and near infrared spectral bands. The reflectance curves in Fig.1 illustrate the large range of soil spectral signatures *(a)* and the soil type impact (dark chernozem-*1*, light alluvial-*2*) on grass reflectance *(b)* with different vegetation cover ratio p_v.

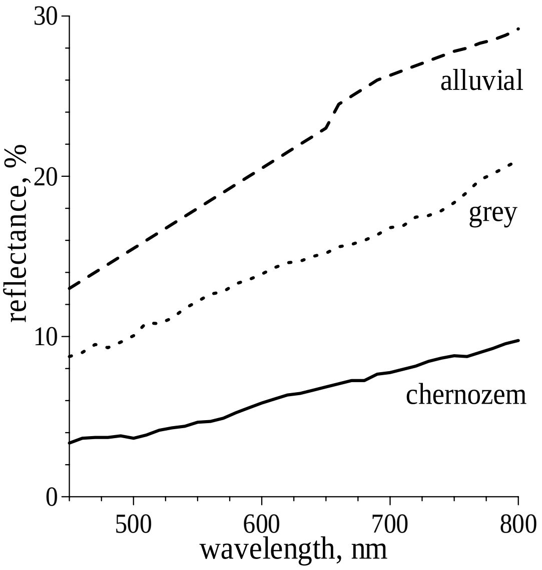

Fig. 1a. Reflectance spectra of soils

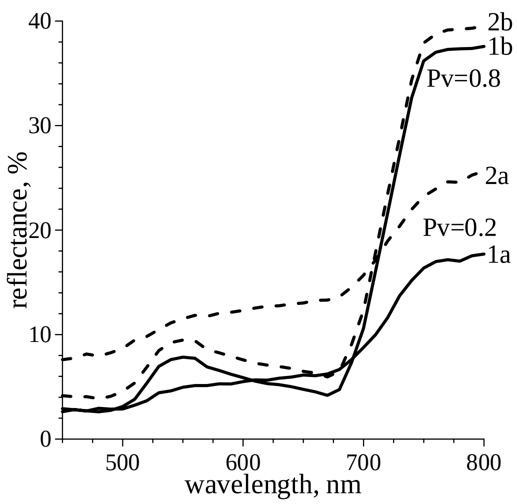

Fig. 1b. Reflectance spectra of soil-green vegetation mixtures

The senescence effects on vegetation reflectance are qiute similar to the soil impact. An illustration of this is Fig. 2 where the reflectance spectra of 2-component mixtures containing green vegetation (p_v=0.6) and soil (p_s=0.4) – dark (1) or light (2) or dried (p_d=0.4) foliage (3) are shown. Curve 3 as well as the curves of the three-component mixtures (3a and 3b where $p_s + p_d$=0.4) repeat the behaviour of soil-vegetation samples with different green coverage.

The tristimulus values *X,Y,Z* for the estimation of the chromaticity coefficients *x,y,z* were computed in the spectral range 450-750 nm following the CIE 1964 methods for D_{65} light source:

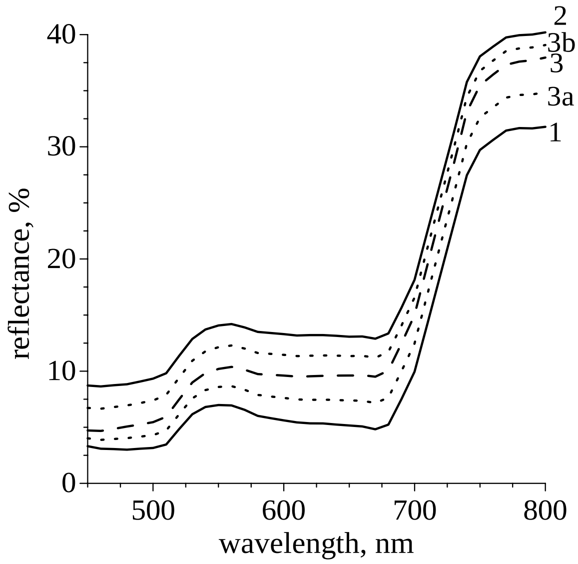

Fig. 2. Reflectance spectra of 2 and 3-component mixtures of soil, green and senescent vegetation

$$X = k \sum_{\lambda} D_{65} r(\lambda) \bar{x} \Delta\lambda$$

and

$$x = \frac{X}{X + Y + Z}$$

According to the additive theory (Mishev, 1992):

$$X_{sv} = \sum_{\lambda} D_{65} \left[p_v (r_v - r_s) + r_s \right] \bar{x} \Delta\lambda \quad (4)$$

$$X_{sv} = p_v (X_v - X_s) + X_s \quad (5)$$

$$x_{sv} = \frac{p_v (X_v - X_s) + X_s}{p_v (W_v - W_s) + W_s} \quad (6)$$

W=X+Y+Z.

As seen from (6), the chromaticity coefficients defining the position of soil-vegetation mixtures on the color diagram (color locus) depend on the relative amounts of the pure classes.

Regression analysis was applied to reveal the relationship between the dominant wavelength λ_d of soil-vegetation mixtures and the vegetation cover p_v.

Results and discussion

The (x_{sv},y_{sv}) coordinates define the position of soil-vegetation mixtures on the color locus and depend on the components relative portions *p*. They express the chromaticity of an object and define another important color feature – the dominant wavelength λ_d which in our case was determined for bare soils, full-cover vegetation plots and plant-soil mixtures (Fig. 3-4).

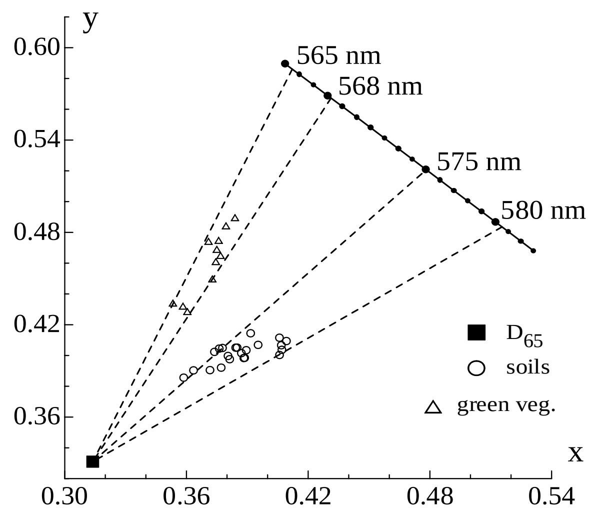

Fig. 3. Dominant wavelengths of bare soils (dark and light) and full-cover green canopies

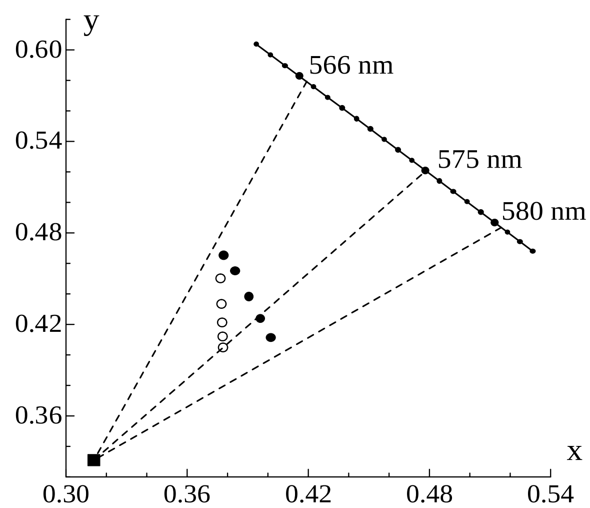

Fig. 4. Chromaticity location of mixtures in different plant-soil proportions: ● dark soil-green vegetation; ○ light soil-green vegetation

Strong correlation was found between the green canopy cover p_v and the dominant wavelength λ_d of soil-vegetation mixtures. The fitted dependences $p_v=f(\lambda_d)$ are second degree polynomials with coefficients of determination 0.92 and 0.86 (at $p<0.05$ probability level) and standard error of estimation 0.07 and 0.09 for the dark and light soil case respectively. An explanation of the better predictive accuracy of the dark soil model could be the bigger differences of λ_d values between mixtures with different p_v (Fig. 5). The implementation of a combined model, i.e. without considering the soil type, may lead to bigger retrieval mistakes (the correlation ratio is 0.77).

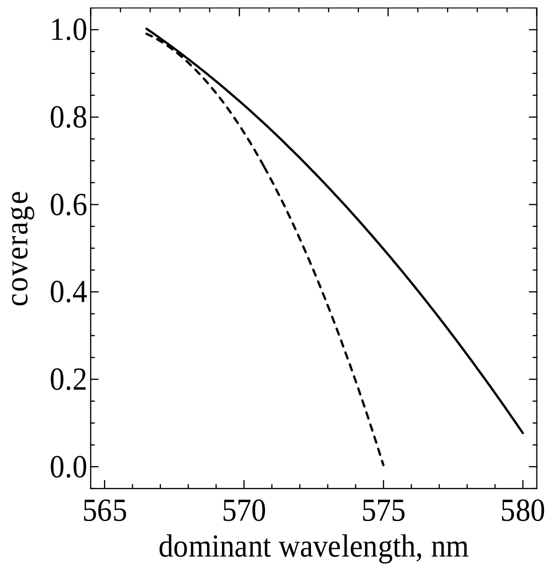

Fig. 5. Green coverage fitting models $p_v=f(\lambda_d)$

Conclusions

The advantage in using color features is that the visible spectral range is closely related to biophysical parameters of the objects and that the whole reflectance curve is used normalized on the spectral distribution of the incident radiation. Besides, λ_d allows the comparison of slightly differing color stimuli. A disadvantage is the big sensitivity to the regression coefficients in $p_v=f(\lambda_d)$ retrieving models. But as a whole the obtained results are an encouraging confirmation of the potential of mixture analysis for vegetation state monitoring especially using both techniques – spectral reflectance transformation and colorimetric analysis. Future work is intended in precising the dependences of *VI* and λ_d on green canopy coverage by larger experimental data sets as well as their verifying and effective accuracy testing using low-height airborne spectral data.

References

Mishev, D. 1991. Spectral characteristics of mixed classes of natural formations. – *Acta Astron.*, *25*, 8-9, 443-446.

Mishev, D. 1992. Colour coordinates of mixed class. – *Compt. Rend. Acad. Bulg. Sci.*, *45*, 3, 51-54.

Препоръчана за публикуване от
Катедра "Приложна геофизика", ГПФ