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High-rate thermal imaging systems in volcano surveillance: the case of El Reventador volcano (Ecuador)

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Imaging-based thermal monitoring systems have demonstrated their reliability in detecting the occurrence of different volcanic phenomena by providing temperature measurements. These systems are set in various modes and configurations in volcano surveillance; e.g. permanent installations, air-borne periodical measurements, ground-based surveys, among others. We analyze here the critical points for the operation of permanent systems: housing, timing, and data volume, with the aim to provide practical and sustainable solutions.

Typical outdoor conditions in the Ecuadorian Andes, like in many other volcanic regions, could be extremely rough and changing. For El Reventador, located in the sub-andean region, extremely high rain and humidity lead to a rapid degradation of the monitoring instruments. In order to keep our thermal monitoring system safe under these extreme environments, we mounted the camera and the controller inside a waterproof case equipped with an IR Window.

The second critical point is timing. Typically thermal cameras need to be systematically GPS synchronized in order to obtain continuous temperature measurements which can be correlated with other geophysical parameters like seismicity, gas emissions, or infra-sound recordings. This is easily achieved during short term campaigns, when the camera is directly handled by an operator. However, permanent systems tend to loose the GPS time synchronization after a few hours or days in the field. In order, to avoid this time drift, we use a Raspberry Pi© board as controller coupled with a GPS device so that it can continuously synchronize the clock and provide precise timing accuracy.

The third critical point is the extremely big size of the files containing the thermal images to be stored and transmitted in order to get continuous thermal sequences. Also because of the extreme weather conditions at El Reventador, there are only few hours per day of good visibility of the crater. In order to avoid recording and storing useless images from which no thermal information can be retrieved, we designed software pieces, written in C++, to control the camera behavior. The controller sets the camera with basic parameters in order to get a high-rate stream of thermal data. The software handles two streams, thermal raw data (frames) and the mean temperature of a given region (user defined) in the field of view. This mean-temperature stream is recorded in a text file with the corresponding GPS-time. Whenever the temperature surpasses a user defined threshold, a trigger is produced, telling the controller to start recording also the thermal images. The system can be coupled to a communication module that will transmit only the triggered sequences, saving bandwidth and memory space.

This system is proven to save storage space, processing time and to provide a temperature data set with a precise GPS time, able to be correlated with other parameters. Once the threshold is well defined, the system can be also used as a warning of enhanced volcanic activity.