PR Qualitative 2A-23 Swath Data [L2A_23_SWATHDATA]

The following parameters are used in describing the formats:

· nscan: the number of PR scans within one granule (9150, on average).

· nray: the number of rays within one PR scan line (49).

Scan Time (Vdata Table, record size 8 bytes, nscan records)

Name	Name in the TOOLKIT	Format	Description
Scan Time	scanTime	8-byte float	Scan Time is the center time of 1 scan (the time at center of the nadir beam transmitted pulse). It is expressed as the UTC seconds of the day.

Geolocation (SDS, array size 2 x 49 x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
Geolocation	geolocation(2,49)	4-byte float	The earth location of the center of the IFOV at the altitude of the earth ellipsoid. The first dimension is latitude and longitude, in that order. The next dimensions are pixel and scan. Values are represented as floating point decimal degrees. Off earth is represented as less than or equal to -9999.9 Latitude is positive north, negative south. Longitude is positive east, negative west. A point on the 180th meridian is assigned to the western hemisphere.

Scan Status (Vdata Table, record size 15 bytes, nscan records):
The status of each scan is represented in terms of quality, platform and instrument control data, and fractional
orbit number. All bytes in Scan Status are copied from the 1B-21 Scan Status including the Missing byte. 2A-23 should reset the Missing byte if it determines data is missing or there is no-rain.

Name	Name in the TOOLKIT	Format	Description
Missing	scanStatus.missing	1-byte integer	Missing indicates whether information is contained in the scan data. The values are: 0: Scan data elements contain information 1: Scan was missing in the telemetry data 2: Scan data contains no elements with rain
Validity	scanStatus.validity	1-byte integer	Validity is a summary of status modes. If all status modes are routine, all bits in Validity = 0. Routine means that scan data has been measured in the normal operational situation as far as the status modes are concerned. Validity does not assess data or geolocation quality. Validity is broken into 8 bit flags. Each bit = 0 if the status is routine but the bit = 1 if the status is not routine. Bit 0 is the least significant bit (i.e., if bit i = 1 and other bits = 0, the unsigned integer value is 2**i). The non-routine situations follow: Bit Meaning if bit = 1 0: Spare (always 0) 1: Non-routine spacecraft orientation (2 or 3) 2: Non-routine ACS mode (other than 4)

			3: Non-routine yaw update status (0 or 1) 4: Non-routine instrument status (other than 1) 5: Non-routine QAC (non-zero) 6: Spare (always 0) 7: Spare (always 0)
QAC	scanStatus.qac	1-byte integer	The Quality and Accounting Capsule of the Science packet as it appears in Level-0 data. If no QAC is given in Level-0, which means no decoding errors occurred, QAC in this format has a value of zero.
Geolocation Quality	scanStatus.geoQuality	1-byte integer	Geolocation quality is a summary of geolocation quality in the scan. A zero integer value indicates "good" geolocation. A non-zero value broken down into the following bit flags indicates: Bit Meaning if bit = 1 0: latitude limit error 1: geolocation discontinuity 2: attitude change rate limit error 3: attitude limit error 4: satellite undergoing maneuvers 5: using predictive orbit data 6: geolocation calculation error 7: not used
Data Quality	scanStatus.dataQuarity	1-byte integer	Data quality is a summary of data quality in the scan. Unless this is 0 (normal), the scan data is meaningless to higher processing. Bit 0 is the least significant bit (i.e., if bit i = 1 and other bits = 0, the unsigned integer value is 2**i). Bit Meaning if bit = 1 0: missing 5: Geolocation Quality is not normal 6: Validity is not normal
Current Spacecraft Orientation	scanStatus.scOrient	1-byte integer	Value Meaning 0: +x forward 1: -x forward 2: -y forward 3: Inertial - CERES Calibration 4: Unknown Orientation
Current ACS Mode	scanStatus.acsMode	1-byte integer	Value Meaning 0: Standby 1: Sun Acquire 2: Earth Acquire 3: Yaw Acquire 4: Nominal 5: Yaw Maneuver 6: Delta-H (Thruster) 7: Delta-V (Thruster) 8: CERES Calibration
Yaw Update Status	scanStatus.yawUpdateS	1-byte integer	Value Meaning 0: Inaccurate 1: Indeterminate 2: Accurate

PR Mode	scanStatus.prMode	1-byte integer	Value Meaning 0: Other Mode 1: Observation Mode
PR Status 1	scanStatus.prStatus1	1-byte integer	The flags listed here indicate warnings of PR conditions (noise level, echo power and echo position, and mode change). In data processing, users should be cautions with the following as a scan with non-zero status includes questionable range bins or angle bins. 0: LOGAMP noise limit error 1: Noise level limit error (The meaning of this warning is the same as the System Noize Warning Flag) 2: Out of PR dynamic range (Surface echo is so strong that it exceeds the PR receiver dynamic range. Calibration with the saturated echo may be questionable.) 3: Not reach surface position (If Surface echo is out of range window, Bin Surface Peak and related data become uncertain.) 7: FCIF mode change
PR Status 2	scanStatus.prStatus2	1-byte integer	In some cases, antenna sidelobes are directed to nadir receive surface echo positions. When the main beam is off nadir, the timing of such nadir-surface clutter can contaminate the rain echo. In “PR STATUS2,” a warning flag is set ON (1) when the nadir surface echo (at the nadir angle bin #25) exceeds a predetermined threshold. When the flag is ON, please be careful about the echoes at all angle bins around the same logical range bin number as the Bin-surface-peak at nadir (angle bin number 25).
Fractional Orbit Number	scanStatus.fracOrbitN	4-byte float	The orbit number and fractional part of the orbit at Scan Time. The orbit number will be counted from the beginning of the mission. The fractional part is calculated as: (Scan Time - Orbit Start Time) / (Orbit End Time - Orbit Start Time)

Navigation (Vdata, record size 88 bytes, nscan records):

Name	**Name in the TOOLKIT**	**Format**	**Description**
Spacecraft Geocentric Position [3]	navigate.scPosX navigate.scPosY navigate.scPosZ	3 X 4-byte float	The position (m) of the spacecraft in Geocentric Inertial Coordinates at the Scan mid-Time (i.e., time at the middle pixel/IFOV of the active scan period). The order of components is: x, y, and z. Geocentric Inertial Coordinates are also commonly known as Earth Centered Inertial coordinates. These coordinates will be True of Date (rather than Epoch 2000 which are also commonly used), as interpolated from the data in the Flight Dynamics Facility ephemeris files generated for TRMM.

Spacecraft Geocentric Velocity [3]	navigate.scVelX navigate.scVelY navigate.scVelZ	3 X 4-byte float	The velocity (ms $^{-1}$) of the spacecraft in Geocentric Inertial Coordinates at the Scan mid-Time. The order of components is: x, y, and z.
Spacecraft Geodetic Latitude	navigate.scLat	4-byte float	The geodetic latitude (decimal degrees) of the spacecraft at the Scan mid-Time.
Spacecraft Geodetic Longitude	navigate.scLon	4-byte float	The geodetic longitude (decimal degrees) of the spacecraft at the Scan mid-Time. Range is -180 to 179.999999.
Spacecraft Geodetic Altitude	navigate.scAlt	4-byte float	The altitude (m) of the spacecraft above the Earth Ellipsoid at the Scan mid-Time.
Spacecraft Attitude [3]	navigate.scAttRoll navigate.scAttPitch navigate.scAttYaw	3 X 4-byte float	The satellite attitude Euler angles at the Scan mid-Time. The order of the components in the file is roll, pitch, and yaw. However, the angles are computed using a 3-2-1 Euler rotation sequence representing the rotation order yaw, pitch, and roll for the rotation from Orbital Coordinates to the spacecraft body coordinates. Orbital Coordinates represent an orthogonal triad in Geocentric Inertial Coordinates where the Z-axis is toward the geocentric nadir, the Y-axis is perpendicular to the spacecraft velocity opposite the orbit normal direction, and the X-axis is approximately in the velocity direction for a near circular orbit. Note this is geocentric, not geodetic, referenced, so that pitch and roll will have twice orbital frequency components due to the onboard control system following the oblate geodetic Earth horizon. Note also that the yaw value will show an orbital frequency component relative to the Earth fixed ground track due to the Earth rotation relative to inertial coordinates.
Sensor Orientation Matrix [3 X 3]	navigate.att1 navigate.att2 navigate.att3 navigate.att4 navigate.att5 navigate.att6 navigate.att7 navigate.att8 navigate.att9	3 X 3 X 4-byte float	The rotation matrix from the instrument coordinate frame to Geocentric Inertial Coordinates at the Scan mid-Time.
Greenwich Hour Angle	navigate.greenHourAng	4-byte float	The rotation angle (degrees) from Geocentric Inertial Coordinates to Earth Fixed Coordinates.

Rain Flag (SDS, array size nray x nscan, 1-byte integer):

Name	**Name in the TOOLKIT**	**Format**	**Description**
Rain Flag	rainFlag(49)	1-byte integer	The Rain Flag is almost identical to the Minimum Echo Flag of 1C21: 0: no rain; 10: rain possible 11: echo greater than rain threshold #1 in clutter region 12: echo greater than rain threshold #2 in clutter region 20: rain certain

Rain Type Flag (SDS, array size nray x nscan, 1-byte integer):

Name	Name in the TOOLKIT	Format	Description

Rain Type Flag	rainType(49)	1-byte integer	The Rain Type Flag is set as follows:
			10: Stratiform certain.
			When R_type_V = T_stra; (BB exists)
			and R_type_H = T_stra;
			11: Stratiform certain.
			When R_type_V = T_stra; (BB exists)
			and R_type_H = T_others;
			12: Probably stratiform.
			When R_type_V = T_others;
			and R_type_H = T_stra;
			13: Maybe stratiform.
			When R_type_V = T_stra; (BB detection certain)
			and R_type_H = T_conv
			20: Convective certain.
			When R_type_V = T_conv; (no BB)
			and R_type_H = T_conv;
			21: Convective certain.
			When R_type_V = T_others;
			and R_type_H = T_conv;
			22: Convective certain.
			When R_type_V = T_conv;
			and R_type_H = T_others;
			23: Probably convective.
			When R_type_V = T_conv; (BB exists)
			and R_type_H = T_conv;
			24: Maybe convective.
			When R_type_V = T_conv;
			and R_type_H = T_stra;
			25: Maybe convective.
			When R_type_V = T_stra; (BB detection not so confident)
			and R_type_H = T_conv;
			30: Others.
			When R_type_V = T_others;
			and R_type_H = T_others;
			where
			R_type_V: rain type classified by the V-profile method,
			R_type_H: rain type classified by the H-pattern method,
			which is based on SHY95 developed by Prof. Houze and his group.
			The above assignment of numbers has the following meaning:
			Rain Type Flag / 10 = 1: stratiform,
			2: convective,
			3: others.
			Rain Type Flag % 10 = This indicates the level of confidence, which decreases as the number increases.
			where Rain Type Flag % 10 means MOD (Rain Type Flag, 10) in FORTRAN.

			When it is “no rain” or “data missing”, Rain Type Flag contains the following values: -88: no rain -99: data missing

Warm Rain Flag (SDS, array size nray x nscan, 1-byte integer):

Name	Name in the TOOLKIT	Format	Description
Warm Rain Flag	warmRain(49)	1-byte integer	The Warm Rain Flag is set as follows: 0: warm rain is not detected; 1: there may be “warm” rain; 2: warm rain is detected (with high confidence). -88: no rain -99: data missing

Status Flag (SDS, array size nray x nscan, 1-byte integer):

Name	Name in the TOOLKIT	Format	Description
Status Flag	status(49)	1-byte integer	The Status Flag indicates whether the data are obtained over sea or land and the confidence of 2A-23 product data. It is set as follows: 0: good (over ocean) 10: BB detection may be good (over ocean) 20: R-type classification may be good (over ocean) (BB detection is good or BB does not exist) 30: Both BB detection and R-type classification may be good (over ocean) 50: not good (because of warnings) (over ocean) 100: bad (possible data corruption) (over ocean) 1: good (over land) 11: BB detection may be good (over land) 21: R-type classification may be good (over land) (BB detection is good or BB does not exist) 31: Both BB detection and R-type classification may be good (over land) 51: not good (because of warnings) (over land) 101: bad (possible data corruption) (over land) 2: good (over coastline) 12: BB detection may be good (over coastline) 22: R-type classification may be good (over coastline) (BB detection is good or BB does not exist) 32: Both BB detection and R-type classification may be good (over coastline) 52: not good (because of warnings) (over coastline) 102: bad (possible data corruption) (over coastline) 4: good (over inland lake) 14: BB detection may be good (over inland lake) 24: R-type classification may be good (over inland lake) (BB detection is good or BB does not exist) 34: Both BB detection and R-type classification may be good (over inland lake) 54: not good (because of warnings) (over inland lake) 104: bad (possible data corruption) (over inland lake)

			9: may be good (land/sea unknown) 19: BB detection may be good (land/sea unknown) 29: R-type classification may be good (BB detection is good or BB does not exist) (land/sea unknown) 39: Both BB detection and R-type classification may be good (land/sea unknown) 59: not good (because of warnings) (land/sea unknown) 109: bad (possible data corruption) (land/sea unknown) When it is “no rain” or “data missing”, Status Flag contains the following values: -88: no rain -99: data missing Assignment of the above numbers are based on the following rules: When Status ≥ 0 Status/100 = 0: good, may be good, or not good 1: doubtful (Status/10) % 10 = 0: good, may be good when status <100, and not good when status ≥100 1: BB detection not so confident 2: R-type classification not so confident (but BB detection is good, or when BB does not exist) 3: BB detection is not so confident and R-type classification not so confident 5: Over-all quality of the processed data for the j-th scan angle is not good (but may not be too bad to be classified as bad data) Status % 10 = 0: over ocean 1: over land 2: over coastline 4: over inland lake 9: land/sea unknown In other words, we can check the confidence level of 2A-23 by the following way: Status Flag ≥ 100 : bad (untrustworthy because of possible data corruption) 100> Status Flag ≥ 10 : result not so confident (warning) Status Flag = 9 : may be good 9> Status Flag ≤ 0 : good The last digit of Status Flag indicates over ocean, land, etc.

Range Bin Number (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Range Bin Number	rangeBinNum(49)	2-byte integer	A positive Range Bin Number corresponds to the height of bright band. Negative values are defined as follows: -1111: No bright band -8888: No rain

Height of Bright Band (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Height of Bright Band	HBB(49)	2-byte integer	A positive Height of Bright Band is defined in meters above mean sea level. Negative values are defined as follows: -1111: No bright band -8888: No rain -9999: Data missing

Height of Freezing Level (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Height of Freezing Level	freezH(49)	2-byte integer	A positive Height of Freezing Level is the height of the 0°C isotherm above mean sea level in meters, estimated from climatological surface temperature data. Negative values are defined as: -5555: When error occurred in the estimation of Height of Freezing Level -8888: No rain -9999: Data missing

Height of Storm (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Height of Storm	stormH(49)	2-byte integer	A positive Height of Storm is the height of the storm top above mean sea level in meters. A positive Height of Storm is given only when rain is present with a high degree of confidence in 1C21, i.e., the Minimum Echo Flag in 1C21 has the value of 2 (rain certain). Negative values are defined as: -1111: Height of Storm not calculated because rain is not present with a high level of confidence in 1C21 -8888: No rain -9999: Data missing

Bright Band Intensity (SDS, array size nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
Bright Band Intensity	BBintensity(49)	4-byte float	The maximum value of the bright band (dBZ) obtained from normal samples. The range is from 0.00 to 100.0 dBZ. Negative values are defined as: -1111: No bright band -8888: No rain -9999: Data missing

Spare (SDS, array size nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
Spare	spare(49)	4-byte float	Spare will characterize the width of the bright band. Since this characterization requires much research, the meaning is not disclosed.