EarthCARE-GPM Coincidence Dataset

Version 1

Prepared by:

[1]Shunsuke Aoki, [1]Takuji Kubota, and [2]Francis J. (Joe) Turk

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[1] Earth Observation Research Center, Japan Aerospace Exploration Agency, Tsukuba, Ibaraki, 305-8505, Japan
[2] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, USA

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1. Introduction.

Owing to the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Measurement (GPM) core satellite's unique asynchronous orbits, their orbital ground tracks intersect the orbital of many other sun-synchronous satellites. The CloudSat–GPM and CloudSat–TRMM coincidence dataset (CSATGPM and CSATTRMM; Turk et al. 2021) have provided "pseudo three-frequency" radar profiles (W-band from CPR, Ku/Ka-band from DPR), and the multi-channel passive microwave radiometer (13-channel (10–183 GHz) GMI and 9-channel (10–85 GHz) for TMI). These combined passive/active data are useful for many scientific purposes. Examples include algorithm evaluation and identification of deficiencies, snow and light rain sensitivity studies, radiative transfer simulations, training of machine learning techniques, and studying how land surface properties affect the radar, radiometer, and combined radar+radiometer precipitation retrieval algorithms (*Turk et al*., 2021).

The Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) satellite (Illingworth et al., 2015; Wehr et al., 2023), launched in May 2024, is equipped with four sensors that employ different observation methods: radar, lidar, imager, and radiometer. Particularly, the Cloud-Profiling Radar (CPR; W-band), developed by the Japan Aerospace Exploration Agency (JAXA) and the National Institute of Information and Communications Technology (NICT), provides world's first measurement of Doppler velocity. The coincidence observation dataset from EarthCARE and GPM provides new information on vertical hydrometeor motion inside clouds, complementing previous studies based on CloudSat. In addition, this new dataset enables both daytime and nighttime analysis, whereas the CSATGPM was limited to daytime because CloudSat operated only under daylight conditions during the GPM mission period. It also includes observations from other EarthCARE instruments, contributing to a better understanding of aerosols and cloud radiative effects.

This document summarizes Version 1 (V01) of EarthCARE–GPM coincidence dataset (Aoki et al. 2025). The coincidence identification algorithm is based on CSATGPM Version 5. The full contents of each EarthCARE and GPM data product are copied over with each variable in each group maintaining the same name, units, scale, offset and type as the native dataset that they were extracted from.

2. Data Processing.

The processing flow is driven by a pre-generated list of the ±15-minute time coincidences between the GPM-EarthCARE ground tracks. EarthCARE's tracks are obtained from orbital propagation using daily-updated two-line elements (TLE) provided by ESA, while GPM's tracks are obtained from GPS. For GPM, the current dataset spans the period starting from 1 August 2024. Table 1 shows the datasets used for each coincidence file.

Dataset Name	Source	Version	Description
2A.GPM.DPR	DPR	V07	DPR Ku-only and Ku/Ka-band radar reflectivity and precipitation profile
2B.GPM.DPRGMI. CORRA	DPR+GMI	V07	DPR+GMI combined algorithm (CORRA) precipitation profile
1C-R.GPM.GMI	GMI	V07	GMI Level 1C brightness temperatures
2A-CLIM.GPM.GMI.GPROF	GMI	V07	GPROF precipitation algorithm for GMI
1D.EC.AUX_JSG	EarthCARE	vBa	EarthCARE joint standard grid (JSG) product (X-JSG). Not included in output files.
2A.EC.CPR_ECO	CPR	vBa	CPR one-sensor echo (radar reflectivity and Doppler velocity) product.
2A.EC.CPR_CLP	CPR	vBb	CPR one-sensor cloud (cloud mask, ice and liquid water content, terminal fall speed, and vertical air motion) product
ECMWF.AUX-2D	ECMWF	vBb	Auxiliary ECMWF Meteorological analysis and forecast fields interpolated to X-JSG grid.

Table 1. Individual datasets included in the EarthCARE-GPM coincidence datasets. For 2A.GPM.DPR, data from "HS" group is omitted. For 2B.GPM.DPRGMI.CORRA, data from the "OptEst" group is omitted.

First, the EarthCARE AUX_JSG, and the GPM 1C-R.GPM.GMI and GPM 2A.GPM.DPR files are located that straddle the coincidence time (shaded rows in Table 1). Horizontal grid of the AUX_JSG is generated according to CPR footprint, and identical to horizontal grid of the CPR_ECO, CPR_CLP and AUX-2D. Owing to the orbitization of data from each spacecraft (GPM orbits begin at the southernmost latitude, and EarthCARE orbits are separated into 8 segments), these may cover more than one file. Since the AUX_JSG has finer along-track sampling (~1-km) than the GPM radars (~5-km), the GPM beam locations are mapped to each EarthCARE profile location using a very simple nearest-neighbor approach to avoid any spatial or temporal resampling artifacts. For vertical bin matching, indices are provided to allow the user to map GPM radar levels to EarthCARE radar levels, or vice versa. In addition to the data from these files, other EarthCARE and GPM precipitation products (Table 1) are extracted for each EarthCARE position. These EarthCARE-mapped data are written into a single netCDF4 file, with data from each product contained in its own group (Section 5).

2.1. Along-track segments.

The horizontal matching procedure is identical to CSATGPM product. For details, please see following:
https://arthurhou.pps.eosdis.nasa.gov/Documents/CSAT_TRMM_GPM_COIN_ATBD_V05.pdf

The vertical bin matching is done two different ways, depending on whether the user prefers the DPR bins mapped to EarthCARE, or EarthCARE bins mapped to DPR. This process uses the height information in each data product. For DPR, this is the *height* variable in the FS/PRE group. For EarthCARE, the *height* variable in the CPR_CLP product ranges from −500 m to 20,000 m at 100-m intervals. Since each EarthCARE product uses a different vertical coordinate system, data with vertical axes in products other than CPR_CLP are mapped to the CPR_CLP vertical coordinate using nearest-neighbor approach. The original height reference is retained in a separate variable (e.g., the *bin_height* variable in the CPR_ECO product). For each 100-m EarthCARE bin, the first 125-m DPR bin that lies above this is located (and vice versa if the user prefers the EarthCARE bins mapped to DPR). The DPR+GMI combined algorithm (CORRA) reports its profiles at a 250-m (every other) DPR bin location. In the 2A.GPM.DPR group, the indices to map the profiles either way are provided (Section 5.3.3). Note that this simple nearest-neighbor bin in latitude, longitude and height does not modify or average any values in the native dataset.

2.2. Swath segments.

To provide the user some flexibility in mapping or depicting the precipitation in the region of the coincidence, a "swath" segment of selected variable from GMI, GPROF, DPR and CORRA segments are added to the end of each product group, along with the associated geolocation variables (discussed in Section 5). This swath segment covers the area encompassed by the EarthCARE coincidence curtain. With these swath data segments, users are able to display maps of TB imagery, or plot vertical radar cross sections away from the coincidence curtain.

3. File Format and Naming Details.

The output files are written in netCDF4 format, and average about 150 MB size, depending upon latitude (at the highest GPM latitudes, the GPM radar scans more in a N-S direction, so the coincidence distance segment is shorter than it is near the equator). For EarthCARE, which does not scan, the along-track dimension is referred to as a *beam*. For DPR, the along-track and across-track dimensions are referred to as a *scan* and *ray*, respectively. For GMI, the along-track and across-track dimensions are referred to as a *scan* and *pixel*, respectively, and each radiometer frequency is referred to as a *channel*. This maintains common dimension names. The file names are chosen to be consistent with existing PPS standards. An example name is:

2B.ECAREGPM.COIN.COIN2025. 20250205-S153627-E154051.062114.V01.nc4

The fifth field carries the start and end times of the GPM data that encompass the coincidence segment (**20250205-S153627-E154051**), the sixth field is the starting GPM orbit revolution number (**062114**), and the fourth field provides the name of the coincidence algorithm (**COIN2025**). Data from each GPM and EarthCARE data product (Table 1) are contained in its own group in the coincidence file. Details on the contents of each of these groups are provided in Section 5.

4. Associated Quick-Look Imagery.

For each output datafile, an associated image is created, showing depictions of the radar vertical profiles and the GMI TB. These have the same name as the datafiles, but with a "**prof.png**" in place of "**nc4**", respectively. These images are intended for quick visual inspection of the precipitation conditions during the coincidence time. They depict the GMI TB segment, the EarthCARE reflectivity vertical segment, and the DPR-Ku and DPR-Ka reflectivity vertical segments. The EarthCARE ground track is shown overlaid on top of two GMI channels, mapped onto a polarstereo grid centered at the coincidence location.

An example is provided in Figure 1. In this example, the EarthCARE-GMI coincidence occurs with a 60 second time offset (i.e., the start of the GPM data occurred 60 seconds after the start of the EarthCARE data). EarthCARE data occur between 153627-154051 UTC on 5 February 2025, covering tropical organaized convective cloud system in western Pacific. The EarthCARE-GMI intersection curtain is of length 1846; that is extends across 1846 EarthCARE profiles (*nbeam*=1846).

Using the GMI data contained in the swath segment (Section 2.2), the left side of the image displays the GMI 18.7H and 166H GHz channels for the GMI swath segment that covers the extent of this EarthCARE track intersection, mapped onto a polarstereo grid centered at the orbit intersection location (*center_lat*, *center_lon*) (Section 5). The EarthCARE track is drawn with 10 ~equally spaced markers along the track (0, 180, 360, 540,…1620), so that the vertical structure can be identified from the EarthCARE and DPR profiles on the right side. The two solid lines show the (more limited) segment covered by the DPR Ku-band swath during this coincidence.

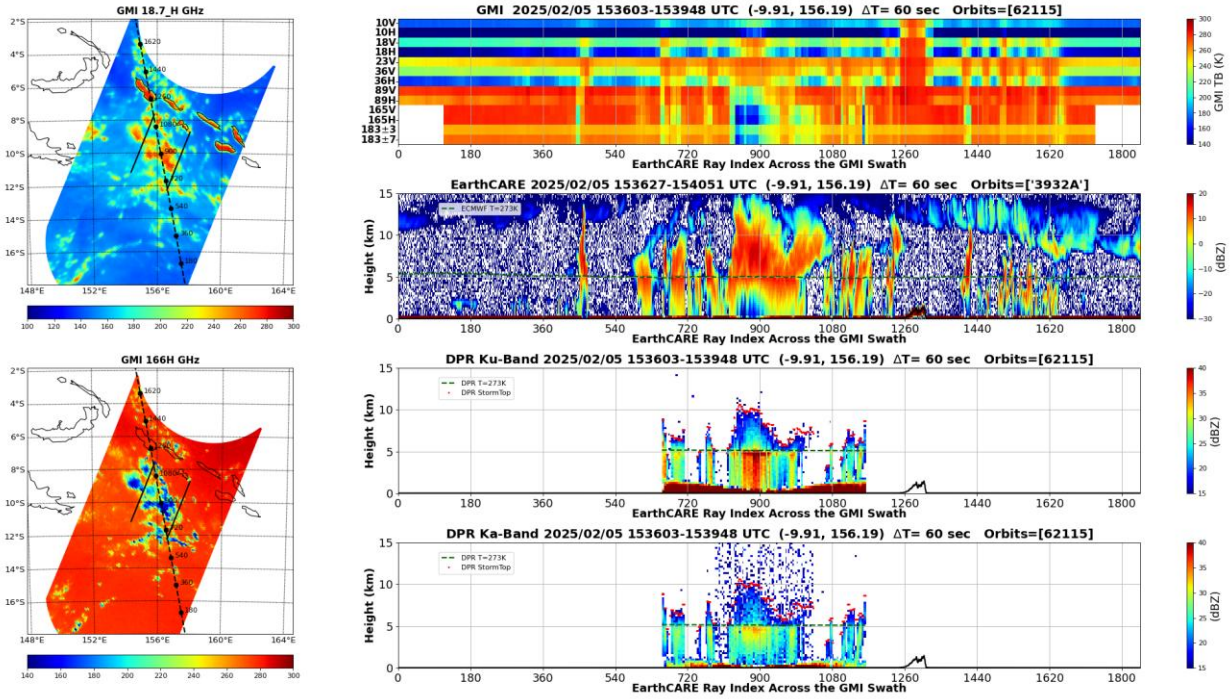

Figure 1. Example quick-look GMI TB, and EarthCARE and DPR profile imagery, for the EarthCARE and GPM coincidence that occurred for EarthCARE between 153627-154051 UTC on 5 February 2025. Each EarthCARE beam is about 1-km apart (x-axis of profiles). The digital elevation map (DEM) used by the EarthCARE and GPM data are shown as a heavy black line near the surface (more evident for the over-land cases that are over terrain). The zero-degree isotherm line is shown as a green dashed line (labeled "T=273K"). The color scale on the right indicates TB Kelvin units (blue=cold, red=warm), and equivalent radar reflectivity factor (dB) for the four radar profiles.

The right side of the image has four rows. The top row displays the trace of the GMI TB along this same coincidence curtain (i.e., at the same 1846 locations, first row) is shown above EarthCARE, for the 13 GMI channels (Table 2).

Below this, is the EarthCARE 94 GHz reflectivity profile (the *integrated_radar_reflectivity_1km* variable in the 2A.EC.CPR_ECO group) profile (second row) between 153627-154051 UTC on 5 February 2025, occurring along the southernmost tip of South America. The dashed green line indicates the height of the freezing level (~5-km) from the associated ECMWF.AUX-2D product.

The third and fourth rows show the associated DPR Ku- and Ka-band radar reflectivity profiles from the *zFactorMeasured* variable in the 2A.GPM.DPR group (Section 5). The dashed green line indicates the height of the freezing level from the 2A.GPM.DPR variable FS/VER/*heightZeroDeg*. These DPR data occur between 193327-193913 UTC. As a consequence of the more limited DPR swath relative to GMI, the DPR profiles extend across a shorter distance in the middle of the coincidence segment. As has been shown previously, the DPR captures a more limited depiction of the rain structure.

5. Description of File Contents.

The variables in each group maintain the same name, units, scale, offset and type as the native dataset that they were extracted from. Therefore, for further description the user can refer to the original algorithm product description documents or algorithm theoretical basis documents (ATBD):

Description of EarthCARE-related data products:
https://www.eorc.jaxa.jp/EARTHCARE/data/L2prd_list_std_e.html

Description of GPM-related data products:
https://gpm.nasa.gov/science/precipitation-algorithms

The output files are written in netCDF4 format. Depending upon the distance of the coincidence segment, the files range in size between 100-350 MB. For EarthCARE, which does not scan, the along-track dimension is referred to as a *beam*. For DPR, the along-track and across-track dimensions are referred to as a *scan* and *ray*, respectively. For GMI, the along-track and across-track dimensions are referred to as a *scan* and *pixel*, respectively, and each radiometer frequency is referred to as a *channel*. This maintains common dimension names.

Each file has a set of global attributes and a collection of groups, where the name of each group

corresponds to the Dataset name in Table 1. Running a "ncdump –h**"** command on a file will list all groups, and every variable contained in the group.

5.1. Global attributes

Each netCDF4 file contains several global attributes, providing the *center*_date, *center_lat*, *center_lon* and *EC_minus_GPM_timediff* (seconds) at the coincidence cross-over point, determined from the actual data. For reference, the predicted latitudes, longitudes and dates from each of GPM and EarthCARE are also provided, that were determined by the orbital tracking (Section 2). For example:

```
// global attributes:
               :center_date_GPM = "2025/02/05 15:37:37" ;
               :center_lat = -9.90814315863554 ;
               :center_lon = 156.194205199316 ;
               :center_date_ECARE = "2025/02/05 15:38:38" ;
               :EC_minus_GPM_timediff = 60LL ;
               :predicted_lat_GPM = -9.962 ;
               :predicted_lon_GPM = 156.195 ;
               :predicted_date_GPM = "2025/02/05 15:37:37" ;
               :predicted_lat_ECARE = -9.936 ;
               :predicted_lon_ECARE = 156.199 ;
               :predicted_date_ECARE = "2025/02/05 15:38:33" ;
               :predicted_EC_minus_GPM_timediff = 56LL ;
               :start_date = "2025/02/05 15:36:27" ;
               :end_date = "2025/02/05 15:40:51" ;
               :description = "EarthCARE+GPM coincidence dataset" ;
               :algorithm_name = "COIN2025" ;
               :version = "1" ;
               :production_date = "2025/08/06 19:00:53" ;
```

5.2. EarthCARE-related groups

The X01 test dataset includes CPR_ECO, CPR_CLP, and AUX-2D products.

- CPR_ECO is a product that applies corrections to radar reflectivity and Doppler velocity and includes quality controlling. It contains raw, uncorrected values and provides precise observation altitudes within 100 m, making it useful when such detailed information is needed.

- CPR_CLP is a one-sensor cloud product from CPR, offering cloud mask, radar reflectivity, and Doppler velocity, as well as additional variables such as ice and liquid water content, terminal fall speed, and vertical air motion. For analysis purposes, CPR_CLP is recommended as a first choice, since it incorporates the corrections made in CPR_ECO and is therefore easier to handle.

- AUX-2D provides auxiliary data such as temperature, pressure, and specific humidity from ECMWF forecasts.

The first data group reported contains all variables from EarthCARE CPR_ECO. The dimension **nbeam** provides the number of EarthCARE beams that are contained in this coincidence curtain, and **nbin_ec** provides the number of EarthCARE bins. Variables with vertical axes in CPR_ECO are mapped to the CPR_CLP vertical coordinate (from −500 m to 20,000 m at 100-m intervals)

using nearest-neighbor approach. For reference, the added variables *beam_index*, *beam_orbit*, and *beam_frame* provides the beam index number from the original CPR_ECO dataset, and the EarthCARE orbit revolution number and frame number associated with each of these beams.

```
group: \2A.EC.CPR_ECO {
  dimensions:
        nbeam = 1846 ;
        nbin_ec = 206 ;
        num_surface_elevation_10km = 3 ;
  variables:
        int Beam_index(nbeam) ;
               Beam_index:_FillValue = -9999 ;
               Beam_index:longname = "EarthCARE CPR_ECO Beam index" ;
        int Beam_orbit(nbeam) ;
               Beam_orbit:_FillValue = -9999 ;
               Beam_orbit:longname = "EarthCARE orbit revolution number that corresponds to the
EarthCARE CPR_ECO Beam index" ;
        int Beam_frame(nbeam) ;
               Beam_frame:_FillValue = -9999 ;
               Beam_frame:longname = "EarthCARE frame revolution number (A-H)-->(0-7)" ;
```

All variables from CPR_ECO are then provided for each of these **nbeam** locations. Variables of interest are *integrated_radar_reflectivity_1/10km*, *unfolded_doppler_velocity_1/10km_bias_corr*, and *bin_height*.

This CPR_ECO group is then followed by additional EarthCARE groups each containing all variables from the EarthCARE data products provided in Table 1 (CPR_CLP, ECMWF.AUX-2D, etc.). All of these data products are mapped to the same EarthCARE locations (i.e., have the same **nbeam** value).

Note that not all data products are always available, and as a consequence many files will have missing groups for missing data products. This can be accommodated by first checking if the desired group exists.

5.3. GPM-related groups

The last four groups contain the matched variables from 1C-R.GPM.GMI, 2A.GPM.GPROF, 2A.GPM.DPR and 2B.GPM.DPRGMI. The data from these GPM products are also mapped to the same EarthCARE locations (i.e., have the same **nbeam** value).

5.3.1. 1C-R.GPM.GMI group

This group contains the GMI intercalibrated TB product variables associated with the 1C-R.GPM.GMI files used, which is explained in the official ATBD for this data product.

For 1C-R.GPM.GMI, the variable *scan_indices* points to the GMI scan line and pixel locations from the 1C-R.GPM.GMI file listed in the group attributes. The *time_diff* and *distance_diff* provide the time separation and spatial offset between the EarthCARE beam location and the GMI coordinates, respectively. While this dataset processing is driven by maximum ±15-minute time

coincidences between the GPM- EarthCARE ground tracks, the pixel-to-pixel time separation *time_diff* can sometimes be several minutes larger than this, depending upon the orbital direction of each satellite. As shown in Figure 1, *distance_diff* will oscillate between ~ 0.5-5 km as the EarthCARE locations move across the GMI scanning pattern. Owing to the coarser GMI sampling spacing, the same GMI pixel is repeated ~ 5 times.

```
group: \1C-R.GPM.GMI {
  dimensions:
        nbeam = 1846 ;
        nchannel = 13 ;
        scan_pixel = 2 ;
  variables:
        int scan_indices(nbeam, scan_pixel) ;
               scan_indices:_FillValue = -9999 ;
               scan_indices:longname = "GMI scan line and pixel indices that corresponds to the
EarthCARE beam index" ;
        int scan_orbit(nbeam) ;
               scan_orbit:_FillValue = -9999 ;
               scan_orbit:longname = "GPM orbit revolution that corresponds to the EarthCARE beam
index" ;
        int time_diff(nbeam) ;
               time_diff:_FillValue = -9999 ;
               time_diff:units = "seconds" ;
               time_diff:longname = "GMI-minus-EarthCARE time difference" ;
        float distance_diff(nbeam) ;
               distance_diff:_FillValue = -9999.f ;
               distance_diff:units = "km" ;
               distance_diff:longname = "GMI-EarthCARE distance difference" ;
        double scan_time(nbeam) ;
               scan_time:_FillValue = -9999. ;
               scan_time:units = "seconds" ;
               scan_time:longname = "seconds since 1 Jan 1970" ;

  // group attributes:
               :satname = "GPM" ;
               :sensor = "GMI" ;
               :files_used = "1C-R.GPM.GMI.XCAL2016-C.20250205-S151707-E165022.062115.V07B.HDF5" ;
               :orbits_used = 62115 ;
               :description = "variables from the 1C-R.GPM.GMI dataset, along the coincidence
curtain" ;
```

This is followed by the **S1** group which contains all variables for the GPM 1C-R files listed in the group attributes above. In most cases there is only one 1C-R file needed, but depending upon the southernmost latitudes of GPM, two files may be concatenated to accommodate the coincidence segment. For most users, the variables of interest are *Quality*, *incidenceAngle* and *Tc*.

The 1C-R.GPM.GMI group closes with an additional group called **SWATH**. This provides a small subset of the Tc swath encompassing the area of the coincidence curtain. In this group, three variables are provided, namely *Latitude*, *Longitude* and *Tc*.

```
group: SWATH {
  dimensions:
    nscan = 125 ;
    npixel = 221 ;
    nchannel = 13 ;
  variables:
    float Latitude(nscan, npixel) ;
           Latitude:_FillValue = -9999.9f ;
           Latitude:longname = "latitude of S1 channels" ;
           Latitude:units = "degrees" ;
```

```
        float Longitude(nscan, npixel) ;
                Longitude:_FillValue = -9999.9f ;
                Longitude:longname = "longitude of S1 channels" ;
                Longitude:units = "degrees" ;
        float Tc(nscan, npixel, nchannel) ;
                Tc:_FillValue = -9999.9f ;
                Tc:longname = "brightness temperature channels (10-89 GHz) from the 1C-R S1 group,
channels (166 and 183 GHz) from the 1C-R S2 group" ;
                string  Tc:channel_order  =  "10.65_V",  "10.65_H",  "18.7_V",  "18.7_H",  "23.8_V",
"36.5_V", "36.5_H", "89.0_V", "89.0_H", "166V", "166H", "183.31+/-3", "183.31+/-7" ;
                Tc:units = "K" ;

      // group attributes:
                :description = "selected full-swath variables from S1 groups, that encompass the
coincidence curtain.  S2 variables are merged into the S1 swath." ;
      } // group SWATH
    } // group S1
  } // group \1C-R.GPM.GMI
```

5.3.2. 2A.GPM.GMI.GPROF

This group contains the GPROF precipitation product variables that were derived from the 1C-R.GPM.GMI files used, and which is explained in the official ATBD for this data product. The layout of the main group is similar to the content in the 1C-R.GPM.GMI main group:

```
group: \2A.GPM.GMI.GPROF {
  dimensions:
        nbeam = 1846 ;
        scan_pixel = 2 ;
        nscan = 125 ;
        npixel = 221 ;
        nspecies = 5 ;
  variables:
        int scan_indices(nbeam, scan_pixel) ;
                scan_indices:_FillValue = -9999 ;
                scan_indices:longname = "GMI scan line and sample indices" ;
        int scan_orbit(nbeam) ;
                scan_orbit:_FillValue = -9999 ;
                scan_orbit:longname = "GPM orbit revolution number that corresponds to the EarthCARE
beam index" ;
        int time_diff(nbeam) ;
                time_diff:_FillValue = -9999 ;
                time_diff:units = "seconds" ;
                time_diff:longname = "GMI-minus-EarthCARE time difference" ;
        float distance_diff(nbeam) ;
                distance_diff:_FillValue = -9999.f ;
                distance_diff:units = "km" ;
                distance_diff:longname = "GMI-EarthCARE distance difference" ;
        double scan_time(nbeam) ;
                scan_time:_FillValue = -9999. ;
                scan_time:units = "seconds" ;
                scan_time:longname = "seconds since 1 Jan 1970" ;

  // group attributes:
                :satname = "GPM" ;
                :sensor = "GMI" ;
                :files_used = "GPMCOR_GMI_2502051517_1650_062115_L2S_GL2_07C.h5" ;
                :description = "variables from the 2A.GPM.GMI.GPROF dataset, along the coincidence
curtain" ;
```

Variables of interest are *qualityFlag*, *pixelStatus*, *surfaceTypeIndex* and *surfacePrecipitation*. The 2A.GPM.GMI.GPROF group closes out with a "**SWATH**" group containing *Latitude*,

Longitude and *surfacePrecipitation* that encompasses the coincidence curtain, allowing users to plot or analyze the precipitation horizontal pattern.

```
    group: SWATH {
      dimensions:
        nscan = 125 ;
        npixel = 221 ;
      variables:
        float Latitude(nscan, npixel) ;
               Latitude:_FillValue = -9999.9f ;
               Latitude:units = "degrees" ;
        float Longitude(nscan, npixel) ;
               Longitude:_FillValue = -9999.9f ;
               Longitude:units = "degrees" ;
        float surfacePrecipitation(nscan, npixel) ;
               surfacePrecipitation:_FillValue = -9999.9f ;
               surfacePrecipitation:units = "mm/hr" ;

      // group attributes:
               :description = "selected full-swath variables from S1 groups, that encompass the
coincidence curtain" ;
      } // group SWATH
    } // group S1
  } // group \2A.GPM.GMI.GPROF
```

5.3.3. 2A.GPM.DPR

This group contains the DPR precipitation product variables associated with the 2A.GPM.DPR files used, which is explained in the official ATBD for this data product.

The variable *scan_indices* points to the DPR scan and ray locations from the 2A.GPM.DPR file listed in the group attributes. The variable *scan_indices* points to the DPR scan and ray locations from the 2A.GPM.DPR file listed in the group attributes. The *time_diff* and *distance_diff* provide the time separation and spatial offset between the EarthCARE beam location and the DPR coordinates, respectively. While this dataset processing is driven by maximum ±15-minute time coincidences between the GPM-EarthCARE ground tracks, the pixel-to-pixel time separation *time_diff* can sometimes be several minutes larger than this, depending upon the orbital direction of each satellite. As shown in Figure 1, *distance_diff* will oscillate between ~ 0.5-5 km as the EarthCARE locations move across the DPR scanning pattern. Owing to the coarser DPR sampling spacing, the same DPR pixel is repeated ~ 5 times.

```
group: \2A.GPM.DPR {
  dimensions:
        nbeam = 1846 ;
        nbin_ec = 206 ;
        scan_ray = 2 ;
        nbin = 176 ;
        nscan = 87 ;
        nray = 49 ;
        nfreqHI = 3 ;
        nNode = 5 ;
        nbinSZP = 7 ;
        nfreq = 2 ;
        nDSD = 2 ;
        nNUBF = 3 ;
        LS = 2 ;
        method = 6 ;
```

```
        three = 3 ;
        foreBack = 2 ;
        nearFar = 2 ;
        nsdew = 3 ;
        four = 4 ;
        nNP = 4 ;
        XYZ = 3 ;
  variables:
        int scan_indices(nbeam, scan_ray) ;
                scan_indices:_FillValue = -9999 ;
                scan_indices:longname = "scan and ray indices" ;
        int scan_orbit(nbeam) ;
                scan_orbit:_FillValue = -9999 ;
                scan_orbit:longname = "GPM orbit revolution number that corresponds to the EarthCARE
beam index" ;
        int time_diff(nbeam) ;
                time_diff:_FillValue = -9999 ;
                time_diff:units = "seconds" ;
                time_diff:longname = "DPR-minus-EarthCARE time difference" ;
        float distance_diff(nbeam) ;
                distance_diff:_FillValue = -9999.f ;
                distance_diff:units = "km" ;
                distance_diff:longname = "DPR-EarthCARE distance difference" ;
        double scan_time(nbeam) ;
                scan_time:_FillValue = -9999. ;
                scan_time:longname = "number of seconds since 1 Jan 1970" ;
                scan_time:units = "seconds" ;
        float bin_height_dpr(nbeam, nbin_ec) ;
                bin_height_dpr:_FillValue = -9999.f ;
                bin_height_dpr:units = "m" ;
                bin_height_dpr:longname = "DPR bin height above the reference surface matched with
the EarthCARE bin height" ;
        short bin_dpr(nbeam, nbin_ec) ;
                bin_dpr:_FillValue = -9999s ;
                bin_dpr:longname = "bin number from the DPR profile that matched with the EarthCARE
bin height" ;
                bin_dpr:valid_min = 0s ;
                bin_dpr:valid_max = 175s ;
        float bin_height_ec(nbeam, nbin) ;
                bin_height_ec:_FillValue = -9999.f ;
                bin_height_ec:units = "m" ;
                bin_height_ec:longname = "EarthCARE bin height above the reference surface matched
with the DPR bin height" ;
        short bin_ec(nbeam, nbin) ;
                bin_ec:_FillValue = -9999s ;
                bin_ec:longname = "bin number from the EarthCARE profile that matched with the DPR
bin height" ;
                bin_ec:valid_min = 0s ;
                bin_ec:valid_max = 205s ;

  // group attributes:
                :files_used = "GPMCOR_DPR_2502051517_1650_062115_L2S_DD2_07C.h5" ;
                :description = "variables from the 2A.GPM.DPR dataset" ;
                :satname = "GPM" ;
                :sensor = "DPR" ;
```

In this coincidence dataset, all EarthCARE and DPR profiles are each provided at their full vertical levels (*nbin*= 176 for DPR, *nbin_ec*= 206 for EarthCARE). Mapping indices are provided for users who prefer to map DPR to EarthCARE, and vice versa. The variable *bin_dpr* provide the DPR bin indices to map DPR to the 206 bins of the EarthCARE profile. *bin_height_dpr* provides the associated height of the DPR bin. Conversely, the variable *bin_ec* provide EarthCARE bin indices to map EarthCARE to the 176 bins of the DPR profile. *bin_height_ec* provides the associated height of the EarthCARE bin.

The variables in this group are written in the same sub-group hierarchy (FS main group, followed by various sub-groups) as the 2A.GPM.DPR files used (see the ATBD for this product for the group structure). Variables of interest are the Ku- and Ka-band reflectivity factors contained in the preprocessing module FS/PRE/*zFactorMeasured*, and the near-surface precipitation rate in the solver module group FS/SLV/*precipRate*.

The 2A.GPM.DPR FS group closes out with a "**SWATH**" group containing *Latitude*, *Longitude*, *height* and *zFactorMeasured* that encompasses the coincidence curtain. From this, the reflectivity profile can be depicted in the region surrounding the coincidence curtain.

```
    group: SWATH {
      dimensions:
        nscan = 87 ;
        nray = 49 ;
        nbin = 176 ;
        nfreq = 2 ;
      variables:
        float Latitude(nscan, nray) ;
               Latitude:_FillValue = -9999.9f ;
               Latitude:units = "degrees" ;
        float Longitude(nscan, nray) ;
               Longitude:_FillValue = -9999.9f ;
               Longitude:units = "degrees" ;
        float height(nscan, nray, nbin) ;
               height:_FillValue = -9999.9f ;
               height:units = "m" ;
        float zFactorMeasured(nscan, nray, nbin, nfreq) ;
               zFactorMeasured:_FillValue = -9999.9f ;
               zFactorMeasured:units = "dBZ" ;

      // group attributes:
               :description = "selected full-swath variables from FS groups, that encompass the
coincidence curtain" ;
      } // group SWATH
    } // group FS
  } // group \2A.GPM.DPR
```

5.3.4. 2B.GPM.DPRGMI

This group contains the combined DPR+GMI precipitation product (CORRA) variables associated with the 1C-R.GPM.GMI files used, which is explained in the official ATBD for this data product.

The variable *scan_indices* points to the DPR scan and ray locations from the 2A.GPM.DPR file listed in the group attributes. The *time_diff* and *distance_diff* provide the time separation and spatial offset between the EarthCARE beam location and the DPR coordinates, respectively. While this dataset processing is driven by maximum ±15-minute time coincidences between the GPM- EarthCARE ground tracks, the pixel-to-pixel time separation *time_diff* can sometimes be several minutes larger than this, depending upon the orbital direction of each satellite. As shown in Figure 1, *distance_diff* will oscillate between ~ 0.5-5 km as the EarthCARE locations move across the DPR scanning pattern. Owing to the coarser DPR sampling spacing, the same DPR pixel is repeated ~ 5 times.

```
group: \2B.GPM.DPRGMI {
  dimensions:
```

```
        nbeam = 1846 ;
        scan_ray = 2 ;
        nbin_ec = 206 ;
        nscan = 87 ;
        nray = 49 ;
        nBnEnv = 10 ;
        nBnPSD = 88 ;
        nemiss = 13 ;
        XYZ = 3 ;
        nPhsBnN = 5 ;
        nKuKa = 2 ;
  variables:
        int scan_indices(nbeam, scan_ray) ;
                scan_indices:_FillValue = -9999 ;
                scan_indices:longname = "scan and ray indices" ;
        int scan_orbit(nbeam) ;
                scan_orbit:_FillValue = -9999 ;
                scan_orbit:longname = "GPM orbit revolution number that corresponds to the EarthCARE
beam index" ;
        int time_diff(nbeam) ;
                time_diff:_FillValue = -9999 ;
                time_diff:units = "seconds" ;
                time_diff:longname = "DPR-minus-EarthCARE time difference" ;
        float distance_diff(nbeam) ;
                distance_diff:_FillValue = -9999.f ;
                distance_diff:units = "km" ;
                distance_diff:longname = "DPR-EarthCARE distance difference" ;
        double scan_time(nbeam) ;
                scan_time:_FillValue = -9999. ;
                scan_time:longname = "number of seconds since 1 Jan 1970" ;
                scan_time:units = "seconds" ;
        float bin_height_cmb(nbeam, nbin_ec) ;
                bin_height_cmb:_FillValue = -9999.f ;
                bin_height_cmb:units = "m" ;
                bin_height_cmb:longname = "CORRA bin height above the reference surface that matched
with the EarthCARE bin height" ;
        short bin_cmb(nbeam, nbin_ec) ;
                bin_cmb:_FillValue = -9999s ;
                bin_cmb:longname = "bin number from the CORRA profile that matched with the EarthCARE
bin height" ;
                bin_cmb:valid_min = 0s ;
                bin_cmb:valid_max = 87s ;
        float bin_height_ec(nbeam, nBnPSD) ;
                bin_height_ec:_FillValue = -9999.f ;
                bin_height_ec:units = "m" ;
                bin_height_ec:longname = "EarthCARE bin height above the reference surface that
matched with the CORRA bin height" ;
        short bin_ec(nbeam, nBnPSD) ;
                bin_ec:_FillValue = -9999s ;
                bin_ec:longname = "bin number from the EarthCARE profile that matched with the CORRA
bin height" ;
                bin_ec:valid_min = 0s ;
                bin_ec:valid_max = 205s ;

  // group attributes:
                :files_used = "GPMCOR_CMB_2502051517_1650_062115_L2S_CL2_07C.h5" ;
                :description = "variables from the 2B.GPM.DPRGMI CORRA dataset" ;
                :satname = "GPM" ;
                :sensor = "DPR+GMI" ;
```

The CORRA product is posted at 88 levels (*nBnPSD*= 88), which is one-half of the DPR 176 bin levels (*nbin*= 176 for DPR, *nbin_ec*= 206 for EarthCARE). Mapping indices are provided for users who prefer to map CORRA to EarthCARE, and vice versa. The variable *bin_cmb* provide the CORRA bin indices to map CORRA to the 206 bins of the EarthCARE profile. *bin_height_cmb* provides the associated height of the DPR bin. Conversely, the variable *bin_ec* provide EarthCARE bin indices to map EarthCARE to the 88 bins of the CORRA profile.

bin_height_ec provides the associated height of the EarthCARE bin.

The variables in this group are written in the same sub-group hierarchy (KuGMI and KuKaGMI groups, representing the single frequency radar and dual-frequency radar solutions, respectively) as the 2A.GPM.DPRGMI files used (see the ATBD for this product for the group structure). For most users, the variables of interest are the precipitation profiles contained in KuGMI/*precipTotRate* and KuKaGMI/ *precipTotRate*, and the near-surface precipitation rate contained in KuGMI/*nearSurfPrecipTotRate* and KuKaGMI/*nearSurfPrecipTotRate*.

The 2A.GPM.DPRGMI KuGMI and KuKaGMI groups each close out with a "**SWATH**" group containing *Latitude*, *Longitude*, and *correctedReflectFactor* that encompasses the coincidence curtain.

```
    group: SWATH {
      dimensions:
        nscan = 87 ;
        nray = 49 ;
        nBnPSD = 88 ;
        nKuKa = 2 ;
      variables:
        float Latitude(nscan, nray) ;
                Latitude:_FillValue = -9999.9f ;
                Latitude:units = "degrees" ;
        float Longitude(nscan, nray) ;
                Longitude:units = "degrees" ;
                Longitude:_FillValue = -9999.9f ;
        float correctedReflectFactor(nscan, nray, nBnPSD, nKuKa) ;
                correctedReflectFactor:_FillValue = -9999.9f ;
                correctedReflectFactor:units = "dBZ" ;

      // group attributes:
                :description = "selected full-swath variables from KuKaGMI groups, that encompass
the coincidence curtain" ;
      } // group SWATH
    } // group KuKaGMI
  } // group \2B.GPM.DPRGMI
```

6. References

Further information on the EarthCARE data products is available from JAXA G-Portal and ESA Earth Online. Further information on the GPM data products is available from the JAXA G-Portal, and the NASA Precipitation Measurement Missions (PMM) and the Precipitation Processing System (PPS).

Aoki, Shunsuke, Takuji Kubota, and F. Joseph Turk: Exploring vertical motions in convective and stratiform precipitation using spaceborne radar observations: Insights from EarthCARE and GPM coincidence dataset, Atmos. Meas. Tech. Discuss. [preprint], https://doi.org/10.5194/egusphere-2025-3596, 2025, under review.

JAXA G-Portal:
https://gportal.jaxa.jp/gpr/?lang=en

JAXA/EORC EarthCARE web site - Data Sources of EarthCARE
https://www.eorc.jaxa.jp/EARTHCARE/data/product_operation_info_e.html

ESA Earth Online
https://earth.esa.int/eogateway/missions/earthcare

NASA Precipitation Measurement Mission online documentation:
https://gpm.nasa.gov/resources/documents

NASA Precipitation Processing System Science Team Online Request Module (STORM):
https://storm.pps.eosdis.nasa.gov/storm/

Turk, F. Joseph, Sarah E. Ringerud, Andrea Camplani, Daniele Casella, Randy J. Chase, Ardeshir Ebtehaj, Jie Gong, et al. "Applications of a CloudSat-TRMM and CloudSat-GPM Satellite Coincidence Dataset." *Remote Sensing* 13, no. 12 (January 2021): 2264. https://doi.org/10.3390/rs13122264.

7. Change Log

August 2025

Version 1 for test dataset was developed based on CSATGPM Version 5.

8. Example of File Content

TBD

Data availability

Data can be downloaded from the JAXA/EORC ftp server.

Location: /2B.ECAREGPM.COIN/Version/YYYY/MM/DD

The predicted orbit intersection points of EarthCARE and GPM are reported below:

/2B.ECAREGPM.COIN/Version/daily_coincidence/GPM_EARTHCARE

The columns are

2, 3: YYYYMMDD and HHMMSS of GPM
4: epoch seconds of GPM
5,6: latitude, longitude of GPM
7,8: YYYYMMDD and HHMMSS of EarthCARE
9: epoch seconds of EarthCARE
10,11: latitude,longitude of EarthCARE
12: GPM−EARTHCARE time offset in seconds
13: spatial offset in km (always 3-4 km or less, since the positions are calculated every second)

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