Vega-Les Information System. Actual Features and Future Evolution

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Abstract. The paper describes the Vega-Les (“Les” is the Russian word meaning “forest”) information system developed in the Space Research Institute of the Russian Academy of Sciences (IKI) for complex monitoring of the Russian forests with satellite data. The Vega-Les information system provides online access to continuously updated long term Earth remote sensing data and derived products archives and automated data processing, analysis and synthesis online tools for wide range of remote users for forest resources monitoring and research. The paper gives information about system’s main features, available satellite data and provides examples of data analysis and processing tools.

1. Introduction

Fast development of Earth remote sensing (ERS) satellite systems over the last decades and their evolution from observational to measuring systems (providing radiometrically calibrated and geometrically precise data) led to creation of novel methods and technologies of vegetation cover, including forests [1-8] mapping and estimation. Principal features of these methods are:

- Transition from analysis of single images to analysis of observations time-series, providing the usage of seasonal dynamics phenological features for analysis of various forest cover types;
- Development of approaches to automatic adaptation of classification algorithms to vegetation development specifics in different regions providing regular mapping of forests on large areas;
- High level of data processing methods and algorithms automation providing, in particular, unbiased (human independent) information about forest health.

Simultaneously with the significant growth of operational Earth observation satellite systems their quality and performance has also increased significantly. Besides that, methods of obtaining the satellite data have evolved impressively. Access to large volumes of data from many satellite systems became free. Along with that new technologies for efficient management of very large data volumes available emerged. Results of research and development in this area, conducted in IKI, are comprehensively published, e.g. in [8-9].

The indicated aspects enable the continuous complex monitoring of forest cover on large areas. Possibilities of such monitoring in our country have been tested during the development and operational testing of the Primorye Territory forest resources complex monitoring system [10]. It should be also noticed that long-term archives (since the beginning of the XXI century) of satellite data and derived forest cover data for all the territory of Russia are now available.
Thus, integration of available forest cover data obtaining and continuous updating methods and technologies based on remote monitoring technologies into a single information system (IS) becomes possible. Such a system will provide distributed access and analysis of this information and, finally, conduction of remote (primarily scientific) monitoring of the forests of Russia. In 2019, based on the “IKI-Monitoring” Shared Use Center (SUC) [11] infrastructure, functional prototype of the system was developed by IKI [12]. The paper describes the system’s main features, available satellite data and provides examples of ERS data analysis and processing tools.

2. Methods and Materials
Vega-Les provides online access to continuously updated long-term ERS data and derived products archives and automated processing, analysis and synthesis tools for various complex forest monitoring information including:

- acquisition of annually updated information on qualitative and quantitative characteristics of forests (incl. area, stock, dominant species, density, site quality, age and others);
- acquisition of forest fires and related forest damage (incl. information about fires dynamics, burnt areas, forest damage grade and post-fire loss);
- acquisition of information about forest damage grade and area after biotic, meteorological and other (insects, illnesses, droughts etc.) impacts;
- acquisition of information about industrial forest logging (incl. areas, stock and species of logged wood);
- acquisition of information about carbon budget in forests (incl. main pools dynamics, emission and absorption amounts).

2.1. Available satellite data
The base for Vega-Les operation is formed by continuously updated ERS data archives of the “IKI-Monitoring” SUC [12]. The archives mainly contain data from the Landsat, Sentinel (1, 2, 3, 5P) series, Terra, Aqua, Suomi NPP and NOAA-20 satellites, but the list is not limited by these names. Right now the Vega-Les users have access to more than 3 Pb of online data from more than 40 satellites. It should be noted that the system provides rather long-term data archives with depth exceeding 35 years for some regions. This feature provides the possibility of analysis of both forest processes taking place right now and changes over the long time span. It is necessary to highlight the online availability of all the archives without any special data ordering procedures.

Besides the low processing level (not lower than L1B) satellite data the system provides basic data products of higher processing levels, incl. the regular noise- and cloud-free composite images. These products form the basis for the data time-series required for various forest mapping, health analysis and change detection tasks. The Vega-Les now provides composite images with various spatial resolutions (from 10 to 250 meters) with various time span (day, four days, week, month, season etc.). Examples of such images are given on the figure 1-3. Production of these images is fully automatic and based on methods and technologies developed by IKI [8-9].

As it was aforementioned, Vega-Les provides a notable amount of regularly updated maps of various forest health characteristics. The characteristics of some of these maps are given in the table 1, some examples are shown on figure 4-6.
Figure 1. Example of cloud-free composite images provided by Vega-Les: Weekly NDVI image derived from MODIS data.

Figure 2. Example of cloud-free composite images provided by Vega-Les: Annual winter composite derived from PROBA-V data.
Figure 3. Example of cloud-free composite images provided by Vega-Les: Annual vegetation period composite image derived from Landsat data.

Figure 4. Example of forest characteristics thematic maps provided by Vega-Les include: Landcover types (23 classes).
Figure 5. Example of forest characteristics thematic maps provided by Vega-Les include: Dominant forest species.

Figure 6. Example of forest characteristics thematic maps provided by Vega-Les include: Wood stock.
Table 1. Examples of thematic maps of the forests of Russia provided by Vega-Les.

| Map description                                      | ERS data used and spatial resolution | Update rate | Temporal span          |
|------------------------------------------------------|--------------------------------------|-------------|------------------------|
| Landcover types                                      | MODIS, 250 m                         | Annual      | 2001- now              |
|                                                      | Proba-V, 100 m                       |             | 2015- now              |
| Dominant species                                     | MODIS, 250 m                         | Annual      | 2001- now              |
| Wood stock                                           | MODIS, 250 m                         | Annual      | 2001- now              |
| Active forest fires (thermal anomalies detection     | MODIS, 1 km                          | Daily       | 2001- now              |
| results)                                             | VIIRS, 375 m, 750 m                  |             |                        |
| Burnt forest area                                    | MODIS, 250 m                         | 10 days     | 2006 – now             |
| Forest fire damage grade (condition class)           | MODIS, 250 m                         | Annual      | 2006 – now             |

2.2. Analysis features

Alongside with access to very large ERS satellite data archives the Vega-Les users have a wide range of data analysis tools. These tools provide nearly the same data processing features compared to dedicated desktop geoinformation systems (GIS) applications. Contrary to these complex and expensive applications, the Vega-Les users require only a modern web browser and broadband internet connection for work, and all the data processing is done on the “IKI-Monitoring” SUC remote processing hardware. Analysis and processing of various spatial data is performed with the map web-interface based on IKI developed technologies. The interface provides:

- data access, compare and selection for further analysis selection features;
- interactive analysis and processing of available satellite data (including data with different imaging times) with remote computation resources provided by the system. The toolset includes supervised and non-supervised classification, segmentation, spectral index calculation, pixel-based calculations, color correction etc.;
- graph-based analysis of temporal, spatial and spectral data series;
- objects length and area measurement and statistical parameters calculation with available data;
- joint analysis of satellite data and meteorological information;
- presentation creation for various phenomena and processes illustration with available data.

More detailed description of data analysis features provided by the “IKI-Monitoring” SUC based systems is given in [12].

Besides that the Vega-Les map interface provides a set of special tools for forest cover analysis. These interactive tools provide logging detection, damaged by various factors forest area mapping and estimation, local landcover mapping etc. with high resolution data (up to 10 m).

Another data analysis feature of Vega-Les system is implemented with BI-technologies, providing temporal and spatial analysis of data on various integration levels [12]. These tools provide the possibility of forest cover characteristics dynamics estimation.

3. Conclusion

As can be seen from above, the Vega-Les system integrates various satellite data, derived processing products and tools for research and monitoring of different characteristics of forests of Russia. The development of the system implies further integration and development of new information products and analysis tools for complex forest monitoring. It should be particularly noted that distributed data analysis features of the system enables conduction of fundamental and applied projects by scientific teams from multiple organizations. It is also necessary to note the already functional online data services provided by Vega-Les to dedicated fundamental and applied information systems.
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