Dear Referee,

Thank you for your comments, questions and complete analysis of our methodology. It lead us to bring some change to the text and the Figure 1 in order to make the explanation of the approach clearer to the reader.

Please consider the changes in the text and the answer to your more specific questions.

The manuscript proposes a new methodology to calculate the magnitude probability density function (PDF) for fault systems considering the fault-to-fault ruptures and seismic moment accumulation. Proposed methodology might be a good and repeatable alternative for the "grand inversion" technique used in UCERF3; therefore, I found the technical content of the manuscript important and worth to be published after the following issues are clarified:

1) The method proposed here is built on the assumption that the G-R distribution is valid for the faults and fault systems. Earthquakes in seismically active regions are observed to follow an exponential distribution of magnitudes (G-R distribution); however, the size distribution of earthquakes on faults has been the subject of debate. According to Hecker et al. (2013), the common practice in probabilistic seismic-hazard analysis (PSHA) is to favor a characteristic-earthquake distribution for faults, but to incorporate an exponential distribution in some aspect of the modeling. In Figure 1 of Hecker et al. (2013) a very clear example of the overestimation of the rates of small-to-moderate earthquakes when the G-R distribution applied to Hayward Fault is provided. Therefore, the authors should discuss the reasoning behind the selection of the target MFD as a G-R distribution. Would the Youngs and Coppersmith (1985) composite model be a better target MFD for fault-to-fault ruptures?

The YC model is often preferred for single faults. If a fault network is large enough, a GR can be appropriate as it is often observed in wide regions.

GR seems to work for the WCR. This is true that for other fault networks the YC distribution might be more appropriate. When this choice is unclear, our methodology can allow to explore it in a logic tree and to perform a reality check and observe if one performs better than the other. If the GR distribution overestimates the rate of magnitude 5 earthquakes, the model will not perform well.

We hope the change in the Perspectives section can help the reader to understand this issue better:

P8 R34 : "The methodology presented in this article can be applied to other fault systems, in different tectonic environments. In order to implement this approach, the geometries and slip-rates of the faults have to be known within uncertainties, FtF rupture scenarios sets have to be defined and the shape of the regional MFD needs to be assumed or inferred from the regional catalog. If for the WCR the GR distribution seems adapted, it has been shown that a Youngs and Coppersmith distribution (Youngs and Coppersmith, 1985) can be more appropriate for other fault systems (Hecker et al., 2013). In such a case, the methodology can be applied in applied in the same way for any other target MFD."

2) The computational steps for proposed methodology should be clearly demonstrated. Annex 1-Figure 1 is quite adequate for this purpose, but it is not properly explained in Section 2. Here is how I interpret the method from the text and Figure 1:

a) Maximum magnitude and the magnitude bins for each fault are defined. For the example in Figure 1, Mmax=6.2, 6.3, and 6.6 for F1, F2 and F1+F2, respectively.

Yes.

b) According to the figure, the computations start from the maximum magnitudes (Figure , panel 2). Since there is no other combination that can end-up in M=6.6, Mo for M=6.6 is calculated and reduced from F1+F2. Is my interpretation correct?

Yes.

c) The computations continue with decreasing magnitude. For the smaller M (for example M=6.2), all faults can be responsible. According to the text, the seismotectonic source that can be responsible for that is selected randomly. It can be F1, F2 or F1+F2. This point forward needs more explanation. What happens then? If F1 is randomly selected, the budgets for F1 and F1+F2 are both reduced? What happens to F2 e.g. can F2 also result in a magnitude 6.2 in this procedure?

F1 or F2 can be responsible but not F1+F2 since both single faults can accommodate this magnitude. This way, the geological interpretation of the segmentation is respected, only larger earthquakes can break through the barrier. If F1 is selected, only the slip-rate budget of F1 is reduced. Nothing happens to the slip-rate budget of F2 at that iteration. F1+F2 doesn't have a budget of its own. For a magnitude 6.4 for example, F1+F2 will be the selected source and the slip-rate budget of both F1 and F2 will be reduced by the increment dsr.

d) The incremental MFD on Figure 1 is equal to dre/dMo. Is this correct? dre/dMo is basically equal to the seismic moment for that bin, coming from all fault combinations?

It should be noted that dre/$d\dot{M}_0$doesn't have the dimension of a moment rate. $d\dot{M}_0$is the increment of moment rate of the fault when spending the increment of slip-rate dsr on this fault. dre is the increment of rate of the picked magnitude on the picked source when spending the increment of slip-rate dsr. We hope the changes made in the text and Figure 1 help clarifying the explanation of the methodology.

e) Page 4, Line 6: "As the magnitude bins are picked according to a distribution based on the moment rate…" Can you please clarify that? Are the magnitude bins selected in a decreasing order (because the figure implies that)?

Yes, the implication of using a moment rate based distribution is that the higher magnitudes are more likely to be picked.

f) Since the slip rates are spend in the decreasing order of magnitudes, this model somehow supports the characteristic assumption; the faults may not create small magnitude events if the budget is spent. This is consistent with Figure 3 third panel where the distribution looks like a skewed normal distribution. However, the rate of the largest magnitude event (dre/dMo) would be larger if dre/dMo=Mo(M=6.6). That's not consistent with Figure 1.

dre/ $d\dot{M}_0$ doesn't have the dimension of a moment rate. The initial distribution (GR in this paper) is imposed and the final MFD of the system will be in a shape of this distribution.

The random picking of the magnitude will indeed pick more often the large magnitude. The $d\dot{M}_0$ on one fault is fixed, independently of the magnitude (equation 1). The increase of the rate of earthquakes (dre) will be much greater for smaller magnitude than for greater ones. This leads to respect the GR distribution in terms of frequency of earthquake and in terms of moment rate.

We hope the changes in the text and the figure clarify the methodology.

g) Page 4, Lines 9-11: "The target MFD for the whole fault-system is then calculated based on the imposed regional b value and the average rate of the three highest magnitude bins (0.3 being the range of uncertainties in the scaling laws used to assess the maximum magnitude)". To my understanding based on this statement and Figure 1, the activity rate (or the intercept of target MFD) is determined based on the known slope fitted to large magnitude rates. Can you please discuss the assumption that the slope is constant under the assumption that proposed model has a "close to characteristic" shape?

The target MFD is fitted to the larger magnitudes earthquake rates with a fixed b value. The fault system MFD is, in this example, a GR distribution. However, the MFD of each fault is not imposed but deduced from the methodology and can be quite different from the shape of the target MFD. In the case of the Corinth Rift we observe that some faults present a distribution close to characteristic some present a distribution close to GR. The sum of those different distributions respects the target GR with a fixed b-value.

h) At the end, the shape achieved is "kind of" similar to the composite model of Young and Coppersmith (1985). Please discuss this similarity (or lack thereof) by plotting the proposed model and composite model in moment rate space. Based on the questions raised above, the text explaining the procedure should be rewritten in more details for the sake of the reader, since it's the heart of the paper. Adding the spreadsheet for the example given in Figure 1 would also be very useful.

As said before, the final MFD on each fault is not imposed but is an output of the methodology. The shape is neither a perfect Youngs and Coppersmith or GR MFD and can be different for each fault in the system. We can however notice a trend of more “characteristic” behavior of the faults compared to a GR MFD. It is also worth noting that on a plot like Figure 6 b and c, the larger earthquakes happen not only on the Aigion fault, but also on the neighboring faults involved in the FtF rupture. In Figure 5, the slip-rate budget of the large earthquakes is shared on several faults. Therefore, the MFD of different faults in the system are not mutually exclusive and a simple comparison with a Youngs and Coppersmith distribution might be misleading since this distribution takes into account the whole area where the earthquake occurs. However, Figure 6 can be compared to the historical catalogue and paleo earthquake where we know that “at least” the Aigion fault ruptured during these earthquakes.

Thank you for your very complete analysis and comment of the procedure. We think that question d, e and f were due to a misunderstanding of the methodology. This led us to re-write the methodology section of the article and change figure 1. We hope the changes can help the reader understand the methodology better.

Attached to this answer, you will find the excel spreadsheet containing the values for each fault and scenario of Figure 1.

3) Proposed methodology does not have a check point. In the study referenced by the authors (Gülerce and Ocak, 2013), or in Hecker et al. (2013), assumed magnitude recurrence model is tested by the rate of earthquakes associated with that particular fault system for consistency. It seems like the authors foresee such a check point according to Figure 2 and 4. I recommend that the check is also added as the last step of the procedure.

Thank you for this suggestion. We formally added this last step in our methodology (P5 R8) as it is indeed crucial to weight the different explored hypothesis before running any hazard calculation.

P5 R8 : **“**(5) Exploring the epistemic uncertainties: Many assumptions have to be made when setting up the methodology (scaling law, FtF rupture set, faults parameters …) and the different possible hypothesis should be explored in a logic tree.
(6) Reality check: The last step of the methodology involves comparing the modeled earthquake rates with independent data such as the seismicity rates deduced from the catalogue and from paleoearthquake rates deduced from trench studies. Each branch of the logic tree is then weighted according to its performance with this independent data.”

4) Second part of the manuscript presents the application of the proposed methodology on western Corinth rift fault system. A few questions regarding the application side:

a) The b-value is assumed as 1.15. Please provide the reason why it is not calculated from the catalogue but assumed.

The b-value used in this study is based on the b value for normal fault system. The choice of using a global value was made in order to shorten the paper and to focus the attention on the methodology and not on the catalogue used nor on the inversion method of the b value. When looking at the Figure 2, it seems that the value of 1.15 is appropriate for the Corinth Rift. For other applications, the b value calculated using the catalogue can be used.

b) Page 5, Line 32: “We propagate the uncertainties on the earthquake magnitudes and on the time of completeness of the catalog in the seismic moment rate and earthquake rate calculations”. Please explain this statement since the application procedure does not elaborate these matters.

An explanation has been added in the paper (P6 R35). We hope it can clarify this matter.

P6 R35: "The seismicity catalogue presented on Figure 2 is the SHEEC catalogue (Giardini et al., 2013; Stucchi et al., 2012; Grünthal et al., 2013) developed in the framework of the SHARE project updated for 6 historical earthquakes (Albini et al., 2017) and 3 instrumental earthquakes (based on Baker et al 1997 study and personal communication from the 3-HAZ Corinth project). The updates and their implication on the catalogue are summarized in Table 3. We propagate the uncertainties on the earthquake magnitudes and on the time of completeness of the catalog in the estimate of seismic moment rate and earthquake rate calculations by randomly sampling the magnitude of each earthquake with the uncertainties (Stucchi et al, 2012, Albini et al, 2017) and using two hypothesis of completeness (Table 4): the times for Greece calculated by the SHARE project (Stucchi et al., 2012) and the times calculated by Boiselet 2014 using the Stepp 1972 approach at the scale of the Corinth Rift region."

c) I'm assuming that the catalogue completeness levels are considered in comparing the earthquake rates from the catalogue to the proposed MFD, specifically in Figure 4. Please clarify that issue.

We explore two completeness periods. One was calculated by the SHARE project for the Greece area and the other was calculated by Boiselet 2014 at the scale of the Corinth Rift. We modified the text to clarify this matter:

P6 R34: "We propagate the uncertainties on the earthquake catalog in the estimate of seismic moment rate and earthquake rate calculations by randomly sampling the magnitude of each earthquake with the uncertainties (Stucchi et al, 2012, Albini et al, 2017) and using two hypothesis of completeness (Table 4): the times for Greece calculated by the SHARE project (Stucchi et al., 2012) and the times calculated by Boiselet 2014 using the Stepp 1972 approach at the scale of the Corinth Rift region."

Figure 1 caption: "Modelled seismicity for the WCR fault network and comparison to the seismicity rate based on the earthquake catalogue of the complete period"

d) One of the significant problems in utilizing the moment-balanced PSHA in the extensional regimes is the slip rate participation on parallel dipping faults (as in N. Erratini and S. Erratini Faults in Figure 2). Please explain how the extensional slip rate is calculated for these systems and how the uncertainty affects the proposed methodology.

The slip-rate of the faults is inferred from geological information individually on each of the faults. In the case of the offshore faults, seismic profiles and boreholes have been used to calculate the long term slip-rate of the faults. The partitioning of the slip-rate on different faults is a problem when geodetic measurements are used to invert the slip-rate.

In order to make clear to the reader that the slip-rate is inferred for each individual fault, the text has been modified.

P6 R2: "The faults slip-rates Western Corinth Rift (WCR) were inferred from the displacement of geologic markers in the field or from seismic profiles on each individual fault with the exception of the two blind 1995 and Pyrgos faults for which the microseismicity recorded close to the fault was transformed into slip-rate on the fault plan. These latter slip-rates are therefore subject to a very large uncertainty. The geological extension rate expressed by the sum of the horizontal projection of the geological slip-rates of the faults is in the range of 3 to 6 mm per year, three times less than the geodetic extension rate. Given this disagreement, the WCR is a good candidate to test if the earthquake rates calculated using our methodology that relies only on geological information can account for the occurrence of large earthquakes that have been observed in the region (Albini et al 2017)."

e) Finally, the maximum magnitudes of the faults used in the example are not that big (none of them are above 6.5). Please comment on the applicability of this method for larger faults that can produce M>7 events.

Assuming a MFD for the fault system (GR, YC or other…) covering the whole range of magnitudes, and a set of possible FtF ruptures our methodology should be applicable to any system where estimates of the slip-rate of each individual fault (with its uncertainties) are available.

P8 R34: "The methodology presented in this article can be applied to other fault systems, in different tectonic environments. In order to implement this approach, the geometries and slip-rates of the faults have to be known within uncertainties, FtF rupture scenarios sets have to be defined and the shape of the regional MFD needs to be assumed or inferred from the regional catalog. If for the WCR the GR distribution seems adapted, it has been shown that a Youngs and Coppersmith distribution (Youngs and Coppersmith, 1985) can be more appropriate for other fault systems (Hecker et al., 2013). In such a case, the methodology can be applied in applied in the same way for any other target MFD."