S E S ' 2 0 0 5

Scientific Conference "SPACE, ECOLOGY, SAFETY" with International Participation

10–13 June 2005, Varna, Bulgaria

MULTICHANNEL NADIR SPECTROMETER FOR THEMATICALLY ORIENTED REMOTE SENSING INVESTIGATIONS

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Keywords: remote sensing; reflectance characteristics, airborne spectrometric system

Abstract - The paper presents the construction concept of a multichannel spectrometric system operating in the visible and near infrared range of the electromagnetic spectrum and designed for remote sensing observation, development and validation of spectral-biophysical models for land cover features estimation and state assessment. The multichannel spectrometric system is designed to measure in (64 - 128) spectral channels the reflected by ground objects solar radiation in the range 450 ÷ 900 nm. The measurements will be performed on board of a remotely-controlled airborne platform (helicopter) in a main working regime - nadir, platform velocity – up to 20 km/h, altitude – up to 1000 m (optimal 200 m), flight duration - up to 60 min.

Destination of the spectrometric system and main investigation tasks

The paper presents the development of a multichannel spectrometric system for operating in the visible and near infrared range of the electromagnetic spectrum. The system will be used for measuring the reflected by ground objects (soils, vegetation etc.) solar radiation on board of a remotely-controlled airborne platform (helicopter). The multichannel spectrometer is designed for remote sensing observations with the following purposes:

- recognition of land covers (soils, natural and agricultural vegetation, water areas);
- development and validation of spectral-biophysical models for land cover monitoring;
- application of the developed models and the remotely sensed spectrometric data for land cover feature estimation (soil type, moisture content, surface texture; vegetation type, phenological stage, biomass, canopy cover, leaf area index etc), state assessment and stress detection.

Components of the system

- VIS-NIR multichannel spectrometer
- optical unit – lenses and fiber
- optional color digital still camera
- data control on-board system – consists of spectrometer control, onboard storage module (flash disk), GPS (for Earth investigations)
- on-board power supply device – rechargeable lithium battery
- fitting elements for installation of the system on board of the airborne platform
- module for pre-processing of spectrometric data
- communication system for data transmission

Technical specification of the spectrometric system:

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	4×10^4
per scan	2000 : 1
Exposure time:	(3 ÷ 60) ms
Measurement duration:	(10 ÷ 30) min

Requirements to the spectrometric system:

- Navigational - flight conditions and spectrometric system operational regimen;
- Constructional - location and installation of the spectrometric system;
- Composition and relief of the studied territories;
- Necessity of a digital camera and requirements for linking the spectrometric data with the site images;
- Requirements for geometric corrections, radiometric calibration, map and time control of the spectrometric data (technical parameters of the GPS interface);
- Requirements to the data processing system (hardware, software);
- Development of data processing and interpretation algorithms (digital filtration, visualization and user interpretation).

Laboratory investigations with the spectrometric system

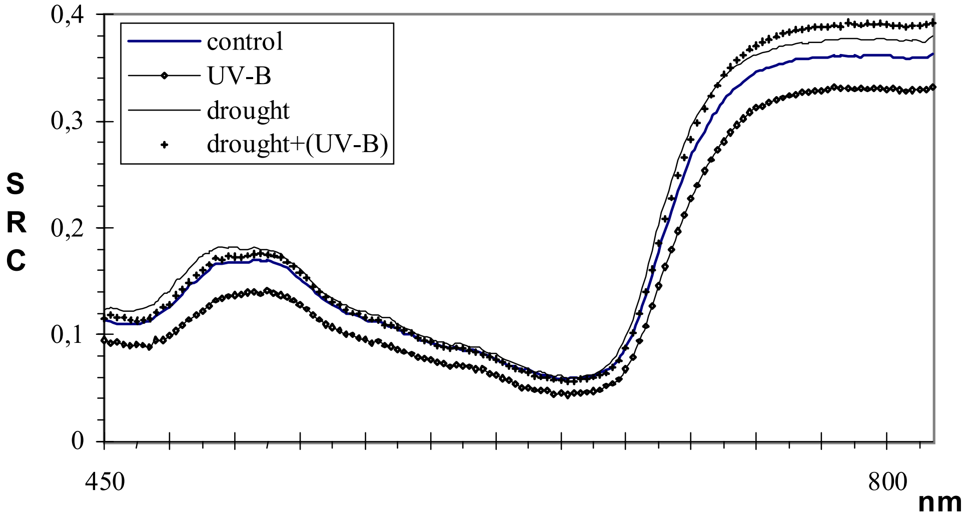

Fig.1 Spectral reflectance characteristics of maiz leaves
for plants under normal stress growing conditions

In the visible (VIS) spectral band (400÷710 nm) vegetation optical properties depend mainly on plant pigment content and concentration. In Fig.1 the spectral reflectance curves of maize leaves are shown for the case of plant normal (control) and stress growing conditions. A reflectance local maximum is observed at 550 nm, i.e. in the green region where the absorption of the incident radiation is relatively low.

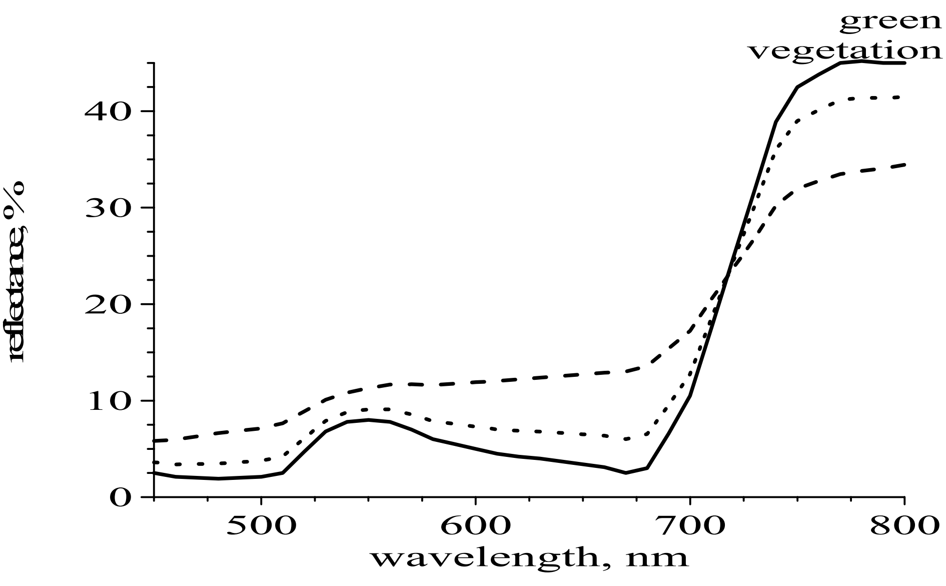

Fig.2 reflectance spectra of green wheat plants
and plants with different degree of senescence

Plant senescence or stress factors inhibiting chlorophyll synthesis or causing chlorophyll destruction decrease the amount of the absorbed solar radiation in the red (670 nm) spectral band where the zone of vegetation minimum reflection is located. This leads to higher reflectance values in this spectral band. In the near infrared region (NIR) of the spectrum the vegetation reflectance ability increases, a steep slope being observed in the wavelength range 700÷760 nm. Reflectance variation in the NIR band depends on plant structural parameters and can be used for vegetation classification and state assessment. In Fig. 2 the reflectance spectra of wheat crops are presented for green plants and plants with different degree of senescence. Soils have a reflectance increase in the VIS-NIR spectral range. The reflectance behavior is a function of various soil parameters (mineral composition, organic matter content, surface moisture and roughness, etc.).Fig.3 shows soil spectral reflectance with defferent moisture content.

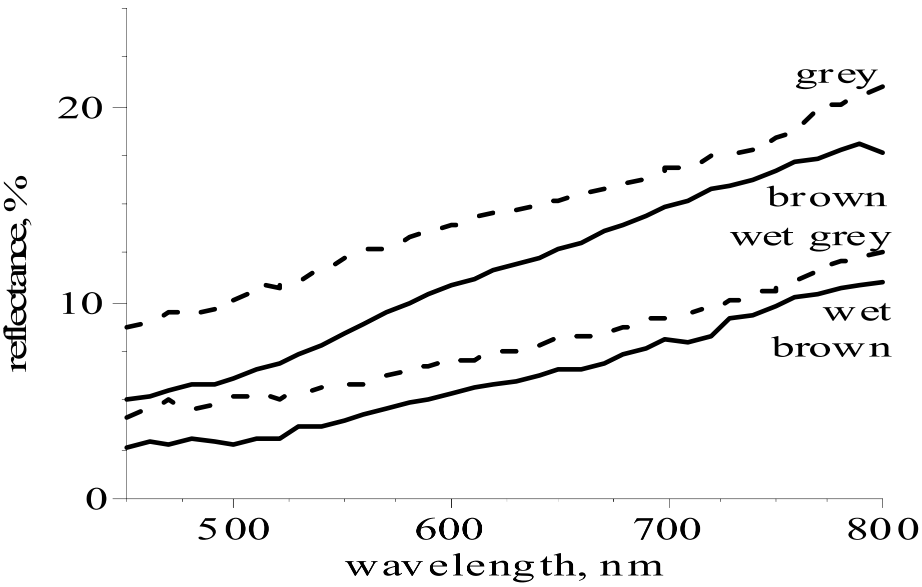

Fig.3 Spectral reflectance of two soil types with different moisture content

In Fig 3 the functional diagram of the optical unit of the spectrometric system is shown.

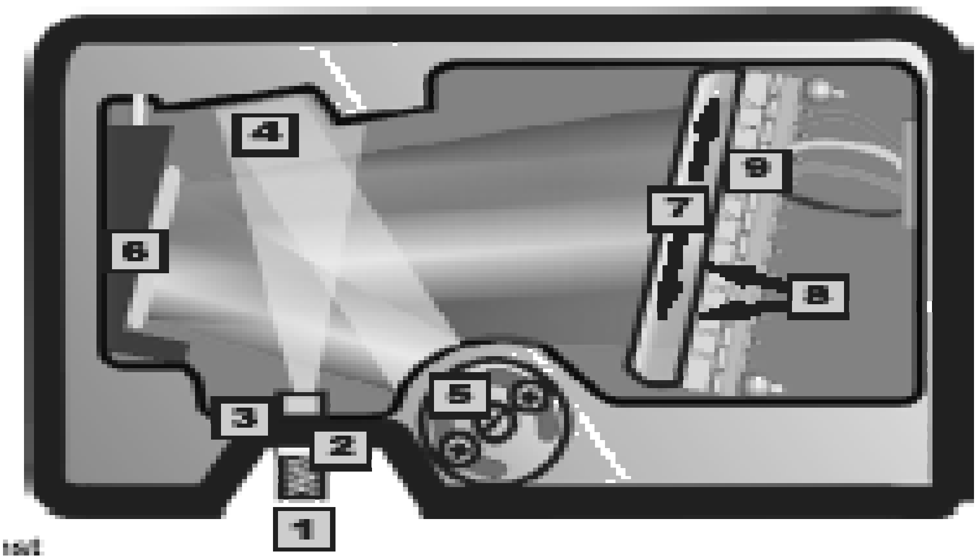

Fig 3. Functional diagram of the optical unit: 1 - SMA connector, 2 - Fixed slit, 3 - Absorbance filter, 4 - Collimating mirror, 5 - Grating, 6 - Focusing mirror, 7 - Detector collection lens, 8 - OVLF filter, 9 - CCD line detector

The autonomous chopper system is presented in Fig.4. It is provided by the AAMU-HSCaRS-NSSTC, Alabama, USA.

Fig. 4 Autonomous chopper system

Physical Characteristics:
Length – 3.58 m
Weight – 22.68 kg
Main Blades – 1.03 m
Engine – 120 cc
Range – 161 km
Payload Capacity – 20.41 kg
Fuel Tank – 32 oz

Passive Sensor Packages:
Wavelengths – 3, 6 or 21 cm
Sensitivity – 0.3-0.5 K
3-db beamwidth – 30 deg
Power supply – 27 V DC
Power consumption – 15 VA
Weight – 2-6 kg

Navigation Means:
Novatel GPS
Senix Ultrasonic altimeter
Crossbow altitude & heading reference system
Futaba 601 heading-hold gyro
WinSys embedded flight Computer

Conclusions

The goal for designing the multichannel spectrometric system is to provide a large number of scientists and researchers with a reliable device for remote sensing observation of different targets of natural and anthropogenic origin. As it is proved by laboratory measurements the results are promising since the spectral accuracy of the spectrometer is comparable with this of similar commercial systems.