Comparison of S-Pol, NEXRAD, and GPM DPR Ku reflectivities observed during PRECIP

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March 2023

Introduction

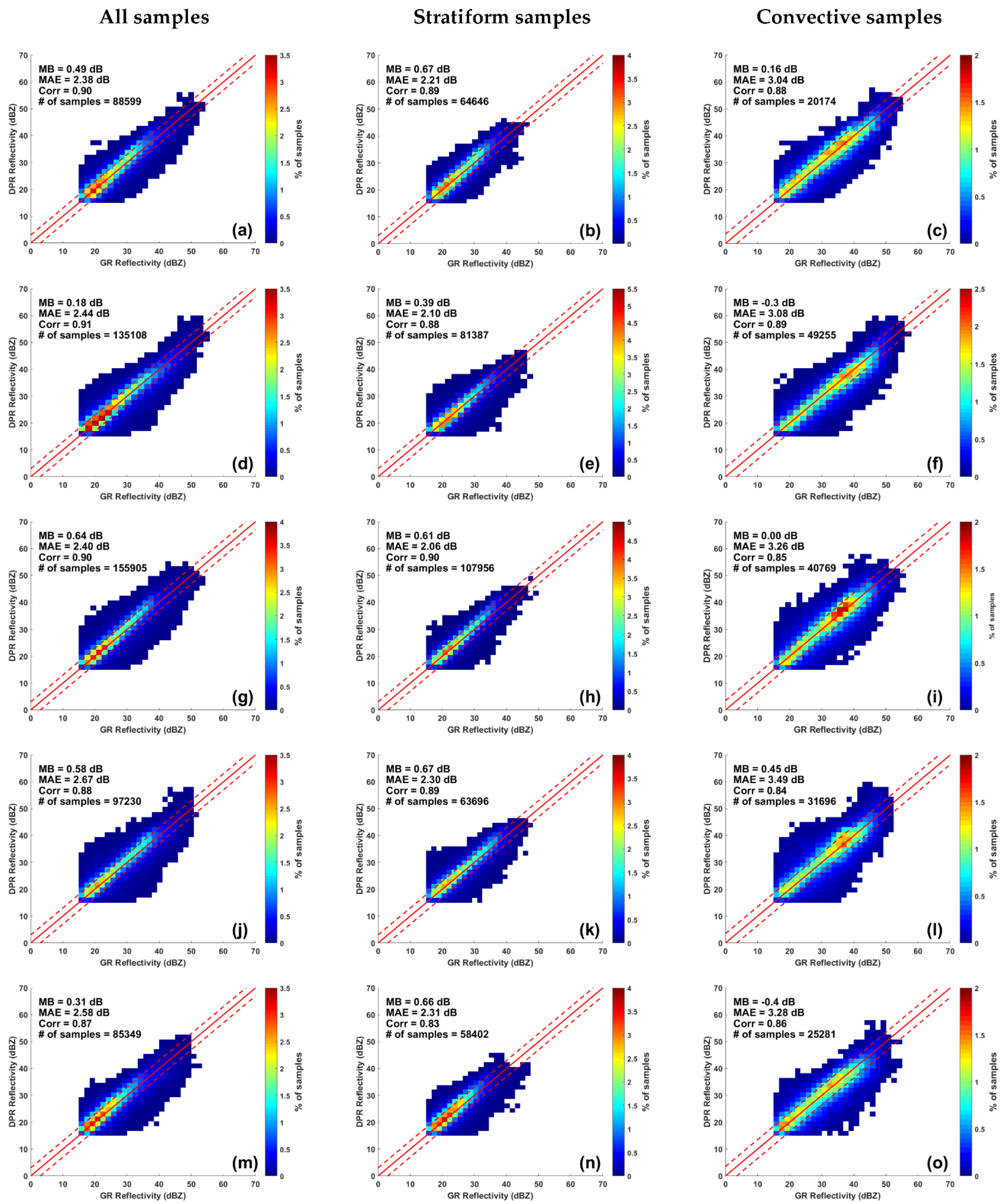
S-Pol data collected during PRECIP has undergone extensive quality control procedures and calibration checks, which are described here. We are confident that the calibration of the Version 1.0 data is consistent throughout the project. The goal of the current analysis is to compare the calibration with other established radars and to investigate the possibility of an overall bias.

We would like to note that we are aiming to conduct a basic calibration check, not a full scientific study. We only did a very basic literature review and our method is rather simple with lots of room for improvement. The relatively small number of suitable GPM overpasses over S-Pol limits the availability of comparison data which weakens the robustness of our conclusions.

Method

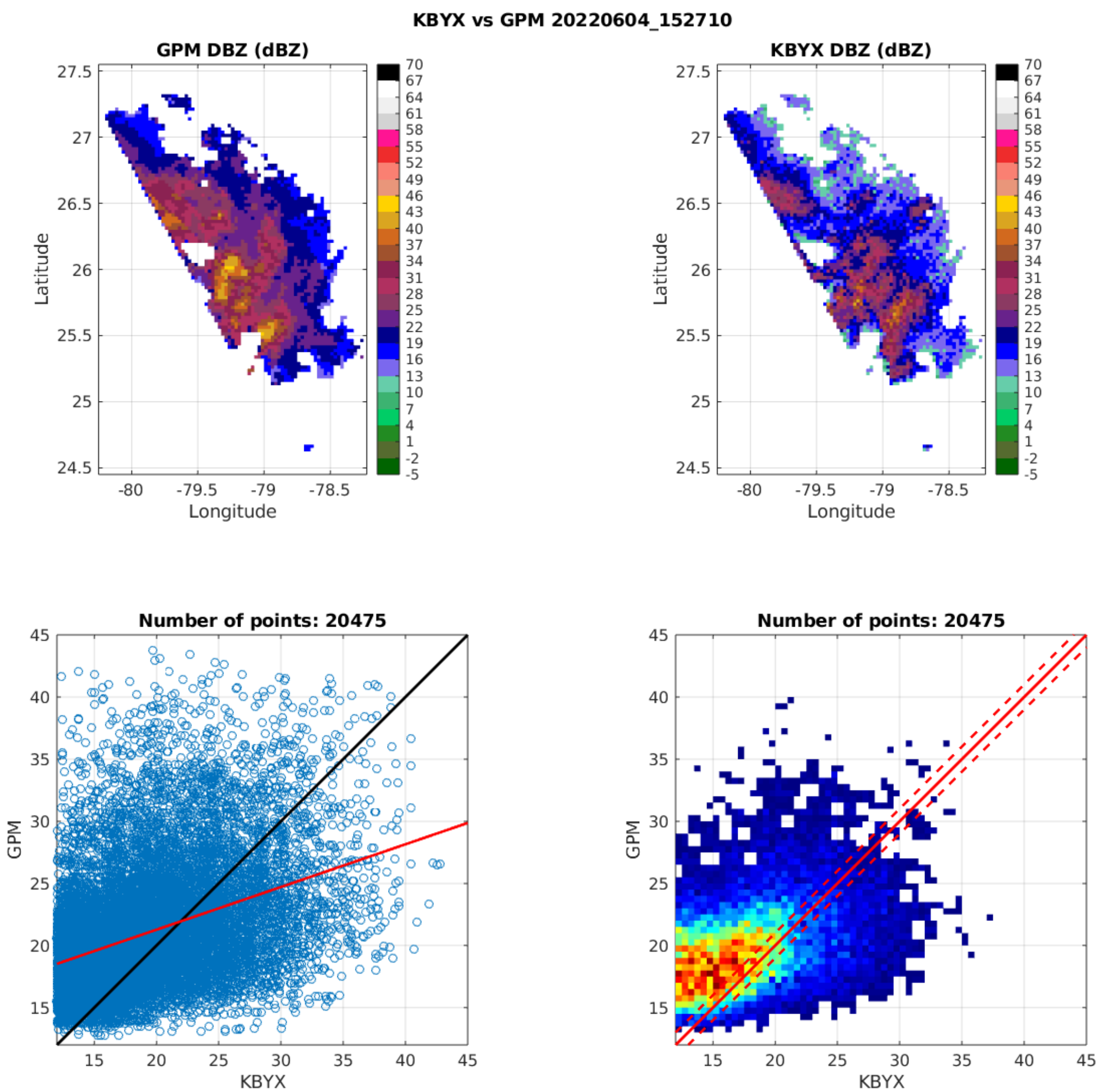
The calibration of the Ku-band channel of the Dual-Frequency Precipitation Radar (DPR) onboard the GPM satellite has been studied extensively. Checking S-Pol calibration against the DPR Ku-band is therefore a logical first step. There are several studies which compare DPR Ku-band reflectivities with those from NEXRADs and we therefore use NEXRADs to establish our comparison methodology.

Biswas and Chandrasekar (2018) compare observations from 250 GPM overpasses with 5 NEXRADS and find good agreement (see their Figure 4, copied below). To establish a comparison methodology we decided to conduct a similar analysis. We downloaded four months (May to August 2022) of data from DPR and four NEXRADS from Florida (KAMX, KBYX, KMLB, and KTBW). Florida was chosen to at least somewhat mimic the conditions in Taiwan.



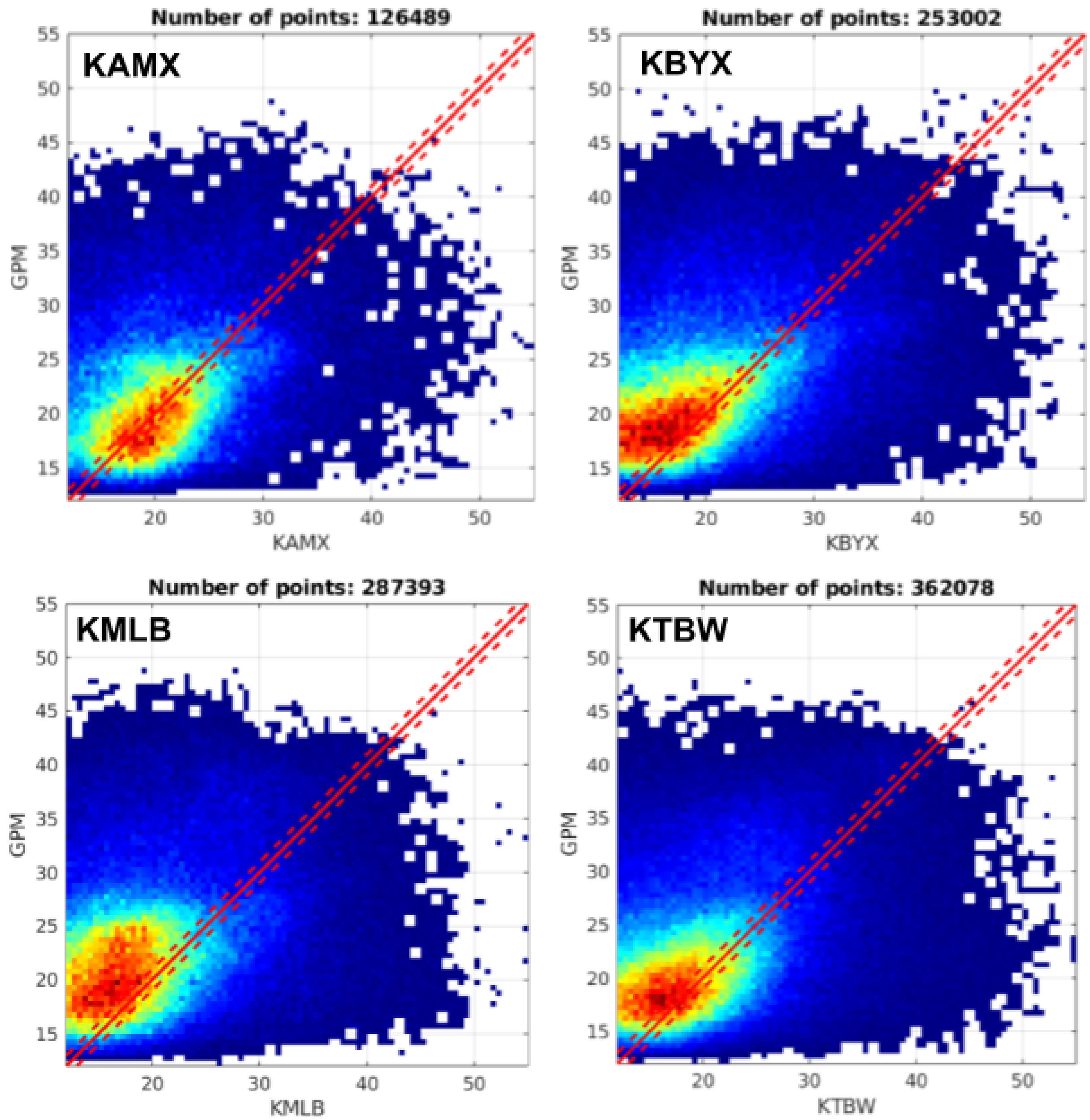
To compare the two datasets the data first needs to be resampled onto the same grid. While Biswas and Chandrasekar (2018) use a sophisticated re-gridding technique (Bolen and Chandrasekar, 2000, 2003, Schwaller and Morris, 2011), we simply used Radx2Grid to interpolate both datasets onto a grid with 0.025 deg horizontal resolution. The vertical levels had a spacing of 0.25 km up to 3 km altitude, 0.5 km up to 9 km altitude, and 1 km up to 20 km altitude. Once the data were on the same grid, we went through all GPM overpasses and matched them to the NEXRAD volumes that were closest in time. We then removed all non-overlapping data points and only kept “good” volumes for further analysis that had a significant number of overlapping data points. The numbers of good volumes were 6 for KAMX, 10 for KBYX, 13 for KMLB, and 17 for KTBW.

For the DPR Ku-band, we assumed that attenuation could be an issue and that the data points closer to the top of the storms would result in a better comparison. To identify those data points, we loop through all vertical grid columns with non-missing data in the NEXRAD volume and identify the pixel that is closest to the storm top that exceeds a certain reflectivity threshold. For the comparison we only use grid points that are above that pixel. With those pixels we made scatter plots similar to those by Biswas and Chandrasekar (2018) and an example for the KBYX radar, with a 35 dBZ reflectivity threshold, is shown below.



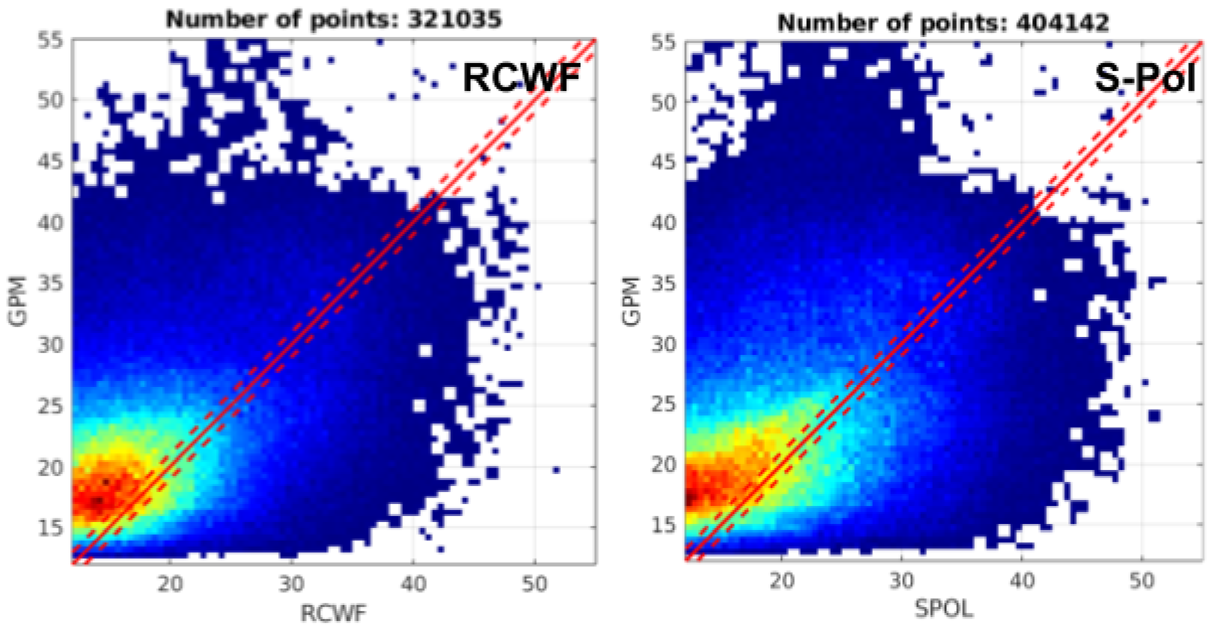
Scatter plot comparison

We combined all cases of each radar and made the same types of scatter plots. The reflectivity threshold was varied between 35 dBZ and 55 dBZ but, interestingly, the results did not change significantly for different thresholds.



Our method does not reproduce the good results from Biswas and Chandrasekar (2018). For all radars except KAMX, the DPR was measuring higher reflectivity values than the NEXRADs. The difference is particularly high at low reflectivities. That DPR measures higher reflectivity values is somewhat surprising because as a first guess, one would expect lower reflectivities in the DPR data because of attenuation.

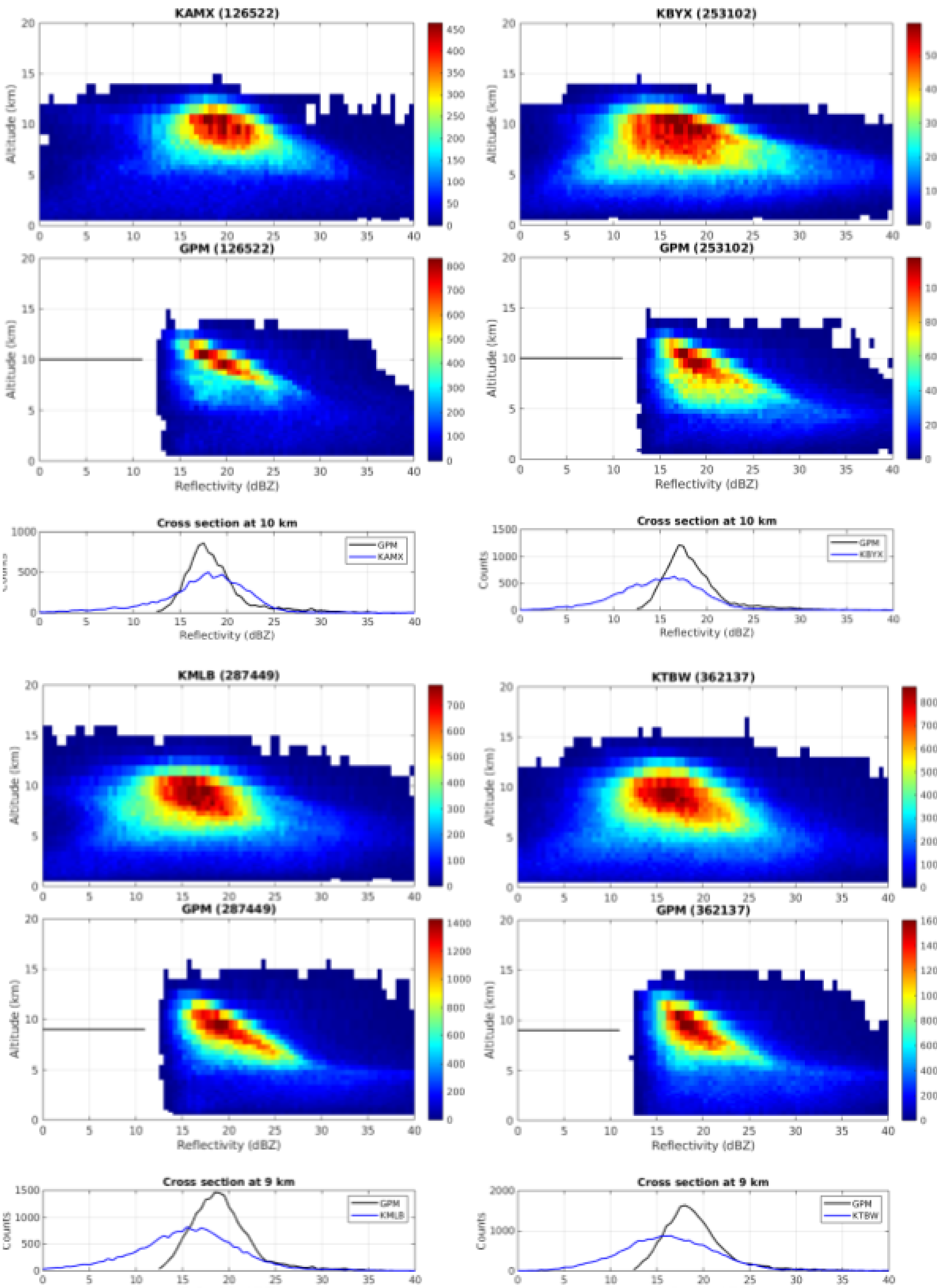
We ran the same method on the Taiwan “NEXRAD” RCWF, where we found 8 good volumes, and on S-Pol (10 good volumes). The results are very similar to those of the US NEXRADs.



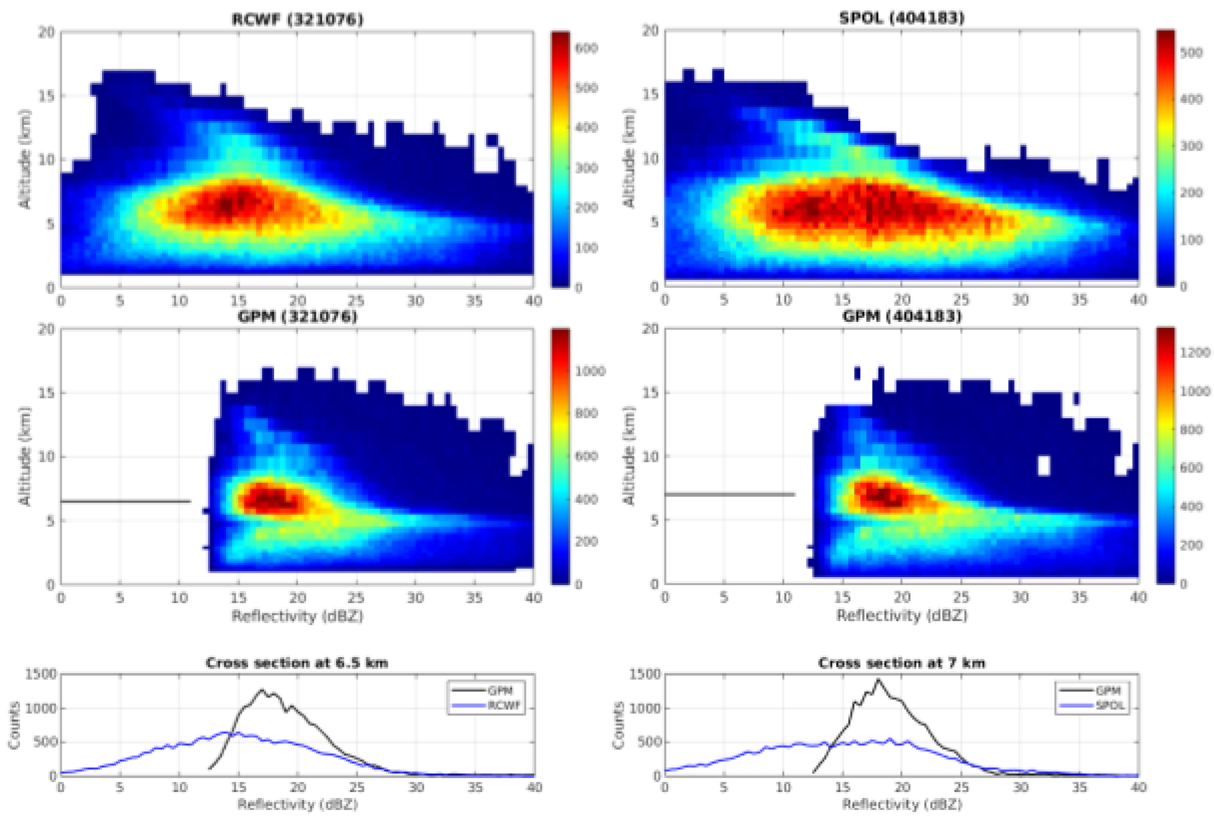
We currently do not have an explanation for why the DPR would measure higher reflectivities. We also do not know if the bias is a result of our gridding method or if it is real - which would contradict the results of Biswas and Chandrasekar (2018).

CFADS

To investigate the possibility of a gridding issue, we made CFADS (Yuter and Houze, 1995) using all overlapping grid points. Again, areas of maximum counts are shifted towards higher reflectivity values for DPR compared to all other radars except KAMX. To get a better feel for the magnitude of that shift, we plotted a cross section at the altitude level where we found the highest DPR count. (The altitude of the cross section is indicated by the black line in the second row of the plots.)



KAMX (126522)
KBYX (253102)
GPM (126522)
GPM (253102)
Altitude (km)
Reflectivity (dBZ)
Cross section at 10 km
Counts
GPM
KAMX
KBYX
KMLB (287449)
KTBW (362137)
GPM (287449)
GPM (362137)
Cross section at 9 km
KMLB
KTBW



Conclusions

Comparing the scatter plots, CFADs, and the peaks of the cross sections, it seems that the bias is relatively similar between the different radars, except for KAMX (which may indicate a calibration issue with that specific radar). The US NEXRADs KBYX, KMLB, and KTBW are similar to each other and the Taiwan radars RCWF and S-Pol also show similarities. Unfortunately, the S-Pol CFAD distribution is rather broad, which makes exact comparisons difficult.

Since all data was collected during the same time period, we know that the DPR calibration did not change. The fact that the S-Pol/DPR bias looks similar to that from four other radars leads us to the conclusion that we do not see any evidence of a systematic bias. The limited availability of data suitable for comparison, and the fact that we cannot explain the existence of a bias in the first place, are caveats to keep in mind.

References

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