Operational Implementation of a Robust Near-real Time Radar Calibration and Monitoring Technique for BoM Operational Radars

Australian Government
Bureau of Meteorology

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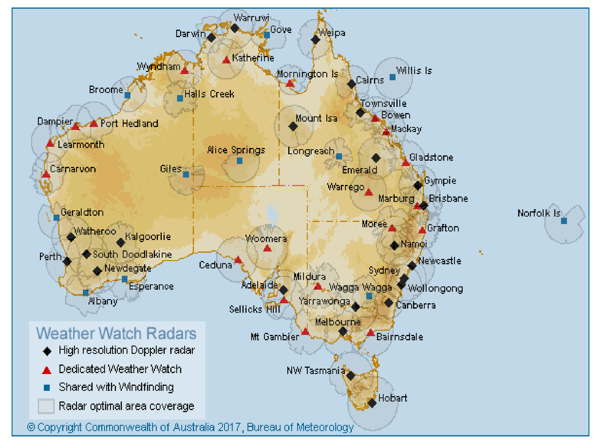


www.bom.gov.au/australia/radar/about/radar_coverage_national.shtml

Introduction

A well calibrated weather radar is one of the best source of high-resolution spatiotemporal rainfall data and for other hydro-meteorological variables. However, forecasters learn to live with dodgy radar calibration and they adjust their decision making with the reflectivity level that they are used to. What if they move to another region?

The accuracy of radar's rainfall estimation depends on:

- Measurement of the returned power and its conversion to reflectivity (Seven sources of errors), and
- Transformation of the measured reflectivity to rainfall intensity (Two sources of errors)

$R = 0.0364\, Z^{0.625}$

$Z = 35\, dBZ,\ R \sim 6\, mm\, hr^{1}$

$Z = 40\, dBZ,\ R \sim 12\, mm\, hr^{1}$

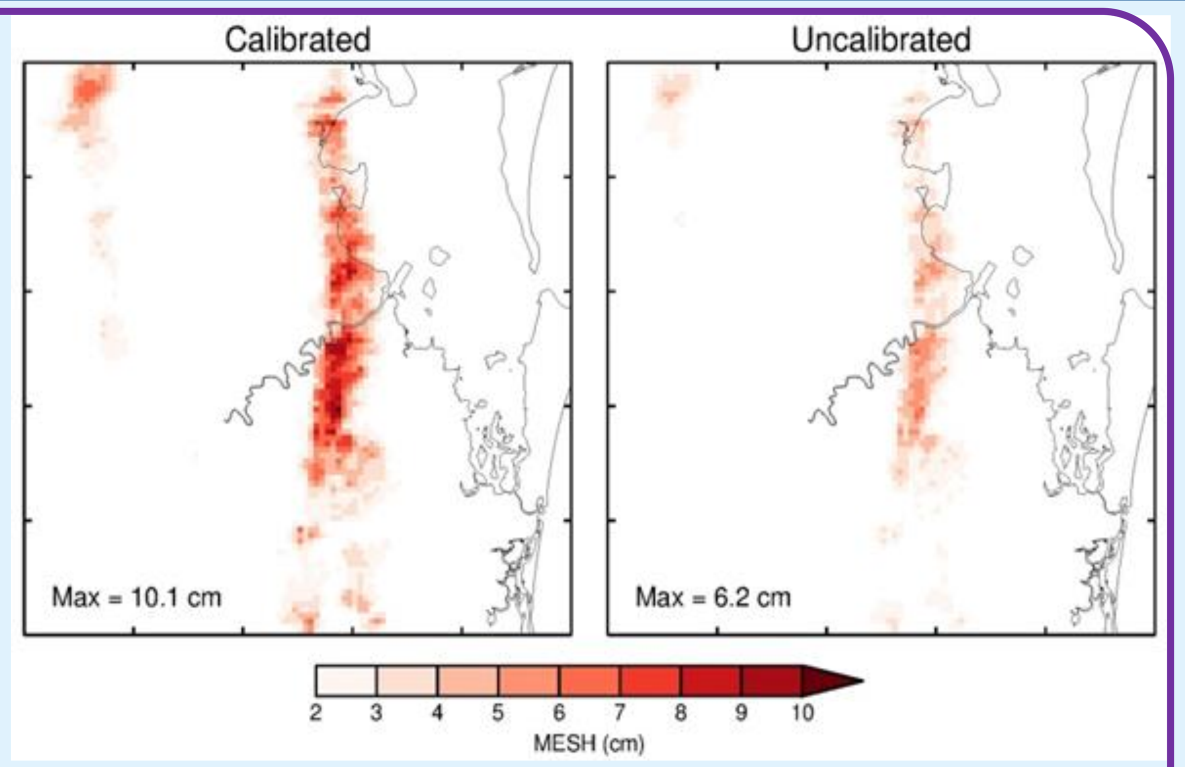


Fig.1 Maximum Expected Hail Size (MESH) for 27th Nov. 2014 Brisbane Hailstorm using calibrated and uncalibrated reflectivities (Source: Warren et al.)

Objective:

Develop a robust radar calibration and monitoring technique for the Australian Bureau of Meteorology (BoM) radar networks that can address the radar calibration issue in near-real time for a better quality control of radar reflectivity.

Data:

Un-corrected (ground clutter) and corrected reflectivities from the ground radar (GR)

Measured reflectivity (V5) from the space-borne precipitation radar (Ku-band) onboard the Global Precipitation Measurement (GPM) satellite (SR)

Table 1 Description of the BoM radars that currently provide un-corrected and corrected reflectivities

ID	Name	Radar Type	ω (°)	r_{max} (km)	Δr (m)	N_θ	Time (min)	Height (m)
02	Melbourne	Meteor1500(S)	1.0	225	250	14	06	42
03	Wollongong	DWSR8502(S)	1.9	300	500	14	06	449
40	Canberra	DWSR74(S)	1.9	300	500	14	06	1384
48	Kalgoorlie	DWSR2502(C)	1.0	225	250	14	06	388
54	Sydney	WF100-6(C)	1.9	225	250	14	06	64
69	Namoi	DWSR8502(S)	1.9	300	500	14	10	699

Description of RCA Method and Results:

- Uses the probability distribution of reflectivity in clutter areas near stationary, ground-based radar and provides an automated tool for tracking relative changes in calibration (Rinehart 1978, Silberstein et al. 2008, Wolff et al. 2015).
- Probert-Jones (1962) Radar Equation:
  - $10logZ = 10logP_t + 20logr - 10logC$
- Hence, any variation in ground clutter reflectivity is caused by a change in radar calibration provided no changes in surface-based structures responsible for ground clutter and in the radar elevation angle.
  - $\Delta Z_c = \Delta(10logC)$
- The RCA technique collects the echoes from ground clutter and then computes the PDF and CDF to calculate the 95th percentile reflectivity for a given lowest beam elevation scan to estimate the RCA as below
  - $RCA(dB) = dBZ95_{ref} - dBZ95$

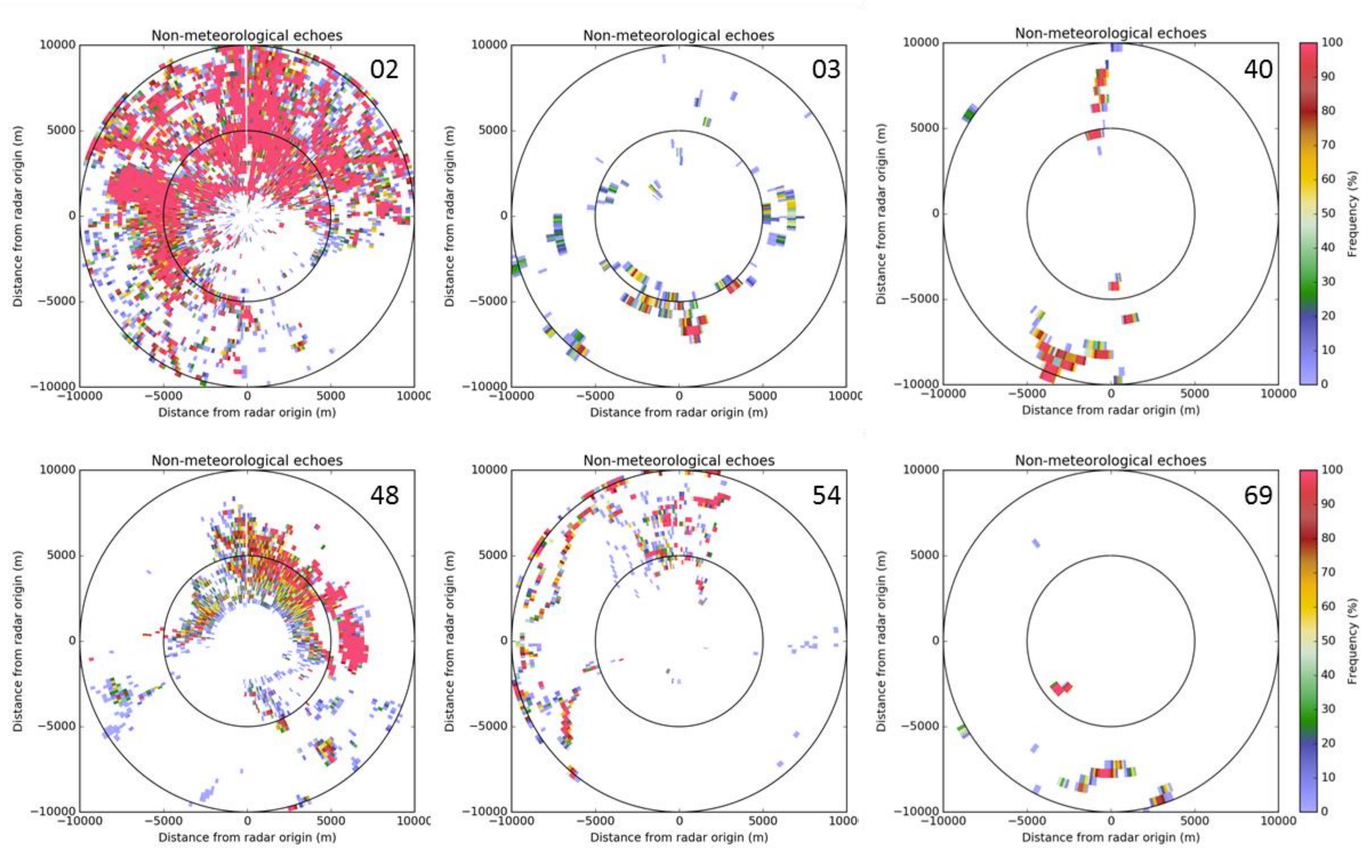


Fig. 2 Clutter area maps for six BoM Operational Radar Networks

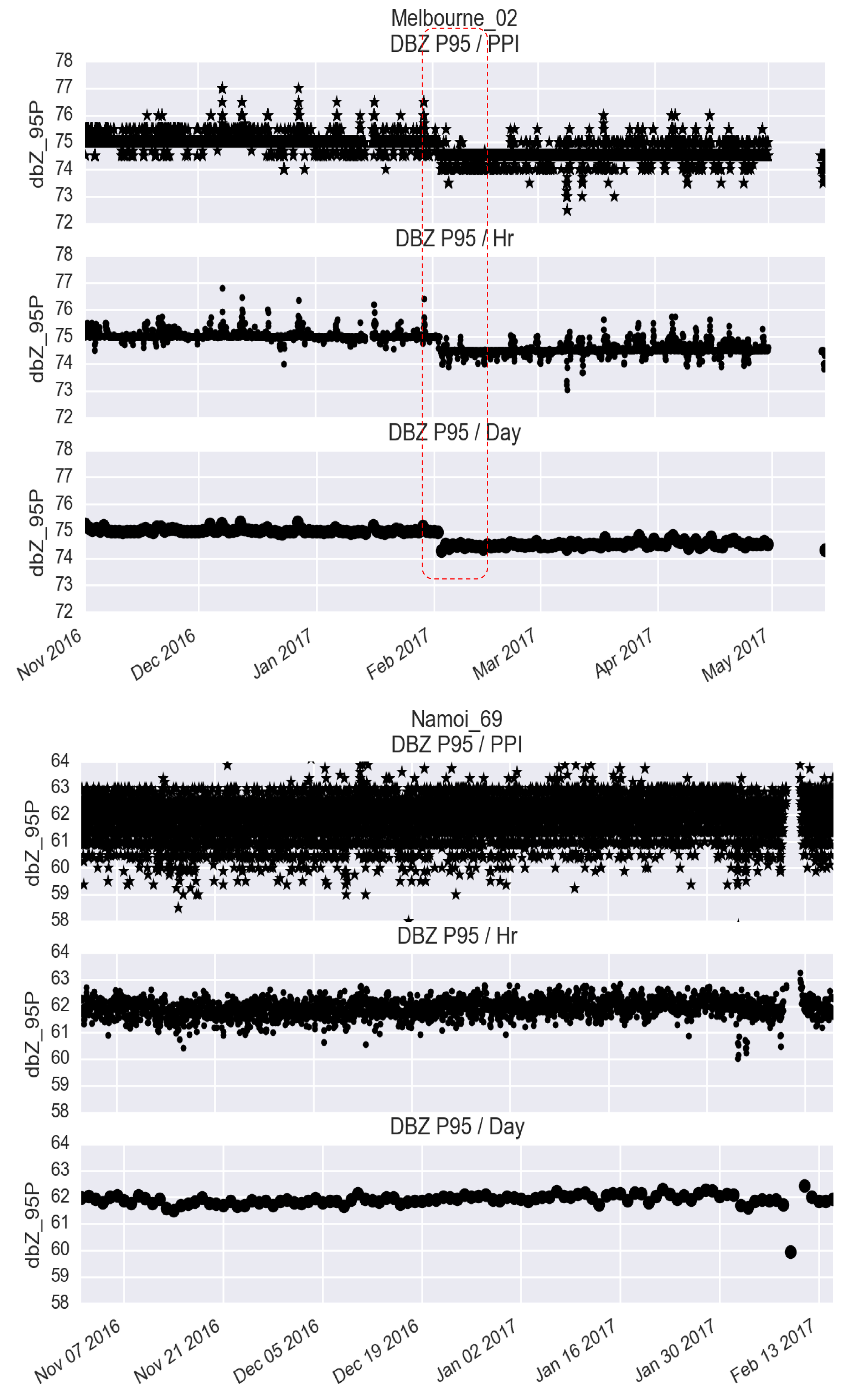
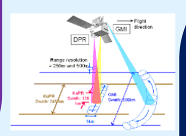
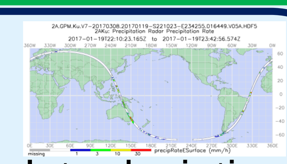


Fig. 3 Variations in the 95th percentile reflectivity of the clutter region for the Melbourne and Namoi radars.

Description of Volume Matching Method and Results:





The GPM calibration technique compares common volumes from the ground and satellite radars to derive the absolute deviation in ground radar calibration. The technique is based on the algorithm developed by Schwaller and Morris (2011) and described in detail by Warren et al. (in preparation).

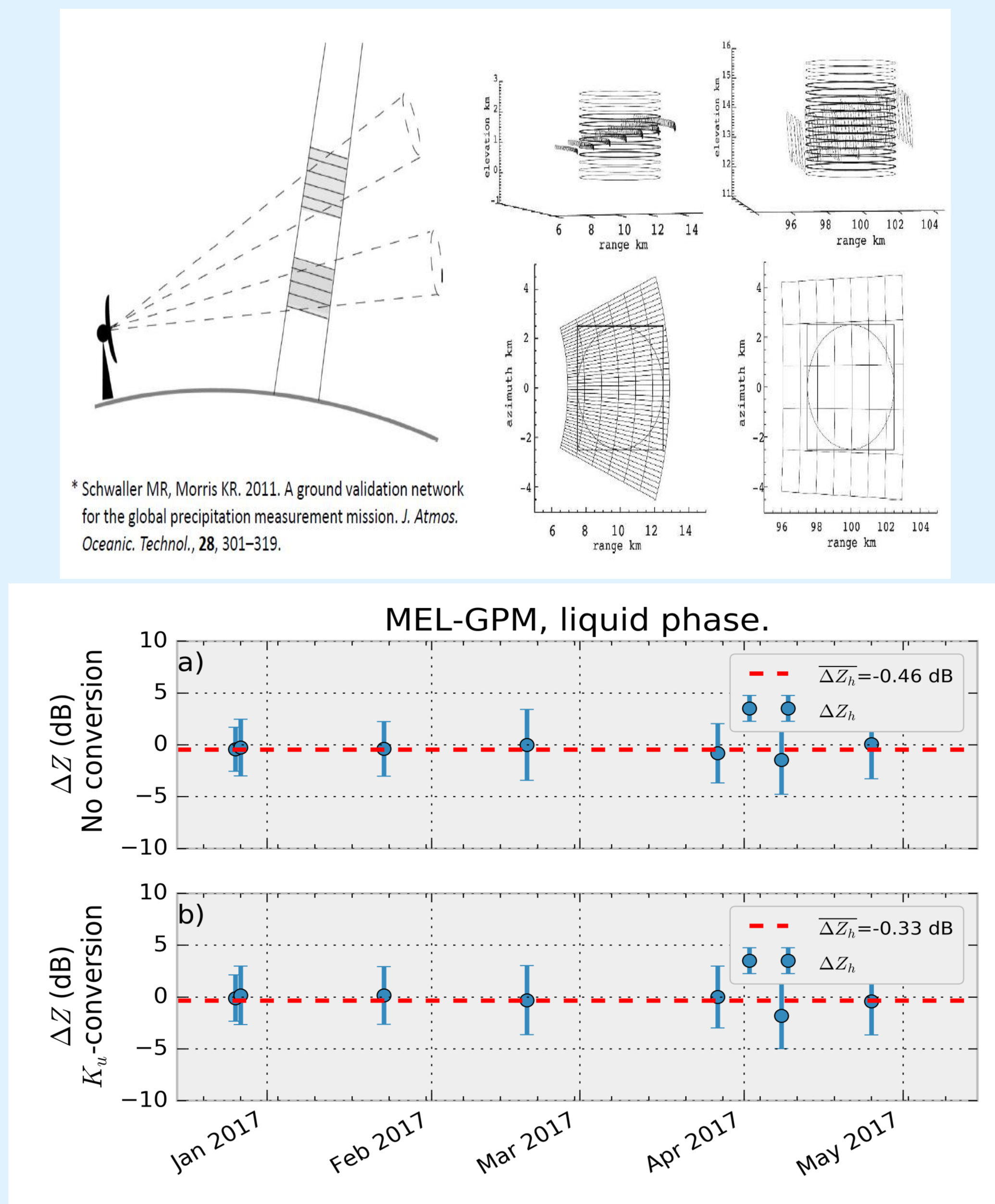


Fig. 5 Time series of mean reflectivity differences of Melbourne radar with the GPM.

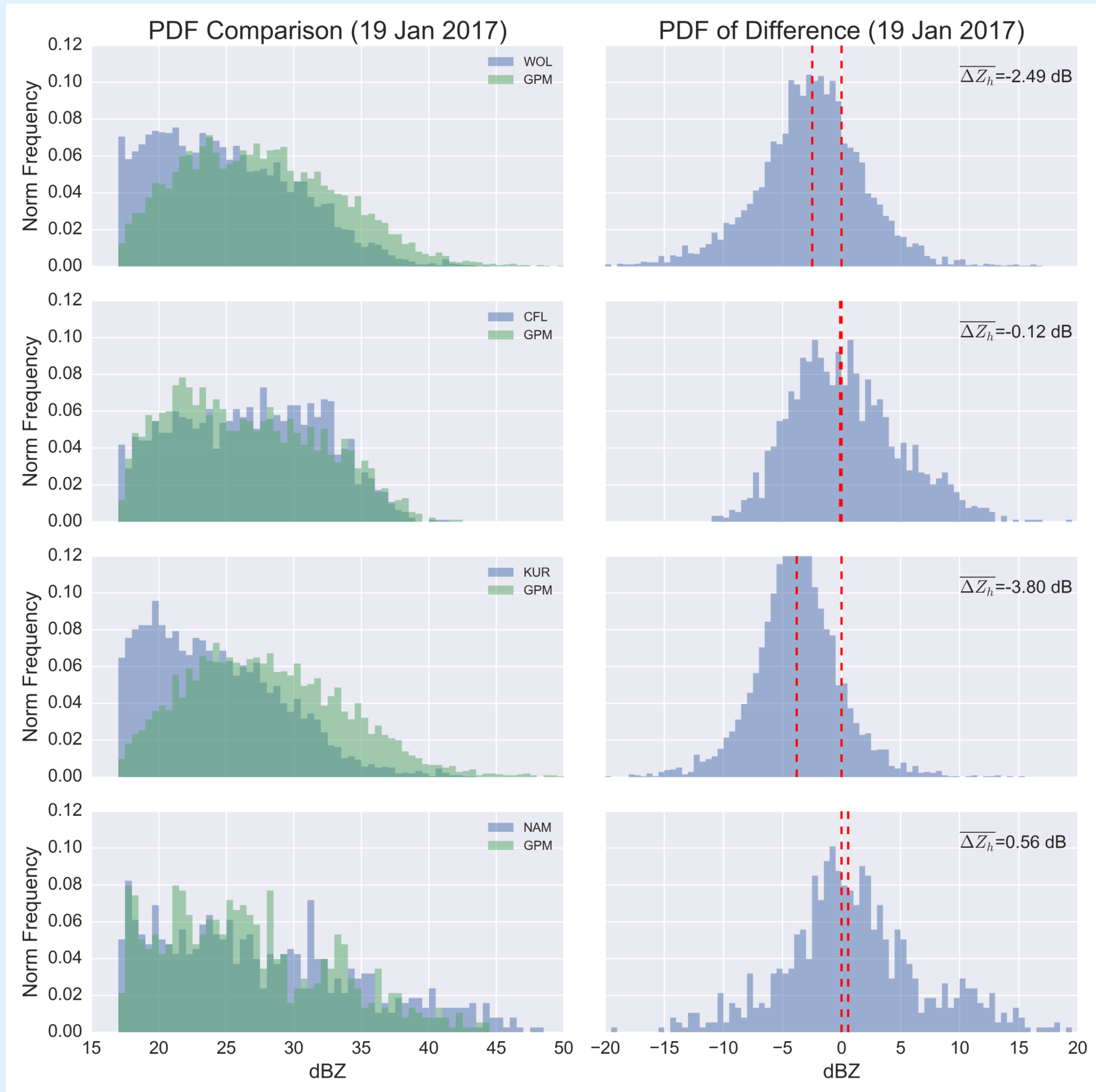


Fig. 4 Left panel: comparison of PDF of reflectivities estimated by the different GRs with GPM for 19 Jan and right panel: PDF of differences in reflectivities for the same date.

Conclusion:

The RCA technique provides a way to monitor changes in calibration with high precision (better than 0.3 dB), but does not provide an absolute calibration. In contrast the GPM comparisons provide an absolute calibration, but with uncertainties for each overpass generally exceeding 1.5 dB.

We are working on an operational implementation of a hybrid RCA-GPM technique, which identifies stable periods of calibration using RCA, and averages all individual estimates of absolute calibration from the GPM technique over these stable periods. Our first results indicate that the errors on absolute calibrations are lower than 1 dB.

Reference

- Rinehart, R. E., 1978: On the use of ground return targets for radar reflectivity calibration checks. J. Appl. Meteor., 17, 1342–1350.
- Silberstein, D. S., D. B. Wolff, D. A. Marks, D. Atlas, and J. L. Pippitt, 2008: Ground clutter as a monitor of radar stability at Kwajalein, RMI. J. Atmos. Oceanic Technol., 25, 2037–2045.
- Schwaller, M.R. and K.R. Morris, 2011: A Ground Validation Network for the Global Precipitation Measurement Mission. J. Atmos. Oceanic Technol., 28, 301–319.
- Warren et al. (In preparation): Calibration of ground-based radars using TRMM and GPM.
- Wolff, D.B., D.A. Marks, and W.A. Petersen, 2015: General Application of the Relative Calibration Adjustment (RCA) Technique for Monitoring and Correcting Radar Reflectivity Calibration. J. Atmos. Oceanic Technol., 32, 496–506.