III

КОПИЯ НА РЕЗЮМЕТАТА НА ПУБЛИКАЦИИТЕ

на

гл. ас. д-р инж. Деница Стефанова Борисова
секция “Системи за дистанционни изследвания”
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за участие в конкурс за заемане на академичната длъжност „доцент” в област на висше образование 4. Природни науки, математика и информатика, професионално направление 4.4. Науки за Земята; научна специалност „Дистанционни изследвания на Земята и планетите” за нуждите на секция „Системи за дистанционни изследвания” при ИКИТ-БАН, обявен от ИКИТ-БАН в ДВ бр.42/03.06.2016 г.

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EXPLORATIONS COSMIQUES

CYTOGENETIC AND SPECTROMETRIC STUDY ON CADMIUM POLLUTION IN PEAS[1]

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(*Submitted on December 16, 1998*)

Introduction. Environmental pollution is a world problem whose importance is to a great extent linked to the toxic action of a number of substances on plant biosystems. A special interest is demonstrated towards the contamination of soils and waters with heavy metals and their influence on the physiological development, adaptive ability and productivity of agricultural species. The mutagenic effect of heavy metals deserves serious attention and studies. Last but not least is the problem of toxic elements accumulation in plants and the ecological quality of production. The investigation of these issues is the subject of the experiments carried out for determining the effect of cadmium contamination on biometric, biochemical and cytological parameters in peas. The measurement of spectral reflection characteristics aims at the assessment of the stress factor impact on plant state and growth parameters.

Materials and methods. Field and laboratory experiments with the fodder variety of peas Pleven-4 were carried out. Dry and metabolically activated seeds (soaked in water for 24 hours) were used. For the detection of the potential clastogenic activity of $CdCl_2$ and its influence on mitosis cytological studies were also carried out. They were based on two tests – anaphase analysis for determination of the induced injuries in the mitotic chromosomes of peas and mitotic index (MI).

Two expositions of treatment were applied – 1(*) and 24(**) hours with the following $CdCl_2$ concentrations: 0.5, 2.5, 5, 10, 20, 30 mg/l. Root tips of lengths from 1.2 and 1.5 cm were fixed in a mixture of Clarke and staining after Feulgen. Temporary preparations were made – 10-15 roots for each variation. Two types of control were used: a negative control (distilled water) and a positive one (ethylmethane sulfonate – EMS and ethylene amine – EI).

For the study of the soil contamination effect both on peas growth and heavy metal accumulation in various parts of the plants pot experiments were performed (in 4 replications) with the following $CdCl_2.2.5H_2O$ concentrations: 5, 10, 15, 20, 30 mg/kg. For determining of Cd content in the soil and plants atomic-absorption spectral analysis implementing the wet mineralization method was applied [1]. The cadmium concentration of the pot treatments was measured before plant sowing and at the end

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EXPLORATIONS COSMIQUES

EFFECTS OF CADMIUM POLLUTION IN *PISUM SATIVUM* DEPENDING ON THE GROWING CONDITIONS

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(*Submitted by Academician D. Mishev on November 11, 2000*)

Introduction. Environmental contamination arouses serious problems in agriculture and imposes the searching of approaches to plant protection and soil sanitation. Cadmium is among the most toxic heavy metals and belongs to the elements that are not necessary for plant metabolism. It provokes disturbances in their vital processes whose symptoms are depressed growth, root system damages, chlorosis, etc. [1-3] being at the same time a potential mutagenic factor [4].

This study has two main goals. The first is to compare the Cd-pollution impact on biological parameters of *Pisum sativum* grown in water and algae supernatant. It is prompted by the supposition [5] that green algae could probably block to some extent the heavy metal effects on plant systems. The second purpose concerns the possibility of plant state diagnostics using their spectral reflectance characteristics [6,7].

Materials and methods. Five days old *Pisum sativum* sprouts of cultivar "Bogatir" were grown during 15 days in water and algae supernatant with $CdCl_2$ introduced in concentrations 0, 10, 20 and 30 mg/l. The supernatant was obtained as described in [8] from *Chlamydomonas reinhardtii* cell wall less mutant strain (kindly provided by Prof. Btyant, St. Andrews University, U.K.) cultivated 5–7 days in nutrient medium.

The spectral reflectance measurements were performed by a multichannel radiometer in the visible and near infrared region (400–820 nm). For the interpretation of the spectrometric data various vegetation indices (VI) [6,7,9] were used. Their choice (wavelengths and formulae) were meant to point out specific changes in the reflectance properties due to plant state variations.

The stem length, the fresh above-ground biomass, the canopy cover and the concentration of plastid pigments were used as bioindicators of the cadmium toxic effects. Its impact on plant root system does not reveal itself directly in the spectral characteristics so it is a subject of another publication.

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EXPLORATIONS COSMIQUES

PLANT CANOPY COVERAGE AND COLOUR FEATURES

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(*Submitted on December 20, 2001*)

Abstract

The colorimetric characteristics of a mixed "soil-vegetation" class are studied. An original approach is proposed for estimating plant canopy coverage.

Key words: spectral reflectance, colour coordinates, mixed class, vegetation coverage

Introduction. One main goal of the remote sensing of vegetation is plant state assessment. The evaluation of crop status is given on the basis of a number of phytoparameters such as biomass, hight, leaf area index, etc. Spectral transformations of multichannel radiometric data (ratios, normalized differences) relating plant reflectance properties to bioparameters are commonly used for thier estimation [1, 2].

The objective of this work is to investigate the relationship between canopy coverage and some colour characteristics of the "soil-vegetation" system.

Canopy coverage is an essential plant feature, especially with agricultural crops, because:

— it is a growth parameter and can be used as an indicator of normal plant development or stress impacts during the vegetation process [3];

— it strongly correlates with the other bioparameters [2, 3] thus being in a way their joint expression.

In respect to remote sensing of "soil-vegetation" systems the canopy coverage is of great interest as it represents the relative proportion of the two components within the mixed class object and defines its spectral reflectance [4]. This determines the dependence of the "soil-vegetation" colour characteristics on the canopy coverage.

Another reason for the conducted investigation is the small number of examples about the utilization of colour features in crop monitoring [5, 6] as well as our ambition to explore their potential in respect to vegetation studies.

Materials and methods. Reflectance data were collected from greenhouse grown peas. The plants were grown on alluvial-meadow soil. The illumination source was a halogen lamp. Barium sulfate was used as a reference standard. The canopy coverage of the plots varied from bare soil to full vegetation cover.

From each spectral reflectance curve the tristimulus values XYZ and the trichromatic coefficients xyz were computed. The colorimetric analysis included also the determination of the dominant wavelength λ_d and the excitation purity p_e. The calculations

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EXPLORATIONS COSMIQUES

TWO TECHNIQUES FOR SPECTRAL CLASSES DECOMPOSITION FROM THEIR MIXTURE REFLECTANCE

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(*Submitted by Academician D. Mishev on November 27, 2002*)

Abstract

On the example of soil-vegetation covers two methods are studied for their potential to decompose mixture components from spectral reflectance data. The reliability of the methods is examined and their improved accuracy when used together is shown.

Key words: mixture reflectance, canopy coverage, colour features, dominant wavelength, mixed classes decomposition

Introduction. Decomposition of mixed classes and determination of their components' proportions are an essential task in remote sensing. Soil-vegetation covers are a typical example and most common case of mixed classes. The goal of this study is to compare different techniques (colorimetric analysis [1] and reflectance spectra transformations [2,3]) for canopy coverage estimation from multispectral data. The coverage coefficient defines, on the one hand, the proportions of soil and vegetation in the mixture and, on the other hand, is an important bioindicator of plant state and growth, thus being of particular interest in remote sensing crop monitoring [4].

Materials and methods. Reflectance and biometrical data from *Pisum sativum*, *Hordeum vulgare*, rye-grass and *Hibiscus rosa-sinensis* were used in the study. Ground-based reflectance measurements were performed under artificial illumination (halogen lamp) with a nadir multiband radiometer in the spectral range 400-800 nm with a 10 nm step. For the peas plots they were carried out weekly during two months of plants' growth.

Colorimetric analysis was performed according to the CIE 1964 standard methods [5] in the spectral range 450-700 nm for D_{65} light source. The tristimulus values X, Y, Z, trichromatic coefficients x, y, z and dominant wavelength λ_d were calculated from each spectral reflectance curve. The spectral transformations (so-called vegetation indices VI) used in the study are presented in Table 1. Some of them were chosen for the reason of being among the most widely used in vegetation monitoring (ratios, contrasts and normalized differences in the red (R) and near infrared (NIR) spectral bands – VI 1, 2, 3 ,4), and others for being considered colour indices (VI 5) or modified (VI 6, 7) and integral (VI 8, 9, 10) colour indices. A new spectral index (VI 12) proposed in [6] was also tested.

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INFORMATIONAL POTENTIAL OF VEGETATION SPECTRAL REFLECTANCE IN ANTHROPOGENIC IMPACT STUDIES

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ABSTRACT
The serious ecological problems relevant to the anthropogenic impact on the environment, and first of all on the biosphere, impose the necessity of methods for assessing these effects especially on vegetation land covers. In agriculture the possibility for timely identification of abnormal crop state is of particular importance. This paper is devoted to the implementation of reflectance spectra as informational featute about plant status as well as for the assessment of anthropogenic factors impact on plant development. Some results from ground-based reflectance measurements of plants grown up under different conditions (nutrient regime, heavy metal pollution) are presented.

The special attention paid to ecological problems associated with the anthropogenic impact on the environment, and first of all on vegetation, determines the importance of studies directed towards the development of efficient means for early phytodiagnostics. The identification of abnormal plant state (Kancheva, *et al.*, 1992; Shibayama *et al.*, 1993 Кънчева *и др.*, 1996) caused by various stress factors such as soil toxic contamination is of particular interest. Remote sensing has proved abilities in this respect.

The goal of the this paper is to illustrate the use of spectral reflectance data for crop monitoring when anthropogenic factors are applied, represented here by nitrogen fertilization and soil heavy metal pollution.

The specific reflectance, absorption and emission of solar radiation by land covers is the basis of multispectral remote sensing. Widely used in soil and vegetation monitoring is the visible and near infrared (0.4-1.3 μm) spectral range due to some its advantages, such as: concentrates the largest portion of solar energy, covers the biologically active spectra, requires relatively simple technical devices, shows significant sensitivity to plant parameters variations.

At the root of spectrometric studies lies the fact that the reflected by the object radiation contains information about its biophysical properties. This information is carried by the specific spectral and energy distribution of the reflected solar radiation, i.e. by the reflectance coefficients $r(\lambda_i)$ which form the spectral reflectance characteristic $R\{r(\lambda_i)\}$ and are spectral informational features of the studied object, its 'spectral image'. Vegetation covers are characterized by a composition of biomorphological parameters Φk which are their 'substantial features'.

The so called 'inverse task' is to be solved that means to estimate the parameters Φk using measured spectral reflectance $R\{r(\lambda_i)\}$. A basis for the purpose provides the dependence of the reflectance features on the kind, properties and current state of the object. This dependence actually determines the informational content of spectral features. Vegetation reflectance for instance is a function of a number of bioparameters such as density, height, biomass, leaf area, chlorophyll, etc. This means that plant parameters variation cause reflectance spectra changes, i.e. between the radiometric and biophysical properties there exist adequate relationships $R\{r(\lambda_i)\}=f(\Phi k)$ which not only determine the informational content of spectral data but attaches to it quantitative expression.

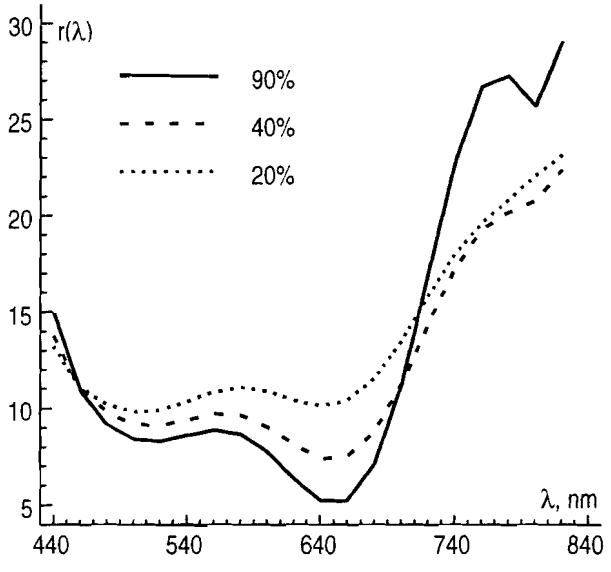

Figure 1. Spectral reflectance of spring barley plots with different plant canopy coverage.

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EXPLORATIONS COSMIQUES

PLANT SENESCENCE AND SOIL BACKGROUND IMPACT ON VEGETATION REFLECTANCE AND COLOUR FEATURES[1]

R. Kancheva, D. Borisova

(*Submitted by Academician S. Panchev on January 21, 2004*)

Abstract

Spectral transformation techniques and colorimetrical analysis of experimental and modelled data sets are used to reveal plant senescence effects (physiological changes during the growing period or stress symptoms) and the impact of soil spectral properties (varying with soil type and colour, surface roughness, moisture, etc.) on vegetation reflectance. Some results of this study concerning the estimation of green vegetation amount are presented.

Key words: reflectance properties, vegetation indices, colour features, dominant wavelength, soil background, plant senescence, spectral mixture decomposition

Introduction. Plant growth monitoring by remote sensing is closely connected to vegetation amount estimation. The actual usefulness of the applied methods depends on their accuracy and reliability. A basic problem in data processing and interpretation is spectral mixture decomposition and land cover classification. The objective of this paper is to study the effects of plant senescence and soil background on vegetation reflectance with respect to green canopy estimation. Spectral ratio and colorimetrical analyses of experimental and modelled data are used for mixture decomposition and components' proportions evaluation.

Materials and methods. Ground-based in situ and greenhouse reflectance measurements of various vegetation types (alfalfa, wheat, barley, peas, carrots, maize, sunflower, grass) with different soil background and degree of senescence were performed in the spectral range 400–820 nm. The soil diversity was presented by dark and light soils (chernozem, brown, laterite red, grey forest, alluvial, meadow) with different properties (mineral composition, organic and moisture content, surface roughness and salinity). The spectral reflectance curves of some of them are given in Fig. 1*a* illustrating the large range of soil reflectance signatures.

The variety of green and dried vegetation amounts (the latter related to chlorophyll decrease in mature plants or plant damage) was achieved during plant development

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I. ЧОВЕК И БИОСФЕРА

УСТАНОВЯВАНЕ НА ФИЗИОЛОГИЧЕН СТРЕС ПРИ РАСТИТЕЛНОСТ ЧРЕЗ ИЗПОЛЗВАНЕ НА СПЕКТРАЛНИ ДАННИ

Румяна Кънчева, Илко Илиев, Деница Борисова, Стефка Чанкова, Венета Капчина

DETECTION OF PLANT PHYSIOLOGICAL STRESS USING SPECTRAL DATA

Rumiana Kancheva, Ilko Iliev, Denitsa Borisova, Stefka Chankova, Veneta Kapchina

Abstract: Ecological problems relevant to anthropogenic impacts on the environment and first of all on the biosphere, are of global importance and draw the attention of various scientists. They impose the necessity of efficient means for assessing the effects of anthropogenic factors especially on vegetation land covers. The heavy metal pollution is one of the most severe problems concerning natural vegetation resources as well as agricultural crops. Among the different methods used for plant phytodiagnostics an increasing role become to play the spectrometric ones. The radiation behavior of land covers lies at the root of the spectrometric studies. The visible and near infrared (0.4 - 0.9 μm) measurements have proved abilities for vegetation monitoring. The reason is that this wavelength range reveals significant sensitivity to plant biophysical properties. The information is carried by the specific vegetation spectral characteristics which depend on such plant parameters as biomass amount, leaf area; cover ratio, chlorophyll content, etc. These parameters are associated with plant development and are closely related to vegetation physiological state. In this study multispectral data of transmitted by peas leaves irradiance in the (540-800) nm spectral range have been used to show the possibility for detection of plant physiological stress caused by heavy metal pollution. The effects of CdCl2 applied in different concentration are associated with plant chlorophyll and carotenoid variations.

Key words: spectrometric studies, vegetation physiological state, heavy metal pollution, plant stress detection

ВЪВЕДЕНИЕ

Екологичните проблеми, свързани с антропогенното замърсяване на околната среда, отдавна стоят в центъра на вниманието на съвременния индустриален свят. Растителната покривка е сериозно потърпевша от последиците на това замърсяване, поради което е обект на многостранни, различни по характер и мащабност изследвания относно влиянието на редица токсични вещества. Голяма част от тези изследвания касаят физиологията и развитието на растенията, адаптацията, репродуктивната им способност, генетичните изменения и пр. Наред с традиционните средства, все по-широко разпространяваща се технология за растителен мониторинг са дистанционните методи, при които се регистрират спектрално-енергетичните характеристики на обектите.

Сред различните приложения на спектрометричните методи, използвани за изследване на растителната покривка, съществено място заема фитодиагностиката. Неин важен аспект е откриването на аномални състояния на растителните обекти. Идентификацията на такива състояния се осъществява въз основа на факта, че стресовите въздействия причиняват потискане в развитието, отразявайки се върху редица растителни биопоказатели като биомаса, листов индекс, проективно покритие, пигментно съдържание и пр. Освен че са показатели за състоянието на растителната покривка, тези параметри определят нейните спектрални свойства и съответно измерваните спектрални характеристики [1-4]. Настоящата работа е част от серия експерименти, провеждани с различни агрокултури (ечемик, люцерна, грах) и екологични условия на отглеждане (замърсяване с никел,

CROP SPECTRAL REFLECTANCE WITH REFERENCE TO GROWING CONDITIONS

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Abstract

Ecological problems relevant to anthropogenic impacts on the environment, and first of all on the biosphere, are of global importance and draw the attention of various scientists. They impose the necessity of efficient means for assessing the effects of anthropogenic factors on vegetation land covers, for instance. In agriculture the possibility for early phytodiagnostics and timely identification of abnormal crop state is of particular importance. Remote sensing techniques have proved abilities in this respect. The goal of the paper is to illustrate the implementation of spectral reflectance data for crop monitoring during plant growth. Vegetation reflectance spectra are used as an informational feature about crop development under different conditions which are represented here by nitrogen fertilization and heavy metal contamination.

The anthropogenic impact on the environment, and first of all on the biosphere, impose the necessity of efficient means for vegetation monitoring. In agriculture, for instance, crop state assessment and detection of stress situations is of particular importance. This paper shows the potential of crop spectral reflectance as an informational feature about plant growing conditions.

The different radiation behaviour of land covers lies at the root of spectrometric studies. The visible and near infrared (0.4 - 0.9 μm) measurements have proved abilities for crop monitoring [1,2]. The reason is that this wavelength range reveals significant sensitivity to plant biophysical properties. The information is carried by the specific distribution of the reflected radiation which depends on such plant parameters as biomass amount, leaf area, vegetation cover ratio, chlorophyll content, etc. They are growth parameters associated with crop phenological and physiological development and closely related to the growing conditions.

Some results are presented here from experiments with spring barley and peas treatments grown under different nutrient and contamination conditions. Ground-based reflectance measurements have been performed with multichannel radiometers [3-5] and regression analyses of the

SPECTROSCOPY OF LUNAR AND TERRESTRIAL BASALTS

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Abstaract

Reflectance spectroscopy is a rapidly growing science that could be used to derive significant information about mineralogy. Absorption bands in telescopic spectral reflectance of the moon and other solar system objects are potential for obtaining mineralogical and chemical information. Real land and solar bodies' covers are mixtures of materials and the theory of mixed spectral classes is an efficient method to study various rocks and minerals. Laboratory spectral measurements of basalt samples have been performed in the visible, near infrared and thermal infrared bands with multi-channel radiometers. Basalts are mixed classes of their rock-forming minerals and the data obtained have been used to illustrate the application of spectral mixture analysis for mineralogical and chemical differentiation.

Since the earliest days of spectroscopic remote sensing [1] of the lunar surface electronic transition bands exhibited by lunar soils and rocks in the visible and near-infrared regions of the spectrum are used to determine mineralogical composition [2]. Much less is known about the spectral behaviour of lunar rocks in the thermal infrared.

The interpretation of reflectance spectra of unknown materials requires an understanding of how the reflectance of different components combines into a single curve. An efficient method for spectrometric data processing is the mixed classes' theory [3]. The real land cover is a mixture of materials at just about any scale we view it. Rocks are mixture of their rock-forming minerals. Of particular interest are iron-containing rock-forming minerals because they are widespread.

Description of measured basalt samples:

1) Terrestrial samples are light grey porphyritic rocks with green olivine phenocrysts; dark grey slightly vesicular rocks consisting of black and light green phenocrysts; vesicular rocks with small phenocrysts.

2) Lunar samples are mare regolith.

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RECOGNITION OF IRON-CONTAINING ORE MINERALS AND ROCKS USING REMOTELY SENSED DATA

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Summary

Abstract Recognition of iron-containing ore minerals and rocks using remotely sensed data is a special case. Spectral mixture analysis has as one of the basic objective the definition of subpixel (subclass) proportions of spectral endmembers (classes) which are related to mappable surface constituents. Spectral mixture analysis decomposes the mixed pixel determining the fractions of each spectral endmember which combine to produce the mixed pixel's spectral signature. The spectral signature of the pixel is a combination (linear or non-linear) of the spectral signatures of the component surfaces. Assuming linear mixing, (the spatial fractions = the spectral fractions) we consider these fractions to be the area fractions. In this paper a study on ore minerals and rocks reflectance and emissivity was conducted. The data used during our study consists of reflectance VIS-NIR spectra derived from an image of the region of interest and modern topographic map. Remotely sensed data obtained in year 2000 for a region near an opencast mine in Bulgaria are compared with laboratory multispectral measurements of rock and mineral samples performed in the visible, near infrared and thermal infrared bands with multi-channel radiometers. Field data were collected to describe the characteristics of these classes in terms of land cover. Our results confirmed that successful methodology for remotely sensed data interpretation has been worked out.

Introduction

Iron-containing ore minerals and rocks are a special case for remote sensing because they are so ubiquitous. The iron absorption at (0.8-1.0)-um range is reduced in depth according to it content. The 0.9-um-absorption line shifts position with elements substituted for iron. For example, continuum removal and scaling the hematite absorption to similar depth shows the wide variety of band shapes and positions that can be found in nature. Pixels comprising mixed spectral information about the objects under study are commonly found in remotely sensed data. This is due to the limitations of the spatial resolution of the airborne instruments (such as Landsat, SPOT, etc.) and the heterogeneity of features on the ground. The mixture spectra are often generated when the pixel covers more than one land cover class. To obtain better results the mixed pixels are decomposed into different proportions of mineral components. Characteristic spectral signatures are also used in recognition of the iron-containing ore minerals and rocks. This paper aims to demonstrate a practical approach in unmixing spectra and detection of ore minerals from Kremikovtzi obtained from laboratory, in-situ and airborne instruments. Our basic assumption is that airborne data measured as reflectance in red, near infrared and mid infrared ranges of electromagnetic spectrum and emissivity spectra in thermal infrared range are a linear mixture of the mineral composition of studied area. These results are compared with the results obtained in studying basalts as iron-containing rock type.

SPECTRAL MODELS FOR CROP STATE ASSESSMENT CONSIDERING SOIL AND ANTHROPOGENIC IMPACTS

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Abstract: In the contemporary world aerospace information gathered by different sensors and numerous observation missions has become a genuine necessity in various investigation and application fields. Remote sensing technologies are used for natural resources management, ecosystem change detection, environment preservation and in many other world significant problems. Vegetation monitoring is among the priorities of remote sensing being associated with plant growth assessment, stress detection, yield forecasting. This paper is devoted to the relationship between agricultural vegetation spectral and biophysical features with consideration of plant growth conditions. The influence of soil properties and anthropogenic factors (fertilization, heavy metal pollution) on crop spectral response has been examined in relation to the applicability of spectral models to estimate plant variables and assess crop state.

Keywords: remote sensing, vegetation monitoring, spectral reflectance, soil impact, anthropogenic factors, fertilization, heavy metal pollution, spectral-biophysical modeling

INTRODUCTION

In the contemporary world aerospace information gathered by different sensors and numerous observation missions has become a genuine necessity in various investigation and application fields. Vegetation monitoring is among the priorities of these investigations. In agriculture remote sensing is a tool that can be used to assess plant development process and retrieve information about plant growth parameters for subsequent input into models for crop state assessment and yield forecasting. Ground-based studies are a reference source for verification of remotely sensed data. Especially advantageous is the ability to vary and control experiment conditions getting a precise picture of plant spectral response to different factors as well as to track in detail temporal aspects of plant spectral properties during the ontogenetic process.

Numerous papers have the objective of retrieving quantitative information using vegetation reflective and emissive spectra. Prevailing part of them deal with green phytomass estimation, plant growth evaluation and yield prediction (Goel, 1986; Thenkabail, 1994; Clevers, 1989; Rudorff, 1990b; Shibayama, 1989). Empirical modelling appears to be one of the most widely spread tecnique for vegetation assessment (Weiser, 1986; Gardner, 1986; Malthus, 1993; Kancheva, 1992) although different conclusions have been made about the applicability of the obtained models, their dependence on local conditions and site-to-site or year-to year discrepancy. (Wiegand, 1990; Weiser, 1986)

This paper is further dedicated to spectral-biophysical modelling of agricultural vegetation considering growth conditions. The objective is to examine the impact of soil properties and anthropogenic favtors (fertilization, heavy metal pollution) on plant spectral behaviour in relation to crop state evaluation and stress assessment. Ground-based VIS and NIR spectral measurements have been carried out along with phenological and biometrical observations in order to establish empirical relationships between plant reflectance features, growth variables, productivity and treatments applied.

MATERIALS AND METHODS

Reflectance, biometrical and phenological data were gathered from spring barley and peas plants within a green-house experiment. The treatments (twice replicated) comprised of different soil type, heavy metal pollution and fertilization conditions. The experiment was conducted with peas grown over alluvial-meadow soil and three concentrations of Cd contamination (10, 20 and 30 mg/kg). The spring barley experiment consisted of two parts: NH_4NO_3 fertilization treatments over chernozem soil with different nitrogen concentrations (from 0 to 1000 mg/kg) including two more fertilizer compounds $Ca(NO_3)_2$ and KNO_3 for the nitrogen concentration of 800 mg/kg, and a second part of Ni-polluted barley treatments grown over dark chernozem soil (neutral with pH=7.0-7.5) and brighter grey forest soil (acid with pH=5.0-5.5) chosen for two reasons - their different reflectance spectra and different response to heavy metal pollution. Four Ni concentrations of 100, 200, 300 and 400 mg/kg and equal nutrient amount of NH_4NO_3 were applied.

Reflectance data were acquired with a multichannel portable spectrometer from the nadir position over the wavelength range 0.4-0.8 μm at a 10 nm interval. Spectral measurements were performed weekly during plant development, from emergence till full maturity for barley plots and till flowering for peas. Among the various growth and ecologically relevant variables that were measured, the presented here results concern mainly plant canopy cover, above-ground biomass and yield. The reason is that variations in vegetation reflectance are most attributed to green coverage which is at the same time a primary indicator of crop state. Biomass amount is also a growth parameter related to plant development and yield forming processes.

The data sets were statistically analysed to determine correlations and derive empirical relationships between plant reflectance spectra, biophysical variables and applied treatments. A regression analysis was run on vegetation spectral indices using band ratios, contrasts, normalized differences as a routinely implemented data transformation (Qi, 1994; Chappelle, 1992; Penuelas, 1994). The wavelengths selected correspond to absorptions and high reflectance bands of vegetation spectra in the green (550 nm), red (670 nm) and near infrared (800 nm) range. Spectral indices were chosen from those having the best statistical correlation with plant bioparameters and applied factors, the obtained empirical regressions being significant at the 95% level of confidence. Special attention was paid to temporal aspects of plant spectral properties throughout the growing period. The temporal behaviour of vegetation indices was regarded as a function of plant ontogenesis and used as a crop diagnostic feature and yield predictor. Significant variations in plant state, and consequently in spectral performance, were found associated with the impact of soil properties and anthropogenic factors.

RESULTS AND DICUSSION

Various combinations of spectral ratios (Yanev, 1994; Чимитдоржиевр 1998) were examined for their correlation with plant bioparameters and heavy metal contamination. Many of them demonstrated high R^2 values from 0.86 to 0.97. In Fig. 1 the statistical relationships of NIR/R and R/(G+R+NIR) with barley canopy cover at pre-heading stage are shown. The dependences were derived separately for grey soil (1) and chernozem soil (2) plots. If soil-integrated regression curves are used the estimation error increases almost twice, the canopy cover of the brighter soil treatments being systematically underestimated and overestimated for the dark soil treatments.

СПЕКТРАЛНИ ХАРАКТЕРИСТИКИ НА ПОЧВИ, ПОЧВООБРАЗУВАЩИ СКАЛИ И СМЕСИ ЗА АНАЛИЗ НА КОМПОНЕНТНИЯ СЪСТАВ

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Увод

Спектралната отражателна способност на почвата е функция на редица почвени параметри - минерален и механичен състав, хумусно съдържание, влажност и др. (16,17), които представляват интерес от гледна точка на множество изследвания и приложения. При дистанционните изследвания се използва зависимостта на измерваните в различни области на електромагнитния спектър спектрални характеристики от споменатите почвени параметри (3,12,13). Тази зависимост дава възможност по спектрални данни да се съди за интересуващи ни почвени свойства.

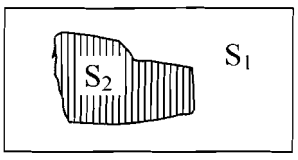
Принципен въпрос при дистанционните изследвания на обекти върху земната повърхност е въпросът за смесените класове (8,15), тъй като има общ характер и се отнася до същността на голяма част от решаваните задачи. Затова един от основните проблеми при обработката и интерпретацията на получаваните от спектрометрични измервания данни е декомпозицията на спектрални смеси [5-8], с което се цели извличане на информация както за вида, така и за някои свойства на обектите, формиращите смесения клас. Тъй като общият характер на почвите се определя от почвообразуващите скали и минерали, то предмет на настоящата работа е да изследва спектралните отражателни характеристики на скали, почви и скално-почвени смеси във връзка с компонентния им състав. Използвани са различни методи за анализ на спектралните данни с оглед разделянето на съставните компоненти по отношение на техния вид и пропорции в смесения клас. За целта са проведени лабораторни измервания на спектралните отражателни характеристики на почвообразуващи скали и съответните почви. На примера на гранити, пясъчници и кафяви горски почви са показани резултати от численото моделиране на смесени класове и анализа на спектрометричните данни чрез използване на линейна спектрална декомпозиция, двумерен спектрален анализ, контрастни коефициенти, наклон на спектралната отражателна характеристика. Представени са също резултати за връзката между спектралните характеристики и процентното съдържание на желязо в изследваните скали и почви.

Материали и методи

В лабораторни условия са проведени измервания на спектралните отражателни характеристики на гранити, пясъчници и кафяви горски почви (алфисоли). Използвана е многоканална спектрометрична система, разработена в ЦЛСЗВ-БАН (14). Измерванията са извършени във видимия и близкия инфрачервен диапазон 0.55-1.1 μm със стъпка $\Delta\lambda$=0.01 μm. За всеки от обектите са измерени по 5 образеца, като при всяко измерване са регистрирани по 10 спектрограми, които са усреднени. Спектралните характеристики на смесените класове "скала-почва" са получени чрез числено моделиране на данните за чистите класове (гранит, пясъчник, почва) посредством използване на изложения по-долу подход.

Смесен клас (Фиг. 1) се нарича пикселът (измерваната повърхност), в пределите на който попадат повече от едни вид обекти. Как се формират спектралните отражателни характеристики на смесен клас от два обекта? Площта на пиксела ппредставлява сума от площите S_1 и S_2, заети от двата наблюдавани обекта, при което общата площ на пиксела е S=100 %:

(1) $S=S_1+S_2$



Фиг.1. Смесен клас от два обекта

Каква част от общата площ е заета от единия и каква от другия обект се определя чрез съответния коефициент на покритие $p_{1,2}$, който представлява относителния дял на заеманата от обекта площ в рамките на пиксела :

(2) $p_1=S_1/(S_1+S_2)$ и $p_2=S_2/(S_1+S_2)$, като $p_1+p_2=1$.

Общият коефициент на отражение $r_\Sigma(\lambda_i)$ на разглеждания смесен клас, прилагайки принципа за адитивност на отразената радиация (8,15), се дава с израза:

(3) $r_\Sigma(\lambda_i)=p_1r_1(\lambda_i)+p_2r_2(\lambda_i)$,

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MODELING AND VERIFICATION IN VEGETATION SPECTRAL STUDIES

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ABSTRACT. Remote sensing technologies are recognized as an efficient tool for getting information about land covers and have a wide range of investigation and application fields. In agriculture, remotely sensed data are used for plant growth monitoring, precision agriculture running and yield prediction. The interpretation of airborne and satellite data require explicit apriory information about crop spectral behaviour under different conditions. Besides, the necessity to use various geoinformation technologies incorporating remote sensing and in-situ observations, ancillary data and etc., imposes data integration and sharing between different data sources. The paper is devoted to ground-level spectrometric studies as an integral part of remotely sensed data analysis.

МОДЕЛИРАНЕ И ВЕРИФИКАЦИЯ ПРИ СПЕКТРАЛНИТЕ ИЗСЛЕДВАНИЯ НА РАСТИТЕЛНОСТ

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РЕЗЮМЕ. Различните модели за оценка на вегетационното развитие на земеделските културите се нуждаят от детайлна информация относно състоянието на растенията, почвените характеристики, местните условия и пр.. Като част от геоинформационната система (ГИС), дистанционните методи са основен инструмент, с чиято помощ се получават данни от големи площи относно параметри на растителната покривка, използвани в подобни модели. Особенно ценни за оценка на състоянието на посевите и условията на развитие са пространствено-времеви аспекти на получаваната информация. В работата са представени основите на въпроса, дискутира се необходимостта и алгоритмите за съвместното използване на наземни и дистанционни данни за целите на растителния мониторинг.

Introduction

Aerospace information gathered by different sensors has become a genuine necessity in various scientific studies and application fields. Vegetation is among the priorities of remote sensing investigations. They are related to vegetation biodiversity and state monitoring, stress detection and etc. as well as too many world significant problems such as environmental changes, anthropogenic impact on ecosystems, desertification processes. In agriculture remote sensing is a tool that is used to retrieve information about plant development and growth conditions implementing the obtained data for crop agrodiagnostics and yield prediction (Kancheva et al., 1992; Кънчева, 1995; Кънчева и Георгиев, 2000; Kancheva et al., 2003).

The development of efficient algorithms for multispectral and multitemporal data analysis is still one of the most essential issues of remote sensing. The importance of this issue is related to the ever-increasing quantity of data provided by numerous sensors and Earth observation missions. Another reason is the strong stress that is being put recently on the operational use of acquired data. Here immediately arises the question about the reliability of data interpretation. An answer to this question is the use of various geoinformation technologies incorporating remote sensing and in-situ measurements, data sharing and integration. Though the idea of data integration is not new it has become recently a leading concept in data application.

This paper is devoted to the performance of ground-based studies as an element of remote sensing. Ground-based studies are an integral part of remote sensing technologies. They play an important role in the geoinformational system being the most cost effective and technically appropriate way of aiding the interpretation of remotely sensed data. Ground measurements provide a reference source for testing and validation of data processing algorithms and for verification of results (Kancheva, 2003; Kancheva, 2004; Kancheva and Borisova, 2005).

Especially advantageous in vegetation ground studies is the ability to vary and control experiment conditions getting a precise picture of plant spectral response to different factors (soil background, growth conditions, stress impacts, etc.) as well as to track in detail temporal aspects of plant spectral properties during the ontogenetic process. Here we present an approach for vegetation ground-level modeling and verification of spectrally retrieved data. The goal is to show and explain the main steps and procedures of the algorithm as applied to crop monitoring, state assessment and prediction using remotely sensed multispectral and multitemporal data.

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VEGETATION GROUND-BASED MODELS IN CROP STATE MONITORING

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ABSTRACT

The development of efficient algorithms for multispectral and multitemporal data analysis is still one of the most essential issues of remote sensing. The importance of this issue is related to the ever-increasing quantity of data provided by numerous radiometric and imaging sensors. Besides, the necessity to use various geoinformation technologies incorporating remote sensing, in-situ observations, ancillary data etc., imposes information sharing and integration. This paper is devoted to ground-based spectral modeling as an integral part of vegetation remote sensing monitoring. It examines the relationship between agricultural crop spectral and biometrical features with consideration of growing conditions and plant ontogenesis. The influence of soil properties and anthropogenic factors (fertilization, heavy metal pollution) on crop spectral response has been studied. VIS and NIR ground-based reflectance measurements have been related to plant growth features to derive empirical models. Some results of crop state assessment using these models and airborne radiometric data are presented. Good agreement has been found between model estimates and ground-truth data.

INTRODUCTION

Nowadays the aerospace information gathered by different sensors and numerous Earth observation missions has become a genuine necessity in various investigations and application fields. Vegetation is among the priorities of these investigations which are related to many world significant problems such as environmental changes, anthropogenic impact on ecosystems, desertification processes, etc. In agriculture remote sensing is used for retrieving information about plant development and yield forecasting. Ground-based studies are an integral part of vegetation remote sensing technologies serving as a reference and verification source of remotely sensed data. Especially advantageous is the ability to vary and control experiment conditions getting a precise picture of plant spectral response to different factors as well as to track in detail temporal aspects of plant spectral properties during the ontogenetic process.

A great number of papers is devoted to the possibility of deriving quantitative information about vegetation using reflective and emissive spectra. Many of them deal with plant growth evaluation, biomass estimation and yield prediction (i, ii, iii, iv, v). Empirical modelling is one of the most widely spread technique for vegetation assessment (i, vi, vii, viii, ix) although different conclusions have been made about the applicability of the obtained models, their dependence on local conditions and site-to-site or year-to year discrepancy (vi, x).

This paper is further dedicated to spectral-biophysical modelling of agricultural vegetation. One of the objectives is to examine the impact of soil properties and anthropogenic factors (fertilization and heavy metal pollution) on plant spectral behaviour in relation to stress detection. The other goal is to test the applicability of spectral models for crop state assessment using airborne radiometric data.

MATERIALS AND METHODS

Reflectance, biometrical and phenological data were gathered from cereals throughout the growing season. A spring barley green-house experiment was conducted which consisted of two parts: NH_4NO_3 fertilization treatments over chernozem soil with different nitrogen concentrations (from 0 to 1000 mg/kg) and treatments with $Ca(NO_3)_2$ and KNO_3 fertilizers for the nitrogen concentration of

Agricultural ground-level spectral modeling in support of remotely sensed data interpretation

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Keywords: agricultural crop monitoring, spectral modeling, remote sensing

ABSTRACT: Remote sensing technologies are recognized as an efficient tool for getting information to manage problems of global importance such as reasonable and sustainable land use, environment protection, natural resources preservation and etc. In agriculture, remotely sensed data is used for plant growth monitoring, yield prediction, precision agriculture running. The interpretation of airborne and satellite data require explicit a priori information about cropland spectral behaviour under different conditions. Besides, the necessity to use various geoinformation technologies incorporating remote sensing and in-situ observations, ancillary data and etc., imposes information sharing between different databases and data integration. This paper is devoted to ground-level spectrometric studies as an integral part of remotely sensed data analysis. A general concept of developing and using ground-based models is presented. The algorithm steps of applying these models in crop remote sensing assessment are discussed.

1 INTRODUCTION

Two underlying trends of remote sensing data application in agriculture can be identified recently. The first of them refers to macroeconomic tasks (food provision) on large regional, state and global levels, and the second concerns microscale issues on the level of farm precision agriculture running. In both cases, however, the main idea is the same and explores the concept of operational monitoring and accurate predicting of crop development by using information from remote sensing observations. The specifics of European agricultural lands are the great number of comparatively small areas and the vast array of local conditions. This requires high resolution data (spatially and temporally) and leads to increased operational costs. An efficient solution could be airborne sources of information provision. The advantage of an airborne crop growth monitoring approach is the easier and more frequent performance of data gathering and calibration, coupled with a detailed, site-specific database, and consideration of local conditions. An important role here play ground-based studies being the most cost effective and technically appropriate way of aiding the interpretation of remotely sensed data. They provide a reference source for testing and validation of algorithms and for verification of data processing results. Especially advantageous is the ability to vary and control the experiment conditions getting a precise picture of plant spectral response to different factors and to track temporal variability of crop spectral properties during the ontogenetic process.

This paper is devoted to the implementation of ground-based studies as an integral component of a geoinformational system, particularly for agricultural purposes. Though the idea of data integration is not new it has become recently a leading concept of data application. Here we present an algorithm for ground-based and airborne data implementation in crop monitoring, state assessment and prediction. The goal is to show and substantiate the steps of the algorithm as applied to a task

Spectral models for crop state assessment considering soil and anthropogenic impacts

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Aerospace information gathered by different sensors and Earth observation missions has become an undoubted necessity in various investigation and application fields. Remote sensing data address many world significant problems such as ecosystem change detection, natural resources management, environment preservation, etc. Vegetation monitoring is among the priorities of these investigations being the most important component of the biosphere. In agriculture remote sensing applications are associated with plant growth assessment, stress detection, yield forecasting. This paper is devoted to the relationships between agricultural vegetation spectral and biophysical features with consideration of some growth conditions. The influence of soil properties and anthropogenic factors (fertilization, heavy metal pollution) on crop spectral response has been examined in relation to the applicability of spectral models to estimate plant variables and assess crop state and stress impacts.

INTRODUCTION

In the contemporary world aerospace information gathered by different sensors has become a necessity in various investigation and application fields. Vegetation monitoring is among the priorities of these investigations. In agriculture remote sensing is a tool that is used to assess plant development process and retrieve information about plant growth parameters for subsequent input into models for crop state assessment and yield forecasting. Ground-based studies are a reference source for verification of remotely sensed data. Especially advantageous is the ability to vary and control the experimental conditions getting a precise picture of plant spectral response to different factors as well as to track in detail temporal aspects of plant spectral properties during the ontogenetic process.

The retrieving of quantitative information using vegetation reflective and emissive spectra is the objective of numerous papers. Prevailing part of them deal with green phytomass estimation, plant growth evaluation and yield prediction [1-5]. Empirical modelling is one of the most widely spread technique for vegetation assessment [6-9]. Different conclusions have been made about the applicability of the obtained models because of their dependence on local conditions and site-to-site or year-to-year discrepancy [6, 10].

This paper is further dedicated to the spectral-biophysical modelling of agricultural vegetation considering the growth conditions. The goal is to examine the impact of soil properties and anthropogenic factors (nutrient supply and heavy metal pollution) on plant spectral behaviour in relation to crop state evaluation and stress assessment. Ground-based VIS and NIR spectral measurements have been carried out along with phenological and biometrical observations in order to establish empirical relationships between plant reflectance features, growth variables, productivity and applied treatments.

MATERIALS AND METHODS

Reflectance, biometrical and phenological data were gathered from spring barley plots within a green-house experiment. The treatments comprised of two soil types (grey forest soil and chernozem soil), Ni pollution in different concentrations and different fertilization conditions. The spring barley was grown over neutral (pH=7.0-7.5) chernozem soil and acid (pH=5.0-5.5) grey forest soil. The soils were chosen for two reasons - their different reflectance spectra and different response to heavy metal pollution. Four Ni concentrations of 100, 200, 300 and

Влияние минерального состава гранитов на измеряемые спектры яркости

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Граниты являются определяющим компонентом континентальной земной коры, формируя ту сушу, на которой мы живем и в пределах которой сосредоточено большинство доступных для разработки месторождений полезных ископаемых. Граниты на 90% состоят из равных долей кварца, плагиоклаза и калишпата, к которым в небольшом количестве (5-7%) добавляются магнезиально-железистые силикаты, называемые темноцветными минералами. Несмотря на постоянство соотношений первых трех главных минералов, именуемых салическими, граниты очень разнообразны в составе темноцветной части: широко представлены в природе биотитовые, роговообманковые, диопсидовые, гиперстеновые, двуслюдяные граниты, известны и более экзотические разновидности. Если добавить к этому вариации в составе плагиоклаза (Ca-Na-полевого шпата), взаимной смесимости натрового и калиевого полевых шпатов, степени их структурной упорядоченности, то количество видов гранита, различающихся минеральным составом, будет намного более сотни. Но при всех вариациях состава гранит всегда остается гранитом.

Для изучения столь большого разнообразия гранитов способствует и дистанционное зондирование Земли, в частность полевые и лабораторные спектрометрические методы. Настоящий доклад посвящен исследованию влияния минерального состава гранитов на измеряемые спектры яркости, для чего проведено спектрометрирование гранитов в лабораторных условиях в диапазоне 0,5-1,1 мкм. Для анализирования полученных данных использованы методы декомпозиции спектральных смесей, “почвенная линия” на плоскости NIR-Red, регрессионный угол наклона зависимости стойности спектрального отражения от длины волн и индексы-отношения яркостей спектральных каналов.

Работа выполнена при поддержки проектов НСНИ-МОН №НЗ-1410/04 и №МУНЗ-1502/05.

Introduction

The spectrometric measurements are a part of remote sensing and they could be used as an additional opportunity to derive significant information about petrography and mineralogy. Real land covers are mixtures of materials and the theory of the mixed spectral classes [1] is an efficient method to study various rocks and minerals. Granites are two sub-classes of one and the same class (group) of granite and rhyolite [2]. For remote sensing the granites are mixed class of their rock-forming minerals.

The goal of the present paper is the study the behaviour of the granite reflectance spectra depends to their rock-forming minerals.

Methods and materials

It is well known the specific reflectance, absorption and emission of solar radiation by land covers are the basis of remote sensing, of spectrometric measurements in particular [3, 4].

In the reflected by the petrographic object radiation holds the mineralogical information. Containing this information the reflectance spectra $R\{r(\lambda_i)\}$ present the spectral informational features of the studied object. The parameters of studied object based on measured spectral reflectance $R\{r(\lambda_i)\}$ could be defined. The dependence of the reflectance signatures behaviour to type and rock-forming minerals of the granites provides a basis for the purpose.

Mineral content of the studied objects is of particular importance. It determines the distribution of reflected from surface radiation. The amount of reflected light is dependent on mineral content [5-7]. As the rock-forming minerals darker, more light is absorbed and the reflectance drops. The reflectance increases as the content of the salic minerals increase.

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DETERMINING THE OVERBURDEN DUMPS BY SUB-PIXEL METHOD

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KEY WORDS: Remote Sensing, Environment, Data Processing, Landsat Data, Classification Accuracy

ABSTRACT:

Delineation of overburden dumps by means of remotely sensed multispectral data with moderate spatial resolution (e.g. Landsat TM/ETM+ 30m) is a challenging task. The major difficulties arise from: 1) large period using the dump (introducing multitemporality); 2) the unknown proportions of vegetation and soil/rock samples in the marginal areas. A variety of methods have been proposed to overcome the problems with impure pixels, but a promising one is the soft classification which assign a pixel to several land cover classes in proportion to the area of the pixel that each class covers. In this scenario for every pixel of the data the correct proportion of the end-members should be found and then co-registered with the corresponding original pixel. As a result this sub-pixel classification procedure generates a number of fraction images equal to the number of land cover classes (end-members). All sub-pixel mapping algorithms have one property in common: accuracy assessment of sub-pixel mapping algorithms is impossible because of missing high resolution ground truth imagery. In this case one possible solution is to use laboratory and in-situ measured spectrometric data. This study presents a successful implementation of soft classification method with additional, precise spectrometric data for determination of dump area of the copper plant. The results were used for proving the in-situ gathered data and coincidence of 93.5% was achieved.

1. INTRODUCTION

Traditional classification techniques are “hard” in the sense that a single pixel is assigned to a single land cover class. At coarse resolutions pixels predictably become mixed. For these mixed pixels “soft” classifiers can be used, which assign a pixel to several land cover classes in proportion to the area of the pixel that each class covers.

Several researchers have addressed this sub-pixel mixture problem. Among the most popular techniques for sub-pixel classification are mixture modeling (Kerdiles and Grondona, 1996) and supervised fuzzy c-means classification (Foody,, 1994).

These techniques aim at estimating the proportions of specific classes that occur within each pixel. The result is a number of fraction images, one for each land cover class concerned. This information describes the class composition, it does not provide any indication as to how this is spatially distributed within the pixel. The result is thus quite different from the classic classification algorithms, where a single land cover map, containing all classes, is produced. One way to go from fraction images to a classic land cover map would be to use "hardeners", where rules can be formulated to determine which class dominates the pixel. The main disadvantage is that information is lost much in the same way as happens with classic hard classifiers. Atkinson (1997) has formulated an idea for an alternative approach. It consists of converting raster data to vector data by threading the vector boundaries through the original image pixels (instead of between pixels, as classic raster-to-vector conversion algorithms would do). This process is called sub-pixel mapping. The key problem is determining where the relative proportions of each class are most likely to occur.

2. METHODS

2.1 Sub-pixel Classification

The spectral unmixing technique that will be applied is based upon Linear Mixture Modeling. The basic hypothesis is that the image spectra are the result of mixtures of surface materials and that each of these components is linearly independent of the other. The mixtures in the image are expressed as linear combinations of their respective spectra in the image. Spectral response of each image pixel in every spectral band can be considered as a linear combination of the response of each component (end-member) present in the mixture. Therefore, every pixel contains information about the proportion (or fraction) and spectral response of each component.

Hence the spectral reflectance r, for every image pixel in any band, can be modeled as follows:

$$r_{\Sigma}(\lambda_i)=p_1 r_1(\lambda_i)+p_2 r_2(\lambda_i)...+p_m r_m(\lambda_i)+\varepsilon=\sum_{j=1}^{m} p_j r_j(\lambda_i)+\varepsilon \quad (1)$$

where p = fraction cover,
r for pure component reflectance
λ is wavelength
and ε is an error term.

This equation can become a linear system of n equations and k unknowns in two ways:

- applying the equation to every pixel in a single band (n pixels)
- applying the equation to every band of a single pixel (n bands)

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Plant Spectral Signatures as Growth Stress Indicators

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Abstract

Spectral properties of land covers are bearers of information and lie at the root of remote sensing technologies which are widely used in natural resources management, change detection, crop assessment, ecosystems preservation and many other world significant problems. In agriculture remote sensing is applied for monitoring of plant development, evaluating of physiological processes and growth conditions. Especially valuable are the spatio-temporal aspects of the remotely sensed data in detecting crop state differences and stress situations. The implementation of airborne and satellite data requires efficient algorithms for data analysis as well as explicit information about vegetation spectral behaviour under different conditions for higher reliability of the derived information.

Our paper focuses on different techniques for handling data from multispectral and multitemporal measurements analysing plant spectral signatures with respect to stress factors. Plant spectral properties have been examined for their ability to serve as sustainable stress indicators. Reflectance features, vegetation indices, "red edge" position, transmittance and fluorescent emission characteristics have been studied. The obtained results indicate that growth conditions cause statistically significant variations of plant spectral signatures that allow not only to discriminate between stressed and healthy vegetation but also to quantitatively describe the stress impact in terms of crop agronomical parameters and yield.

Introduction

During the last years destructive processes caused by natural disasters or anthropogenic activity are in the focus of the scientific research and occupy the attention of social communities and government authorities. Recent developments in environmental studies are greatly connected with worldwide ecological problems related to anthropogenic impacts on the biosphere and first of all on vegetation. Advanced monitoring and alerting techniques, on-time information extraction, modeling and forecasting technologies are a preposition for successful data application and decision support in environmental studies.

Nowadays the aerospace information gathered by different sensors and numerous observation missions has become an indispensable necessity in various investigation and application fields. Remote sensing technologies are used for natural resources management, crop assessment, land covers change detection, ecosystems preservation and many other world significant problems. The development of efficient algorithms for data analysis is one of the most essential and challenging issues associated with the higher reliability of the derived information and resulting in the possibility to solve complex problems related to Earth monitoring. The implementation of airborne and satellite data requires explicit information about land covers spectral behavior under different conditions. In this context detailed radiometric studies complement the vast array of geo-spatial data products.

Being the most important and anthropogenic-affected component of the biosphere, the vegetation has a leading position among the priorities of remote sensing investigations. In agriculture remote sensing technologies are applied for retrieving information about plant development, evaluating plant growth processes and yield forecasting. They are recognized as an efficient tool used to derive plant bioparameters, to assess crop current state and make predictions. Numerous papers have the objective of analyzing vegetation reflective and emissive spectra in order to quantitatively estimate green phytomass and physiological variables related to plant growth and productivity [1-6]. Studies are being carried out with the goal of vegetation assessment, stress detection and evaluation of desertification processes. Especially valuable are the spatio-temporal aspects of the remotely sensed data in detecting stress situations [7-12].

With all this in view our paper focuses on different techniques for handling data from multispectral and multitemporal measurements analysing plant spectral signatures in terms of plant response to stress factors. Some results from studies on crop state assessment using spectral-biophysical modeling approach are presented.

Materials and Methods

The investigations were conducted on various agricultural species (winter wheat, spring barley, peas, alfalfa) grown under different conditions (soil type, fertilization regimen represented by the nitrogen amount and compound, toxic pollution). The study comprised laboratory, green-house or field experiments. The soil acidity, nutrient deficiency and heavy metal contamination (Cd, Ni,) were stress factors that affected the development and caused variations of crop state.

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VEGETATION STRESS INDICATORS DERIVED FROM MULTISPECTRAL AND MULTITEMPORAL DATA

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Abstract — Remote sensing is already an operational tool widely used in vegetation studies for ecological monitoring, change detection of natural ecosystems and in agriculture for crop state assessment and yield prediction. A strong stress is being put on the accuracy of the retrieved information. This requires reliable indicators of plant growth and physiological status. The development of efficient means for data analysis is still one of the most essential issues. The importance of this issue is directly related to the ever-increasing amount of data provided by numerous sensors. The use of multispectral and multitemporal remotely sensed data and the implementation of advanced data processing technologies results in the possibility of getting different information needed for decision-making in solving problems related to vegetation preservation and agricultural land use. The application of satellite data requires knowledge of land covers spectral behaviour under different environmental conditions considering regional and local peculiarities. In this context detailed ground-based and airborne spectrometric studies complement the array of geo-spatial data products. These studies are the most appropriate way of aiding the interpretation and providing a reference source for validation of remotely sensed data. This paper is devoted to plant stress detection using VIS and NIR multispectral data. Empirical modelling of various agricultural crops under different soil and ecological conditions has been performed in order to describe the relationships between plant spectral and biophysical features and to derive sustainable spectral indicators of plant state.

1. INTRODUCTION

During the last years destructive processes caused by natural disasters or human activity are in the focus of the scientific research and occupy the attention of social communities and government authorities. A great variety of projects has been developed aimed at environmental monitoring and control. Recent developments in environmental studies are greatly connected with worldwide ecological problems related to anthropogenic impacts on the biosphere and first of all on vegetation. Advanced monitoring and alerting techniques, on-time information extraction, modeling and forecasting technologies are a preposition for successful data application and decision support in environmental studies. The interrelated nature of many environmental problems has imposed the need of multipurpose programs, data integration and information sharing between different databases.

Remote sensing technologies are widely used for natural resources management, crop assessment, land covers change detection, ecosystems preservation and many other world significant problems. Two issues are of essential importance for the application of airborne and satellite data: the development of efficient algorithms for data analysis and the explicit information about land covers spectral behavior under different conditions, both associated with a higher reliability of the derived information. Being the most important and anthropogenic-affected component of the biosphere, the vegetation has a leading position among the priorities of the remote sensing investigations. In agriculture remote sensing is applied for assessing plant development processes and growth conditions. Along with other databases provision, it is a tool that is used for retrieving agronomical variables in order to evaluate crop current state and make predictions. Especially valuable are the temporal aspects of the remotely sensed data in identifying of stress situations. Numerous papers have the objective of analyzing vegetation reflective and emissive spectra

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New Developments and Challenges in Remote Sensing, Z. Bochenek (ed.)

Chlorophyll fluorescence as a quantitative measure of plant stress

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Keywords: chlorophyll fluorescence, photosynthesis, plant stress

ABSTRACT: Chlorophyll fluorescence is a measure of the efficiency of photosynthesis and can be used, therefore, as an indicator of vegetation health and vitality. This paper reports some results from laboratory measurements of chlorophyll fluorescence excited by a blue light source at 470 nm. The experiments were conducted with hydroponically grown barley (*Hordeum vulgare*) contaminated with heavy metals (Cd and Cu). Fluorescence spectra were taken from leaf samples of 14-days old plants. The objective of the study was to investigate the degree of stress detectable from fluorescence measurements and the sensitivity of various fluorescence parameters as plant response to growing conditions. Plant stress was quantified through leaf chlorophyll content. The analysis of fluorescence emission revealed a high correlation between red and far red fluorescence features and leaf chlorophyll at an early stage of plant development. The results were confirmed by repeated experiments proving the consistence of the established relationships under the given experiment conditions.

1 INTRODUCTION

The spreading acceptance of the concept of precision agriculture running (M. Rasher 2000) generated much interest in the early detection of plant growth stress. The implementation of modern remote sensing technologies is one of the basic assumptions of this concept, special attention being paid to vegetation monitoring in relation to stress detection. That is why the assessment from spectral data of the crop state (A. Kuusk 1991, R. Kancheva *et al*. 2005) and growing conditions has been and still is at the focus of numerous investigations and experimental studies (R. Kancheva 1999, A. Mehandjiev *et al*. 2000).

Important here are early warning signs of plant inhibition which should be directly connected to fundamental physiological processes. Such a process is the photosynthesis and the connection has been found in vegetation fluorescence (R. Valentini *et al*. 1994, K. Smorenburg *et al*. 2002). The optical signatures of leaves are mostly defined by the composition of photosynthetic pigments and their stress-induced changes and as such they are indicative of plant short-term or long-term stresses. Though being studied for decades, light induced fluorescence has not lost its attractiveness. Moreover, it experiences ever-increasing interest as a response to different stresses that might be qualified and quantified from plant fluorescence behaviour. In recent years, the

New Developments and Challenges in Remote Sensing, Z. Bochenek (ed.)

Spectrally-dependent attenuation of microwaves by vegetation canopies

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Keywords: passive microwave radiometry, attenuation, vegetation canopy

ABSTRACT: A wide-band waveguide transmission system and measuring technique have been developed to obtain continuous attenuation spectra of microwaves by vegetation in the frequency range 0.8–10.0 GHz. Laboratory experiments have been performed in order to examine the spectral dependence of the attenuation by different trees and tree fragments. Some results are presented showing the distinct difference of the attenuation as a function of the wavelength, vegetation type and moisture content.

1 INTRODUCTION

The attenuation of the microwave electromagnetic radiation by vegetation canopies is an essential factor in land cover radiometric studies. The knowledge of the attenuation effects is extremely important for remote sensing investigations as well as for improving the reliability of radio communications. The multiple dependence of the attenuation on such factors as the wavelength, incident angle, polarization, vegetation moisture, density and structural peculiarities makes the solution of the problem still more difficult.

The available experimental data on microwave attenuation are quite limited and acquired at single wavelengths. Actually, there are almost no data over larger wavelength ranges and continuously changing frequency.

Laboratory experiments could provide data about the spectral dependence of the attenuation by vegetation fragments along with a direct control of the biometric parameters. However, in this case some problems arise. For the correct data interpretation, similar or near to the free space propagation conditions should be provided. At the same time, the influence of surrounding objects (walls, etc.) on the measurements should be minimized. These problems can be avoided by conducting measurements in an anechoic room or using a waveguide camera.

In this paper some results are presented from laboratory measurements of the microwave attenuation by different vegetation types and vegetation fragments (leaves, branches with and without leaves) taking into account vegetation moisture content. Not less valuable are the obtained spectral dependences of the attenuation in a wide wavelength range.

New Developments and Challenges in Remote Sensing, Z. Bochenek (ed.)

Regional monitoring of the Earth's surface

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Keywords: remote sensing, land cover monitoring, optical and microwave radiometry

ABSTRACT: The main tasks and expected results of a joint Russian-Bulgarian scientific collaboration and research activities are discussed. Investigations are planned to be carried out in the frameworks of a project on the development and implementation of advanced technologies in aerospace remote sensing of the Earth's surface within 2006–2010.

1 INTRODUCTION

During the last years, destructive processes caused by natural disasters or anthropogenic activity are in the focus of scientific research and occupy the attention of state and government authorities. A great variety of multipurpose programs and projects on the environment study and control has been developed. In all of them the first and most essential step is land cover, phenomena and processes monitoring at regional and global scale. The necessary data can be provided by a complex of instruments installed on airborne and satellite platforms thus implementing a multiscale and multitemporal approach. On the other hand, the interrelated nature of many environmental problems predetermines the need of data integration and information sharing between different databases.

Since the environmental situation varies from site to site it is necessary to begin with regional monitoring and then to cover larger territories. We suggest for regional monitoring to rely on cost-effective research from well equipped small aircraft platforms in combination with ground-based stations. Land cover state assessment and change detection will be performed and risk processes will be evaluated by using data in the visible, infrared and microwave spectral bands. In this paper we present the main goals and tasks of the project, the technical equipment and some aspects of the methodology in applying a synergistic investigation approach using radiometric and imaging sensors. The results of aerospace observations and implementation of advanced data processing technologies will permit to work out proposals and recommendations for forecasting ecological catastrophes and their consequences, and to detect ecological systems in a risk state.

2 PROJECT GOALS

- Thematically oriented studies of land covers and water objects;
- Suggestions on the instrumentation content and technical parameters for ground-based and aircraft platforms;

Comparison between Reflectance/Emittance Spectra of Iron-containing Minerals

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Abstract **Correct estimation of the distribution of the iron oxides in open pit mines and the neighbouring regions is a key issue for the ecological state assessment of land cover. For this study airborne (satellite and aircraft) data combined with in-situ and laboratory acquired data were used for assessment of the environmental state from previous mining activities. As main indicator for presence of pollution the iron content was chosen since it could be reliably identified in the ranges used in this study and because of the wide-spread iron in the most of the rock types and soils. The number of samples from every source was taken in the way to be statistically confident. Soil samples together with GPS measurements were collected during a field campaign in the study area for two types of laboratory measurements – chemical and mineralogical analysis and non-destructive spectroscopy. Spectroscopy measurements (laboratory, in-situ and satellite) in visible and near infrared (VNIR) and thermal (TIR) ranges were performed using follows spectrometric systems: ISOH, 0.4-0.8 micrometers; SRM, 0.4-0.82 micrometers; TIRES, 8-16 micrometers; ASTER, 0.4-16 micrometers. Spectral transformations such as normalized difference and relation using two wavelengths were applied for the proper comparison between the data obtained from different sources. Dependence between various spectral transformations and the quantitative content of the iron was established. The achieved results proved that this methodology could be extended for other regions of the country polluted by mining activities mostly by cooper or lead plants.**

I. Introduction

Surface mining activities in Europe are estimated to cover an area of 5–10 000 km^2 and range from large open-cast coal and base metal mines, to much smaller aggregate (rock, gravel and sand), industrial minerals (potash, clay) and building materials (granite and marble) quarries. Earth observation applications in the mining industry include the production of thematic maps for ground inspection and mineral alteration maps for exploitation. In recent times, the monitoring of reclamation activities undertaken by local authorities or business based on Landsat Thematic Mapper (TM/ETM+) data is particularly functional since it offers good ratio spatial resolution / area coverage.

Detection of iron-containing minerals is a particular case in remote sensing investigations since the objects under study are so ubiquitous. Iron containing rocks or soils is found in many places on the Earth's surface in large variety of chemical compositions.

In the near infrared part of the electromagnetic spectrum (EMS) 0.8 μm - 1.0 μm the depth of iron absorption curve is closely related to its content. The 0.9-μm-absorption line shifts position with elements substituted for iron. For example, continuum removal and scaling the hematite absorption to similar depth shows the wide variety of band shapes and positions that can be found in nature [1]. In the Ref. [2] the properties of the wide absorption dip concerning iron content in soil samples around 550 nm (D550) are investigated.

In most of cases when remotely sensed data are used the information about iron-containing types of land cover is contained in mixed spectra recorded by spectrophotometer in one measuring element. Due to the limitations of the spatial resolution of the airborne instruments (such as Landsat, SPOT, etc.) and the heterogeneity of features on the ground so called pure pixels are hard to find. As a rule the mixture spectrum is generated when the pixel covers more than one land cover class. Typical spectral signatures, obtained from spectral libraries [1,5] and laboratory measurements were also used in recognition of the iron-containing minerals. In this study this measurements were used as an a priori knowledge for specific end member definition.

This paper aims to demonstrate one possible comparison between spectra acquired from different spectrometric systems in one and the same range of EMS on similar rock and soil samples. Spectral transformations such as normalized difference and relation using two wavelengths were applied on the different sets of data for the proper comparison between the data obtained from different sources in order to evaluate the similarity. Dependence between various spectral transformations and the quantitative content of the iron was established.

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Spectral Predictors of Crop Development and Yield

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Abstract **Remote sensing enters still wider into its application stage when the goal is to bring the up-to-now investigation results to an operational use. Agricultural monitoring is among the priorities of remote sensing observations supplying early information on crop growth. Interest is rapidly spreading over the past years in the application of hyperspectral data to precision farming. In this paper, we propose and investigate the performance of an approach for providing crop state assessment and yield forecasts. In order crop information to be obtained from remotely sensed data the approach comprised: development of models between plant spectral reflectance and biophysical parameters for estimation of crop state variables from radiometric data; development of yield forecasting models from single-date and time-series spectral data; verification of remote sensing predictions through comparison with estimations from yield relationships with crop agronomical parameters. The algorithm was realized on winter wheat. In-situ high- resolution visible and near-infrared reflectance data were acquired throughout the growing season, along with detailed datasets of crop parameters. Spectral-biophysical models were developed relating crop variables and yield to different spectral predictors. The algorithm was tested and validated using airborne remote sensing data. A good correspondence was found between predicted and actual yield.**

I. Introduction

The rapid advances of space technologies concern almost all scientific fields from aeronautics to medicine and application areas from communications to crop yield predictions. Remote sensing is an accepted source of information in environmental sciences. It enters still wider into its application stage when the goal is to bring the up-to-now investigation results to an operational use. The operational application of remote sensing data becomes more and more a highlight of all recent investigations and development works. Agricultural monitoring is among the priorities of Earth observations supplying early information on the development and growth conditions of crops [1-3]. Various approaches are implemented for crop behaviour assessment in order to provide objective, timely and quantitative yield forecasts at regional and national scales [4-6]. On the other hand, continues the research to improve the reliability of the results by implying, for instance, different sampling strategies and statistical data analysis, by integrating agro-meteorological and remotely sensed data from various sources [2,6,7]. Particular efforts are put into the elaboration of methods for assimilation of remote sensing data of high spatial-temporal resolution in agronomical models, in order to produce information needed in agricultural practice [8].

A major application of remote sensing involves the characterization of agricultural vegetation canopies through measurement of multispectral response data [8-11]. Spectral data collected over vegetative targets are analyzed to estimate plant parameters that are bioindicators of crop growth. Monitoring of farmland dynamics during plant growing period is performed with the goal to: track crop development and determine the phenological stage; to assess crop state at different moments of observation (defined by key agronomical variables); to forecast crop production.

In this paper we propose an approach for providing crop state assessment and yield forecasts. The algorithm was developed over winter wheat. High-resolution visible and near-infrared spectral data were acquired throughout plant growing season, along with ground-truth data of crop biophysical parameters. In order crop information to be obtained from remotely sensed data, the approach comprised: development of phenologically-specific regression models between crop spectral reflectance and biophysical parameters for estimation of crop state variables from radiometric data; development of yield forecasting models from single-date and time-series spectral data; establishment of physiological relationships between plant bioparameters and between bioprameters and yield. The performance of the approach was examined by two-fold verification of the airborne predictions comparing them with ground-truth yield data and with yield estimations from yield relationships with crop agronomical variables.

II. Materials and Methods

The present study was taken for winter wheat crops within ten fields. Different fertilizer rates and fertilizer types were applied in order to obtain a wide range of plant state and reflectance spectra. The varied fertilizer application as well as the irrigation regimen affected plant vigor during the ontogenetic process. Several sampling sites were selected per each field to reflect the within field variability. Crop spectral and growth data were acquired throughout the growing period at the main phenological stages. Plant parameters were recorded per unit area basis and comprised vegetation canopy cover C (%)), leaf area index LAI (m^2/m^2), plant height h (m), stem number N, total above-ground and leaf biomass (kg/m^2) - wet M_w, M_d and dry M_L, M_{Ld}. The in-situ spectral measurements were performed with a portable multichannel radiometer within the 400-800 nm wavelength band at 10 nm intervals.

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Vegetation Effects on Passive Microwave Measurements

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Abstract. The developed laboratory waveguide transmission system for measuring the attenuation of microwaves by vegetation canopies is discussed. Some results obtained for the attenuation effects by fragments of trees in the frequency band 0.8 – 10.0 GHz are presented. The waveguide transmission system and the measuring procedure provide the acquiring of continuous attenuation spectra in a wide frequency band under controlled vegetation parameters. The propagation characteristics of the electromagnetic waves in the ultra-wide band waveguide transmission system are similar to the propagation characteristics in the free space. This makes possible to use the laboratory results in practice.

I. Introduction

Forests play a vital role in human life since they represent about 90% of the standing biomass and determine the hydrological and biogeochemical cycles of the Earth. Remote sensing techniques, in particular microwave radiometry, have the potential of monitoring and assessing forest canopies. However, the interpretation of the microwave radiometric data requires a series of efforts such as developing an appropriate theoretical model of forest canopies, establishing a relation between electro-dynamic properties of the forest medium and its biometric features, and estimating forest parameters from radiometric data. In this respect, knowledge of the attenuation effects of forest canopies on microwave measurements is extremely important. First of all, the propagation properties of the forest canopy play a key role in modeling the microwave emission behavior of the canopy. Further, attenuation values and their dependence on the frequency, incident angle, polarization, and vegetation biometrical features, lay at the root of remote sensing retrieval algorithms.

Microwave radiometry is based on measurements of the emitted by the Earth surface electromagnetic radiation in the millimeter to decimeters wavelength range. Within this spectral band the microwave radiation is primarily a function of the free water content in the soil being influenced also by soil texture, water salinity and temperature, as well as by the above-ground vegetation biomass.

The measure of the microwave radiation intensity is referred to as brightness temperature (Tb) which is a product of the emissivity (æ) and the thermodynamic temperature (Te) within the effectively emitting layer of the object. The emissivity is a function of the dielectric permittivity of the surface. It is negatively correlated with the moisture content. Figure 1 shows the microwave radiation intensity of different surfaces (metal, water, soil) with varying properties.

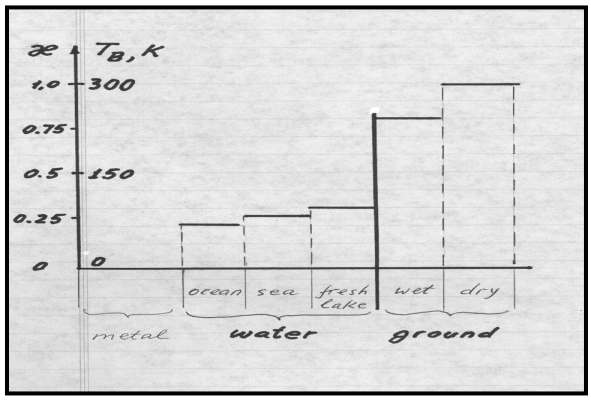

Fig. 1. Microwave radiation intensity of different surfaces

In this paper a wide-band waveguide transition system has been created and a measuring technique has been developed to obtain continuous attenuation spectra of vegetation fragments in the frequency range 0.8-10.0 GHz is presented. The system consists of a wide-band rectangular waveguide, two horn antennas matched with the waveguide, and a Vector Network Analyzer. The antennas serve as filters of spatial harmonics providing a single-mode propagation regimen in the waveguide and correct interpretation of attenuation measurements.

Attenuation spectra of aspen, birch, maple and other tree types have been obtained from different tree components. Some results of the performed measurements are presented, which show the distinct difference in the magnitude and frequency dependence of the attenuation by different tree types and tree components. Besides, the influence of vegetation parameters such as moisture content has been examined and found to have a significant effect on microwave measurements.

II. Materials and Methods

Microwave techniques, though used for years in environmental remote sensing studies, have not revealed yet in full their potential in different application fields. One of the reasons is the fact that microwave measurements are greatly affected by various factors which are not always possible to be

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СРАВНЕНИЕ МЕЖДУ ОТРАЖАТЕЛНИТЕ СПЕКТРИ НА ГРАНИТИ ПОЛУЧЕНИ С РАЗЛИЧНА СПЕКТРОМЕТРИЧНА АПАРАТУРА

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РЕЗЮМЕ. Дистанционните изследвания на скали и минерали намират все по-широко приложение във връзка с актуалните разработки на ESA (Европейска космическа агенция), NASA (Национална космическа агенция на САЩ) и ИКИ-РАН (Институт за космически изследвания – Руска академия на науките), за изучаване на минералния и химичен състав на повърхността на Марс и спътника му Фобос. За целта на настоящата работа са проведени лабораторни спектрометрични измервания на гранити от територията на България във видимата и близката инфрачервена области от електромагнитния спектър като са използвани следните спектрометрични системи: SRM, 0.4-0.82 микрометра; SPS-1, 0,55-1,1 микрометра. Избрани са две дължини на вълната с цел сравнение на данните, получени с помощта на различните апаратури. Също така е установена зависимостта между количественото съдържание на скалообразуващите минерали на гранитите и стойността на спектралния кефициент на отражение при подбрани дължини на вълната. Получените резултати показват, че тази методика може да бъде приложена и за други скални разновидности, представени на територията на България.

CORRELATION BETWEEN GRANITE REFLECTANCE SPECTRA OBTAINED BY DIFFERENT SOURCES

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ABSTRACT. Remote sensing methods for studying of rocks and minerals are closely related to current EAS, NASA and SRI-RAS programs for mineral and chemical composition research of Mars and Phobos surface. For the purpose of present paper ex-situ spectroscopy measurements of the granites from the territory of Bulgaria in visible and near infrared (VNIR) range of the electromagnetic spectrum were performed using follows spectrometric systems: SRM, 0.4-0.82 micrometers; SPS-1, 0.55-1.1 micrometers. Two wavelengths were selected and were applied for the proper comparison between the data obtained by different sources. Dependence between reflectance values at chosen wavelengths and the quantitative content of the rock-forming minerals was established. The achieved results proved that this methodology could be extended for other rock types presented in the territory of Bulgaria.

Въведение

Дистанционните изследвания на скали и минерали са актуални в настоящия момент във връзка с редица международни програми за изучаване на състава на повърхността на Марс и спътника му Фобос. За целта на настоящата работа са проведени спектрометрични измервания на гранити от територията на България във видимата и близката инфрачервена области от електромагнитния спектър (EMC) като са използвани спектрометрични системи SRM, 0.4-0.82 μm и SPS-1, 0,55-1,1 μm. Апаратурите са разработени в ЦЛСЗВ-БАН и са използвани при изучаването на растителна и почвена покривка. За сравнение на данните, получени с помощта на различните апаратури, са избрани две дължини на вълната. За подбрани дължини на вълната е установена зависимостта между количественото съдържание на скалообразуващите минерали на гранитите и стойността на спектралния коефициент на отражение. Получените резултати показват, че тази методика може да бъде приложена и за други скални разновидности, представени на територията на България.

Материали и методи

Обекти на проведените експериментални изследвания са общо 10 скални образеца от групата на гранита и риолита. Групата се счита като главна, защото гранитите са най-разпространените скали между интрузивните магмени скали. Тук се влючват кисели и ултракисели скали и по-малко със среден химичен състав. Повечето от скалните видове са светли (левкократни) и съдържат средно около 10% цветни минерали (Маринов, 1989). Също така обект на изследване са отделните основни скалообразуващи минерали, които формират гранитите. Те са измерени като единични масивни образци от калиев фелдшпат, ортоклаз, кварц и мусковит, чиито размери са съобразени и съвместими с полезрението на използваната система SRM. Липсата на единични природни минерали от плагиоклаз, биотит и амфибол с нужните за полезрението на спектрометъра размери наложи използването на многоканална спектрометрична апаратура SPS-1. С помощта на тази апаратура бяха измерени спектралните отражателни характеристики на всички представени минерали като включения в изследваните скални образци, както и всеки образец.

Chlorophyll fluorescence as a plant stress indicator

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The objective of the work is to determine the degree of plant stress detectable from fluorescence measurements. Experiments have been conducted with Hordeum vulgare grown in greenhouse conditions for 2–3 weeks. Plant stress in response to the application of different concentrations of Cd has been quantified by changes of leaf pigment content. Heavy metals affect plant photosynthetic apparatus causing. Fluorescence spectra exited at 470 nm have been taken in the red and far-red spectral region (640-800 nm). Significant increase of fluorescence emission of stressed plants in comparison to control plants has been observed. The variance of different fluorescence parameters has been statistically related to chlorophyll decrease. The results show that the heavy metal induced stress is detectable from chlorophyll fluorescence demonstrating that the analysis of fluorescence spectra may timely and accurately indicate the onset of stress in plants.

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Introduction

Much interest in the early assessment of growth stress of agricultural crops has been generated recently by the spreading acceptance of the precision agriculture running concept. The implementation of modern remote sensing technologies is a basic assumption of this concept [1]. That is why the assessment from spectral data of crop state and growing conditions is in the focus of many investigations and experimental studies [2-4]. Special attention is paid to vegetation monitoring in relation to stress detection [5-8].

Stress-induced changes in the composition of photosynthetic pigments change the optical signatures of leaves and as such are indicative of plant functioning and short-term or long-term stresses. The early detection of plant inhibited growth should be directly connected to fundamental processes of plant physiology. Such a fundamental process is photosynthesis and the connection has been found in vegetation fluorescence. Chlorophyll fluorescence is a measure of the efficiency of photosynthesis and can be used, therefore, as an indicator of vegetation health and vitality. Though being studied for decades, light induced fluorescence has not lost its attractivity to experimental plant physiology. Moreover, it experiences ever-increasing interest as a response to different stresses that might be qualified and quantified from plant fluorescence behaviour. In recent years, the screening of plant fluorescence signatures is developing as a specific tool which could be applied to detect the functioning and health status of plants [7,9,11]. Compared to reflectance, induced fluorescence might be a more accurate indicator of plant state and be able to detect stress impacts at earlier growth stages.

The objective of this paper was to examine the relationship between fluorescence emission spectrum and barley growth inhibition under stress conditions (heavy metal contamination). Fluorescence changes appeared to be high-sensitive to chlorophyll decrease at a very early stage of plant development before visual color or morphological signs had been observed.

Materials and Methods

In the experiment barley plants (*Hordeum vulgare* L., standard karyotype) were used. Seeds were imbibed in tap water for 1 h at 27°C and germinated for 48 hrs between two layers of wet filter paper at 27°C in darkness. The seedlings were planted on perforated polystyrene plates, floating on distilled water in glass pots, and were grown during 5 days under day/night environmental conditions. Then the plants

Анализ спектральных характеристик гранитов Болгарии

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Граниты являются основным компонентом континентальной земной коры, формируя ту сушу, на которой мы живем и в пределах которой сосредоточено большинство доступных для разработки месторождений полезных ископаемых. Для изучения большого разнообразия гранитов способствует и дистанционное зондирование Земли, в частность полевые и лабораторные спектрометрические методы исследования. Исследованы два типа гранитоидов Болгарии разного геологического возраста. Для изучения спектральных характеристик проведено спектрометрирование гранитов в лабораторных условиях в диапазоне 0,5-1,1 мкм, для чего использована конструированная в ЦЛСЗВ-БАН аппаратура. Для анализирования полученных данных использованы методы декомпозиции спектральных смесей, индексы-отношения яркостей спектральных каналов, регрессионный и кластерный статистический анализ.

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Петрографическое описание исследованных гранитоидов

Объект настоящего исследования два типа гранитоидов Болгарии разного геологического возраста – палеозойский в Центральном Средногории, где находяться так называемые Южноболгарские гранитоиды и верхний мел в юговосточной (ЮВ) Болгарии. Средногорские гранитоиды вмещены в метаморфические горные породы докембрийского возраста, а гранитоиды ЮВ Болгарии рассекают докембрийские метаморфиты, палеозойские граниты и триаские породы.

Во время палеозойских магматических процессов в Средногории установлены два этапа. Первый этап отмечен маленькими ультраосновными и основными телами из пироксенита, габбра и габбродиорита. Второй этап охарактеризируеться многократным внедрением гранитоидной магмы. Обособленны три интрузивные комплекса [1] и каждый из них представляеться несколькими отдельными плутонами.

Первый интрузивный комплекс характеризуеться более основным составом и обширной фазовой изменчивости формирующих плутоничных горных пород: гранитов, гранодиоритов, кварцдиоритов и диоритов. Смиловенский, Поибренский и Хисарский плутоны относяться к этому комплексу. Их возраст (342±27 млн. лет – ранний карбон) определен Rb/Sr методом [2].

Петрографический состав второго интрузивного комплекса однообразен и содержит в основном биотитовые и двуслюдяные граниты, немного гранодиориты и плагиограниты. К этому комплексу относяться Копривщенский, Мытенишкий и Пыстровский плутоны. Их возраст (320±58 млн. лет – поздний карбон) определен Rb/Sr методом [3].

Третий интрузивный комплекс состоиться из биотитовых и двуслюдяных гранитов. К этому комплексу относяться Стрелчанский, Каравеловский и Лесичовский плутоны. Их возраст (238±37 млн. лет – поздний перм) определен Rb/Sr методом [3].

Исследованы группы образцов Средногорских гранитов из Смиловенского (обр. 4), Пыстровского (обр. 3, 8) и Стрелчанского (обр. 2) плутонов, а так-же гранитоиды ЮВ Болгарии из Гранитово-Чернозомского (обр. 9, 10) и Оманского (обр. 5) плутонов.

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Vegetation Spectral Response to Stress Conditions

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Remote sensing is already an operational tool widely used in vegetation studies for ecological monitoring, change detection of natural ecosystems and in agriculture for crop state assessment and yield prediction. A strong stress is being put on the accuracy of the retrieved information. This requires reliable indicators of plant growth and physiological status. The development of efficient means for data analysis is still one of the most essential issues. The importance of this issue is directly related to the ever-increasing amount of data provided by numerous sensors. The use of multispectral and multitemporal remotely sensed data and the implementation of advanced data processing technologies results in the possibility of getting different information needed for decision-making in solving problems related to vegetation preservation and agricultural land use. The application of satellite data requires knowledge of land covers spectral behaviour under different environmental conditions considering regional and local peculiarities. In this context detailed ground-based and airborne spectrometric studies complement the array of geo-spatial data products. These studies are the most appropriate way of aiding the interpretation and providing a reference source for validation of remotely sensed data. This paper is devoted to plant stress detection using VIS and NIR multispectral data. Empirical modelling of various agricultural crops under different soil and ecological conditions has been performed in order to describe the relationships between plant spectral and biophysical features and to derive sustainable spectral indicators of plant state.

Introduction

During the last years destructive processes caused by natural disasters or human activity are in the focus of the scientific research and occupy the attention of social communities and government authorities. A great variety of projects has been developed aimed at environmental monitoring and control. Recent developments in environmental studies are greatly connected with worldwide ecological problems related to anthropogenic impacts on the biosphere and first of all on vegetation. Advanced monitoring and alerting techniques, on-time information extraction, modeling and forecasting technologies are a preposition for successful data application and decision support in environmental studies. The interrelated nature of many environmental problems has imposed the need of multipurpose programs, data integration and information sharing between different databases.

Remote sensing technologies are widely used for natural resources management, crop assessment, land covers change detection, ecosystems preservation and many other world significant problems. Two issues are of essential importance for the application of airborne and satellite data: the development of efficient algorithms for data analysis and the explicit information about land covers spectral behavior under different conditions, both associated with a higher reliability of the derived information. Being the most important and anthropogenic-affected component of the biosphere, the vegetation has a leading position among the priorities of the remote sensing investigations. In agriculture remote sensing is applied for assessing plant development processes and growth conditions. Along with other databases provision, it is a tool that is used for retrieving agronomical variables in order to evaluate crop current state and make predictions. Especially valuable are the temporal aspects of the remotely sensed data in identifying of stress situations. Numerous papers have the objective of analyzing vegetation reflective and emissive spectra in order to quantitatively estimate green phytomass and physiological variables related to plant growth and productivity [1-6]. Studies are being carried out with the goal of vegetation assessment, stress detection and evaluation of desertification processes. Especially valuable are the temporal aspects of the remotely sensed data in detecting stress situations [7-12].

With all this in view our paper focuses on different techniques for handling data from multispectral and multitemporal measurements analyzing plant spectral signatures in terms of plant state and response to stress factors. Results are presented from a study devoted to crop state assessment using spectral-biophysical modeling approach. The investigations were carried out on various agricultural species (winter wheat, spring barley, peas, alfalfa) grown under different conditions (soil properties, fertilization, heavy metal pollution). Soil acidity, nutrient deficiency and toxic contamination were stress factors that affected crop development. Their impact was evaluated through different plant spectral signatures (reflectance, absorption, transmittance, fluorescence) which were examined for their ability to serve as sustainable stress indicators at different stages of plant ontogenesis. Statistical relationships were established between the stress factors, plant spectral and biophysical response thus attaching a quantitative measure to crop stress spectral indicators. A comparison was made between stress bioindicators (reduced biomass and leaf area index, chlorophyll inhibition) and a variety of spectral stress indicators (vegetation indices, red edge position, chlorophyll fluorescence) demonstrating a very good agreement.

Materials and Methods

The experiments were conducted on various agricultural species (winter wheat, spring barley, peas, alfalfa) grown under different conditions (soil type, toxic pollution and fertilization regimen represented by the nitrogen amount and compound). The study comprised laboratory and green-house or field experiments. The soil acidity, nutrient deficiency and heavy metal contamination (Cd, Ni,) were stress factors that

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ИЗМЕРЕНИ И МОДЕЛИРАНИ ОТРАЖАТЕЛНИ СПЕКТРИ НА ГРАНИТИ

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РЕЗЮМЕ. С помощта на конструираната в ЦЛСЗВ-БАН апаратура SPS-1 са измерени в лабораторни условия отражателните спектри на петрографски образци гранити, взети от различни райони на България (Централно Средногорие, Пирин и Югоизточна България). Същевременно със същата апаратура са проведени и измервания на отражателните спектри както на основните скалообразуващи минерали като мономинерални образци от кварц, калиев фелдшпат и мусковит, така и като минерали участващи в състава на скалите. Работният диапазон на SPS-1 е във видимата и близката инфрачервена част от електромагнитния спектър от 550 nm до 1100 nm. Сравнени са получените и моделираните, въз основа на теорията за смесените класове обекти, отражателни спектри на изучаваните гранити. Получените корелационните зависимости показват, че тази методика може да бъде приложена и за други скални разновидности, представени на територията на България.

MEASURED AND MODELED GRANITE REFLECTANCE SPECTRA

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ABSTRACT. Laboratory spectroscopy measurements of petrographic granite samples from different regions of Bulgaria (Central Srednogorie, Pirin, and South-East Bulgaria) are carried out using designed and constructed in STIL-BAS spectrometric system SPS-1. The system works in visible and near-infrared (VNIR) range of electromagnetic spectrum between 550 nm and 1100 nm. Parallel laboratory measurements of the rock-forming minerals as monominerals (quartz, feldspar, and muscovite) and as a part of the granite samples are performed. Reflectance spectra of the granites are modeled using the theory of mixed classes. Measured and modeled spectra are compared. Established high correlation between measured and modeled reflectance spectra of the studied granites confirms that this methodology could be extended for other rock types presented in the territory of Bulgaria.

Въведение

Дистанционните изследвания на скали и минерали са актуални в настоящия момент във връзка с редица европейски програми, основно GMES (Global Monitoring of Environment and Security). За целта на настоящата работа са проведени спектрометрични измервания на гранити и техните скалообразуващи минерали в два варианта – като минерали в самите скални образци и като отделни кристали. Всички образци са от територията на България – Централно Средногорие, Пирин и Югоизточна България. Киселите скали са широко разпространени в земната кора, като плутоничните им представители преобладават многократно над вулканските. Гранитоидите са съществена част от континенталната земна кора където участват в изграждането на огромни сложно устроени батолити в орогенните пояси. Според модалната QAP класификация на МСГН (Международен съюз по геологически науки) въз основа на различните съотношения на К-фелдшпати и плагиоклазите сред киселите плутонични скали се разграничават алкалнофелдшпатов гранит, гранит, гранодиорит и тоналит.

Гранитите са светлосиви, сиви, сивожълтеникави до розови. Структурата им е едро-, средно-, дребнозърнеста, равномернозърнеста или неравномернозърнеста (порфироидна), гранитова, а текстурата – масивна. Главните скалообразуващи минерали са кварц, кисел плагиоклаз и K-Na фелдшпат. Второстепенните минерали са биотит, амфибол и значително по-рядко – мусковит и гранат, а акцесорните – циркон, аланит, титанит, рутил, апатит и турмалин. Цветният индекс на гранитите е около 10. Съдържанието на SiO_2 е между 68 и 73%, а на алкалните оксиди Na_2O+K_2O – 4.8-10%. Основните разновидности гранити са биотитов, амфибол-биотитов и двуслюден.

Гранодиоритите са сивозелени, едро-, средно-, дребнозърнести, равномерно- и неравномернозърнести (порфироидни). Структурата им е гранитова, по-рядко монцонитова, а текстурата – масивна. Главните скалообразуващи минерали са плагиоклази, кварц, K-Na фелдшпат, амфибол и биотит, а акцесорните – титанит, апатит, циркон, аланит и магнетит. Цветният индекс е около 20. Съдържанието на SiO_2 е между 64 и 68%, а на алкалните оксиди Na_2O+K_2O – 3-10%. Според съдържанието на цветни минерали гранодиоритите се поделят на амфиболови, биотит-амфиболови, авгит-амфиболови.

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Tracing soil pollution dynamics near mining dump site lakes, Mirkovo flotation plant

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Keywords: land cover change detection, vegetation indices, soil line concept, soil reclamation

ABSTRACT: Mining plants are one of the factors having major negative impact on the area where they are situated. In the case of Mirkovo floatation plant, located in the outskirts of Stara Planina Mountain in the middle of Bulgaria, the pollution comes from two major sources – dust from milling shop and waste water from floatation shop. The investigations are carried out deal with determination of the impact on the soils and vegetation in the neighborhood areas using reflectance information from multispectral data and supporting hyperspectral in-situ measurements. During the research preliminary information about mineral content of the ore material coming from the mine and soil type is also considered.
Numerous studies have analyzed the variance of spectral reflectance of rocks, soils and vegetation in response to their cover using remote sensing. The goal of the study is to show land cover changes detected through vegetation indices as NDVI, RVI, SAVI and the soil line concept in remote sensing. On the next step change detection methods are used to support local authorities in preparation of short-term reclamation plans and as well to recommend farmers in planting suitable vegetation spices in assisting the rehabilitation of the top soils. In this research the data from Landsat TM/ETM+ combined with in-situ measured data are used. The obtained results show that the analyzed data and the implemented approach are useful in environmental monitoring and economically attractive for the company responsible for the ecological state of the region.

1 INTRODUCTION

Traditional classification techniques are “hard” in the sense that a single pixel is assigned to a single land cover class. At coarse resolutions pixels predictably become mixed. For these mixed pixels “soft” classifiers can be used, which assign a pixel to several land cover classes in proportion to the area of the pixel that each class covers.

Several researchers have addressed this sub-pixel mixture problem. Among the most popular techniques for sub-pixel classification are mixture modeling (Kerdiles and Grondona, 1996) and supervised fuzzy c-means classification (Foody,, 1994).

These techniques aim at estimating the proportions of specific classes that occur within each pixel. The result is a number of fraction images, one for each land cover class concerned. This information describes the class composition, it does not provide any indication as to how this is spatially distributed within the pixel. The result is thus quite different from the classic classification algorithms, where a single land cover map, containing all classes, is produced. One way to go from fraction images to a classic land cover map would be to use "hardeners", where rules can be formulated to determine which class dominates the pixel. The main disadvantage is that information is lost much in the same way as happens with classic hard classifiers. Atkinson (1997) has formulated an idea for an alternative approach. It consists of converting raster data to vector data by threading the vector boundaries through the original image pixels (instead of between pixels, as classic raster-to-vector conversion algorithms would do). This process is called sub-pixel mapping. The key problem is determining where the relative proportions of each class are most likely to occur.

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Colorimetrical analysis in vegetation state assessment

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Keywords: spectral reflectance, colorimetrical analysis, vegetation parameters

ABSTRACT: Remote sensing is an established technique in environmental studies. First of all, this concerns soil-vegetation ecosystems where 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 this approach.
In this paper we report some results of the colorimetrical analysis of vegetation spectral data. The work was conducted in order to reveal plant senescence effects due to plant growth or stress factors and the impact of the soil background on vegetation reflectance. One of the goals of the study was to evaluate the potential of various colorimetric features for vegetation assessment. Another objective was to compare this approach to the results of the implementation of vegetation indices for plant bioparameters retrieval from multispectral data. The integration of both methods was examined as well showing good predictive capabilities.

1 INTRODUCTION

The problem of mixed classes is essential in remote sensing and concerns most aspects of data processing and interpretation. It is associated with spectral mixture decomposition and classification. Soil-vegetation covers are a typical example and a most common case of mixed classes where the determination of the components' proportions is of a particular interest. The objective of the paper is to study the influence of different soil background and plant senescence on vegetation reflectance and color features as well as to reveal the potential of colorimetric analysis technique for mixture decomposition focusing on the accuracy of green cover estimation which is related to vegetation state assessment.

2 MATERIALS AND METHODS

In-situ and green-house reflectance measurements of various vegetation types (alfalfa, wheat, spring barley, peas, carrots, grass) with different soil background and degree of senescence were performed in the spectral range 400-820 nm.

The soil diversity was presented by dark soils (black, brown, reddish laterite) and light soils (grey forest, alluvial, meadow) with different properties (mineral composition, organic and moisture content, surface roughness and salinity). The spectral reflectance curves of some of these soils are given in Fig.1 illustrating the large range of soil reflectance signatures.

The variety of green and dry vegetation amounts (the latter related to chlorophyll decrease in mature plants or plant stress conditions) was achieved during plant development as well as simulated from bare soil and vegetation full-canopy cover reflectance using the theory of mixed classes (Mishev 1991):

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6518

Granite and granodiorite identification using spectral unmixing techniques

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SUMMARY

The development of efficient technologies for data analysis is one of the most challenging issues that the remote sensing community is facing. Matters of data reduction, processing algorithms accuracy, information amount, cost and time saving determines the efficiency of data analysis. The importance of this issue is directly connected with the ever-increasing quantity of data provided by numerous airborne, field and laboratory operated sensors, with their synergistic use as well as with the accuracy of data processing algorithms and results verification.
We present here some results from a study of different spectral unmixing techniques over two similar rock types such as granite and granodiorite in relation to objects type and proportions determination. Experimental data from field and laboratory spectral reflectance measurements in the visible and near infrared band are used. Various decomposition methods (linear unmixing, clustering) are applied and evaluated.
Spectral linear unmixing is efficient approach to the spectral decomposition of multichannel remotely sensed data. A main problem to its process is that the number of spectral components (has to be correctly distinguished. Therefore, the evaluating of the possibility of using spectral mixture decomposition in relation to their type and proportion determination for subpixel identification is described.

Different Methods for Plant Chlorophyll Estimation

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Abstract — **Increasing role for plant phytodiagnostics becomes to play different spectrometric techniques used as a part of remote sensing applications. The radiation behavior of land covers and the spectral response to changing conditions lies at the root of these studies. The visible and near infrared (0.4 - 0.9 μm) measurements have proved abilities in vegetation monitoring. The reason is that this wavelength range reveals significant sensitivity to plant biophysical properties. The information is carried by the specific vegetation spectral characteristics which depend on such plant parameters as chlorophyll content, biomass amount, leaf area, etc. These parameters are associated with plant development and stress factors being closely related to vegetation physiological state. In our study, multispectral data of reflected, transmitted and emitted by plant leaves irradiance have been used to show the possibility for plant chlorophyll estimation. Different methods such as vegetation indices, red edge analysis and fluorescence emission have been applied and compared.**

Keywords: multispectral data, chlorophyll estimation, vegetation indices, red edge, fluorescence

I. INTRODUCTION

Recent developments in environmental studies are greatly connected with worldwide ecological problems related to anthropogenic impacts on the biosphere and first of all on vegetation. Advanced monitoring and alerting techniques, on-time information extraction, modeling and forecasting technologies are a preposition for successful data application and decision support in environmental studies.

The spreading acceptance of the concept of precision agriculture running [1] generated much interest in the early detection of plant growth stress. The implementation of modern remote sensing technologies is one of the basic assumptions of this concept, special attention being paid to vegetation monitoring in relation to stress detection. That is why the assessment from spectral data of crop state [2,3] and growing conditions has been and still is at the focus of numerous investigations and experimental studies [4,5].

Important here are early warning signs of plant inhibition which should be directly connected to fundamental physiological processes. Such a process is the photosynthesis and the connection has been found in vegetation fluorescence [6,7]. The optical signatures of leaves are mostly defined by the composition of photosynthetic pigments and their stress-induced changes and as such they are indicative of plant short-term or long-term stresses. Though being studied for decades, light induced fluorescence has not lost its attractiveness. Moreover, it experiences ever-increasing interest as a response to different stresses that might be qualified and quantified from plant fluorescence behaviour. In recent years, the screening of plant fluorescence signatures is developing as a specific tool which could be applied to detect the functioning and health status of plants [8-10]. Compared to reflectance, induced fluorescence might be a more accurate indicator of plant state and be able to detect stress impacts at earlier growth stages.

In our study, multispectral data of reflected, transmitted and emitted by plant leaves irradiance have been used to show the possibility for plant chlorophyll estimation. Different methods such as vegetation indices, red edge analysis and fluorescence emission have been applied and compared. A comparison was made between stress bioindicator (reduced concentration of chlorophyll pigments, chlorophyll inhibition) and a variety of spectral stress indicators (vegetation indices, red edge position, chlorophyll fluorescence) demonstrating a very good agreement. Good correspondence was found between both physiological and spectral indicators of plant status. The results were confirmed by repeated experiments proving the consistence of the established relationships.

II. MATERIALS AND METHODS

The investigations were conducted on various agricultural species (winter wheat, spring barley, peas, alfalfa) grown under different conditions (soil type, fertilization regimen represented by the nitrogen amount and compound, toxic pollution). The study comprised laboratory, green-house or field experiments. The soil acidity, nutrient deficiency and heavy metal contamination (Cd, Ni,) were stress factors that affected the development and caused variations of crop state. Their impact was evaluated through plant spectral features (reflectance, absorption, transmittance, fluorescence). These features were examined for their ability to serve as sustainable stress indicators during plant growth.

Spectral, biometrical and phenological data were gathered at different stages of plant ontogenesis. The ground-based reflectance measurements were carried out at canopy level with a multichannel radiometer operating from the nadir position in the visible and near infrared wavelength range 400-820 nm at a 10 nm step. The transmittance and fluorescence measurements were performed over detached plant leaves with a laboratory spectrometric system [11]. The biometrical sampling included

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Fusion of Landsat TM and ground spectrometry data in monitoring of non-operating mine

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ABSTRACT

Surface mining activities in Europe are estimated to cover an area of 5–10 000 km^2. In this paper we suggest that the availability of Landsat Thematic Mapper (TM) for Earth observation allows the collection of environmental and mine-related data for use in the planning and undertaking of mine restoration work on cost-effective basis. The advantage is that these data are acquired digitally and can be easily processed and utilized in various information formats. Important step in the data processing is the verification of airborne data. For this purpose ground spectrometry measurements of samples taken from test sites have been performed. In the last decade several mining areas and corresponding dumps are subject to reclamation process in Bulgaria. We focused our research on one of the most important in the copper production for 20 year period for our country – Asarel-Medet deposit. This mining complex consists of an open mine, the dumps and a processing plant. After ceasing the exploitation of Medet deposit in 1994 a rehabilitation program for soil cover and hydrographic network was established and launched. A continuous task is the monitoring of these activities from the beginning for at least 15 years period, which is to end this year. To process the data, which characterize the progress of the land cover restoration, several techniques, both standard, such as basic and advanced statistics, image enhancement and data fusion, and novel methods for supervised classification were used. The results obtained show that used data and the implemented approach are useful in environmental monitoring and are economically attractive for the company responsible for the ecological state of the region.

Keywords: Remote Sensing, Environment, Change Detection, Decision Support, Multisensor Data, Fusion

1. INTRODUCTION

The geological exploration of the copper-bearing rocks in the Sredna gora region, located in the middle of Bulgaria, started in the late 50-ies of 20-th century. As a result the mining plant "Medet" was built who started its production 1964. The main activity of this plant is extraction and recovery of copper together with all relevant engineering and commercial actions. The experience for exploration and mine plant construction gained on this site was implemented on other mine plants across Bulgaria during 60 and 70-ies of same century. In 1994 the open pit mine "Medet" was closed, but the newly developed "Asarel" mine started its operation.

In both cases the ore deposits are developed by open pit mining and together with them the dump areas are one of the largest pollutants of the environment in this region. That is the reason to start monitoring and rehabilitation activities for the region as a whole eco system. A monthly bulletin about the quality of the air and water is published and distributed in by local authorities. In the 2003 the company Assarel-Medet SJSCo implemented an integrated control system according to the international standards ISO part of which is an environmental standard ISO 14001:1996. This policy for ecologically clean production could be supported to great extend by data obtained by existing and new remote sensing instruments having moderate to high spatial resolution. Compared with the data taken 20 years ago the spatial precision of the data improved more then twice which may result in better decision support. This is the motivation of the team – to develop better understanding of the reclamation process and its monitoring.

The methodology of widely used *change* detection*,* based on *in-situ* digital data, is the process related to the changes of the land-cover properties. By this means the changes in the land cover between two dates are highlighted. Change detection has been used in many applications such as land-use changes, rate of deforestation, urban areas alteration implementing remotely sensed data along with spatial and temporal analysis procedures and digital image processing techniques.

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Test-Sites in Remote Sensing Studies and Earth Observations

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The recognition and the spreading use of remote sensing as a tool in land cover/land use monitoring makes the question of data quality still more acute. In transferring remote sensing techniques to operative applications, data accuracy and information reliability are critical. Currently, the remote sensing community is recognizing, again and deeper, the indispensable necessity of ground-truth information in support of Earth observation missions. Supporting and raising the capacity of remote sensing investigations encompasses the implementation of a wide range of information sources, making full use of in-situ ground-based monitoring and airborne surveys along with space observations. In this context the paper presents a vision on the objectives of in-situ networks for data acquisition on target selected test-sites with the aim to enhance remote sensing scientific and modelling capacities and to meet the need for multidisciplinary research and multipurpose data application. The paper aims also at rising the interest in international collaboration.

Introduction

The challenges posed by the increasing natural and man-made pressures on the environment and its resources require efficient and coordinated research at different levels. Dealing with the consequences of the anthropogenic impact on the environment requires more informed policies. The same refers to geo-hazards such as floods, landslides, wildfires, pollution, etc. Improved assessment and forecasting are needed to mitigate risks. This implies a multidisciplinary and integrated approach to surveys and data analysis. Acknowledged and justified is the recognition of remote sensing as a powerful tool in land use/land cover monitoring for a large number of purposes ranging from agricultural practices to global ecology and environment protection. However, a better data provision is needed to fill existing gaps [1,2]. This is despite the fact that over the last years considerable progress has been made in space-borne devices and observation systems.

Ecosystem assessment is one of the most important areas in using remote sensing data. Land cover dynamics is strongly influenced by a great number of factors, generating the need for adequate monitoring tools. As a consequence, robust and sophisticated analysis methods are required for efficient data handling and accurate information extraction adapted to the rapid advances in sensor technologies. Besides, multi-temporal and multi-sensor approaches are becoming more and more important not only for change detection but also for the development of more detailed state assessment methods. In the study of land covers the information requirements can be effectively met by using conventional (terrestrial) and modern remote sensing techniques [3]. Often remote sensing data alone do only perform a part of the job since comprehensive end-user products are a result of the combination of remotely sensed data coupled with ground survey and modeling. Data accuracy, data processing, and the creation of customer specific and dedicated products are keys for a breakthrough of remote sensing applications.

The remote sensing community recognizes the indispensable necessity of ground-truth information in support of satellite Earth observation missions. In order the remote sensing techniques to be widely transferred to operative applications, data quality and retrieved information reliability are critical. Algorithms and quantitative models for estimating various land surface variables from remotely sensed observations need to be validated using ground-truth data [4-6]. Supporting and raising the capacity of remote sensing investigations encompasses the implementation of a wide range of information sources, making full use of in-situ surveys (ground-based and airborne) and space monitoring.

The paper presents a vision on the necessity and the objectives of an in-situ infrastructure for data acquisition on target selected and representative of different ecosystems and environmental conditions test-sites. The development of an integrated in-situ and remote sensing information system responds to the needs for coordinated multi-disciplinary data acquisition, integration and multi-use in monitoring the state of the environment, including air, water, soil, natural landscape and farmlands.

In-Situ Support - Closing the Gaps

Spatial information (any data with reference to a specific location or geographical area) plays a special role in environment monitoring because it allows information to be integrated from a variety of sources and disciplines for a variety of uses. However, the widespread use of spatial information is still not a routine. The main problems relate to data gaps and incompatible data sets due e.g. to varying data needs, standards, undefined quality and barriers to sharing, accessing and using of data. Remote sensing is an important source of information for a large number of Earth sciences and application fields. Data acquisition technologies and information extraction methods are pushed to give shift to user-oriented approaches where quantitative and reliable assessments, trend evaluations and forecasts are demanded. To achieve this, it is necessary to make full use of data collected from space-borne, airborne and field observation systems (the latter two composing the in-situ system). The way is to optimize the infrastructure for data acquisition, efficient processing, integration and use. The optimization includes adequate instrumentation and better timing and coordination in information collecting and management.

ГОДИШНИК НА МИННО-ГЕОЛОЖКИЯ УНИВЕРСИТЕТ “СВ. ИВАН РИЛСКИ”, Том 52, Св. I, Геология и геофизика, 2009
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ПОЛЕВИ И ЛАБОРАТОРНИ ИЗМЕРВАНИЯ НА МАГМЕНИ, СЕДИМЕНТНИ И МЕТАМОРФНИ СКАЛИ ЗА ПОПЪЛВАНЕ НА БАЗА ДАННИ ПРИ ДИСТАНЦИОННИ НАБЛЮДЕНИЯ НА ЗЕМЯТА

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РЕЗЮМЕ. Наземните измервания в комплекса на дистанционните изследвания се много важни в съставянето и попълването на бази данни. За целта са проведени лабораторни и полеви спектрометрични измерванния на образци от магмени, седиментни и метаморфни скали от България. Използван е тематично ориентиран спектрометър, работещ в диапазона 400-900 nm. Спектрометърът е конструиран в ИСЗВ-БАН. Получените данни ще бъдат включени в база данни за допълнителна информация при дистанционни изследвания на земната повърхност.

IN-SITU AND EX-SITU MEASUREMENTS OF IGNEOUS, SEDIMENTARY AND METAMORPHIC ROCKS IN EARTH OBSERVATION DATA BASE COMPLEMENT

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ABSTRACT. Ground-truth data in remote sensing investigation complement are very important. For this purpose laboratory and field spectroscopy measurements of samples of the igneous, sedimentary and metamorphic rocks are performed. The thematically oriented spectrometer working in 400-900 nm range is used. The spectrometer was designed and constructed in STIL-BAS. The obtained data will be included in data base for Earth observation complement.

Въведение

Наземните измервания в комплекса на дистанционните изследвания се много важни при съставяне и попълване на бази данни. За целта са проведени полеви и лабораторни спектрометрични измерванния на образци от някои магмени, седиментни и метаморфни скали от България. Използван е тематично ориентиран спектрометър TOMS, работещ в диапазона 400-900 nm. Планирано е получените данни в табличен и графичен вид да бъдат включени в геобаза данни за допълване на информацията при дистанционни изследвания на земната повърхност.

Материали и методи

Спектралните характеристики от наземните измервания се събират в геобаза данни за следните цели: калибриране и валидация на изображения и спектрални данни при дистанционни изследвания; проверка на приложимостта на спектралните измервания при самолетни и сателитни мисии; основно проучване на взаимовръзките между физическите свойства и електромагнитното отражение на изучаваните обекти; определяне на пряката зависимост на отражението от обектите от осветяването им и видимата им структура.

От началото на 80-те години на XX век са проведени множество измервания на спектралните характеристики на природни и антропогенни обекти с помощта на полеви спектрометри, работещи във видимата и инфрачервената области от електромагнитния спектър. Не по-малко усилия са направени да се систематизират и интерпретират получените данни, наречени първични данни (метаданни). Сравнението на спектралните криви от спектрометричните полеви измервания е затруднено поради различните методики за получаването им (Milton, 2001). Оползотворяването на данните от множеството изследвания изисква качествена оценка, която е направена спрямо поставената задача. Според Kancheva, 1999, Milton et al., 2006, точността зависи от коректното определяне на това, което ще бъде измервано. В геобазата данни трябва да се включи и информация за условията по време на полевия експеримент.

Първичните данни са нужни при употребата и интерпретацията на научните данни (Michener, 2000).

Spectral Data for Plant Chlorophyll Assessment

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An increasing role in plant phytodiagnostics becomes to play different spectrometric techniques used as a part of remote sensing applications. The radiation behavior of land covers and the spectral response to changing conditions lies at the root of these studies. The visible and near infrared (400 - 900 nm) measurements have proved abilities in vegetation monitoring. The reason is that this wavelength range reveals significant sensitivity to plant biophysical properties. The information is carried by the specific vegetation spectral characteristics which depend on such plant parameters as chlorophyll content, biomass amount, leaf area, etc. These parameters are associated with plant development and stress factors being closely related to vegetation physiological state. In our study, multispectral data of reflected, transmitted and emitted irradiance have been used to show the possibility for plant chlorophyll assessment. Different methods such as vegetation indices, red edge analysis and fluorescence spectra have been applied and compared.

Key words: – multispectral data, chlorophyll estimation, vegetation indices, red edge, fluorescence

INTRODUCTION

Recent developments in environmental studies are greatly connected with worldwide ecological problems related to anthropogenic impacts on the biosphere and first of all on vegetation. Advanced monitoring and alerting techniques, on-time information extraction, modeling and forecasting methods are a preposition for successful data application and decision support in environmental studies.

The spreading acceptance of the concept of precision agriculture running [1] generated much interest in the early detection of plant growth stress. The implementation of modern remote sensing technologies is one of the basic assumptions of this concept, special attention being paid to vegetation monitoring in relation to stress detection. That is why the assessment from spectral data of crop state [2,3] and growing conditions has been and still is at the focus of numerous investigations and experimental studies [4,5].

Important here are early warning signs of plant inhibition which should be directly connected to fundamental physiological processes. Such a process is the photosynthesis and the connection has been found in vegetation fluorescence [6,7]. The optical signatures of leaves are mostly defined by the composition of photosynthetic pigments and their stress-induced changes, and as such they are indicative of plant short-term or long-term stress. Though being studied for decades, light induced fluorescence has not lost its attractiveness. In recent years, the screening of plant fluorescence signatures is developing as a specific tool which could be applied to detect the functioning and health status of plants [8-10]. Compared to reflectance, induced fluorescence might be a more accurate indicator of plant state and be able to detect stress impacts at earlier growth stages.

In our study, multispectral data of reflected, transmitted and emitted by plant leaves irradiance have been used to show the possibility for plant chlorophyll estimation. Different methods such as vegetation indices, red edge analysis and fluorescence emission have been applied

Unmixing techniques for better segmentation of urban zones, roads and open pit mines

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ABSTRACT

In this paper the linear unmixing method has been applied in classification of manmade objects, namely urbanized zones, roads etc. The idea is to exploit to larger extent the possibilities offered by multispectral imagers having mid spatial resolution in this case TM/ETM+ instruments. In this research unmixing is used to find consistent regression dependencies between multispectral data and those gathered in-situ and airborne-based sensors. The correct identification of the mixed pixels is key element for the subsequent segmentation forming the shape of the artificial feature is determined much more reliable. This especially holds true for objects with relatively narrow structure for example two-lane roads for which the spatial resolution is larger that the object itself. We have combined ground spectrometry of asphalt, Landsat images of RoI, and in-situ measured asphalt in order to determine the narrow roads. The reflectance of paving stones made from granite is highest compared to another ones which is true for open and stone pits. The potential for mapping is not limited to the mid-spatial Landsat data, but also may be used if the data has higher spatial resolution (as fine as 0.5 m). In this research the spectral and directional reflection properties of asphalt and concrete surfaces compared to those of paving stone made from different rocks have been measured. The in-situ measurements, which plays key role have been obtained using the Thematically Oriented Multichannel Spectrometer (TOMS) – designed in STIL-BAS.

Keywords: mixed pixels, in-situ multispectral data, segment lines definition

1. INTRODUCTION

In the present work statistical method for analyzing the spectral data in the segmentation of the roads, dumps open pits and quarries was applied. This is done by using the multitemporal acquisitions offered by multispectral imaging sensors with medium spatial resolution sensors such as TM/ETM+ onboard Landsat 5/7. In this research the unmixing method in whose base are the stable and reliable statistical relationships between field data and multispectral digital image data obtained from sensors on board a flying apparatus, is applied for improving the results for the segmentation process. After proper identification of the mixed pixels on the curve delineating the homogenous areas of the studied land cover types can be considered as more reliable. Field measurements were made on the gravel pit near the village of Smolsko and Beli breg coal open mine. Multispectral data used are from TM/ETM+ instruments (WRS2 path182/row30 and path183/row30) from different dates in order to establish better statistics for the objects under study. Several campaigns for spectrometric measurements were conducted in-situ by means of field spectrometer TOMS, designed and constructed in STIL-BAS. Also geological survey and petrologic studies were performed.

Carry out the segmentation on satellite images is a necessary step before start the process of classification (supervised/unsupervised) of distinct land covers. In the segmentation phase, relying on pixel by pixel calculations, the separating line between the homogenous areas should be drawn. For images with low and middle spatial resolution as rule this line is composed by mixed pixels. In order to decrease the uncertainty if the pixel is part of the segmentation line essential is to find out the correct proportions of pure classes (endmembers) in the single pixel. Our contribution is mainly in the finding statistically reliable relationships between linear mixed endmembers and multispectral data from TM/ETM+. In this study main focus was put on finding correct segmentation for an open pit coal mine and a quarry.

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ГОДИШНИК НА МИННО-ГЕОЛОЖКИЯ УНИВЕРСИТЕТ “СВ. ИВАН РИЛСКИ”, Том 53, Св. I, Геология и геофизика, 2010
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ТЕХНИКИ ЗА СЕГМЕНТИРАНЕ НА ОТКРИТИ РУДНИЦИ И КАРИЕРИ

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РЕЗЮМЕ. В тази работа е приложен метод за анализиране на спектрални данни при сегментирането на открити рудници и кариери. Идеята е да се използват множеството възможности, предлагани от многоспектрални изображения със средна резолюция като TM на борда на Landsat 5. Чрез методът, който прилагаме, се търсят стабилни статистически зависимости между полевите многоспектрални данни и данните от изображенията, получени от сензори на борда на летящи апарати. След коректно разпознаване на съответните пиксели последващото сегментиране на изследваната наземна форма може да се определи като надеждно. Полевите измервания са извършени на кариера за трошен камък близо до с. Смолско. За района са обработени съответните изображения от спътника Landsat 5 от различни дати. Проведени са геоложки наблюдения, петрографски изследвания, фотодокументация и in-situ спектрометрични измервания.

TECHNIQUES FOR SEGMENTATION OF OPEN PIT AND STONE MINES

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ABSTRACT. In this paper a statistical method has been applied in the segmentation of human made land covers as open pit and stone mines. The idea is to exploit to larger extent the possibilities offered by multispectral imagers having mid spatial resolution such as TM onboard Landsat 5. The method has been applied in the framework of our research is to find consistent statistical dependencies between multispectral data gathered in-situ and the corresponding ones in images offered by airborne-based sensors. After correct identification of the pixels the subsequent segmentation forming the shape of the artificial feature is determined much more reliable. This especially holds true for objects with relatively narrow structure for example two-lane roads for which the spatial resolution of one pixel is larger that the object itself. We have been combined ground spectrometry of stone-pit near Smolsko village, Landsat images of region of interest (RoI), and in-situ condition surveys for assessment of stone pit area. Geological observations, petrographical investigations, photo documentation and in-situ spectrometric measurements have been performed.

Въведение

В настоящата работа е приложен статистически метод за анализиране на спектрални данни при сегментирането на открити рудници и кариери. По този начин се използват множеството възможности, които се предлагат от многоспектрални изображения със средна резолюция от сензори като TM на борда на Landsat 5. Чрез методът, който прилагаме, се търсят стабилни статистически зависимости между полевите многоспектрални данни и цифровите данни от изображенията, получени от сензори на борда на летящи апарати. След коректно разпознаване на съответните пиксели последващото сегментиране на изучаваната наземна форма може да се определи като надеждно. Полевите измервания са извършени на кариера за трошен камък близо до с. Смолско. За района са обработени съответните изображения от спътника Landsat 5 от различни дати. Проведени са in-situ спектрометрични измервания, за което е използван полеви спектрометър TOMS, разработен и конструиран в ИСЗВ-БАН (Petkov, 2005). Проведени са геоложки наблюдения, петрографски изследвания и фотодокументация на кариерата.

Материали и методи

Извършени са теренни изследвания и опробване на карбонатни скали (доломити) от района на с. Смолско за периода 2000-2010 г. Изследван е състава, текстурните и структурните особености на доломитите. Образците са изследвани макроскопски и с бинокулярна лупа Olympus. С помощта на оптическата микроскопия (микроскопи Amplival и Leitz Orthoplan-Pol) са определени състава и структурните особености на скалите. Химичните анализи са извършени с Атомно-емисионен спектрометър с източник на възбуждане индуктивно свързана плазма (AES ICP) (апарат SPECTRO Analytical instruments, Germany) в МГУ “Св. Иван Рилски”.

Полевите спектрометрични измервания на доломитите от кариерата са осъществени между 2008 и 2010 г. За репер при разпознаването на изучаваната кариера на спътникови изображения може да се използва наличието на вода, поради което са проведени и спектрометрични измервания на водната площ през 2010 г. Основното измерително устройство на полевия спектрометър TOMS е USB2000 (фиг. 1). Предварителната обработка за въвеждане на корекции на получените данни е проведена

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Декомпозиция спектральных смесей почва – растительность

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Одно из важнейших применений дистанционных исследований земной поверхности, имеющих существенное практическое значение – мониторинг растительности. Различные вопросы оценки сельскохозяйственных посевов методами дистанционного зондирования связаны с наблюдением вегетационнотго развития культур, обнаружением стрессовых состояний, прогнозированием урожая. Основной задачей дистанционного мониторинга, особенно в отношении условий и хода роста сельскохозяйственных культур, является оценка состояния посевов в различных периодах их развития. Целесообразность проводимых исследований зависит от их точности и надежности. Повышению последних способствуют наземные эксперименты, предназначенные для создания и валидации применяемых алгоритмов. В работе рассматриваются два метода определения такого важного агропараметра, каким является проективное покрытие растительности. Один из методов основан на использовании спектральных преобразований (вегетационных индексов), а второй заключается в проведении колориметрического анализа измеряемых спектральных отражательных характеристик. Обращено внимание на специфику спектральных характеристик системы почва-растительность как динамического объекта и как спектральной смеси двух классов объектов. Цель работы – проиллюстрировать и сравнить оба подхода для определения проективного покрытия растительности по многоспектральным данным.

Ключевые слова: спектральные отражательные характеристики, система почва-растительность, проективное покрытие, вегетационные индексы, колориметрический анализ.

Введение

Своевременная оценка состояния земледельческих угодий и посевов представляет особый практический интерес, так как имеет важное значение для управления аграрных систем, прогнозирования их развития и урожая. Аэрокосмическая информация дает возможность дистанционного мониторинга, проводимого для оценки состояния растительного покрова. Ее достоверная интерпретация в значительной степени зависит от наличия спектрально-биофизических моделей, связываюших многоспектральные данные с различными характеристиками и агропоказателями растительности. Для этого широко используется спектральное отражение почвенно-растительного покрова в видимом и ближнем инфракрасном диапазонах. Основным подходом является разработка и применение разнообразных вегетационных индексов, представляющих собой главным образом различной сложности отношения коэффициентов отражения для двух или более длин волн [1, 2, 5]. На основе экспериментальных данных создаются статистические модели, которые служат для определения ряда растительных биопоказателей [1, 3-6]. Колориметрический анализ редко применяется по отношению к растительности, но представляет определенные возможности, на что указывают результаты наших исследований [7-10].

Цель данной работы – провести сравнение этих двух методов для определения проективного покрытия растительности, которое выбрано в качестве обобщенного параметра, отражающего структурные различия и изменения посевов, и, следовательно, наиболее общим образом характеризующего их состояние. В работе показаны особенности применения вегетационных индексов и цветовых характеристик объектов, интерпретация которых проводи-

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Раннее обнаружение физиологического стресса растительности по многоспектральным данным

43. (I.91.)

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Экологические вопросы, связанные с влиянием человеческой деятельности на природную среду и, прежде всего, на биосферу, имеют глобальное распространение и исключительную важность. Они привлекают внимание государственных учреждений и ученых различных областей и требуют развития эффективных средств оценки влияния антропогенных факторов на окружающую среду, в первую очередь на растительность. Загрязнение почв, воды и воздуха тяжелыми металлами является одной из наиболее серьезных проблем, касающих природных растительных ресурсов и земледельческих культур. Среди методов фитодиагностики возрастающую роль играет анализ радиационных характеристик растительных покровов. Измерения в видимом и ближнем инфракрасном спектральных диапазонах обладают доказанными возможностями мониторинга растительности и оценки ее состояния. Такие показатели как биомасса, листовой индекс, пигментное содержание и пр. являются индикаторами не только развития и состояния растений, но и условий их прорастания. В данной работе рассматривается использование многоспектральных данных для раннего обнаружения физиологического стресса гороха (Pisum sativum), вызванного влиянием кадмия. Горох выращивался в гидропонных условиях при загрязнении среды раствором $CdCl_2$ в различных концентрациях. Влияние тяжелого металла и степени физиологического стресса оценивались по изменениям пигметного содержания. растений.

Ключевые слова: многоспектральные данные, растительность, диагностика, тяжелые металлы, физиологический стресс, хлорофилл, каротиноиды.

Введение

Экологические проблемы, связанные с антропогенным загрязнением окружающей среды, давно стоят в центре внимания современного мира. Последствия всякого рода загрязнений в наиболее серьезной степени сказываются на растительном покрове, из-за чего растительность является объектом многосторонних, различных по характеру и масштабности исследований. Большая часть исследований касается физиологии и развития растений, их адаптации, репродуктивной способности, генетических изменений и пр. Экофизиологические направления исследований представляют собой существенный интерес для сельского хозяйства, особенно ввиду непрерывно растущего неблагоприятного влияния человеческой деятельности на окружающую среду. Наряду с традиционными методами, все шире применяются технологии дистанционного мониторинга растительного покрова.

Фитодиагностика занимает главное место среди различных применений растительного мониторинга. Многоспектральные данные используются дла обнаружения стрессовых состояний путем оценки ряда растительных биопараметров, являющихся индикаторами отрицательного воздействия стрессовых факторов [1-5, 10]. Пигментное содержание, прежде всего хлорофилла и каротиноидов, наиболее чувствительно к условиям среды и преставляет собой важнейшим показателем физиологического состояния

Sub-pixel method for analysis of optical data in determining the overburden dumps and open pit mines

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ABSTRACT

Mining plants are one of the factors having major negative impact on the area where they are situated. In our study this is the case of the mine production plant consisting of Elacite mine and Mirkovo floatation plant both located in central part of Stara Planina Mountain. In this study an attempt is made to delineate the overburden dumps and open pit mines by means of remotely sensed multispectral data with moderate spatial resolution (e.g. Landsat TM/ETM+ 30m) is a challenging task. The major difficulties arise from: 1) large period using the dump (introducing the need for multitemporal data); 2) the unknown proportions of vegetation, soil and embedding rock samples in the boundary areas and their seasonal variations; 3) relatively restricted access to places of interest. A variety of methods have been proposed to overcome the problems with pixels corresponding to two or more end-members, but a promising one is the soft classification which assign single pixel to several land cover classes in proportion to the area of the pixel that each class covers. In this scenario for every pixel of the data the correct proportion of the end-members should be found and then co-registered with the corresponding original pixel. As a result this sub-pixel classification procedure generates a number of fraction images equal to the number of land cover classes (end-members). The sub-pixel mapping algorithms we have exploited so far have one property in common: accuracy assessment of sub-pixel mapping algorithms is not easy because of missing high resolution ground truth data. One possible solution is to incorporate in the method adopted additional ex-situ and in-situ measured data from field and laboratory spectrometers with bandwidth about 1 nm. This study presents a successful implementation of soft classification method with additional, precise spectrometric data for determination of dump areas of the copper plant and open ore mine. The results achieved are proving that the in-situ gathered data provide coincidence of 93.5%. The main advantage of the presented technique is that mixed pixels are used during the training phase. Compared to these other techniques, the present one is simple, cheap and objective oriented. The results of this sub-pixel mapping implementation indicate that the technique can be useful to increase the resolution while keeping the classification accuracy high.

Keywords: optical data, sub-pixel method, environmental monitoring

1. INTRODUCTION

The improved spectral resolution (over 32 spectral channels) of the recently developed remote sensing instruments, e.g. plane based AVIRIS, provoked the interest to the sub-pixel data interpretation. As a matter of fact most of the real world problems need high spectral and spatial resolution since in one pixel of the image data more than one object is located. Usually the transaction between these should be found which is not always possible. In conventional image processing methods the human interpreter should rely on targets' spectral and/or spatial properties such as spectral contrast, variability, similarity and discriminability to be able to detect targets effectively at sub-pixel level.

One general approach proposed in[1,2] is based on spectral mixture analysis[3]. During this study the above formulated problem for sub-pixel spectral discrimination was investigated and two different approaches are discussed in the next paragraphs. One is a spectral class abundance-constrained approach. It is a constrained least squares spectral mixture analysis method, which implements a non-negativity constraint on the abundance fractions of targets of interest.

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Monitoring Water Quality in Open Basins of Non-operating Mines and Dumps

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SUMMARY

Within this research we explore time and seasonal behavior of multispectral satellite data with middle to high spatial resolution in order to estimate the content of metal particles in the water basins formed by non-operating copper mine and dumps. The aim is to test if regression model could be created between metal polluted water and the spectral response of the basins. As basis the spectral response of the embedded rocks of the copper mine and sands on the beaches of the dump site have been investigated. Similar to the well known vegetation indices such as NDVI several spectral indices are suggested, analyzed and the results are reported. The obtained results showed that the analyzed data and the implemented approach are proved to be useful in environmental monitoring process for the mining company responsible for the ecological state of the region. Also the successful implementation of method could be considered as basis for establishment of airborne monitoring of the ecological state of these areas.

CROP GROWTH AND YIELD AS AFFECTED BY SOIL CONDITIONS

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Abstract

More and more attention is being paid recently to man-induced environmental changes and anthropogenic risk impacts on natural resources. To the biggest extent this concerns soil and vegetation resources. Remote sensing is an efficient tool for obtaining various information about land covers. It has, for instance, encouraging capabilities in agriculture for crop state and productivity assessment. Detecting vegetation stress by remote sensing techniques could also be a tool for recognizing soil degradation caused by different factors. Three issues are considered in the paper: inherent soil properties and soil contamination on crop growth and yield, crop stress detection from multispectral data, and multitemporal behaviour of crop spectral features as an indicator of plant development with respect to the specific soil conditions. Results are presented from the analysis of experimental data gathered over spring barley plots grown on two soil types with different properties (pH, organic content), different fertilization treatment (fertilizer type and N-amount), and heavy metal (Ni) pollution in different concentrations. The effect of these factors on plant development (separately and in combinations) has been examined and quantified by empirical relationships. Agronomic parameters retrieval and yield assessment from spectral models have been performed, and crop state has been associated with the anthropogenic impact on the soil conditions. The green-house experiments were realized in the Institute of Soil Science "N. Poushkarov".

Keywords: remote sensing, reflectance, multispectral data, vegetation indices, crop stress, soil contamination, heavy metals, fertilization, nutrient deficiency

Introduction

The spreading acceptance of the concept of precision agriculture running (Liaghat S. and S. Balasundram, 2010; Rasher M., 2000) generates much interest in the early detection of plant growth stress. The implementation of modern remote sensing technologies is one of the basic assumptions of this concept. Remote sensing has been recognized as a powerful tool in vegetation studies for natural resources management, land cover monitoring, ecosystem preservation and other significant problems. Special attention is being paid to vegetation monitoring in relation to change detection (Kokaly R., et al., 2007). Agricultural observations supply information on crop growth processes and stress situations (Kancheva R., et al., 2005; Kancheva R., 1999; MehandjIev A., et al., 2000; Glenn E., et al., 2008; Penuelas J., et al., 1994). The assessment of crop growth conditions from spectral data has been and still is the focus of numerous investigations and experimental studies (Kancheva R., et al., 2005; MehandjIev A., et al., 2000; Kokaly R., et al., 2007). Their goal is to further develop and precise the up-to-now investigation results and bring them to an operational use. This requires advanced data processing technologies, development of models for assessment of impacts on agriculture and implementation of monitoring systems that consider variousl factors influencing crop growth. Efficientl methodologies to monitor crop vigor, diseases, and stresses are needed as well as improved analytical techniques to evaluate biological and physical processes.

Interest is rapidly spreading over the past years in the application of hyperspectral data for retrieving plant agronomic variables and yield predicting. Two issues are of essential importance for the application of airborne and satellite data: development of efficient algorithms for data analysis and explicit information about land covers spectral behavior under different conditions, both associated with a higher reliability of the derived information. In this context detailed ground-based spectrometric studies (Kancheva R., 1999; Glenn E., et al., 2008) complement the array of geo-spatial data products providing information on crop spectral behaviour under different environmental conditions and considering regional and local peculiarities. Being the most vital and anthropogenic-affected component of the biosphere, the vegetation has a leading position among the priorities of remote sensing observations applied for assessment of plant development and stress detection.

The goal of the paper is to examine the impact of soil properties and anthropogenic factors on crop development and spectral behaviour and to quantitatively describe the relationships between growing conditions, crop spectral reflectance and plant variables. Such relationships serve for crop state evaluation and stress assessment.

Matrials and methods

Reflectance, biometrical and phenological data were gathered from spring barley treatments throughout the entire growing season. The treatments comprised neutral (pH=7.0-7.5) chernozem soil and acid

ДИСТАНЦИОННИ МЕТОДИ ЗА ИЗСЛЕДВАНЕ НА ПОЧВЕНОТО ЗАСОЛЯВАНЕ

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REMOTE SENSING FOR SOIL SALINITY INVESTIGATION

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Abstract

Soil cover is with no doubt among the priorities of remote sensing investigations. The reason is the need for fine-scale detailization and updating of soil maps as well as the state assessment of agricultural lands. The detection and monitoring of degaradation processes is of significant importance for soil and crop management planning. Salinization is one of these processes depending on climatic and anthropogenic factors. Soil salinization is becoming an increasing problem, especially in arid and semi-arid regions and wherever irrigation is practiced. It is considered as a serious „soil threat" to agriculture. Salinity is an ecological factor of considerable importance which imposes the necessity of detection, monitoring and mapping salt-affected soils and also the evaluation of the degree of salinization. Recognition and classification of soil salinity is the first step to combat against salinization. Recent advances in the application of remote sensing technology in monitoring degraded lands, especially salt-affected soils, have shown some success. The objective of this work is to show the implementation of multispectral data acquired in the visible and near infrared bands for the identification of saline soils and to evaluate the utility of saline soils spectra for characterizing soil salinization. Different techniques have been applied for processing spectral data from field-derived and airborne measurements of different classes of saline soils.

Keywords: remote sensing, multispectral data, soil salinity

Увод

Прецизно и устойчиво земеделие са понятия, които от концепция доскоро, сега са на път да се превърнат в технология [1, 2]. Често ги характеризират като еволюционна стъпка в селското стопанство. Те включват стратегически въпроси, касаещи вида на отглежданите култури, почвените свойства, наторяването, проследяване на вегетационното развитие, прогнозиране на добивите. Освен необходимостта от нарастване на производството обаче, тук стои и въпросът за опазване на природните ресурси. Една от основите, върху която се гради концепцията за прецизно и устойчиво земеделие, са новите информационни възможности, предоставяни от дистанционните средства за наблюдение.

Почвената покривка е особено важен компонент и ресурс на природната среда. Тя отразява взаимовръзките между останалите компоненти (скали, води, климат, растителност, дейност на човека) и представлява индикатор за екологичното състояние на ландшафта. Прецизното земеделие изисква по-точно характеризиране на почвата и променливите й свойства, като оценката на състоянието на почвата е от значение за следене на почвената деградация и мерките за нейното оздравяване. В този смисъл почвената покривка несъмнено заема едно от първостепенните места при дистанционните изследвания [3-7]. Сред причините за това са необходимостта както от детайлизация и обновяване на почвените карти, така и от оценка на състоянието на обработваемите земи. От изключително важност е откриването и следенето на процеси, водещи до деградация на почвените ресурси. Един от тях е засоляването, което зависи от редица природни и антропогенни фактори – високи температури, слаб дренаж, повишена минерализация на подпочвените води, усилено напояване и наторяване. Почвеното засоляване е един от основните проблеми, свързани с "износването" на почвените ресурси и се счита за сериозна заплаха за земеделието, отразявайки се силно върху плодородието на почвите. Затова от практическа гледна точка е важно да се установи както наличието и разпространението му, така и интензивността на процеса, т.е. да се направи количествена оценка на степента и скоростта на засоляване.

Множество работи са посветени на използването на различни данни от дистанционните изследвания за характеристика на засолени земи [8-17], като отбелязваните трудности се състоят в сложността, взаимосвързаните фактори и динамичността на този процес, зависещ от климатичните условия, свойствата на почвите и аграрната дейност. Ярък пример за сериозния екологичен проблем,

ГЕНЕЗИС, ГЕОГРАФИЯ И КЛАСИФИКАЦИЯ НА ПОЧВИТЕ, ГЕО-ИНФОРМАЦИОННИ СИСТЕМИ

REMOTE SENSING TECHNIQUE IN SOIL MONITORING IN RISK AREAS

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Abstract

Remote sensing is an established technique in environmental studies. Soil monitoring in risk areas such as open pit mines, landslides, etc. is associated with rock appearance detection. The actual usefulness of the remote sensing information depends on its accuracy and reliability. The objective of this paper is to study soils, embedding rocks and their mixtures in relation to color features. It is shown that the colorimetrical analysis provides means for soil and rock evaluation. In the paper we report some results of the colorimetrical analysis of reflectance multispectral data obtained in laboratory, in-situ and airborne measurements. Experimental data was used to model reflectance and color characteristics of soils and relevant soil-rock mixtures. This is of a particular interest in remote sensing as far as the proportion determination of mixtures' components is concerned being an important issue in data interpretation. The results provide further confirmation of the potential of remote sensing technique LSMA (linear spectral mixtures analysis) for soil monitorring in risk areas.

Keywords: remote sensing, environment, reflectance additive theory, multisensor remotely sensed data, rock-soil spectral modeling, change detection, decision support

Introduction

The geological exploration of the copper-bearing rocks in the Sredna gora region, located in the middle of Bulgaria, started in the late 50-ies of 20-th century. As a result the mining plant "Medet" was built who started its production 1964. The main activity of this plant is extraction and recovery of copper together with all relevant engineering and commercial actions. The experience for exploration and mine plant construction gained on this site was implemented on other mine plants across Bulgaria during 60 and 70-ies of same century. In 1994 the open pit mine "Medet" was closed, but the newly developed "Asarel" mine started its operation. In both cases the ore deposits are developed by open pit mining and together with them the dumps are one of the largest risk areas in the environment in this region. That is the reason to start monitoring and rehabilitation activities for the region as a whole eco system. Compared all the data taken 20 years ago the spatial precision of the data improved more then twice which result in better decision support. This is the motivation of the team – to develop better understanding of the reclamation process and its monitoring.

Risk areas monitoring by remote sensing is closely connected to vegetation, soil and rock amount estimation. The actual usefulness of the applied methods depends on their accuracy and reliability. A basic problem in data processing and interpretation is spectral mixture decomposition and land cover classification. The objective of this paper is to study the granite, corresponding soils and their mixture in relation to color features. Laboratory and in-situ measurements of the spectral reflectance the granite and soil samples were performed in the visible and near infrared ranges of the electromagnetic spectrum by means of precise multi-channel spectrometers with channel width less than 1 nm. Experimental data was used to model reflectance and color characteristics of mixtures of the granite samples and their respective soils.

In this research data from air-borne instruments Landsat TM/ETM+ combined with in-situ and ex-situ measured data was used. Four main types of land cover were considered during this study namely - bare rocks, bare top soils, grass and bushes, trees. The other natural phenomena subject to the negative influence of the mining activities, the water, was not studied since the hydrographic network has smaller spatial dimensions than the resolution of the instrumentation used to gather data and this why field measurements were not carried out. The exploitation of mineral resources is always associated with change of the land cover. Thorough monitoring of degraded areas is an essential task for effective management of surface mine recovery.

Materials and methods

Ground-based in-situ and laboratory reflectance measurements of the granites and relevant soils (brown and red) were performed in the (400-800 nm) range of the electromagnetic spectrum using precise

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ДИСТАНЦИОННИ МЕТОДИ ЗА МОНИТОРИНГ НА ОТКРИТИ РУДНИЦИ

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РЕЗЮМЕ. Минната дейност в Европа се разпростира от големи площи с огромни открити рудници до съвсем малки карирери. В настоящата работа са анализирани спектрални данни от апаратурата на борда на спътника Landsat TM с цел определяне на площта на открити рудници и препоръки за планиране и осъществяване на рекултивационни работи. Предимството на този вид данни е, че са в цифров вид, лесни са за обработка и анализ в различни информационни формати. За верификация на резултатите са проведени наземни спектрометрични измервания на образци от изследваните райони. Използвани са дву- и три-компонентни линейни модели за оценка на минералното съдържание в откритите мини като са използвани сателитни данни за същия район. Колективът планира да приложи регресионен и клъстърен анализ за разграничаване на класовете земно покритие. Също така в моделите ще се включат повече минерали, скали и почви.

REMOTE SENSING TECHNIQUES IN MONITORING OF OPEN PIT MINES

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ABSTRACT. Surface mining activities in Europe are estimated to cover a large area and range from large open-cast coal and base metal mines, to much smaller aggregate, industrial minerals, and building materials quarries. In this paper we suggest that the availability of Landsat TM for Earth observation allows the collection of environmental and mine-related data for use in the planning and undertaking of mine restoration work on cost-effective basis. The advantage is that these data are acquired digitally and can be easily processed and utilized in various information formats. For verification of the results spectrometric measurements of samples from test sites are performed. Two- and three-component linear models for estimation of the mineral composition of an open pit are created using satellite data over the same area. Further regression and cluster analysis for distinguishing class covers as dump and open mine is intended. As a future work we consider the development of these models including more minerals, rocks and soils.

Въведение

В настоящата работа са използвани статистически методи за анализиране на спектрални данни при мониторинга на открити рудници като изследванията са извършени в района на находище Елаците и прилежащото хвостохранилище Бенковски. Използвани са множеството възможности, които предлагат многоспектралните изображения със средна резолюция от сензори като TM/ETM+ на борда на Landsat. Чрез методът, който прилагаме, се търсят стабилни статистически зависимости между полевите многоспектрални данни и цифровите данни от изображенията, получени от сензори на борда на летящи апарати. След коректно разпознаване на съответните пиксели последващото определяне на изучаваната наземна форма може да се приеме като надеждно. Полевите измервания са извършени на образци от изучавания район. За него са обработени съответните изображения от сензорите TM/ETM+ на борда на спътника Landsat от различни дати. Проведени са и in-situ спектрометрични измервания, за което е използван полеви спектрометър TOMS, разработен и конструиран в секция Системи за дистанционни изследвания (Petkov et al., 2005). Проведени са геоложки наблюдения и петрографски изследвания на района.

Материали и методи

В процеса на изготвяне на тази работа за получаване, обработка и визуализиране на данните, беше избран програмният продукт MultiSpec. MultiSpec е програма обработваща многоспектрални данни, получени чрез сателитни наблюдения на земната повърхност, най-често посредством спътници от серията Landsat. Програмата разполага с надеждни методи за интерпретация и анализиране на изображения, получени от сателитно базирана апаратура. Възможностите и подобренията в последната версия на тази програма включват:

- визуализиране на многоспектрални изображения в черно-бели или цветни формати, използвайки линейна или квадратична промяна на контраста;
- визуализиране на тематични изображения също в черно-бели или цветни формати, с възможност за контролиране на яркостта;

Multitemporal satellite data in mine waste monitoring of Medet copper deposit

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ABSTRACT

The anthropogenic impact of the mining industry on the environment is seen all over the world. In the last decades several mining areas and corresponding waste disposal sites in Bulgaria are being monitored for ongoing reclamation processes. In this research we were focused on one environmental status of one of the most important copper producing fields for our country - Medet deposit.

The objectives of the study were: (1) to analyze multispectral satellite images for 1980 - 2000 in order to assess the environmental pollution from the mining activity in the Medet open pit mine in temporal perspective; (2) to prove that by means of remote sensing an integrated environmental impact assessment can be made.

After ceasing its exploitation in 1994 a rehabilitation program for soil cover and hydrographic network was established and launched. A continuous task is the monitoring of these activities from the beginning for at least 15 years period. We consider that revealing the potential of satellite multispectral and multitemporal imagery will provide valuable information on the impact of this long-term mining activity on the environment. One of the first tasks was to prepare thematic maps for several, non-successive years of the affected areas at regional scale. On the next step change detection methods were used to assess the short-term reclamation activities by examination of vegetation cover status in the areas surrounding the mine. To complete this tasks data from Landsat TM/ETM+ instruments combined with in-situ measured data was used. For data processing several techniques, both standard, such as basic and advanced statistics, image enhancement and data fusion, and novel methods for supervised classification were used. The results obtained show that used data and the implemented approach are useful in environmental monitoring and economically attractive for the company responsible for the ecological state of the region.

Keywords: mining-concentration industry, multidate remote sensing, pollution, tailings, waste

1. INTRODUCTION

Open pit mining in the last decades brought large increase of pit sizes and extracted ore volumes. Large volumes of waste rock and ore (50,000-100,000 tone per day) are moved. The second largest European open pit mine is Medet/Bulgaria copper mine (11 million tones per year). The main activity of this plant is extraction and recovery of copper together with all relevant engineering and commercial actions. The ore deposits are developed by open pit mining and together with them the dump areas are one of the largest pollutants of the environment in this region. In this research we were focused on one environmental status of one of the most important copper producing fields for our country - Medet deposit.

The objectives of the study were: (1) to analyze multispectral satellite data for a period 1972 - 2011 in order to assess the environmental pollution from the mining activity in the Medet open pit mine in temporal perspective; (2) to prove that by means of remote sensing an integrated environmental impact assessment can be made.

After ceasing its exploitation in 1994 a rehabilitation program for soil cover and hydrographic network was established and launched. A monthly bulletin about the quality of the air and water is published and distributed in by local authorities. This policy for ecologically clean production could be supported to great extend by data obtained by new remote sensing instruments with their increased spatial resolution. Compared with the data taken 20 years ago the spatial precision of the data improved more then twice which may result in better decision support.

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Remote sensing spectrometric system for emergency response on board of unmanned helicopter

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ABSTRACT

The goal of the project is the working out of a multichannel spectrometric system in the visible and near infrared bands of the electromagnetic spectrum for remote sensing with the following purposes: recognition of main land covers (soils, natural and agricultural vegetation, water areas); state assessment of the studied objects.

The multichannel spectrometric system is designed to measure the reflected by ground objects solar radiation in the visible and near infrared range of the electromagnetic spectrum on board of a remotely-controlled airborne platform (helicopter). The measurements will be performed in a main working regime - nadir, helicopter velocity – up to 20 km/h, height – up to 1000 m (optimal 200 m), flight duration - up to 30 min.

Components of the system are: multichannel spectrometer; digital camera (optional); data control on-board system; on-board power supply device; fitting elements for installation on board; ground-based computing system for storage and processing of spectrometric data.

Technical specifications of the spectrometric system are: spectral VIS-NIR range (450-900) nm; number of spectral channels 128–64; channel location even; spectral resolution (3-10) nm; spatial resolution (1-25) m^2; CCD line elements 2048; dynamic range of the system 4 x 104 and per scan 2000:1; exposure time (3-60) ms; measurement flight duration (10-30) min.

Main tasks are investigation of the relationships between the reflectance and biophysical features of the studied objects; development and validation of spectral-biophysical models for estimation of land cover parameters; soil state assessment (type, moisture content, surface texture); vegetation state assessment (type, phenological and growth parameters, detection of stress situations) and emergency response.

Keywords: unmanned copter system, airborne remote sensing, multispectral system, emergency response

1. INTRODUCTION

In the last years the unmanned aerial vehicles (UAV) have been used in large area of applications (i.e. agriculture, forestry, ecological monitoring etc.) for distant and non-destructive examination of natural and manmade objects. The survey we made in the scientific literature showed steady increase of the number of publications where UAV's are the remote sensing experiment platform even special issues for robotic UAV's for data collection were found[1]. Also in the FP7 funded project ImpactMin one of the workpackages is implementing small unmanned aircraft for assessment of the present state of the environment near open pit mines[2]. Another successful application of UAV's is to act as main device for collection of data from scattered wireless sensors/weather stations deployed in agricultural area for monitoring the parameters of the air and soil[3]. This push in UAV's development was mainly due to serious achievements in the fields of microelectromechanics, control electronics and communications, and sensor design. Considering the final price of the data there is no single answer because even with same platform the price of the equipment (sensors, GPS module, Rec/Trans, etc.) needed for the specific problem vary considerably but nevertheless it is cheaper than piloted alternatives. Other factors that can not be estimated at the design phase are the geometric and radiometric accuracy since they vary with the sensors implemented in the system.

In this research we put efforts in creation of a robust and reliable UAV-based system for collection of multispectral data mainly targeted at agriculture biophysical parameters determination and monitoring the ecological state. The main

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Ground-based multispectral measurements for airborne data verification in non-operating open pit mine "Kremikovtsi"

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ABSTRACT

The impact of mining industry and metal production on the environment is presented all over the world. In our research we set focus on the impact of already non-operating ferrous "Kremikovtsi"open pit mine and related waste dumps and tailings which we consider to be the major factor responsible for pollution of one densely populated region in Bulgaria. The approach adopted is based on correct estimation of the distribution of the iron oxides inside open pit mines and the neighboring regions those considered in this case to be the key issue for the ecological state assessment of soils, vegetation and water. For this study the foremost source of data are those of airborne origin and those combined with ground-based *in-situ* and laboratory acquired data were used for verification of the environmental variables and thus in process of assessment of the present environmental status influenced by previous mining activities. The percentage of iron content was selected as main indicator for presence of metal pollution since it could be reliably identified by multispectral data used in this study and also because the iron compounds are widely spread in the most of the minerals, rocks and soils. In our research the number of samples from every source (air, field, lab) was taken in the way to be statistically sound and confident. In order to establish relationship between the degree of pollution of the soil and mulspectral data 40 soil samples were collected during a field campaign in the study area together with GPS measurements for two types of laboratory measurements: the first one, chemical and mineralogical analysis and the second one, non-destructive spectroscopy. In this work for environmental variables verification over large areas mulspectral satellite data from Landsat instruments TM/ETM+ and from ALI/OLI (Operational Land Imager) were used. Ground-based (laboratory and *in-situ*) spectrometric measurements were performed using the designed and constructed in Remote Sensing Systems Department at Space Research and Technology Institute thematically oriented spectrometric system TOMS working in the 0.4-0.9 μm range of the electromagnetic spectrum (EMS). For proper comparison between the data obtained from the different sources mentioned spectral transformations such as normalized difference and rationing data for two wavelengths were applied in order to avoid misinterpretation. Statistically significant dependence between the various spectral transformations and the quantitative content of the iron in the different type of compounds was established. The achieved results provided evidence that methodology used could be extended to other regions of the country polluted by the mining activities and should be also tested in the region of the copper and zinc extraction. In the next step of our research we intend to use the results obtained by the multitemporal analysis of the satellite and ground-based multispectral data for the same and the similar regions of interest.

Keywords: mining-concentration industry, multi-source and multi-scale data, airborne data verification

1. INTRODUCTION

The impact of the mining-concentration industry on the environment is presented all over the world. The exploitation of mineral resources is always associated with significant and in most cases adverse changes of the land cover. Thorough monitoring of degraded areas is an essential task for effective management of the recovery and rehabilitation processes of the surface degraded by mining activities[1]. The geological exploration of the iron-bearing rocks in the "Kremikovtsi" region started in the late 50-ies of 20^{-th} century. As a result the mining processing and flotation plant "Kremikovtsi" was built who started its production 1963. The main activity of this plant was extraction and recovery of iron together with all relevant engineering and commercial actions. The experience for exploration and mine plant construction gained on this site was implemented on other mine plants across Bulgaria during 60 and 70-ies of same century. Starting in early 90-ties of 20-th century the production of "Kremikovtsi" open pit decreased and finally it was discontinued in year 2000. For

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Recurrent neural networks for automatic clustering of multispectral satellite images

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ABSTRACT

In the present work we applied a recently developed procedure for multidimensional data clustering to multispectral satellite images. The core of our approach lays in projection of the multidimensional image to a two dimensional space. For this purpose we used extensively investigated family of recurrent artificial neural networks (RNN) called "Echo state network" (ESN). ESN incorporates a randomly generated recurrent reservoir with sigmoid nonlinearities of neurons outputs. The procedure called Intrinsic Plasticity (IP) that is aimed at reservoir output entropy maximization was applied for adapting of reservoir steady states to the multidimensional input data. Next we consider all possible combinations between steady states of each two neurons in the reservoir as two-dimensional projections of the original multidimensional data. These low dimensional projections were subjected to subtractive clustering in order to determine number and position of data clusters. Two approaches to choose a proper projection among the all possible combinations between neurons were investigated. The first one is based on the calculation of two-dimensional density distributions of each projection, determination of number of their local maxima and choice of the projections with biggest number of these maxima. The second one applies clustering to all projections and chooses those with maximum number of clusters. Multispectral data from Landsat 7 Enhanced Thematic Mapper Plus (ETM+) instrument are used in this work. The obtained number and position of clusters of a multi-spectral image of a mountain region in Bulgaria is compared with the regional landscape classification.

Keywords: multispectral satellite image, data clustering, recurrent neural network, Echo state network, fuzzy C-means

1. INTRODUCTION

In spite of numerous developments[1], clustering of multidimensional data sets is still a challenging task. Among the variety of approaches used to solve it intelligent techniques such as fuzzy logic and neural networks were successfully applied. Among these, exploitation of neurons equilibrium states of different recurrent neural networks (RNN) were successfully used for data classification[2-4]. Such RNNs were trained by unsupervised procedures minimizing an energy function in search of correspondent to the particular data structure connection weights.

A recently proposed and extensively developed during last decade family of RNN called "reservoir computing" is targeted mainly to increasing of the speed of supervised training algorithms of RNNs[5]. A representative member of this family called Echo state network (ESN)[6] incorporates a recurrent reservoir with sigmoid nonlinearities of neurons outputs. Although the ESN reservoir connections were randomly generated, there are numerous works proposing methods for their adjustment to the data in use. Most of them are aimed at entropy maximization[7,8] at the reservoir output. Motivation behind these methods is related to the known biological mechanisms of changing neural excitability in accordance with the distribution of the input stimuli[9]. In all cases additional bias term was used that move the operating point of the reservoir into desired direction. In [9] the authors proposed a gradient method named Intrinsic Plasticity (IP) improvement by adjusting the biases as well as of introduced gain term aimed at achieving the desired distribution of reservoir output. In [10] it was proven by experiments that side effect of IP training is stabilization of even initially unstable reservoirs. During investigations why and how IP reservoir improvement influences reservoir stability another interesting effect was observed: the reservoir neurons equilibrium points are not only moved but also are

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Clustering of Spectral Images using Echo State Networks

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***Abstract*— In the present work we applied a recently developed procedure for multidimensional data clustering to processing of spectral satellite images. The core of our approach lays in projection of multidimensional image to a two dimensional one. The main aim is to discover points with similar characteristics. This was done by clustering of the resulting image. The processing technique exploits equilibrium states of a kind of recurrent neural network - Echo state network (ESN) - that are obtained after intrinsic plasticity (IP) tuning of the ESN using multidimensional data as inputs. The proposed in our previous work automated procedure for multidimensional data clustering is further refined and tested on the satellite image data. The obtained number and position of clusters of a multi-spectral image of a mountain region in Bulgaria is compared with the classification of the region landscape given by the Ministry of Regional Development and Public Works.**

Keywords— echo state network, intrinsic plasticity, data clustering, satelite spectral image

I. INTRODUCTION

In spite of numerous developments, clustering of multidimensional data sets is still a challenging task [1]. There are different approaches for solving it that include variety of intelligent techniques as fuzzy logic and neural networks.

Many well known types of recurrent neural networks (RNN) were successfully used for data classification [2, 3, 4]. All of them rely on unsupervised learning procedures minimizing given energy function in search of correspondent to data structure adjustment of network equilibrium states. An extensively developed branch of RNN called "reservoir computing" is targeted mainly to increasing of training speed of these dynamic networks [5]. A representative member of this family is Echo state network (ESN) [6]. It incorporates a randomly generated recurrent reservoir with sigmoid nonlinearities of neurons outputs (usually hyperbolic tangent). There are several works proposing methods for improvement of the ESN reservoir. Most of them are related to entropy maximization [7, 8] and are motivated by known biological mechanisms of changing neural excitability in accordance with the distribution of the input stimuli [9]. In all cases it was a bias term was used that moves the operating point of the system in the desired direction. In [9] the authors proposed a gradient method named Intrinsic Plasticity (IP) training for adjusting the biases as well as of an additional gain term aimed at achieving the desired distribution of reservoir output. In our previous work [10] it was shown that in fact IP training stabilizes even initially unstable reservoirs. During investigations why and how IP reservoir improvement influences its stability we observed another interesting effect: the reservoir neurons equilibrium points are not only moved but also are concentrated in several regions. Then question aroused: is it possible to use this effect for clustering purposes too?

In [11] for the first time it was proposed to use ESN in image classification to "draw out" silent underlying features of the image data. These extracted features were used further as inputs to a feedforward neural network classifier. In [12] we exploited the same reservoir ability but looking from another perspective: we consider combinations between steady states of each two neurons in the reservoir as numerous two-dimensional projections of the original multidimensional data fed into ESN input. These low dimensional projections can be used next for data clustering. It was shown experimentally that together with improved stability the IP tuned ESN reservoirs possess also better clustering abilities that naturally opens the possibility to apply them for multidimensional data clustering. Based on investigated effect of IP improvement of ESN reservoir we propose a procedure for multidimensional data clustering. It allows discovering multidimensional data structure without specification in advance the clusters number.

The initial investigations in [12] used two small size data sets. But even with these data need of further refinement of our procedure with respect to finding of a proper two dimensional projection among the numerous possible combinations between reservoir neurons was revealed. The initial idea of using neurons density distributions showed that there is need to find a proper value of the bandwidth of used kernels.

In the present paper we move one step further applying a two dimensional density distribution functions and using a procedure from [12] that determines automatically the kernels bandwidth. The improved algorithm was applied for clustering of spectral satellite images – a data set with much more dimensions than those used in our initial work. It is shown that with new improvement we are able to discriminate easier one among all possible two dimensional projections.

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Preprocessing of Field Spectrometric Data

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SUMMARY

Remote sensing using geophysical principles begins with the development and design of equipment for performing research of objects remotely and without disturbing their integrity. In geological remote sensing studies the determination of the chemical/mineral composition and the structure of the objects within the field of view of the instrument either obtained in the lab, with a field spectrometer, or with a remote sensor is a main goal. The aim of this study is to present and test the procedure of preprocessing of the field spectrometric data. Field spectrometric studies of rocks were made to collect spectral signatures of different rock types for the reliable detection and identification of their mineral and chemical composition. The experiments are based on major physical principles such as light scattering, absorption of light, and reflection of light in the electromagnetic spectrum (EMS). Field spectral measurements were made with Thematically Oriented Multi-channel Spectrometer designed and constructed in Remote Sensing Systems Department at SRTI-BAS. The spectrometer with increased spectral resolution works in (400-900) nm range of EMS. The results are compared with similar data from spectral libraries. They correspond to the shape of reflectance spectra in the same range of EMS obtained with other spectrometers.

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Remotely Sensed Data for Water Volume Assessment in Inoperative Mines

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SUMMARY

Abandoned open pit mines create serious ecological risk for the region of their location. This is valid especially for the quality of water since the rainfalls together with underground waters fill the open pit and form water body with different depth. One example for such opencast, inactive copper mine is Medet (Bulgaria). There are many cases reported for water pollution by heavy metals in the rivers running close to this open pit mine after autumn and spring rains. This justifies the need for long term and sustainable monitoring of the area of the water basin of this unused mine in order to estimate its acid drainage. The imaging spectroscopy combined with is-situ investigations is proved to provide reliable results about the area of the water table and the water volume in it. In this study we have investigated historical data gathered by remote sensing which allowed us to make conclusions about the year behavior of this area. The team expects that the results of this research will help in the rehabilitation process of this inactive mine and will provide the local authorities engaged in water quality monitoring with a tool to estimate the possible damage caused to the local rivers.

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ESTIMATION OF WATER AREA INCREASE BY REMOTELY SENSED DATA IN THE NON-OPERATING OPEN PIT MINES MEDET AND KREMIKOVTSI

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ABSTRACT. Abandoned open pit mines create serious ecological risk for the region of their location. This is valid especially for the quality of the water since the rainfalls together with underground waters fill the open pit and form water body with different depth. The examples for such opencast, inactive mines are the copper mine Medet and the ferrous mine Kremikovtsi. There are many cases reported for water and soil pollution by heavy metals in the rivers running close to these open pit mines after autumn and spring rains. This justifies the need for long term and sustainable monitoring of the area of the water basins of these unused mines in order to estimate its acid drainage. The imaging spectroscopy combined with in-situ investigations is proved to provide reliable results about the area of the water table. In this study we have investigated multitemporal data gathered by remote sensing which allowed us to make conclusions about the year behavior of both areas. The team expects that the results of this research will help in the rehabilitation process of the inactive mines and will provide the local authorities engaged in water quality monitoring with a tool to estimate the possible damage caused to the local rivers and to the soils in the neighboring areas.

ОЦЕНКА НА ПРОМЯНАТА НА ВОДНИТЕ ПЛОЩИ ПО ДАННИ ОТ ДИСТАНЦИОННИ ИЗСЛЕДВАНИЯ ЗА НЕРАБОТЕЩИТЕ РУДНИЦИ МЕДЕТ И КРЕМИКОВЦИ

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РЕЗЮМЕ. Изоставените открити рудници създават сериозен екологичен риск за региона, където са разположени. Това важи в голяма степен за качеството на водата, тъй като валежите заедно с подземните води запълват откритията рудник и образуват водно тяло с различна площ, дълбочина и химичен състав. Примери за такива открити неработещи рудници са Медет (медна руда) и Кремиковци (желязна руда). Има много случаи, в които водата и почвата са замърсени с тежки метали от протичащите в близост реки до тези открити рудници, особено след обилни есеннни и пролетни дъждове. Това обосновава необходимостта от дългосрочно и устойчиво наблюдение на района на формираните водоеми в тези неексплоатирани рудници, за да се оцени промяната на pH на водата. В настоящото изследване са използвани многоканални изображения, комбинирани с in-situ измервания, за които е доказано, че предоставят надеждни резултати за площта на водното тяло. В това проучване сме използвали времева поредица данни, събрани чрез дистанционни изследвания, което ни позволи да направим изводи за целогодишното поведение в двата рудника. Екипът се надява, че резултатите от това изследване ще подпомогнат процеса на рехабилитация на рудници извън експлоатация и ще предостави на местните власти, ангажирани в мониторинга на качеството на водите, инструмент за оценка на възможни щети, причинени на местните реки и почви.

Introduction

All human developed technological processes make sensible impact to the environment. This holds true especially for the mining sites irrespective of the method of their exploitation – open or underground. In both cases huge amount of supernumerary product is generated – top soil, waste rock, and lean ore. According to the EU legislation the "management of mining waste disposal facilities must take into consideration long term environmental issues, because these structures will more than likely survive both the mine and the mining company" (*BRGM*, 2001). In this study we focus our research on the long term impact of the water basins formed into two of abandoned mines in Bulgaria – a copper one and a ferrous one. The mentioned water started to accumulate into the pit of copper non-operating mine Medet since 1996 and into the pit of ferrous inoperative mine Kremikovtsi since 2000. The above mentioned observation was ascertained first by multispectral data from remote sensing and after that by in-situ inspection too. In the past decade based on the same data and auxiliary ones we observed a steady increase of the area occupied by water table at both sites. The conclusions we make as results of this study are solely based on the satellite and aerial data since the region where the abandoned mines are located is considered to be of restricted access because it is inside of the mining complexes. In the framework of this research our main task was to estimate the approximate areas inside the pits filled by the water. We believe that this information would help in making future assessments on the possible effect on aquifer/s in the area and on the hydrographic network in the region. Because of lack of data collected from the water basins

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СПЕКТРАЛЕН ПОДХОД ЗА ОЦЕНКА НА ЗЕМЕДЕЛСКА РАСТИТЕЛНОСТ ПРИ СТРЕСОВИ УСЛОВИЯ НА ОТГЛЕЖДАНЕ

Румяна Кънчева, Георги Георгиев, Деница Борисова

Резюме. Съвременните насоки в изучаването на околната среда са до голяма степен свързани с глобални екологични проблеми, произтичащи от антропогенното въздействие върху биосферата и преди всичко върху растителността. Взаимосвързаният характер на повечето екологични проблеми налага необходимостта от осъществяване на междудисциплинарни изследвания и приложение на различни подходи, обмен на информация и съвместяване на данни от различни източници. Съвременните дистанционни технологии за наблюдение и ранно предупреждение, навременно извличане на информация и използването ѝ за моделиране и прогнозиране са предпоставка за вземане на решения по належащи екологични въпроси. Такива значими въпроси са управлението на природните ресурси, опазването на екосистемите и съхранение на биоразнообразието. Дистанционните изследвания използват спектрални характеристики на обектите за оценка на тяхното състояние и изменение под влиянието на фактори от околната среда. В настоящата работа се разглежда използването на различни спектрални признаци за оценка на състоянието на земеделски култури при стресови условия на отглеждане. Изведени са регресионни модели, свързващи растежните параметри със спектрални индикатори на състоянието. Анализирана е възможността на спектрометричните данни за количествена оценка на стресовото влияние на хранителния дефицит и замърсяването с тежки метали.

Ключови думи: дистанционни изследвания, спектрални характеристики, вегетационни индекси, растежни параметри, стрес, тежки метали, хранителен дефицит

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ОЦЕНКА НА ХЛОРОФИЛНОТО СЪДЪРЖАНИЕ И УСТАНОВЯВАНЕ НА СТРЕС ПО ОПТИЧНИТЕ СВОЙСТВА НА РАСТИТЕЛНОСТ

Румяна Кънчева, Деница Борисова. Георги Георгиев

Резюме. Растителният мониторинг е едно от основните приложения на дистанционните изследвания. По отношение на земеделските земи основна цел е да се оцени състоянието на културите по време на вегетационния процес. Методите за дистанционни изследвания използват многоспектрални данни за определяне на растителни биофизични и биохимични характеристики чрез установяване на количествени връзки между растежните показатели и спектралниге свойства на културите. Като физиологичен показател съдържанието на хлорофил е важен биопараметър за оценка на развитието и състоянието на растенията. В настоящата работа представяме някои резултати от наземни спектрометрични изследвания на различни земеделски култури. Данните са използвани за оценка на способността и точността на различни спектрални показатели да служат за определяне на хлорофилното съдържание. Коефициенти на отражение, вегетационни индекси, червената граница на хлорофилното поглъщане, спектри на пропускане, флуоресцентно излъчване и цветови характеристики на растенията са статистически съпоставени с хлорофилното съдържание, за да бъде изследвана значимостта на измененията на спектралните характеристики като функция от пигментните измения. Получената висока корелация е позволила извеждането на достоверни количествени съотношения между хлорофила и различни спектрални признаци. Тези зависимости са използвани за оценка на състоянието на растенията и установяването на стрес от гледна точка на хлорофилното съдържание.

Ключови думи: растителност, хлорофил, стрес, спектрални характеристики, вегетационни индекси.

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DERIVING INFORMATION ON WINTER WHEAT PERFORMANCE FROM IN-SEASON VARIATIONS OF CROP CANOPY REFLECTANCE

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Keywords: *winter wheat, spectral reflectance, vegetation indices, phenology, seasonal spectral response, growth variables, yield prediction*

Abstract: *Agricultural monitoring is an important and continuously spreading activity in remote sensing and applied Earth observations. It supplies valuable information on crop condition and growth processes. Much research has been carried out on vegetation phenology issues. In agriculture, the timing of seasonal cycles of crop activity is important for species classification and evaluation of crop development, growing conditions and potential yield. The correct interpretation of remotely sensed data, however, and the increasing demand for data reliability require ground-truth knowledge of the seasonal spectral behaviour of different species and their relation to crop vigour. For this reason, we performed ground-based study of the seasonal response of winter wheat reflectance patterns to crop growth patterns. The goal was to quantify crop seasonality by establishing empirical relationships between plant biophysical and spectral properties in main ontogenetic periods. Phenology and agro-specific relationships allow to assess crop condition during different portions of the growth cycle and thus effectively track plant development and make yield predictions. The applicability of different vegetation indices for monitoring crop seasonal dynamics, health condition, and yield potential was examined.*

ИЗВЛИЧАНЕ НА ИНФОРМАЦИЯ ЗА РАЗВИТИЕТО НА ЗИМНА ПШЕНИЦА ПО СЕЗОННИ ИЗМЕНЕНИЯ НА СПЕКТРАЛНОТО ОТРАЖЕНИЕ НА РАСТЕНИЯТА

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Ключови думи: *зимна пшеница, спектрални характеристики, вегетационни индекси, сезонна динамика, фенология, параметри на състоянието, прогнозиране на добивите*

Резюме: *Мониторингът в селското стопанство е важно и широко разпространено приложение на дистанционните изследвания, което предоставя ценна информация за състоянието на посевите и процеса на развитието им. Множество изследвания са посветени на въпроси на фенологията. Сроковете и ходът на вегетационната активност са важни при използването на дистанционни данни за класификация на културите, за оценка на тяхното развитие, условията на отглеждане и потенциалния добив. Правилната интерпретация на данните от дистанционните изследвания, както и изискването за по-голяма надеждност на информацията, налагат подробно наземно изучаване на сезонната динамика на спектралните характеристики на различните култури и установяване на връзката им със състоянието на посевите. Поради тази причина са проведени полеви експерименти, чрез които да се проследи сезонния ход на биофизичните и спектралните отражателни характеристики на зимна пшеница. Целта е да се изследват и опишат количествените връзки между биометричните параметри и спектралните свойства на посевите в различни фенологични фази на развитие. Тези зависимости позволяват оценка на състоянието на растенията в различни периоди на вегетаиця, което осигурява ефективно проследяване на сезонната динамика на растежа и по-голяма точност на прогнозирания добив.*

Introduction

The rapid advances of space technologies concern almost all scientific areas from aeronautics to medicine and a wide range of application fields from communications and hazard warning to crop yield prediction. Without a doubt, vegetation monitoring is the most essential application of remote

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АНАЛИЗ НА ГРЕШКИТЕ В СПЕКТРОМЕТРИЧНИТЕ ИЗМЕРВАНИЯ

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Ключови думи: *дистанционни изследвания, видеоспектрометрични системи, неопределености, грешки.*

Резюме: *Спектрометричните измервания се характеризират с огромни възможности по отношение на получаваната информация. Същевременно за да бъдат реализирани тези възможности е необходимо да бъде отстранено влиянието на множество допълнителни ефекти и грешки върху резултатите от измерванията. В работата са разгледани различните източници на лъчение, участващи в формиране на общата мощност на регистрираното от прибора отразено лъчение. Анализирани са и е направена е систематизация на грешките от тези източници и са посочени пътищата за тяхното намаляване и отстраняване. Приведена е класификация на на грешките по определени критерии.*

ERROR ANALYSIS IN THE SPECTROMETRIC MEASUREMENTS

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Keywords: *remote sensing, imaging spectrometer, uncertainties, errors.*

Abstract: *Spectrometric measurements are characterized by a huge potential in terms of the received information. However, to be realized these opportunities need to be removed the influence of a number of additional effects and errors on the measurement results. In the paper are discussed various radiation sources involved in the formation of the registered irradiation. Errors from these sources are analyzed and classified according to specific criteria and are listed ways for their reduction and elimination.*

Въведение

През последните десетилетия дистанционните изследвания се наложиха като водеща научна област и мощен инструмент в изучаването на земната повърхност. Получаваната информация се използва успешно в редица важни области, като геология, селско стопанство, картография, военно дело, екология и др. Кръгът от приложения на дистанционно получени спектрални данни и изображения непрекъснато се разширява, включвайки нови области, като екологичен мониторинг на застрашени зони, мониторинг на глобалните промени на природните ресурси и околната среда, промени в климата и др.

Водещо място в дистанционните изследвания заемат спектрометричните измервания. Съществуващият огромен потенциал на тези изследвания може да бъде използван пълноценно само при наличието получени с висока точност и прецизност спектрални данни и изображения. Това условие, за съжаление, не може да бъде изпълнено априори и първоначално при получаване на суровите данни. Напълно основателно е широко разпространено мнение в

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КОРИГИРАНЕ НА ГРЕШКИТЕ В СПЕКТРОМЕТРИЧНИТЕ ИЗМЕРВАНИЯ

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***Ключови думи**: дистанционни изследвания, видеоспектрометрични системи, неопределености, грешки, корекции на грешките.*

***Резюме:** В работата се разглежда проявлението на грешките в спектрометричните измервания като функция от различните източници на генериране. Направено е разделяне на грешките в зависимост от източниците, което позволява декомпозиране и набелязване на разделни методи за намаляване и елиминиране на отделните съставни. Предложени са алгоритми за корекция на грешките, позволяващи оптимизация на характеристиките на прибора в етапите на разработване и производство и планиране на методи и процедури за намаляване или елиминиране на отделните съставящи.*

ERROR CORRECTIONS IN THE SPECTROMETRIC MEASUREMENTS

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***Keywords:** remote sensing, videospektrometrichni systems uncertainties, errors, corrections of errors.*

***Abstract:** In the paper are examined the appearance of errors in the spectrometric measurements as a function of the various sources of generation. A error partitioning is made depending on the sources, allowing decomposition and identification of separate methods for the reduction and elimination of the component. Error correction algorithms are proposed, allowing optimization of the device characteristics in the stages of development and production and are planning methods and procedures to reduce or eliminate the separate components.*

Въведение

Корекцията на грешките при спектрометричните измервания е изключително сложна задача. Самият процес на оценка и коригиране на грешките започва още с конструирането и изработването на спектрометричен прибор. Включва последователно етапите на калибриране, верификация и валидиране на характеристики и данни. Тези етапи продължават и след изработването на прибора през така наречения експлоатационен период. През този период корекцията на грешките се осъществява на нови два етапа – в лабораторни условия и на терен (или на борда на носителя) по време на работа на прибора. От казаното може да се направи заключение, че процесите на корекция или по общо казано, предварителна обработка, съпътстват целият период на съществуване на прибора.

Analysis of spectrometric optical data from different devices

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ABSTRACT

Remote sensing is a general tool to investigate the different areas of Earth and planets. The development of the implementation capabilities of the optoelectronic devices which are long-term-tested in the laboratory, in the field and are mounted on-board of the remote sensing platforms further improves the capability of instruments to acquire information about the Earth and its resources in different scales. Remote sensing application in the Earth observation begins with the design and the assembling of equipment for carrying out research of the monitored objects remotely and without disturbing their integrity. Ground-truth data in the Earth observation of the environment and in the remote sensing investigations are very important. Remote sensing methods for studying of rocks and minerals are closely related to current programs for the mineral and chemical composition study of the Earth, Mars and Phobos surfaces. The experience and the knowledge from previous experiments in space missions encourage us to continue our efforts to acquire spectral data using different remote sensing systems and to compare the obtained results. The main goal in the geological remote sensing is the determination of the chemical and/or mineral composition and the structure of the rocks. For this purpose the laboratory and the field spectroscopy measurements are performed. These measurements are made to collect, compile and complete guide with spectral characteristics of different rocks for their reliable identification and for the determination of their mineral and chemical composition. The experiments are based on major physical principles such as light scattering, absorption of light, and reflection of light in the electromagnetic spectrum. For the purpose of present paper ex-situ spectroscopy measurements of the granites and their rock-forming minerals from the territory of Bulgaria in visible and near infrared (VNIR) range of the electromagnetic spectrum were performed using following spectrometric systems: SRM, 0.4-0.82 micrometers; SPS-1, 0.55-1.1 micrometers, Thematically Oriented Multi-channel Spectrometer /TOMS/, 0.4-0.9 micrometers, all of them designed and constructed in Remote Sensing Systems /RSS/ Department at SRTI-BAS. The obtained spectral data are compared with similar data from different instruments for Earth observation included in the spectral libraries. They correspond to the shape of the spectral signature in the same spectral range obtained with other spectrometers. Two wavelengths were selected and were applied for the proper comparison between the data obtained by different instruments. The dependence between the reflectance values at the chosen wavelengths and the quantitative content of the rock-forming minerals was established. The achieved results proved that this methodology could be applied for comparing the spectral data from different sources. These promising results encourage us to plan the next campaigns for the field spectroscopy measurements in different regions of Bulgaria.

Keywords: optical data, multi-source data, remote sensing data analysis

1. INTRODUCTION

Remote sensing methods for studying of rocks and minerals are closely related to current international programs for the mineral and chemical composition studies of the Earth, Moon, Mars and Phobos surfaces. For the purpose of the present paper ex-situ spectroscopy measurements of the granites and their rock-forming minerals from the territory of Bulgaria in the visible and near infrared (VNIR) range of the electromagnetic spectrum (EMS) are performed using following optical spectrometric systems in selected ranges: SRM, 0.4-0.82 micrometers; SPS-1, 0.55-1.1 micrometers, and Thematically Oriented Multi-channel Spectrometer /TOMS/, 0.4-0.9 micrometers. All the systems have been developed in RSS at SRTI-BAS. The obtained spectral data are compared with similar data from different instruments for Earth observation included in the spectral libraries. They correspond to the shape of the spectral signature in the same spectral range obtained with other spectrometers. For proper comparing of the spectrometric optical data obtained using different devices two wavelengths are selected. The dependence between the reflectance values at the chosen wavelengths and the quantitative content of the rock-forming minerals in the granites is established and analysed. The achieved results proved that this methodology could be applied for comparing the spectral data from different sources.

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Algorithms for lineaments detection in processing of multispectral images

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ABSTRACT

Satellite remote sensing is a universal tool to investigate the different areas of Earth and environmental sciences. The advancement of the implementation capabilities of the optoelectronic devices which are long-term-tested in the laboratory and the field and are mounted on-board of the remote sensing platforms further improves the capability of instruments to acquire information about the Earth and its resources in global, regional and local scales. With the start of new high-spatial and spectral resolution satellite and aircraft imagery new applications for large-scale mapping and monitoring becomes possible. The integration with Geographic Information Systems (GIS) allows a synergistic processing of the multi-source spatial and spectral data. Here we present the results of a joint project DFNI I01/8 funded by the Bulgarian Science Fund focused on the algorithms of the preprocessing and the processing spectral data by using the methods of the corrections and of the visual and automatic interpretation. The objects of this study are lineaments. The lineaments are basically the line features on the earth's surface which are a sign of the geological structures. The geological lineaments usually appear on the multispectral images like lines or edges or linear shapes which is the result of the color variations of the surface structures. The basic geometry of a line is orientation, length and curve. The detection of the geological lineaments is an important operation in the exploration for mineral deposits, in the investigation of active fault patterns, in the prospecting of water resources, in the protecting people, etc. In this study the integrated approach for the detecting of the lineaments is applied. It combines together the methods of the visual interpretation of various geological and geographical indications in the multispectral satellite images, the application of the spatial analysis in GIS and the automatic processing of the multispectral images by Canny algorithm, Directional Filter and Neural Network. Landsat multispectral images of the Eastern Rhodopes in Bulgaria for carrying out the procedure are used. Canny algorithm for extracting edges represents series of filters (Gaussian, Sobel, etc.) applied to all bands of the image using the free IDL source. Directional Filter is applied to sharpen the image in a specific preferred direction. Another method is the Neural Network algorithm for recognizing lineaments. The lineaments are effectively extracted using different methods of automatic. The results from the above mentioned methods are compared to the results derived from the visual interpretation of satellite images and from the geological map. In conclusion, the rose-diagrams of the distribution of the geological lineaments and the maps of their density are completed.

Keywords: processing algorithms, analysis of multispectral images, geological hazards, Eastern Rhodopes, lineaments

1. INTRODUCTION

The objects of this study are linear structures (lineaments) in a part of Eastern Rhodopes (Figure 1). Eastern Rhodopes occupy a small part of the Rila-Rhodope massif and covers 5839 km^2. The area of region of interest (RoI) is 36 km^2. In RoI lower and highly segmented north part and higher and a massive southern part are distinguished. The character of the relief is hilly (72% of total area) and mountain (about 24% of the total area). Altitudes above 1000 m occupy only 1% of the whole area, and flat terrains - 3%. The average altitude is only 320 m, and increases from North to South[1].

The main goal is to determine the lineaments in the study area using algorithms for analyzing remote sensing data (Canny algorithm, Directional Filter and Neural Network) in GIS software. The following main tasks are performed:

- Implementation of various algorithms on a Landsat ETM+ image.
- Detection and analysis of lineaments.
- Map of lineaments density.

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A framework for air quality monitoring based on free public data and open source tools

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ABSTRACT

In the recent years more and more widely accepted by the Space agencies (e.g. NASA, ESA) is the policy toward provision of Earth observation (EO) data and end products concerning air quality especially in large urban areas without cost to researchers and SMEs. Those EO data are complemented by increasing amount of in-situ data also provided at no cost either from national authorities or having crowdsourced origin. This accessibility together with the increased processing capabilities of the free and open source software is a prerequisite for creation of solid framework for air modeling in support of decision making at medium and large scale. Essential part of this framework is web-based GIS mapping tool responsible for dissemination of the output generated.

In this research an attempt is made to establish a running framework based solely on openly accessible data on air quality and on set of freely available software tools for processing and modeling taking into account the present status quo in Bulgaria. Among the primary sources of data, especially for bigger urban areas, for different types of gases and dust particles, noted should be the National Institute of Meteorology and Hydrology of Bulgaria (NIMH) and National System for Environmental Monitoring managed by Bulgarian Executive Environmental Agency (ExEA). Both authorities provide data for concentration of several gases just to mention CO, CO_2, NO_2, SO_2, and fine suspended dust (PM10, PM2.5) on monthly (for some data on daily) basis. In the framework proposed these data will complement the data from satellite-based sensors such as OMI instrument aboard EOS-Aura satellite and from TROPOMI instrument payload for future ESA Sentinel-5P mission. Integral part of the framework is the modern map for the land use/land cover which is provided from EEA by initiative GIO Land CORINE. This map is also a product from EO data distributed at European level.

First and above all, our effort is focused on provision to the wider public living in urbanized areas with one reliable source of information on the present conditions concerning the air quality. Also this information might be used as indicator for presence of acid rains in agriculture areas close to industrial or electricity plants. Its availability at regular basis makes such information valuable source in case of manmade industrial disasters or incidents such as forest fires. Key issue in developing this framework is to ensure the delivery of reliable data products related to air quality at larger scale that those available at the moment.

Keywords: air quality, large scale map, air quality modeling, free and open source software, public awareness

1. INTRODUCTION

Air quality in urbanized areas is the most tangible issue everyone is facing. Its long and short term the impact on the health of the people living in the mentioned areas is undisputable and data show that due to *particles in the air reduce average life expectancy by eight months and in some areas even by 36 months*[1]. Particulate matter (PM) and some gaseous pollutants, such as O_3, NO_X and SO_2, have been recognized as key environmental problem in many cities around the world.

The air pollutants originate from almost all economic and societal activities. Due to efforts for implementation of restrictive policies at the European, national and sectoral level have over time resulted in decreased emissions of many air pollutants and have led to acceptable air quality levels across Europe for some pollutants, e.g. CO and Pb. Still as main pollutants considered are the following: road transport, industry, power plants, households and agricultural

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A Comparison of Image Segmentation Algorithms

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Abstract

When it comes to remote sensing, recognizing each object is a top priority. The identification of the land cover with a satellite image, for instance, is very important for the agriculture, the transport and for most of the economics spheres. In general, the image segmentation is known as a basic option for the process of classification. Moreover – it works as an improving element for the performance, as well as for the accuracy.

The graph theory is a significant data that determines all the algorithmic process of the image process. The abstract results and theories provide a support in analysis of methods. This article explains four particular algorithms that are both – compared and examined – due to the fact that they are graph-based image segmentations. To be more specific the best ones merge algorithm of Beaulieu, Goldberg and Tilton, while tree merge segmentation of Felzenszwalb, minimum mean cut segmentation of Wang and Siskind. Last, but not least, we need to mention the normalized cut algorithm of Shi and Malik. The creators of this article will explain the basic theory and the execution of the algorithm segmenting in details. Plus – they will meet you with several eventual improvements to accomplish.

Introduction

The main role behind the image processing is to provide the recognition of the shapes and objects in an image. On the other side, in this process a segment has a significant role. A segment is actually a homogenous and adjacent part of any image. Taking a survey of a running image processing application, it becomes clear that examining, refining and combining of already outlined segments are featured. Meanwhile, the delineation of the segments, which is the previous process, is momentous, too, when it comes to the quality of the results. Reading this article, you will get familiar with four segmentation algorithms, as well as the comparisons of their different basic theories, as well the practical implementation and experience achieved during their application.

The main goal behind this article is to make a comparison between efficiency and effectiveness of several image segmentation algorithms, which are graph-based. In the beginning, we will speak over the role of the segmentation in remote sensing. Then, we will continue with the basic information about the four chosen graph-based segmentation algorithms. Last, but not least, we will present the results from the experiments.

The important meaning of segmentation in remote sensing

The digital image process is extremely important for numerous areas in today`s life. Mainly, we can point you the most significant ones – Earth observation, as well as the medical science. The basic goal of any image processing system is to identify all of the elements from the "reality" in an image. There are several alternatives for a resolution of this harsh chore. Despite the different types of images, as well as the kinds of their acquisition and processing, several general methods, known as "building blocks" exist. The process of object recognition is executed after performing a

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Detection of minerals using spectrometric measurements

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Keywords: remote sensing, spectral reflectance, minerals

Abstract
Spectrometric measurements as a part of remote sensing are used for different practical investigations. The objective of the present paper is to check the possibility of the spectrometric measurements for detection of minerals. In the present investigations laboratory spectral reflectance measurements of the iron-containing minerals in the visible and near infrared (VNIR) range of the electromagnetic spectrum are performed. For the interpretation of the obtained spectrometric data and establishing of the dependence between the content of the iron in the minerals and the reflectance value spectral transformations are used. In brief, spectrometric measurements when properly used are a helpful technique for detection of the minerals.

Спектрометрични измервания за определяне на минерали

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Ключови думи: дистанционни изследвания, спектрални характеристики, минерали

Резюме
Спектрометричните измервания, като част от дистанционните изследвания, се използват за различни проучвания с практическо приложение. Целта на настоящата работа е да се провери възможността на спектрометричните измервания за разпознаване на минерали, респективно полезни изкопаеми. В рамките на настоящото изследване са проведени лабораторни спектрометрични измервания на минералите, съдържащи желязо, във видимата и близката инфрачервена (VNIR) област от електромагнитния спектър. За тълкуването на получените спектрометрични данни и за установяването на зависимостите между съдържанието на желязо в изучаваните минерали и отражателната способност се използват спектрални преобразувания. Обобщено, спектрометричните измервания, когато се използват правилно, са полезен начин за разпознаване на минерали.

Introduction

In the 1960's laboratory study conducted mainly by Graham Hunt and John Salisbury (Hunt and Salisbury, 1970) made the pioneering laboratory reflectance measurements of reflectance variations from mineral and rocks. Their research at the Air Force Cambridge Laboratory demonstrated the potential for remote detection of important rock elements and specific minerals. They published their laboratory spectral measurements in Modern Geology. Most of their laboratory spectra were measured under controlled conditions using dry, powdered samples of relatively pure mineral substances from a wide variety of localities which are described. Their work is in the basis of the development of spectral libraries by the U. S. Geological Survey (USGS) and the Jet Propulsion Laboratory (JPL) of the California Institute of technology (CIT).

In the 1960's and 1970's study with laboratory spectrometers determined that minerals associated with mineral deposits have discrete spectral signatures that should allow their detection and mapping in the field. Research in the 1970's found that clays and iron oxides, associated with mineralized systems, could be detected in multiband image data and mapped using their broad spectral signatures. Beginning in the 1980's, study with prototype airborne imaging spectrometer data and ground-based spectrometers recognized groups

НАЦИД

Тема: Изследване на спектралните отражателни характеристики на скали

Анотация: Целта на работата е да се предложи методика за спектрометрични измервания, чрез която да се създаде спектрална библиотека (СБ) /база данни от спектрални отражателни характеристики (СОХ)/ за вида скали от територията на България и минералния им състав, което е от значение за калибриране на аерокосмически сензори за дистанционни изследвания на природни ресурси, опазване на околната среда, геофизиката, петрографията, минералогията и сравнителната планетология. Избрани са интервали от електромагнитния спектър, които са най-подходящи за разпознаване на скали по спектрални данни. Предложен е контрастен коефициент за количествено определяне на разлики в СОХ на видовете скали. Количественото определяне на контрастния коефициент е извършено чрез симулационно моделиране на спектрални смеси. Разработени са специфични спектрални преобразувания за количествено определяне на цветовите характеристики на скали. Предложена е методика за обработка и сравнителна интерпретация на спектралните данни от спектрометричните измервания на скали, която включва сравнителен анализ на: 1) първичните спектрални данни от различни спектрометри; 2) получените експериментални спектрални данни с еталонни такива от спектрални библиотеки; 3) СОХ на групите обекти: минерали, скали, почва, растителност. Генерирана е база данни от първични спектрални измервания за скали въз основа на получените резултати от спектрометричните измервания. Създадена е СБ на изследваните скали

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Remote Sensing Methods in Studying Stone Quarries

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SUMMARY

In Engineering and Environmental Geophysics different methods and techniques are applied. In this paper a remote sensing method has been tested in the segmentation of human made land covers such as open pit mines and stone quarries. The idea is to exploit to larger extent the possibilities offered by multispectral imagers having mind Thematic Mapper /TM/ onboard satellite series Landsat. The method has been used in the framework of our research is to find consistent statistical dependencies between multispectral data gathered in-situ and the corresponding ones in the images offered by airborne-based sensors. After correct identification of the pixels the subsequent segmentation forming the shape of the artificial feature is determined much more reliable. We have been combined ground spectrometry of stone quarry near Smolsko village, Landsat images of region of interest /RoI/, and in-situ condition surveys for assessment of the quarry area. For the purpose of the study geological observations, petrographical investigations, photo documentation and in-situ spectrometric measurements have been performed.

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27005

Remote Sensing Techniques In Soil Degradation Detection

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SUMMARY

Soil salinization as a result of natural or human-induces processes is a serious global-scale problem. Numerous studies and efforts in assessing and controlling soil salinity have been made. Nearly sixty percent of the salt-affected soils around the world are in irrigated farmlands, and this trend is increasing. Salinization is a major reason for degradation of soil resources and decline of soil fertility. From an ecological and economic point of view it is extremely important to establish the occurrence and distribution of soil salinization as well as the intensity of the process. Remote sensing techniques are widely used in soil surveys to detect and map salt-affected areas. However, many constrain in monitoring and evaluating the spatial and temporal variability of the salinization process has been found out. Difficulties also arise in applying remote sensing to the assessment of slightly affected soils. The goal of this paper is to examine the spectral reflectance properties of soils with different degree of salinization and the feasibility of using spectral indicators derived from Vis/NIR data as detectors of salt-affected soils and quantitative estimators of soil salinity level.

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ПРИЛОЖЕНИЕ НА СИСТЕМА ЗА ДИСТАНЦИОННО ИЗСЛЕДВАНЕ

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БЪЛГАРИЯ

Ключови думи: *обработка на изображения, анализ на изображения, полуавтоматизирана система, откриване на обекти*

Резюме: *Представените алгоритми, методи и подходи за обработка на изображения са подходящи за решаването на поставената задача. Системата е съвкупност от алгоритми, които вече са били разработени и техните положителни и отрицателни черти са известни. Те са приложени по оптимален начин в ясна и логична последователност, която е съществена за полуавтоматизираната система. Полуавтоматизираният процес значително повишава степента на откриване на обектите, наблюдавани в изображението, спестявайки време и средства на крайния потребител, в случай, че се решава конкретен проблем. Обработката и анализът на изображенията е с крайна цел сравнение и анализ на резултатите, относно наблюдаваните характеристики на обектите в изображението. Представената система притежава ясна практическа насоченост.*

ВЪВЕДЕНИЕ

Пътната сигнализация и знаци ни предават различни съобщения, касаеща се за състоянието на пътя и за това какво могат да очакват шофьорите. По тази причина, ако бъдат спазвани правилно, те спомагат за поддържането на дисциплината по пътищата. Поставянето им става по начин, който да е във видимостта на шофьорите, което им помага да преценят пътната обстановка, както е описана на знака и ако се налага да променят скоростта [1].

Разпознаването на пътни знаци в дадено изображение е от особено значение, защото това слага основа на разработването на автоматизирани или полуавтоматизирани системи, които биха позволили на водача да бъде подадена информация за знака, неговото значение и т.н., докато управлява превозното средство. Такава информация би била полезна, ако е актуална, получена навреме, правилно анализирана и прецизно интерпретирана. Такива системи са в процес на разработка и представената работа има за цел да представи един от начините, по които може да се осъществи бързо и ефективно разпознаването на обект, и по-точно: пътни знаци, които се наблюдават в изображение (не във видео-поток).

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СПЕКТРАЛНА ХАРАКТЕРИЗАЦИЯ НА ВИДЕОСПЕКТРОМЕТРИЧНИ ПРИБОРИ

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Ключови думи: *видеоспектрометри, спектрална характеризация, алгоритми*

Резюме: *В работата са систематизирани основни прилагани подходи и получавани резултати при изпълнение на процедури за спектрална характеризация на видеоспектрометрични прибори в лабораторни условия. Описани са главните спектрални характеризационни функции на инструментите от този клас и методите за тяхното определяне. Представени са част от резултатите, получавани в процеса на лабораторна характеризация на видеоспектрометри с висока спектрална и пространствена разделителна способност (хиперспектрални прибори). Въз основа на анализ на получените резултати е синтезиран и предложен примерен алгоритъм за спектрална характеризация на видеоспектрометрични прибори.*

SPECTRAL CHARACTERIZATION OF IMAGING SPECTROMETRIC DEVICES

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Keywords*: imaging spectrometers****,*** *spectral characteristics, procedures for spectral characterization*

Abstract: *In the article are considered and systematized basic approaches and applied procedures for spectral characterization of imaging spectrometer devices . The main spectral characteristics of the instruments and methods for their determination are described. A part of the results obtained in the characterization process of the imaging spectrometers with high spectral and spatial resolution (hyperspectral instruments) are shown. Based on analysis of results is proposed an exemplary algorithm for spectral characterization of imaging spectrometer devices.*

1. Въведение

Видеоспектрометрите са прибори за получаване на спектрални изображения в няколко или десетки или стотици (хиперспектрални прибори) спектрални ленти от електромагнитния спектър. Посредством измерването на пристигащото лъчение от всеки пространствен елемент на наблюдаваната повърхност може да бъде направена директна или индиректна идентификация на наблюдаваните обекти от повърхността, използвайки специфичните им молекулярни абсорбционни свойства. Пространствената съставна на получените данни позволява изграждане на карта на повърхността с тяхното количествено разпределение. При хиперспектралните прибори тези данни се отличават с висока спектрална и пространствена разделителна способност [1,2].

2. Основни спектрални характеризационни функции

Спектралната характеризация се използва за верификация на основните спектрални функции на видеоспектрометрични прибори. Като такива се явяват спектрална характеристика на чувствителност, спектрална дисперсна функция, спектрална разделителна способност и др.

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РАДИОМЕТРИЧНА ХАРАКТЕРИЗАЦИЯ НА ВИДЕОСПЕКТРОМЕТРИ

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Ключови думи: *видеоспектрометри, радиометрична характеризация, алгоритми*

Резюме: *В работата са описани основни характеристики на видеоспектрометрични прибори влияещи върху радиометричната точност на инструментите, посочени са методите за тяхното определяне и са представени са част от резултатите, получавани в процеса на лабораторна характеризация на видеоспектрометри с висока спектрална и пространствена разделителна способност. Резултатите са обобщени в предложен примерен алгоритъм за радиометрична характеризация на видеоспектрометрични прибори.*

RADIOMETRIC CHARACTERIZATION OF IMAGING SPECTROMETERS

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Keywords*: imaging spectrometers, radiometric characteristics, procedures for radiometric characterization*

Abstract: *In this work are described basic radiometric characteristics of imaging spectrometers defining radiometric accuracy of the instruments and are referred the methods for their determination. A part of the results obtained in the process of laboratory imaging spectrometers characterization are presented. The results are summarized in a proposed algorithm for radiometric characterization of imaging spectrometer devices.*

1. Въведение

Видеоспектрометрите се установиха като основен инструмент за изследване на повърхността на Земята. Високата спектрална и пространствена дименсионалност на тези прибори прави възможно отделяне на тесни спектрални линии или част от области от електромагнитния спектър, присъстващи в повечето обекти от изследваната повърхност. Такава мощна възможност, която позволява един задълбочен анализ на физическите, биологични и биофизични процеси, а също така и на динамиката на тези процеси, е особено важна за приложенията на дистанционните изследвания [1,2].

Едни от най-важните характеристики с които се описват подобни прибори са характеристиките, свързани с определяне на радиометричните му показатели. Без подходящи приети методи за отнасяне на измерените фотони към стойностите на радиацията на входа на прибора снетите данни не биха могли да бъдат използвани от научната и управленчестата общности. Методите, отнасящи се до тези количествени съотношения включват калибрационния процес като връзка между тези величини. Терминът калибриране е използван често като един по общ термин за означаване на комплексните процеси за характеризация, калибриране и потвърждаване (validation) на основните технически характеристики на прибора. Характеризационният процес предполага установяване на отклика на инструмента по отношение на пристигащата на входа на сензора радиация [1,2,3]. Необходимо е да се отбележи, че този процес не може да бъде използван за отстраняване или компенсиране на евентуални не добри технически характеристики на системата, детерминирани от етапите на конструиране. Крайният резултат от този процес е получаване на един относително независим от сензора сигнал, който може да бъде използван за бъдещи анализи в спектроскопията.