

PR Profile 2A-25 Clutter Flag [CLUTTER_FLAGS]

The Clutter Flags are identical to the clutter information in 1B-21 in the Ray Header.

Clutter Flag (Vdata Table, record size 4 bytes, 49 records)

Name	Name in the TOOLKIT	Format	Description
Mainlobe Clutter Edge	clutFlag(49).mainlobeEdge	1-byte integer	Absolute value of the difference in Range bin Numbers between the detected surface and the edge of the clutter from the mainlobe.
Sidelobe Clutter Range [3]	clutFlag(49).sidelobeRange (3)	3 x 1-byte integer	Absolute value of the difference in Range Bin Numbers between the detected surface and the clutter position from the sidelobe. A zero means no clutter indicated in this field since less than 3 bins contained significant clutter.

PR Profile 2A-25 Swath Data [L2A_25_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).
- ngeo: the number of geolocation data (2).
- ncell1: the number of radar range cells at which the rain rate is estimated (80).
- ncell2: the number of radar range cells at which the Z-R parameters are output (5).
- nmeth: the number of methods used (2).

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.

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.dataQuality	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 cautious 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 Noise 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	3 X 3 X 4-byte float	The rotation matrix from the instrument coordinate frame to Geocentric Inertial Coordinates at the Scan mid-Time.

	navigate.att8 navigate.att9		
Greenwich Hour Angle	navigate.greenHourAng	4-byte float	The rotation angle (degrees) from Geocentric Inertial Coordinates to Earth Fixed Coordinates.

Rain Rate (SDS, array size ncell x nray x nscan, 2-bytes integer):

Name	Name in the TOOLKIT	Format	Description
Rain Rate	rain(80,49)	2-byte integer	This is the estimate of rain rate at the radar range gates from 0 to 20 km. It ranges from 0.0 to 3000.0 mm/h and is multiplied by 10 and stored as a 2-byte integer. A value of -88.88 mm/hr (stored as -889) means ground clutter.

Reliability (SDS, array size ncell x nray x nscan, 1-byte integer):

Name	Name in the TOOLKIT	Format	Description
Reliability	reliab(80,49)	1-byte integer	The Reliability is that for estimated rain rates at the radar range gates from 0 to 20 km. It ranges from 0 to 255. If data are missing, the reliability will be set as 10000000 in binary. The default value is 0 (measured signal below noise). 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 following meanings are assigned to each bit in the 8-bit integer if the bit = 1. <ul style="list-style-type: none"> • bit 0 rain • bit 1 rain certain • bit 2 bright band • bit 3 large attenuation • bit 4 weak return ($Z_m < 20$ dBZ) • bit 5 estimated $Z < 0$ dBZ • bit 6 main-lobe clutter or below surface • bit 7 missing data

Corrected Z-factor (SDS, array size ncell x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Corrected Z-factor	correctZFactor(80,49)	2-byte integer	This is the attenuation corrected Z-factor at the radar range gates from 0 to 20 km. It ranges from 0.1 to 80.0 dB of mm^6m^{-3} and is multiplied by 10 and stored as a 2-byte integer. A value of -88.88 dB (stored as -889) means ground clutter. A value of -77.77 dB (stored as -778) means Z was less than 0 dBZ.

Attenuation Parameter Node (SDS, array size ncell2 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Attenuation Parameter Node	attenparmNode(5,49)	2-byte integer	The Attenuation Parameter Node gives the range bin numbers of the nodes at which the values of Attenuation Parameter Alpha are given (see below). The values of Alpha between the nodes are linearly interpolated. This variable ranges from 0 and 79 and is unitless.

Attenuation Parameter Alpha (SDS, array size 2 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Attenuation	attenParmAlpha(5,49)	2-byte	The attenuation parameter Alpha () relates the

Parameter Alpha		integer	attenuation coefficient, k (dB/km) to the Z-factor: $k = Z^{-1}$. is computed at ncell2 radar range gates for each ray. It ranges from 0.000100 to 0.002000 and is multiplied by 10^6 and stored as a 2-byte integer.
-----------------	--	---------	--

Attenuation Parameter Beta (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Attenuation Parameter Beta	attenParmBeta(49)	2-byte integer	The Attenuation Parameter Beta () relates the attenuation coefficient, k (dB/km) to the Z-factor: $k = Z^{-1}$. is computed at ncell2 radar range gates for each ray. It ranges from 0.500 to 2.000 and is multiplied by 10^3 and stored as a 2-byte integer.

Z-R Parameter Node (SDS, array size ncell2 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Z-R Parameter Node	ZRParmNode(5,49)	2-byte integer	The Z-R Parameter Node gives the range bin numbers of the nodes at which the Z-R parameters “a” and “b” are given (see below). The values of a and b between the nodes are linearly interpolated. This variable ranges from 0 and 79 and is unitless.

Z-R Parameter a (SDS, array size ncell2 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Z-R Parameter a	ZRParmA(5,49)	2-byte integer	Parameter a for Z-R relationship ($R=aZ^b$) is determined from the rain type and the height relative to the freezing level, the non-uniformity parameter () and the correction factor () for the surface reference technique. a is computed at 10 radar range gates for each ray. It ranges from 0.0050 to 0.2000 and is multiplied by 10^4 and stored as a 2-byte integer.

Z-R Parameter b (SDS, array size ncell2 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Z-R Parameter b	ZRParmB(5,49)	2-byte integer	Parameter b for Z-R relationship ($R=aZ^b$) is determined from the rain type and the height relative to the freezing level, the non-uniformity parameter () and the correction factor () for the surface reference technique. b is computed at 10 radar range gates for each ray. It ranges from 0.500 to 1.000 and is multiplied by 10^3 and stored as a 2-byte integer.

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

Name	Name in the TOOLKIT	Format	Description
Maximum Z	zmmax(49)	4-byte float	This is the maximum value of measured reflectivity at each IFOV. It ranges from 0.0 to 100.0 dBz.

Rain Flag (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Rain Flag	rainFlag(49)	2-byte integer	The Rain Flag indicates rain or no rain status and the rain type assumed in rain rate retrieval. The default value is 0 (no rain). Bit 0 is the least significant bit (i.e.,

			<p>if bit i=1 and other bits =0, the unsigned integer value is 2^{**i}).</p> <p>The following meanings are assigned to each bit in the 16-bit integer if the bit = 1.</p> <ul style="list-style-type: none"> • bit 0 rain possible • bit 1 rain certain • bit 2 $\text{zeta}^{\text{beta}} > 0.5$ [Path Integrated Attenuation (PIA) larger than 3 dB] • bit 3 large attenuation (PIA larger than 10 dB) • bit 4 stratiform • bit 5 convective • bit 6 broad band exists • bit 7 warm rain • bit 8 rain bottom above 2 km • bit 9 rain bottom above 4 km • bit 10 not used • bit 11 not used • bit 12 not used • bit 13 not used • bit 14 data missing between rain top and bottom • bit 15 not used
--	--	--	---

Range Bin Number (SDS, array size 6 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Range Bin Number	rangeBinNum(6,49)	2-byte integer	<p>This array gives the Range Bin Number of various quantities for each ray in every scan. The definitions are:</p> <ul style="list-style-type: none"> • top range bin number of the interval that is processed as meaningful data in 2A-25 • bottom range bin number of the interval that is processed as meaningful data in 2A-25 • actual surface range bin number • range bin number of the bright band if it exists • range bin number at which the path-integrated Z-factor first exceeds the given threshold • range bin number at which the measured Z-factor is maximum <p>The Range Bin Numbers in this algorithm are different from the NASDA definition of Range Bin Number described in the ICS, Volume 3. The Range Bin Numbers in the algorithm range from 0 to 79 and have an interval of 250m. The earth ellipsoid is defined as range bin 79.</p>

Averaged Rain Rate (SDS, array size 2 x nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Averaged Rain Rate	rainAve(2,49)	2-byte integer	<p>There are two kinds of Average Rain Rate. The first one is the average rain rate for each ray between the two predefined heights of 2 and 4 km. It ranges from 0.0 to 3000.0 mm h⁻¹ and is multiplied by 10 and stored as a 2-byte integer. The second one is the integral of rain rate from rain top to rain bottom. It ranges from 0.0 to 3000</p>

			mm km h ⁻¹ and is multiplied by 10 and stored as a 2-byte integer.
--	--	--	---

Weight (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Weight	weightW(49)	2-byte integer	The Weight is the weighting function of an estimate of the path-integrated attenuation and its reliability. It ranges from 0.000 to 1.000 and is multiplied by 10 ³ and stored as a 2-byte integer.

Method Flag (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Method Flag	method	2-byte integer	<p>This flag indicates which method is used to derive the rain rate. The default value is 0 (including no rain case). Bit 0 is the least significant bit (i.e., if bit i =1 and other bits =0, the unsigned integer value is 2^{*i}).</p> <p>Bits 0 and 1 contain the following values:</p> <ul style="list-style-type: none"> 0 - rain over ocean 1 - rain over land 2 - rain over coast 3 - rain over other surface (inland lake, etc.) <p>The following meanings are assigned to the other bits in the 16-bit integer if the bit = 1.</p> <ul style="list-style-type: none"> • bit 2 constant-Z-near-surface method • bit 3 rain less than 5 bins • bit 4 not enough (<5) successive rain data • bit 5 positive slope near surface • bit 6 zeta >= 1.0 • bit 7 quadratic weighting • bit 8 NUBF correction very large (> 2.0) • bit 9 No NUBF because NSD unreliable • bit 10 NUBF for Z-R below lower bound • bit 11 NUBF for PIA above upper bound • bit 12 NUBF for PIA below lower bound • bit 13 surface attenuation after NUBF correction > 60 dB • bit 14 data missing between rain top and bottom • bit 15 not used

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

Name	Name in the TOOLKIT	Format	Description
Epsilon	epsilon(49)	4-byte float	The Epsilon () is the correction factor for the surface reference. It ranges from 0.0 to 100.0.

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

Name	Name in the TOOLKIT	Format	Description
Zeta	zeta(2,49)	4-byte float	The Zeta () roughly represents the rain rate integrated along the ray using two different methods. It ranges from 0.0 to 100.0 and is unitless.

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

Name	Name in the TOOLKIT	Format	Description
Zeta_mn	zeta_mn(2,49)	4-byte float	Zeta_mn (mn) is the average of zeta () in the vicinity of each beam position (average over three scans and three IFOVs). It is calculated using two methods. It ranges from 0.0 to 100.0 and is unitless.

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

Name	Name in the TOOLKIT	Format	Description
Rain Oversample	zeta_sd(2,49)	4-byte float	Zeta_sd (sd) is the standard deviation of zeta () in the vicinity of each beam position (using three scans and three IFOVs). It is calculated using two methods. It ranges from 0.0 to 100.0 and is unitless.

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

Name	Name in the TOOLKIT	Format	Description
Xi	xi(2,49)	4-byte float	The Xi is the normalized standard deviation defined as Zeta_sd/Zeta_mn. When Zeta_mn takes on small values (or zero) Xi is set to 99.0. It is calculated using two methods. Xi ranges from 0.0 to 99.0 and is unitless.

Thresholded PIZ Thickness (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Thresholded PIZ Thickness	thickThPIZ(49)	2-byte integer	This is the number of range bins (250m resolution) between the highest range at which rain is certain and the range at which the Path-Integrated Z-factor (PIZ) first exceeds a threshold. This is a unitless quantity and it ranges from 0 to 79.

NUBF Correction Factor (SDS, array size 2 x nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
NUBF Correction Factor	nubfCorrectFactor(2,49)	4-byte float	The Non-Uniform Beam Filling (NUBF) Correction Factor is used as a correction to reflectivity and attenuation calculations. The two NUBF Correction Factors are given for the K-Z and Z-R relations. The ranges are 1.0 to 2.0 and .9 to 1.0, respectively. Both are unitless quantities.

Quality Flag (SDS, array size nray x nscan, 2-byte integer):

Name	Name in the TOOLKIT	Format	Description
Quality Flag	qualityFlag(49)	2-byte integer	This quality flag gives the overall error that affects the entire angle bin data, such as the error associated with the non-uniform beam filling effect and the surface reference reliability. It ranges from 0 to 255. If data are missing, the reliability will be set as 10000000 in binary. The default value is 0 (normal). 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 following meanings are assigned to each bit in the 16-bit integer if the bit = 1. <ul style="list-style-type: none"> • bit 0 unusual situation in rain average

			<ul style="list-style-type: none"> • bit 1 mean of zeta too small for NSD (xi) calculation • bit 2 NSD of zeta (xi) calculated from less than 6 points • bit 3 mean of PIA too small for NSD (PIA) calculation • bit 4 NSD of PIA calculated from less than 6 points • bit 5 epsilon not reliable (sigma0 marginally reliable) • bit 6 2A21 input data not reliable • bit 7 2A23 input data not reliable • bit 8 range bin error • bit 9 sidelobe clutter removal • bit 10 not used • bit 11 not used • bit 12 not used • bit 13 not used • bit 14 data missing between rain top and bottom • bit 15 not used
--	--	--	--

Near Surface Rain (SDS, array size nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
Near Surface Rain	nearSurfRain(49)	4-byte float	Rainfall rate near the surface. The range is 0 to 3000 mm/hr.

Near Surface Z (SDS, array size nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
Near Surface Z	nearSurfZ(49)	4-byte float	Reflectivity near the surface. The range is 0.0 to 100.0 dBZ.

PIA 2A25 (SDS, array size nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
PIA 2A25	pia2a25(49)	4-byte float	The Path Integrated Attenuation (PIA) estimated by 2A25 The range is 0.0 to 50.0 dB.

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

Name	Name in the TOOLKIT	Format	Description
Error Rain	errorRain(49)	4-byte float	The error in Near Surface Rain Rate. The range is 0 to 3000 mm/hr.

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

Name	Name in the TOOLKIT	Format	Description
Error Z	errorZ(49)	4-byte float	The error in Near Surface Z. The range is 0.0 to 100.0 dBZ.

Spare (SDS, array size 2 x nray x nscan, 4-byte float):

Name	Name in the TOOLKIT	Format	Description
Spare	spare(49)	4-byte float	Contents and ranges are not public.