

Response to Anonymous Referee #1's Comments

This paper presents an analysis of urban-scale typhoon precipitation characteristics and spatiotemporal patterns, using Ningbo, China as a case study. The findings are of great significance for enhancing the understanding of typhoon-induced rainfall and for flood mitigation and disaster reduction. The study is based on a meticulous analysis and makes a valuable contribution to advancing the knowledge of coastal typhoon precipitation.

The following specific revision suggestions are provided for your reference.

Appreciation is due to Reviewer 1 for the careful review of the manuscript. The comments are all valuable and very helpful for revising and improving the paper, as well as having important guiding significance for the work undertaken. It is believed that all comments have been addressed, as can be seen from the point-by-point responses.

Comment #1 Why was 500 km selected as the threshold for typhoon rainfall? Please provide the specific basis for this choice. Additionally, could you please conduct a corresponding sensitivity analysis?

Thank you for the suggestion. The manuscript has been revised accordingly, and the detailed changes are listed below:

1. The following supplementary explanation has been added to the revised manuscript near Line 140: “The fixed 500 km radius remains the most widely used benchmark for typhoon rainfall estimation, as it represents an empirical standard formed by considering typical typhoon circulation, observational data coverage, and robustness of climate statistics. This threshold captures primary typhoon precipitation, as validated by observations from the Shanghai Typhoon Institute of CMA (Ren et al., 2007; Lu et al., 2022; Morin et al., 2024; Kumar et al., 2025).”.

2. The related references have been supplemented:

Ren, F., Wang, Y., Wang, X., and Li, W.: Estimating tropical cyclone precipitation from station observations, *Adv. Atmos. Sci.*, 24, 700–711, <https://doi.org/10.1007/s00376-007-0700-y>, 2007.

Lu, Y., Chen, P., Yu, H., Fang, P., Gong, T., Wang, X., and Song, S.: Parameterized Tropical Cyclone Precipitation Model for Catastrophe Risk Assessment in China, *J. Appl. Meteorol. Climatol.*, 61(9), 1291–1303, <https://doi.org/10.1175/JAMC-D-21-0157.1>, 2022.

Morin, G., Boudreault, M., and García-Franco, J. L.: A Global Multi-Source Tropical Cyclone Precipitation (MSTCP) Dataset, *Sci. Data*, 11, 609, <https://doi.org/10.1038/s41597-024-03395-w>, 2024.

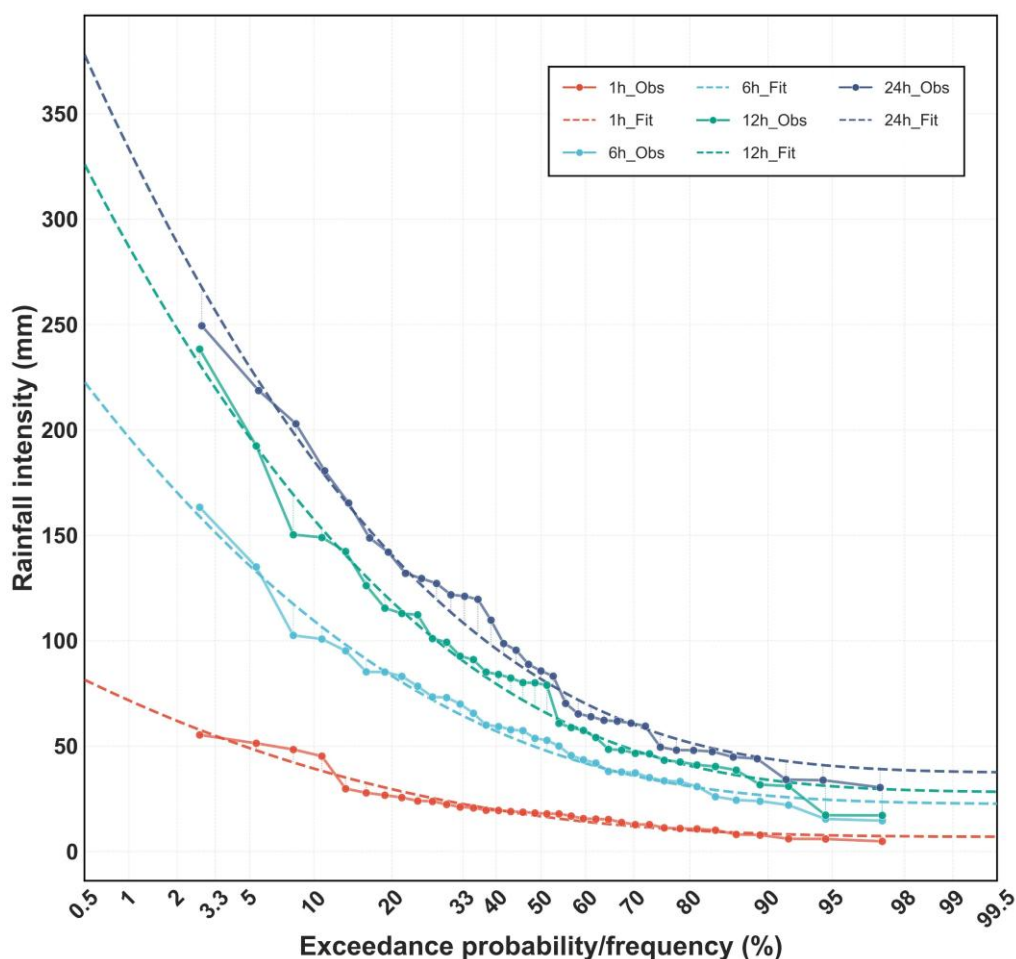
Kumar, M. S., Geethalakshmi, V., Pazhanivelan, S., Subrahmanian, K., Dheebakaran, G., Saravanakumar, V., Bhuvaneshwari, K., and Pugazenthi, K.: Tropical cyclone-induced rainfall estimation using the distance approach: a systematic review, *Natural Hazards*, 121, 22297–22339, <https://doi.org/10.1007/s11069-025-07689-z>, 2025.

3. This paper adopts the widely accepted threshold of 500 km to extract the main component of typhoon precipitation over Ningbo, although this threshold is somewhat crude. The following statement has been added to Section 4 (Summary and outlook) of the manuscript near Line 451: “The widely used 500 km threshold adopted here is a physically grounded and validated benchmark for typhoon rainfall. Nevertheless, the sensitivity to this distance threshold remains an important

question deserving dedicated, in-depth investigation in future studies to more accurately quantify typhoon precipitation. It is also possible to develop more physically consistent methods for dynamically identifying precipitation influence areas by combining high-resolution observations, numerical simulations, and artificial intelligence techniques.”.

Comment #2 For Figure 3, it is recommended to add a legend for the different rainfall durations. Although the authors have included labels in the figure, the one-to-one correspondence between the labels and the data remains unclear.

Thank you for the suggestion. To present the results more clearly, Figure 3 has been revised to retain only the results from several important durations with sufficient intervals, and the legend has been enriched accordingly.



Comment #3 To enhance accessibility for an international audience, please refrain from mentioning specific place names. The manuscript should minimize the use of overly detailed or localized geographical terms.

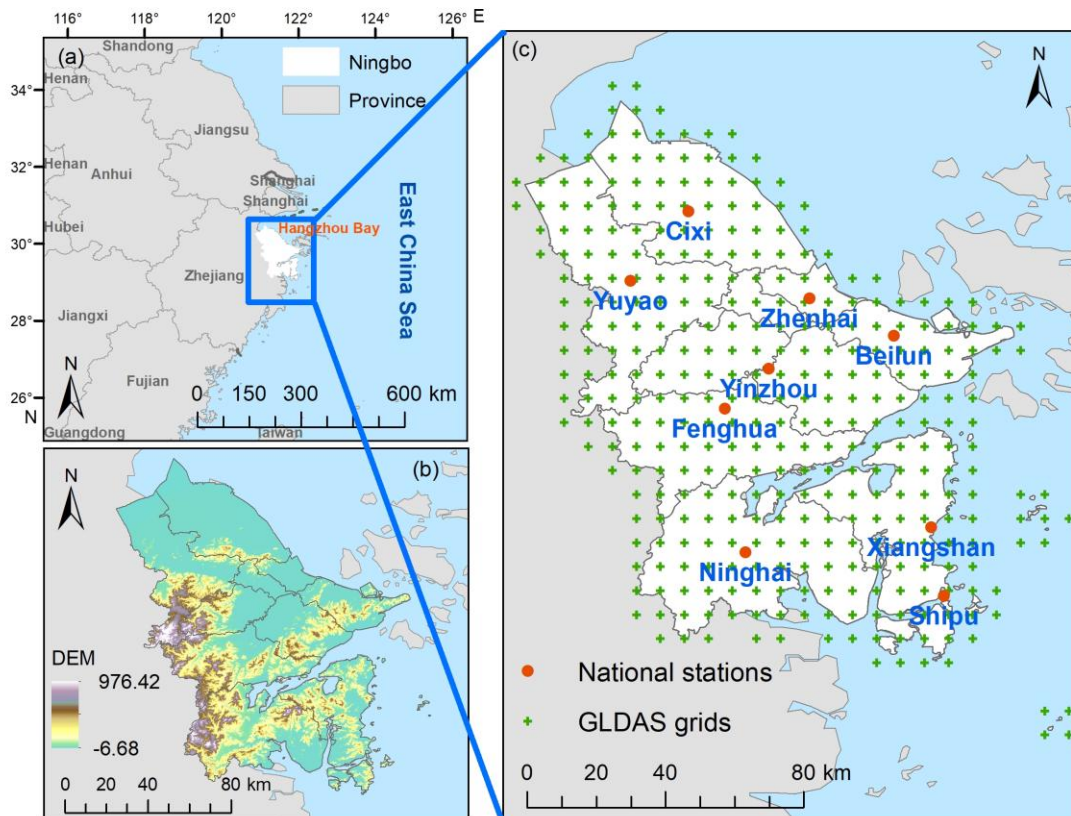
Thank you for the suggestion. Following the suggestion, the overly detailed and localized geographical terms that appear in the manuscript but are not depicted in detail in Figure 1 have been revised to enhance accessibility for the international audiences:

1. “Yuyao City in Zhejiang Province”, in Line 37 has been modified to “Yuyao, a county-level city in Ningbo, Zhejiang Province”.

2. “and inundating entirely Linhai City in Zhejiang Province” in Line 40 has been modified to “and a county-level city in Zhejiang Province was nearly entirely inundated”.

3. “Ningbo has a dense network of rivers, including the Yongjiang River, one of Zhejiang Province’s eight major water systems. The Yuyao River and Fenghua River converge within the urban area, flowing north-eastward into the East China Sea.” in Line 108-109 has been modified into “The study area has a dense network of rivers, including one of the eight major water systems of Zhejiang Province. Two major rivers converge within the urban area, flowing north-eastward into the East China Sea.”.

4. Figure 1 has been updated to include information on Hangzhou Bay and the East China Sea.



Comment #4 While the paper presents extensive analyses of rainfall characteristics, it lacks mechanistic explanations. The authors should strengthen the mechanistic analysis and discuss the potential implications. Specifically, the mechanisms driving differences in rainfall patterns—such as how they relate to typhoon intensity, duration, and landfall processes—warrant further investigation.

Thank you for the suggestion. It should be noted that the extracted rainfall patterns are primarily derived from typical 24-hour rainfall processes of typhoons. Informed by previous findings, the discussion consequently focuses on the relationships between typhoon intensity, track, speed, and rainfall pattern characteristics, as these internal factors may play a more direct role in influencing the spatiotemporal rainfall patterns. Also considering Comment #25 of Reviewer 2, a preliminary analysis of the influencing factors that were initially taken into account is added, and the results are as follows:

1. Figure 10 and its analysis have been added.

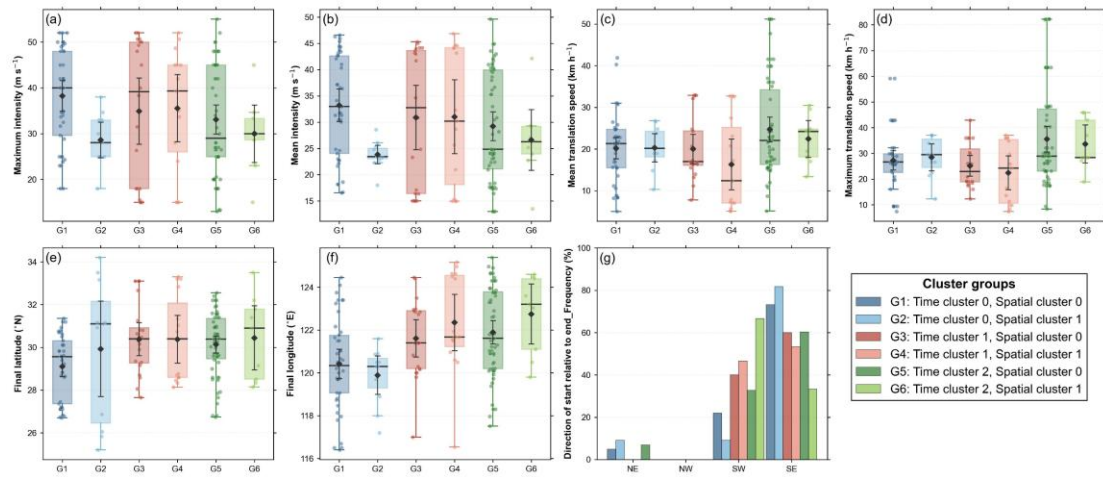


Figure 10 Typhoon characteristics corresponding to typical 24-hour rainfall processes under each spatiotemporal rainfall pattern (G1–G6): (a) maximum intensity; (b) mean intensity; (c) mean translation speed; (d) maximum translation speed; (e) latitude and (f) longitude of the track endpoint; and (g) direction of the track start position relative to the endpoint during the 24-hour rainfall process.

Further statistics were conducted on the characteristics of typhoon intensity, translation speed, and track during the 24-hour rainfall process of typical typhoons. Based on the median and mean values, stronger typhoons are associated with a larger and more dispersed spatial distribution of rainfall (Figs. 10a and b), while a slower average translation speed is associated with a stronger and more localized rainfall (Figs. 10c and d). For the central peak and spatially concentrated pattern, the regional concentration of rainfall may be related to other factors. In terms of track characteristics, cases with stronger local influence correspond to typhoon track endpoints that are more northward (Fig. 10e). As the track endpoint moves further northwest, the typhoon rainfall impact area tends to extend further toward the northwest inland (Figs. 10f and g). The overall tracks of typhoons are predominantly northeastward and northwestward, with northwestward tracks being more frequent (Fig. 10g). This implies that, for the processes examined in this study, typhoons affecting the Ningbo region are mainly of the northwestward track type. Combined with the rotational characteristics of typhoons, such tracks can bring a continuous supply of water vapor from the eastern sea.

(i) The sentence “The statistical results show that stronger typhoons correspond to a larger rainfall-affected area and a more dispersed rainfall distribution. A slower average typhoon translation speed is associated with a stronger local concentration of rainfall. Additionally, the typhoon track is linked to the location of the rainfall-impacted region.” has been added in the summary.

(ii) The sentences “Current discussions on the factors influencing spatial rainfall patterns rely primarily on qualitative analyses based on regional characteristics. Future studies should further incorporate relevant influencing factors to conduct quantitative analyses and deepen the understanding of this issue.” have been changed into “Future work would combine high-resolution numerical simulations to conduct more targeted and quantitative research, deepening the understanding of the dynamic-thermodynamic mechanisms underlying rainfall pattern formation under multi-factor coupling effects.”.