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Analysis of the 2016 Amatrice earthquake macroseismic data

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Abstract

On August 24, 2016, a sudden M_W 6.0 seismic event hit Central Italy, causing 298 victims and significant damage to residential buildings and cultural heritage. In the days following the mainshock, a macroseismic survey was conducted by teams of the University of Padova, according to the European Macroseismic Scale (EMS98). In this contribution, a critical analysis of the collected macroseismic data is presented and some comparisons were performed with the recent 2012 Emilia sequence.

I. INTRODUCTION

Central Italy inhabitants were woken up on August 24, 2016 due to the occurrence of a strong M_W 6.0 earthquake, that hit a large area between Lazio, Umbria, Marche and Abruzzo regions, historically prone to seismic hazard. The instrumental epicenter was located at 42.70°N and 13.24°E by the Istituto Nazionale di Geofisica e Vulcanolgia (INGV), close to the Municipalities of Accumoli and Amatrice. This area is one of the most prone to seismic hazard in Italy and was affected in the past centuries by several events, as illustrated in the Parametric Catalogue of Italian Earthquakes [Rovida et al. 2016]. The historical most severe events which caused extensive damage and victims in Accumoli and Amatrice were the 1627 Monti della Laga (I_O 7-8 MCS), 1639 Amatrice (I_O 8-9 MCS), 1703 Valnerina (I_O 10 MCS), 1730 Valnerina (I_O 7 MCS), 1883 Monti della Laga (I_O 7 MCS) and 1916, 1950 and 1979 (MCS 7-8) earthquakes [Rovida et al. 2016]. The capability to forecast seismic scenarios has assumed a great importance in the last decades, not only in terms of measureable ground motion parameters, but also of macroseismic intensities [Rotondi et al. 2016]. Particularly, intensity-based analyses are required if a direct correlation between damage and ground shaking is necessary, especially for non-seismologist public. These relationships can also be applied to study the statistical properties of seismicity, and compare historical descriptive information with recent data. This work shows some preliminary results derived from the analysis of the macroseismic data collected by teams of the University of Padova. In particular, macroseismic epicentral parameters are derived and a comparison between collected data and existing macroseismic-instrumental literature relationships is performed and discussed.

II. MACROSEISMIC SURVEY

In the days following the mainshock, teams of the University of Padova organized a field survey aimed to develop an exhaustive macroseismic assessment, according to the European Macroseismic Scale (EMS) [Grünthal 1998]. Results of the survey can be found in detail in Zanini et al. (2016). Figure 1 illustrates the intensity I_{EMS} distribution over the struck territories. A total of 180 sites were surveyed, in same cases more times, and I_{EMS} intensities were assessed on the basis of the damage detected on residential buildings.

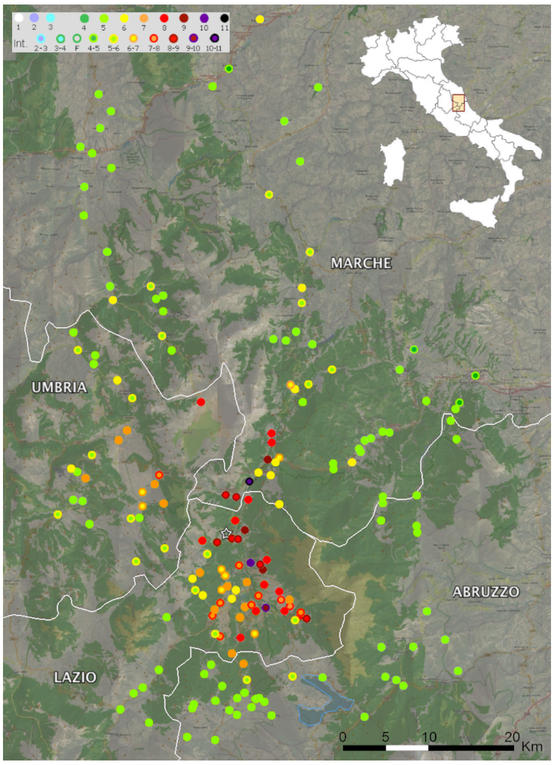

Figure 1: *I_{EMS} intensities observed after the August 24, 2016 event (damage up to September 6, 2016).*

Figure 2 shows the I_{EMS} frequencies observed: 13 sites suffered I_{EMS} at least equal to 8-9. Accordingly, the *EMS* epicentral coordinates and intensity were assessed using Boxer software [Gasperini et al. 2010], resulting in 42.697°N and 13.281°E, slightly westwards with respect to the instrumental one, and with I_{EMS} 10.

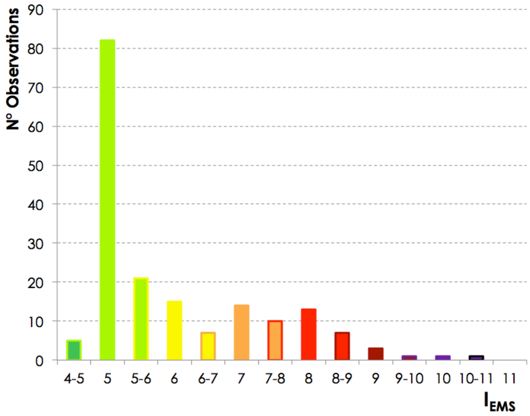

Figure 2: *I_{EMS} macroseismic data collected.*

III. MACROSEISMIC-INSTRUMENTAL CORRELATION

The potential correlation between EMS intensities assessed on site and instrumental ground motion data recorded by the Italian Accelerometric Network (IAN) was investigated. The analysis of this correlation allows comparing recent seismic events (for which instrumental measures are usually available) with historical earthquakes, whose intensity is derived *a posteriori*, only on the basis of the macroseismic evaluation of damage. The first step was the definition of the instrumental intensity values of interest: peak ground acceleration (PGA), velocity (PGV) and spectral accelerations at 0.3s and 1.0s (SA0.3, SA1.0) were considered as relevant instrumental parameters (data retrieved online at http://shakemap.rm.ingv.it, last access on November 4, 2016).

Once identified the accelerometric stations in the area of interest, only sites for which an EMS intensity is available and placed at a distance less than 6 km were taken into account in the analysis (see Appendix).

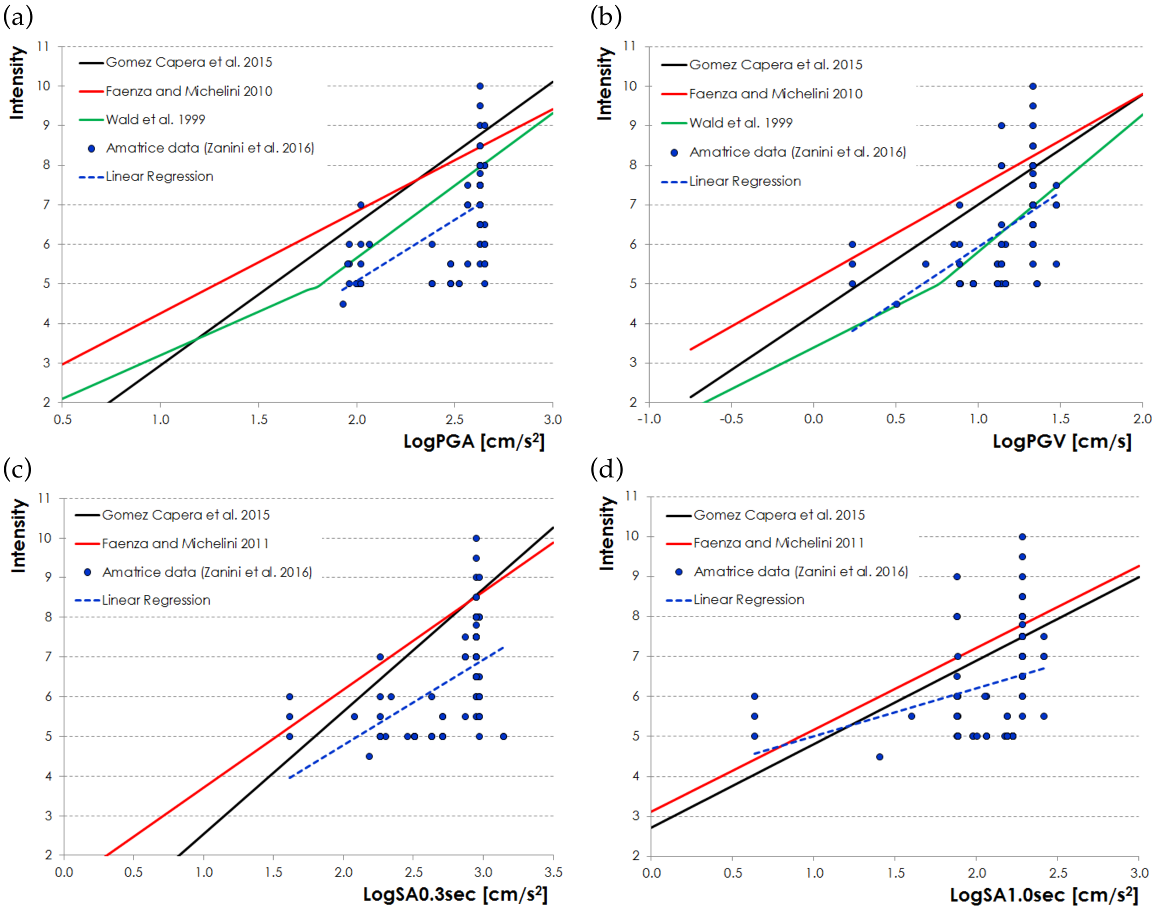

Figure 3: *Comparisons between observed I_{EMS} for the 2016 Amatrice sequence and predicted MCS values from literature models based on PGA (a), PGV (b), SA(0.3) (c) and SA(1.0) (d) data.*

A total of 86 sites were thus considered: for each, the intensity value was associated to the instrumental ground motion parameters recorded at the closest IAN accelerometric station. Figure 3 shows the results obtained for the Amatrice earthquake, in terms of observed I_{EMS} and logarithm of PGA, PGV, SA0.3, SA1.0. There, dashed lines represent linear regression equations. According to Musson et al. 2010, in general terms, the evaluation of the intensities with the Mercalli-Cancani-Sieberg (MCS) scale (Mercalli 1902) can reasonably lead to the same intensity value derived from the application of the EMS scale. Hence, EMS-instrumental data were compared to the most recent literature correlation equations between MCS and instrumental ground motion measures, calibrated for Italy [Faenza and Michelini 2010; Faenza and Michelini 2011], Europe [Gomez Capera et al. 2015] and US [Wald et al. 1999]. Figure 3 seems highlighting how provisional literature equations overestimate macroseismic intensities in most the cases. A further comparison was then performed with intensity data presented in recent literature

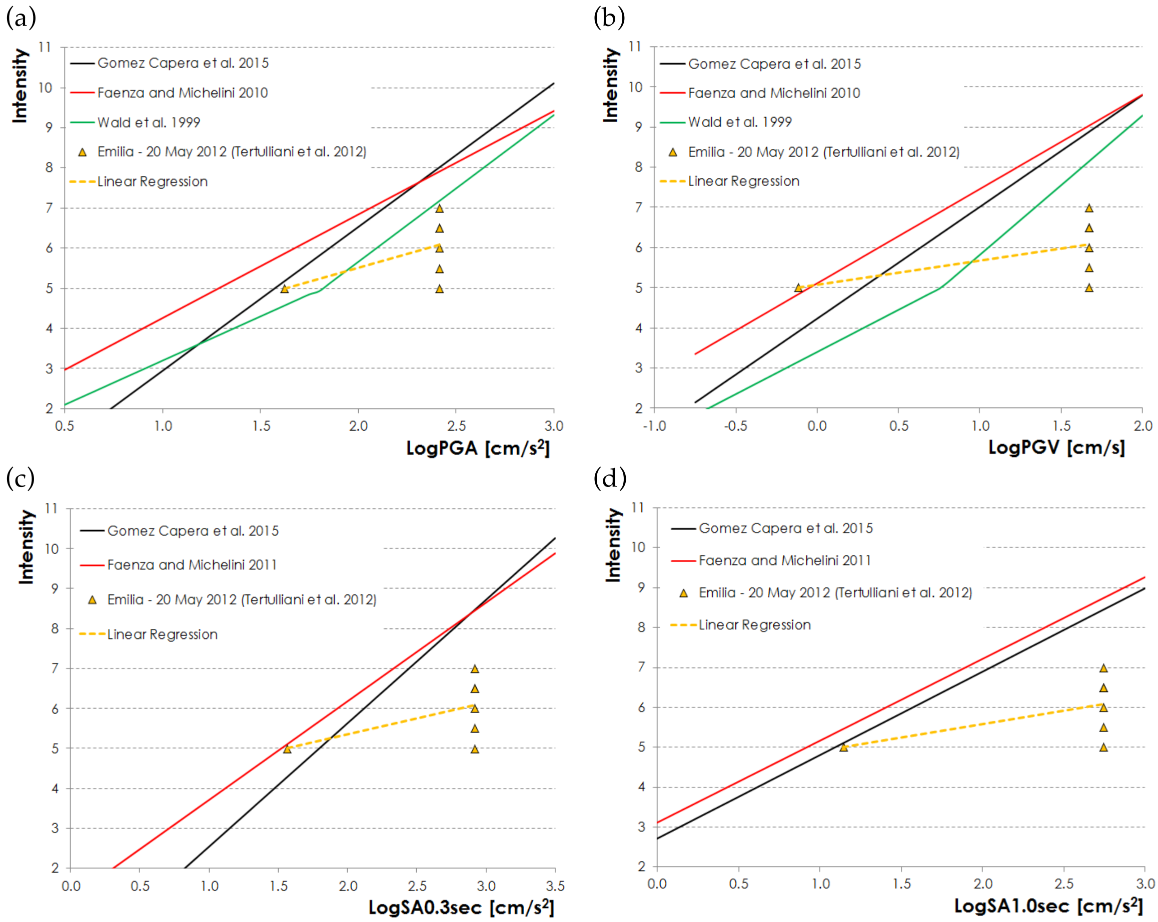

Figure 4: *Comparisons between I_{EMS} for the 20 May 2012 Emilia first mainshock (Tertulliani et al. 2012) and predicted MCS values from literature models based on PGA (a), PGV (b), SA(0.3) (c) and SA(1.0) (d) data.*

Figures 4 and 5 illustrate the same comparisons with data derived from the first mainshock (May 20, 2012) and the second one (May 29, 2012). In the former case, few stable accelerometric stations were present, so only 7 of 39 were considered. In the following days, several accelerometric stations were installed in the area, thus leading to a higher number of data (45 of 70) for the latter event. In this case, the main issue was how associating to each intensity estimate a proper instrumental value. Indeed, intensities are related to the cumulative damage effects caused by the whole seismic sequence. Hence, for each site, we decided to couple intensity estimate with the respective highest value of the instrumental parameter between those recorded due to May 20 and 29 events. In such a way, instrumental data can be viewed as an envelope of the recorded in for the 2012 Emilia earthquake [Tertulliani et al. 2012]. strumental values at each IAN accelerometric station. Results seem evidencing also in this case a remarkable discrepancy with the prediction provided by literature equations.

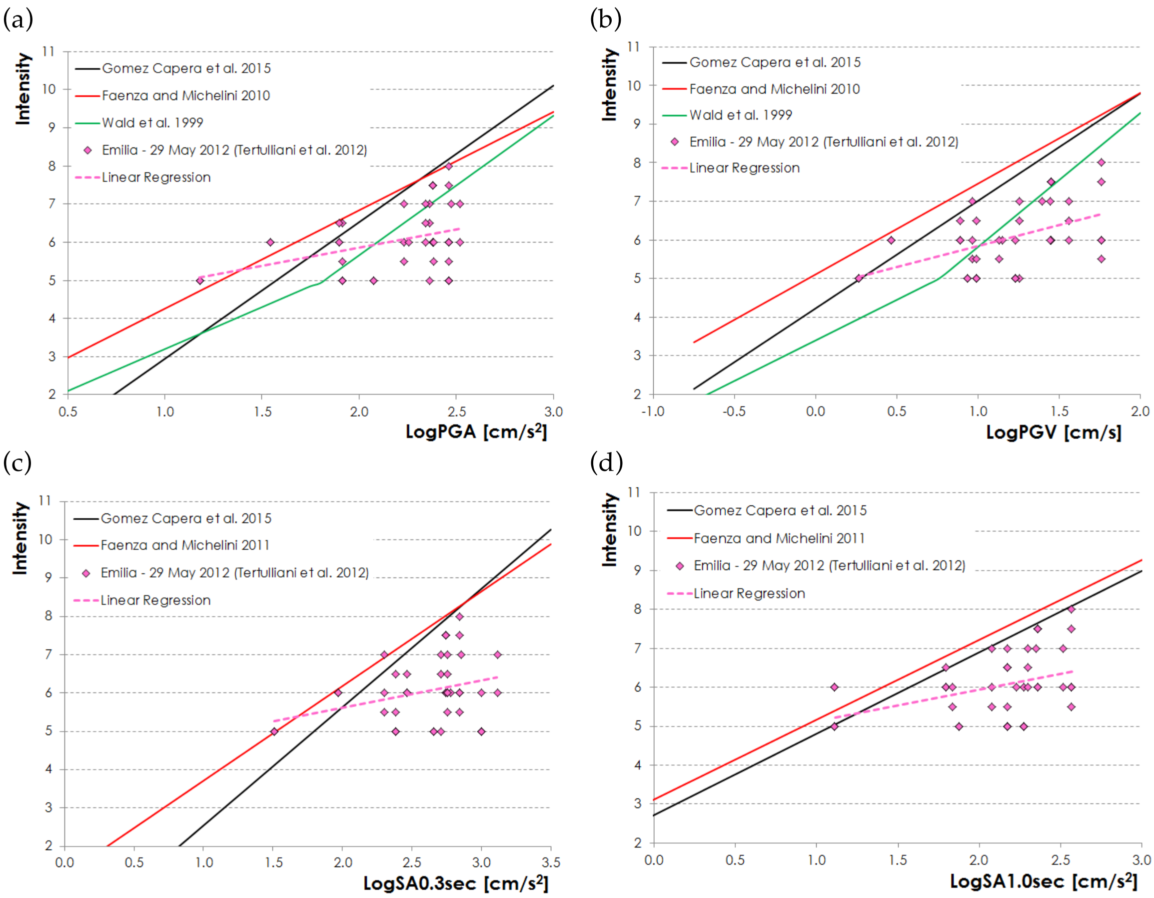

Figure 5: *Comparisons between I_{EMS} for the 29 May 2012 Emilia second mainshock (Tertulliani et al. 2012) and predicted MCS values from literature models based on PGA (a), PGV (b), SA(0.3) (c) and SA(1.0) (d) data.*

IV. CONCLUSIONS

This work presents some results derived from the analysis of an EMS macroseismic survey performed on 180 sites in the area hit by the August 24, 2016 Amatrice earthquake. In particular, the EMS macroseismic epicenter was identified and correlations between EMS intensities and instrumental values were investigated. Results seem evidencing intensity overestimations if existing literature equations are used, also in the comparison with the 2012 Emilia earthquake data: this effect, although remarkable, might be to the scarce numerousness of data sample. A denser accelerometric stations network should contribute in future to improve quality in the definition of macroseismic-instrumental relationships.

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