TROPICAL RAINFALL MEASURING MISSION PRECIPITATION PROCESSING SYSTEM

File Specification
2A25

Version 7

March 23, 2015

0.1 2A25 - PR Profile

2A25, "PR Profile", produces an estimate of vertical rainfall rate profile for each radar beam. The rainfall rate estimate is given at each resolution cell of the PR radar. To compare with ground-based radar data, the attenuation corrected Z profile is also given. The average rainfall rate between the two pre-defined altitudes is calculated for each beam position. Other output data include parameters of Z-R relationships, integrated rain rate of each beam, range bin numbers of rain layer boundaries, and many intermediate parameters. The following sections describe the structure and contents of the format.

Dimension definitions:

nscan	var	Number of scans in the granule.
nray	49	Number of angle bins in each scan.
ncell1	80	Number of radar range cells at which the rain rate is estimated. The cells range from 0 to 79. Each cell is 250m apart, with cell 79 at the earth ellipsiod.
ncell2	5	Number of radar range cells at which the Z-R parameters are output.
nmeth	2	Number of methods used.
nestmeth	6	Number of estimation methods.

Figure 1 through Figure 7 show the structure of this product. The text below describes the contents of objects in the structure, the C Structure Header File and the Fortran Structure Header File.

FileHeader (Metadata):
FileHeader contains general metadata. This group appears in all data products. See Metadata for TRMM Products for details.

InputRecord (Metadata):
InputRecord contains a record of input files for this granule. This group appears in Level 1 and Level 2 data products. Level 3 time averaged products have the same information separated into 3 groups since they have many inputs. See Metadata for TRMM Products for details.

NavigationRecord (Metadata):
NavigationRecord contains navigation metadata for this granule. This group appears in Level 1 and Level 2 data products. See Metadata for TRMM Products for details.

FileInfo (Metadata):
FileInfo contains metadata used by the PPS I/O Toolkit (TKIO). This group appears in all data products. See Metadata for TRMM Products for details.

JAXAInfo (Metadata):
JAXAInfo contains metadata requested by JAXA. Used by PR algorithms only. See Metadata for TRMM Products for details.

Parameters_General (Metadata):
ASCII text of the general parameters used by 2A25 at runtime.

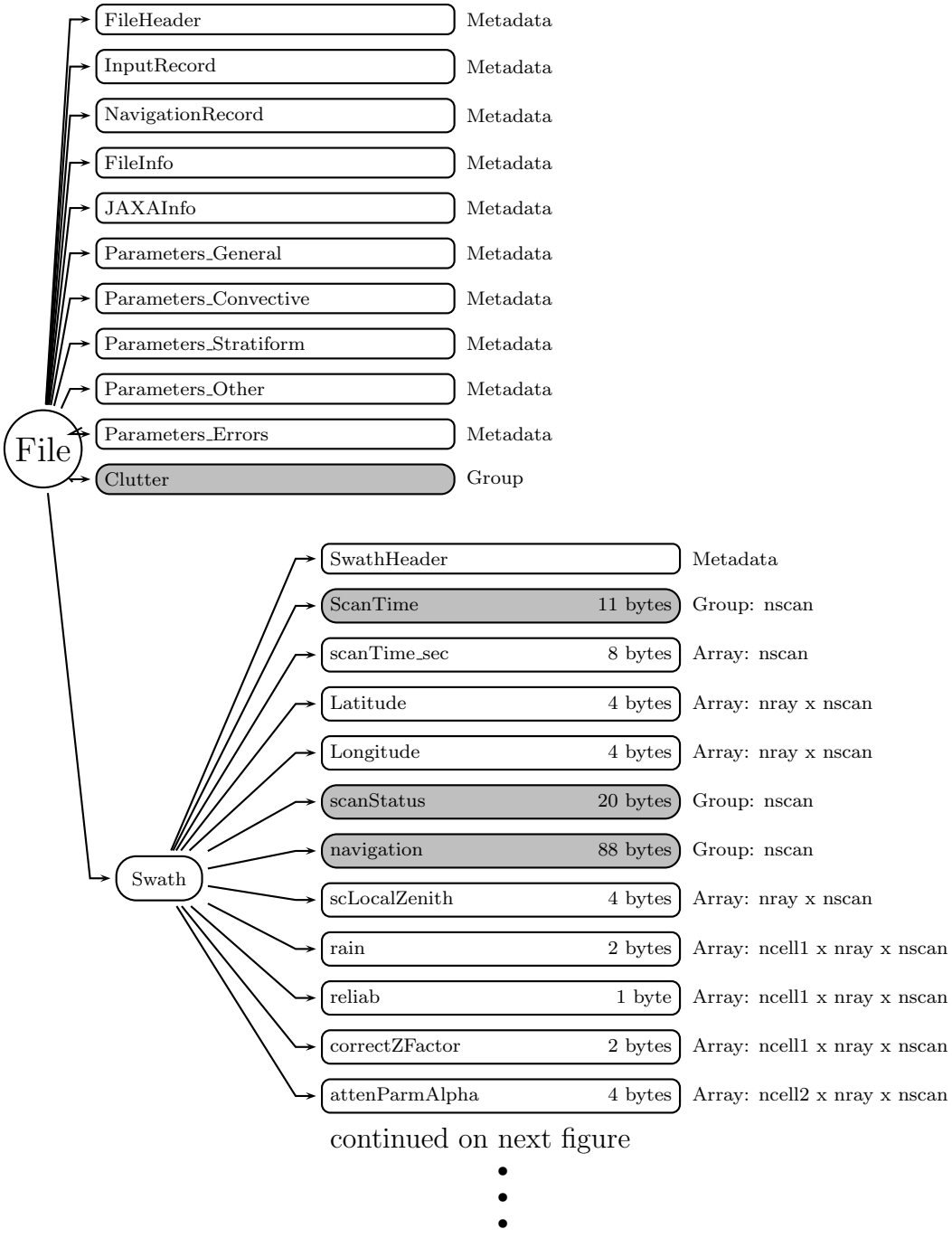

Figure 1: Data Format Structure for 2A25, PR Profile

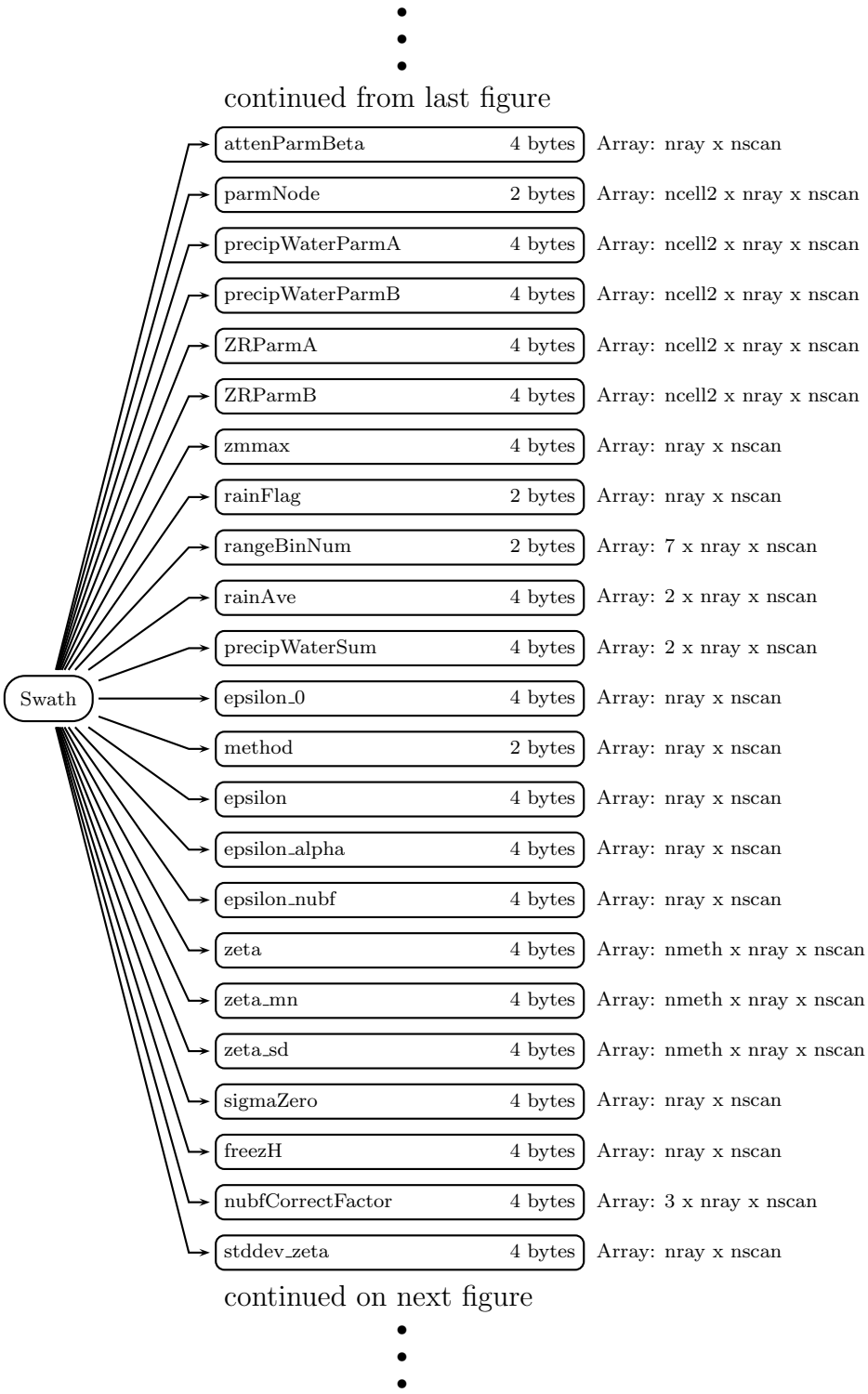

Figure 2: Data Format Structure for 2A25, PR Profile

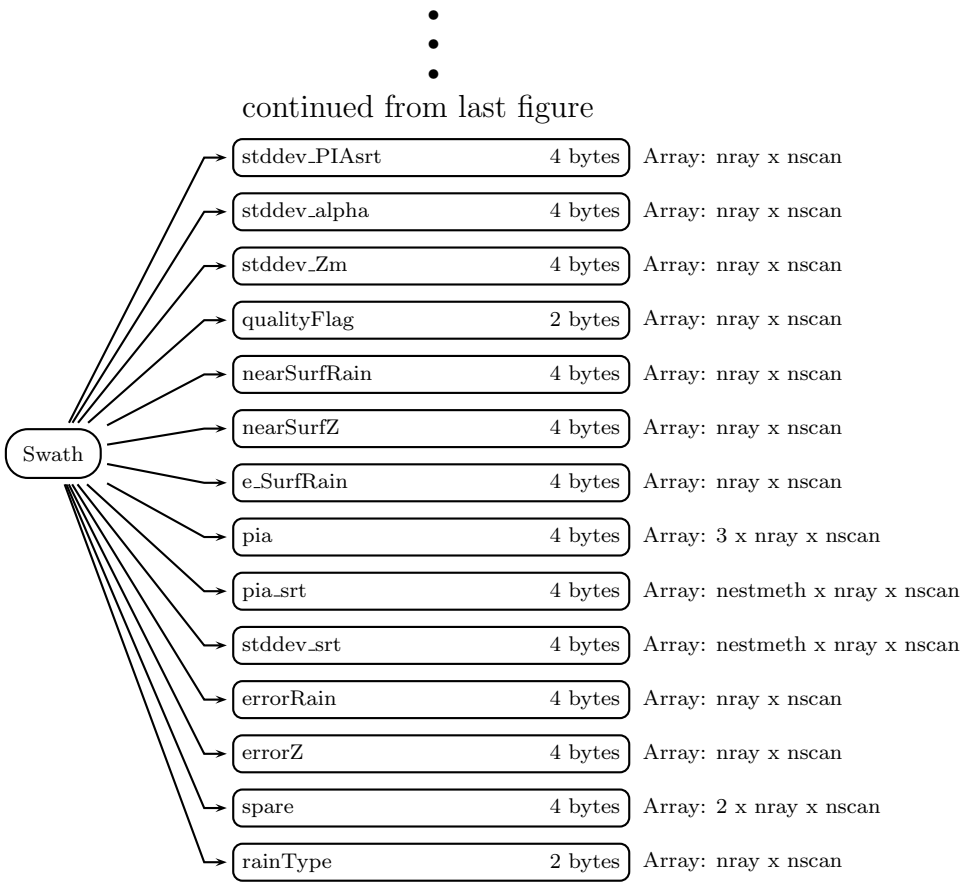

Figure 3: Data Format Structure for 2A25, PR Profile

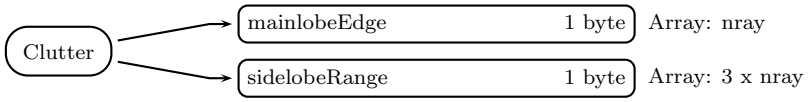

Figure 4: Data Format Structure for 2A25, Clutter

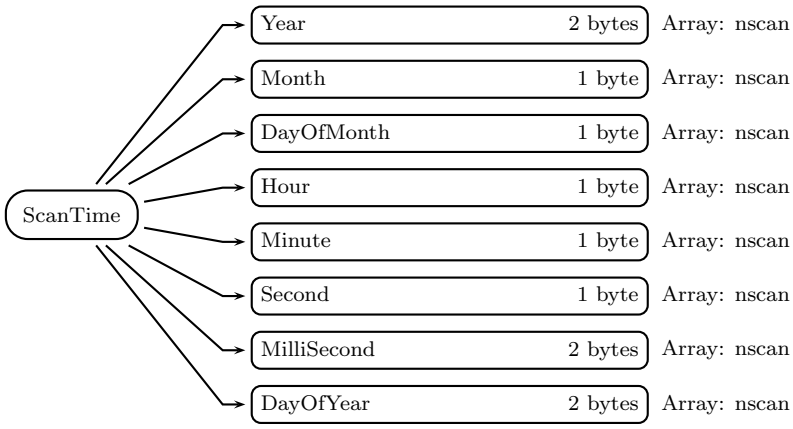

Figure 5: Data Format Structure for 2A25, ScanTime

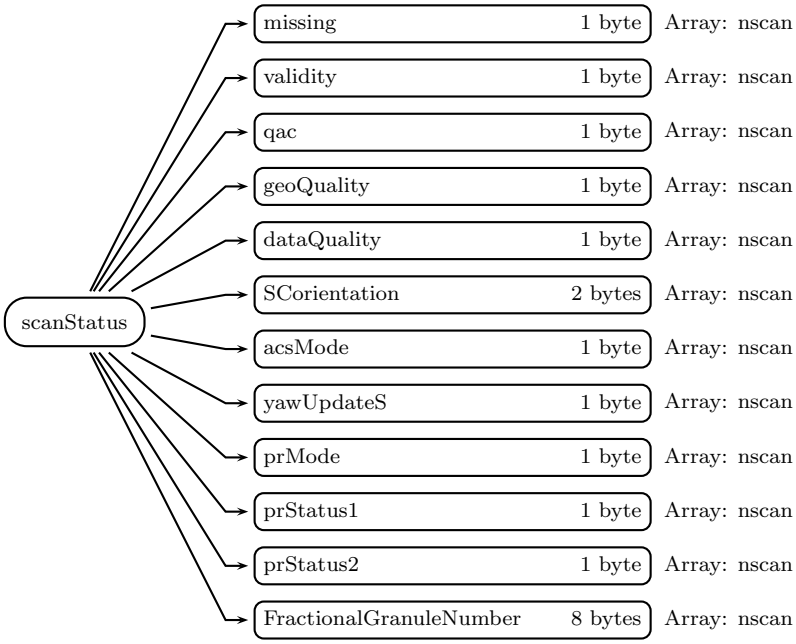

Figure 6: Data Format Structure for 2A25, scanStatus

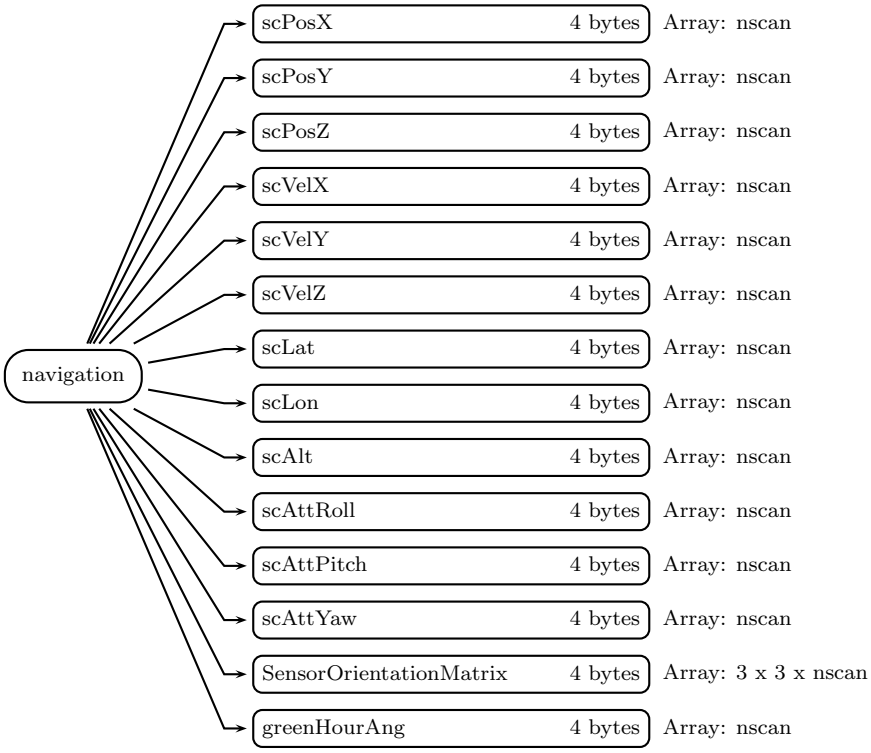

Figure 7: Data Format Structure for 2A25, navigation

Parameters_Convective (Metadata):
ASCII text of the parameters for Convective rain used by 2A25 at runtime.

Parameters_Stratiform (Metadata):
ASCII text of the parameters for Stratiform rain used by 2A25 at runtime.

Parameters_Other (Metadata):
ASCII text of the parameters for Other rain used by 2A25 at runtime.

Parameters_Errors (Metadata):
ASCII text of the Error parameters used by 2A25 at runtime.

Clutter (Group)

mainlobeEdge (1-byte integer, array size: nray):
Absolute value of the difference in Range Bin Numbers between the detected surface and the edge of the clutter from the mainlobe.

sidelobeRange (1-byte integer, array size: 3 x nray):
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.

Swath (Swath)

SwathHeader (Metadata):
SwathHeader contains metadata for swaths. This group appears in Level 1 and Level 2 data products. See Metadata for TRMM Products for details.

ScanTime (Group)
A UTC time associated with the scan.

Year (2-byte integer, array size: nscan):
4-digit year, e.g., 1998. Values range from 1950 to 2100 years. Special values are defined as:
-9999 Missing value

Month (1-byte integer, array size: nscan):
Month of the year. Values range from 1 to 12 months. Special values are defined as:
-99 Missing value

DayOfMonth (1-byte integer, array size: nscan):
Day of the month. Values range from 1 to 31 days. Special values are defined as:
-99 Missing value

Hour (1-byte integer, array size: nscan):
UTC hour of the day. Values range from 0 to 23 hours. Special values are defined as:
-99 Missing value

Minute (1-byte integer, array size: nscan):
Minute of the hour. Values range from 0 to 59 minutes. Special values are defined as:
-99 Missing value

Second (1-byte integer, array size: nscan):
Second of the minute. Values range from 0 to 60 s. Special values are defined as:
-99 Missing value

MilliSecond (2-byte integer, array size: nscan):
Thousandths of the second. Values range from 0 to 999 ms. Special values are defined as:
-9999 Missing value

DayOfYear (2-byte integer, array size: nscan):
Day of the year. Values range from 1 to 366 days. Special values are defined as:
-9999 Missing value

scanTime_sec (8-byte float, array size: nscan):
A time associated with the scan. scanTime_sec is expressed as the UTC seconds of the day. Values range from 0 to 86400 s. Special values are defined as:
-9999.9 Missing value

Latitude (4-byte float, array size: nray x nscan):
The earth latitude of the center of the IFOV at the altitude of the earth ellipsiod. Latitude is positive north, negative south. Values range from -90 to 90 degrees. Special values are defined as:
-9999.9 Missing value

Longitude (4-byte float, array size: nray x nscan):
The earth longitude of the center of the IFOV at the altitude of the earth ellipsiod. Longitude is positive east, negative west. A point on the 180th meridian has the value -180 degrees. Values range from -180 to 180 degrees. Special values are defined as:
-9999.9 Missing value

scanStatus (Group)

missing (1-byte integer, array size: nscan):
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 (1-byte integer, array size: nscan):
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 (1-byte integer, array size: nscan):
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.

geoQuality (1-byte integer, array size: nscan):
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 the following, where 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   latitude limit error
1   geolocation
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
```

dataQuality (1-byte integer, array size: nscan):
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
```

SCorientation (2-byte integer, array size: nscan):
The positive angle of the spacecraft vector (v) from the satellite forward direction of motion, measured clockwise facing down. We define v in the same direction as the spacecraft axis +X, which is also the center of the TMI scan. If +X is forward, SCorientation is 0. If -X is forward, SCorientation is 180. If -Y is forward, SCorientation is 90. Values range from 0 to 360 degrees. Special values are defined as:
-8003 Inertial
-8004 Unknown
-9999 Missing value

acsMode (1-byte integer, array size: nscan):

```
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
```

yawUpdateS (1-byte integer, array size: nscan):

```
Value Meaning
0     Inaccurate
1     Indeterminate
2     Accurate
```

prMode (1-byte integer, array size: nscan):

```
Value Meaning
1     Observation Mode
2     Other Mode
```

prStatus1 (1-byte integer, array size: nscan):
This status is a warning for scan data. Unless this is 0, the scan data may include a little questionable value though it is not a problem (such as break of caution limit). This field is used only for NASDA's data analysis.

prStatus2 (1-byte integer, array size: nscan):
Initialization in Onboard Surface Search Algorithm.

```
Value Meaning
0     Not initialized
1     Initialized
```

FractionalGranuleNumber (8-byte float, array size: nscan):
The floating point granule number. The granule begins at the Southern-most point of the spacecraft's trajectory. For example, FractionalGranuleNumber = 10.5 means the spacecraft is halfway through granule 10 and starting the descending half of the granule. Values range from 0 to 100000. Special values are defined as:
-9999.9 Missing value

navigation (Group)

scPosX (4-byte float, array size: nscan):
The x component of 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). 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.

scPosY (4-byte float, array size: nscan):
The y component of the position (m) of the spacecraft in Geocentric Inertial Coordinates. See scPosX.

scPosZ (4-byte float, array size: nscan):
The z component of the position (m) of the spacecraft in Geocentric Inertial Coordinates. See scPosX.

scVelX (4-byte float, array size: nscan):
The x component of the velocity (ms^{-1}) of the spacecraft in Geocentric Inertial Coordinates at the Scan mid-Time.

scVelY (4-byte float, array size: nscan):
The y component of the velocity (ms^{-1}) of the spacecraft in Geocentric Inertial Coordinates at the Scan mid-Time.

scVelZ (4-byte float, array size: nscan):
The z component of the velocity (ms^{-1}) of the spacecraft in Geocentric Inertial Coordinates at the Scan mid-Time.

scLat (4-byte float, array size: nscan):
The geodedic latitude (decimal degrees) of the spacecraft at the Scan mid-Time.

scLon (4-byte float, array size: nscan):
The geodedic longitude (decimal degrees) of the spacecraft at the Scan mid-Time.

scAlt (4-byte float, array size: nscan):
The altitude (m) of the spacecraft above the Earth Ellipsiod at the Scan mid-Time.

scAttRoll (4-byte float, array size: nscan):
The satellite attitude Euler roll angle (degrees) 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.

scAttPitch (4-byte float, array size: nscan):
The satellite attitude Euler pitch angle (degrees) 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.

scAttYaw (4-byte float, array size: nscan):
The satellite attitude Euler yaw angle (degrees) 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.

SensorOrientationMatrix (4-byte float, array size: 3 x 3 x nscan):
SensorOrientationMatrix is the rotation matrix from the instrument coordinate frame to Geocentric Inertial Coordinates at the Scan mid-Time. It is unitless.

greenHourAng (4-byte float, array size: nscan):
The rotation angle (degrees) from Geocentric Inertial Coordinates to Earth Fixed Coordinates.

scLocalZenith (4-byte float, array size: nray x nscan):
The angle, in degrees, between the local zenith and the PR ray center line. The local (geodetic) zenith at the intersection of the ray and the earth ellipsoid is used. Ranges from - 30.0 to +30.0. This is an exact copy of the satellite local zenith angle in the 1C21 product.

rain (2-byte integer, array size: ncell1 x nray x nscan):
This is the estimate of rain rate at the radar range gates from 0 to 20 km along the slant range. It ranges from 0.0 to 300.0 mm/hr and is multiplied by 100 and stored as a 2-byte integer. A value of -88.88 mm/hr (stored as -8888) means ground clutter.

reliab (1-byte integer, array size: ncell1 x nray x nscan):
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.

```
bit 0   rain possible
bit 1   rain certain
bit 2   bright band
bit 3   large attenuation
bit 4   weak return (Zm less than 20 dBZ)
bit 5   estimated Z less than 0 dBZ
bit 6   main-lobe clutter or below surface
bit 7   missing data
```

correctZFactor (2-byte integer, array size: ncell1 x nray x nscan):
This is the attenuation corrected reflectivity factor (Z) at the radar range gates from 0 to 20 km along the slant range. It ranges from 0.0 to 80.0 dBZ and is multiplied by 100 and

stored as a 2-byte integer. Values of reflectivity less than 0.0 dBZ are set to 0.0 dBZ. A value of -88.88 dB (stored as -8888) is a ground clutter flag.

attenParmAlpha (4-byte float, array size: ncell2 x nray x nscan):
The attenuation parameter alpha relates the attenuation coefficient, k (dB/km) to the Z-factor: k = $alpha * Z^{beta}$. Alpha is computed at ncell2 radar range gates for each ray. It ranges from 0.000100 to 0.002000.

attenParmBeta (4-byte float, array size: nray x nscan):
The attenuation parameter Beta in k(dB/km) = $alpha * Z^{beta}$. Computed at ncell2 radar range gates for each ray.

parmNode (2-byte integer, array size: ncell2 x nray x nscan):
The Parameter Node gives the range bin numbers of the nodes at which the values of Attenuation and Z-R Parameters are given (see below). The values of the parameters between the nodes are linearly interpolated. This variable ranges from 0 and 79 and is unitless.

precipWaterParmA (4-byte float, array size: ncell2 x nray x nscan):
Parameter A in the M = AZ^B relationship. A is computed at each node (ncell2) for each ray. It ranges from ? to ?

precipWaterParmB (4-byte float, array size: ncell2 x nray x nscan):
Parameter B in the M = AZ^B relationship. B is computed at each node (ncell2) for each ray. It ranges from ? to ?

ZRParmA (4-byte float, array size: ncell2 x nray x nscan):
Parameter a for Z-R relationship (R=aZb) 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 ncell2 radar range gates for each ray. It ranges from 0.0050 to 0.2000.

ZRParmB (4-byte float, array size: ncell2 x nray x nscan):
Parameter b for Z-R relationship (R=aZb) 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 ncell2 radar range gates for each ray. It ranges from 0.500 to 1.000.

zmmax (4-byte float, array size: nray x nscan):
This is the maximum value of measured reflectivity factor at each IFOV. It ranges from 0.0 to 100.0 dBZ.

rainFlag (2-byte integer, array size: nray x nscan):
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., 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.

```
bit 0   rain possible
bit 1   rain certain
```

```
bit 2   zeta**beta greater than 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   bright 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
```

rangeBinNum (2-byte integer, array size: 7 x nray x nscan):
This array gives the Range Bin Number of various quantities for each ray in every scan. The definitions are:

- 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 (can be larger than 79)
- range bin number of the bright band if it exits
- 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
- range bin number of near surface bin

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 82 and have an interval of 250m. The earth ellipsoid is defined as range bin 79.

rainAve (4-byte float, array size: 2 x nray x nscan):
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 300 mm h-1 km.

precipWaterSum (4-byte float, array size: 2 x nray x nscan):
Vertically integrated value of sum precipitation water content calculated from Ze at each range bin. The first index is the precipitation liquid water content from the freezing height

to the actual surface. The second index is the sum of precipitation ice content from the top of the storm to the freezing height. Units are $gkm/m^3(kg/m^2)$ and it ranges from 0.0 to 50.0.

epsilon_0 (4-byte float, array size: nray x nscan):
The adjustment parameter computed from the filtered surface reference PIA (2A21). Unitless and it ranges from 0.0 to 100.0.

method (2-byte integer, array size: nray x nscan):
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). The default value is 0 (including no rain case). The following meanings are assigned to each bit in the 16-bit integer.

```
     0: (bit  1)    no rain
if rain
     0: (bit  1)    over ocean
     1: (bit  1)    over land
     2: (bit  2)    over coast, river, etc.
     3: (bit  2)    others (impossible)
    +4: (bit  3)    PIA from constant-Z-near-surface assumption
    +8: (bit  4)    spatial reference
   +16: (bit  5)    temporal reference
   +32: (bit  6)    global reference
   +64: (bit  7)    hybrid reference
  +128: (bit  8)    good to take statistics of epsilon.
  +256: (bit  9)    HB method used, SRT totally ignored
  +512: (bit 10)    very large pia\_srt for given zeta
 +1024: (bit 11)    very small pia\_srt for given zeta
 +2048: (bit 12)    no ZR adjustment by epsilon
 +4096: (bit 13)    no NUBF correction because NSD unreliable
 +8192: (bit 14)    surface attenuation > 60 dB
+16384: (bit 15)    data partly missing between rain top and bottom
```

epsilon (4-byte float, array size: nray x nscan):
The Epsilon (?) is the final correction factor applied to the assumed drop size distribution. Unitless and it ranges from 0.0 to 100.0.

epsilon_alpha (4-byte float, array size: nray x nscan):
Value used as a multiplicative correction to alpha used to modify R-Ze and LWC-Ze relations. Unitless and ranges from 0.0 to 100.0.

epsilon_nubf (4-byte float, array size: nray x nscan):
NUBF correction factor for k-Ze relation. Unitless and it ranges from 0.8 to 1.0.

zeta (4-byte float, array size: nmeth x nray x nscan):
Integral of $0.2 * ln(10) * beta * alpha * Zm^{beta}$ from rain top to the clutter-free bottom.

First index is from the rain top to the bottom. Second index is PIA_est from epsilon corrected zeta. It ranges from 0.0 to 100.0 and is unitless.

zeta_mn (4-byte float, array size: nmeth x nray x nscan):
Zeta_mn is the average of zeta in the vicinity of each beam position (average over three scans and three IFOVs). First index is mean of zeta. Second index is mean of PIA_est. It ranges from 0.0 to 100.0 and is unitless.

zeta_sd (4-byte float, array size: nmeth x nray x nscan):
Zeta_sd is the standard deviation of zeta in the vicinity of each beam position (using three scans and three IFOVs). First index is the standard deviation of zeta. Second index is the standard deviation of PIA_est. It ranges from 0.0 to 100.0 and is unitless.

sigmaZero (4-byte float, array size: nray x nscan):
The Sigma-zero is the normalized surface cross section. It ranges from -50.00 to 20.00 dB. This field is copied from the 2A21 product file.

freezH (4-byte float, array size: nray x nscan):
A positive Height of Freezing Level is the height of the 0^oC isotherm above mean sea level in meters, estimated from GANAL (Global analysis data by Japanese Meteorological Agency) surface temperature data. This field is copied from the 2A23 product. Negative values are defined as:

```
-5555: When error occurred in the estimation of Height of Freezing Level
-8888: No rain
-9999: Data missing
```

nubfCorrectFactor (4-byte float, array size: 3 x nray x nscan):

```
The Non-Uniform Beam Filling (NUBF) Correction Factor
is used as a correction to reflectivity and attenuation calculations.
It's range is between 1.0 and 10.0 and is unitless.
The dimension of 3 has the following meanings (in C):
  0    NUBF correction factor for the surface  reference
  1    NUBF correction factor for the R-Ze relation
  2    NUBF correction factor for the LWC-Ze relation
Note that the NUBF correction factor for the k-Ze relation
is stored in epsilon nubf.
```

stddev_zeta (4-byte float, array size: nray x nscan):
Standard deviation of zeta. Unitless.

stddev_PIAsrt (4-byte float, array size: nray x nscan):
Standard deviation of PIAsrt given by surface reference technique. Units are dB.

stddev_alpha (4-byte float, array size: nray x nscan):
Standard deviation of epsilon total corresponds to estimated uncertainty of alpha. Unitless.

stddev_Zm (4-byte float, array size: nray x nscan):
Standard deviation of epsilon_f. Unitless.

qualityFlag (2-byte integer, array size: nray x nscan):
This is a quality flag and ranges from 0 to 32767. 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.

```
    0:   normal
   +1:   unusual situation in rain average
   +2:   NSD of zeta (xi) calculated from less than 6 points
   +4:   NSD of PIA calculated from less than 6 points
   +8:   NUBF for Z-R below lower bound
  +16:   NUBF for PIA above upper bound
  +32:   epsilon not reliable, epsi\_sig less than or equal to 0.0
  +64:   2A21 input data not reliable
 +128:   2A23 input data not reliable
 +256:   range bin error
 +512:   sidelobe clutter removal
+1024:   probability=0 for all tau
+2048:   pia\_surf\_ex less than or equal to 0.0
+4096:   const Z is invalid
+8192:   reliabFactor in 2A21 is NaN
+16384:  data missing
```

nearSurfRain (4-byte float, array size: nray x nscan):
Rainfall rate near the surface. The range is 0 to 300 mm/hr. A value of -99.99 mm/hr. is a missing flag.

nearSurfZ (4-byte float, array size: nray x nscan):
Reflectivity near the surface. The range is 0.0 to 100.0 dBZ. A value of -99.99 dBZ is a missing flag.

e_SurfRain (4-byte float, array size: nray x nscan):
The rainfall estimate at the true (detected) surface bin. Units are mm/hr and ranges from 0 to 300 mm/hr. A value of -99.99 mm/hr is a missing flag.

pia (4-byte float, array size: 3 x nray x nscan):
Path integrated attenuation (PIA) (two-way) estimates for three cases: - The final adjusted PIA estimate - The difference between the PIA at the surface and near surface range bins - The PIA estimate from 2A21 The units are dB. Values are in dB. Special values are defined as:
-9999.9 Missing value

pia_srt (4-byte float, array size: nestmeth x nray x nscan):
Path integrated attenuation estimates from 2A21. First index is the method of estimation:

```
0 - best estimate (copy of 2A21 pathAtten)
1 - spatial, forward
2 - hybrid, forward (ocean only)
3 - spatial, backward
4 - hybrid, backward (ocean only)
5 - temporal (should be the same forward or backward)
```

Values range from -50 to 50 dB. Special values are defined as:
-9999.9 Missing value

stddev_srt (4-byte float, array size: nestmeth x nray x nscan):
Standard deviation of the SRT PIA estimates computed from the SRT PIA and the 2A21 reliability factor. First index is the method of estimation:

```
0 - best estimate (copy of 2A21 pathAtten)
1 - spatial, forward
2 - hybrid, forward (ocean only)
3 - spatial, backward
4 - hybrid, backward (ocean only)
5 - temporal (should be the same forward or backward)
```

Values range from -50 to 50 dB. Special values are defined as:
-9999.9 Missing value

errorRain (4-byte float, array size: nray x nscan):
The error in Near Surface Rain Rate. The units are dB.

errorZ (4-byte float, array size: nray x nscan):
The error in Near Surface Z. The range is 0.0 to 100.0 dBZ.

spare (4-byte float, array size: 2 x nray x nscan):
Contents and ranges are not public.

rainType (2-byte integer, array size: nray x nscan):
This is a copy of the 2A23 Rain Type field, See 2A23 description.

C Structure Header file:

```
#ifndef _TK_2A25_H_
#define _TK_2A25_H_

#ifndef _L2A25_NAVIGATION_
#define _L2A25_NAVIGATION_
```

```
typedef struct {
    float scPosX;
    float scPosY;
    float scPosZ;
    float scVelX;
    float scVelY;
    float scVelZ;
    float scLat;
    float scLon;
    float scAlt;
    float scAttRoll;
    float scAttPitch;
    float scAttYaw;
    float SensorOrientationMatrix[3][3];
    float greenHourAng;
} L2A25_NAVIGATION;

#endif

#ifndef _L2A25_SCANSTATUS_
#define _L2A25_SCANSTATUS_

typedef struct {
    signed char missing;
    signed char validity;
    signed char qac;
    signed char geoQuality;
    signed char dataQuality;
    short SCorientation;
    signed char acsMode;
    signed char yawUpdateS;
    signed char prMode;
    signed char prStatus1;
    signed char prStatus2;
    double FractionalGranuleNumber;
} L2A25_SCANSTATUS;

#endif

#ifndef _L2A25_SCANTIME_
#define _L2A25_SCANTIME_

typedef struct {
```

```
    short Year;
    signed char Month;
    signed char DayOfMonth;
    signed char Hour;
    signed char Minute;
    signed char Second;
    short MilliSecond;
    short DayOfYear;
} L2A25_SCANTIME;

#endif

#ifndef _L2A25_SWATH_
#define _L2A25_SWATH_

typedef struct {
    L2A25_SCANTIME ScanTime;
    double scanTime_sec;
    float Latitude[49];
    float Longitude[49];
    L2A25_SCANSTATUS scanStatus;
    L2A25_NAVIGATION navigation;
    float scLocalZenith[49];
    float rain[49][80];
    signed char reliab[49][80];
    float correctZFactor[49][80];
    float attenParmAlpha[49][5];
    float attenParmBeta[49];
    short parmNode[49][5];
    float precipWaterParmA[49][5];
    float precipWaterParmB[49][5];
    float ZRParmA[49][5];
    float ZRParmB[49][5];
    float zmmax[49];
    short rainFlag[49];
    short rangeBinNum[49][7];
    float rainAve[49][2];
    float precipWaterSum[49][2];
    float epsilon_0[49];
    short method[49];
    float epsilon[49];
    float epsilon_alpha[49];
    float epsilon_nubf[49];
```

```
    float zeta[49][2];
    float zeta_mn[49][2];
    float zeta_sd[49][2];
    float sigmaZero[49];
    float freezH[49];
    float nubfCorrectFactor[49][3];
    float stddev_zeta[49];
    float stddev_PIAsrt[49];
    float stddev_alpha[49];
    float stddev_Zm[49];
    short qualityFlag[49];
    float nearSurfRain[49];
    float nearSurfZ[49];
    float e_SurfRain[49];
    float pia[49][3];
    float pia_srt[49][6];
    float stddev_srt[49][6];
    float errorRain[49];
    float errorZ[49];
    float spare[49][2];
    short rainType[49];
} L2A25_SWATH;

#endif

#ifndef _L2A25_CLUTTER_
#define _L2A25_CLUTTER_

typedef struct {
    signed char mainlobeEdge[49];
    signed char sidelobeRange[49][3];
} L2A25_CLUTTER;

#endif

#endif
```

Fortran Structure Header file:

```
STRUCTURE /L2A25_NAVIGATION/
    REAL*4 scPosX
    REAL*4 scPosY
    REAL*4 scPosZ
```

```
    REAL*4 scVelX
    REAL*4 scVelY
    REAL*4 scVelZ
    REAL*4 scLat
    REAL*4 scLon
    REAL*4 scAlt
    REAL*4 scAttRoll
    REAL*4 scAttPitch
    REAL*4 scAttYaw
    REAL*4 SensorOrientationMatrix(3,3)
    REAL*4 greenHourAng
END STRUCTURE

STRUCTURE /L2A25_SCANSTATUS/
    BYTE missing
    BYTE validity
    BYTE qac
    BYTE geoQuality
    BYTE dataQuality
    INTEGER*2 SCorientation
    BYTE acsMode
    BYTE yawUpdateS
    BYTE prMode
    BYTE prStatus1
    BYTE prStatus2
    REAL*8 FractionalGranuleNumber
END STRUCTURE

STRUCTURE /L2A25_SCANTIME/
    INTEGER*2 Year
    BYTE Month
    BYTE DayOfMonth
    BYTE Hour
    BYTE Minute
    BYTE Second
    INTEGER*2 MilliSecond
    INTEGER*2 DayOfYear
END STRUCTURE

STRUCTURE /L2A25_SWATH/
    RECORD /L2A25_SCANTIME/ ScanTime
    REAL*8 scanTime_sec
    REAL*4 Latitude(49)
```

```
REAL*4 Longitude(49)
RECORD /L2A25_SCANSTATUS/ scanStatus
RECORD /L2A25_NAVIGATION/ navigation
REAL*4 scLocalZenith(49)
REAL*4 rain(80,49)
BYTE reliab(80,49)
REAL*4 correctZFactor(80,49)
REAL*4 attenParmAlpha(5,49)
REAL*4 attenParmBeta(49)
INTEGER*2 parmNode(5,49)
REAL*4 precipWaterParmA(5,49)
REAL*4 precipWaterParmB(5,49)
REAL*4 ZRParmA(5,49)
REAL*4 ZRParmB(5,49)
REAL*4 zmmax(49)
INTEGER*2 rainFlag(49)
INTEGER*2 rangeBinNum(7,49)
REAL*4 rainAve(2,49)
REAL*4 precipWaterSum(2,49)
REAL*4 epsilon_0(49)
INTEGER*2 method(49)
REAL*4 epsilon(49)
REAL*4 epsilon_alpha(49)
REAL*4 epsilon_nubf(49)
REAL*4 zeta(2,49)
REAL*4 zeta_mn(2,49)
REAL*4 zeta_sd(2,49)
REAL*4 sigmaZero(49)
REAL*4 freezH(49)
REAL*4 nubfCorrectFactor(3,49)
REAL*4 stddev_zeta(49)
REAL*4 stddev_PIAsrt(49)
REAL*4 stddev_alpha(49)
REAL*4 stddev_Zm(49)
INTEGER*2 qualityFlag(49)
REAL*4 nearSurfRain(49)
REAL*4 nearSurfZ(49)
REAL*4 e_SurfRain(49)
REAL*4 pia(3,49)
REAL*4 pia_srt(6,49)
REAL*4 stddev_srt(6,49)
REAL*4 errorRain(49)
REAL*4 errorZ(49)
```

```
    REAL*4 spare(2,49)
    INTEGER*2 rainType(49)
END STRUCTURE

STRUCTURE /L2A25_CLUTTER/
    BYTE mainlobeEdge(49)
    BYTE sidelobeRange(3,49)
END STRUCTURE
```