Interactive comment on "Improving the rainfall rate estimation in the midstream of the Heihe River Basin using rain drop size distribution" by G. Zhao et al.

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Although the manuscript's research have been studied extensively in the past, a study in which measured raindrop size distributions on the Quinghai-Tibet Plateau has never been given. We found the relations between the rain rate and the radar reflectivity factor is different from other area'. Ryzhkov(1995,2002)'s conclusion was $R=a\times z^{b}$, but our conclusion was $R=a\times 10^{b\times Z}$. Park(2005) also got a conclusion that the relationship between the R and Z was $R=a\times z^{b}$. Chandrasekar(2002) got a relationship between R and Z_{DR}($R=c\times Z^{a}\times 10^{b\times Zdr}$), but our conclusion was $R=a\times 10^{b\times Z+c\times Zdr}$. China meteorological administration has several vehicle X-band polarimetric radars, because the raindrop size distribution's arealvariation, the past rain rate estimates can not fit for these radars. This work can help them to improve the rainfall rate estimation.

There is an X-band polarimetric radar (714XDP) are used in The Watershed Airborne Telemetry Experimental Research(WATER). The polarimetric radar has a Vaisala Sigmet Digital IF Receiver and Signal Processor RVP8.

The performance of the laser-optical Particle Size Velocity (PARSIVEL) disdrometer is evaluated to determine the characteristics of falling snow. PARSIVEL's measuring principle is reexamined to detect its limitations and pitfalls when applied to solid precipitation.. In this manuscript, we studied the raindrop size distributions with the OTT Parsivel. PARSIVEL's fall velocity measurement may not be accurate for a single snowflake particle. For rain, while a small drop has a spherical shape, a larger drop tends to have an oblate spheroid shape with a slightly flatter base, PAPSIVEL's measurement is more accurate than snow. The raindrop size data also has been collected, during the second part of the Watershed Airborne Telemetry Experimental Research (WATER) project, we found snow drop size can reached 12mm, while rain drop's largest drop is 0.6mm. Most raindrops are nearly spherical shape.

We use the PARSIVEL's raindrop size data and the relationship between the terminal velocity of the rain drop and the diameter (mm) of a rain drop to compute the rainfall rate R, Z, Z_{DR}, and K_{DP}.

We fit a power-law relation between raindrop fall velocity and diameter, and argue that the difference between their relation and that of Atlas and Ulbrich is caused by differences in atmospheric conditions due to the high altitude of the measurements. This argument is base on the theory that thin air of the high altitude, this will reduce air-resistance while the raindrop through the air. Table.1 shows the terminal velocity of the rain drop with different diameters. There the terminal velocity and rain drop diameters are got from PASIVEL directly. Because PASIVEL got the terminal velocity are rang of diameter, In Table 1 and Figure 1, one point contained lots of raindrop diameters.

We can not agree with your conclusion about Figure 2a. An important reason for the uncertainty between Z and R is the raindrop size distributions' variation. We use Figure 2a and Figure 2b in order to illustrate the variation about DSD. We introduce Z_{DR} and K_{DP} to eliminate the uncertainty.

We make a distinction between stratiform and convective rainfall with the image of radar. Fig.1 shows the stratiform rainfall and Fig. 2 shows the convective rainfall.

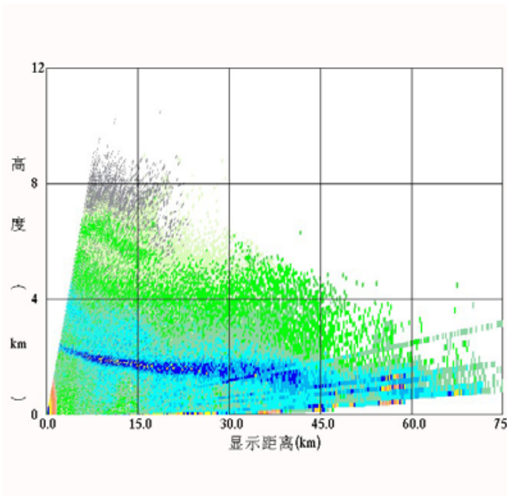

Fig.1 Stratiform rainfall cloud

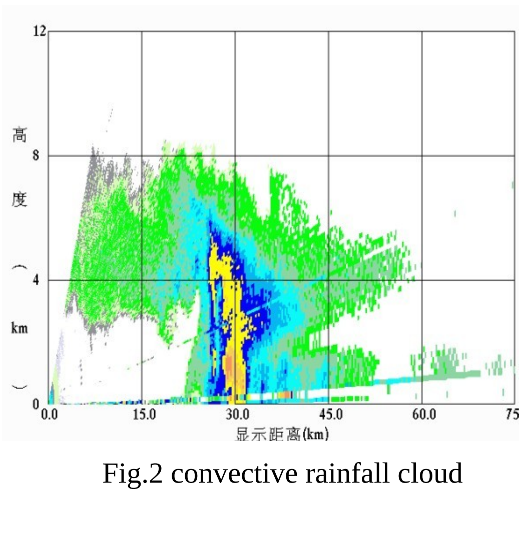

Fig.2 convective rainfall cloud

The combination of polarimetric variables such as R (Z, Z_{DR}) and R (K_{DP}, Z, Z_{DR}) are superior to R(Z) because of the less sensitivity of Z_{DR} an K_{DP} to DSD variations. The differential phase (K_{DP}) can be used to correct the reflectivity factor for loss due to beam blockage by topography, attenuation, and anomalous propagations (Ryzhkov and Zrnic 1996; Ryzhkov et al. 2000). The lower sensitivity of $R(K_{DP}, Z, Z_{DR})$ and the higher sensitivity of $R(Z)$ to variations in DSD can be explained by the fact that the difference between the forward-scattering amplitudes at horizontal (H) and vertical (V) polarizations $f_H(D)$-$f_V(D)$ in the definition of K_{DP} is proportional to the 3rd power of the diameter of a raindrop for the mono-disperse DSD model, while the reflectivity factor Z is proportional to the 6th power of the diameter. There is an X-band polarimetric radar and several rain gauges available for testing these rainfall rate estimation. The follow table is given for testing. Fig.3 shows the radar reflectivity of precipitation。

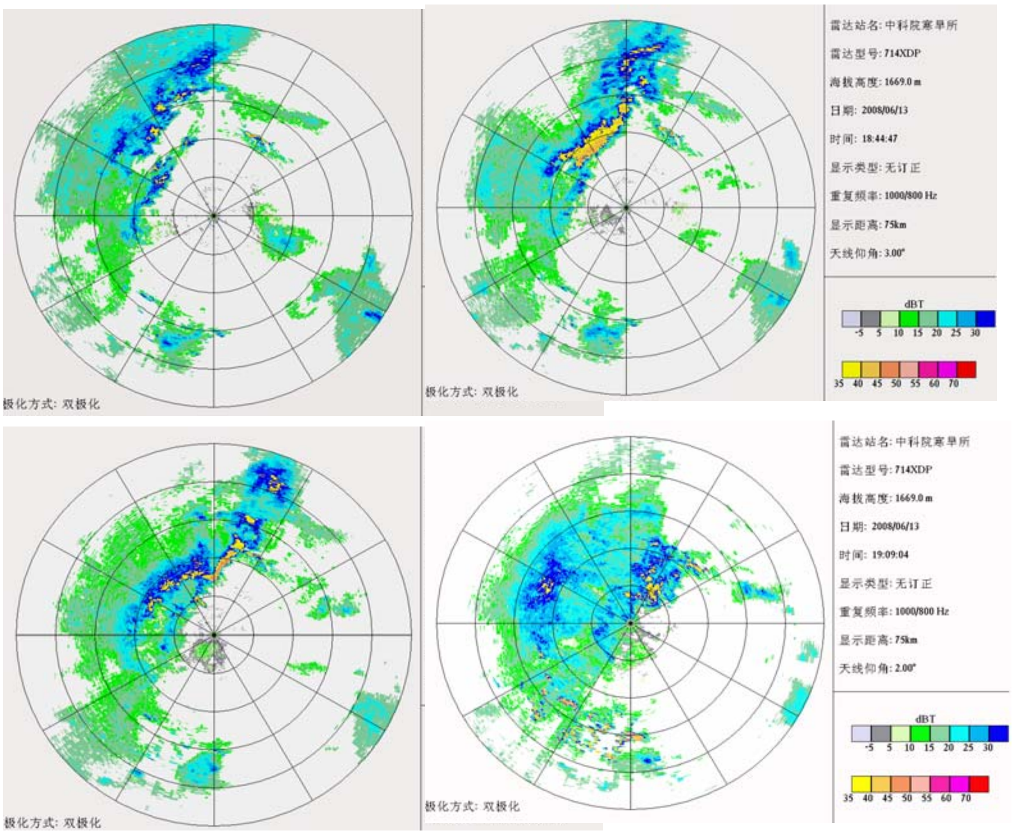

Fig. 3 The radar reflectivity of precipitation

Table 1 The reliability of the rainfall estimators

Rain gauge	Z_H(dBZ)	Z_{DR}(dB)	K_{DP}(degkm^{-1})	$R(Z)$/Err	$R(Z,Z_{DR})$/Err	$R(Z,Z_{DR},K_{DP})$ /Err	R_{gauge}
NO.03	29	0.8	1.2	1.9/17%	2.1/8%	2.0/13%	2.3
NO.05	35	1.4	0.3	4.1/46%	4.9/75%	2.0/28%	2.8
NO.11	35	1.9	1.4	4.1/2%	4.2/5%	4.5/12%	4.0
NO.12	31	1.0	0.3	2.5/21%	2.8/12%	3.8/18%	3.2
NO.14	38	2.0	2.2	6.1/39%	6.3/43%	4.7/7%	4.4
NO.19	35	1.3	2.9	4.1/29%	5.1/12%	5.9/2%	5.8
NO.26	23	1.3	0.6	0.7/75%	0.38/5%	0.31/22%	0.4
NO.29	35	4.6	1.6	4.5/26%	5.3/13%	6.0/1%	6.1

There are no typing mistakes in eq.(9) and eq.(10), the normalized error *(NE)*, the percentage root-mean-squared error *(PRMSE)*. These errors are defined as:

$$NE = \langle |R_{est} - R_{dis}| \rangle / \langle R_{dis} \rangle$$

$$PRMSE = \langle \sqrt{(R_{est} - R_{dis})^2} / R_{dis} \rangle$$

There, < > means the average for a certain interval of rain rate

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As your conclusions, we also found errors in these Figures after we submitted this manuscript. We were not carefully when we chose these Figures. These were typing mistakes. Now, the right Figures are giving as follows. The same datasets are used for all of these graphs.

Fig.3 Scatter plots of the radar reflectivity (*Z*) and the rain rate (*R*)

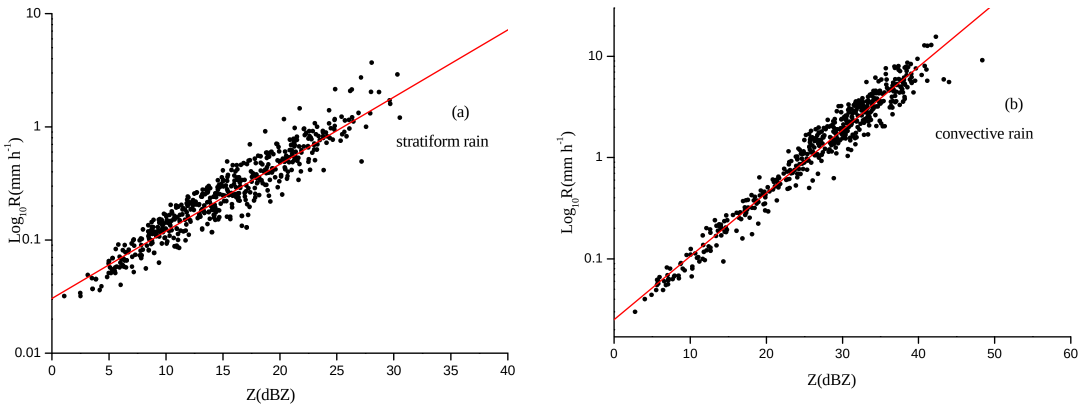


Fig. 4 Scatter plots of the radar reflectivity (*Z*) and the rain water content (*M*)

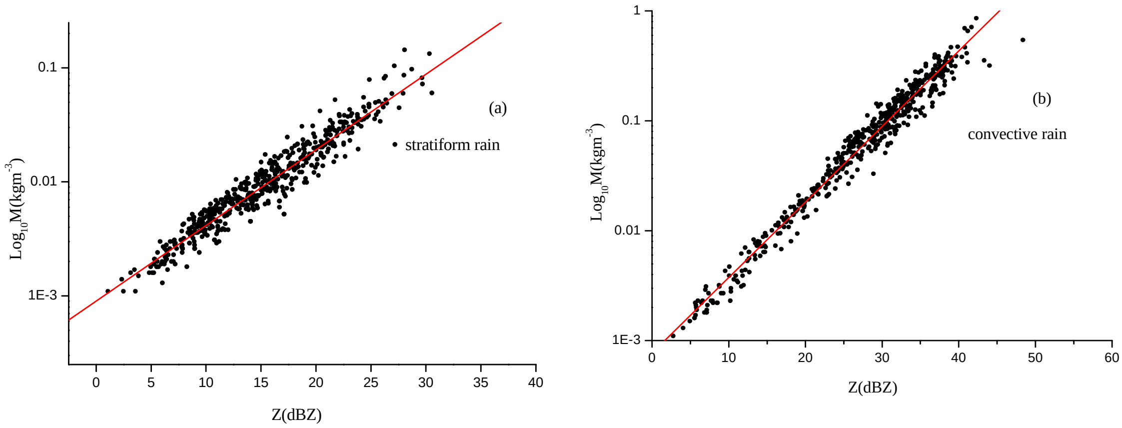


Fig.5 Scatter plots of the specific differential phase (K_{DP}) and the rain rate (R)

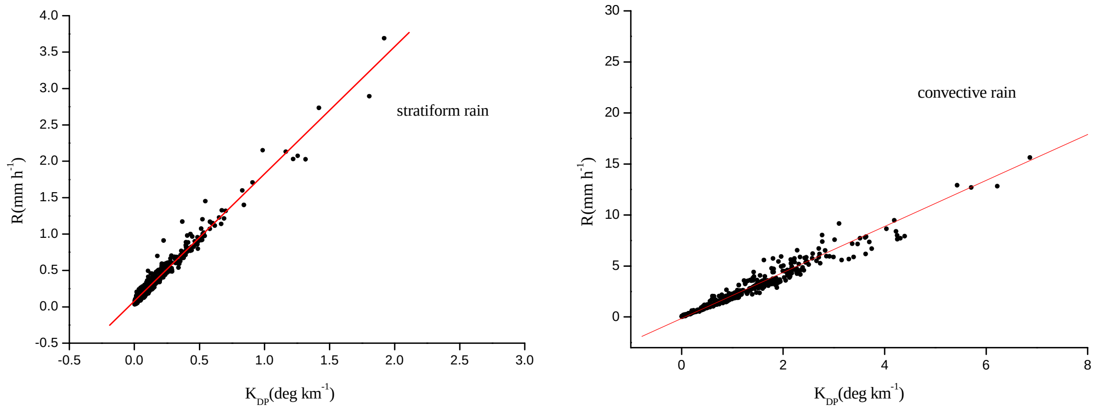


Fig.6 Scatter plots of the specific differential phase (K_{DP}) and the rain water content (M)

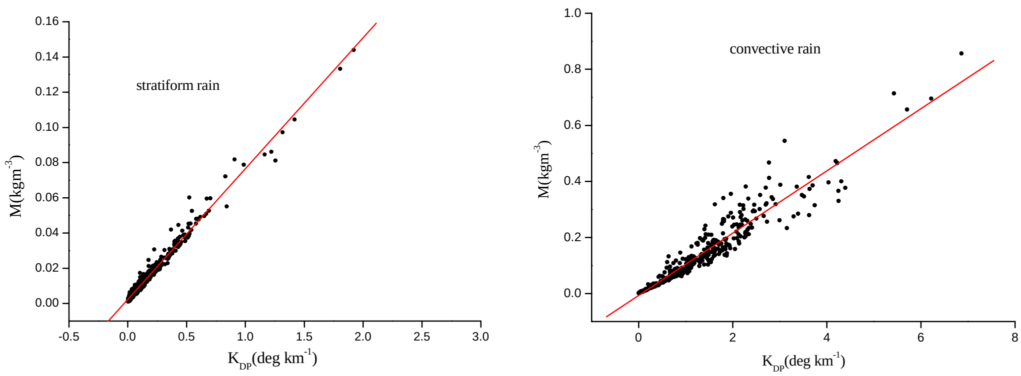


Fig.7 Scatter plots of R_{cal} calculated from measured drop size distribution and R estimated by four types for rain rate estimators (a) R (Z), (b) R (K_{DP}), (c) R (Z, Z_{DR}) (d) R (K_{DP}, Z, Z_{DR})

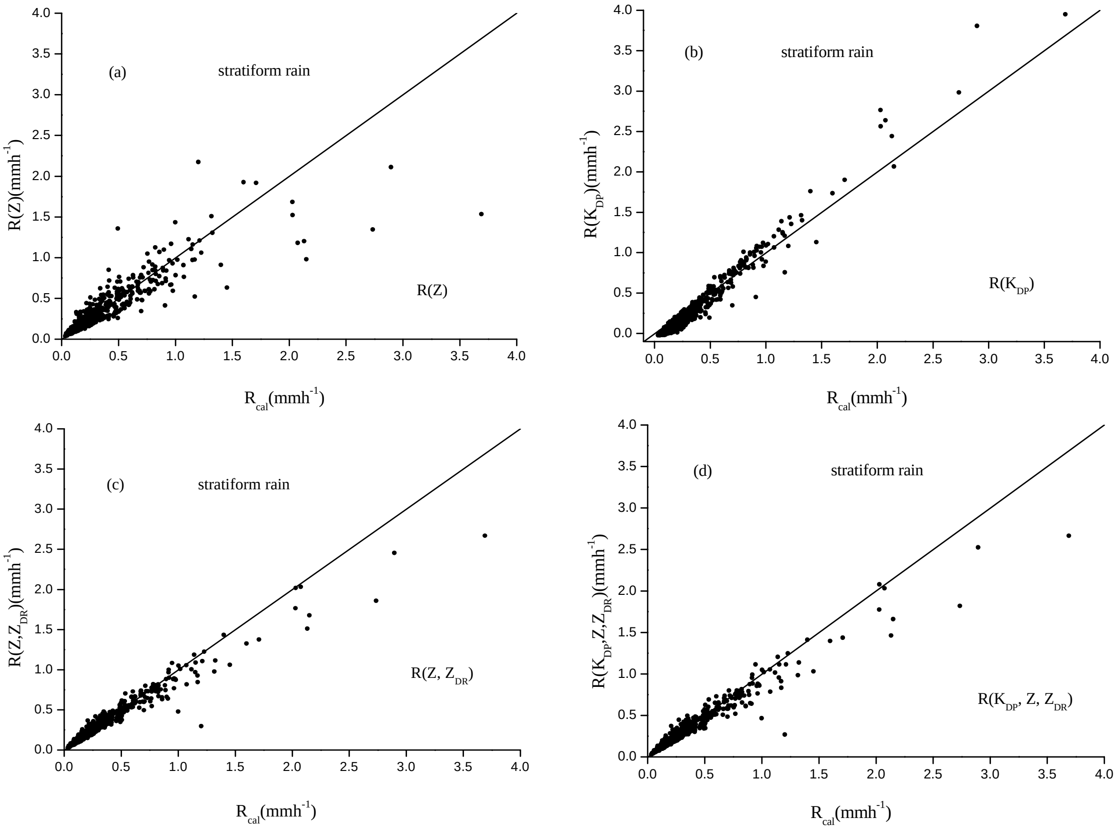
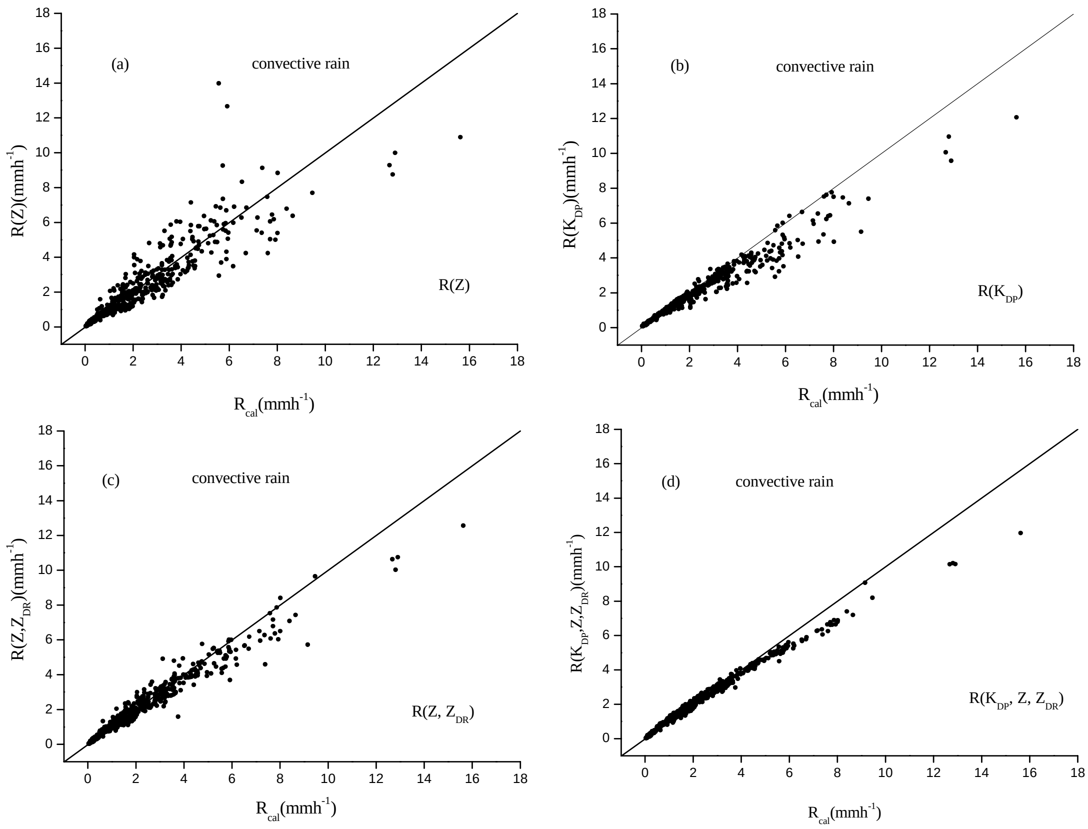


Fig.8 Scatter plots of R_{cal} calculated from measured drop size distribution and R estimated by four types for rain rate estimators (a) R (Z), (b) R (K_{DP}), (c) R (Z, Z_{DR}) (d) R (K_{DP}, Z, Z_{DR})



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