ANALYSIS OF REMOTE SENSING METHODS FOR FOREST ECOMONITORING IN DIFFERENT SEASONS

Rumen Nedkov, Albena Pavlova

Space Research Institute – BAS

Abstract

Contemporary space technologies enable wide application of remote sensing methods for impartial investigation and control of environment conditions. An important point especially is a research of processes dynamic in ecosystems in local, regional and global scale.

Various aerospace methods allow data receiving in different temporal modes. These data are information source for the actual state of the investigated object in different seasons. Annual information is important in the case of complex monitoring with main aim to study phenological variations of particular land cover type. This assumes exploitation of different methods and aerospace data for one and the same time period (climatic season). Unseasonable factors, which give influence over individual elements of ecosystems, suppose casual character upon their progress for short time period. All this requires a profound analysis of the advantages and disadvantages of different remote and aerospace methods, which must be utilize for an optimal eco-monitoring in various climatic seasons.

In the proposed paper is made comparative analysis of aerospace methods and used data enclosed to monitoring of forest vegetation.

Key wards: remote sensing methods, eco-monitoring, temporal diapason

1. Seasonal Changes in vegetation associated to the pigment alteration and water content in respect of radiant energy

Seasonal changes in the forest occur naturally and are usually easily detected. Seasonal changes in vegetation are a consequence from the rotation of the earth around the sun and its own axis. The earth is slightly tilted at approximately 23.5°. This tilt is what's responsible for the temperature variation and change of length of days from season to season in temperate regions. It is hot in the summer time because the rays of the sun are more direct and summer days are long because more time is spent in sunlight due to the tilt of the earth. On the other hand, winter days are short and cold because the rays are less direct and there is less sunlight each day. These seasonal changes affect every organism living on earth.

1.1. Climatic conditions

Plants are of interest when studying seasonal changes because most leaves change color and fall off the trees. The primary factor in this spectacular phenomenon is termed “photoperiod” or in other words, the amount of sunlight a specific region receives over the course of the year. Some areas receive a sufficient amount of sunlight all year and some do not receive enough sunlight in the winter. It is essential for the food making process that occurs in plants known as “photosynthesis” The leaves have pigments in them that absorb light. The main one is chlorophyll which is responsible for the green color in leaves because it absorbs the blue and red light waves and reflects green wavelengths. When the fall season arrives, the amount of sunlight and temperature both decrease. This causes the chlorophyll absorption of light to become low. Approximately two weeks before the leaves undergo a change in color, a hardened cell layer forms at the bottom of the leaf due to the lack of photosynthesis. This hardened layer blocks off important nutrients such as magnesium and phosphorus and moisture from flowing to the leaf. This process inhibits the production of chlorophyll. The remaining chlorophyll starts to break down as the nutrients are absorbed into the trunk and roots. When enough chlorophyll has broken down, the green color starts to disappear and the yellow color starts to emerge. The yellow color is actually present year round but is never showed due to the high amounts of chlorophyll. The yellow color of the leaf is actually due to a pigment known as carotenoid. The red color that appears in leaves is due to the sugars becoming trapped in the leaves. The red color becomes more resonant when there is an increase in sunny days but cool nights. The pigments are known as anthocyanins which protect the leaves from frost. Photosynthesis is not the only factor in plants affected by a change in season; water content of woody tissues of trees also undergoes seasonal fluctuations. The wood of young trees undergoes an annual cycle of water content, varying from 100% of dry weight in the carry spring to as little as 60% in the late summer. The temperate coniferous forests receive most of their precipitation during the fall, winter, and spring, and are subject to summer drought. Seasonal drought usually lasts between July and October. In particularly dry summers, carbon is often allocated for deep root growth. Roots involved principally in water uptake are not active in the surface layers, but occur only in the deeper soil layers where moisture is persistent during summer periods. So when precipitation is infrequent in the summer, the lack of an active upper root layer prevents significant water uptake from that upper soil layer. Deciduous trees usually dominate temperate forests, where the growing season is moist and at least 4 months long. These forests generally receive more winter precipitation than temperate grasslands. Winters in deciduous forests last from 3 to 4 months, and although snowfall may be heavy, winters in these forests are relatively mild.

1.2. Anthropogenic influence

The seasonal changes describe above are typical for climatic factors and processes.

The vegetation is quite sensitive to anthropogenic impacts. Anthropogenic changes are likely to alter growth patterns of plant species which will result in changed patterns of forest succession. Forest fires made by human carelessness, indiscriminate slaughter, pollution from tourism, and effects on water supply are the some of the anthropogenic influence, which can alter the forest structure and canopy. Forest damages are concerned with variables as defoliation, discoloration, growth reduction.

Human impact on the forest results in change of chlorophyll content, photosynthetic activity and leaves structure, which can reduce the time of natural changes in forest canopy. That’s why the study of forest phenology and forest parameters, which are related to forest canopy are of great importance in assessing seasonal changes.

1.3. Parameters in forest cover

The physiological activity of a forest stand is influenced by the vitality and health status of the trees. Most forest parameters are related to each other. A large group of parameters is connected to tree size and canopy structure (age, stem volume, crown cover, forest density, tree height, biomass), and another group of parameters is related to the chemical composition of trees and leaves/needles (chlorophyll concentration, water content, pigment concentrations, health condition, defoliation, mineral content, chemical stress). Also soil type, climatic conditions and landscape structure are related to the forest type and forest parameters. In most cases remote sensing instruments do not measure the desired forest parameter directly and parameter retrieval algorithms rely on adequate correlation between the measurable physical properties and the desired forest parameter. The relations between parameters are mostly specific to local species.

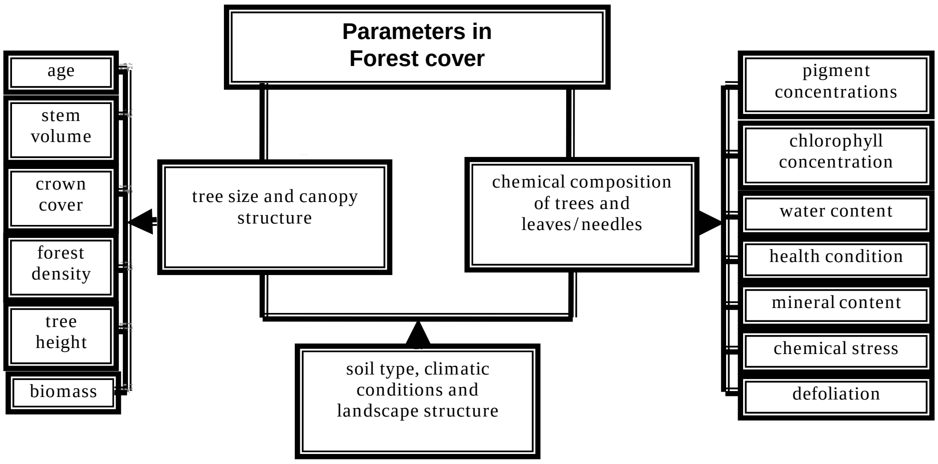

Fig.1 Parameters in forest cover

The forest parameters are can be divided into two main types: categorical variables and continuous variables. Categorical variables can be obtained through a classification process, in which each pixel is attributed to one of a set of categories or classes. Estimators of continuous parameters are established by identifying a function that describes the relationship between the observed pixel values and the desired forest parameter.

Parameter estimation and classification can be performed directly on the observed data, but in many cases it is advantageous to compute certain features from the original image data, and then effectuate the parameter estimation on the feature vectors. The features may e.g. describe the texture of a set of neighboring pixels. Finding an estimator of a continuous forest parameter typically consists of establishing a relationship between the image data and measurements of this forest parameter. This may include physical models or statistical models. Statistical modeling relies on estimation of the relationship between the image data and the parameter using a combination of training data and prior knowledge regarding the type of relationship. The prior knowledge mentioned here is generally based on knowledge about physical processes. A frequently used class of methods is regression analysis. There is a large family of well-established models for multivariate data in the class of generalized linear models in literature.

Land cover change forms a complex and interactive system at different spatial and temporal scales.

2. Analysis of aerospace methods for monitoring of forest vegetation.

Remote sensing is a way to obtain information on forest biomass and stand conditions over large areas in a timely and cost-effective manner. Remote sensing utilizes aerial photographs, satellite images, laser altimetry, and radar.

Visible and infrared sensors just measure the amount of sunlight reflected off of a surface. They use the optical properties of the components of the forest canopy, which are important to the understanding of how plants interact with their environment and how this information may be used to determine vegetation characteristics by means of remote sensing. Unlike solar illumination which, coming from a distant source, sends its signal as continuous parallel rays of light (photons) onto a sensed surface, radar sends a discontinuous (intermittent) series of photon pulses from a point source that then spreads out as an angular beam. Laser altimetry, or lidar (light detection and ranging), is an alternative remote sensing technology that promises to both increase the accuracy of biophysical measurements and extend spatial analysis into the third (z) dimension. Lasers for terrestrial applications generally have wavelengths in the range of 900–1064 nanometers, where vegetation reflectance is high. Lidar sensors directly measure the three-dimensional distribution of plant canopies as well as subcanopy topography, thus providing high-resolution topographic maps and highly accurate estimates of vegetation height, cover, and canopy structure. In addition, lidar has been shown to accurately estimate LAI and aboveground biomass even in those high-biomass ecosystems where passive optical and active radar sensors typically fail to do so [1].

Table 1 Tasks for forest monitoring and the demands for Remote Sensing systems

Main goals	Season and period for observations	Effective time for image processing	Spatial resolution, m	Scale of the output maps	Spectral resolution
Investigation of forest damages from pests and diseases	**summer one month**	**5 days**	**1-2 5-10**	**1:10000-1:5000**	**0,470; 0,555; 0,659; 865; 1,240; 1,640 2,130 μm (0,5-0,6; 0,6-0,7; 0,8-0,9 μm)**
forest damages on account of natural factors (winds, land slides)	**summer-autumn two month**	**10 days**	**5-10 (20-30)**	**1:10 000 1:25 000**	**0,5-0,6; 0,6-0,7; 0,8-0,9 μm**
technogenic	**spring**	**1 month**	**20-30**	**1:25000**	**0,470; 0,555; 0,659;**

contamination in forest	**summer autumn single image**				**0,865; 1,240; 1,640 and 2,130 µm**
rehabilitation of coppices and burnt forest	**Summer single image**	**1 month**	**1-2 (5-10) 20-30**	**1:10000-1:25000**	**0,5-0,6; 0,6-0,7; 0,8-0,9 µm**
Assessment of the forest phonological condition	**spring autumn**	**1 day**	**150-1000**	**1: 200000**	**0,5-0,6; 0,6-0,7; 0,8-0,9 µm**
Assessment of forest eco-diversity	**Summer single image**	**1 month**	**10-20**	**1: 25000**	**0,5-0,6; 0,6-0,7; 0,7-0,8; 0,8-0,9 µm**
Assessment of the forest phytomass	**Summer single image**	**1 month**	**20-30 (1-5)**	**1: 25000**	**0,5-0,6; 0,6-0,7; 0,7-0,8; 0,8-0,9 µm radar X, S, L range**
effect from forest fire, anthropogenic activity and the processes connected with the carbon accumulation	**Summer single image**	**1 month**	**20-30 (1-5)**	**1: 25000**	**0,5-0,6; 0,6-0,7; 0,7-0,8; 0,8-0,9 µm radar X, S, L range**
Definition the degree of wetness of burning materials	**Spring summer autumn 12-24 hour**	**1 hour**	**5-10**	**1: 5000 1: 10000**	**0,7-1,2; 1,5-2,5; 3-5; 8-14 µm radiometer 0,8-3; 10-50 cm**
Large scale thematic mapping of forest	**Summer single image**	**1 month**	**10-20**	**1:50000**	**0,5-0,6; 0,6-0,7; 0,8-0,9 µm**

Conclusion

The possibility of remote sensing of objects on the earth's surface by space methods is based on objective, existing relations between the characteristics (parameters) of the environment and the radiation (reflected and natural) field of the earth's surfaces. Some parameters are directly measurable. Optical and infrared multichannel instruments will react to the forest structure and spectral properties (determined by chemical composition) of trees and leaves (health condition, content of chlorophyll). All optical methods, including aerial photography and satellite imagery, are essentially observations of leaf area development because that is the forest component that most strongly reflects or absorbs visible and near-infrared radiation. Laser altimeters, scanning lidars and ranging scatterometers

(radars) measure the tree height directly. Also the crown cover extent can be measured in most cases with these instruments. The backscattering coefficient measured by SAR instruments depends on ground and canopy water content and distribution. At the P-band a major contribution to the backscattering coefficient comes from the double reflection from tree trunks, which contain water. Therefore, a P-band SAR will provide information on the forest density and stem volume. At L- and C-band branch- and leaf-related reflection and scattering become more pronounced.
Laser and radar methods are able to give much more detailed images, but are generally more expensive and aren't as extensive yet.

References

1. Michael A. Lefsky Warren B. Cohen, and co., Lidar Remote Sensing for Ecosystem Studies, *BioScience:* Vol. 52, No. 1, pp. 19–30
2. http://www-eosdis.ornl.gov/SNF/guides/leaf_optical_tms.html
3. Сухих В. И., Функциональная структура космического сегмента мониторинга лесов Росси, Изследование земли из Космоса, 2001, №3, с. 61-67
4. Лукашевич Е.Л., Карпухина О.А., и др. Информационное обеспечение решения задач экологического мониторинга космеческой видеоинформацией – соществувющие и потенциальные возможности, Госцентър „Природа"