Solid Earth
Discussions

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Interactive
comment

Interactive comment on "From mapped faults to earthquake magnitude: A test on Italy with methodological implications" *by* Fabio Trippetta et al.

Fabio Trippetta et al.

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Our Responses to Referees' and Colleagues' Comments

Dear Editors,

Please, find below our responses to all Referees' comments and related explanations for changes in the text, figures, and tables. We thank very much the two Referees, the Editors, and all colleagues who provided constructive comments in the Discussion Forum. Main changes in the submitted material are the following ones: following the Referee2 suggestions, we provided additional analyses on the sensitivity of the used cell

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Discussion paper

size (Lines 16 onward p. 9, Figs. S1, S2, and S3) and on the null hypothesis analysis (Lines 9 onward p. 14, Fig. 14, Tables S1 and S2). Please, see below for explanations about these additional analyses. Concerning the comments provided by Valensise et alii, we have already replied to all these comments in the Discussion Forum. Below, we report only those comments (with our responses and explanations) by Valensise et alii that involved changes in our submitted material. We acknowledge also changes in the panel of authors. Dr. Fabio Chiaravalli stepped out as author for reasons connected with his Company (Sogin). Dr. Anna Maria Lombardi (annamaria.lombardi@ingv.it), who is a mathematician from INGV-Rome expert in statistical analysis of seismological data, joined this panel of author performing, in particular, some new statistical analyses requested by Referee2 (see Figure 14, and Tables S1 and S2).

Looking forward to hearing from you Sincerely Andrea Billi and co-authors Rome, March 2019

Referee #1

Comment 1 Main comments This manuscript describes an approach to evaluate the maximum possible earthquake magnitude from the geometry of active faults in Italy. The topic has a broad interest, in particular for fault-based seismic hazard modelling, because the correct evaluation of the seismic potential of a seismogenic source is one of the main required parameters for seismic hazard studies. The use of active faults in seismic hazard assessment has become extensive in the last decades due to efforts of data compilation and analysis. Active faults provide the information to extend the observational time of large magnitude earthquakes, which often is not captured by the existing catalogues of observed seismicity. The authors apply one empirical scaling relationship (not correctly defined by the authors as scaling law!) between fault length and expected magnitude, to a clearly incomplete and inhomogeneous fault database, to evaluate the maximum possible earthquake magnitude in Italy. The manuscript is mostly well written and the figures are clear but, from my point of view, the approach has several misconceptions and incompleteness and the conclusions are not

supported by the results. For these reasons, the manuscript does not represent a substantial contribution to scientific progress in seismic hazard assessment and seismic risk reduction, as required by a high-level Journal as Solid Earth. The applied methods are valid but too simplistic and applied to incomplete and inhomogeneous data with consequently a poor scientific significance of the manuscript. Moreover, the references used for the fault database compilation is largely incomplete.

Response 1 We acknowledge that the main goal of this paper is not the seismic hazard that is defined as: "the probability that an earthquake will occur in a given geographic area, within a given window of time, and with ground motion intensity exceeding a given threshold. With a hazard thus estimated, risk can be assessed and included in such areas as building codes for standard buildings, designing larger buildings and infrastructure projects, land use planning and determining insurance rates."; nor is the seismic risk that is defined as: "the risk of damage from earthquake to a building, system, or other entity. It particular, it can be also defined, for most management purposes, as the potential economic, social and environmental consequences of hazardous events that may occur in a specified period of time."

Our main goal is different and is clearly stated (now improved in the new version) several times in the manuscript: - In the title: "From mapped faults to Fault-Length Earthquake Magnitude (FLEM): A test on Italy with methodological implications" - At Lines 1-4, p. 1: "Empirical scaling relationships between fault/slip dimensions and earthquake magnitudes are often used to assess the maximum possible earthquake magnitude of a territory. In this paper, upon the assumption of the reactivability of any fault, these seismic scaling relationships are benchmarked at the national scale in Italy against catalogued earthquake magnitudes, considering all known faults regardless of their age, stress field orientation, strain rate, or else." - At Lines 15-19, p. 1: "The main advantages of this method is its independence from temporal and (paleo)seismological information, whereas the main novelty is its use at the national scale also for faults considered inactive. Our work can provide a perspective time-

independent seismic potential of faults; however, it cannot be a substitute for time-dependent (paleo)seismological methods for seismic hazard assessments." - At Lines 13-22, p. 3: "We anticipate that, with this work, we do not intend to propose an alternative method for seismic hazard assessment or to better previous methods (e.g., Giardini et al., 1999; Jimenez et al., 2001; Michetti et al., 2005 Field et al., 2009, 2015; Reicherter et al., 2009). Our main aim is to test whether solely considering the known mapped faults (both active, inactive, and undetermined) and disregarding further information (e.g., historically- and instrumentally-recorded earthquakes as well as the regional stress field and strain rate) it is possible to provide, through existing seismic scaling relationships of faults and earthquakes, reasonable assessments of the maximum possible earthquake magnitude over an entire nation. The resulting (assessed) magnitudes (FLEMs) are compared (i.e., the mathematical difference) with catalogued earthquake magnitudes that are the only existing points of reference against which assessed magnitudes can be compared. Note that these results should be considered more in a theoretical and methodological perspective for comparison with future similar studies rather than in an applicative perspective for the case of Italy. In particular, our assessed earthquake magnitudes (FLEMs) for the Italian territory are proposed in this paper for scientific reasons and not for their use for civil protection and prevention purposes."

Therefore, our manuscript is not at all intended to be "a substantial contribution to scientific progress in seismic hazard assessment and seismic risk reduction" as stated by Referee 1. The possible perspective of this manuscript is now better stated at 13-22, p. 3. Note also that we have modified the term FLEM (Potential Earthquake Maximum Magnitude) – that seemed a term for the seismic hazard assessment – into the term FLEM (Fault-Length Earthquake Magnitude) – that should merely represent what we have done in this work, i.e. computing the earthquake magnitude from the length of mapped faults through known empirical relationships.

We have now used the term scaling relationship rather than scaling law over the entire

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manuscript as suggested by Referee 1.

Following suggestions by Referee 2, the applied method has been significantly improved in the new version (e.g.,see the new Figures 14, S1, S2, and S3, and Tables S1 and S2), whereas the datasets and references are not incomplete as explained below.

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Comment 2 Detailed comments 1. Fault database: the database is largely incomplete and inhomogeneous, with an incompleteness variable in space. The suggestions to improve the database are: a. Consider the abundant literature in the compilation of active fault database for Italy, mostly more recent than the used one (in the following references a partial and not yet complete list of papers not considered in the manuscript);

Response 2 As it is now specified in the manuscript (Lines 27-30, p. 8), our fault database is a big compilation of faults (total number of faults = 12467; specifically, 9169 A-type faults and 3298 B-type faults) from the main available datasets (from Line 5 onward, p. 6). Obviously, any national fault database can be improved, but, in our case, considering 12467 faults in Italy as an incomplete database seems to be an underestimate. Note that, as stated in the Introduction, our focus is not on active faults (from Line 22 onward, p. 2). Therefore, although our database can be improved with any single active fault discovered and published in the new literature, such literature-hunting is beyond the scope of our work, which becomes significant when done rather quickly with the available fault datasets; otherwise, other existing datasets (accurately compiled over long times) of active faults and/or seismogenic sources are already available for Italy (e.g., DISS, http://diss.rm.ingv.it/diss/).

Concerning the inhomogeneity, we specify what follows (from Lines 10 onward, p. 6): "The strength point of our approach is the assemblage of different fault datasets heterogeneously built for different purposes and based on different primary information and methods. In this approach, we consider all known faults (see above) to form a dataset as comprehensive as possible.

Moreover, although different, the common point of all used datasets is that they have faults mapped and therefore measurable over the Earth's surface."

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Comment 3 b. Separate in the database the recognized active faults to the not clearly active ones. In literature are available several definitions of fault activity, taking into account the age of the involved deposits, the associated earthquakes, the continuity and kinematics compatibility, and many others, and the authors need to consider it. In this way the authors could define more classes of faults (more than the two defined in the manuscript) based on the goodness of data and recent activity and need to treat separately the classes in the approach to evaluate the seismogenic potential;

Response 3 Please, see our previous response. Our scope is not working only on (presumably-)active faults, but working on all faults and on their potential over future long terms (from Line 26 onward, p. 2, and from Line 12 onward, p. 3).

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Comment 4 c. Evaluate and handle with the spatial variable incompleteness of the database;

Response 4 Our dataset (12467 faults) cannot be considered incomplete (please, see Response 2). However, following the suggestions by Reviewer 2, we have now added a sensitivity analysis on the used cell size (Line 16 onward, p. 9 + Figures S1, S2, and S3). This analysis should help in better understanding the spatial relevance of our test and results as suggested by the Reviewers.

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Comment 5 Consider the fault segmentation variability in the correct evaluation of the seismogenic potential, essential in fault-based seismic hazard approaches, as confirmed by recent complex coseismic ruptures (e.g., 2010 M 7.1 Canterbury, 2012 Mw 8.6 Sumatra, 2016 Mw 7.8 Kaikōura, 2016 Mw 6.5 central Italy);

Response 5 On one hand, our input is simply the fault length in map view (Line 25 onward, p. 8: "Starting from the entire dataset of faults in Italy, as a first step, we measured the length of each fault as the real fault trace length in map view, i.e., the length of the vertical projection of the fault trace as observed on the Earth's surface over a horizontal plane (Fig. 2; supplement; Petricca et al., 2018)."). Therefore, fault segmentation is already properly considered when properly mapped in the original datasets used for this work.

On the other hand, the lack of a proper segmentation in the process of fault mapping is right one of the targets of our analysis. In other words, where the computed FLEM (largely) exceeds the corresponding catalogued earthquake magnitude, the most probable cause for such excess is the lack of high-resolution datasets that allow characterizing fault geometry and in particular segmentation. The most straightforward example in our study are the class B faults. Therefore our study is useful to detect areas where faults have not been properly characterized (i.e., segmented), these areas require further detailed studies for a better comprehension of the seismic potential.

To this end (fault segmentation), we have also added this relevant statement at Lines 2 onward, p. 14: "To this end, it is also noteworthy that studies on the 2016 Amatrice-Norcia (central Italy) earthquakes (Mw 6.0 and 6.5) revealed that the length of the causative faults was only partially activated by the seismogenic slip (e.g., Cirella et al., 2018); however, as this co-seismic behaviour of faults seems rather frequent (Freymueller et al., 1994; Milliner et al., 2016; Chousianitis and Konca, 2018), it is most likely that this same behaviour is incorporated and implicitly expressed by the above-mentioned empirical scaling relationships between fault length and earthquake magnitude (e.g., Wells and Coppersmith, 1994; Leonard, 2010; Thingbaijan et al., 2017)."

Comment 6 Organize a table with earthquake-fault associations, in order to avoid the double counting or the source missing. There are several examples of 'problems' in the *kmz of the authors, as the missing of the Paganica fault, responsible of the M6.3

2009 L'Aquila earthquake, the double counting of some faults in the Fucino area where the M7 1915 earthquake occurred, and the not correct definition of the total length of the fault responsible in the Irpinia region of the M6.8 1980 earthquake;

Response 6 As previously explained, we consider all faults (from a number of existing datasets) disregarding their age and/or their association with historical/instrumental earthquakes (Lines 2-5 p. 1, 14-16 p. 3, and 10-12 p. 6). We do not double-count faults. Our only criterion to choose the fault from which the FLEM of the considered cell will be computed is the greatest fault length in map view. In such a way, only one fault (the longest one) will provide the FLEM in a given cell. Therefore, faults cannot be and are not double-counted (Line 30 onward p. 8).

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Comment 7 Consider also the seismogenic depth and the length of the faults along dip, to better define the total potential rupture area, better linked to the seismogenic potential of the sources;

Response 7 These parameters are available only for a limited number of (active) faults in Italy, whereas we consider all faults over the national territory (Lines 2-5 p. 1, 14-16 p. 3, and 10-12 p. 6). Moreover, the input of the used empirical relationship by Leonard (2010) is simply the fault length in map view (Line 5 onward p. 9).

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Comment 8 Deal with greater accuracy the empirical scaling relationships, by: a. Compare the results of the approach using the different available relationships; b. Handle with the uncertainties, both inter- the different relationships and intrathe single relationships (sometimes the authors define very large standard deviation in the empirical relationship not treated in the manuscript);

Response 8 This comparison is done in Fig. 6 and at Lines 16 onward p. 10. Moreover, the new analyses concerning the cell size sensitivity (Figs. S1-S3 and Lines 16 onward p. 9) and the null hypothesis (Fig. 14, Tables S1 and S2

and Lines 9 onward p. 14) provide new robustness and soundness to our results.

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Comment 9 Compare the results using different geometrical parameters, e.g. the surface rupture length, the subsurface rupture length, the rupture area (and so considering the seismogenic thickness) together with the different kinematics, treated separately in the different scaling relationships;

Response 9 The one proposed by the Reviewer is a totally different approach. We only consider the length of all known faults. As stated in the Conclusions section, this approach has its pros and cons: "Our results are partly encouraging and suggest the testing and validation of this experiment elsewhere. This method cannot, however, be a substitute for time-dependent (paleo)seismological methods for seismic hazard assessments. Rather, it can provide an approximate perspective time-independent seismic potential of faults and highlight areas where further detailed studies are required." For what concerns different kinematics, we refer the reader to Lines 11 onward p. 10. Note also that, for the Italian territory, the influence of the seismogenic thickness on the potential earthquake magnitude has already been treated in recent articles by some of us (Petricca et al., 2015, Tectonophysics 656, 202-214; Chiarabba and De Gori, Terra Nova, 2016; Petricca et al., 2018, Physics of the Earth and Planetary Interiors 284, 72-81).

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Comment 10 Handle with the uncertainties in the results, comparing the differences between the seismogenic potential of the faults estimated by the empirical relationships and the earthquakes in the historical catalogue, in terms of seismic moment and not only magnitude. Magnitude is a logarithmic quantity and so a simple comparison as done by the authors in the conclusions has a clear bias;

Response 10 Although the suggestion is surely right from a theoretical point of view, practically, the problem of using seismic moments is that for many earth-

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quakes (particularly in historical catalogs but also in old instrumental catalogs), independent assessments of the seismic moments do not exist. This makes impossible the use of seismic moments in our approach, which includes historical and instrumental earthquake catalogs for an entire nation. In other words, the only parameter available for the entire nation over the historical and instrumental periods is the earthquake magnitude and not the seismic moment.

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Comment 11 Treat the probability of occurrence in the conclusions. In seismic hazard models is necessary to define the seismic rates for the different magnitude classes and so the probability of occurrence of a defined magnitude depends on the average recurrence time of that value in a specific area. The conclusions of the authors show the largest expected magnitudes in areas with very low seismicity, like Sardinia, suggesting there high seismic hazard values. Such conclusions have to be more strongly supported by considerations in terms of probability of occurrence.

Response 11 As previously explained (Response 1), the seismic hazard and the probability of earthquake occurrence are not the scope of our work. Consider that, in a long term perspective (e.g. IAEA, www.iaea.org; Lines 29 onward p. 2), any fault could be reactivated. Our scope is stated at Lines 14 onward p. 3: "Our main aim is to test whether solely considering the known mapped faults (both active, inactive, and undetermined) and disregarding further information (e.g., historically- and instrumentally-recorded earthquakes as well as the regional stress field and strain rate) it is possible to provide, through existing seismic scaling relationships of faults and earthquakes, reasonable assessments of the maximum possible earthquake magnitude over an entire nation."

Referee #2 (Nandan)

Comment 12 In general, I have found the work presented in the manuscript to be very clearly described. I also like the style of writing of the authors as they have stated the

caveats of the study very clearly. However, I fail to appreciate the novelty of the work presented in this paper. I am wondering if it is the compilation of the comprehensive fault catalog using the existing databases or the estimation of the FLEMs. If it is the former, I would suggest that the authors stress it more in the manuscript and show what were the hurdles that they had to overcome when compiling the comprehensive fault database. If it is the latter then, I feel that the authors have oversimplified the task of estimation of FLEMs.

Response 12 We thank Dr Nandan for its appreciation. The scope and novelty of our work are not in the compilation of the fault database, rather they are in the estimation of FLEMs using all known faults over a national territory and in the comparison between FLEMs and catalogued earthquake magnitudes. These concepts are clearly stated and now better emphasized in the manuscript:

- In the title: "From mapped faults to Fault-Length Earthquake Magnitude (FLEM): A test on Italy with methodological implications" - At Lines 1-4, p. 1: "Empirical scaling relationships between fault/slip dimensions and earthquake magnitudes are often used to assess the maximum possible earthquake magnitude of a territory. In this paper, upon the assumption of the reactivability of any fault, these seismic scaling relationships are benchmarked at the national scale in Italy against catalogued earthquake magnitudes, considering all known faults regardless of their age, stress field orientation, strain rate, or else." - At Lines 15-19, p. 1: "The main advantages of this method is its independence from temporal and (paleo)seismological information, whereas the main novelty is its use at the national scale also for faults considered inactive. Our work can provide a perspective time-independent seismic potential of faults; however, it cannot be a substitute for time-dependent (paleo)seismological methods for seismic hazard assessments." - At Lines 13-22, p. 3: "We anticipate that, with this work, we do not intend to propose an alternative method for seismic hazard assessment or to better previous methods (e.g., Giardini et al., 1999; Jimenez et al., 2001; Michetti et al., 2005 Field et al., 2009, 2015; Reicherter et al., 2009). Our main aim is to test whether solely

considering the known mapped faults (both active, inactive, and undetermined) and disregarding further information (e.g., historically- and instrumentally-recorded earthquakes as well as the regional stress field and strain rate) it is possible to provide, through existing seismic scaling relationships of faults and earthquakes, reasonable assessments of the maximum possible earthquake magnitude over an entire nation. The resulting (assessed) magnitudes (FLEMs) are compared (i.e., the mathematical difference) with catalogued earthquake magnitudes that are the only existing points of reference against which assessed magnitudes can be compared. Note that these results should be considered more in a theoretical and methodological perspective for comparison with future similar studies rather than in an applicative perspective for the case of Italy. In particular, our assessed earthquake magnitudes (FLEMs) for the Italian territory are proposed in this paper for scientific reasons and not for their use for civil protection and prevention purposes."

Since the focus of our work is the FLEM estimation and the comparison between FLEMs and catalogued earthquake magnitudes, to avoid an oversimplification of this task (as stated by Referee 2), we have followed the Referee's suggestions and provided additional analyses on the sensitivity of the used cell size (Lines 16 onward p. 9, Figs. S1, S2, and S3) and on the null hypothesis analysis (Lines 9 onward p. 14, Fig. 14, Tables S1 and S2). Please, see below for explanations about these additional analyses.

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Comment 13 1. What are the main challenges in compiling the comprehensive fault database from existing fault databases? How is this task difficult?

Response 13 As stated in our previous response (Response 12), our scope and novelty is not the fault database that is a compilation from existing databases as thoroughly explained at Lines 5 onward p. 6.

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Comment 14 2. How do the authors identify and remove the duplicate faults in the

regions where the two databases overlap?

Response 14 Please, see above our Response 6. We do not double-count faults. Our only criterion to choose the fault from which the FLEM of the considered cell will be computed is the greatest fault length in map view. In such a way, only one fault (the longest one) will provide the FLEM in a given cell. Therefore, faults cannot be and are not double-counted (Line 30 onward p. 8).

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Comment 15 3. How sensitive are the results of the authors to the assumptions described in section 4.2? For instance, would the results dramatically change if one considers a different grid resolution? Same applies for the other assumptions. I think authors should do more effort than just outlining their assumptions. A sensitivity analysis is a minimum they should strive for.

Response 15 Following the Referee's suggestion, we have performed a sensitivity analysis on the grid size (Lines 16 onward p. 9, Figs. S1, S2, and S3).

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Comment 16 4. The authors claim that the calculated FLEMs are consistent with the largest observed earthquakes at least for the geologically well-constrained fault. First of all, it is obvious that this consistency is strongly dependent on the grid resolution that the authors will choose. Secondly, what is the reference level for consistency? What I mean to say is any prediction and observation can be deemed consistent if allow for enough uncertainty. To account for this, one needs to come up with a reasonable null hypothesis and compare the new predictions to the predictions of the null hypothesis. In this case, a reasonable null hypothesis could be an untruncated Gutenberg Richter law, with a given b-value. The authors could pose their model as the GR law with the same b-value but with the truncation at the FLEMs estimated using their approach. They can then estimate the likelihood of the largest earthquakes (M>M_threshold) and compare the two likelihoods using standard statistical tests. In this manner, the authors

would have reference level that would allow them to objectively assess the quality of their prediction.

Response 16 Following the Referee's suggestion, we have performed a statistical test to check, as far as possible, the reliability of our estimated FLEM values (Lines 9 onward p. 14, Fig. 14, Tables S1 and S2). It is known that, even for excellent data and weak hypotheses (as the untruncated Gutenberg Richter), from an earthquake catalog alone it is substantially impossible, through a statistical test, to discriminate, with sufficient confidence, among competitive maximum magnitude values (Holschneider et al., 2014). This is mainly due to the upper cutoff of the Gutenberg-Richter distribution, where only rare earthquakes with magnitudes close to the maximum possible value occur. In light of these limitations, we are able to check the reliability of the estimated FLEM values, but we cannot compare different competitive FLEMs. Therefore, our analysis consisted in the following steps. Firstly, we selected cells for which the doubly truncated Gutenberg-Richter law, with a b-value equal to 1, could not be rejected. In this way, we excluded that a possible rejection of the estimated FLEM was actually due to the unreliability of the Gutenberg-Richter law or to the uncertainty about the b-value. Then, in the reliable cells, we tested the FLEM values, assuming them as null hypothesis. We found that in all the analyzed cells they cannot be rejected, both in the case of the CSIv1.1 catalog and in the case of the ISIDe catalog. However, we cannot exclude that the used data may be inadequate to reveal failure of the FLEM values, nor, for the above-mentioned reasons, we can compare alternative reliable FLEM values. This new analysis is now fully reported and explained at Lines 9 onward p. 14, Fig. 14, Tables S1 and S2.

Valensise et alii

Introduction Comments by Valensise et alii, as happens also for most comments by Referee 1, seem influenced by an initial and radical misunderstanding. Our manuscript IS NOT titled "A new map of expected earthquake magnitudes for seismic hazard and risk mitigation in Italy Simply, this is not the goal of the article. Our maps (Figs. 7 and

8) ARE NOT AT ALL predictive maps of seismic hazard.

Our manuscript is titled "From mapped faults to earthquake magnitude: A test on Italy with methodological implications" and our aim is stated clearly from the introduction where we say: "We anticipate that, with this work, we do not intend to propose an alternative method for seismic hazard assessment or to better previous methods (e.g., Giardini, 1999; Jiménez et al., 2001; Michetti et al., 2005; Field et al., 2009, 2015; Reicherter et al., 2009). Our main aim is to test whether solely considering the known mapped faults (both active, inactive, and undetermined) and disregarding further information (e.g., historically- and instrumentally-recorded earthquakes as well as the regional stress field and strain rate) it is possible to provide, through existing seismic scaling laws of faults and earthquakes, reasonable assessments of the maximum possible earthquake magnitude over an entire area. The resulting (assessed) magnitudes (FLEM) are compared (i.e., the mathematical difference) with catalogued earthquake magnitudes that are the only existing points of reference against which assessed magnitudes can be presently compared."

The empirical relationships (used by many geoscientists including Valensise et alii) between fault size and earthquake magnitude are notoriously problematic for issues such as fault segmentation, fault continuity, and seismic partial activation of long faults. These problems have been ascertained ex-post on most single faults after earthquakes. We work on these same problems at the national scale with a different approach (ex-ante). That is, given a set of "official" faults of a nation (from geological maps and other official datasets), is it possible to test, quantify, and ascertain the above-mentioned problems connected with the empirical relationships? One way to do this, is to apply the relationship to the fault dataset and then compare the results with a seismic catalogue. This is what we do in Figs. 10, 11, 12, and 13 + Table 1. The results of this work cannot be used for Seismic Hazard Assessment but rather, they can highlight areas where further studies are required to better asses expected earthquake magnitudes

In the revision we will better emphasize the above-mentioned concepts, starting from the abstract that in the previous version of the manuscript could have left some space for misinterpretation. We will also add disclaimers in Figures 7 and 8 saying that these figures are not at all for use for Civil Protection, officials, and, in general, for seismic hazard. (Lines 15-18 p. 1, 12-23 p. 3, + captions to Figs. 7 and 8).

Comment 3: For instance, a very general statement such as "Larger earthquakes characterize the Apennines southern portion (Calabria), with historical seismic events that reached magnitudes up to 6.9-7.5" is backed by a reference to Cello et al. (2003), a 15 years-old paper dealing with a specific earthquake in Val d'Agri, 50 km north of Calabria, and to Gasparini et al. (1985), a 33 years-old paper that belongs to a distant past of seismotectonics in Italy. A simple reference to the Catalogo Parametrico dei Terremoti Italiani (CPTI), the Italian reference parametric catalogue, would have been enough; it would also have prevented a mistake, since no M 7.5 earthquake is reported anywhere in Italy

Response 3: This criticism refers to a sentence extracted from the seismotectonic setting and not from the method and results sections. We will accept with pleasure the suggestion by Valensise et alii and will enrich the Seismotectonic Setting with some recent references in the revised version of our manuscript (Line 18 p. 5). However, we have to point out that the core and science of our paper is not at all affected by a supposed lack of consideration of previous works, as argued by the comment.

More importantly, in section 3.2 earthquake data, we do mention CPTI together with the most comprehensive catalogues of instrumental and historical seismicity like CSI1.1 and ISIDe.

Comment 5: It is unfortunate that the fault database that should support this bold statement is not accessible (see Petricca, P., et al., Revised dataset of known faults in Italy, GFZ Data Services, https://doi.org/10.5880/fidgeo.2018.003, http://pmd.gfz-potsdam.de/panmetaworks/, 2018; the first link leads to an error page, while the sec-

ond leads to a generic page of the GFZ website).

Response 5: The database is fully and publicly available at the indicated database under this link that we will be report also on the revised manuscript (Lines 5 onward p. 17): http://pmd.gfz-potsdam.de/panmetaworks/review/924b171fd21c78f295d58a7e9e321e8ad07667ab6201634b23d3cb5a3f170d10/

Comment 8: A basic consideration is that by assembling faults from such different and nonhomogeneous sources, Petricca et al. inevitably put together a) alternative views on the same faults, possibly stemming from widely alternative conceptual models; b) faults that are mutually exclusive due to their geometry (typically, faults crossing each other in the subsurface: if one fault ends against another, its seismic potential based solely on length is largely overestimated); c) faults that cannot be simultaneously active, or reactivated, in the current stress regime; and d) blind faults whose actual length may be strongly biased by the availability and density of subsurface data.

Response 8: We think that this is the strength of our work. For the reasons explained above (Response 4) we propose that most of the faults within the Italian territory can host an earthquake. Therefore a comprehensive fault dataset, as the one used in the present work, can help in: 1) reducing bias induced by the availability and density of subsurface data; 2) highlighting areas where detailed future studies are required to improve seismic hazard, that is not the target of this work.

All this is clearly stated in the Introduction and in the Conclusions sections. However, we will better stress the above-mentioned concepts in the Abstract, Introduction, and Conclusions of the revised manuscript (Lines 15-18 p. 1, 12-23 p. 3, + captions to Figs. 7 and 8). This is a product for scientific use only (i.e. testing the empirical relationships).

Comment 13: The authors never admit that their results are pointless, even when they remark (Page 12) that "... the negative occurrences are very limited...", i.e. that the number of predicted magnitudes that are larger than those observed in the historical

record outnumbers by far the opposite case, resulting in the very asymmetric pattern shown in Figure 12. In fact, they refer to a "...limited difference... between FLEMs and the catalogued earthquake magnitudes..." (!), neglecting the obvious consideration that magnitude is a logarithmic quantity, implying that a 0.2 increase in Mw, for example from 6.0 to 6.2, doubles the seismic moment. For a typical continental fault having an aspect ratio in the range 2-3 and standard scaling for coseismic slip, doubling the moment implies that fault length may increase by over 20%. For a magnitude increase of 0.5, for example from 6.0 to 6.5, the seismic moment becomes 5.6 times larger, which may require a fault that is 100% or more longer than that necessary to generate the smaller earthquake.

Response 13: Thanks. We accept this comment. We will rephrase this statement (the negative occurrences are very limited...). We agree that it is useless commenting this result as very limited. We will susbstitute "very limited" with the exact numbers that we obtain from the experiment. The term limited is too vague and subjective. However, once again, it is worth to underline that we are not proposing a forecast method, we are testing very well-known scaling laws at the national scale (Line 11 p. 13).

Comment 16: The conclusions of this paper are worrisome, in consideration of the large number of areas where the authors envision the possibility of M 7.5 and larger earthquakes, that is to say earthquakes bigger than the largest magnitude ever recorded in Italy, without any consideration as to how frequently this may occur. In a standard PSHA approach these large magnitudes would be assigned a very low probability of occurrence, leading to a minimal statistical impact on the expected ground shaking for short average return periods. The information about the possible largest earthquakes may generate a great deal of confusion if not appropriately communicated. We cannot imagine how the residents of Bologna, Ancona, Pescara, but also Padua, Trento, Vicenza and even Venice, cities lying in areas that are currently considered mid- to low-hazard, would react to knowing that very large earthquakes may occur below their feet at any moment.

Response 16: We completely agree with the sentence "The information about the possible largest earthquakes may generate a great deal of confusion if not appropriately communicated". In fact, we are NOT proposing a new seismic hazard map, and this is really clear by reading the paper (not only looking at the figures). We simply compute potential earthquake magnitude from fault size and compare these results with seismic catalogs (Figs. 10-13 and Table1) to reason upon the validity of the scaling relationships between fault attributes and earthquake magnitude at the national scale with available fault datasets. The comment by Valensise et alii is therefore inappropriate.

However, in the revised manuscript we will better stress the above-mentioned concepts (i.e., our aim is not a new and reliable map of expected earthquakes in Italy). We will also add disclaimers in Figures 7 and 8 saying that these figures are not at all for use for Civil Protection, officials, and, in general, for seismic hazard. They are a product for scientific use only (i.e. testing the empirical relationships) (Lines 15-18 p. 1, 12-23 p. 3, + captions to Figs. 7 and 8).

Comment 17: Another major flaw in the approach taken by Trippetta and co-workers lies in their discretisation of seismogenic zones into 25x25 km sub-areas. Of course, some discretisation is inevitable, but one has to be aware that a 25x25 km cell may host a 35 km-long fault, at the most. According to the equation proposed by Leonard (2010), the empirical law adopted by Trippetta and co-workers, a 35 km fault length corresponds to a Mw 6.8 earthquake. Hence, any larger earthquake will necessarily encompass two or more cells. A close inspection of Figures 7 and 8 of the paper, however, reveals that several cells filled in red or dark red, which according to the adopted colour-coding should correspond to an expected Mw in the range 7.4 to 7.8, occur isolated, i.e., surrounded by cells for which the expected FLEM is much smaller. According to same equation by Leonard (2010), this magnitude range corresponds to a fault length in the range 78 to 135 km, which should involve a minimum of 2 to 4 adjacent cells, depending on fault strike. An isolated cell capable of a Mw 7.4 earthquake is hence a seismological paradox that has no physical meaning, as the

earthquake causative fault will necessarily extend to adjacent cells.

Response 17: At which cell are Valensise et alii referring to? As we can see from figure 7 and 8 there are no red (M.7.5) isolated cells. In each cell, we consider the longest fault that touches/crosses the cell. This means that the faults can be longer than 35 km as indicated by Valensise et alii. This is clearly stated in our method section at Lines 27-28 Page 8: "The length of the longest fault crossing each cell determined the parameter "fault length" (Lf) of the considered cell." Our computation is selfsustained and the complete database is available at the following link for reproducibility of our results (see also the Data availability section) (Lines 5 onward p. 17): http://pmd.gfz-potsdam.de/panmetaworks/review/924b171fd21c78f295d58a7e9e321e8ad07667ab6201634b23d3cb5a3f170d10/

Thanks a lot Andrea Billi and co-authors