Interactive comment on “Vertical air motions derived from a descending radiosonde using a lightweight hard ball as the parachute” by H. Chen et al.

Anonymous Referee #3

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The manuscript “Vertical air motions derived from a dropsonde using a lightweight hard ball as the parachute” by C.H.B., Chen et al. introduces a new dropsonde type for measuring vertical wind speed. The authors claim that the added value of their new dropsonde is related to the spherical symmetry of the parachute allowing an easier deduction of appropriate drag coefficients to be used in the calculation of the dropsonde descent rate and, therefore, in the retrieval of the wind vertical velocity. This is stated in a few lines reported in section 2 where the spherical symmetry of the dropsonde is presented in opposition with the traditional dropsonde design. The introduction of a new technique is a very important moment for the scientific community towards the improvement of our knowledge of the atmospheric processes. To this purpose, the new technique should be presented along with measurements, simulations (when needed), comparisons and tests able to show the advantages and the improved or comparable performances of the new technique with respect to what has been already presented in the past literature. However, the measurements reported in the manuscript mainly aim at showing the sensor stability but there are not enough information to quantify the real advantages in using this dropsondes respect to previous designs presented in literature. There is only one comparison with a ground based wind profiler: the comparison of vertical wind velocity profiles showed in Fig. 9, limited to altitude below 5 km above the ground, is quantified by the authors as reasonable, also considering both the presence of large uncertainties in the measurement of wind when small values are measured and the uncertainty due to the collocation of atmospheric measurements. The comparison, instead, reveals large differences, partly hidden by the poor quality of the same figure. Moreover, when small values are detected the agreement looks much better than for larger wind values. This is clearly visible by the comparison of the values of the vertical wind in the boundary layer, in contrast with the authors’ considerations reported in the manuscript. The manuscript is also quite short, includes repetitive sentences and, as already highlighted in the first stage of the review process, and it looks more suitable for an extended abstract of a conference or for a report than as a scientific publication. A larger number of comparisons with other techniques should be provided to allow the reader to identify the effective advantages in using the new dropsonde design. This will largely improve the quality of the manuscript. Minor issues, in the general frame of the manuscript, but highly relevant, are the absence of any quantitative estimation of the uncertainty affecting the estimation of wind velocity and the lack of a description of the sensors used to measure the temperature and relative humidity, shown in Fig. 9. In conclusion, I ask a major revision of this manuscript and I think the manuscript can be accepted only if a more extensive characterization of this new dropsonde type will be provide by the authors. I also suggest the authors to read more about the other techniques mentioned in the manuscript for the measurements of vertical wind velocity and about the step forward and the high accuracy already achieved with them (e.g. cloud radars).

Responses:
More studies are conducted by us, which are specified as follows.

Fig. S1 shows the orientation and distance from the launch site for the radiosondes losing signal during descent at Baochang in 2012. The distances are generally less than 50 km; meanwhile, they are very close for the radiosondes launched on the same day.

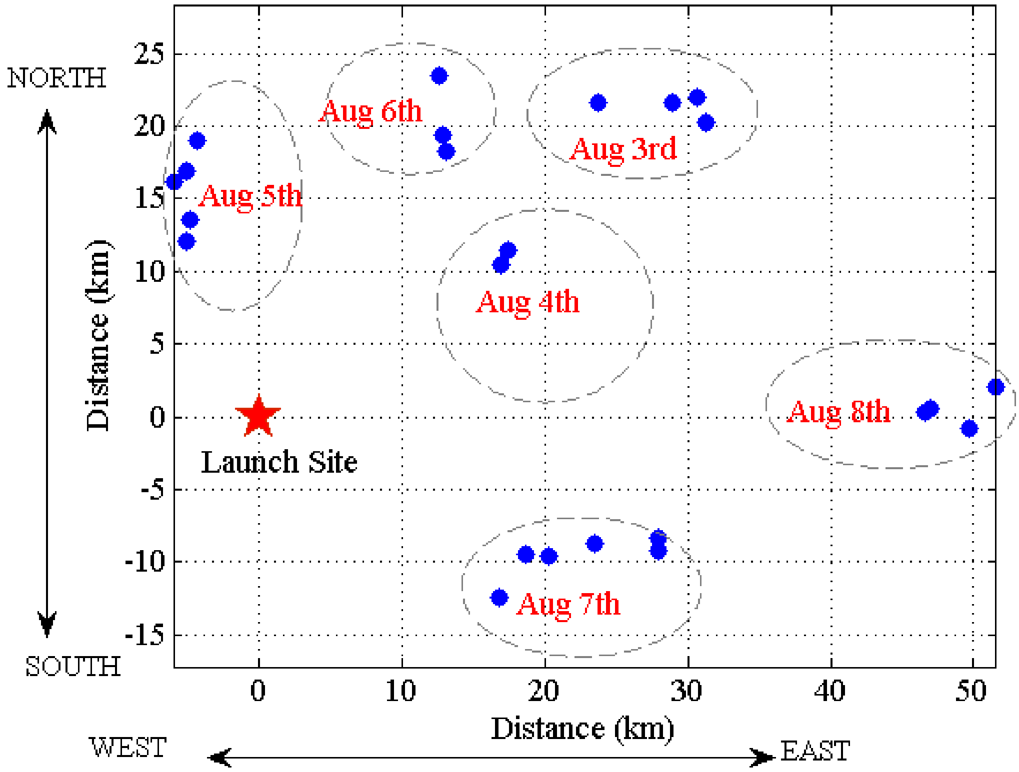

Fig. S1. The orientation and distance from the launch site for the radiosondes losing signal during descent at Baochang in 2012.

The radar used in this study can provide vertical air motion profiles at a temporal resolution of 5 minutes from the surface upwards to 4.5 km above ground level (a.g.l.). One radiosonde launch generally takes less than 5 minutes to fall down from 4.5 km to ~0.5 km a.g.l where the receiver usually misses the data signal due to blocking by the terrain. The radar samples with the observational time closest to the radiosonde measurements, including horizontal wind and vertical wind (VW), are selected to compare with the radiosonde results.

Fig. S2 presents the comparisons of horizontal wind for U and V components derived from radiosonde and wind profiler radar at Baochang in 2011 and 2012. Overall, the agreement between horizontal wind retrievals from two approaches is reasonable. The correlation coefficient and root mean square are 0.90 and 2.0 m/s for the U component, which are 0.93 and 2.0 m/s for the U component.

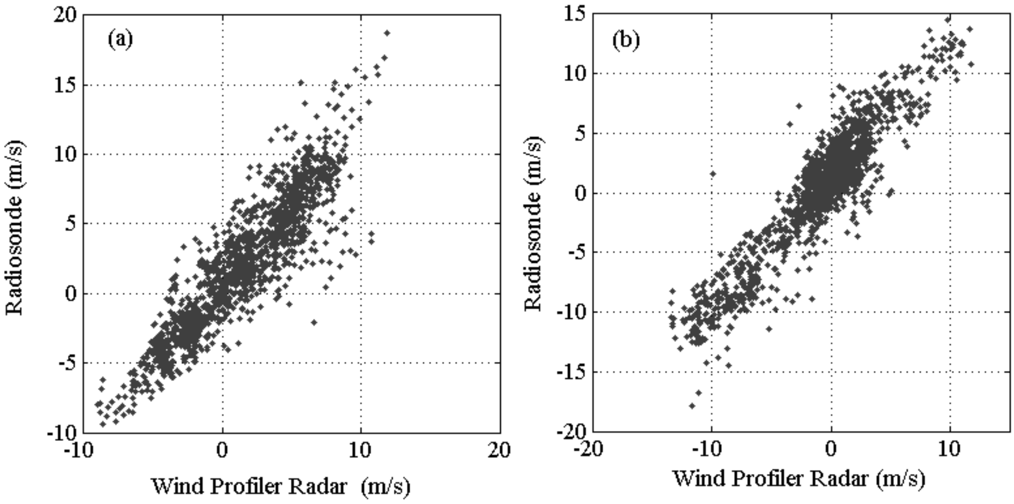

Fig. S2. The comparisons of horizontal wind for U component (a) and V component (b) derived from radiosonde and wind profiler radar.

Fig. S3 shows the comparisons of VW derived from two methods; their correlation coefficient, variance, and covariance are -0.13, 0.85, and -0.04, respectively. Overall, the agreement of VW from two approaches is not good, which should be associated with different objects detected by two instruments caused by a drifting radiosonde and the fixed radar. So, it seems to be difficult to obtain point-to-point data of the vertical wind measurements for comparisons.

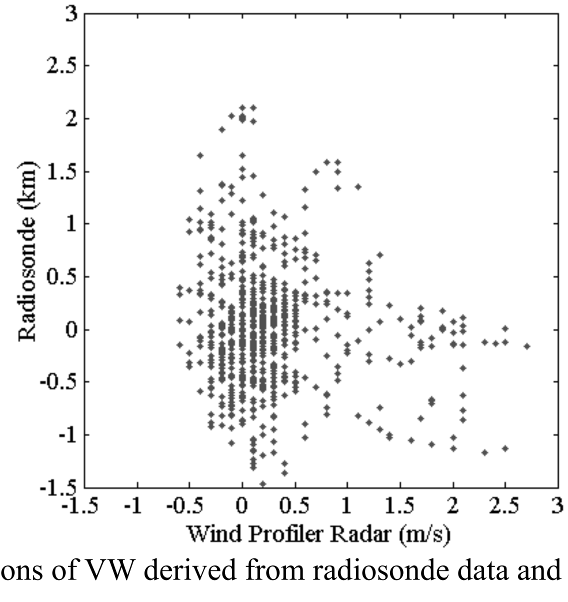

Fig. S3. Comparisons of VW derived from radiosonde data and wind profiler radar.

Fig. S4 illustrates the average difference of radiosonde- and radar-retrieved VW and their standard deviations. The larger value of VW is obtained by radar than that by radiosonde at most levels; the maximum difference is ~0.7 m/s located around 2 km. The standard deviations are generally less than 2 m/s.

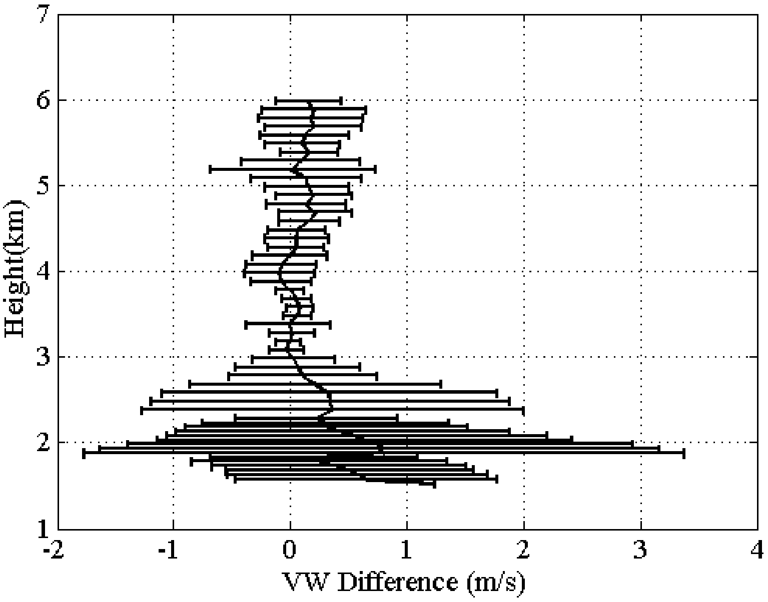

Fig. S4. Average VW difference between wind profiler radar and radiosonde retrievals (radar-radiosonde) and their standard deviations.

Error analysis was carried out based on the formula to derive the air vertical wind (VW) which is given by

$$VW = -(V_d - W_d) \qquad \text{(i)}$$

where Vd is the observed descent velocity and Wd is the calculated descent velocity in the still air. Note that both Vd and Wd are positive toward the surface. The error in Vd is related to the radiosonde pendulum motion and mainly to the truncation of GPS-given height value. The pendulum motion is very small during the radiosonde descent, so it causes small error in Vd which can be ignored. While the value of height given by the differential surface and radiosonde GPS data has ~±0.5m of uncertainty. So, the maximum uncertainty in V_d at one height could be 1m/s. This random error is observed in the V_d profile and can be reduced through smoothness. The error in V_d is estimated to be ±0.35m/s if 10-point moving average is applied.

The calculated W_d is a function of m_s, C_d, A_b and ρ:

$$W_d = W_d(m_s,\ C_d,\ A_b,\ \rho) \qquad \text{(ii)}$$

The error in W_d is a composite of the contributions of the individual accuracies or uncertainties of different parameters listed above. The uncertainties for these parameters are given in Table 1. Some of the error contributions depend on air pressure, such that the overall uncertainty of the W_d calculation will be a function of pressure i.e. altitude. The uncertainties are assumed to be random and following Gaussian statistics thus Gaussian law of error propagation [e.g. Bevington and Robinson, 1992] is applied to Eq.(ii). The overall relative uncertainty of W_d is expressed as:

$$\frac{\Delta W_d}{W_d} = \sqrt{(\frac{\Delta m_s}{m_s})^2 + (\frac{\Delta C_d}{C_d})^2 + (\frac{\Delta A_b}{A_b})^2 + (\frac{\Delta \rho}{\rho})^2} \qquad \text{(iii)}$$

The cross-section area of radiosonde box and the string is about 5% in comparison with that of the hard ball. For the purpose of simplicity in calculating Cd, the drag effects of radiosonde box and the string on the W_d calculation are not taken into account due to its complexity. This neglect will result in some uncertainty in Wd calculation. Analysis shows that another main error in calculating Wd comes from the uncertainty of the drag coefficient estimation. The maximum relative error in Wd, obtained by employing the maximum relative uncertainty for all parameters, is estimated in the order of ~8.3%, leading to an absolute error of about 1-2 m/s. However, some of these errors can be mutually cancelled or significantly reduced by means of smoothness. So, it is estimated that the calculated Wd has an error of about ±1 m/s.

In combination of all errors in V_d and W_d, the vertical wind is derived with an error of about 1.5m/s.

Table 1 Technical specification of the descending radiosonde

	Value	Uncertainty	Maximum relative uncertainty
m_s	675-710g	0-3g	0.0044
C_d	0.3229- 0.3326	0.0074- 0.0206	0.0621
A_b	0.1960 m^2	0.0100 m^2	0.0500
P	0.2582- 1.0035 kg/m^3	0.0005-0.0078 kg/m^3	0.0221

Reference:

Bevington, P. R. and D. K. Robinson (1992), Data reduction and error analysis for the physical sciences, MacGraw-Hill Inc, New York.