Dear Editor,

Thank you very much for handling our paper titled " Spatiotemporal seismicity pattern of the Taiwan orogen". We have read the review carefully and have accordingly made substantive modifications to the manuscript and explained the details in the response letter below. Line numbers refer to the clean version of the manuscript. We believe the revision can draw your reconsideration of publication in Natural Hazards and Earth System Sciences.

Sincerely,
Yi-Ying Wen and co-authors

Reviewer #1:

We thank the reviewer for the insightful and positive review of our work. We have read the review carefully and have accordingly made substantive modifications to the manuscript and explained the details in the response letter below. Line numbers refer to the clean version of the manuscript.

Comment:
For this paper the authors try to distinguish two different behaviors of RTL for eight events at different locations in Taiwan. Four of the events analyzed show what the authors recognize to have quiescence before the target event (Q type) and four show activation before the target event (A type). The time periods or the amplitudes of quiesce and activation appear to differ significantly in each case. They argue that Q type events (1, 2, 5, 8) are located in southern Taiwan and the other four are in central Taiwan because of difference in tectonics between these two regions. They also try to distinguish them by looking at the frequency-magnitude plots (Figure 5). Overall, I appreciate the statistical analysis of seismic catalog to look for patterns. The results could be useful in studying developmental variations in seismicity and crustal stresses before significant earthquakes. However, the differences between the two groups resulting RTL's shown in Figure 2) are very subtle; if Sobolev et al.'s diagrams were examples of successful detection of signs of upcoming events, the precursory changes for events 2, 5, 3, 4, in particular, are in comparison quite small and one wonders how a "signal" can be detected.
Reply: We appreciate reviewer's encouragement. In this work, our scope is not to detect the seismic precursor but attempts to further understand the relationship between the seismicity changes with the regional tectonics (L. 63-66). As the description in L. 83-84, the weighted RTL value reflects the combined deviation from the background seismicity level (R_{bk}, T_{bk} and L_{bk}). The negative RTL value represents the seismic quiescence, and the positive RTL value suggests the seismic activation. Therefore, the investigated events are classified by the seismicity change before their occurrences. Wen and Chen (2017) used various periods of catalog (8- to 24-yrs) to examine the influence of the background seismicity. They found that the temporal RTL functions of different background lengths show similar main patterns with different values. Although the absolute RTL values prior

to event Nos. 2, 5, 3 and 4 are small, they could still reflect the seismicity changes increased or decreased from the background rates.

Comment: The association of the RTL behaviors described by the authors to the central and southern Taiwan tectonics raises some questions. The geology, crustal structures and plate tectonic setting indicate that in terms of petrology, faults, plate boundaries the differences between eastern and western Taiwan are much more dramatic than between central and southern Taiwan. The local tectonic environment of the eight events are very different. To put them in the two baskets needs much more justification.
Reply: We agree with reviewer that, from several points of view, the differences between eastern and western Taiwan are significant, and some studies analyze the seismicity of these two groups (e.g., Hsu et al., 2021). We indeed discuss four events in eastern Taiwan in L. 299-301. Also, some studies divide the Taiwan region into several zones based on the seismic characteristics or tectonics, e.g., Lin (2000), Shyu et al. (2005) and Wu and Chen (2007). We do not classify the A-type or Q-type events into two regions on purpose, however, this coincide gives us the motivation to look whether the characteristics of spatial seismicity pattern related to the regional tectonics. From Shyu et al. (2005), Taiwan might be divided into three regions based on the Wadati-Benioff zones of the two subducting systems: north, post-collisional collapse and extension; central, collision and suturing; south, pre-collisional rapid and distributed convergence. GPS velocity field, geodetic strain-rate field and stress field also show different pattern between central and southern Taiwan (Hsu et al., 2009; Chen et al., 2017). Therefore, the discussion between central and southern Taiwan is reasonable, and, as reviewer's comment, the results could be useful in studying developmental variations in seismicity and crustal stresses before significant earthquakes.

Comment: Throughout this papers it would be useful to have more discussions regarding the physical significance of the various parameters in the calculations. For example, r sub 0 and t sub 0 were initially called characteristic distance and characteristic times, without saying what they are characteristic of. Later they were given some numbers but what do these numbers depend on physically? Having scanned some of the seminal papers on the RTL method and its application by Sobolev, Q. Huang, Nagao etc., in which the physics was never left out, I think such discussion gives the readers a much better grasp of the significance of such studies.
Reply: Several studies discuss influence and determination of the characteristic parameters, r_0 and t_0 (e.g., Chen and Wu, 2006; Huang and Ding, 2012; Nagao et al., 2011), but it is out of the scope for this work. We understand reviewer's consideration, therefore, we add some description in L. 85-86.

Comment: Section 3.2 intends to show spatial distributions of activation or quiescence for the 8 events studies. I find it quite hard to conclude the general relationship between the distribution and the event location.
Reply: In this section, we just show the results of spatial distributions of activation or quiescence for the investigated events. As discussed in Wen et al. (2016), the spatial seismic activation/quiescence map provides the information of influence of surrounding seismicity state to the target event during the abnormal (activation/quiescence) stage.

However, the additional analysis is needed to explain the occurrence mechanism of the target event. We add more description in L. 170-172. In this work, we describe the detailed discussion in section 4.

Comment: In the Discussion section, it struck me that the word "reveal" was used ten times. I recall reading a comment years ago that this word is not particular suitable for discussing scientific results. Careful evaluations of the main results. Also the discussions in this section is some "anecdotal" rather than systematic.
Reply: Thank for reviewer for pointing out this inappropriate usage. We have replaced the word with other ones in the manuscript. Considering both reviewers' comments, we have also modified Discussion section.

Comment: Some specific texts in the introduction section are particularly obscure:
Lines (51-54): "The coastal plain and foothill region, which represent the southern tip of the fold-and-thrust belt in western Taiwan and show very low seismicity, mainly consist of Miocene shallow marine deposits and a Pliocene–Pleistocene foreland basin as well as mudstones." Question: Which part exactly? What do you mean by southern tip, where is it?
Reply: We have modified L. 55-56, which mainly describes the northwest domain of the southern Taiwan, and added the major geological units in Taiwan in Fig. 3 to be helpful for reading.

Comment: Lines (55-58): "…the southern Central Range is mainly composed of Oligocene to Miocene metamorphic slates and contains ductile folds and cleavages as well as superimposed faults. Central Taiwan, which is experiencing rapid to full collision, mainly consists of the Coastal Range, Central Range and Western Foothills.." Question: Is the intent to point out the differences between the two sections of the Central Range? But similar rocks are found in both sections of the Central Range! Also, the rate of uplift in the two parts may be somewhat different, but both parts are rising fast based on leveling results. Also, what are the superimposed faults?
Reply: Thank reviewer for pointing out the unclear description. In this section, we mainly focus on introducing the tectonic settings of the central and southern Taiwan. The description has been modified in L. 49-58.

Reviewer #2:

We thank the reviewer for the constructive and positive review of our study. We have read the review carefully and have accordingly made substantive modifications to the manuscript and explained the details in the response letter below. Line numbers refer to the clean version of the manuscript.

Comment: In this paper by Wen et al., resubmitted for publication to NHESS, a statistical analysis based on the RTL algorithm is performed to the seismicity of Taiwan to investigate possible spatiotemporal changes prior to eight M>6 events. The main

conclusions of the analysis imply that seismic quiescence is observed in southern Taiwan before the occurrence of the M>6 events (Q-type events), while seismic activation occurs in central Taiwan before the investigated M>6 events (A-type events). The authors are based on these observations to argue that these patterns are related to the tectonic setting. Furthermore, they argue that Q-type events occur within high b-value regions, while A-type events occur within low b-value regions. The results are interesting, but perhaps a better justification of the main conclusions is required. Section 4.2, where the tectonic setting is discussed, is rather vague and the differences between central and southern Taiwan that may generate A- or Q-type events are obscure. Hence, a better explanation on the physics and tectonics in these two regions is required.
Reply: Deeply thank for reviewer's appreciation. In this study, we use two different methods to investigate the characteristics of seismicity behavior for eight earthquakes. We do not intend to group them spatially in the beginning, but the results do. GPS velocity field, geodetic strain-rate field and stress field also show different pattern between central and southern Taiwan (Hsu et al., 2009; Chen et al., 2017). This gives another point of view for the seismicity pattern in different tectonics. Our results, which show many consistencies with several previously studies, are reliable and meaningful. As another reviewer's comment, our results could be useful in studying developmental variations in seismicity and crustal stresses before significant earthquakes. Considering both reviewers' suggestion, we have modified the Discussion section.

Comment: On one hand, the authors say that southern Taiwan is dominated by thrust faulting (Line 248) and on the other hand they say that the southern Central Range shows significant heterogeneity in faulting types (Line 266). There seems to be a contradiction, or do the authors refer to different regions? Perhaps showing the region names on a map can help the reader to follow the discussion. Some other points are listed below.
Reply: We correct that the major thrust faults are identified in "southwestern" Taiwan (L. 242). Following reviewer's suggestion, we have added the major geological units in Taiwan in Fig. 3 to be helpful for reading.

Comment: Lines 280-281. The authors say that faulting style corresponds to stress buildup accumulating from interseismic loading. What do they mean by that? Is the faulting style (normal, thrust or strike-slip) dependent on the stress build-up?
Reply: Hsu et al. (2009) derived the principal stress axes from stress tensor inversion and found that the orientations of principal strain-rate generally agree with the inferred stress axes. This implies that a large scale variation of stress orientations from the surface to the base of the crust is insignificant and suggests the predicted faulting style is consistent with stress buildup during the interseismic loading.

Comment: The authors refer to southern Taiwan as a high b-value region, but b-values are rather normal around unity.
Reply: We mean that the b-value in southern Central Range is relatively high comparing with the adjacent area. We have modified the description and added the previous study (in L. 262) as the reference.

Comment: The RTL values for the events #2, #5, #3 and #4, highlighted by the vertical dashed lines, are quite small. Are these variations statistically significant?

Reply: The weighted RTL value reflects the combined deviation from the background seismicity level (R_{bk}, T_{bk} and L_{bk}). The negative RTL value represents the seismic quiescence, and the positive RTL value suggests the seismic activation. Therefore, the investigated events are classified by the seismicity change before their occurrences. Wen and Chen (2017) used various periods of catalog (8- to 24-yrs) to examine the influence of the background seismicity. They found that the temporal RTL functions of different background lengths show similar main patterns with different values. Although the absolute RTL values prior to event Nos. 2, 5, 3 and 4 are small, they could still reflect the seismicity changes.

Comment: Lines 170-171 "Fig. 4 shows that Q-type events occurred on the edge of the seismic quiescence area and A-type events occurred on the edge of the seismic activation area". This is not entirely true, as some of the events seem to occur within the seismic quiescence or the seismic activation area.

Reply: The spatial seismic activation/quiescence map provides the information of influence of surrounding seismicity state to the target event during the abnormal stage. We have modified the description in L. 168-172.

Comment: Lines 201-203. The authors say that "the boundaries appear at approximately 23.2°N and 24.5°N for the abnormal seismicity distributions, which coincide with the distribution of declustered seismicity in Fig. 3". What do the authors mean by "abnormal" and how this is related to the distribution of declustered seismicity?

Reply: The 'abnormal' seismicity means the seismic quiescence and activation region shown in Fig. 4, and it seems a north limit at 24.5°N. The locations of A-type and Q-type events are seperated around 23.2°N. The seismicity boundaries appear at approximately 23.2°N and 24.5°N, might be related to the Wadati-Benioff zones of the two subducting systems, could be identified by the declustered seismicity (Fig. 3). To avoid misleading, we delect this unclear discreption.

Comment: The cumulative frequency-magnitude distributions are estimated within a radius of 25 km from the epicenter of each mainshock. Why don't the authors use as radius the estimated r0 value?

Reply: This technique is similar with the b-value analysis. Chan et al. (2012) analyzed the spatial and temporal evolution of b-values before large earthquakes in Taiwan, with a radius of 30 km. In this work, we focus on the seismicity related to source area of the investigated events. Based on the available finite fault models of these eight events, the fault length of rupture area is between 12 to 33 km. Thus, we set a radius of 25 km from the epicenter after testing, which can cover a length of 50 km.