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Interactive comment on "Correlation between the fractal of aftershock spatial distribution and active fault on Sumatra" *by* Bahary Setyawan and Benyamin Sapiie

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Received and published: 28 December 2019

Dear Francesco Visini,

first of all, I thank and appreciate your detailed comments, which of course take your time. the responses are in below:

Detailed comments. 23) Abstract: Please, introduce a brief explanation of fractal dimensions to make it easy to understand to a wide and diversified audience.

Author's Response: will be considered

Page 1 24) Line 18: Please specify what do you mean with "slip segmentation", it is

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not clear.

Author's Response: it means that The Sumatran Plate Boundary is a slip-partitioned system. Dip-slip is accommodated across the subduction zone and strike-slip is accommodated by Sumatra Fault Zone (SFZ) as a dextral fault.

25) Line 20: I'd suggest to introduce here the figure1 with faults and seismicity to show the tectonics. Please, add also a wide tectonic scheme to introduce readers that are not-familiar with the region.

Author's Response: will be considered

26) Line 21-22: Please, add the references to support this.

Author's Response: The following references have been added: References : Bhattacharya, P. M., and Kayal, J. R.: Application of fractal in marine sciences: Study of the 2004 Sumatra earthquake (Mw 9.3) sequence in Andaman-Nicobar islands, Indian J. Mar. Sci., 36(2), 136–140, 2007. Roy, S., Ghosh, U. and Hazra, S.: Fractal dimension and b -value mapping in the Andaman-Sumatra subduction zone, Nat. Hazard, 27–37, doi:10.1007/s11069-010-9667-6, 2011. Sukmono, S., Zen, M. T., Kadir, W. G. A., Hendrajaya, L., Santoso, D. and Dubois, J.: Fractal Geometry of the Sumatra Active Fault System and Its Geodynamical Implications, J. Geodyn., 22(112), 1–9, 1996. Etc.

27) Line 25: the reference is Turcotte, 1997 (delete the name)

Author's Response: will be considered

28) Line 28: Please, add the references to support that GR is considered as SOC.

Author's Response: The following references have been added: References: Dimri, V. P.: Fractal Behaviour of the Earth System, edited by V. P. Dimri, Berlin., 2005. Donald L. Turcotte: Fractals and Chaos in Geology and Geophysics, 2nd ed., Cambridge University Press, New York., 1997.

Page 2 29) Line 4: I think it will be more clear than now if you remove ". In the same

study the correlation between both fractal values is SOC, the equation being as follows"
and just left ":".

Author's Response: will be considered

30) Line 8: please specify what do you mean with "satellite faults".

Author's Response: satellite faults are faults that surround the main-shock fault Ya-
mashita and Knopoff (1987). Fir 1.

31) Line 13: "This result is more affected by the large uncertainty relative to the vari-
ation of D2.".Question1: More than what? Question2: is there a reference to support
this statement? Or, if it is your idea, it has to be supported by a quantitative analysis.

Author's Response: it is from Padhy et al., (2013). Will be rephrased into "there is no
correlation due to the large uncertainty of D2"

32) Line 22-25: Please rephrase because it is not clear.

Author's Response: The data were obtained from PuSGeN catalog (National Earth-
quake Study Centre) which was collected from International Seismological Centre
(ISC), National Earthquake Information Centre U.S. Geological Survey (NEIC-USGS),
EHB catalog (Engdahl et. al., 1998) and Badan Meteorologi, Klimatologi, dan Geofisika
(BMKG) catalog that was relocated by Shiddiqi et. al. (2015).

33) Line 25: "This catalog has all the earthquake data with the magnitude above 4.5
Mw, starting from 1900 to 2016", Please add a reference or show a completeness
analysis to support this statement.

Author's Response: Pusat Studi Gempa Nasional, Pusat Litbang Perumahan dan Per-
mukiman.: Peta Sumber dan Bahaya Gempa Indonesia (in bahasa)., Pusat Penelitian
dan dan pengembangan perumahan dan permukiman Kementerian Pekerjaan Umum
dan Perumahan Rakya, Bandung, 2017.

Page 3 34) Line 2: "Active faults were identified based on morphology that had been

carried out in previous studies." Please add a reference

Author's Response: Pusat Studi Gempa Nasional, Pusat Litbang Perumahan dan Permukiman.: Peta Sumber dan Bahaya Gempa Indonesia (in bahasa)., Pusat Penelitian dan dan pengembangan perumahan dan permukiman Kementerian Pekerjaan Umum dan Perumahan Rakya, Bandung, 2017.

35) Line 3: "The SFZ was divided into 42 segments, while the WAF was divided into 4 segments" Who did this segmentation? and what it is based on?

Author's Response: Pusat Studi Gempa Nasional (PuSGeN) did it. It is based on morphology and earthquake distribution.

36) Line 4: Are there paleoseismological studies to support the activity of these faults?

Author's Response: yes, there are. I'd consider adding paleoseismology studies in the regional or tectonic setting in the manuscript.

37) Line 5: can you be sure this is not a bias due to the seismic network configuration? How did you select the aftershock? Is a time-radius magnitude dependent approach?

Author's Response: yes indeed, it is based on a time-radius magnitude approach.

Page 4 38) Regarding the mainshocks shown in the Table 1. You stated that "This catalogue has all the earthquake data with the magnitude above 4.5 Mw, starting from 1900 to 2016", but there are only earthquakes after the 1967 (I suppose this is the beginning of the instrumental period). So, this table is a selection of events? And if so, please specify the reasons. Or these are just the earthquakes with a correlation? And in this case you should show all the results.

Author's Response: the table contains selected events from the catalog. The event that has aftershock least than 9 earthquakes would generate high uncertainty (error).

39) At line 3 you wrote : "Tab. 1 is a tabulation of the results of the identified aftershocks and the correlation result". It is not clear if Tab 1 list the mainshocks. Please, specify

how you build this table.

Author's Response: Tab. 1 means earthquake event that was identified or selected, including aftershocks and main-shocks.

40) Finally, please use the dot for decimals.

Author's Response: will be considered

41) Eq2 and later: Please use the same letter for distance R or r. Or are them different?

Author's Response: they are different in that eq. R means distances between epicenters and r mean given distance that was used in the calculation.

42) Line 11-13: Please rephrase because, I think a verb is missing. It is not clear here, how D2 was estimated. Please consider to explain variables in the order they are presented.

Author's Response: D2 was estimated by $(r) \sim r^{(D\_2)}$, and to calculate it I used the least-square fit method. C(r) is the correlation of integral and r means given distance that was used in the calculation.

43) Line 6: "Conversely, a small D2 value indicates a tight earthquake distribution.", please specify what do you mean with a tight earthquake distribution. It is not clear if you are referring to the epicentral distribution or something else.

Author's Response: it means dense epicentral spatial distribution.

44) Line 6: delete "Donald L. "

Author's Response: will be considered

45) Line 7: The box-counting method is to make boxes in the aftershock cluster, please rephrase, because it is not clear.

Author's Response: In this method, square grids that cover the aftershock cluster were created.

46) Line 9: "length of the box (r)". This is the first time you mentioned length of box. Define all the parameters you are using to do your calculations.

Author's Response: yes, I would redefine the parameters

Page 5 47) Line 6: please correct in: "Figure 2 shows". Specify that this is an example.

Author's Response: yes, I would

48) The C(r) value calculation was conducted by using Python 3.7 Python is a language, what do you mean? Is there a specific function that you used?

Author's Response: I'd consider deleting this sentence. Functions used are R =cos−1 {cosðİŽij1cosðİŽij2+ sinðİŽij1sinðİŽij2cos(ðİŽ¡1−ðİŽ¡2)} and ðİŘű(ðİŚ§)= 1ðİŚĄ2∑ðİŘż(ðİŚ§−ðİŚĚ).

49) D2 estimation has a fairly high level of biases due a lack of complete catalogue or limited number of data points (Padhy et al., 2013). Can you give a quantitative analysis of this?

Author's Response: it was mentioned in Padhy et al., 2013.

50) Line 8-9: "The estimations were performed multiple times in several points to find a lower error value as done by Nanjo & Nagahama (2004)", please specify lower than what.

Author's Response: the lowest.

51) Here you are introducing "points" for the first time. What are them? They are numbered, but you do not specify what is the range. Please specify what these points are and, if possible, add them in figures.

Author's Response: the points are the projection points in r and C(r) curve or r and N(r) curve, which were the result of the calculation. I would add them in figures.

Page 6 52) Line 10: "We found three correlations and two earthquake occurrences that

did not follow the three correlations (Tab. 1 and Fig. 4)", do you mean that "Basing on values of slopes and intercepts of Do versus D2, we identified 3 groups of D2-D0. For the first group, we calculated a correlation with a slope greater or equal than 1.6 and an intercept of X.X. For the second group, we calculated a correlation with a slope greater or equal than xxx and an intercept of X.X…..? Please, rephrase this sentence because it is not very clear.

Author's Response: will be considered

Page 7 53) Line 7: However, that study was outside of our scope. What do you mean?

Author's Response: Bhattacharya and Kayal (2007)'s study was outside our study area.

54) Line 8: "The results obtained are relatively similar, but there is a significance difference in Oreng and Aceh-Center segment. It is due to differences in the morphological interpretation of active faults in that segments. Please, discuss in detail what are the reasons for such a differences, and how you define if they are significant or not.

Author's Response: the reason is the difference in active fault interpretation (completeness of fault database) between this study and the study from Sukmono et al., (1996). In my study, significant means that there is a 0.1 difference in D0 between both studies.

55) Line 13: "The third and the first correlation show a nearly identical value with only 0.06 differences". Please specify which value, I think it is the slope, but you should be clear.

Author's Response: yes, it is the slope. I'd be more specific.

56) Line 13: " A significant difference in the intercept shows the scale variation". What do you mean with scale variation?

Author's Response: it means scale invariance.

57) Line 15: We estimated b-value variation for both correlation 1 and 3 to find out whether there was an influence of the value (Tab. 2). How do you calculate the b? in

table 2 you show b value much higher than 1-1.2, this is quite strange and needs to be explained in detail. Is that the b- of the sequence? Please specify in detail your computation

Author's Response: to calculate b-value I used a least-square fit method. It is the b-value of aftershock and main-shock sequences.

58) Line 18: "Different catalogue also did not show significant differences." For example, b-value moves from to 2 to 1.3, is that not significant?

Author's Response: I mean the significant difference between correlation 1 and 3. I would rephrase the sentence.

59) Line 18-21: The number of the aftershock looked quite significant. In correlation 1, the number of aftershocks was above 18, whereas in the third the opposite occurred. However this result also cannot strongly explained why there was a scale difference in the number of aftershocks generated. Please rephrase this sentence because it is not clear. What do you mean with "opposite" and "aftershocks generated" ?

Author's Response: opposite mean in the correlation 3 the number aftershocks below 18. "aftershocks generated", I would delete the "generated" word.

Page 8 60) Line 10: correct in 0.4

Author's Response: yes, thank you

61) I'd suggest to add a column in the table with the difference in the occurrence between mainshock and largest aftershock (in years).

Author's Response: yes, I would

Page 9 62) Line 5-9. This paragraph should be completely re-written, it is not clear.

Author's Response: the earthquakes occurred because of the satellite fault in the near of main-shock cluster. The main-shock of Nicobar 2015 earthquake might be the Nico-

bar 2014 earthquake and the Tapanuli 2005 might be the satellite fault from the main fault of Mentawai 2005.

63) In the discussions, there are no clues about the possible effect of completeness of the fault database and earthquake catalog on estimations of D2 ad Do and their correlation. Do the correlations show a spatial significance or not?

Author's Response: yes, indeed. The completeness of the fault database and earthquake catalog would be significant. I would discuss the effect in the revised version. The correlation shows a spatial difference but I have not discussed it in this manuscript because I need further research.

64) The last conclusion, "Finally, this study can be used as a model to predict the spatial distribution of aftershocks with variations of general earthquakes, doublet earthquakes and scales", it is not discussed in the manuscript before. If number of aftershock impact the bvalue, and the correlations are done on basing on the observed number of aftershock, how is it possible predict spatial distributions? What do you mean with general earthquakes? Scales? Please, discuss this point in the discussion before state it in the conclusion.

Author's Response: I would discuss it first in the discussion section in the revised version. It can only predict the density of aftershock spatial distribution (D2) from the distribution of active fault. General earthquake means the earthquake that was caused by general mechanism. This term was used to differs the afore-mentioned earthquake to doublet earthquake that has a different mechanism Scale means scale invariance of the active fault.
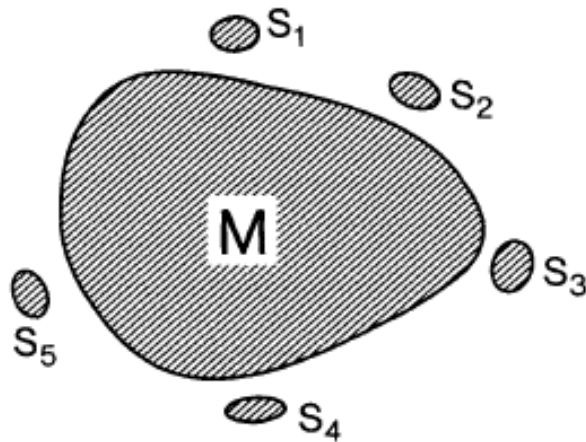
best regard.

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Figure 2. Schematic diagram for Model II. The shaded area M denotes the main-shock slip zone. The smaller cracks S_i, denote small satellite faults that surround the main-shock fault. The gaps between the satellites and the edge of the main shock fracture disappear by stress corrosion.

Fig. 1.