Enhancing the consistency of spaceborne and ground-based radar comparisons by using quality filters

Irene Crisologo et al.

Review by:

Anonymous Referee

General Comments:

The authors provide an analysis of their technique to assess the calibration bias of a ground-based radar against TRMM/GPM in the Philippines. Their contribution to the scientific community is not only a peer-reviewed technique (Schwaller and Morris 2011) applied to a new dataset, but also a quality control procedure to assist with uncertainty caused by beam blockage from terrain and other terrestrial objects. This is useful to the scientific community because of the recent popularity of comparing GR to SR (e.g., 3 papers published this year: Warren et al. 2018, Han et al. 2018, Zhang et al. 2018) which could improve calibration results by including the quality-weighted average suggested by the authors here. Furthermore, the added value of the software being open-source allows for future investigations to implement this methodology easily and quickly.

It is suggested that the paper be accepted with minor revisions after addressing the following concerns:

Comments on other sources of uncertainty in calibration assessment:

1) *Attenuation at Ku-band:*

The authors should address the uncertainties with attenuation correction at Ku-band. The attenuation correction tech. used for just Ku-band is the HB-SRT method (Seto and Iguchi 2015). It is known that using the HB method alone does not work well in higher rain rates (> 20 mm hr^{-1}, Seto and Iguci 2011, but as low as 12 mm hr^{-1} Rose and Chandrasekar 2005). Furthermore, the SRT method is more uncertain over land (larger standard deviation of the surface backscatter cross-section, Meneghini et al. 2000). It is anticipated that since the radar is located in the tropics both of the issues above could occur (more likely in convective precipitation). Please discuss these uncertainties and how they could impact your results of the bias correction.

It is mentioned in the conclusions that for C-band attenuation correction is vital, but GPM and TRMM are Ku-band, thus isn't it vital as well?

2) *Ground Clutter for the SR:*

In radar gates near the surface, with respect to the SR, ground clutter is a problem. How are the authors dealing with ground clutter from the SR? Are they using gates below the lowest clutter free bin estimate (included in the GPM file)? If so, is the lowest clutter free gate being assigned to all the gate below it? If you plot it out, a lot of times that's what is done. Essentially the data looks smeared from the lowest clutter free bin to the surface, which isn't to realistic and it is suggested to just not consider these gates. Please comment on this, potentially in Section 2.3. If you are including these interpolations, you may wish to not (it will introduce error).

3) NUBF:

Please also include some discussion of the potential impacts of non-uniform beam filling (NUBF) on your analysis. Edges of large systems, individual cumulus showers could result in NUBF in SR because of the quasi-large footprint. Lowering the reflectivity value in the gate.

Specific Comments:

1) Page 2, line 5: Please add the Kummerow et al. (1998) paper for TRMM, and the Hou et al. (2014) for the GPM reference (page 2, line 6). This will help readers who are not entirely familiar with both platforms.

2) Page 6, line 3: "The gates below and above the brightband were considered in the comparison". Please provide a brief reason why this is done. I do not want to assume the authors reasoning.

3) Figure 4 & Section 3.1: It is not clear what you are plotting. The figure titles state the quality index but the figure caption and text states beam blockage fraction. Please clarify.

4) Section 3.1.1: Why are the number of overpasses here different than when they were listed earlier (section 2.1.2)? I am referring to the numbers before applying the criteria in Table 2.

5) Case studies (Section 3.1.2 and 3.1.3): Could you include the mean BB level height? You can add it to the bottom right with the other statistics. Also comment on fraction of stratiform vs convective. These two will help readers assess the amount of attenuation and NUBF that could be involved (e.g. uncertainty in the SR measurements).

6) Figure 5 + 6 + 7 a and b: Suggestion. Consider changing the colorscale to one that is perceptually uniform and color-deficient friendly. For example, try the HomeyerRainbow or the LangRainbow included in Pyart (https://github.com/ARM-DOE/pyart)

7) Page 10, Line 12: "Major parts of that sector did not receive any signal due to total beam blockage". Where is this occurring? The reader can refer back to Figure 4, but it might be helpful to outline the circles with a thin black line in Figure 5d where there is SR data, but no GR data. That way the readers would see where there is 100% beam blockage and thus no signal from the GR, but also gain insight of size of the precipitating system.

8) Page 10, Line 24-25: "That might be considered counterintuitive, as one might expect the blockage to disappear with higher elevations". Please provide some discussion explaining why this is the case.

9) Page 16, Lines 13 – 16. ‘We could’ and ‘we could also’ imply that you did not conduct this analysis when it seems you have. I suggest to change these phrases to be definitive. ‘We showed that…’ ‘we also demonstrated that…’

Technical corrections:

0) Page 3, line 20: The most current GPM version is version 5, version 6 is not released yet.

1) Page 18, line 18: Reference Cao et al. 2013 is incorrect. It should be:
    a. Empirical conversion of the vertical profile of reflectivity from Ku-band to S-band frequency

2) The reference Warren et al. should be 2018, published Feb 2018 in J. Atmo. + Ocean. Tech.. Page 2, line 8;Page 3,line 25;Page 5,line 11;Page 15,line 14

3) Figure 4: Missing y-ticks and tick labels on bottom left subplot

4) Page 8, line 5-6. No need for new paragraph. You can combine the two.

5) Figure 5: Figure caption has Zpr instead of Zsr

References:

Han, J., Chu, Z., Wang, Z., Xu, D., Li, N., Kou, L., Xu, F. and Zhu, Y.: The establishment of optimal ground-based radar datasets by comparison and correlation analyses with space-borne radar data. Meteorological Applications, 25, 161 – 170, 2018.

Hou, A., Kakar, R. K., Neeck, S., Azarbarzin, A. A., Kummerow, C. D., Kojima, M., Oki, R., Nakamura, K. and Iguchi, T.: The global precipitation measurement mission. BAMS, 95, 701 – 722, 2014.

Kummerow, C., Barnes, W., Kozu, T., Shiue, J. and Simpson, J.: The tropical rainfall measuring mission (TRMM) sensor package. Journal of Atmospheric and Oceanic Technology, 15, 809 – 817, 1998.

Meneghini, R., Iguchi, T., Kozu, T., Liao, L., Okamoto, K., Jones, J. A. and Kwiatkowski, J.: Use of the surface reference technique for path attenuation estimates from TRMM precipitation radar. Journal of Applied Meteorology, 39, 2053 – 2070, 2000.

Seto, S. and Iguchi, T.: Applicability of the iterative backward retrieval method for the GPM dual-frequency precipitation radar. IEEE Transactions on Geoscience and Remote Sensing, 49, 1827 – 1838, 2011.

Zhang, S., Zhu, Y., Wang, Z. and Wang, Y.: Consistency analysis and correction of ground-based observations using space-borne radar. Journal of Atmospheric and Solar-Terrestrial Physics, 169, 114 – 121, 2018.