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OPTICAL AND RADAR IMAGE PROCESSING FOR VEGETATION EFFECTS MONITORING

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***Abstract**: Drought is one of the major natural calamities causing important damages to natural vegetation, agriculture and the society. Therefore, climate changes from recent years set the vegetation monitoring as the highest priority in Romania among the other strategies. In this study, optical data gathered by different sensors were used for extracting the Leaf Area Index (LAI), NDVI and hydric and thermal stress, while from radar data the surface soil moisture was estimate science that retrieving soil moisture with Synthetic Aperture Radar (SAR) measurements depends on soil texture, surface roughness and vegetation cover. Radar and optical data sensor integration provide reliable information about vegetation effects.*

***Key words:** remote sensing, NDVI, plant water content, vegetation monitoring*

1. INTRODUCTION

Vegetation monitoring using satellite techniques was starting in Romania sconce 1994 when multitemporal Landsat TM images were processed to classify land cover maps and assess landscape pattern changes. Based on classifications' results, Romanian scientific community was interested to use satellite data in vegetation health monitoring affected by the climate changes, air pollution and human activity.

This study is focused both on vegetation parameter extraction especially on normalized difference vegetation index (NDVI) from SPOT Vegetation images and canopy water content estimation from Radarsat-1 images.

2. METHODOLOGY

The development of vegetation indices is based on differential absorption, transmittance and energy reflectance by vegetation in the red and near-infrared regions of the electromagnetic spectrum. Many studies have been shown that only NDVI is least affected by topographic factors and is an indicative of the plant photosynthetic activity (Burgess et all, 1995; D.P. Roy, 1997).

Normalized Difference Vegetation Index is a non-linear transformation of the visible (red) and near-infrared bands of satellite information that is defined as the difference between the spectral reflectance in near-infrared (NIR) ρ_{NIR} and visible (red) ρ_R bands over their sum (Reed et all, 1994).

$$NDVI = \frac{\rho_{NIR} - \rho_R}{\rho_{NIR} + \rho_R}, \quad NDVI \in [-1,1] \qquad (1)$$

NDVI reduce multispectral measurements to a single value for predicting and assessing vegetation characteristics such as species, leaf area, stress and biomass.

In this paper we use Spot Vegetation multitemporal images acquired during 2008 and 2009 years. VEGETATION is a multispectral instrument on board of the Spot 4 and Spot 5 Earth Observation satellites whose spectral bands were dedicated to vegetation studies. The sensor has a wide field of view (about 1 Km) covering 2400 km area. The first three spectral bands are very similar to the HRVIR and HRV sensors of the previous generation allowing studies, analysis and interpretations in many spatial and temporal scales.

The optical sensor main's disadvantage is his dependence on the weather conditions so that it can be use microwave sensors due to all weather and day/ night measurements capacities and their sensitivity to the soil moisture content (0-5 cm), soil roughness and vegetation effects. To retrieve the surface parameters the models can be divided in three general classes: the theoretical models based on the field (i.e. the physical optical model, the geometrical optics and small perturbation model) (Ulaby et all, 1990) or intensity approaches (i. e. radiative transfer method), the semi-empirical models (a statistical relationship) and SAR interferometry (i.e. correlation). Theoretical models require complex sets of equations with many variables and parameters, so they cannot be easily inverted. SAR interferometry depend both on correlation between images and coherence which can be lost due to high canopy. On the other hand, the semi- empirical model "water-cloud" seems to be the most suitable to use due to very simple sets of equations involving few variables and parameters such as: plant water content or leaf area index for vegetation and the surface soil moisture for the soil.
Simplifying, "water-cloud" model can be express as:

Whole canopy: $$\sigma^o = \sigma^o_{veg} + \tau^2 \sigma^o_{soil} \qquad (2)$$

Vegetation: $$\sigma^o_{veg} = A\cos\theta(1-\tau^2) \qquad (3)$$

$$\tau^2 = \exp(-2Bm_v/\cos\theta) \qquad (4)$$

Soil: $$\sigma^o_{soil} = C + Dm_v \quad (dB) \qquad (5)$$

The variations in the canopy descriptors used in the models that describe canopy backscattering are due to complexity of vegetation structure and to the relative simplicity of these models: there is no general theoretical background allowing to define the best set of canopy descriptors and to predict the values of the A and B parameters. A and B parameters are influenced by geometrical structure of the canopy and are always determined by fitting the models against experimental data sets.

3. RESULTS

3.1 NDVI data

Two sets of the Spot Vegetation images representing the Romania surface area were acquired in Octomber 2008 and March 2009. These images were been processed in ENVI 4.5 and integrated in ArcMap in order to make a cartographic map in Stereo 70 projection. This projection was adopted by the Romanian authorities in 1973 and is still in use. The results are shown in Fig. 1 and Fig. 2.

Vegetation usually has NDVI values in the range from 0.1 to 0.7. Higher index values are associated with higher levels of healthy vegetation cover, whereas clouds and snow will cause index values near zero, making it appear that the vegetation is less green.

3.2 Radar data

During ADAM project (2000 – 2002) 6 RadarSat images (C-band, HH) in low mode at 16^o incidence angle with a spatial resolution of 20 x 20 m^2 were collected. The parameter A and B were estimated from each SAR using in-situ data on the calibration units. The temporal evolution of the vegetation constituents is shown in figure 3.

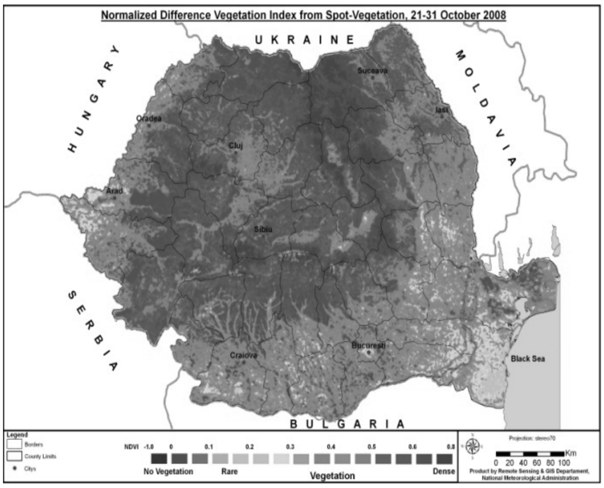

Fig. 1. NDVI from Spot VEGETATION, October 2008

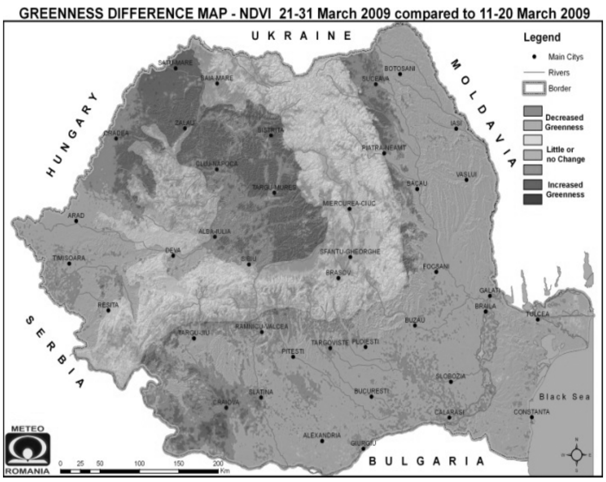

Fig.2. NDVI from Spot Vegetation, March 2009

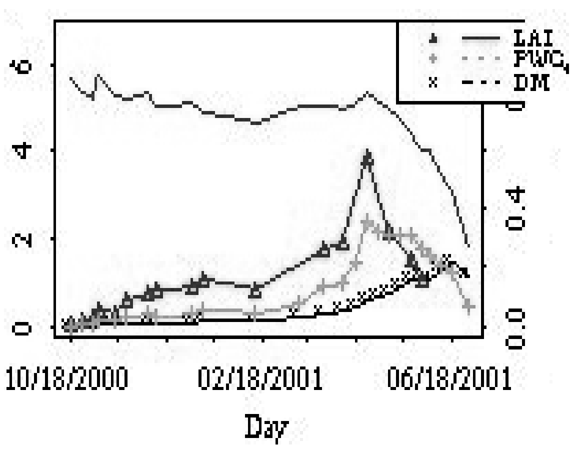

Fig. 3. Vegetation constitutients during 2001 campaign

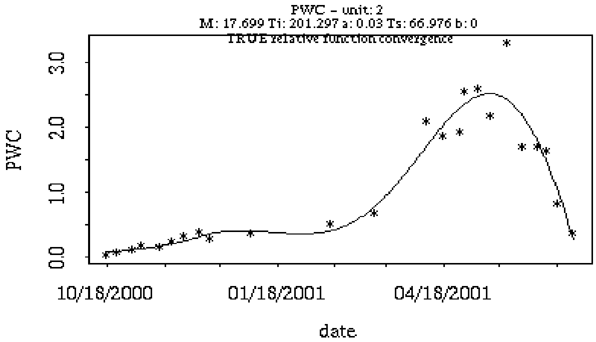

Fig. 4. Plant water content fitted at the acquisition date

The canopy water content was interpolated at the radar acquisition dates using a classical generalised logistic function of time, fitted to the experimental data (figure 4).

We observe that the radar signal decreases when the plant water content increases. The parameter A $\cong$ 0 so as we neglected. The attenuation by the canopy (B) decreases from VV to HH polarisation. This can be explaining by the vertical structure of the canopy (i.e. contribution of the steams) which leads to smaller interactions when the electric field has a vertical component.

4. CONCLUSION

SPOT Vegetation data with its high temporal resolution has potential for vegetation parameters mapping and the high frequency of coverage enhances the likelihood for could-free observations and makes it possible to monitor changes in health vegetation over short periods.

In this paper, an approach based on semi-empirical water cloud model for the estimation of soil moisture from Radarsat imagery was used to reduce the effect of vegetation on backscatter coefficient. The aim was to simplify the model by minimizing the inclusion of a number of vegetation descriptors in the water cloud model.

Future work will be focused on leaf area index and surface soil moisture estimation in order to be integrated into a system for monitoring and drought risk analysis in Romania that will be implemented in the SIAT framework project coordinated by Romanian Space Agency.

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