Response to Reviewer Comments of the First Reviewer

Dear Reviewer and Editors:

We are sincerely grateful to the editor and reviewer for their valuable time for reviewing our manuscript. The comments are very helpful and valuable, and we have addressed the issues raised by the reviewer in the revised manuscript. Please find our point-by-point response (in blue text) to the comments (in black text) raised by the reviewer. We have revised the paper according to your comments (highlighted in red text of the revised manuscript).

Overview:

This study analyzed the impact of urban areas on thunderstorm organization processes and CG flash activity through ground observations and numerical simulations. City size may be an important factor affecting thunderstorm processes. In addition, the building density may also alter the organization process of thunderstorms. Overall, I believe that the research presented in this article has some innovation and the conclusions are also very interesting. The organization and writing of this article need improvement, and I would like to suggest significant revisions to this paper.

Response: Thank you for your recognition of our work and for your valuable feedback. As per your request, we have undertaken significant revisions throughout the manuscript.

Firstly, we have expanded the Introduction section to provide a more detailed overview of relevant research in the field. We refresh and highlight the scientific question on how to modulate thunderstorm disasters on the urban underlying surface of Beijing.

Secondly, in the Data and Methodology section, we have revised the descriptions of lightning location data, radar products, and LCZ datasets. These updates ensure that readers have a clear understanding of the analytical approach we have taken.

Lastly, we have thoroughly revised the Abstract and Conclusion sections to highlight our main findings. Specifically, we have reorganized the mechanisms by which urban underlying surface play different dominant role in thunderstorm disasters.

We are grateful for your time and effort in reviewing our work and for your guidance in improving the manuscript. We hope that these revisions have addressed your concerns and have enhanced the clarity of our research.

Major comments：

1. The author has failed to provide a definition of a thunderstorm that is grounded in radar reflectivity or other pertinent parameters, leaving the reader without a clear understanding of the term's scientific context.

Response: I apologize for any confusion caused by the lack of clarity in defining thunderstorms based on radar echoes in our previous submission. This was indeed an oversight on our part, and we sincerely appreciate your bringing it to our attention.

In response, we have made substantial revisions in the Data section of the manuscript. Specifically, we have provided additional information on the radar data used and the clearer criteria for identifying thunderstorms from the radar echoes. Line 98-107 in the revised manuscript:

"Doppler Radar Data. This radar observation system consists of a data acquisition subsystem, a product generation subsystem, and a main user terminal subsystem. It enables real-time data transmission and image stitching, significantly boosting the monitoring and early warning capabilities for disastrous weather conditions such as severe convective weather, tropical cyclones, and heavy rainfall. The radar data employed in this paper is the Composite Reflectivity (CR) product generated by the S-band Doppler Radar stationed at the Beijing Nanjiao Observatory. Previous studies have consistently recognized a threshold of 35 dBZ as a pivotal marker signifying the presence of a convective echo (Dixon & Wiener, 1993; Roberts & Rutledge, 2003; Mecikalski & Bedka, 2006). Consequently, this research adopts this well-established reflectivity threshold as the criterion for identifying thunderstorms. In addition, to gain a broader understanding of the synoptic background of thunderstorms, we utilized sounding data from the Beijing Nanjiao Observatory. These sounding data were collected at 02:00, 08:00, 14:00, and 20:00 Beijing time every day."

Reference:

Dixon M, Wiener G.: TITAN: thunderstorm identification, tracking, analysis, and nowcasting–A radar-based methodology. Journal of Atmospheric and Oceanic Technology, 10, 785–797, https://doi.org/10.1175/1520-0426(1993)0102.0.CO;2, 1993.

Mecikalski, J. R., Bedka, K. M.: Forecasting convective initiation by monitoring the evolution of moving cumulus in daytime GOES imagery. Monthly Weather Review, 134, 49–78, https://doi.org/10.1175/MWR3062.1, 2006.

Roberts, R. D., Rutledge, S.: Nowcasting storm initiation and growth using GOES-8 and WSR-88D data. Weather and Forecasting, 18, 562–584, https://doi.org/10.1175/1520-0434(2003)0182.0.CO;2, 2003.

2. This article highlights a specific thunderstorm process that exhibited barrier effect through both observations and simulations. However, to strengthen the argument that this phenomenon is widespread or common, the author should provide additional cases or statistical results to support their findings.

Response: Thank you for bringing to my attention the lack of clarity regarding the definition of thunderstorms. I apologize for any confusion caused by the previous omission. I have now supplemented the manuscript with the necessary information. Specifically, I have included statistical results from recent years, focusing on thunderstorms that have traversed the Beijing area and exhibited the barrier effect. Line 254-262 in the revised manuscript:

"Based on the above analysis, when the thunderstorm passed over the built-up area, it exhibited a bifurcated process due to the barrier effect. Utilizing this pattern as a screening criterion, we categorized thunderstorms passing over the built-up area of Beijing from 2010 to 2017 into bifurcated thunderstorms (BT) and non-bifurcated thunderstorms (NBT). According to Figure S3, the year with the highest number of BT was 2013, with eight events, accounting for 23.5% of the total thunderstorms; the lowest number of BT was observed in 2010, with two events, representing 15.4% of the total thunderstorms. These results indicated that the barrier effect of the urban underlying surface was a prevalent phenomenon in long-term thunderstorm observations."

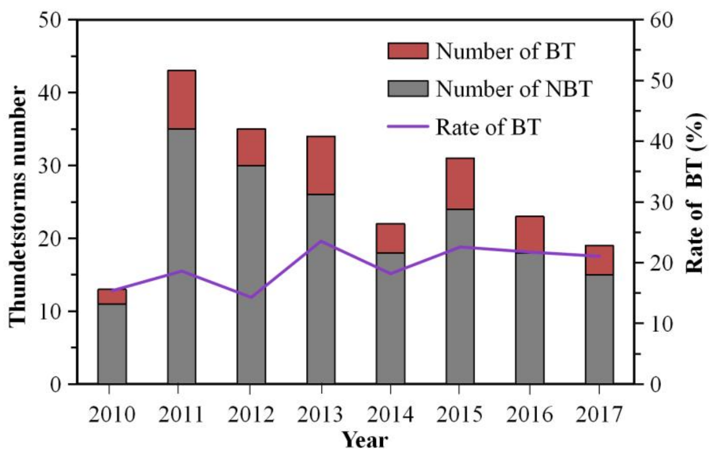

Figure S3: Interannual variation of bifurcated thunderstorms (BT) and non-bifurcated thunderstorms (NBT) in the built-up area of Beijing.

3. Has Figure 3 exclusively analyzed CG events that occurred during the summer? If so, please include a relevant description in the caption of Figure 3. Furthermore, the author should provide a clear description of the data in the data section.

Response: Thank you for bringing this to our attention. We apologize for the oversight and have made the necessary revisions to clarify the information.

We have updated the caption of Figure 3 to explicitly state that it exclusively analyzes CG events that occurred during the summer months. Additionally, in the Data section of our manuscript, we have included a clear description of the data used, specifying that the summer period refers to June through August.

We appreciate your careful review and hope these revisions address your concerns. Please let us know if you have any further questions or suggestions.

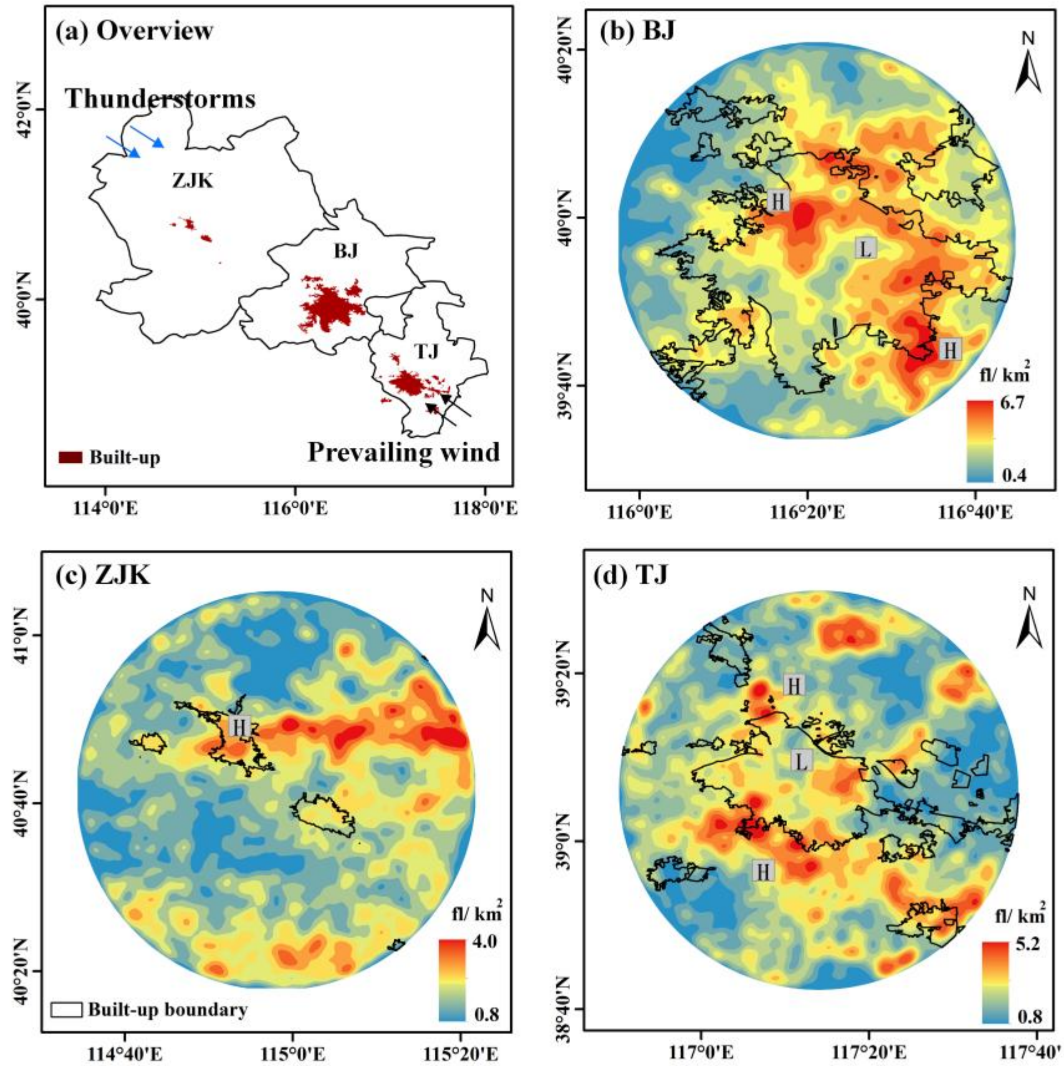

Figure: 3 Overview of the built-up areas in Beijing (BJ), Zhagnjiakou (ZJK), and Tianjin (TJ) (a). Spatial patterns of CG density in the built-up areas of Beijing (b), Zhangjiakou (c), and Tianjin (d) during the summertime of 2010-2017.

4. Please add the symbolization of red line in Figure 8.

Response: Thank you for bringing this to our attention. We sincerely apologize for any confusion caused by the absence of clear symbolization for the red line in Figure 7 (original Figure 8). In response to your feedback, we have promptly revised the figure to include a clear explanation of the meaning of the red line.

Furthermore, we have conducted a thorough review of all figures in the manuscript to prevent any similar oversights in the future.

We appreciate your careful scrutiny and the opportunity to improve our work.

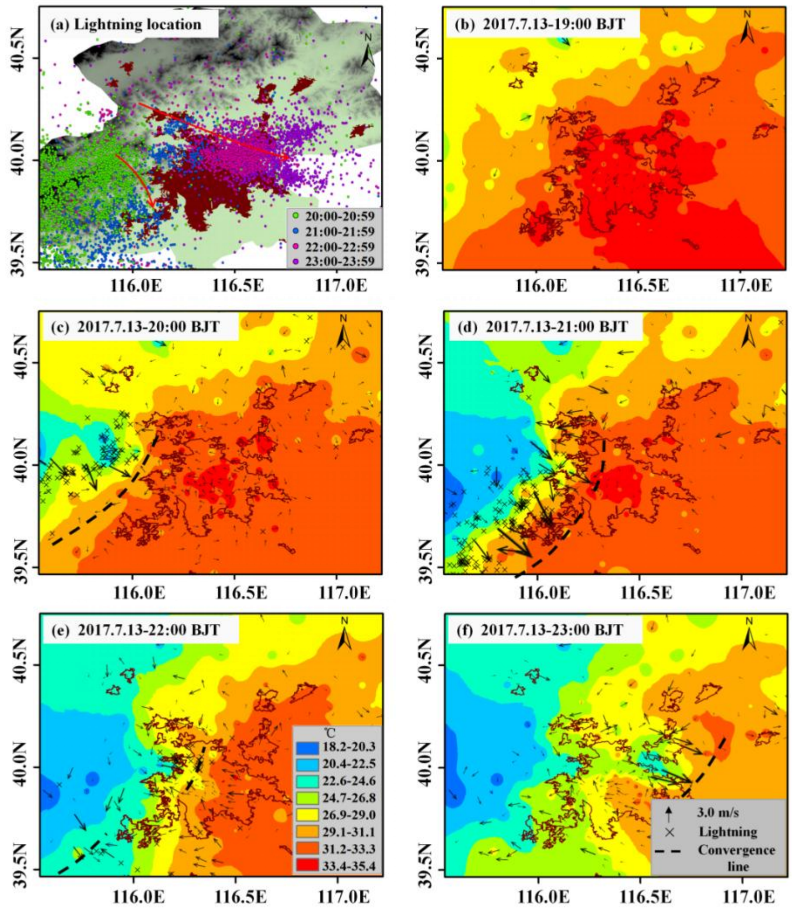

Figure 7: (a) The spatial pattern of CG activities. The dots represent cloud-to-ground lightning, and the red line represents the movement trajectory of the thunderstorm. (b-f) The near-surface thermal-dynamic fields of the "0713" case passing over the built-up area.