Integrate Processing of Seismic and Infrasound Monitoring in Northeast Italy: The Fadalto Case

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Introduction

The Earth Science Department of the Florence University http://www.unifi.it/) in Italy has a long experience in monitoring avalanches, volcano and seismic activities in the infrasound band, also in the framework of several international and EU funded project, and in the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO, http://www.ctbto.org/) activities.

The Seismological Research Center (http://www.crs.inogs.it/) of the OGS (Italian National Institute for Oceanography and Experimental Geophysics, http://www.inogs.it/) in Udine (Italy) after the strong earthquake of magnitude M_w=6.4 occurred in 1976 in the Italian Friuli-Venezia Giulia region, started to operate the North-eastern Italy Seismic Network: it currently consists of 17 very sensitive broad band and 18 simpler short period seismic stations, all telemetered to and acquired in real time at the OGS-CRS data centre in Udine. Real time data exchange agreements in place with other Italian, Slovenian, Austrian and Swiss seismological institutes lead to a total number of about 100 seismic stations acquired in real time, which makes the OGS the reference institute for seismic monitoring of North-eastern Italy (Bragato et al., 2011).

In 2012 in the Fadalto area in the Belluno province in Northeast Italy several strong rumbles were heard, which eventually scared population and concerned authorities. OGS and University of Firenze installed in cooperation a real time seismic and infrasound monitoring system in the area. A description of the technical system capabilities, together with the preliminary results of the analysis of several months of recordings will be here illustrated.

The Area

The Lapisina Valley is located in North-eastern Italy, Venetian Prealps, and separates the Belluno Prealps in the West from the Cansiglio Plateau in the Est. It is a typical glacial valley, with wide bottom, and steep longitudinal profile and represents the original course of the Piave River, abandoned during the Late Glacial epoch for the obstruction of the valley due to the Fadalto landslide, detached from the Costa-Millifret Mount (Pellegrini, 2000).

The pre-Quaternary rock in the Fadalto Valley are all sedimentary (glacial, landslide, talus slope). Fadalto landslide is chaotic and consists of predominantly calcareous debris, in silty-sandy matrix (Autostrade SpA, 1985). The coarse grain decrease in size from North to South. At the edge and bottom of the valley there are Mesozoic formation which are transitional sequence among predominantly pelagic and escarpment faces.

From the tectonic point of view the complex syncline at the bottom of the valley has been dislocated by a system of inverse and transcurrent faults, connected with the line 'Longhene-Fadalto-Cadola', striking almost NNE-SSW (Pellegrini and Surian, 1996).

The Lapisina Valley does not posses a main stream, but from North to South is characterized by four lakes (the main lake of Santa Croce, and the smallest Dead, Restello and Negrisiola lakes, modified for the exploitation of hydroelectric resources, since the beginning of the twentieth century). From the hydro-geological point of view, the Sella of Fadalto represents the watershed between the basin of the Piave and Livenza rivers. Meschio is the only river that collects underground waters from karst relieves of Col Visentin. Farther East, sources give rise to Livenza (Gorgazzo, Santissima, Molinetto), picking up the circulation of karst Group Cansiglio-Cavallo. The position of the water table is heavily influenced by the regime of precipitation and water level of the lakes.

Figure 1 – Seismic network installed by OGS in Val Lapisina, Fadalto

The instrumentation

The seismic network installed by OGS to monitor the Fadalto area is illustrated in Fig. 1. The configuration changed over time according to findings in the actual data, while the initial configuration reflected the population perception of the rumbles (CRS staff, 2011). The seismic stations used were made of Reftek C130 acquisition units and Lennartz LE3D 1 second seismometers. The RefTek 130S-01 Broadband Seismic Recorder (http://www.reftek.com/products/seismic-recorders-130-01.htm) digitizes and stores analog input from a variety of external sensors, including seismometers, accelerometers, tiltmeters and other geophysical sensors. The 130S-01 hardware is optimized for field deployments and is designed to be easy to use: compact, light in weight, low power consumption, and requires few maintenance. The Lennartz LE-3Dlite (http://www.lennartz-electronic.de/index.php?option=com_content&view=article&id=50&Itemid=55) is a 1 Hz to 100 Hz passband, low-power, low-noise, rugged and compact seismometer for applications requiring short-period sensitivity, field worthiness and portability.

The seismic network was completed with the FADA station made of a Quanterra Q330 digital acquisition unit (orange box in Fig. 2, left) with 6 channels, 24 bit digitizer sampled at 200 sps and a Lennartz LE-3D Lite short period seismometer (bronze cylinder up right on the left of Fig. 2) with eigenfrequency 1Hz, upper corner frequency 100Hz, and a dynamic range > 136dB. The Quanterra Q330 (http://www.kinemetrics.com/p-78-Q330.aspx) is a low-power 3-6 channel remote broad-band seismic system: it includes Quanterra's ultra-low-power delta-sigma 24-bit A/D, a DSP/RAM module containing 8Mb, a GPS receiver, power conversion, sensor control, and a telemetry management module. For these characteristics the FADA station was connected via GPRS modem transmitting data in real time to the OGS seismic data centre in Udine. A simple Short Time Average/Long Time Average (STA/LTA) detector after high pass filtering the data at 20 Hz tagged events of interest in real time, automatically sending alarm messages via email and Short Message System (SMS) to OGS and Civil Defence of the Veneto Region personnel.

The FADA station, being the only one in the network sending data in real time, was also equipped with an iTEm infrasonic sensor model "prs 0110a" (right in Fig. 2), with a sensitivity of 25 mV/Pascal @ 1 Hz, ± 100 Pa full scale range, frequency response 0.01 – 100 Hz -3 dB@ 0.02 Hz, and self noise -52 dB relative to 1 Pa. iTEM is a consulting and system design company spin off from Florence University based in Florence (Italy) working in the Earth Sciences and Geophysics (http://www.item-geophysics.it/).

Figure 2 – Seismic (left) and infrasound (right) sensors installed in Fadalto

Data Analysis

After a first analysis of several months of combined seismic and infrasound recordings in the Fadalto area, after automatically pre-selecting of interesting event time windows based on high pass filter above 20 Hz and STA/LTA detector on vertical component of the seismic signal, we categorized events of interest in several categories, including:

1. Seismic and acoustic recordings of local earthquakes: seismic and acoustic signals share the same high frequency content (10-50 Hz), suggesting that the infrasonic signals is produced by ground-coupled waves.
2. Signals not associated with earthquakes or rumbles generated by the same high frequency and resonant source (Fig. 3): similar signals have been recorded by Florence University with an infrasound sensor in the Valle d'Aosta site during helicopter over flights. MacAyeal et al. (2008) however suggested in a personal communication that these signals might express stick and slip of land masses, perhaps premonitory to a large landslide.

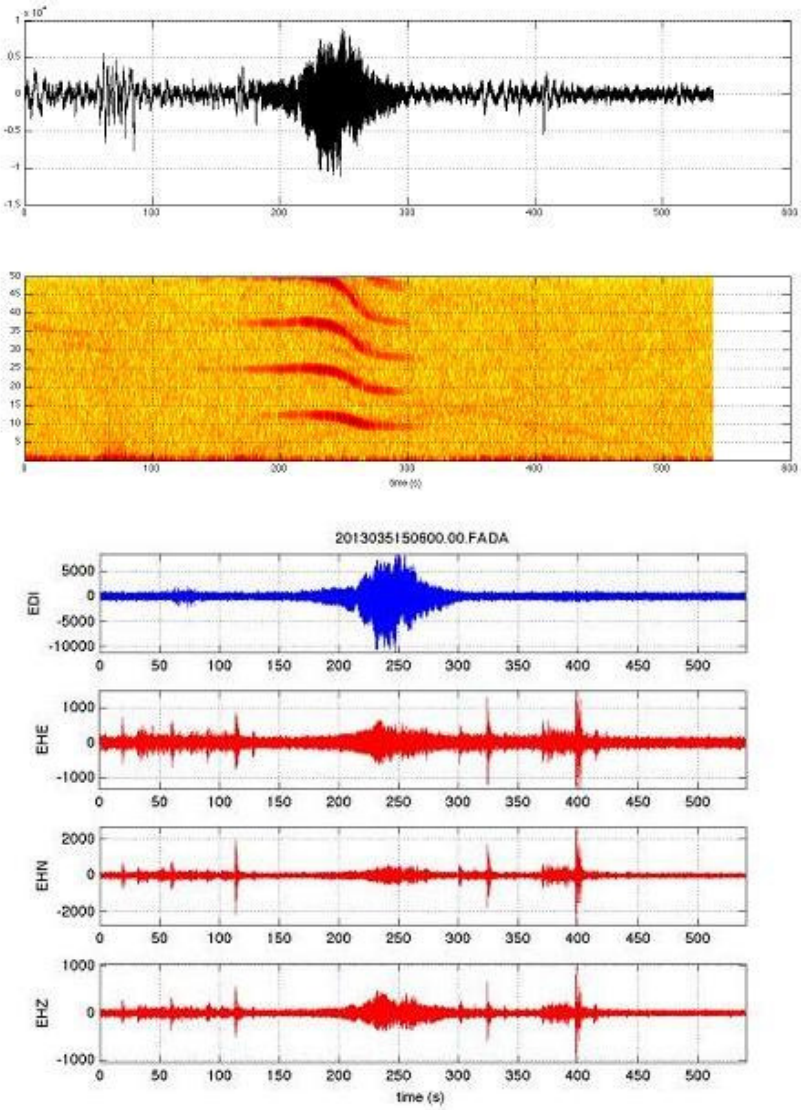

Figure 3 – Infrasound (black top and blue bottom) and seismic (red bottom) waveforms of observed event with infrasound spectrogram (top)

Conclusions

No direct evidence in the recordings were found of the rumbles. A deeper seismic analysis of the phenomena however indicated that the rumbles can be associated to variation of underground water levels which in turn causes:

1. micro fractures (change in pressure in the pores);
2. water flow in karst conduits with phenomena type exhaust siphons, water hammer, etc.

The experience of combining Università di Firenze infrasound instrumentation and expertise and OGS seismic instrumentation and expertise proved in the Fadalto case to be very valuable and useful for other Civil Defence and nuclear test explosions monitoring (CTBTO) applications and

purposes. Moreover, OGS and Università di Firenze are planning to join forces to star addressing the issue of real time seismic and infrasound monitoring of snow avalanches (Valt et al., 2009).

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