Response to Reviewer 2's comments

[General] *In this study, authors examined the convective initiation and subsequent persistent heavy rainfall over North China during the period from 29 July to 2 August 2023 with station observation data and WRF model simulations. From observations, it is found that the rainfall was featured by long duration and widespread coverage but low intensity, like a warm front rainfall. Further analyses based on the WRF model simulations show that this persistent precipitation was caused by a combination of a remnant vortex originating from typhoon Doksuri(2305), the tropical storm Khanun(2306), the west Pacific subtropical high (WPSH) with an unusual westward extension of the northwestern corner, and stable cold dry air from over northern China. These results are important for understanding the reasons of this extreme precipitation event occurring over North China. But there are some flaws in the manuscript which are needed to improve. The comments are as follows:*

Response: Thank you very much for agreeing with us on the intention of this manuscript. We appreciate you for providing valuable comments and constructive remarks, which have helped improve our manuscript significantly.

1.In the title of the manuscript, "miscellaneous synoptic forcings" is not reasonable. Actually authors only analyzed the remnant vortex originating from typhoon Doksuri(2305), the tropical storm Khanun(2306), the west Pacific subtropical high (WPSH) with an unusual westward extension of the northwestern corner, and stable cold dry air from over northern China. These factors are only the synoptic circulation patterns, not "forcings";

Response: Thank you very much for your kind comments. In this study, we investigated the roles of different weather systems within the atmosphere in this extreme precipitation event. Indeed, as you pointed out, they are not "forcings" and, the title has been therefore revised to "**The unique features in the four-day widespread extreme rainfall event over North China in July 2023**"

2.Line 67："such large-scale weather conditions", what is such large-scale weather conditions? It is not clear;

Response: Thanks for the kind reminder. We revised the sentence as follows:

"Previous studies (e.g., Hirata and Kawamura,2014; Gao et al.,2022; Yang et al., 2017) pointed out that large amounts of water vapor brought by a typhoon over the

North Pacific were favorable for heavy rainfall generation in eastern China."

3.Line 74： "surface rainfall"， surface should be deleted;

Response: Thanks. It has been deleted.

4.Line 85： "emerged in this precipitation"， probably there is something wrong in this sentence;

Response: To make it clearer, we revised this sentence as follows.

"Although operational forecasts gave reasonable results at that time, several unusual features were found to exist in this extreme rainfall event."

5.Line 101-103：" The spatial distribution of heavy rainfalls is consistent with the orography of the Yanshan Mountains on the north and the Taihang Mountains on the south, suggesting that the heavy rainfall may be associated with the orography." Generally speaking, the spatial distribution of heavy rainfalls is consistent with the orography, but for this event, there are only three heavy rainfall centers near MTG、YX and XT, they are not distributed with Yanshan and Taihang Mountains;

Response: Thank you very much for pointing this out. The spatial distribution of the rain belt with three heavy rainfall cores is consistent with the orography of the Yanshan Mountains on the north and the Taihang Mountains on the south. We revised the sentence as follows.

"The spatial distribution of rain belt with three heavy rainfall cores is consistent with the orography of the Yanshan Mountains on the north and the Taihang Mountains on the south, suggesting that orography plays an important role in the precipitation."

6.Is Xiangtai (XT) right? It seems Xingtai(XT);

Response: It is corrected. Thank you!

7.How to identify the wind direction in Figure 2?

Response: Usually, the wind variations within the planetary boundary layer have an important effect on precipitation. Therefore, we pay attention to the wind field in levels below 2 km.

8.Line 139-142： "One can see that the large-scale flow patterns exhibited a coexistence of a remnant vortex originating from typhoon Doksuri(2305) and

tropical storm Khanun(2306). The former weakened significantly into a vortex at this time, while the latter was in the rapid development stage." It is known from this sentence that tropical storm Khanun(2306) is in the rapid development stage, so the circulation associated with tropical storm Khanun(2306) is not remnant vortex.

Response: Sorry for the misunderstanding. This part has been revised as follows:

"One can see that the large-scale flow patterns exhibited a coexistence of the tropical storm Khanun(2306) with a remnant vortex originating from typhoon Doksuri(2305). Note that the Khanun was in the rapid development stage, while the vortex weakened significantly at this time."

9.In the caption of Fig. 6, (a-d) observed and (e-h) simulated daily rainfall are not consistent with that in the text;

Response: Thanks for pointing this out. The text has been updated. We went through the entire manuscript to eliminate such mistakes.

10.The caption of Figure 7: How many stations/grid points over the (a, d) MTG, (b,e) YX, and (c,f) XT regions used to draw these figures?

Response: Thank you very much for the kind suggestion. The stations/grid points are provided in the captions.

"In total, 74, 19, and 67 observations are used for (a) MTG, (b) YX, and (c) XT, respectively. For the simulation, there are (d) 2296, (e) 2365, and (f) 2420 grid points."

11.Line 240-241：Based on the wind profile and rainfall features, the simulated rainfall is roughly divided into two stages？What is the rationale to divide the precipitation into two stages? For this event, the rainfall belt moved from south to north with the Typhoon Doksuri movement, so it can not be divided into two stages;

Response: Thanks for your comments. Yes, as pointed by you, the rain belt moved from south to north during the four days. However, except for the remnant vortex originating from typhoon Doksuri(2305), the rainfall was also influenced by the tropical storm Khanun(2306). In the early stage (see Fig. 9 in the manuscript), the remnant vortex was active and the tropical storm Khanun was far away from China. As a result, water vapor is mainly provided by the counterclockwise southwesterly flow with the vortex. In the late stage (Fig. 12), the vortex weakened significantly, and the

typhoon Khanun developed rapidly and approached China. Water vapor was mainly supplied by the southeasterly flow associated with typhoon Khanun. Therefore, the rainfall was roughly divided into two stages according to wind profiles and rainfall features.

12.Line 353-354：”Consequently, the rainfall intensity is increased, compared to those in the first stage (Figs. 7d,e). The weak convections may be attributed to ……”， rainfall intensity increase is inconsistent with the weak convections;

Response: Thanks for pointing this out. This sentence is too abrupt and so has been removed from the revised version.

13.The sub-title of Part 4 "Characteristics of the rainfall event" is not reasonable. The contents of this part are only physical quantity diagnoses, not related to the miscellaneous synoptic forcings.

Response: Thanks for this point. The sub-title has been changed into "Unique features for the extreme rainfall".

We appreciate you very much for your positive and constructive comments and suggestions on our manuscript, which are valuable in improving the quality of our manuscript.