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REMOTE SENSING - MEANS OF STUDY AND GENERAL ANALYSIS OF THE FOREST

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Abstract: *The satellite remote sensing is a relatively new technique which allows, through its means, the acquisition of satellite images on large land surfaces. Amongst the sectors in which the remote sensing data have immediate applicability there is also the forestry one. This article presents, in synthesis, the main aspects regarding the applications of the satellite remote sensing at the level of study and general analysis of the forest, and also at the level of the stands. The biophysical parameters of the forest are included in the first category, while the description of the structural characteristics of the stands is included in the second category.*

Key words: *satellite images, sensors, remote sensing.*

1. Introduction

The satellite remote sensing represents the unique technique of evaluation and surveillance on large surfaces of the forestry real estate and of the different activities which unfold in this sector. The remote sensing technologies allow the processing of digital multiscale and multiresolution images, the pixel having different sizes, according to the type of the sensor, its sizes being from the kilometre order to tens of centimetres. The fact that the remote sensing data are acquired repetitively (daily, once every few days, monthly) helps the regular surveillance of the forest resources. These registrations can be used even in the real time, being very useful for the surveillance of different aspects and events of the forestry real estate such as forest fires. We must not forget about the fact that the satellite data have a synoptic cover and the information can be acquired from areas with low accessibility or inaccessible to mankind. Without replacing the classical ground survey, the remote sensing data bring supplementary information which largely helps the sustainable management of the forests.

The realizations of the satellite remote sensing are emphasized through the studies performed at different levels (global, zonal, local) for evaluating the forest resources, the analyses being based on the spectral signatures or on the simple vegetation indexes calculated by using the spectral reflectance. In general, given the specific remote sensing technologies, its realizations in the domain of forestry can

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be taken into consideration from the point of view of the description and analysis of the forests and stands, of the determination of biophysical parameters of the forest and of the preparation of mapping products, other than the thematic ones (Figure 1).

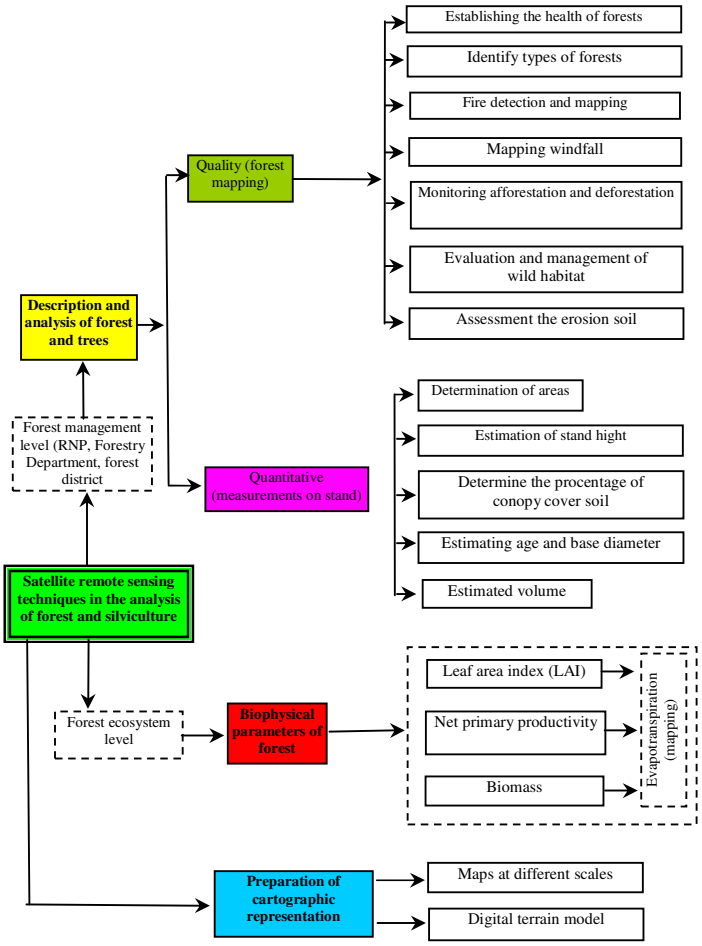

Fig. 1. *Satellite remote sensing techniques in the analysis of forest and silviculture*

The first category is represented by the qualitative applications which have as final product the obtainment of thematic maps and by the quantitative ones regarding the determinations of the stands. Thus, the qualitative applications consist of the mapping of the forest types, the individual identification of the species, the detection of forest fires, the mapping of the forest fires risk, the stability of the forests health status (strength, hydric stress, insects attacks, air pollution, water pollution, forest soil pollution), the evaluation of the damages made by the wind and by other extreme climatic factors, the surveillance of the activities of exploitation, reforestation and deforestation, the management of the protected areas, the design of the forest roads, the evaluation of the soil erosion, the evaluation and the management of the recreational forests, the evaluation and the management of the wild habitat etc. The

quantitative applications are the ones regarding the determination of the forestry real estate surface, the estimation of the covering percentage of the soil from the stand top, the estimation of the stand height, of the basic diameter, of the age, of the basic surface and of the volume.

The second category is represented by the determination of the leaf area index (LAI), the net primary productivity (NPP) and the biomass. Regarding the preparation of mapping products, the realizations of the satellite remote sensing are materialized in obtaining maps with different scales, according to the type of the used satellite images, and obtaining the digital model of the land based on the stereoscopic satellite images.

2. The Mapping of the Land Cover by Using Satellite Images

The remote sensing provides practical and economic means for the study of the land cover and of the changes emerged in its context, especially on large surfaces [1], [2]. Due to the high potential for realizing the systematic observations on different scales, the remote sensing technologies ensure the possibility of creating the data archives from the moment of launching the satellites up to the present. In this respect, the researchers and the specialist practitioners have made considerable efforts in order to outline the land cover at different levels through the remote sensing images.

Internationally, the Geosphere-Biosphere Program initiated in 1992 was the first one in the global mapping of the land cover (Global Land Cover Characterization - GLCC Database) which was based on NOAA-AVHRR data with a spatial resolution of 1 km. In 1999, the Joint Research Institute of Italy in collaboration with over 30 research teams from all over the world implemented a similar project called Global Land Cover (GLC 2000) in order to make a global mapping of the land cover and to collect a VEGA 2000 database by using data taken by the Spot 4-Vegetation sensor with spatial resolution of 1 km. Two years later, NASA set up a database regarding the land cover by using MODIS images taken each month by the Terra MODIS satellite, between January-December 2001, the data had processing levels of 2 and 3. In 1996 the Pan-European Land Cover Monitoring project was made, a project which had as objective the realization of a database by using images with spatial resolution of 1 km NOAA-AVHRR, base which covered the entire European continent [3]. Besides these databases collected at a global and continental scale, there were set up certain databases at regional and national level. An example is represented by the program USGS-NPS Vegetation Mapping made by the U.S. Geological Survey and National Park Service, started in 1994. Its purpose was to obtain detailed maps of the vegetation made in digital format for 250 national parks in the United States of America.

The surveillance of the forests health status at European level was carried out by the UN-ECE/ICP-Forests program, starting in 1986, with the annual evaluation of the health for 320000 trees.

The Corine Land Cover (CLC) program of the European community had as objective the provision of uniform and comparable information on the land cover of the surfaces of the member states for the applications regarding the environment. The data acquisition was carried out on the scale of 1 : 100000 based on the evaluation of the satellite images Landsat 5 TM, distinguishing 44 classes of the land cover. The minimum mapping unit was about 25 ha and for the linear details the minimum width taken into consideration was of 100 m.

In the first CLC inventory unfolded between the years 1985-1995 in the

countries of the European Union and of those which benefit from the Phare program, the visual interpretation was carried out based on the satellite images. Starting in 2000, the sets of Corine data have been updated. The operation is carried out directly, by digitizing the images, which substantially increases the accuracy and cutting the costs. The differences between the two classifications are obvious regarding the registrations, the spatial resolution of the images, the geometric precision, the cots etc. The main source for introducing the data in order to update the database is represented by the mosaic made at European level of the orthorectified satellite images (Landsat 7 ETM+) dated in 2000 (IMAGE 2000) with a maximum allowed deviation of 1 year (1999-2001). The operation, called "Snapshot of Europe for year 2000" allowed the preparation of a new map of the land cover (CLC 2000) based on these data and completed at the end of 2003.

In Romania the realizations in this domain are pretty modest, the first researches in the domain of satellite remote sensing starting in Braşov in the '80s, when we first had the means of satellite registrations. They consisted of the automatic processing of the satellite registrations and of the preparation of certain thematic maps of the forestry real estate (A. Rusu, N. Bos, A. Kiss, Gh. Chitea). The researches continued with the analysis of the forests health status based on the normalized differential index of the vegetation, the classification of the contents of the satellite images through segmentation, the usage of remote sensing with GIS, Photogrammetry and GPS technique in the forestry sector.

Parallel to the preoccupations within the Faculty of Forestry and Forest Exploitation of Braşov, starting in 1980, at the Institute of Forest Management there have been carried out research studies regarding the introduction and use of the satellite remote sensing in forestry. Amongst the researchers interested in this domain, we mention Seceleanu and Ianculescu (1980), Patrascoiu and Oprescu (1985), O. Badea, V. Gancz (1990), S. Trofimov (1993).

In 1995, there was founded the collective specialized in GIS and remote sensing within the Forest Research and Management Institute of Bucharest which was equipped with all the means necessary for the modern processing of images. Having as main objective the implementation of remote sensing in forestry and, especially, in forest management, there' have been approached works regarding the usage of the satellite registrations in the forestry monitoring, for elaborating the maps on forest formations and, along with the digital model of the land, for preparing the basic plans used as mapping support in the works of forest management.

Besides the mentioned activities, there has been unfolded a series of programs in the domain of satellite remote sensing with international collaboration: "Forest Ecosystem Mapping" in collaboration with the Institute of Common Researches of the European Commissions from Ispra having as objective the preparation of certain supervised classifications for delimitating certain forest ecoregions and "TAFIMRO" (Technical Assistance for Forest Information Management in Romania), completed in 2002 in collaboration with the Center of GIS Support of the Flemish Agency, Belgium, through which there were made automatic classifications of the contents of the Landsat 7 ETM+ [4] images.

An important role belongs to the national parks: "Piatra Craiului", "Retezat", "Vânători Neamț" and others founded within the National Forest Administration which use effectively and intensively the satellite images in these areas in order to monitor the included areas and the realization of different studies and researches.

3. Sensors Used in the Forest Analysis and Study

The satellite sensors used for the registrations had a spectacular evolution, especially in the last decade since there have been launched satellites equipped with sensors which acquire images with metric and submetric spatial resolutions. The realizations of the satellite remote sensing are strongly related to the ones of the satellite sensors which have the main role in processing the registrations. Thus, the realizations of the satellite remote sensing through the launched satellite sensors, are beneficial to all the sectors of the national economy which manage the natural resources and the forestry sector. These are more valuable when certain remote sensing techniques allow the registration processing in stereoscopic mode. In this respect, the analyses can be made both on singular satellite images and on stereoscopic images in the case of the satellite sensors which have this capacity (ASTER, Spot).

The images taken by the optical satellites can be registered in the panchromatic mode (a large spectral band with a small width and with a low spatial resolution). Because of technical reasons, it is difficult to manufacture very sensitive sensors with narrow spectral tape, the sensors with fine spatial resolution (less than one meter) operate in the visible domain in the expanded panchromatic mode (almost 400 nm). These images allow the highlight of the limits between the forest types, the stand types, the cutting types, the types of exploitation roads, the texture of the top etc. The multispectral mode is more adapted to the characteristics of vegetation and it allows the determination of the top density, the surveillance of the photosynthesis activity, of the hydric stress, of the forest fires etc. The width of the satellite sensor bands is generally around 100 nm, but a part of the sensors with small spatial resolutions such as MODIS (500 and 1000 m) presents narrow bands (10 to 30 nm) more adapted for highlighting certain biophysical features. Thus, the spectral bands of the visible mode, close infrared and short infrared, are used for vegetation surveillance. The domain of the thermal infrared is used for the study of the water flows between the vegetation and the atmosphere, for the estimation of the evaporation of the vegetation top, detecting the hydric stress.

In order to make correct decisions in the forestry sector based on the data of the satellite remote sensing, it is necessary to understand the satellite sensors and their performances. The range of sensors is a large one and, in time, it diversifies, thus the most representative satellite sensors which make registrations also used in the forestry sector, for the increase of the spatial resolution, are: AVHRR (Advanced Very High Resolution Radiometer), ASTER (Advanced Spaceborn Thermal Emission and Reflection Radiometer), MODIS, ALI (Advanced Land Imager), Landsat 5 TM (Thematic Mapper), Landsat 7 ETM+ (Enhanced Thematic Mapper Plus), Spot 4 and 5, Ikonos-2, Quickbird-2, Worldview-2 and Geoeye-1. Each sensor is characterized by a spatial, spectral, radiometric and temporal resolution, elements which determine the cost and the function which establish their advantages and disadvantages. The data taken by the sensors are available both as gross data and as processed data, being corrected by the effects of the atmosphere and other effects which cause distortions in the images [4].

The active sensors which take the registrations used in forestry are not so diversified as compared to the optical ones, but, in time, they are completed by new sensors. In general, these are represented by radar sensors which allow the usage of a self energy source in order to make registrations. These systems do not require solar light as in the case of optical systems

and they can make registrations both by day and by night and, even more, they can enter the clouds between certain limits, given the wavelength in which they work without having an effect on the registrations.

The SAR (Synthetic Aperture Radar) system is the technique which allows the processing of the registrations of high resolution and which depends on the properties of the registered surface, such as slope, roughness, humidity, texture and dielectric constant. The usage of these registrations in the forestry sector can be made in order to obtain topographical maps and for the surveillance of the land usage [4].

Amongst the satellites equipped with active sensors which collect information used in the study and analysis of the forest, we mention: ERS-1/2 (European Remote Sensing Satellite 1 and 2) which take the registration in band C, with polarization in the vertical plane and which have a resolution of 30 x 26 m; RADARSAT-1 and RADARSAT-2 with registrations in band C and a resolution of 8-100 x 8-100 m for RADARSAT-1 and 3-100 x 2,4-100 m for RADARSAT-2; IGESAT GLAS of LIDAR type. Besides the above mentioned satellites, considered to be significant for the forestry sector, we can also mention the satellites JERS-1 (Japan) whose mission ended in 1997 and SRTM shuttle. Along with these sensors, we can also mention Envisar ASAR (EU), TerraSAR-X (Germany), ALOS PALSAR and IBUKI (Japan), COSMO SkyMed (Italy).

4. Conclusions

The usage of the satellite remote sensing in the study and analysis of the forest in our country is conditioned by the availability of these registrations and by the existence of the programs for processing the satellite images. In our country, the usage of the digital satellite registrations on a larger scale took place along with the foundation of natural and national parks, this fact leading to the acquisition of satellite data. We have to notice the fact that due to the economic conditions, the forestry sector (of the state and the private one) was not interested in the acquisition of satellite registrations, especially of those of very high resolution, given their very high price.

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