The use of geographic information systems for forest monitoring

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Abstract. In the article, the authors consider the need to use geographic information systems and remote zoning data for better and more effective forest monitoring. Each plant on our planet has the ability to reflect or absorb light waves. As a technology for monitoring forests, the method of visualization of the normalized vegetation index (NDVI) is used, which is also called the relative index of vegetation. Today, NDVI is the most common index for solving problems using quantitative estimates of vegetation cover. Each range of values is able to identify a specific object. All spectral values are stored in a special database and are inextricably linked with the coordinates on the resulting map. Files with maps and spectral values are in HDF format. Satellite images that allow you to work with the NDVI index are created using various instruments, one of which is a scanning image sensor – MODIS spectroradiometer. The introduction of the proposed technology will significantly increase the mobility and effectiveness of monitoring. The implementation of remote sensing results in the analysis of the state of forests based on the use of the normalized difference vegetation index (NDVI) is based on the interconnectedness of surface estimates and analytical interpretation of satellite images. The user gets the opportunity to select the format of the exported file, as well as highlighting the desired section of the observed area. The necessary spectra are filtered to find NDVI and other vegetation indices.

1. Introduction

Forest monitoring is carried out to determine the area of forest stands, and the current identification of areas where reforestation is required after deforestation, fires. In modern conditions, measures to control the state of forests are relevant and very important, since there is a significant reduction in the area of forests. This is due to various reasons. This and forest fires, which take on enormous proportions and cover large areas, are spreading at a tremendous speed. Illegal logging is carried out, especially in hard-to-reach places where it is quite difficult to control. The changing climate also negatively affects the condition and quality of forests throughout the planet.

Studying the state of forests is carried out in various ways, including by ground means, as well as recently, in connection with the development of modern digital technologies using data from space satellites [1, 2, 3, 4, 5, 6]. Which provide the most relevant information and allow you to explore large expanses of forests. The use of cartographic materials does not provide adequate information since many are outdated and not updated. In addition, the materials are still classified under secret.

Therefore, for better and more efficient forest monitoring, the use of geographic information systems and remote zoning data obtained from space satellites is required. This will allow you to receive relevant information for various periods of time and for any spatial coverage. What is relevant
for the territory of our country, where recently fires have become more frequent in large areas of Siberia and the Far East.

Geographic information systems are a powerful tool for environmental monitoring in many countries of the world [7, 8, 9, 10].

2. Research methodology
Geoinformation systems are especially relevant in forestry enterprises, where the technological monitoring system is almost completely absent.

Each plant on our planet has the ability to reflect or absorb light waves. A person has long known that plants have their own green tint thanks to a special pigment called chlorophyll. The peculiarity of chlorophyll is that it reflects the so-called “green” waves very well, which allows the human eye to see this object in this particular color. However, only “red” waves, which are responsible for photosynthesis, allow the plant to develop actively.

After absorbing such waves, the plant begins to reflect infrared waves (figure 1).

![Figure 1. Chlorophyll Reflection Feature.](image)

As a technology for monitoring forests, the method of visualization of the normalized vegetation index (NDVI) is used, which is also called the relative index of vegetation [11]. NDVI allows you to see how a particular plant is able to absorb and reflect various wave spectra. In this way you can determine his health.

Thanks to satellite images, mankind can get quite extensive data on the vital activity of plants on almost any part of the planet. Today, NDVI is the most common index for solving problems using quantitative estimates of vegetation cover. The formula for calculating the NDVI index has been adjusted many times, but in 1973, thanks to scientists from the Texas Tech University, it became possible to bring the index values to ranges from -1 to 1, which greatly facilitated the calculation system. Due to this, the index began to be called "normalized." At the moment, this formula is as follows:

\[
NDVI = \frac{NIR - RED}{NIR + RED}
\]

NDVI is also actively used to monitor soil moisture and saturation, evaporation and precipitation. In these cases, the NDVI parameters are not always objective since many features of the current location should be taken into account for measuring such data (figure 2).

Thanks to the values showing the reflections of red and infrared rays, it became possible to clearly distinguish living objects on the surface of the planet from non-living ones. Each range of values is able to identify a specific object using the ratio of the reflections of the red and infrared spectra.
Values from -1 to 0 are assigned to objects of inanimate nature and infrastructure: water, stones, sand, snow, etc. Objects of wildlife, such as plants, are characterized by values in the range from 0 to 1 (figure 3).

The closer the value is to unity, the more dense vegetation prevails in the area. Each value is assigned a specific color (table 1).

| Type of objects                      | NDVI value |
|--------------------------------------|------------|
| High, dense vegetation (forest)      | 0.7 – 1.0  |
| Sparse vegetation (shrubs, pastures) | 0.2 – 0.5  |
| Open soil                            | 0.025 – 0.2|
| Clouds                               | 0          |
| Snow, ice, dust, rocks               | -0.1 – 0.1 |
| Water                                | -0.42 - -0.33|
| Artificial materials (concrete, asphalt) | -0.5       |

3. Results of a research
All spectral values are stored in a special database, and are inextricably linked with the coordinates on the resulting map. Files with maps and spectral values are in HDF format. HDF is a hierarchical file format designed to store a large amount of information (figure 4).

Libraries for working with this format are under a free license and are used by many commercial and non-commercial programs. Satellite images that allow working with the NDVI index are created using various instruments, one of which is a scanning image sensor - MODIS (Moderate Resolution Imaging Spectroradiometer) [12, 13, 14, 15].
Today MODIS is located immediately on two artificial Earth satellites “Terra” and “Aqua”. The structure of Modis is shown in figure 5 [16]

The introduction of the proposed technology will significantly increase the mobility and effectiveness of monitoring. Particular changes will affect the research process of unfavorable forest areas. The normalized vegetative index NDVI is able to visualize even the most inaccessible areas of the forest, with the least cost of financial and human resources.

Using satellite imagery MODIS allows you to receive data quickly and in an automated mode, which are freely available for wide use. The user gets the opportunity to select the format of the exported file, as well as highlighting the desired section of the observed area. The necessary spectra are filtered to find NDVI and other vegetation indices.

4. Conclusions
The technique of visualizing the vegetation state of nature sites using near-Earth satellites is the best solution for monitoring forests. The implementation of remote sensing results in the analysis of the
state of forests based on the use of the normalized difference vegetation index (NDVI) is based on the interconnectedness of surface estimates and analytical interpretation of satellite images.

With the help of this technique, it will be possible to monitor the state of forests, determine places for reforestation. This technique allows the converter of complex data from satellites to be easier to read. An opportunity to facilitate visualization of the received data. In this case, significant financial costs for obtaining information are not required.

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