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SUPPLEMENTARY MATERIAL TO

THE NEW ITALIAN SEISMIC HAZARD MODEL (MPS19)

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APPENDIX A: List of participants, review panel, and external experts which contribute to MPS19

Besides the authors of this paper the following researchers contributed at different levels to the preparation of MPS19.

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Laurentiu Danciu (ETH Zurich), Danijel Schorlemmer (GFZ Potsdam).

External review panel

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APPENDIX B. Iterations with the participatory review panel

From the beginning, the work carried out in the preparation phase of MPS19 has been revised by the experts identified by National Civil Protection Department (DPC). In particular, from 2015 to 2017, the revision was made by the National Commission for major risks prediction and prevention (section Seismic Risk; MRC hereafter), the Operational Committee of DPC. At the beginning of 2018 a new Commission has been appointed; in order to not interrupt the review process, DPC named a participatory review panel with 5 out of 12 previous members of MRC (listed in Appendix A). The 5 reviewers followed the work carried out by the MPS19 Working Group until the end of the project.

The interaction was realized through periodic meetings, production of internal reports, elaborations, graphs. The reviewers asked details on the advancements with respect to construction of the model, the testing phase, the weights assigned to ERMs e GMMs, and so on.

The reviewers asked for several improvements of the model during its elaboration. Among them, one of the most important is the introduction of macroareas for testing and weighing the ERMs; the rationale is that some ERM could be more efficient in some regions and less in others. Then they proposed to evaluate the stability of our results comparing the model outcomes with the ones produced by an additional ERM built with the same operating choices of the European SHARE model (Woessner et al., 2015). The reviewers also asked to develop a new GMPE that adopted the so-called "backbone" approach; this new equation was then not implemented in MPS19 model, because not yet published in peer review journal, but we verify that the outcomes were comparable with MPS19. Since the testing phase is one of the most important points in our project, the reviewers asked to implement more the testing phase, for example evaluating the reliability of some crucial assumptions, such as the stationarity of seismicity and the suitability of the Gutenberg-Richter law, in some regions were the data showed some apparent discrepancies from these assumptions.

The reviewers shared their final evaluation on MPS19 model in a document, which was submitted to DPC. The main points of the evaluation are reported in the following, in its Italian formulation and then translated in English by automatic translator (Google Translate), in order to not introduce any subjective consideration. The few changes introduced by us are reported in italics.

L'operazione di test […], a rigore non è definibile come "validazione" - che è una procedura statistica ben codificata - visto che il learning set di dati e il voting set di dati non sono indipendenti. Questo confronto, tuttavia, fornisce un importante controllo di coerenza (sanity check): se i risultati di un modello sono in disaccordo con la sismicità storica, potranno credibilmente essere in accordo con quella futura? Da questo punto di vista, MPS19 costituisce un indubbio progresso non solo rispetto a MPS04 ma anche, a conoscenza del GDL, a tutte le procedure PSHA che sono state adottate per derivare la mappe di pericolosità nazionali attualmente esistenti al mondo.

Un ulteriore elemento significativo della robustezza del modello finale è dato dalla sostanziale coerenza tra tassi di eccedenza di intensità macrosismiche osservate e quelle calcolate dal modello. Questo confronto, pur con tutte le limitazioni del caso dovute all'incertezza sui dati osservati e alla completezza degli stessi, è importante, perché i dati di intensità macrosismica non sono stati usati in modo esplicito durante lo sviluppo del modello MPS19, se si eccettua l'utilizzo per la stima della magnitudo di eventi pre-strumentali. Inoltre, ancorché non richiesto dal GDL e non discusso nella bozza di rapporto del 27 febbraio 2019, è importante segnalare che l'adeguatezza del modello MPS19 è stata anche testata mediante un confronto, presentato nella riunione del 27 febbraio 2019, tra le stime dei tassi di eccedenza di PGA misurate in stazioni accelerometriche operative da almeno 30 anni e quelle predette dal modello. Anche in questo caso le stime del modello MPS19 dei tassi di eccedenza delle PGA sono risultate compatibili con quelle osservate.

Per quanto riguarda i risultati pratici, il pregio fondamentale di MPS19 è il mostrare chiaramente le incertezze delle stime di pericolosità, che nel caso del modello ensemble hanno un ragionevole grado di credibilità. Poiché l'incertezza costituisce un aspetto fondamentale per il normatore, il GDL suggerisce di presentare le mappe fianco a fianco con media e media+deviazione standard delle accelerazioni spettrali a 0.5, 1 e 3 Hz, corrispondenti ai periodi di ritorno più rappresentativi (ad esempio, 475 anni, 975 anni e 2475 anni). Allo stesso modo, il GDL suggerisce di presentare per i suddetti periodi di ritorno le mappe con la stima di PGA di MPS19 fianco a fianco a quelle di MPS04 utilizzando la stessa scala di colori, in modo da garantire una comprensione immediata delle differenze.

Infine, si esprime soddisfazione per l'onestà intellettuale portata dai ricercatori nell'interazione con il GDL e la trasparenza con cui MPS19 è stato sviluppato, caratteristiche che costituiscono la migliore garanzia per ulteriori avanzamenti. Gli aggiornamenti futuri delle mappe di pericolosità derivate da MPS 18 troveranno dei fondamenti robusti su cui basarsi.

The test operation […], strictly speaking, cannot be defined as "validation" - which is a well-coded statistical procedure - since the learning data set and the voting data set are not independent. This comparison, however, provides an important sanity check: if the results of a model disagree with historical seismicity, can they credibly agree with the future one? From this point of view, MPS19 represents an undoubted progress not only compared to MPS04 but also, to the knowledge of the GDL *(the reviewers' panel)*, to all the PSHA procedures that have been adopted to derive the national hazard maps currently existing in the world.
A further significant element of the robustness of the final model is the substantial coherence between the observed macroseismic intensity excess rates and those calculated by the model. This comparison, even with all the limitations of the case due to the uncertainty on the observed data and the completeness of the same, is important, because the data of macroseismic intensity were not used explicitly during the development of the MPS19 model, except for the 'use for estimating the magnitude of pre-instrumental events. Furthermore, although not required by the GDL and not discussed in the draft report of 27 February 2019, it is important to point out that the adequacy of the MPS19 model was also tested by means of a comparison, presented at the meeting of 27 February 2019, between the *PGA exceedances* rate measured in accelerometric stations operating for at least 30 years and those predicted by the model. Also in this case, the estimates of the MPS19 model of the PGA *exceedances* rate were found to be compatible with those observed.
As far as practical results are concerned, the fundamental advantage of MPS19 is that it clearly shows the uncertainties of the hazard estimates, which in the case of the ensemble model have a reasonable degree of credibility. Since uncertainty is a fundamental aspect for the regulator, the GDL suggests presenting the maps side by side with mean and mean + standard deviation of the spectral accelerations at 0.5, 1 and 3 Hz, corresponding to the most representative return periods (for example , 475 years, 975 years and 2475 years). Similarly, the GDL suggests presenting for the aforementioned return periods the maps with the PGA estimate of MPS19 side by side with those of MPS04 using the same color scale, in order to ensure an immediate understanding of the differences.
Finally, satisfaction is expressed for the intellectual honesty brought by the researchers in the interaction with the GDL and the transparency with which MPS19 was developed, characteristics that constitute the best guarantee for further progress. Future updates of MPS19-derived hazard maps will find robust foundations to build upon.

APPENDIX C. Brief description of ERMs

1 Area source models (MA)

1.1 MA1

(contribution by M. Santulin, A. Tamaro, D. Slejko, F. Sani, L. Martelli, M. Bonini, G. Corti, M. E. Poli, A. Zanferrari, A. Marchesini, M. Busetti, M. Dal Cin, D. Spallarossa, S. Barani, D. Scafidi, G. Barreca, C. Monaco, A. Rebez)

The seismotectonic zoning model (SZ) of MA1 was built by integrating new and updated seismotectonic data into the Meletti et al. (2008) zoning scheme. Where the difference between the new SZs and those of the Meletti et al. (2008) were found negligible, in terms of geographical boundaries and seismotectonic characteristics, the SZ9 zones were used. Individual seismicity rates have been computed for each zone, using the declustered CPTI15 catalogue (Rovida et al., 2016), with the completeness provided by Meletti et al. (2019), using two different approaches: (i) zones were grouped into some macroareas to evaluate the b-value and then this b-value is used to calculated seismicity rates into the zones according to a Gutenberg-Richter magnitude-frequency distribution (the zones are kept independent for the a-value computation) and; (ii) observed seismicity rates for each zone. MA1 explores uncertainties on maximum magnitude, completeness approaches (historical and statistical) and approach for seismicity rates (GR and observed).

1.2 MA2 and MA3

(contribution by R. Basili, P. Burrato, U. Fracassi, V. Kastelic, G. Tarabusi, M. M. Tiberti, G. Valensise, P. Vannoli)

The two models, MA2 and MA3, are here described together as they use the same approach to evaluate seismicity rates but different definition of area sources. Both models used a two-level area source model. MA2 and MA3 defined a 2D subdivision of the crustal space in large regions consistent with geotectonic properties inspired by concepts and definitions of plate tectonics (Bates and Jackson, 1980), and already used in earthquake hazards studies (Delavaud et al., 2012; Selva et al., 2016; Basili et al., 2020). In addition to these large regions, MA2 and MA3 defined two different seismotectonic zoning, that were topologically coherent subdivisions of the former, considering geotectonic properties at the local scale, including the presence of volcanoes. For the seismicity annual rate calculations, MA2 and MA3 used large regions to estimate b and the corner moment of a tapered-Pareto frequency-moment. Seismotectonic zone were then used to estimate the annual rate (a-value) by anchoring the theoretical FMD to the observations from the CPTI15 earthquake catalog. MA2 and MA3 considered uncertainties on completeness studies, and partitioning rates approaches (from superzones to zones).

1.3 MA4

(contribution by C. Meletti, F. Visini, B. Pace, V. D'Amico, A. Rovida, S. Pondrelli)

SZ of MA4 represents an update the previous model SZ9 (Meletti et al., 2008), which is the reference source model for MPS04. MA4 is consistent with the general background delineated by the geodynamic model proposed for MPS04 and incorporate all recent advances on the understanding of the active tectonics of the Italian territory and on the distribution of seismogenic sources (e.g., DISS Working Group, 2018). To estimate the expected seismicity rates, firstly zones were grouped into macroareas, according to their tectonic regime. Assuming that the distribution of the earthquake sizes follows a truncated Gutenberg-Richter model, b and a parameters were estimated applying the Weichert (1980) approach to each macroarea. Then, 4 approaches to distribute activity rates form a macroarea to the zones included, were used. In addition, Weichert (1980) was also applied to the single zones, but upper and lower bounds to b was introduced. MA4 explored uncertainties on completeness studies (historical and statistical), maximum magnitude and activity rates evaluations (from macroareas to zone).

1.4 MA5

(contribution by R. Rotondi, E. Varini)

MA5 uses the same SZ of MA4, but it applied a different approach, in respect of MA4, to estimate the seismicity rates. The MA5 estimated jointly the completeness time and the seismicity rate of the complete part of data sets associated with each seismogenic zone and constituted by events of magnitude exceeding a varying threshold (Rotondi and Garavaglia, 2002). Assuming that the main earthquakes follow a homogeneous Poisson process with constant rate, and that the beginning of the complete part of the catalog corresponds to a change in the Poisson parameter, the problem was translated into a change-point problem which combines stochastic simulation methods with a Bayesian hierarchical model (Pievatolo and Rotondi, 2008). Assuming that the process has two rates, one in the incomplete part and another in the complete one, following the Bayesian approach, both the two rates and the time when the process changes rate were considered as random variables, and the method computed, in addition to their estimates, the entire probability distribution of these variables as well.

2 Fault-based models (MF)

2.1 MF1

(contribution by R. Basili, P. Burrato, U. Fracassi, V. Kastelic, F. E. Maesano, , G. Tarabusi, M. M. Tiberti, G. Valensise, P. Vannoli)

MF1 is a fault-based seismicity model using exclusively geological information taken from the DISS 3.2.1. Other datasets, such as earthquake catalogues, focal mechanisms, stress orientations, and crustal models were used to constrain various parameters of the model but not the seismicity rates. Although the model was based on fault information only, an empirical proximity function has been specifically developed to predict off-fault seismicity, i.e. the occurrence of earthquakes of any size away from the faults. These characteristics ensured the independence of the seismicity rates predicted by this model from the earthquake catalogue, thereby providing a valid alternative to explore the epistemic uncertainty in PSHA. The basic idea of this model was that potentially seismogenic faults can provide a representation of the seismicity on a time frame much longer than that of any earthquake catalogue. The seismic moment rate $\dot{M}s$ of a seismogenic fault is derived from the geologic moment rate, by multiplying the shear modulus, fault length and width, slip rate, and a coefficient (often referred to as seismic efficiency) that determines how much of the geologic rate is converted into the seismic rate. Using the moment conservation principle, the seismic moment rate of any seismogenic fault was related to the annual earthquake rate of a Truncated GR magnitude-frequency distribution using the formulations by Kagan (2002a; 2002b) and assuming a unique beta equal to 0.667 for all the faults. To evaluate the off-fault seismicity rates, MF1 followed an empirical approach aimed to capture the natural distribution of the observed earthquakes around the faults and the respective location uncertainties. To this aim, an empirical proximity function representing the frequency at which an earthquake has occurred at any distance from a mapped fault was developed. Then, the earthquakes predicted by the calculated magnitude-frequency distributions, as previously described, are symmetrically spread around proportionally to the magnitude and distance pairs dictated by the empirical proximity function.

2.2 MF2

(contribution by M. Murru, R. Console, G. Falcone, M. Taroni)

The MF2 model combines the seismic rates obtained by three different databases in order to cover all the Italian territory: seismogenic sources, the historical seismic catalogue CPTI15 and the Instrumental catalogue provided by Meletti et al. (2019). For the historical catalog, two different criteria of completeness were used. In this approach we adopted over all Italy a tapered Gutenberg-Richter relation with a unique b-value (0.99) and a unique corner magnitude (7.3 Mw) estimated by the catalogs.
As regards the seismogenic sources, MF2 considered a revised group of 126 individual sources from DISS Working Group (2018). The seismic moment rate of each individual source was computed using the seismic-moment conservation principle (Field et al., 1999), that allows to derive seismic moment rate from long-term slip rate and geometry of the fault source. Successively, balancing the seismic moment rate over a tapered Gutenberg-Richter magnitude-frequency distribution, from magnitude greater or equal than Mw 4.5, seismicity rates of occurrence were evaluated for each individual source. Moreover, using the smoothed-seismicity approach proposed by Frankel (1995), with the correction for time varying completeness magnitude (Hiemer et al., 2014), having as input the combined historical and instrumental catalogue, rates of occurrences for Mw greater or equal than Mw 4.5 were computed over a grid. Finally, for cells of the grid intersected by a portion of the surface projection of an individual fault, the rates of occurrence evaluated by the smoothed seismicity approach, were combined with the rates estimated for that individual source, in a quantity proportional to the area of the intersection. Considering the three

different combinations of the seismogenic source rate and seismic catalog rate, we obtained a total of six different ensemble models.

3 Smoothing seismicity models (MS)

3.1 MS1

(contribution by A. Akinci, M. Moschetti, M. Taroni)

MS1 model is developed using smoothed seismicity methods for long-term earthquake rate space-time. A forecast of the probabilities of ($M \geq 4.5$) earthquakes is calculated from ensemble smoothed seismicity models derived from longer Italian historical (Catalogue Parametrico dei Terremoti Italiani, CPTI15, 1000-2014) and shorter instrumental (1981-2016) earthquake catalogs. Two different smoothed seismicity methods are adopted for the MS1 model construction following; 1) the well-known and widely applied fixed smoothing (Frankel, 1995) such that the kernels used to smooth catalog-derived seismicity rates were invariant to spatial variations in seismicity rate and 2) the most recent adaptive smoothing method (Helmstetter et al., 2007) which determines the smoothing distance for each earthquake from its distance to neighboring earthquake epicenters. The optimized fixed smoothing distances and adaptive neighbor numbers are identified ranking the ability of all of the trial smoothed seismicity models to forecast the location of earthquakes in the recent part of the earthquake catalog with a likelihood parameter. Finally, MS1 is created as an ensemble model that combines two different equally weighted smoothing models (adaptive and fixed) from the two earthquake catalogs (historical and instrumental), through a logic tree approach to improve the forecast capability. MS1 takes into account and considers the uncertainties in the model constructions using different percentage combinations of the models obtained from two different smoothing approaches (for details see, Akinci et al., 2018).

3.2 MS2

(contribution by C. G. Lai, E. Zuccolo)

MS2 followed the Woo (1996) approach and proposed a zone-free method solely based on the use of the earthquake catalogue. Proxy seismogenic sources were created from the epicentral locations of the events that are smoothed according with their fractal distribution in space.

A square sub-grid of point sources (approximate dimensions 0.1°x0.1° with step 0.2 km) was defined around each node of the a grid and the activity rates of each point source were calculated from the density and proximity of events lying within the considered magnitude range. The contribution of each earthquake to the seismicity of the region was smeared over all sub-grid points falling within an epicentral distance that depends on the magnitude of the event itself.

Finally, the activity rates referred to each node of the grid were computed by summing the activity rates of the point sources multiplied by the area of the sub-cells.

To consider the uncertainties associated with some model assumptions (namely kernel shape, kernel directionality, completeness periods), the MS2 model was created by producing 8 models that were integrated, with proper weights, within a logic tree framework.

4 Geodetic models (MG)

4.1 MG1

(contribution by N. D'Agostino)

MG1 is a geodetically-derived seismicity model based on the analysis of 919 GPS horizontal interseismic velocities and on the hypothesis that future seismic moment release will scale linearly with the rate of present-day strain accumulation (Ward, 1998; Ward, 2007). The strain rate tensor field has been a) calculated on a regular 0.1° x 0.1° grid using the VISR software (Shen et al., 2015) taking into account the variable station spacing for the optimal smoothing parameters, and b) converted in rates of seismic moment accumulation following Kostrov (1974). The rate of seismic moment accumulation density was finally converted to earthquake rate density (or earthquake potential) under the assumption that seismic moment distributes into earthquake sizes that follow a tapered Gutenberg- Richter distribution of given b-value and corner magnitude (Kagan, 2002b). The effect of uncertainties and spatial varations in the seismogenic thickness and b-values has been introduced by considering alternative realizations of the seismicity model and considering the 50th, 5th and 95th percentiles as representative of the median and associated uncertainties of the final seismicity model. To account for the effects of declustering and aseismic component, the forecasted seismicity rate has been scaled to the seismic moment release of the declustered CPTI15 catalogue in the interval 1787-2015. Following the approach described above the seismicity rates forecasted by MG1 satisfy the overall 1787-2015 CPTI15 historical moment release while respecting the spatial variations shown by the geodetic strain rate field.

4.2 MG2

(contribution by M. M. C. Carafa, P. Bird, V. Kastelic, G. Valensise)

MG2 uses GPS interseismic horizontal velocities and stress-azimuth data to determine both the interseismic and long-term strain-rates and velocities on a finite element grid with NeoKinema code version 5.2 (Bird and Liu 2007, Bird 2009, Bird and Carafa 2016). Short term geodetic and non-tectonic (e.g. landslide movements) transients are modeled as principal factors in the covariance matrix (Carafa and Bird 2016) before running NeoKinema, and the strain rate in Calabria is calculated only for the upper plate under the assumption of a locked subduction (Carafa et al., 2018). The methodology to compute models of the long-term earthquake rates density for shallow earthquakes from the long-term strain rate follows Bird and Liu (2007), Bird et al. (2010), and Bird and Kreemer (2015). The parameters of the Tapered Gutenberg-Richter frequency-magnitude relations and seismic coupling were computed at the regional scale of the broader study area. The seismic moment rate for each cell of the grid is calculated in a two-step procedure: first, the interseismic strain-rates of the portion of the finite elements falling in the individual grid cell are converted to long-term tectonic moment rates; then the long-term tectonic moment-rates are converted to seismic moment rates.

APPENDIX D. ERMs for Etna, Tyrrhenian subduction, and sources outside Italy.

ERM for Etna

(contribution by R. Azzaro, G. Barberi, S. D'Amico, T. Tuvè, R. Gee, B. Pace, L. Peruzza)

The ERM for Etna has been adapted from Azzaro et al. (2017) and Peruzza et al. (2017). The ERM includes a rather high degree of detail and complexity, motivated by the great availability of geological, seismological and geodetic data for the area. The Etna original ERM consists of 3 versions, in which all these complexities are explored, and the hazard estimates are elaborated taking into account the topography that influences the site-source distances. For the purposes of application to the MPS19 project, the time-dependent model is discarded, and the focus is exclusively on the Poisson model. Furthermore, the topography is not incorporated, due to homogeneity with the ERMs on a national scale, but the sources are all modeled with respect to the sea level. The final ERM consists of a combination of individual sources (seismogenic faults) and gridded seismicity. The individual sources estimate the highest seismicity using a historical approach, and therefore with the rates estimated by maximum magnitudes observed and relative average times of recurrence; the gridded seismicity estimates the lower magnitude seismicity (3.5 $<$M $<$4.5) with point sources with variable depth.

ERM for subduction

(contribution by R. Basili, F. E. Maesano, M. M. Tiberti, F. Visini)

The ERF input for the subduction of the Calabrian Arc uses the slab geometry from Maesano et al. (2017), specifically created for the tsunami hazard model NEAMTHM18 (Basili et al., 2020) and MPS19. We consider a shallowest portion of the slab, corresponding to the surface of the slab interface between 18 and 40 km of depth (the limits correspond respectively to the main change of slope of the slab below the accretion prism and at the intersection with the Moho of the upper plate), and a deepest portion that corresponds to the actual intraslab, between 20 and 440 km depth For the intraslab, we resampled the three-dimensional geometry of the intraslab with a 10-km-spaced grid of points. The slab thickness was taken equal to the crustal thickness (seafloor to Moho) measured in the undeformed part of the subduction (Ionian Sea) which then constrained other seismogenic parameters such as the expected nodal planes that were assigned to the grid points to have earthquake ruptures at 45° angle with respect to the local slab dip and their size confined within the subduction body. (4) the expected seismicity rates were calculated according to the Weichert (1980) approach using, as input data, the deep earthquakes in the CPTI15 catalog, the statistical approach for estimating completeness, and a magnitude-frequency distribution of the type Tapered, with corner magnitude equal to Mw 7.5. The total magnitude-frequency distribution the seismicity rate was uniformly distributed on the grid points. It is wort noting that two of the eleven ERMs, specifically MF1 and MG2, had been able to separate seismicity due to the interface from the crustal tectonic seismicity, therefore we added only to them the interface ERM. Both the two MF1 and MG2 ERF have then failed the regional statistical tests for this particular subregion, and their earthquake rates were replaced in that subregion by the weighted average of the other consistent ERMs (according to the procedure described in the section 4 of thr main text). The intraslab ERM was added to all the ERF inputs.

ERM for external sources

(contribution by F. Visini, C. Meletti)

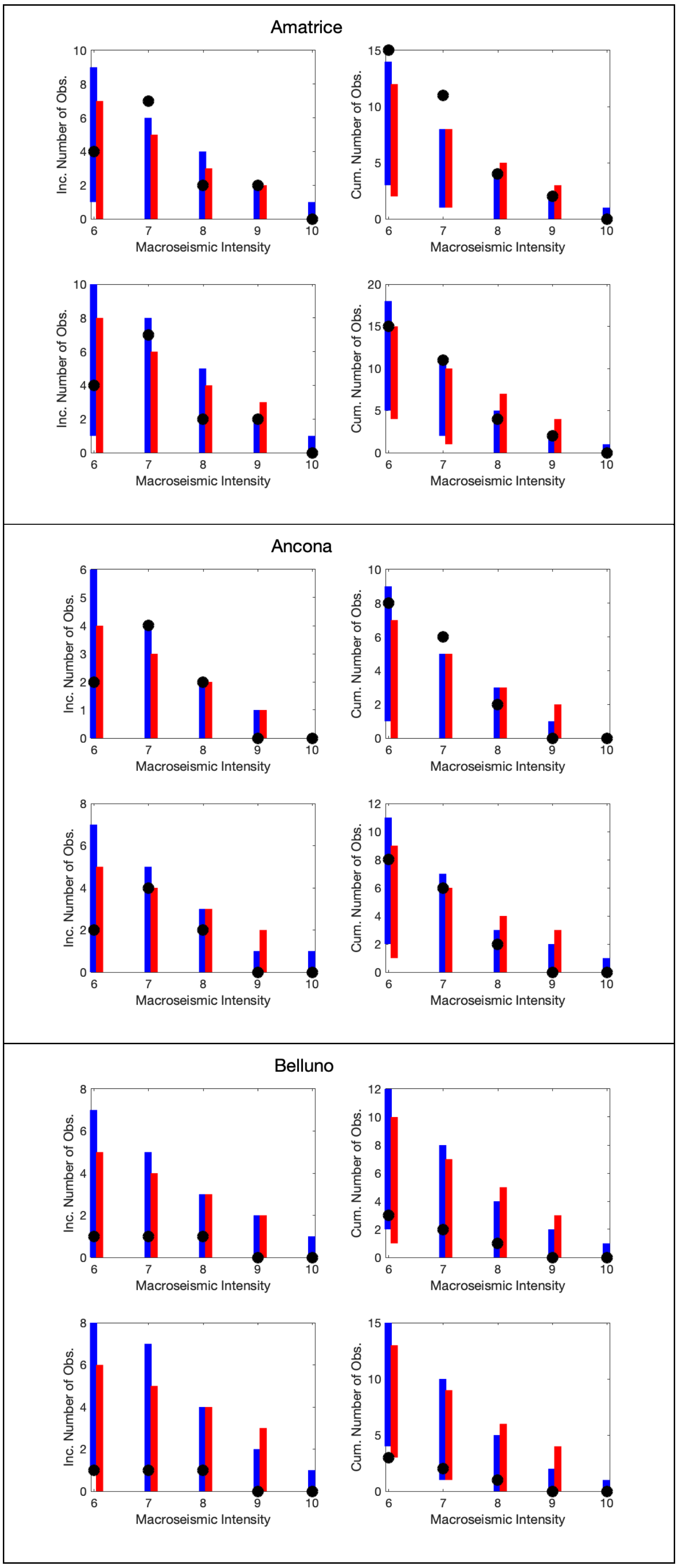
To parametrize sources located outside reliability area of the CPTI15 catalog, and to minimize edge effects, we consider the ESHM European hazard model (Woessner et al., 2015), which, by extension, methodologies and typologies of ERMs, is deemed useful for the purpose. The ESHM model consists of three types of seismicity models: areas; faults and background (FSBG); smoothed seismicity and faults (SEIFA). To avoid as much as possible the overlapping of MPS19 sources with the external ones, the three types of seismogenic sources of ESHM sources have been treated. The area source model and the FSBG are resampled according to a regular grid spacing 0.2°x 0.2°. To each point of this grid, we assign a weighted seismicity rate of the three models, in accordance to the weights of ESHM for the return periods between 475 and 2475 years, and respectively for area, FSBG and SEIFA of 0.5, 0.2.0.3. For each of the 11 ERM, only the points located outside the area covered by the ERM and within 100 km from the outer edge, are included.

APPENDIX E. Description of the experts' elicitation session.

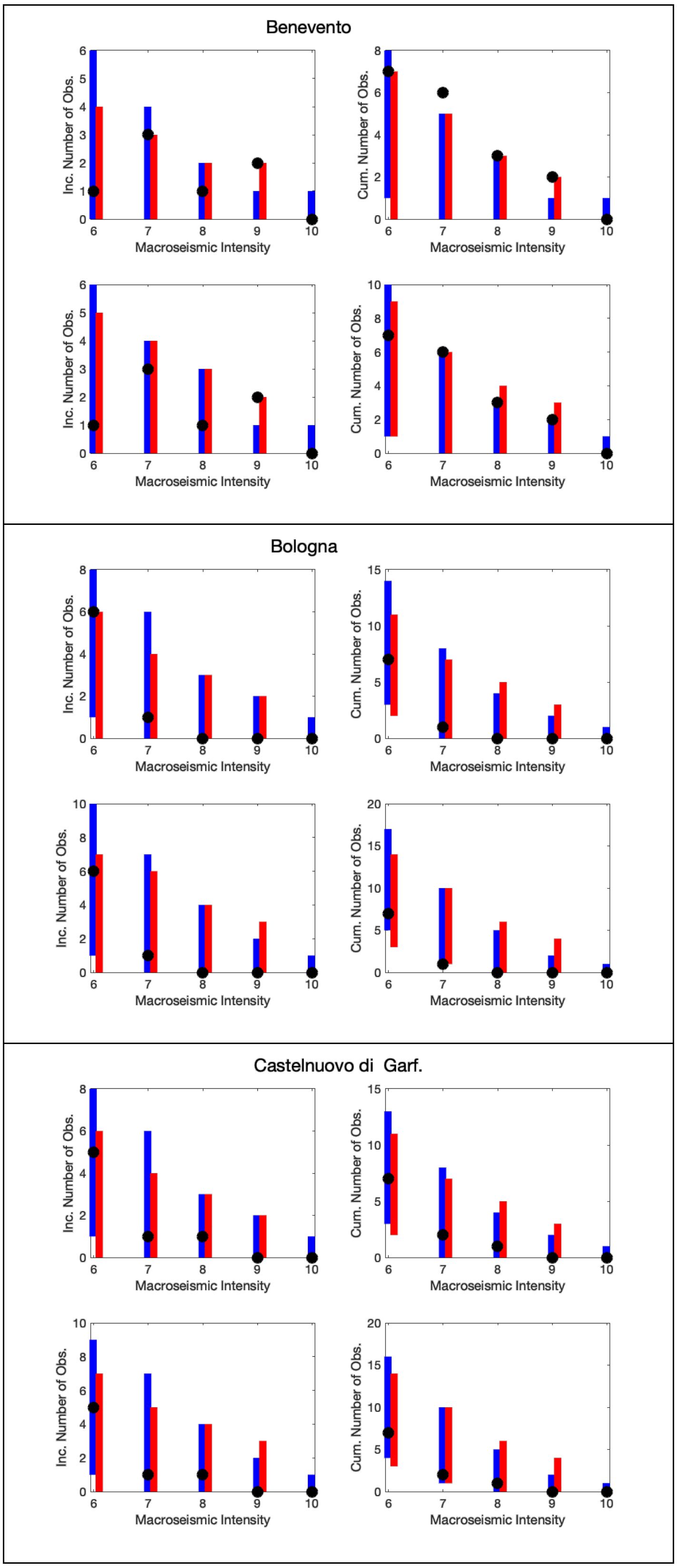
The elicitation sessions (one for ERMs and one for GMMs) are carried out by a group of experts (GoE) which have not been involved in the preparation of the models: Warner Marzocchi, Carlo Meletti (only for GMM), Dario Albarello, Iunio Iervolino, Marco Pagani, plus two additional external experts, Danijel Schorlemmer from GFZ, and Laurentiu Danciu from ETH. To avoid overlapping with the results of the scoring statistics, and to avoid well-known cognitive biases, such as anchoring and confirmation (Kahneman 2011), GoE members are not allowed to see the statistical scoring (possible anchoring), but only to evaluate the scientific coherence of the models. The conformation bias is likely pervasive on PSHA, i.e., the human tendency to favor models that confirms one's preexisting beliefs of how the seismic hazard should be – e.g., the last seismic hazard model – while giving disproportionately less consideration to alternative possibilities. To minimize this possibility,
experts' are asked to evaluate the reliability of each ERM and GMM without knowing at their overall impact in terms of seismic hazard.

For the elicitation sessions we use one procedure that is named Analytic Hierarchy Process (AHP; Saaty, 1980). AHP is a multi-criteria decision-making method that is useful to make decisions under complex problems. The hierarchy process breaks down the complex decisions into a series of pairwise comparisons, synthesizes the results, and then helps to take into account both subjective and objective aspects of the decision. Additionally, the process incorporates a useful technique for checking the consistency of each expert judgments, thus reducing bias and incoherent results. Specifically, in two separate sessions experts are elicited on the prioritization of ERM and GMM compared pairwise, and the results provide a sort of ranking of the scientific credibility of all ERMs and GMMs. Results are shown in the manuscript, and more details are in the final report of MPS19 (in italian).

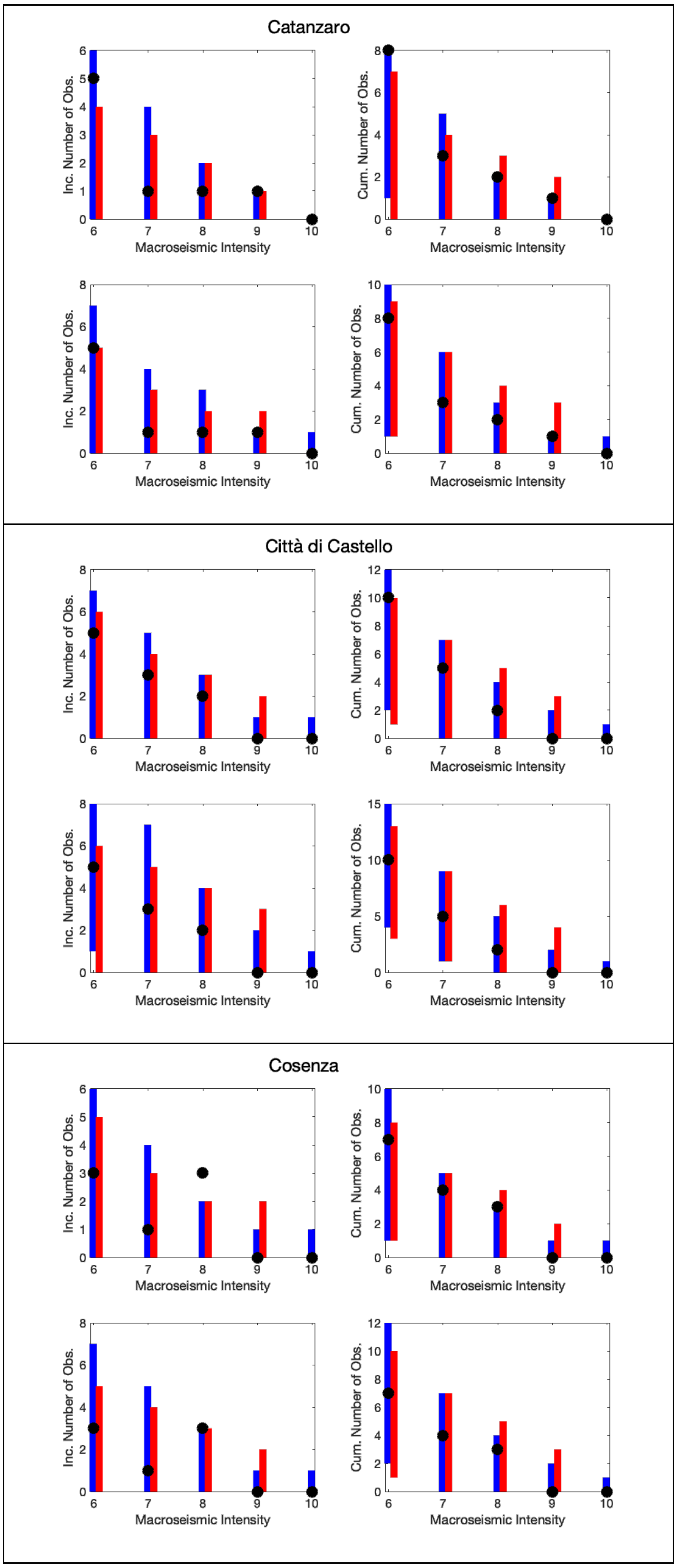
APPENDIX F. Test of the macroseismic intensity at different sites



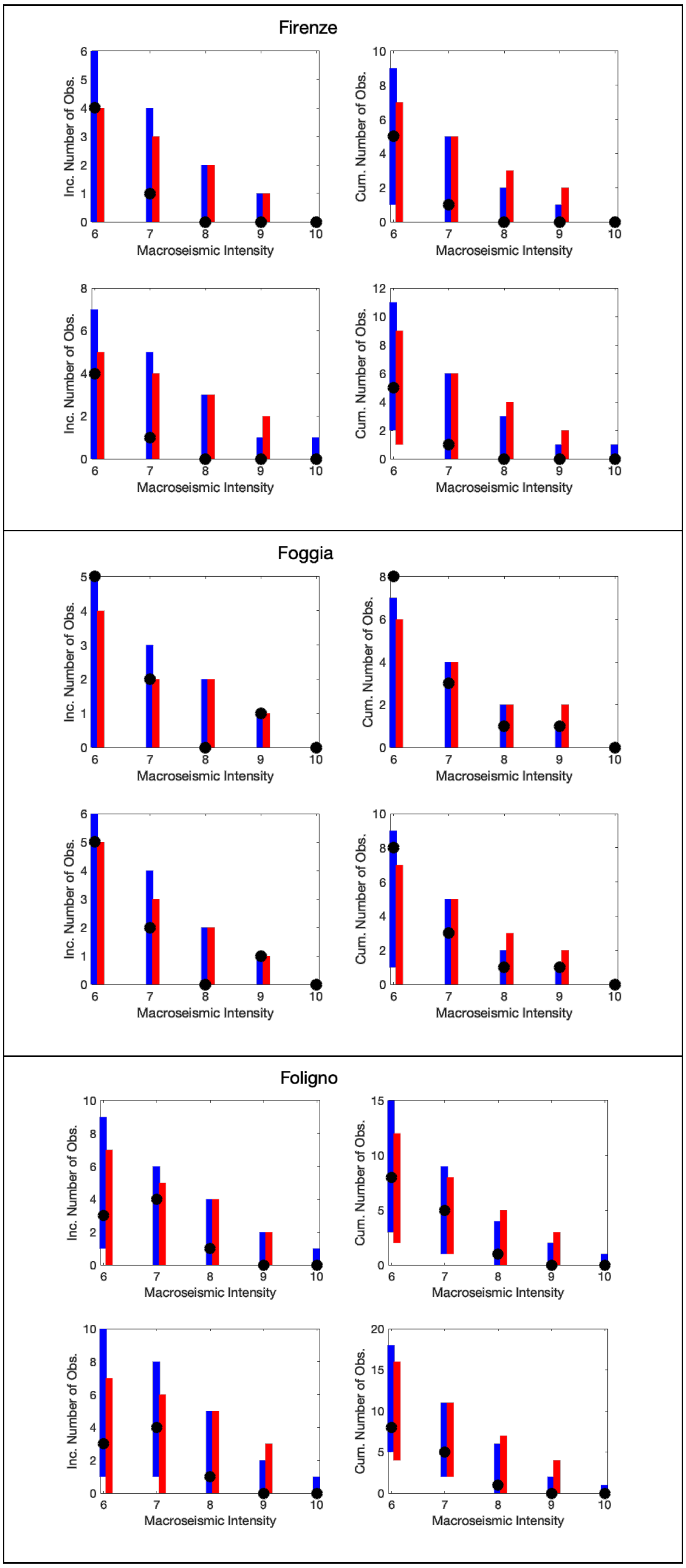
As for Figure 10 in the text but relative to Amatrice (top), Ancona (center), Belluno (below)



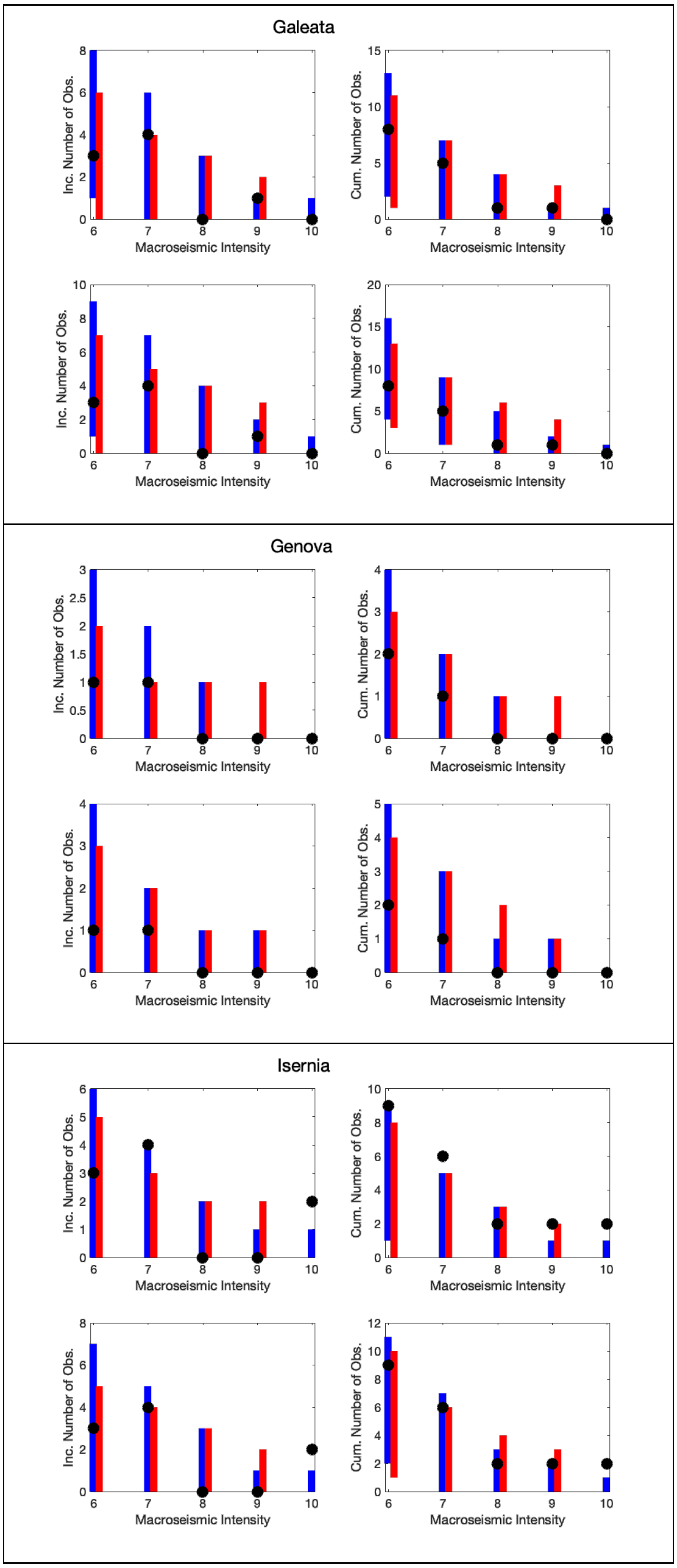
As for Figure 10 in the text but relative to Benevento (top), Bologna (center), Castelnuovo di Garfagnana (below)



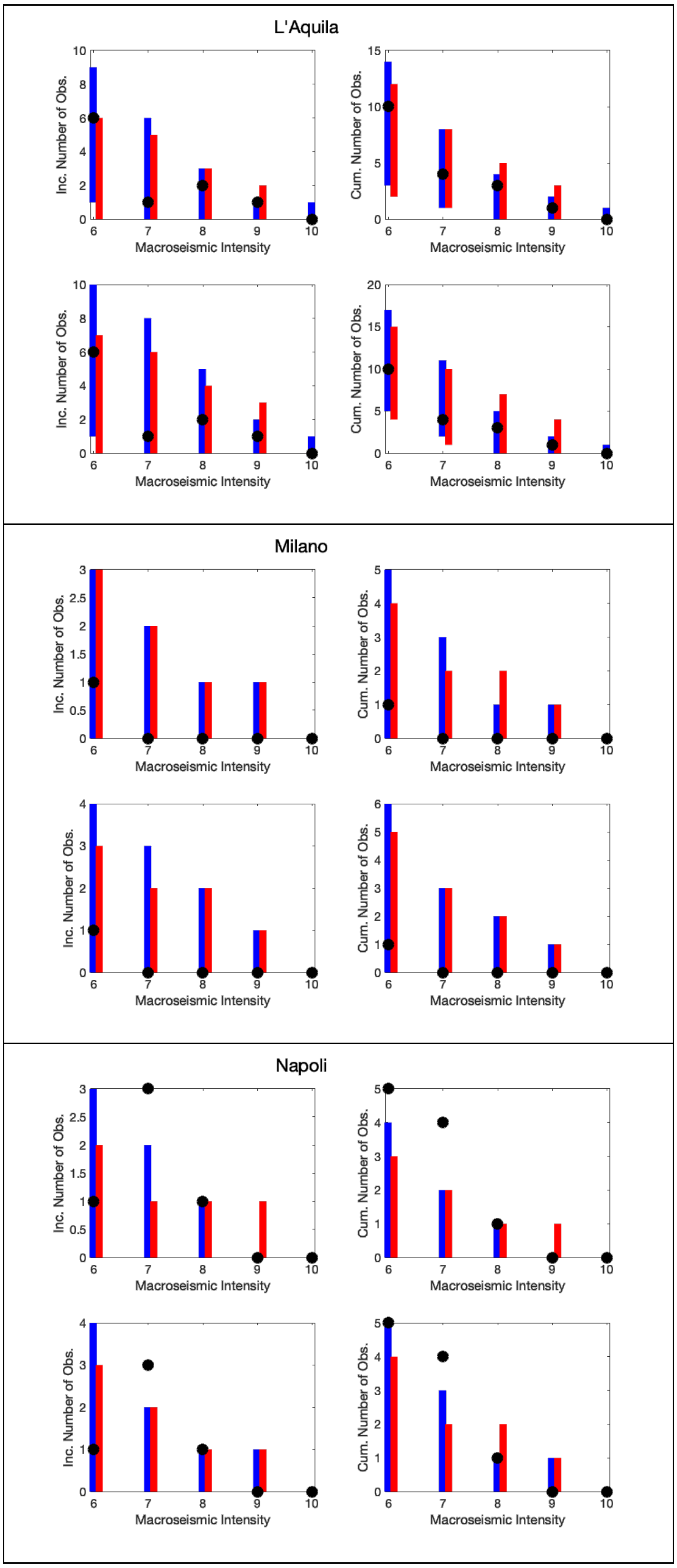
As for Figure 10 in the text but relative to Catanzaro (top), Città di Castello (center), Cosenza (below)



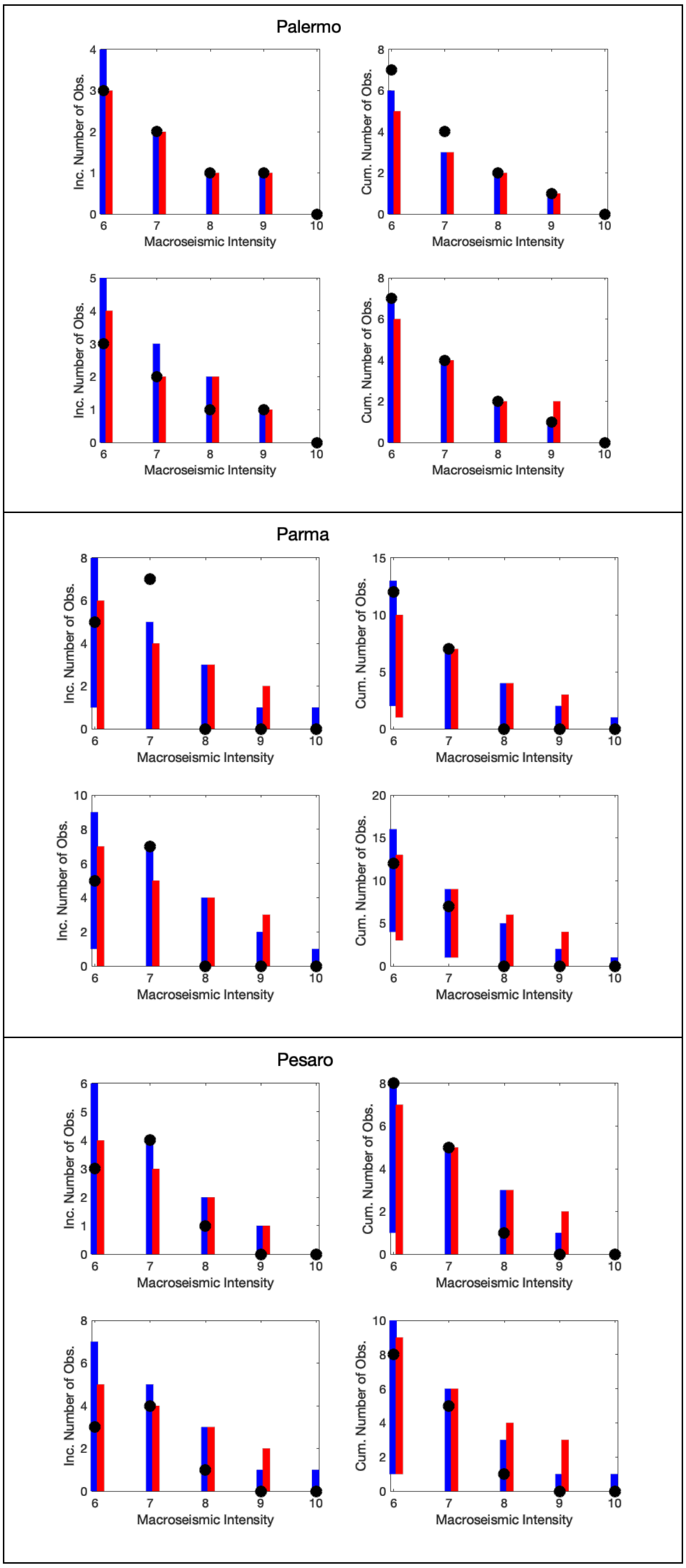
As for Figure 10 in the text but relative to Firenze (top), Foggia (center), Foligno (below)



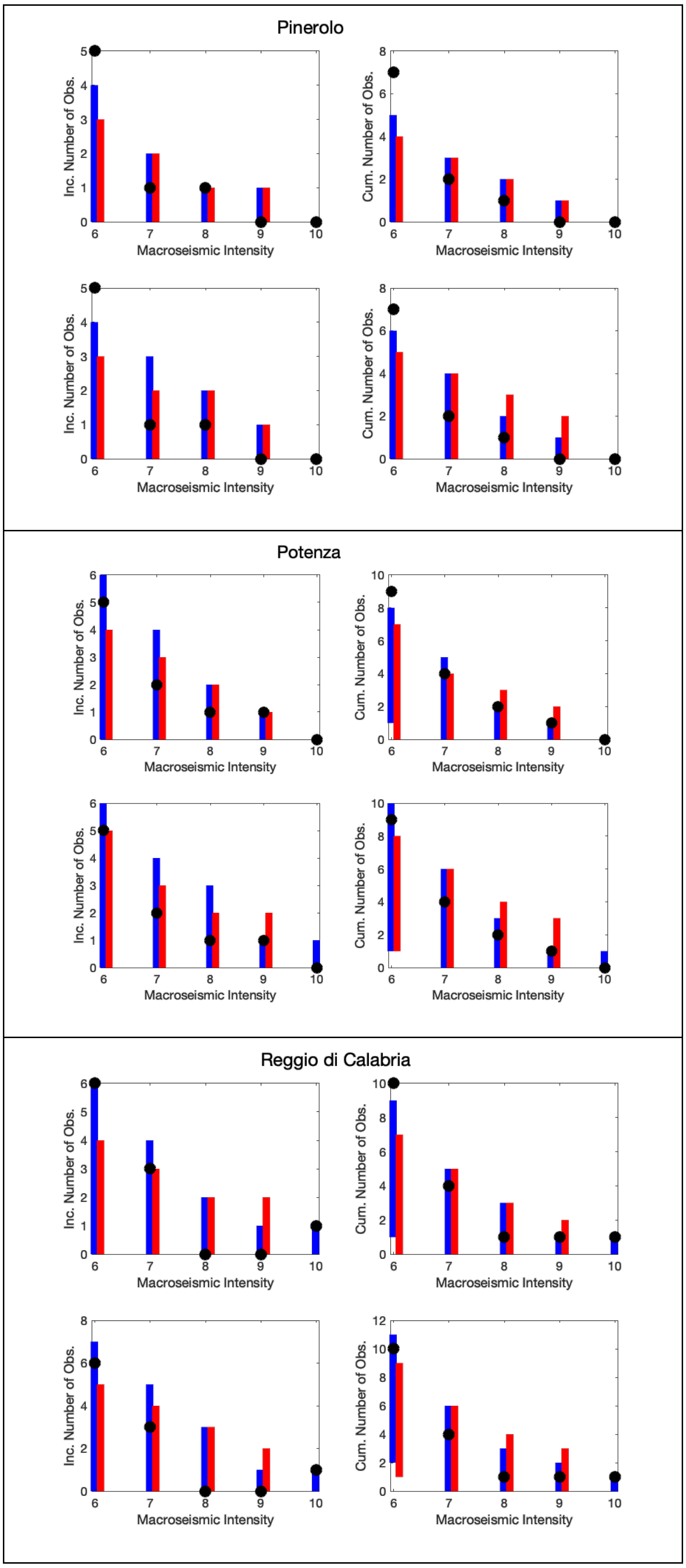
As for Figure 10 in the text but relative to Galeata (top), Genova (center), Isernia (below)



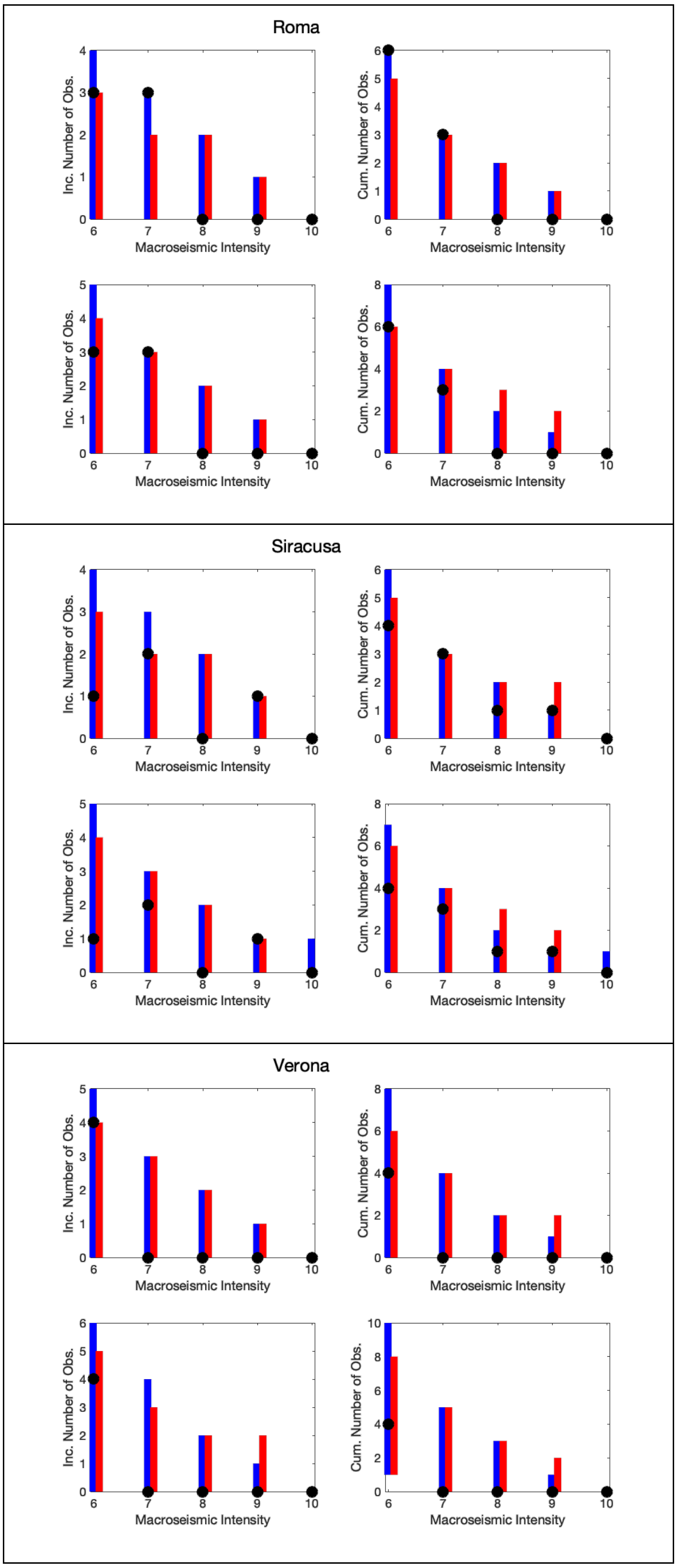
As for Figure 10 in the text but relative to L'Aquila (top), Milano (center), Napoli (below)



As for Figure 10 in the text but relative to Palermo (top), Parma (center), Pesaro (below)



As for Figure 10 in the text but relative to Pinerolo (top), Potenza (center), Reggio di Calabria (below)



As for Figure 10 in the text but relative to Roma (top), Siracusa (center), Verona (below)

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