Inhomogeneity of macroseismic intensities in Italy and consequences for macroseismic magnitude estimation

Gianfranco Vannucci[1]*, Barbara Lolli[1] and Paolo Gasperini[1,2]

[1]Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Bologna

[2]Dipartimento di Fisica e Astronomia, Università di Bologna

***Corresponding author: gianfranco.vannucci@ingv.it**

Supplemental material

Declaration of Competing Interests:

The authors acknowledge there are no conflicts of interest recorded.

This supplemental material includes figures S1, S2 and S3, reproducing Tables 3, 4 and 5 respectively of Molin (2009) and their English translations and Table S1, listing parameters computed for all intensity datasets considered.

Table captions

Table S1- Epicentral coordinates, macroseismic magnitudes (Mw) and epicentral intensities (I_0) computed by BOXER method "0" (i.e. barycenter) (Gasperini et al., 2010) for various intensity datasets, using the calibration by Rovida et al. (2020). Dates reported as extended periods (May 2012, Aug-Oct 2016, Aug 2018) refer to intensities assessed after the occurrence of several strong shocks of seismic sequences. MCS OTC and MCS MON refer to intensities assigned by only considering the buildings in old town centers and monumental buildings respectively. Cumulative intensities evaluated for the sequences of 20-29 May 2012 shocks or 24 August-30 October 2016 shocks or the 14-16 August 2018 shocks are indicated with May 2012, Aug-Oct 2016 and Aug 2018, respectively.

Figure Captions

Figure S1 - Table 3 from Molin (2009) and its English translation

Figure S2 - Table 4 from Molin (2009) and its English translation

Figure S3 - Table 5 from Molin (2009) and its English translation

Table S1- Epicentral coordinates, macroseismic magnitudes (Mw) and epicentral intensities (I_0) computed by BOXER method "0" (i.e. barycenter) (Gasperini et al., 2010) for various intensity datasets, using the calibration by Rovida et al. (2020).

Date	Time	Latitude	Longitude	Mw	I_0	Dataset
14/09/2003	21:42	44.244	11.246	4.78	6	Bernardini et al. (2003) (EMS)
14/09/2003	21:42	44.241	11.282	4.84	6	Bernardini et al. (2003) (MCS)
14/03/2009	09:26	37.717	15.127	4.07	5	Azzaro et al. (2014) (EMS)
14/03/2009	09:26	37.722	15.123	4.01	5	D'Amico et al. (2009) (MCS)
25/01/2012	08:06	44.921	10.497	4.59	5.5	Arcoraci et al. (2012) (EMS)
25/01/2012	08:06	44.921	10.497	4.60	5.5	Arcoraci et al. (2012) (MCS)
20/05/2012	02:03	44.826	11.240	5.16	7	Tertulliani et al. (2012) (EMS)
20/05/2012	02:03	44.841	11.206	5.20	7	Galli et al. (2012a,b) (MCS)
May 2012		44.864	11.019	5.43	7.5	Tertulliani et al. (2012) (EMS)
May 2012		44.877	11.004	5.20	7	Galli et al. (2012a,b) (MCS)
May 2012		44.872	11.029	5.71	8	Graziani et al (2015) (MCS OTC)
May 2012		44.851	11.110	5.96	8.5	Graziani et al. (2015) (MCS MON)
21/06/2013	10:33	44.182	10.170	4.67	6	Arcoraci et al. (2013) (EMS)
21/06/2013	10:33	44.182	10.170	4.69	6	Arcoraci et al. (2013) (MCS)
24/08/2016	01:36	42.683	13.278	6.38	10	Rossi et al. (2019) (EMS)
24/08/2016	01:36	42.698	13.280	6.34	10	Zanini et al. (2016) (EMS)
24/08/2016	01:36	42.675	13.281	6.37	10	Rossi et al. (2019) (MCS)
24/08/2016	01:36	42.668	13.282	6.51	10.5	Galli et al. (2017) (MCS)
26/10/2016	19:18	42.942	13.105	5.67	8	Rossi et al. (2019) (EMS)
26/10/2016	19:18	42.942	13.105	5.66	8	Rossi et al. (2019) (MCS)
26/10/2016	19:18	43.010	13.106	5.84	9	Galli et al. (2017) (MCS
30/10/2016	06:40	42.718	13.259	6.99	11	Rossi et al. (2019) (EMS)
30/10/2016	06:40	42.732	13.259	6.99	11	Rossi et al. (2019) (MCS)
30/10/2016	06:40	42.674	13.278	6.95	11	Galli et al. (2017) (MCS)
Aug-Oct 2016		42.709	13.262	6.98	11	Rossi et al. (2019) (EMS)
Aug-Oct 2016		42.716	13.267	6.97	11	Rossi et al. (2019) (MCS)
18/01/2017	10:14	42.657	13.446	5.62	8	Rossi et al. (2019) (EMS)
18/01/2017	10:14	42.640	13.433	5.45	7.5	Rossi et al. (2019) (MCS)
Aug 2018		41.870	14.774	4.44	5	Castellano et al. (2018) (EMS)
Aug 2018		41.870	14.774	4.66	5.5	Castellano et al. (2018) (MCS)

Dates reported as extended periods (May 2012, Aug-Oct 2016, Aug 2018) refer to intensities assessed after the occurrence of several strong shocks of seismic sequences. MCS OTC and MCS MON refer to intensities assigned by only considering the buildings in old town centers and monumental buildings respectively. Cumulative intensities evaluated for the sequences of

20-29 May 2012 shocks or 24 August-30 October 2016 shocks or the 14-16 August 2018 shocks are indicated with May 2012, Aug-Oct 2016 and Aug 2018, respectively.

Tabella 3 – Livelli di danno previsti nella scala MCS (1930)	
1) danni leggeri	[leggere spaccature negli intonaci con limitati distacchi degli stessi; possibile caduta di qualche tegola o pietra di camino]
2) danni moderati	[lievi lesioni nei muri, notevole caduta di intonaci e stucchi, mattoni e tegole; molti fumaioli vengono lesi da incrinature con fuoriuscita di pietre; camini si rovesciano sopra il tetto e lo danneggiano; da torri e costruzioni alte cadono decorazioni mal fissate]
3) danni gravi	[tali da produrre "inabitabilità"; corrispondono a gravi lesioni nei muri, che al momento possono pregiudicare la stabilità degli edifici, ma che possono essere riparate; gli edifici sono quindi recuperabili]
4) distruzioni	[corrispondono a gravissime lesioni nei muri e a crolli parziali, tali da rendere non recuperabili gli edifici]
5) crolli	[pressoché totali]

Table 3 – Damage levels provided on the MCS scale	
1) slight damage	[slight cracks in the plaster with limited detachment of the same; possible fall of some tile or chimney stone]
2) moderate damage	[slight damage to the walls, considerable fall of plaster and stucco, bricks and tiles; many smokestacks are damaged by cracks with leaking stones; chimneys overturn over the roof and damage it; poorly fixed decorations fall from towers and tall buildings]
3) heavy damage	[such as to produce "uninhabitability"; correspond to serious damage to the walls, which can temporally affect the stability of buildings, but which can be repaired; the buildings are therefore recoverable]
4) destructions	[correspond to very serious damage to the walls and to partial collapses, which make the buildings irrecoverable]
5) collapses	[almost total]

Figure S1 - Table 3 from Molin (2009) and its English translation

Tabella 4 - Percentuali di danneggiamento previste dalla scala MCS (1930) per i gradi d'intensità ≥V e secondo i cinque livelli di danno.

Gradi di intensità	Livelli di danno e percentuali 1	2	3	4	5
V	-	-	-	-	-
VI	5	(5)	-	-	-
VII	-	50	-	-	(5)
VIII	-	-	50	25	5
IX	-	-	75	50	25
X	-	-	-	75	50
XI	-	-	-	-	100
XII	-	-	-	-	-

Table 4 - Damage percentages provided by the MCS scale for the degrees of intensity ≥V and according to the five levels of damage.

Intensity degrees	Damage levels and percentages 1	2	3	4	5
V	-	-	-	-	-
VI	5	(5)	-	-	-
VII	-	50	-	-	(5)
VIII	-	-	50	25	5
IX	-	-	75	50	25
X	-	-	-	75	50
XI	-	-	-	-	100
XII	-	-	-	-	-

Figure S2 - Table 4 from Molin (2009) and its English translation

Tabella 5 – Schema delle progressioni del danneggiamento utili per una applicazione omogenea della scala MCS-1930 per i gradi ≥V.

Gradi di intensità	Livelli di danno e percentuali 1	2	3	4	5
V	[5]	-	-	-	-
V-VI	[25]	[5]	-	-	-
VI	[50]	[25]	[5]	-	-
VII	-	50	[25]	[5]	-
VIII	-	-	50	25	5
IX	-	-	75	50	25
X	-	-	-	75	50
XI	-	-	-	-	[75]
XII	-	-	-	-	[100]

Table 5 - Scheme of the damage progressions useful for a homogeneous application of the MCS scale for grades ≥V.

Intensity degrees	Damage levels and percentages 1	2	3	4	5
V	[5]	-	-	-	-
V-VI	[25]	[5]	-	-	-
VI	[50]	[25]	[5]	-	-
VII	-	50	[25]	[5]	-
VIII	-	-	50	25	5
IX	-	-	75	50	25
X	-	-	-	75	50
XI	-	-	-	-	[75]
XII	-	-	-	-	[100]

Figure S3 - Table 5 from Molin (2009) and its English translation