Current Capabilities of the "IKI-Monitoring" Center for Collective Use

Andrey A. Proshin, Evgeny A. Loupian, Alexandr V. Kashnitskii, Ivan V. Balashov, Mihail A. Bourtsev

Space Research Institute RAS, Moscow

Abstract. Solution of many scientific and applied problems requires access to long-term archives of satellite data, as well as considerable computational resources for data processing and analysis. Building the necessary infrastructure for this is not always possible in framework of individual projects. The article gives the description of current capabilities of the "IKI-Monitoring" center, which provides solution for such tasks on the basis of high-performance resources of the data providing center.

Keywords: Earth remote sensing, satellite data archives, satellite data access systems, satellite data processing, big data.

1 Introduction

Over the past few decades, there has been an almost exponential increase in the volume of data obtained by the satellite remote sensing systems [1]. As of the beginning of 2018, more than 400 remote sensing spacecraft operated in earth orbit, the data of several dozen of which are publicly available. At the same time, there is an increase in the quality of data obtained by modern remote sensing systems, which have largely turned from observation to measurement systems. As a result, the demand for Earth remote sensing data, which are currently used for a variety of research and application tasks related to the monitoring of the natural environment and anthropogenic objects, has increased significantly. It is important that many of these tasks require access to large multi-year archives of satellite data and various data products derived from them, as well as significant computing resources for their processing and analysis. However, it is not always possible to build infrastructure for storage and processing of large amounts of satellite data within the framework of individual thematic projects, as it is often expensive.

Development of modern information technologies has made it possible to implement fundamentally new approaches to the management of satellite data processing, ensuring the effective collective use of expensive computing resources of the data centers for remote sensing data collection, processing and presentation. They enable not only providing users with access to satellite data of interest, but also providing them with a variety of services for data processing and analysis. These new technologies and approaches were used in 2012 to launch the "IKI-Monitoring" Center for collective use of systems for archiving, processing and analysis of satellite observations data in IKI RAS [2]. Its main purpose is to provide distributed processing of extra large satellite data archives for various scientific and applied projects. The center was created with use of technologies and software developed in IKI RAS [3,4,5,6]. To date, more than 70 different scientific organizations have taken advantage of this opportunity. A variety of resources provided by the "IKI-Monitoring" CCU were used in the implementation of dozens of scientific projects including the ones supported by RSF, RFBR and the Ministry of science and education of the Russian Federation.

This article describes to the current capabilities of the "IKI-Monitoring" CCU. It provides an overview of the accumulated archives of satellite data and thematic products derived from their processing. The main mechanisms for providing access to satellite data archives are discussed below, with special attention paid to the description of the tools implemented to date for remote data analysis and processing. The article also provides examples of information systems implemented on the basis of the capabilities provided by the "IKI-Monitoring" CCU.

2 Archives

Currently, the archives of the "IKI-Monitoring" CCU contain data obtained by more than 35 different observation instruments installed on both Russian and foreign satellites for Earth remote sensing. Thanks to the cooperation of IKI RAS and "Planeta" Research Center for Space Hydrometeorology, users of the center are also enabled to access archives of the Unified System Satellite Data Processing of SIC "Planeta" [7]. The total amount of data available to users online is currently about 2,5 petabytes. About 3 terabytes of new data are being stored into the archives daily. One of the key advantages of the "IKI-Monitoring" CCU is the temporal and spatial data coverage, currently equal more than 27% of the land surface area of the Earth, which is unprecedentedly large compared to Russian data

resources. Currently, the area of interest for permanent acquisition and processing of satellite data includes almost the entire territory of Northern Eurasia, including the Arctic territories, the border seas of Russia, as well as a number of regions in Africa, Asia, North and South America. It is significant that the archives of the center currently have quite a long series of data. For example, the data archives of Landsat series of satellites begin in March 1984.

The main sources of satellite data in the archives of the "IKI-Monitoring" CCU are shown in Fig.1. Most of the data comes from foreign satellite data distribution centers, in particular, from various departments of the American research government organization USGS, and the European space Agency ESA. The data of Russian satellite systems are being acquired mainly from the units of the SIC "Planeta", which also receives and processes data from many foreign satellites for Earth remote sensing. In addition, the data of a number of Russian satellites are being supplied by the Scientific Center for Earth Operative Monitoring (NTS OMZ). We should also mention manual upload of data files by the users of "IKI-Monitoring" CCU.

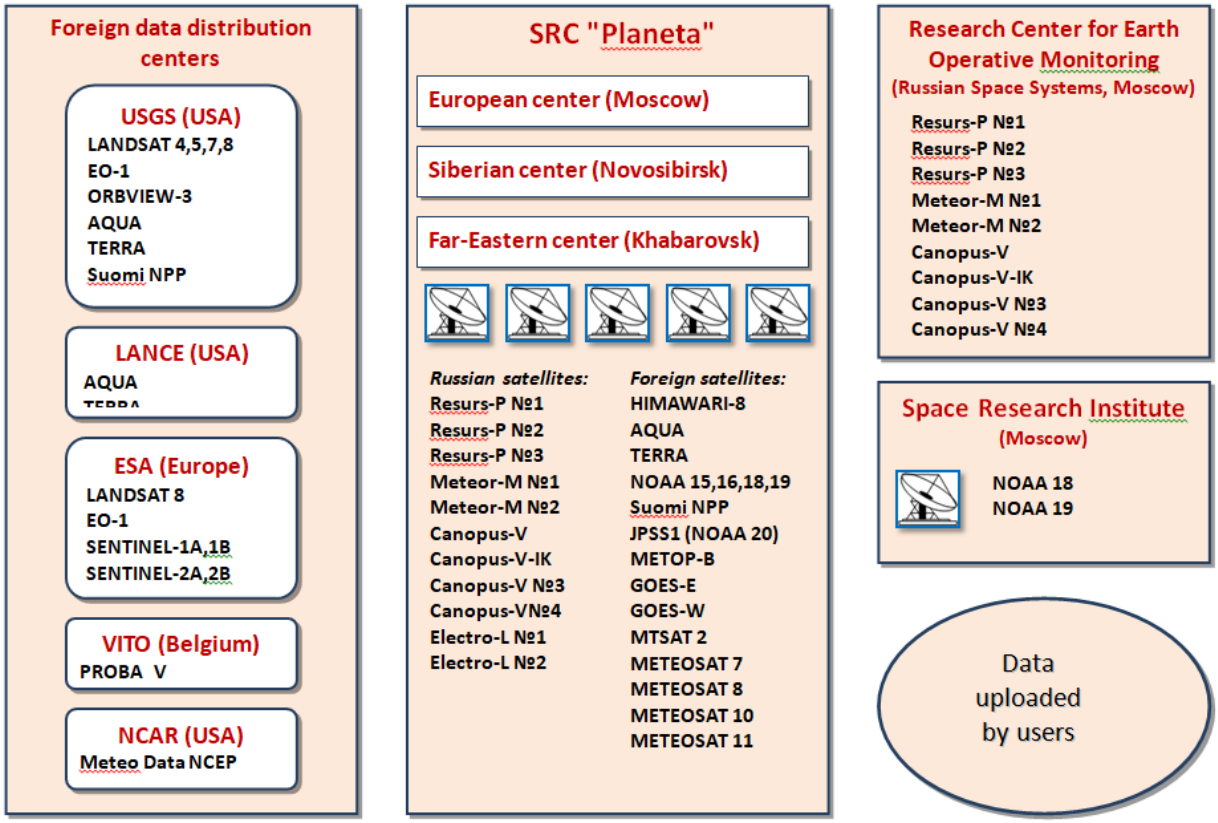

Figure. 1. The main sources of data in the archives of the "IKI-Monitoring" CCU

Up-to-date information about the data available to users is can be found on the information server of the center in the section "Data Archives" (http://ckp.geosmis.ru/default.aspx?page=6). It Should be borne in mind that this section provides information on the amount of data physically stored in the archives, most of which are satellite source data used to dynamically generate a wide range of various "virtual" data products.

3 Access to the Data in the Archives

In framework of the "IKI-Monitoring" CCU, the data access has been implemented in three ways:

- the "VEGA-SCIENCE" (http://sci-vega.ru) satellite information service providing the remote users with interactive access to the data archives of the "IKI-Monitoring" CCU, as well as with facilities for data processing and analysis [8.9];
- software interfaces for data access from auxiliary information systems;
- software gateway that provides access to data physically stored in external satellite data archives.

The "VEGA-SCIENCE" satellite information service provides users with access to the data of the archives of the "IKI-Monitoring" CCU based on the use of the multi-functional cartographic interface. Within this interface, a wide range of various tools for remote analysis and processing of satellite data is implemented [6]. Many of them until recently were available only in specialized local (desktop) and quite expensive software for satellite data analysis. In addition, users have access to a variety of reporting forms, graphs and histograms containing quantitative information derived from the analysis and processing of satellite data, as well as the necessary data from other sources. Based on the use of BI-technology (Business Intelligence), various interactive analysis tools (dynamic reporting forms, histograms, graphs and maps) are implemented, containing both information obtained from the processing of satellite data and data from other sources [10].

Software interfaces for data access are designed to use the capabilities of the "IKI-Monitoring" CCU in various specialized information systems. In addition to the basic functionality for data processing, these systems typically also implement some specialized features designed to solve certain scientific or applied problems.

Software gateways allow users of the center to access data physically located in the external archives of satellite data. Based on this approach, in particular, it is possible to access the data of the Roscosmos Geoportal [11].

4 Interactive data analysis and processing capabilities

By now, the IKI RAS specialists have implemented a wide range of various procedures for remote interactive analysis and processing of satellite data. At the same time, most of the currently developed tools are available to users of the satellite information service "VEGA-Science" (http://sci-vega.ru), which also gives a fairly detailed description of the available tools for data analysis and processing and get acquainted with the possible scenarios of using the tools. The following are the main functional groups of tools implemented by now.

1. The data access and selection tools allow users to prepare homogenous data sets of interest from various satellite data archives using search criteria such as geographic area, date range, satellite, instrument, product, cloud cover and others. The user can view the data in a range of spatial resolutions and projections, and a make an overlay of relevant map layers. If necessary, the user can perform additional geo-referencing of imagery. It is also possible to generate data sets for further processing and/or export.
2. Tools for satellite data processing implement a wide range of different data processing operations. The following are examples of such tools:
    - Tools for calculating spectral indices and image algebra, allowing to carry out arithmetic, logical operations and various mathematical transformations on the data, as well as to calculate spectral indices with arbitrary selected channels.
    - Supervised and non-supervised classification of satellite data, allowing split the area of the image into a number of classes according to certain parameters.
    - Color adjusting of images and color composition of several images, including multi temporal composition.
    - Using the palettes.
    - Data correction. This tool enables image filtering, topographic correction, limiting area of interest applied to selected channels of any selected satellite images from the archive.
    - Structural image analysis. This tool implements LESSA (Lineament Extraction and Stripe Statistical Analysis) technology. This technology is designed to automate the analysis in geological studies of the data of various types, including images, diagrams, digital elevation models (DEM).
3. Data series tools enable graphical analysis of temporal, spatial, and spectral data series. Particularly they allow to carry out the analysis of:
    - time series of data: values at specified points, indices on objects (fields), meteorological variables, etc.;
    - spectral profiles at selected points or selected objects;
    - meteorological data, including vertical profiles;
    - spatial profiles along arbitrary routes.
4. Tools for analyzing various characteristics of the data enable the measurement of length and area of geo-objects, analysis of one- and two-dimensional histograms, calculation of various statistical characteristics images of arbitrary regions of images.
5. Specialized tools for analysis and monitoring of various objects. Examples of tasks solved with these tools are:
    - monitoring and analysis of the state of agricultural fields and monitoring the dynamics of agricultural crops;
    - detection of forest logging based on the use of a time series of spectral channels of satellite images sensitive to changes in vegetation cover;
    - identification of ash plumes and determination of their characteristics;
    - detection of burnt area based on high resolution data.
6. Modeling tools are designed to predict the changes of certain objects of observation in time:
    - Modeling the behavior of ash plumes from volcanoes.
    - Modeling of fire dynamics.
7. Tools for meteorological data analysis

8. Web presentation toolkit makes it possible to demonstrate various phenomena and processes. With the use of this tool, all received and analyzed information from the information system can be represented briefly and conveniently for public presentation and discussion.

5 Examples of implemented information systems

Currently, a large number of various systems for scientific and applied purposes are functioning with use of the capabilities of the "IKI-Monitoring" Center for Collective Use (http://smiswww.iki.rssi.ru/default.aspx?page=11). Below are some examples of the information systems implemented on the basis of the center's capabilities:

- "See the Sea" satellite service (http://ocean.smislab.ru/) developed for solving interdisciplinary tasks of the ocean studies. [12]
- Information system "Remote monitoring of Kamchatka and Kuril volcanoes activity" VolSatView (http://volcanoes.smislab.ru/) [13].
- Information system of remote monitoring of the Federal Forestry Agency "ISDM-Rosleskhoz" (https://aviales.ru) [14], designed to provide real time remote monitoring of forest fires and their consequences.

6 Conclusion

"IKI-Monitoring" CCU provides unique capabilities for efficient processing of Earth remote sensing data to solve various scientific and research tasks, allowing the user to avoid the need for building expensive infrastructure for each of the projects. The implemented functionality, providing distributed analysis and data processing, makes "IKI-Monitoring" CCU the leading center in Russia and comparable to the most advanced world systems of this class.

In the future, first of all, it is planned to continue the development in improving and expanding the functionality provided to users for interactive analysis and processing of satellite data.

Acknowledgements. The basic functionality of the created system was developed with the support of FANO (the "Monitoring" theme, registration no. 01.20.0.2.00164); elements connected to the support of the virtual products functionality were developed with the support of RFBR (grant 16-37-00427 mol_a), functions that support the interaction of nodes of extra-large satellite data archives were worked out using distributed satellite data archives in the centers of SRC “Planeta” with the support of RFBR (grant 15-29-07953 ofi-m), Since 2019, technologies have also been developed with the support of FANO (the “Big Data in space research: astrophysics, solar system, geosphere" theme, registration no. 0024-2019-0014).

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