GPM Validation Network Data and Analysis Resources for Multiple Applications

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Datasets and Goals:

The GPM Validation Network (VN) collects, archives, and analyzes satellite data from the GPM Dual-Frequency Precipitation Radar (DPR), the GPM Microwave Imager (GMI), and constellation satellite microwave imagers; and coincident radar data from U.S. and international ground radar (GR) networks. Ground radar measurements are used to validate satellite measurements of DPR reflectivity and Drop Size Distribution (DSD) parameters, and DPR, GMI, and constellation satellite rain rate estimates. Additional goals are to evaluate the effectiveness of the DPR attenuation correction techniques and support GPM data retrieval algorithm development. Satellite data products (HDF5 file format) and primary data variables include:

- **GPM DPR**: 2A-DPR, 2A-Ka, 2A-Ku (measured and attenuation-corrected reflectivity, path-integrated attenuation (PIA), DSD, rain rate)
- **GPM DPR/GMI Combined**: 2B-DPRGMI (attenuation-corrected reflectivity, PIA, DSD, rain rate)
- **GPM GMI and Constellation Microwave Imagers**: 2A-GPROF (rain rate), 1C-R-XCAL (Calibrated Tbb)

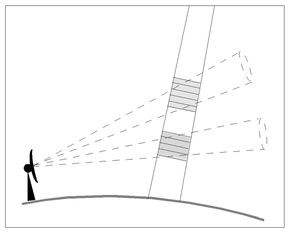
Ground radar data are quality-controlled to eliminate non-precipitation echoes, and for dual-polarization sites, algorithms are applied to derive additional dual-polarization parameters, hydrometeor types, and rain rate estimates. GR data are written to data files in Universal Format (UF).

Satellite/GR Spatial Matching:

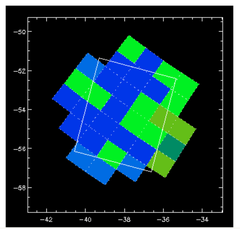
We use DPR/GR and GMI/GR volume matching techniques ("Geo-Match") based on geometric intersection of the two instruments' scans. DPR data are reduced to the vertical resolution and coverage of the individual GR sweeps intersected by the DPR rays by a vertical averaging between the top and bottom of each GR elevation sweep. GR data are averaged only in the horizontal, over the area defined by an intersecting DPR ray's half-power points. For analysis details, see Schwaller and Morris, 2011: A Ground Validation Network for the Global Precipitation Measurement Mission. *J. Atmos. Oceanic Technol.*, 28, 301–319.

GR data are volume matched to the GMI/constellation data in two manners: along the GMI line-of-sight (similar to the DPR matching), and in a vertical column above the GMI surface footprint. The first method describes microphysical conditions the GMI is observing, the second defines the profiles of radar-sensed microphysical conditions contributing to surface rain at the footprint location. All DPR and GMI volume-match data are written to files in netCDF format.

The primary volume-match data quality metrics are the fraction of the DPR and GR range gates in the volume average that exceed the nominal DPR reflectivity detection threshold, taken to be 15 dBZ, and the standard deviation of the reflectivity bin values included in the average. The higher the fraction above threshold, the better the data quality (reduction in beam filling effects). Low standard deviations are desirable to avoid areas of strong reflectivity gradients.



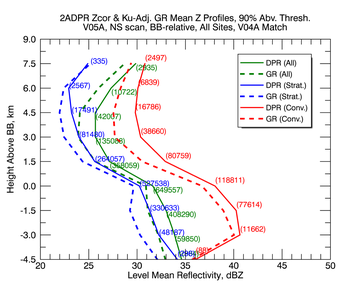
Sample DPR matching volumes (shaded) from intersection with two GR elevation sweeps (dotted). Upper volume is an average of five DPR gates (each ~5km wide by 125m or 250m deep), lower is an average of four PR gates.



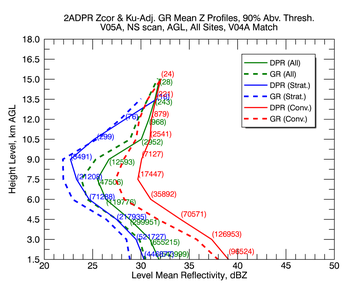
GR 1 km × 1 degree beamwidth gates (colored) are averaged over the area of an intersecting DPR ray. Solid white rectangle shows the boundaries of the geo-match samples as they would be plotted on a PPI or CAPPI.

Analysis Methods:

Volume-matched data area analyzed at scales ranging from summary ("bulk") statistics over the entire dataset down to pixel-to-pixel comparisons in individual storms. Below are examples of bulk analysis, showing the mean reflectivity profiles of attenuation-corrected DPR reflectivity and ground radar reflectivity, by rain type, over the complete DPR-GR volume match dataset (all rainy overpasses of all VN radars).



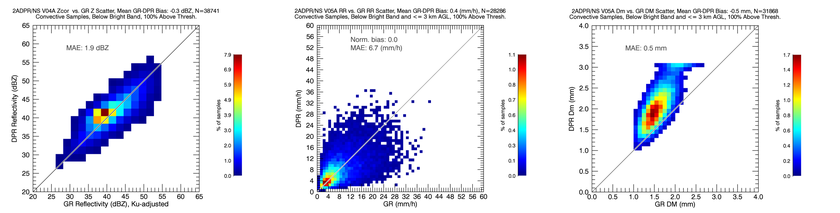
Mean Ku-DPR and Ku-adjusted ground radar reflectivity profiles by rain type, for Version V05A DPR. Heights of data samples are normalized with respect to the height of the bright band (freezing level) above the surface.



Mean Ku-DPR and Ku-adjusted ground radar reflectivity profiles by rain type, for Version V05A DPR. Heights of data samples are with respect to the earth surface.

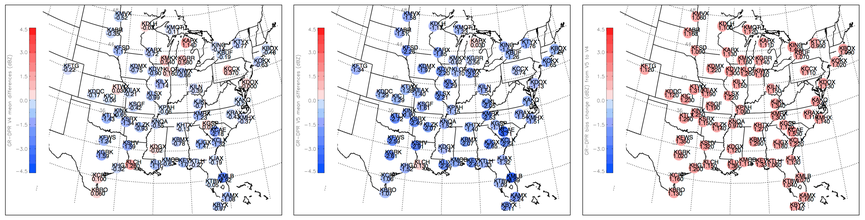
Bulk Analysis results, cont.:

Mean Ku-DPR vs. ground radar reflectivity (Z, left), rain rate (RR, center) and mean drop diameter (D_m, right) scatter for convective rain type below the freezing level, for all sites and rain events in the VN data set, for GPM version V05A. Data samples are constrained to those with 100% of reflectivity range gates in the volume averages above 15 dBZ. GR rain rate is from the DROPS2.0 algorithm (Chen et al., 2015).



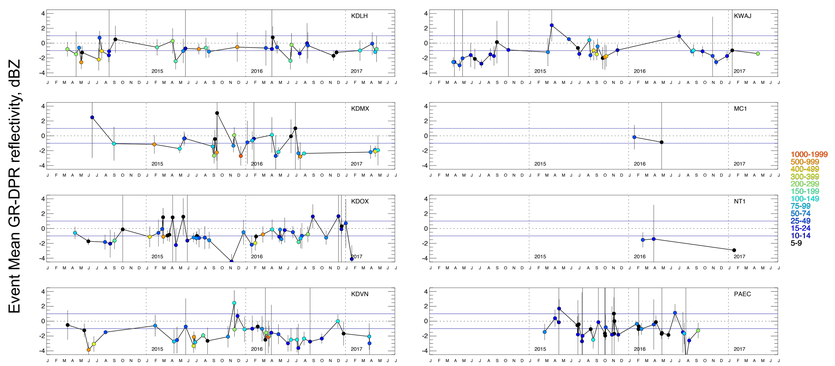
Site-Specific GR-DPR Reflectivity Differences:

Site-specific mean GR-DPR reflectivity differences are shown in the maps below. To minimize beam filling, gradient, and attenuation issues, these differences were limited to samples above the Bright Band, characterized as Stratiform rain type in the DPR product, and having >=90% of reflectivity range gates in their volume averages above 15 dBZ. S-band reflectivity from the GR has been adjusted to equivalent Ku-band reflectivity, as above. Ku-DPR calibration for version V05A (center map) increased DPR reflectivity by 1.3 dBZ over Version V04A (left map). Resulting V4-V5 bias differences are shown in the map on the right.



Site-Specific GR-DPR Reflectivity Difference Time Series:

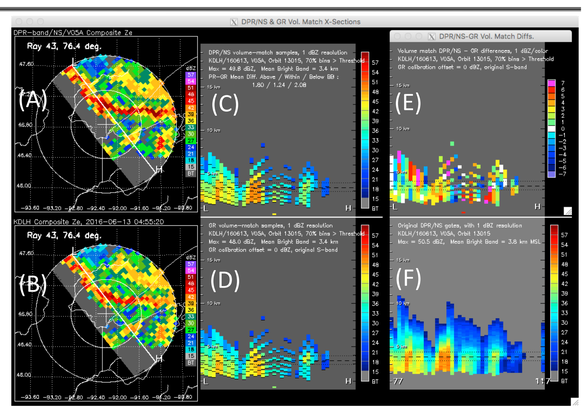
Example time series of site-specific mean GR-DPR reflectivity differences for Version V05A are shown in the plots below. Data are processed in the same manner as in the bias maps above. Points are color-coded by the number of samples in each site overpass rain event that meet the data constraints.



Cross Section Analysis:

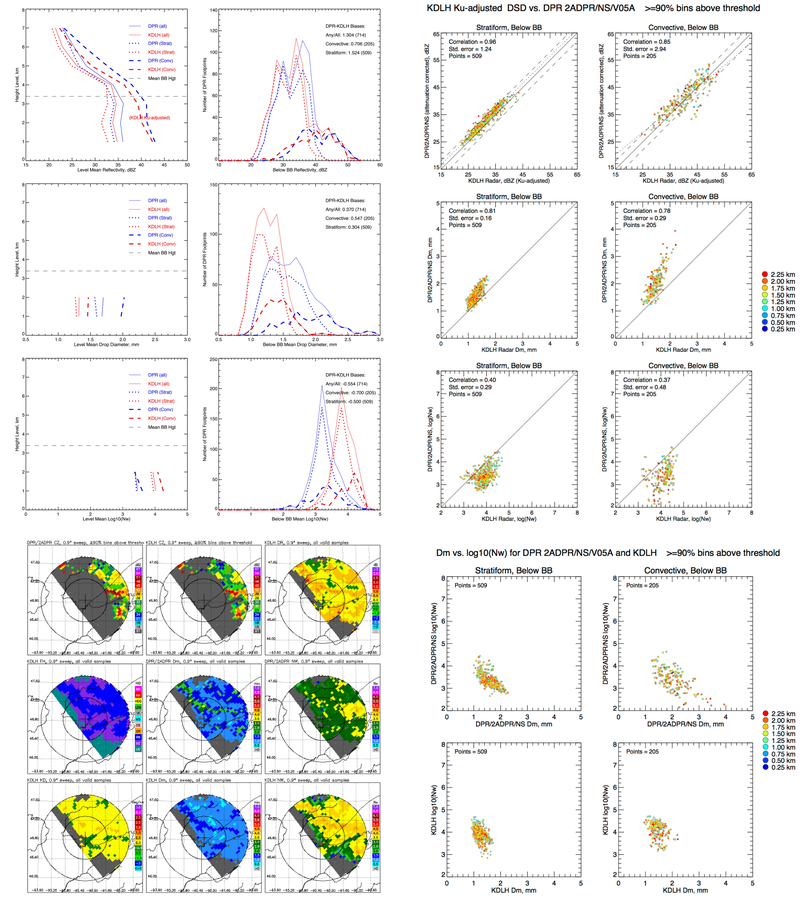
Example output of the VN vertical cross section analysis tool showing volume-matched GR and DPR reflectivity for Version V05A for a single event.

A)PPI plot of DPR volume match composite reflectivity showing the location of the cross section (L-H line). Line is parallel to the orbit at a constant DPR look angle.
B)As in (A), but for the GR data.
C)Vertical cross section of volume-matched DPR attenuation-corrected reflectivity along the L-H line in (A).
D)As in (C), but for GR data.
E)DPR-GR reflectivity difference between data in (C) and (D).
F)As in (C), but plotting the full-vertical-resolution (250 m) Ku-DPR corrected reflectivity along the cross section line.



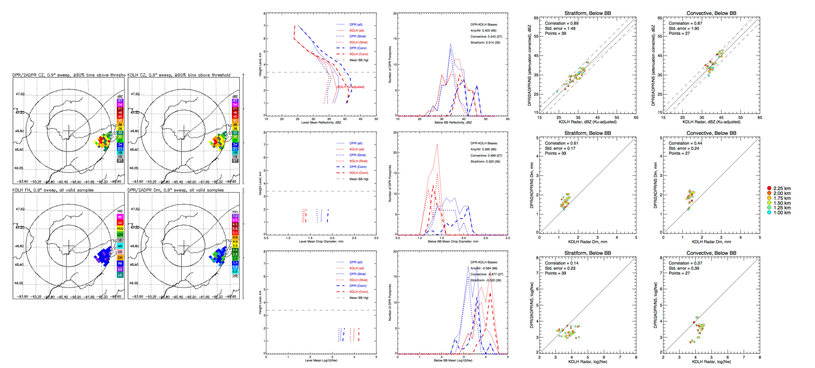
Event-Specific GR-DPR Statistical Analysis:

Example outputs from Z and DSD analysis of single site overpass precipitation event. Analysis is for the entire DPR/GR overlap region within 100 km of the GR.



Storm-scale GR-DPR Statistical Analysis:

For same case as shown above, but analysis is for a single storm region defined by a contiguous area of 35 dBZ or greater in the data columns.



Access GPM constellation satellite and ground radar data, geometry matched data products, documentation, and open source code for volume matching and data analysis and display:

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

Contact us: https://pmm.nasa.gov/contact