

Referee #2

Major Comment

Q:The manuscript it's not totally convincing unless the authors also show zenith and off-zenith retrievals under non-precipitating conditions, so to demonstrate that there's no systematic issue with zenith retrievals. Figures 4-9 seem to qualitatively suggest that zenith and off-zenith retrievals are closer during non-precipitating conditions, but a statistical analysis, similar to Figures 1-3 but in non-precipitating conditions, would demonstrate that quantitatively. I strongly suggest the authors to add this analysis. It could be condensed in one figure with 3 panels showing RMSE for temperature (panel 1), relative humidity (panel 2), and vapor density (panel 3), each with zenith and off-zenith method in non-precipitating conditions.

A:The comparison between zenith and off-zenith observations in non-precipitating conditions was studied by Xu et.al (2014). We add the citation of results from this paper and also showed the RMSE of temperature, relative humidity and vapor density under non-precipitating conditions, using the data around the time of snowfall. The results are shown in Fig.1 and page 8 (lines 10-14).

Minor Comments

Q: Several typos are present: e.g. page 2 (line 5), page 3 (line 12), page 5 (line 12 retrieved -> retrieval), Many times "clear" and "clearly" are misused: e.g. page 9 (lines 1, 5, and 9) But I stop here and leave these to the technical editor.

A:"retrieving method" is replaced by "retrieval algorithm".

"off-zenith retrievals" means "profiles retrieved from MWR off-zenith observations", so we think the formulation is ok.

"Retrieved algorithm" is replaced by "retrieval algorithm".

The misused "clear" and "clearly" have been rectified.

Q: page 4, line 18: "The distances between them are all less than 30 m." Please rephrase to clarify that the distances between MWR, RAOB launching station and meteorological sensors are all less than 30 m. Observations may be much more distant due to radiosonde drifting, among other reasons.

A: we rephrase to "The distances between RAOB launching station, disdrometer, MWR and meteorological sensors are all less than 30 m, but the distance between sounding profile and MWR retrieval in high altitude may become larger due to radiosonde drifting." (Page 4, lines 20-22)

Q: page 5, line 3: "up to 10 km" Please remove "up to 10 km" as it is incorrect and does not add anything here. 10 km is just the upper boundary of the vertical

range for which the MWR software computes retrievals. Technically speaking the penetration depth depends upon absorption, i.e. it's different for each MWR channel.

A: "up to 10 km" is removed.

Q: page 5, line 15: "radiative transfer equations" Please rephrase to clarify that radiative transfer model is used in the training phase of the retrieval algorithm, not in the real-time retrieval computation.

A: We rephrase the citation. "The retrieval algorithm developed by the factory can automatically convert the microwave, infrared, and surface meteorological measurements into temperature, humidity, and liquid profiles with the aid of neural networks (Xu et al. 2015). Long time radiosondes and liquid water content profiles that generated from radiosondes were processed within a radiative transfer model and will be used as the neural network training set (Ware et al. 2013)." (Page 6, lines 2-8)

Q: page 6, line 6: "the RAOB profiles are interpolated to the height levels of the MWR" Interpolation does not account for the inherent MWR smoothing error. Ideally one should smooth the RAOB profiles at the original resolution considering the MWR averaging kernels and then interpolate on the MWR levels. The authors shall at least mention this issue.

A: we used this method in this paper and table 2, Fig 2-4 are reworked according to the new data. (Page 6, lines 19-21; page 20 table 2; pages 22-24 Fig 2-4)

Q: page 7, lines 18-19: "where the correlation coefficient rapidly increases from 0.01 to 0.92" The above sentence is misleading; it seems to hint that the correlation coefficient increases in a continuous way from 0.01 to 0.92, while it's either 0.01 (zenith) or 0.92 (off-zenith). I suggest to remove it.

A: We improve the description to avoid misleading. "As shown in Fig. 2, the temperature correlation coefficients in zenith observation are smaller than those in off-zenith observation below 6 km, but the situation is opposite above 6 km." (Page 8, lines 15-17)

Q: page 9, lines 7-8: "yet it is generally smaller than" I believe this refers to off-zenith, but this information is missing.

A: "yet it is generally smaller than 1.0 g m^{-3} with a peak of 1.47 g m^{-3} in off-zenith observation." (Page 10, lines 4-5)

Q: page 9, lines 13-14: "are not reasonable as those" I believe the authors mean "are

not as reasonable as those”. Please check.

A: “Snowfall, as one of precipitations, does not be considered in the MWR retrieval algorithm, so the MWR-retrieved atmospheric profiles in snow conditions are not as reasonable as those in non-precipitation conditions.” (Page 10, lines 9-11)

Q: page 9, line 19: “great” I suggest replacing this word with “some”, as otherwise the authors should say with respect to what (similarly on page 11, line 8).

A: “great” is replaced by “some”.

Q: page 10, lines 2-6: “the off-zenith observations are more representative of the conditions in which radiosonde observations are also taken” It’s not clear whether the paper Xu et al. 2014 analyses data from the same site and synoptical conditions. If so, please state that clearly. Otherwise I believe their results cannot be generalised to the site/conditions presented in the manuscript. (Similarly on page 14, lines 21-22)

A: the paper Xu et al. 2014 analyses data from the same site but the conditions is not the same as this manuscript. Xu discussed the precipitation condition but we focus on snow condition. In this section, we try to discuss the probable reasons why off-zenith observation has well measurement accuracy. The radiosondes are drifting, so the RAOB profiles are different from MWR zenith retrievals. Off-zenith observation is slant and it is more similar to the radiosonde.

Q: page 10, lines 17-18: “the greater temperature is well accordant with the snowfall time” in Figure 4 I see the warming of zenith retrievals during the snowfall. But I also see a warmer spot before the snowfall (around 12 UTC of 4 Feb). This is also evident in relative humidity and vapour density retrievals (Fig. 6 and 8, respectively). The authors completely ignore this feature, while I believe it must be discussed. Maybe there was liquid precipitation? A time series of precipitation rate and type would be very useful.

A: Yes, there was liquid precipitation at that time. We add the precipitation rate and type using the data collected by a disdrometer in the same site. (Fig. 5, page 11, lines 12-21)

Q: page 11, lines 1-3: It seems to me obvious that the less snow, the less impact; so it is reasonable that heavy snow causes 10 K contrast, while light snow causes 3 K contrast. I don’t see why the authors say that “light snow on the radome is blown away immediately”? The effect is there, 3 K it’s far from being negligible.

A: “light snow on the radome will be blown away more easily”. The 3 K in light snowfall may not be caused only by snowfall. But for heavy snowfall, 10 K is not reasonable. (Page 12, lines 12-14)

Q: page 11, lines 10-12: The authors shall dwell more on the reason why snow causes larger temperature and humidity retrievals. I think Kneifel et al. 2010 provide some qualitative explanation.

A: we add the discussion about how snow causes larger temperature and humidity retrievals with the help of this paper (Kneifel et al. 2010). (Page 14, lines 6-21)

Q: page 11, line 14: “temperature in zenith method is more reasonable” I believe the author mean in off-zenith

A: Off-zenith observation significantly minimizes contamination from ice and snow, so the MWR-retrieved temperature in off-zenith observation is more reasonable especially when heavy snowfall. (Page 13, lines 2-4)

Q: page 12, lines 1-5: Not clear, please check grammar and possibly rephrase.

A: we rephrase “However, in light snowfall condition, the discrepancies of relative humidity between zenith and off-zenith observations are not clear and the variation with time is also more stable without the high relative humidity above 6 km that appeared in heavy snowfall condition (Fig. 9). ” (page 13, lines 12-15)

Q: page 13, lines 1-2: Please check grammar and possibly remove. I think it is obvious that larger impact is associated to heavier snowfall.

A: It is removed.