2011 EGU General Assembly 2011 Vienna | Austria | 03 – 08 April 2011 Session SM1.3/G3.8/GD3.7/GI-19/TS8.7

The INGV Mobile Telemetered Network (Re.Mo.Tel.): long-term monitoring analysis.

Luigi Abruzzese[1], Gianpaolo Cecere[1], Alberto Delladio[1], Giovanni De Luca[1], Alessandro Marchetti[1], Salvatore Mazza[1], Francesco Mele[1],
[1]Istituto Nazionale di Geofisica e Vulcanologia, Centro Nazionale Terremoti

Abstract

Since 2008, the Istituto Nazionale di Geofisica e Vulcanologia (INGV) developed a temporary real-time seismic network infrastructure (Re.Mo.Tel.) to densify the Italian National Seismic Network in epicentral areas, thus improving the location of the aftershocks after a mainshock.[Abruzzese et al. 2011].

The aim of this poster is to analyze the impact of the Re.Mo.Tel. on earthquakes detection and real-time monitoring of the sequence evolution, the location improvement due to the deployment of stations closer to the epicentral area (with installations that followed the early evolution and complexity of fault fractures) and the network reliability in terms of data stored throughout the working period.

L'Aquila earthquake

The April, 6th, 2009 Mw 6.3 L'Aquila earthquake represented the first real-case where the entire Re.Mo.Tel. infrastructure has been deployed. Less than 6 hours after the earthquake occurrence, a first accelerometric station was streaming data to the INGV seismic monitoring headquarters. A total number of 9 seismic stations was installed within 4 days after the main event, with the aim of recording continuous data to contribute in the aftershocks detection. In detail the first day a number of 3 stations was installed, surrounding the mainshock. Then the rest of the stations was deployed on the third and the fourth day to the south and the north, following the post-seismic evolution.

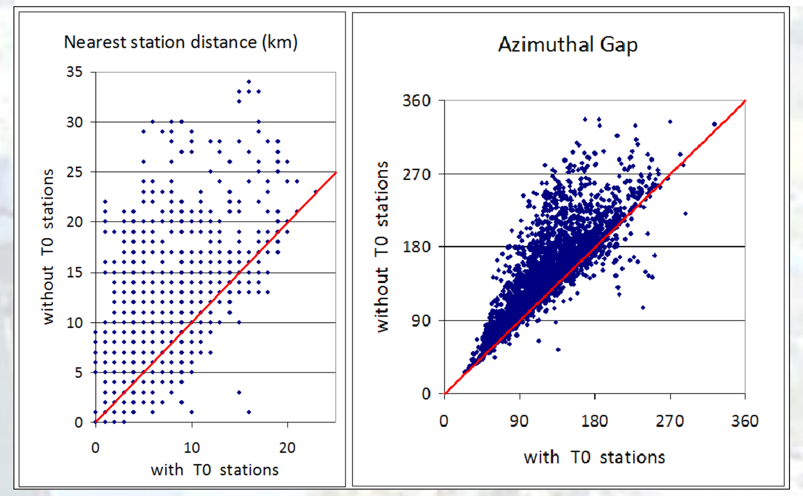
Figure 2 illustrate some of the stations installed during the sequence.

Figure 1 Vsat Terminal with solar panels and a Wi-Fi antenna on the pole. The red boxes contains batteries to provide electricity during the night.

Location and magnitude analysis

Soon after the Mw 6.3 L'Aquila earthquake, the daily human revision of the aftershocks recorded by the *Italian National Seismic Network*, integrated in real time with the signals of the *Portable Telemetered Seismic Network* (T0 Stations hereafter), allowed a rapid analysis of the evolution and geometry of the complex fault system reactivated by that seismic sequence [Di Luccio et al. 2010].

The *Bollettino Sismico Italiano* (http://ISIDe.rm.ingv.it/) reports 16416 events, localized after the installation of the first T0 stations in the L'Aquila region, (in the time period starting from April 6th, 2009, 17:50 UTC, to July 31st, 2010), in an area spanning 42.2° to 42.6° of latitude North, and 13.25° to 13.6° of longitude East. During those 16 months of operations the T0 stations, fully included in the real time analysis of the *Italian National Seismic Network*, contributed to the location of 8836 earthquakes; 1521 of them wouldn't have been localized without the signals of the T0 stations.



In **Figure 3 (left)** we report the distance of the closest station (in km) as found in the location obtained using the T0 stations (x axes), versus the distance of the closest station obtained locating the earthquakes without the T0 stations (y axes). The mean distance of the closest station was reduced from 7.9 to 6.7 km. Nevertheless the azimuthal gap was reduced by more than 10°, from 110.5° to 100.4° (the median was reduced from 99° to 92°). The **Figure 3 (right)** shows the azimuthal gap of the full location (with T0 stations) versus the azimuthal gap of the reduced location (without T0 stations).

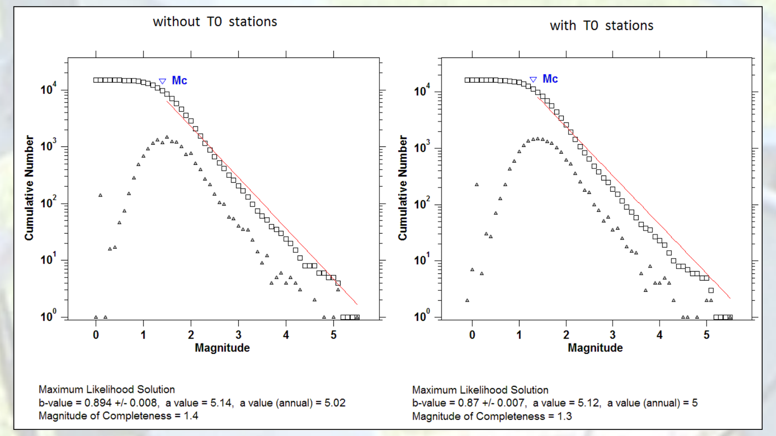
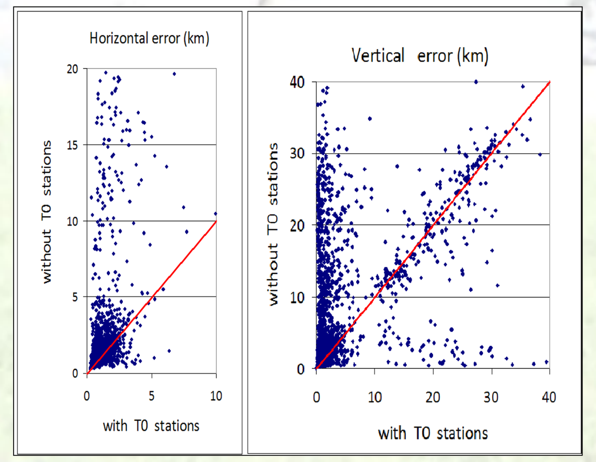


Figure 5 shows the Gutenberg-Richter distribution for 14895 events localized without the T0 stations **(left)** and of 16416 events localized with the T0 stations **(right)**. The minimum magnitude of completeness, computed with the maximum likelihood method [ZMAP, Wiemer 2001] decreases from ML 1.4 to ML 1.3.

We have localized with HYPOINVERSE 2000 [Klein, 2002] the remaining 7315 events, both with and without the T0 stations, in order to evaluate the contribution of the T0 Stations to the knowledge of the seismic sequence. In this group of earthquakes the T0 Stations produced 21056 valid P and S phases in a total of 138097 phases (an average of 2.9 phases per event in a total average of 18.9 phases per event).



In **Figure 4 (left)** the use of the T0 stations in the location reduces the mean of the formal horizontal errors by 25%, from 1.17 km to 0.88 km. It also reduces the number of earthquakes located with a formal horizontal error greater than 5 km. A greater reduction **(Figure 4 right)** is found (38%) in the average formal vertical error, from 2.71 km to 1.69 km, while the 95th percentile is reduced from 17.3 km to 4.86 km. Without the T0 stations the depth was held fixed by the Hypoinverse procedure in 635 events, but was fixed in 287 events only while using T0 data.

Performance management analysis

A network performance analysis must be comprehensive of the entire acquisition system. In a complex structure as the INGV, the data, once arrived physically at the acquisition center, must go through several different processes. A fault in one or more components could be disruptive as the transmission issue at the remote site. It is for this reason that in order to have a complete analysis of the accuracy of data, we investigate the data in the archive, which is the last node in the acquisition system.

Station code name	Installed	Decomissioned
T0101	april 6th 2009	september 1th 2009
T0102	april 6th 2009	september 1th 2009
T0103	april 6th 2009	june 12th 2009
T0104	april 7th 2009	not yet
T0105	april 8th 2009	september 1th 2009
T0106	april 8th 2009	not yet
T0107	april 9th 2009	not yet
T0110	september 8th 2009	not yet

The **table 1** shows when the single stations are installed. Some of the stations have not been removed yet, because they are part of a new project financed by Civil Defense Agency (DPC).

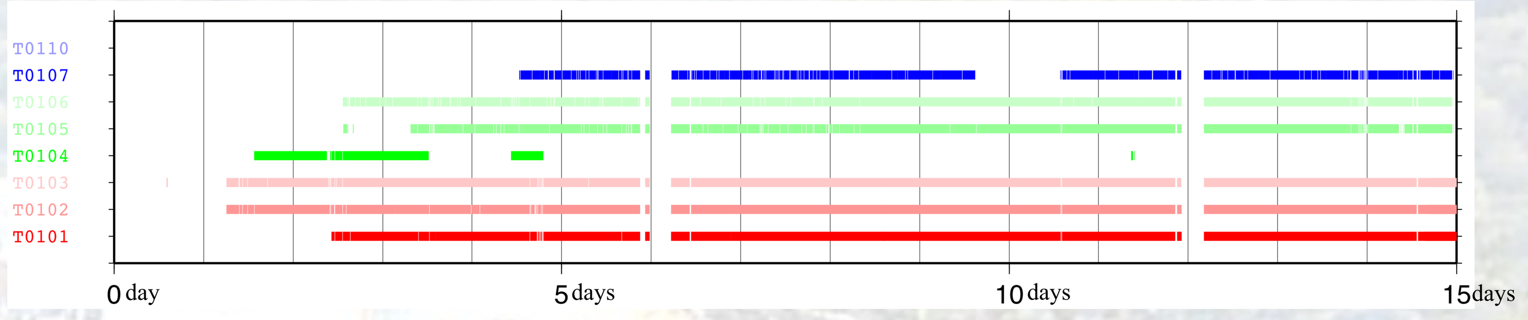


Figure 6 shows data availability for the first fifteen days. Starting from the bottom we can clearly see that although the first three stations were installed on day 0 (April 6th) data coming from two of them (T0102 and T0103) were available only one day later, while the T0101 was fully available only starting from the third day of installation (April 8th). Similar remarks are valid for the stations installed in the successive days.

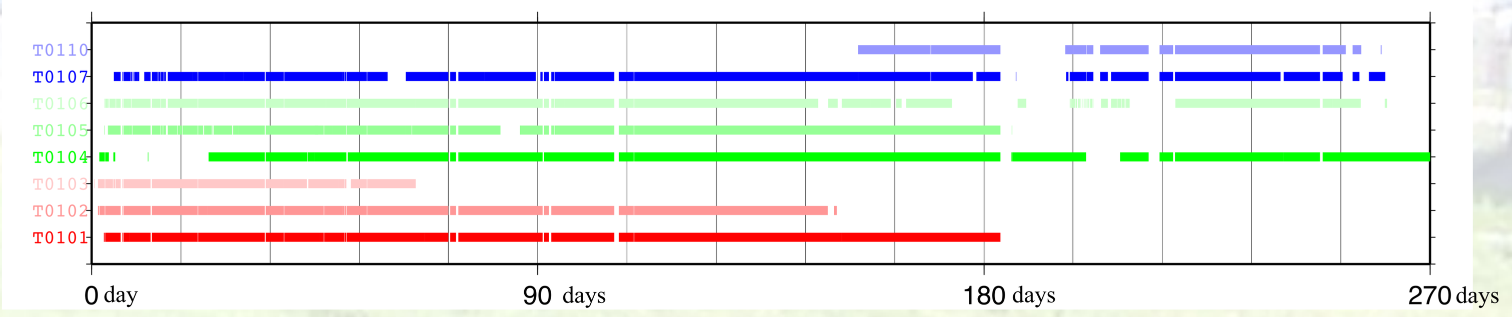


Figure 7 shows a window of 270 days starting from April 6th. Approximately we stored most of the data, although few general gaps are present, together with other gaps mainly due to the transmission medium.

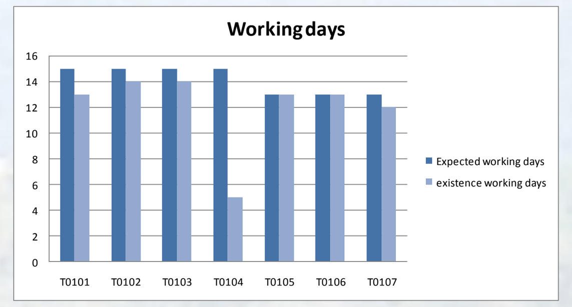


Figure 8 compares for each portable station the number of working days versus the installation days. There is an evident problem with T0104, which has only 5 days of data on a basis of 15 days of installation.

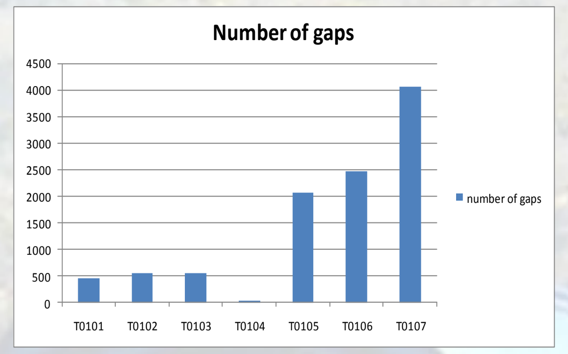


Figure 9 shows the number of gaps found in the data**.** T0101 was 4 Km from the radio link center, while T0107 was at 17km. The number of gaps increases with increasing distance. T0104 was directly connected to the satellite, consequently no relevant gaps were detected.

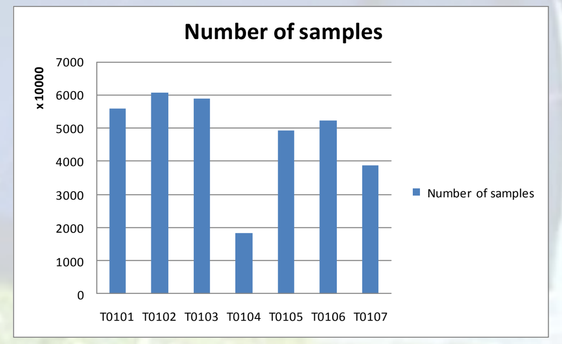


Figure 10 express the completeness of data in terms of samples. T0101, T0102 and T0103 were supposed to have the same amount of data, as T0105 T0106 and T0107. Again T0104 has a number of samples that shows a break down in the acquisition system.

Conclusions

For the first time in Italy, during a major seismic crisis, the signals provided by a portable network were integrated in real time into the routine operations of the National Seismic Network. Analysis of recorded data showed how the Re.Mo.Tel. basically provided a good coverage of the L'Aquila sequence. Although the existence of few major gaps, the data stored throughout the period of reference (April 2009-july 2010) contribute to locate 8836 earthquakes on a total of 16416. This experience allowed us to point out both weaknesses and advantages of the entire portable network, suggesting future developments in the connection facilities and in the procedures for real time data quality check.

References

- Abruzzese Luigi, De Luca Giovanni, Cattaneo Marco, Cecere Gianpaolo, Cardinale Vincenzo, Castagnozzi Angelo, D'Ambrosio Ciriaco, Delladio Alberto, Demartin Martina, Falco Luigi, Franceschi Diego, Govoni Aladino, Memmolo Antonino, Migliari Franco, Minichiello Felice, Moretti Milena, Moschillo Raffaele, Pignone Maurizio, Selvaggi Giulio, Zarrilli Luigi, (2011) La Rete sismica Mobile in telemetria satellitare (Re.Mo.Tel.), Rapporto Tecnico INGV n° 177.
- Di Luccio, F, G. Ventura, R. Di Giovambattista, A. Piscini, and F. R. Cinti (2010). Normal faults and thrusts reactivated by deep fluids: The 6 April 2009Mw 6.3 L'Aquila earthquake, central Italy. J. Geophys. Res., 115, B06315, doi:10.1029/2009JB007190,2010.
- Wiemer, S., (2001). A software package to analyze seismicity: ZMAP, Seismol. Res. Lett., 72, 373-382.
- Klein, F. W., (2002). User's guide to HYPOINVERSE2000, a Fortran program to solve for earthquake locations and magnitudes. Open-file Report 02–171 (US Geological Survey, 2002).