# SOFTWARE PLATFORM FOR VOLCANO VIDEO MONITORING

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Video observation is the type of instrumental observations used to monitor and visually estimate the state of various objects, including natural objects such as volcanoes. Using the video camera allows remote and permanent observations of an object and, also, analyzing changes in its state, and/or an occurring eruption based on a set of images.

Owing to high activity of Kamchatka volcanoes and the necessity to conduct their studies and operative monitoring, implementing the multifunctional video observation system is carried out by the joint efforts of Kamchatkan Volcanic Eruption Response Team (KVERT) [Girina et al, 2007] of the Institute of Volcanology and Seismology, the Far Eastern Branch, Russian Academy of Sciences, (IVS FEB RAS), and the Computing Center, Far Eastern Branch, Russian Academy of Sciences, (CC FEB RAS). In order to visually monitor the state of Sheveluch, Klyuchevskoy, Avachinsky and Gorely volcanoes, 7 video cameras have been installed since December, 2009, in the settlement of Klyuchi and the city of Petropavlovsk-Kamchatsky. All cameras are connected to CC FEB RAS Data Center (Khabarovsk).

To manage the video observation network created, the special software platform was developed, providing the problems solution related to objects and observation facilities inventory, video camera managing, data archiving and image processing. It consists of several components interacting each other as modules of unified "Signal" platform [Sorokin et al., 2015], used to provide the operation of the instrumental observation network of FEB RAS and to manage its resources (Fig. 1).

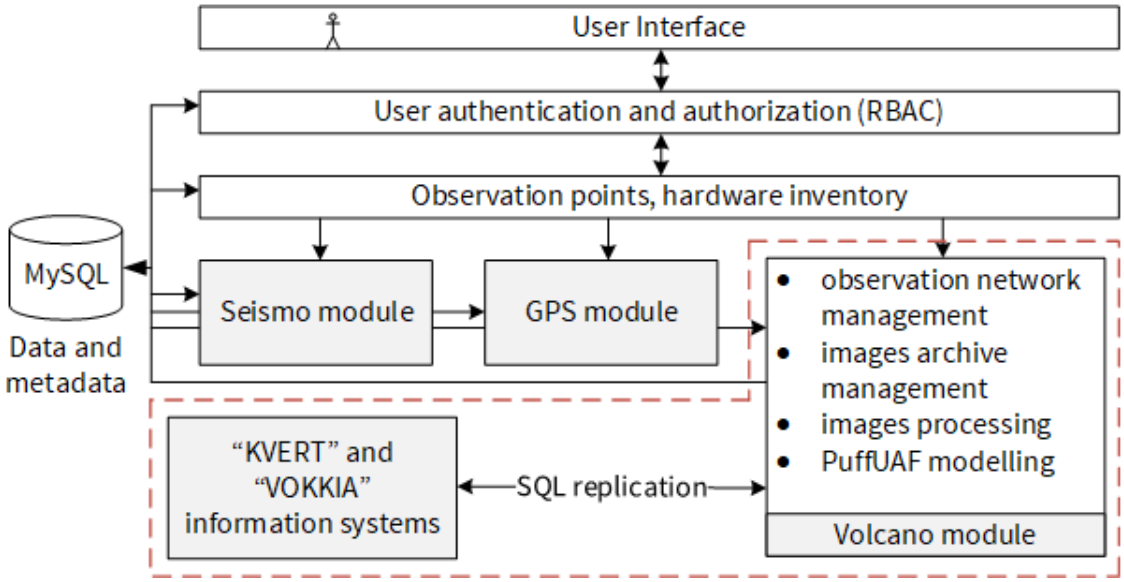


*Fig. 1. General "Signal" architecture with volcano video module integrated*

**Network inventory module.** The module provides basic infrastructure operations including:
- basic metadata management of studied objects;
- video cameras inventory;
- observation point inventory;
- role-based access control of system objects and data archive access.

**Metadata synchronization subsystem.** VOKKIA (Volcanoes of the Kurile-Kamchatka Island Arc) [Romanova et al., 2012] and KVERT information systems are the main source of Kamchatka volcanoes metadata and their actual state data. The most important information is current Aviation Color Code of the volcano, concerned with aviation safety in the region and assumed to be used as the formalized indicator of the volcano state, and ash ejections data included in Volcano Observatory Notice for Aviation (VONA) [Gordeev et al, 2014]. All this data, produced by KVERT scientists and recorded to master database, is automatically replicated to slave database of "Signal". A statement based MySQL replication approach is used giving the following advantages:

- new data is available right after publication, i.e. there is no need to check new data availability periodically;
- due to MySQL replication architecture, it is resistant to communication errors;
- it has the smallest impact on information systems to integrate.

Once data is replicated to slave-server, a special developed trigger used to transfer it to corresponding subsystems and modules: Aviation Color Code is used to control image fetch schedule (the more active volcano is, the more frequent fetch should be performed), ash cloud metadata is used to simulate its propagation during next period of time.

**Image fetch subsystem.** The subsystem performs periodic fetch and storage of images from video cameras. Fetch period is defined by metadata synchronization subsystem individually for each volcano based on its current Aviation Color Code. After the image has been fetched and further archived, appropriate image metadata (the observation object, video camera ID, fetch time, size) is populated in RDBMS. Fetched images are also estimated by different metrics in specialized processing module.

Due to limited bandwidth of WAN network links at places, where video cameras are installed, it is sometime not impossible to fetch images with second time resolution. To eliminate this limitation, a local archive approach is developed now. The main idea is to fetch images with second time resolution period using high-speed local link, and then apply special rules based on synchronized metadata to purge local archive and transmit only most important images to Data Center, saving network bandwidth.

**Image processing module.** Manual analyze of archived volcano images is very laborious and time-consuming task. Besides that, captured images informativity could be affected by different factors (weather conditions, etc.). In order to unequivocally identify and classify the images that are neither qualitative nor informative, we are developing the algorithms and methods for evaluation of volcano images and their implementation as the image processing module [Kamaev et al, 2018]. While archiving captured image, module analyzes the contour visibility of the volcano for day-time images as well as thermal anomalies for night-time images on IR-filter equipped cameras. Results are recorder to image metadata and can be used for fast analyze of volcano activity using image archive.

**Ash propagation modelling module.** When metadata synchronization subsystem receives VONA message containing eruption basic information (date, time, duration, plume height), the modelling is carrying out to calculate ash cloud trajectory during next period of time. Puff-UAF model is used [Sorokin et al, 2016]. Modelling results are recorded to GIF, JPG, KML files as well as to RDBMS for future mapping using WFS interface.

**REST API module.** Observation network inventory data, archives images and their metadata, ash propagation modelling results are available through special module, providing HTTP-based REST API [Korolev et al, 2018]. Using standard GET-query one can query information in JSON format. The following URLs are available as for now:

| URL | Dataset |
|---|---|
| */volcanoes* | Volcano full list |
| */volcanoes/#id* | Volcano metadata by *#id* |
| */cameras* | Video cameras full list |
| */cameras/#id* | Video camera metadata by *#id* |
| */photos* | Images search |
| */tasks* | Ash propagation modelling results full list |
| */tasks/#id* | Ash propagation modelling result by *#id* |

The developed API are used as one of the data sources in a comprehensive information system VolSatView for monitoring Kamchatka volcanoes [Gordeev et al, 2016]. Based on the joint analysis of data obtained using various types of observations which involve video observations, remote sensing data, computer modelling, etc., the system allows complex investigation of Kamchatka volcanoes.

The created video observation software platform allows the solution of the necessary set of problems that are related to the centralized imagery management, searching for the images in the database, and, also, their transmittance to the external specialized information systems for further joint analysis in combination with the data obtained using other types of observations for Kamchatka volcanoes.

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