Reviewer #2:

This manuscript presents a high-resolution dataset of horizontal divergence and vertical vorticity profiles derived from a radar wind profiler mesonet in Beijing. Utilizing the triangle method on continuous wind measurements throughout 2023, the study provides important datasets into mesoscale convective processes and the precursors to convective rainfall events. The authors demonstrate that these radar-derived parameters differ from ERA5 reanalysis, highlighting potential shortcomings of the latter at capturing mesoscale systems. In general, the scientific merits of the dataset are clear. I would recommend the publication of this paper after minor revisions.

Response: Thank you for your positive evaluation. We appreciated tremendously your constructive and thorough comments, which help improve much the quality of our manuscript. We have addressed the reviewer' concerns one by one to the best of our ability. For clarity purpose, here we have listed the reviewers' comments in plain font, followed by our response in bold italics, and the modifications to the manuscript are in italics.

Minor comments:

1. The manuscript would benefit from a clearer discussion regarding the uncertainties inherent in RWP measurements. It is recommended to acknowledge potential biases caused by vertical velocity retrieval errors, radar signal attenuation under varying meteorological conditions, and sampling inaccuracies associated with spatial-temporal resolutions.

Response: Per your kind suggestion, we have added more specific information about the RWP' s measurement principle and its inherent uncertainty for the wind measurements in Sections 2.1 and 2.2, which are presented as follows:

"The RWPs detect vertically resolved wind fields by transmitting and receiving electromagnetic beams in five directions, including a zenith and four inclined directions of 15 ^{0} in the east, south, west and north, respectively. By analyzing the Doppler shifts of radial velocities from any three beams, horizontal and vertical wind components are retrieved. However, the falling of small targets (particulate scatterers) and raindrops

may cause the potential biases of vertical velocity in such a way that vertical velocity cannot usually be used directly (Angevine, 1996; Wang et al., 2014). The fluctuating component of the horizontal velocity is not affected under varying meteorological conditions since it is much larger in magnitude.

To ensure the integrity of the data, a test for the acquisition rate of the horizontal wind profiles spanning a whole year of 2023 is conducted. As shown in Figure 1b, the observations below 4.11 km AGL for six RWPs relatively meet the requirements of continuity in time with the average missing rate less than 20%. These relatively low acquisition of the RWP data at high altitude could be attributed to the well-known limitations that the radar signal attenuation constitutes the inherent uncertainty sources. Therefore, the horizontal winds derived from six RWPs at the heights of 0.15–4.11 km AGL in 2023 are collected in this study.

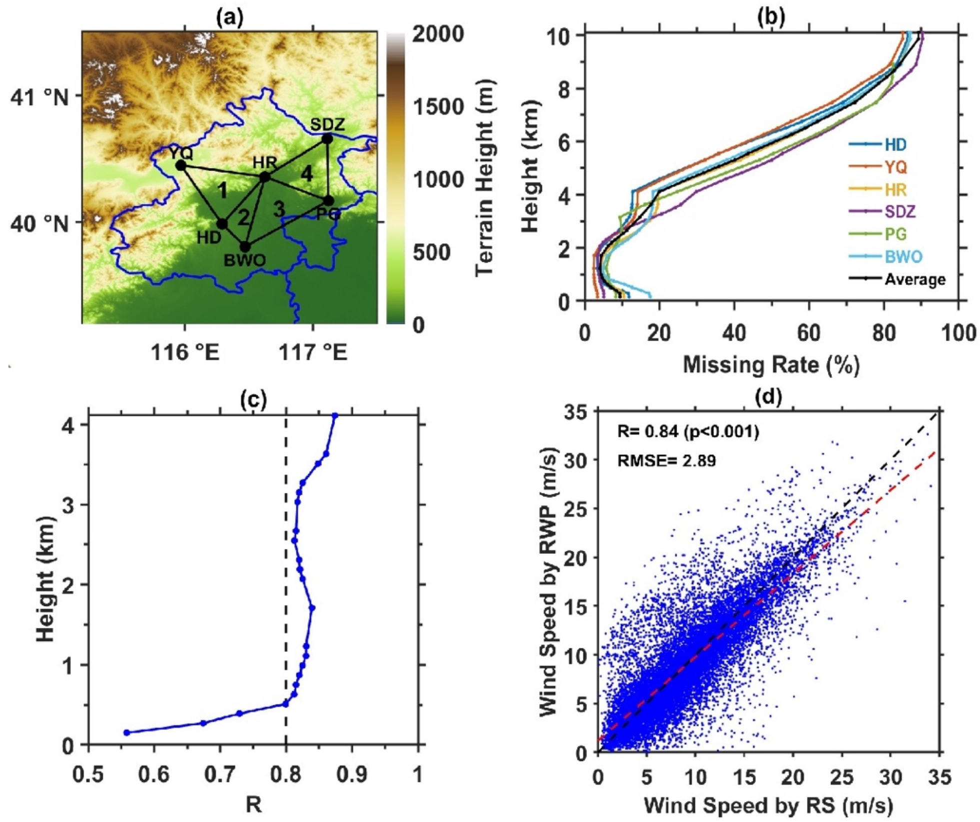

Figure 1. *(a) Locations of the six radar wind profiler (RWP) stations (black dots). The blue line denotes the administrative boundaries at the provincial level. Four black triangles with number denote the regions used to calculate the horizontal divergence*

and vertical vorticity with the triangle method. (b) The missing rate of horizontal wind speeds at different heights derived from six RWPs. (c) Vertical profile of the correlation coefficient (R) between horizontal wind speeds derived from the RWP and those from the upper-air soundings (RS) at the Beijing Weather Observatory (BWO). (d) Scatterplots of the horizontal wind speeds at the range of 0.51-4.11 km above ground level (AGL) from the RWP versus RS at the BWO. The red and black dashed lines denote the linear regression and 1:1 line respectively.

To further evaluate the data quality of the RWPs, horizontal wind speeds at every level from the BWO are validated against radiosonde measurements. Upper-air sounding balloons are launched at the BWO twice daily at 0800, and 2000 Local Standard Time (LST), providing the vertical profiles of temperature, pressure, relative humidity, and horizontal winds with a vertical resolution of 5–8 m (Guo et al., 2020). During summer months (June-August), an intensive observation is added at 1400 LST. From Figure 1c, the correlation coefficient (R) was greater than 0.8 from 0.51 to 4.11 km AGL. Nevertheless, the accuracy and reliability of the RWP data below 0.51 km is limited by the interference of near-surface clutter. Scatterplots obtained by aggregating all the samples between 0.51 and 4.11 km AGL produce a correlation coefficient (R) value as high as 0.84 (Figure 1d). Thus, the horizontal winds derived from RWPs in the heights of 0.51–4.11km AGL are believed to be reliable enough and then be adopted here for the generation of atmospheric dynamic dataset. "

2. The representativeness of divergence and vorticity profiles calculated using the triangle method strongly depends on the geometry and spacing of the profiler network. It may be helpful to discuss the potential effects of the heterogeneous urban landscape and complex terrain of the Beijing region.

Response: Per your suggestions, inevitable sampling inaccuracies associated with spatial resolutions have been acknowledged in Section 2.4.

"Specifically, the value of divergence and vorticity is inversely proportional to the area of triangle using the triangle method. Therefore, the magnitudes of results are

larger for triangle 2, which could be attributed partly to the smallest area of triangle 2 used for area-averaged calculations compared to those of other triangles. This coincides with the fact that the gradient of velocity between two points, including $\frac{\partial u}{\partial x}$*,* $\frac{\partial v}{\partial x}$*,* $\frac{\partial u}{\partial y}$ *and* $\frac{\partial v}{\partial y}$*, will increase when the distance is shortened."*

Additionally, the accuracy and reliability of the RWP data below 0.51 km is limited by the interference of near-surface clutter. Considering the six RWPs located at different terrain elevations, the horizontal velocities measured by each RWP are interpolated to the same altitude that starts upwards from 0.51 km above mean sea level (AMSL). Therefore, the potential effects of the heterogeneous urban landscape and complex terrain of the Beijing region cannot be discussed temporarily. We consider using wind lidar to compensate for the lack of near-surface observations in the future, which will be beneficial for exploring the bifurcation of flow by the high risings over the built-up area and revealing the meso-scale circulation by the urban heat island effect.

3. Does the triangle method inherently assume linear variations of wind fields across measurement sites? If so, could nonlinear mesoscale dynamics during rapidly evolving convective conditions significantly impact the accuracy or sensitivity of divergence and vorticity retrievals?

Response: The triangle method without the linear interpolation doesn't assume linear variations of wind fields across measurement sites.

4.The authors highlight the potential application of this dataset for rainfall nowcasting. It may be helpful to further discuss how the derived divergence and vorticity profiles could practically benefit short-term forecasting of convective rainfall events compared to existing methods. Providing clearer context or practical examples could strengthen the manuscript' s discussion of its predictive capability and lead-time advantages.

Response: Per your kind suggestions, we added more detailed explanation about the potential application of the RWP-derived divergence profiles for capture the CI and subsequent rainfall in section 4.2 by a case study.

"Due to the direct connection between horizontal divergence and vertical motion, we attempt to further discuss how the RWP-derived divergence could practically benefit short-term forecasting of a convective rainfall event. The evolution of 30-min accumulated rainfall from rain gauge measurements is given in Figure 6. After 0400 LST 22 July, 2023, an early-morning event occurred in Beijing with a maximum rainfall rate exceeding 10 mm within 30 minutes. This event was associated with the transport of moisture as the subtropical moved northward. The main region of precipitation was located to the southeast of Beijing before 0500 LST, there was no significant rainfall within the RWP mesonet (Figure 6a, b). As the major convective storm slowly propagated northward and approached the edge of triangle 3 after 0500 LST (Figure 6c), the precipitation then took placed. Interestingly, a few new cells at the meso-γ-scale formed in triangle 1 at the same time (Figure 6d-e) and expanded rapidly to other triangles (Figure 6f-h). The uneven precipitation caused by these isolated and scattered convection cells was a difficult problem in monitoring and nowcasting. Of relevance to this study was the potential application of the RWP-derived divergence profiles for capture the CI and subsequent rainfall.

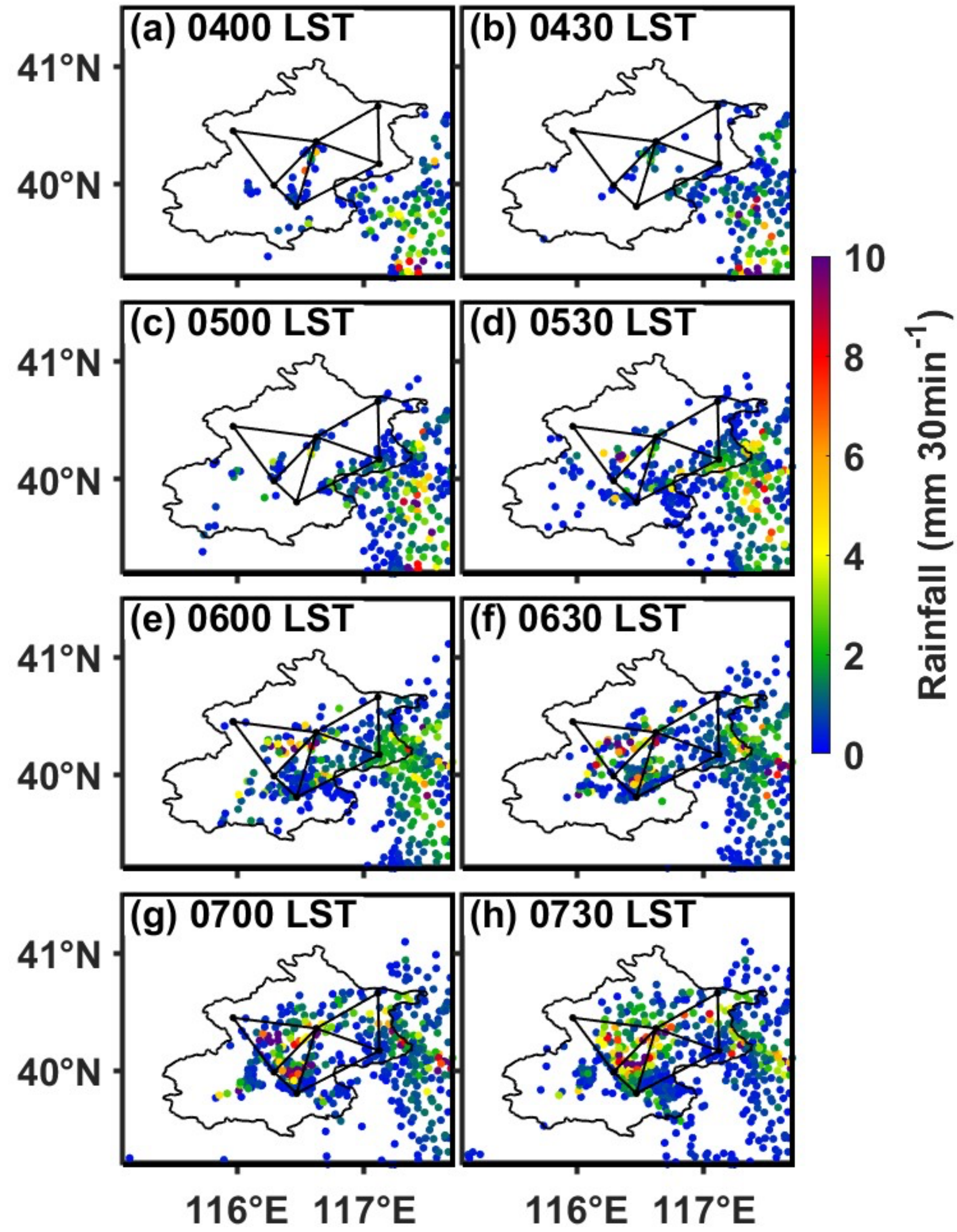

Figure 6. Accumulated precipitation (mm 30min^{-1}; colored dots) at (a) 0400 (b) 0430, (c) 0500, (d) 0530, (e) 0600, (f) 0630, (g) 0700 and (h) 0730 LST 22 July, 2023. The RWP mesonet is also plotted (see Figure 1a for the location).

Figure 7a–d display the time series of the rainfall rates and vertical profiles of the area-averaged divergence during the period of 0400-0730 LST 22 July, 2023 in triangles 1-4 respectively. Specifically, one can see the presence of weak convergence below 2 km AMSL with significant divergence above after 0400 LST in triangle 1 from

Figure 7a. Subsequently, the convergence layer deepened up to 3.5 km AGL from 0430 LST. The low-level convergence simultaneously strengthened with the maximum value of $-1.4 \times 10^{-4}\, s^{-1}$ *near 1 km AMSL at 0448 LST. The signals of prevailing convergence in the lower troposphere provided favorable upward motions for the important lifting of water vapor in the PBL in advance of the convective rainfall. The more intense convergence and upward motion were also well detected in triangle 2 below 1.23 km AMSL after 0448 LST (Figure 7b) which coincided with the generation of rainfall in triangle 1. The inflow over triangle 2 could be attributed to the fact that cold downdraft air in triangle 1 tended to converge into the mesotrough ahead of convection. Even considering the strongest convergence of triangle 2 was resulted from the smallest area to a certain extent, such a significant enhanced trend was evident. Similarly, the rainfall in triangle 2 started at 0530 LST closely related to pronounced convergence and upward motion in the lower troposphere.*

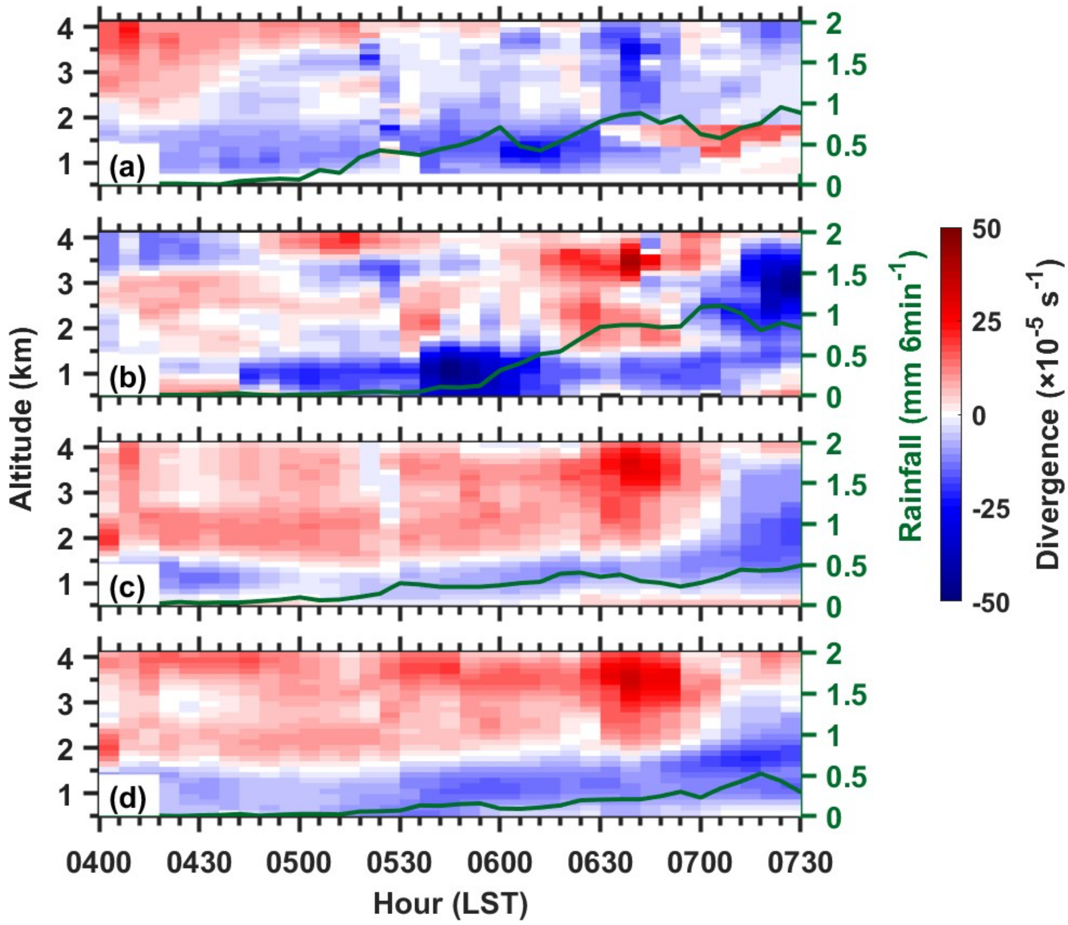

Figure 7. *The vertical profiles of the triangle-averaged divergence (10^{-5} s^{-1}, shading) derived from the RWP mesonet in Beijing at 120 m vertical resolution between 0.51 and 4.11 km AMSL at 6-min intervals during the period of 0400–0730 LST 22 July, 2023 for (a) triangle 1, (b) triangle 2, (c) triangle 3, and (d) triangle 4 (see their distributions in Figure 1a). Green-dotted lines represent the triangle-area-averaged rainfall amount (mm 6min^{-1}).*

As shown in Figure 7c and 7d, the relationship between vertical profiles of divergence and rainfall for triangle 3 and 4 during the rainy period was analogous to that for triangle 1 and 2. Nevertheless, triangle 3 and 4 experienced relatively weaker low-level convergence below 1.5 km AMSL. The presence of dominated divergence layer above is not conducive to the extension of upward movement and formation of convective clouds. The weaker peak area-averaged rainfall rate was seen in triangle 3 and 4 in contrast. Clearly, it has been proved that the RWP mesonet has the capability of detecting the continuous vertical profiles of divergence leading to the onset of precipitation at high spatial and temporal resolutions. However, the development of convection is also affected by many other thermal and dynamic variables, it should be noted that it's feasible to qualitatively determine the change of rainfall rather than quantitatively. "