



Early aftershocks of the 2016 Mw 6.0 Amatrice, Mw 5.9 Visso and Mw 6.5 Norcia earthquakes in central Italy: analysis of the Seismic Bulletin

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The Amatrice-Visso-Norcia seismic sequence (AVN.s.s in the following) includes the strongest earthquake occurred over the last 30 years in Italy. The seismic sequence started on August 24th, 2016 with two strong-moderate earthquakes (Mw 6.0 and Mw 5.4), causing extensive damages and 294 fatalities; they were followed by thousands of aftershocks, and two other moderate earthquakes on October 26th (Mw 5.4 and Mw 5.9). On October 30th the strongest earthquake of the sequence (Mw 6.5) struck Central Italy, causing no fatalities but more than 40,000 refugees. Four more moderate earthquakes ($Mw \geq 5.0$) occurred on January 18th, 2017. By early 2018, the INGV had already located more than 80000 earthquakes of the AVN.s.s.

All the waveforms recorded by temporary stations deployed by the SISMIKO emergency group, as well as the stations of the national permanent seismic network, were available in real-time at the INGV surveillance room in Roma. In the last 3 years the Italian Seismic Bulletin working group (Bollettino Sismico Italiano-BSI) developed procedures that allow the integration of signals from temporary seismic stations, even if they are not acquired in real time, but they are rapidly archived in EIDA (European Integrated Data Archive: <http://eida.rm.ingv.it/>).

The analysis strategy of the BSI group for the AVN.s.s was to select the earthquakes located in the box with min/max latitude: 42.2/43.2 - and min/max longitude: 12,4/14,1. We separately analyzed the selected events with specific rules, to prepare a special issue of the BSI on the seismic sequence (expected for June 2018); the earthquakes outside the box were published in the regular releases of BSI on <http://cnt.rm.ingv.it/bsi>.

Moreover, we decided to carefully review the earthquakes that immediately followed the major shocks (special days). The first few hours after a strong earthquake are the most critical for seismic surveillance, when countless light, minor and moderate felt earthquakes occur, the demand for information from the population becomes more pressing, and it becomes crucial to follow the evolution of the seismic sequence in order to understand if and when it extends to the neighboring regions.

We compared the seismicity analyzed by the seismologists on duty in the surveillance room in Rome, with the earthquakes revised by the analysts of the BSI. In particular, for the "special days" (with moderate-strong earthquakes in the range 5+ of magnitude) BSI revised all automatic locations performed by the Earthworm system. For each day, the revision of the analysts increases the number of located earthquakes by a factor of three, on average.

The early aftershocks were located using different location techniques to illuminate the different portions of the faults they activated. Moreover we identify some early-events with an anomalous content in low frequency, occurred within the activated faults system. We also present time moment tensor of the seismic sequence and focal mechanisms obtained from first pulse polarity.

The locations of the early aftershocks give very important clues on the initial fault activation and are fundamental to understand the physical mechanisms of the earthquake source.