**Global Precipitation Mission (GPM)**

**Ground Validation System**

**Validation Network Data Product User’s Guide**

Volume 2 – GPM Data Products

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**Document History**

| Document Version | Date | Changes |
| --- | --- | --- |
| 1.0 | October 22, 2014 | Initial document and netCDF matchup file version |
| 1.1 | March 1, 2015 | - Added definitions of GR\_RC\_rainrate and GR\_RP\_rainrate variables, and DPR variables piaFinal and stormTopHeight for GRtoDPR matchup file version 1.1.  - Modified description of the matchup netCDF data directory structure to reflect the new hierarchical structure under the directory data/gpmgv/netcdf/geo\_match.  - Changed matchup file version descriptor from “V\_v” to “F\_f” to be consistent throughout document. |
| 1.2 | November 16, 2015 | - Added definitions for GR\_DM and GR\_N2 variables and their “have” flags and the DPR\_decluttered variable for GRtoDPR matchup file version 1.2.  - Added definition of GR\_blockage variable and its “have” flag for GRtoDPR matchup file version 1.21, and added both slant path and VPR versions of these variables for the GRtoGPROF file.  - Added description of IDL binary SAVE files in the **blockage** data directory.  - Fixed and generalized GRtoGPROF file directory and naming conventions descriptions.  - Added Brazil radar IDs and locations to Table 1-1, and BrazilRadars orbit subset definition to Table 4-2. |

**Contact Information**

Additional information, including information on VN points-of-contact, can be obtained from the GPM Ground Validation web site:

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

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# Introduction

This document provides a basic set of documentation for the data products available from the GPM Ground Validation System (GVS) Validation Network (VN). In the GPM era the VN performs a direct match-up of GPM’s space-based Dual-frequency Precipitation Radar (DPR) data with ground radar data from the U.S. network of NOAA Weather Surveillance Radar-1988 Doppler (WSR-88D, or “NEXRAD”). Ground radar networks from international partners are also part of the VN. The VN match-up will help evaluate the reflectance attenuation correction algorithms of the DPR and will identify biases between ground observations and satellite retrievals as they occur in different meteorological regimes. A prototype of the capability performed a match-up of Tropical Rainfall Measuring Mission (TRMM) Precipitation Radar (PR) data with ground-based radar (GR) measurements from a subset of the WSR-88D sites now included in the VN operational radar data network (Fig. 1-1). TRMM data and their matching GR observations continue to be part of the VN operations in the GPM era. Volume 1 of the Validation Network Data User’s Guide describes the TRMM-based VN data set.

The approaches to the DPR-to-GR data matching developed for the VN is a *geometry matching technique* based on determining the intersection of the individual DPR rays with each of the elevation sweeps of the circularly-scanning ground radar. The horizontal and vertical locations and number of data points in the geometry matching technique are different for each case due to the randomness of the ray-to-sweep intersections. Section 5 of this document describes the algorithm used to generate geometry-matched data. Data output from the geometry matching technique are stored as netCDF files, with each netCDF file being specific to the GPM overpass of an individual GR site.

A separate but nearly identical matchup technique performs a geometry matching of GR data to the GPM 2B-DPRGMI “Combined” product. A slightly different set of variables is included in the GRtoDPRGMI matchup, but the basic algorithm is the same as for the DPR-to-GR data matching.

A prototype GPM Microwave Imager (GMI)-to-GR geometry matching technique has also been developed. For this product, the GMI near-surface rain rate field from the 2A-GPROF algorithm is matched to the GR reflectivity and dual-polarization fields in two manners. First, the GR data are matched to the GMI at the intersections of the GMI line-of-sight with the GR elevation sweeps, in a similar manner to how the DPR ray intersections with the GR sweeps are computed. Second, the GR sweep intersections along a vertical column above the GMI surface footprint are computed to give the vertical profile of GR reflectivity above the location where the GMI rain rate estimate is assigned in the GPM 2A-GPROF product. This technique will also work with any GPM constellation satellite Microwave Imager data processed with the 2A-GPROF algorithm (e.g. TRMM/TMI, GCOMW1/AMSR2, F15/SSMIS, F16/SSMIS, F17/SSMIS, F18/SSMIS, METOPA/MHS, NOAA18/MHS, NOAA19/MHS). The utility of the GPROF-GR geometry match data has not been vetted by the GPM GMI algorithm developers and is to be considered an experimental product.

For purposes of this document, the term DPR data refers to any of the following products: 2A-DPR, 2A-Ka, and 2A-Ku. Any of these products may be used as valid input to the DPR-to-GR volume-matching algorithm, and the output data format is the same regardless of the GPM DPR Level 2A product used.

## Data Availability

VN match-up, input, and ancillary data are available via anonymous ftp from the site:

[**ftp://hector.gsfc.nasa.gov/gpm-validation/data**](ftp://hector.gsfc.nasa.gov/gpm-validation/data)**.** The site provides access to the raw GPM DPR and GMI data, raw ground radar data, quality controlled ground radar data, as well as geometrically matched DPR-GR, GMI-GR, and DPRGMI-GR data. The directory structure of the ftp site is described in detail in Section 4 of this document. GPM and constellation satellite data products are documented in “PRECIPITATION PROCESSING SYSTEM, GLOBAL PRECIPITATION MEASUREMENT, File Specification for GPM Products”. The naming convention for these products is documented in “[PPS File Naming Convention for Precipitation Products for The Global Precipitation Measurement (GPM) Mission](http://pps.gsfc.nasa.gov/Documents/FileNamingConventionForPrecipitationProductsForGPMMissionV1.4.pdf).” The current version of each of these documents is available from <http://pps.gsfc.nasa.gov/GPMprelimdocs.html> .

## Software Availability

Software to perform the DPR-to-GR, DPRGMI-to-GR, and GMI-to-GR geometry matching, and to display and compute DPR-GR reflectivity and rainrate and GMI-GR rainrate statistics and analysis products from the data is available. Contact a member of the GPM GV team listed at http://pmm.nasa.gov/science/ground-validation.

## Period of Record

The current period of record for the VN match-up datasets starts on 4 March 2014 (GMI) and 8 March 2014 (DPR, Ka, Ku, DPRGMI) and runs to the present. Data for all dates are reprocessed for the latest version of the products, where earlier version of the products are terminated on the date the version is superseded. Because the input ground radar data for the VN match-ups are quality controlled by a human analyst there may be a time lag of several days up to several weeks from observation to VN product generation.

## Match-up Sites

At present, 75 WSR-88D sites are included in the VN operational network (Figure 1-1). Table 1-1 lists the VN site identifiers, long names, and the latitude and longitude of each. The VN short names are used in the VN product file naming convention described in Section 2 of this document. Although the list below was current at the time that this document was written, it is expected that additional routine VN sites will be added from time to time. In addition to these WSR-88D sites, there will be additional GR sites with selected periods/dates of data included in the VN data set. More up-to-date information may be available on the GPM GV web site:

[**http://pmm.nasa.gov/science/ground-validation**](http://pmm.nasa.gov/science/ground-validation)

Check with the GPM GV points-of-contact for current status.

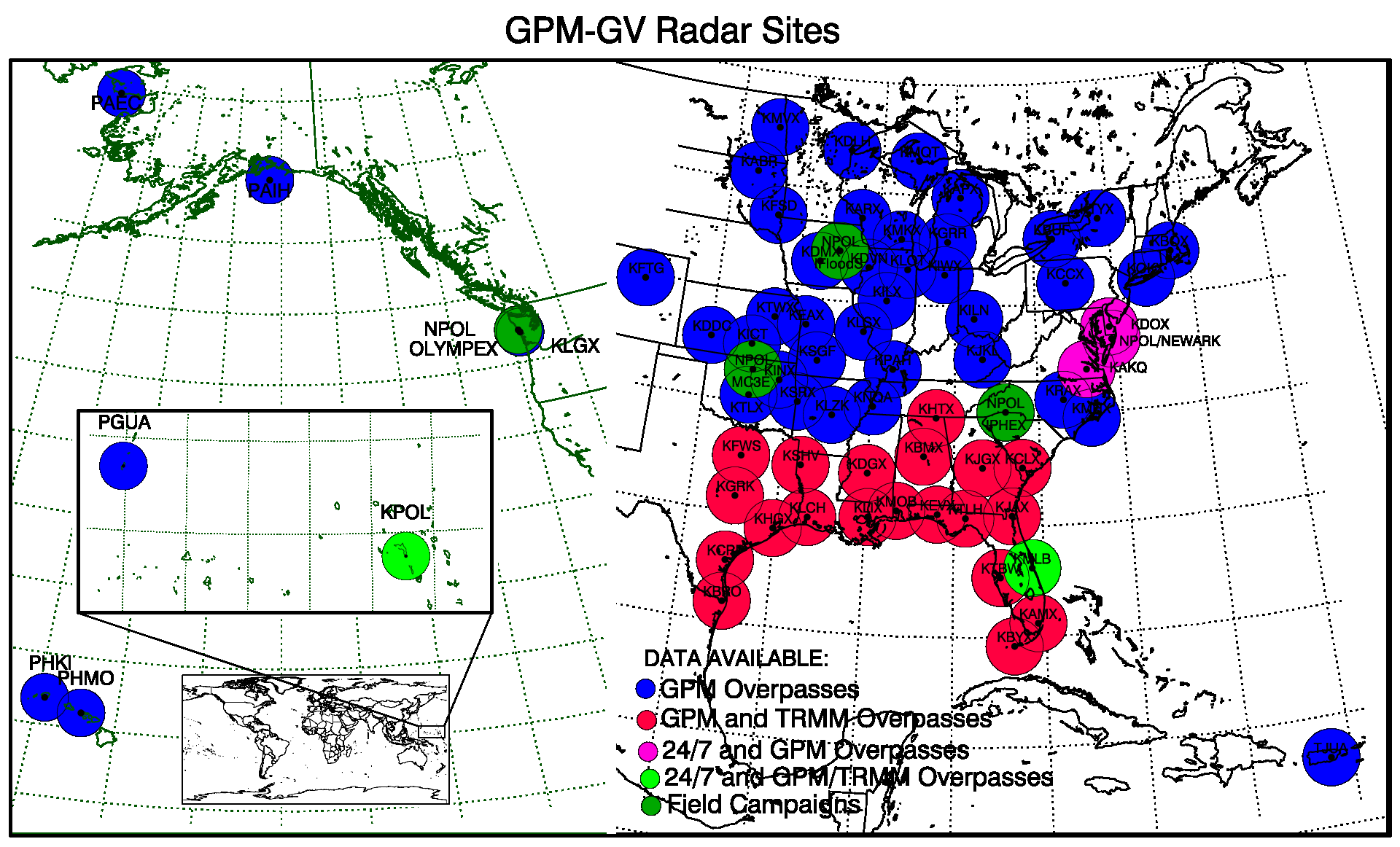
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Figure 1-1. Location of VN match‑up sites in the U.S. For each site, ground radar observation limits are also illustrated.

Table 1-1. WSR-88D and other (in italics) ground radar sites routinely used in the GPM GVS Validation Network.

| Site ID | Site Name | Latitude (N) | Longitude (E) |
| --- | --- | --- | --- |
| KABR | Aberdeen, SD | 45.4558 | -98.4131 |
| KAKQ | Wakefield, VA | 36.9839 | -77.0072 |
| KAMX | Miami, FL | 25.6111 | -80.4128 |
| KAPX | North Central Lower Michigan, MI | 44.9072 | -84.7197 |
| KARX | La Crosse, WI | 43.8228 | -91.1911 |
| KBMX | Birmingham/Alabaster, AL | 33.1722 | -86.7697 |
| KBOX | Boston/Taunton, MA | 41.9558 | -71.1369 |
| KBRO | Brownsville, TX | 25.9161 | -97.4189 |
| KBUF | Buffalo/Cheektowaga, NY | 42.9489 | -78.7367 |
| KBYX | Miami/Boca Chica Key, FL | 24.5975 | -81.7031 |
| KCCX | Central Pennsylvania/Rush, PA | 40.9231 | -78.0036 |
| KCLX | Charleston/Grays, SC | 32.6556 | -81.0422 |
| KCRP | Corpus Christi, TX | 27.7842 | -97.5111 |
| KDDC | Dodge City, KS | 37.7608 | -99.9689 |
| KDFX | Austin/San Antonio/Us Hwy 90, TX | 29.2728 | -100.281 |
| KDGX | Brandon, MS | 32.2797 | -89.9842 |
| KDLH | Duluth, MN | 46.8369 | -92.2097 |
| KDMX | Des Moines/Johnston, IA | 41.7311 | -93.7228 |
| KDOX | Wakefield/Ellendale State Fo, DE | 38.8256 | -75.4397 |
| KDVN | Quad Cities/Davenport, IA | 41.6117 | -90.5808 |
| KEAX | Kansas City/Pleasant Hill, MO | 38.8103 | -94.2644 |
| KEVX | Tallahassee/Eglin AFB, FL | 30.5644 | -85.9214 |
| KFSD | Sioux Falls, SD | 43.5878 | -96.7294 |
| KFTG | Denver/Boulder, CO | 39.7867 | -104.546 |
| KFWS | Dallas/Fort Worth, TX | 32.5731 | -97.3031 |
| KGRK | Dallas/Fort Worth/Ft Hood, TX | 30.7219 | -97.3831 |
| KGRR | Grand Rapids, MI | 42.8939 | -85.5447 |
| KHGX | Houston/Galveston/Dickinson, TX | 29.4719 | -95.0792 |
| KHTX | Birmingham/Northeastern Al, AL | 34.9306 | -86.0833 |
| KICT | Wichita, KS | 37.6547 | -97.4428 |
| KILN | Cincinnati/Wilmington, OH | 39.4203 | -83.8217 |
| KILX | Central Illinois/Lincoln, IL | 40.1506 | -89.3369 |
| KINX | Tulsa/Inola, OK | 36.175 | -95.5647 |
| KIWX | Northern Indiana/North Webster, IN | 41.4086 | -85.7 |
| KJAX | Jacksonville, FL | 30.4847 | -81.7019 |
| KJGX | Atlanta/State Hwy 96, GA | 32.6753 | -83.3511 |
| KJKL | Jackson/Noctor, KY | 37.5908 | -83.3131 |
| KLCH | Lake Charles, LA | 30.1253 | -93.2158 |
| KLGX | Langley Hill NW WA, WA | 47.1158 | -124.107 |
| KLIX | New Orleans/Baton Rouge/Slidell, LA | 30.3367 | -89.8256 |
| KLOT | Chicago/Romeoville, IL | 41.6047 | -88.0847 |
| KLSX | St. Louis/St Charles, MO | 38.6989 | -90.6828 |
| KLZK | Little Rock/N Little Rock, AR | 34.8364 | -92.2622 |
| KMHX | Morehead City/Newport, NC | 34.7761 | -76.8761 |
| KMKX | Milwaukee/Dousman, WI | 42.9678 | -88.5506 |
| KMLB | Melbourne, FL | 28.1133 | -80.6542 |
| KMOB | Mobile, AL | 30.6794 | -88.2397 |
| KMQT | Marquette, MI | 46.5311 | -87.5483 |
| KMRX | Knoxville/Tri-cities/Morristown TN | 36.1686 | -83.4017 |
| KMVX | Eastern North Dakota/Mayville, ND | 47.5278 | -97.3256 |
| KNQA | Memphis/Millington, TN | 35.3447 | -89.8733 |
| KOKX | New York City/Upton, NY | 40.8656 | -72.8639 |
| KOTX | Spokane, WA | 47.6803 | -117.627 |
| KPAH | Paducah, KY | 37.0683 | -88.7719 |
| KRAX | Raleigh/Durham/Clayton, NC | 35.6656 | -78.4897 |
| KSGF | Springfield, MO | 37.2353 | -93.4006 |
| KSHV | Shreveport, LA | 32.4508 | -93.8414 |
| KSRX | Tulsa/Western Arkansas, AR | 35.2906 | -94.3617 |
| KTBW | Tampa Bay Area/Ruskin, FL | 27.7056 | -82.4017 |
| KTLH | Tallahassee, FL | 30.3975 | -84.3289 |
| KTLX | Oklahoma City/Norman, OK | 35.3331 | -97.2778 |
| KTWX | Topeka/Alma, KS | 38.9969 | -96.2325 |
| KTYX | Montague/Fort Drum, NY | 43.7558 | -75.68 |
| PAEC | Nome, AK | 64.5114 | -165.295 |
| PAIH | Anchorage/Middleton Island, AK | 59.4614 | -146.303 |
| PGUA | Guam | 13.4544 | 144.808 |
| PHKI | Kauai, HI | 21.8942 | -159.552 |
| PHMO | Molokai, HI | 21.1328 | -157.18 |
| TJUA | San Juan, PR | 18.1156 | -66.078 |
| *KWAJ*  *(KPOL)* | *Kwajalein, Marshall Islands* | *8.71796* | *167.733* |
| *AL1* | *Almenara, MG, Brazil* | *-16.2019* | *-40.6742* |
| *JG1* | *Jaraguari, MS, Brazil* | *-20.2915* | *-54.4658* |
| *MC1* | *Maceio, AL, Brazil* | *-9.55139* | *-35.7708* |
| *NT1* | *Natal, RN, Brazil* | *-5.90444* | *-35.254* |
| *PE1* | *Petrolina, PE, Brazil* | *-9.36722* | *-40.5728* |
| *SF1* | *Sao Francisco, SC, Brazil* | *-16.0173* | *-44.6953* |
| *ST1* | *Santa Teresa, RJ, Brazil* | *-19.9888* | *-40.5794* |
| *SV1* | *Salvador, BA, Brazil* | *-12.9025* | *-38.3267* |
| *TM1* | *Tres Marias, MG, Brazil* | *-18.2072* | *-45.4606* |

## The “100-in-100” Criterion

In all cases, data products generated by the VN adhere to the “100-in-100” criterion. That is, event files described in subsequent sections of this document have 100 or more gridpoints indicating “Rain\_Certain,” as defined by the GPM DPR 2A-Ku product, that fall within 100 km of a ground radar. For this purpose, selected 2A-Ku variables are analyzed to temporary 4-km-resolution grids of 300x300 km extent, one centered on each GR site overpassed in a given orbit. Metadata concerning the precipitation and DPR/GR overlap statuses of each overpass event are computed from the temporary grids and stored in the GPM GV database, which can be queried to determine which events meet the “100-in-100” criterion, or other user-defined criteria. Matched-up DPR and GR data products and GMI and GR data products in the form of netCDF files are generated and stored on the VN ftp director**y data/gpmgv/netCDF/geomatch/** for any event that meets the DPR 100-in-100 criterion (see Section 4 for a complete description of the VN ftp directory structure and file naming conventions).

The VN’s internal database actually stores GPM DPR, DPRGMI and GMI, TRMM PR and TMI, and ground radar data for *all* coincident events where the TRMM or GPM passes within 200 km of the ground radar, whether it is raining or not. Ground radar data are stored in the **data/gpmgv/gv\_radar** directory and GPM and TRMM data are stored in the **data/gpmgv/orbit\_subsets** directory of the VN ftp site. See Section 4 for a complete description of the VN ftp directory structure and file-naming conventions.

## Validation Network data product netCDF format

The DPR-GR, DPRGMI-GR, and GMI-GR geometry match data products are formatted according to the network Common Data Format (netCDF) standard. The netCDF standard is maintained by the Unidata Program of the University Corporation for Atmospheric Research (UCAR). More information on netCDF can be found on the Unidata website:

**http://www.unidata.ucar.edu/software/netcdf**

There are three basic components of the netCDF files termed *attributes, dimensions* and *variables*, which are described briefly below.

*Attributes* contain auxiliary information about each netCDF *variable*. Each *attribute* has a name, data type and length associated with it. netCDF also permits the definition of *global attributes*, which typically apply to the data set as a whole, rather than to individual variables in the data. The PR-GR netCDF matchup files contain seven *global attributes*, and the GMI-GR netCDF matchup files contain four.

*Dimensions* are named integers that are use to specify the size (dimensionality) of one or more *variables*.

*Variables* are scalars or multidimensional arrays of values of the same data type. Each *variable* has a size, type and name associated with it. *Variables* also typically have *attributes* that describe them.

# Geometry-Matched Data Products

## Archive site directory

As previously described in Section 1.1, VN match-up data are available via anonymous ftp from:

[**ftp://hector.gsfc.nasa.gov/gpm-validation/data**](ftp://hector.gsfc.nasa.gov/gpm-validation/data)**/gpmgv**

Data from the geometry-matching techniques are located under the subdirectory **netcdf/geo\_match**. The geometry-matching technique allows for comparison of actual space and ground network measurements (i.e., data are **not** resampled in 3 dimensions). This method has replaced the heritage gridding technique, which is no longer used as a primary VN data comparison method.

## File Name Convention

Geometry matching data in the **netcdf/geo\_match** directory are stored as gzip-compressed netCDF files by site (4-letter site ID, see Table 1-1), event date, and orbit number (see Section 4). The data volume of each file varies depending on the numbers of GR sweep elevations and DPR/GR “overlap” points in each file, but files of 10 to 100 or more MByte are typical (larger for DPRGMI matchup files due to the inclusion of all scan types in the 2B-DPRGMI file).

The site-specific gzip file unpacks to a netCDF-format file identifiable by matchup GPM data type (DPR, DPRGMI, or GMI), GR site, date, GPM orbit number, product version, DPR 2A data type (DPR, KA, or KU), DPR swath type used (HS, MS, or NS) and geometry match file version according to the file naming conventions:

GRtoDPR.SHORTNAME.YYMMDD.ORBIT.Vnnv.TT.SS.F\_f.nc.gz

GRtoDPR.SHORTNAME.YYMMDD.ORBIT.Vnnv.TT.SS.F\_f.RHI.nc.gz

GRtoDPRGMI.SHORTNAME.YYMMDD.ORBIT.Vnnv.F\_f.nc.gz

GRtoGPROF.SHORTNAME.YYMMDD.ORBIT.Vnnv.F\_f.nc.gz

where:

|  |  |
| --- | --- |
| GRtoXXX | = matchup type, literal GRtoDPR, GRtoDPRGMI, or GRtoGPROF |
| SHORTNAME | = GR site identifier (see Table 1-1) |
| YY | = 2-digit year |
| MM | = 2-digit month |
| DD | = 2-digit day (in UTM) |
| ORBITNUMBER | = GPM orbit number |
| Vnnv | = GPM product algorithm major (nn) and minor (v) version, beginning with literal “V” character, e.g., V02B |
| TT | = DPR 2A data type (DPR, KA, or KU). Field does not apply to GRtoGPROF or GRtoDPRGMI matchup filenames |
| SS | = type of swath used in the GR-DPR matchup (HS, MS, or NS). Field does not apply to GRtoGPROF and GRtoDPRGMI filenames |
| F\_f | = Geometry match file Major/minor file version indicator, e.g. 2\_1 for version 2.1 matchup file |
| RHI | Literal “RHI” to indicate that the GR data used in the matchup are from a Range-Height Indicator (RHI) vertically-scanned volume rather than the usual Plan Position Indicator (PPI) horizontal sweep volume scan |
| .nc | Literal “.nc” characters indicating a netCDF file format |
| .gz | Literal “.gz”, only present if the file is compressed using *gzip* |

The .nc designation indicates that the files are in the netCDF format. The .gz extension, if present, indicates that the file is compressed using the *gzip* utility.

Each GRtoDPR file type includes GPM DPR and ground radar data stored in netCDF format as described in Section 3 of this document. DPR reflectivity and rain rate profile data are obtained from the standard Level 2A GPM DPR products. A surface type flag, near-surface rain rate, bright band height, rain type, rain/no-rain flag and other variables are also included from these DPR products. See the geometry-match netCDF file summary in Section 3.

Each GRtoDPR matchup file uses DPR data from only one of the available scan types (stored in the 2A HDF5 files as separate “swaths”) of data present in the Level 2A DPR product. The 2A-DPR HDF5 files contain all three of the swath types: high-resolution scan (HS), matched scan (MS), and normal scan (NS). The 2A-KA HDF5 files contain HS and MS swaths, and the 2A-KU HDF5 file contains only the NS swath. In contrast, the GRtoDPRGMI matchup files contain volume-matched data for all instrument/swath combinations present in the 2B-DPRGMI HDF5 dataset: HS, MS, and NS.

Ground radar data included in these files are normally derived from the horizontal-sweep-scanning (PPI) radar data that has been quality-controlled and processed into an intermediate 1C‑UF product data file in Universal Format (UF). An alternate matchup method for the GRtoDPR product uses vertically-scanned (RHI) data from the ground radar in the UF format. The output GRtoDPR netCDF file format is the same for either type of GR scan.

Geometry matchup of the DPR and ground radar data is performed using methods based on those described by Bolen and Chandrasekar[[1]](#footnote-1). Matchup of ghe DPRGMI and ground radar data follows an identical method. Matchup of the GMI and ground radar data uses a similar approach to the DPR matchups, with modifications for the GMI viewing geometry. See Section 5 for algorithm details.

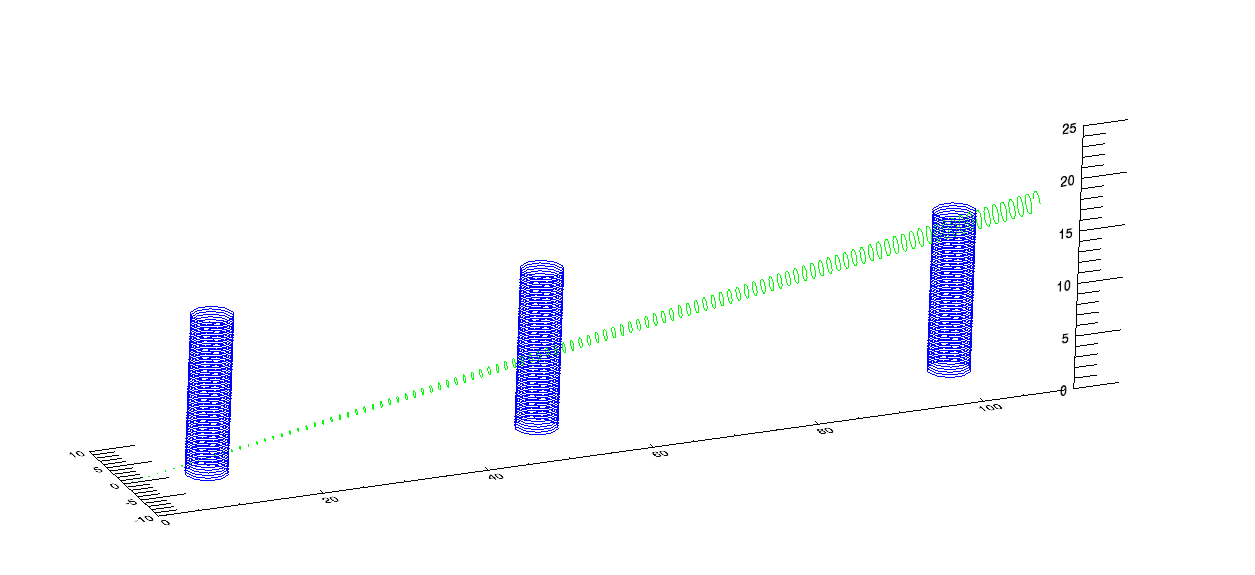
## DPR-GR Geometry Matching Data Characteristics

The single- and multi-level spatial data fields in the geometry match data are not at fixed locations. Their horizontal locations are defined by the location of the DPR rays within the DPR scans. The number of DPR rays whose data are included in the product depends on the number of rays whose surface location is within 100 km (by default -- range is configurable) of the corresponding ground radar location. The vertical locations of the data points are defined by the intersections of the DPR ray with each of the elevation sweeps of the ground radar. See Figure 2-1 for an illustration of the intersection of DPR footprints with GR echoes. The DPRGMI geometry is essentially the same as the DPR geometry, so these descriptions apply to both datasets.

The multi-level, spatial data variables are stored as 2-D arrays in the geo-match products, with dimensions of [elevationAngle, fpdim], where elevationAngle is the number of elevation sweeps (or elevation steps in the cae of an RHI scan) in the ground radar volume scan, and fpdim is the number of DPR rays (footprints) within the 100 km of the ground radar location. The variables holding the x- and y-locations of the four corners of the DPR footprints (used only for plotting the data as images) with the additional dimension ‘xydim’, and the variable ‘GR\_HID’ for GR hydrometeor type with the additional dimension ‘hidim’ are the only multi-level variables in the file requiring 3 dimensions.

The single-level, spatial data variables stored as 2-D (ray,scan) fields in the satellite data products are stored as 1-D arrays in the geo-match products, with dimension of [fpdim]. Each single-level and multi-level “science” variable has an associated scalar ‘flag’ variable (e.g., have\_TypePrecip) that indicates whether the variable is populated with actual values (flag = 1) or is just initialized with “Fill” values (flag = 0).

The original DPR date file name and the scan and ray number corresponding to each DPR ray in the fpdim dimension are stored in the matchup netCDF files, such that it is possible to read additional DPR variables from the original DPR data files at the same locations as the fields contained in the matchup files.



**Figure 2-1.** An illustration of the intersection between Ground Radar sweeps and Precipitation Radar footprints. Only a select number of radar echoes are illustrated in either case.

Since the horizontal and vertical positions of each data point in the geometry matching data set are essentially random, each data value of the spatial data variables has a set of associated horizontal and (for the multi-level variables) vertical position variables. All points have both a latitude and a longitude value, corrected for viewing angle in the case of the multi-level variables. The multi-level variables also have associated variables specifying the x- and y-corners of the DPR footprint **for data plotting purposes** (in km, relative to a Cartesian coordinate system centered at the location of the ground radar, with the +y axis pointing due north), and the top and bottom height of the ground radar elevation sweep at the DPR ray intersection point, in km above the surface. A summary is provided in Section 3 of this document of all *dimensions, attributes,* and *variables* in the Geometry Matching netCDF files.

## The “expected/rejected” Matchup Variables

One set of DPR-GR geometry match variables in the netCDF files is concerned with the coincidence of ground radar (GR) and satellite precipitation radar (DPR) range gates. These variables provide a metric that can be used to assess the “goodness” of the matchup between the radars. These “expected/rejected” variables are described in some detail below, because their content and meaning may otherwise be difficult to understand. As for the other geometry matchup variables, valid values for categorical variables are listed in Section 3 of this document. The meaning of all other variables can be deduced from the complete list of the geometry matchup variables and their associated units, which can also be found in Section 3 of this document.

For a given DPR ray, several GR range gates and rays will typically intersect several PR range gates, as illustrated in vertical cross section in Figure 2-1, above. The geometry matching algorithm converts DPR and GR dBZ to Z, and then vertically averages Z values for all DPR range gates within the vertical extent (defined by the GR beam width and range from the radar) of a GR elevation scan for those areas where a GR elevation sweep intersects a DPR ray (Fig. 2.2). In contrast, GR data are averaged only in the horizontal in the area surrounding the matched DPR field-of-view for each DPR ray, treating each GR sweep as a separate entity, as shown in Figure 2-3.

Only those gates at or above a specified reflectivity or rain rate threshold are included in the DPR and GR gate averages (variables DPR\_dBZ\_min, GR\_dBZ\_min, and rain\_min). The VN algorithm calculates the number of DPR and GR gates expected (from a strictly geometric standpoint) and rejected (below the applicable measurement threshold) in generating these averages and stores them in netCDF variables as defined below.

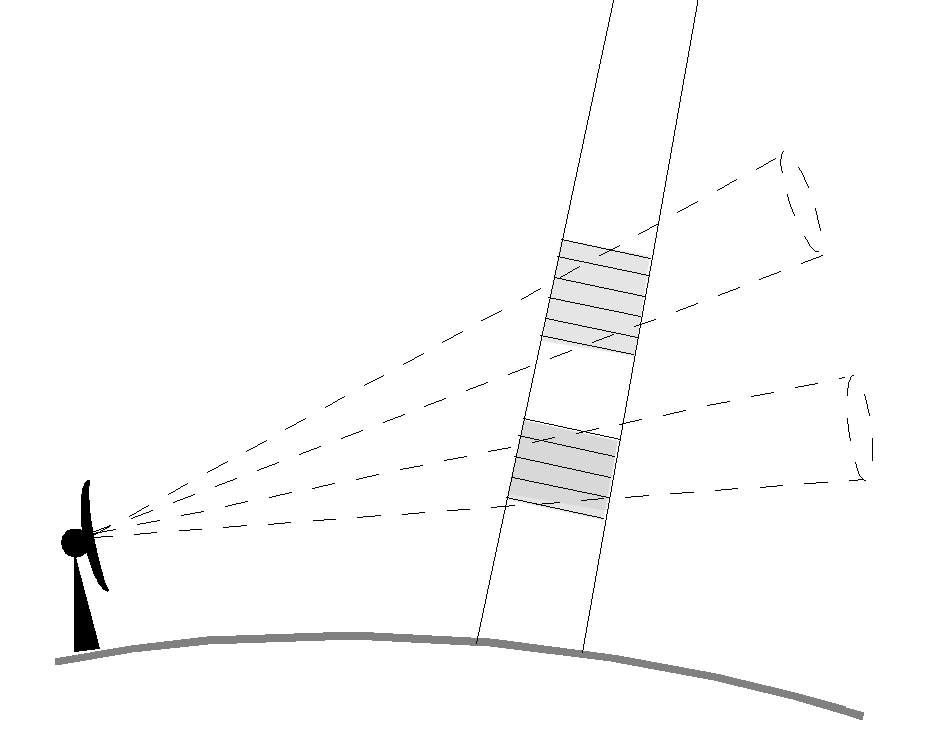
• GR reflectivity: n\_gr\_expected, n\_gr\_rejected

• DPR uncorrected reflectivity: n\_dpr\_expected, n\_dpr\_meas\_z\_rejected

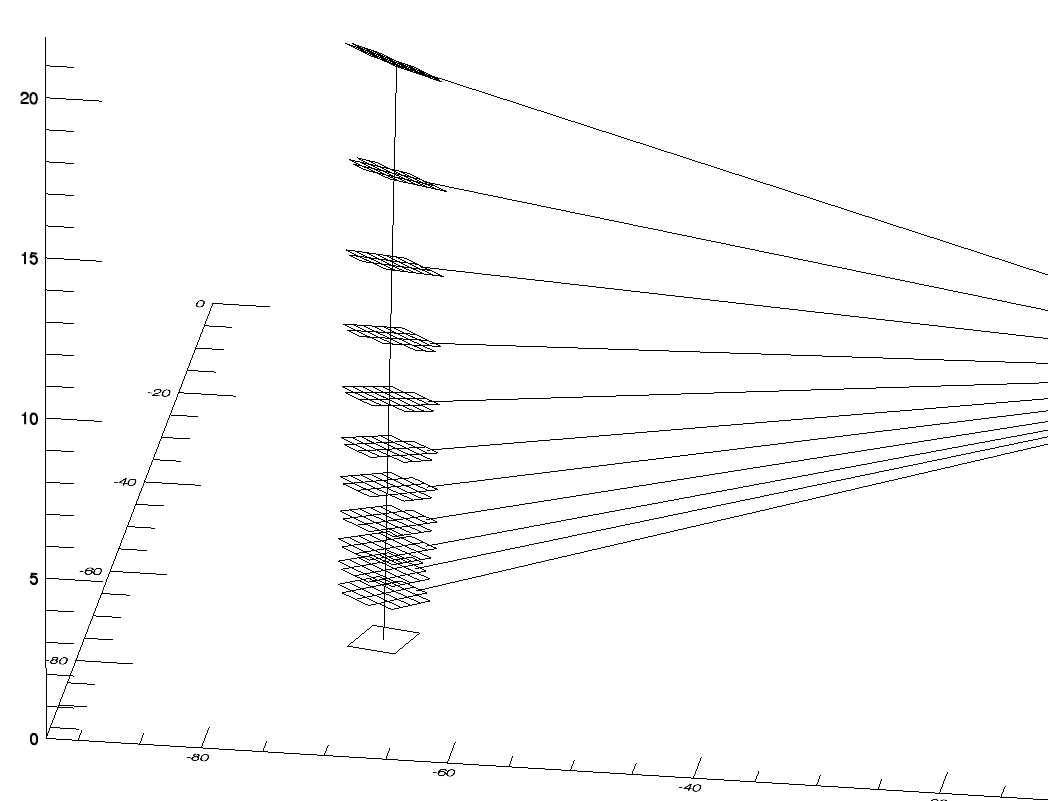
• DPR corrected reflectivity: n\_dpr\_expected, n\_dpr\_corr\_z\_rejected.

The effects of non-uniform beam filling can be minimized in cases where the number of rejected gates is zero in both of the GR and DPR match-up volumes, and where the standard deviation of GR reflectivity (GR\_Z\_StdDev variable in netCDF matchup file) is low. Use of the DPR-GR expected/rejected variables and cutoff thresholds and their effects on the reflectivity comparisons results is presented in detail in Appendix 1.

Only the GR expected/rejected variables are included in the GMI-GR matchup data, as there is no averaging of GMI data in the volume matching. In the GMI matching algorithm, the quasi-vertical DPR ray boundaries shown in Figs. 2-2 and 2-3 would be replaced with the highly sloping GMI line-of-sight from the satellite to the surface footprint for purposes of determining the GR intersections with the GMI. In addition to the line-of-sight matchups, GR data are also averaged along a vertical column above the GMI surface footprint, resulting in a second set of GR volume average and expected/rejected matchup variables in the GMI-GR data files.



**Figure 2-2.** Schematic of DPR gate averaging at GR sweep intersections. Shaded areas show individual DPR gates intersecting the vertical extent of two GR sweeps (dashed) at different elevation angles. Only one DPR ray is shown. The reflectivity values of the individual DPR gates are averaged over the vertical extent of the GR sweeps, resulting (in this example) in two matching volumes.



**Figure 2-3.** Schematic representation of GR volume matching to DPR. Square outline at surface, plotted from the x- and y-corners of the DPR footprint stored in the matchup netCDF file, shows the earth-surface location of a single DPR ray whose centerline is shown as a vertical line. The "waffle" areas show the horizontal outline of GR gates mapped to the DPR ray for each individual elevation sweep of the ground radar, which is located off the right side of the figure at X=0, Y=0, where X, Y, and Z are in km. Sloping lines are drawn between the GR sample volumes and the ground radar along the GR sweep surfaces. GR range gates are inverse-distance-weighted from the DPR ray centerline to compute the GR averages for the matching volumes. Vertical extent and overlap of the GR gates is not shown. GR azimuth/range resolution is 1° by 1 km in the plot.

# Summary of the Geometry Match netCDF files

Geometry matching netCDF data files are formatted with 6 dimensions: 4 for data arrays, and 2 for character variables. There are 116 regular variables and 19 global attributes in the DPR-GR matchup files, and 114 regular variables and 11 global attributes in the GMI-GR matchup files. The two types of matchup files are described in detail in Sections 3.1 and 3.2, below.

## DPR-GR Geometry Match netCDF file description

The format and content of Version 1.21 of the GRtoDPR-type Geometry Match netCDF file is presented below, in the form of partial netCDF file creation instructions. The values for dimensions having a fixed size for all files are specified, while those for dimensions which vary on a file by file basis by site overpass event (fpdim and elevationAngle) are left unspecified. Note that the fill values for non-int variables have a type indicator appended to the numerical value, e.g. ‑888.f for a FLOAT fill value, 1s for a SHORT integer fill value. The global attributes DPR\_Version, DPR\_Scantype, DPR\_2AKU\_file and GR\_file have been assigned values based on a real 2A-Ku matchup for purposes of the example. A different GV\_UF\_Z\_field value (depends on the type of GR radar site) would result if a different data field is used as the source of reflectivity data from the GR data file used as input to the geometry matching application. Other GV\_UF\_xxx\_field global variables for GR dual-polarization derived fields (Zdr, Kdp, etc.) are left at their default values.

Table 3.1-1 summarizes the name, type, dimension, and special values (e.g., Missing Data) associated with each “science” and geolocation array variable in the GRtoDPR-type geo-match netCDF files. Table 3.1-2 provides the definitions of the values of categorical variables.

dimensions:

fpdim = ;

elevationAngle = ;

xydim = 4 ;

hidim = 15 ;

len\_atime\_ID = 19 ;

len\_site\_ID = 4 ;

variables:

float elevationAngle(elevationAngle) ;

elevationAngle:long\_name = "Radar Sweep Elevation Angles" ;

elevationAngle:units = "degrees" ;

int numScans ;

numScans:long\_name = "Number of DPR scans in original datasets" ;

numScans:\_FillValue = -888 ;

short numRays ;

numRays:long\_name = "Number of DPR rays per scan in original datasets" ;

numRays:\_FillValue = -888s ;

float rangeThreshold ;

rangeThreshold:long\_name = "Dataset maximum range from radar site" ;

rangeThreshold:\_FillValue = -888.f ;

rangeThreshold:units = "km" ;

float DPR\_dBZ\_min ;

DPR\_dBZ\_min:long\_name = "minimum DPR bin dBZ required for a \*complete\* DPR vertical average" ;

DPR\_dBZ\_min:\_FillValue = -888.f ;

DPR\_dBZ\_min:units = "dBZ" ;

float GR\_dBZ\_min ;

GR\_dBZ\_min:long\_name = "minimum GR bin dBZ required for a \*complete\* GR horizontal average" ;

GR\_dBZ\_min:\_FillValue = -888.f ;

GR\_dBZ\_min:units = "dBZ" ;

float rain\_min ;

rain\_min:long\_name = "minimum DPR rainrate required for a \*complete\* DPR vertical average" ;

rain\_min:\_FillValue = -888.f ;

rain\_min:units = "mm/h" ;

short DPR\_decluttered ;

DPR\_decluttered:long\_name = "decluttered flag for DPR volume average data fields" ;

DPR\_decluttered:\_FillValue = 0s ;

short have\_GR\_Z ;

have\_GR\_Z:long\_name = "data exists flag for GR\_Z" ;

have\_GR\_Z:\_FillValue = 0s ;

short have\_GR\_Zdr ;

have\_GR\_Zdr:long\_name = "data exists flag for GR\_Zdr" ;

have\_GR\_Zdr:\_FillValue = 0s ;

short have\_GR\_Kdp ;

have\_GR\_Kdp:long\_name = "data exists flag for GR\_Kdp" ;

have\_GR\_Kdp:\_FillValue = 0s ;

short have\_GR\_RHOhv ;

have\_GR\_RHOhv:long\_name = "data exists flag for GR\_RHOhv" ;

have\_GR\_RHOhv:\_FillValue = 0s ;

short have\_GR\_RC\_rainrate ;

have\_GR\_RC\_rainrate:long\_name = "data exists flag for GR\_RC\_rainrate" ;

have\_GR\_RC\_rainrate:\_FillValue = 0s ;

short have\_GR\_RP\_rainrate ;

have\_GR\_RP\_rainrate:long\_name = "data exists flag for GR\_RP\_rainrate" ;

have\_GR\_RP\_rainrate:\_FillValue = 0s ;

short have\_GR\_RR\_rainrate ;

have\_GR\_RR\_rainrate:long\_name = "data exists flag for GR\_RR\_rainrate" ;

have\_GR\_RR\_rainrate:\_FillValue = 0s ;

short have\_GR\_HID ;

have\_GR\_HID:long\_name = "data exists flag for GR\_HID" ;

have\_GR\_HID:\_FillValue = 0s ;

short have\_GR\_Dzero ;

have\_GR\_Dzero:long\_name = "data exists flag for GR\_Dzero" ;

have\_GR\_Dzero:\_FillValue = 0s ;

short have\_GR\_Nw ;

have\_GR\_Nw:long\_name = "data exists flag for GR\_Nw" ;

have\_GR\_Nw:\_FillValue = 0s ;

short have\_GR\_Dm ;

have\_GR\_Dm:long\_name = "data exists flag for GR\_Dm" ;

have\_GR\_Dm:\_FillValue = 0s ;

short have\_GR\_N2 ;

have\_GR\_N2:long\_name = "data exists flag for GR\_N2" ;

have\_GR\_N2:\_FillValue = 0s ;

short have\_GR\_blockage ;

have\_GR\_blockage:long\_name = "data exists flag for ground radar blockage fraction" ;

have\_GR\_blockage:\_FillValue = 0s ;

short have\_ZFactorMeasured ;

have\_ZFactorMeasured:long\_name = "data exists flag for ZFactorMeasured" ;

have\_ZFactorMeasured:\_FillValue = 0s ;

short have\_ZFactorCorrected ;

have\_ZFactorCorrected:long\_name = "data exists flag for ZFactorCorrected" ;

have\_ZFactorCorrected:\_FillValue = 0s ;

short have\_piaFinal ;

have\_piaFinal:long\_name = "data exists flag for piaFinal" ;

have\_piaFinal:\_FillValue = 0s ;

short have\_paramDSD ;

have\_paramDSD:long\_name = "data exists flag for paramDSD variables (Dm and Nw)" ;

have\_paramDSD:\_FillValue = 0s ;

short have\_PrecipRate ;

have\_PrecipRate:long\_name = "data exists flag for PrecipRate" ;

have\_PrecipRate:\_FillValue = 0s ;

short have\_LandSurfaceType ;

have\_LandSurfaceType:long\_name = "data exists flag for LandSurfaceType" ;

have\_LandSurfaceType:\_FillValue = 0s ;

short have\_PrecipRateSurface ;

have\_PrecipRateSurface:long\_name = "data exists flag for PrecipRateSurface" ;

have\_PrecipRateSurface:\_FillValue = 0s ;

short have\_SurfPrecipTotRate ;

have\_SurfPrecipTotRate:long\_name = "data exists flag for SurfPrecipTotRate" ;

have\_SurfPrecipTotRate:\_FillValue = 0s ;

short have\_heightStormTop ;

have\_heightStormTop:long\_name = "data exists flag for heightStormTop" ;

have\_heightStormTop:\_FillValue = 0s ;

short have\_BBheight ;

have\_BBheight:long\_name = "data exists flag for BBheight" ;

have\_BBheight:\_FillValue = 0s ;

short have\_BBstatus ;

have\_BBstatus:long\_name = "data exists flag for BBstatus" ;

have\_BBstatus:\_FillValue = 0s ;

short have\_qualityData ;

have\_qualityData:long\_name = "data exists flag for qualityData" ;

have\_qualityData:\_FillValue = 0s ;

short have\_FlagPrecip ;

have\_FlagPrecip:long\_name = "data exists flag for FlagPrecip" ;

have\_FlagPrecip:\_FillValue = 0s ;

short have\_TypePrecip ;

have\_TypePrecip:long\_name = "data exists flag for TypePrecip" ;

have\_TypePrecip:\_FillValue = 0s ;

short have\_clutterStatus ;

have\_clutterStatus:long\_name = "data exists flag for clutterStatus" ;

have\_clutterStatus:\_FillValue = 0s ;

float latitude(elevationAngle, fpdim) ;

latitude:long\_name = "Latitude of data sample" ;

latitude:units = "degrees North" ;

latitude:\_FillValue = -888.f ;

float longitude(elevationAngle, fpdim) ;

longitude:long\_name = "Longitude of data sample" ;

longitude:units = "degrees East" ;

longitude:\_FillValue = -888.f ;

float xCorners(elevationAngle, fpdim, xydim) ;

xCorners:long\_name = "data sample x corner coords." ;

xCorners:units = "km" ;

xCorners:\_FillValue = -888.f ;

float yCorners(elevationAngle, fpdim, xydim) ;

yCorners:long\_name = "data sample y corner coords." ;

yCorners:units = "km" ;

yCorners:\_FillValue = -888.f ;

float topHeight(elevationAngle, fpdim) ;

topHeight:long\_name = "data sample top height AGL" ;

topHeight:units = "km" ;

topHeight:\_FillValue = -888.f ;

float bottomHeight(elevationAngle, fpdim) ;

bottomHeight:long\_name = "data sample bottom height AGL" ;

bottomHeight:units = "km" ;

bottomHeight:\_FillValue = -888.f ;

float GR\_Z(elevationAngle, fpdim) ;

GR\_Z:long\_name = "GV radar QC Reflectivity" ;

GR\_Z:units = "dBZ" ;

GR\_Z:\_FillValue = -888.f ;

float GR\_Z\_StdDev(elevationAngle, fpdim) ;

GR\_Z\_StdDev:long\_name = "Standard Deviation of GV radar QC Reflectivity" ;

GR\_Z\_StdDev:units = "dBZ" ;

GR\_Z\_StdDev:\_FillValue = -888.f ;

float GR\_Z\_Max(elevationAngle, fpdim) ;

GR\_Z\_Max:long\_name = "Sample Maximum GV radar QC Reflectivity" ;

GR\_Z\_Max:units = "dBZ" ;

GR\_Z\_Max:\_FillValue = -888.f ;

float GR\_Zdr(elevationAngle, fpdim) ;

GR\_Zdr:long\_name = "DP Differential Reflectivity" ;

GR\_Zdr:units = "dB" ;

GR\_Zdr:\_FillValue = -888.f ;

float GR\_Zdr\_StdDev(elevationAngle, fpdim) ;

GR\_Zdr\_StdDev:long\_name = "Standard Deviation of DP Differential Reflectivity" ;

GR\_Zdr\_StdDev:units = "dB" ;

GR\_Zdr\_StdDev:\_FillValue = -888.f ;

float GR\_Zdr\_Max(elevationAngle, fpdim) ;

GR\_Zdr\_Max:long\_name = "Sample Maximum DP Differential Reflectivity" ;

GR\_Zdr\_Max:units = "dB" ;

GR\_Zdr\_Max:\_FillValue = -888.f ;

float GR\_Kdp(elevationAngle, fpdim) ;

GR\_Kdp:long\_name = "DP Specific Differential Phase" ;

GR\_Kdp:units = "deg/km" ;

GR\_Kdp:\_FillValue = -888.f ;

float GR\_Kdp\_StdDev(elevationAngle, fpdim) ;

GR\_Kdp\_StdDev:long\_name = "Standard Deviation of DP Specific Differential Phase" ;

GR\_Kdp\_StdDev:units = "deg/km" ;

GR\_Kdp\_StdDev:\_FillValue = -888.f ;

float GR\_Kdp\_Max(elevationAngle, fpdim) ;

GR\_Kdp\_Max:long\_name = "Sample Maximum DP Specific Differential Phase" ;

GR\_Kdp\_Max:units = "deg/km" ;

GR\_Kdp\_Max:\_FillValue = -888.f ;

float GR\_RHOhv(elevationAngle, fpdim) ;

GR\_RHOhv:long\_name = "DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv:units = "Dimensionless" ;

GR\_RHOhv:\_FillValue = -888.f ;

float GR\_RHOhv\_StdDev(elevationAngle, fpdim) ;

GR\_RHOhv\_StdDev:long\_name = "Standard Deviation of DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_StdDev:units = "Dimensionless" ;

GR\_RHOhv\_StdDev:\_FillValue = -888.f ;

float GR\_RHOhv\_Max(elevationAngle, fpdim) ;

GR\_RHOhv\_Max:long\_name = "Sample Maximum DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_Max:units = "Dimensionless" ;

GR\_RHOhv\_Max:\_FillValue = -888.f ;

float GR\_RC\_rainrate(elevationAngle, fpdim) ;

GR\_RC\_rainrate:long\_name = "GV radar Cifelli algorithm Rainrate" ;

GR\_RC\_rainrate:units = "mm/h" ;

GR\_RC\_rainrate:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_StdDev(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_StdDev:long\_name = "Standard Deviation of GV radar Cifelli algorithm Rainrate" ;

GR\_RC\_rainrate\_StdDev:units = "mm/h" ;

GR\_RC\_rainrate\_StdDev:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_Max(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_Max:long\_name = "Sample Maximum GV radar Cifelli algorithm Rainrate" ;

GR\_RC\_rainrate\_Max:units = "mm/h" ;

GR\_RC\_rainrate\_Max:\_FillValue = -888.f ;

float GR\_RP\_rainrate(elevationAngle, fpdim) ;

GR\_RP\_rainrate:long\_name = "GV radar Pol Z-R Rainrate" ;

GR\_RP\_rainrate:units = "mm/h" ;

GR\_RP\_rainrate:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_StdDev(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_StdDev:long\_name = "Standard Deviation of GV radar Pol Z-R Rainrate" ;

GR\_RP\_rainrate\_StdDev:units = "mm/h" ;

GR\_RP\_rainrate\_StdDev:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_Max(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_Max:long\_name = "Sample Maximum GV radar Pol Z-R Rainrate" ;

GR\_RP\_rainrate\_Max:units = "mm/h" ;

GR\_RP\_rainrate\_Max:\_FillValue = -888.f ;

float GR\_RR\_rainrate(elevationAngle, fpdim) ;

GR\_RR\_rainrate:long\_name = "GV radar DROPS Rainrate" ;

GR\_RR\_rainrate:units = "mm/h" ;

GR\_RR\_rainrate:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_StdDev(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_StdDev:long\_name = "Standard Deviation of GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_StdDev:units = "mm/h" ;

GR\_RR\_rainrate\_StdDev:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_Max(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_Max:long\_name = "Sample Maximum GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_Max:units = "mm/h" ;

GR\_RR\_rainrate\_Max:\_FillValue = -888.f ;

short GR\_HID(elevationAngle, fpdim, hidim) ;

GR\_HID:long\_name = "DP Hydrometeor Identification" ;

GR\_HID:units = "Categorical" ;

GR\_HID:\_FillValue = -888s ;

float GR\_Dzero(elevationAngle, fpdim) ;

GR\_Dzero:long\_name = "DP Median Volume Diameter" ;

GR\_Dzero:units = "mm" ;

GR\_Dzero:\_FillValue = -888.f ;

float GR\_Dzero\_StdDev(elevationAngle, fpdim) ;

GR\_Dzero\_StdDev:long\_name = "Standard Deviation of DP Median Volume Diameter" ;

GR\_Dzero\_StdDev:units = "mm" ;

GR\_Dzero\_StdDev:\_FillValue = -888.f ;

float GR\_Dzero\_Max(elevationAngle, fpdim) ;

GR\_Dzero\_Max:long\_name = "Sample Maximum DP Median Volume Diameter" ;

GR\_Dzero\_Max:units = "mm" ;

GR\_Dzero\_Max:\_FillValue = -888.f ;

float GR\_Nw(elevationAngle, fpdim) ;

GR\_Nw:long\_name = "DP Normalized Intercept Parameter" ;

GR\_Nw:units = "1/(mm\*m^3)" ;

GR\_Nw:\_FillValue = -888.f ;

float GR\_Nw\_StdDev(elevationAngle, fpdim) ;

GR\_Nw\_StdDev:long\_name = "Standard Deviation of DP Normalized Intercept Parameter" ;

GR\_Nw\_StdDev:units = "1/(mm\*m^3)" ;

GR\_Nw\_StdDev:\_FillValue = -888.f ;

float GR\_Nw\_Max(elevationAngle, fpdim) ;

GR\_Nw\_Max:long\_name = "Sample Maximum DP Normalized Intercept Parameter" ;

GR\_Nw\_Max:units = "1/(mm\*m^3)" ;

GR\_Nw\_Max:\_FillValue = -888.f ;

float GR\_Dm(elevationAngle, fpdim) ;

GR\_Dm:long\_name = "DP Retrieved Median Diameter" ;

GR\_Dm:units = "mm" ;

GR\_Dm:\_FillValue = -888.f ;

float GR\_Dm\_StdDev(elevationAngle, fpdim) ;

GR\_Dm\_StdDev:long\_name = "Standard Deviation of DP Retrieved Median Diameter" ;

GR\_Dm\_StdDev:units = "mm" ;

GR\_Dm\_StdDev:\_FillValue = -888.f ;

float GR\_Dm\_Max(elevationAngle, fpdim) ;

GR\_Dm\_Max:long\_name = "Sample Maximum DP Retrieved Median Diameter" ;

GR\_Dm\_Max:units = "mm" ;

GR\_Dm\_Max:\_FillValue = -888.f ;

float GR\_N2(elevationAngle, fpdim) ;

GR\_N2:long\_name = "Tokay Normalized Intercept Parameter" ;

GR\_N2:units = "1/(mm\*m^3)" ;

GR\_N2:\_FillValue = -888.f ;

float GR\_N2\_StdDev(elevationAngle, fpdim) ;

GR\_N2\_StdDev:long\_name = "Standard Deviation of Tokay Normalized Intercept Parameter" ;

GR\_N2\_StdDev:units = "1/(mm\*m^3)" ;

GR\_N2\_StdDev:\_FillValue = -888.f ;

float GR\_N2\_Max(elevationAngle, fpdim) ;

GR\_N2\_Max:long\_name = "Sample Maximum Tokay Normalized Intercept Parameter" ;

GR\_N2\_Max:units = "1/(mm\*m^3)" ;

GR\_N2\_Max:\_FillValue = -888.f ;

float GR\_blockage(elevationAngle, fpdim) ;

GR\_blockage:long\_name = "ground radar blockage fraction" ;

GR\_blockage:\_FillValue = -888.f ;

float ZFactorMeasured(elevationAngle, fpdim) ;

ZFactorMeasured:long\_name = "DPR Uncorrected Reflectivity" ;

ZFactorMeasured:units = "dBZ" ;

ZFactorMeasured:\_FillValue = -888.f ;

float ZFactorCorrected(elevationAngle, fpdim) ;

ZFactorCorrected:long\_name = "DPR Attenuation-corrected Reflectivity" ;

ZFactorCorrected:units = "dBZ" ;

ZFactorCorrected:\_FillValue = -888.f ;

float PrecipRate(elevationAngle, fpdim) ;

PrecipRate:long\_name = "DPR Estimated Rain Rate Profile" ;

PrecipRate:units = "mm/h" ;

PrecipRate:\_FillValue = -888.f ;

float Dm(elevationAngle, fpdim) ;

Dm:long\_name = "DPR Dm from paramDSD" ;

Dm:units = "mm" ;

Dm:\_FillValue = -888.f ;

float Nw(elevationAngle, fpdim) ;

Nw:long\_name = "DPR Nw from paramDSD" ;

Nw:units = "dB 1/(mm\*m^3)" ;

Nw:\_FillValue = -888.f ;

short clutterStatus(elevationAngle, fpdim) ;

clutterStatus:long\_name = "Clutter region sample adjustment status" ;

clutterStatus:units = "Categorical" ;

clutterStatus:\_FillValue = -888s ;

short n\_gr\_z\_rejected(elevationAngle, fpdim) ;

n\_gr\_z\_rejected:long\_name = "number of bins below GR\_dBZ\_min in GR\_Z average" ;

n\_gr\_z\_rejected:\_FillValue = -888s ;

short n\_gr\_zdr\_rejected(elevationAngle, fpdim) ;

n\_gr\_zdr\_rejected:long\_name = "number of bins with missing Zdr in GR\_Zdr average" ;

n\_gr\_zdr\_rejected:\_FillValue = -888s ;

short n\_gr\_kdp\_rejected(elevationAngle, fpdim) ;

n\_gr\_kdp\_rejected:long\_name = "number of bins with missing Kdp in GR\_Kdp average" ;

n\_gr\_kdp\_rejected:\_FillValue = -888s ;

short n\_gr\_rhohv\_rejected(elevationAngle, fpdim) ;

n\_gr\_rhohv\_rejected:long\_name = "number of bins with missing RHOhv in GR\_RHOhv average" ;

n\_gr\_rhohv\_rejected:\_FillValue = -888s ;

short n\_gr\_rc\_rejected(elevationAngle, fpdim) ;

n\_gr\_rc\_rejected:long\_name = "number of bins below rain\_min in GR\_RC\_rainrate average" ;

n\_gr\_rc\_rejected:\_FillValue = -888s ;

short n\_gr\_rp\_rejected(elevationAngle, fpdim) ;

n\_gr\_rp\_rejected:long\_name = "number of bins below rain\_min in GR\_RP\_rainrate average" ;

n\_gr\_rp\_rejected:\_FillValue = -888s ;

short n\_gr\_rr\_rejected(elevationAngle, fpdim) ;

n\_gr\_rr\_rejected:long\_name = "number of bins below rain\_min in GR\_RR\_rainrate average" ;

n\_gr\_rr\_rejected:\_FillValue = -888s ;

short n\_gr\_hid\_rejected(elevationAngle, fpdim) ;

n\_gr\_hid\_rejected:long\_name = "number of bins with undefined HID in GR\_HID histogram" ;

n\_gr\_hid\_rejected:\_FillValue = -888s ;

short n\_gr\_dzero\_rejected(elevationAngle, fpdim) ;

n\_gr\_dzero\_rejected:long\_name = "number of bins with missing D0 in GR\_Dzero average" ;

n\_gr\_dzero\_rejected:\_FillValue = -888s ;

short n\_gr\_nw\_rejected(elevationAngle, fpdim) ;

n\_gr\_nw\_rejected:long\_name = "number of bins with missing Nw in GR\_Nw average" ;

n\_gr\_nw\_rejected:\_FillValue = -888s ;

short n\_gr\_dm\_rejected(elevationAngle, fpdim) ;

n\_gr\_dm\_rejected:long\_name = "number of bins with missing Dm in GR\_Dm average" ;

n\_gr\_dm\_rejected:\_FillValue = -888s ;

short n\_gr\_n2\_rejected(elevationAngle, fpdim) ;

n\_gr\_n2\_rejected:long\_name = "number of bins with missing N2 in GR\_N2 average" ;

n\_gr\_n2\_rejected:\_FillValue = -888s ;

short n\_gr\_expected(elevationAngle, fpdim) ;

n\_gr\_expected:long\_name = "number of bins in GR\_Z average" ;

n\_gr\_expected:\_FillValue = -888s ;

short n\_dpr\_meas\_z\_rejected(elevationAngle, fpdim) ;

n\_dpr\_meas\_z\_rejected:long\_name = "number of bins below DPR\_dBZ\_min in ZFactorMeasured average" ;

n\_dpr\_meas\_z\_rejected:\_FillValue = -888s ;

short n\_dpr\_corr\_z\_rejected(elevationAngle, fpdim) ;

n\_dpr\_corr\_z\_rejected:long\_name = "number of bins below DPR\_dBZ\_min in ZFactorCorrected average" ;

n\_dpr\_corr\_z\_rejected:\_FillValue = -888s ;

short n\_dpr\_corr\_r\_rejected(elevationAngle, fpdim) ;

n\_dpr\_corr\_r\_rejected:long\_name = "number of bins below rain\_min in PrecipRate average" ;

n\_dpr\_corr\_r\_rejected:\_FillValue = -888s ;

short n\_dpr\_dm\_rejected(elevationAngle, fpdim) ;

n\_dpr\_dm\_rejected:long\_name = "number of bins with missing Dm in DPR Dm average" ;

n\_dpr\_dm\_rejected:\_FillValue = -888s ;

short n\_dpr\_nw\_rejected(elevationAngle, fpdim) ;

n\_dpr\_nw\_rejected:long\_name = "number of bins with missing Nw in DPR Nw average" ;

n\_dpr\_nw\_rejected:\_FillValue = -888s ;

short n\_dpr\_expected(elevationAngle, fpdim) ;

n\_dpr\_expected:long\_name = "number of bins in DPR averages" ;

n\_dpr\_expected:\_FillValue = -888s ;

float DPRlatitude(fpdim) ;

DPRlatitude:long\_name = "Latitude of DPR surface bin" ;

DPRlatitude:units = "degrees North" ;

DPRlatitude:\_FillValue = -888.f ;

float DPRlongitude(fpdim) ;

DPRlongitude:long\_name = "Longitude of DPR surface bin" ;

DPRlongitude:units = "degrees East" ;

DPRlongitude:\_FillValue = -888.f ;

float piaFinal(fpdim) ;

piaFinal:long\_name = "DPR path integrated attenuation" ;

piaFinal:units = "dBZ" ;

piaFinal:\_FillValue = -888.f ;

short LandSurfaceType(fpdim) ;

LandSurfaceType:long\_name = "DPR LandSurfaceType" ;

LandSurfaceType:units = "Categorical" ;

LandSurfaceType:\_FillValue = -888s ;

float PrecipRateSurface(fpdim) ;

PrecipRateSurface:long\_name = "DPR Near-Surface Precipitation Rate" ;

PrecipRateSurface:units = "mm/h" ;

PrecipRateSurface:\_FillValue = -888.f ;

float SurfPrecipTotRate(fpdim) ;

SurfPrecipTotRate:long\_name = "2B-DPRGMI Near-Surface Estimated Rain Rate" ;

SurfPrecipTotRate:units = "mm/h" ;

SurfPrecipTotRate:\_FillValue = -888.f ;

short heightStormTop(fpdim) ;

heightStormTop:long\_name = "DPR Estimated Storm Top Height (meters)" ;

heightStormTop:units = "m" ;

heightStormTop:\_FillValue = -888s ;

float BBheight(fpdim) ;

BBheight:long\_name = "DPR Bright Band Height above MSL" ;

BBheight:units = "m" ;

BBheight:\_FillValue = -888.f ;

short BBstatus(fpdim) ;

BBstatus:long\_name = "Bright Band Quality" ;

BBstatus:units = "Categorical" ;

BBstatus:\_FillValue = -888s ;

short qualityData(fpdim) ;

qualityData:long\_name = "DPR FLG group qualityData" ;

qualityData:units = "Categorical" ;

qualityData:\_FillValue = -888s ;

short FlagPrecip(fpdim) ;

FlagPrecip:long\_name = "DPR FlagPrecip" ;

FlagPrecip:units = "Categorical" ;

FlagPrecip:\_FillValue = -888s ;

short TypePrecip(fpdim) ;

TypePrecip:long\_name = "DPR TypePrecip (stratiform/convective/other)" ;

TypePrecip:units = "Categorical" ;

TypePrecip:\_FillValue = -888s ;

short scanNum(fpdim) ;

scanNum:long\_name = "product-relative zero-based array index of DPR scan number" ;

scanNum:\_FillValue = -888s ;

short rayNum(fpdim) ;

rayNum:long\_name = "product-relative zero-based array index of DPR ray number" ;

rayNum:\_FillValue = -888s ;

double timeNearestApproach ;

timeNearestApproach:units = "seconds" ;

timeNearestApproach:long\_name = "Seconds since 01-01-1970 00:00:00" ;

timeNearestApproach:\_FillValue = 0. ;

char atimeNearestApproach(len\_atime\_ID) ;

atimeNearestApproach:long\_name = "text version of timeNearestApproach, UTC" ;

double timeSweepStart(elevationAngle) ;

timeSweepStart:units = "seconds" ;

timeSweepStart:long\_name = "Seconds since 01-01-1970 00:00:00" ;

timeSweepStart:\_FillValue = 0. ;

char atimeSweepStart(elevationAngle, len\_atime\_ID) ;

atimeSweepStart:long\_name = "text version of timeSweepStart, UTC" ;

char site\_ID(len\_site\_ID) ;

site\_ID:long\_name = "ID of Ground Radar Site" ;

float site\_lat ;

site\_lat:long\_name = "Latitude of Ground Radar Site" ;

site\_lat:units = "degrees North" ;

site\_lat:\_FillValue = -888.f ;

float site\_lon ;

site\_lon:long\_name = "Longitude of Ground Radar Site" ;

site\_lon:units = "degrees East" ;

site\_lon:\_FillValue = -888.f ;

float site\_elev ;

site\_elev:long\_name = "Elevation of Ground Radar Site above MSL" ;

site\_elev:units = "km" ;

float version ;

version:long\_name = "Geo Match File Version" ;

// global attributes:

:DPR\_Version = "V01G" ;

:DPR\_ScanType = "NS" ;

:GV\_UF\_Z\_field = "CZ" ;

:GV\_UF\_ZDR\_field = "DR" ;

:GV\_UF\_KDP\_field = "KD" ;

:GV\_UF\_RHOHV\_field = "RH" ;

:GV\_UF\_RC\_field = "RC" ;

:GV\_UF\_RP\_field = "RP" ;

:GV\_UF\_RR\_field = "RR" ;

:GV\_UF\_HID\_field = "FH" ;

:GV\_UF\_D0\_field = "D0" ;

:GV\_UF\_NW\_field = "NW" ;

:DPR\_2ADPR\_file = "no\_2ADPR\_file" ;

:DPR\_2AKU\_file = "2A-CS-CONUS.GPM.Ku.V5-20140522.20140601-S200600-E201309.001465.V01G.HDF5" ;

:DPR\_2AKA\_file = "no\_2AKA\_file" ;

:DPR\_2BCMB\_file = "no\_2BCMB\_file" ;

:GR\_file = "KAMX\_2014\_0601\_200509.uf.gz" ;

NOTES:

1) The variables **topHeight** and **bottomHeight** are in units of km above ground level (km AGL), while **BBheight** and **heightStormTop** are in units of meters above mean sea level (m above MSL). Assuming all heights are converted to units of km, then the variable **site\_elev** (km above MSL) relates “Above MSL” and “AGL”: HeightAGL = HeightMSL - site\_elev

2) Actual values for the dimension variables “**fpdim**” and “**elevationAngle**” must be specified at time of netCDF file creation.

3) Only one of the global variables DPR\_2ADPR\_file, DPR\_2AKU\_file, DPR\_2AKA\_file will have a real file name in a given matchup file, the other variables will be set to their default “no\_XXX\_file” value. The variable DPR\_2BCMB\_file will be an actual file name if a 2B-DPRGMI data file is optionally included in the matchup processing for the DPR, Ka, or Ku matchup. Otherwise it takes the default value “no\_2BCMB\_file” to indicate that no 2B-DPRGMI data was included.

4) GR\_HID is not an average, it is an array of values representing a histogram that counts the number of GR range gates in each hydrometeor category (integer HID code), for those GR range gates geometrically matched to the DPR footprint. The first array element is a special element that counts the number of GR range bins where the HID category is MISSING (includes No Precipitation or Unclassified {‘UC’}). Array elements 2-12 give the number of GR bins in each HID category: 'DZ' (drizzle), 'RN' (rain), 'CR' (ice crystals), 'DS' (dry snow/aggregates), 'WS' (wet snow), 'VI' (vertical ice), 'LDG' (low density graupel), 'HDG' (high density graupel), 'HA' (hail), 'BD' (big drops), ‘HR’ (mixed Rain/Hail). Array elements 13-15 are spares at this time.

5) clutterStatus is a code representing the state of the DPR range gates included in the geometry-match sample averages for the multi-level DPR variables. See Table 3.1-2, below.

**Table 3.1‑1.** Variable name, type, dimensions, and interpretation of special data values for science and geolocation variables in DPR-GR Geometry Match netCDF files.

| **Variable Name(s)** | **Type** | **Dimension(s)** | **Special Value(s)** |
| --- | --- | --- | --- |
| GR\_Z  GR\_Z\_StdDev  GR\_Z\_Max  ZFactorMeasured  ZFactorCorrected | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range PR scan edge delimiter  -9999.0: Missing data  -100.0: Below dBZ cutoff value |
| GR\_Zdr  GR\_Zdr\_StdDev  GR\_Zdr\_Max  GR\_Kdp  GR\_Kdp\_StdDev  GR\_Kdp\_Max  GR\_RHOhv  GR\_RHOhv\_StdDev  GR\_RHOhv\_Max  GR\_R\*\_rainrate  GR\_R\*\_rainrate\_StdDev  GR\_R\*\_rainrate\_Max  GR\_Dzero  GR\_Dzero\_StdDev  GR\_Dzero\_Max  GR\_Nw  GR\_Nw\_StdDev  GR\_Nw\_Max  GR\_Dm (note 12)  GR\_Dm\_StdDev  GR\_Dm\_Max  GR\_N2 (note 12)  GR\_N2\_StdDev  GR\_N2\_max  GR\_blockage (note 13)  (see note 10) | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range PR scan edge delimiter  -9999.0: Missing data  -100.0: Below threshold cutoff value, or all GR bin values are MISSING |
| GR\_HID | short | elevationAngle, fpdim, hidim | -888.0: Range edge delimiter, Fill Value |
| PrecipRate | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range PR scan edge delimiter  -88.88: Below rain rate cutoff threshold |
| Dm (note 9)  Nw (note 9) | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range PR scan edge delimiter  -9999.0: Missing data |
| n\_gr\_z\_rejected  n\_gr\_zdr\_rejected  n\_gr\_kdp\_rejected  n\_gr\_rhohv\_rejected  n\_gr\_rc\_rejected  n\_gr\_rp\_rejected  n\_gr\_rr\_rejected  n\_gr\_hid\_rejected  n\_gr\_dzero\_rejected  n\_gr\_nw\_rejected  n\_gr\_dm\_rejected (note 12)  n\_gr\_n2\_rejected (note 12)  n\_gr\_expected  n\_dpr\_meas\_z\_rejected  n\_dpr\_corr\_z\_rejected  n\_dpr\_corr\_r\_rejected  n\_dpr\_expected | short | elevationAngle, fpdim | -888: Fill Value |
| latitude,  longitude,  topHeight,  bottomHeight | float | elevationAngle, fpdim | -888.0: Fill Value |
| xCorners,  yCorners | float | elevationAngle, fpdim, xydim | -888.0: Fill Value |
| DPRlatitude,  DPRlongitude | float | fpdim | -888.0: Fill Value |
| LandSurfaceType  BBstatus  qualityData  FlagPrecip  TypePrecip  heightStormTop (note 11) | short | fpdim | -888: Range edge delimiter, Fill Value |
| piaFinal (note 11)  PrecipRateSurface  SurfPrecipTotRate  BBheight | float | fpdim | -888.0: Range edge delimiter, Fill Value |
| scanNum  rayNum | int | fpdim | -1: Edge-of-Range indicator  -2: In-range PR scan edge indicator |
| clutterStatus | short | fpdim | None, see Notes, above. |
| elevationAngle | float | elevationAngle | N/A |

Notes on Table 3.1-1:

1. Special Values are values outside of the normal physical range of the data field, and which indicate a special meaning at the data point (e.g., Missing data).
2. Range edge points are the footprints of the nearest PR rays outside of, but immediately adjacent to, the range ring surrounding the ground radar at distance = **rangeThreshold**, for a given PR scan. These points form a partial circle around points for the PR rays within the **rangeThreshold** of the ground radar, where the latter points contain actual data values.
3. PR scan edge points are the footprints of single PR rays extrapolated just beyond either edge of the PR scan, and which fall within or immediately adjacent to the **rangeThreshold** distance from the ground radar.
4. The combination of the Range Edge points and the Scan Edge points serve to completely enclose the in-range PR footprints on the surface: a) defined by each elevation sweep (for multi-level variables), or b) at the earth surface (for single level variables). The purpose of these points is to prevent the extrapolation of “actual” PR data values outside of the in-range area, if the data are later analyzed to a regular grid using an objective analysis technique.
5. Range Edge points and Scan Edge points are indicated by **scanNum** and **rayNum** values of -1 and -2, respectively. **scanNum** and **rayNum** values of 0 or greater are actual array indices of PR rays within the full data arrays in the source PR product files.
6. ***Range and Scan Edge points are optional in the POLAR2DPR program that generates the GR/DPR matchup data and, as a default, are disabled from being computed and output. If the “Mark Edges” parameter’s default value is overridden, then these types of points will then be computed and output as described above.***
7. **Fill Value** is the value to which scalar or array variables in the netCDF file are initialized when the file is created. These values remain in place unless and until the data value is overwritten.
8. The variables **topHeight** and **bottomHeight** represent height above ground level (AGL) (i.e., height above the ground radar) ***in km***, while **BBheight** represents height above mean sea level (MSL; the earth ellipsoid, actually), ***in meters***. The difference between AGL height and MSL height is given by the value of the **site\_elev** variable, the height above MSL of the ground radar, in km. To compare **BBheight** to **topHeight** or **bottomHeight**, first convert **BBheight** to km units. Then, either subtract **site\_elev** from **BBheight** to work in AGL height units, or add **site\_elev** to **topHeight** and **bottomHeight** to work in MSL height units.
9. **Dm** and **Nw** together comprise the **paramDSD** element of the Level 2A DPR products. They are stored as separate variables in the GRtoDPR matchup netCDF files.
10. In the family of variables beginning with “**GR\_R\*\_rainrate**”, the wildcard \* is replaced by C, R, and P to indicate that there are 3 sets of these variables. The **GR\_RC\_rainrate** set is for the Cifelli rainrate algorithm, the **GR\_RP\_rainrate** set is for the Polarimetric Z-R algorithm (a.k.a. “Bringi” algorithm), and the **GR\_RR\_rainrate** set is for the DROPS algorithm. The RC and RP variables are present only in version 1.1 or later GRtoDPR netCDF files.
11. The **piaFinal** and **heightStormTop** DPR variables are present only in version 1.1 or later GRtoDPR netCDF files.
12. The **GR\_Dm** and **GR\_N2** family of variables and the **DPR\_decluttered** variable are present only in the version 1.2 or later GRtoDPR netCDF files.
13. GR\_blockage is present only in the version 1.21 or later GRtoDPR netCDF files.

**Table 3.1‑2.** Values of categorical variables in the DPR-GR geometry matching technique netCDF files.

| **Variable** | **Category definitions** |
| --- | --- |
| DPR\_decluttered | 0 = DPR clutter detection/rejection not used in matchup  1 = DPR clutter detection/rejection used in matchup |
| LandSurfaceType | 0-99 = Water  100-199 = Land  200-299 = Coast  300-399 = Inland Water  -9999 = Missing in DPR product  -888 = Point not coincident with PR |
| typePrecip | Precipitation type, expressed by an 8-digit number. The three major rain categories, stratiform, convective, and other, can be obtained as follows. When typePrecip is greater than zero, then:  Major rain type = typePrecip/10000000 where:  1 = stratiform  2 = convective  3 = other  Otherwise, if typePrecip < 0 then:  No rain = -1111  Missing data = -9999  No data = -888 (not coincident with PR) |
| FlagPrecip | 0 = No Precipitation  1 = Precipitation  -9999 = Missing Value in DPR product |
| BBstatus | The “BBstatus” variable in the netCDF file is an unmodified copy of the “qualityBB” variable in the 2ADPR, 2AKa, or 2AKu file. It indicates the status of the bright band detection.  1 = Good,  0 = BB not detected with rain present  -1111 = No-rain value  -9999 = Missing |
| clutterStatus | **clutterStatus** is a code representing the state of the DPR range gates included in the geometry-match sample averages for the multi-level DPR variables. It is an internally-computed variable produced as part of the geometry-matching algorithm, unlike the variables above which are simply copies of values present in the DPR data product. For those DPR range gates geometrically matched to a GR elevation sweep for the given DPR ray, the **clutterStatus** code values 0-2 indicate one of 3 possible situations:  0 = all geometry-matched DPR gates above surface clutter region, no substitution or truncation  1 = one or more geometry-matched DPR gates below lowest clutter-free gate, DPR average truncated to include only those range gates in the clutter-free region  2 = all geometry-matched DPR gates below lowest clutter-free gate, value for vertically-averaged DPR variables set to value of the lowest DPR clutter-free gate  In addition, if DPR\_decluttered is set to 1 (ON), then additional DPR clutter detection along the DPR rays above the lowest clutter-free gate is performed. If any clutter range gates are detected and rejected from a geometry-match sample average, then 10 will be added to the clutterStatus values listed above, resulting in clutterStatus values of 10, 11, or 12. |
| GR\_HID | See NOTES in preceding text box. |

## GMI-GR Geometry Match netCDF file description

The format and content of Version 1.11 of the GRtoGPROF-type Geometry Match netCDF file is presented below, in the form of partial netCDF file creation instructions. See Section 3.1 for details related to dimensions and netCDF variable types. Table 3.2-1 summarizes the name, type, dimension, and special values (e.g., Missing Data) associated with each “science” and geolocation array variable in the GRtoGPROF-type geometry match netCDF files. While the descriptions are in terms of GR-to-GMI matchups, this same file format also applies to GR-to-GPROF matchup data for any GPM constellation satellite Microwave Imager data (e.g. TRMM/TMI, GCOMW1/AMSR2, F15/SSMIS, F16/SSMIS, F17/SSMIS, F18/SSMIS, METOPA/MHS, METOPB/MHS, NOAA18/MHS, NOAA19/MHS).

dimensions:

fpdim = ;

elevationAngle = ;

xydim = 4 ;

hidim = 15 ;

len\_atime\_ID = 19 ;

len\_site\_ID = 4 ;

variables:

float elevationAngle(elevationAngle) ;

elevationAngle:long\_name = "Radar Sweep Elevation Angles" ;

elevationAngle:units = "degrees" ;

float rangeThreshold ;

rangeThreshold:long\_name = "Dataset maximum range from radar site" ;

rangeThreshold:\_FillValue = -888.f ;

rangeThreshold:units = "km" ;

float GR\_dBZ\_min ;

GR\_dBZ\_min:long\_name = "minimum GR bin dBZ required for a \*complete\* GR horizontal average" ;

GR\_dBZ\_min:\_FillValue = -888.f ;

GR\_dBZ\_min:units = "dBZ" ;

float gprof\_rain\_min ;

gprof\_rain\_min:long\_name = "minimum XMI rainrate required" ;

gprof\_rain\_min:\_FillValue = -888.f ;

gprof\_rain\_min:units = "mm/h" ;

float radiusOfInfluence ;

radiusOfInfluence:long\_name = "Radius of influence for distance weighting of GR bins" ;

radiusOfInfluence:\_FillValue = -888.f ;

radiusOfInfluence:units = "km" ;

short have\_GR\_Z\_slantPath ;

have\_GR\_Z\_slantPath:long\_name = "data exists flag for GR\_Z\_slantPath" ;

have\_GR\_Z\_slantPath:\_FillValue = 0s ;

short have\_GR\_RC\_rainrate\_slantPath ;

have\_GR\_RC\_rainrate\_slantPath:long\_name = "data exists flag for GR\_RC\_rainrate\_slantPath" ;

have\_GR\_RC\_rainrate\_slantPath:\_FillValue = 0s ;

short have\_GR\_RP\_rainrate\_slantPath ;

have\_GR\_RP\_rainrate\_slantPath:long\_name = "data exists flag for GR\_RP\_rainrate\_slantPath" ;

have\_GR\_RP\_rainrate\_slantPath:\_FillValue = 0s ;

short have\_GR\_RR\_rainrate\_slantPath ;

have\_GR\_RR\_rainrate\_slantPath:long\_name = "data exists flag for GR\_RR\_rainrate\_slantPath" ;

have\_GR\_RR\_rainrate\_slantPath:\_FillValue = 0s ;

short have\_GR\_Zdr\_slantPath ;

have\_GR\_Zdr\_slantPath:long\_name = "data exists flag for GR\_Zdr\_slantPath" ;

have\_GR\_Zdr\_slantPath:\_FillValue = 0s ;

short have\_GR\_Kdp\_slantPath ;

have\_GR\_Kdp\_slantPath:long\_name = "data exists flag for GR\_Kdp\_slantPath" ;

have\_GR\_Kdp\_slantPath:\_FillValue = 0s ;

short have\_GR\_RHOhv\_slantPath ;

have\_GR\_RHOhv\_slantPath:long\_name = "data exists flag for GR\_RHOhv\_slantPath" ;

have\_GR\_RHOhv\_slantPath:\_FillValue = 0s ;

short have\_GR\_HID\_slantPath ;

have\_GR\_HID\_slantPath:long\_name = "data exists flag for GR\_HID\_slantPath" ;

have\_GR\_HID\_slantPath:\_FillValue = 0s ;

short have\_GR\_Dzero\_slantPath ;

have\_GR\_Dzero\_slantPath:long\_name = "data exists flag for GR\_Dzero\_slantPath" ;

have\_GR\_Dzero\_slantPath:\_FillValue = 0s ;

short have\_GR\_Nw\_slantPath ;

have\_GR\_Nw\_slantPath:long\_name = "data exists flag for GR\_Nw\_slantPath" ;

have\_GR\_Nw\_slantPath:\_FillValue = 0s ;

short have\_GR\_blockage\_slantPath ;

have\_GR\_blockage\_slantPath:long\_name = "data exists flag for GR\_blockage\_slantPath" ;

have\_GR\_blockage\_slantPath:\_FillValue = 0s ;

short have\_GR\_Z\_VPR ;

have\_GR\_Z\_VPR:long\_name = "data exists flag for GR\_Z\_VPR" ;

have\_GR\_Z\_VPR:\_FillValue = 0s ;

short have\_GR\_RC\_rainrate\_VPR ;

have\_GR\_RC\_rainrate\_VPR:long\_name = "data exists flag for GR\_RC\_rainrate\_VPR" ;

have\_GR\_RC\_rainrate\_VPR:\_FillValue = 0s ;

short have\_GR\_RP\_rainrate\_VPR ;

have\_GR\_RP\_rainrate\_VPR:long\_name = "data exists flag for GR\_RP\_rainrate\_VPR" ;

have\_GR\_RP\_rainrate\_VPR:\_FillValue = 0s ;

short have\_GR\_RR\_rainrate\_VPR ;

have\_GR\_RR\_rainrate\_VPR:long\_name = "data exists flag for GR\_RR\_rainrate\_VPR" ;

have\_GR\_RR\_rainrate\_VPR:\_FillValue = 0s ;

short have\_GR\_Zdr\_VPR ;

have\_GR\_Zdr\_VPR:long\_name = "data exists flag for GR\_Zdr\_VPR" ;

have\_GR\_Zdr\_VPR:\_FillValue = 0s ;

short have\_GR\_Kdp\_VPR ;

have\_GR\_Kdp\_VPR:long\_name = "data exists flag for GR\_Kdp\_VPR" ;

have\_GR\_Kdp\_VPR:\_FillValue = 0s ;

short have\_GR\_RHOhv\_VPR ;

have\_GR\_RHOhv\_VPR:long\_name = "data exists flag for GR\_RHOhv\_VPR" ;

have\_GR\_RHOhv\_VPR:\_FillValue = 0s ;

short have\_GR\_HID\_VPR ;

have\_GR\_HID\_VPR:long\_name = "data exists flag for GR\_HID\_VPR" ;

have\_GR\_HID\_VPR:\_FillValue = 0s ;

short have\_GR\_Dzero\_VPR ;

have\_GR\_Dzero\_VPR:long\_name = "data exists flag for GR\_Dzero\_VPR" ;

have\_GR\_Dzero\_VPR:\_FillValue = 0s ;

short have\_GR\_Nw\_VPR ;

have\_GR\_Nw\_VPR:long\_name = "data exists flag for GR\_Nw\_VPR" ;

have\_GR\_Nw\_VPR:\_FillValue = 0s ;

short have\_GR\_blockage\_VPR ;

have\_GR\_blockage\_VPR:long\_name = "data exists flag for GR\_blockage\_VPR" ;

have\_GR\_blockage\_VPR:\_FillValue = 0s ;

short have\_surfaceTypeIndex ;

have\_surfaceTypeIndex:long\_name = "data exists flag for surfaceTypeIndex" ;

have\_surfaceTypeIndex:\_FillValue = 0s ;

short have\_surfacePrecipitation ;

have\_surfacePrecipitation:long\_name = "data exists flag for surfacePrecipitation" ;

have\_surfacePrecipitation:\_FillValue = 0s ;

short have\_pixelStatus ;

have\_pixelStatus:long\_name = "data exists flag for pixelStatus" ;

have\_pixelStatus:\_FillValue = 0s ;

short have\_PoP ;

have\_PoP:long\_name = "data exists flag for PoP" ;

have\_PoP:\_FillValue = 0s ;

short have\_freezingHeight ;

have\_freezingHeight:long\_name = "data exists flag for freezingHeight" ;

have\_freezingHeight:\_FillValue = 0s ;

float latitude(elevationAngle, fpdim) ;

latitude:long\_name = "Latitude of data sample" ;

latitude:units = "degrees North" ;

latitude:\_FillValue = -888.f ;

float longitude(elevationAngle, fpdim) ;

longitude:long\_name = "Longitude of data sample" ;

longitude:units = "degrees East" ;

longitude:\_FillValue = -888.f ;

float xCorners(elevationAngle, fpdim, xydim) ;

xCorners:long\_name = "data sample x corner coords." ;

xCorners:units = "km" ;

xCorners:\_FillValue = -888.f ;

float yCorners(elevationAngle, fpdim, xydim) ;

yCorners:long\_name = "data sample y corner coords." ;

yCorners:units = "km" ;

yCorners:\_FillValue = -888.f ;

float topHeight(elevationAngle, fpdim) ;

topHeight:long\_name = "data sample top height AGL" ;

topHeight:units = "km" ;

topHeight:\_FillValue = -888.f ;

float bottomHeight(elevationAngle, fpdim) ;

bottomHeight:long\_name = "data sample bottom height AGL" ;

bottomHeight:units = "km" ;

bottomHeight:\_FillValue = -888.f ;

float topHeight\_vpr(elevationAngle, fpdim) ;

topHeight\_vpr:long\_name = "data sample top height AGL along local vertical" ;

topHeight\_vpr:units = "km" ;

topHeight\_vpr:\_FillValue = -888.f ;

float bottomHeight\_vpr(elevationAngle, fpdim) ;

bottomHeight\_vpr:long\_name = "data sample bottom height AGL along local vertical" ;

bottomHeight\_vpr:units = "km" ;

bottomHeight\_vpr:\_FillValue = -888.f ;

float GR\_Z\_slantPath(elevationAngle, fpdim) ;

GR\_Z\_slantPath:long\_name = "GV radar QC Reflectivity" ;

GR\_Z\_slantPath:units = "dBZ" ;

GR\_Z\_slantPath:\_FillValue = -888.f ;

float GR\_Z\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_Z\_StdDev\_slantPath:long\_name = "Standard Deviation of GV radar QC Reflectivity" ;

GR\_Z\_StdDev\_slantPath:units = "dBZ" ;

GR\_Z\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_Z\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_Z\_Max\_slantPath:long\_name = "Sample Maximum GV radar QC Reflectivity" ;

GR\_Z\_Max\_slantPath:units = "dBZ" ;

GR\_Z\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_slantPath(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_slantPath:long\_name = "GV radar Cifelli Rain Rate" ;

GR\_RC\_rainrate\_slantPath:units = "dBZ" ;

GR\_RC\_rainrate\_slantPath:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_StdDev\_slantPath:long\_name = "Standard Deviation of GV radar Cifelli Rain Rate" ;

GR\_RC\_rainrate\_StdDev\_slantPath:units = "dBZ" ;

GR\_RC\_rainrate\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_Max\_slantPath:long\_name = "Sample Maximum GV radar Cifelli Rain Rate" ;

GR\_RC\_rainrate\_Max\_slantPath:units = "dBZ" ;

GR\_RC\_rainrate\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_slantPath(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_slantPath:long\_name = "GV radar PolZR Rain Rate" ;

GR\_RP\_rainrate\_slantPath:units = "dBZ" ;

GR\_RP\_rainrate\_slantPath:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_StdDev\_slantPath:long\_name = "Standard Deviation of GV radar PolZR Rain Rate" ;

GR\_RP\_rainrate\_StdDev\_slantPath:units = "dBZ" ;

GR\_RP\_rainrate\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_Max\_slantPath:long\_name = "Sample Maximum GV radar PolZR Rain Rate" ;

GR\_RP\_rainrate\_Max\_slantPath:units = "dBZ" ;

GR\_RP\_rainrate\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_slantPath(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_slantPath:long\_name = "GV radar DROPS Rain Rate" ;

GR\_RR\_rainrate\_slantPath:units = "dBZ" ;

GR\_RR\_rainrate\_slantPath:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_StdDev\_slantPath:long\_name = "Standard Deviation of GV radar DROPS Rain Rate" ;

GR\_RR\_rainrate\_StdDev\_slantPath:units = "dBZ" ;

GR\_RR\_rainrate\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_Max\_slantPath:long\_name = "Sample Maximum GV radar DROPS Rain Rate" ;

GR\_RR\_rainrate\_Max\_slantPath:units = "dBZ" ;

GR\_RR\_rainrate\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_Zdr\_slantPath(elevationAngle, fpdim) ;

GR\_Zdr\_slantPath:long\_name = "DP Differential Reflectivity" ;

GR\_Zdr\_slantPath:units = "dB" ;

GR\_Zdr\_slantPath:\_FillValue = -888.f ;

float GR\_Zdr\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_Zdr\_StdDev\_slantPath:long\_name = "Standard Deviation of DP Differential Reflectivity" ;

GR\_Zdr\_StdDev\_slantPath:units = "dB" ;

GR\_Zdr\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_Zdr\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_Zdr\_Max\_slantPath:long\_name = "Sample Maximum DP Differential Reflectivity" ;

GR\_Zdr\_Max\_slantPath:units = "dB" ;

GR\_Zdr\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_Kdp\_slantPath(elevationAngle, fpdim) ;

GR\_Kdp\_slantPath:long\_name = "DP Specific Differential Phase" ;

GR\_Kdp\_slantPath:units = "deg/km" ;

GR\_Kdp\_slantPath:\_FillValue = -888.f ;

float GR\_Kdp\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_Kdp\_StdDev\_slantPath:long\_name = "Standard Deviation of DP Specific Differential Phase" ;

GR\_Kdp\_StdDev\_slantPath:units = "deg/km" ;

GR\_Kdp\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_Kdp\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_Kdp\_Max\_slantPath:long\_name = "Sample Maximum DP Specific Differential Phase" ;

GR\_Kdp\_Max\_slantPath:units = "deg/km" ;

GR\_Kdp\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_RHOhv\_slantPath(elevationAngle, fpdim) ;

GR\_RHOhv\_slantPath:long\_name = "DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_slantPath:units = "Dimensionless" ;

GR\_RHOhv\_slantPath:\_FillValue = -888.f ;

float GR\_RHOhv\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_RHOhv\_StdDev\_slantPath:long\_name = "Standard Deviation of DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_StdDev\_slantPath:units = "Dimensionless" ;

GR\_RHOhv\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_RHOhv\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_RHOhv\_Max\_slantPath:long\_name = "Sample Maximum DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_Max\_slantPath:units = "Dimensionless" ;

GR\_RHOhv\_Max\_slantPath:\_FillValue = -888.f ;

short GR\_HID\_slantPath(elevationAngle, fpdim, hidim) ;

GR\_HID\_slantPath:long\_name = "DP Hydrometeor Identification" ;

GR\_HID\_slantPath:units = "Categorical" ;

GR\_HID\_slantPath:\_FillValue = -888s ;

float GR\_Dzero\_slantPath(elevationAngle, fpdim) ;

GR\_Dzero\_slantPath:long\_name = "DP Median Volume Diameter" ;

GR\_Dzero\_slantPath:units = "mm" ;

GR\_Dzero\_slantPath:\_FillValue = -888.f ;

float GR\_Dzero\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_Dzero\_StdDev\_slantPath:long\_name = "Standard Deviation of DP Median Volume Diameter" ;

GR\_Dzero\_StdDev\_slantPath:units = "mm" ;

GR\_Dzero\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_Dzero\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_Dzero\_Max\_slantPath:long\_name = "Sample Maximum DP Median Volume Diameter" ;

GR\_Dzero\_Max\_slantPath:units = "mm" ;

GR\_Dzero\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_Nw\_slantPath(elevationAngle, fpdim) ;

GR\_Nw\_slantPath:long\_name = "DP Normalized Intercept Parameter" ;

GR\_Nw\_slantPath:units = "1/(mm\*m^3)" ;

GR\_Nw\_slantPath:\_FillValue = -888.f ;

float GR\_Nw\_StdDev\_slantPath(elevationAngle, fpdim) ;

GR\_Nw\_StdDev\_slantPath:long\_name = "Standard Deviation of DP Normalized Intercept Parameter" ;

GR\_Nw\_StdDev\_slantPath:units = "1/(mm\*m^3)" ;

GR\_Nw\_StdDev\_slantPath:\_FillValue = -888.f ;

float GR\_Nw\_Max\_slantPath(elevationAngle, fpdim) ;

GR\_Nw\_Max\_slantPath:long\_name = "Sample Maximum DP Normalized Intercept Parameter" ;

GR\_Nw\_Max\_slantPath:units = "1/(mm\*m^3)" ;

GR\_Nw\_Max\_slantPath:\_FillValue = -888.f ;

float GR\_blockage\_slantPath (elevationAngle, fpdim) ;

GR\_blockage\_slantPath:long\_name = "ground radar blockage fraction" ;

GR\_blockage\_slantPath:\_FillValue = -888.f ;

short n\_gr\_expected(elevationAngle, fpdim) ;

n\_gr\_expected:long\_name = "number of bins in GR slantPath averages" ;

n\_gr\_expected:\_FillValue = -888s ;

short n\_gr\_z\_rejected(elevationAngle, fpdim) ;

n\_gr\_z\_rejected:long\_name = "number of bins below GR\_dBZ\_min in GR\_Z\_slantPath average" ;

n\_gr\_z\_rejected:\_FillValue = -888s ;

short n\_gr\_rc\_rejected(elevationAngle, fpdim) ;

n\_gr\_rc\_rejected:long\_name = "number of bins below gprof\_rain\_min in GR\_RC\_rainrate\_slantPath average" ;

n\_gr\_rc\_rejected:\_FillValue = -888s ;

short n\_gr\_rp\_rejected(elevationAngle, fpdim) ;

n\_gr\_rp\_rejected:long\_name = "number of bins below gprof\_rain\_min in GR\_RP\_rainrate\_slantPath average" ;

n\_gr\_rp\_rejected:\_FillValue = -888s ;

short n\_gr\_rr\_rejected(elevationAngle, fpdim) ;

n\_gr\_rr\_rejected:long\_name = "number of bins below gprof\_rain\_min in GR\_RR\_rainrate\_slantPath average" ;

n\_gr\_rr\_rejected:\_FillValue = -888s ;

short n\_gr\_zdr\_rejected(elevationAngle, fpdim) ;

n\_gr\_zdr\_rejected:long\_name = "number of bins with missing Zdr in GR\_Zdr\_slantPath average" ;

n\_gr\_zdr\_rejected:\_FillValue = -888s ;

short n\_gr\_kdp\_rejected(elevationAngle, fpdim) ;

n\_gr\_kdp\_rejected:long\_name = "number of bins with missing Kdp in GR\_Kdp\_slantPath average" ;

n\_gr\_kdp\_rejected:\_FillValue = -888s ;

short n\_gr\_rhohv\_rejected(elevationAngle, fpdim) ;

n\_gr\_rhohv\_rejected:long\_name = "number of bins with missing RHOhv in GR\_RHOhv\_slantPath average" ;

n\_gr\_rhohv\_rejected:\_FillValue = -888s ;

short n\_gr\_hid\_rejected(elevationAngle, fpdim) ;

n\_gr\_hid\_rejected:long\_name = "number of bins with undefined HID in GR\_HID\_slantPath histogram" ;

n\_gr\_hid\_rejected:\_FillValue = -888s ;

short n\_gr\_dzero\_rejected(elevationAngle, fpdim) ;

n\_gr\_dzero\_rejected:long\_name = "number of bins with missing D0 in GR\_Dzero\_slantPath average" ;

n\_gr\_dzero\_rejected:\_FillValue = -888s ;

short n\_gr\_nw\_rejected(elevationAngle, fpdim) ;

n\_gr\_nw\_rejected:long\_name = "number of bins with missing Nw in GR\_Nw\_slantPath average" ;

n\_gr\_nw\_rejected:\_FillValue = -888s ;

float GR\_Z\_VPR(elevationAngle, fpdim) ;

GR\_Z\_VPR:long\_name = "GV radar QC Reflectivity along local vertical" ;

GR\_Z\_VPR:units = "dBZ" ;

GR\_Z\_VPR:\_FillValue = -888.f ;

float GR\_Z\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_Z\_StdDev\_VPR:long\_name = "Standard Deviation of GV radar QC Reflectivity along local vertical" ;

GR\_Z\_StdDev\_VPR:units = "dBZ" ;

GR\_Z\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_Z\_Max\_VPR(elevationAngle, fpdim) ;

GR\_Z\_Max\_VPR:long\_name = "Sample Maximum GV radar QC Reflectivity along local vertical" ;

GR\_Z\_Max\_VPR:units = "dBZ" ;

GR\_Z\_Max\_VPR:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_VPR(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_VPR:long\_name = "GV radar Cifelli Rain Rate along local vertical" ;

GR\_RC\_rainrate\_VPR:units = "dBZ" ;

GR\_RC\_rainrate\_VPR:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_StdDev\_VPR:long\_name = "Standard Deviation of GV radar Cifelli Rain Rate along local vertical" ;

GR\_RC\_rainrate\_StdDev\_VPR:units = "dBZ" ;

GR\_RC\_rainrate\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_Max\_VPR(elevationAngle, fpdim) ;

GR\_RC\_rainrate\_Max\_VPR:long\_name = "Sample Maximum GV radar Cifelli Rain Rate along local vertical" ;

GR\_RC\_rainrate\_Max\_VPR:units = "dBZ" ;

GR\_RC\_rainrate\_Max\_VPR:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_VPR(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_VPR:long\_name = "GV radar PolZR Rain Rate along local vertical" ;

GR\_RP\_rainrate\_VPR:units = "dBZ" ;

GR\_RP\_rainrate\_VPR:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_StdDev\_VPR:long\_name = "Standard Deviation of GV radar PolZR Rain Rate along local vertical" ;

GR\_RP\_rainrate\_StdDev\_VPR:units = "dBZ" ;

GR\_RP\_rainrate\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_Max\_VPR(elevationAngle, fpdim) ;

GR\_RP\_rainrate\_Max\_VPR:long\_name = "Sample Maximum GV radar PolZR Rain Rate along local vertical" ;

GR\_RP\_rainrate\_Max\_VPR:units = "dBZ" ;

GR\_RP\_rainrate\_Max\_VPR:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_VPR(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_VPR:long\_name = "GV radar DROPS Rain Rate along local vertical" ;

GR\_RR\_rainrate\_VPR:units = "dBZ" ;

GR\_RR\_rainrate\_VPR:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_StdDev\_VPR:long\_name = "Standard Deviation of GV radar DROPS Rain Rate along local vertical" ;

GR\_RR\_rainrate\_StdDev\_VPR:units = "dBZ" ;

GR\_RR\_rainrate\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_Max\_VPR(elevationAngle, fpdim) ;

GR\_RR\_rainrate\_Max\_VPR:long\_name = "Sample Maximum GV radar DROPS Rain Rate along local vertical" ;

GR\_RR\_rainrate\_Max\_VPR:units = "dBZ" ;

GR\_RR\_rainrate\_Max\_VPR:\_FillValue = -888.f ;

float GR\_Zdr\_VPR(elevationAngle, fpdim) ;

GR\_Zdr\_VPR:long\_name = "DP Differential Reflectivity along local vertical" ;

GR\_Zdr\_VPR:units = "dB" ;

GR\_Zdr\_VPR:\_FillValue = -888.f ;

float GR\_Zdr\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_Zdr\_StdDev\_VPR:long\_name = "Standard Deviation of DP Differential Reflectivity along local vertical" ;

GR\_Zdr\_StdDev\_VPR:units = "dB" ;

GR\_Zdr\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_Zdr\_Max\_VPR(elevationAngle, fpdim) ;

GR\_Zdr\_Max\_VPR:long\_name = "Sample Maximum DP Differential Reflectivity along local vertical" ;

GR\_Zdr\_Max\_VPR:units = "dB" ;

GR\_Zdr\_Max\_VPR:\_FillValue = -888.f ;

float GR\_Kdp\_VPR(elevationAngle, fpdim) ;

GR\_Kdp\_VPR:long\_name = "DP Specific Differential Phase along local vertical" ;

GR\_Kdp\_VPR:units = "deg/km" ;

GR\_Kdp\_VPR:\_FillValue = -888.f ;

float GR\_Kdp\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_Kdp\_StdDev\_VPR:long\_name = "Standard Deviation of DP Specific Differential Phase along local vertical" ;

GR\_Kdp\_StdDev\_VPR:units = "deg/km" ;

GR\_Kdp\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_Kdp\_Max\_VPR(elevationAngle, fpdim) ;

GR\_Kdp\_Max\_VPR:long\_name = "Sample Maximum DP Specific Differential Phase along local vertical" ;

GR\_Kdp\_Max\_VPR:units = "deg/km" ;

GR\_Kdp\_Max\_VPR:\_FillValue = -888.f ;

float GR\_RHOhv\_VPR(elevationAngle, fpdim) ;

GR\_RHOhv\_VPR:long\_name = "DP Co-Polar Correlation Coefficient along local vertical" ;

GR\_RHOhv\_VPR:units = "Dimensionless" ;

GR\_RHOhv\_VPR:\_FillValue = -888.f ;

float GR\_RHOhv\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_RHOhv\_StdDev\_VPR:long\_name = "Standard Deviation of DP Co-Polar Correlation Coefficient along local vertical" ;

GR\_RHOhv\_StdDev\_VPR:units = "Dimensionless" ;

GR\_RHOhv\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_RHOhv\_Max\_VPR(elevationAngle, fpdim) ;

GR\_RHOhv\_Max\_VPR:long\_name = "Sample Maximum DP Co-Polar Correlation Coefficient along local vertical" ;

GR\_RHOhv\_Max\_VPR:units = "Dimensionless" ;

GR\_RHOhv\_Max\_VPR:\_FillValue = -888.f ;

short GR\_HID\_VPR(elevationAngle, fpdim, hidim) ;

GR\_HID\_VPR:long\_name = "DP Hydrometeor Identification along local vertical" ;

GR\_HID\_VPR:units = "Categorical" ;

GR\_HID\_VPR:\_FillValue = -888s ;

float GR\_Dzero\_VPR(elevationAngle, fpdim) ;

GR\_Dzero\_VPR:long\_name = "DP Median Volume Diameter along local vertical" ;

GR\_Dzero\_VPR:units = "mm" ;

GR\_Dzero\_VPR:\_FillValue = -888.f ;

float GR\_Dzero\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_Dzero\_StdDev\_VPR:long\_name = "Standard Deviation of DP Median Volume Diameter along local vertical" ;

GR\_Dzero\_StdDev\_VPR:units = "mm" ;

GR\_Dzero\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_Dzero\_Max\_VPR(elevationAngle, fpdim) ;

GR\_Dzero\_Max\_VPR:long\_name = "Sample Maximum DP Median Volume Diameter along local vertical" ;

GR\_Dzero\_Max\_VPR:units = "mm" ;

GR\_Dzero\_Max\_VPR:\_FillValue = -888.f ;

float GR\_Nw\_VPR(elevationAngle, fpdim) ;

GR\_Nw\_VPR:long\_name = "DP Normalized Intercept Parameter along local vertical" ;

GR\_Nw\_VPR:units = "1/(mm\*m^3)" ;

GR\_Nw\_VPR:\_FillValue = -888.f ;

float GR\_Nw\_StdDev\_VPR(elevationAngle, fpdim) ;

GR\_Nw\_StdDev\_VPR:long\_name = "Standard Deviation of DP Normalized Intercept Parameter along local vertical" ;

GR\_Nw\_StdDev\_VPR:units = "1/(mm\*m^3)" ;

GR\_Nw\_StdDev\_VPR:\_FillValue = -888.f ;

float GR\_Nw\_Max\_VPR(elevationAngle, fpdim) ;

GR\_Nw\_Max\_VPR:long\_name = "Sample Maximum DP Normalized Intercept Parameter along local vertical" ;

GR\_Nw\_Max\_VPR:units = "1/(mm\*m^3)" ;

GR\_Nw\_Max\_VPR:\_FillValue = -888.f ;

float GR\_blockage\_VPR(elevationAngle, fpdim) ;

GR\_blockage\_VPR:long\_name = "ground radar blockage fraction along local vertical " ;

GR\_blockage\_VPR:\_FillValue = -888.f ;

short n\_gr\_vpr\_expected(elevationAngle, fpdim) ;

n\_gr\_vpr\_expected:long\_name = "number of bins in GR\_Z\_VPR, GR\_rainrate\_VPR averages" ;

n\_gr\_vpr\_expected:\_FillValue = -888s ;

short n\_gr\_z\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_z\_vpr\_rejected:long\_name = "number of bins below GR\_dBZ\_min in GR\_Z\_VPR average" ;

n\_gr\_z\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_rc\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_rc\_vpr\_rejected:long\_name = "number of bins below gprof\_rain\_min in GR\_RC\_rainrate\_VPR average" ;

n\_gr\_rc\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_rp\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_rp\_vpr\_rejected:long\_name = "number of bins below gprof\_rain\_min in GR\_RP\_rainrate\_VPR average" ;

n\_gr\_rp\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_rr\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_rr\_vpr\_rejected:long\_name = "number of bins below gprof\_rain\_min in GR\_RR\_rainrate\_VPR average" ;

n\_gr\_rr\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_zdr\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_zdr\_vpr\_rejected:long\_name = "number of bins with missing Zdr in GR\_Zdr\_VPR average" ;

n\_gr\_zdr\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_kdp\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_kdp\_vpr\_rejected:long\_name = "number of bins with missing Kdp in GR\_Kdp\_VPR average" ;

n\_gr\_kdp\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_rhohv\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_rhohv\_vpr\_rejected:long\_name = "number of bins with missing RHOhv in GR\_RHOhv\_VPR average" ;

n\_gr\_rhohv\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_hid\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_hid\_vpr\_rejected:long\_name = "number of bins with undefined HID in GR\_HID\_VPR histogram" ;

n\_gr\_hid\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_dzero\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_dzero\_vpr\_rejected:long\_name = "number of bins with missing D0 in GR\_Dzero\_VPR average" ;

n\_gr\_dzero\_vpr\_rejected:\_FillValue = -888s ;

short n\_gr\_nw\_vpr\_rejected(elevationAngle, fpdim) ;

n\_gr\_nw\_vpr\_rejected:long\_name = "number of bins with missing Nw in GR\_Nw\_VPR average" ;

n\_gr\_nw\_vpr\_rejected:\_FillValue = -888s ;

float XMIlatitude(fpdim) ;

XMIlatitude:long\_name = "Latitude of XMI surface bin" ;

XMIlatitude:units = "degrees North" ;

XMIlatitude:\_FillValue = -888.f ;

float XMIlongitude(fpdim) ;

XMIlongitude:long\_name = "Longitude of XMI surface bin" ;

XMIlongitude:units = "degrees East" ;

XMIlongitude:\_FillValue = -888.f ;

short surfaceTypeIndex(fpdim) ;

surfaceTypeIndex:long\_name = "2A-GPROF surfaceTypeIndex" ;

surfaceTypeIndex:units = "Categorical" ;

surfaceTypeIndex:\_FillValue = -888s ;

float surfacePrecipitation(fpdim) ;

surfacePrecipitation:long\_name = "2A-GPROF Estimated Surface Rain Rate" ;

surfacePrecipitation:units = "mm/h" ;

surfacePrecipitation:\_FillValue = -888.f ;

short pixelStatus(fpdim) ;

pixelStatus:long\_name = "2A-GPROF pixelStatus" ;

pixelStatus:units = "Categorical" ;

pixelStatus:\_FillValue = -888s ;

short PoP(fpdim) ;

PoP:long\_name = "2A-GPROF probabilityOfPrecip" ;

PoP:units = "percent" ;

PoP:\_FillValue = -888s ;

short freezingHeight(fpdim) ;

freezingHeight:long\_name = "Freezing Height" ;

freezingHeight:units = "meters" ;

freezingHeight:\_FillValue = -888s ;

int rayIndex(fpdim) ;

rayIndex:long\_name = "XMI product-relative ray,scan IDL 1-D array index" ;

rayIndex:\_FillValue = -888 ;

double timeNearestApproach ;

timeNearestApproach:units = "seconds" ;

timeNearestApproach:long\_name = "Seconds since 01-01-1970 00:00:00" ;

timeNearestApproach:\_FillValue = 0. ;

char atimeNearestApproach(len\_atime\_ID) ;

atimeNearestApproach:long\_name = "text version of timeNearestApproach, UTC" ;

double timeSweepStart(elevationAngle) ;

timeSweepStart:units = "seconds" ;

timeSweepStart:long\_name = "Seconds since 01-01-1970 00:00:00" ;

timeSweepStart:\_FillValue = 0. ;

char atimeSweepStart(elevationAngle, len\_atime\_ID) ;

atimeSweepStart:long\_name = "text version of timeSweepStart, UTC" ;

char site\_ID(len\_site\_ID) ;

site\_ID:long\_name = "ID of Ground Radar Site" ;

float site\_lat ;

site\_lat:long\_name = "Latitude of Ground Radar Site" ;

site\_lat:units = "degrees North" ;

site\_lat:\_FillValue = -888.f ;

float site\_lon ;

site\_lon:long\_name = "Longitude of Ground Radar Site" ;

site\_lon:units = "degrees East" ;

site\_lon:\_FillValue = -888.f ;

float site\_elev ;

site\_elev:long\_name = "Elevation of Ground Radar Site above MSL" ;

site\_elev:units = "km" ;

float version ;

version:long\_name = "Geo Match File Version" ;

// global attributes:

:PPS\_Version = "V03C" ;

:GV\_UF\_Z\_field = "CZ" ;

:GV\_UF\_ZDR\_field = "DR" ;

:GV\_UF\_KDP\_field = "KD" ;

:GV\_UF\_RHOHV\_field = "RH" ;

:GV\_UF\_RC\_field = "RC" ;

:GV\_UF\_RP\_field = "RP" ;

:GV\_UF\_RR\_field = "RR" ;

:GV\_UF\_HID\_field = "FH" ;

:GV\_UF\_D0\_field = "D0" ;

:GV\_UF\_NW\_field = "NW" ;

:2AGPROF\_file = "2A-CS-CONUS.GPM.GMI.GPROF2014v1-4.20141102-S080338-E081111.003853.V03C.HDF5" ;

:GR\_file = "KBOX\_2014\_1102\_080541.uf.gz" ;

NOTES:

1) The variables **topHeight** and **bottomHeight** are in units of km above ground level (km AGL). Assuming all heights are in units of km, then the variable **site\_elev** (km above MSL) relates heights above mean sea level (MSL) and AGL:

HeightAGL = HeightMSL - site\_elev

2) Actual values for the dimension variables “**fpdim**” and “**elevationAngle**” must be specified at time of netCDF file creation.

**Table 3.2‑1.** Variable name, type, dimensions, and interpretation of special data values for science and geolocation variables in GMI-GR Geometry Match netCDF files.

| **Variable Name(s)** | **Type** | **Dimension(s)** | **Special Values** |
| --- | --- | --- | --- |
| GR\_Z\_slantPath  GR\_Z\_StdDev\_slantPath  GR\_Z\_Max\_slantPath  GR\_Z\_VPR  GR\_Z\_StdDev\_VPR  GR\_Z\_Max\_VPR | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range GMI scan edge delimiter  -9999.0: Missing data  -100.0: Below dBZ cutoff value |
| GR\_R\*\_rainrate\_slantPath  GR\_R\*\_rainrate\_StdDev\_slantPath  GR\_R\*\_rainrate\_Max\_slantPath  GR\_R\*\_rainrate\_VPR  GR\_R\*\_rainrate\_StdDev\_VPR  GR\_R\*\_rainrate\_Max\_VPR  (see note 10) | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range GMI scan edge delimiter  -9999.0: Missing data  -100.0: Below rainrate cutoff value |
| GR\_Zdr\_slantPath  GR\_Zdr\_StdDev\_slantPath  GR\_Zdr\_Max\_slantPath  GR\_Kdp\_slantPath  GR\_Kdp\_StdDev\_slantPath  GR\_Kdp\_Max\_slantPath  GR\_RHOhv\_slantPath  GR\_RHOhv\_StdDev\_slantPath  GR\_RHOhv\_Max\_slantPath  GR\_Dzero\_slantPath  GR\_Dzero\_StdDev\_slantPath  GR\_Dzero\_Max\_slantPath  GR\_Nw\_slantPath  GR\_Nw\_StdDev\_slantPath  GR\_Nw\_Max\_slantPath  GR\_blockage\_slantPath  GR\_Zdr\_VPR  GR\_Zdr\_StdDev\_VPR  GR\_Zdr\_Max\_VPR  GR\_Kdp\_VPR  GR\_Kdp\_StdDev\_VPR  GR\_Kdp\_Max\_VPR  GR\_RHOhv\_VPR  GR\_RHOhv\_StdDev\_VPR  GR\_RHOhv\_Max\_VPR  GR\_Dzero\_VPR  GR\_Dzero\_StdDev\_VPR  GR\_Dzero\_Max\_VPR  GR\_Nw\_VPR  GR\_Nw\_StdDev\_VPR  GR\_Nw\_Max\_VPR  GR\_blockage\_VPR | float | elevationAngle, fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range PR scan edge delimiter  -9999.0: Missing data  -100.0: Below threshold cutoff value, or all GR bin values are MISSING |
| GR\_HID\_slantPath  GR\_HID\_VPR | short | elevationAngle, fpdim, hidim | -888.0: Range edge delimiter, Fill Value |
| surfacePrecipitation  PoP (note 9) | float | fpdim | -888.0: Range edge delimiter, Fill Value  -777.0: In-range GMI scan edge delimiter  -9999.9: Missing data |
| n\_gr\_expected  n\_gr\_z\_rejected  n\_gr\_rc\_rejected  n\_gr\_rp\_rejected  n\_gr\_rr\_rejected  n\_gr\_zdr\_rejected  n\_gr\_kdp\_rejected  n\_gr\_rhohv\_rejected  n\_gr\_hid\_rejected  n\_gr\_dzero\_rejected  n\_gr\_nw\_rejected  n\_gr\_vpr\_expected  n\_gr\_z\_vpr\_rejected  n\_gr\_rc\_vpr\_rejected  n\_gr\_rp\_vpr\_rejected  n\_gr\_rr\_vpr\_rejected  n\_gr\_zdr\_vpr\_rejected  n\_gr\_kdp\_vpr\_rejected  n\_gr\_rhohv\_vpr\_rejected  n\_gr\_hid\_vpr\_rejected  n\_gr\_dzero\_vpr\_rejected  n\_gr\_nw\_vpr\_rejected | short | elevationAngle, fpdim | -888: Fill Value |
| latitude,  longitude,  topHeight,  bottomHeight  topHeight\_vpr,  bottomHeight\_vpr  (see note 8) | float | elevationAngle, fpdim | -888.0: Fill Value |
| xCorners,  yCorners | float | elevationAngle, fpdim, xydim | -888.0: Fill Value |
| XMIlatitude,  XMIlongitude | float | fpdim | -888.0: Fill Value |
| surfaceTypeIndex  pixelStatus | short | fpdim | -888: Range edge delimiter, Fill Value  -777: In-range GMI scan edge delimiter  -99: Missing data |
| rayIndex | int | fpdim | -1: Edge-of-Range indicator  -2: In-range GMI scan edge indicator |
| elevationAngle | float | elevationAngle | N/A |

Notes on Table 3.2-1:

1. Special Values are values outside of the normal physical range of the data field, and which indicate a special meaning at the data point (e.g., Missing data).
2. Range edge points are the nearest GMI footprints lying outside of, but immediately adjacent to, the range ring surrounding the ground radar at distance = **rangeThreshold**, for a given GMI scan. These points form a partial circle around points for the GMI footprints within the **rangeThreshold** of the ground radar, the latter which contain actual data values.
3. In-range GMI scan edge points are the computed positions single GMI footprints extrapolated just beyond either edge of the GMI scan, and which fall within or immediately adjacent to the **rangeThreshold** distance from the ground radar.
4. The combination of the Range Edge points and the Scan Edge points serve to completely enclose the in-range GMI footprints on the surface: a) defined by each elevation sweep (for multi-level variables), or b) at the earth surface (for single level variables). The purpose of these points is to prevent the extrapolation of “actual” GMI data values outside of the in-range area, if the data are later analyzed to a regular grid using an objective analysis technique.
5. Range Edge points and Scan Edge points are indicated by **rayIndex** values of -1 and -2, respectively. **rayIndex** values of 0 or greater are actual 1-D equivalent array indices of GMI footprints within the full data arrays in the 2A-GPROF data files.
6. ***Range and Scan Edge points are optional and, as a default, are disabled from being computed and output. If the “Mark Edges” parameter’s default value is overridden, then these types of points will then be computed and output as described above.***
7. **Fill Value** is the value to which scalar or array variables in the netCDF file are initialized when the file is created. These values remain in place unless and until the data value is overwritten.
8. The variables **topHeight,** **bottomHeight**, **topHeight\_vpr,** and **bottomHeight\_vpr** represent height above ground level (AGL) (i.e., height above the ground radar) ***in km***.
9. **PoP** values are assigned only for GMI footprints with **surfaceType** “water”, and are undefined (-99) over land and coast.
10. In the family of variables beginning with “**GR\_R\*\_rainrate**”, the wildcard \* is replaced by C, R, and P to indicate that there are 3 sets of these variables. The **GR\_RC\_rainrate** set is for the Cifelli rainrate algorithm, the **GR\_RP\_rainrate** set is for the Polarimetric Z-R algorithm, and the **GR\_RR\_rainrate** set is for the DROPS algorithm.

**Table 3.2‑2.** Values of categorical variables in the GMI-GR geometry matching technique netCDF files.

| **Variable** | **Category definitions** |
| --- | --- |
| surfaceTypeIndex | 1 : Ocean  2 : Sea-Ice  (3-12 are ’land classification’)  3 : Maximum Vegetation  4 : High Vegetation  5 : Moderate Vegetation  6 : Low Vegetation  7 : Minimal Vegetation  8 : Maximum Snow  9 : Moderate Snow  10 : Low Snow  11 : Minimal Snow  12 : Standing Water and Rivers  13 : Water/Land Coast Boundary  14 : Water/Ice Boundary  15 : Land/Ice Boundary  -99 : Missing value |
| pixelStatus | 0 : Valid pixel  1 : Boundary error in landmask  2 : Boundary error in sea-ice check  3 : Boundary error in sea surface temperature  4 : Invalid time  5 : Invalid latitude/longitude  6 : Invalid brightness temperature  7 : Invalid sea surface temperature  -99 : Missing value |
| GR\_HID\_slantPath  GR\_HID\_VPR | See GR\_HID description for GRtoDPR matchup file. |

## DPRGMI-GR Geometry Match netCDF file description

The format and content of Version 1.1 of the GRtoDPRGMI-type Geometry Match netCDF file is presented below, in the form of partial netCDF file creation instructions. See Section 3.1 for details related to dimensions and netCDF variable types. Special values associated with each “science” and geolocation array variable in the GRtoDPRGMI-type geometry match netCDF files follow those for similarly named variables in the DPRtoGR matchup files, as listed in Table 3.1-1. Exceptions are those variables with special values defined in the 2B-DPRGMI file itself, as documented in ***PRECIPITATION PROCESSING SYSTEM, GLOBAL PRECIPITATION MEASUREMENT, File Specification for GPM Products***, available from <http://pps.gsfc.nasa.gov/ppshome/GPMprelimdocs.html>. The DPRGMI product contains data for two swaths in the HDF5 data files: the narrower MS swath for Ka scans matched to inner Ku footprints, and the wider NS swath for Ku footprints. Note that both the MS and NS swaths are processed in the GR-DPRGMI matchup and are included in the GRtoDPRGMI netCDF files. Where there is a swath-type dependency to a variable its name is repeated, once with an ‘\_MS’ indicator in the name and once with an ‘\_NS’ indicator in the name, where there is a difference between swath types for the data in the variable. Note also that for certain MS swath variables there is an additional dimension “nKuKa” in the variable as compared to the NS swath version of the variable, indicating that there are both Ka- and Ku-derived values in the variable.

Depending on the rangeThreshold used and the proximity of the GPM orbit to the ground radar, there may be no overlap of the narrower MS swath with the matchup domain. In this case, the **have\_swath\_MS** flag variable is zero, the various “\_MS” variables are dimensioned to only one footprint (**fpdim\_MS** = 1), and their data values are populated with their netCDF FillValue.

dimensions:

fpdim\_MS = ;

fpdim\_NS = ;

elevationAngle = ;

xydim = 4 ;

hidim = 15 ;

nPSDlo = 2 ;

nBnPSDlo = 9 ;

nKuKa = 2 ;

nPhsBnN = 5 ;

timedimid\_MS = ;

timedimid\_NS = ;

len\_atime\_ID = 19 ;

len\_site\_ID = 4 ;

variables:

float elevationAngle(elevationAngle) ;

elevationAngle:long\_name = "Radar Sweep Elevation Angles" ;

elevationAngle:units = "degrees" ;

short have\_swath\_MS ;

have\_swath\_MS:long\_name = "data exists flag for MS swath" ;

have\_swath\_MS:\_FillValue = 0s ;

short Year\_MS(timedimid\_MS) ;

Year\_MS:long\_name = "Year of DPR MS scan" ;

Year\_MS:\_FillValue = -888s ;

byte Month\_MS(timedimid\_MS) ;

Month\_MS:long\_name = "Month of DPR MS scan" ;

Month\_MS:\_FillValue = -88b ;

byte DayOfMonth\_MS(timedimid\_MS) ;

DayOfMonth\_MS:long\_name = "DayOfMonth of DPR MS scan" ;

DayOfMonth\_MS:\_FillValue = -88b ;

byte Hour\_MS(timedimid\_MS) ;

Hour\_MS:long\_name = "Hour of DPR MS scan" ;

Hour\_MS:\_FillValue = -88b ;

byte Minute\_MS(timedimid\_MS) ;

Minute\_MS:long\_name = "Minute of DPR MS scan" ;

Minute\_MS:\_FillValue = -88b ;

byte Second\_MS(timedimid\_MS) ;

Second\_MS:long\_name = "Second of DPR MS scan" ;

Second\_MS:\_FillValue = -88b ;

short Millisecond\_MS(timedimid\_MS) ;

Millisecond\_MS:long\_name = "Millisecond of DPR MS scan" ;

Millisecond\_MS:\_FillValue = -888s ;

short Year\_NS(timedimid\_NS) ;

Year\_NS:long\_name = "Year of DPR NS scan" ;

Year\_NS:\_FillValue = -888s ;

byte Month\_NS(timedimid\_NS) ;

Month\_NS:long\_name = "Month of DPR NS scan" ;

Month\_NS:\_FillValue = -88b ;

byte DayOfMonth\_NS(timedimid\_NS) ;

DayOfMonth\_NS:long\_name = "DayOfMonth of DPR NS scan" ;

DayOfMonth\_NS:\_FillValue = -88b ;

byte Hour\_NS(timedimid\_NS) ;

Hour\_NS:long\_name = "Hour of DPR NS scan" ;

Hour\_NS:\_FillValue = -88b ;

byte Minute\_NS(timedimid\_NS) ;

Minute\_NS:long\_name = "Minute of DPR NS scan" ;

Minute\_NS:\_FillValue = -88b ;

byte Second\_NS(timedimid\_NS) ;

Second\_NS:long\_name = "Second of DPR NS scan" ;

Second\_NS:\_FillValue = -88b ;

short Millisecond\_NS(timedimid\_NS) ;

Millisecond\_NS:long\_name = "Millisecond of DPR NS scan" ;

Millisecond\_NS:\_FillValue = -888s ;

int startScan\_MS ;

startScan\_MS:long\_name = "Starting DPR MS overlap scan in original dataset, zero-based" ;

startScan\_MS:\_FillValue = -888 ;

int endScan\_MS ;

endScan\_MS:long\_name = "Ending DPR MS overlap scan in original dataset, zero-based" ;

endScan\_MS:\_FillValue = -888 ;

short numRays\_MS ;

numRays\_MS:long\_name = "Number of DPR MS rays per scan in original datasets" ;

numRays\_MS:\_FillValue = -888s ;

int startScan\_NS ;

startScan\_NS:long\_name = "Starting DPR NS overlap scan in original dataset, zero-based" ;

startScan\_NS:\_FillValue = -888 ;

int endScan\_NS ;

endScan\_NS:long\_name = "Ending DPR NS overlap scan in original dataset, zero-based" ;

endScan\_NS:\_FillValue = -888 ;

short numRays\_NS ;

numRays\_NS:long\_name = "Number of DPR NS rays per scan in original datasets" ;

numRays\_NS:\_FillValue = -888s ;

float rangeThreshold ;

rangeThreshold:long\_name = "Dataset maximum range from radar site" ;

rangeThreshold:\_FillValue = -888.f ;

rangeThreshold:units = "km" ;

float DPR\_dBZ\_min ;

DPR\_dBZ\_min:long\_name = "minimum DPR bin dBZ required for a \*complete\* DPR vertical average" ;

DPR\_dBZ\_min:\_FillValue = -888.f ;

DPR\_dBZ\_min:units = "dBZ" ;

float GR\_dBZ\_min ;

GR\_dBZ\_min:long\_name = "minimum GR bin dBZ required for a \*complete\* GR horizontal average" ;

GR\_dBZ\_min:\_FillValue = -888.f ;

GR\_dBZ\_min:units = "dBZ" ;

float rain\_min ;

rain\_min:long\_name = "minimum DPR rainrate required for a \*complete\* DPR vertical average" ;

rain\_min:\_FillValue = -888.f ;

rain\_min:units = "mm/h" ;

short have\_GR\_Z ;

have\_GR\_Z:long\_name = "data exists flag for GR\_Z" ;

have\_GR\_Z:\_FillValue = 0s ;

short have\_GR\_Zdr ;

have\_GR\_Zdr:long\_name = "data exists flag for GR\_Zdr" ;

have\_GR\_Zdr:\_FillValue = 0s ;

short have\_GR\_Kdp ;

have\_GR\_Kdp:long\_name = "data exists flag for GR\_Kdp" ;

have\_GR\_Kdp:\_FillValue = 0s ;

short have\_GR\_RHOhv ;

have\_GR\_RHOhv:long\_name = "data exists flag for GR\_RHOhv" ;

have\_GR\_RHOhv:\_FillValue = 0s ;

short have\_GR\_RC\_rainrate ;

have\_GR\_RC\_rainrate:long\_name = "data exists flag for GR\_RC\_rainrate" ;

have\_GR\_RC\_rainrate:\_FillValue = 0s ;

short have\_GR\_RP\_rainrate ;

have\_GR\_RP\_rainrate:long\_name = "data exists flag for GR\_RP\_rainrate" ;

have\_GR\_RP\_rainrate:\_FillValue = 0s ;

short have\_GR\_RR\_rainrate ;

have\_GR\_RR\_rainrate:long\_name = "data exists flag for GR\_RR\_rainrate" ;

have\_GR\_RR\_rainrate:\_FillValue = 0s ;

short have\_GR\_HID ;

have\_GR\_HID:long\_name = "data exists flag for GR\_HID" ;

have\_GR\_HID:\_FillValue = 0s ;

short have\_GR\_Dzero ;

have\_GR\_Dzero:long\_name = "data exists flag for GR\_Dzero" ;

have\_GR\_Dzero:\_FillValue = 0s ;

short have\_GR\_Nw ;

have\_GR\_Nw:long\_name = "data exists flag for GR\_Nw" ;

have\_GR\_Nw:\_FillValue = 0s ;

float latitude\_MS(elevationAngle, fpdim\_MS) ;

latitude\_MS:long\_name = "Latitude of 3-D data sample" ;

latitude\_MS:units = "degrees North" ;

latitude\_MS:\_FillValue = -888.f ;

float longitude\_MS(elevationAngle, fpdim\_MS) ;

longitude\_MS:long\_name = "Longitude of 3-D data sample" ;

longitude\_MS:units = "degrees East" ;

longitude\_MS:\_FillValue = -888.f ;

float xCorners\_MS(elevationAngle, fpdim\_MS, xydim) ;

xCorners\_MS:long\_name = "data sample x corner coords." ;

xCorners\_MS:units = "km" ;

xCorners\_MS:\_FillValue = -888.f ;

float yCorners\_MS(elevationAngle, fpdim\_MS, xydim) ;

yCorners\_MS:long\_name = "data sample y corner coords." ;

yCorners\_MS:units = "km" ;

yCorners\_MS:\_FillValue = -888.f ;

float topHeight\_MS(elevationAngle, fpdim\_MS) ;

topHeight\_MS:long\_name = "data sample top height AGL" ;

topHeight\_MS:units = "km" ;

topHeight\_MS:\_FillValue = -888.f ;

float bottomHeight\_MS(elevationAngle, fpdim\_MS) ;

bottomHeight\_MS:long\_name = "data sample bottom height AGL" ;

bottomHeight\_MS:units = "km" ;

bottomHeight\_MS:\_FillValue = -888.f ;

float GR\_Z\_MS(elevationAngle, fpdim\_MS) ;

GR\_Z\_MS:long\_name = "GV radar QC Reflectivity" ;

GR\_Z\_MS:units = "dBZ" ;

GR\_Z\_MS:\_FillValue = -888.f ;

float GR\_Z\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_Z\_StdDev\_MS:long\_name = "Standard Deviation of GV radar QC Reflectivity" ;

GR\_Z\_StdDev\_MS:units = "dBZ" ;

GR\_Z\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_Z\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_Z\_Max\_MS:long\_name = "Sample Maximum GV radar QC Reflectivity" ;

GR\_Z\_Max\_MS:units = "dBZ" ;

GR\_Z\_Max\_MS:\_FillValue = -888.f ;

float GR\_Zdr\_MS(elevationAngle, fpdim\_MS) ;

GR\_Zdr\_MS:long\_name = "DP Differential Reflectivity" ;

GR\_Zdr\_MS:units = "dB" ;

GR\_Zdr\_MS:\_FillValue = -888.f ;

float GR\_Zdr\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_Zdr\_StdDev\_MS:long\_name = "Standard Deviation of DP Differential Reflectivity" ;

GR\_Zdr\_StdDev\_MS:units = "dB" ;

GR\_Zdr\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_Zdr\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_Zdr\_Max\_MS:long\_name = "Sample Maximum DP Differential Reflectivity" ;

GR\_Zdr\_Max\_MS:units = "dB" ;

GR\_Zdr\_Max\_MS:\_FillValue = -888.f ;

float GR\_Kdp\_MS(elevationAngle, fpdim\_MS) ;

GR\_Kdp\_MS:long\_name = "DP Specific Differential Phase" ;

GR\_Kdp\_MS:units = "deg/km" ;

GR\_Kdp\_MS:\_FillValue = -888.f ;

float GR\_Kdp\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_Kdp\_StdDev\_MS:long\_name = "Standard Deviation of DP Specific Differential Phase" ;

GR\_Kdp\_StdDev\_MS:units = "deg/km" ;

GR\_Kdp\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_Kdp\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_Kdp\_Max\_MS:long\_name = "Sample Maximum DP Specific Differential Phase" ;

GR\_Kdp\_Max\_MS:units = "deg/km" ;

GR\_Kdp\_Max\_MS:\_FillValue = -888.f ;

float GR\_RHOhv\_MS(elevationAngle, fpdim\_MS) ;

GR\_RHOhv\_MS:long\_name = "DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_MS:units = "Dimensionless" ;

GR\_RHOhv\_MS:\_FillValue = -888.f ;

float GR\_RHOhv\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_RHOhv\_StdDev\_MS:long\_name = "Standard Deviation of DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_StdDev\_MS:units = "Dimensionless" ;

GR\_RHOhv\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_RHOhv\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_RHOhv\_Max\_MS:long\_name = "Sample Maximum DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_Max\_MS:units = "Dimensionless" ;

GR\_RHOhv\_Max\_MS:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_MS(elevationAngle, fpdim\_MS) ;

GR\_RC\_rainrate\_MS:long\_name = "GV radar Cifelli Rainrate" ;

GR\_RC\_rainrate\_MS:units = "mm/h" ;

GR\_RC\_rainrate\_MS:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_RC\_rainrate\_StdDev\_MS:long\_name = "Standard Deviation of GV radar Cifelli Rainrate" ;

GR\_RC\_rainrate\_StdDev\_MS:units = "mm/h" ;

GR\_RC\_rainrate\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_RC\_rainrate\_Max\_MS:long\_name = "Sample Maximum GV radar Cifelli Rainrate" ;

GR\_RC\_rainrate\_Max\_MS:units = "mm/h" ;

GR\_RC\_rainrate\_Max\_MS:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_MS(elevationAngle, fpdim\_MS) ;

GR\_RP\_rainrate\_MS:long\_name = "GV radar PolZR Rainrate" ;

GR\_RP\_rainrate\_MS:units = "mm/h" ;

GR\_RP\_rainrate\_MS:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_RP\_rainrate\_StdDev\_MS:long\_name = "Standard Deviation of GV radar PolZR Rainrate" ;

GR\_RP\_rainrate\_StdDev\_MS:units = "mm/h" ;

GR\_RP\_rainrate\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_RP\_rainrate\_Max\_MS:long\_name = "Sample Maximum GV radar PolZR Rainrate" ;

GR\_RP\_rainrate\_Max\_MS:units = "mm/h" ;

GR\_RP\_rainrate\_Max\_MS:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_MS(elevationAngle, fpdim\_MS) ;

GR\_RR\_rainrate\_MS:long\_name = "GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_MS:units = "mm/h" ;

GR\_RR\_rainrate\_MS:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_RR\_rainrate\_StdDev\_MS:long\_name = "Standard Deviation of GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_StdDev\_MS:units = "mm/h" ;

GR\_RR\_rainrate\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_RR\_rainrate\_Max\_MS:long\_name = "Sample Maximum GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_Max\_MS:units = "mm/h" ;

GR\_RR\_rainrate\_Max\_MS:\_FillValue = -888.f ;

short GR\_HID\_MS(elevationAngle, fpdim\_MS, hidim) ;

GR\_HID\_MS:long\_name = "DP Hydrometeor Identification" ;

GR\_HID\_MS:units = "Categorical" ;

GR\_HID\_MS:\_FillValue = -888s ;

float GR\_Dzero\_MS(elevationAngle, fpdim\_MS) ;

GR\_Dzero\_MS:long\_name = "DP Median Volume Diameter" ;

GR\_Dzero\_MS:units = "mm" ;

GR\_Dzero\_MS:\_FillValue = -888.f ;

float GR\_Dzero\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_Dzero\_StdDev\_MS:long\_name = "Standard Deviation of DP Median Volume Diameter" ;

GR\_Dzero\_StdDev\_MS:units = "mm" ;

GR\_Dzero\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_Dzero\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_Dzero\_Max\_MS:long\_name = "Sample Maximum DP Median Volume Diameter" ;

GR\_Dzero\_Max\_MS:units = "mm" ;

GR\_Dzero\_Max\_MS:\_FillValue = -888.f ;

float GR\_Nw\_MS(elevationAngle, fpdim\_MS) ;

GR\_Nw\_MS:long\_name = "DP Normalized Intercept Parameter" ;

GR\_Nw\_MS:units = "1/(mm\*m^3)" ;

GR\_Nw\_MS:\_FillValue = -888.f ;

float GR\_Nw\_StdDev\_MS(elevationAngle, fpdim\_MS) ;

GR\_Nw\_StdDev\_MS:long\_name = "Standard Deviation of DP Normalized Intercept Parameter" ;

GR\_Nw\_StdDev\_MS:units = "1/(mm\*m^3)" ;

GR\_Nw\_StdDev\_MS:\_FillValue = -888.f ;

float GR\_Nw\_Max\_MS(elevationAngle, fpdim\_MS) ;

GR\_Nw\_Max\_MS:long\_name = "Sample Maximum DP Normalized Intercept Parameter" ;

GR\_Nw\_Max\_MS:units = "1/(mm\*m^3)" ;

GR\_Nw\_Max\_MS:\_FillValue = -888.f ;

short n\_gr\_z\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_z\_rejected\_MS:long\_name = "number of bins below GR\_dBZ\_min in GR\_Z average" ;

n\_gr\_z\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_zdr\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_zdr\_rejected\_MS:long\_name = "number of bins with missing Zdr in GR\_Zdr average" ;

n\_gr\_zdr\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_kdp\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_kdp\_rejected\_MS:long\_name = "number of bins with missing Kdp in GR\_Kdp average" ;

n\_gr\_kdp\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_rhohv\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_rhohv\_rejected\_MS:long\_name = "number of bins with missing RHOhv in GR\_RHOhv average" ;

n\_gr\_rhohv\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_rc\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_rc\_rejected\_MS:long\_name = "number of bins below rain\_min in GR\_RC\_rainrate average" ;

n\_gr\_rc\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_rp\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_rp\_rejected\_MS:long\_name = "number of bins below rain\_min in GR\_RP\_rainrate average" ;

n\_gr\_rp\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_rr\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_rr\_rejected\_MS:long\_name = "number of bins below rain\_min in GR\_RR\_rainrate average" ;

n\_gr\_rr\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_hid\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_hid\_rejected\_MS:long\_name = "number of bins with undefined HID in GR\_HID histogram" ;

n\_gr\_hid\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_dzero\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_dzero\_rejected\_MS:long\_name = "number of bins with missing D0 in GR\_Dzero average" ;

n\_gr\_dzero\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_nw\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_nw\_rejected\_MS:long\_name = "number of bins with missing Nw in GR\_Nw average" ;

n\_gr\_nw\_rejected\_MS:\_FillValue = -888s ;

short n\_gr\_expected\_MS(elevationAngle, fpdim\_MS) ;

n\_gr\_expected\_MS:long\_name = "number of bins in GR\_Z average" ;

n\_gr\_expected\_MS:\_FillValue = -888s ;

float precipTotPSDparamHigh\_MS(elevationAngle, fpdim\_MS) ;

precipTotPSDparamHigh\_MS:long\_name = "2B-DPRGMI precipTotPSDparamHigh for MS swath" ;

precipTotPSDparamHigh\_MS:units = "mm\_Dm" ;

precipTotPSDparamHigh\_MS:\_FillValue = -888.f ;

float precipTotPSDparamLow\_MS(elevationAngle, fpdim\_MS, nPSDlo) ;

precipTotPSDparamLow\_MS:long\_name = "2B-DPRGMI precipTotPSDparamLow for MS swath" ;

precipTotPSDparamLow\_MS:units = "Nw\_mu" ;

precipTotPSDparamLow\_MS:\_FillValue = -888.f ;

float precipTotRate\_MS(elevationAngle, fpdim\_MS) ;

precipTotRate\_MS:long\_name = "2B-DPRGMI precipTotRate for MS swath" ;

precipTotRate\_MS:units = "mm/h" ;

precipTotRate\_MS:\_FillValue = -888.f ;

float precipTotWaterCont\_MS(elevationAngle, fpdim\_MS) ;

precipTotWaterCont\_MS:long\_name = "2B-DPRGMI precipTotWaterCont for MS swath" ;

precipTotWaterCont\_MS:units = "g/m^3" ;

precipTotWaterCont\_MS:\_FillValue = -888.f ;

short n\_precipTotPSDparamHigh\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_precipTotPSDparamHigh\_rejected\_MS:long\_name = "number of bins below rain\_min in precipTotPSDparamHigh average for MS swath" ;

n\_precipTotPSDparamHigh\_rejected\_MS:\_FillValue = -888s ;

short n\_precipTotPSDparamLow\_rejected\_MS(elevationAngle, fpdim\_MS, nPSDlo) ;

n\_precipTotPSDparamLow\_rejected\_MS:long\_name = "number of bins below rain\_min in precipTotPSDparamLow average for MS swath" ;

n\_precipTotPSDparamLow\_rejected\_MS:\_FillValue = -888s ;

short n\_precipTotRate\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_precipTotRate\_rejected\_MS:long\_name = "number of bins below rain\_min in precipTotRate average for MS swath" ;

n\_precipTotRate\_rejected\_MS:\_FillValue = -888s ;

short n\_precipTotWaterCont\_rejected\_MS(elevationAngle, fpdim\_MS) ;

n\_precipTotWaterCont\_rejected\_MS:long\_name = "number of bins below rain\_min in precipTotWaterCont average for MS swath" ;

n\_precipTotWaterCont\_rejected\_MS:\_FillValue = -888s ;

int precipitationType\_MS(fpdim\_MS) ;

precipitationType\_MS:long\_name = "2B-DPRGMI precipitationType for MS swath" ;

precipitationType\_MS:units = "Categorical" ;

precipitationType\_MS:\_FillValue = -888 ;

float surfPrecipTotRate\_MS(fpdim\_MS) ;

surfPrecipTotRate\_MS:long\_name = "2B-DPRGMI surfPrecipTotRate for MS swath" ;

surfPrecipTotRate\_MS:units = "mm/h" ;

surfPrecipTotRate\_MS:\_FillValue = -888.f ;

float surfaceElevation\_MS(fpdim\_MS) ;

surfaceElevation\_MS:long\_name = "2B-DPRGMI surfaceElevation for MS swath" ;

surfaceElevation\_MS:units = "m" ;

surfaceElevation\_MS:\_FillValue = -888.f ;

int surfaceType\_MS(fpdim\_MS) ;

surfaceType\_MS:long\_name = "2B-DPRGMI surfaceType for MS swath" ;

surfaceType\_MS:units = "Categorical" ;

surfaceType\_MS:\_FillValue = -888 ;

short phaseBinNodes\_MS(fpdim\_MS, nPhsBnN) ;

phaseBinNodes\_MS:long\_name = "2B-DPRGMI phaseBinNodes for MS swath" ;

phaseBinNodes\_MS:units = "None" ;

phaseBinNodes\_MS:\_FillValue = -888s ;

float DPRlatitude\_MS(fpdim\_MS) ;

DPRlatitude\_MS:long\_name = "Latitude of DPR surface bin for MS swath" ;

DPRlatitude\_MS:units = "degrees North" ;

DPRlatitude\_MS:\_FillValue = -888.f ;

float DPRlongitude\_MS(fpdim\_MS) ;

DPRlongitude\_MS:long\_name = "Longitude of DPR surface bin for MS swath" ;

DPRlongitude\_MS:units = "degrees East" ;

DPRlongitude\_MS:\_FillValue = -888.f ;

short scanNum\_MS(fpdim\_MS) ;

scanNum\_MS:long\_name = "product-relative zero-based DPR scan number for MS swath" ;

scanNum\_MS:\_FillValue = -888s ;

short rayNum\_MS(fpdim\_MS) ;

rayNum\_MS:long\_name = "product-relative zero-based DPR ray number for MS swath" ;

rayNum\_MS:\_FillValue = -888s ;

float ellipsoidBinOffset\_MS(fpdim\_MS, nKuKa) ;

ellipsoidBinOffset\_MS:long\_name = "2B-DPRGMI Ku and Ka ellipsoidBinOffset for MS swath" ;

ellipsoidBinOffset\_MS:units = "m" ;

ellipsoidBinOffset\_MS:\_FillValue = -888.f ;

short lowestClutterFreeBin\_MS(fpdim\_MS, nKuKa) ;

lowestClutterFreeBin\_MS:long\_name = "2B-DPRGMI Ku and Ka lowestClutterFreeBin for MS swath" ;

lowestClutterFreeBin\_MS:units = "None" ;

lowestClutterFreeBin\_MS:\_FillValue = -888s ;

int precipitationFlag\_MS(fpdim\_MS, nKuKa) ;

precipitationFlag\_MS:long\_name = "2B-DPRGMI Ku and Ka precipitationFlag for MS swath" ;

precipitationFlag\_MS:units = "Categorical" ;

precipitationFlag\_MS:\_FillValue = -888 ;

short surfaceRangeBin\_MS(fpdim\_MS, nKuKa) ;

surfaceRangeBin\_MS:long\_name = "2B-DPRGMI Ku and Ka surfaceRangeBin for MS swath" ;

surfaceRangeBin\_MS:units = "None" ;

surfaceRangeBin\_MS:\_FillValue = -888s ;

float correctedReflectFactor\_MS(elevationAngle, fpdim\_MS, nKuKa) ;

correctedReflectFactor\_MS:long\_name = "2B-DPRGMI Ku and Ka Corrected Reflectivity Factor for MS swath" ;

correctedReflectFactor\_MS:units = "dBZ" ;

correctedReflectFactor\_MS:\_FillValue = -888.f ;

float pia\_MS(fpdim\_MS, nKuKa) ;

pia\_MS:long\_name = "2B-DPRGMI Ku and Ka Path Integrated Attenuation for MS swath" ;

pia\_MS:units = "dB" ;

pia\_MS:\_FillValue = -888.f ;

short n\_correctedReflectFactor\_rejected\_MS(elevationAngle, fpdim\_MS, nKuKa) ;

n\_correctedReflectFactor\_rejected\_MS:long\_name = "numbers of Ku and Ka bins below DPR\_dBZ\_min in correctedReflectFactor average for MS swath" ;

n\_correctedReflectFactor\_rejected\_MS:\_FillValue = -888s ;

short n\_dpr\_expected\_MS(elevationAngle, fpdim\_MS, nKuKa) ;

n\_dpr\_expected\_MS:long\_name = "numbers of expected Ku and Ka bins in DPR averages for MS swath" ;

n\_dpr\_expected\_MS:\_FillValue = -888s ;

float latitude\_NS(elevationAngle, fpdim\_NS) ;

latitude\_NS:long\_name = "Latitude of 3-D data sample" ;

latitude\_NS:units = "degrees North" ;

latitude\_NS:\_FillValue = -888.f ;

float longitude\_NS(elevationAngle, fpdim\_NS) ;

longitude\_NS:long\_name = "Longitude of 3-D data sample" ;

longitude\_NS:units = "degrees East" ;

longitude\_NS:\_FillValue = -888.f ;

float xCorners\_NS(elevationAngle, fpdim\_NS, xydim) ;

xCorners\_NS:long\_name = "data sample x corner coords." ;

xCorners\_NS:units = "km" ;

xCorners\_NS:\_FillValue = -888.f ;

float yCorners\_NS(elevationAngle, fpdim\_NS, xydim) ;

yCorners\_NS:long\_name = "data sample y corner coords." ;

yCorners\_NS:units = "km" ;

yCorners\_NS:\_FillValue = -888.f ;

float topHeight\_NS(elevationAngle, fpdim\_NS) ;

topHeight\_NS:long\_name = "data sample top height AGL" ;

topHeight\_NS:units = "km" ;

topHeight\_NS:\_FillValue = -888.f ;

float bottomHeight\_NS(elevationAngle, fpdim\_NS) ;

bottomHeight\_NS:long\_name = "data sample bottom height AGL" ;

bottomHeight\_NS:units = "km" ;

bottomHeight\_NS:\_FillValue = -888.f ;

float GR\_Z\_NS(elevationAngle, fpdim\_NS) ;

GR\_Z\_NS:long\_name = "GV radar QC Reflectivity" ;

GR\_Z\_NS:units = "dBZ" ;

GR\_Z\_NS:\_FillValue = -888.f ;

float GR\_Z\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_Z\_StdDev\_NS:long\_name = "Standard Deviation of GV radar QC Reflectivity" ;

GR\_Z\_StdDev\_NS:units = "dBZ" ;

GR\_Z\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_Z\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_Z\_Max\_NS:long\_name = "Sample Maximum GV radar QC Reflectivity" ;

GR\_Z\_Max\_NS:units = "dBZ" ;

GR\_Z\_Max\_NS:\_FillValue = -888.f ;

float GR\_Zdr\_NS(elevationAngle, fpdim\_NS) ;

GR\_Zdr\_NS:long\_name = "DP Differential Reflectivity" ;

GR\_Zdr\_NS:units = "dB" ;

GR\_Zdr\_NS:\_FillValue = -888.f ;

float GR\_Zdr\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_Zdr\_StdDev\_NS:long\_name = "Standard Deviation of DP Differential Reflectivity" ;

GR\_Zdr\_StdDev\_NS:units = "dB" ;

GR\_Zdr\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_Zdr\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_Zdr\_Max\_NS:long\_name = "Sample Maximum DP Differential Reflectivity" ;

GR\_Zdr\_Max\_NS:units = "dB" ;

GR\_Zdr\_Max\_NS:\_FillValue = -888.f ;

float GR\_Kdp\_NS(elevationAngle, fpdim\_NS) ;

GR\_Kdp\_NS:long\_name = "DP Specific Differential Phase" ;

GR\_Kdp\_NS:units = "deg/km" ;

GR\_Kdp\_NS:\_FillValue = -888.f ;

float GR\_Kdp\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_Kdp\_StdDev\_NS:long\_name = "Standard Deviation of DP Specific Differential Phase" ;

GR\_Kdp\_StdDev\_NS:units = "deg/km" ;

GR\_Kdp\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_Kdp\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_Kdp\_Max\_NS:long\_name = "Sample Maximum DP Specific Differential Phase" ;

GR\_Kdp\_Max\_NS:units = "deg/km" ;

GR\_Kdp\_Max\_NS:\_FillValue = -888.f ;

float GR\_RHOhv\_NS(elevationAngle, fpdim\_NS) ;

GR\_RHOhv\_NS:long\_name = "DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_NS:units = "Dimensionless" ;

GR\_RHOhv\_NS:\_FillValue = -888.f ;

float GR\_RHOhv\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_RHOhv\_StdDev\_NS:long\_name = "Standard Deviation of DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_StdDev\_NS:units = "Dimensionless" ;

GR\_RHOhv\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_RHOhv\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_RHOhv\_Max\_NS:long\_name = "Sample Maximum DP Co-Polar Correlation Coefficient" ;

GR\_RHOhv\_Max\_NS:units = "Dimensionless" ;

GR\_RHOhv\_Max\_NS:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_NS(elevationAngle, fpdim\_NS) ;

GR\_RC\_rainrate\_NS:long\_name = "GV radar Cifelli Rainrate" ;

GR\_RC\_rainrate\_NS:units = "mm/h" ;

GR\_RC\_rainrate\_NS:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_RC\_rainrate\_StdDev\_NS:long\_name = "Standard Deviation of GV radar Cifelli Rainrate" ;

GR\_RC\_rainrate\_StdDev\_NS:units = "mm/h" ;

GR\_RC\_rainrate\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_RC\_rainrate\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_RC\_rainrate\_Max\_NS:long\_name = "Sample Maximum GV radar Cifelli Rainrate" ;

GR\_RC\_rainrate\_Max\_NS:units = "mm/h" ;

GR\_RC\_rainrate\_Max\_NS:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_NS(elevationAngle, fpdim\_NS) ;

GR\_RP\_rainrate\_NS:long\_name = "GV radar PolZR Rainrate" ;

GR\_RP\_rainrate\_NS:units = "mm/h" ;

GR\_RP\_rainrate\_NS:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_RP\_rainrate\_StdDev\_NS:long\_name = "Standard Deviation of GV radar PolZR Rainrate" ;

GR\_RP\_rainrate\_StdDev\_NS:units = "mm/h" ;

GR\_RP\_rainrate\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_RP\_rainrate\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_RP\_rainrate\_Max\_NS:long\_name = "Sample Maximum GV radar PolZR Rainrate" ;

GR\_RP\_rainrate\_Max\_NS:units = "mm/h" ;

GR\_RP\_rainrate\_Max\_NS:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_NS(elevationAngle, fpdim\_NS) ;

GR\_RR\_rainrate\_NS:long\_name = "GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_NS:units = "mm/h" ;

GR\_RR\_rainrate\_NS:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_RR\_rainrate\_StdDev\_NS:long\_name = "Standard Deviation of GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_StdDev\_NS:units = "mm/h" ;

GR\_RR\_rainrate\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_RR\_rainrate\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_RR\_rainrate\_Max\_NS:long\_name = "Sample Maximum GV radar DROPS Rainrate" ;

GR\_RR\_rainrate\_Max\_NS:units = "mm/h" ;

GR\_RR\_rainrate\_Max\_NS:\_FillValue = -888.f ;

short GR\_HID\_NS(elevationAngle, fpdim\_NS, hidim) ;

GR\_HID\_NS:long\_name = "DP Hydrometeor Identification" ;

GR\_HID\_NS:units = "Categorical" ;

GR\_HID\_NS:\_FillValue = -888s ;

float GR\_Dzero\_NS(elevationAngle, fpdim\_NS) ;

GR\_Dzero\_NS:long\_name = "DP Median Volume Diameter" ;

GR\_Dzero\_NS:units = "mm" ;

GR\_Dzero\_NS:\_FillValue = -888.f ;

float GR\_Dzero\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_Dzero\_StdDev\_NS:long\_name = "Standard Deviation of DP Median Volume Diameter" ;

GR\_Dzero\_StdDev\_NS:units = "mm" ;

GR\_Dzero\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_Dzero\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_Dzero\_Max\_NS:long\_name = "Sample Maximum DP Median Volume Diameter" ;

GR\_Dzero\_Max\_NS:units = "mm" ;

GR\_Dzero\_Max\_NS:\_FillValue = -888.f ;

float GR\_Nw\_NS(elevationAngle, fpdim\_NS) ;

GR\_Nw\_NS:long\_name = "DP Normalized Intercept Parameter" ;

GR\_Nw\_NS:units = "1/(mm\*m^3)" ;

GR\_Nw\_NS:\_FillValue = -888.f ;

float GR\_Nw\_StdDev\_NS(elevationAngle, fpdim\_NS) ;

GR\_Nw\_StdDev\_NS:long\_name = "Standard Deviation of DP Normalized Intercept Parameter" ;

GR\_Nw\_StdDev\_NS:units = "1/(mm\*m^3)" ;

GR\_Nw\_StdDev\_NS:\_FillValue = -888.f ;

float GR\_Nw\_Max\_NS(elevationAngle, fpdim\_NS) ;

GR\_Nw\_Max\_NS:long\_name = "Sample Maximum DP Normalized Intercept Parameter" ;

GR\_Nw\_Max\_NS:units = "1/(mm\*m^3)" ;

GR\_Nw\_Max\_NS:\_FillValue = -888.f ;

short n\_gr\_z\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_z\_rejected\_NS:long\_name = "number of bins below GR\_dBZ\_min in GR\_Z average" ;

n\_gr\_z\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_zdr\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_zdr\_rejected\_NS:long\_name = "number of bins with missing Zdr in GR\_Zdr average" ;

n\_gr\_zdr\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_kdp\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_kdp\_rejected\_NS:long\_name = "number of bins with missing Kdp in GR\_Kdp average" ;

n\_gr\_kdp\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_rhohv\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_rhohv\_rejected\_NS:long\_name = "number of bins with missing RHOhv in GR\_RHOhv average" ;

n\_gr\_rhohv\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_rc\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_rc\_rejected\_NS:long\_name = "number of bins below rain\_min in GR\_RC\_rainrate average" ;

n\_gr\_rc\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_rp\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_rp\_rejected\_NS:long\_name = "number of bins below rain\_min in GR\_RP\_rainrate average" ;

n\_gr\_rp\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_rr\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_rr\_rejected\_NS:long\_name = "number of bins below rain\_min in GR\_RR\_rainrate average" ;

n\_gr\_rr\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_hid\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_hid\_rejected\_NS:long\_name = "number of bins with undefined HID in GR\_HID histogram" ;

n\_gr\_hid\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_dzero\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_dzero\_rejected\_NS:long\_name = "number of bins with missing D0 in GR\_Dzero average" ;

n\_gr\_dzero\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_nw\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_nw\_rejected\_NS:long\_name = "number of bins with missing Nw in GR\_Nw average" ;

n\_gr\_nw\_rejected\_NS:\_FillValue = -888s ;

short n\_gr\_expected\_NS(elevationAngle, fpdim\_NS) ;

n\_gr\_expected\_NS:long\_name = "number of bins in GR\_Z average" ;

n\_gr\_expected\_NS:\_FillValue = -888s ;

float precipTotPSDparamHigh\_NS(elevationAngle, fpdim\_NS) ;

precipTotPSDparamHigh\_NS:long\_name = "2B-DPRGMI precipTotPSDparamHigh for NS swath" ;

precipTotPSDparamHigh\_NS:units = "mm\_Dm" ;

precipTotPSDparamHigh\_NS:\_FillValue = -888.f ;

float precipTotPSDparamLow\_NS(elevationAngle, fpdim\_NS, nPSDlo) ;

precipTotPSDparamLow\_NS:long\_name = "2B-DPRGMI precipTotPSDparamLow for NS swath" ;

precipTotPSDparamLow\_NS:units = "Nw\_mu" ;

precipTotPSDparamLow\_NS:\_FillValue = -888.f ;

float precipTotRate\_NS(elevationAngle, fpdim\_NS) ;

precipTotRate\_NS:long\_name = "2B-DPRGMI precipTotRate for NS swath" ;

precipTotRate\_NS:units = "mm/h" ;

precipTotRate\_NS:\_FillValue = -888.f ;

float precipTotWaterCont\_NS(elevationAngle, fpdim\_NS) ;

precipTotWaterCont\_NS:long\_name = "2B-DPRGMI precipTotWaterCont for NS swath" ;

precipTotWaterCont\_NS:units = "g/m^3" ;

precipTotWaterCont\_NS:\_FillValue = -888.f ;

short n\_precipTotPSDparamHigh\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_precipTotPSDparamHigh\_rejected\_NS:long\_name = "number of bins below rain\_min in precipTotPSDparamHigh average for NS swath" ;

n\_precipTotPSDparamHigh\_rejected\_NS:\_FillValue = -888s ;

short n\_precipTotPSDparamLow\_rejected\_NS(elevationAngle, fpdim\_NS, nPSDlo) ;

n\_precipTotPSDparamLow\_rejected\_NS:long\_name = "number of bins below rain\_min in precipTotPSDparamLow average for NS swath" ;

n\_precipTotPSDparamLow\_rejected\_NS:\_FillValue = -888s ;

short n\_precipTotRate\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_precipTotRate\_rejected\_NS:long\_name = "number of bins below rain\_min in precipTotRate average for NS swath" ;

n\_precipTotRate\_rejected\_NS:\_FillValue = -888s ;

short n\_precipTotWaterCont\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_precipTotWaterCont\_rejected\_NS:long\_name = "number of bins below rain\_min in precipTotWaterCont average for NS swath" ;

n\_precipTotWaterCont\_rejected\_NS:\_FillValue = -888s ;

int precipitationType\_NS(fpdim\_NS) ;

precipitationType\_NS:long\_name = "2B-DPRGMI precipitationType for NS swath" ;

precipitationType\_NS:units = "Categorical" ;

precipitationType\_NS:\_FillValue = -888 ;

float surfPrecipTotRate\_NS(fpdim\_NS) ;

surfPrecipTotRate\_NS:long\_name = "2B-DPRGMI surfPrecipTotRate for NS swath" ;

surfPrecipTotRate\_NS:units = "mm/h" ;

surfPrecipTotRate\_NS:\_FillValue = -888.f ;

float surfaceElevation\_NS(fpdim\_NS) ;

surfaceElevation\_NS:long\_name = "2B-DPRGMI surfaceElevation for NS swath" ;

surfaceElevation\_NS:units = "m" ;

surfaceElevation\_NS:\_FillValue = -888.f ;

int surfaceType\_NS(fpdim\_NS) ;

surfaceType\_NS:long\_name = "2B-DPRGMI surfaceType for NS swath" ;

surfaceType\_NS:units = "Categorical" ;

surfaceType\_NS:\_FillValue = -888 ;

short phaseBinNodes\_NS(fpdim\_NS, nPhsBnN) ;

phaseBinNodes\_NS:long\_name = "2B-DPRGMI phaseBinNodes for NS swath" ;

phaseBinNodes\_NS:units = "None" ;

phaseBinNodes\_NS:\_FillValue = -888s ;

float DPRlatitude\_NS(fpdim\_NS) ;

DPRlatitude\_NS:long\_name = "Latitude of DPR surface bin for NS swath" ;

DPRlatitude\_NS:units = "degrees North" ;

DPRlatitude\_NS:\_FillValue = -888.f ;

float DPRlongitude\_NS(fpdim\_NS) ;

DPRlongitude\_NS:long\_name = "Longitude of DPR surface bin for NS swath" ;

DPRlongitude\_NS:units = "degrees East" ;

DPRlongitude\_NS:\_FillValue = -888.f ;

short scanNum\_NS(fpdim\_NS) ;

scanNum\_NS:long\_name = "product-relative zero-based DPR scan number for NS swath" ;

scanNum\_NS:\_FillValue = -888s ;

short rayNum\_NS(fpdim\_NS) ;

rayNum\_NS:long\_name = "product-relative zero-based DPR ray number for NS swath" ;

rayNum\_NS:\_FillValue = -888s ;

float ellipsoidBinOffset\_NS(fpdim\_NS) ;

ellipsoidBinOffset\_NS:long\_name = "2B-DPRGMI ellipsoidBinOffset for NS swath" ;

ellipsoidBinOffset\_NS:units = "m" ;

ellipsoidBinOffset\_NS:\_FillValue = -888.f ;

short lowestClutterFreeBin\_NS(fpdim\_NS) ;

lowestClutterFreeBin\_NS:long\_name = "2B-DPRGMI lowestClutterFreeBin for NS swath" ;

lowestClutterFreeBin\_NS:units = "None" ;

lowestClutterFreeBin\_NS:\_FillValue = -888s ;

int precipitationFlag\_NS(fpdim\_NS) ;

precipitationFlag\_NS:long\_name = "2B-DPRGMI precipitationFlag for NS swath" ;

precipitationFlag\_NS:units = "Categorical" ;

precipitationFlag\_NS:\_FillValue = -888 ;

short surfaceRangeBin\_NS(fpdim\_NS) ;

surfaceRangeBin\_NS:long\_name = "2B-DPRGMI surfaceRangeBin for NS swath" ;

surfaceRangeBin\_NS:units = "None" ;

surfaceRangeBin\_NS:\_FillValue = -888s ;

float correctedReflectFactor\_NS(elevationAngle, fpdim\_NS) ;

correctedReflectFactor\_NS:long\_name = "2B-DPRGMI Corrected Reflectivity Factor for NS swath" ;

correctedReflectFactor\_NS:units = "dBZ" ;

correctedReflectFactor\_NS:\_FillValue = -888.f ;

float pia\_NS(fpdim\_NS) ;

pia\_NS:long\_name = "2B-DPRGMI Path Integrated Attenuation for NS swath" ;

pia\_NS:units = "dB" ;

pia\_NS:\_FillValue = -888.f ;

short n\_correctedReflectFactor\_rejected\_NS(elevationAngle, fpdim\_NS) ;

n\_correctedReflectFactor\_rejected\_NS:long\_name = "number of bins below DPR\_dBZ\_min in correctedReflectFactor average" ;

n\_correctedReflectFactor\_rejected\_NS:\_FillValue = -888s ;

short n\_dpr\_expected\_NS(elevationAngle, fpdim\_NS) ;

n\_dpr\_expected\_NS:long\_name = "number of expected bins in DPR averages for NS swath" ;

n\_dpr\_expected\_NS:\_FillValue = -888s ;

double timeNearestApproach ;

timeNearestApproach:units = "seconds" ;

timeNearestApproach:long\_name = "Seconds since 01-01-1970 00:00:00" ;

timeNearestApproach:\_FillValue = 0. ;

char atimeNearestApproach(len\_atime\_ID) ;

atimeNearestApproach:long\_name = "text version of timeNearestApproach, UTC" ;

double timeSweepStart(elevationAngle) ;

timeSweepStart:units = "seconds" ;

timeSweepStart:long\_name = "Seconds since 01-01-1970 00:00:00" ;

timeSweepStart:\_FillValue = 0. ;

char atimeSweepStart(elevationAngle, len\_atime\_ID) ;

atimeSweepStart:long\_name = "text version of timeSweepStart, UTC" ;

char site\_ID(len\_site\_ID) ;

site\_ID:long\_name = "ID of Ground Radar Site" ;

float site\_lat ;

site\_lat:long\_name = "Latitude of Ground Radar Site" ;

site\_lat:units = "degrees North" ;

site\_lat:\_FillValue = -888.f ;

float site\_lon ;

site\_lon:long\_name = "Longitude of Ground Radar Site" ;

site\_lon:units = "degrees East" ;

site\_lon:\_FillValue = -888.f ;

float site\_elev ;

site\_elev:long\_name = "Elevation of Ground Radar Site above MSL" ;

site\_elev:units = "km" ;

float version ;

version:long\_name = "Geo Match File Version" ;

// global attributes:

:DPR\_Version = "V03C" ;

:GV\_UF\_Z\_field = "CZ" ;

:GV\_UF\_ZDR\_field = "DR" ;

:GV\_UF\_KDP\_field = "KD" ;

:GV\_UF\_RHOHV\_field = "RH" ;

:GV\_UF\_RC\_field = "RC" ;

:GV\_UF\_RP\_field = "RP" ;

:GV\_UF\_RR\_field = "RR" ;

:GV\_UF\_HID\_field = "FH" ;

:GV\_UF\_D0\_field = "D0" ;

:GV\_UF\_NW\_field = "NW" ;

:DPR\_2BCMB\_file = "2B-CS-CONUS.GPM.DPRGMI.CORRA2014.20141018-S145636-E150514.003624.V03C.HDF5" ;

:GR\_file = "KBRO\_2014\_1018\_150336.uf.gz" ;

NOTES:

1) The variables **topHeight** and **bottomHeight** are in units of km above ground level (km AGL). Assuming all heights are in units of km, then the variable **site\_elev** (km above MSL) relates heights above mean sea level (MSL) and AGL:

HeightAGL = HeightMSL - site\_elev

2) Actual values for the dimension variables “**fpdim\_MS**”, “**fpdim\_NS**”, “**elevationAngle**”, “**timedimid\_MS**”, and “**timedimid\_NS**” must be specified at time of netCDF file creation. The fpdim dimensions represent the number of DPR footprints in the DPR/GR overlap area for the indicated swath type. The timedimid dimensions represent the number of DPR scans in the overlap area for the indicated swath type.

# Directory Structure of the VN ftp site

This section describes the directory structure for the VN data ftp site:

[**ftp://hector.gsfc.nasa.gov/gpm-validation/data**](ftp://hector.gsfc.nasa.gov/gpm-validation/data)**/gpmgv**

In the directory structures shown below, all directory and filename values and/or fields indicated in regular text are literal fields that never vary from those shown. The fields shown in ***bold italics*** vary according to the value of the field code they represent. Fields enclosed in [brackets] are optional, and the brackets are not part of the file names. The field codes are defined in Table 4-1.

/blockage (Note-8)

/*XXXX*/

*XXXX*.BeamBlockage\_*AA.aa*.sav

/coincidence\_tables (Note-1)

/***YYYY***

/***MM***

/***DD***/

CT***.SSSS.YYYYMMDD.jjj***.txt

CT***.SSSS.YYYYMMDD.jjj***.unl

/db\_backup/ (Note-2)

gpmgvDBdump.gz

gpmgvDBdump.old.gz

/gv\_radar (Note-3)

/finalQC\_in (Note-3)

/***xxxx***

/1CUF

/***YYYY***

/***MMDD***/

***XXXX\_YYYY\_MMDD\_hhmmss***.uf.gz (Note-6)

***XXXX\_YYYY\_MMDD\_hhmmss\_***rhi.uf.gz (Note-6)

/images

/***YYYY***

/***MMDD***/

***XXXX \_YYYY\_MMDD\_hhmmss\_FF.***sw***ee***\_PPI.png

/raw

/***YYYY***

/***MMDD***/

***XXXXYYYYMMDD\_hhmmss***.gz

/mosaicimages (Note-4)

/archivedmosaic/

***YYYY-MM-DD\_hhmm***.gif

Multiple directory trees exist under netcdf/geo\_match/GPM. Each is described separately, below.

/netcdf (Note-5)

/geo\_match

/GPM

/2A***type***

/***scan***

**/*version***

**/*F\_f***

**/*YYYY*/**

GRtoDPR.\*

where the GRtoDPR.\* matchup netCDF file names follow the conventions:

GRtoDPR.***XXXX.YYMMDD.#####.version.type.scan.F\_f.***nc.gz

GRtoDPR.***XXXX.YYMMDD.#####.version.type.scan.F\_f.***RHI.nc.gz

/netcdf (Note-5)

/geo\_match

/GPM

/2BDPRGMI

**/*version***

**/*F\_f***

**/*YYYY*/**

GRtoDPRGMI.\*

where the GRtoDPRGMI.\* matchup netCDF file names follow the convention:

GRtoDPRGMI.***XXXX.YYMMDD.#####.***nc.gz

A slightly different directory tree exists under netcdf/geo\_match for the microwave imager (GRtoGPROF) matchup files. This tree is described below.

/netcdf (Note-5)

/geo\_match

***/SSSS***

***/instrument***

/2AGPROF

**/*version***

**/*F\_f***

**/*YYYY*/**

GRtoGPROF.\*

where the GRtoGPROF.\* matchup netCDF file names follow the convention:

GRtoGPROF.***SSSS.instrument.XXXX.YYMMDD.#####.version.F\_f.***nc.gz

/orbit\_subset

***/SSSS***

***/instrument***

***/algorithm***

***/version***

***/UUUU*** (Note-7)

***/YYYY***

***/MM***

***/DD/***

***PPS\_filename***

**Table 4-1.** Field Definitions for Directory and Filename Conventions

| **Field Code**  **or**  **Name** | **Definition** |
| --- | --- |
| ##### | Satellite orbit number, 1 to 6 digits |
| AA.aa | Radar elevation angle, in degrees, whose beam blockage is defined in the file. |
| algorithm | Product algorithm (For GPM: 2ADPR, 2AKa, 2AKu, 2AGPROF, 2BDPRGMI) |
| ee | sequential elevation sweep number, zero-based |
| FF | radar field variable: DZ (reflectivity), CZ (post-QC reflectivity), VR (radial velocity), DR (differential reflectivity), KD (Kdp), PH (Differential Phase), RH (RHOhv), SD (), ZZ () |
| F\_f | Volume matching file major (V) and minor (v) version number, e.g., 2\_1 |
| hhmm | 2-digit hour (hh) and minute (mm) |
| hhmmss | 2-digit hour (hh), minute (mm), and second (ss) |
| instrument | Satellite instrument ID: DPR, Ka, Ku, GMI, DPRGMI, SSMIS, TMI, etc. |
| MM | 2-digit month |
| MMDD | 2-digit month (MM) and day of month (DD) |
| N | nominal hour of data, from rounding up (1-24) |
| PPS\_filename | Data file name formatted according to the PPS File Naming Convention. Refer to the document: ***File Naming Convention for Precipitation Products For the Global Precipitation Measurement (GPM) Mission,  PPS\_610.2\_P550.***  EXAMPLE:  2A-CS-CONUS.GPM.Ku.V5-20140617.20140704-S230210-E230826.001980.V02A.HDF5 |
| SSSS | Satellite identifier (F15, F16, F17, F18, GCOMW1, GPM, METOPA, NOAA18, NOAA19, TRMM) |
| scan | DPR scan type used in the GR-DPR matchup: HS, MS, or NS |
| type | DPR product subtype: DPR, Ka, or Ku |
| UUUU | CS (Coincidence Subset) Product Subset ID for products from the PPS (Note-7) |
| version | product algorithm major/minor version, e.g., V02B |
| xxxx | lower-case version of XXXX |
| XXXX | radar station ID (e.g., Table 1-1) |
| YYMM | 2-digit year (YY) and month (MM) |
| [YY]YYMMDD | 2- or 4-digit year (YY or YYYY), month (MM), and day of month (DD) |
| YYYY | 4-digit year |

**Note-1.** Files in the **coincidence\_tables** directory are satellite-specific Daily Coincidence Table (CT) files from the Precipitation Processing Subsystem (PPS). The tables contain the orbit number, date, time, distance, and direction of the satellite orbital subtrack’s nearest approach to the ground radar sites configured for this purpose in the PPS. The CT cutoff distance is 700 km. Files in the form CT***.SSSS.YYYYMMDD.jjj***.txt are the complete, original CT files from the PPS. Those with the “.unl” file extension contain CT data reformatted in a form to be loaded in the GPM GV PostgreSQL database, for only the ground radar sites used in the GPM Validation Network.

**Note-2.** Files in the **db\_backup** directory contain a backup (dump) of the GPM VN’s PostgreSQL database ‘gpmgv’, created using the pg\_dump utility, and compressed using gzip. The latest dump of the database is in the file ‘gpmgvDBdump.gz’. This file is renamed to ‘gpmgvDBdump.old.gz’ as each new backup is performed. Only the current and previous dumps are retained.

**Note-3.** The files in under the top-level **gv\_radar** directory contain ground radar data in multiple file formats. These radar data come mostly from U.S. domestic WSR-88D radars, but data from other ground radars are also located in this directory structure. Files that fall under the directory **raw** are original-format radar data files for the given radar site. Files under the higher-level directory **1CUF** are those that were subject to both automated and human quality control and, optionally, computation of additional dual-polarization data fields. The files in the **1CUF** subdirectories contain a full volume scan of ground radar data conforming to the “Universal Format” (UF) data format. Each data file contains data for one ground radar volume scan. Within the individual data file names, the fixed field “uf “ designates that this is a radar file in Universal Format.

Files in the **images** subdirectories are Plan Position Indicator (PPI) display images of various data fields from the ground radar, for selected elevation sweeps. The variable fields FF in the individual file names indicate the data field plotted in the PPI image. Within the individual data file names, the fixed field “png” designates that the image file is in PNG image format.

Files in the **raw** subdirectory are the original radar data files in their native format, as obtained from the data source. For the WSR-88D sites, the files are in the NEXRAD Level-II archive format, not to be confused with the TRMM GV Level 2 gridded radar products (refer to Vol.1 of this document).

**Note-4.** Files under the **mosaicimages** directory are National Weather Service (NWS) WSR-88D national-scale radar mosaic images (RIDGE mosaics). RIDGE national mosaics are produced every 10 minutes by the NWS. Only those mosaics corresponding to the time of GPM and TRMM overpasses of the GPM Validation Network area in the continental U.S. are contained in the **archivedmosaic** subdirectory.

**Note-5.** The three types of GPM-specific files in the **netcdf/geo\_match** directory structure contain (1) geometrically-matched ground radar and GPM Precipitation Radar (GRtoDPR) data, (2) geometrically-matched ground radar and GPM Combined GMI/Precipitation Radar (GRtoDPRGMI) data, and (3) geometrically matched ground radar and GPM Microwave Imager (GRtoGPROF) data, in netCDF format as described above in Section 2 of the VN Data User’s Guide. Each file corresponds to single ground radar volume scan taken nearest in time to where a GPM satellite orbit’s subtrack passes within 200 km of the ground radar during a “significant” rainfall event. . The addition of the “**.RHI**” designator in the file name indicates use of an RHI volume scan for the GR data.

A more detailed summary of the data directory structures contained under the common directory gpm-validation/data/gpmgv/netcdf/geo\_match/ is as follows:

The top-level directory gpm-validation/data/gpmgv/netcdf/geo\_match/

holds netCDF-format files consisting of volume-matched satellite and

ground radar (GR) observations in a hierarchical directory structure, where

matchup files are organized by type and date into a subdirectory tree under

the top level directory. These directory tree structures are described below

for each matchup type.

1) GPROF-GR Matchups for TRMM TMI (from GPM-era 2A-GPROF TMI products)

Volume matched data between the TRMM TMI and ground radar (GRtoGPROF files) as

derived using TMI data from the GPM-era TMI 2A-GPROF product are organized into

the following directory structure under the top-level directory

gpm-validation/data/gpmgv/netcdf/geo\_match/:

TRMM/ (literal "TRMM")

TMI/ (literal "TMI")

2AGPROF/ (literal "2AGPROF")

PPS\_version/ (e.g., "V03C", "V03D")

Matchup\_version/ ("1\_0" or "2\_0")

YYYY/ (4-digit year of data, e.g., 2014)

For instance:

TRMM/TMI/2AGPROF/V03A/1\_0/2014/GRtoGPROF.TRMM.TMI.KAMX.140205.92423.V03A.1\_0.nc.gz

2) GPROF-GR Matchups for GPM GMI

Volume matched data between the GPM GMI and ground radar (GRtoGPROF files) as

derived from a matchup between data from the GPM GMI 2A-GPROF product and

the GRs are organized into the following directory structure under the

top-level directory gpm-validation/data/gpmgv/netcdf/geo\_match/:

GPM/ (literal "GPM")

GMI/ (literal "GMI")

2AGPROF/ (literal "2AGPROF")

PPS\_version/ (e.g., "V03C", "V03D")

Matchup\_version/ (e.g., "1\_0", "1\_1")

YYYY/ (4-digit year of data, e.g., 2015)

For instance:

GPM/GMI/2AGPROF/V03D/1\_1/2015/GRtoGPROF.GPM.GMI.KMLB.150113.4970.V03D.1\_1.nc.gz

3) GPROF-GR Matchups for GPM Constellation Satellites

Matchup files for 2A-GPROF products for microwave imagers on constellation satellites follow the same type of directory structure and file naming convention as for TRMM TMI and GPM GMI, under the top-level directory

gpm-validation/data/gpmgv/netcdf/geo\_match/:

satellite/ (F18, METOPA, NOAA19, etc.)

instrument/ (SSMIS, MHS)

2AGPROF/ (literal "2AGPROF")

PPS\_version/ (e.g., "V03C", "V03D")

Matchup\_version/ (e.g., "1\_0", "1\_1")

YYYY/ (4-digit year of data, e.g., 2015)

For instance:

F17/SSMIS/2AGPROF/V03C/1\_1/2015/GRtoGPROF.GPM.GMI.KMLB.150113.4970.V03C.1\_1.nc.gz

4) DPR-GR Matchups for GPM

Volume matched data between the GPM DPR and ground radar (GRtoDPR files) as

derived from a matchup between data from the GPM 2A-DPR, 2A-Ka, and 2A-Ku

products and the GRs are organized into the following directory structure under

the top-level directory gpm-validation/data/gpmgv/netcdf/geo\_match/:

GPM/ (literal "GPM")

algorithm/ ("2ADPR", "2AKa", or "2AKu")

scan\_type/ ("HS", "MS", or "NS")

PPS\_version/ (e.g., "V03B")

Matchup\_version/ (e.g., "1\_0", "1\_1")

YYYY/ (4-digit year of data, e.g., 2014)

The available scan\_type values (subdirectories) vary by algorithm, as follows:

2ADPR/HS/

2ADPR/MS/

2ADPR/NS/

2AKa/HS/

2AKa/MS/

2AKu/NS/

where all three scan\_type directories (HS, MS, NS) are present under the 2ADPR

directory, only HS and MS are present under the 2AKa directory, and only the NS

scan\_type exists for the 2AKu algorithm. Below the scan\_type directory level any or all of the PPS\_version, Matchup\_version, and YYYY subdirectories may

exist for any algorithm/scan\_type/ directory combination.

For instance:

GPM/2ADPR/HS/V03B/1\_1/2014/GRtoDPR.KFWS.141013.3541.V03B.DPR.HS.1\_1.nc.gz

GPM/2ADPR/MS/V03B/1\_1/2014/GRtoDPR.KFWS.141013.3541.V03B.DPR.MS.1\_1.nc.gz

GPM/2ADPR/NS/V03B/1\_1/2014/GRtoDPR.KFWS.141013.3541.V03B.DPR.NS.1\_1.nc.gz

GPM/2AKa/HS/V03B/1\_1/2014/GRtoDPR.KFWS.141013.3541.V03B.KA.HS.1\_1.nc.gz

GPM/2AKa/MS/V03B/1\_1/2014/GRtoDPR.KFWS.141013.3541.V03B.KA.MS.1\_1.nc.gz

GPM/2AKu/NS/V03B/1\_1/2014/GRtoDPR.KFWS.141013.3541.V03B.KU.NS.1\_1.nc.gz

5) DPRGMI-GR Matchups for GPM

Volume matched data between the GPM 2B-DPRGMI "combined" product and ground

radar (GRtoDPRGMI files), as derived from the GPM 2B-DPRGMI product and the

GRs, are organized into the following directory structure under the

top-level directory gpm-validation/data/gpmgv/netcdf/geo\_match/:

GPM/ (literal "GPM")

2BDPRGMI/ (literal "2BDPRGMI")

PPS\_version/ (e.g., "V03C", "V03D")

Matchup\_version/ (e.g., "1\_1")

YYYY/ (4-digit year of data, e.g., 2014)

For instance:

GPM/2BDPRGMI/V03C/1\_1/2014/GRtoDPRGMI.PAIH.140630.1915.V03C.1\_1.nc.gz

GPM/2BDPRGMI/V03D/1\_1/2014/GRtoDPRGMI.KAKQ.141209.4432.V03D.1\_1.nc.gz

**Note-6.** The filename convention for the 1CUF files changed beginning with the inclusion of dual-polarimetric variables in the data files. Prior to the dual-pol upgrade, the name convention followed the ***YYMMDD.N.TTTT.V.hhmm***.uf.gz pattern. After the upgrade and once TRMM GV began to include the dual-polarization data variables in the files, the name convention changes to the ***XXXX\_YYYY\_MMDD\_hhmmss***.uf.gz pattern. The dual-polarization file names include the NWS site identifiers (XXXX field) in the 1CUF file names and directory trees, such that the legacy TRMM GV site IDs for the WSR-88D sites are no longer used in the 1CUF file names. The date of the changeover to dual-polarization data files differs by site, but predates the GPM era. The addition of the “**\_rhi**” designator in the file name following ***hhmmss*** indicates an RHI scan type.

**Note-7.** The Coincidence Subset (CS) product subset identifiers are short descriptive names for the rectangular latitude/longitude area boundaries defining the area of coverage for the product subset. The identifiers and the latitude/longitude boundaries defining the CS areas are defined in Table 4-2. The orbit subset products are produced for a given CS area and instrument whenever one or more “surface footprints” in the instrument’s scan strategy lies within the latitude/longitude rectangle defining the CS region. Complete scan lines for all scans with at least one footprint in the CS area are included in the CS product, regardless of the fraction of the scan that overlaps the CS area. That is, the scan data are not strictly clipped to the CS rectangle.

Note-8. The **blockage** directory contains ground radar beam blockage data in site- and elevation-angle-specific binary files created in IDL using the SAVE procedure. The data for each ground radar site are contained in a separate subdirectory named according to the radar site ID. Within the site subdirectories, each file contains saved data for five variables: site, elev, azimuths, ranges\_out, and blockage\_out, as follows:

site: Type STRING, name of the ground radar site (e.g., 'KAMX'). This value is also defined as part of the blockage file name.

elev: Type FLOAT, elevation angle that pertains to the beam blockage data. This value is also defined as part of the blockage file name.

azimuths: FLOAT array, contains the list of azimuths that the beam blockage data are defined on (0-359 degrees, every degree). Contains nAz=360 values.

ranges\_out: INTEGER array, contains the list of ranges from the radar that the beam blockage data are defined on (1-230 km). Contains nRng=230 values.

blockage\_out: FLOAT array of dimensions (nRng,nAz) that contains the fractional beam blockage (0.0 ≤ blockage ≤ 1.0) along each radial in the data set. Value of 0.0 indicates No Blockage. Value of 1.0 indicates that the beam blocking object exists at that range gate. Values between 0.0 and 1.0 indicate the fraction of the ground radar beam blocked by the object between that gate and the radar.

The data in these files are only available use within an IDL procedure or function, using the IDL "RESTORE" procedure. Data are currently available only for WSR-88D sites in the continental U.S. At least one blockage file is present in each subdirectory, containing the beam blockage for the lowest elevation scan of the given radar. Data files for higher elevation scans are included only for scans where there is non-zero beam blockage present at that elevation angle. The complete set of fixed elevation angles (in degrees) on which the blockage data may be defined includes:

00.50, 00.90, 01.30, 01.45, 01.50, 01.80, 02.40, 02.50, 03.10, 03.35, 03.50,

04.00, 04.30, 04.50, 05.10, 05.25, 06.00, 06.20, 06.40, 07.50, 08.00, 08.70,

09.90, 10.00, 12.00, 12.50, 14.00, 14.60, 15.60, 16.70, 19.50

**Table 4-2.** Coincidence Subset geographical definitions for VN orbit subsets

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CSI Name** | **Description** | **North latitude bound** | **South latitude bound** | **West longitude bound** | **East longitude bound** |
| AKradars | Middleton Island and Nome WSR-88D radars, Alaska | 66.5 N | 55.0 N | -167.0 E | -134.0 E |
| BrazilRadars | Brazilian radars | -3.0 N | -23.0 N | -57.0 E | -32.0 E |
| CONUS | Contiguous 48 United States | 50.0 N | 23.0 N | -126.0 E | -66.0 E |
| DARW | Darwin, Australia CPOL radar | -10.0 N | -14.5 N | 128.74 E | 133.35 E |
| Guam | Guam WSR-88D radar | 15.7 N | 11.2 N | 142.56 E | 147.06 E |
| Hawaii | Hawaii WSR-88D radars | 24.15 N | 16.85 N | -162.2 E | -153.32 E |
| KOREA | South Korean radars | 39.0 N | 32.5 N | 124.5 E | 130.5 E |
| SanJuanPR | San Juan, Puerto Rico WSR-88D | 20.37 N | 15.87 N | -68.35 E | -63.85 E |
| KWAJ | Kwajalein KPOL radar | 10.97 N | 6.47 N | 165.47 E | 170.01 E |

# Geometry Matching Algorithm Descriptions

The following sections provide a high-level schematic of the DPR-GR and GMI-GR geometry matching algorithms. The DPRGMI-GR is essentially identical to the DPR-GR algorithm. Detailed documentation of the algorithms is contained in the source code.

## DPR match-up sampling to GR

The basic DPR-to-GR data processing algorithm is as follows:

1. For each DPR ray in the product, compute the range of the ray's earth intersection point from the ground radar location. If greater than 100 km (adjustable at run time; see ***rangeThreshold*** variable in netCDF matchup file), ignore the ray. If within 100 km, proceed as follows:
2. Examine the corrected reflectivity values along the DPR ray. If one or more gates are at or above a specified threshold (18 dBZ by default, see ***DPR\_dBZ\_min*** variable in netCDF matchup file), proceed with processing the ray, otherwise set the DPR and GR match-up values to “below threshold” and proceed to the next DPR ray.
3. Using the range from step 1, determine the height above ground level where the DPR ray intersects the centerline of each of the elevation sweeps of the GR, and the width (as a vertical distance) of the GR beam at this range;
4. Compute a parallax-adjusted location of the DPR footprint center at each GR sweep intersection height from step 3, as a function of height, the DPR ray angle relative to nadir, and the orientation (azimuth) of the DPR scan line. Retain these adjusted horizontal locations for the processing of the GR data;
5. Using the beam heights and widths from step 3, compute the upper and lower bound heights of each GR sweep at its intersection with the DPR ray, correcting for height above MSL (the earth ellipsoid) as required for the DPR height definition;
6. For each GR sweep intersection, determine the total number, and along-ray positions, of the DPR range gates geometrically located between the upper and lower bound heights from step 5, accounting for DPR scan angle away from nadir in computing the DPR gate heights;
7. For the DPR 3-D fields, perform a simple average of values over the set of range gates identified in step 6, for each GR sweep intersection (Figure 2-2). If any of these DPR range gates is below the lowest clutter-free gate, leave them out of the computation. If ALL of these gates are below the lowest clutter-free gate, then take the lowest clutter-free gate reflectivity value as the sample average DPR reflectivity. Set the clutterStatus variable value according which of these three actions were taken. Reflectivity is converted from dBZ to Z before averaging, then the average Z is converted back to dBZ. Only those gates with values at or above specified reflectivity (18 dBZ) or rain rate (0.01 mm h-1) thresholds are included in the average. Keep track of the number of below-threshold DPR gates *rejected* from the vertical averages, and the number of gates *expected* in the averages from a geometric standpoint (from step 6);
8. For the 2-D DPR field values (e.g., surface rain rate, bright band height), simply extract or derive the scalar field value for the given DPR ray.
9. Using the parallax-adjusted locations of the DPR footprints from step 4, compute the four x- and y-corners of the DPR footprint, which can be used to plot the DPR data on a map or image in a contiguous, non-overlapping manner. Each corner point is computed as the midway point between the DPR footprint center x,y coordinates and those of the four diagonally-adjacent DPR footprints (extrapolated if at the edge of the DPR scan). These corner coordinates do not represent the area of the actual DPR measurement in any physical manner.

The 3-D DPR fields which are vertically averaged, yielding one value per intersected GR sweep per DPR ray, include:

• Raw DPR reflectivity (ZFactorMeasured in 2A product)

• Attenuation-Corrected DPR reflectivity (ZFactorCorrected in 2A product)

• Rain rate (mm/h) (PrecipRate in 2A product)

The 2-D DPR variables which are taken unaveraged, one value per DPR ray, include:

• Surface type (land/ocean/coastal) flag (LandSurfaceType)

• Near-surface rain rate, mm/h (PrecipRateSurface)

• Path-integrated attenuation, dBZ (piaFinal)

• Echo top height (stormTopHeight)

• Bright band height and status (BBheight, BBstatus)

• Rain type categorization (convective, stratiform, other) (TypePrecip)

• Rain/no-rain flag (FlagPrecip).

These scalar values are directly extracted and/or derived from data fields within DPR level 2A products (2A-DPR, 2A-Ka, 2A-Ku).

## GR match-up sampling to DPR

The basic GR-to-DPR data processing algorithm is as follows:

1. For each DPR ray processed (i.e., not skipped in Step 2, above), and for each elevation sweep of the GR, repeat the following:
2. Compute the along-ground distance between each GR bin center and the parallax-adjusted DPR footprint center (from DPR step 4);
3. Flag the GR bins within a fixed distance of the DPR center. The fixed distance is equivalent to the maximum radial size of all the DPR footprints processed. Ignore GR bins above 20 km above ground level
4. Examine the reflectivity values of the flagged GR bins from step 3. If all values fall below 0.0 dBZ, then skip processing for the point and set its match-up value to “below threshold”. Otherwise:
5. Perform an inverse distance weighted average of the GR reflectivity values over the bins from step 4 (Figure 2-3), using a Barnes gaussian weighting. Reflectivity is converted from dBZ to Z before averaging, then the average Z is converted back to dBZ. All GR bins with values at or above 0.0 dBZ are included in the average. Keep track of the total number of bins included in the average, and the number of these GR bins with values meeting a specified reflectivity threshold (GR\_dBZ\_min variable in netCDF file; 15 dBZ by default). Also compute the maximum and the standard deviation of reflectivity among the bins included in the average.
6. Repeat steps 4 and 5 for the ground radar dual-polarization variables except hydrometeor type (GR\_HID), but doing a simple arithmetic average of all non-missing data values (no conversion to/from dBZ). For GR\_HID, just determine the number of bins in each HID category and save the array of counts.

## GMI match-up sampling

The only computations that take place on the GMI data are to determine which GMI footprints are within a given range threshold of the GR site, and for each in-range GMI footprint, to compute the intersection of the GMI instrument field-of-view with each of the GR sweeps. The basic GMI-to-GR data processing algorithm is as follows:

1. For each GMI footprint in the product, compute the range of the footprint's earth intersection point from the ground radar location. If greater than 100 km (adjustable), ignore the ray. If within 100 km, proceed as follows:
2. Compute the azimuth between the GMI footprint and the GPM satellite’s nadir subpoint. This gives the earth-relative direction along which the GMI is viewing.
3. Using the range and azimuth from steps 1 and 2, and the fixed GMI scan incidence angle relative to the ground, determine the height above ground level where the GMI view centerline intersects the centerline of each of the elevation sweeps of the GR, and the width (as a vertical distance) of the GR beam at this range;
4. Compute a parallax-adjusted location of the GMI footprint center at each GR sweep intersection height from step 3, as a function of height, the GMI incidence angle, and the orientation (azimuth) of the GMI scan line. Retain these adjusted horizontal locations for the processing of the GR data;
5. Using the beam heights and widths from step 3, compute the upper and lower bound heights of each GR sweep at its intersection with the GMI scan sample;
6. Taking the GMI footprint’s surface position, and ignoring GMI viewing parallax, project the GMI footprint along the local vertical to the earth surface and determine the height above ground level where local vertical intersects the centerline of each of the elevation sweeps of the GR, and the width (as a vertical distance) of the GR beam at this range. Retain the unadjusted surface footprint locations for the processing of the GR data;
7. Using the beam heights and widths from step 6, compute the upper and lower bound heights of each GR sweep at its intersection with the local vertical above the GMI surface footprint;
8. For the 2-D GMI field values (e.g., surface rain rate), simply extract the scalar field value for each in-range GMI footprint.
9. Using the parallax-adjusted locations of the GMI footprints from step 4, compute the four x- and y-corners of the GMI footprint, which can be used to plot the GMI data on a map or image in a contiguous, non-overlapping manner. Each corner point is computed as the midway point between the GMI footprint center x,y coordinates and those of the four diagonally-adjacent GMI footprints (extrapolated if at the edge of the GMI scan). These corner coordinates do not represent the area of the actual GMI measurement in any physical manner.

The GMI 2A-GPROF variables which are included in the matchups, one value per GR-GMI overlapping footprint, include:

• Surface rain rate, mm/h (surfacePrecipitation)

• GMI latitude (surface footprint center position) (XMIlatitude)

• GMI longitude (ditto) (XMIlongitude)

• Surface type (land/ocean/coast: surfaceTypeIndex)

• Data flag (pixelStatus)

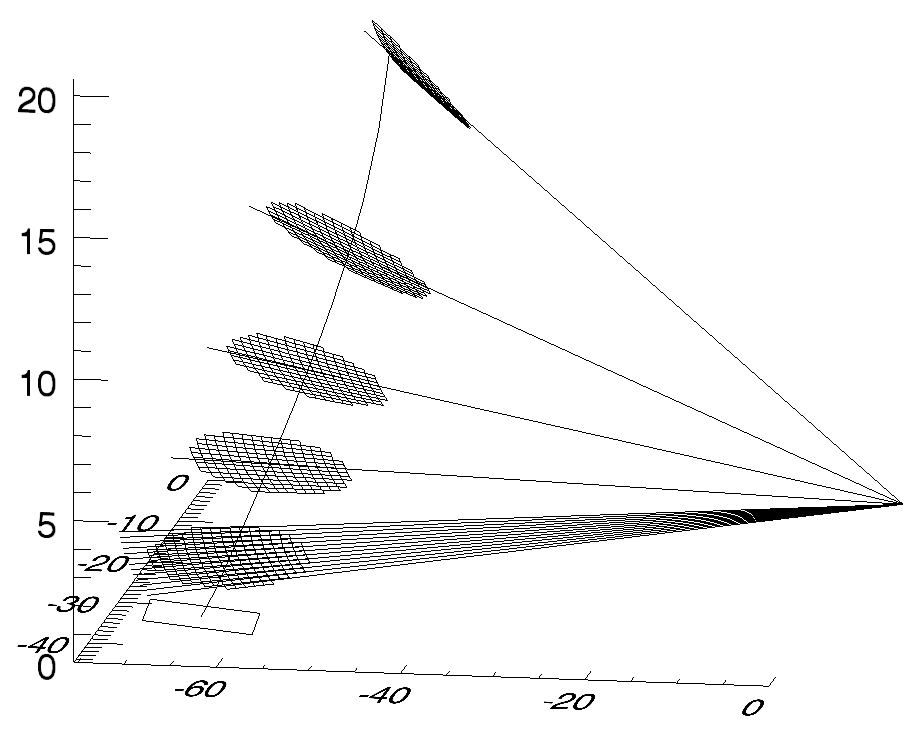
• Probability of Precipitation (PoP)

These values are directly extracted from data fields within the GMI 2A-GPROF product.

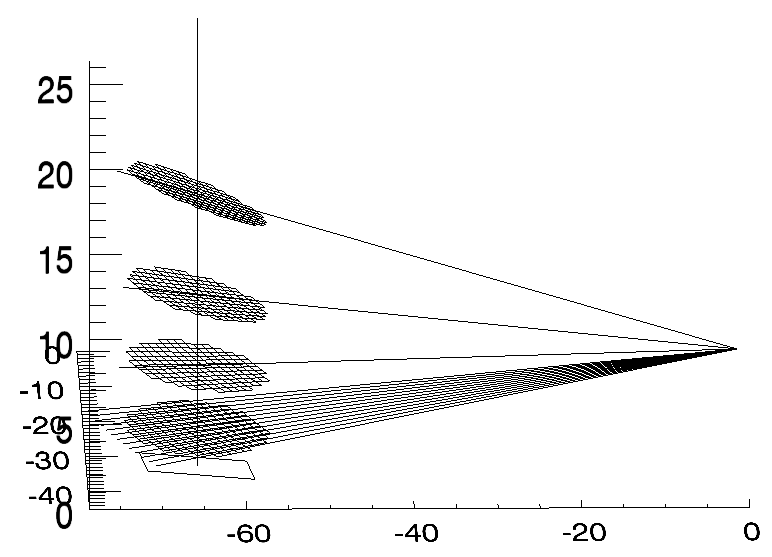
## GR match-up sampling to GMI

The GR-to-GMI algorithm is nearly identical to the GR-to-DPR algorithm, except for GMI we compute two sets of GR matchup samples, one along the sloping GMI instrument scan line-of-sight (Fig. 5.4-1), and one along the local vertical above the GMI surface footprint position (Fig. 5.4-2). The basic GR-to-GMI data processing algorithm is as follows:

1. For each in-range GMI footprint processed, and for each elevation sweep of the GR, repeat the following:
2. Compute the along-ground distance between each GR bin center and the parallax-adjusted GMI footprint center (from GMI step 4);
3. Flag the GR bins within a fixed distance of the GMI footprint center (Figure 5.4-1). The fixed distance is equivalent to the spacing between adjacent GMI surface footprints along a diagonal. Ignore GR bins above 20 km above ground level.
4. Examine the reflectivity values of the flagged GR bins from step 3. If all values fall below a 0.0 dBZ threshold, then skip processing for the point and set its match-up value to “below threshold”. Otherwise:
5. Perform an inverse distance weighted average of the GR reflectivity values over the bins from step 4, using a Barnes gaussian weighting. Reflectivity is converted from dBZ to Z before averaging, then the average Z is converted back to dBZ. All GR bins with values at or above 0.0 dBZ are included in the average. Keep track of the total number of bins included in the average, and the number of these GR bins with values meeting a specified reflectivity threshold (15 dBZ by default).
6. Repeat step 2, but for the unadjusted GMI footprint center (along the local vertical, from GMI step 6).
7. Repeat step 3 for the GMI footprint center in step 6, as shown in Fig. 5.4-2.
8. Repeat steps 4 and 5 for the GR bins flagged in step 7.



**Figure 5.4-1.** Schematic representation of GR volume matching to GMI along the GMI line-of-sight. Rectangular outline at surface locates the surface intersection of a single GMI surface footprint whose field-of-view centerline is shown as a slightly curving vertical line (due to the projection of the curved earth onto a flat surface). The "waffle" areas show the horizontal outline of GR gates mapped to the GMI footprint for individual elevation sweeps of the ground radar, which is located in the figure at X=0, Y=0, Z=0, where X, Y, and Z are in km. Sloping lines are drawn between the GR sample volumes and the ground radar along the sweep surfaces, where the lowest sweep shows the GR ray centers for each ray mapped to the GMI footprint. GR range gates are inverse-distance-weighted from the GMI field-of-view center to compute the GR averages for the matching volumes. Vertical extent and overlap of the GR gates is not shown, and only every third GR sweep is plotted for clarity. GR azimuth/range resolution is 1° by 1 km in the plot.



**Figure 5.4-2.** As in Figure 5.4-1, except GR averaging is along the local vertical above the GMI surface footprint center rather than along the GMI instrument line-of-sight.

# Acronyms and Symbols

| **ACRONYM** | **DEFINITION** |
| --- | --- |
| 3-D | 3-Dimensional |
| AGL | Above Ground Level |
| CSI | Coincident Subsetted Intermediate |
| DAAC | Distributed Active Archive Center |
| dBZ | Decibels (dB) of radar Reflectivity (Z) |
| DISC | (Goddard Earth Sciences) Data and Information Center |
| DP | Dual Polarization (radar) |
| DPR | (GPM) Dual-frequency Precipitation Radar |
| GMI | GPM Microwave Imager |
| GPM | Global Precipitation Measurement |
| GR, gr | Ground Radar (a.k.a. GV radar) |
| GSFC | Goddard Space Flight Center |
| GV | Ground Validation |
| GVS | Ground Validation System |
| HDF | Hierarchical Data Format (HDF-4 or HDF-5) |
| HID | Hydrometeor ID |
| ID | Identification, Identifier |
| IDL | Interactive Data Language |
| km | kilometers |
| m | meters |
| mm/h | millimeters (mm) per hour (h) |
| MSL | (above) Mean Sea Level |
| NASA | National Aeronautics and Space Administration |
| NCAR | National Center for Atmospheric Research (part of UCAR) |
| netCDF | network Common Data Form |
| NEXRAD | Next-generation Weather Radar (a.k.a. “WSR-88D”) |
| NOAA | National Oceanic and Atmospheric Administration |
| PMM | Precipitation Measuring Missions |
| PoP | Probability of Precipitation |
| PPI | Plan Position Indicator |
| PPS | Precipitation Processing Subsystem |
| PR | (TRMM) Precipitation Radar |
| QC | Quality Control |
| TMI | TRMM Microwave Imager |
| TRMM | Tropical Rainfall Measuring Mission |
| UCAR | University Corporation for Atmospheric Research |
| UF | (radar) Universal Format |
| US | United States |
| UTC | Coordinated Universal Time |
| VN | Validation Network |
| VPR | Vertical Profile of Reflectivity |
| WSR-88D | Weather Surveillance Radar - 1988 Doppler (a.k.a. “NEXRAD”) |

# Appendix

Extended Abstract

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

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1. Bolen, S.M. and V. Chandrasekar. 2003. Methodology for aligning and comparing spaceborne radar and ground-based radar observations. Journal of Atmospheric and Oceanic Technology 20:647-659. [↑](#footnote-ref-1)