SENSITIVITY OF SPACEBORNE AND GROUND RADAR COMPARISON RESULTS TO DATA ANALYSIS METHODS AND CONSTRAINTS

K. Robert Morris (SAIC, NASA/GSFC) and Mathew Schwaller (NASA/GSFC)

Q: How does the spaceborne TRMM Precipitation Radar (PR) reflectivity compare to ground radar (GR) measurements?

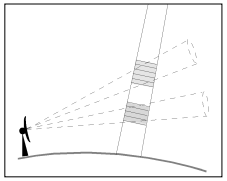
A: It depends … on numerous factors.

We use a PR/GR volume matching technique ("Geo-Match") based on geometric intersection of the two instruments' scans. The matched data have the horizontal resolution and location of the PR, and the vertical resolution and location of the individual GR sweeps intersected by the PR rays. Each sample carries metadata on the PR and GR range gates averaged to produce the matched reflectivity values, including the number of PR and GR gates averaged; maximum and standard deviation of GR reflectivity; sample top and bottom height; rain type of the sample; fraction of the matching volume filled with reflectivity above the PR detection threshold (18 dBZ); PR and GR observation date and time; and others. These metadata allow fine control over the data samples included in a comparison. ***Categorizing the data by permutations of these metadata attributes affects the reflectivity comparison results by varying degrees, and is the objective of this study.***

We also compare and contrast the categorized Geo-Match results against results based on analyzing PR and GR data to fixed Cartesian grids, as in multiple prior studies (e.g., Anagnostou et al., 2001; Liao et al., 2001; see paper). The gridded dataset has only limited attributes allowing the data to be categorized: height, rain type, and average PR-GR time difference.

Geometry-Matching Method and definition of "Percent Above Threshold"

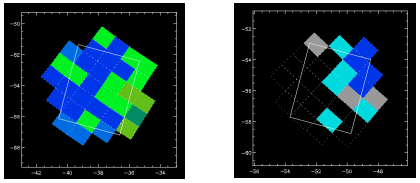
PR data are averaged only in the vertical, between the top and bottom of each GR elevation sweep. The height and number of PR range gates varies by the height and depth of the GR beam at the location of the intersection, and the PR scan angle from the vertical. Each PR gate is weighted equally in the averaging.



PR matching volumes (shaded) from intersection with two GR elevation sweeps (dotted). Upper volume is an average of five PR gates (each ~5km wide by 250m deep), lower volume is an average of four PR gates.

PR's Percent Above Threshold is the percent of intersecting gates with Z_e of 18 dBZ or greater. **Gates below 18 dBZ are excluded from PR volume average, so all non-zero PR Geo-Match samples are >= 18 dBZ.**

GR data are averaged only in the horizontal, over the area defined by the PR ray's half-power points. Each PR ray and GR elevation sweep is treated separately. GR reflectivity values are weighted by volume, and by distance from the PR beam center to roughly approximate the PR illumination function. GR sample's Percent Above Average is the percent of the GR range gates in the sample average having a Z_e at/above a selected detection threshold (15.0 and 18.0 dBZ used in the study). **GR gates with Z_e above 0.0 dBZ but below the detection threshold are NOT excluded from the GR volume average, so GR reflectivities are > 0.0 dBZ.**

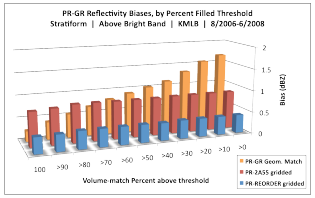


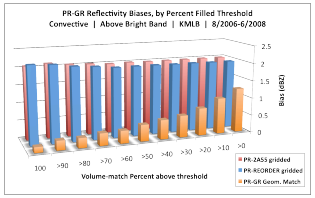
GR 1 km × 1 degree beamwidth gates, averaged over the area of the intersecting PR ray. GR gates at/above 15 dBZ are gray/colored, gates below 15 dBZ are outlines only. Sample on left has a GR Percent Above Threshold of 100%. Sample on right has Percent Above Threshold of 44% (12 of 27 gates >= 15 dBZ). Solid rectangle shows the boundaries of the geo-match samples as they would be plotted on a PPI or CAPPI. Axes show x- and y-distances from the GR, in km.

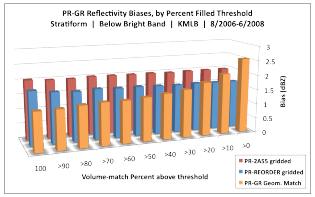
Sensitivity to Percent Above Threshold

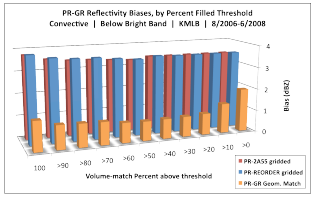
We computed mean PR-GR reflectivity differences split out by Stratiform and Convective rain type, Above and Below the Bright Band (Melting Layer), and varied the minimum Percent Above Threshold from >0% (all valid samples) to 100% (all gates above threshold dBZ) by 10% steps. PR data are from TRMM product 2A-25, attenuation corrected. GR data are from Melbourne, FL (KMLB) WSR-88D, quality controlled to eliminate spurious echoes. Data set includes all rainy cases between 8/2006 and 6/2008. Geo-Match PR samples are 18 dBZ or greater for any Percent Above Threshold, while GR Geo-Match minimum possible reflectivity varies between 15 dBZ for 100% above threshold, to just above 0.0 dBZ for >0%. PR (GR) percent above threshold is based on a threshold of 18 (15) dBZ in these figures. Geo-Match data results are plotted below in the series labeled **PR-GR Geom. Match**.

Mean differences for data analyzed to fixed grids are also plotted, in series labeled **PR-2A55 gridded** and **PR-REORDER gridded**. 2A55 refers to GR data from the TRMM 2A55 GV product, down-sampled from 2 to 4 km resolution. The 2A55 uses the SPRINT radar remapping program. REORDER refers to GR data analyzed to a 4-km resolution grid using the REORDER radar remapping program. Both gridded sets share a common 4-km resolution PR gridded analysis based on a Delaunay triangulation technique. Grid-based results are limited to common PR/GR grid points of 18.0 dBZ or greater.



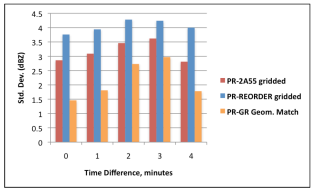






Sensitivity to PR-GR Time Difference

Mean reflectivity differences as computed in the study vary little within the allowed range (4 minutes or less) of time differences between the PR and GR. However, the scatter and Standard Deviation of the point-to-point differences are sensitive to the time offset. Results are shown for Geo-Match data with a Percent Above Threshold of 100%, combining convective and stratiform rain, above and below bright band.



Sensitivity to GR Minimum Reflectivity Threshold

Two sets of Geo-Match data were run, one with a 15 dBZ GR reflectivity threshold and one with an 18 dBZ threshold as the basis for Percent Above Threshold. PR threshold is 18 dBZ for both data sets. The reasoning behind a 15 dBZ default threshold for the GR is to allow up to a 3 dBZ calibration offset of a GR site, while maintaining a close match to the 18 dBZ PR detection threshold. Results are limited to PR and GR samples with 100% of the averaged gates above their respective threshold. Results do not apply to gridded analyses.

Rain Type / Location	15 dBZ GR threshold		18 dBZ GR threshold	
	mean PR-GR	N	mean PR-GR	N
C / Above BB	0.27	1922	-0.01	1269
C / Below BB	1.03	1154	0.92	1006
S / Above BB	-0.27	2894	-0.63	1566
S / Below BB	2.17	3174	2.10	2382

Sensitivity to Range from the GR

Mean PR-GR differences are computed for 0-50 and 50-100 km range from the GR, for Geo-Match data with a 100% above threshold constraint. Note opposite result between Convective and Stratiform data subsets. These data only are for all of 2008 and 2009, for KMLB.

Rain Type / Location	0-50 km		50-100 km	
	mean PR-GR	N	mean PR-GR	N
C / Above BB	0.30	165	0.14	1182
C / Below BB	1.55	445	1.17	443
C / Within BB	3.04	85	0.37	840
S / Above BB	-0.03	237	0.28	1497
S / Below BB	1.19	1540	1.53	1100
S / Within BB	-2.40	105	-0.66	2818

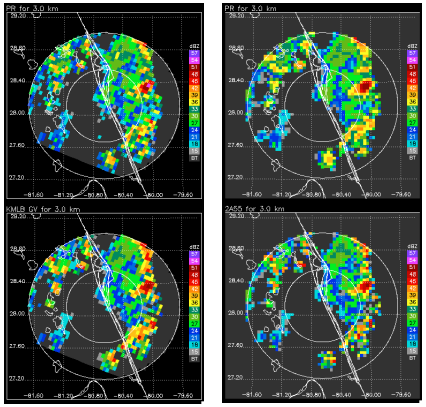
Effects of Radar Frequency Matching

Mean PR-GR differences are computed using both original and Ku-adjusted GR S-band reflectivity, using Liao and Meneghini [2009] adjustments. Effect is greater for convective samples with higher overall reflectivities, due to non-linearity of adjustments as a function of Z.

Rain Type / Location	Unadjusted GR		Ku-adjusted GR	
	mean PR-GR	N	mean PR-GR	N
C / Above BB	0.16	1347	1.35	1347
C / Below BB	1.36	888	-0.30	888
S / Above BB	0.24	1734	0.73	1734
S / Below BB	1.33	2640	0.61	2640

Sample Plots of Geometry-Match and Grid-based Volume Match Data

Geometry-Match (left figure) and Gridded (right figure) PR and GR data are plotted as CAPPIs at 3 km height above the surface. PR data are in the upper CAPPIs, GR data are in the lower CAPPIs. Note the preservation of high PR reflectivity values and echo areas for the Geo-Match data compared to the gridded data, particularly in the strong convective region on the right, and the relative spreading and smoothing of echo features in the grid analysis of the PR data (upper right CAPPI). Data are for Melbourne, FL (KMLB), TRMM orbit 50405 around 2210 UTC on 9 September 2006. Grid data resolution is 4 km horizontal, 1.5 km vertical. Geo-Match horizontal resolution is ~5km; vertical resolution varies with range as a function of the GR beam width.



Access TRMM PR and WSR-88D GR data, geometry match data products and documentation, and open source code:

http://pmm.nasa.gov/science/ground-validation

E-mail: kenneth.r.morris@nasa.gov, mathew.r.schwaller@nasa.gov