"IKI-Monitoring" shared use center support and development — possible solutions

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Abstract. The paper considers various problems of support and development of the IKI RAN shared use center (SUC) for satellite data archiving, processing and analysis (SUC "IKI-Monitoring", http://ckp.geosmis.ru/). First, the paper provides brief information on present capabilities and structure of the SUC along with general information about archives contents, capabilities of the VEGA-Science satellite service, a unique scientific unit integrated into the SUC, and various dedicated information systems using data services provided by the SUC. Second, the key advanced technologies developed by IKI and used as a basis for the SUC development are given. The last part of the paper highlights the crucial problems of the SUC support and evolution and their possible solutions. An advanced distributed structural model of the SUC to improve its operation to a new orbit is proposed.

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1. Introduction

Earth remote sensing (ERS) data is presently used for a broad range of research and applied natural resources and anthropogenic impact monitoring tasks. During the last decades the amount of ERS spacecraft on the Earth orbit is rising exponentially, so do the volumes and quality of the ERS data [1–3]. Development of information technologies gave new ways to satellite data management providing efficient shared usage of expensive computational resources of ERS data collection, processing and dissemination centres. These ways both provide data access and online processing and analysis services. Based on these ways and technologies, in 2012 the IKI RAN shared use center (SUC) for satellite data archiving, processing and analysis ("IKI-Monitoring" SUC) was introduced [4, 5]. Its primary goal is provision of distributed utilization of very large satellite data archives for various research and applied projects.

"IKI-Monitoring" SUC provides a broad range of Russian and foreign satellite data long term time series application capabilities. The total volume of data available to users at the beginning of August 2020 is reaching 4 petabytes. More than 90 research and educational organizations along with a number of dedicated research and applied information systems are using the SUC services. The Satellite Monitoring Technologies department team of IKI is continuously improving both the SUC infrastructure and the software services provided to users. Still, efficient SUC development and evolution cannot be carried on by a single collective, even a large one. Thus, it is reasonable to consider the evolution options with SUC nodes deployment in other interested organizations.

The paper provides brief information on present capabilities and structure of the SUC along with general information about archives contents, capabilities of the VEGA-Science satellite service, a unique scientific unit integrated into the SUC, and various dedicated information systems using data services provided by the SUC. Next, the key advanced technologies developed by IKI and used as a basis for the SUC development are given. More detailed information on the SUC is given in [4, 5]. The final part of the paper highlights the crucial problems of the SUC support and evolution and their possible solutions. An advanced distributed structural model of the SUC to improve its operation to a new orbit is proposed.

2. "IKI-Monitoring" SUC brief facts

"IKI-Monitoring" SUC archives keep the data from more than 40 instruments onboard more than 60 Russian and foreign spacecrafts. Total volume of data available at the beginning of Aug 2020 is getting close to 4 petabytes, growing for approximately 3 terabytes a day. Through the cooperation agreement between RAS and SRC "Planeta" the SUC users also have access to archives of the SRC "Planeta" United satellite data management system [6]. The regular area of interest now covers about 30 % of the Earth surface. An essential feature of the SUC archives is the availability of long term data time series. E.g., the Landsat data series in the SUC archives begins from 1984. Current information about actual SUC archives contents is available here: http://ckp.geosmis.ru/default.aspx?page=6. It should be noticed that this link provides information about physically stored satellite data, mostly of L1B and higher processing levels, used for dynamic creation of various "virtual" information products [7].

Access to satellite data and processing and analysis instruments is provided by VEGA-Science satellite service (http://sci-vega.ru) [8, 9]. The service provides access to the SUC archives, primarily for vegetation research and analysis tasks. Image processing and analysis tools are provided within the cartographic web interface of the service. Along with imagery and derived products users are provided with various analytical reports, graphs and charts also derived from satellite data, and supplemental data from other sources.

More than 12 dedicated research information systems were developed and operate on the SUC basis, including:

- "Kamchatka and Kuril Islands volcanic activity remote monitoring" (VolSatView, http://volcanoes.smislab.ru/) [10]. The system's main task is to provide the volcanologist experts with relevant, near real time satellite data and derived products for Kamchatka and Kuril Islands volcanoes research and monitoring;
- See the Sea satellite service (STS, http://ocean.smislab.ru/) [11] — information system for ocean interdisciplinary research with satellite data. Special emphasis is made on radar data and its application. At the moment, the centre provides the ability to work with archives of radar data obtained from satellite systems Envisat and Sentinel-1. Also, additional functionality was implemented to ensure the receipt and work with various information products used to monitor and study various processes on the sea surface.
- The information system "VEGA-GEOGLAM" [12] (http://vega.geoglam.ru/) was developed by the IKI RAS with the support of the European Commission SIGMA project (https://twitter.com/SIGMA_GEOGLAM). The purpose of the system is to provide tools for the analysis of remote sensing data for the development of methods and approaches for global monitoring of agriculture for the benefit of the GEOGLAM project (http://geoglam.org).
- Besides the research systems, several applied information systems were developed and operate on the same basis, including:
  - Remote Monitoring Information System of the Federal Forestry Agency (ISDM-Rosleskhoz, http://aviales.ru) [13], a system for collection of data about fires over the Russian territory and state of environment, production of data necessary for fires state and impact analysis and near real time data dissemination;
  - "VEGA-Agrometeorolog" information system (http://agrometeo.geosmis.ru) [14], a system for complex agrometeorological monitoring, developed by IKI in cooperation with the Hydrometeorological Centre of Russia, SRC "Planeta" and VNIISKhM (Russian Agricultural Meteorology Research Institute).

The "IKI-Monitoring" SUC hardware and software infrastructure is based on the technologies and core software developed in the Satellite Monitoring Technologies Department of IKI. For instance, data archives are built with the UNISAT technology for very large distributed heterogeneous satellite data archives [7]. Data processing pipeline uses the distributed multithreaded processing and control technology for efficient management of dozens of automatic processing stations [15]. Cartographic web interfaces are built with the GEOSMIS technology [16]. Maintenance and support problems are solved with the documentation and monitoring system (SDKP) [17].

3. Evolution prospects

During the past five years the total volume of data in the SUC archives has grown more than thrice, leading to relevant improvement of the storage and processing hardware. Amount of satellite data and derived products types, processing and analysis tools and methods has also grown dramatically. Thus, perpetual improvement of user services and software for all the stages of data lifecycle is going on, same as the steady rise of complexity of the SUC infrastructure and management.

Yet, despite the good progress and all the achievements, further evolution of the "IKI-Monitoring" SUC is quite problematic at the expense of the single institution. Rapid evolution of satellite ERS systems leads to exponential growth of satellite data available and requires more and more expensive storage and processing hardware, imposing a lot of limitations for growth. Moreover, fail-safe data storage and fast access require keeping the data in several copies. These requirements along with limited manpower for maintenance and development make the evolution, relevant enough for modern ERS data resource utilization, a hard task.

Another important circumstance is the potential fault point of all the SUC services due to deployment of all the hardware in the single center. Any critical hardware or networking error can make the SUC totally unavailable. Next weakness of the current SUC state is the networking speed. Despite great progress in the broadband networking speeds, remote users and centers still may experience problems with large data volumes. The last major problem is the diversity of satellite data applications. The SUC is cooperating with many research and educational teams, but it's obviously not enough to cover many ERS application areas and to adapt the SUC services for them.

All these problems and weak spots make a distributed architecture model the most promising direction for the "IKI-Monitoring" SUC development. This model involves deployment of dedicated SUC nodes in major research and educational centers and satellite data receiving and processing centers. Transition to this model will make possible the creation of a united shared use center supported and developed by multiple research and educational institutions. Different kinds of SUC nodes are proposed in accordance with host institution specifics:

- Research nodes.
- Educational nodes.
- Data assimilation nodes.

Research nodes are designed for studies support in the areas of environment monitoring, atmosphere and climate research, ocean and ice research, geology and geophysics, ionosphere research and many others, led by Russian and international teams. Introduction of such research nodes will be beneficial in various research teams cooperation and interdisciplinary studies. Such nodes can be deployed, for example, in regional research centers, already cooperating with or using the SUC services.

Educational nodes are designed for various academic programs support, providing the students with satellite data and processing and analysis tools for practical and laboratory courses, research projects and graduation works. Some premises are already made for this, because IKI hosts an industrial chair with MSU Space Research Faculty (https://cosmos.msu.ru) for an "Earth Remote Sensing Methods and Technologies" master's programme. Educational nodes will be beneficial in training of highly skilled researchers capable of using ERS data in their work.

Data assimilation nodes are designed for collection and processing of data from modern and advanced Russian and foreign ERS spacecraft. Main goals of these nodes are automatic processing of collected data to L1B level and higher, efficient data storage and access provision, along with interactive processing and analysis. It should be noted that IKI has a solid experience of fruitful cooperation with SRC "Planeta" data receiving and processing centres and their improvement in the way of SUC nodes deployment there is of real interest for both parts.

4. Conclusions

At the moment, "IKI-Monitoring" SUC is a unique service provider for very large and long term satellite data archives access and analysis. Still, further development of the center at the expense of the single organization can't meet all the challenges set by satellite data evolution. That's why the most promising way of the "IKI-Monitoring" SUC growth is transition to a distributed architecture implying deployment of SUC nodes in major research and educational centers along with satellite data receiving and processing centers.

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