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Response to Reviewer #3 Anonymous Referee

Chieh-Chen Chang et al.

Author comment on "Quantifying the probability and uncertainty of multiple-structure rupture and recurrence intervals in Taiwan" by Chieh-Chen Chang et al., Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2022-46-AC3, 2022

We highly appreciate the reviewer's insightful comments and have revised our manuscript, nhess-2022-46, entitled, "Quantifying the probability and uncertainty of multiple-structure rupture and recurrence intervals in Taiwan," accordingly. Below, we have quoted the comments in italics and provided our detailed responses. All the changes are underlined in the revised manuscript.

Huang et al., in the manuscript "Quantifying the probability and uncertainty of multiple-structure rupture and recurrence intervals in Taiwan" presents a new approach by integrating the physics-based model (static Coulomb stress change) and statistic model (Gutenberg-Richter law) to evaluate the earthquake recurrence time for the possible multiple-rupture scenario. According to their assumption, multi-rupture only occurs if the stress transfer on the nearby fault reaches a certain value, and the slip rate of the multiple-rupture structure is the sum of the associated slip rate in related ruptures. Although I acknowledge this topic as a valuable contribution in the field of hazard assessment, however, this current manuscript needs improvements, especially I am still not clear about how the author partitioned the slip rates between different ruptures.

To clearly describe our algorithm for slip rate partitioning, we revised our procedure to first introduce the slip rate partitioned to individual structure ruptures (equations 8 and 9), followed by the obtained partitioned rates (equations 10 and 11). By combining them, the slip rate partitioned to the multiple-structure rupture from the original structures could be obtained (described in Lines 123-140).

We hope the present version of the manuscript meets the standards of *Natural Hazards and Earth System Sciences* and is now ready for publication.

The structure of the description.

I think section 3 is the core of the methodology in this study, as far as I can tell this study use simple equations, but the description makes it extremely difficult to follow. In general, I think the whole section of 3.1 and 3.2 should be reformulate, for example:

Equation (2),D^dot represents the slip rate, dose this slip rate indicates the long-term slip rate obtained from other measurements?

The slip rate ($_{L1}$, shown in equation 2) is obtained from the TEM seismogenic structure database (Table 1).

To clearly describe our algorithm for the recurrence interval of multiple-structure ruptures, especially for slip rate partitioning, we modified Section 3 and hope the current version achieves the desired clarity (lines 97-190).

Equation (7), the author used the Mw-Mo scaling law by Kanamori (1977), but the equation in the manuscript is from Hanks and Kanamori (1979) with the unit of dyne-cm.

We thank the reviewer highly for having identified this oversight in our paper. We have revised the manuscript accordingly and simplified equation 7.

Equation (8) and (9), there appear two parameters D_L1' and D_L2' with no explanations until equation (12) and equation (13).

Equation (10), dose the ML1 indicates the maximum magnitude in L1 ? D_L1+L2 is the displacement of the multiple-structure rupture, dose this means D_L1+L2 = D_L1 + D_L2? More practical parameter annotation should be carefully addressed.

Equation (14), this equation is hard to follow, in Line 146 : the sum of the slip rates for the multiple-structure…. I don't understand what is the sum of the slip rates for the multiple-structure? and this statement is not correspond to the equation (14).

To clearly describe our algorithm for evaluating the recurrence interval of multiple-structure ruptures, we first introduced the slip rate partitioned to individual structure ruptures (equations 8 and 9), followed by the obtained partitioned rates (equations 10 and 11). By combining them, the slip rate partitioned to the multiple-structure rupture from the original structures could be obtained (described in lines 123-140).

The author took 1906 Meishan earthquake as an example, they argued that closed-by Chiayi frontal structure also ruptured during the coseismic period because liquefaction took place on the west of the Meishan fault, however, I think this statement is little-bit weak because liquefaction could occur when the stress is perturbated through seismic wave propagation from the mainshock.

To better illustrate the rupture behavior of the Maishan earthquake, we provided evidence such as the larger magnitude than the characteristic magnitude of the Meishan fault, the focal mechanism of oblique thrust faulting being oriented in the northeast–southwest direction, and the large ground shaking with liquefaction that took place to the west. All infer the Chiayi frontal structure might rupture simultaneously.

Also, I got confused when reading the line from 286 to 288, dose the author really hints that Meishan earthquake is initiated on the Chiayi frontal structure?

The description of the simplified Coulomb stress change model has been removed.

For model uncertainty, this sensitivity test is focus only on the rake angles for estimating the Coulomb stress change, I was wondering what if they change the friction coefficient? Friction coefficient also plays an important role on evaluating the stress impart from the mainshock, especially recent studies suggest that friction coefficient is depth dependence (i.e., Carpenter et al., 2012,2015). Besides the Coulomb stress model, G-R law also make a strong contribution on this approach, I am wondering if they consider different type of G-R law will change the result significantly (for example the truncated model)?

We followed the reviewer's comment and discussed the impact of the friction coefficient. We considered μ'=0.2 and 0.5, the boundaries of its reasonable range determined from focal mechanisms in Taiwan. Considering the stress threshold of ΔCFS$\geq$0.1 bar and a distance threshold of 5 km, the potential paired structures were identified (Table 6). The results suggest slight differences within the reasonable effective friction coefficient (lines 54-56, 259-267). Besides, we explained our model without implementing a poroelastic assumption since previous studies (e.g., Chan and Stain, 2009) concluded that the differences in their results were trivial for assuming reasonable values of Skempton's coefficients (between 0.5 and 0.9) and dry friction (0.75) (lines 259-262).

minor comments:

Line 131, show in equation 1 -> equation 3

This sentence has been removed.

Line 157, what is characteristic earthquake means? rupture or slip or magnitude?

This paragraph has been removed.

Line 159~ , The author addresses the exact value of each parameter very carefully, but I do think those repetitive equations and number should be removed and only use a simple table to present. Line 284, missing the ID for Chiayi frontal structure.

This paragraph has been removed.

Please also note the supplement to this comment:
https://nhess.copernicus.org/preprints/nhess-2022-46/nhess-2022-46-AC3-supplement.pdf