Applications of FreeWave Radios in Seismic and Volcanic Monitoring in Ecuador

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Overview

Since 1983, the *Instituto Geofísico* [Institute of Geophysics of Ecuador] has been responsible for seismic and volcanic monitoring throughout the country. The institute's mission is to improve disaster preparedness and lessen the impact of seismic and volcanic phenomena throughout Ecuador via constant monitoring, scientific research and technology that promotes the creation of a precautionary culture. Thanks to the *Red Nacional de Sismógrafos* [National Seismograph Network] and the *Red de Observatorios Volcánicos* [National Volcano Observatories], the Institute is able to issue early warnings so that authorities and citizens have enough time to take the appropriate precautionary measures, based on risk maps produced by scientists. In the case of the recent eruptions of the Tungurahua Volcano in July and August 2006, December 2008 and the last in December 2010 this helped warn hundreds of thousands of people early, got them out of harm's way, and saved countless lives.

Challenge

The Institute's monitoring network has been growing over the past 28 years due to new needs, technological advances and the involvement of international organizations that have donated equipment and trained personnel. However, this rapid progress also gave rise to new problems and challenges for which the Institute has been trying to find immediate solutions.

The primary challenge was to build a real-time telemetry network highly capable of transmitting data. Previously, no adequate data collection equipment for seismic and volcanic monitoring, much less digital technology, had ever been installed in the country. The existing equipment could not transmit information and only collected local data. This meant time and money to periodically visit remote sites to collect the data.

To start with, digital telemetry was used for applications that did not require, continuous transmission in real time, but the data are transmitted with regular intervals of time, as is the case with lahars and deformation networks. With this new technology in place, fairly ideal results were achieved. There were no interference problems, but the equipment used was not robust enough for the climate conditions in which it needed to operate.

Later, however, the demand for continuous and real time applications increased. New projects were undertaken and the need to find equipment that met monitoring conditions and requirements grew so that the Institute could fulfill its commitment to the community.

Solution

Given the problem of implementing an affordable, real-time telemetry system that is simple and sturdy, new options were considered, and, for first time, an international organization installed FreeWave (www.freewave.com) radios DGR series for to transmit data of the deformation of the Cotopaxi Volcano and the Galapagos Islands. Although the mechanics, features, advantages and cost of these radios were not known at the time, very good results were obtained, reducing maintenance of monitoring stations to zero. Later, one of the institute's engineers set up a photographic camera with serial transmission using FreeWave for the Reventador Volcano.

These changes took place around 2002 and the institute began to gain more experience in using FreeWave radios. It also became familiar with programming. The system's connections have proven reliable, as well as its performance in extreme conditions. This gave the Institute the idea that it was on to a solution for solving its real-time, digital transmission problem.

Currently, the Institute has added FreeWave radios to many of its monitoring networks and used them in various monitoring applications and implementation activities. Among the primary monitoring applications are: real-time broadband seismic stations in the active Volcanoes and tectonic faults, accelerometers located in the cities, meteorological stations, stations to monitor volcanic gases, deformation stations using GPS technology and borehole sensors, remote digital cameras, and stations to quantify mud flow.

At the present, the Institute has a big challenge with the implementation to the geological and volcanic national survey in Ecuador, it includes to install 150 further stations with different applications and with many telecommunication solutions, in order to get data in real time, then the new FreeWave versions will be very useful, for example the FGRE-2PE who has two built-in serial ports plus two switched Ethernet ports offer unprecedented flexibility and meet connectivity requirements as to connect two monitoring instruments allocated at the same site.

Furthermore the Institute will start using the HT Plus model, with high throughput, very useful when many signals are concentrated at the same node and after they are transmitted together to the other node.

Results

Over the past six years, the work with FreeWave radios has met the Institute's expectations in many regards. Connections at different distances have proven highly reliable and stable. Performance in extreme conditions has met its needs, as evidenced by a radio that transmits images from the top of the highest active volcano in the world, which operates at below zero degree temperatures from a height of 5947 m above sea level (seen in figures 1 and 2).

Figure 1

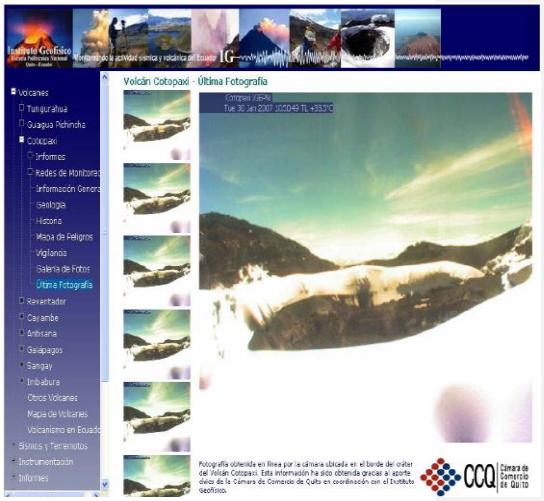
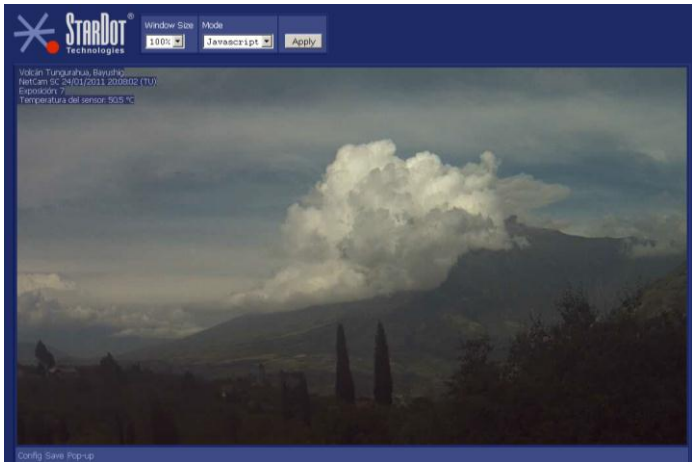
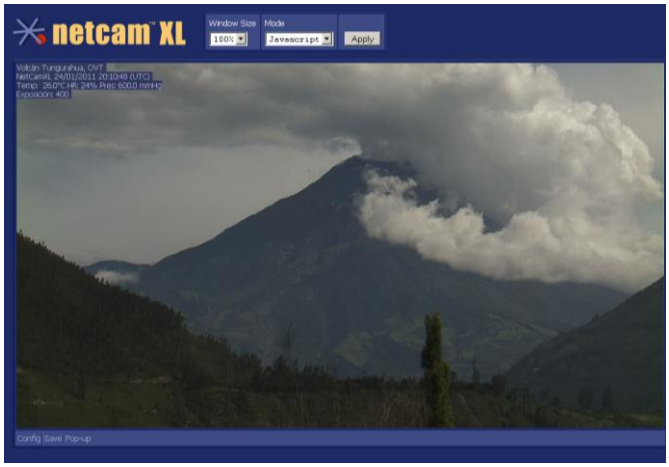


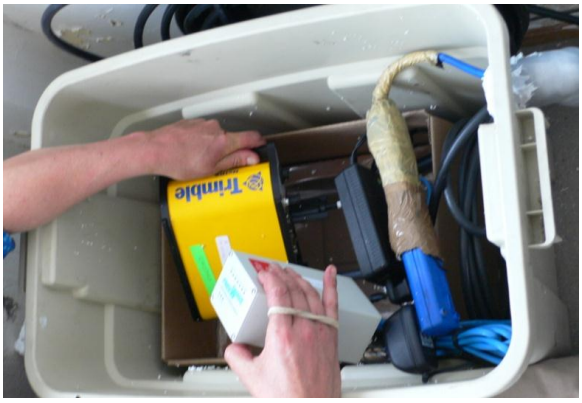
Figure 2

About this application a cameras network was installed in Tungurahua volcano for visualizing the volcano from four critical zones in real time, the figures show the volcano from west side and from the Tungurahua Volcano Observatory





A solution also was found for the latest models of deformation equipment using GPS technology. The equipment required transmission using TCP/IP protocol. Currently, the Institute has a network with 5 GPS receivers on the Cotopaxi, 4 on the Tungurahua, 1 on the Chimborazo , 1 on the Antizana Volcanoes and 7 around the country. In this year will be installed 51 further GPS. An example of a station can be seen in figure 3.



Comment [TD1]: Has this increased or chang

The best thing about this solution is that each piece of equipment is connected to the Institute's internal network allowing access to the equipment from any part of the network without needing a specific PC or software. This makes processing data easier for the volcanologists. A diagram of the Cotopaxi network is shown below.

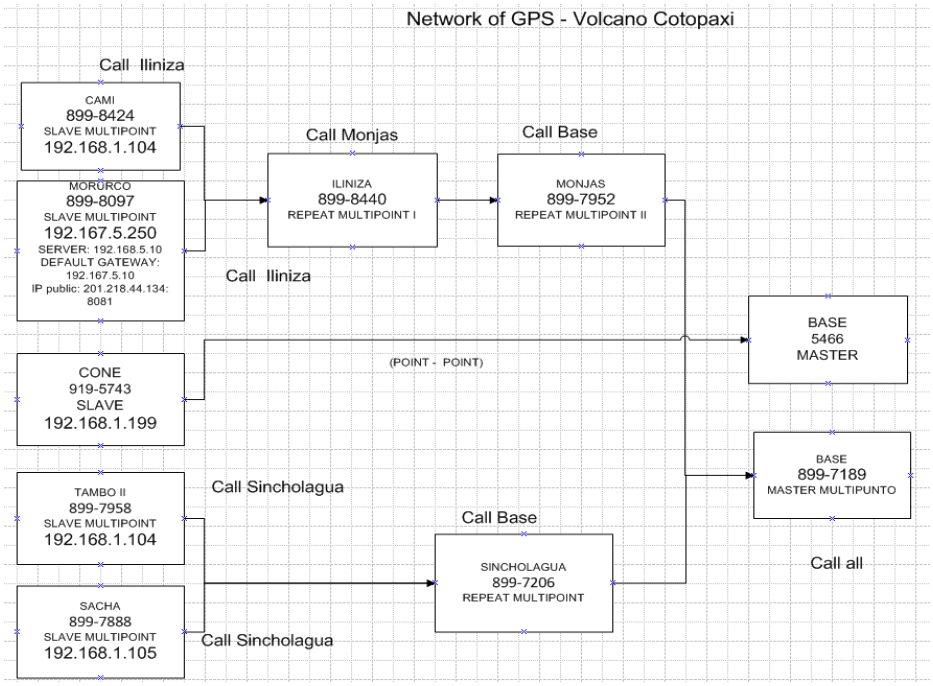


Figure 4

One example of a solution for monitoring volcanoes using FreeWave radios is the Institute's real-time monitoring of gases, as can be seen in the following images.

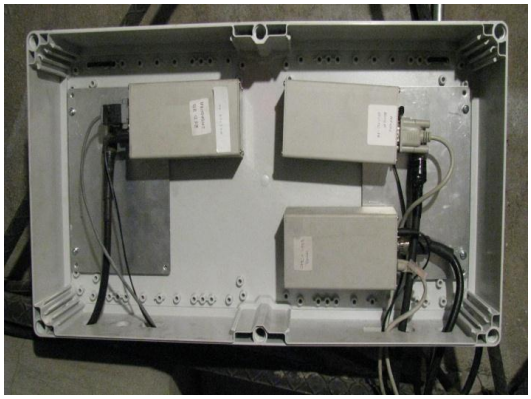


Figure 5

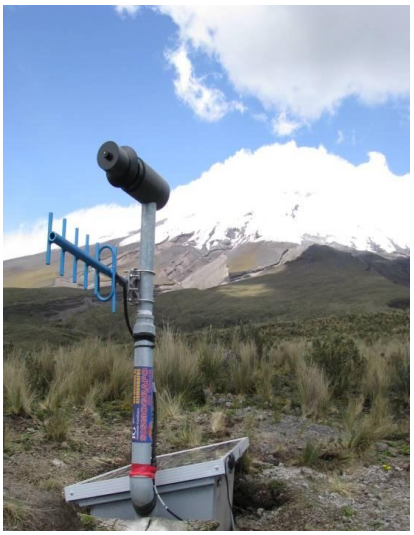
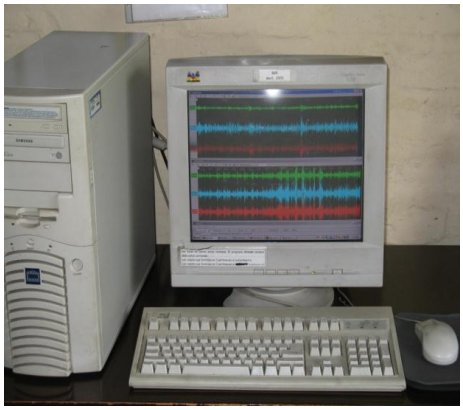


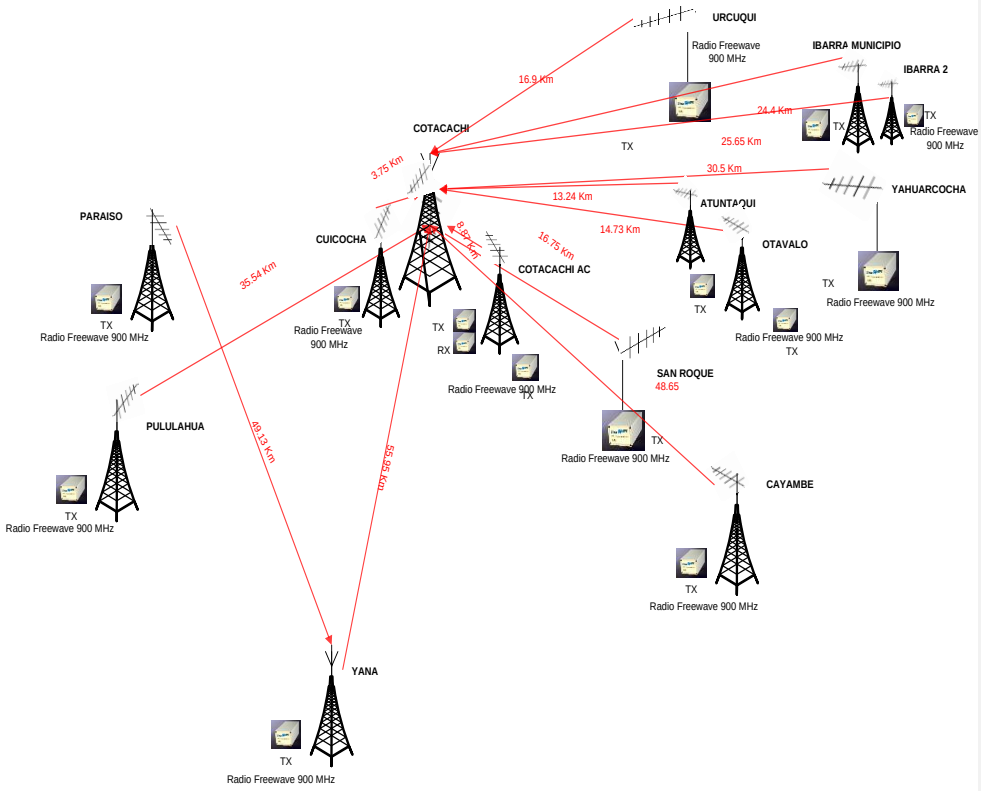
Figure 6

Seismic broadband monitoring using FreeWave radios made it possible for the Institute to give early warning about the eruptions of the Tungurahua Volcano in 2006, 2008 and 2010, since the connected sensors allowed it to see signs that other sensors did not.

Comment [C2]: Have the radios helped give early warning to additional volcanic eruptions?



A example of a new sub-network will be deployed this year in Imbabura volcano as part of geological and volcanic national survey is showed the following figure:



Benefits

Among the key benefits of using FreeWave radios:

- Reliable connections
- High performance under extreme conditions
- Easy configuration
- Compatibility among all versions
- Transparent radios
- Different data interfaces
- Far-reaching
- Fast transmission
- Immune to interference

Conclusion

Finally, due to the performance and flexibility of FreeWave radios, as the new characteristics in new versions, engineers at the Institute continue to consider this transmission equipment as the best option for different applications and projects already underway, the cost-benefit ratio is excellent for the our job and our budget, these radios play an important role in the big responsibility that the Institute has with the community in Ecuador for warning the people at risk.

About the author:

Cristina Ramos received her Master Degree in Wireless System and related technology at Politecnico di Torino.Italy in 2004. Electronic and Telecommunications Engineer at Polytechnic National School. Quito-Ecuador in 2001. She has worked like research engineer at Telcom Italia in 2004. Currently she works at Geophysics Institute of Polytechnic National School, she has 10 years telecommunications experience, and she is field engineer and has designed many telemetry networks and solutions for data transmission for volcanoes and seismic monitoring. Actually is working with the design the new telecommunications networks as spread spectrum, microwave, fiber optics and satellite solutions. Also she is professor at Technology School of Telecommunications at Polytechnic National School.