CORRELATION OF THE SATELLITE AND VIDEO DATA FOR OPERATIVE MONITORING OF VOLCANIC ACTIVITY IN KAMCHATKA

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Various remote sensing methods are successfully used for operative monitoring and forecast of volcanic activity worldwide. For example, for the detection of the thermal anomalies, algorithms of analyses of the infrared satellite data from AVHRR, MODIS, VIIRS sensors were developed (Wright et al., 2004; Coppola et al., 2016). From 8 to 12 Terra, Aqua, Suomi NPP satellites with MODIS and VIIRS sensors installed pass Kamchatka and Kurile island territoties every day. Nevertheless, due to the high eruptive activity of the volcanoes, which intensity may change during several minutes, the frequency of satellite images derivation is a very important aspect in monitoring of volcanic activity. To solve the problem of the increase of the frequency of the remote sensing data, it is rational to use AHI sensor installed at geostationary satellite Himawari-8 (Japan Meteorological Agency). This satellite was put into orbit in 2014, it has better radiometric, spectral and areal resolution than its predecessor – MTSAT satellite. AHI allows to survey Earth surface each 10 minutes, which sufficiently increase its informative in respect to the monitoring of active volcanoes. In Russia, Himawai-8 data is received and processed by Far-Eastern Center of State Research Center for Space Hydrometeorology «Planeta» (FEC SRC «Planeta», Khabarovsk). Due to the joint use of facilities of the data processing of FEC SRC «Planeta» и IKI (IKI RAS) center for collective use "IKI-Monitoring", the information that is received on a base of Himawari-8 data, is integrated to the informative system "Information system for Monitoring the Volcanic Activity in Kamchatka and on the Kuril Islands" (VolSatView) (Gordeev et al., 2016; Lupian et al., 2015). AHI data processing has been done ultimately in VolSatView. For the each satellite image, the brightness temperature in diapason 3.9 µm was automatically detected above the active volcano.

To verify satellite information we used data of the video observations from the web-cameras of the Institute of the volcanology and seismology, installed in Klyuchi village. These cameras perform continuous monitoring of Sheveluch volcano activity. Last years, web-cameras became very important instruments for the continuous monitoring of the current volcanic activity, but in most cases they are used mainly for the qualitative monitoring. Several algorithms of the web-cameras images processing for quantitative estimations of volcanic activity were lately demonstrated in a series of publications (Patrick et. al., 2010; Lovick et. al, 2008). The web-camera which we used, has image frequency 1/minute. This camera automatically switches to the night mode regime, at which it uses close infrared diapason from 0.7 to 1.0 µm. Authors developed a bash-script (Linux) which automatically chooses only night images and processes them. Images were converted from the coloured (RGB) image to the grey scale images according to the formula (Gonzalez, 2016) $Y = (0.299*R) + (0.587*G) + (B*0.114)$, were R, G, B – are the intensity of the red, green and blue colors and Y is the brightness. Coefficients are provided for the color temperature 6500 K. Due to this converting the image is represented by 256 gradations of grey, or brightness (0 corresponds to black, 256 – white color). The base of analyses is the method of statistical processing of images. For each image, the standard deviation (grey scale) was determined **-** the exponent of scattering the values of a random variable relative to its mathematical expectation, which allows one to estimate how much the values in the set may differ from the mean value. As a result, we can obtain quantitative characteristics of the luminescence intensity of the thermal anomaly within the active part of the volcano.

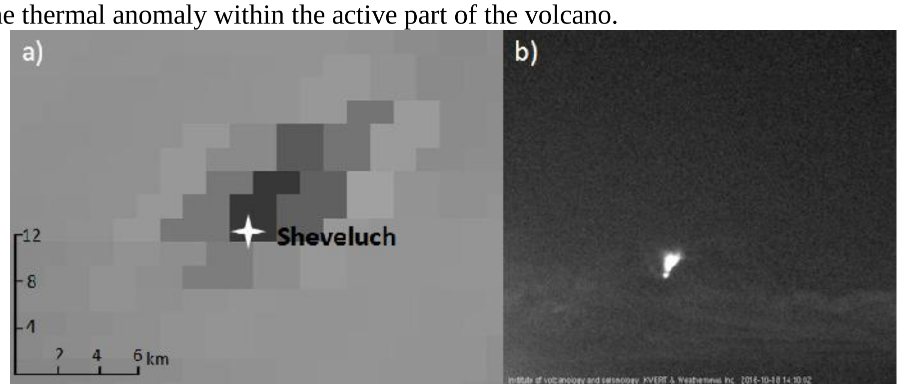

Fig. 1. Satellite image AHI Himawari-8, infrared channel 3.9 µm (a) above the Sheveluch volcano. Several "hot" pixels are observed. Night infrared image of Shiveluch volcano from web-camera in Klyuchi village (b). Bright glow is observed above the lava dome of the volcano. Date and time for both images: 18.10.2016 at 14:10 UTC.

As an example of verification and correlation of the satellite AHI Himawari-8 images and web-camera images we provide here information Sheveluch activity on 18.10.2016 (Fig.1). At Fig. 2, we show the diagram of the brightness temperature distribution according to AHI data and standard deviation for web-camera images. As it is show at Fig. 2, both graphs correlate quite well: large maximums correspond to the explosive events, and smaller peaks correspond to the extrusion of the hot lava dome parts. Sharp beginning of the events with following attenuation is registered at both graphs.

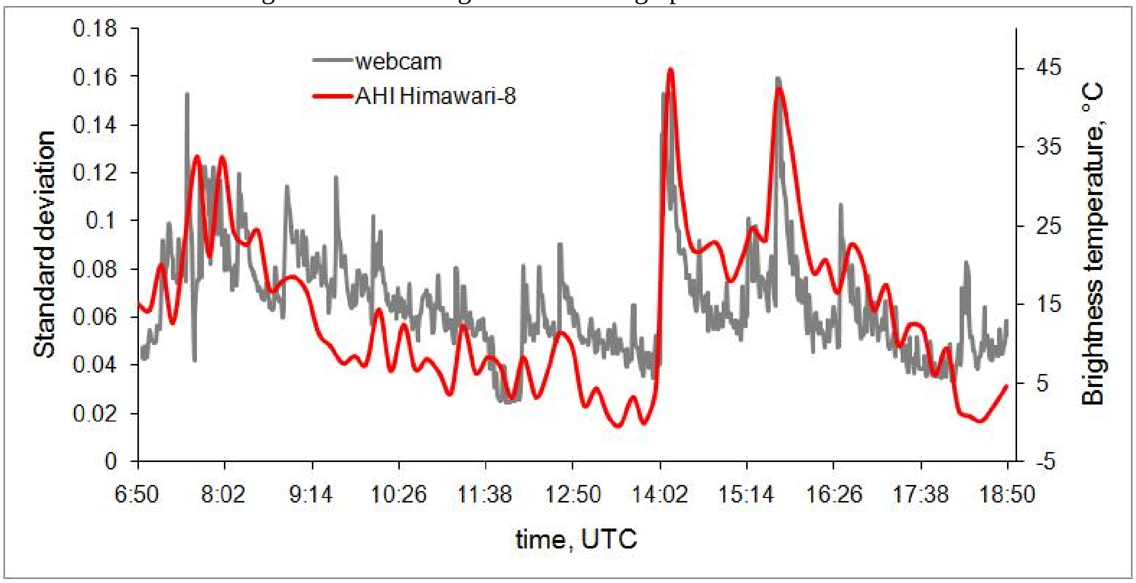

Fig. 2. Brightness temperature distribution above Sheveluch volcano according to AHI Himawari-8 (1 image per 10 minutes) and standard deviation for web-camera images (1 image per 1 minute) during night time at 18.10.2016 UTC.

We show that the increase of the time detailing of the data allows us to distinguish the stages of the preparation and developing of the eruptive activity and to increase the informative value of the operative monitoring of the current eruptions of volcanoes. Two methods of processing and analyses of the remote sensing data (satellite and video) represented in this abstract, may be used both independent and complementary.

This work was supported by the Russian Science Foundation, project № 16-17-00042

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