Review #2

I have reviewed the manuscript "Spatiotemporal 1 Heterogeneity of b Values Revealed by a Data-Driven Approach for June 17, 2019 Ms 6.0, Changning Sichuan, China earthquake Sequence" by Jiang et al. The paper focuses on investigating the spatiotemporal heterogeneity of b values for Changning Sichuan, China earthquake sequence, using a data-driven approach. Based on their analysis, the authors have shown strong spatiotemporal heterogeneity of b values on the horizontal surface distribution, depth profile distribution and distance-rank index map. The study of Jiang et al. provides detailed calculations of the spatiotemporal distribution of Changning earthquake sequence that are potentially important to improve the seismic hazard assessment. Moreover, this work may support the application of the data-driven methods to estimate better b values, which may be of interest to a broad audience. I suggest that the paper can be published with minor revisions. However, I have several concerns from the current version of this study, which are listed below.

RE: Thank the reviewer for your positive comments and encouragement.

1. The calculations of *b* values strongly rely on choice of cut-off magnitude (Harte, 2016). However, the authors did not show efficient information on this issue. I suggest the authors provide more information on choice of cut-off magnitude and completeness magnitude of the seismic catalog.

RE: We thank the reviewer for pointing this out. In order to show the results of the minimum completeness magnitude and discuss its impact on the calculation of the *b* values, we have added Figure S4 of the M_c distribution in the *Supplementary Materiasl*, and discussed whether the completeness of the earthquake catalogue affects the result of the *b* values. This added Figure S4 is also posted here.

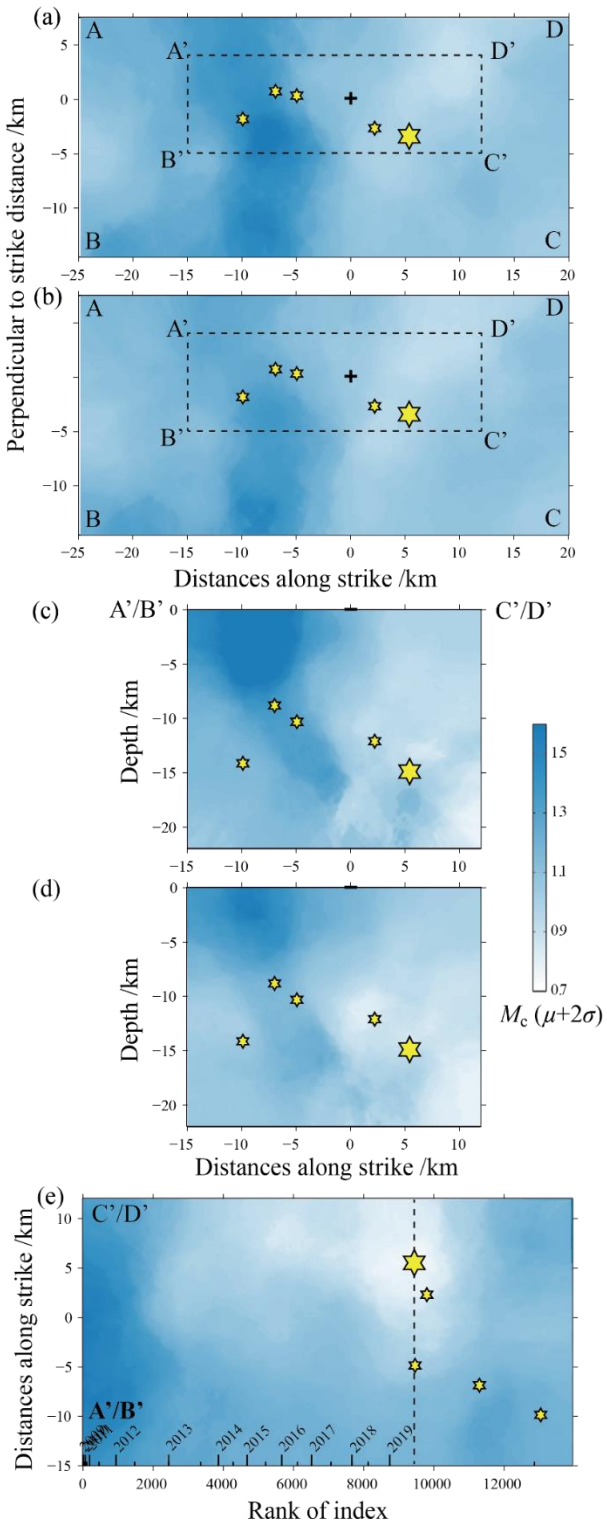

Fig. S4 Distribution of minimum magnitude of completeness $M_c(\mu+2\sigma)$. (a) Distribution of $M_c(\mu+2\sigma)$ on the horizontal plane after the rotation calculated by the events before the Changning M_S 6.0 earthquake; (b) Distribution of $M_c(\mu+2\sigma)$ on the horizontal plane after the rotation calculated by all the events including the aftershocks of the Changning M_S 6.0 earthquake; (c) Distribution of $M_c(\mu+2\sigma)$ in the rectangular frame A'B'C'D' on the depth profile calculated by the events before the Changning M_S 6.0 earthquake; (d) Distribution of $M_c(\mu+2\sigma)$ in the rectangular frame A'B'C'D' on the depth profile calculated by all events including aftershocks of the Changning M_S 6.0 earthquake. The hexagonal star

marks the locations of the mainshock and four aftershocks with magnitude no less than 5.0.

2. The choice of region selection is also an important issue in calculation of b values (Gulia and Wiemer, 2019; Dascher-Cousineau et al., 2019). For the data-driven method, how does the selection of region effect the calculation of b values? I suggest the authors at least discuss the potential impacts their selection of regions ABCD and A'B'C'D'.

RE: The question pointed out by the reviewer is very important. The data-driven method relies on a large number of random Voronoi meshing and automatic selection of BIC values to achieve close-to-real *b* values and other parameters, and the continuous function of the OK1993 model can also make full use of incompletely recorded seismic events. Due to the above two characteristics, the calculation result of the *b* value has little relationship with the selection of the region in theory. Considering that there are very few earthquake events outside the region ABCD, and region A'B'C'D' is the natural range of aftershocks, we did not further test whether changing the two regions will affect the *b* value results. In our ongoing research on data-driven methods for the calculation of b-values in a larger study area, we will consider this enlightening suggestion.

3. The authors provide a spatiotemporal distribution of *b* values on depth profile. Their findings are interesting and provide additional understanding of seismic hazard at depth. However, the uncertainties of depth location are usually large (several kilometers). The authors claimed the vertical uncertainty of relocation is 0.654 km, which may need more information to support this. At least, the authors should consider the potential influence of uncertainty of depth in the calculation of *b* values.

RE: We thank the reviewer for pointing this out. In order to investigate the potential influence of uncertainty of depth in the calculation of *b* values, we conducted random disturbance tests on the locations of the earthquake sources in Figure 4c.

We performed a random disturbance of ±1km in the horizontal position of the earthquake, and used the uncertainty of ±2km, ±4km and the random distribution in the range of [-22km 0km] to disturb the original depth respectively. The above-mentioned disturbance amplitude at these depths should be much larger than the uncertainty caused by the earthquake location method. In order to prevent the occurrence of air-quake with depth ≥0 km during random disturbance, we force the random number generator to run repeatedly until the depth <0 km.

The random test results show that the difference between the *b* values distribution and Figure 4c is not significant when the depth disturbance scale is ±2km, and the *b* values distribution can be kept similar even when the disturbance reaches ±4km. But when the depth is a completely random number, the distribution characteristics of the *b* values on the depth profile disappear. The above three random test results imply that the uncertainty of depth is difficult to significantly affect the

distribution characteristics of the *b* values in Figure 4c.

For a detailed explanation of the above content, please refer to Figure S1 and the text in the *Supplementary Materials*. We also briefly described the above supplementary content in the "Spatial Distributions of *b* Values on Surface and Depth Profiles" section of the revised manuscript. This added Figure S1 is also posted here.

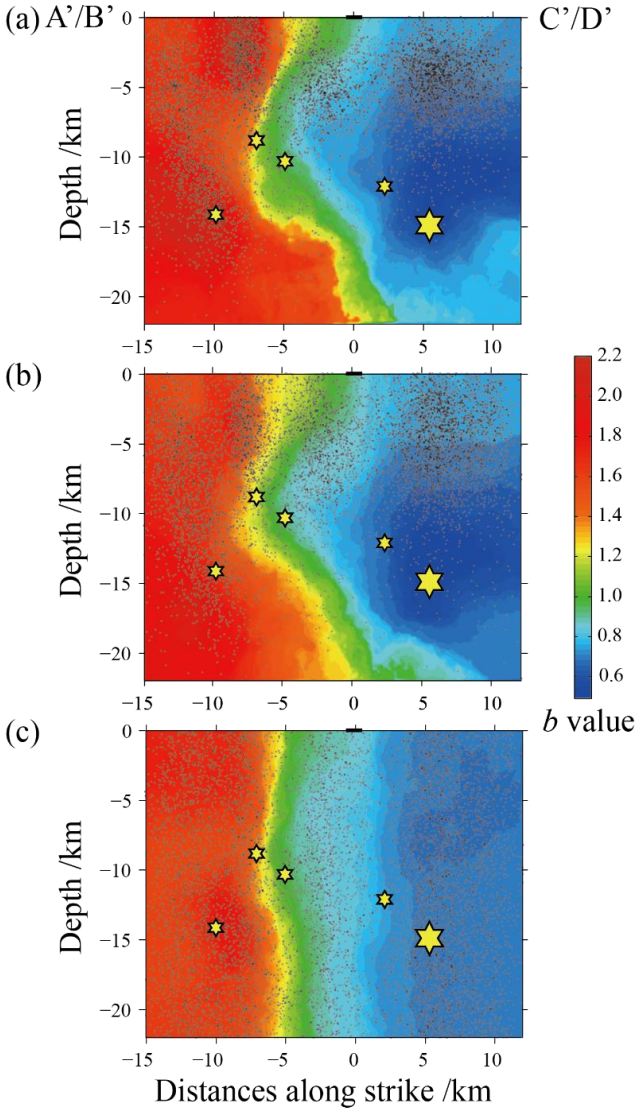

Fig. S1 The spatial distribution of the ensemble median *b* values on the depth profile obtained after random perturbation experiments on the focal depth in Figure 4c. (a) Distribution of ensemble median *b* values calculated from the earthquake catalog obtained by ±1km disturbance in horizontal position and ±2km disturbance in depth; (b) Distribution of ensemble median *b* values calculated from the earthquake catalog obtained by ±1km disturbance in horizontal position and ±4km disturbance in depth; (c) Distribution of ensemble median *b* values calculated from the earthquake catalog obtained by ±1km disturbance in horizontal position and random distribution in depth. The black dots mark the seismic events whose locations are randomly disturbed and used for *b* values calculation. The hexagonal star marks the locations of the mainshock and four aftershocks with magnitude no less than 5.0 that have undergone random disturbances.

4. Figure 4 clearly provide spatiotemporal heterogeneity of *b* values before the Changning earthquake and for the entire study period. I suggest the authors add results of *b* values for Changning mainshock and aftershock sequence to present comparisons between *b* values before and after Changning mainshock.

RE: Thanks for the reviewer's suggestion. We used the mainshock and aftershocks to calculate the *b* values and its uncertainty for comparison with Figures 4 and Figure 5. For the corresponding results, please see Figure S2 in the *Supplementary Materials*.

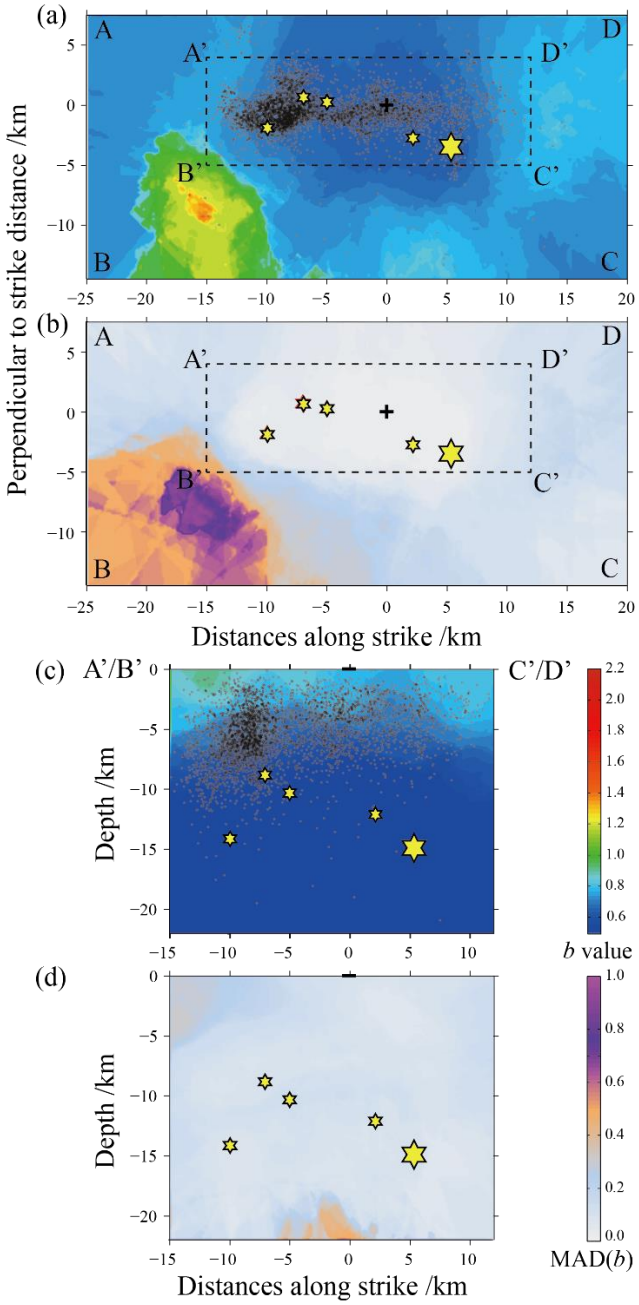

Fig. S2 The spatial distribution of the ensemble median *b* values and MAD *b* values of the best-100 solutions after the Changning M_S 6.0 earthquake. (a) The ensemble median *b* values is distributed on the horizontal plane after the rotation; (b) The ensemble MAD *b* values is distributed on the horizontal

plane after the rotation; (c) Distribution of the ensemble median *b* values in the rectangular frame A'B'C'D' on the depth profile; (d) Distribution of ensemble MAD *b* values in the rectangular frame A'B'C'D' on the depth profile. The black dots mark the seismic events used in the calculation.

5. Line 270-275. The authors show that the occurrence of the Changning mainshock has a great impact on the continuity of temporal b values. In addition, there were four M>=5.0 aftershocks, which might also contribute to the continuity of temporal *b* values. Their effects should be considered or discussed.

RE: The question pointed out by the reviewer is very important. Like the main shock, the four M>=5.0 aftershocks will also contribute to the continuity of temporal variation of *b* values. We have made a supplementary discussion on this issue in the "Discussion" section and clarified the possibility of this impact. See the revised manuscript for details.

Minor/general comments:

Line 3. “Earthquake”.

L70. Consider replace “found out” with “investigated”.

L159-160. Remove “There were”.

L166. Remove “As can be seen”, and use capital form of “from”.

L184. Remove “is shown”.

L185. “shows”.

L189. “Distributions”.

L210. Remove “where”.

L259. Remove “occurred”.

L266. Remove “occurred”.

L300. I suggest replace “Although the b values to drop” with “Although the decrease of b values”

L301. Remove the last “,”.

L303. Replace “b values time variation” with “temporal variations of b values”.

L304. Replace “(Parsons, 2007), or some studies” with “(Parsons, 2007). Some studies”.

L312. Replace “calculated the pattern migration” with “investigated the migration pattern”. Replace “space” with “dimension”.

L316. “migration pattern”

L331. “we believe” to “we deduce”.

L333. “mainshock triggering” to “mainshock which triggered”

L334. “earthquakes” to “aftershocks”

L337. “the b values” are not specific, because there are a lot “b values” calculated in this manuscript.

L346. “people” to “studies”.

L347. The author should refer Gulia and Wiemer (2019) at the end of this sentence.

L351. Remove “a parameter calculation method for ”.

L364-365. The “fluid intrusion” and “increased pore pressure” is not opposite, therefore it could be confusing. Please, rephrase it. The same problem is in L367-368.

L367. “It may be that the mainshock triggered” to “The mainshock may triggered”.

L380. Lack of the second bracket.

L583. “fromall” to “from all”.

RE: Thanks to the reviewer for above detailed comments on the grammar and expression. We have revised them one by one.

L254-255. The sentence “study the entire period as a whole ….. were studied separately” should be rewritten.

RE: This sentence has been rewritten as “One is to study the seismicity before and after the mainshock as a whole, and the other is to study the seismicity before and after the mainshock as two independent periods”. Please refer to the revised version.

L315-318. The logic of this sentence is not clear. I can’t figure out how the migration pattern could lead to “increase the pore fluid pressure”. The author should rephrase this.

RE: The expression of sentence L315-318 is indeed logically problematic. We have revised it to "under the assumption that the fault - structural heterogeneity will not change in the short term, and based on previous understanding of the correlation between high b values and fluid induced seismicity, the migration pattern in this paper may be explained by the erosion of fluid in the high differential stress area where the nucleation point is located”. Please refer to the revised version.

Fig. 4. Is that possible to plot small earthquakes in the spatial distribution of the ensemble median b values? This could help compare spatial distributions of seismicity and b values.

RE: According to the reviewer’s suggestions, we plotted the distribution of earthquakes used in the calculation on Figure 4. Please see Figure 4 of the revised manuscript, which is also posted below:

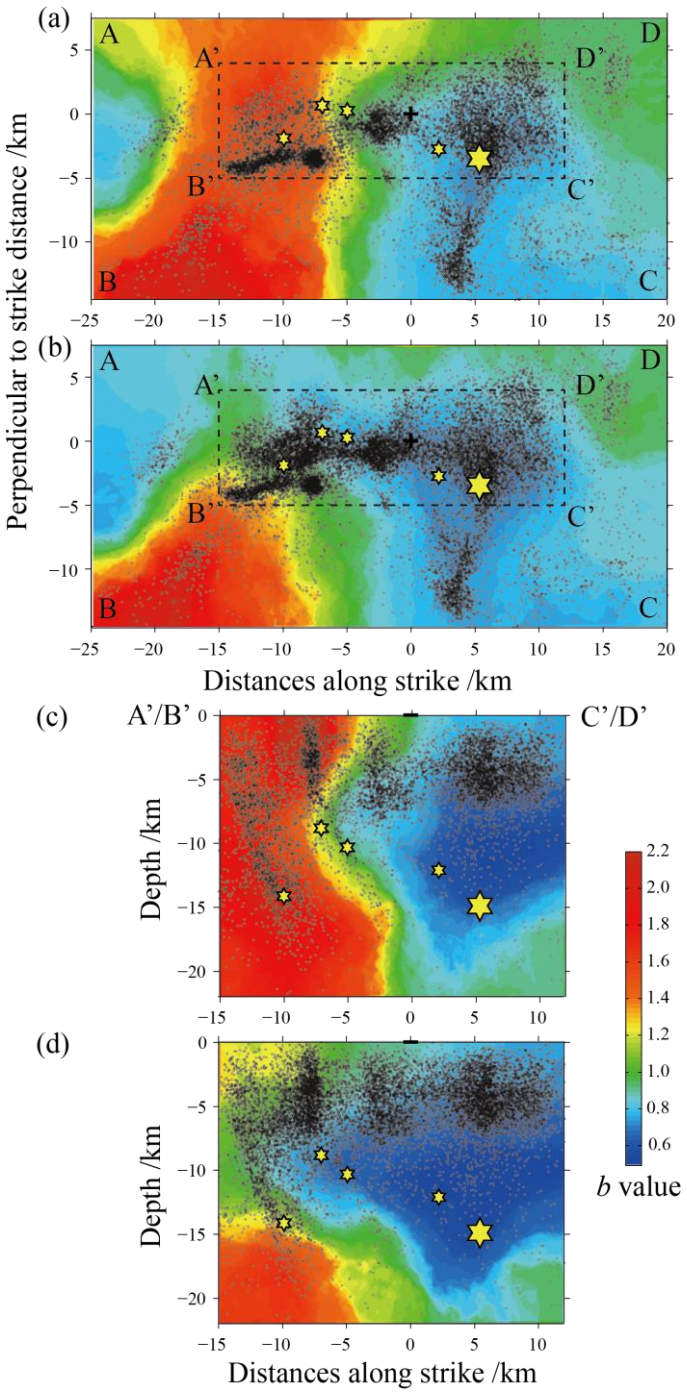

Fig. 4 The spatial distribution of the ensemble median *b* values of the best-100 solutions for N_v=2~40 in the Changning area. (a) The ensemble median *b* values before the Changning M_S 6.0 earthquake is distributed on the horizontal plane after the rotation; (b) The ensemble median *b* values obtained by calculation of all the earthquake including the aftershocks of the Changning M_S 6.0 earthquake is distributed on the horizontal plane after the rotation; (c) distribution of the ensemble median *b* values before the occurrence of the Changning M_S 6.0 earthquake in the rectangular frame A'B'C'D' on the depth profile; (d) distribution of ensemble median *b* values obtained by calculation of all earthquakes including aftershocks of the Changning M_S 6.0 earthquake in the rectangular frame A'B'C'D' on the depth profile. The black dots on each subgraphs mark the seismic events used in the calculation.

Fig. 6-7. I suggest plot the time at the upper x-axis to better show temporal evolution of b values.

RE: We added the time scale at the upper *x*-axis according to the reviewer's suggestions. Please see Figure 6 and 7 of the revised manuscript, they are also posted below:

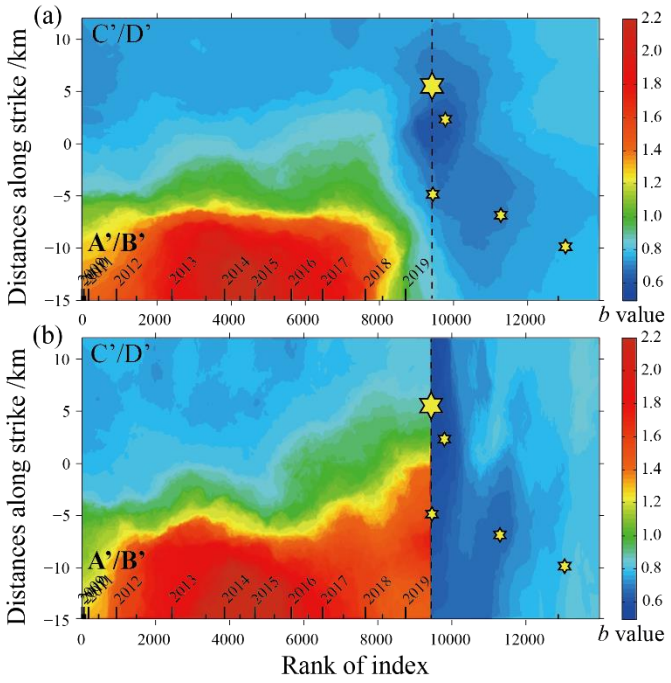

Fig. 6 Spatiotemporal distribution of the ensemble median *b* values of the best-100 solutions for N_v=2~40 on a 2-D space consisting of distance alone strike and rank of index. (a) The ensemble median *b* values obtained from all data before and after the Changning M_S 6.0 earthquake; (b) The ensemble median *b* values obtained from the data before and after the Changning M_S 6.0 earthquake, respectively. The vertical dotted line shows where the M_S 6.0 earthquake occurred. The time scale is marked at the upper *x*-axis, including the time of whole year marked by long tick and the half-year time marked by short tick.

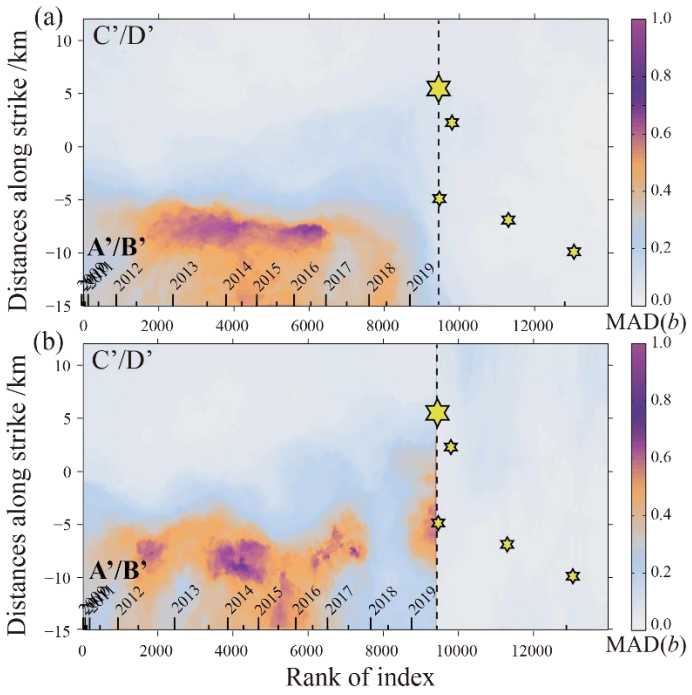

Fig. 7 Spatiotemporal distribution of the median absolute deviation (MAD) of the *b* values of the best-100 solutions for N_v=2~40 on a 2-D space consisting of distance alone strike and rank of index. (a) The ensemble MAD *b* values obtained from all data before and after the Changning M_S 6.0 earthquake; (b) The ensemble MAD *b* values obtained from the data before and after the Changning M_S 6.0 earthquake, respectively. The vertical dotted line shows where the M_S 6.0 earthquake occurred. The time scale is marked at the upper *x*-axis, including the time of whole year marked by long tick and the half-year time marked by short tick.