

Response to Reviewer Comments

Manuscript: "Precursor dynamical factors in the local lower atmosphere of Warm-Sector Heavy Rainfall over South China: Evidence from Wind Profiler Radar Observations"

Manuscript number: **egusphere-2025-2955**

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Response to Reviewer 1

RC1.1 (General Comment 1)

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The manuscript performed a study of eight Warm Sector Heavy Rainfall (WSHR) events in 2019 using wind profiler radar and other ground-based observations. Four selected precursor signals of WSHR are analyzed along with the impact of monsoon activities and topography considered. Despite the analysis is quite detailed, many are known. The novel part may be the time evolution of precursor signals and the implications for nowcasting. However, the number of cases is so few that the time estimation given in section 5.2 is not so meaningful. In addition, with only 8 WSHR events in total, I am not convinced any solid and general conclusions can be made in terms of the different mechanisms in western, eastern and central regions.

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Response: We fully agree with this criticism and have comprehensively revised the study in response. The analysis has been expanded from 8 case studies drawn from 2019 to 226 objectively identified WSHR events spanning the 2016–2020 pre-flood seasons (April–June). Events were identified using an automated objective algorithm (Sect. 2.2) applied to hourly precipitation records from more than 3000 AWS. The three sub-regional samples are: western GD (n = 65), central GD (n = 88), and eastern GD (n = 73). All findings are now supported by non-parametric statistical tests with bootstrap 95% confidence intervals. The formerly qualitative time-estimation in Sect. 5.2 has been replaced by quantitative Spearman rank correlations across four pre-onset windows (t = –6 to –4 h, –4 to –2 h, –2 to –1 h, –1 to 0 h).

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RC1.2 (General Comment 2)

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Quality of figures needs to be improved, such as resolution, font size, and missing x or y axis.

Response: All figures have been redrawn at ≥ 300 dpi. The font sizes on all panels have been increased to ensure legibility. The axis labels and tick marks are now present and clearly annotated in every figure. Specific figure-level changes are noted in the individual technical comments below.

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RC1.3 (L36)

front → frontal

Response: Corrected. "Frontal" is now used consistently throughout.

RC1.4 (L49)

a noun is missed after "southerly"

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Response: Corrected. The phrase now reads "southerly low-level winds". [L51]

RC1.5 (L56)

2022a?

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Response: Clarified. Zhang et al. (2022a) refers to Zhang, L., Ma, X., Zhu, S., et al. (2022, Atmos. Res., 280, 106425), which developed a methodology to identify WSHR precursor signals at coastal Guangdong using LLJ intensity, warm-moist tongue, and low-level convergence indices. It is cited alongside Zhang et al. (2022b, Mon. Wea. Rev., 150, 603–624), a different paper by the same first author on the impacts of coastal terrain on MCSs, hence the disambiguation of a/b. Both references are fully listed in the revised reference list.

RC1.6 (L70)

45 | *"a precipitation" → precipitation*

Response: Corrected.

RC1.7 (L75)

| *"profiler" → profilers*

50 **Response:** Corrected. "Wind profiler radars" (plural) is now used consistently where the instrument is referenced as a class.

RC1.8 (L89)

| *explain "c-averaged"*

55 **Response:** The term "c-averaged" has been removed. The sentence now reads: "...1-hour average C-band data (OOBS) from 14 wind profiler radars...", where OOBS denotes the operationally processed 1-hour output product, defined at first use in Sect. 2.1.

RC1.9 (L106)

| *The two requirements in (3) appear redundant and conflicting. Please clarify.*

60 **Response:** We thank the reviewer for identifying this ambiguity. The manuscript has been rewritten for clarity: (1) the absence of typhoon or tropical depression disturbances; (2) daily precipitation ≥ 50 mm at three or more neighboring stations within 100 km, with a consecutive 3-hour period in which each hourly precipitation ≥ 5 mm and the 3-hour cumulative total ≥ 30 mm; and (3) vertical profiles of θ_{se} and temperature advection along the representative station longitude confirm warm-sector conditions, defined as either no distinct frontal system with low-to-middle-level southerly flow and surface northerly wind more than 200 km away, or a clear frontal system present but the precipitation area more than 200 km
65 from the front. In the revised manuscript, candidate warm-sector days are still identified following Liu et al. (2019) as Stage 1 (Sect. 2.2). Stage 2 then objectively identifies individual events on each candidate day within each of the three sub-regions separately, using a regional mean precipitation threshold (≥ 1.0 mm h^{-1} for ≥ 3 consecutive hours), an inter-event gap criterion (≥ 3 consecutive dry hours), an accumulation threshold (≥ 5 mm area-averaged), and a representative WPR station assignment rule. This
70 two-stage design is made fully explicit in Sect. 2.2 and yields 226 independent events.

RC1.10 (L160)

| *σ_w ?*

75 **Response:** The BLH estimation section has been fully rewritten (Sect. 2.3.4). We used the vertical velocity standard deviation σ_w (not σ_w^3) in the revised method. BLH is identified from the sharp decrease in σ_w between adjacent 200 m bins using a gradient criterion ($\Delta\sigma_w/\Delta z$), with 3σ outlier removal and recursive temporal smoothing. Validated against radiosonde data from Hong Kong Kings Park and Qingyuan, the method reduces mean bias from +1524 m to +300 m (RMSE ≈ 351 m). [L189-199]

RC1.11 (L162)

| *two [duplicated word]*

80 **Response:** Corrected.

RC1.12 (L234)

| *what does "3 earlier" mean?*

Response: This ambiguous expression has been removed. Temporal references now explicitly state the relevant window, e.g. "in the 1–2 or 3 h preceding onset". [L 362–363].

85 RC1.13 (Fig. 6)

| *do the numbers on the x axis indicate UTC hour? Add x axis and descriptions in the caption.*

Response: The original Fig. 6 showed time–altitude diagrams for each of the eight individual cases, where the x-axis represented the UTC clock time specific to each event. In the revised manuscript, these

90 individual case plots have been replaced by composite time–height cross-sections aligned to the onset time ($t = 0$) across all events in each sub-region (revised Fig. 6). The x-axis of revised Fig. 6 explicitly shows "Hours relative to onset", with $t = 0$ marked by a red dashed line, removing any ambiguity with UTC time. The caption has been expanded to explain the vertical velocity anomaly baseline ($t = -6$ to -4 h), the composite reference scale of the wind vector, the magenta contour levels, and the event counts (n) for each panel. [line 301–306]

95 **RC1.14 (Fig. 7)**

| *The definitions of "high altitude" and "low altitude" are unclear.*

Response: "High altitude" and "low altitude" have been replaced with explicit definitions: Layer 1 (0.5–1.5 km) and Layer 2 (1.5–3.0 km), labeled directly on the revised Fig. 7 with gray horizontal bands. The physical rationale for these layer choices is explained in Sect. 4.1.

100 **RC1.15 (L256)**

| *"the all" → all the*

Response: Corrected throughout.

RC1.16 (Fig. 9)

105 | *The BLH in blue line appear fixed at 400 most of the time. Is that real? Also, red line indicates after in your legend, but the figure caption states "after (blue)".*

Response: The original Fig. 9 showed the temporal evolution of LLJI, VWS, ALI, and BLH before and after the onset of the South China Sea monsoon in the western region cases. The reviewer correctly identified two problems: the BLH blue line appearing artificially flat near 400 m, and a color labelling inconsistency between the figure legend and caption. First issues was consequences of the very small sample size, which produced an unreliable composite result. In the revised manuscript, the original Fig. 9 has been completely replaced by Fig. 8 with BLH no longer fixed most of the time. Moreover, the monsoon-stratified analysis is now presented in the revised Fig. 10a–b, based on pre-monsoon and post-monsoon subsets of the full 226-event dataset. Composite medians are shown with bootstrap 95% confidence intervals, and the color convention (red = pre-monsoon, blue = post-monsoon) is now consistent between figure panels and captions throughout.

RC1.17 (Fig. 11)

| *Why do VWS, ALI and BLH look so similar before and after the onset time for the western region?*

Response: The original Fig. 11 showed composite temporal evolutions of all four indices across three regions. In the revised manuscript, this figure has been restructured. The temporal evolution of all five indices based on 226 events is now in revised Fig. 8, and stratified composites (strong vs. weak rainfall, pre- vs. post-monsoon, daytime vs. nighttime) are in revised Fig. 10 and Supplementary Figs. S1–S3. The finding that VWS, ALI, and BLH show a limited systematic temporal change in western GD is real and is now explicitly discussed in Sect. 4.2: the dominant temporal precursor in western GD is LLJI, which roughly doubles in the final 1–2 h before onset, consistent with the direct BLJ-forcing mechanism identified for that region.

RC1.18 (Fig. 17)

| *This is not "As in Figure 16" as you stated in the caption.*

Response: The original Fig. 17 (3-hour mean VWS triangular diagrams for four stations) no longer exists as a standalone figure in the revised manuscript. The relevant information has been integrated into the restructured Sect. 4.5 through revised Fig. 15 (temporal index evolution at four sites) and revised Fig. 16 (triangle-method vorticity and divergence profiles). The erroneous cross-reference has been eliminated.