

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	<ul style="list-style-type: none"> - 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	<ul style="list-style-type: none"> - 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.
1.3	July x, 2016	<p>Added 1C-R-XCAL type to the GPM and Constellation products included in the VN database.</p> <p>Added definitions of XXX and YYY variables added to the GRtoDPRGMI matchup file for Version 1.21.</p> <p>Added definitions of common calibrated brightness temperature variables added to the GRtoGPROF file.</p> <p>Added definitions of AUS-East and AUS-West subsets to Table 4-2.</p>

Document Version	Date	Changes
1.4	March, 2021	Added additional GPM and GR fields to DPR and DPRGMI Added GR derived snowfall water equivalent fields Changed 100 in 100 criteria to 20 in 100 to pick up smaller convective precipitation events Changed VN netcdf file version to 2.0 for DPR and DPRGMI

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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1. 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, METOPB/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.

1.1 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>. 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." The current version of each of these documents is available from <http://pps.gsfc.nasa.gov/GPMprelimdocs.html>.

1.2 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>.

1.3 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.

1.4 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>

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

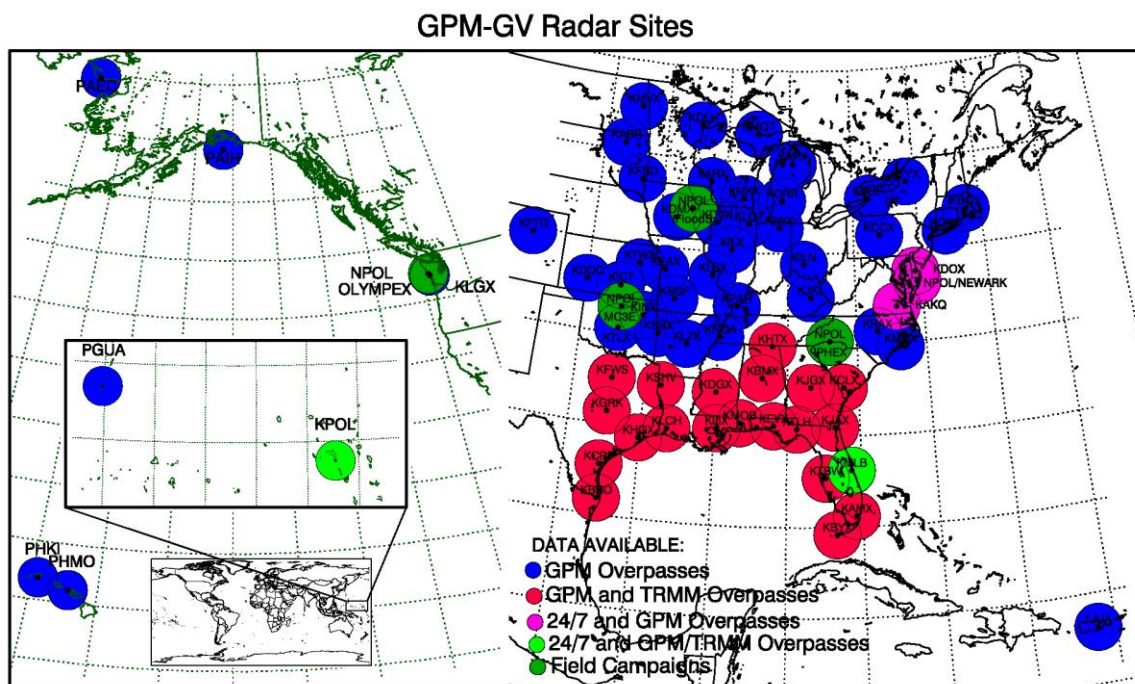


Figure 1-1. Location of VN match-up sites in the U.S. For each site, ground radar observation limits are also illustrated.

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

Site ID	Site Name	Latitude (N)	Longitude (E)
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

Site ID	Site Name	Latitude (N)	Longitude (E)
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
<i>KWAJ (KPOL)</i>	<i>Kwajalein, Marshall Islands</i>	<i>8.71796</i>	<i>167.733</i>
<i>AL1</i>	<i>Almenara, MG, Brazil</i>	<i>-16.2019</i>	<i>-40.6742</i>
<i>JG1</i>	<i>Jaraguari, MS, Brazil</i>	<i>-20.2915</i>	<i>-54.4658</i>
<i>MC1</i>	<i>Maceio, AL, Brazil</i>	<i>-9.55139</i>	<i>-35.7708</i>
<i>NT1</i>	<i>Natal, RN, Brazil</i>	<i>-5.90444</i>	<i>-35.254</i>
<i>PE1</i>	<i>Petrolina, PE, Brazil</i>	<i>-9.36722</i>	<i>-40.5728</i>
<i>SF1</i>	<i>Sao Francisco, SC, Brazil</i>	<i>-16.0173</i>	<i>-44.6953</i>
<i>ST1</i>	<i>Santa Teresa, RJ, Brazil</i>	<i>-19.9888</i>	<i>-40.5794</i>
<i>SV1</i>	<i>Salvador, BA, Brazil</i>	<i>-12.9025</i>	<i>-38.3267</i>
<i>TM1</i>	<i>Tres Marias, MG, Brazil</i>	<i>-18.2072</i>	<i>-45.4606</i>

1.5 The “20-in-100” Criterion

In all cases, data products generated by the VN adhere to the “20-in-100” criterion. That is, event files described in subsequent sections of this document have 20 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 “20-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 directory **data/gpmgv/netCDF/geomatch/** for any event that meets the DPR 20-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.

1.6 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 used 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.

2. Geometry-Matched Data Products

2.1 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/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.

2.2 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 <i>gzip</i>

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 Chandrasekar¹. Matchup of the 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.

2.3 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 case 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 data 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.

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.

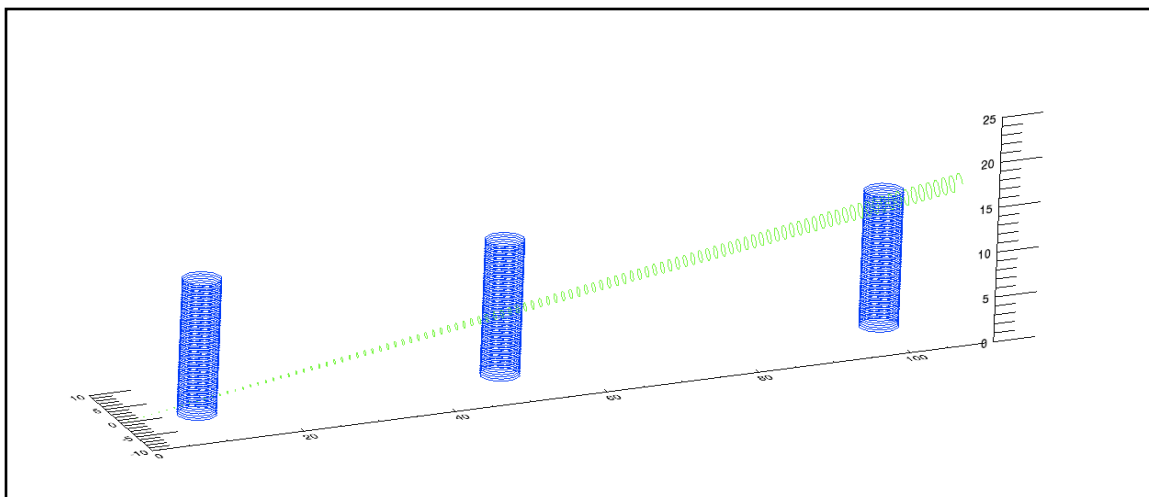


Figure 2-1. An illustration of the intersection between Ground Radar sweeps and Precipitation Radar footprints. Only a select number of radar echoes are illustrated in either case.

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.

2.4 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.

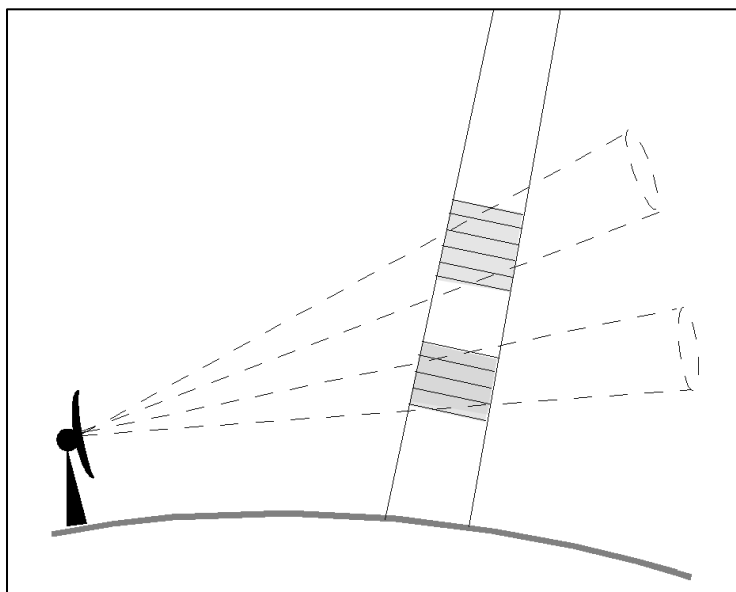


Figure 2-2. Schematic of DPR gate averaging at GR sweep intersections. Shaded areas show individual DPR gates intersecting the vertical extent of two GR sweeps (dashed) at different elevation angles. Only one DPR ray is shown. The reflectivity values of the individual DPR gates are averaged over the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

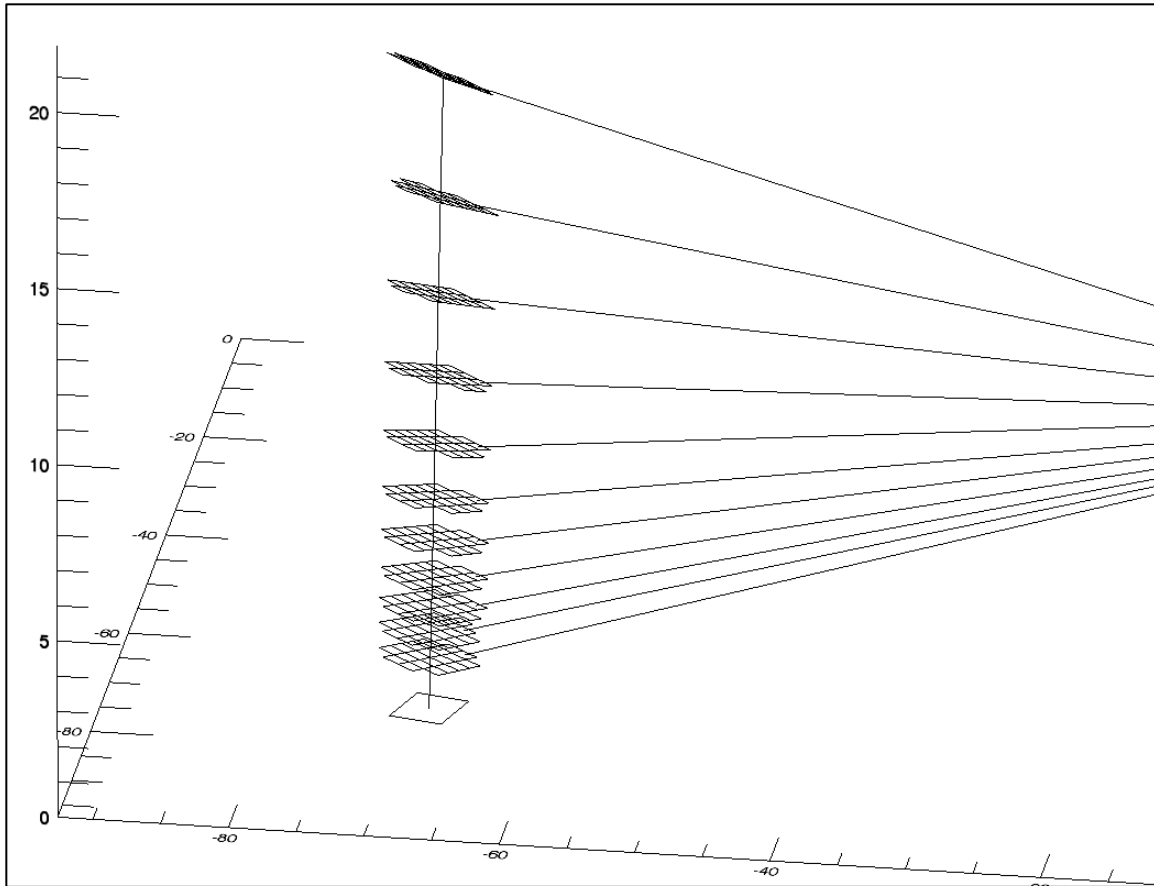


Figure 2-3. Schematic representation of GR volume matching to DPR. Square outline at surface, plotted from the x- and y-corners of the DPR footprint stored in the matchup netCDF file, shows the earth-surface location of a single DPR ray whose centerline is shown as a vertical line. The "waffle" areas 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.

3. 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.

3.1 DPR-GR Geometry Match netCDF file description

The format and content of Version 2.0 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. Note that the “fpdim” and “elevationAngle” dimensions vary between files.

dimensions:

fpdim = 562;

elevationAngle = 9;

xydim = 4;

hidim = 15;

len_atime_ID = 19;

len_site_ID = 4;

variables:

```
float elevationAngle(elevationAngle=9);
:long_name = "Radar Sweep Elevation Angles";
:units = "degrees";

int numScans;
:long_name = "Number of DPR scans in original datasets";
:_FillValue = -888; // int

short numRays;
:long_name = "Number of DPR rays per scan in original datasets";
:_FillValue = -888S; // short

float rangeThreshold;
:long_name = "Dataset maximum range from radar site";
:_FillValue = -888.0f; // float
:units = "km";

float DPR_dBZ_min;
:long_name = "minimum DPR bin dBZ required for a *complete* DPR vertical average";
:_FillValue = -888.0f; // float
:units = "dBZ";

float GR_dBZ_min;
:long_name = "minimum GR bin dBZ required for a *complete* GR horizontal average";
:_FillValue = -888.0f; // float
:units = "dBZ";

float rain_min;
:long_name = "minimum DPR rainrate required for a *complete* DPR vertical average";
:_FillValue = -888.0f; // float
:units = "mm/h";
```

```
short DPR_decluttered;  
:long_name = "decluttered flag for DPR volume average data fields";  
:_FillValue = 0S; // short
```

```
short have_GR_Z;  
:long_name = "data exists flag for GR_Z";  
:_FillValue = 0S; // short
```

```
short have_GR_Zdr;  
:long_name = "data exists flag for GR_Zdr";  
:_FillValue = 0S; // short
```

```
short have_GR_Kdp;  
:long_name = "data exists flag for GR_Kdp";  
:_FillValue = 0S; // short
```

```
short have_GR_RHOhv;  
:long_name = "data exists flag for GR_RHOhv";  
:_FillValue = 0S; // short
```

```
short have_GR_RC_rainrate;  
:long_name = "data exists flag for GR_RC_rainrate";  
:_FillValue = 0S; // short
```

```
short have_GR_RP_rainrate;  
:long_name = "data exists flag for GR_RP_rainrate";  
:_FillValue = 0S; // short
```

```
short have_GR_RR_rainrate;  
:long_name = "data exists flag for GR_RR_rainrate";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_HID;
```

```
:long_name = "data exists flag for GR_HID";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Dzero;
```

```
:long_name = "data exists flag for GR_Dzero";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Nw;
```

```
:long_name = "data exists flag for GR_Nw";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Dm;
```

```
:long_name = "data exists flag for GR_Dm";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_N2;
```

```
:long_name = "data exists flag for GR_N2";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_blockage;
```

```
:long_name = "data exists flag for ground radar blockage fraction";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_SWE;
```

```
:long_name = "data exists flag for ground radar snowfall water equivalent rate";
```

```
:_FillValue = 0S; // short
```

```
short have_pwatIntegrated;
```

```
:long_name = "data exists flag for GPM integrated pw, liquid and ice";  
:_FillValue = 0S; // short
```

```
short have_ZFactorMeasured;  
:long_name = "data exists flag for ZFactorMeasured";  
:_FillValue = 0S; // short
```

```
short have_ZFactorCorrected;  
:long_name = "data exists flag for ZFactorCorrected";  
:_FillValue = 0S; // short
```

```
short have_piaFinal;  
:long_name = "data exists flag for piaFinal";  
:_FillValue = 0S; // short
```

```
short have_paramDSD;  
:long_name = "data exists flag for paramDSD variables (Dm and Nw)";  
:_FillValue = 0S; // short
```

```
short have_PrecipRate;  
:long_name = "data exists flag for PrecipRate";  
:_FillValue = 0S; // short
```

```
short have_Epsilon;  
:long_name = "data exists flag for DPR Epsilon variable";  
:_FillValue = 0S; // short
```

```
short have_LandSurfaceType;  
:long_name = "data exists flag for LandSurfaceType";  
:_FillValue = 0S; // short
```



```
short have_PrecipRateSurface;  
:long_name = "data exists flag for PrecipRateSurface";  
:_FillValue = 0S; // short
```

```
short have_SurfPrecipTotRate;  
:long_name = "data exists flag for SurfPrecipTotRate";  
:_FillValue = 0S; // short
```

```
short have_heightStormTop;  
:long_name = "data exists flag for heightStormTop";  
:_FillValue = 0S; // short
```

```
short have_heightZeroDeg;  
:long_name = "data exists flag for heightZeroDeg";  
:_FillValue = 0S; // short
```

```
short have_BBheight;  
:long_name = "data exists flag for BBheight";  
:_FillValue = 0S; // short
```

```
short have_BBstatus;  
:long_name = "data exists flag for BBstatus";  
:_FillValue = 0S; // short
```

```
short have_qualityData;  
:long_name = "data exists flag for qualityData";  
:_FillValue = 0S; // short
```

```
short have_FlagPrecip;  
:long_name = "data exists flag for FlagPrecip";  
:_FillValue = 0S; // short
```

```
short have_TypePrecip;  
:long_name = "data exists flag for TypePrecip";  
:_FillValue = 0S; // short
```

```
short have_clutterStatus;  
:long_name = "data exists flag for clutterStatus";  
:_FillValue = 0S; // short
```

```
float latitude(elevationAngle=9, fpdim=562);  
:long_name = "Latitude of data sample";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float longitude(elevationAngle=9, fpdim=562);  
:long_name = "Longitude of data sample";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
float xCorners(elevationAngle=9, fpdim=562, xydim=4);  
:long_name = "data sample x corner coords.";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float yCorners(elevationAngle=9, fpdim=562, xydim=4);  
:long_name = "data sample y corner coords.";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float topHeight(elevationAngle=9, fpdim=562);  
:long_name = "data sample top height AGL";
```

```
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float bottomHeight(elevationAngle=9, fpdim=562);  
:long_name = "data sample bottom height AGL";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float GR_Z(elevationAngle=9, fpdim=562);  
:long_name = "GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr(elevationAngle=9, fpdim=562);  
:long_name = "DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of DP Differential Reflectivity";  
:units = "dB";
```

```
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp(elevationAngle=9, fpdim=562);  
:long_name = "DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv(elevationAngle=9, fpdim=562);  
:long_name = "DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float  
  
float GR_RC_rainrate(elevationAngle=9, fpdim=562);  
:long_name = "GV radar Cifelli algorithm Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_RC_rainrate_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV radar Cifelli algorithm Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_RC_rainrate_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV radar Cifelli algorithm Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_RP_rainrate(elevationAngle=9, fpdim=562);  
:long_name = "GV radar Pol Z-R Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_RP_rainrate_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV radar Pol Z-R Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_Max(elevationAngle=9, fpdim=562);
:long_name = "Sample Maximum GV radar Pol Z-R Rainrate";
:units = "mm/h";
:_FillValue = -888.0f; // float

float GR_RR_rainrate(elevationAngle=9, fpdim=562);
:long_name = "GV radar DROPS Rainrate";
:units = "mm/h";
:_FillValue = -888.0f; // float

float GR_RR_rainrate_StdDev(elevationAngle=9, fpdim=562);
:long_name = "Standard Deviation of GV radar DROPS Rainrate";
:units = "mm/h";
:_FillValue = -888.0f; // float

float GR_RR_rainrate_Max(elevationAngle=9, fpdim=562);
:long_name = "Sample Maximum GV radar DROPS Rainrate";
:units = "mm/h";
:_FillValue = -888.0f; // float

short GR_HID(elevationAngle=9, fpdim=562, hidim=15);
:long_name = "DP Hydrometeor Identification";
:units = "Categorical";
:_FillValue = -888S; // short

float GR_Dzero(elevationAngle=9, fpdim=562);
:long_name = "DP Median Volume Diameter";
:units = "mm";
:_FillValue = -888.0f; // float

float GR_Dzero_StdDev(elevationAngle=9, fpdim=562);
```

```
:long_name = "Standard Deviation of DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw(elevationAngle=9, fpdim=562);  
:long_name = "DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm(elevationAngle=9, fpdim=562);  
:long_name = "DP Retrieved Median Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of DP Retrieved Median Diameter";
```

```
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum DP Retrieved Median Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_N2(elevationAngle=9, fpdim=562);  
:long_name = "Tokay Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_N2_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of Tokay Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_N2_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum Tokay Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_blockage(elevationAngle=9, fpdim=562);  
:long_name = "ground radar blockage fraction";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEDP(elevationAngle=9, fpdim=562);  
:long_name = "GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```



```
float GR_SWEDP_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_SWEDP_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
short n_gr_swedp_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_SWEDP average";  
:_FillValue = -888S; // short  
  
float GR_SWE25(elevationAngle=9, fpdim=562);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_SWE25_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
float GR_SWE25_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float  
  
short n_gr_swe25_rejected(elevationAngle=9, fpdim=562);
```

```
:long_name = "number of bins below rain_min in GR_SWE25 average";  
:_FillValue = -888S; // short
```

```
float GR_SWE50(elevationAngle=9, fpdim=562);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE50_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE50_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe50_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_SWE50 average";  
:_FillValue = -888S; // short
```

```
float GR_SWE75(elevationAngle=9, fpdim=562);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE75_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE75_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe75_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_SWE75 average";  
:_FillValue = -888S; // short
```

```
float GR_SWEMQT(elevationAngle=9, fpdim=562);  
:long_name = "GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMQT_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMQT_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swemqt_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_SWEMQT average";  
:_FillValue = -888S; // short
```

```
float GR_SWEMRMS(elevationAngle=9, fpdim=562);  
:long_name = "GV snowfall water equivalent rate, MRMS relationship";
```

```
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMRMS_StdDev(elevationAngle=9, fpdim=562);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMRMS_Max(elevationAngle=9, fpdim=562);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swemrms_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_SWEMRMS average";  
:_FillValue = -888S; // short
```

```
float ZFactorMeasured(elevationAngle=9, fpdim=562);  
:long_name = "DPR Uncorrected Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float ZFactorCorrected(elevationAngle=9, fpdim=562);  
:long_name = "DPR Attenuation-corrected Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float PrecipRate(elevationAngle=9, fpdim=562);  
:long_name = "DPR Estimated Rain Rate Profile";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float Dm(elevationAngle=9, fpdim=562);  
:long_name = "DPR Dm from paramDSD";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float Nw(elevationAngle=9, fpdim=562);  
:long_name = "DPR Nw from paramDSD";  
:units = "dB 1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float Epsilon(elevationAngle=9, fpdim=562);  
:long_name = "DPR Epsilon";  
:_FillValue = -888.0f; // float
```

```
short clutterStatus(elevationAngle=9, fpdim=562);  
:long_name = "Clutter region sample adjustment status";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
short n_gr_z_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below GR_dBZ_min in GR_Z average";  
:_FillValue = -888S; // short
```

```
short n_gr_zdr_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with missing Zdr in GR_Zdr average";  
:_FillValue = -888S; // short
```

```
short n_gr_kdp_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with missing Kdp in GR_Kdp average";  
:_FillValue = -888S; // short
```

```
short n_gr_rho_hv_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with missing RHO_hv in GR_RHO_hv average";  
:_FillValue = -888S; // short
```

```
short n_gr_rc_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_RC_rainrate average";  
:_FillValue = -888S; // short
```

```
short n_gr_rp_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_RP_rainrate average";  
:_FillValue = -888S; // short
```

```
short n_gr_rr_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins below rain_min in GR_RR_rainrate average";  
:_FillValue = -888S; // short
```

```
short n_gr_hid_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with undefined HID in GR_HID histogram";  
:_FillValue = -888S; // short
```

```
short n_gr_dzero_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with missing D0 in GR_Dzero average";  
:_FillValue = -888S; // short
```

```
short n_gr_nw_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with missing Nw in GR_Nw average";  
:_FillValue = -888S; // short
```

```
short n_gr_dm_rejected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins with missing Dm in GR_Dm average";
```

```
:_FillValue = -888S; // short

short n_gr_n2_rejected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins with missing N2 in GR_N2 average";
:_FillValue = -888S; // short

short n_gr_expected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins in GR_Z average";
:_FillValue = -888S; // short

short n_dpr_meas_z_rejected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins below DPR_dBZ_min in ZFactorMeasured average";
:_FillValue = -888S; // short

short n_dpr_corr_z_rejected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins below DPR_dBZ_min in ZFactorCorrected average";
:_FillValue = -888S; // short

short n_dpr_corr_r_rejected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins below rain_min in PrecipRate average";
:_FillValue = -888S; // short

short n_dpr_dm_rejected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins with missing Dm in DPR Dm average";
:_FillValue = -888S; // short

short n_dpr_nw_rejected(elevationAngle=9, fpdim=562);
:_long_name = "number of bins with missing Nw in DPR Nw average";
:_FillValue = -888S; // short

short n_dpr_epsilon_rejected(elevationAngle=9, fpdim=562);
```

```
:long_name = "number of bins below 0.0 in Epsilon average";  
:_FillValue = -888S; // short
```

```
short n_dpr_expected(elevationAngle=9, fpdim=562);  
:long_name = "number of bins in DPR averages";  
:_FillValue = -888S; // short
```

```
float DPRlatitude(fpdim=562);  
:long_name = "Latitude of DPR surface bin";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float DPRlongitude(fpdim=562);  
:long_name = "Longitude of DPR surface bin";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
float piaFinal(fpdim=562);  
:long_name = "DPR path integrated attenuation";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
short LandSurfaceType(fpdim=562);  
:long_name = "DPR LandSurfaceType";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
float PrecipRateSurface(fpdim=562);  
:long_name = "DPR Near-Surface Precipitation Rate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```



```
float SurfPrecipTotRate(fpdim=562);  
:long_name = "2B-DPRGMI Near-Surface Estimated Rain Rate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short heightStormTop(fpdim=562);  
:long_name = "DPR Estimated Storm Top Height (meters)";  
:units = "m";  
:_FillValue = -888S; // short
```

```
float BBheight(fpdim=562);  
:long_name = "DPR Bright Band Height above MSL";  
:units = "m";  
:_FillValue = -888.0f; // float
```

```
short BBstatus(fpdim=562);  
:long_name = "Bright Band Quality";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
int qualityData(fpdim=562);  
:long_name = "DPR FLG group qualityData";  
:units = "Categorical";  
:_FillValue = -888; // int
```

```
short FlagPrecip(fpdim=562);  
:long_name = "DPR FlagPrecip";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
short TypePrecip(fpdim=562);
:long_name = "DPR TypePrecip (stratiform/convective/other)";
:units = "Categorical";
:_FillValue = -888S; // short

int scanNum(fpdim=562);
:long_name = "product-relative zero-based array index of DPR scan number";
:_FillValue = -888; // int

short rayNum(fpdim=562);
:long_name = "product-relative zero-based array index of DPR ray number";
:_FillValue = -888S; // short

float pwatIntegrated_liquid(fpdim=562);
:long_name = "Precipitation water vertically integrated";
:_FillValue = -9999.9f; // float

float pwatIntegrated_solid(fpdim=562);
:long_name = "Precipitation water vertically integrated";
:_FillValue = -9999.9f; // float

float heightZeroDeg(fpdim=562);
:long_name = "Height of the level of 0 degree centigrade (msl)";
:_FillValue = -9999.9f; // float
:units = "meters";

double timeNearestApproach;
:units = "seconds";
:long_name = "Seconds since 01-01-1970 00:00:00";
:_FillValue = 0.0; // double
```

```
char atimeNearestApproach(len_atime_ID=19);  
:long_name = "text version of timeNearestApproach, UTC";
```

```
double timeSweepStart(elevationAngle=9);  
:units = "seconds";  
:long_name = "Seconds since 01-01-1970 00:00:00";  
:_FillValue = 0.0; // double
```

```
char atimeSweepStart(elevationAngle=9, len_atime_ID=19);  
:long_name = "text version of timeSweepStart, UTC";
```

```
char site_ID(len_site_ID=4);  
:long_name = "ID of Ground Radar Site";
```

```
float site_lat;  
:long_name = "Latitude of Ground Radar Site";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float site_lon;  
:long_name = "Longitude of Ground Radar Site";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
float site_elev;  
:long_name = "Elevation of Ground Radar Site above MSL";  
:units = "km";
```

```
float version;  
:long_name = "Geo Match File Version";
```

```
// global attributes:
:DPR_Version = "V06A";
: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";
:GV_UF_DM_field = "DM";
:GV_UF_N2_field = "N2";
:DPR_2ADPR_file = "2A-CS-CONUS.GPM.DPR.V8-20180723.20140817-S231705-E232543.002665.V06A.HDF5";
:DPR_2AKU_file = "no_2AKU_file";
:DPR_2AKA_file = "no_2AKA_file";
:DPR_2BCMB_file = "no_2BCMB_file";
:GR_file = "KARX_2014_0817_232213.uf.gz";
:PR_2APR_file = "no_2APR_file";
:PR_2BPRTMI_File = "no_2BPRTMI_file";
```

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": $\text{HeightAGL} = \text{HeightMSL} - \text{site_elev}$
- 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

Variable Name(s)	Type	Dimension(s)	Special Value(s)
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

Variable	Category definitions
clutterStatus	<p>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:</p> <p>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</p> <p>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.</p>
GR_HID	See NOTES in preceding text box.

3.2 GMI-GR Geometry Match netCDF file description

The format and content of **Version 1.2** 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). Note that the “fpdim” and “elevationAngle” dimensions vary between files.

dimensions:

```
fpdim = 651;
elevationAngle = 9;
xydim = 4;
hidim = 15;
Tbdim = 13;
Tbten = 21;
len_atime_ID = 19;
len_site_ID = 4;
```

variables:

```
char Tc_channel_names(Tbdim=13, Tbten=21);
:long_name = "Tc channel frequency/polarization names";
```

```
float elevationAngle(elevationAngle=9);
:long_name = "Radar Sweep Elevation Angles";
:units = "degrees";
```

```
float rangeThreshold;
:long_name = "Dataset maximum range from radar site";
:_FillValue = -888.0f; // float
```

```
:units = "km";
```

```
float GR_dBZ_min;
```

```
:long_name = "minimum GR bin dBZ required for a *complete* GR horizontal average";
```

```
:_FillValue = -888.0f; // float
```

```
:units = "dBZ";
```

```
float gprof_rain_min;
```

```
:long_name = "minimum XMI rainrate required";
```

```
:_FillValue = -888.0f; // float
```

```
:units = "mm/h";
```

```
float radiusOfInfluence;
```

```
:long_name = "Radius of influence for distance weighting of GR bins";
```

```
:_FillValue = -888.0f; // float
```

```
:units = "km";
```

```
short have_GR_Z_slantPath;
```

```
:long_name = "data exists flag for GR_Z_slantPath";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RC_rainrate_slantPath;
```

```
:long_name = "data exists flag for GR_RC_rainrate_slantPath";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RP_rainrate_slantPath;
```

```
:long_name = "data exists flag for GR_RP_rainrate_slantPath";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RR_rainrate_slantPath;
```

```
:long_name = "data exists flag for GR_RR_rainrate_slantPath";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Zdr_slantPath;  
:long_name = "data exists flag for GR_Zdr_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_Kdp_slantPath;  
:long_name = "data exists flag for GR_Kdp_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_RHOhv_slantPath;  
:long_name = "data exists flag for GR_RHOhv_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_HID_slantPath;  
:long_name = "data exists flag for GR_HID_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_Dzero_slantPath;  
:long_name = "data exists flag for GR_Dzero_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_Nw_slantPath;  
:long_name = "data exists flag for GR_Nw_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_blockage_slantPath;  
:long_name = "data exists flag for GR_blockage_slantPath";  
:_FillValue = 0S; // short
```

```
short have_GR_Z_VPR;
```

```
:long_name = "data exists flag for GR_Z_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_RC_rainrate_VPR;  
:long_name = "data exists flag for GR_RC_rainrate_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_RP_rainrate_VPR;  
:long_name = "data exists flag for GR_RP_rainrate_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_RR_rainrate_VPR;  
:long_name = "data exists flag for GR_RR_rainrate_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_Zdr_VPR;  
:long_name = "data exists flag for GR_Zdr_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_Kdp_VPR;  
:long_name = "data exists flag for GR_Kdp_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_RHOhv_VPR;  
:long_name = "data exists flag for GR_RHOhv_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_HID_VPR;  
:long_name = "data exists flag for GR_HID_VPR";  
:_FillValue = 0S; // short
```

```
short have_GR_Dzero_VPR;  
:long_name = "data exists flag for GR_Dzero_VPR";  
:_FillValue = 0S; // short  
  
short have_GR_Nw_VPR;  
:long_name = "data exists flag for GR_Nw_VPR";  
:_FillValue = 0S; // short  
  
short have_GR_blockage_VPR;  
:long_name = "data exists flag for GR_blockage_VPR";  
:_FillValue = 0S; // short  
  
short have_surfaceTypeIndex;  
:long_name = "data exists flag for surfaceTypeIndex";  
:_FillValue = 0S; // short  
  
short have_surfacePrecipitation;  
:long_name = "data exists flag for surfacePrecipitation";  
:_FillValue = 0S; // short  
  
short have_pixelStatus;  
:long_name = "data exists flag for pixelStatus";  
:_FillValue = 0S; // short  
  
short have_PoP;  
:long_name = "data exists flag for PoP";  
:_FillValue = 0S; // short  
  
short have_freezingHeight;  
:long_name = "data exists flag for freezingHeight";  
:_FillValue = 0S; // short
```

```
short have_Tc;
:long_name = "data exists flag for Tc";
:_FillValue = 0S; // short

float latitude(elevationAngle=9, fpdim=651);
:long_name = "Latitude of data sample";
:units = "degrees North";
:_FillValue = -888.0f; // float

float longitude(elevationAngle=9, fpdim=651);
:long_name = "Longitude of data sample";
:units = "degrees East";
:_FillValue = -888.0f; // float

float xCorners(elevationAngle=9, fpdim=651, xydim=4);
:long_name = "data sample x corner coords.";
:units = "km";
:_FillValue = -888.0f; // float

float yCorners(elevationAngle=9, fpdim=651, xydim=4);
:long_name = "data sample y corner coords.";
:units = "km";
:_FillValue = -888.0f; // float

float topHeight(elevationAngle=9, fpdim=651);
:long_name = "data sample top height AGL";
:units = "km";
:_FillValue = -888.0f; // float

float bottomHeight(elevationAngle=9, fpdim=651);
```



```
:long_name = "data sample bottom height AGL";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float topHeight_vpr(elevationAngle=9, fpdim=651);  
:long_name = "data sample top height AGL along local vertical";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float bottomHeight_vpr(elevationAngle=9, fpdim=651);  
:long_name = "data sample bottom height AGL along local vertical";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "GV radar Cifelli Rain Rate";
```

```
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar Cifelli Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar Cifelli Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "GV radar PolZR Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar PolZR Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar PolZR Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "GV radar DROPS Rain Rate";  
:units = "dBZ";
```

```
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar DROPS Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar DROPS Rain Rate";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
short GR_HID_slantPath(elevationAngle=9, fpdim=651, hidim=15);  
:long_name = "DP Hydrometeor Identification";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
float GR_Dzero_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_StdDev_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_Max_slantPath(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_blockage_slantPath(elevationAngle=9, fpdim=651);
```

```
:long_name = "ground radar blockage fraction";  
:_FillValue = -888.0f; // float
```

```
short n_gr_expected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins in GR slantPath averages";  
:_FillValue = -888S; // short
```

```
short n_gr_z_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins below GR_dBZ_min in GR_Z_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_rc_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins below gprof_rain_min in GR_RC_rainrate_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_rp_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins below gprof_rain_min in GR_RP_rainrate_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_rr_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins below gprof_rain_min in GR_RR_rainrate_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_zdr_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing Zdr in GR_Zdr_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_kdp_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing Kdp in GR_Kdp_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_rhohv_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing RHOhv in GR_RHOhv_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_hid_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with undefined HID in GR_HID_slantPath histogram";  
:_FillValue = -888S; // short
```

```
short n_gr_dzero_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing D0 in GR_Dzero_slantPath average";  
:_FillValue = -888S; // short
```

```
short n_gr_nw_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing Nw in GR_Nw_slantPath average";  
:_FillValue = -888S; // short
```

```
float GR_Z_VPR(elevationAngle=9, fpdim=651);  
:long_name = "GV radar QC Reflectivity along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar QC Reflectivity along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar QC Reflectivity along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_VPR(elevationAngle=9, fpdim=651);  
:long_name = "GV radar Cifelli Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float  
  
float GR_RC_rainrate_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar Cifelli Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float  
  
float GR_RC_rainrate_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar Cifelli Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float  
  
float GR_RP_rainrate_VPR(elevationAngle=9, fpdim=651);  
:long_name = "GV radar PolZR Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float  
  
float GR_RP_rainrate_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar PolZR Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float  
  
float GR_RP_rainrate_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar PolZR Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float  
  
float GR_RR_rainrate_VPR(elevationAngle=9, fpdim=651);
```



```
:long_name = "GV radar DROPS Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of GV radar DROPS Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum GV radar DROPS Rain Rate along local vertical";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_VPR(elevationAngle=9, fpdim=651);  
:long_name = "DP Differential Reflectivity along local vertical";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Differential Reflectivity along local vertical";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Differential Reflectivity along local vertical";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_VPR(elevationAngle=9, fpdim=651);  
:long_name = "DP Specific Differential Phase along local vertical";
```

```
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Specific Differential Phase along local vertical";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Specific Differential Phase along local vertical";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOHV_VPR(elevationAngle=9, fpdim=651);  
:long_name = "DP Co-Polar Correlation Coefficient along local vertical";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOHV_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Co-Polar Correlation Coefficient along local vertical";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOHV_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Co-Polar Correlation Coefficient along local vertical";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
short GR_HID_VPR(elevationAngle=9, fpdim=651, hidim=15);  
:long_name = "DP Hydrometeor Identification along local vertical";  
:units = "Categorical";
```

```
:_FillValue = -888S; // short
```

```
float GR_Dzero_VPR(elevationAngle=9, fpdim=651);  
:long_name = "DP Median Volume Diameter along local vertical";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Median Volume Diameter along local vertical";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Median Volume Diameter along local vertical";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_VPR(elevationAngle=9, fpdim=651);  
:long_name = "DP Normalized Intercept Parameter along local vertical";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_StdDev_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Standard Deviation of DP Normalized Intercept Parameter along local vertical";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_Max_VPR(elevationAngle=9, fpdim=651);  
:long_name = "Sample Maximum DP Normalized Intercept Parameter along local vertical";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_blockage_VPR(elevationAngle=9, fpdim=651);
:long_name = "ground radar blockage fraction along local vertical";
:_FillValue = -888.0f; // float

short n_gr_vpr_expected(elevationAngle=9, fpdim=651);
:long_name = "number of bins in GR_Z_VPR, GR_rainrate_VPR averages";
:_FillValue = -888S; // short

short n_gr_z_vpr_rejected(elevationAngle=9, fpdim=651);
:long_name = "number of bins below GR_dBZ_min in GR_Z_VPR average";
:_FillValue = -888S; // short

short n_gr_rc_vpr_rejected(elevationAngle=9, fpdim=651);
:long_name = "number of bins below gprof_rain_min in GR_RC_rainrate_VPR average";
:_FillValue = -888S; // short

short n_gr_rp_vpr_rejected(elevationAngle=9, fpdim=651);
:long_name = "number of bins below gprof_rain_min in GR_RP_rainrate_VPR average";
:_FillValue = -888S; // short

short n_gr_rr_vpr_rejected(elevationAngle=9, fpdim=651);
:long_name = "number of bins below gprof_rain_min in GR_RR_rainrate_VPR average";
:_FillValue = -888S; // short

short n_gr_zdr_vpr_rejected(elevationAngle=9, fpdim=651);
:long_name = "number of bins with missing Zdr in GR_Zdr_VPR average";
:_FillValue = -888S; // short

short n_gr_kdp_vpr_rejected(elevationAngle=9, fpdim=651);
:long_name = "number of bins with missing Kdp in GR_Kdp_VPR average";
```

```
:_FillValue = -888S; // short
```

```
short n_gr_rho_hv_vpr_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing RHO_hv in GR_RHO_hv_VPR average";  
:_FillValue = -888S; // short
```

```
short n_gr_hid_vpr_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with undefined HID in GR_HID_VPR histogram";  
:_FillValue = -888S; // short
```

```
short n_gr_dzero_vpr_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing D0 in GR_Dzero_VPR average";  
:_FillValue = -888S; // short
```

```
short n_gr_nw_vpr_rejected(elevationAngle=9, fpdim=651);  
:long_name = "number of bins with missing Nw in GR_Nw_VPR average";  
:_FillValue = -888S; // short
```

```
float XMIlatitude(fpdim=651);  
:long_name = "Latitude of XMI surface bin";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float XMIlongitude(fpdim=651);  
:long_name = "Longitude of XMI surface bin";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
short surfaceTypeIndex(fpdim=651);  
:long_name = "2A-GPROF surfaceTypeIndex";  
:units = "Categorical";
```

```
:_FillValue = -888S; // short
```

```
float surfacePrecipitation(fpdim=651);  
:long_name = "2A-GPROF Estimated Surface Rain Rate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short pixelStatus(fpdim=651);  
:long_name = "2A-GPROF pixelStatus";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
short PoP(fpdim=651);  
:long_name = "2A-GPROF probabilityOfPrecip";  
:units = "percent";  
:_FillValue = -888S; // short
```

```
short freezingHeight(fpdim=651);  
:long_name = "Freezing Height";  
:units = "meters";  
:_FillValue = -888S; // short
```

```
short Quality(fpdim=651, Tbdim=13);  
:long_name = "1C-R-XCAL Common Calibrated Brightness Temperatures Quality";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
float Tc(fpdim=651, Tbdim=13);  
:long_name = "1C-R-XCAL Common Calibrated Brightness Temperatures, Tc";  
:units = "Kelvins";  
:_FillValue = -888.0f; // float
```

```
int rayIndex(fpdim=651);  
:long_name = "XMI product-relative ray,scan IDL 1-D array index";  
:_FillValue = -888; // int
```

```
char Tc_names(Tbdim=13, Tblen=21);  
:long_name = "Tc channel names";
```

```
double timeNearestApproach;  
:units = "seconds";  
:long_name = "Seconds since 01-01-1970 00:00:00";  
:_FillValue = 0.0; // double
```

```
char atimeNearestApproach(len_atime_ID=19);  
:long_name = "text version of timeNearestApproach, UTC";
```

```
double timeSweepStart(elevationAngle=9);  
:units = "seconds";  
:long_name = "Seconds since 01-01-1970 00:00:00";  
:_FillValue = 0.0; // double
```

```
char atimeSweepStart(elevationAngle=9, len_atime_ID=19);  
:long_name = "text version of timeSweepStart, UTC";
```

```
char site_ID(len_site_ID=4);  
:long_name = "ID of Ground Radar Site";
```

```
float site_lat;  
:long_name = "Latitude of Ground Radar Site";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float site_lon;  
  :long_name = "Longitude of Ground Radar Site";  
  :units = "degrees East";  
  :_FillValue = -888.0f; // float  
  
float site_elev;  
  :long_name = "Elevation of Ground Radar Site above MSL";  
  :units = "km";  
  
float version;  
  :long_name = "Geo Match File Version";  
  
// global attributes:  
:PPS_Version = "V05A";  
: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 = "Unspecified";  
:GV_UF_NW_field = "NW";  
:1CRXCAL_file = "Unspecified";  
:2AGPROF_file = "Unspecified";  
:GR_file = "Unspecified";
```


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:

$$\text{HeightAGL} = \text{HeightMSL} - \text{site_elev}$$

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

Variable Name(s)	Type	Dimension(s)	Special Values
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.

3.3 DPRGMI-GR Geometry Match netCDF file description

The format and content of Version 2.0 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. Note that “fpdim_MS”, “fpdim_NS”, and “elevationAngle” dimensions vary between files.

dimensions:

```
fpdim_MS = 835;  
fpdim_NS = 1214;  
elevationAngle = 9;  
xydim = 4;  
hidim = 15;  
nPSDlo = 2;  
nBnPSDlo = 9;  
nKuKa = 2;
```

```
nPhsBnN = 5;
timedimid_MS = 41;
timedimid_NS = 41;
len_atime_ID = 19;
len_site_ID = 4;
variables:
  float elevationAngle(elevationAngle=9);
    :long_name = "Radar Sweep Elevation Angles";
    :units = "degrees";

  short have_swath_MS;
    :long_name = "data exists flag for MS swath";
    :_FillValue = 0S; // short

  short Year_MS(timedimid_MS=41);
    :long_name = "Year of DPR MS scan";
    :_FillValue = -888S; // short

  byte Month_MS(timedimid_MS=41);
    :long_name = "Month of DPR MS scan";
    :_FillValue = -88B; // byte

  byte DayOfMonth_MS(timedimid_MS=41);
    :long_name = "DayOfMonth of DPR MS scan";
    :_FillValue = -88B; // byte

  byte Hour_MS(timedimid_MS=41);
    :long_name = "Hour of DPR MS scan";
    :_FillValue = -88B; // byte

  byte Minute_MS(timedimid_MS=41);
```

```
:long_name = "Minute of DPR MS scan";  
:_FillValue = -88B; // byte
```

```
byte Second_MS(timedimid_MS=41);  
:long_name = "Second of DPR MS scan";  
:_FillValue = -88B; // byte
```

```
short Millisecond_MS(timedimid_MS=41);  
:long_name = "Millisecond of DPR MS scan";  
:_FillValue = -888S; // short
```

```
short Year_NS(timedimid_NS=41);  
:long_name = "Year of DPR NS scan";  
:_FillValue = -888S; // short
```

```
byte Month_NS(timedimid_NS=41);  
:long_name = "Month of DPR NS scan";  
:_FillValue = -88B; // byte
```

```
byte DayOfMonth_NS(timedimid_NS=41);  
:long_name = "DayOfMonth of DPR NS scan";  
:_FillValue = -88B; // byte
```

```
byte Hour_NS(timedimid_NS=41);  
:long_name = "Hour of DPR NS scan";  
:_FillValue = -88B; // byte
```

```
byte Minute_NS(timedimid_NS=41);  
:long_name = "Minute of DPR NS scan";  
:_FillValue = -88B; // byte
```



```
byte Second_NS(timedimid_NS=41);
:long_name = "Second of DPR NS scan";
:_FillValue = -88B; // byte

short Millisecond_NS(timedimid_NS=41);
:long_name = "Millisecond of DPR NS scan";
:_FillValue = -888S; // short

int startScan_MS;
:long_name = "Starting DPR MS overlap scan in original dataset, zero-based";
:_FillValue = -888; // int

int endScan_MS;
:long_name = "Ending DPR MS overlap scan in original dataset, zero-based";
:_FillValue = -888; // int

short numRays_MS;
:long_name = "Number of DPR MS rays per scan in original datasets";
:_FillValue = -888S; // short

int startScan_NS;
:long_name = "Starting DPR NS overlap scan in original dataset, zero-based";
:_FillValue = -888; // int

int endScan_NS;
:long_name = "Ending DPR NS overlap scan in original dataset, zero-based";
:_FillValue = -888; // int

short numRays_NS;
:long_name = "Number of DPR NS rays per scan in original datasets";
:_FillValue = -888S; // short
```

```
float rangeThreshold;  
:long_name = "Dataset maximum range from radar site";  
:_FillValue = -888.0f; // float  
:units = "km";  
  
float DPR_dBZ_min;  
:long_name = "minimum DPR bin dBZ required for a *complete* DPR vertical average";  
:_FillValue = -888.0f; // float  
:units = "dBZ";  
  
float GR_dBZ_min;  
:long_name = "minimum GR bin dBZ required for a *complete* GR horizontal average";  
:_FillValue = -888.0f; // float  
:units = "dBZ";  
  
float rain_min;  
:long_name = "minimum DPR rainrate required for a *complete* DPR vertical average";  
:_FillValue = -888.0f; // float  
:units = "mm/h";  
  
short have_GR_Z;  
:long_name = "data exists flag for GR_Z";  
:_FillValue = 0S; // short  
  
short have_GR_Zdr;  
:long_name = "data exists flag for GR_Zdr";  
:_FillValue = 0S; // short  
  
short have_GR_Kdp;  
:long_name = "data exists flag for GR_Kdp";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RHOhv;
```

```
:long_name = "data exists flag for GR_RHOhv";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RC_rainrate;
```

```
:long_name = "data exists flag for GR_RC_rainrate";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RP_rainrate;
```

```
:long_name = "data exists flag for GR_RP_rainrate";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_RR_rainrate;
```

```
:long_name = "data exists flag for GR_RR_rainrate";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_HID;
```

```
:long_name = "data exists flag for GR_HID";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Dzero;
```

```
:long_name = "data exists flag for GR_Dzero";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Nw;
```

```
:long_name = "data exists flag for GR_Nw";
```

```
:_FillValue = 0S; // short
```

```
short have_GR_Dm;
```

```
:long_name = "data exists flag for GR_Dm";  
:_FillValue = 0S; // short
```

```
short have_GR_N2;  
:long_name = "data exists flag for GR_N2";  
:_FillValue = 0S; // short
```

```
short have_GR_blockage;  
:long_name = "data exists flag for ground radar blockage fraction";  
:_FillValue = 0S; // short
```

```
short have_GR_SWE;  
:long_name = "data exists flag for ground radar snowfall water equivalent rate";  
:_FillValue = 0S; // short
```

```
float latitude_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Latitude of 3-D data sample";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float longitude_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Longitude of 3-D data sample";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
float xCorners_MS(elevationAngle=9, fpdim_MS=835, xydim=4);  
:long_name = "data sample x corner coords.";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float yCorners_MS(elevationAngle=9, fpdim_MS=835, xydim=4);
```

```
:long_name = "data sample y corner coords.";
:units = "km";
:_FillValue = -888.0f; // float
```

```
float topHeight_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "data sample top height AGL";
:units = "km";
:_FillValue = -888.0f; // float
```

```
float bottomHeight_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "data sample bottom height AGL";
:units = "km";
:_FillValue = -888.0f; // float
```

```
float GR_Z_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "GV radar QC Reflectivity";
:units = "dBZ";
:_FillValue = -888.0f; // float
```

```
float GR_Z_StdDev_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "Standard Deviation of GV radar QC Reflectivity";
:units = "dBZ";
:_FillValue = -888.0f; // float
```

```
float GR_Z_Max_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "Sample Maximum GV radar QC Reflectivity";
:units = "dBZ";
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "DP Differential Reflectivity";
```

```
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";
```

```
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV radar Cifelli Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV radar Cifelli Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV radar Cifelli Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV radar PolZR Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV radar PolZR Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV radar PolZR Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV radar DROPS Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV radar DROPS Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV radar DROPS Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short GR_HID_MS(elevationAngle=9, fpdim_MS=835, hidim=15);  
:long_name = "DP Hydrometeor Identification";  
:units = "Categorical";  
:_FillValue = -888S; // short
```



```
float GR_Dzero_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_MS(elevationAngle=9, fpdim_MS=835);
```

```
:long_name = "DP Retrieved Median Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of DP Retrieved Median Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum DP Retrieved Median Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_N2_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Tokay Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_N2_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of Tokay Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_N2_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum Tokay Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_blockage_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "ground radar blockage fraction";
```

```
:_FillValue = -888.0f; // float

short n_gr_z_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins below GR_dBZ_min in GR_Z average";
:_FillValue = -888S; // short

short n_gr_zdr_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins with missing Zdr in GR_Zdr average";
:_FillValue = -888S; // short

short n_gr_kdp_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins with missing Kdp in GR_Kdp average";
:_FillValue = -888S; // short

short n_gr_rhohv_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins with missing RHOhv in GR_RHOhv average";
:_FillValue = -888S; // short

short n_gr_rc_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins below rain_min in GR_RC_rainrate average";
:_FillValue = -888S; // short

short n_gr_rp_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins below rain_min in GR_RP_rainrate average";
:_FillValue = -888S; // short

short n_gr_rr_rejected_MS(elevationAngle=9, fpdim_MS=835);
:_long_name = "number of bins below rain_min in GR_RR_rainrate average";
:_FillValue = -888S; // short

short n_gr_hid_rejected_MS(elevationAngle=9, fpdim_MS=835);
```

```
:long_name = "number of bins with undefined HID in GR_HID histogram";  
:_FillValue = -888S; // short
```

```
short n_gr_dzero_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins with missing D0 in GR_Dzero average";  
:_FillValue = -888S; // short
```

```
short n_gr_nw_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins with missing Nw in GR_Nw average";  
:_FillValue = -888S; // short
```

```
short n_gr_dm_rejected_MS(elevationAngle=9, fpdim_NS=1214, fpdim_MS=835);  
:long_name = "number of bins with missing Dm in GR_Dm average";  
:_FillValue = -888S; // short
```

```
short n_gr_n2_rejected_MS(elevationAngle=9, fpdim_NS=1214, fpdim_MS=835);  
:long_name = "number of bins with missing N2 in GR_N2 average";  
:_FillValue = -888S; // short
```

```
short n_gr_expected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins in GR_Z average";  
:_FillValue = -888S; // short
```

```
float GR_SWEDP_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEDP_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";
```

```
:_FillValue = -888.0f; // float
```

```
float GR_SWEDP_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swedp_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins below rain_min in GR_SWEDP average";  
:_FillValue = -888S; // short
```

```
float GR_SWE25_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE25_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE25_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe25_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins below rain_min in GR_SWE25 average";  
:_FillValue = -888S; // short
```

```
float GR_SWE50_MS(elevationAngle=9, fpdim_MS=835);
```

```
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE50_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE50_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe50_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins below rain_min in GR_SWE50 average";  
:_FillValue = -888S; // short
```

```
float GR_SWE75_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE75_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE75_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";
```

```
:_FillValue = -888.0f; // float
```

```
short n_gr_swe75_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins below rain_min in GR_SWE75 average";  
:_FillValue = -888S; // short
```

```
float GR_SWEMQT_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMQT_StdDev_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMQT_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swemqt_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins below rain_min in GR_SWEMQT_rainrate average";  
:_FillValue = -888S; // short
```

```
float GR_SWEMRMS_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMRMS_StdDev_MS(elevationAngle=9, fpdim_MS=835);
```

```
:long_name = "Standard Deviation of GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMRMS_Max_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swemrms_rejected_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "number of bins below rain_min in GR_SWEMRMS_rainrate average";  
:_FillValue = -888S; // short
```

```
float precipTotPSDparamHigh_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "2B-DPRGMI precipTotPSDparamHigh for MS swath";  
:units = "mm_Dm";  
:_FillValue = -888.0f; // float
```

```
float precipTotPSDparamLow_MS(elevationAngle=9, fpdim_MS=835, nPSDlo=2);  
:long_name = "2B-DPRGMI precipTotPSDparamLow for MS swath";  
:units = "Nw_mu";  
:_FillValue = -888.0f; // float
```

```
float precipTotRate_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "2B-DPRGMI precipTotRate for MS swath";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float precipTotWaterCont_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "2B-DPRGMI precipTotWaterCont for MS swath";  
:units = "g/m^3";
```



```
:_FillValue = -888.0f; // float
```

```
float precipTotWaterContSigma_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "2B-DPRGMI precipTotWaterContSigma for MS swath";  
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float cloudLiqWaterCont_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "2B-DPRGMI cloudLiqWaterCont for MS swath";  
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float cloudIceWaterCont_MS(elevationAngle=9, fpdim_MS=835);  
:long_name = "2B-DPRGMI cloudIceWaterCont for MS swath";  
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float tbSim_19v_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI simulatedBrightTemp 19v for MS swath";  
:units = "K";  
:_FillValue = -888.0f; // float
```

```
float tbSim_37v_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI simulatedBrightTemp 37v for MS swath";  
:units = "K";  
:_FillValue = -888.0f; // float
```

```
float tbSim_89v_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI simulatedBrightTemp 89v for MS swath";  
:units = "K";  
:_FillValue = -888.0f; // float
```

```
float tbSim_183_3v_MS(fpdim_MS=835);
:long_name = "2B-DPRGMI simulatedBrightTemp 183_3v for MS swath";
:units = "K";
:_FillValue = -888.0f; // float

short n_precipTotPSDparamHigh_rejected_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "number of bins below rain_min in precipTotPSDparamHigh average for MS swath";
:_FillValue = -888S; // short

short n_precipTotPSDparamLow_rejected_MS(elevationAngle=9, fpdim_MS=835, nPSDlo=2);
:long_name = "number of bins below rain_min in precipTotPSDparamLow average for MS swath";
:_FillValue = -888S; // short

short n_precipTotRate_rejected_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "number of bins below rain_min in precipTotRate average for MS swath";
:_FillValue = -888S; // short

short n_precipTotWaterCont_rejected_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "number of bins below rain_min in precipTotWaterCont average for MS swath";
:_FillValue = -888S; // short

short n_precipTotWaterContSigma_rejected_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "number of bins below rain_min in precipTotWaterContSigma average for MS swath";
:_FillValue = -888S; // short

short n_cloudLiqWaterCont_rejected_MS(elevationAngle=9, fpdim_MS=835);
:long_name = "number of bins below rain_min in cloudLiqWaterCont average for MS swath";
:_FillValue = -888S; // short

short n_cloudIceWaterCont_rejected_MS(elevationAngle=9, fpdim_MS=835);
```

```
:long_name = "number of bins below rain_min in cloudIceWaterCont average for MS swath";  
:_FillValue = -888S; // short
```

```
int precipitationType_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI precipitationType for MS swath";  
:units = "Categorical";  
:_FillValue = -888; // int
```

```
float surfPrecipTotRate_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI surfPrecipTotRate for MS swath";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float surfaceElevation_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI surfaceElevation for MS swath";  
:units = "m";  
:_FillValue = -888.0f; // float
```

```
float zeroDegAltitude_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI zeroDegAltitude for MS swath";  
:units = "m";  
:_FillValue = -888.0f; // float
```

```
short zeroDegBin_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI zeroDegBin for MS swath";  
:units = "N/A";  
:_FillValue = -888S; // short
```

```
int surfaceType_MS(fpdim_MS=835);  
:long_name = "2B-DPRGMI surfaceType for MS swath";  
:units = "Categorical";
```

```
:_FillValue = -888; // int

short phaseBinNodes_MS(fpdim_MS=835, nPhsBnN=5);
:long_name = "2B-DPRGMI phaseBinNodes for MS swath";
:units = "None";
:_FillValue = -888S; // short

float DPRlatitude_MS(fpdim_MS=835);
:long_name = "Latitude of DPR surface bin for MS swath";
:units = "degrees North";
:_FillValue = -888.0f; // float

float DPRlongitude_MS(fpdim_MS=835);
:long_name = "Longitude of DPR surface bin for MS swath";
:units = "degrees East";
:_FillValue = -888.0f; // float

short scanNum_MS(fpdim_MS=835);
:long_name = "product-relative zero-based DPR scan number for MS swath";
:_FillValue = -888S; // short

short rayNum_MS(fpdim_MS=835);
:long_name = "product-relative zero-based DPR ray number for MS swath";
:_FillValue = -888S; // short

float ellipsoidBinOffset_MS(fpdim_MS=835, nKuKa=2);
:long_name = "2B-DPRGMI Ku and Ka ellipsoidBinOffset for MS swath";
:units = "m";
:_FillValue = -888.0f; // float

short lowestClutterFreeBin_MS(fpdim_MS=835, nKuKa=2);
```

```
:long_name = "2B-DPRGMI Ku and Ka lowestClutterFreeBin for MS swath";  
:units = "None";  
:_FillValue = -888S; // short
```

```
short clutterStatus_MS(elevationAngle=9, fpdim_MS=835, nKuKa=2);  
:long_name = "Matchup Ku and Ka clutterStatus for MS swath";  
:units = "None";  
:_FillValue = -888S; // short
```

```
int precipitationFlag_MS(fpdim_MS=835, nKuKa=2);  
:long_name = "2B-DPRGMI Ku and Ka precipitationFlag for MS swath";  
:units = "Categorical";  
:_FillValue = -888; // int
```

```
short surfaceRangeBin_MS(fpdim_MS=835, nKuKa=2);  
:long_name = "2B-DPRGMI Ku and Ka surfaceRangeBin for MS swath";  
:units = "None";  
:_FillValue = -888S; // short
```

```
float correctedReflectFactor_MS(elevationAngle=9, fpdim_MS=835, nKuKa=2);  
:long_name = "2B-DPRGMI Ku and Ka Corrected Reflectivity Factor for MS swath";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float pia_MS(fpdim_MS=835, nKuKa=2);  
:long_name = "2B-DPRGMI Ku and Ka Path Integrated Attenuation for MS swath";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float stormTopAltitude_MS(fpdim_MS=835, nKuKa=2);  
:long_name = "2B-DPRGMI Ku and Ka stormTopAltitude for MS swath";
```

```
:units = "m";  
:_FillValue = -888.0f; // float
```

```
short n_correctedReflectFactor_rejected_MS(elevationAngle=9, fpdim_MS=835, nKuKa=2);  
:long_name = "numbers of Ku and Ka bins below DPR_dBZ_min in correctedReflectFactor average for MS swath";  
:_FillValue = -888S; // short
```

```
short n_dpr_expected_MS(elevationAngle=9, fpdim_MS=835, nKuKa=2);  
:long_name = "numbers of expected Ku and Ka bins in DPR averages for MS swath";  
:_FillValue = -888S; // short
```

```
float latitude_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Latitude of 3-D data sample";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float longitude_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Longitude of 3-D data sample";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
float xCorners_NS(elevationAngle=9, fpdim_NS=1214, xydim=4);  
:long_name = "data sample x corner coords.";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float yCorners_NS(elevationAngle=9, fpdim_NS=1214, xydim=4);  
:long_name = "data sample y corner coords.";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float topHeight_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "data sample top height AGL";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float bottomHeight_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "data sample bottom height AGL";  
:units = "km";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Z_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV radar QC Reflectivity";  
:units = "dBZ";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_StdDev_NS(elevationAngle=9, fpdim_NS=1214);
```

```
:long_name = "Standard Deviation of DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Zdr_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum DP Differential Reflectivity";  
:units = "dB";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_Kdp_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum DP Specific Differential Phase";  
:units = "deg/km";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOhv_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of DP Co-Polar Correlation Coefficient";
```



```
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RHOHV_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum DP Co-Polar Correlation Coefficient";  
:units = "Dimensionless";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV radar Cifelli Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV radar Cifelli Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RC_rainrate_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV radar Cifelli Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV radar PolZR Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV radar PolZR Rainrate";  
:units = "mm/h";
```

```
:_FillValue = -888.0f; // float
```

```
float GR_RP_rainrate_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV radar PolZR Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV radar DROPS Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV radar DROPS Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_RR_rainrate_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV radar DROPS Rainrate";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short GR_HID_NS(elevationAngle=9, fpdim_NS=1214, hidim=15);  
:long_name = "DP Hydrometeor Identification";  
:units = "Categorical";  
:_FillValue = -888S; // short
```

```
float GR_Dzero_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dzero_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum DP Median Volume Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Nw_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum DP Normalized Intercept Parameter";  
:units = "1/(mm*m^3)";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "DP Retrieved Median Diameter";  
:units = "mm";  
:_FillValue = -888.0f; // float
```

```
float GR_Dm_StdDev_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "Standard Deviation of DP Retrieved Median Diameter";
:units = "mm";
:_FillValue = -888.0f; // float

float GR_Dm_Max_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "Sample Maximum DP Retrieved Median Diameter";
:units = "mm";
:_FillValue = -888.0f; // float

float GR_N2_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "Tokay Normalized Intercept Parameter";
:units = "1/(mm*m^3)";
:_FillValue = -888.0f; // float

float GR_N2_StdDev_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "Standard Deviation of Tokay Normalized Intercept Parameter";
:units = "1/(mm*m^3)";
:_FillValue = -888.0f; // float

float GR_N2_Max_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "Sample Maximum Tokay Normalized Intercept Parameter";
:units = "1/(mm*m^3)";
:_FillValue = -888.0f; // float

float GR_blockage_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "ground radar blockage fraction";
:_FillValue = -888.0f; // float

short n_gr_z_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below GR_dBZ_min in GR_Z average";
```

```
:_FillValue = -888S; // short
```

```
short n_gr_zdr_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins with missing Zdr in GR_Zdr average";  
:_FillValue = -888S; // short
```

```
short n_gr_kdp_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins with missing Kdp in GR_Kdp average";  
:_FillValue = -888S; // short
```

```
short n_gr_rhohv_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins with missing RHOhv in GR_RHOhv average";  
:_FillValue = -888S; // short
```

```
short n_gr_rc_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_RC_rainrate average";  
:_FillValue = -888S; // short
```

```
short n_gr_rp_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_RP_rainrate average";  
:_FillValue = -888S; // short
```

```
short n_gr_rr_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_RR_rainrate average";  
:_FillValue = -888S; // short
```

```
short n_gr_hid_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins with undefined HID in GR_HID histogram";  
:_FillValue = -888S; // short
```

```
short n_gr_dzero_rejected_NS(elevationAngle=9, fpdim_NS=1214);
```

```
:long_name = "number of bins with missing D0 in GR_Dzero average";  
:_FillValue = -888S; // short
```

```
short n_gr_nw_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins with missing Nw in GR_Nw average";  
:_FillValue = -888S; // short
```

```
short n_gr_dm_rejected_NS(elevationAngle=9, fpdim_NS=1214, fpdim_MS=835);  
:long_name = "number of bins with missing Dm in GR_Dm average";  
:_FillValue = -888S; // short
```

```
short n_gr_n2_rejected_NS(elevationAngle=9, fpdim_NS=1214, fpdim_MS=835);  
:long_name = "number of bins with missing N2 in GR_N2 average";  
:_FillValue = -888S; // short
```

```
short n_gr_expected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins in GR_Z average";  
:_FillValue = -888S; // short
```

```
float GR_SWEDP_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEDP_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, Bukocvic et al (2017)";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEDP_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, Bukocvic et al (2017)";
```

```
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swedp_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_SWEDP average";  
:_FillValue = -888S; // short
```

```
float GR_SWE25_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE25_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE25_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 25%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe25_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_SWE25 average";  
:_FillValue = -888S; // short
```

```
float GR_SWE50_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE50_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE50_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 50%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe50_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_SWE50 average";  
:_FillValue = -888S; // short
```

```
float GR_SWE75_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE75_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWE75_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, PQPE conditional quantiles 75%";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swe75_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_SWE75 average";
```



```
:_FillValue = -888S; // short
```

```
float GR_SWEMQT_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMQT_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMQT_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, Marquette relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swemqt_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_SWEMQT_rainrate average";  
:_FillValue = -888S; // short
```

```
float GR_SWEMRMS_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMRMS_StdDev_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Standard Deviation of GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float GR_SWEMRMS_Max_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "Sample Maximum GV snowfall water equivalent rate, MRMS relationship";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
short n_gr_swemrms_rejected_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "number of bins below rain_min in GR_SWEMRMS_rainrate average";  
:_FillValue = -888S; // short
```

```
float precipTotPSDparamHigh_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "2B-DPRGMI precipTotPSDparamHigh for NS swath";  
:units = "mm_Dm";  
:_FillValue = -888.0f; // float
```

```
float precipTotPSDparamLow_NS(elevationAngle=9, fpdim_NS=1214, nPSDlo=2);  
:long_name = "2B-DPRGMI precipTotPSDparamLow for NS swath";  
:units = "Nw_mu";  
:_FillValue = -888.0f; // float
```

```
float precipTotRate_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "2B-DPRGMI precipTotRate for NS swath";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float precipTotWaterCont_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "2B-DPRGMI precipTotWaterCont for NS swath";  
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float precipTotWaterContSigma_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "2B-DPRGMI precipTotWaterContSigma for NS swath";
```

```
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float cloudLiqWaterCont_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "2B-DPRGMI cloudLiqWaterCont for NS swath";  
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float cloudIceWaterCont_NS(elevationAngle=9, fpdim_NS=1214);  
:long_name = "2B-DPRGMI cloudIceWaterCont for NS swath";  
:units = "g/m^3";  
:_FillValue = -888.0f; // float
```

```
float tbSim_19v_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI simulatedBrightTemp 19v for NS swath";  
:units = "K";  
:_FillValue = -888.0f; // float
```

```
float tbSim_37v_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI simulatedBrightTemp 37v for NS swath";  
:units = "K";  
:_FillValue = -888.0f; // float
```

```
float tbSim_89v_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI simulatedBrightTemp 89v for NS swath";  
:units = "K";  
:_FillValue = -888.0f; // float
```

```
float tbSim_183_3v_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI simulatedBrightTemp 183_3v for NS swath";  
:units = "K";
```

```
:_FillValue = -888.0f; // float

short n_precipTotPSDparamHigh_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below rain_min in precipTotPSDparamHigh average for NS swath";
:_FillValue = -888S; // short

short n_precipTotPSDparamLow_rejected_NS(elevationAngle=9, fpdim_NS=1214, nPSDlo=2);
:long_name = "number of bins below rain_min in precipTotPSDparamLow average for NS swath";
:_FillValue = -888S; // short

short n_precipTotRate_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below rain_min in precipTotRate average for NS swath";
:_FillValue = -888S; // short

short n_precipTotWaterCont_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below rain_min in precipTotWaterCont average for NS swath";
:_FillValue = -888S; // short

short n_precipTotWaterContSigma_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below rain_min in precipTotWaterContSigma average for NS swath";
:_FillValue = -888S; // short

short n_cloudLiqWaterCont_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below rain_min in cloudLiqWaterCont average for NS swath";
:_FillValue = -888S; // short

short n_cloudIceWaterCont_rejected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of bins below rain_min in cloudIceWaterCont average for NS swath";
:_FillValue = -888S; // short

int precipitationType_NS(fpdim_NS=1214);
```

```
:long_name = "2B-DPRGMI precipitationType for NS swath";  
:units = "Categorical";  
:_FillValue = -888; // int
```

```
float surfPrecipTotRate_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI surfPrecipTotRate for NS swath";  
:units = "mm/h";  
:_FillValue = -888.0f; // float
```

```
float surfaceElevation_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI surfaceElevation for NS swath";  
:units = "m";  
:_FillValue = -888.0f; // float
```

```
float zeroDegAltitude_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI zeroDegAltitude for NS swath";  
:units = "m";  
:_FillValue = -888.0f; // float
```

```
short zeroDegBin_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI zeroDegBin for NS swath";  
:units = "N/A";  
:_FillValue = -888S; // short
```

```
int surfaceType_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI surfaceType for NS swath";  
:units = "Categorical";  
:_FillValue = -888; // int
```

```
short phaseBinNodes_NS(fpdim_NS=1214, nPhsBnN=5);  
:long_name = "2B-DPRGMI phaseBinNodes for NS swath";
```

```
:units = "None";  
:_FillValue = -888S; // short
```

```
float DPRlatitude_NS(fpdim_NS=1214);  
:long_name = "Latitude of DPR surface bin for NS swath";  
:units = "degrees North";  
:_FillValue = -888.0f; // float
```

```
float DPRlongitude_NS(fpdim_NS=1214);  
:long_name = "Longitude of DPR surface bin for NS swath";  
:units = "degrees East";  
:_FillValue = -888.0f; // float
```

```
short scanNum_NS(fpdim_NS=1214);  
:long_name = "product-relative zero-based DPR scan number for NS swath";  
:_FillValue = -888S; // short
```

```
short rayNum_NS(fpdim_NS=1214);  
:long_name = "product-relative zero-based DPR ray number for NS swath";  
:_FillValue = -888S; // short
```

```
float ellipsoidBinOffset_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI ellipsoidBinOffset for NS swath";  
:units = "m";  
:_FillValue = -888.0f; // float
```

```
short lowestClutterFreeBin_NS(fpdim_NS=1214);  
:long_name = "2B-DPRGMI lowestClutterFreeBin for NS swath";  
:units = "None";  
:_FillValue = -888S; // short
```

```
short clutterStatus_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "Matchup clutterStatus for NS swath";
:units = "None";
:_FillValue = -888S; // short

int precipitationFlag_NS(fpdim_NS=1214);
:long_name = "2B-DPRGMI precipitationFlag for NS swath";
:units = "Categorical";
:_FillValue = -888; // int

short surfaceRangeBin_NS(fpdim_NS=1214);
:long_name = "2B-DPRGMI surfaceRangeBin for NS swath";
:units = "None";
:_FillValue = -888S; // short

float correctedReflectFactor_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "2B-DPRGMI Corrected Reflectivity Factor for NS swath";
:units = "dBZ";
:_FillValue = -888.0f; // float

float pia_NS(fpdim_NS=1214);
:long_name = "2B-DPRGMI Path Integrated Attenuation for NS swath";
:units = "dB";
:_FillValue = -888.0f; // float

float stormTopAltitude_NS(fpdim_NS=1214);
:long_name = "2B-DPRGMI stormTopAltitude for NS swath";
:units = "m";
:_FillValue = -888.0f; // float

short n_correctedReflectFactor_rejected_NS(elevationAngle=9, fpdim_NS=1214);
```

```
:long_name = "number of bins below DPR_dBZ_min in correctedReflectFactor average";
:_FillValue = -888S; // short

short n_dpr_expected_NS(elevationAngle=9, fpdim_NS=1214);
:long_name = "number of expected bins in DPR averages for NS swath";
:_FillValue = -888S; // short

double timeNearestApproach;
:units = "seconds";
:long_name = "Seconds since 01-01-1970 00:00:00";
:_FillValue = 0.0; // double

char atimeNearestApproach(len_atime_ID=19);
:long_name = "text version of timeNearestApproach, UTC";

double timeSweepStart(elevationAngle=9);
:units = "seconds";
:long_name = "Seconds since 01-01-1970 00:00:00";
:_FillValue = 0.0; // double

char atimeSweepStart(elevationAngle=9, len_atime_ID=19);
:long_name = "text version of timeSweepStart, UTC";

char site_ID(len_site_ID=4);
:long_name = "ID of Ground Radar Site";

float site_lat;
:long_name = "Latitude of Ground Radar Site";
:units = "degrees North";
:_FillValue = -888.0f; // float
```



```
float site_lon;
:long_name = "Longitude of Ground Radar Site";
:units = "degrees East";
:_FillValue = -888.0f; // float

float site_elev;
:long_name = "Elevation of Ground Radar Site above MSL";
:units = "km";

float version;
:long_name = "Geo Match File Version";

// global attributes:
:DPR_Version = "V06A";
: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 = "Unspecified";
:GV_UF_NW_field = "NW";
:GV_UF_DM_field = "DM";
:GV_UF_N2_field = "Unspecified";
:DPR_2BCMB_file = "2B-CS-CONUS.GPM.DPRGMI.CORRA2018.20190118-S154924-E155803.027784.V06A.HDF5";
:GR_file = "KABR_2019_0118_154758.cf.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:

$$\text{HeightAGL} = \text{HeightMSL} - \text{site_elev}$$

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.

4. Directory Structure of the VN ftp site

This section describes the directory structure for the VN data ftp site:

<https://pmm-gv.gsfc.nasa.gov/pub/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. <i>aa</i> .sav	

/coincidence_tables	(Note-1)
/YYYY	
/MM	
/DD/	
CT. <i>SSSS.YYYYMMDD.jjj</i> .txt	
CT. <i>SSSS.YYYYMMDD.jjj</i> .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.swee_PPI.png	

```

/raw
  /YYYY
    /MMDD/
      XXXXYYYYMMDD_hhmmss.gz

```

```

/mosaicimages
  /archivedmosaic/
    YYYY-MM-DD_hhmm.gif

```

Multiple directory trees exist under netcdf/geo_match/GPM. Each is described separately, below.

```

/netcdf
  /geo_match
    /GPM
      /2Atype
        /scan
          /version
            /F_f
              /YYYY/
                GRtoDPR.*

```

(Note-5)

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
  /geo_match
    /GPM
      /2BDPRGMI
        /version
          /F_f
            /YYYY/
              GRtoDPRGMI.*

```

(Note-5)

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
  /geo_match
    /SSSS
      /instrument
        /2AGPROF
          /version
            /F_f
              /YYYY/
                GRtoGPROF.*

```

(Note-5)

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
            /YYYY
              /MM
                /DD/
                  PPS_filename

```

(Note-7)

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: 1CRXCAL, 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 (RHO _{hv}), 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)

Field Code or Name	Definition
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: <i>File Naming Convention for Precipitation Products For the Global Precipitation Measurement (GPM) Mission, PPS_610.2_P550.</i> EXAMPLE: 2A-CS-CONUS.GPM.Ku.V5-20140617.20140704-S230210-E230826.001980.V02A.HDF5
SSSS	Satellite identifier (F15, F16, F17, F18, GCOMW1, GPM, METOPA, METOPB, 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 ($0.0 \leq \text{blockage} \leq 1.0$) 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
AUS-East	East Australia	-9.4 N	-40.4 N	128.67 E	155.49 E
AUS-West	West Australia	-15.7 N	-37.19 N	111.42 E	130.55 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
Finland	Finland radars	62.8435 N	60.8435 N	22.288 E	26.288 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
KWAJ	Kwajalein KPOL radar	10.97 N	6.47 N	165.47 E	170.01 E
SanJuanPR	San Juan, Puerto Rico WSR-88D	20.37 N	15.87 N	-68.35 E	-63.85 E

5. 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.

5.1 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).

5.2 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.

5.3 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) (XMllatitude)
- GMI longitude (ditto) (XMllongitude)
- 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.

The GMI 1C-R-XCAL fields variables that are included in the matchups, N values per GR-GMI overlapping footprint, where N is the number of channels in the GMI instrument, include:

- Common Calibrated Brightness Temperature
- Quality flag

These values are directly extracted from data fields within the GMI 1C-R-XCAL product.

5.4 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.

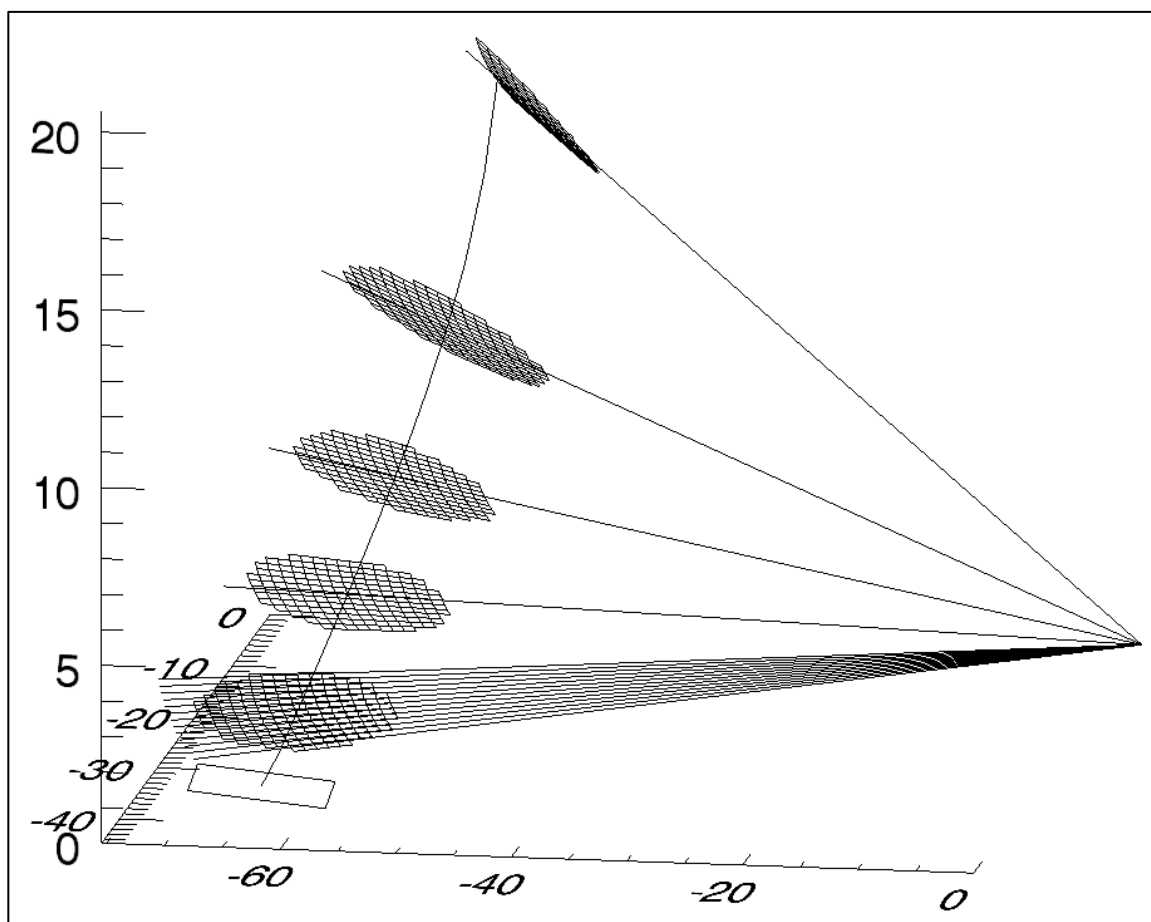


Figure 5.4-1. Schematic representation of GR volume matching to GMI along the GMI line-of-sight. Rectangular outline at surface locates the surface intersection of a single GMI surface footprint whose field-of-view centerline is shown as a slightly curving vertical line (due to the projection of the 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.

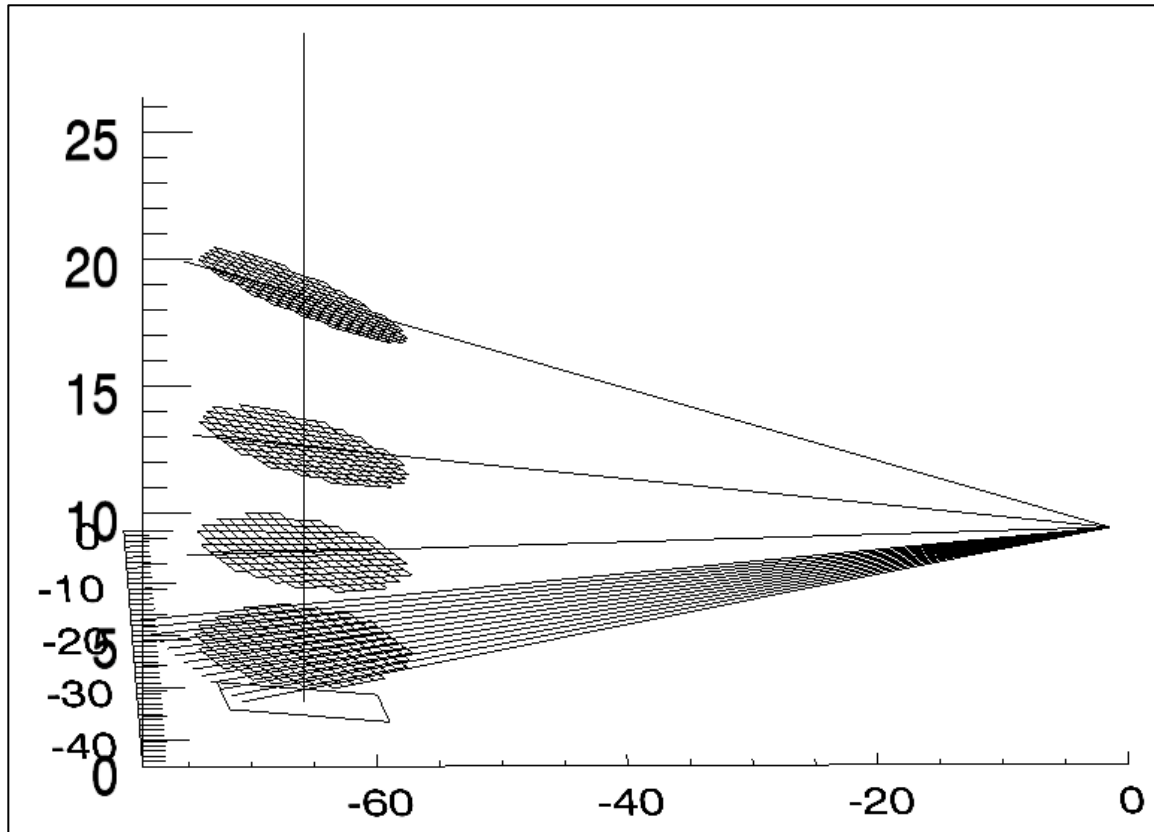


Figure 5.4-2. As in Figure 5.4-1, except GR averaging is along the local vertical above the GMI surface footprint center rather than along the GMI instrument line-of-sight.

6. 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

ACRONYM	DEFINITION
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")

7. Appendix

Extended Abstract

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

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